



GLOBEC International Integration and Synthesis Blueprint

Prepared by Manuel Barange and the GLOBEC Scientific Steering Committee

GLOBEC IPO, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH. Phone: +44 (0)1752 633160. Fax: +44 (0)1752 633101. E-mail: M.barange@pml.ac.uk and globec@pml.ac.uk. Webpage: www.globec.org.

1. Introduction

“Natural variability, occurring over a variety of time scales, dominates the health of complex marine ecosystems, regardless of fishing or other environmental pressure. We are only now beginning to compile quantitative documentation of such variability, and consequently our knowledge concerning its causes remains at the level of hypotheses. Understanding of the role of variability in the function of marine eco-systems is essential if we are to effectively manage global marine living resources such as fisheries during this period of tremendously increased human impact, and concurrent dependence, on these resources.”

GLOBEC Science Plan, 1997.

GLOBEC, a study of Global Ocean Ecosystem Dynamics, was initiated by SCOR and the IOC of UNESCO to understand how global change, in the broadest sense, will affect the abundance, diversity and productivity of marine populations comprising a major component of oceanic ecosystems. A Science Plan was subsequently developed and was submitted to the Scientific Committee of the IGBP for consideration and adoption as an element in its international global change effort (GLOBEC Report No. 9 / IGBP Report No. 40, 1997). Planning was followed by the publication of a detailed Implementation Plan (GLOBEC Report No. 13 / IGBP Report No. 47, 1999) which set the rationale for the GLOBEC goal:

“To advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change”.

GLOBEC considers “global change” in the broad sense to encompass the gradual processes of climate change as a result of greenhouse warming and their impacts on marine systems, as well as those shorter-term changes resulting from anthropogenic pressures such as population growth in coastal areas, increased pollution, overfishing, changing fishing practices and changing human uses of the seas. In pursue of the above goal, four research objectives were identified:

- Objective 1 - To better understand how multiscale physical environmental processes force large-scale changes in marine ecosystems
- Objective 2 - To determine the relationships between structure and dynamics in a variety of oceanic systems which typify significant components of the global ocean ecosystem, with emphasis on trophodynamic pathways, their variability and the role of nutrition quality in the food web

- Objective 3 - To determine the impacts of global change on stock dynamics using coupled physical, biological and chemical models linked to appropriate observation systems and to develop the capability to predict future impacts
- Objective 4 - To determine how changing marine ecosystems will affect the global earth system by identifying and quantifying feedback mechanisms

2. GLOBEC Implementation

The GLOBEC Science and Implementation Plans set out the framework for the international research programmes, but in practice national funding agencies had to respond to national scientific priorities, resources and expertise. The role of the international programme has been to provide a significant “value added” effect to these diverse national efforts, coordination and by the facilitation of those activities which require cooperation between nations, such as data management and sharing, development of methodology, efficient deployment of major resources such as research vessels, and eventually, the emergence of a truly global synthesis of scientific results which is the ultimate goal of all large-scale global change research programmes.

The international GLOBEC programme was structured along four main components which are described in detail in this Implementation Plan: the four research Foci, four crosscutting Framework activities, and six (originally four) Regional Programmes, and finally the Integrating Activity. These are the elements that have been planned by, and implemented under the auspices of, the GLOBEC SSC.

The four Foci define the overall practical research approaches, and are implemented through international appointed working groups:

- Focus 1: Retrospective analyses and time series studies
- Focus 2: Process studies
- Focus 3: Predictive and modelling capabilities
- Focus 4: Feedbacks from changes in marine ecosystem structure.

The four crosscutting Framework activities are broad efforts requiring international coordination, and which are developed through the direct leadership of the international GLOBEC SSC and the International Project Office (IPO):

- Sampling and models: protocols and inter-comparisons
- Data management
- Scientific networking
- Capacity building.

