JIMAR ANNUAL REPORT FOR FY 2008

P.I./SPONSOR NAME: Patrick Lehodey, John Sibert

NOAA OFFICE (Of the primary technical contact): PIFSC

PROJECT PROPOSAL TITLE: Climate and Fishing Impacts on the Spatial Population Dynamics of Tunas (Project no. 657425)

P. Lehodey, O. Maury, O. Aumont, V. Faure, A. Fonteneau, C.E. Menkes, R. Murtugudde, I. Senina, G. Watters, Julien Jouanno, Julien Trolet

FUNDING AGENCY: NOAA

NOAA GOAL (Check those that apply):

- ☒ To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- ☒ To understand climate variability and change to enhance society's ability to plan and respond
- ☐ To serve society's needs for weather and water information
- ☐ To support the nation's commerce with information for safe, efficient, and environmentally sound transportation

PURPOSE OF THE PROJECT:

A high priority for effective management of large pelagic fishes is the capability to discriminate between the effects of exploitation and climate dynamics on the sustainability of tuna populations. Climate related changes are believed to strongly influence the pelagic habitats of tuna, and thus movement and migration patterns. High frequency ENSO recruitment response appears to play out into low frequency decadal variations of tuna population biomass. Large changes in Pacific tuna catch rates in the 1950s-1960s were associated with natural climatic fluctuations. But not all tuna respond the same way to climate cycles, thus there should be demonstrable differences in survivorship during recruitment and responses to exploitation patterns. Empirical and analytical evidence are needed to explain the relative importance of environmental and fishing variability in structuring pelagic ecosystems. There is need to determine the mechanisms involved in observed variability across species, trophic connections, and oceanic regions. In this proposal, two spatial bio-physical models are proposed to be run for several tuna species concurrently with different long-term (up to 50 years) climate regime datasets. It is anticipated that the models will enable researchers to evaluate potential alternative system states due to physical and anthropogenic forcing and to help

determine if the impacts of natural climate variability could be anticipated in such a way as to help establish a management regime that accommodates exploitation pressures and natural variability to build sustainable tuna fisheries.

PROGRESS DURING FY 2008:

The planned activities for year 2 of the project were:

1. Preparation and analyses of physical-biogeochemical reanalyses to be transmitted to CLS and IRD-Sète for starting simulations with SEAPODYM and APECOSM.
2. Run physical-biogeochemical offline coupling at ESSIC (Univ. Maryland) to provide one additional forcing data set for the simulation ensemble.
3. Recruit a fishing database engineer to collaborate in the development of a global tuna fishing database (SARDARA) that will be accessible through the web
4. Recruit computer engineer for APECOSM for code parallelisation at IRD
5. Achieve the parameterisation of SEAPODYM using optimisation for yellowfin tuna in the Pacific Ocean.
6. Achieve the parameterisation of APECOSM for one species in the Indian Ocean.
7. Using biogeophysical reanalyses provided, run global SEAPODYM simulations with parameterisation achieved in the Pacific Ocean.
8. Attend the CLIOTOP symposium in La Paz, Mexico (Dec 2007), PI meeting in Hawaii (Nov. 2007) and / or the tuna conference in Lake Arrowhead in May 2008.

The project post-doc scientist, Dr Vincent Faure, provided the two (NCEP and ERA40) ORCA2-PISCES physical-biogeochemical reanalyses to CLS on a regular grid. Unfortunately files were corrupted. One reanalysis (forced by NCEP) was reprocessed in CLS to be used with SEAPODYM. The other (forced by ERA40) as well as ORCA05-PISCES has been directly provided to IRD-Sète by O. Aumont. The biogeochemical outputs of the two simulations were evaluated by the postdoc scientist. In general, the modelled chlorophyll appears stronger than the observations, especially in ORCA2-ERA40. The modelled surface chlorophyll concentration appears correct at temperate latitudes, both horizontally and vertically. Outputs are much less satisfactory for the interannual variability and in highly dynamic zones. ORCA05-PISCES outputs have not yet been analyzed.

