CLimate Impacts on Oceanic TOp Predators program.

A new **GLOBEC** regional program for open ocean ecosystem processus comparative analysis

ABSTRACT:

The GLOBEC (http://www.globec.org) Scientific Steering Committee decided recently to encourage and support the establishment of a new GLOBEC regional program for a global comparative project and in association with the existing multi-national Pacific OFCCP (Oceanic Fisheries and Climate Change) GLOBEC.

This new-borne CLIOTOP (CLimate Impacts on open Ocean TOp Predators) will be based on a large scale (between regions, oceans and species) comparative approach of the processes linking pelagic top predators dynamics to climate forcing. It is based on the idea that the very different types of climate/oceanography in the three oceans give the unique opportunity of a large scale comparative study of ecosystems functioning.

CLIOTOP would be devoted to the application of the comparative method to identify patterns and better understand the ecosystem processes involving pelagic top predators. It would ideally be a catalyst for cooperation and coordination between already existing teams and projects. It should be like a forum organized around meetings, working groups and publications. Field studies or modeling work will not be attempted directly by the project but, independently, by its participating teams. Hence, CLIOTOP aims at federating and coordinating efforts of ongoing projects around apex predators pelagic ecosystems.

The next step will be to establish a formal Scientific Plan. This scientific plan will have to be elaborated during a CLIOTOP/OFCC organizational meeting which should be held in the next few months in Sete (France).

1 - BACKGROUND & RATIONALE

Improvements in scientific knowledge are needed by the international community in order to develop effective science-based strategies for the management and preservation, in a context of climate change, of populations of tunas and other high sea top predators and of the ecosystems in which they serve as important functional elements. CLIOTOP aims at developing such a quantitative understanding of the functioning of open ocean pelagic ecosystems.

The GLOBEC[1] Scientific Steering Committee decided recently to encourage and support the establishment of CLIOTOP as a

1 GLOBEC program (Global Ocean Ecosystem dynamics, http://www.globec.org) is one of the nine programs constituting IGBP (International Geosphere-Biosphere Programme, http://www.igbp.kva.se). Together with JGOFS (which is being replaced by SOLAS and OCEANS http://www.igbp.kva.se/obe/), GLOBEC is one of the two IGBP programs focused on oceans. GLOBEC is co-financed by IGBP, SCOR (Scientific Committee on Oceanic Research) and the IOC

new GLOBEC regional program.

CLIOTOP will organize a **large-scale worldwide comparative effort** aimed at identifying and elucidating the **key processes involved in ecosystem functioning** and, in particular, to determine the **impact of climate variability at various scales** on the structure and function of open ocean pelagic ecosystems, the ultimate objective being the development of a reliable predictive capability. In view of need for prediction of effects that may lie beyond the range of current data and experience, it will be important to move beyond the usual phenomenological approach in order to focus upon developing a quantitative understanding of the operation of the main causal ecosystem processes and mechanisms.

Apart from its predictive objectives, CLIOTOP is intended to be structured by strong scientific questions. For example:

- What are the effects of the climate variability and climate change on the structure and functioning of high-sea pelagic ecosystems?
- How the adaptive strategies of the different species considered are structured at a basin scale by the spatio-temporal organization of the pelagic environment?
- How the adaptive processes do interact when they occur at different scales?

A number of scientific teams in various countries are currently making efforts toward elucidating the linkages between climate variability and ecosystem dynamics in tropical and subtropical oceanic systems. There should be much to gain by incorporating these efforts within a large scale comparative framework that would facilitate identification of informative patterns.

The core of CLIOTOP will be the development of a collaborative comparative approach involving research teams currently working in process-oriented projects which address the mechanisms linking physical forcing, zooplankton production, prey abundance and distribution and apex predator dynamics at various scales from individual behavior to long term biomass trends. CLIOTOP will seek to bring together independent projects in the three oceans for an inferential process of comparison and contrast of ecosystem processes in various regions, focusing on the dynamics of various apex predators species at all relevant scales impacting resource populations and overall ecosystem dynamics.

Scientific advances by CLIOTOP itself would rely mostly on interregional applications of the comparative method and associated global pattern recognition, whereas its member projects might be involved in actual field operations, data acquisition and modeling exercises. Hence, CLIOTOP will seek to integrate projects focused both on retrospective analyses and process studies. Modern tools such as modeling, acoustics, electronic tagging, and remote sensing will receive special attention. Genetic investigations may also be an important component of the CLIOTOP programmatic approach. However the actual operations would be funded and implemented within the separate component projects.

Two main integrated program thrusts are envisioned :

1 to evaluate the impact of climate variations on marine ecosystems inhabited by open ocean top predators by analyzing long-term data series, field observations, in situ and laboratory experiments and measurements;
2 to use modeling and extensive simulations in a comparative framework to deduce and understand the dynamics of the ecosystem and its dependent resource populations, leading toward development of next-generation models which embody a high degree of realism and predictive skill.

