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 activities around passive acoustic monitoring (PAM), growing interest in PAM research 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 / data centers 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 capability. Along with the enhanced search capability, 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 elevates the already cutting-edge OBIS-SEAMAP mapping and visualization tools toward those suitable for researches using PAM data. Through these improvements, it is aimed at more PAM data registered in the OBIS-SEAMAP database and made available to broader marine science communities.

APPROACH AND WORK PLAN

There are three primary component we are developing for 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.

We are working with a sister NOPP project "Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets" led by Marie Roche, San Diego State University to establish the extended metadata standards for PAM data. This work is also supported by metadata experts from the National Geophysical Data Center (NGDC). On our end, Ei Fujioka is extending the existing OBIS-SEAMAP metadata management 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 is being conducted by Jesse Cleary and Ben Donnelly.

Ei Fujioka also leads the development of enhanced mapping and visualization tools for PAM data. Scientific advice is also being provided by Melissa Soldevilla, a former Duke researcher, now a NOAA Southeast Fisheries Science Center staff member; and technical support is being given by Marie Roche.

To evaluate the quality and functionality of newly developed products, we are taking PAM datasets provided by BOEM or other agencies as test cases and consult with relevant researchers for future improvements.

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

In the coming year (2013), through the close collaboration with our partners, we will finish our effort in integrating the PAM metadata standards into OBIS-SEAMAP and establishing data transfer mechanism with the partners' systems. We will also make published the mapping and visualization tools we are developing in this project through the OBIS-SEAMAP web site.

WORK COMPLETED

Continuing from the previous reporting period, we have been making significant improvements to the integration of passive acoustic monitoring data and metadata into the OBIS-SEAMAP infrastructure. To achieve more integrated mapping and visualization of PAM data along with other data types such as traditional aerial/shipboard surveys, animal tracking data and photo-identification, we are developing a new version of the OBIS-SEAMAP online interface. We have implemented advanced functionality designed specifically for PAM data in the existing OBIS-SEAMAP interface (e.g. diel plots of clicks detected, mapping of hydrophones with effort etc.) This development has resulted in different operations for different data types and is requiring further effort to simplify the interface across different data types. This has also produced an extra burden on developing PAM data features while maintaining and improving more generic features of the OBIS-SEAMAP web site. In the new version of OBIS-SEAMAP, we are reforming the database structure, renovating the methods and scripts to search and extract data and improving how the data are visualized so that all data types are processed in the same manner and visualized in a consistent way. In particular, we have been working on the following improvements:

In the previous versions, there was inconsistent rendering of multiple data types depending on how the user reached the map (e.g. the map looked different when the user selected species first or dataset first) and was not able to map acoustic monitoring effort when other data types were mingled. The new version has improved these issues and it has become easier to distinguish PAM data when mapped with other data types (

- Figure 1);
- We have consolidated chart features for all data types. Previously, the PAM data produced different charts than those for other data types;

As reported in the previous report, the existing chart features were not suitable for complex themes of graphing. We themes of graphing. We have successfully upgraded the framework for charts with the latest technologies (technologies (

- Figure 2);

We have developed a framework to make linkage between locations of detections and sound data in the same way data in the same way for photo-identification data (i.e. animal sightings and their fin images;

- Figure ***3***). Since the linkage is made in the form of the Internet URL, sound data can be stored in either our facility or partners' online services.

We have been in direct collaboration with the sister NOPP project "Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets" led by Marie Roche, San Diego State University and Sofie Van Parijs, NOAA Northeast Fisheries Science Center. They are establishing metadata standards for PAM data and developing a database system 'Tethys' that maintains and distributes PAM metadata. We have gotten their draft metadata schema and started figuring out what an appropriate approach is to integrate this new PAM metadata into the OBIS-SEAMAP metadata management system.

