Developing the Next Generation Marine Mammal Information Center for Integrated Ocean Observing: OBIS-SEAMAP 2.0

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LONG-TERM GOALS

The central work-plan for this renewal continues to be a strategic expansion of the OBIS-SEAMAP information system in depth, breadth, functionality and the user community. In addition to maintaining the existing system on a growth trajectory, we are targeting five specific focal areas:

1. Data gap analysis and prioritized expansion of the marine mammal geodatabase;
2. Inclusion of new data types (acoustics, photo-ID, 4D telemetry, model outputs and turtle nesting);
3. Expanded functionality with mapping, species profiles, metadata, and web services;
4. Expanded functionality with oceanographic data; and
5. Development of new partnerships focusing on data and technology.

APPROACH AND WORK PLAN

1) OBIS-SEAMAP (http://seamap.env.duke.edu) compiles geo-referenced data on marine mammals, sea birds and sea turtles, with tools to query these observations in a dynamic, searchable environment. The information system is designed specifically to be publicly available. OBIS-SEAMAP has developed into a multi-function information system that serves data necessary for ocean stewardship to scientists, managers, students and educators under the NOPP program. We are currently 2.25 years into our 3-year project, and report here on our work from November 2008 to October 2009.

2) Principal investigators Patrick Halpin and Andrew Read provide oversight of project development and guidance. PI Halpin also actively works as a member of the strategic planning committee for the newly formulated OBIS international portal under the IOC program of UNESCO-IODE. Ei Fujioka leads the technical development, making sure that OBIS-SEAMAP is at the forefront of data sharing and visualization. Connie Kot has been conducting the comprehensive gap analysis work (described below). Andrew DiMatteo works in data acquisition, management and input with a focus on sea turtles and also contributes to tool and interface design. Kim Urian leads the development of the photo-

identification online matching system, including expansion to new species and partnerships. Melissa Soldevilla is leading the incorporation of acoustic data into OBIS-SEAMAP and works with data holders to maximize the utility of the data archive and attract more acoustic datasets. Ben Donnelly and Jesse Cleary provide support in system architecture, user interface and web programming. Transfer of project management responsibilities is underway; Lucie Hazen has moved to the west coast and her work duties are being assumed by a new research associate, Jennifer Dunn, a talented addition to the team whom we are pleased to have on board.

3) Work plans for the upcoming year include: establishing new collaborations and maintaining existing partnerships; successfully transferring data of various types (point, track, acoustic, photo-ID) to the OBIS-SEAMAP database; improving interactive features of the website; and improving linkages between OBIS and OBIS-SEAMAP.

Collaborations and data sources: Connie Kot is conducting a Gap Analysis to better understand areas, time periods, and species in which observations are missing from OBIS-SEAMAP. This multi-step, detailed analysis is focused on identifying existing data sets that are not currently included in OBIS-SEAMAP from 1983-2003. This analysis has provided a clear picture of where we should focus our data gathering efforts. A manuscript describing the findings of the Gap Analysis is currently in preparation. Dataset acquisition efforts (mainly led by Connie Kot and Andrew DiMatteo) are ongoing as we continue to extend geographic, temporal and taxonomic coverage.

We held a number of workshops and poster presentations in this reporting period (described in "TRANSITIONS" below) to seek new partnerships and strengthen existing collaborations. For example, a significant partnership is developing between OBIS-SEAMAP and Brazilian researchers who conduct cetacean surveys off Brazil. The southwestern Atlantic is one of the biggest spatial data gaps and this collaboration will substantially improve our knowledge of cetacean distribution in this area. Ei Fujioka is coordinating the data transfer into the OBIS-SEAMAP database. Additionally, Ei Fujioka is working with the Provincetown Center for Coastal Studies, which holds more than 200,000 cetacean sightings from the Gulf of Maine, to incorporate these data into OBIS-SEAMAP.

Thanks to the successful customization of SEAMAP tools made for the European Seabirds at Sea initiative (ESAS), the Joint Nature Conservation Committee, the leading organization for ESAS, is now soliciting other groups to submit their data to OBIS-SEAMAP. As data are compiled from these requests, it is expected that OBIS-SEAMAP will experience significant growth in its data holdings.