V. Faure has decided to leave the project after the first year and has been replaced by Dr Julien Jouanno since May 1st. The initial 18-month contract has been reduced to 12 months due to the drop in the USD-Euro exchange rate since the submission of the project. J. Jouanno is based in CLS, taking in charge the simulations and analysis of the SEAPODYM mid-trophic simulations. The first one with the NCEP-ORCA2 reanalysis has been produced and is currently analyzed. Unfortunately other forcing data sets are still not available. Recruitment of computer engineer for APECOSM has been postponed and will be effective the 1st of October.

The fishing database engineer has been recruited in IRD-Sète in Nov 2007. The new scheme of the database SARDARA and its implementation are achieved. Then, the treatments for catch and effort data have been completed for both Indian and Atlantic Oceans. For the Pacific Ocean, data should be processed after the last release by the SPC/WCPFC in the coming month. A first (alpha) version of the web site will be released soon. The goal is to provide a user-friendly interface to build requests for accessing, extracting and displaying fishing data.

Due to the delay in the transmission of forcing data sets, the parameterization of SEAPODYM for Pacific tuna species was conducted with a reanalysis that was provided previously by ESSIC. Parameter optimization has been obtained for skipjack and bigeye. Size frequency data of yellowfin tuna for the eastern Pacific fisheries are still missing despite several requests by GW to IATTC. Given the importance of this region for the yellowfin tuna fisheries, we have delayed the optimization experiment for this species until we can obtain and use these data. We used a global forcing data set from a climate change scenario (IPCC A2) provided by L. Bopp (IPSL) to test at global scale the parameterization achieved in the Pacific. Results are plausible and encouraging, though a formal evaluation cannot be conducted as long as fishing data of Indian and Atlantic Oceans will be not available.

Concerning APECOSM, a 3D 1° global grid has been designed based on a modified LEVITUS grid and the model has been modified to run on this new toric grid. APECOSM has also been modified to be explicitly 3D to take into account variable vertical distributions and diel movements of the 3 layers of the model. This has been possible using mathematical/numerical techniques derived from the slow/fast systems theory. The model has been modified to consider explicitely variable bathymetry and it is now producing 3D outputs. The global configuration using the inter-annual forcing 1958-2001 (15 forcing steps per year) has been set up. A new management of inputs/outputs has been developped. To achieve reasonable computing times, APECOSM has been parallelized using the openMPI standards to run on the CRH cluster of PCs. Deep modifications of the code have been undertaken for that purpose. The 6D netcdf outputs of the model (x, y, z, t, size, community) being too voluminous on the global grid, a new set of routines has been implemented to output projections of the 6 dimensional outputs on reduced numbers of dimensions. The first global 3D results have been recently presented at the AMEMR Symposium (Advances in Marine Ecosystems Modelling Research 23-26/06/2008, Plymouth, UK) Extensive tests are being conducted and a paper is being written.

PIs and collaborators of the project attended the CLIOTOP symposium in la Paz, Mexico in Dec 2007. The project was presented in Hawaii PFRP-PI meeting by Dr. John Sibert. PL gave a presentation at the International Symposium on the Effects of Climate Change on the World's Oceans, Gijón, Spain (May 19 - 23, 2008). O.M gave a presentation at the Advances in Marine Ecosystem Modelling Research Symposium (AMEMR) in Plymouth (June 23-26 2008).

PLANS FOR THE NEXT FISCAL YEAR:

Due to the delay in the production of physical-biogeochemical runs, achievement of the project will likely occur in 2010 instead of mid-2009. For the financial year 2009 (Jul-2008-Jul 2009), planned activities are listed below.