The six Regional GLOBEC programmes are, in effect, the mechanism for the practical implementation of many of the Activities within the four research foci:

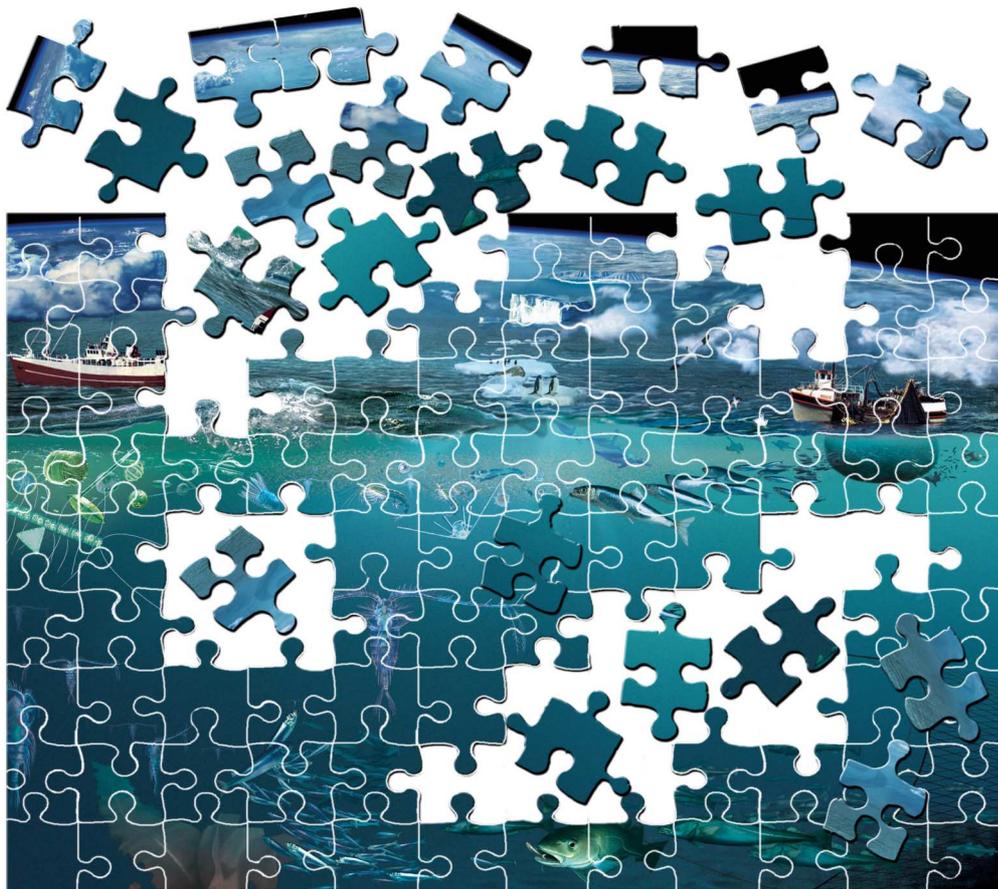
- The GLOBEC-ICES CCC Programme in the North Atlantic Ocean,
- The GLOBEC-PICES CCCC Programme in the North Pacific Ocean,
- The Southern Ocean GLOBEC (SO-GLOBEC) Programme
- The Small Pelagic Fishes and Climate Change (SPACC) Programme
- The Climate Impacts on Oceanic Top Predators (CLIOTOP) Programme and
- The Ecosystem Studies of Sub-Arctic Seas (ESSAS) Programme.

The first two were developed primarily by two important regional partners with GLOBEC: ICES and PICES. The middle two have been entirely developed through the efforts of the SSC and its working groups and involve the participation of many national GLOBEC programmes. The last two are new projects, still in planning, but which are designed as integrative efforts from the start.

The Integration activity is aimed at designing how the observations and results from the various pieces of the GLOBEC programme will be drawn together and integrated in an effective manner in order to develop the global synthesis which must be its final legacy. This Integrating Activity aims towards a GLOBEC synthesis, will focus on ecosystem comparisons, and will enable us to achieve the understanding of the functioning of marine ecosystems and their responses to physical forcing that is the GLOBEC goal. This document sets out a blueprint for this Integration activity. It is drafted as a living document which will develop through GLOBEC's Integration and Synthesis Phase (I+S), expected to last from 2005 to 2010.

