

INTEGRATION OF NOAA AERIAL MONITORING AND GIS PROGRAMS FOR RESEARCH, EDUCATION, AND MANAGEMENT WITHIN THE CHANNEL ISLANDS NATIONAL MARINE SANCTUARY

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ABSTRACT

The objective of this project is to monitor and analyze physical and anthropogenic phenomena within the National Oceanic and Atmospheric Administration's (NOAA) Channel Islands National Marine Sanctuary using a Geographic Information System (GIS) and aerial Global Positioning System (GPS) collection strategy. Data are used to enhance Sanctuary goals of research, education, and resource management. The aerial monitoring program allows near-realtime collection of data vital to coastal zone management and resource protection. Collected floral and faunal data are used to monitor kelp distribution; marine mammal populations and migration patterns; and general resource health within the Sanctuary. Vessel traffic and type surveys allow anthropogenic use patterns to be studied. Data downloaded into the Sanctuary's GIS are used to analyze historical trends and detect correlations across data types. Maps are created and made available via the World Wide Web as a public education tool. Additionally, the program is being prototyped as a response tool for resource emergencies such as oil spills. Data collected on spill perimeter changes, oil types, and oiled animals can be downloaded to a portable GIS at Unified Command Centers to aid in both immediate response decisions and long term impact analysis.

Keywords: Aerial, Geographic Information System, Global Position System, vessel traffic, marine mammal.

INTRODUCTION

The Channel Islands National Marine Sanctuary (CINMS) is one of twelve National Marine Sanctuaries administered by the National Oceanic and Atmospheric Administration (NOAA). As part of the National Marine Research and Sanctuaries Act of 1972, the Sanctuary's mission includes promotion of research, recreation, education, and conservation within its boundaries. It additionally supports commercial industries such as fishing and tourism while providing protection to endangered species and cultural artifacts. The 1,252 square nautical mile CINMS administrative zone (Figure 1) exists within a six nautical mile boundary extending out from the shorelines of five of the California Channel Islands (San Miguel, Santa Rosa, Santa Cruz,

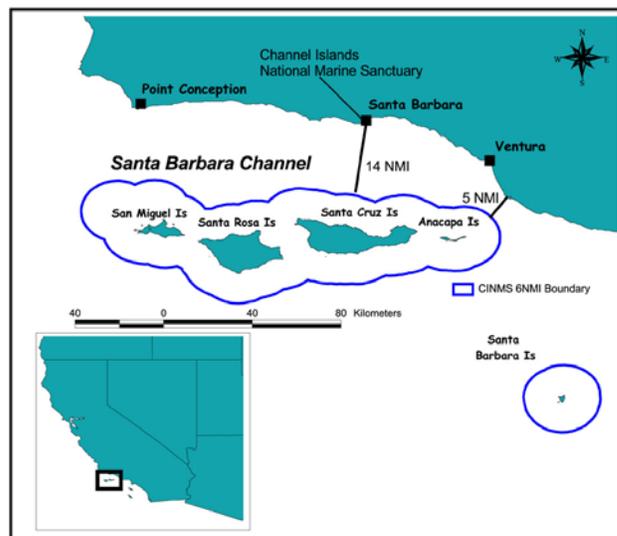


Figure 1. Location map with CINMS administrative boundary.

Anacapa, and Santa Barbara). The minimum distance between the Sanctuary boundary and the mainland off Port Hueneme, California, is approximately five nautical miles. The distance to the Sanctuary boundary from the CINMS offices in Santa Barbara, California, is about 14 nautical miles.

This somewhat remote location of the Sanctuary relative to CINMS headquarters increases the difficulty of monitoring and responding to physical and cultural activities within its boundaries. To alleviate this problem, and to better study the Sanctuary environment, CINMS instituted an aerial survey program in June of 1997. Using a Lake Seawolf seaplane, transects of the entire Sanctuary are flown in approximately five hours (versus about four days for boat coverage of the same area). Equipped with an on-board Global Positioning System (GPS) and a laptop computer containing a custom designed software package, the aircraft allows CINMS personnel to frequently and efficiently monitor and spatiotemporally record physical and anthropogenic phenomena within and adjacent to Sanctuary boundaries. These data are then returned to CINMS headquarters and put into a Geographic Information System (GIS) for analysis. Biological data collected during surveys include pinniped sightings, cetacean sightings, and giant kelp (*Macrocystis*

pyrifera) canopy locations. Cultural data collected include sea vessel and aircraft types and locations and marine debris sightings.