Photo-ID researchers working on several cetacean species have expressed interest in replicating the system developed for bottlenose dolphins. Kim Urian and Ei Fujioka are framing a work plan with Dr. Steve Swartz (NOAA), who studies gray whales in the eastern Pacific. The existing system will be modified to meet specific search criteria and functions required by Dr. Swartz and his colleagues.

Website improvements: In the third year of this project, we will continue to enhance interactive and exploratory features on the OBIS-SEAMAP web site. Ei Fujioka has already introduced novel mapping and visualization techniques to the web site. He is also an active member of the Mapping & Visualization project for Census of Marine Life, exploring further innovative visualization techniques. His achievements in the Census of Marine Life project will be, in turn, incorporated into OBIS-SEAMAP. Additional improvements will include: more oceanographic data with additional visualization options; and enhanced spatial search capability with data filtering in relation to commonly used areas, such as Exclusive Economic Zones and global marine protected areas.

After the launch of the online interface for the State of the World's Sea Turtle (SWOT) data, Andrew DiMatteo has begun data collection for the latest year. The new data will be added to the existing SWOT database, allowing users to explore changes in sea turtle nesting data over years. We will work on streamlining the data collection and, if warranted, develop an online data collection interface.

Improving the linkages between OBIS-SEAMAP, OBIS-USA and the international OBIS portal:
The international OBIS portal has recently been adopted as an official project of the UNESCO / IODE / IOC program. This move now provides a highly visible and permanent home for the portal under the auspices of a UN agency. Project PI Halpin recently participated in a strategic planning meeting for the new IOC/OBIS system in Oostende, Belgium in November 2009 and represented the interests of the OBIS-SEAMAP project in this new international organization context. In addition, PI Halpin met with Mark Fornwall (USGS) the representatives of the OBIS-USA regional node to develop more streamlined methods for efficient data sharing and cooperation between the OBIS-SEAMAP and OBIS-USA data centers. We are planning to implement a non-redundant data exchange between OBIS and OBIS-SEAMAP. Ei Fujioka, Ben Donnelly and Jesse Cleary are involved in an OBIS Portal renewal project (see "TRANSITIONS"). With help from the OBIS team, led by Edward Vanden Berghe, these individuals will improve the OBIS database and its online search interface.

WORK COMPLETED

Since the launch of the OBIS-SEAMAP 2.0 interface a year ago, we have been continually improving the user interface and adding new features and novel visualization tools. Tabular data are now presented with a spreadsheet-like interface, providing more features to the user, including the option to change the column width and sorting order. All OBIS-SEAMAP observation data are now accompanied by synoptic, remotely sensed oceanographic data (when available), including bathymetry, sea surface temperature, sea surface height and chlorophyll a concentration. These observations can be visualized with interactive graphing tools at various time scales (Figure 1). We have also recently added a novel visualization capability, including a multi-resolution map of species richness (the number of species per unit cell) and a hierarchical resolution map for the observation data (Figure 2). Finally, we added a new download option in which the user can download subsets of data in ESRI shapefile format, the most commonly used GIS data format.

Data acquisition in this reporting period remains as strong as in the previous year. We obtained 43 new datasets, 33 of which are now published on OBIS-SEAMAP. These new datasets add more than 150,000 observations; more are currently being processed or reviewed. One of the notable additions is the "Dugong relative density and distribution" dataset from James Cook University, Australia, in which OBIS-SEAMAP presents visualizations of model-derived density estimates as a new data type.

A Spatial Decision Support System (SDSS), a product of the Strategic Environmental Research and Development Program (SERDP), is now available through the web site (Figure 3). This is a new, advanced data type that extends the capacity of OBIS-SEAMAP to products derived from raw survey data and also allows users to conduct analyses beyond mapping and visualization. The successful implementation of this SDSS will position OBIS-SEAMAP as a key player in current efforts focused on marine spatial planning for wildlife conservation.

In collaboration with the Tagging of Pacific Predator Project (TOPP), OBIS-SEAMAP is now equipped with a filtering algorithm for ARGOS satellite telemetry data. This feature allows unfiltered,

telemetry data to be registered into the database. The raw data are run through the filtering algorithm and outliers are detected and excluded. However, the online mapping interface is able to display both excluded data (outliers) and observations that passed the filter. This feature expands the potential of more advanced analyses, such as space-state models where unfiltered data are of great importance.

