GIS-Based Visualizations for the Cordell Bank National Marine Sanctuary

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ABSTRACT
NOAA's Cordell Bank Marine Sanctuary is a 526 square mile sanctuary located 50 miles northwest of San Francisco. As a part of a review of management plans for the Sanctuary, an extensive GIS has been created. To improve the ability of Sanctuary managers, scientists and the general public to understand the patterns and processes occurring at the Sanctuary, we have created a 3D virtual world with these datasets. The goal of this project is to enable users to visualize the Sanctuary as a three dimensional entity rather than as a series of two dimensional maps.

Introduction

The Cordell Bank National Marine Sanctuary (CBNMS) is located about 50 miles northwest of San Francisco. It is a 526 square mile sanctuary located to the north of the Gulf of the Farallones Sanctuary. The Sanctuary encompasses Cordell Bank - a pinnacle rising from the seafloor to within 120 feet of the sea surface - and the surrounding waters. Cordell Bank is a granitic block transported to the area by the San Andreas Fault. Since the Bank extends upwards into nutrient rich waters, it is densely populated and supports a unique and diverse ecosystem. The complexity of the Bank and its interactions with the surrounding waters has led Sanctuary managers to want a truly three-dimensional representation of the region. They envisage using such a visualization for management and outreach purposes. It will become a part of a larger biogeography of the Sanctuary.

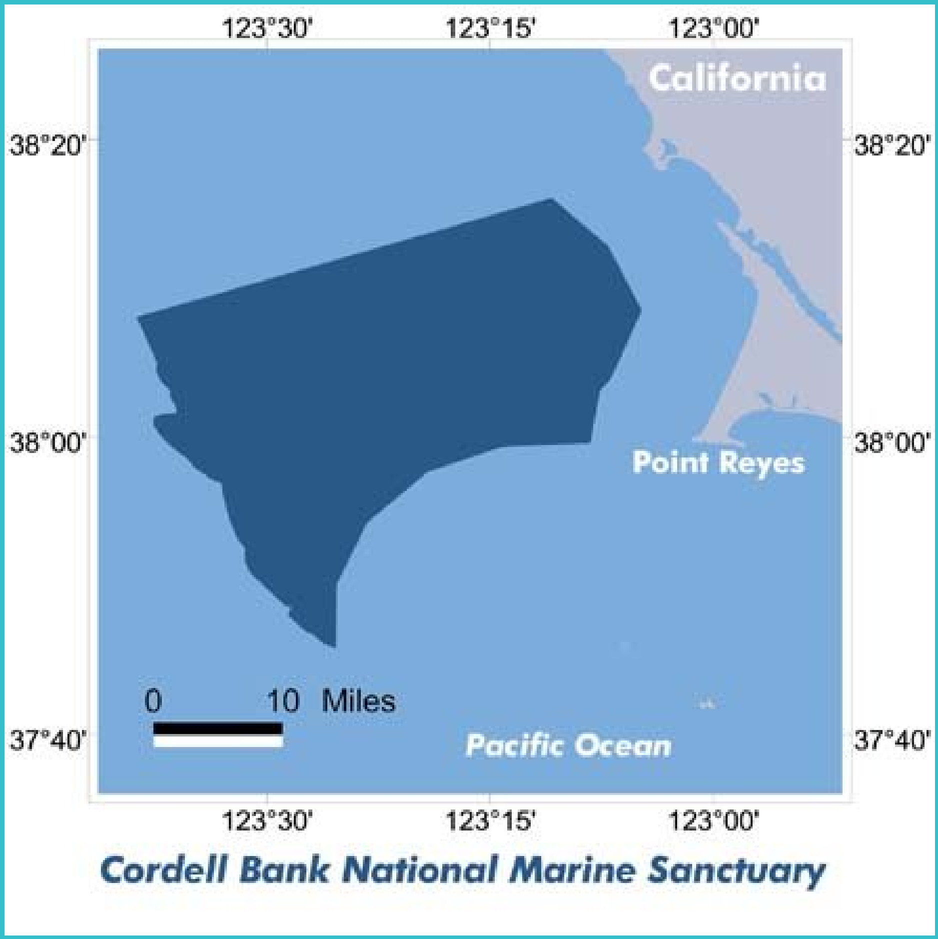


Figure 1. The Cordell Bank National Marine Sanctuary

Datasets

As a part of a review of management plans for the Sanctuary, an extensive GIS has been created. Data layers include bathymetry, topography, Sanctuary boundaries and coastlines, sea surface temperature (SST), conductivity-temperature-depth (CTD) data, bottom type, and hydroacoustic and other datasets for fish abundances. Bathymetry data are from NOS surveys and CTD data are from a variety of sources. Fish abundance data are from hydroacoustic and trawl surveys conducted by the Northwest and Alaska Fisheries Science Centers of NOAA. Bottom type data are from the USGS and university sources while SST data are from satellite images gathered by NOAA. Coastlines and boundaries are from the Sanctuary.