METHODS

Aerial surveys typically take place with the pilot (as a left side observer) and a data recorder (as a right side observer) on board. Flights take place on at least a weekly basis (weather and aircraft maintenance permitting). The normal survey flight is 100 kn at 1,000 ft, flown in “figure eight” transects between the northern islands (Anacapa, Santa Cruz, Santa Rosa, and San Miguel), and a double outward radiating spiral at Santa Barbara Island. A laptop computer is plugged into the aircraft’s GPS unit and receives one-minute interval updates on horizontal and vertical position, which are fed into the computer’s aerial survey software. The laptop can manually receive position data at up to one-second intervals if required.

The aerial survey software is custom designed in Visual Basic 5.0 to meet the needs of Sanctuary data acquisition, but is also capable of being adapted to a wide-range of survey criteria. When the program initiates, a window (Figure 2) appears requesting environmental data (e.g., water color and clarity; sea state; sun glare angle; light conditions). The environmental data can be changed mid-transect as many times as necessary, with the changes recorded in the survey output file. Once environmental data are input, observation recording can begin. When a sighting is called out, the data recorder immediately registers the coordinates with a single keystroke on the computer, then switches to an observation input window (Figure 3). The initial observation input screen requests a sighting identification to be entered (species, vessel type, etc.). In the event of uncertain identification, a subroutine has recently been added that brings up “identification aid” menus, which call up aerial photographs of biological and cultural features, along with text descriptions to aid new observers in correctly identifying difficult sightings (e.g. differentiating fin whales from blue whales). Once identification has been made, a “sighting details” window appears, requesting a count if a sighting includes a group of attributes (such as a pod of dolphins), number of young, observer identification, and sighting angle (estimated by interval markings on the aircraft’s side windows). This procedure continues until the transect is complete. Most transects are flown focusing on one general data type (e.g., pinnipeds, or cetaceans, or vessels), however, the software allows for transects covering multiple data types, which can be shown as a single coverage or else parsed out into separate categories. Once a transect is complete, the data recorder exits the software, which writes a data file containing numerically encoded sighting records ready for import into a GIS.

Once the flight crew returns to CINMS headquarters, the day’s data are reviewed using a spreadsheet program. They are parsed as necessary and saved in DBF format. The DBF data are then imported into an ArcView 3.0a basemap

Figure 2. The environmental and observer identification entry screen of aerial survey software. Entries include (from upper left to lower right): weather, sea state, left observer, right observer, water color, water clarity, right observer, light conditions, sun glare angle, and data recorder.

Figure 3. Sighting identification entry screen.

as point attributes using the “add event theme” command. The new data are then viewed in combination with past mission data to analyze trends such as cetacean migration patterns over time and vessel distributions. Attributes are also viewed and analyzed across data types to find spatiotemporal relationships between attributes, such as urchin vessel locations relative to kelp beds. Maps of cetacean sightings are created on a monthly basis and posted on the CINMS web page as part of the Sanctuary’s public education program.

DISCUSSION

Example Analyses

The integration of the aerial survey data with the Sanctuary’s GIS program has been a tremendous aid in the visualization of spatial data within the CINMS administrative boundary. The ability to perform comparative analyses within the data types collected in the program, allows physical, biological, and anthropogenic trends to be explored.

