Census of the Fishes

Summary of a Conceptual Workshop
20-22 April 1998
Southampton Oceanography Centre
Southampton, U.K.

1.Introduction

1.1. A Conceptual Workshop entitled 'Census of the Fishes' was held on 20-22 April 1998 at Southampton Oceanography Centre, Southampton, UK, hosted by Professor J G Shepherd and sponsored by the Alfred P Sloan Foundation of New York. The Workshop was held under the auspices of the International Council for the Exploration of the Sea (ICES) Planning Group on the Census of the Fishes (Chairman Dr R. C. A. Bannister, UK). Other PlanningGroup members are: Prof. J.G. Shepherd, Prof J.G.Pope, Dr. J. Steele, Dr. V. Holiday, Dr. K. Foote, Dr. M. Reeve, and Dr. M. Sissenwine. The Sloan Foundation was represented by Professor Jesse Ausubel, of Rockefeller University, New York, Over forty participants attended from Europe, USA and Canada, of whom five were members of the ICES Planning Group. Participants included representatives of the fields of fisheries resources and assessment, marine ecology, oceanography, acoustics, taxonomy, various species groups, and international marine committees. They were selected at a preliminary steering group meeting held in Southampton on 9-10 February, 1998, which also devised the programme for the Workshop.

2. Format of the Workshop

2.1. Day 1 opened with presentations describing the interests of Sloan (Jesse Ausubel), the role of ICES (Colin Bannister),existing international programmes (John Shepherd), and, as a scientific taster, the possible use of size spectra to describe marine species assemblages (John Pope). This was followed by brainstorming sessions aimed at giving participants full scope to identify potential scientific objectives, methods and constraints. Representatives of the principal scientific disciplines were allocated across three groups facilitated by John Pope, Debbie Steinberg and Annelies Pierrot-Bults, whose overviews were presented and discussed in plenary session. These overviews were sufficiently uniform and coherent to form the basis for the framework programme summarised in the main body of this report.

2.2. Day 2 of the Workshop opened in plenum with a follow-up synthesis (Colin Bannister) and discussions, plus a summary of the Monterey Workshop (John Shepherd). Participants then assigned themselves to three new brainstorming groups to discuss:

- Sampling : what needs to be sampled and how (facilitator Nigel Merrett)
- Biodiversity (facilitator Martin Angel)
- Change and its measurement (facilitator John Caddy)

Overviews were presented and discussed in plenum

Day 3 comprised extended plenary synthesis and discussion (facilitator, Colin Bannister).The meeting finished at 1300 hours.

3.The Sloan Perspective

3.1. Jesse Ausubel outlined the Sloan Foundation interest in stimulating the development of novel, large scale observational programmes such as the Digital Sky Survey. Sloan was particularly interested in the application of technology and data bases to innovative questions driven by curiosity and the desire to advance knowledge and understanding of our world, especially if the project could capture the imagination of the public as well as scientists. The 'Census of the Fishes' was a potential Millenium Grand Challenge of this kind with a possible decadel time scale. Several Workshops had already been held in the United Sates on global assessment programmes on ecology and ichthyology, marine benthos, associated technology, non-fish nekton. Sloan was funding the Workshop to give marine scientists the chance to discuss:

- What aspects of marine biology represented a useful global study
- Whether such a study would be feasible, identifying the most useful elements
- The extent of such a study in terms of quality, quantity, and processes
- The areas of the ocean which would be of most interest or utility
- The technology and other resources required to undertake such a programme
- The likely degree of support from the marine science community globally
- The problems involved in undertaking such a programme

4. The ICES Perspective

4.1. As an interdisciplinary body with a wide range of interests and expertise in North Atlantic oceanography, fisheries, and marine ecology, the International Council for the Exploration of the Sea (ICES), based in Copenhagen, could stimulate and co-ordinate interest in a North Atlantic component of a 'Census' programme. If ICES member countries agree, ICES Working Groups and Study Groups could facilitate planning, theoretical or technical developments, and database co-ordination. In 1997, following informal contact between Jesse Ausubel and Colin Bannister, then chair of the ICES Consultative Committee, an informal meeting was held at the ICES Annual Science Conference (ASC) at Baltimore, USA, with a small group of experts who were later formally constituted by ICES Resolution (1997/2.9) as the ICES Planning Group on the Census of the Fishes (Chairman Dr R. C. A. Bannister, UK). The ICES Planning Group Report will be presented to the 1998 ICES ASC in Lisbon, and will be the basis for any further action by ICES.