1. Several physical-biogeochemical reanalyses still need to be delivered to CLS and IRD-Sète to produce the ensemble simulation with SEAPODYM and APECOSM. RM proposed to update the reanalysis using ESSIC model and to provide one more forcing data set by running offline the biogeochemical model PISCES with the physical reanalysis SODA025. For this latter task, a budget of USD 54,000 would be allocated to ESSIC (i.e., equivalent to the initial budget proposed for ESSIC, combining the six-month postdoc and 4 months of engineer).
2. The 1st version of the fishing database will be published and accessible on the web for project collaborators.
3. A computer engineer will be recruited in IRD to assist in the APECOSM model development.
4. The parameterization of SEAPODYM using optimization will be achieved for yellowfin tuna in the Pacific Ocean, and tested together with skipjack and bigeye tuna at global scale, using biogeophysical reanalyses provided.
5. The parameterization of APECOSM will be achieved using optimization for skipjack tuna in the Indian Ocean and tested at global scale.
6. PIs and collaborators will attend the PI meeting in Hawaii in November 2008 and / or the tuna conference in Lake Arrowhead in May 2009, the GLOBEC symposium in June 2009 (Victoria BC Canada), and will organize a project meeting in spring 2009 in Toulouse.

LIST OF PAPERS PUBLISHED IN REFERRED JOURNALS DURING FY 2008

Lehodey P., Senina I., Murtugudde R. (*in press*). A Spatial Ecosystem And Populations Dynamics Model (SEAPODYM) - modeling of tuna and tuna-like populations. *Progress in Oceanography*

Maury O., 2008. An overview of APECOSM, a Spatialized Mass Balanced "Apex Predators ECOSystem Model" to Study Physiologically Structured Tuna Population Dynamics in their Ecosystem. *In* Parameterisation of Trophic Interactions in Ecosystem Modelling, M. St John, P. Monfray (eds). *Prog. Oceanogr*. 2008. Accepted.

Senina I., Sibert J., Lehodey P. (*in press*). Parameter estimation for basin-scale ecosystem-linked population models of large pelagic predators: application to skipjack tuna. *Progress in Oceanography*

OTHER PAPERS, TECHNICAL REPORTS, ETC.:

Faure, V. (2008). Presentation of PISCES offline model and first analysis for the evaluation of biogeochemical simulations. PFRP project "Climate and Fishing Impacts on the Spatial Population Dynamics of Tunas", Technical Report #3: 27 pp.

Trolet, J. (2008). Global tuna fishing database. Activity report 2- Climate and Fishing Impacts on the Spatial Population Dynamics of Tunas. PFRP/CLIOTOP WG4.

GRADUATES (Names of students graduating with MS or PhD degrees during FY 2008; Titles of their Thesis or Dissertation):

AWARDS (List awards given to JIMAR employees or to the project itself during the period):

PUBLICATION COUNT (Total count of publications for the reporting period and categorized by NOAA lead author and Institute (or subgrantee) lead author and whether it was peer-reviewed or non peer-reviewed (not including presentations):

	JI Lead Author	NOAA Lead Author	Other Lead Author
Peer Reviewed			2
Non-Peer Reviewed			

PERSONNEL:
For projects that awarded subcontracts in the fiscal year, please provide the number of supported postdocs and students from each subgrantee.

One post-doc researcher is subgranted by CLS with 100% NOAA-PFRP funding. Dr Vincent Faure finished in end of April 2008 and Dr Julien Jouanno started on 1 May 2008, in CLS.

One database engineer is subgranted by IRD with 100% NOAA-PFRP funding. Julien Trolet started on 1st Nov 2007 in IRD-CRH. A postdoc for parameter optimization will be recruited in IRD-CRH in October 2008 for 18 months.