Turtle nesting data collected and compiled by the State of the World Sea Turtles (SWOT) are fully incorporated into OBIS-SEAMAP and a customized online mapping interface is now available (Figure 4). This interface adopts an innovative approach to represent three commonly used count types (females/crawls/clutches) on a single interactive map. Based on expert knowledge and literature, we devised conversion formulas so that missing values for a count type are calculated from the others. This conversion allows the user to choose a preferred count type to map the nesting sites without missing those in which the data were not recorded as the selected count type.

We have been working hard to expand the capability of OBIS-SEAMAP to include acoustic data. Five acoustic datasets are now in review by data providers; two will soon be published. Publication of the remaining three data sets awaits declassification of hydrophone locations. Several new features were added to the OBIS-SEAMAP web site to better visualize this unique data type. Notably, recording effort and occurrence (as hour-bins) of dolphin clicks detected from single moored instruments can be plotted together and viewed at multiple time scales (Figure 5). The hourly time scale is useful for examining diel variation in vocalizations.

The Mid-Atlantic Bottlenose Dolphin Catalog (MABDC) photo-ID system has integrated dorsal fin images from a number of additional research groups and study sites. In total, more than 1,000 images were added to OBIS-SEAMAP in this reporting period. Contributors are now beginning to make potential matches through the online interface.

RESULTS

Our ongoing efforts to communicate with data providers are critical to the successful expansion of the OBIS-SEAMAP project in both functionality and data holdings. OBIS-SEAMAP is now a significant data center and also an important source of expertise in mapping and visualization.

IMPACT AND APPLICATIONS

Science Education and Communication

The PIs continue to work with the broader scientific community to plan for the future of the data archive and to ensure that our current efforts meet critical management and conservation needs of this community. We have introduced OBIS-SEAMAP to several federal agencies this year. For example, Andy Read presented to an Interagency Workshop to Identify and Discuss Needs and Requirements for Marine Mammal Density, Abundance, and Distribution Data in June 2009 and Pat Halpin gave a similar talk to the NMFS Science Board in October 2009. These dialogues, especially with NOAA, NSF, the Navy and MMS, will be critical to the future integration of OBIS-SEAMAP into the missions of these agencies.

TRANSITIONS

Economic Development

OBIS-SEAMAP is the largest open access data center of its kind. The architecture of the data portal allows users to streamline their search efforts and improve efficiency. The online Photo-ID system is one example of how we are improving the efficiency of a scientific workflow to maximize the information exchange among collaborating researchers.

Science Education and Communication

We were invited to present at the first Indian Ocean Cetacean Symposium, which took place in the Maldives in July 2009. Lucie Hazen made a presentation at this meeting that generated substantial interest. This region is greatly underrepresented in OBIS-SEAMAP, so it was important to introduce the project and highlight the benefits of participation. Melissa Soldevilla introduced OBIS-SEAMAP at the 4th International Workshop on Detection, Classification and Localization of Marine Mammals Using Passive Acoustics in September 2009 in Pavia, Italy. This presentation introduced OBIS-SEAMAP to acousticians who were generally unfamiliar with our work. We also held a workshop at the 18th Biennial Conference on the Biology of Marine Mammals in Quebec City in October 2009. The attendees ranged from students and researchers to resource and data managers. The newly enhanced advanced mapping capabilities were demonstrated and well-received. We also featured OBIS-SEAMAP in a poster presentation at the Biennial Conference.

OBIS-SEAMAP team members are actively involved in the Census of Marine Life Mapping & Visualization project. One notable development of this cross-pollination is that a pre-loaded layer for the Census of Marine Life is added to Google Earth. Place mark popups from this layer have direct links to the OBIS-SEAMAP web pages, drawing more attention from the general public to OBIS-SEAMAP (Figure 6). Team members are also involved in the international Convention of Biological Diversity's (CBD) effort to define criteria for identifying ecologically and biologically significant areas on the open oceans and deep seas. OBIS-SEAMAP data holdings of loggerhead turtle telemetry were used for one of the illustrations in "Special importance for life history of species" criterion (http://openoceansdeepseas.org/illustration/lifecycle-2). This CBD effort will be highlighted in the tenth meeting of the Conference of the Parties (COP 10; October 2010, Nagoya, Japan) where OBIS-SEAMAP will reach global conservation communities.

