Expansion of metadata management, visualization and data processing functionality of OBIS-SEAMAP for passive acoustic monitoring data

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LONG-TERM GOALS

In the light of increasing usage of passive acoustic monitoring (PAM) data, expanding research on PAM data collection and mounting demands to incorporating PAM data into habitat modeling and marine spatial planning, this project aims to enhance the standards and accessibility of PAM data to develop novel tools for advanced spatio-temporal analyses and visualization and to improve interoperability of PAM data among institutions hosting PAM data.

OBJECTIVES

Through the close collaboration with a sister NOPP project "Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets," this project incorporates the extended metadata standards for passive acoustic monitoring data into the OBIS-SEAMAP metadata management, allowing for more diverse, flexible data search capabilities. Along with the enhanced search capabilities, the project develops a framework for mutual linkages between PAM data centers to achieve seamless, more interoperable data access through the data centers. The project also expands the OBIS-SEAMAP mapping and visualization tools to make them more directly suitable for research using PAM data. Through these improvements we have significantly increased the volume of PAM data registered in the OBIS-SEAMAP database and are making this data available to a broader range of marine science communities.

APPROACH AND WORK PLAN

We see three aspects/components of this project: 1) extended metadata standards for passive acoustic monitoring data; 2) enhanced mapping and visualization tools for PAM data; and 3) seamless, interoperable data transfer and linkage mechanisms among PAM data holders. In the upcoming year, we will mainly focus on the first two aspects.

We will be working with a sister NOPP project "Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets" led by Marie Roch, San Diego State University, to establish the extended metadata standards for PAM data. This work will be also supported by metadata experts from the National Geophysical Data Center (NGDC). On our end, Research Analyst E. Fujioka will extend the existing OBIS-SEAMAP metadata management protocols to incorporate the extended metadata standards and develop the search functionality for the metadata. This development requires

an upgrade of the existing OBIS-SEAMAP database that will be implemented by Research Analysts J. Cleary and B. Donnelly.

Research Analysts Fujioka is also leading the development of enhanced mapping and visualization tools for PAM data. Through this development, scientific advice will be provided by M. Soldevilla, a former Duke researcher, now a NOAA Southeast Fisheries Science Center staff member, and additional technical inputs will be given by Marie Roch from UC-San Diego.

To evaluate the quality and functionality of newly developed products, we will take PAM datasets provided by BOEM as test cases and consult with B. Hooker and/or J. Price, BOEM for future improvements.

PI P. Halpin oversees the entire activities and communicates with the current partners as well as future potential collaborators.

WORK COMPLETED

As the project just began in July 2011, most of the tasks are under way and at their early stages of development. However, there are significant accomplishments to report in this short period of time.

Building on efforts from our previous NOPP/NSF OBIS-SEAMAP project (Award Number: OCE-07-39199 completed June 2011) we have successfully integrated passive acoustic monitoring data into the OBIS-SEAMAP system. A series of PAM datasets from the *Density Estimation of Cetaceans from Passive Acoustic Fixed Sensors* (DECAF) project were published on the OBIS-SEAMAP web site in November 2011. These include (primary contributor in the parentheses):

- PMFR Minke Whales - Multiple Sensor - Boing Associations (Steve Martin, Space and Naval Warfare Systems Center)
- PMFR Minke Whales - Multiple Sensor - Manual Boing Detections (Steve Martin, Space and Naval Warfare Systems Center)
- PMFR Minke Whales - Multiple Sensor - Automated Boing Detections (Steve Martin, Space and Naval Warfare Systems Center)
- PMFR Minke Whales - Multiple Sensor - Boing Localizations (Steve Martin, Space and Naval Warfare Systems Center)
- AUTEC Beaked whales - Multiple Sensors - Click counts (Jessica Ward, Naval Undersea Warfare Center)
- AUTEC Sperm Whales - Multiple Sensors – Samples (Jessica Ward, Naval Undersea Warfare Center)
- AUTEC Sperm Whales - Multiple Sensors - Complete Dataset Samples (Jessica Ward, Naval Undersea Warfare Center)
- AUTEC Beaked Whales - Multiple Sensors - DTag Samples (Jessica Ward, Naval Undersea Warfare Center)
- AUTEC Beaked Whales - Single Sensor case study (Elizabeth Kusel, Oregon State University)
- AUTEC Beaked Whales - Multiple Sensors - DTag Seafloor array presence Samples (Jessica Ward, Naval Undersea Warfare Center)

In total, these 10 datasets contribute 178,000 records to the OBIS-SEAMAP database.