IMAGES AND CAPTIONS

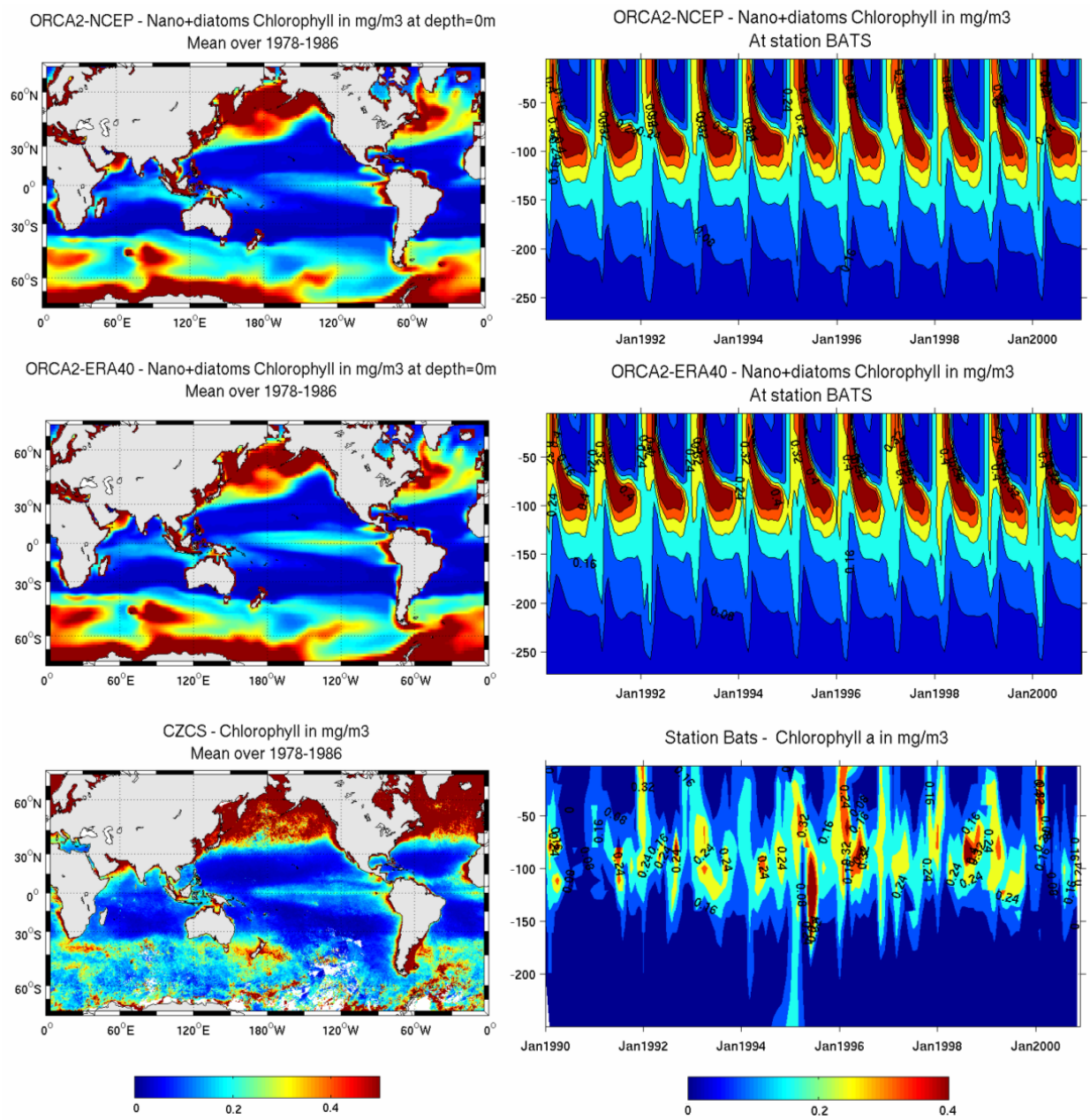
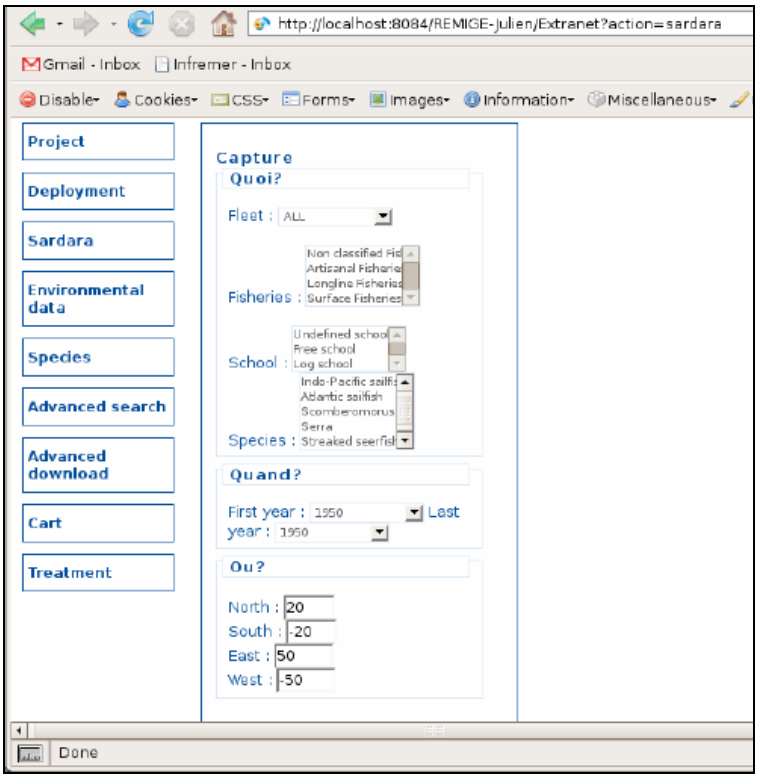