Given the complex nature of its foci, the CLIOTOP program should strongly encourage the co-operation and exchanges with other IGBP programs such as OCEANS, SOLAS, GAIM and JGOFS as well as WCRP programs such as CLIVAR. Being able to make use of the tools and expertise provided by those international programs will be crucial for an effective “open sea” project.

2 - OBJECTIVES

The general objective is to improve basic knowledge, theory and modeling of the functioning of open sea pelagic ecosystems. Ultimately, the goal is to develop a reliable predictive ability of those ecosystems dynamic in a climate change context.

This means:

(Intergovernmental Oceanographic Commission) of UNESCO.

GLOBEC has been adopted in 1995 The aim of GLOBEC is “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”.

- To conduct a global comparative study between oceans, regions, species and models for patterns recognition concerning the key processes linking pelagic top predators dynamics to climate forcing at various scales ranging from very shorts time scales to secular time scales.
- To federate and coordinate internationally scientific projects and research groups working in the field.

3 - PROJECT ORGANIZATION

CLIOTOP will focus on **adaptive processes** leading to pelagic apex predators ecosystem evolution in response to climate forcing at a broad range of scales and organizational levels.

To understand this causal mechanisms, **integrative process-oriented studies** (including retrospective analysis, field experiments, surveys and monitoring) in a **comparative framework** will be a key issue. In this respect, **a strong modeling component** will also be fundamental for CLIOTOP. It will include a range of models of different complexity from simple energy budget models or behavioral models to spatially explicit ecosystem models driven by OGCM.

To be able to conduct homogeneous worldwide comparative analysis, an homogeneous comprehensive record of climate variability, ocean and atmospheric circulation changes and related regional and local environmental changes is needed. In this perspective, the ocean and atmospheric reanalyses (SODA-NCEP/NCAR) for the last 50 years will be used by CLIOTOP. This record has short term, interannual, decadal and longer time-scale variability embedded in it, including a possible global warming signal. This record will provide a very high level of details for both retrospective analyses and forcing of ecosystem models. Most of the climate patterns, regime shifts and secular trends known today are present in this 50 year record and there is no evidence right now that global warming or climate change will project onto any new patterns other than these known patterns. This may also provide a unique opportunity to synthesize long term fisheries data over the last 50 years and yield unprecedented framework for CLIOTOP comparative studies.

Four key thematic questions have to be addressed to answer CLIOTOP's objectives:

I - How climate variability affects biology at an individual level?

- plasticity of life history traits as a function of environment,
- physiological capacity to adapt to a changing environment,
- energetic needs of apex predators,
- larval physiology,
- individual behavior (aggregative, reproductive, feeding and movements -horizontal and vertical-),
- Behavioral response to small and meso-scale environmental features,
- etc

II - How climate variability affects top predators population dynamics?

- processes driving large scale massive movements and distributional changes to adapt to environment variability,
- life cycle adaptive strategies to optimize population fitness,
- larval ecology (larvae may build their own planktonic food web structure -cannibalism- to exploit the oligotrophic conditions to which tuna have adapted their reproductive strategies), survival as a function of environment,
- genetic heterogeneity of populations,
- etc

III - How climate variability affects pelagic ecosystems?

- impact of competition between species on growth, survival, movements,
- impact of size-based predation,

- ecology, distribution and response to climate forcing of the micronektonic community of preys (including zooplankton), impact of its biodiversity on energy transfer from phytoplankton to apex predators,
- evolution of energy flows, pathways between trophic levels (effects of global change on ecosystems will impact via both bottom up control -impact of modified availability of limiting nutrients and light- and top down control -impacts of higher trophic levels determining the community structure and function),
- ecosystem structure (top-down impact of changes in abundance or distribution of apex predators, bottom-up impact of changes in phyto and zoo-plankton productivity),
- socio-economical impacts of global changes related to apex predators ecosystems,
- etc

IV - How to model the top predator pelagic species, populations and ecosystems?

- Individual based models,
- Population dynamic models,
- Statistical exploratory models,
- Ecosystem models,
- Coupling with physical process,
- Nested models,
- etc

To answer these four questions, CLIOTOP will be organized around **working groups, workshops and meetings** focused on precisely defined aspects. A first series of workshops is proposed for each scientific thematic:

1 Synthesis of results from archival or pop-up archival tags from different regional ocean environments to develop models of species-specific habitat use over a range of diverse ocean habitats.

2 Comparing small and large pelagics recruitment variability in relation with climate change. Are the process driving the survival of the larvae really different for both categories of species? Why are the reproductive strategies developed so different?