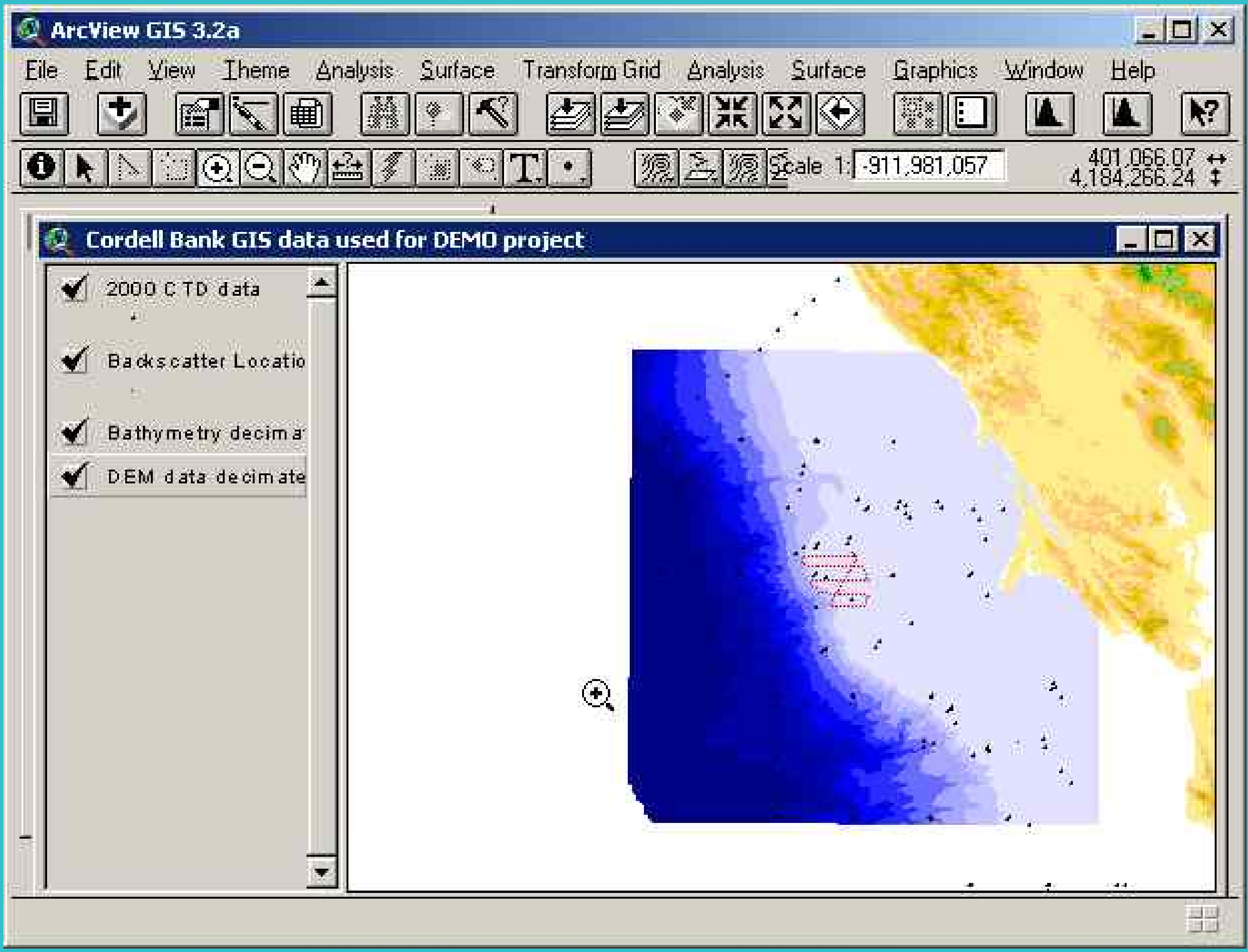


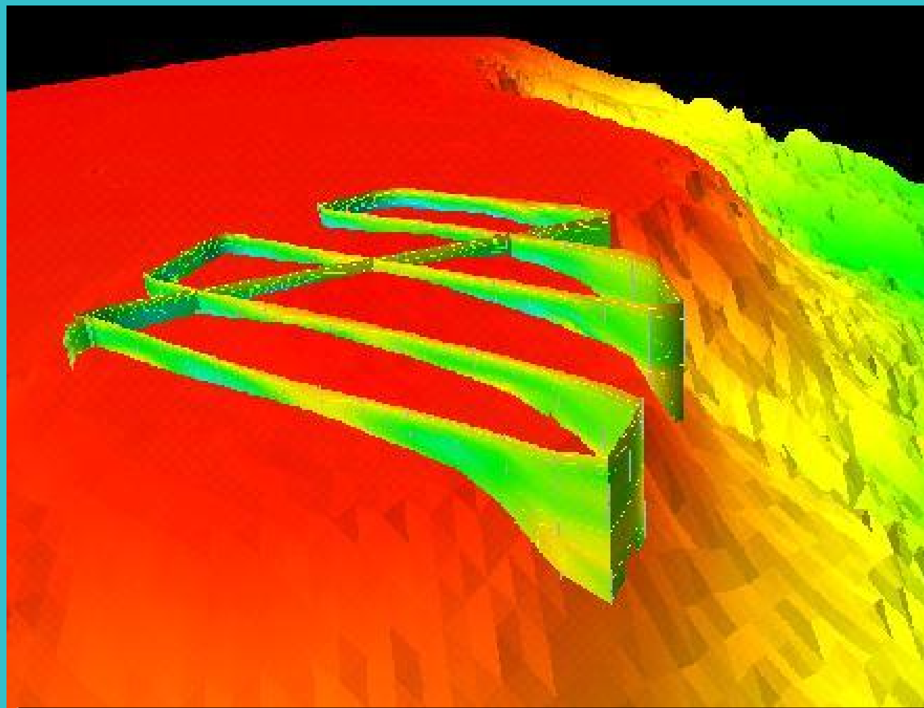
Figure 2. ArcView project containing various data layers used in the visualizations

Visualizations

To improve the ability of Sanctuary managers, scientists and the general public to understand the patterns and processes occurring at the Sanctuary, we have created a 3D virtual world with these datasets. For the visualizations in this project we have used a variety of packages to create VRML files that have been meshed to produce the final view. VRML was chosen for its flexibility, ease of transfer and for the viewing options it allows users. ArcView 3.2 has been used to create VRML files for the coastlines, shorelines, bottom type and the bathymetry. VRML scenes of Cordell Bank conditions were created in ArcView 3.2 and 3D Analyst by taking existing bathymetry, Digital Elevation Model (DEM) output, in-situ observations taken around Cordell Bank and marine sanctuary boundaries. We created 3D shapes out of the point data and draped the bathymetry and DEM data over gridded data that were assigned a realistic exaggeration factor. 3D scenes were exported either into VRML 2.0 by ArcView Spatial Analyst as full scenes with bathymetry, topography and in-situ data or as discrete pieces that were later edited using standard VRML editing routines. 3D Analyst and the new ArcScene provide the novice user the ability to change viewpoints, scale and horizons in the scene prior to exporting it into VRML.

CTech's EVS has been used to create files for the CTD data and the hydroacoustic data. Isosurfaces and vertical fenceline plots that were used to look at CTD transects and zooplankton abundance on and off Cordell Bank were created using EVS-Pro software package. Once the visualizations were created and scaled, EVS-PRO allows the user to export the scene to VRML2.0.

Fenceline visualizations, 3D temperature plumes and isosurfaces were exported individually and combined with the VRML output from ArcView's 3D Analyst to create the visualizations used by the Sanctuary managers.