RELATED PROJECTS

Our complementary Census of Marine Life Mapping & Visualization (M&V) project is in full swing. As The Census of Marine Life is approaching its culmination in October 2010, the connection between OBIS and OBIS-SEAMAP will become tighter and we expect the public exposure of the OBIS-SEAMAP project to increase.

PUBLICATIONS

Halpin P.N, A.J. Read, E. Fujioka, B.D. Best, B. Donnelly, L.J. Hazen, C. Kot, K. Urian, E. LaBrecque, C. Good , L.B. Crowder, and K.D. Hyrenbach. 2009. OBIS-SEAMAP: The world data center for marine mammal, sea bird and sea turtle distributions. *Oceanography* 22(2): 104-115.

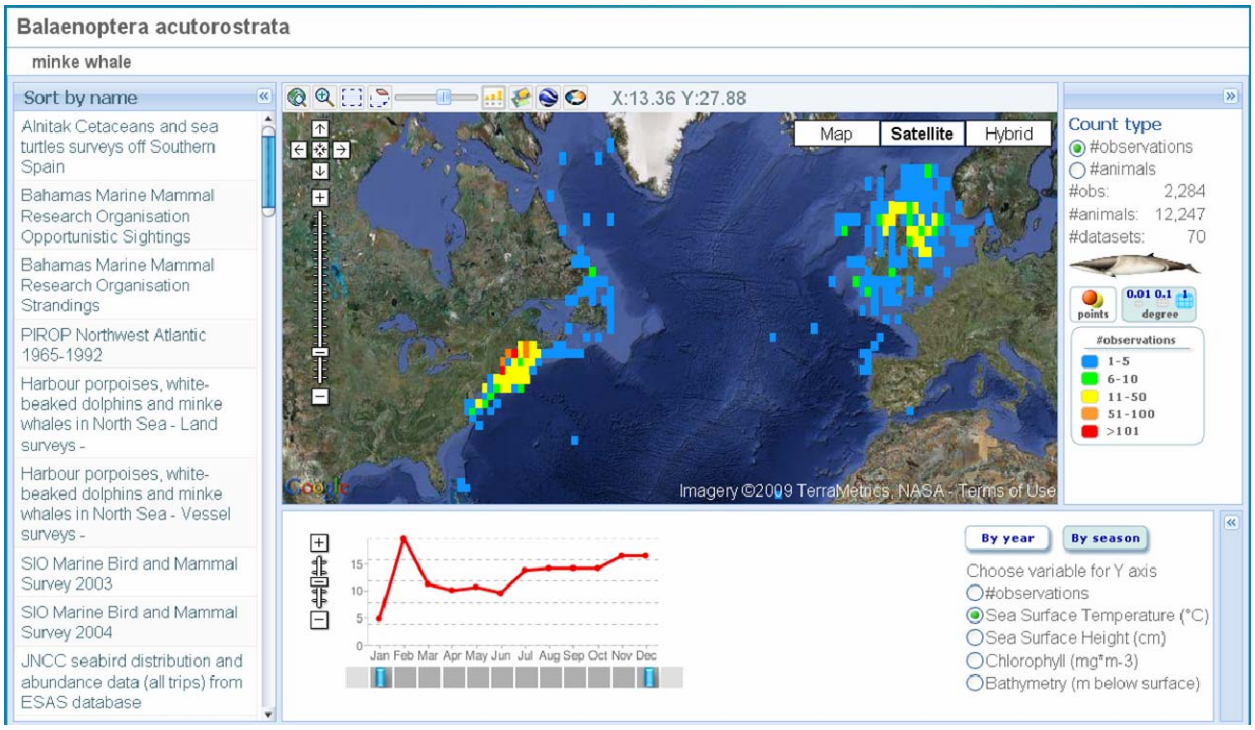

Figure 1: Improved OBIS-SEAMAP mapping interface with graphing tools for sampled environmental data. Monthly sea surface temperature of minke whale observations from 70 datasets is shown. All of the OBIS-SEAMAP observation data have oceanographic data sampled (when oceanography data are available), which are displayed with interactive graphing tools at various time scales.

