JIMAR ANNUAL REPORT FOR FY 2011

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NOAA OFFICE *(Of the primary technical contact)*: PIFSC

NOAA SPONSOR NAME: Sam Pooley

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 2011 *(One-two paragraphs)*:
Include a comparison of the actual accomplishments to the objectives established for the period, along with reasons for the slippage if established objectives were not met

Shipboard surveys were conducted in March 2011 along the 158°W meridional from 22°45′N to 36°N and along the 161°W meridional from 31°30′N to 35°N to study the oceanography of the Transition Zone between the subarctic and the subtropical gyres (TZ) and the associated Chlorophyll Front (CF). Bioacoustics 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 every at every 0.25˚. Bioacoustics and CTD data have been processed and some preliminary analyses conducted. Results indicate that the TZ and the CF were very closely positioned along 161°W at approximately 32°N. However, further to the east (along 158°W) the TZ and CF split with the TZ moving to 31°N and the CF to 33°45′N. Interestingly, changes in micronekton characteristics along 158°W seemed to correspond to the CF, which is opposite from observations conducted in March 2009. Along 161°W, changes in micronekton characteristics, obtained from the acoustic backscatter, occurred at around 33°N, north of the TZCF. Along both meridional, micronekton backscatter decreased in intensity from south to north, while Chl-a, both from *in situ* and satellite measurements, increased. The depth of both the shallow and deep scattering layers decreased from 0-200 to 0 to 150 m and from 450-800 to 350-600 m from south to north.

Bioacoustics data from the 2009 March cruise to the TZCF have been provided for model assimilation. Additional data have been provided from colleagues of the CSIRO (Australia) for the Tasman Sea region. 38 kHz full resolution acoustic data were converted for assimilation into NASC values proportional to fish biomass (Mac Lennan et al., 2002). Since the 38 kHz frequency signal is dominated by \micronektonic organisms, the integration of NASC is believed to be representative of the total biomass of the 6 functional groups of the model. The energy transfer coefficients are optimized to fit the relative ratios of micronekton biomass (or NASC) between layers changing during day and night periods. These ratios are computed by integrating the NASC in space (in each cell grids of the model and in each layer) and time (during night-time and day-time, and excluding transition periods). Then the values are scaled by the integrated value from the surface to the bottom boundary of the deepest layer of the model. We use the adjoint technique to optimize the model as described in Senina et al. (2008). Further modifications included a restart option in the optimization to avoid the spin-up at each evaluation of the cost function, and the options to compute sensibility analysis (using model predictions or likelihood), profiling (projection of the cost function in 2D) or the Hessian matrix. The code was validated by a derivative check (approximation between analytical gradient and finite difference stay very low for at least two consecutive step sizes for all parameter), and twin experiments.

In a twin experiment, the initial parameterization of the model is considered as the truth. A set of pseudo-observations is extracted from these simulation outputs (Fig. 2). Then values of parameters are changed and optimization experiments run to check that the model converges towards the 'true' (i.e., initial) parameter values (Fig. 2).

PLANS FOR THE NEXT FISCAL YEAR *(One paragraph)*:

We are in the final phase of the project that should include:

- Processing of the last acoustic data
- Providing two sets of acoustic data for model: from the region of the Northern Mariana Islands (2010) and the region of TZCF (2011)
- Optimization experiments with actual acoustic data
- Writing scientific articles on (1) Vertically migrating micronekton and macrozooplancton communities around Guam and the Northern Mariana Islands, and (2) the optimization approach of the MTL model.
- Present the impact of updated MTL parameterization on tuna (albacore) stock assessment with SEAPODYM at the scientific committee meeting of the Western Central Pacific Fisheries Commission.