3 Comparative analysis of ecosystem models from different ocean regions to understand how the ecosystem structure and function varies with the physical structure. For example there are a number of pelagic Ecopath models for different areas in the ocean which could serve as a basis for comparison.

4 From individual scales to ecosystem models. IBM development and integration of archival tagging observations into population models.

4 - TERMS OF REFERENCE:

- To review the current state of knowledge and the different theories concerning climate forcing on pelagic ecosystems.
- To identify and select the key processes and the relevant scales for studying top predators ecosystem adaptive dynamics to climate variability.
- To identify, for each processes to be studied, the pilot ocean/region/species combinations to be compared.
- To organize working groups according to the selected scales, pilot cases and processes to be studied. The work done in CLIOTOP should be based on flexible "easy-to-manage" small working groups having precise goals.
- To identify patterns by comparing the pilot cases and formulate explanatory hypothesis.
- To develop a set of models to represent, test and explore the consistency of the inferred processes.

- To set up observations, measures and experiments to confirm hypotheses, estimate parameters and validate models.
- To run simulations to explore ecosystems dynamics response to both fishing and climate variability from short to long term.

5 - TIME TABLE:

- January 2003: Beginning of the project, first meeting of the Steering group.
- November 2003: Organizational meeting (Sète, France). Working groups creation.
- Each working group should meet at least once a year.
- 2005: First CLIOTOP meeting.
- 2008: CLIOTOP synthesis meeting.
- CLIOTOP could continue until 2008 in the GLOBEC framework.

6 - MEMBERSHIP:

Studying the dynamics of large pelagic ecosystems in a climate change perspective involves several fields ranging from climate modeling and oceanography to population biology and ecology, fishery science and socio-economy. Scientific projects representing a variety of disciplines are proposed to adequately cover topics, species and appropriate geographic distributions.

Co-chairmens:

Patrick Lehodey (SPC)

Olivier Maury [2], (IRD)

"Steering Group":

Andrew Bakun (RSMAS-CSF)

Patrick Lehodey (SPC)

Olivier Maury, (IRD)

Raghu Murtugudde (ESSIC)

Jeffrey Polovina (NMFS)

"Overview Advisory Group"

Juergen Alheit (SPACC and GLOBEC "Focus 1 WG"),

Robert Cowen (CSF-Billfish),

Jean-Marc Fromentin (IFREMER-CLS),

Alberto Garcia (TUNABAL),

John Gunn (CSIRO),

Patrick Lehodey (OFCCP),

Francis Marsac (IRD-THETIS),

[2] Contact person:
Dr. Olivier MAURY
IRD (Institut de Recherche pour le Développement)
SFA BP 570
Victoria, Iles Seychelles
tel: (248) 670 337, fax: (248) 224 742
maury@ird.fr

Arthur Miller (SCRIPPS)

Ian Perry (PICES, GLOBEC "Focus 4" WG and GLOBEC/CLIVAR),

Claude Roy (SPACC and GLOBEC "Focus 2" WG),

Gary Sharp (CCORS).

PRESENT LIST OF PARTICIPATING PROJECTS AND MAIN FOCUS

APCP-EA, contact James F. Kitchell, Univ. of Wisconsin, Madison USA;

- *APCP-EA: Apex Predators in the Central Pacific: An Ecosystem Approach*
- *Trophic interactions in the central north Pacific ecosystem.*
- *Modeling analyses at three scales: bioenergetics of individual fish species, predator-prey interactions and ecosystem models.*
- *Experimental Approach to Modeling.*
- *Modeling to Include Environmental Drivers.*
- *Bycatch and Ecological Interactions.*

AZTI tuna section, contact Haritz Arrizabalaga, AZTI Fundazioa, Sukarrieta, Spain

- *New environment dependent stock-recruitment relationships for albacore (in collaboration with ULPGC).*
- *Relationship between bluefin tuna catch rates and environmental conditions in the Bay of Biscay.*
- *Relationships between albacore recruitment and oceanographical conditions in the spawning areas and migration paths.*

CCORS, contact Gary D. Sharp, Monterey, USA.

CSIRO, contact John Gunn, CSIRO, Australia.

ERL-NEA, contact Molly Lutcavage, Boston, USA.

- *Movements and behavior of large pelagics in relation to their environment.*
- *Large scale deployment of popup archival sat tags on BFT.*
- *Regional and Atlantic-wide BFT movements in relation to SST, primary productivity, and ocean frontal systems.*
- *Movements of whale sharks in relation to prey/and frontal systems in the Indian Ocean.*

ESSIC, contact Raghu Murtugudde, ESSIC, USA

- *OGCM models, process study.*
- *Bio-geochemical numerical models.*

IATTC, contact Robin Allen, Rick Deriso, Martin Hall.

IFREMER-CLS, contact Jean-Marc Fromentin, IFREMER, Sète, France.

