JIMAR ANNUAL REPORT FOR FY 2010

P.I./SPONSOR NAME:

P.I./SPONSOR NAME: Kevin Weng, Réka Domokos and Patrick Lehodey

NOAA OFFICE (Of the primary technical contract): PIFSC

PROJECT PROPOSAL TITLE: Assimilating *in situ* bioacoustic data in a mid-trophic level model and its impact on predicted albacore feeding habitat in the American Samoa waters

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.
- ☐ Mission Support

PURPOSE OF THE PROJECT (One paragraph):

Pacific tuna stocks are facing increasing fishing pressure while they are also under the influence of natural variability and climate change. Nevertheless, the management of these species is still based on annual statistical stock assessment analyses ignoring environmental and climate variability. There is a need for new complementary approaches for management that relies on the development of ecosystem end-to-end models integrating both natural and anthropological effects. Such models, which describe the spatial population dynamics of tuna in relation to their bio-physical environment (e.g., SEAPODYM, a basin-scale ocean model), require key information and parameterization of the forage for tuna, the Mid-Trophic Level (MTL) micronekton, which is one of the less known components of the ocean ecosystem. To optimize the parameters of the basin-scale SEAPODYM MTL sub-model, *in situ* micronekton biomass should be incorporated at all representative regions within an ocean basin. Therefore, this project undertakes the task of incorporating *in situ* multi-frequency bioacoustic data from four different regions of the Pacific Ocean into SEAPODYM-MTL with a rigorous mathematical method of data assimilation. The incorporation of data from these first four regions is instrumental in the development of SEAPODYM and will lead to massive improvements of the model in the future. Further, the impact of this new parameterization will be tested on the prediction of the feeding habitat and population dynamics of south Pacific albacore tuna in the Samoa region by comparison of model results to *in situ* data.

PROGRESS DURING FY 2010 (One-two paragraphs, including a comparison of the actual accomplishments to the objectives established for the period, and the reasons for the slippage if established objectives were not met):

The planned activities for the first year of the project were:
1. Conduct shipboard surveys (cruise 1) in the western north Pacific.
2. Process acoustic, ADCP and CTD data from the two surveys conducted in the past and from the survey during Year I, along with satellite altimetry and sea surface chlorophyll from the same time periods.
3. Check the definition of vertical layers
4. Develop the approach and code needed for acoustic data assimilation in the model.
5. Run the first simulations with existing data and use both model outputs and cruise data for analysis.

1 – Shipboard surveys were conducted around the Commonwealth of the Northern Mariana Islands (CNMI) and Guam. The surveys were conducted along 3 meridional and two zonal transects between March 20 and April 12, 2010. Bioacoustic and current data (from an acoustic Doppler current profiler --- ADCP) were collected continuously down to 1200 and 800 m, respectively, along with data from Conductivity-Temperature-Depth (CTD) casts down to 1000 m depth, spaced at every 0.25˚.

2 - Processing of acoustic, ADCP, and CTD data, collected during FY09 in the north central Pacific and during FY10 at CNMI and Guam, have been completed along with satellite altimetry and sea surface chlorophyll from the corresponding time periods. Results indicate a uncoupling of the physical and biological fronts between the Transition Zone (TZ), the boundary between the subtropical and subarctic gyres, and the Chlorophyll Front (CF), the front between oligotrophic and mesotrophic regions associated with waters south and north of the TZ, respectively. During the north central Pacific survey (22˚30'-36˚00'N, 158˚00'W), the TZ was observed at ~31˚N, while the CF further north, at ~ 35˚N (Figure 1). Changes in the bioacoustic scattering layers, composed of micronekton (forage for higher trophic level organisms), were associated with the TZ as opposed to the CF (Figure 1). At CNMI and Guam, prominent meridional differences were observed in both physical and biological variables, including acoustic backscatter, presumably due to characteristics of the North Equatorial Current (south) and waters within the subtropical gyre. Zonal differences were observed only in the bioacoustics data, most likely due to island effects. Micronekton biomass from the acoustics data at the central and western north Pacific is being currently calculated for data assimilation into the model.