The script provided by Marie Roche that extracts sunrise and sunset times at a specified location from the JPL the JPL HORIZONS service (http://ssd.jpl.nasa.gov/?horizons) was used to obtain data at the stationary stationary hydrophone locations during the survey effort periods for the Density Estimation of Cetaceans from Cetaceans from Passive Acoustic Fixed Sensors (DECAF) datasets. The resulting sunset/sunrise data are stored in are stored in the OBIS-SEAMAP database, which contains 77,000 records spanning from 2005-03-21 to 2008-01-04 to 2008-01-04 for 94 hydrophone locations. A draft SQL query statement that calculates diel detections along with along with sunrise/sunset times was created, the results of which are served to diel plots (

Figure 4). We are currently developing the shaded day/night illumination laid over the diel plots of detections. For this effort, we have been exploring the possibility of integrating a Matlab function Marie Roche developed into the OBIS-SEAMAP system. This visualization will be helpful to explore animal diel behaviors. For statistical analysis and hypothesis testing, the data used for diel plots will be also downloadable in data matrix format from the OBIS-SEAMAP web site.

In November 2012 we released the first set of the Sperm Whale Seismic Study (SWSS) data provided by BOEM, by BOEM, which is our first attempt to consolidate multiple data types (i.e. Photo-ID, ARGOS telemetry and telemetry and genetic sampling) into a single, coherent and scientifically more valuable dataset (http://seamap.env.duke.edu/dataset/810;

Figure 5). This unification of multiple data types into a coherent product is a useful showcase of the benefits that that can be gained from data fusion in a biogeographic data center such as OBIS-SEAMAP. This dataset is also an excellent example of the linkage between tagged animal locations and fin images to planned linkage between detection locations and relevant sound data. We are currently eagerly exploring other types of the SWSS data including visual sightings and PAM data.

We have been coordinating with Sofie Van Parijs (NOAA-NEFSC) to register an additional set of PAM data into the OBIS-SEAMAP database and discussing the possibility of direct association between detection records and associated sound data.

RESULTS

In this reporting period, we have made significant advancement on the integration of PAM data with other types of data. This integration broadens the spatial and temporal coverage of species occurrence data, which in turn improves analyses of habitats and distributions of species in question. At this moment of writing, for example, while there are no visual sighting records of minke whales in the Hawaiian waters registered in the OBIS-SEAMAP database, detections from PAM hydrophones prove the existence of minke whales in that region (Figure 6). In addition, PAM collects species detections in

deep seas as well as at night, both of which are usually not possible with visual surveys. With such detections in deep seas and at night visualized along with other data, the new version of OBIS-SEAMAP will allow researchers to investigate an unprecedented collection of species occurrence data with novel online visualization tools.

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 mammals' 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, the abovementioned development of the integrated tools for multiple data types will greatly improve the overall quality and usability of the OBIS-SEAMAP database and its web site.

Since the OBIS-SEAMAP team is also the leading developer for the OBIS Portal and will become so for OBIS-USA, our skills and knowledge acquired during this project will directly contribute to the advancement of these associated projects. In particular, our effort in integrating multiple data types will have significant effect on such portals as they are trying to expand their schema to archive various data types.

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).

Another potential collaborative work of our team will take place with NOAA's Integrated Ocean Observing System (IOOS) program that is aimed at incorporating PAM data into the IOOS structure. We have started the preliminary discussion with Shane Guan and Hassan Moustahfid (NOAA-IOOS)

on how to collaborate each other and transfer PAM data in the OBIS-SEAMAP database to the IOOS system.

RELATED PROJECTS

The NOPP project "Acoustic Metadata Management and Transparent Access to Networked Oceanographic Data Sets" led by Marie Roche, 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. Jesse Cleary, an OBIS-SEAMAP team member, is 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.

