ICES SGBIODIV REPORT 2009

ICES MARINE HABITAT COMMITTEE

ICES CM 2009/MHC: 05

REF. SCICOM, BEWG, AND ACOM

Report of the Study Group on Biodiversity Science (SGBIODIV)

17–20 March 2009

Wilhelmshaven, Germany

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2009. Report of the Study Group on Biodiversity Science (SGBIODIV), 17–20 March 2009, Wilhelmshaven, Germany. ICES CM 2009/MHC:05. 51 pp.
https://doi.org/10.17895/ices.pub.8772

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Executive summary

Despite the importance of biodiversity, as well as the legal and other requirements to protect the marine environment and regulate human impacts in the North Atlantic, Biodiversity Science has not traditionally been considered a core focus of the ICES community. In recent years, biodiversity issues have become an increasingly important element of ICES advisory work and biodiversity is one of the research topics identified in the ICES Science Plan as being of strategic importance to the advisory needs of ICES. The European Commission's (EC) recent Marine Strategy Framework Directive (MSFD) also highlights the importance of marine biodiversity, and so requests for information from ICES on the monitoring, assessment and integration of biodiversity information will likely increase. Although a wide variety of ICES Expert Groups are involved in certain aspects of marine biodiversity, there has to date been little coordinated integration and synthesis of the information and advice they produce.

There are critical gaps in current research expertise and data management, which affect the ability of ICES to provide effective management advice in terms of biodiversity. A better understanding of the resilience and stability of marine ecosystems as well as the role of disturbance is required in order to assess anthropogenic impacts on biodiversity. Better syntheses of biodiversity information, including its functional and social-economic importance is needed to allow managers to make more informed decisions.

SGBIODIV has explored options for the integration of Biodiversity Science into the present ICES science and advisory structure. These options seek to deliver biodiversity information at both an operational level (i.e. to respond to immediate client requests), as well as on a more strategic level (i.e. to improve ICES' ability to undertake Biodiversity Science and to develop integrated biodiversity advice). Specifically, SGBIODIV has:

- reviewed the assessment, advisory and governance structure within ICES in order to determine the most appropriate levels at which Biodiversity Science should be coordinated,
- explored options for the integration of Biodiversity Science into the ICES science and advisory community and
- developed a working plan to integrate and communicate ICES Biodiversity Science.

Biodiversity is an overarching theme to much of ICES' work, and in order to address ICES' fundamental goals, it is vital that Biodiversity Science be addressed in a better coordinated and more integrated way. Key recommendations include:

- The establishment of SGBIODIV as a Working Group on Biodiversity (WGBIODIV) with a mandate to deliver Biodiversity Science as an overarching theme and in a coordinated manner.
- The development of a structured work plan for ICES Biodiversity Science that considers the issues identified by SGBIODIV with regard to the availability and quality of relevant expertise and data, better integration of biodiversity information into management strategies, the development, application and utility of biodiversity indicators and future communication of ICES Biodiversity Science.

Pressures on marine biodiversity are global and, as stated in the ICES Science Plan "global problems require global approaches".

1 Opening of the meeting

The Study Group on Biodiversity Science (SGBIODIV) met from 17–20 March 2009 at the German Centre for Marine Biodiversity Research in Wilhelmshaven, Germany. The Chair, Michaela Schratzberger (Cefas), was unable to participate for the whole meeting and Jim Ellis (Cefas) acted on her behalf, welcoming seven participants from five countries (Annex 1) and recording apologies from other members of the group.

2 Appointment of Rapporteur

Dr J. Andrew Cooper (DFO-Canada) was appointed as Rapporteur.

3 Adoption of the agenda

The agenda for the SGBIODIV meeting (Annex 2) followed the Terms of Reference adopted as a resolution by the ICES 2008 Annual Science Conference and Statutory Meeting.

4 Introduction

Over the past few hundred years, biodiversity has faced major challenges, including a growing demand for biological resources caused by population growth and increased consumption. This increased exploitation of biological resources has resulted in the loss of species at levels currently estimated to be 100 times faster than the natural rate of loss prior to significant human intervention. Recognition of this problem is hardly new, and scientists and policy-makers have worked to develop mechanisms to document, conserve and sustainably use biodiversity (International Institute for Sustainable Development, 2005).

Human actions are fundamentally, and to a great extent irreversibly, changing the diversity of life on earth, and most of these changes represent a loss of biodiversity. Because diversity has many components, no single component, whether genes, species, communities or ecosystems, is consistently a good indicator of overall biodiversity as the components can vary independently. Changes in important components of biodiversity were more rapid in the past 50 years than in any time in human history. Projections and scenarios indicate that these rates will continue, or accelerate, in the future. Virtually all of the Earth's ecosystems have now been dramatically transformed through human actions (Millennium Ecosystem Assessment, 2005).

Quantifying and understanding biodiversity is among the most serious problems facing mankind today. While the pressures on marine biodiversity are global, many of its drivers are local. As a result, potential solutions to address biodiversity loss often require detailed local or regional knowledge. Hence, information on the distribution of the components of biodiversity is vital if we are to make wise and informed decisions to help protect marine ecosystems (Ball and Henshall, 2006). The protection of marine biodiversity beyond national jurisdiction is receiving increased attention at both European and international level (e.g. Rochette and Billé, 2008; Webb, 2009). However, work at global level needs to take into account the regional dimension not only for scientific but also for advisory and political reasons (for example see 'Marine Ecoregions of the World' approach by Spalding *et al.*, 2007;

www.worldwildlife.org/MEOW; www.nature.org/MEOW).

Without question, one of the most pressing challenge is to establish the scientific foundations for appropriate future management actions, aimed at maintaining 'acceptable levels' and dynamics of biological diversity. Therefore, biodiversity must be integrated, based on existing knowledge, into the criteria considered in socio-economic and policy decisions, as well as environmental management. There is a clear need for the best scientific advice to improve the quality, transparency and accountability of the policy-making process, to ensure biodiversity is a mainstream consideration and to enable more aligned strategic decision-making.

Despite the importance of biodiversity, and the legal and other requirements to protect the marine environment and regulate human impacts in the North Atlantic (e.g. CBD, OSPAR), Biodiversity Science has not traditionally been considered a core focus of the ICES community (Rice, 2006). In recent years, biodiversity issues have become an increasingly important element of ICES' advisory work. In order to help ICES to rationalise and re-focus its activities in terms of its contribution to understanding and conserving the components of marine biodiversity, following its 2008 meeting, SGBIODIV recommended that ICES Expert Groups should be organised within a single framework based on the components of marine biodiversity. This, we proposed, would require a fundamental shift in ICES' perspective on biodiversity components, i.e. from being a cross-cutting to an overarching theme.

In light of recent changes to the ICES science and advisory structure (see section 6.3) and the necessity that Biodiversity Science becomes an overarching theme within ICES, our primary aim in 2009 was to investigate levels at which Biodiversity Science should be coordinated. Mindful of challenges associated with the integration of a new concept for marine science within a complex organisation such as ICES, we explored a number of options and approaches, and identifying key aspects for any biodiversity strategy. In this way, we can develop a working plan to integrate and communicate ICES Biodiversity Science aimed at exerting scientific leadership in marine biodiversity.

5 Terms of Reference

ToR a) Review the assessment, advisory and governance structure within ICES in order to determine the most appropriate levels at which Biodiversity Science should be coordinated.

In light of recent changes in the advisory structure and the necessity that Biodiversity Science becomes an overarching theme within ICES, SGBIODIV will examine the interactions between assessment, advice, and governance within ICES. This would be to ensure that the integrative nature of Biodiversity Science is effectively served within an advisory climate that may not specifically request information and advice in this holistic context.

ToR b) Explore options for the integration of Biodiversity Science into the ICES science and advisory community.

Understanding that integrating a new paradigm for marine science within a complex and already fully engaged organisation will be challenging and best served if the ICES advisory and governance structure was able to assess various approaches to this direction with associated tasks, timelines and risks.

ToR c) Develop a working plan to integrate and communicate ICES Biodiversity Science.

It will be important to identify key activities for the integration of capacities within ICES to improve knowledge of ecosystem processes. Additionally, ICES needs to engage capacities outside the traditional ICES community that can improve our knowledge of the structure and processes for those components of biodiversity in which the ICES community has not traditionally invested.

It will also be important to offer a plan to communicate the ICES approach to Biodiversity Science and its vision within the ICES science community, to help redefine customer needs (including the EC, NEAFC, OSPAR, NASCO, HELCOM) and to bring common understanding for integrated advice that serves specific management questions but in ecosystem context.

SGBIODIV will report by 24 April 2009 to the attention of the Science Committee.

6 Review of the assessment, advisory and governance structure within ICES in order to determine the most appropriate levels at which Biodiversity Science should be coordinated (ToR a)

6.1 Context

Technological advances during the past 50 years have dramatically modified how human society has made use of the oceans. Multiple human uses, including commercial fisheries, oil and gas industries, mining, dredging and aggregate extraction, offshore wind farms, the release of hazardous and radioactive substances, eutrophication, the introduction of non-native species and climate change have been affecting the structure, function and diversity of marine ecosystems.

At the 1992 United Nations Conference on the Environment and Development in Rio de Janeiro, most countries recognised the importance of the world's biodiversity and committed to the study and preservation of biodiversity in all ecosystems, by approving the Convention on Biological Diversity (CBD, http://www.biodiv.org).

In 2002, the Parties to the CBD committed themselves "to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth". During the 2002 World Summit on Sustainable Development in Johannesburg, this biodiversity target was subsequently endorsed and it was furthermore agreed to establish a world-wide network of marine protected areas (MPAs) by the year 2012.

For the implementation of the CBD, governments and stakeholders are in need of scientific advice on how the environment regulates biological diversity and ecosystem function, and how human activities may influence ecosystems (Balmford and Bond, 2005; Balmford *et al.*, 2005). Qualified advice on the management of biological communities over short and medium time frames, as well as better predictions of potential climate change effects on ecosystems are needed to guarantee the sustainable use of biological resources.

In addition to the CBD, there are two important regional seas conventions in the ICES area that control human activities and *inter alia* coordinate the implementation of the CBD in marine systems. The Oslo-Paris (OSPAR) Convention regulates international

cooperation on the protection of the marine environment of the North-East Atlantic and the Helsinki Convention follows analogous aims for the Baltic Sea. Each year ICES consults with OSPAR and HELCOM on scientific information and advice to be provided and data activities to be undertaken. Although these regional seas conventions do not have any direct legal competences in the management of human activities, their contracting parties have committed themselves to ensure ecosystem health. For example, in its Biodiversity and Ecosystems Strategy, OSPAR seeks to "protect and conserve the ecosystems and the biological diversity of the maritime area which are, or could be, affected as a result of human activities, and to restore, where practicable, marine areas which have been adversely affected" (OSPAR, 2003).

At the Fifth International Conference on the Protection of the North Sea in Bergen (2002), the North Sea States committed to the implementation of an Ecosystem Approach for the management of the biological resources of the North Sea. In addition to this, the Joint Ministerial Meeting of the OSPAR and HELCOM conventions in Bremen in 2003 adopted the Ecosystem Approach for the whole marine area of the North-East Atlantic and the Baltic and signed the 'Statement towards an Ecosystem Approach to the Management of Human Activities'. Requests to ICES from both OSPAR and HELCOM, particularly on proposals of marine protected areas, will become an increasing challenge for ICES within the next years.

The European Marine Strategy Framework Directive (MSFD), adopted in June 2008, emphasises that "The marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive." (CEC, 2008). The directive's aim is to achieve Good Environmental Status (GES) by 2020 and its major programme is biodiversity-related. Of the eleven defined qualitative descriptors for determining GES, one is specifically designated as an overarching indicator for biodiversity (MSFD descriptor 1) and four others reflect biodiversity-related issues (Table 6.1). This may require new monitoring programmes and assessment schemes, or the modification of existing monitoring programmes and the EC has asked that "monitoring methods are consistent across the marine region or subregion so as to facilitate comparability of monitoring results" (CEC, 2008). Consequently, ICES will likely be involved in ensuring standardised sampling and analyses for such programmes and has been given the task to facilitate Expert Groups for developing some of the descriptors.

Besides the quality descriptors for determining GES, EU member states shall also make use of the 'Indicative lists of characteristics' of the MSFD (see Annex III, Table 1 of the MSFD), which consist largely of biodiversity elements ("habitat types", "biological features").