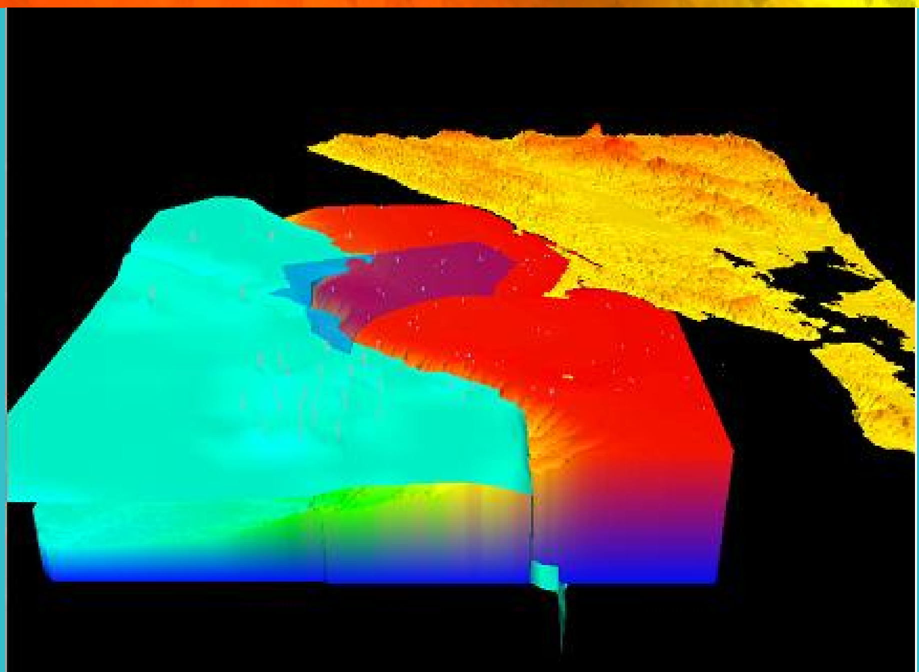


Figure3. Fenceline view of hydroacoustic data

Figure 4. Isosurfaces of water temperatures from CTD data

User Interface

The VRML content is navigated through an HTML page with an embedded VRML object and linked Java applet. The VRML object and Java applet communicate with one another through the External Authoring Interface (EAI). This allows the user to select different data representations (isosurfaces, color-coded contour slices, vector fields, etc.) for each data set. Data that are time-dependent are linked through the EAI as a Java-script embedded VRML object, with animation controls written in VRML2.0. The user loads the visualization into a VRML- and Java-aware web browser (Netscape or Internet Explorer), and is presented with coastline and bathymetry/topography data in the VRML window. The user has typical 3-D navigation control in the VRML window, and can load, view, and (in the case of time-dependent data), animate data as the scene is rotated and scaled. Simple radio-button choices are given for dataset choices, and animation controls appear as time-dependent data are loaded.