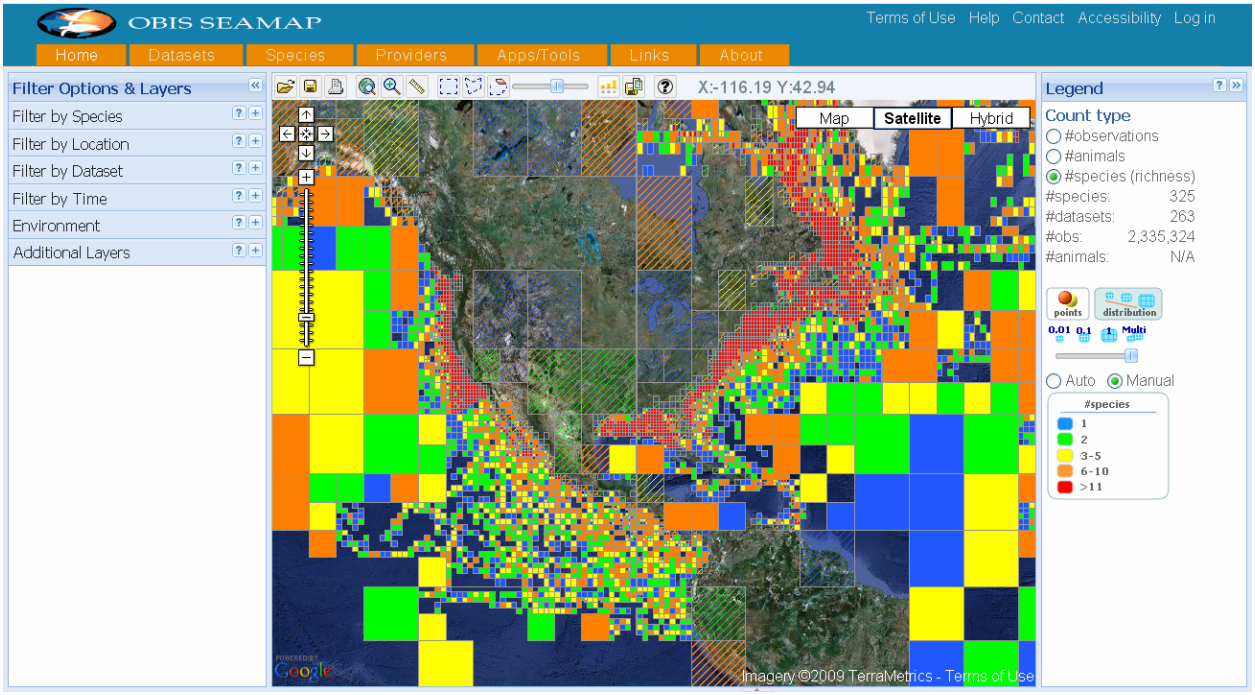

Figure 2: A hierarchical map illustrates the distribution and intensity of the observation data at once. The areas with fewer observations are represented by coarser grids while the heavily surveyed areas are represented by finer grids. The above map is color-coded by species richness.