The European Union has recently established a new integrated maritime policy, of which the 'European Strategy for Marine and Maritime Research' (Com (2008) 534 final, 3.9.2008 - 'A European strategy for marine and maritime research: a coherent European research area framework in support of a sustainable use of oceans and seas') is a fundamental part. The strategy highlights the importance of integration between established marine and maritime research disciplines in order to reinforce excellence in science.

In Canada, the 'Oceans Act' (1996) recognises the need of promoting studies with the purpose of understanding oceans and their living resources and ecosystems, and other acts, such as the 'Species at Risk Act' (SARA), are also involved with various elements of marine biodiversity.

Table 6.1. Qualitative descriptors for determining Good Environmental Status (GES) in the European Marine Strategy Framework Directive (MSFD; 2008/56/EC), their direct relevance for Biodiversity Science and the current involvement of ICES in their development.

	Descriptor of Good Environmental Status	Direct relevance to biodiversity	ICES involvement
1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions	✓	
2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems	✓	Yes
3	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock	✓	Yes
4	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity	✓	Yes
5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters		
6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected	✓	Yes
7	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems		
8	Concentrations of contaminants are at levels not giving rise to pollution effects		
9	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards		
10	Properties and quantities of marine litter do not cause harm to the coastal and marine environment		
11	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment		Yes

6.2 Relevant recent biodiversity initiatives

6.2.1 European Platform for Biodiversity Research Strategy (EPBRS)

The European Platform for Biodiversity Research Strategy (www.epbrs.org) is a forum at which natural and social scientists, policy-makers and other stakeholders identify structure and focus strategically important research that is essential to:

- Use the components of biodiversity in a sustainable way
- Maintain ecosystem functions that provide goods and services
- Conserve, protect and restore the natural world
- Halt biodiversity loss.

The mission of the EPBRS is to contribute with regular advice to the implementation of the EU Biodiversity Strategy. EPBRS is composed of 27 EU and associated member states, with a total of 32 partner countries. There are two delegates per country (one science-policy and one scientist). EPBRS meetings are usually held twice a year in the country of the EU Presidency. Prior to each meeting, an electronic conference, widely open to the scientific community, is organised. Contributions are summarised and reported to the delegates for discussion and recommendations may be adopted at the end of the meeting. These recommendations are presented to EC Scientific Officers (one from DG-Research and one from DG-Environment).

The EPBRS is an expert advisory group for biodiversity research strategy in the EC and its role is to:

- Review science topics relevant to current international policy issues in the field of biodiversity
- Develop an Action Plan for biodiversity research in Europe
- Assess research needs (e.g. communication from the Commission on halting the loss of biodiversity by 2010 and the new communication for biodiversity strategy, which is in progress)
- Review science topics relevant to current international policy issues in the field of biodiversity, e.g. invasive alien species (France); monitoring and indicators (Denmark); Mediterranean ecosystems (Spain); marine biodiversity (Portugal); biodiversity and business (France).

Criteria for the selection of thematic areas are:

- Apply to terrestrial (including freshwater) as well as marine biodiversity
- Holistic approaches could be applied
- Help to solve problems of the 'real world' but should also provide enough space for basic research
- Can be tackled from various angles and disciplines (natural and social sciences) and provide opportunities for interdisciplinary research.

EPBRS is much involved in the preparation of IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) which is in progress.

6.2.2 Foundation for Research on Biodiversity (FRB–France)

FRB was created in March 2008 by eight major scientific institutions with the support of the Ministries in charge of ecology and research. This merged the activities of two former organisations, Institut Français de la Biodiversité (IFB) and the Bureau of Genetic Resources (BRG), and widened their scope of activities.

FRB's purpose and mandate is to:

- Collect and analyse information on biodiversity research
- Coordinate research on biodiversity across all fields of science and promote cooperation at the European and international level
- Enhance dissemination of research results and their use by public and private decision makers
- Establish a sustainable partnership with the private sector to promote science and the management of biodiversity, including genetic resources.

The governance of FRB is organised with three interactive components: the Board (chaired by the President of Foundation) which has eight representatives from research organisations and five stakeholder representatives, the Scientific Council (20 experts) and the Steering Committee (40 representatives of stakeholders from industry, protected areas, civil society organisations and NGOs, territorial collectivities, associations of professionals including fishermen, farmers, etc.). A core team with a staff of around 20 people implements operational activities.

FRB activities fall largely into five groups:

- Networking the research community and strategic planning, (through the scientific panel and working groups)
- Scientific information: symposia and other events, newsletters and publications
- Supporting/managing research programmes and calls for proposals
- Sustaining networks and national collections for the management of genetic resources
- Developing working groups and other partnerships with stakeholders (managers and private sector).

FRB international and European involvement can be summarised as follows:

- FP6: involved in the coordination of BiodivERsA and member of the European Platform for Biodiversity Research Strategy (EPBRS) (as the French biodiversity platform)
- French platform of Diversitas (international programme on biodiversity research)
- National scientific focal point of SBSTTA (CBD component)
- FP7: national contact point for 'Environment'
- Involved in international networks for conservation of genetic resources
- Executive secretariat of IMoSEB (towards an IPBES – Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem).

FRB publications are available electronically (www.fondationbiodiversite.fr). These include publications on 'Halting the loss of biodiversity: understanding funds and

policies', 'Integrating biodiversity into business strategies' and 'Selecting indicators for management of biodiversity'.

6.2.3 Canadian Healthy Oceans Network (CHONe)

The Canadian Healthy Oceans Network (CHONe), based at Newfoundland's Memorial University and led by Paul Snelgrove, brings together 65 top marine researchers from 14 universities across Canada, the Department of Fisheries and Oceans, and several federal laboratories to develop science-based guidelines for the conservation and sustainable use of marine biodiversity resources in Canada's three oceans.

The goals of the network are to:

- create a marine biodiversity database for the three oceans,
- help train the next generation of marine scientists and
- raise public awareness of the importance of Canada's oceans.

The network focuses on three research themes:

- Theme marine biodiversity is addressing how patterns of biological biodiversity are related to habitat diversity
- Theme population connectivity is addressing how dispersal of marine organisms, typically by early life stages such as eggs and larvae, influences patterns of diversity, resilience, and source/sink dynamics (recruitment hotspots versus poor areas for new individuals) of species and biological communities
- Theme ecosystem function is determining how ecosystem function (processes such as nutrient cycling) and health (whether ecosystems are able to maintain these processes) are linked to biodiversity and natural and anthropogenic disturbances.

The outcomes of each of these themes across the network will be synthesised to identify approaches to bridge science and policy. CHONe is expected to provide a baseline of information against which future changes in the oceans can be monitored and understood.

6.3 The ICES Science Plan

The ICES Council approved the new Science Plan and the new science structure at its meeting in October 2008. The new Science Plan is ambitious and will involve challenges but also opportunities to bring the ICES science forward to a leading role in Europe and North America.

It has been recognised within ICES that the challenge of delivering the new Science Plan requires more flexibility in its science and advisory structure, and improved coordination across its organisational structures (such as Expert Groups and Committees). Consequently, the science and advisory process have been reformed radically over the past twelve months. Prior to the restructuring, three Advisory Committees provided advice on marine ecosystem issues (Advisory Committee on Fishery Management (ACFM), Advisory Committee on the Marine Environment (ACME) and Advisory Committee on Ecosystems (ACE)). This work is now carried out by a single Advisory Committee (ACOM), the 'advisory pillar' of the ICES structure.

Together with the new Science Committee (SCICOM, replacing the eight former Science Committees, which have been dissolved), the Advisory Committee pulls together scientific advice from the work of the 100 or more Expert Groups that ICES coordinates. The shared responsibility between ACOM and SCICOM to collectively deliver the ICES advisory and science programmes should help deliver the much-sought integrated advice.

It is ICES' hope that all Expert Groups will take an active role in shaping the new science structure and implementing the new Science Plan. The Chair of the Consultative Committee (ConC) and the Head of Science thus suggested to add a generic Term of Reference to all Expert Groups to "Explore the potential of the group for delivery of the new Science Plan and review different options for how this can translate into the new Science Programme under SCICOM." (ICES CM 2008/CONC:01). There was no consensus amongst former Chairs of Science Committees on this ToR. Some saw it as additional workload, others considered it superfluous because a Planning Group was being installed for the transition. It was felt to be more beneficial to have a list of all Expert Groups including their expertise and capacities and this inventory should then be communicated to the new SCICOM. It is unclear, however, whether responsibility for such review would fall upon SCICOM or Expert Groups. In the first instance, SGBIODIV addressed this request by defining its role (within its remit agreed in 2008) in the light of the new Science Plan and science structure (see section 6.4).

The adoption of the new ICES Science Plan, addressing both ongoing short-term needs as well as longer-term strategic issues, is well-motivated. The plan focuses primarily on research activities critical to the demands for advice over a 5 to10-year period. Based upon a review of the emerging research priorities in the member countries, 16 research topics have been identified as being of strategic importance to the advisory needs of ICES. These topics have been organised in three thematic areas (Table 6.2), all of which require the involvement of Biodiversity Science: The ecology of species, populations and their interactions (thematic area 1), the interactions of human activities with these biodiversity elements (thematic area 2) and the management of human activities to minimise negative effects on biodiversity elements (thematic area 3). The ICES Science Plan also states that "The study of the relative resilience of shelf seas exploited ecosystems through a comparative approach will provide knowledge and understanding of biodiversity which will be of importance to several research topics", and the underlying science to support the study of biodiversity will inform many of the other research topics, highlighting the overarching nature of biodiversity. Other fundamental dimensions to biodiversity, in addition to resilience, include stability of ecosystems and the role of disturbance (Sousa, 2001).

Table 6.2. Summary of the 16 research topics identified in the ICES Science Plan as being of strategic importance to the advisory needs of ICES over the next 5 to 10 years.

Understanding ecosystem functioning	Understanding interactions of human activities with ecosystems	Development of options for for sustainable use of ecosystems
Climate change processes Fish ecology Biodiversity Coastal zone habitat Top predators Sensitive ecosystems Integration of surveys	Impacts of fishing Effects of mariculture Effects of renewable energy resources Effects of contaminants, eutrophication and habitat changes Effects of invasive species	Management tools Operational modelling Marine spatial planning Socio-economic understanding of ecosystems

6.4 Defining the role of SGBIODIV in the context of the new Science Plan

We used the proposed ToRs of SCICOM (Annex 3) to define the future role of SGBIODIV in the new ICES science and advisory climate. In line with the ICES mission statement, the remit of SGBIODIV is to "Recommend mechanisms that will advance ICES' capacity to understand and provide advice on the effects of human activities and natural change on marine biodiversity."

6.4.1 Overseeing the scientific interests of ICES and its scientific work

The analysis, description and prediction of changes in ecosystem function as well as goods and services in relation to environmental conditions remains the key focus of ICES' scientific and advisory activities with the Ecosystem Approach to Management. This illustrates the transition from traditionally maintaining fish stocks at a healthy state to maintaining ecosystem health (Gavaris *et al.*, 2005). Since SGBIODIV was formed in 2007, changes in several policies (e.g. EU MSFD, see section 6.1) require member states to manage the marine environment in a more comprehensive way. These developments imply that ICES must build its scientific capacity to support these policy changes. The Science Plan therefore recognises that because of the emerging needs of advice on ecosystem considerations, a broader range of scientific expertise is required.

Recognising new directions and priorities for the ICES and the wider biodiversity research community, both nationally and internationally, SGBIODIV is taking a strategic role in identifying key biodiversity research across the 16 research topics. This review will form the basis for considerations under ToR c (see section 8). Important knowledge gaps associated with a number of biodiversity research themes will be identified and solutions suggested for attaining scientific capacity in areas where advice has not been given historically.

In order to raise the profile of ICES scientific and advisory activities in Biodiversity Science within the science and regulatory community, the role of SGBIODIV should not be limited to addressing ToRs, but also include the dissemination of relevant results to a wide range of audiences. SGBIODIV thus explored the opportunity to contribute to a book on marine conservation ecology, edited by John Roff (SGBIODIV member), Mark Zacharias and Jon Day. The expected audience includes environmental managers, policy-makers and governments, non-governmental organisations (NGOs), scientists and students. The draft table of contents is given in Annex 4. In a meeting between John Roff, Jim Ellis and Michaela Schratzberger on 16 April 2009, it was agreed that ICES could serve as an example for an international organisation, addressing biodiversity-related questions. It was proposed that:

- A specific contribution would include a colour-coded diagram summarising ICES' biodiversity-related activities. This diagram would be based on amended tables produced by SGBIODIV in 2008, listing the contribution of various ICES Study and Working Groups to research activities or information on the components of marine biodiversity and to the management of the components of marine biodiversity (see ICES 2008).
- SGBIODIV members would review and comment on draft book chapters, dealing with particular topics within members' area of expertise as well as comment on chapters concerned with biodiversity issues more generally.