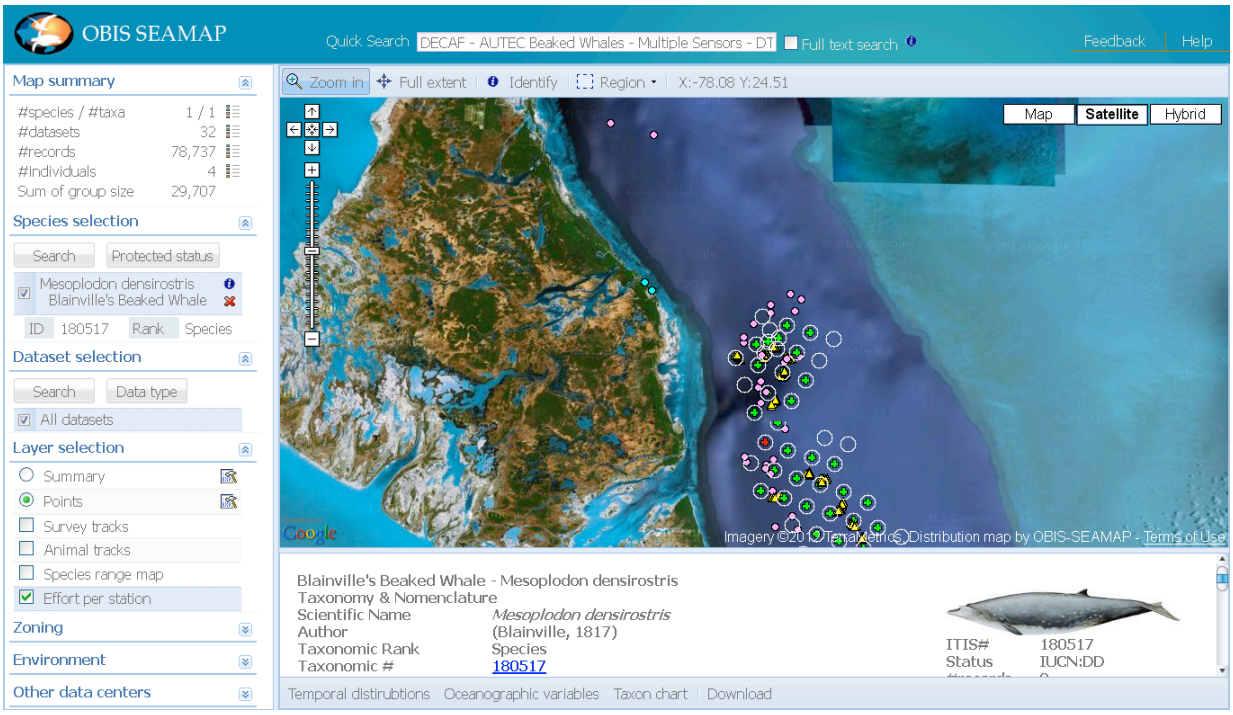

Figure 1: *The integration of PAM data with other data types has been greatly improved. Sightings from shipboard surveys (pink and right blue circles), locations of animals tagged with a DTag sensor (yellow triangles) and acoustic detections by stationary hydrophones (green crosses) are mapped together. Non-filled, gray circles indicate the effort at the hydrophones. All data are of blainville's beaked whales.*