In order to provide detailed visualization of the DECAF datasets, the mapping and visualization functionality of the OBIS-SEAMAP web site required significant improvements. The highlights of the improvements include:

- Fixed sensor locations are now mapped with indication of effort presence circling around the location (Figure 1);
- Individual sensors are now selectable for further investigation online;
- Interactive time-series graphs visualizing click counts and detections per species with effort hours are now available;
- In addition to the time-series graphs, diel plots are available to depict the tendency of animal's daily behavior (Figure 2);
- To effectively visualize the dive profile of animals tagged with DTags, 3D mapping capability using Google Earth (and the Google Earth plugin for the browser) is now introduced (Figure 3).

Other tasks to report in this reporting period are:

- We received approximately 1 terabyte of passive acoustic monitoring data of sperm whales in the Gulf of Mexico from J. Price, U. S. Bureau of Ocean Energy Management (BOEM), and have begun exploring it in detail to incorporate it into the OBIS-SEAMAP database. We also have started discussion with Brian Hooker, Bureau of Ocean Energy Management (BOEM) to establish the data transfer mechanism between BOEM and OBIS-SEAMAP;
- We held a preliminary meeting in August 2011 with the collaborators from the sister project joined by metadata standards experts from the National Geophysical Data Center (NGDC) to discuss the approach and work plan for the extended metadata for PAM data. We will continue investigating the Sensor Model Language (SensorML) and ISO Metadata Standards as the base of the extended metadata for PAM.
- We have built and evaluated a prototype of the proposed upgraded OBIS-SEAMAP database. The data migration from the existing database to an upgraded database was successful and most of the OBIS-SEAMAP functionality was proven to work fine with the upgraded database. We have, however, found that the prototype, built on a shared server, did not provide sufficient performance. In response we will now prepare a dedicated server for the PAM database and rebuild the prototype for better performance. Upgrading the existing database to the newest version is necessary to develop advanced visualization tools for PAM data and improved metadata search functionality.

RESULTS

In this short reporting period from July to December 2011, we have received growing interests from researchers engaged in passive acoustic monitoring, including those from BOEM, in collaborative work with OBIS-SEAMAP. This is a clear evidence that what we have achieved in this reporting period demonstrate very well that OBIS-SEAMAP is a suitable data center for PAM data. OBIS-SEAMAP's strong reputation as a significant data center and as an important source of expertise in mapping and visualization led to a collaborative project with a NOAA Cetacean Mapping working group that aims at developing density models and a data gap analysis which is indented to support Marine Spatial Planning in the US.

IMPACT AND APPLICATIONS

Science Education and Communication

Successful development of a sophisticated data center for passive acoustic monitoring data will encourage PAM researchers to submit their data to OBIS-SEAMAP, which in turn facilitates broader, more integrated analyses of habitat modeling, species density estimates, human impacts on marine species and conservation issues in general. This will broaden the potential and opportunity and increase the importance of PAM researches and data. For example, in 2011, the U.S. National Oceanic and Atmospheric Administration (NOAA) initiated several efforts to improve methods to manage cumulative impacts of human activities on marine mammals. One of such efforts is the Cetacean Density and Distribution Mapping Group (CetMap) in which PAM data are being used to improve marine mammal presence maps.

TRANSITIONS

Science Education and Communication

While the project focuses on passive acoustic monitoring data, the enhanced mapping and visualization tools on the OBIS-SEAMAP web site are applicable to other data types such as observations obtained in traditional ship or aerial surveys or satellite telemetry data. For example, 3D visualization developed for the DECAF DTag dataset will be directly used for other DTag datasets. More importantly, the overall quality of OBIS-SEAMAP (e.g. metadata accuracy, data consistency) has been greatly improved through this project.

Our skills and knowledge acquired during this reporting period as well as the previous OBIS-SEAMAP project have resulted in significant contribution to the renovated iOBIS Portal. E. Fujioka, J. Cleary and B. Donnelly in this project led the development of the iOBIS Portal and will continue to play essential roles in the iOBIS Portal development.