6.4.2 Strengthening relations between science and advice

Not all research topics in the Science Plan link to the elements of the advisory process in the same manner. The research topics in theme one (understanding ecosystem functioning), including 'biodiversity and the health of marine ecosystems', are indirectly linked to assessment and decision support aspects of the advisory process. Whilst the Science Plan recognises the importance of the biodiversity topic across all three themes, it is not explicit in how Biodiversity Science can be integrated effectively in the ICES advisory process, thereby attaining the status of being overarching. SGBIODIV addresses this in more detail in sections 7 and 8.

6.4.3 Facilitating international work

There is an increasing opportunity for scientists to get involved in and to cover areas of biodiversity research where ICES has not given advice previously. Seeking the involvement of scientists outside the usual ICES network will present a new and significant challenge. As such, ICES needs to further engage the marine science community, including a wider range of experts from universities and research council institutes.

Due to the nature of the subject, the work of SGBIODIV depends partly on participation of academics, who may not have access to travel funds to attend Expert Group meetings. Following a request from the SGBIODIV Chair (M Schratzberger) in 2008, the issue was raised in ICES by the Head of Science Programme, because the problem may emerge in future groups related to areas in the Science Plan which are new to ICES. ICES' reply to the SGBIODIV request stated that, in principle, ICES cannot fund participation in Expert Groups, unless they are explicitly invited by the ICES Secretariat. However, a general policy on how to deal with the problem in the future was considered necessary since a lack of support for participation in ICES activities by academics has been identified previously by the US as an area of concern. Even if additional funding is not available, it is important that ICES focuses on developing ways to make the organisation more attractive to the academic community.

It was recommended that SCICOM should take on the problem and find ways to better attract academics into the ICES community. Consequently, an item was added to the SCICOM meeting agenda for January 2009, entitled "How to engage new science communities with ICES: academics and research network." Attracting academics to participate more in EGs could also include contributions of Working Documents and working towards peer-reviewed papers within the EG.

6.4.4 Initiating and supporting scientific conferences

During discussions amongst members of the Marine Habitat Committee (MHC) in 2008, biodiversity emerged as a strong candidate for an overarching theme in the 2010 Annual Science Conference. Consequently, Tom Noji, the parting Chair of SGBIODIV's former Science Committee, proposed to convene a theme session in collaboration with SGBIODIV. Several high-level international biodiversity programmes are currently at a critical stage of synthesis and completion, including the Census of Marine Life (CoML) and the EU network on Marine Biodiversity and Ecosystem Function (MarBEF), respectively.

Outcomes and lessons learnt from both initiatives and the World Conference on Marine Biodiversity in November 2008 are expected to inform and shape future ASC 2010 discussions. The enhanced focus on biodiversity work under ICES auspices is

welcomed. There will be more biodiversity issues in the future and ICES may take on a role in coordinating work in the north Atlantic (see ICES CM 2008/ConC:04).

Building on the theme session entitled "Marine biodiversity: a fish and fisheries perspective", convened at the 2007 ASC in Helsinki, SGBIODIV will put forward proposals for a theme session at the 2010 ASC in Nantes, entitled "Marine biodiversity: have we halted its loss by 2010 and what do we need to do now?" Nominated co-conveners could include Heye Rumohr, Jake Rice or Andrew Cooper and Adriaan Rijnsdorp.

SGBIODIV considered how such a theme session could examine progress toward the internationally endorsed 2010 Biodiversity Target "Halt the loss of biodiversity by 2010". SGBIODIV listed a number of issues that should be considered within this session. These can organised within 3 subthemes:

1) Monitoring data and its application in biodiversity science - This included issues of data integrity, progress on taxonomy including rapid methods of identification, the quality and precision of data for monitoring and/or assessing changes in multi-species distribution and abundance, and data interoperability and standards. It was suggested that we review the biodiversity of ICES eco-regions for dominant marine taxa and identify relevant data sets for examining temporal and spatial changes. Have we been able incorporate use of historic information to define natural baselines?

2) Biodiversity indicators – Our capacity to estimate rates of loss is central to the 2010 Biodiversity Target. Reviewing existing approaches to biodiversity indicators to date would allow us to better assess if current indicators are useful to understanding the effects of fisheries and aquaculture. Can we model biodiversity and species distribution in order to be more predictive? Have Regional Fisheries Management Organisations (RFMOs) been successful in preventing biodiversity loss?

3) The role of biodiversity – Applying biodiversity issues in fisheries management requires an understanding of its role in the environment including the socio-economic value of biodiversity or, more specifically, ICES' role in addressing this. Questions that could be examined include: Are non-native species bad? What is the role of alien species on native diversity? The role of habitat in structuring fish communities and supporting biodiversity needs to be better understood in many offshore areas. What is the importance of genetic diversity to conservation of marine resources, ecological hotspots, their value and how to manage them? What is the role of structured habitats in the productivity of fish populations?

6.5 Biodiversity Science and advice

Biodiversity may be broadly attributed to three hierarchical levels: intra-specific diversity (e.g. genetic diversity, age structure of a fish stock), species diversity (e.g. the range of species and their associated biological traits and functions in an area) and habitat/ecosystem diversity.

Marine biodiversity research can operate on a range of temporal and spatial scales, as well as be of taxonomic focus. On one extreme, it may be driven by geographical research to provide an inventory of 'all' taxa occurring at a site or in a region of interest,

thus utilising a range of sampling gears and methodologies and data sources. Such research provides an invaluable baseline for the site in question; although it is often of restricted geographical scope, is typically descriptive and undertaking comparable work over wider spatial scales or with frequent updates over time may be prohibitively expensive. Such studies are exemplified by the regional faunal lists that have been compiled for various marine biological stations around Europe, including Plymouth (Marine Biological Association, 1957), the Isle of Man (Bruce *et al.*, 1963), Milford Haven (Crothers, 1966), St Andrews (Laverack and Blackler, 1974) and Cullercoats (Foster-Smith, 2000).

At present, a major practical demand for information and advice derived from Biodiversity Science is arising through a number of European and international policy frameworks (e.g. European Directives, CBD, Regional Seas Conventions). An example for the importance of robust Biodiversity Science is the establishment of MPA networks. Here, Biodiversity Science is indispensable in delivering baseline data for the identification of ecologically/biologically sensitive and/or important areas, for the delineation of specific sites and for the practical management of human impacts on populations, species and ecosystems. In recent years there have been several projects undertaking intensive, multi-disciplinary sampling of certain sites. Such projects typically involve multi-gear sampling in habitats of particular scientific or management interest, such as has been undertaken on Le Danois Bank, off northern Spain (e.g. Cartes *et al.*, 2007; Guerra-Garcia *et al.*, 2008; Sanchez *et al.*, 2008).

Many field studies examining biodiversity over broader regional and/or temporal scales, including monitoring programmes, have traditionally focused on the use of a particular gear and/or taxon, and often use standardised sampling to examine temporal and/or spatial patterns in "diversity", where this "diversity" is a part of the overall biodiversity. Within the North Sea, for example, there have been several studies examining the diversity and assemblage structure of the epibenthic and demersal fauna (e.g. Jennings *et al.*, 1999; Zühlke *et al.*, 2001; Callaway *et al.*, 2002) and these studies have used a standardised trawl to illustrate a gear-specific index of diversity. Such studies are not always coordinated with other investigations examining the diversity of other components of the ecosystem, such as the infauna (e.g. Rees *et al.*, 2007). In addition to gear-specific studies, other workers have focused on specific taxa, such as nematodes (Schratzberger *et al.*, 2006, 2007), brachyuran crabs (Gonzalez-Gurriaran *et al.*, 1991) or fish.

6.6 Biodiversity Science in ICES

Many ICES Expert Groups are involved in certain aspects of marine biodiversity (see ICES, 2007a, 2008), especially in terms of marine fish diversity (Figure 6.1, Annex 5).

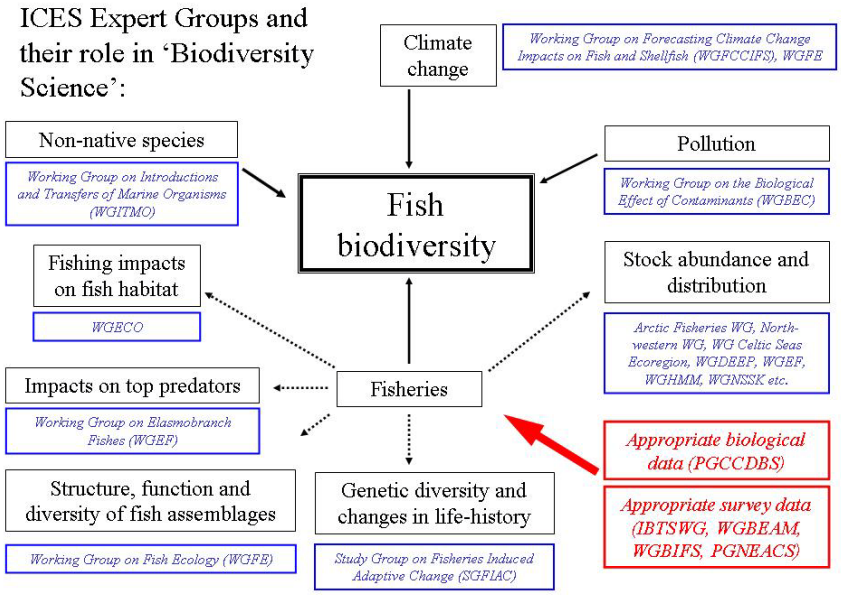

Figure 6.1. Illustration indicating some of the main factors that may affect various components of fish diversity (black boxes). Blue boxes represent ICES Expert Groups that may be able to undertake biodiversity-relevant studies or provide advice. Red boxes represent ICES Expert Groups, coordinating sampling which may provide the data used to examine the various components of fish diversity.

There are also a variety of other Expert Groups that are interested in biodiversity issues for other components of the marine ecosystem, such as plankton communities, benthic ecosystems, sea birds and marine mammals, or through their work on assessing human impacts, including fisheries (Figure 6.2, also see Annex 5 for an update on biodiversity-related activities of some Expert Groups in 2008).

This highlights that ICES has a great capacity for examining various facets of biodiversity, and that this capacity is distributed widely across several groups. **At present, there is no focal point for coordinating biodiversity-related work and enabling the ICES community to be more proactive with regards to Biodiversity Science**. Such a focal point is required to bring together the various ongoing work of relevance to marine biodiversity in order to provide a more comprehensive and holistic overview.

Although any one ICES Expert Group may be able to provide or review information on one facet of marine biodiversity, or on one specific question, there is no obvious ICES forum for integrating gear-, taxa- or region-specific information on biodiversity or to provide a more holistic synthesis for managers and ICES' clients.

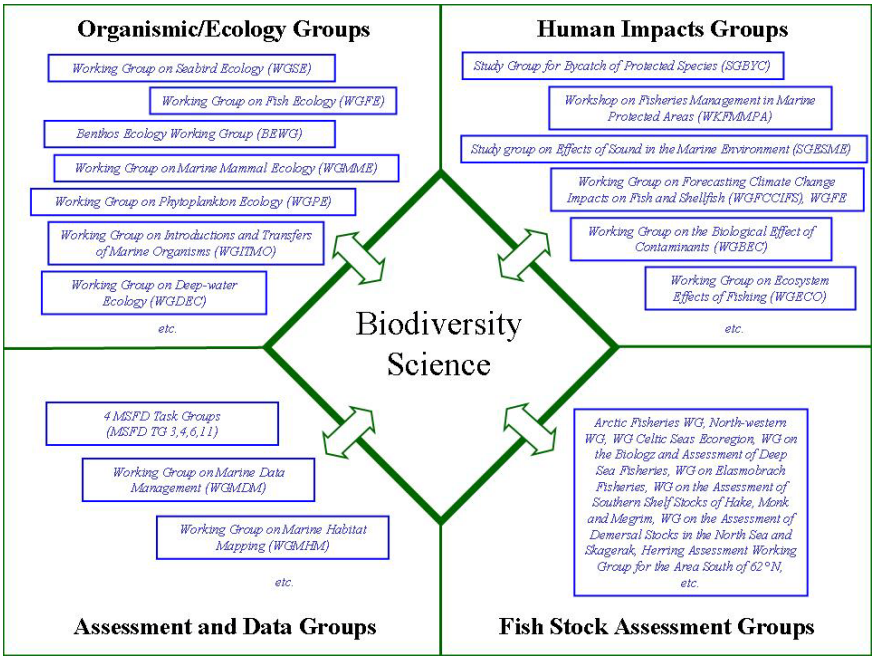

Figure 6.2. Illustration indicating how biodiversity covers parts of the remits of many existing ICES Expert Groups (examples given), all of which should be able to contribute to particular aspects of Biodiversity Science.