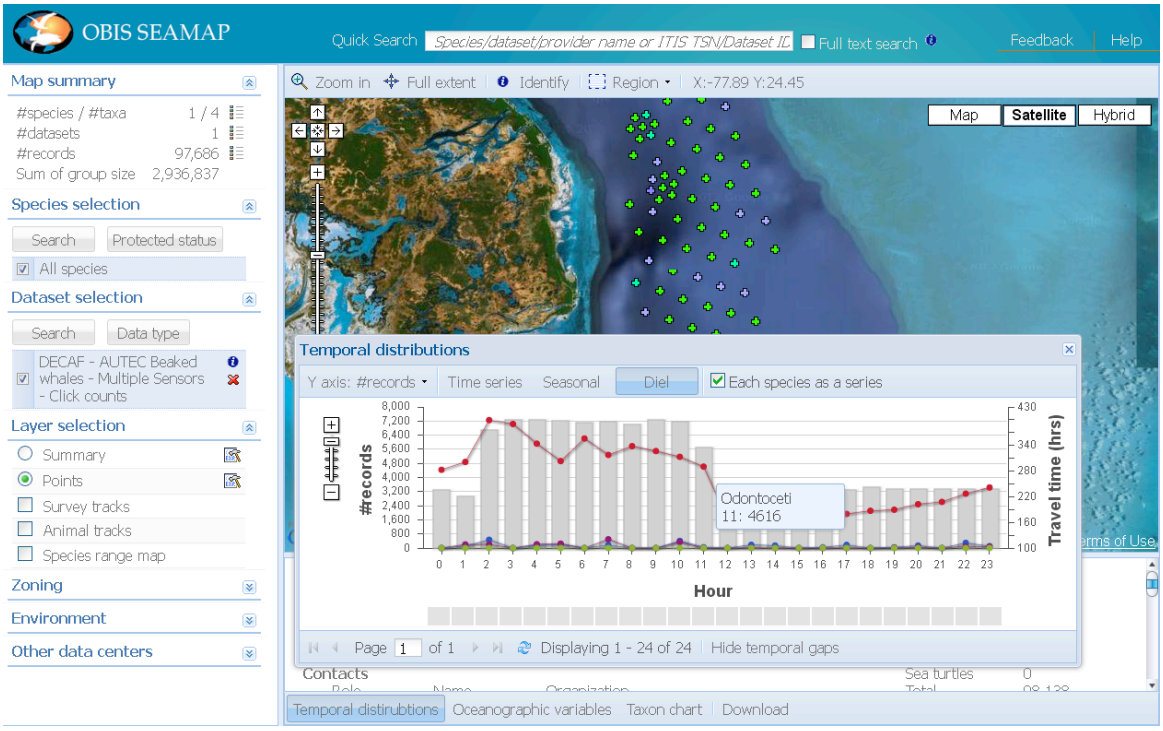

Figure 2: *Chart features for PAM data and for other data types are integrated with the latest technologies.*