Human activity data show some interesting trends in Sanctuary use. Mapping locations of recreational vessels versus commercial fishing (sea urchin) vessels (Figure 4) for instance, indicates a distinct spatial divergence of commercial and recreational vessel traffic. Urchin fishing vessels are concentrated around San Miguel Island, Santa Rosa Island, and the western portion of Santa Cruz Island. Recreational vessels are concentrated around eastern Santa Cruz Island and Anacapa Island. Explanations of this use pattern can be found by adapting push-pull analysis from the urban geography realm (Hartshorn 1992), comparing vessel data layers with historical layers of persistent kelp (a favorite food of urchins) and data on the predominant sea state in the Santa Barbara Channel. The relatively cooler, nutrient rich waters surrounding the northwest islands create a favorable environment for giant kelp, which prefers colder waters (Snyderman 1987). More kelp equals more urchins, creating a pull factor for urchin boats. Contributing to this divergence is the Point Conception wind shadow which creates an area of generally calmer water in the eastern Santa Barbara Channel (significant wave height may be 10 ft near San Miguel Island while only 3 ft near Anacapa Island at the same point in time). The relatively rougher waters of the western channel create a push factor, keeping smaller recreational boats in the calmer conditions of the eastern channel.

Program Status and Goals

The aerial program has been focusing predominately on cetacean sightings and vessel traffic within the Sanctuary. Though CINMS has collected nearly two years of weekly flight data, the database still needs to be increased substantially to create a statistically sound baseline sample set for accurate analysis and trend extrapolation (Shaw and Wheeler 1994). Some data in the current archive (such as those in Figure 4) seem to clearly represent trends. Other data (such as cetacean sightings) will require larger data sets to account for seasonality and climate anomalies, like the El Niño

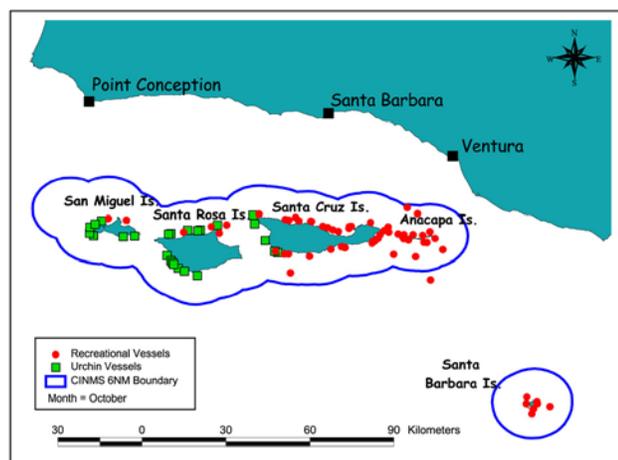


Figure 4. Distribution map of recreational vessels and commercial fishing (urchin) vessels.

Southern Oscillation (ENSO), which can affect biological presence within the Sanctuary.

The Sanctuary is also looking at new uses for the Aerial/GIS program. During the 1997-1998 ENSO event, we (in conjunction with Dr. Leal Mertes of the Department of Geography at the University of California, Santa Barbara) prototyped the program as a tool to map the perimeters of sediment plumes emanating from coastal watersheds. As these plumes often carry pollutants into the marine environment, the ability to quickly map their progress and extent in a GIS ready form can be an important analysis component in plume studies.

CINMS is also currently prototyping the Aerial/GIS program as a coastal oil spill response tool. The adaptability of the aerial survey software allows for the mapping of spill perimeters as multiple points that can be connected into a polygon via a GIS. It allows for input of oil types (e.g., light, heavy, tarballs) as well as oiled animals sighted within a spill perimeter. By mapping the spill in this manner, the collected data can be transferred from the aircraft via cellular phone directly to a GIS capable laptop at a Unified Command Center. This will allow for near realtime overlay mapping of a spill extent against environmentally sensitive data (Waltenberger et al. 1996) already stored in the GIS. The ability to rapidly map changes in spill extent and direction will support and enhance efficient resource protection in the event of a resource emergency.

CONCLUSION

Integrating our aerial survey and GIS programs has created a powerful tool for monitoring activity within the Sanctuary. The efficiency of the aircraft platform has greatly increased the Sanctuary's ability to collect data used to investigate, manage, and respond to events within our boundaries. Adapting the programs to monitor and track phenomena such as oil spills will further expand program usefulness in emergency response decision-making. As the database grows with time, it will allow more complex and statistically significant spatiotemporal analyses to be made.

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