3. Towards a GLOBEC Integration and Synthesis: Ecosystem Comparisons

- *Integration.* The act or process of making whole or entire. The process by which the manifold is compacted into the relatively simple and permanent.
- *Synthesis.* Composition, or the putting of two or more things together, as in compounding medicines. The art or process of making a compound by putting the ingredients together, as contrasted with analysis; thus, water is made by synthesis from hydrogen and oxygen.



GLOBEC I+S in a picture: Integration can only be build from pieces that actually fit together. The result of this integration is a new vision of the structure and functioning of the marine ecosystem, the ultimate GLOBEC synthesis.

Integration is the process of putting together a whole from its individual pieces. It must be built around well-posed scientific questions and it must be developed by all relevant groups collaborating from the beginning, including the framing of the guiding questions. The work must be undertaken on a common platform/structure, built and owned by all. Synthesis is a process through which we gain a new understanding, and which could not come about without this process.

The ultimate objective of the GLOBEC I+S phase is the development of a new mechanistic understanding of the functioning of the marine ecosystem, building on the pieces of the puzzle provided by the national, multinational and regional GLOBEC projects), through:

- The development of marine ecosystem typologies and classification of ecosystems into these typologies
- The identification of key ocean systems not presently being studied by GLOBEC activities, and encouragement of programmes in these regions
- The synthesis of the responses by characteristic “ecosystem-types” to large-scale global changes.

I+S activities will also involve comparisons of processes within and among marine ecosystems, and comparisons of ecosystem responses to large-scale forcings (both natural, such as climate variability, and anthropogenic, such as fishing). Understanding and prediction of the different responses by these “ecosystem-types” to such large-scale forcing is a core objective of GLOBEC which involves local, regional, and global concerns.

Table 1. Overview of approaches for comparisons among ecosystems, structured from more simple to more complex in both approach and information requirements (After Gaedke, U. 1995. A comparison of whole-community and ecosystem approaches (biomass size distributions, food web analysis, network analysis, simulation models) to study the structure, function and regulation of pelagic food webs. *J. Plank. Res.* 17: 1273-1305)

Observational basis	Concepts and techniques	Potential insights
abundances and body mass (biomass spectra)	biological species, allometric relationships, time-series analyses, biomass size distribution, trophic continuum concept	species list, quantitative importance of species with respect to biomass (and process rates), size conversion efficiency, variations in time and space
abiotic parameters	regression analyses	potential abiotic impacts
trophic interactions (binary web)	aggregation of species into trophic guilds, food web analyses	food web structure, connectance, linkage density, potential direct interactions
process rates (<i>e.g.</i> production, respiration), diet compositions, trophic webs	population dynamics, flow analyses, network analyses, trophic level concepts	mass-balance flow diagrams, trophic transfer efficiencies, trophic structure and function (direct and indirect effects)
regulation of flows	dynamic simulation models	direct and indirect effects and dynamic interactions
adaptability, adaptive interaction web	fully reactive and predictive simulation models with a flexible community structure	prediction of community structure and function for different environmental scenarios

4. The legacy of GLOBEC

The GLOBEC SSC, at its 9th meeting in Swakopmund, Namibia, 16-18 April 2004, considered its plans for the Integration and Synthesis phase. The following responds to the desire of the SSC to identify what GLOBEC will be remembered for, and which should guide the plans for synthesis:

A. What encapsulates GLOBEC's philosophy

1. Multi/ interdisciplinary international collaboration
2. Physical-biological interactions
3. From key species to ecosystems/ from individuals to populations
4. Coupled models as integrative tools
5. Multi-scale (time, space, institutional) analysis