Figure 1. Comparison of predicted and observed chlorophyll a concentration.
Left: mean global average predicted from ORCA2-ERA40-PISCES, ORCA2-NCEP-PISCES and observed with CZCS satellite (Units: mg m-3. Computed over 1978-1986). Right: Time/depth chlorophyll a concentration predicted by simulations ORCA2-NCEP-PISCES and ORCA2-ERA40-PISCES, and observed at station BATS (32°N-64°W) between 1990-2000 (Units: mg m^{-3})



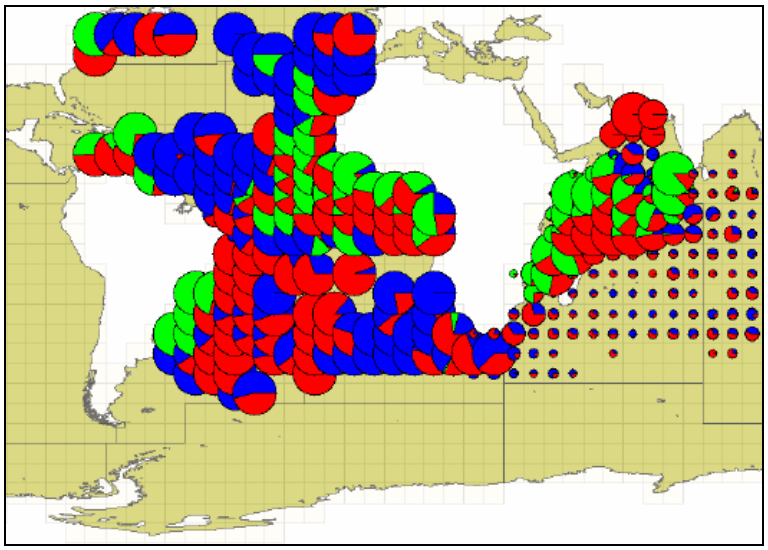


Figure 2 – Web page of the global tuna fishing database SARDARA and example of an output with the map tool.