5. A framework programme

5.1. As a basis for a Census of the Fishes programme, leading questions raised by the Workshop included:

- what lives in the oceans?
- where does it live?

- how much is there?
- what is the pattern of diversity, and how does it vary?
- what are the interactions and processes?
- what control systems are operating?
- how much fine-scale resolution is required?
- what can the present tell us about changes since the past?
- is the ocean healthy?
- how much change can it assimilate?
- do observed responses reflect universal mechanisms?
- is global warming real?
- what predictions can we make about the future?
- what baseline is required for assessing change in the future?
- what will we need to know over the next 10 to100 years?

5.2. Following the detailed brainstorming sessions, it was concluded that the Census study should provide a first global synoptic view of marine living resources. It should obtain an extended snapshot of the structure and function of the marine ecosystem as a baseline for measuring change against historical information, and new information that may be collected in the future. As this snapshot will take several years to collect, sampling protocols must take into account seasonal and inter-annual differences. The programme needs to be extensive in both the horizontal and the vertical scale. The horizontal scale should range from coastal waters (possibly including lagoons, but excluding areas with problems of jurisdiction) to the shelf, slope and open ocean, from the poles to the tropics. The vertical scale should range from surface productivity, to the deep sea pelagic zone, and the least known benthic layer. Sampling would be on a broad scale, say as a living resource analogue of WOCE, or GOOS. It would undertake extensive low intensity sampling possibly using advanced technology, coupled with intensive detailed sampling at selected stations and depths. Biogeographic provinces could be the basis for a primary choice of sampling strata, although these are not absolute in character because phytoplankton are affected by climate and latitude, zooplankton by ocean circulation and fronts, and benthos by depth and the nature of the sea floor. An overlay of various existing maps could serve as an initial starting point for decisions about the sampling strata and could include WOCE tracks, coupled with an overlay of maps showing biogeographic zones.

5.3. The primary objective should be to attempt to quantify the time-space distribution of marine organisms, both in numbers and biomass, since the geographical and depth distribution of these may well differ. It was proposed to study the distribution of micronektonic species of fish and crustacea of a minimum size of 2 cm up to 100 cm, but also, for example, groups such as cephalopods, salps, siphonophores, cetaceans and sea birds, as well as macrobenthos. The resolution should preferably be at the level of dominant species, since this is the interface where evolution, ecology, environment, and anthropogenic factors meet. As significant constraints will be imposed by available identification knowledge and skills, however, achievable resolution in less well studied areas or zones may be at a more aggregated level of functional groups or assemblages.

5.4. The use of data on the distribution of numbers and biomass as a measure of diversity is important but should not be an end in itself. As a secondary objective, it would be particularly

valuable to identify linkages, functions, and processes, so that we can understand enough to measure changes, or to understand the implications of change. This will require information about life-history stages, trophic relationships, behaviour and migration. Emergent properties such as size spectra, the ratio of demersal and pelagic biomass, or the ratio of other component species groups, could all be valuable, but in addition to, not instead of, species information.

5.5. Although extensive intensive sampling would make use of opening and closing nest, and benthic trawls, the potential role for more sophisticated technology is substantial. This ranges from the use of satellites to measure the distribution and intensity of surface production, to the use of ROV's, submersibles and various towed arrays for optical and acoustical observations. A summary of the possible scope for technological development was available (Van Holliday), but at this stage it was not clear if the emphasis would be on maximising the value of existing technology, or if there will be sufficient time for major technical development.

5.6. All aspects of the use of sampling gear, optical and acoustic technology, and species identification skills, will require standardisation and calibration. Taxonomists will require to use existing archives of specimens, and taxonomic data bases, and should be encouraged to develop new ones. It may be necessary to extend taxonomic expertise by developing training programmes. There may be scope for using molecular genetics to assist with the identification of difficult groups, or their unknown relatives, such as copepods. Questions about bias, precision, and replication need to be resolved at all levels. The potential for synergy and also competition with existing national and global programmes (e.g. WOCE, GOOS) and funding cycles needs to be evaluated.