B. What body of knowledge would GLOBEC contribute to?

1. Ecosystem Structure and Function
 - a. How are ecosystems structured and how does structure affect function (High/Low latitudes., coastal/open)
 - b. Demonstrate the role of Climate variability in affecting marine ecosystem changes
 - c. Identify the relative role of ecosystem components (plankton, fish, humans) in ecosystem functioning
 - d. Enhanced understanding of the role of high trophic levels and top-down controls (hierarchical)
2. Forcings
 - a. Determine the space/time modes of variability in natural climate processes
 - b. Highlight the mechanisms behind ecosystem teleconnections
 - c. Recognise the role of Humans as forces of change
3. Physical/ Biological/ Human interactions and Feedbacks

C. What innovative methodologies has GLOBEC introduced/ advanced?

1. Sampling and technological advances in support of GLOBEC science
2. Coupled Models (trophic, scale, time) to investigate structure, function and variability
3. Retrospective studies (particularly multidecadal to centennial) on past ecosystem states
4. Comparative approach (mostly regional)

D. Successes in transferring information to management bodies

1. Policy (providing conceptual understanding of ecosystem function)
2. Managers (providing tools to incorporate climate-driven variability)
3. Communities (enhancing communication on GEC and marine sustainability)

E. What education/ outreach objectives has GLOBEC achieved?

1. Curriculum development
2. Web-based approaches
3. Animations (scenarios)
4. Lessons learned

5. Implementing GLOBEC's Integration and Synthesis: Planned Symposia 2004-2010

The following table identifies planned symposia which will underpin the synthesis of GLOBEC. These symposia will be preceded and followed by a number of workshops (see below) that would provide the regional and cross-cutting synthesis. The GLOBEC SSC will act as the body responsible for the I+S phase, providing continuity between workshops and symposia (e.g. by maintaining a presence in the organising committees).

Table 2. GLOBEC planned Integration and Synthesis symposia 2004-2010, by region or research topic. Shaded boxes indicate symposia that have been planned to a certain level. White boxes indicate symposia that, although proposed, have not had any planning developed as yet.

2004	2005	2006	2007	2008	2009	2010
1-North Atlantic	2-Sub-Arctic Seas	3-North Pacific	4-FOCUS 4	7-Southern Ocean		
			5-US GLOBEC		8-CCC Synthesis	
			6-Zooplankton		9-GLOBEC OSM	

- 1- ICES/GLOBEC “**The influence of Climate change on North Atlantic fish stocks**”, Bergen, Norway. 11-14 May 2004 (CCC Regional synthesis symposium)
- 2- GLOBEC “**Climate variability and sub-arctic marine ecosystems**”. Victoria, Canada, 16-20 May 2005
- 3- PICES/GLOBEC “**Climate Change and Ecosystem impacts in the North Pacific**”, Honolulu, USA, 19-21 April 2006 (CCCC Regional synthesis symposium)
- 4- GLOBEC Focus 4 “**Natural and Human system implications of large-scale changes in marine systems**” Venue and date to be announced.
- 5- US GLOBEC Synthesis meeting. Venue and date to be announced, but would include NE, NW and Antarctic US and Canadian GLOBEC research.
- 6- PICES/ICES/GLOBEC 4th “**Zooplankton Production Symposium**”. Hiroshima, Japan, June 2007
- 7- SO GLOBEC Symposium. Venue and date to be announced.
- 8- ICES/GLOBEC Final Synthesis symposium. Venue and date to be announced.
- 9- Final GLOBEC Open Science Meeting (Note: It has been suggested that GLOBEC should host a symposium on “Incorporating Marine Ecosystem Science into Fisheries Management”. Perhaps this should be the focus of the final OSM?)

Other symposia may be called if necessary, particularly related to the two new regional programmes of GLOBEC, namely CLIOTOP and ESSAS.

In addition to these symposia the I+S phase of GLOBEC will include a number of workshops, task teams and writing teams, to tackle specific issues. For details visit the GLOBEC website, www.globec.org.