3 - The definition of vertical layers is a critical step for the MTL modeling in SEAPODYM since all the dynamics is then based on the average fields of temperature and currents within these layers. In the current version the epipelagic layer is defined by the euphotic depth (Z_{eu}), the mesopelagic is between one and

$3xZ_{eu}$ and the bathypelagic layer is between $3xZ_{eu}$ and 1000 m. We use satellite derived primary production computed according to the VGPM model (Behrenfeld and Falkowski (1997), in which the euphotic depth follows the definition of Morel and Berthon (1989) based on surface chlorophyll-a concentration. The Ocean Productivity Team undertook recently a major reprocessing of all sea color satellite data (http://oceancolor.gsfc.nasa.gov/REPROCESSING/R2009/) and we had to restart also our modeling work from this new updated dataset. The new profile carried out along the longitude 158°W between 23 and 36°N allowed to collect in situ data, especially chloropigments that are a useful indicator of the euphotic depth. Based on these data the predicted euphotic depth would be underestimated by ~50% and thus we would need to account for a corrective factor (Figure 2). However a new parameterization proposed by Morel (2001, 2006) may reduce this error. We are going to test this updated parameterization and then check the result with several other acoustic profiles.

4- The approach for **acoustic data assimilation** is currently being developed. The adjoint code for the transport model has been already developed for the tuna model (Senina et al. 2008). The optimization of the relative energy transfer coefficients (E'_n) will be achieved using a cost function that is based on the comparison of relative ratio in the 3 vertical layers during day or night of observed acoustic signal and predicted MTL biomass. Optimization experiments will start soon after the vertical layers will be definitively selected and acoustic data processed in the appropriate format (Figure 3).

5- **Run first assimilation experiments**: To have the most realistic predicted environment, we use a model configuration that allows for mesoscale activity (resolution 1/4 deg x 6 day), and based on satellite-derived primary production (e.g., Behrenfeld & Falkowski, 1997) and physical variables (temperature and currents) from a physical ocean reanalysis with data assimilation (GLORYS provided by MERCATOR-OCEAN). We reprocessed the whole dataset after the revision of primary production data set and run an initial reference simulation from which we will compare the predicted biomass in each layer to relative strength of acoustic signal.

PLANS FOR THE NEXT FISCAL YEAR (One paragraph):

1- Conduct shipboard surveys (cruise 2) in the central north Pacific.
2- Process acoustic, ADCP and CTD along with satellite altimetry and sea surface chlorophyll from the same time periods.
3- Run optimization experiments using acoustic data
4- Test the impact of new MTL parameterization on albacore assessment.
5- Write manuscripts on results.

LIST OF PAPERS PUBLISHED IN REFERRED JOURNALS DURING FY 2010, in the following format: (Author or authors with last name and initials, publication year: Article title. *Journal name*, volume, page range.) For example: Charney, J.G., and A. Eliassen, 1964: On the growth of the hurricane depression. *J. Atmos. Sci.*, 21, 68-75.

none

OTHER PAPERS, TECHNICAL REPORTS, ETC.:

Domokos, R., 2010. Oceanographic investigation of waters around the Commonwealth of the Northern Mariana Islands (CNMI) and Guam. Report to the Western Pacific Regional Fishery Management Council, April.

GRADUATES (Names of students graduating with MS or PhD degrees during FY 2010; Titles of their Thesis or Dissertation): none

AWARDS (List awards given to JIMAR employees or to the project itself during the period): none