5.7. Resources will need to be harnessed and co-ordinated on a world-wide basis, both round existing programmes as well as new elements. It is envisaged that the programme might run over a decade, starting in 2002 or 2003, and that to make progress, a Programme Officer will need to be appointed, with an appropriate mission statement, objectives, target dates, and communications via a web site.

5.8. Other questions raised during discussion of the brainstorming reports included:

- Are there exploitable quantities of fish in the deep ocean?
- Can we extend our knowledge of siphonophore biology, mesopelagic structure and function?
- Can we map the European shelf?
- Can we make an inventory of the Mediterranean?
- What biological changes result from changes in oceanic circulation?
- Can we study the flux moving past sediment traps?
- Can we fill the gap in knowledge about large pelagic species with regard to climate, migration and time-scales?

5.9. Substantial detail was recorded by rapporteurs for the individual sessions, and this will be archived for later use.

6. Conclusions

At the end of the workshop participants were of the view that a global "Grand Challenge" was useful, attractive, and potentially feasible, but would be a major long term undertaking. It would study:

- Distribution of marine life in space and time across biogeographic zones
- Biomass in terms of numbers and size of best-known and numerically dominant species, together with some indication of species diversity where possible (linked to the Rio Convention). For example, pelagos (surface to sea floor) and macrobenthos of a minimum size of 2cm and maximum of 100cm,.also larger marine life such as fish, cephalopods, salps, siphonophores, cetaceans and sea birds.
- Possible use of acoustic & optical size spectra
- Marine ecosystem variability, trophic structure, dynamics, and processes
- Use of historical data and the Census data to assess change in marine ecosystems related to climate, eutrophication, rapid cooling, trends, seasonal variability, global warming
- Baseline for assessment of future changes

7. A sample of views presented during the meeting

The operational scale

This would depend on whether the project was part of other programmes e.g. part of GOOS-LMR.

Strategy

If we are to describe patterns, we may not be able to analyse process**.** We need to know how inter-relationships work e.g. trophic patterns.

Protocols

Global standardisation of methods and quality of data is paramount

Measurement of Change

This could be assessed by looking at size, species, ratios e.g. ratios of pelagos to benthos. This can also be assessed by comparing old data with new. Genetic analysis could be used. Causes of change, other than climate, might not be detectable. We need to adopt baselines for change.

Areas of sampling

The pros and cons of sampling shelf and inshore areas versus open oceans were discussed but it was decided to sample the deep open ocean, slope and shelf seas and some coastal areas partly because the majority of fish are in warm shallow water. Sampling in shallow coastal areas would need partnerships with local institutions as a survey of the coast has special problems in terms of sampling strategy, gear and national jurisdiction. Some large

coastal surveys are being undertaken. Seasonal effects may be encountered in some estuaries. The open ocean is often of no one's concern and so may be under-sampled. Standard protocols might look similar to the Living Marine Resources initiatives in open and shallow waters. It was agreed that new technology in sampling gear was important.

Observations and sequences

There was an opportunity to prioritise areas by coverage, problems, interest, cost, difficulty, ship-time, special requirements etc. based on a common-sense stratification but possibly weighted by existing commitments. Output would depend on the programme plan and sampling design. Special features and requirements would need to be defined early.

Constraints of Preferential sampling

There was a strong basis for using different biogeographic zones to look at abundance by size and species. Using WOCE tracks and physical measurements could provide a powerful comparison between physical and biological activity, but the original WOCE track took 10 years to complete. In the open ocean we could use fixed buoys with hydrophones, and ROV's.

Biomass vs Biodiversity

Biodiversity was considered important - but was not defined. Many stressed the importance of understanding biodiversity and species distributions to detect ecosystem change. Other questions focussed on whether abundance should be measured by taxa or size. It was agreed that sampling would determine size.