Given the increasing interest in biodiversity (see sections 6.1 and 6.2) and the fact that it is now one of the 16 research topics in the ICES Science Plan (see section 6.3), there is a need to determine how ICES can best address several issues of relevance to biodiversity, including :

- Coordinating marine biodiversity studies
- Ensuring that data collected during existing ICES-coordinated surveys are appropriate for biodiversity studies
- Ensuring that data stored in the ICES Data Centre are appropriate for biodiversity studies
- Coordination of future research to address important data gaps
- Synthesising biodiversity information for regional advice
- Providing integrated biodiversity advice in support of the Ecosystem Approach
- Undertaking scientific research in support of the development of appropriate indicators for biodiversity monitoring.

Given the likely increase in advice requests related to marine biodiversity that ACOM will have to address, and that there is no single Expert Group designated to bring such disparate data and information together, there is a clear role for an Expert Group to coordinate such work. This is particularly true in the light of the already high workloads for some Expert Groups that address some aspects of biodiversity (e.g. WGECO). Potential options for the integration of Biodiversity Science within the current ICES structure are discussed further in section 7 below.

7 Options for the integration of Biodiversity Science into the ICES science and advisory community (ToR b)

7.1 Context

There are critical gaps in research expertise and data management, which affect the ability to provide effective biodiversity-related management advice. A better understanding of the resilience of marine ecosystems is required in order to assess anthropogenic impacts such as pollution, fishing practices, aquaculture and the introduction of alien species on biodiversity. Better syntheses of biodiversity information, including its functional and social-economic importance is also required to allow managers to make more informed decisions.

Understanding that integrating a new paradigm for marine science within a complex and already fully engaged organisation will be challenging and best served if the ICES advisory and governance structure was able to assess various approaches to this direction with associated tasks, timelines and risks.

In 2006, SGBIODIV was set-up to determine the profile Biodiversity Science should have within ICES. In general, ICES Study Groups are established to undertake a specific task during a period not exceeding more than three meetings. Otherwise the conditions as described for Working Groups apply. Working Groups undertake specific tasks within their Terms of Reference, and their longevity varies from several to many years (see Guidelines for chairs of ICES Committees and Expert Groups version 2007–1). SGBIODIV met annually in three consecutive years between 2007 and 2009.

In 2007 and 2008, SGBIODIV served three main functions:

- Review current and emerging European and international biodiversity initiatives and report on progress made to date
- Report on contributions of ICES Expert Groups to Biodiversity Science and how this information is taken up by (the) Advisory and Science Committee(s)
- Identify current and future ICES Biodiversity Science needs and explore how these needs can be met.

It became clear this year that the structure and content of these overviews and syntheses is largely mature. Whilst some updating will be required in the future in the light of new science priorities (e.g. EU FP7, ICES Science Plan) and legislation (e.g. EU MSFD), major revisions and additions are unnecessary at this point.

The changing policy landscape and advisory requirements and the resulting restructuring of ICES' science programme and model for advisory services would require a shift of SGBIODIV's focus. If the activities of SGBIODIV were indeed to continue, the group needs to move on from primarily reviewing biodiversity-related initiatives within ICES and internationally to highlighting and promoting overarching biodiversity issues among the ICES and wider scientific and advisory community. Under such scenario SGBIODIV could:

- help ICES to attain an overview of biodiversity-related research needs and activities and, if necessary, clarify needs on selected issues where these are not well-defined,

- become a forum to discuss and coordinate effective and efficient ICES engagement with European and international biodiversity research issues and
- support liaison and develop strong partnerships with related national and international bodies and initiatives including the EPBRS.

Alternatively, the past and proposed future functions of SGBIODIV could be assimilated into tasks of existing and new Expert Groups. SGBIODIV explored options for the integration of Biodiversity Science into the present ICES science and advisory structure. These options identify who would play the lead role coordinating the necessary actions elaborated in section 8 (ToR c). They seek to deliver on Biodiversity Science at both an operational level, that responds to immediate client requests, as well as on a more strategic level, to improve ICES' ability to develop integrated biodiversity advice. Both levels require a synthesis of information from a number of Expert Groups and external sources in a scientifically robust and timely fashion.

7.2 Integration of Biodiversity Science into ICES structures

The options offered below consider the principles and objectives outlined within the new ICES Science Plan and the Advice Strategy. It is apparent that both SCICOM and ACOM have identified a requirement for Biodiversity Science and SGBIODIV draws guidance from this. The Science Plan explicitly identifies the need to understand the role that biodiversity plays for the health of marine ecosystems (Table 6.2). SGBIODIV goes further by proposing that the ability to identify and understand changes in biodiversity is essential for understanding the interactions of human activities such as fishing, mariculture, renewable energy, contamination, eutrophication, habitat changes and introduction of invasive species with ecosystems.

The emerging new Advice Strategy under ACOM suggests that ICES advice will need to be integrated, respond to more complex issues, have quality assurance and transparency and to support communication between advice users, stakeholders and the scientific community. The high level objectives for the Advice Strategy are based on access to more and better data, engaging the scientific community to enhance ICES' ability to contribute advice, the integration of advice based on scientific advances and ecosystem considerations, a system that is responsive to advice users, has a high degree of credibility, and delivers on the expectation that advice will be harmonised with human and fiscal resources.

What is yet unclear to SGBIODIV is how SCICOM would be organised and what Expert and Working Groups would fall under its management. As a result, SGBIODIV realises that there may be other options, e.g. SCICOM could have a subcommittee on Biodiversity Science, although these have not been explored further. SGBIODIV is aware that SCICOM may be comprised of 5–6 committees, including a 'Marine Biodiversity Committee', to which the ecology Expert Groups would report. However, even if such committee was formed, the forum for synthesising and integrating biodiversity information for regional and holistic advice would still need to be addressed, as considered below.

The options taken into account include:

- Option A: The ICES Council adopts biodiversity as an overarching theme and, through its Advisory and Science Committees, adopts a programme to build Biodiversity Science capacity within existing Expert Groups.

SGBIODIV dissolves, and the various aspects of Biodiversity Science needs, as identified by SGBIODIV, would be assigned by the ICES Secretariat to the relevant existing Expert Groups, along with appropriate modifications of their Terms of Reference.

- Option B: ICES establishes a new Working Group on Biodiversity Science (WGBIODIV). This Working Group would be responsible for coordinating Biodiversity Science needs and products as outlined by SGBIODIV (ToR c), in both an operational and strategic capacity.

Each option was evaluated against a range of criteria that were deemed integral to the delivery of Biodiversity Science (Table 7.1). These criteria covered aspects of achieving the overall objectives for biodiversity as outlined within previous SGBIODIV reports (e.g. biodiversity as overarching theme) as well as some of the more practical considerations (e.g. workload of existing Expert Groups) that would need to be considered when undertaking any expanded or new mandate within ICES.

8 Develop a working plan to integrate and communicate ICES Biodiversity Science (ToR c)

8.1 Context

SGBIODIV proposes the use of a variety of mechanisms to take forward its remit and agenda, which might involve organisation of cross-group workshops, providing an opportunity for engagement with a broader constituency, and dealing with specific and interdisciplinary issues. Underpinning this is a need to ensure that research priorities are promoted more transparently and effectively, so that they are more likely incorporated within ICES' science and advisory strategies.

SGBIODIV explored the different working stages which might be necessary to facilitate Biodiversity Science within ICES and to enable the incorporation of biodiversity issues into ecosystem management and advice strategies. Whatever option for the integration of Biodiversity Science into the ICES science and advisory structures will be applied (see section 7 and Table 7.1), several major aspects should be considered for this integration.

8.2 Basic information/data

The basic component of Biodiversity Science is the availability of relevant data and information. In order to facilitate Biodiversity Science within ICES, data and information have to be archived and made accessible to the scientific community. In this respect, the relevance of ICES as one of the most important data custodians for the Northeast Atlantic has to be highlighted. Most projects and many international initiatives are time-limited and this carries the risk that any scientific gains or data are lost. As already pointed out in earlier SGBIODIV reports (ICES, 2007a), ICES is a long-lived international science organisation and should play a key role in long-term safeguarding of marine biodiversity data.

As data custodian, ICES should facilitate the regular review and quality assurance of these data so that they are appropriate for biodiversity analysis. For example, existing trawl data are known to have a variety of errors (ICES 2007b), which would compromise the analysis of fish communities.

Table 7.1. Two options for integrating Biodiversity Science in the existing ICES structure evaluated against various criteria, identifying positive (✓) and negative points (×).

	ICES Council uses existing Expert Groups. SGBIODIV dissolves. ICES Secretariat receives question and uses current operational expertise to draft ToRs to relevant existing EGs)	Establish a Working Group on Biodiversity (WGBIODIV)
Achieving the objective of ICES Biodiversity Science operating in an overarching manner	✓ This option is potentially at an appropriate high level governance to facilitate the overarching theme of biodiversity	✓ Prerequisite for an overarching and coordinated work programme. The extent depends on status and integration of the Working Group within the ICES structure
	× However, 'expert synthesis' of contributions of Biodiversity Science elements from existing Working Groups is less likely	× However, the success of making Biodiversity Science an overarching theme depends on the ability of the Working Group to develop and provide 'expert synthesis'
Strategic effectiveness	× Not strategic unless ICES Secretariat pro-actively assigns long- term research requirements for data, expertise, and analysis to existing (appropriate) Expert Groups, i.e. more than just addressing questions on an *ad hoc* basis	✓ Strategic by assuming a collaborative and coordinating role in delivering integrated Biodiversity Science and in synthesising the results from other Expert Groups
	× Tendency to be reactive rather than proactive	✓ Reactive and proactive approach would be implied in mandate
Operational effectiveness, e.g. in advice procedures	× ACOM does not have access to integrated biodiversity information for reports and for delivering management advice	✓ ACOM would have access to integrated biodiversity information for reports and management advice
		× There may be a time lag for addressing some questions which require engagement with relevant Expert Groups
Reporting structure given that biodiversity considerations should be integrated into all regional/ecosystem advice	× Information required for drafting advice would be contained in a range of Expert Group reports. Unclear as to where final advice would be drafted	✓ Information required for drafting advice would be contained in a range of EG reports but integrated into reports from WGBIODIV
	× Given the complex nature of biodiversity issues, any Advice Drafting Group would require comprehensive membership	✓ Synthesised information would be available for an Advice Drafting Group

Addressing the current Science Plan and the long term development of scientific expertise	× Biodiversity issues are not adequately represented and communicated within ICES	✓ Biodiversity issues would be adequately represented and communicated within ICES
	× Does not sufficiently address the current Science Plan (e.g. understanding biodiversity's role in ecosystem functioning)	✓ The current Science Plan could be addressed
	× ICES may fail to develop integrated scientific expertise for Biodiversity Science in the long-term	✓ ICES is more likely to develop integrated scientific expertise in Biodiversity Science in the long-term
	× Ensuring that ICES data held is appropriate for biodiversity studies is dependent on individual Expert Groups/ICES Data Centre	✓ WGBIODIV could e.g. serve as a forum for harmonising and quality-securing data from existing (and any future) ICES-coordinated programmes
Appropriate/best expertise used	× Secretariat and chairs of Expert Groups may not be aware of relevant work being undertaken by non-ICES scientists/organisations	✓ WGBIODIV, through its membership, would likely be aware of relevant work being undertaken by non-ICES scientists/organisations
	× Under this option the assignment of communication among Working and Expert Groups is unclear. Groups may not be aware of other biodiversity studies being undertaken within ICES	✓ Such a Working Group may be charged with facilitating communication among other Expert Groups
Workload	✓ No major increase in workload for any one Expert Group, if broadly disseminated	× Establishing a Working Group that is effective in delivering Biodiversity Science will mean more work (such as annual meetings, synthesising information from other Expert Groups, developing underlying science for advice)
	× If a small number of existing groups are nominated to address biodiversity, some (e.g. WGECO, an existing group with a very broad mandate) may not have the time to fully synthesise the information as they already have a heavy workload	
ICES structure	✓ No new group required. Biodiversity Science served within existing structure	× New group (WGBIODIV) required

A large number of ICES-coordinated surveys, mainly for monitoring fish populations, are carried out regularly in the NE Atlantic. It should be investigated whether other, non-target ecosystem components relevant for biodiversity considerations are covered. If necessary, it should be ascertained how existing survey programmes can

be extended towards more integrated surveys to better quantify other components and aspects of marine biodiversity. An integration of surveys is needed for Biodiversity Science to support the implementation of an Ecosystem Approach. As mentioned previously, the EC has asked that "monitoring methods are consistent across the marine region or subregion so as to facilitate comparability of monitoring results" (CEC, 2008), and so ICES will likely be involved in ensuring standardised methods for such programmes. Appropriate taxonomic/identification expertise has to be promoted in the relevant institutions to ensure data reliability and interoperability.

