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Visualization in Marine Science

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Introduction

Most marine scientists will have attended meetings or read papers where authors struggle to explain underlying processes hidden in vast, complex data sets originating from observations and/or models. These authors used a large number of graphs and displayed large tables to distil some meaningful characteristics, but all too often the reader is left puzzled or unconvinced. In part this reflects the spatial and temporal complexity of the marine environment. A range of data analysis techniques and models is required to identify and explain the diversity associated with physical, biological and chemical oceanographic processes. Interdisciplinary communication between physicists, chemists and biologists is complicated by the separate technical ' languages ' that have evolved in their disparate scientific developments. As a result, effective integration of their respective data sets is hindered and insight into their salient characteristics obscured.

Throughout the world marine and coastal ecosystems are under increasing pressure. The destruction of these environments is fastest in the tropics where mangroves and coral reefs are most threatened and presently being destroyed at an alarming rate, although as the paper by Shalovenkov shows, some temperate regions like the Black Sea have been degraded as a result of benign neglect. Sound management of these resources requires integrated knowledge of the ecosystem and unencumbered communication among oceanographers, biologists, chemists and marine resource managers. By facilitating the exchange of information computer visualisation is able to help in the management for sustainable exploitation of marine resources.

This issue of *Estuarine, Coastal and Shelf Science* demonstrates that computer visualization offers a technique to explore complex data sets and readily extract processes or pertinent data. It also demonstrates that computer visualization enables the interaction between scientists of different disciplines and promotes further integration of the different data sets. Examples are given of the use of computer visualization in various applications.

Coastal and estuarine flows are naturally very complex, patchy and unsteady if not chaotic. Shalovenkov animates satellite temperature data and ship-born turbidity data to make obvious this chaotic behaviour for the Black Sea; classical mean flows concepts are not apparent in this chaos. The animations illustrate how the waters mix but do not flush, hence pollutants accumulate. Suzuki and Matsuyama use visualisation to demonstrate the complex 3-D flows in Tokyo Bay under realistic wind forcing, and the difficulty in verifying models for unsteady flows. Wolanski and Spagnol use visualization of field data to demonstrate how, by

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generating a chaotic flow field at spring tides, a matrix of reefs diverts a prevailing net current at spring but not at neap tides. Furukawa observes a patchy distribution of salinity and plankton in shallow waters in Ise Bay, Japan, and relies on animations of model data to explain this patchiness from the shedding of eddies by a headland.

Water quality in coastal waters also shows great patchiness in time and space and this is quantified by Boyer *et al.* using visualization for Florida Bay and SW Florida shelf, U.S.A.

Visualization is also a powerful tool to explain model output and compare it with field data. This is a difficult task when both model and observations shows great patchiness in time and space. Formal algorithms may not be available for such a comparison. Instead authors rely on animations to visually compare observations with model output. Schwab *et al.* compare coastal observed and modelled coastal turbidity plumes in Lake Michigan, U.S.A. Signell *et al.* rely on visualization to quantify the spatial and temporal signature of a sewage plume in Boston Harbor, U.S.A. He and Hamblin evaluate the exchange of water between Hamilton Harbour and Lake Ontario, Canada. These three papers suggest that models underestimate the natural variability and patchiness, thereby opening an important new field of research. Takahashi *et al.* use stunning visualization to show the 3-D movement of anoxic bottom waters in Osaka Bay, Japan. Wolanski *et al.* demonstrate, through visualization, the importance of the spring-neap tide cycle in the flushing of pollutants from a mangrove-fringed estuary in Port Douglas, Australia. Yassuda *et al.* model the relationship between pollution sources and water quality conditions in Charleston Harbor estuary, U.S.A. This information is made explicit by visualization and is readily accessible, and used, by management.

Visualization is also an important tool in marine biology. Micro-video is used by Erard-Le-Denn *et al.* to identify, and elucidate the life cycle of, parasites of toxic red tide phytoplankton. Protist taxonomists require observations not only of fixed cells but also of living organisms. This information can only be stored and published through multimedia techniques. Micro-video is also used by Fabricius and Wolanski to visually demonstrate how mud aggregated on marine snow in coastal water is lethal to coral organisms while in oligotrophic water, at the same concentrations the mud has little impact on the corals. These findings have profound implications for coastal management. Gorsky *et al.* also used video clips from a plankton camera to demonstrate and quantify the prevalence of marine snow and zooplankton, and its role in the ecosystem, in Norwegian fjords and in north Mediterranean waters.

Visualization also helps to quantify and understand geomorphologic changes. Smith *et al.* combine historical charts, aerial observations and remote-sensing to quantify through animation the coastal dynamics at Scolt Head Island, England. Finally Trouw *et al.* animate model predictions of sand movement under waves over a rippled bed. The dynamics show great spatial and temporal variability which is made readily understandable by computer animation.

Each of these papers show how computer visualization opens new and promising ways to process, present, explore and explain complex processes in marine science. The usefulness of this new technology to marine science has been demonstrated. The technology is here to stay.

CD-ROM

We have tried, to make the CD as portable as possible. All animations are encoded in AVI format using either Cinepak compression or Intel Indeo compression (no audio track).

Make sure you have at least version 3.0 of Navigator or Internet Explorer. The latest versions of these browsers for a variety of architectures can be downloaded from *Netscape* (http://home.netscape.com) or *Microsoft* (http://www.microsoft.com) respectively.

Cinepak

For Windows 95 users, the following steps will enable you to check if you have the Cinepak video codec installed:

1. Access *Add/Remove Programs* in the *Control Panel.*
2. Access *Windows Setup* tab.
3. View details of the *Multimedia* entry.
4. Check if the *Video Compression* component is installed. If it is not please do so.

Intel Indeo

For Windows 95/98/NT and MacOS you can download the Indeo Codec from the *Intel Indeo* (http://developer.intel.com/ial/indeo) site.

Navigator/Internet Explorer on Windows 95/98/NT and MacOS

- Netscape: Assuming your plugin works the left mouse button will play/pause the animation, and the right mouse button brings up the options menu.

- Internet Explorer: Assuming your plugins are working and the page with the animation still appears blank, there are two options you need to check.
  1. Choose menu *View/Options*. Click on the *General tab*. Are the ‘ *Show pictures* ’ and ‘ Play videos ’ options on?
  2. From the *View/Options* dialog box choose the *Security tab*. turn on the ‘ *Enable ActiveX controls and plug-ins* ’ and ‘ *Run ActiveX scripts* ’ entries.

UNIX

For UNIX based operating systems the situation is a little more complicated. First check if your vendor supply multimedia programs capable of playing AVI animations.

Xanim can be used but the Cinepak codec is only available for certain architectures. Please check out the *Xanim home page* (http://smurfland.cit.buffalo.edu/xanim/home.html).

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