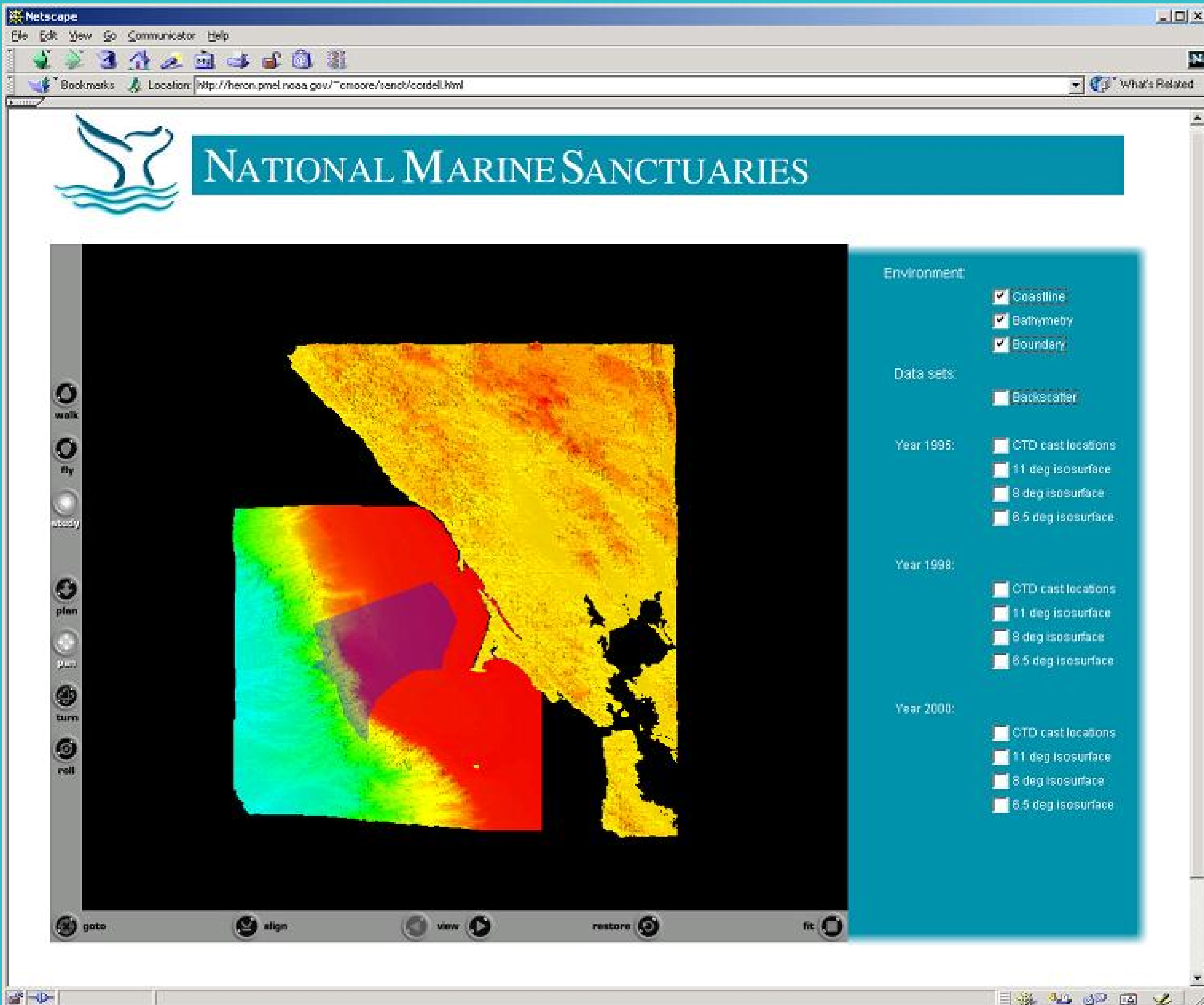


Figure 5. The user interface

Animating the VRML

Animation is controlled through the use of an external prototype node (see the VRML specification at http://www.web3d.org/fs_specifications.htm). This script node is served from our web site at http://www.pmel.noaa.gov/vrml/tools, and can be downloaded, modified, and embedded into the visualization if a free-standing package is needed.