LIST OF PAPERS PUBLISHED IN REFERRED JOURNALS DURING FY 2011
OTHER PAPERS, TECHNICAL REPORTS, ETC.
PUBLICATION COUNT
*complete excel attachment (*JIMAR publications request*)

GRADUATES:
Names of students graduating with MS or PhD degrees during FY 2011; Titles of their Thesis or Dissertation
none

AWARDS:
Name of JIMAR employees or project receiving award during the period, and Name of award

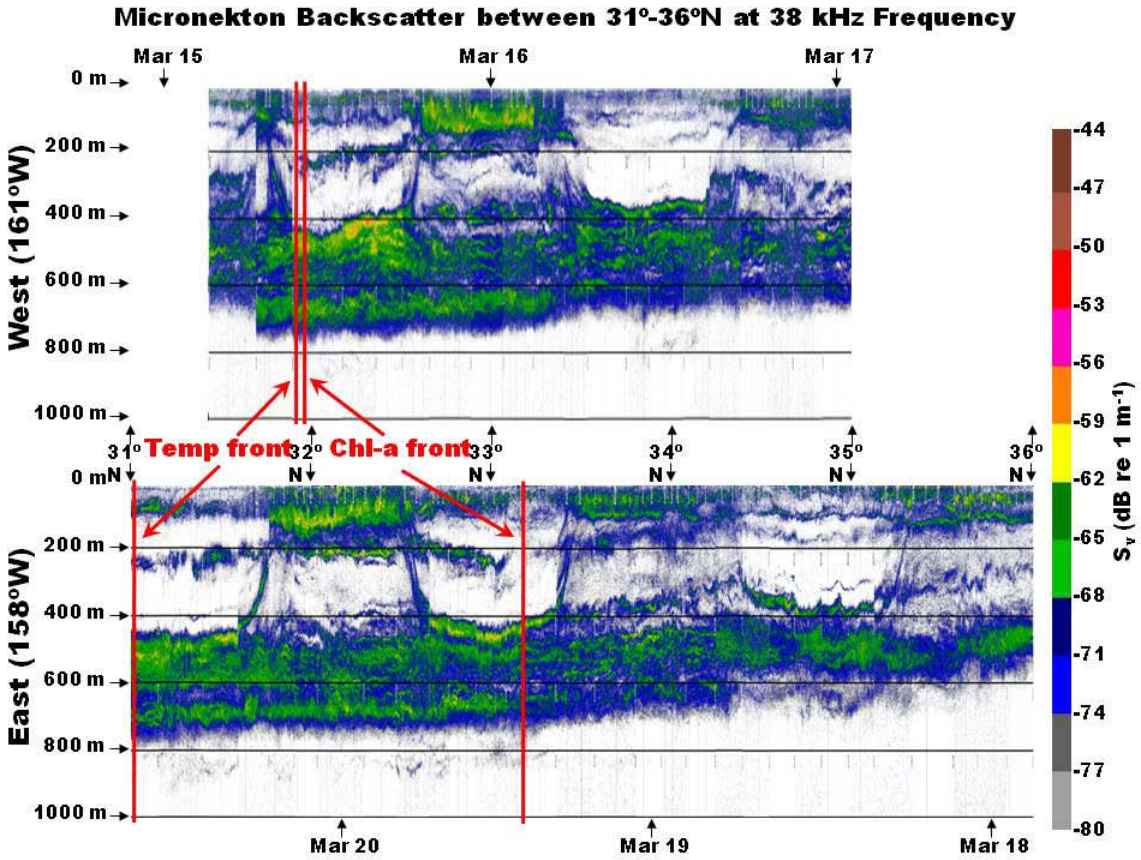
Best Conference Scientific Paper award

Lehodey, P., Senina, I., Calmettes, B., Royer, F., Gaspar, P., Abécassis, M., Jeffrey Polovina, J., Parker, D., **Domokos, R**., Hernandez, O., Dessert, M., Kloser, R., Young, J., Lutcavage, M., Handegard, N.O., John Hampton, J. (2010) Towards operational management of pelagic ecosystems. ICES (International Council for the Exploration of the Sea) CM Documents, 2010, 20-24 September, Nantes, France, 13 pp. ISBN 978-87-7482-085-7.