Similarly, we will collaborate with OBIS-USA to extend and enhance the OBIS-USA database and its online portal. Our first task will be the development of data transfer mechanism from OBIS-SEAMAP to OBIS-USA with richer attributes than those OBIS-USA currently uses.

A growing number of government agencies have expressed their interests to collaborate with the OBIS-SEAMAP team, especially, to feed the OBIS-SEAMAP data into their own applications. NOAA Multipurpose Marine Cadastre (MMC; http://www.marinecadastre.gov/), for example, already incorporated predictive habitat modeling data produced for the Strategic Environmental Research and Development Program and hosted on the OBIS-SEAMAP web site. We will continue expanding this relationship with MMC to exchange a wide variety of data. We have also discussed the data transfer mechanism with the Navy who is planning to consume the OBIS-SEAMAP data into their internal system, Environmental Information Management System (EIMS).

RELATED PROJECTS

The NOPP project “Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets” led by Marie Roch, San Diego State University is a sister to this project and develop metadata standards for passive acoustic monitoring data. The resulting metadata standards will be incorporated into the OBIS-SEAMAP metadata management. The researchers of the sister project

will also be PAM data contributors to OBIS-SEAMAP as well as organizers of their own data centers to which this project will establish the linkages.

The Cetacean Density and Distribution Mapping Group (CetMap; http://www.st.nmfs.noaa.gov/cetsound/) launched by NOAA are using OBIS-SEAMAP data to produce cetacean density and distribution maps. PI Halpin and J. Cleary, OBIS-SEAMAP team members, are actively developing a gap analysis for the CetMap project.

REFERENCES

- Harrison, Jolie; Van Parijs, Sofie; Moore, Sue; Alter, Liz; Barlow, Jay; Best, Ben; Baumgartner, Mark; Cholewiak, Danielle; Cleary, Jesse; Ferguson, Megan; Forney, Karin; Garrison, Lance; Halpin, Pat; Haverland, Tim; Kumar, Anu; Palacios, Daniel, and Redfern, Jessica. 2011. The NOAA Cetacean Density and Distribution Mapping Working Group: Developing Comprehensive Geospatial Tools to Assist Management in Impact Analyses of Cetaceans in US EEZ Waters. Poster presentation, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida, USA. November 27 – December 2, 2011.

PUBLICATIONS

- Fujioka, E, P. N. Halpin, A. J. Read, M. Soldevilla, K. Urian, C. Y. Kot, A. DiMatteo, B. D. Best, J. A. Cleary and B. Donnelly. 2011. Archiving and disseminating non-traditional marine mammal data for growing data needs in marine mammal conservation. Poster presentation, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida, USA. November 27 – December 2, 2011.

OUTREACH MATERIALS

Figures follow.