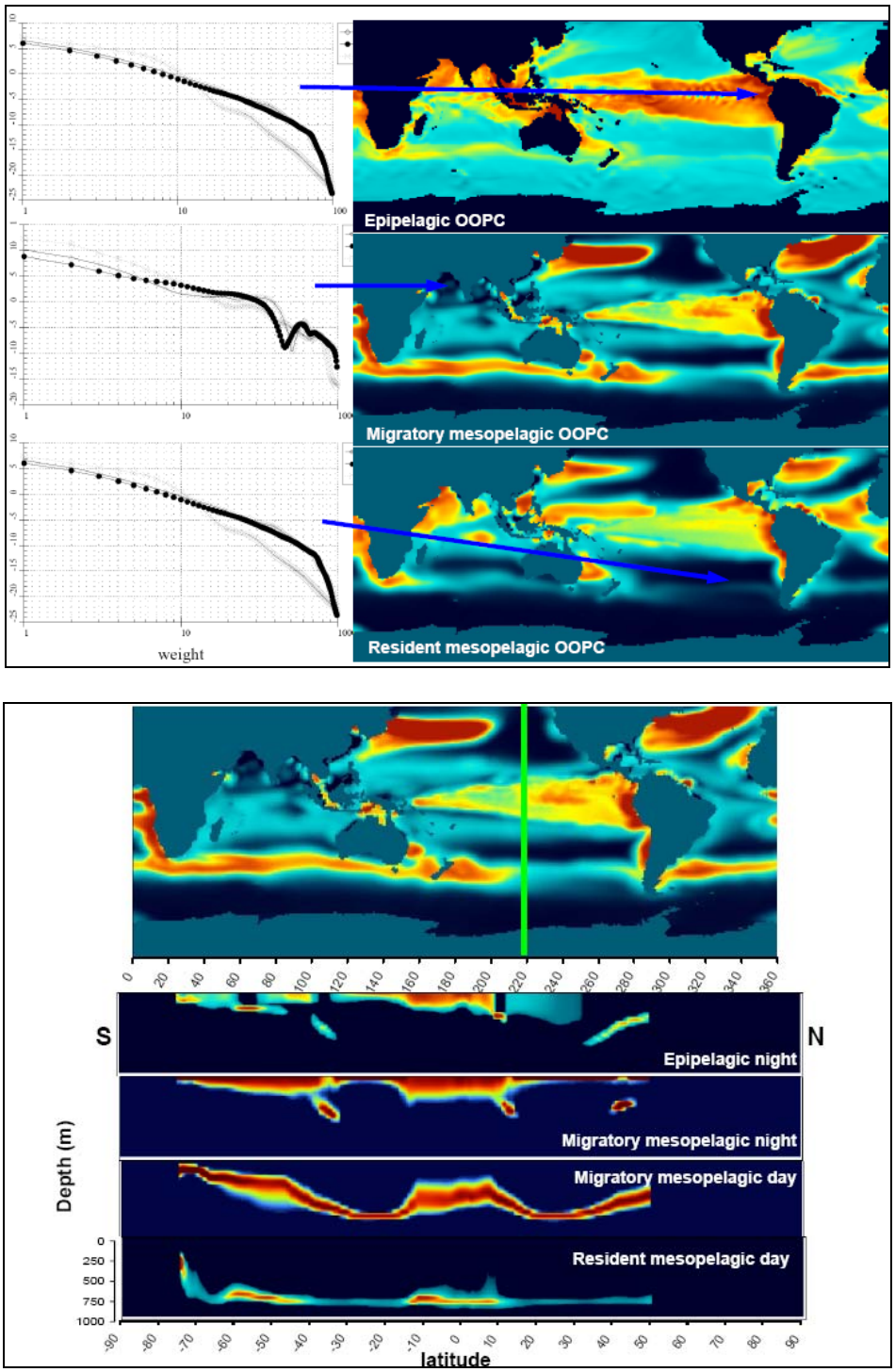


Figure 3. Preliminary outputs from APECOSM. Top panel: comparison of the modeled spatial distribution and size-spectra for the three modeled communities (epipelagic, migratory and mesopelagic) for a given size class, a given time and aggregated over the z dimension. Bottom panel: Preliminary outputs from APECOSM: comparison of the modeled vertical distribution of the three modeled communities (epipelagic, migratory and mesopelagic) along the green transect for a given size class at a given time.