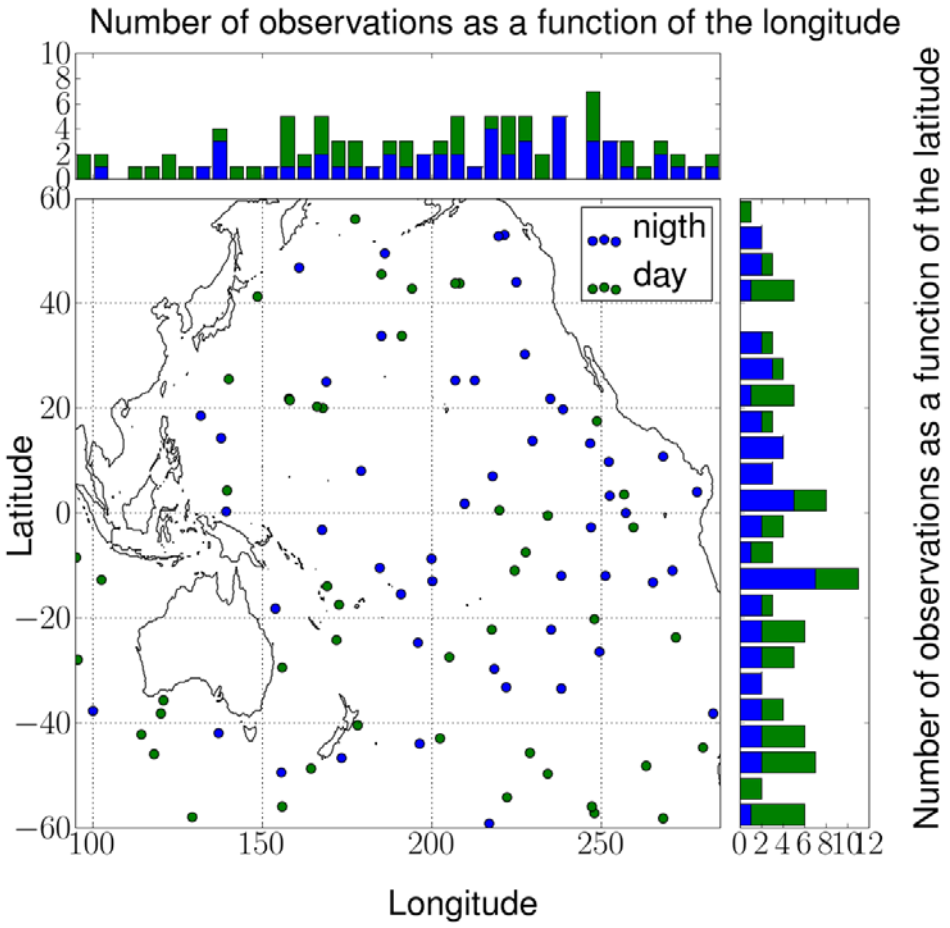
PERSONNEL *(on Subcontracts)*:
For projects that awarded subcontracts in the fiscal year, please provide the number of supported postdocs and students from each subgrantee.
none

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: Micronekton backscatter between 31°N and 36°N at 36 kHz frequency.



- Caption 2: Twin experiments to check the MTL parameters optimization approach using acoustic data assimilation. The map shows the random selection of pseudo-observations and the table gives the results after convergence of parameter values.



	"True" value	Twin experiment 1		Twin experiment 2	
		start	convergence	start	convergence
Epi	0.17	0.16	**0.17**	0.418	**0.17**
Meso	0.10	0.16	**0.0999998**	0.178	**0.10**
Mmeso	0.22	0.17	**0.22**	0.048	**0.22**
Bathy	0.18	0.17	**0.18**	0.116	**0.18**
Mbathy	0.13	0.17	**0.13**	0.076	**0.13**
Hmbathy	0.20	0.17	**0.20**	0.164	**0.20**
Calculation time (hour)			20.1		31.4
Maximal relative error			$2.0\ 10^{-6}$		0

ACRONYMS:

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

SEAPODYM: Spatial Ecosystem And Populations Dynamics Model
MTL: Mid-Trophic Level
NASC: Nautical Area Scattering Coefficient