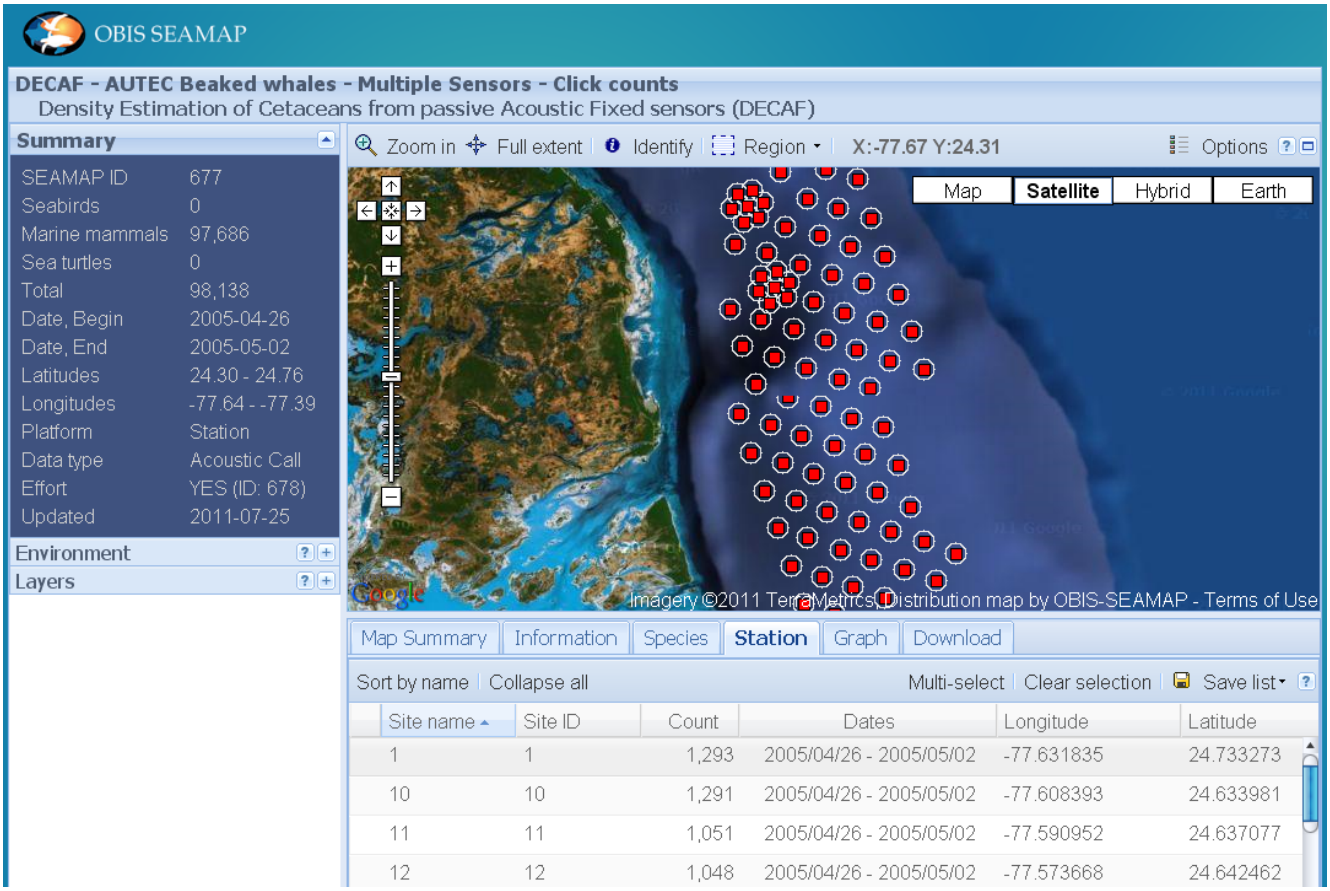

Figure 1 Improved mapping and visualization on the OBIS-SEAMAP web site for PAM data is able to map fixed sensor locations (red rectangles) with presence of effort (white circles). Individual sensor locations are selectable for more detailed investigation.

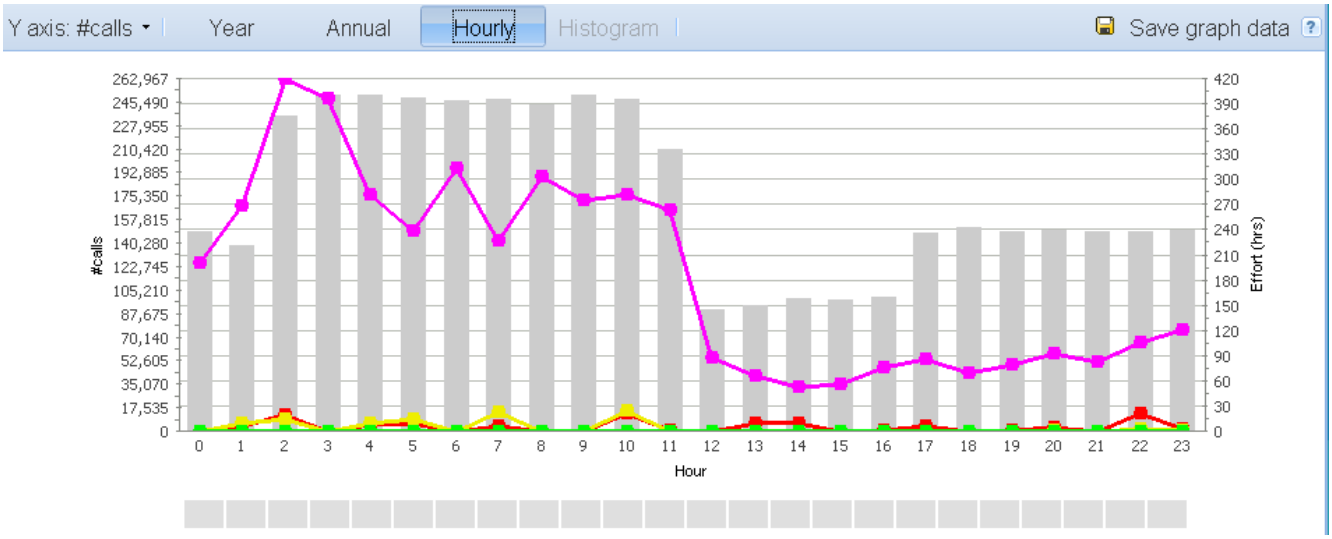

Figure 2 Newly developed diel plots for PAM data are useful to investigate tendency of animal's daily behavior. Multiple species are color-coded.