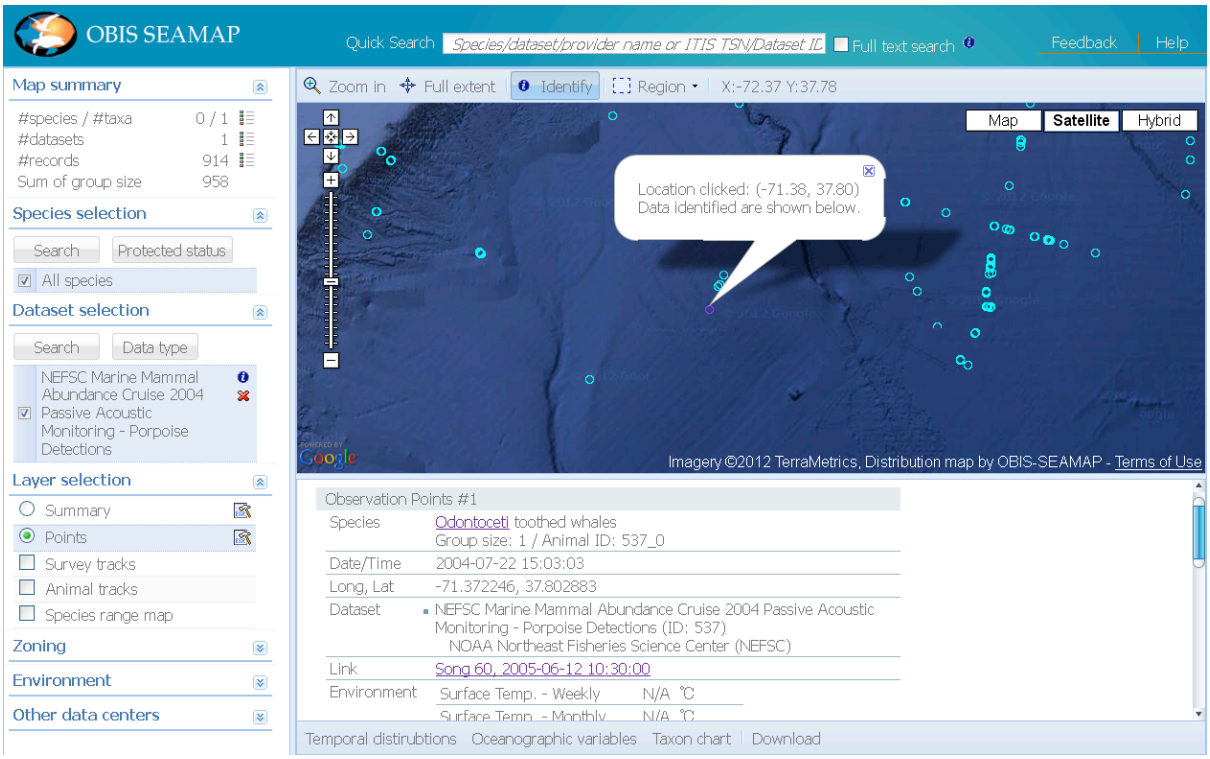

Figure *3: A preliminary example of the linkage between a detection location and associated sound data. By clicking the link 'Song 60…,' the user is able to listen to the sound.*

y_value date	x_value timestamp with tim	hour double p	sunrise timestamp without tin	sunset timestamp without ti	sp1_clicks bigint	sp2_clicks bigint	sp3_clicks bigint	sp4_clicks bigint
2005-04-27	2005-04-27 19:00:00	19	2005-04-27 10:38:00	2005-04-27 23:38:00	21	374	0	40
2005-04-27	2005-04-27 20:00:00	20	2005-04-27 10:38:00	2005-04-27 23:38:00	0	1209	0	0
2005-04-27	2005-04-27 21:00:00	21	2005-04-27 10:38:00	2005-04-27 23:38:00	0	821	0	0
2005-04-27	2005-04-27 22:00:00	22	2005-04-27 10:38:00	2005-04-27 23:38:00	82	1265	0	271
2005-04-27	2005-04-27 23:00:00	23	2005-04-27 10:38:00	2005-04-27 23:38:00	0	1486	0	0
2005-04-28	2005-04-28 00:00:00	0	2005-04-28 10:37:00	2005-04-28 23:38:00	0	1677	0	0
2005-04-28	2005-04-28 01:00:00	1	2005-04-28 10:37:00	2005-04-28 23:38:00	0	326	0	0
2005-04-28	2005-04-28 02:00:00	2	2005-04-28 10:37:00	2005-04-28 23:38:00	131	2027	0	195
2005-04-28	2005-04-28 03:00:00	3	2005-04-28 10:37:00	2005-04-28 23:38:00	0	2435	0	0
2005-04-28	2005-04-28 04:00:00	4	2005-04-28 10:37:00	2005-04-28 23:38:00	91	1811	0	25
2005-04-28	2005-04-28 05:00:00	5	2005-04-28 10:37:00	2005-04-28 23:38:00	135	1535	0	30
2005-04-28	2005-04-28 06:00:00	6	2005-04-28 10:37:00	2005-04-28 23:38:00	0	1734	0	0
2005-04-28	2005-04-28 07:00:00	7	2005-04-28 10:37:00	2005-04-28 23:38:00	159	1435	0	4
2005-04-28	2005-04-28 08:00:00	8	2005-04-28 10:37:00	2005-04-28 23:38:00	0	1517	0	0

Figure 4: *A sample data set of diel detections along with sunrise/sunset times for DECAF AUTEC Beaked whales click counts. Click count columns represent Delphinidae (sp1), Odontoceti (sp2), Physeter macrocephalus (sp3) and Ziphiidae (sp4). The sunrise and sunset times were obtained using the JPL HORIZONS service.*