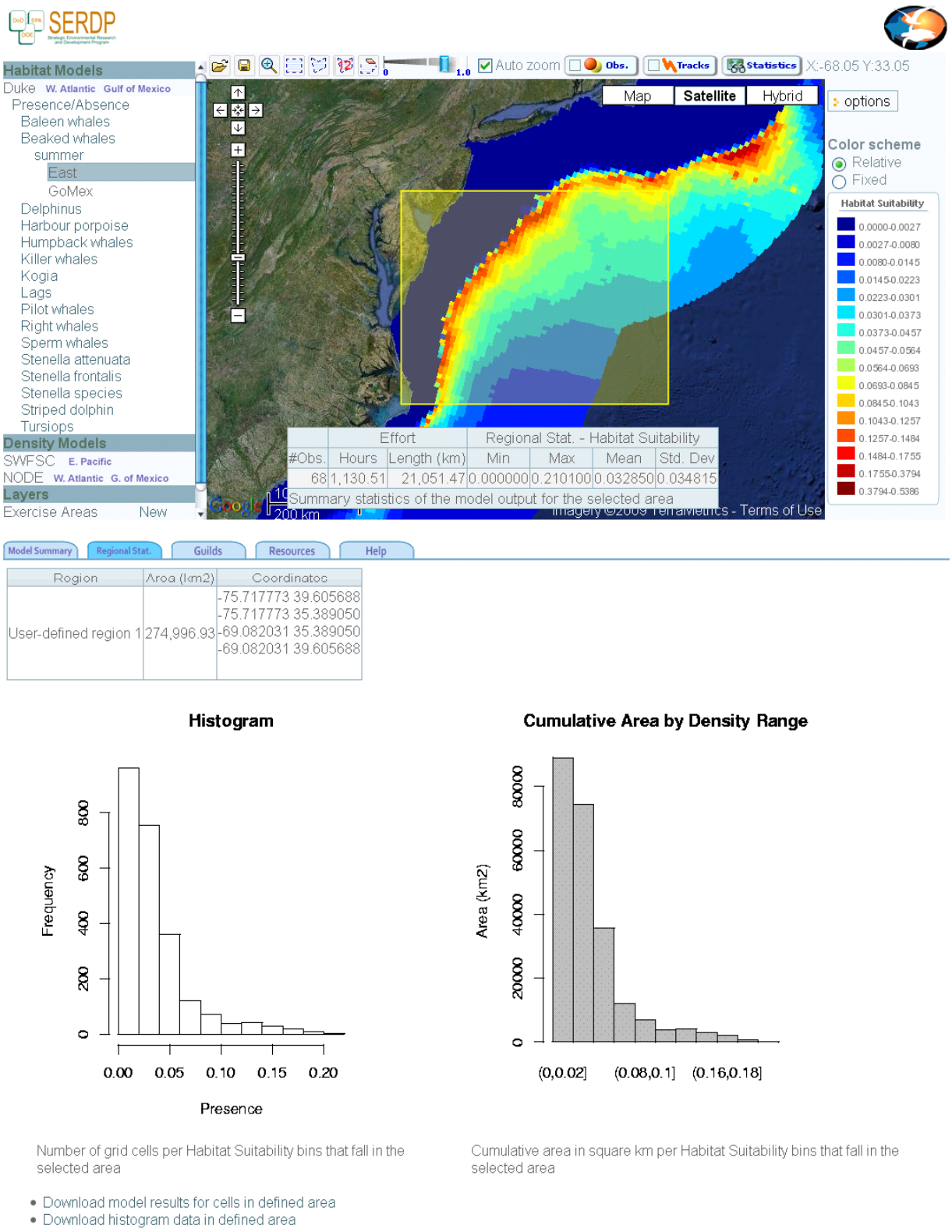

Figure 3: An online spatial decision support system for predictive modeling of marine mammal habitats for SERDP, showing regional summary of a predictive habitat model.

Figure 4: Turtle nesting data from the State of World's Sea Turtles (SWOT) database are published via a customized online mapping interface on the OBIS-SEAMAP web site.