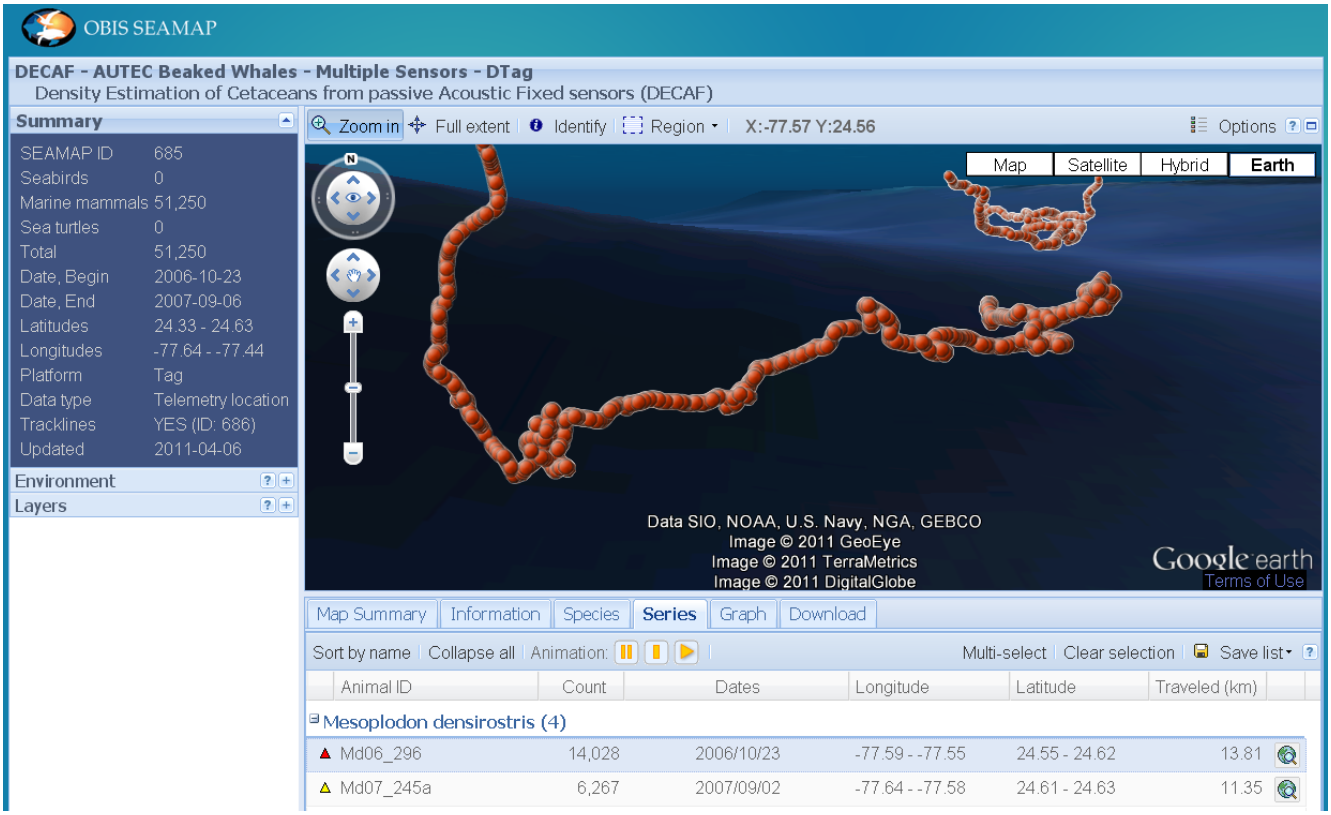

Figure 3 Dive profile of an animal tagged with a DTag instrument is visualized in 3D space using the Google Earth plugin.