The application of internationally recognised biodiversity data standards such as Darwin Core Version 2 need to be promoted within ICES monitoring programs. Such standards are already applied within many current international projects such as the Ocean Biogeographic Information System (OBIS) and World Register of Marine Species (WoRMS). Such standards obligate use of common and mandatory data fields to facilitate research that applies different sources of information in order to study changes in biodiversity on global, multi-jurisdictional scales.

The process of surveys evolving towards ecosystem monitoring platforms is already acknowledged within ICES, as indicated by the Transition-Group on Integrating Surveys for the Ecosystem Approach (TGISUR). IBTSWG and other survey coordination groups have discussed such issues.

SGBIODIV acknowledges the fact that ICES will not be able to address all aspects of Biodiversity Science by its own resources. Therefore, it is highly recommended to link up with existing biodiversity networks and initiatives to broaden the scope of Biodiversity Science within ICES. A large number of national and international initiatives focus on the inventory and classification of biodiversity and on data archiving, which were already compiled and evaluated during previous SGBIODIV meetings (see ICES, 2007a, 2008). Furthermore, ICES should encourage academic marine scientists to participate in ICES Biodiversity Science activities.

Future actions should thus include:

- Evaluating and integrating survey programmes and expanding data collection
- Advancing the role of ICES as an important data custodian for marine biodiversity information
- Identifying data gaps and considering the implications of the absence of such information
- Contributing to method standardisation
- Establishing linkages with other scientific organisations/data sources.

8.3 Conversion of information

Due to the growing commitment to an Ecosystem Approach to Management, particularly in fisheries management, knowledge of biodiversity and the functioning of marine ecosystems is essential. Having a profound expertise in marine management and management advice, ICES is considered to provide the ideal platform for the development of biodiversity indicators, needed for the incorporation into holistic management approaches.

The development, application and utility of biodiversity indicators is discussed controversially in the scientific community. However, the current political demand on advice on biodiversity indicators (e.g. by clients such as the EC) reflects the growing significance of biodiversity considerations. The implementation of the MSFD, for example, will largely depend on assessments through biological indicators. As stated earlier, five out of eleven MSFD descriptors for GES are directly biodiversity-related (Table 6.1).

Biodiversity Science strategies within ICES should facilitate the development, reviewing and quality assessment of potential indicators. Various analytical tools, such as dynamic ecosystem and ecological niche modelling, could enhance analytical and decision support in biodiversity-related investigations and should be addressed more explicitly within ICES Expert Groups. Furthermore, 'feedback control mechanisms' should be implemented to ensure the interoperability among the different components of Biodiversity Science (e.g. to ensure data availability relevant for diversity indicators).

Future actions should thus include:

- Facilitating the development, reviewing and testing of biodiversity indicators
- Improving linkages with external organisations/networks.

8.4 Integration of information

In order to address ICES' fundamental goals, it is vital that Biodiversity Science be addressed in an integrated way. Achieving a cohesive and structured approach is expected to help consolidate and further develop ICES' role as important driver and advocate for Biodiversity Science. The integration process is twofold:

- Integration of biodiversity information to facilitate our understanding of biodiversity and its role for ecosystem functioning and
- Integration of biodiversity information into management strategies to meet objectives with an Ecosystem Approach.

In order to facilitate the fundamental understanding of biodiversity issues, ICES as a user, custodian and processor of biodiversity information, has to identify ways in which it can capitalise on partnerships with European and international initiatives addressing marine biodiversity. Again, the involvement of academic experts is essential to facilitate wider Biodiversity Science.

The incorporation of biodiversity criteria into management strategies and the integration of information from a large variety of different components of biodiversity is probably the most challenging task for the future. One prerequisite for sustainable ecosystem management is the matching of biological processes and management action (ICES 2008). Firstly, biodiversity measures need to be incorporated into management concepts in an ecologically meaningful way. Secondly, the suitability of management tools for influencing biodiversity measures has to be evaluated, followed by an assessment of whether these tools operate on relevant spatial and temporal scales.

In order to enable scientific advice on biodiversity aspects with an Ecosystem Approach, specific management objectives have to be formulated. Defining management objectives may not be in the remit of ICES, but ICES should initiate two-way commu-

nications with advice users (as described in the ICES Advice Strategy), and Expert Groups should be more proactive in identifying appropriate objectives.

A decision-support framework should be developed to specify environmental objectives, targets and biodiversity indicators for use in an Ecosystem Approach. This framework can assist in assessing the impact of proposed management actions on the ecosystem and will be specifically relevant in decision processes with a high demand of integrated information on biodiversity aspects, such as the selection process for MPAs.

Up to now, many indicator-based management approaches are limited to a small number of indicators and are not integrative (e.g. spawning stock biomass in fish stock assessments). The integration of the variety of different indicators, including biodiversity information, can be advanced by the development and application of sustainability indices and status and trend reporting structures.

Future actions should thus include:

- Developing a decision-support framework and sustainability indices to incorporate biodiversity considerations into management strategies
- Promoting cross-group workshops on Biodiversity Science issues to facilitate the integration process (e.g. for regional advice)
- Improving linkages with external organisations/networks.

8.5 Advice and communication

Biodiversity Science needs to be addressed both at international and local (regional) level. ICES works at these different levels. The North Atlantic is an international geographical oceanic region and the new ICES Science Plan has noted the importance of better including other 'adjacent' seas. Two of the six ICES Strategic Plan goals are addressed in the 2009–2013 Science Plan: "Goal 1 (Science): to plan and implement a programme of science in partnership with member countries to deliver the needs to customers and stakeholders. Goal 2 (Collaboration): establish effective mechanisms of collaboration within ICES and with others (organisations, etc.) to deliver and add value to ICES science and advisory programmes."

To achieve these two goals, a strategic plan for advice and communication would be necessary to aid designing objectives. To reach these objectives an action plan should be drawn up based on three pillars:

1) Advice, which is one of the main activities of ICES, so as to answer requests from customers (OSPAR, EC, National Governments, etc.),

2) Integrating relations with existing networks and Science Research Strategy Platforms in Biodiversity Science (e.g. EPBRS, CoML, MarBEF, BiodivERsA, Association of Economists in Environment, etc.) and the new and emerging intergovernmental platforms (IPBES),

3) External communication to promote ICES competences, recommendations and quality of results towards stakeholders in marine biodiversity (e.g. policy-makers, relevant EC DGs, European Parliament, Civil Society Organisations, NGOs, professional associations for the fishing, aquaculture and seafood processing industries etc.). This could include organising international or local-regional workshops and participating in science-policy or public debates on interdisciplinary approaches with research communi-

ties (economists, social scientists etc.) and other stakeholders (e.g. within the framework of Integrated Coastal Zone Management).

Future actions should thus include:

- Developing an advice and communication strategy for Biodiversity Science
- Based on this strategy, setting up and implementing an action plan
- Including Biodiversity Science in regular ICES communications (e.g. ASC, Cooperative Research Reports).

8.6 Potential collaboration between the Ocean Biogeographic Information System (OBIS) and ICES

Informed management of the environment has to be supported by data (Richardson and Poloczanska, 2008; Stokstad, 2008). It is the ambition of the OBIS community to provide a sound basis for ocean management decisions, by facilitating publication of marine biodiversity data and stimulating open and free access for all potential users. Indeed, OBIS is often mentioned as the organisation well suited for this role (e.g. Poloczanska *et al.*, 2008).

OBIS aims to stimulate research, generating new hypotheses concerning evolutionary processes and species distributions. By integrating data from a vast number of sources, OBIS creates opportunities to study the effects of global change on marine biodiversity. By making data publicly available, OBIS assists organisations in complying with regional and international treaties and organisations. By ensuring data are available to all, the creation of international management tools becomes possible. OBIS plays an important role in data repatriation to third-world countries (where the highest diversity is often found), but where resources to study and manage this natural wealth are often lacking.

The Census of Marine Life (CoML), initiated with support from the Alfred P Sloan Foundation and now funded by many governments and other organisations, is nearing the completion of a decade of research on the diversity, distribution and abundance of marine species. Accepted estimates of the number of marine species have been shown to be orders of magnitude too low. One of the CofML deep-sea projects was ranked at number 4 in Time Magazine's top ten discoveries. Discover Magazine named the CoML one of "The six most important experiments in the World" in its December 2007 issue. The results of this research programme are now starting to be used, for example, in nomination of MPAs in polar regions.

When he was the United Kingdom Chief Scientist, Lord May said "Those countries who best know how to correlate, analyse, and communicate biological information will be in the leading position to achieve economic and scientific advances". A recent UK House of Lords report further supported this assertion. OBIS was created as the data integration component of the Census, and helps to make species-level distribution data from the Census Field Projects and other sources available to the scientific community.

For several years now, OBIS has been operating as the central hub in a distributed network of data providers. Its activities include:

- Reliable archiving. OBIS offers, for any data provider who might not have such facilities in its own organisation, a reliable and professionally managed file server system to archive any data file, and guarantee long-term integrity of the data files
- Documentation. Through collaboration with the Global Change Master Directory (GCMD) of the National Air and Space Agency (NASA), OBIS has developed an on-line system for metadata or documentation of datasets, assisting in data discovery by users
- Easy access. OBIS provides access to information through its web interface, or through several web services. Its integration with the Global Biodiversity Information Facility, Encyclopaedia of Life, Barcode of Life and other on-line resources multiplies its value
- Quality control. All data provided by organisations in the network is passed through a quality control procedure, including checks on the integrity of the data, consistency, and conformance with standard vocabularies
- Global integration. OBIS integrates data from a large number of individual datasets, from all marine realms and themes, and on a global scale. Marine life does not stop at the borders of nations or EEZs, and neither should management of the information of marine life.

The maps in Figure 8.1 illustrate how OBIS data can be used for environmental management or for setting research priorities. Figure 8.1a represents the number of records available in OBIS and highlights our lack of data from the open ocean. Figure 8.1b combines actual OBIS observations for an invasive fish species, the lionfish *Pterois volitans* (yellow circles), with an environmental envelope model, showing the potential spread of this invader (red area). Similar environmental envelope techniques can be used to model the expected shifts of species distributions in response to global change.

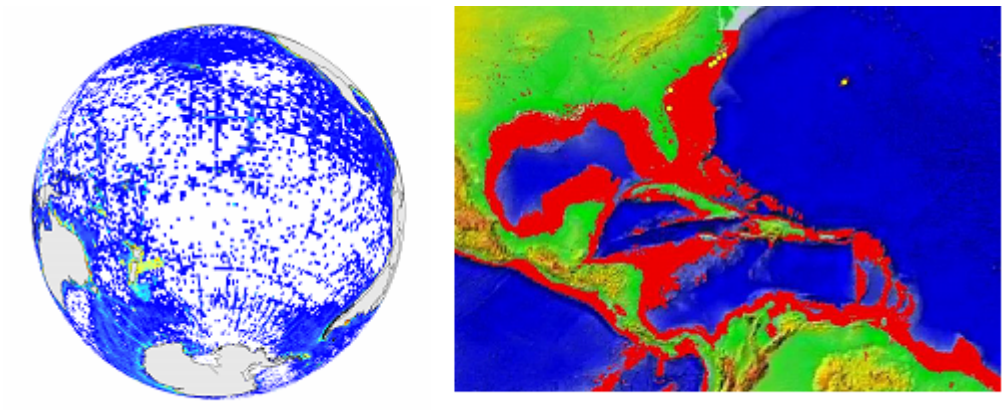

Figure 8.1. a (left) Number of observations in the OBIS database. White are 5x5 degree cells without a single observation; blue represents low, red high number of observations. b (right) Potential spread of the lionfish *Pterois volitans*, an invasive species from the Red Sea. Yellow circles are actual observations in the OBIS data base. Red area is the result of an environmental envelope model, showing the areas with similar physical/chemical oceanographic conditions as where the observations were made, and indicate the potential spread of this species.