Sampling

It was considered relatively easy to sample in coastal areas. Cetaceans and sea birds and siphonophores should be included when designing transects. A programme should concentrate on animals 10cms to 100cms with a focus on nekton and macrobenthos (microbenthos needs specialised trawls). Smaller benthic fauna (microfauna) could be sampled in a restricted geographic range. It was a greed that many samples would be needed with some repeats and replications. Commercial fisheries catch data would be useful, based on the wide array of published fisheries statistics even though these may not always be complete. It might be possible to put technology packages on commercial ships but they would not cover all areas, and biomass data might not be accurate from this source. Many areas cannot be sampled by trawlers e.g. rocky coasts. New nets may have to be designed. e.g. fishing gear. For use inshore acoustic photographic techniques could be used for benthos. A study of higher trophic levels could provide a focus of any potential program but ecological data on primary production, and biological, chemical, and physical oceanography, would need to be incorporated.

Sampling and Variance

Participants agreed the need for repeatable and replicate sampling and calibration techniques.
A role for ICES could be to standardise protocols for analysis methodology giving comparable results.

Technology

This was not discussed in detail. It was thought that a major element of the programme could be the development of up-front technology and ICES could be very helpful in promoting this. Timing was important e.g. to be ready to begin in 2002. Other possible links were with GLOBEC. The Norwegian participants said that new technology is being developed in sampling gear.

Data Base Management

Participants decided that they would need to use new and existing data bases e.g. fish, cephalopods, gelatinous material e.g. 'Species 2000' and that there should be a data base of archived information. They agreed that a data management policy should be set up especially on quality control.

Role of models

Generally the group were uncertain about using models. Some participants felt that they would be useful, others questioned their usefulness because process modelling and testing are time-consuming. The group thought that quantitative data can give guidelines as to what can be done with the data but tropho-dynamic models are more difficult. Physics models may be useful. As bacteria will not be sampled it would be difficult to obtain models on trophic relationships.

8. The way forward

8.1. Participants agreed that one way forward is for delegates to put forward the proposal at various conferences and committee meetings this year e.g. possible ICES workshops. Jesse Ausubel also said that the Sloan Foundation could facilitate other discussions and workshops and by the end of 1998 it may set up an International Planning Committee plus a USA committee in Parallel.

8.2. There must be a manageable unit of operation and people would need to be trained to do the work involving technology, physics and biology. Therefore long lead times were important. It was hoped that global marine programmes involved with some of the less developed countries, could help. Links with ICES, the US, Canada, and alignment with international organisations such as FAO, and SIFR programmes were important. Duplication should be avoided. It was considered best if there was representation at the forthcoming workshops e.g. on technology transfer, remote sensing of species. A pilot study of the North Atlantic shelves might be possible perhaps with the inclusion of southern Atlantic Shelf regions. The Programme should be established in conjunction with existing committees e.g. IOC, PICES, SCOR, GLOBEC, GOOS-

LMR, ICATT, IWC etc. etc However all links have to be worked out diplomatically so that the proposal has the endorsement of all concerned. There could be an Atlantic pilot programme proposed by ICES for shelf, coast and deep-water. Inside the framework separate projects could be developed with the support of FAO and possibly NATO. It was hoped that The Sloan Foundation could co-ordinate some of the work.

8.3 A programme officer. Participants agreed that a Programme Officer would need to be adopted and a mission statement formulated e.g. 'to undertake a global survey of the animal life of the worlds oceans, mainly directed at the higher trophic levels'. It was agreed that it should be similar to the Monterey statement set out in Alice Alldredge's paper, but should refer to a global programme.

8.4 Programme requirements. There was a variety of different views on what funding would be required. Many felt that a pilot program in limited geographic regions might provide the best impetus for consolidating funding. There was general agreement that starting out with a decadel time frame seemed appropriate. Participants suggested that typical funding sources such as the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA) should be augmented by additional non-traditional sources including the fishing industry, the International Monetary Fund (IMF), the Food and Agriculture Organisation (FAO), or other governmental sources, particularly in the developing countries. Participants recognised that "selling the idea" to the public as well as program officers at government agencies and elsewhere would require a clear, concise message with strong societal and scientific relevance.