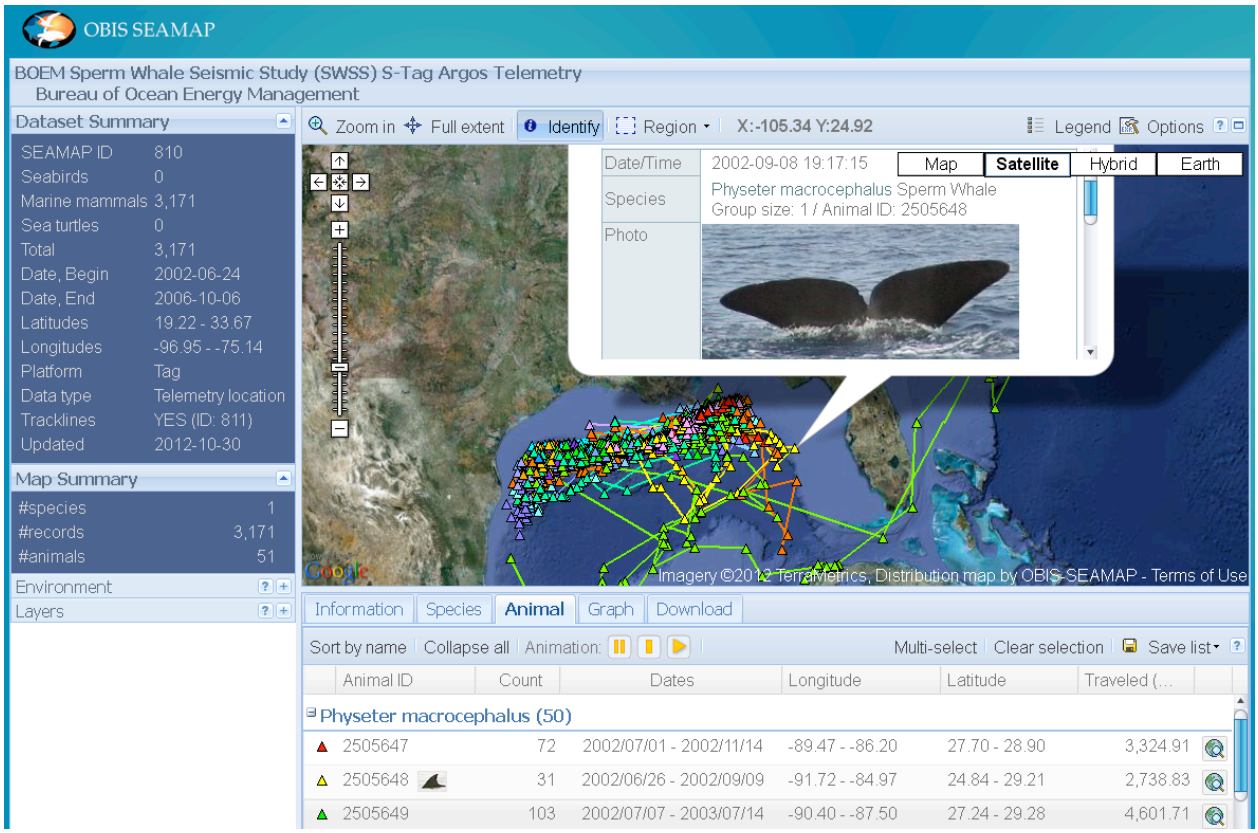

Figure 5: *The Argos telemetry data from BOEM Sperm Whale Seismic Study is published on the OBIS-SEAMAP web site (http://seamap.env.duke.edu/dataset/810). The related PAM data are going through the data processing and will be published by the end of the project.*