There is a discrepancy between OBIS' ambition to establish itself as an element of the international infrastructure for both marine research and management and its critical dependence on project funding (which is usually only available for a restricted time). Part of the strategy to make OBIS sustainable is to have it adopted by a larger international organisation. The Intergovernmental Oceanographic Commission (IOC) of UNESCO is a natural choice for such parent organisation. They deal with the oceans on a global scale; they have a strong interest in data management and capacity building; they are traditionally strong in physical oceanography and are looking to strengthen their expertise in biology and biodiversity. They are concerned with the transition of results and systems from marine research into operational oceanography. Moreover, there are already strong links between OBIS and IOC. OBIS also has several links with ICES:

- They were jointly involved in the organisation of the Ocean Biodiversity Informatics conference held in Hamburg, 2004 and Halifax, 2007
- ICES and OBIS jointly participate in the activities of the IOC group of experts on Biological and Chemical Data Management and Exchange Practices
- OBIS and EurOBIS have been represented at the last ASCs and presented some of the accomplishments
- The Flanders Marine Institute, who hosts the European node of OBIS (EurOBIS), was responsible for the data management for the North Sea Benthos Project 2000, facilitated by an ICES Working Group. After publication of the Cooperative Research Report (Rees *et al*., 2007), the data were published through EurOBIS and are now also available through iOBIS, the international portal of OBIS
- Data from the North Sea Benthos Survey, another ICES activity, are published through EurOBIS.

Apart from these data, the ICES Secretariat now also makes data available from its main databases. Very recently, issues of data ownership, confidentiality and technical problems were addressed and data are being made available to OBIS through EurOBIS. ICES has agreed to accept the World Register of Marine Species, an activity of EurOBIS as a contribution to OBIS, as one of the several potential authoritative sources for taxonomic names. The options for further collaboration between ICES and OBIS could usefully be explored.

9 Recommendations

SGBIODIV makes the following recommendations:

1. The ICES Secretariat sends the SGBIODIV report 2009 to the Advisory and Science Committees for comment: Has SGBIODIV adequately evaluated the relevance of Biodiversity Science within the current and emerging science and advice strategies and structures?

2. After deliberation of the options to develop and deliver Biodiversity Science within the current ICES structure, SGBIODIV considered there to be sufficient rationale for being established as a Working Group (WGBIODIV). Such a group would enable Biodiversity Science to be delivered as an overarching theme in a

more coordinated manner. This would better enable ICES to answer questions on marine biodiversity and to synthesise biodiversity related information as a basis for advice.

If ICES establishes WGBIODIV, this group should meet in 2010 (date, venue and Chair to be confirmed) to address the following terms of reference:

a. To develop a working plan to review the biodiversity of ICES ecoregions for dominant marine taxa and identify relevant data sets for examining temporal and spatial change. Future reviews would be carried out intersessionally, facilitated by relevant delegates from ICES member states.
b. To review existing approaches to the development of biodiversity indicators
c. To synthesise biodiversity information from other EGs for specific advice requests.

3. Regardless of which option is chosen, SGBIODIV recommends that ICES develops and implements a structured work plan that considers the issues identified in Section 8 (ToR c).

Notwithstanding the above, SGBIODIV recommends that:

4. Survey coordination groups (IBTSWG, WGBEAM, WGBIFS, PGNEACS) ensure that data collection is appropriate for studies of biological diversity (e.g. follow the recommendations of WKTQD).

5. The ecology Working Groups (BEWG, WGFE, WGZE etc.) review potential biodiversity indicators for their taxa of expertise.

6. ICES better engage with a wider scientific community on Biodiversity Science issues. In the first instance, this should be facilitated through a biodiversity theme session at the 2010 ASC.

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Annex 2: Agenda

Tuesday, 17 March 2009

9:00 Opening + introduction of all participants

- Adoption of agenda and appointment of rapporteurs

- Short presentation on the history of SGBIODIV (J Ellis)

- Review SGBIODIV 2008 recommendations

10:30 Overview of the new ICES Science Plan and organisational structures (J Ellis)

11:30 Review report from ad hoc ToR a)-group

13:00 – 14:00 Lunch

14:00 Plenary ToR a): Review the assessment, advisory and governance structure within ICES in order to determine the most appropriate levels at which Biodiversity Science should be coordinated.

Draft relevant text for SGBIODIV report 2009

Y Maubras: relevant recent biodiversity initiatives: FRB and EPBRS

Wednesday, 18 March 2009

9:00 Slots for presentation of relevant activities of SGBIODIV members

H Reiss: ICES workshop on climate-related changes in North Sea Benthos

10:30 Review report from ad hoc ToR b)-group

13:00 – 14:00 Lunch

14:00 Plenary ToR b): Explore options for the integration of Biodiversity Science into the ICES science and advisory community

Draft relevant text for SGBIODIV report 2009

Y Maubras: ICES participation in and contribution to IMoSEB

Thursday, 19 March 2009

9:00 Review report from ad hoc ToR c)-group

10:30 Plenary ToR c): Develop a working plan to integrate and communicate ICES Biodiversity Science

Draft relevant text for SGBIODIV report 2009

13:00 – 14:00 Lunch

14:00 Discuss structure of SGBIODIV 2009 report including recommendations, actions and ToRs for 2010

Friday, 20 March 2008

9:00 Finalise SGBIODIV report

Discuss future activities of SGBIODIV

13:00 – 14:00 Lunch and close

Annex 3: Terms of Reference for the ICES Science Committee (used for reference)

One of the principal tasks of the Science Committee is to develop a new structure and 'home' for the work of the Expert Groups in order to deliver the ICES Science Plan and its top 16 priorities. SCICOM successfully set up a Science Leadership Working Group with a mandate to identify the fields and responsibilities of a number of steering groups, which will ultimately form an intermediate working level.

2008/2/SCICOM01 The **Science Committee** [SCICOM] (Chair: Serge Labonté) will meet at ICES Headquarters, Copenhagen, in January and May 2009, and in connection with the Annual Science Conference 2009, to:

a) establish strategy and the structure for implementation of the ICES Science Plan:

By overseeing the scientific interests of the Council and its scientific work:

b) identify the key areas for the ICES contribution to advances in marine science;

c) review progress of activities of Expert Groups with a view to identifying key scientific issues;

d) ensure that key scientific issues are addressed by the Expert Groups and that there are appropriate interactions between scientific disciplines;

e) receive information and advise on the effectiveness of the information, dissemination and communication (specifically publications) functions of ICES.

By strengthening relations between Science and Advice:

f) develop approaches for interaction between science and advice in order to collectively deliver the advisory and science programmes;

g) communicate research results for inclusion in the advisory work at the strategic as well as the operational level.

By facilitating international work:

h) develop plans for cooperation on issues as identified under b), c) and i) and identify durable working relationships with relevant organisations;

By initiating and supporting scientific conferences:

i) review and update the arrangements for future Annual Science Conferences;

j) review status of suggestions for ICES Symposia and prepare resolutions; SCICOM will make its report available for consideration at the October 2009 Statutory Meeting.

Annex 4: Draft chapters of John Roff, Mark Zacharias, Jon Day (eds): "Marine conservation ecology" (Revised 8 February 2009)

Expected Audience

First edition: condensed text: Managers, governments, NGOs

Expanded edition: comprehensive text: Senior undergraduate or graduate students

Each chapter concludes with a section on: Management Implications

Table of Contents

Preface/ Introduction

- Overview of the contents
- Intended use of the book
- What the book does NOT contain: policy, sociology, enforcement, regulation

Chapter 1: Introduction – Why Marine Conservation is necessary

1. Marine Conservation, definition and its different meanings, from biodiversity protection through catch regulation for sustainable exploitation
2. What is marine biodiversity? Its components, patterns, structures and processes from genetic to ecosystem level. How these components can be recognized and studied from single-species or habitat-ecosystem approaches
3. Importance of ocean scientific knowledge. Benefits of conservation for research
4. Marine Conservation and Marine Protected Areas (MPAs)
5. Threats to marine biodiversity. Why should we be concerned, and why protect it? The benefits
6. Variation in biodiversity over geological and historical time
7. Global recognition of need for marine conservation and International Conventions
8. Measures to address threats (legislation, conventions, Marine Protected Areas, management, etc.)
9. A brief history of marine conservation efforts; successes and failures

Chapter 2: The Marine Environment – Physico-chemical Properties

1. The Major Features of Marine Environments. Bathymetric descriptions. Oceanographic characteristics. Physiographic characteristics
2. Divisions of the marine environment: estuaries, coastal zone, shelf, open ocean: high seas, deep seas
3. Spatial and temporal scales in marine environments
4. A review of the chemistry of marine environments. Constancy of composition, variability of nutrients. Temperature and salinity ranges, water masses
5. A review of physical processes in the marine environment. The significance of water motions including: currents, tides, upwelling. Scales of motion and their significance to organisms. Ocean currents. Variable currents
6. Complexity of the Coastal Zone. Geomorphology, Physiography and Coastal Oceanography, a review. The major inlet types, including: estuaries, bays and coves

7. Stratification permanent and seasonal changes

Chapter 3: The Marine Environment – Ecology and Biodiversity

1. Pelagic and Benthic realms, the Fringing Communities and their divisions. Types of habitats, communities and taxonomic groups. Terms and definitions
2. The Pelagic realm and its processes, a review. Production regimes, relationships to upwelling and nutrient cycles. The major taxonomic groups
3. The Benthic realm and its processes, a review. Production processes and pelagic-benthic coupling. The major taxonomic groups
4. The Coastal Zone and Fringing Communities, their structures and processes. The major taxonomic groups of primary producers
5. Main focus of this book - coastal and shelf areas

Chapter 4: Approaches to Marine Conservation

1. Based on scale:
    a. Global: Large Marine Ecosystems – Sherman, Longhurst
    b. Global and regional Biogeography MEoW Spalding
    c. Continental: CEC, Australia, South Africa (Lynath Beckley)
    d. National, Regional and Local
2. Based on the ecological hierarchy and framework:
    a. Geophysical and Species approaches. Representative and Distinctive Areas – definition and recognition
    b. Genetic
    c. Species and populations
    d. Communities
    e. Habitat, Seascape, Ecosystem
    f. Natural Regions/ Bioregions
3. Based on jurisdiction:
    a. Coastal zone management
    b. Fisheries conservation
    c. Ecosystem-based management
4. Interactions among ecological levels. The need to integrate all these approaches
    a. Need for a systematic approach to marine conservation
    b. Scenery vs. Systems
    c. Development of strategies and frameworks

Chapter 5: The Genetic Level

1. Genetic concepts, problems and approaches to Conservation
2. A review of conservation genetics
3. Taxonomy and systematics
4. Global and regional biogeography
5. Significance of genetic diversity
6. Basic units of conservation: ESU's, species conceptand MVPs
7. Fitness measures, loss of genetic diversity, hybridizations
8. invading species, cryptic species
9. Aquaculture escapement
10. Markers to identify poaching and products from endangered species
11. Main issue for conservation is the relation between: ISOLATION and CONNEC-TIVITY
    a. Isolation leads to meta-populations, ESU's

b. Connectivity leads to gene flow and recruitment
c. Genetic implications and data

Chapter 6: Global patterns of biodiversity (as species diversity)

1. Global biogeography
2. Large Marine Ecosystems of the world
3. MEOW system
4. Pelagic and benthic diversity
5. Species Diversity: Theories of Biodiversity (species only)
6. Patterns in species diversity. Where and when species diversity is low and high. Understanding global biodiversity 'hotspots'. Regional and Local patterns. Relationships between Biodiversity, Species Diversity and Habitat Complexity
7. Global gradients: depth, ocean basin and latitude.
8. Coral reefs and tropical systems

Chapter 7: Species, Populations

1. Species Approaches to Conservation - Introduction
   a. Traditional fisheries management – quotas or closed areas? Single species fisheries, economic species.
   b. Focal species, definition of terms: the classical beginnings of marine conservation
   c. Other focal species: keystone, umbrella, parasols, flagships, charismatic
   d. Community composition indicators, community condition indicators
   e. Endangered, threatened, vulnerable, sensitive, etc.
2. Population structures and processes:
   a. Distributions, meta-populations, endemism
   b. Dispersion, migration, recruitment cells - migration and counter-drift mechanisms, retention
   c. Home-range, territories, reproduction, evolution.
   d. Transition areas
   e. Processes controlling populations: Predation, competition, parasitism, disease
   f. Difficulties and information limitation using species level approaches – a never ending task.
3. MPAs for individual species
   a. Non-migratory
   b. Recruitment cells
   c. Pelagic 'mobile' MPAs?