- *Description of the spatial dynamics of Atlantic bluefin tuna population in relation to environmental variations (especially to the mesoscale hydrological structures.*
- *Confrontation of the outputs of an individual based model (ibm) of bluefin tuna behavior with pop-up archival information.*

IRD-ACTIVE, contact Pascal Bach, IRD Sète France.

- *Vertical behaviours of large pelagic fishes, occupation of the pelagic habitat.*
- *Aggregative behaviour of tropical tunas.*

IRD-THETIS, contact Francis Marsac IRD la Réunion, France.

- *Leading mechanisms in the ecosystems controlling the distribution of a highly migratory resource.*
- *Joint effects of the environment and the exploitation on the structure and dynamics of high seas pelagic ecosystems.*
- *Trophodynamics of the high seas pelagic ecosystems.*
- *Effects of the aggregation around drifting floating objects on tropical tuna biology.*
- *Modeling environmental variability effects on spatial dynamics of tuna populations.*

LODYC, contact Olivier Aumont, LODYC, Paris, France..

- *OGCM models (OPA), process study.*
- *Bio-geochemical (N-P-Z-D-DOM) numerical models.*

NMFS-Honolulu Laboratory, contact Jeffrey Polovina, NMFS, Hawaii, USA.

- *Impacts of interannual and decadal climate variation on marine fisheries and ecosystems.*
- *Applications of satellite remote sensing and ocean circulation models to fisheries and protected species research*

NMFS-Miami, contact William J.Richards, NMFS, Miami, USA.

- *Analyze long term data sets to relate ocean climate events to fish population fluctuations.*
- *Focus on early life history stages that preceed any fishing mortality.*

NMFS-Pacific Fisheries Environmental Laboratory, contact George Watters, USA.

- *Data products and services (oceanography, fisheries, environment)*
- *How ocean conditions influence the production of marine resources?*
- *Modeling ecosystems taking into account environmental forcing on population dynamic.*
- *Describing and understanding the processes driving environmental variability on a variety of scales.*

NRIFSF, contact Ziro Suzuki, Shimizu, Japan.

- *Interactions between recruitment of major tunas and oceanographic and/or climate changes.*
- *Relation between migratory patterns of tunas and environmental conditions.*

OFCCP, contact: Patrick Lehodey, SPC, Nouméa.

- *Monitoring the upper trophic levels of the pelagic ecosystem.*
- *Food web structure in the pelagic ecosystem.*
- *Modelling from ocean basin to individual scale.*
- *Socio-economicl impacts.*

PFRP, contact John Sibert, University of Hawaii, Honolulu, USA.

- *Models which integrate individual and population scale variability.*
- *Incorporation of tagging and tracking information into population models.*

RSMAS-CSF, contact: Robert K. Cowen, Miami, USA.

- *Billfish spawning, early life history dynamics and nursery habitats.*
- *Environmental conditions required for spawning and early survival.*
- *Seasonally-resolved understanding of the annual cycle of billfish spawning, larval growth, feeding, and transport within the complex environment of the Straits of Florida (Atlantic Ocean).*

SCRIPPS, contact Arthur J. Miller, USA.

TUNABAL, Contact Alberto Garcia, Spain.

- *Determine the abundance and spatial distribution of tuna larvae*
- *Determine larval daily growth and condition for the main target species and their relationship with environmental parameters.*
- *Analyse the influence of mesoscale phenomena and frontal systems in the distribution of phytoplankton, zooplankton and ichthyoplankton.*

Distribution of the participating projects main focus in term of Ocean and species.

	Atlantic Ocean	**Indian Ocean**	**Pacific Ocean**	**Mediterranean Sea**
Tropical tunas	IRD-thetis NMFS-Miami NRIFSF	IRD-active IRD-thetis CSIRO NRIFSF	IRD-active NMFS-Hawaii OFCCP APCP-EA CSIRO CCORS NRIFSF PFRP IATTC	
Temperate tunas	ERL-NEA AZTI IFREMER-CLS NRIFSF	CSIRO NRIFSF	CSIRO NRIFSF NMFS-PFEL IATTC	IFREMER-CLS TUNABAL
Billfishes	RSMAS-CSF NRIFSF	CSIRO NRIFSF	NMFS-Hawaii NRIFSF PFRP IATTC	
Sharks		ERL-NEA		
Hydrological Biogeochemical	LODYC SCRIPPS	ESSIC LODYC	ESSIC LODYC SCRIPPS NMFS-PFEL	LODYC

7 - CONCLUSION

This project will address:

- The need for a global comparative approach of process linking climate to top predators ecosystems.
- The need for an international effort to urgently elucidate those process in a global change context.
- The need for both improving our basic knowledge and developing a reliable predictive capability.

This project will federate international scientific projects and research groups already involved in those topics.