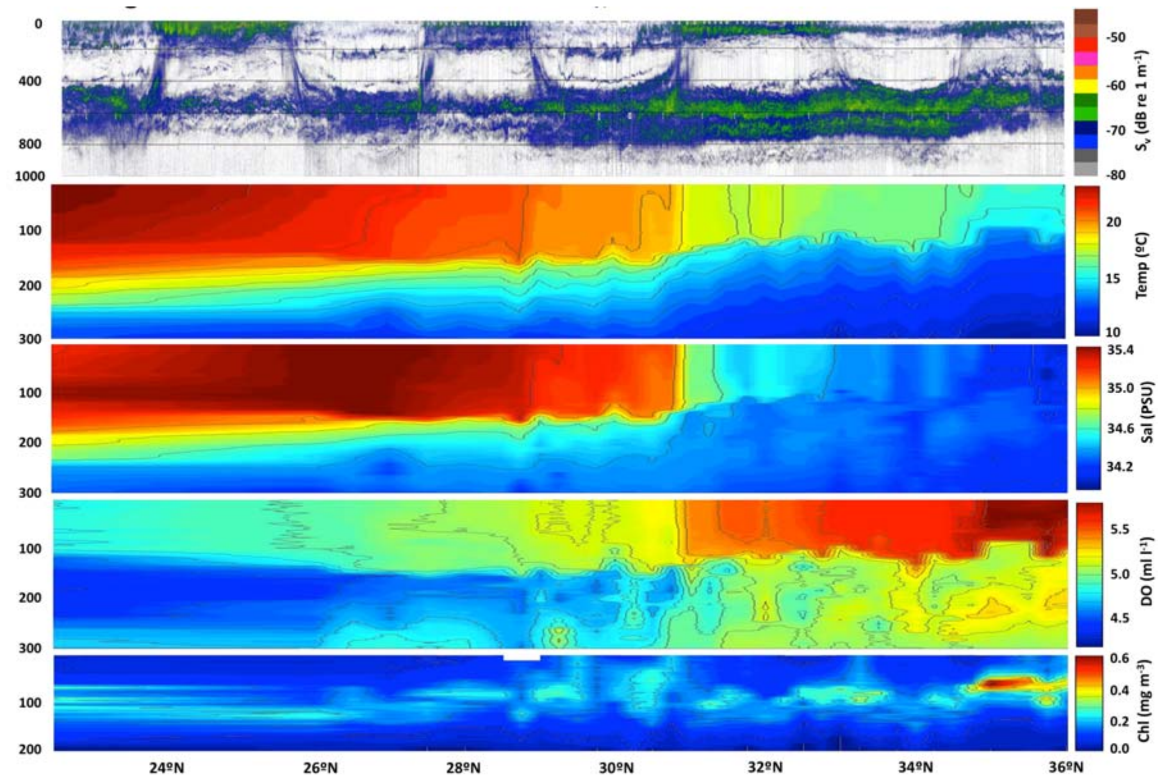
PUBLICATION COUNT (Total count of publications for the reporting period and categorized by NOAA lead author and Institute (or subgrantee) lead author and whether it was peer-reviewed or non peer-reviewed (not including presentations):

	JI Lead Author	NOAA Lead Author	Other Lead Author
Peer Reviewed			
Non-Peer Reviewed		1	

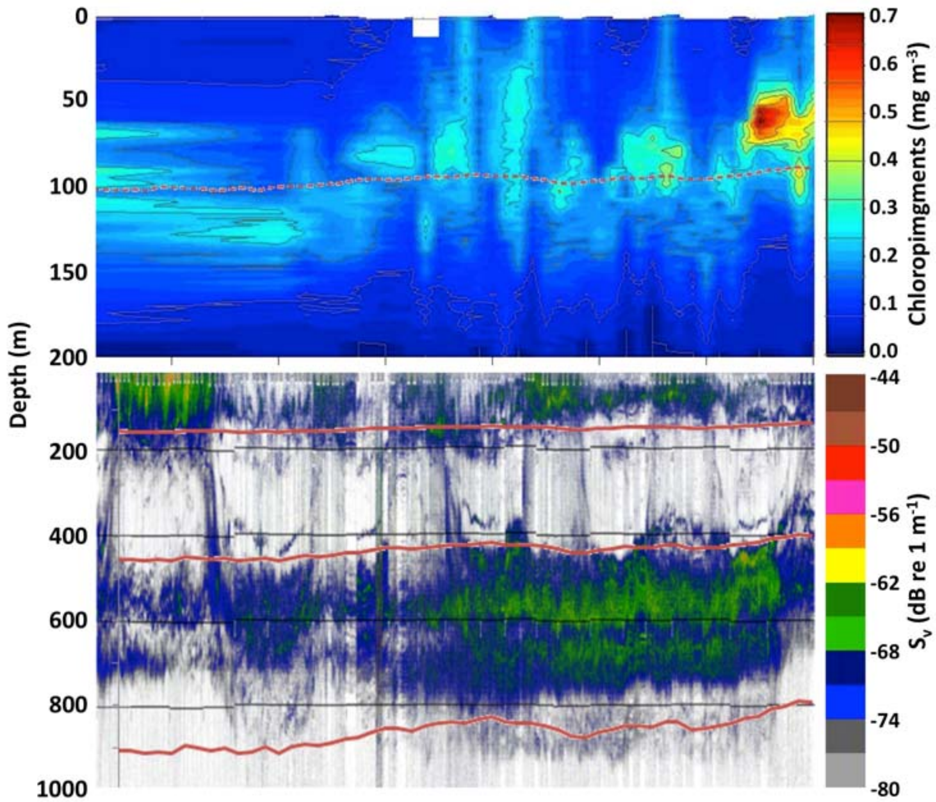
PERSONNEL (on Subcontracts): For projects that awarded subcontracts in the fiscal year, please provide the number of supported postdocs and students from each subgrantee.