Chapter 8. Distinctive Areas – Species and Ecosystems

1. The concept of distinctive areas, their properties and how to recognize them from Focal Species and physical processes
   a. Approach actually combines the species and ecosystem levels
   b. Identification of marine sensitive and vulnerable areas
   c. Focal species - their populations and distributions in relation to distinctive areas, ecological and conservation roles. Concept of EBSAs
   d. Species diversity 'hotspots'. Areas of high taxonomic diversity and/or abundance. How to recognize them (e.g. seamounts)

2. Physiographic and Oceanographic Factors and Processes that define Distinctive areas
    a. Basin and terrestrial topography, bathymetry and depth, sea height (RADARSAT)
    b. Water masses, temperature gradients and anomalies
    c. Significance of anomalies for structures and processes
    d. Production enhancement versus retention of resources
    e. Water motions and retention mechanisms, convergences and divergences, upwellings, nutrients, gyres
    f. Significance of environmental heterogeneity (scale!) in topography and substrate
3. Other Ecologically and Biologically significant areas (EBSAs)
    a. May only be recognized from TEK
    b. Significance for commercial fisheries
4. Ecological Principles for classifying 'Distinctiveness'
    a. Can such areas be classified in a hierarchical framework?
    b. Important to recognize that Distinctive areas also have attributes of representation

Chapter 9: Communities and Community – Habitat relationships

1. What is a marine community? Definitions and hierarchies
2. Community properties and measures
    a. Indicator concepts; Composition indicators, Condition indicators
    b. Functional groups, recurrent groups
    c. Species richness, species evenness
    d. Species abundances, biomass
    e. Species area / species accumulation curves
3. Factors changing community composition
    a. Disturbance regimes
        i. Physical factors and scale: storms, tsunamis, seismic, volcanic
        ii. Biological factors
    b. Seasonal and other succession patterns, alternate stable (transient?) states
    c. Predation, competition and interactions with physical factors
    d. Mutualisms, disease
4. Biogeographic transition areas, 'hotspots' what are they?
5. Community level fisheries management (NOT 'ecosystem-based' management)
6. Biological – geophysical relationships. The problem of lack of biological data in marine conservation. Definitions and relationships between marine habitats and marine communities. An examination of the Marine Recorder database, problems of 'indicator species' scales and quantification
    a. Biological versus physical classifications. Examples e.g. BIOMAR
    b. Review of correspondence between community types and physical factors. Note that this will be a function of scale of observation
    c. Where and when habitat types and community types coincide
    d. Why habitats are more fundamental than communities for marine conservation
    e. Where habitat variation is reduced and communities are discerned as geophysical structures themselves (e.g. corals, seagrasses). Biogenic substrates

f. When we can / must use community analyses

Chapter 10: Habitats, Seascapes and Representative Areas

1. The concept of Representative Areas. Ecological principles for defining and classifying "Marine Representative Units"
   a. Guiding principles for marine representation and 'habitat types'
   b. Hierarchical classifications. Why a hierarchical framework?
   c. Biological Factors for defining Marine Representation (?)
2. Geophysical factors and surrogates used to define marine representation. The selection and significance of 'enduring and recurrent' surrogate factors. Defining and mapping 'seascapes' from hierarchical geophysical variables
   a. Physiographic Factors for defining Marine Representation
   b. Geological history of ocean basin/ Basin morphology and topography/ Geographic position and latitude/ Bathymetry and depth/ Relief and slope/ Substrate and sediment type/ Substrate heterogeneity/ Geology and rock type
   c. Oceanographic Factors for defining Marine Representation
   d. Salinity/ Water masses/ Temperature/ Temperature gradients and anomalies/ Ice cover and scour/ Dimensional segregation/ Depth/ Illumination / Water motions/ Convergences and divergences/ Upwellings/ Stratification and mixing regime/ Nutrients/ Light penetration and turbidity/ Depth and pressure/ Tides; amplitude and currents/ Exposure to waves/ Oxygen, dissolved gases/ biogeochemical cycles
3. Procedures for defining and mapping Marine Representative Units
   a. Examples of International/ National and Regional approaches, WWF/ CLF, Australian National Bioregionalization and Great Barrier Reef, UK Seascapes, CEC in North America and Scotian Shelf
   b. Analysis of water masses
   c. Marine classifications; evaluation of classification systems

Chapter 11: Coastal Zone Conservation and Planning (S. O'Connor, M. Greenlaw, C. Mercer-Clarke)

1. Definitions. Importance of the coastal zone
   a. Why the coastal zone should be treated separately
   b. Humans identify with shoreline, coastal zone and its biological communities.
   c. Relationship between terrestrial and marine systems; inputs to coastal zones
   d. Ecological principles of Coastal Zone Management
   e. Species and genetic considerations in CZM
2. Historical review. Coastal Zone Management, its purpose in context of approaches to conservation. Regulation of human activities and 'ecological integrity'
   a. Integrated' CZM should include:
   b. Intergovernmental – all jurisdictions
   c. Integration across the land-water interface
   d. Intersectoral – across different user groups
   e. Interdisciplinary – ecological, social, economic and cultural
   f. Intergenerational
   g. Failure of CZM – new paradigm 'Sustainable Coasts' and ecological integrity
3. The Coastal Zone. A new approach and hierarchical classification based on GIS analysis of digital physiographic and oceanographic data. Why a new approach is required. Classification of inlets and prediction of habitat types. Surrogates for

salinity, exposure, productivity and complexity. Geophysical and physiographic classifications.

4. Geophysical analysis and mapping of 'coastal landscapes' – GIS and habitat analyses
   a. Hydrographic charts and data availability
   b. Determining 'inlet types', their characteristics, habitat assemblages – a classification scheme
      i. Watersheds and tidal effects, physiography
      ii. Exposure and bathymetry
      iii. Surrogates for pelagic versus benthic production
      iv. Complexity measures
5. How to deal with limited biological data

Chapter 12: The Deep Sea / High Seas environments and dilemmas

1. Significance and classifications based on geomorphic units
2. Deep sea vents.
3. Seamounts
   i. Taylor Columns and production regimes
   ii. From indigenous to cosmopolitan species
4. Pelagic MPAs

Chapter 13: Integrating Distinctive, Representative and Coastal areas to define candidate SETS of MPA's (J. Smith)

1. Guiding principles and selection criteria for candidate MPA's and how they can be integrated
2. The Concept of 'Coherence'
   a. Significance of processes versus structures
3. Ecological Integrity
   a. Does the term have meaning for isolated MPAs?
   b. Ecological Integrity of Networks
4. Recombining MPA types into a regional framework
   a. Analytical approaches and tools - e.g. MARXAN analysis
   b. Recombining Pelagic and Benthic representative areas
   c. Recombining Distinctive (special/ unique) and Representative ('ordinary') areas and MPA's
5. The 'two-phase' process - from 'candidate' MPA's to select members of a 'set' of MPA's
   a. Marine GAP analysis. (Zacharias paper)
   b. Identification of members of a 'set' of MPAs

Chapter 14: Determining the size, boundaries and numbers of MPAs, and proportion of area for networks (J. Baxter, S. Evans)

1. Goal and purposes of Conservation influences selection, design and size of MPAs
   a. Criteria to define size based on primary intended function of an MPA.
   b. Roff, Evans Baxter paper
2. How many MPAs, what proportion of a region?
   a. The SLOSS debate (answer SLAMS!)
   b. What proportion of a region should be protected (20–40% based on fisheries conservation?)

Chapter 15: Networks of MPA's; Coherence, Connectivity

1. The scale of processes and the concept of Connectivity
2. Connectivity is THE major issues in determination of MPA networks
3. Significance of flow patterns – physically oceanography, water masses, currents
4. Patterns of Connectivity among benthic habitats and candidate MPAs. Pelagic-benthic coupling, and patterns of larval recruitment from tropics to polar regions
5. Location of MPA's at extremes of a biogeographic region? (Actually – should be at extremes of connectivity or disconnectivity, i.e. at ends of flow regimes?)
6. Larval development and recruitment processes. Dependence of MPAs upon patterns of larval recruitment and ocean currents. Auto- and allo-recruitment processes and the 'larval lottery'. Models of connectivity. Webdrogue and other programmes
7. Main issue for conservation is the relation between: ISOLATION and CONNECTIVITY
    a. Isolation leads to meta-populations, ESU's
    b. Connectivity leads to gene flow and recruitment
    c. Genetic implications and data
    d. Apparent contradictions between oceanographic and genetic data

Chapter 16: Fisheries Management and Biodiversity

1. Traditional fisheries management
    a. Quotas or closed areas?
    b. Single species fisheries, economic species
    c. Single species stock assessment
    d. Assumption of constant physical and biological environment
    e. Trends in fisheries.
2. Community fisheries management
    a. Multi-species (predator-prey relations)
    b. Ecosystem-based management
3. Impacts of fisheries on Biodiversity
    a. Physical disruption of habitats. Fisheries bottom habitat destruction, remnant fishing gear etc.
    b. Fishing down food chain
    c. Coastal zone and estuaries – Essential Fish Habitat mapping
    d. Deep seas and High seas impacts – Seamounts
    e. Aquaculture effects.
4. Reconciliation of fisheries conservation and biodiversity preservation
    a. Relationships between fisheries conservation and biodiversity conservation.
    b. LMEs, LOMAs, Ecosystem-based management
    c. EBSAs and value; TEK
    d. The multiple roles of MPAs
5. Significance of connectivity for fisheries recruitment
6. Potential use of modelling approaches such as ECOSIM and ECOPATH. The multiple roles of MPAs

Chapter 17: Assessment and Evaluation of Conservation Efforts (T. Bryan)

1. The concept of 'Value' as applied to marine biodiversity
2. Ranking habitats on the basis of ecological structures and processes

3. The added or subtracted values of environmental state and socio-economic issues.
4. Priority conservation areas – what they are – how selected?
   a. Sensitive and vulnerable areas. Areas and species of special concern. 'My favourite area' (Hackman quote)
   b. Evaluating 'value' in marine environments – ecological approach. (S. Derous)
   c. The Delphic approach
   d. What to do first
5. Have all the components of Marine Biodiversity been 'captured' in conservation plans (Kory Lavoie / Roff analyses)? Integration of plans – Global, Regional, Local. The Genetic level of the Ecological Hierarchy
   a. 'How to Capture Marine Biodiversity in Conservation Plans'
   b. How do we know if we have done a comprehensive job?
   c. Examples from ICES and CHONe

Chapter 18: Remaining problems

1. MPA Networks a 'necessary but not a sufficient solution'
2. Disturbance regimes in the marine environment – their effects and roles. Scales and agents of disturbance. Distinguishing between natural and human effects
3. Coastal zone impacts. Coastal zone Eutrophication. Land-water interactions – natural and disturbed. Water quality and the coastal zone environment. A new index based on Redfield Ratios. The role of environmental assessment and impact studies
4. Effects of climate change on planning for marine conservation. Implications for water masses, regional plans and biogeographic concepts
5. Ecosystem based management is really human management
6. Who does what in Marine Conservation? From local to international. Concepts of 'ecosystem-based management. Divided jurisdictions. The failure of Integrated Coastal Zone Management. The alternative – planning for sustainability
7. Other problems

Annex 5: Update on contribution of existing ICES Expert Groups to Biodiversity Science

SGBIODIV reviewed reports from existing Expert Groups produced in 2008 to provide an update on their contribution to Biodiversity Science. In addition, the updated annex includes a wider rationale for each group and their biodiversity-related remit (as perceived by SGBIODIV).

Working Group on Introductions and Transfers of Marine Organisms (WGITMO)

- Rationale: Invasive species are a major threats to biodiversity and economies often suffer as a result, but a harmonised system for tackling the problem and assessing its impact is currently lacking.
- Remit: Investigate main challenges derive related to alien species, including impacts of alien species on native aquatic biodiversity and impacts that genetically altered stocks may have on related natural populations.
- Update on activities: Revised and updated the 2007 report on changes in the distribution, population abundance and condition of introduced marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature.