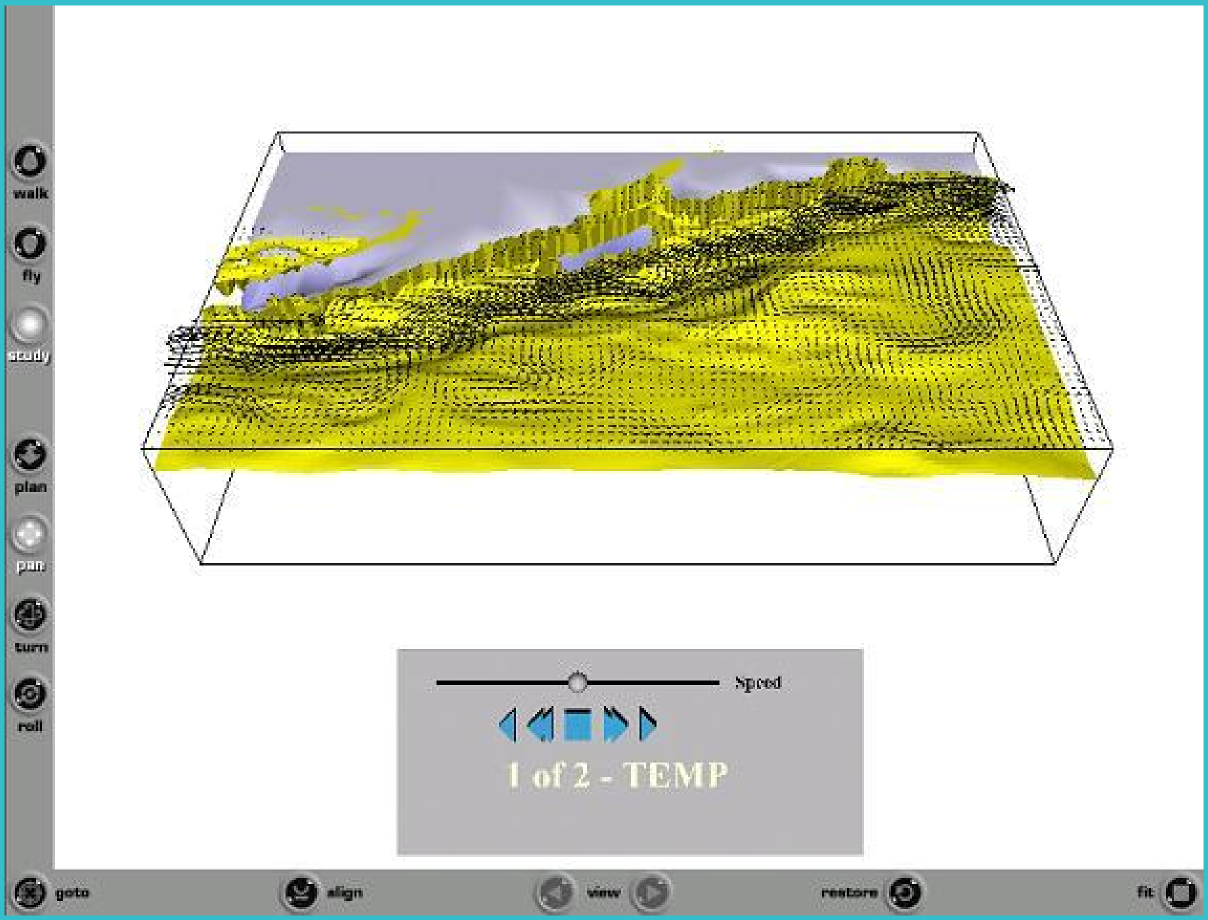


Figure 6. The animation interface

Future Directions

Currently the Cordell Bank visualization is created using the VRML standard External Authoring Interface (EAI). While VRML is an international standard, its use in the field of scientific visualization has been restricted to static VRML objects (isosurfaces, IndexedLineSets). Java3D is more extensible than the EAI, can integrate the static data (VRML) objects into a rendering environment, and can allow the user more control over animation, object manipulation, and data probing. As Java3D is an extension of Java, advantage can be gained by the huge codebase provided by community Java developers.

While Java3D was developed for 3D rendering in general, the field of scientific visualization has produced an Application Program Interface (API) based on Java3D specifically for creating applications to render science data. This API, called VisAD can read in VRML objects created by ESRI products, and render them in an applet or application giving complete rendering control to the user. Since Java3D is platform independent, a VisAD-based Cordell Bank application would run on everything from PC desktops and laptops to SGI and Sun workstations to Linux superclusters to full-featured immersive visualization systems like the ImmersaDesk, CAVE, and GeoWall. A VisAD-based Cordell Bank application could also take advantage of Java's Remote Method Invocation (RMI) framework to operate on two or more computers – a true collaborative product, allowing users to interact with the VRML objects and each other over a network. A collaborative-mode product would mean Cordell Bank managers could share a session with the scientists who collected the data, or a lay person could share a session with a friend.

A test application using RMI has already been coded to render model output from a remote Linux cluster. The VRML reader classes and GeoWall stereo rendering classes have been tested as well. A future Cordell Bank application using Java3D and the VisAD API while still using VRML objects created using ArcGIS and EVS could take advantage of these features, and the continued support of an active coding community.

Conclusions

Visualizations of spatially complicated datasets enable scientists and the general public to understand complex physical and biological processes. These visualizations provide important management and information tools for Sanctuary managers. These geo-visualizations are also becoming a way to disseminate the data as a coherent package. Standard GIS packages provide some tools for the generation of VRML-based visualizations. As PMEL has developed visualizations using VRML and other techniques such as animations, a number of tools and procedures and applications have been needed to create the visualizations. These tools have been developed on an ad hoc basis for specific projects. It has also become apparent that the lack of easy ways to create and modify visualizations has hindered the ability of less technically savvy groups to develop needed visualizations. Future work will continue to implement tools for easier generation of visualizations and the packaging of all the tools in a single GeoViz toolkit.

Acknowledgments

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References

For further details and to view sample visualizations please see http://plover.pmel.noaa.gov/Cordell/home.html

For more information about the NOAA Sanctuaries and Reserves Program, please visit the Sanctuaries homepage at http://www.sanctuaries.nos.noaa.gov/welcome.html

For more information about the Cordell Bank Sanctuary, please visit the Sanctuary homepage at http://www.sanctuaries.nos.noaa.gov/oms/omscordell/omscordell.html

For more information about the Pacific Marine Environmental Laboratory's visualization efforts, please visit the PMEL home page at http://www.pmel.noaa.gov/vrml/3DViz.html and http://www.pmel.noaa.gov/visualization/

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