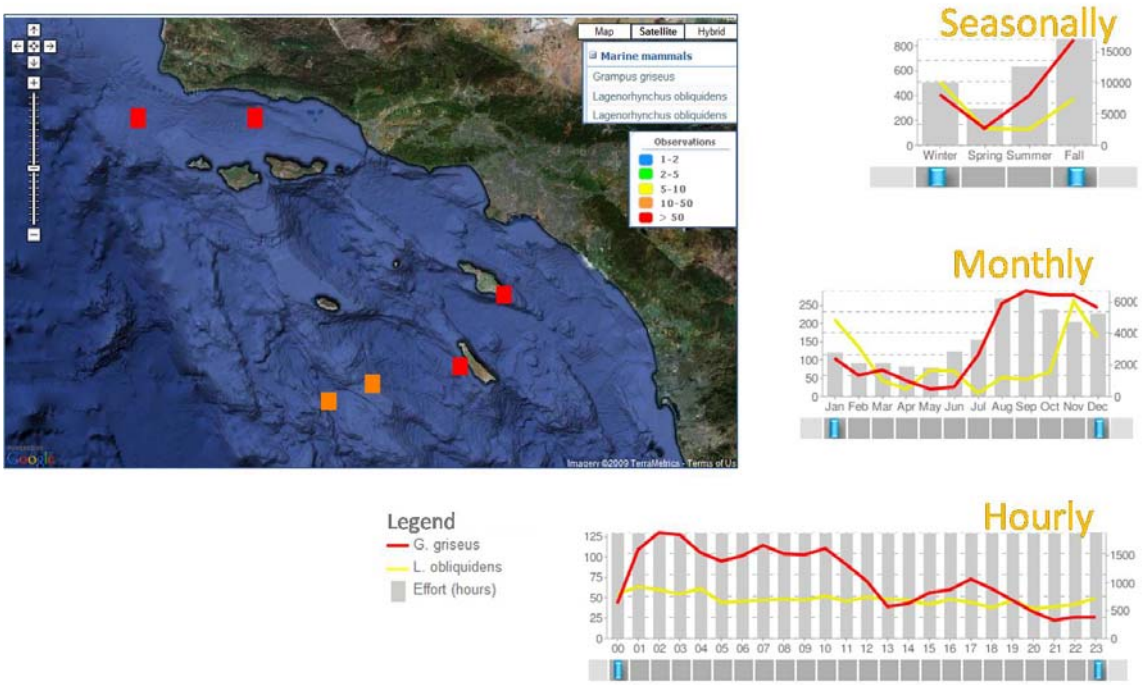

Figure 5: Acoustic data from single moored instruments are visualized in space and time. Recording effort and dolphin clicks detected are graphed together at various time scales (seasonally, monthly, and hourly).

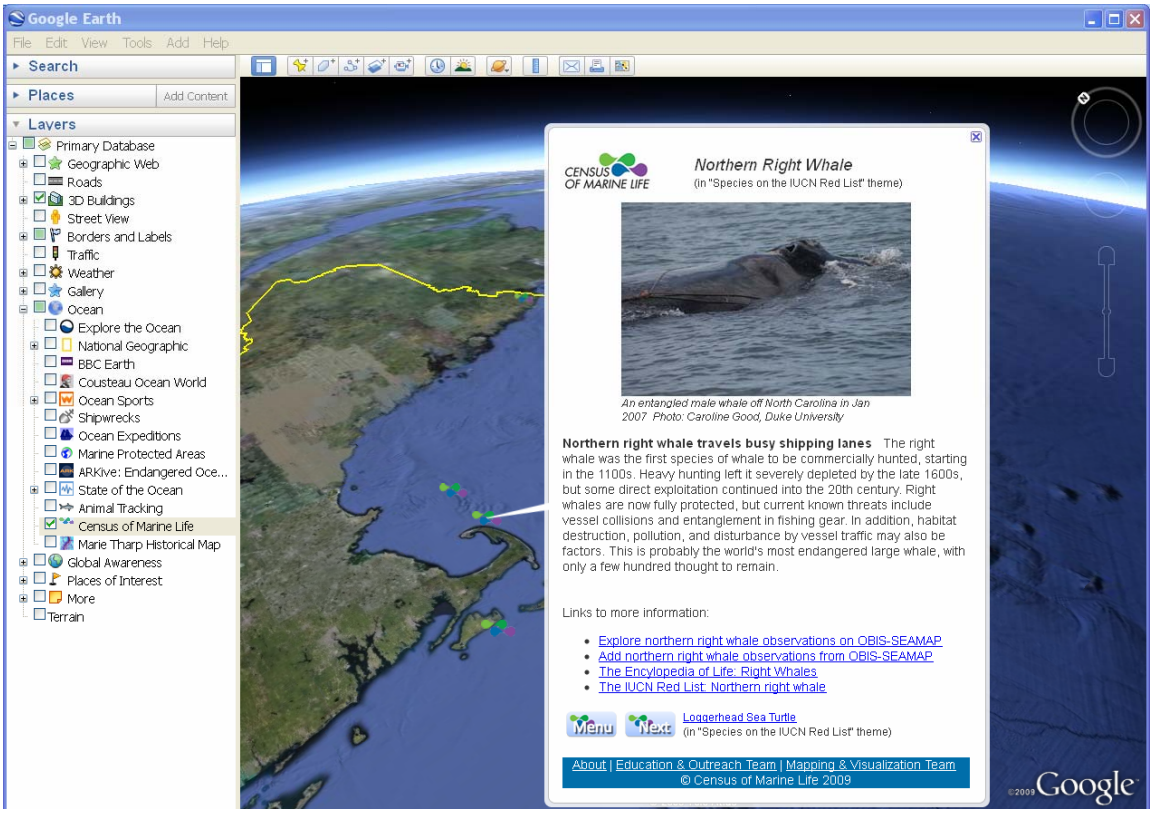

Figure 6: The Census of Marine Life layer is added to Google Earth. Several place mark popups from this layer have direct links to the OBIS-SEAMAP web pages (as shown in "Northern Right Whale" popup).