none

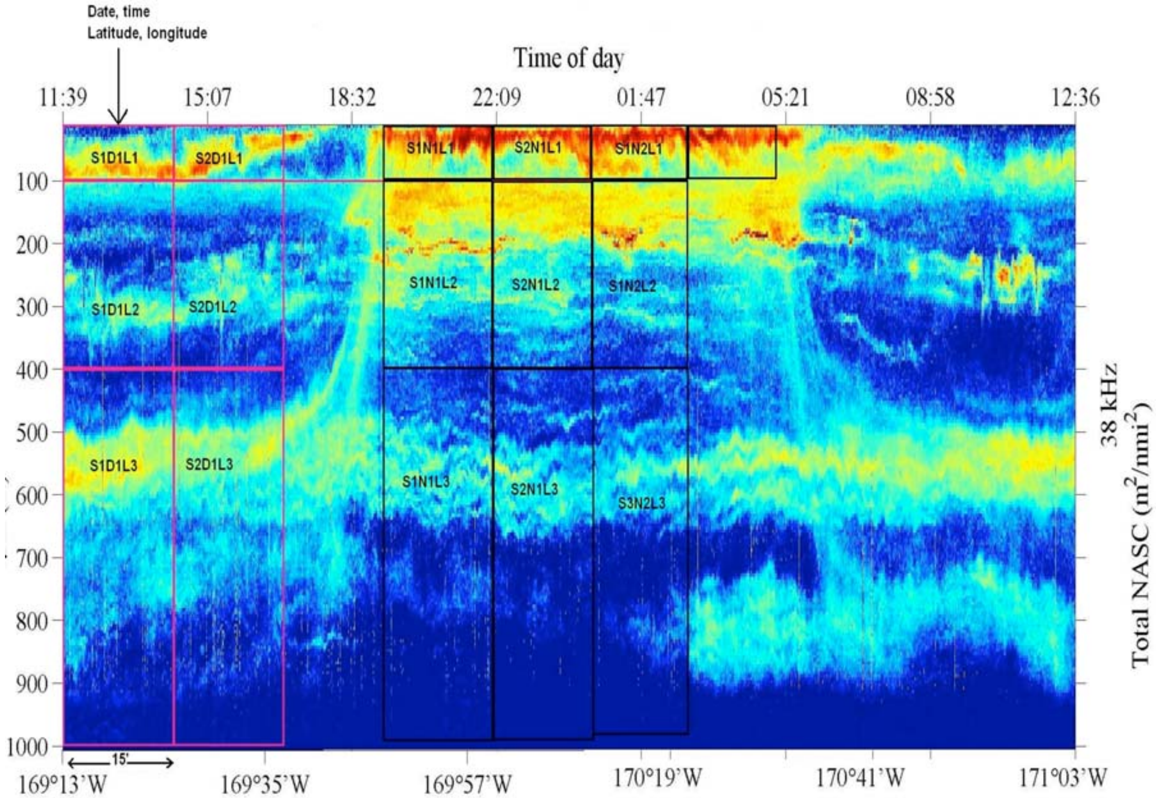
IMAGES AND CAPTIONS (We will also be including images for the annual report. Please send two of your best high-resolution, color images (photo, graphic, schematic) as a **JPEG or TIFF (300 dpi)** with a caption for each image. If you do not have an electronic version of the image, a hardcopy version may be dropped off at the JIMAR office located in the Marine Sciences Building, Room 312):



- Caption 1: From top to bottom: Upper 1000 m bioacoustic backscatter, and upper 300 m temperature, salinity, dissolved oxygen, and chloropigments along 158˚W. Data was collected in March 2009.



- Caption 2: Vertical layer boundaries. Top: Euphotic depth (Z_{eu}) predicted with Morel's definition (1989) superimposed on the chloropigment profiles of the transect sampled during FY09 (central north Pacific). The predicted depth is underestimated by 40-50%. Bottom: predicted layer boundaries after correction by a factor 1.5: 1x Z_{eu}; 3x Z_{eu} (mesopelagic) and 6x Z_{eu} (bathypelagic), superimposed on the 38 kHz backscatter along the same transect.



- Caption 3: Integration of the acoustic signal to be used for assimilation. After the vertical layers have been defined and crepuscular periods excluded, the signal strength is integrated at the spatial resolution of the model (1/4 deg). Acoustic data shown are collected in the American Samoa region during 2006.

ACRONYMS: Please provide the complete descriptions for any acronyms used in any areas of the report. For example: UH (University of Hawaii)