Working Group on Deep Water Ecology (WGDEC)

- Rationale: The immense importance and value of deep sea ecosystems and the biodiversity they contain calls for sustainable management of fish stocks and protection of vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, from destructive fishing practices.
- Remit: Investigate broader distribution patterns of species and habitats across deep water ecosystems in the North Atlantic with a view to identifying variation in biodiversity and advising OSPAR on the nature and impacts of threats, including deep water fisheries.
- Update on activities: Continued descriptions of the distributions of structure-forming sponges and soft corals in the North Atlantic and development of seabed maps.

Working Group on Ecosystem Effects of Fishing Activities (WGECO)

- Rationale: Fisheries are an extensive form of human intervention in marine ecosystems and have a long history. It is therefore appropriate to consider the effects this activity has had and will have on marine ecosystem dynamics, biodiversity and the sustainability of marine resource use.
- Remit: Works across a broad spectrum of issues related to the ecosystem effects of fishing, deals with advisory requests and develops own areas of work.
- Update on activities: Reviewed reports from various Expert Groups on changes that have occurred in the abundance and distribution of marine species, including biodiversity, as a result of climate change as part of OSPAR Quality Status Report 2010.

Working Group on Marine Mammal Ecology (WGMME)

- Rationale: Since marine mammals are generally at high trophic levels exposed to biological effects of biomagnified and accumulated pollutants, these organisms are often selected as potential indicators for ecosystem health.
- Remit: Address questions related to the link between ecosystem/environmental health and different harmful effects on the health status of marine mammals and assesses implications for management.
- Update on activities: Used recommendations from various ad hoc groups to draw up a list of species for intensive study to complete the assessment of changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature.

Working Group on Regional Ecosystem Description (WGRED)

- Rationale: Developing a complete picture of marine ecosystems requires the combined knowledge of a variety of experts in marine related areas of research. Integrated scientific and political communities aid efforts to understand and manage the effects of human activities in marine ecosystems. There are a few examples of some progress in science-policy integration, including this Expert Group composed of experts in a variety of disciplines.
- Remit: Prepare regional ecosystem overviews (including biodiversity issues) and identifies significant environmental events for attention during the Assessment Working Groups' activities (dissolved in 2009).
- Update on activities: Updated 2007 overviews of regional ecosystems and significant environmental events.

Working Group on Fisheries Technology and Fish Behaviour (WGFTFB)

- Rationale: Trawl is one of the most efficient fishing methods to harvest bottom and mid-water fishery resources. It is considered as a highly non-selective gear as it exploits a wide variety of species in different sizes giving rise to problems associated with managing fish stocks and maintaining biodiversity. It is necessary to promote the use of lower impact catch technologies which are technically and economically feasible.
- Remit: Identify behavioural and gear research and assesses basic principles, strategies and effectiveness gear modifications in reducing environmental impact.
- Update on activities: In collaboration with WGECO, selected and described representative examples of gear modifications, which have resulted in changes to their ecosystem effects, including a range of ecosystem components, in each OSPAR region.

Working Group on Zooplankton Ecology (WGZE)

- Rationale: Significant changes have occurred in the abundance, distribution, diversity and population dynamics of zooplankton and phytoplankton, mainly reflecting changes in regional climate. Poor recruitment of several commercial fish species and low seabird breeding productivity recorded in recent years in some regions are associated with changes in plankton biomass and in the seasonal timing of plankton production.
- Remit: Produce a summary reports on zooplankton activities in the ICES area based on the time series obtained in the national monitoring programmes to give a global (ICES scale) and visual overview of zooplankton distributions for the preceding years (in the form of time series) with a brief interpretation of the ecological significance of these results.
- Update on activities: Reviewed the OSPAR request for a 'Scoping report on summaries of the status of biodiversity' and agreed on a list of monitoring activities and products that should be taken into account when considering the status of biodiversity.

International Bottom Trawl Survey Working Group (IBTSWG)

- Rationale: The IBTS consists of a number of internationally-coordinated national surveys that aim at improving standardisation and collaboration between surveys in the North Sea and Western and Southern areas. Goundfish survey data are important for assessing the status of commercial and non-target fish species and provide a major data source for large-scale spatial and temporal analyses of fish assemblages in continental shelf waters, and for the derivation of metrics with which to assess changes in the structure, functioning and diversity of these assemblages.
- Remit: Coordinate the collection of standardised data from international demersal trawl surveys operating over wide spatial areas of the ICES area. These surveys aim to provide information to the Assessment Working Groups on the distribution and relative abundance of commercial fish stocks and biological information on these species and the wider ecosystem.
- Update on activities: In the light of increased use of future and historic IBTS data for studies on fish diversity, made suggestions of how to improve their quality.

Study Group on Fisheries Induced Adaptive Change (SGFIAC)

- Rationale: Fisheries can cause evolutionary responses over time periods as short as 10–20 years, in particular in traits such as the onset of maturation. As these changes will most likely have consequences for conservation of biodiversity and sustainable exploitation of marine species, management objectives and (precautionary) reference points for sustainable exploitation need to be re-defined, and new objectives and reference points for managing fisheries-induced evolution need to be developed (e.g. reducing harvest rates, raising a stock's minimum size).
- Remit: Review and synthesise empirical evidence of fisheries-induced adaptive change, including its consequences for the conservation of biodiversity and sustainable exploitation of marine species within an ecosystem

context and evaluate the impact of existing management measures and tools on fisheries-induced adaptive change.

- Update on activities: Based on a overview in 2007, reviewed the scientific evidence for fisheries-induced evolution and proposed evolutionary impact assessment as a tool for quantifying the evolutionary effects of management measures on the utility components defined by managers.

Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT)

- Rationale: Marine biodiversity is dependent on, and linked to, the physical environment in which it occurs. The impact of aggregate dredging on the physical environment is therefore of major significance in determining any effects on components of marine biodiversity. These effects may be apparent on the seabed, on adjacent intertidal areas, and within the water column. Effects may be limited to discrete areas or more widely dispersed and can occur on a variety of time scale.
- Remit: Review scientific programmes and research projects relevant to the assessment of environmental effects of the extraction of marine sediments (including studies on marine habitat mapping, benthic impact and seabed recovery, modelling and risk assessment, biodiversity and nature conservation of sand and gravel habitats).
- Update on activities: No 2008 report is available.

Working Group on Marine Habitat Mapping (WGMHM)

- Rationale: Species inventories form the basis for much conservation work, but these inventories are only reasonably complete for a small number of taxa such as birds and large mammals. An approach based on habitat types can potentially help to protect both these well-known taxa and lesser-known organisms. For this reason, policy makers, conservation organisations and scientists all require a sound and practical characterisation, inventory, classification and cartography of marine habitats.
- Remit: Conducts regular reviews of relevant national and international programmes, providing a forum for the exchange of information, techniques and strategies.
- Update on activities: Updated 2007 overviews and reviewed a draft document addressing the application of and needs for habitat maps in an ecosystem-based management context.

Working Group on The Application of Genetics in Fisheries and Mariculture (WGAGFM)

- Rationale: Advances in molecular biology over the last decade provide fisheries geneticists with cost-effective tools for resolving unprecedented levels of genetic diversity within the genomes of marine fish and shellfish species. Analysis of the amount and distribution of this diversity can be highly informative, not only as regards the structuring of a species into breeding populations but also, potentially, about the reproductive status of the populations themselves. This approach has the potential to be a valuable management tool.

- Remit: Report on the current knowledge of the application of genetics in fisheries and mariculture.
- Update on activities: Reviewed prospects for genetic monitoring for evaluating the conservation status, intra-specific biodiversity and population health in fishes.

Working Group on Fish Ecology (WGFE)

- Rationale: The rationale behind the formation of WGFE in 2003 was to support ICES on issues of fish community metrics and indicators and to provide advice on threatened marine fishes. Until 2002, fish community issues were considered by WGECO, but as the demands on WGECO increased the establishment of WGFE enabled a more focussed consideration of fish community issues.
- Remit: Address issues on non-commercial fish species, including species of conservation importance, fish communities and assemblages, and other aspects of fish ecology (e.g. feeding habits and prey rations, habitat requirements), so that ICES can provide advice in these areas in relation to ecosystem, biodiversity and nature conservation issues.
- Update on activities: Finalised its 2007 contribution to the OSPAR request to examine impacts of climate induced changes in the marine physical environment on the distribution, abundance and biodiversity of fish. Reviewed case studies examining redundancy between common community indicators for the a North Sea fish community, including diversity indices.

Working Group on Seabird Ecology (WGSE)

- Rationale: As inhabitants of the maritime environment, marine birds are affected by human use of the sea and its coasts, and because fisheries are one of the most widespread uses, by fishing activities in particular. Birds can be harmed by, and can benefit from, the fishing activities of humans and some of the effects can be shown to operate at the population level.
- Remit: Investigate and advise on the threats to seabird populations and diversity.
- Update on activities: Considered further the effects of climate change on seabirds, emphasising the importance of choosing appropriate hydrographic data to explore associations between physical and biological components of the stressed ecosystem. Reviewed the 2007 overview of threats pathogens and parasites pose to seabird populations and biodiversity.

Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH)

- Rationale: Like other areas of low salinity and low biodiversity, the Baltic is particularly vulnerable to human-induces impacts. In order to ensure its sustainable use the development of meaningful policies on the different environmental issues in the Baltic Sea require a holistic consideration of the structure, processes, functions and interactions of the ecosystem.
- Remit: Develop the Baltic ecosystem health concept in relation to the main ecological concerns including eutrophication, hazardous substances, overfishing, marine transport and biodiversity.

- Update on activities: Reviewed progress regarding ecosystem-based approaches to management of the marine environment and developed further ecosystem health issues of the Baltic Sea in relation to biological effects of hazardous substances and loss of biodiversity

Annex 6: Recommendations

Recommendation	For follow up by:
1. The ICES Secretariat sends the SGBIODIV report 2009 to the Advisory and Science Committees for comment: Has SGBIODIV adequately evaluated the relevance of Biodiversity Science within the current and emerging science and advice strategies and structures?	SCICOM/ACOM
2. After deliberation of the options to develop and deliver Biodiversity Science within the current ICES structure, SGBIODIV considered there to be sufficient rationale for being established as a Working Group (WGBIODIV). Such a group would enable Biodiversity Science to be delivered as an overarching theme in a more coordinated manner. This would better enable ICES to answer questions on marine biodiversity and to synthesise biodiversity related information as a basis for advice.	SCICOM
3. Regardless of which option is chosen, SGBIODIV recommends that ICES develops and implements a structured work plan that considers the issues identified in Section 8 (ToR c).	SCICOM
4. Survey coordination groups (IBTSWG, WGBEAM, WGBIFS, PGNEACS) ensure that data collection is appropriate for studies of biological diversity (e.g. follow the recommendations of WKTQD).	BTSWG, WGBEAM, WGBIFS, PGNEACS
5. The ecology Working Groups (BEWG, WGFE, WGZE etc.) review potential biodiversity indicators for their taxa of expertise.	BEWG, WGFE, WGZE
6. ICES better engage with a wider scientific community on Biodiversity Science issues. In the first instance, this should be facilitated through a biodiversity theme session at the 2010 ASC.	

Annex 7: Draft Resolution for SGBIODIV

The **Working Group on Biodiversity** (WGBIODIV), chaired by CHAIR, will be established and will meet on DATE in VENUE [to be confirmed] to:

a) develop a working plan to review the biodiversity of ICES ecoregions for dominant marine taxa and identify relevant data sets for examining temporal and spatial change. Future reviews would be carried out intersessionally, facilitated by relevant delegates from ICES member states;

b) review existing approaches to the development of biodiversity indicators;

c) synthesise biodiversity information from other EGs for specific advice requests.

WGBIODIV will report by DATE to the attention of the XXXXX Committee.

Supporting information

Priority:	High. The work of the Group is essential if ICES is to progress with making biodiversity an integral part of ICES work..
Scientific justification and relation to action plan:	
Resource requirements:	No specific resource requirements beyond the need for members to prepare for and participate in the meeting.
Participants:	Expertise from all areas of the marine benthic and pelagic food web components.. Participation is sought from ICES countries and by scientists both from disciplines and scientific circles not normally represented at ICES.
Secretariat facilities:	Not exceeding the usual requirement
Financial:	None specific.
Linkages to advisory committees:	ACOM.
Linkages to other committees or groups:	Ecology and survey groups, WGDEC, BEWG
Linkages to other organizations:	CBD, IMoSEB, OSPAR, HELCOM