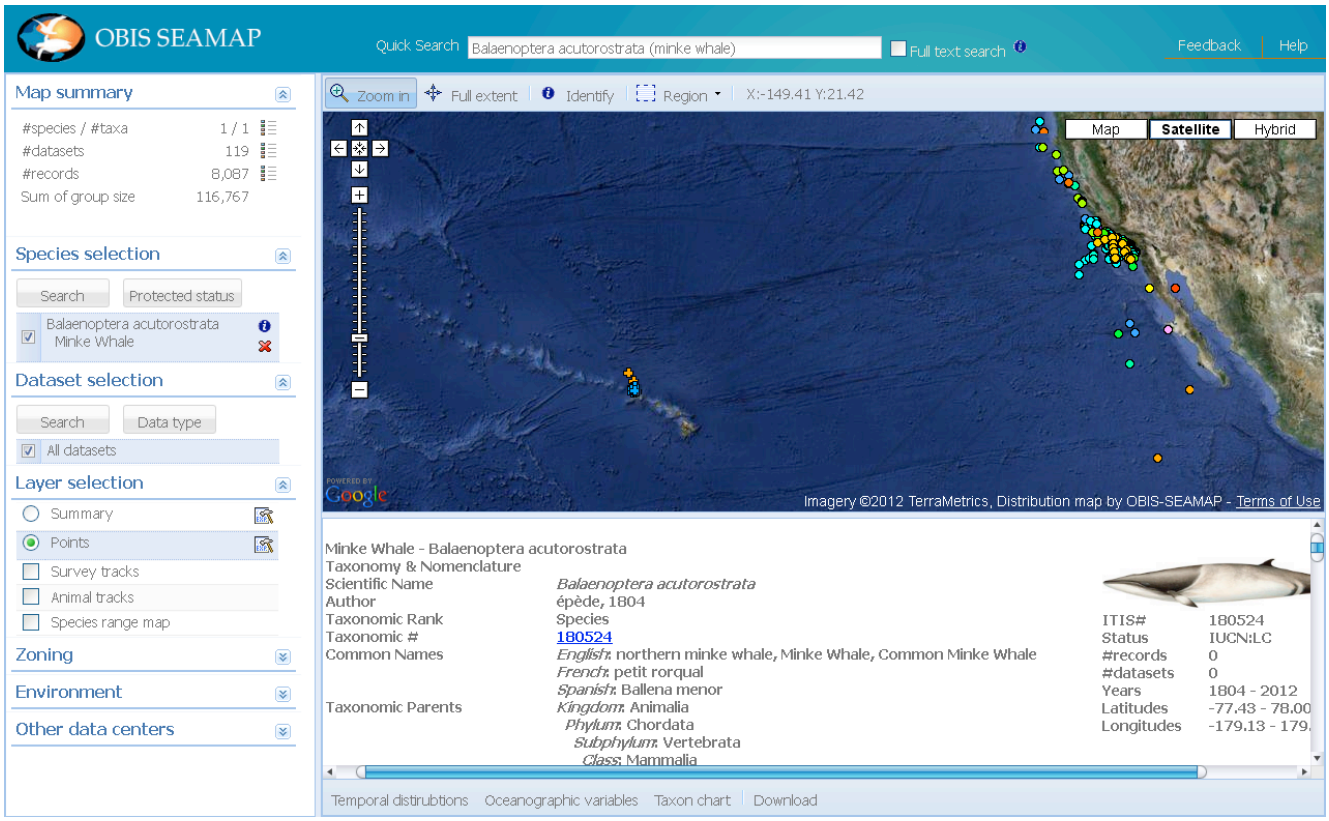

Figure 6 Detections from PAM data proves the existence of minke whales in the Hawaiian waters. As of November 2012, there is no visual sighting record of minke whales (colored circles) in the Hawaiian waters. However, hydrophones placed in the Hawaiian waters in the DECAF project (colored crosses) detected minke whales. The symbols (circles and crosses) are colored by dataset.