Beginning with the *Challenger*

Steven M. Perry and Daphne G. Fautin

The mission of the three-and-a-half-year *Challenger* Expedition (1872–76) was to confirm the existence of deep-sea life and to document it. During a voyage of 79 300 miles, the six staff scientists on board, under the direction of Wyville Thomson, took depth soundings and measured water temperature, salinity and density at 504 stations across the world (Fig. 1). At 277 of these stations, marine life was sampled with the use of dredges or trawls. The *Challenger* Expedition is credited with discovering more than 4 700 new species.

Published during 1880–95 under the direction of John Murray, the fifty-volume *Report on the Scientific Results of the Voyage of the HMS Challenger* meticulously documented and indexed the scientific findings of the Expedition. Because these were collected into a single, well organized resource that was available to scientists in a broad range of physical and biological sciences, it helped to spur interest in further expeditions and stimulated research in oceanography. It has been said that it was the *Report*, rather than the cruise itself, that provided the foundation for the new science of oceanography.

In its pioneering examination of the global distribution of marine species, the *Challenger* Expedition helped to disprove the hypothesis that the deep ocean was devoid of marine life because of high pressures and lack of light. The information we continue to gather about the distribution of marine species allows scientists to understand patterns of biodiversity, providing insight into the evolution, dispersal, and extinction of species.

The process of collecting distributional data for plants and animals has been boosted greatly by electronic tools, which have allowed the creation of large repositories called biogeographic information systems. Such systems, holding geo-referenced observations of accurately identified organisms, are used by scientists to formulate hypotheses on systematics, evolutionary processes, and the health of ecosystems. Many of these hypotheses concern the interaction of organisms with their environment, and databases containing species observations can usefully be linked to those providing environmental information.

Biogeoinformatics of Hexacorals

'Biogeoinformatics of Hexacorals' (http://www.kgs.ku.edu/Hexacoral/) is such a database; it is served by the Kansas Geological Survey at the University of Kansas, Lawrence, Kansas. Its biological component, Hexacorallians of the World (HoW) (http:/hercules.kgs.ku.edu/hexacoral/anemone2/index.cfm), aggregates data on sea-anemones, corals, and their allies. Its environmental component provides oceanographic data such as salinity, chlorophyll concentration, sea-surface temperature and depth.

To guarantee high quality and auditability of information, each species observation in HoW provides the bibliographic reference to the article in which the observation was initially published. Many of the specimen observations are tied to museum holdings, and a user can search the database for bibliographic data including publication, author, or museum, and for images from the original publication and previously unpublished images of type specimens. HoW also contains detailed taxonomic information for each family, genus, and species. In addition to the basic functionality of allowing a search by current valid taxonomic names, most species records are tied to a comprehensive synonymy that lists all names used for the species and references to the publications in which they appeared. There are also common names for some species.

While detailed taxonomic and bibliographic information for each species makes HoW a useful tool for tracking down all the literature associated with a species, its power as a biogeoinformatics system is apparent when examining species distributions. A user can search for species records by locality in a variety of ways. All the occurrences of a species can be plotted on a world map. Alternatively, a search can be for all the species occurring in a geographical area – by the name of a place, including countries as defined by their Exclusive Economic Zone (EEZ), by Longhurst Biogeographic Region, and by Large Marine Ecosystem (LME). Because HoW is tied to a back-end GIS (Geographic Information System) and is integrated with ArcIMS (Arc Internet Map Server), species records can also be searched for using interactive, clickable maps, including maps of the EEZ, Longhurst regions, LMEs, or areas delimited by rectangles drawn on a map.

Many of the species records in the database are from oceanographic expeditions. HoW therefore also

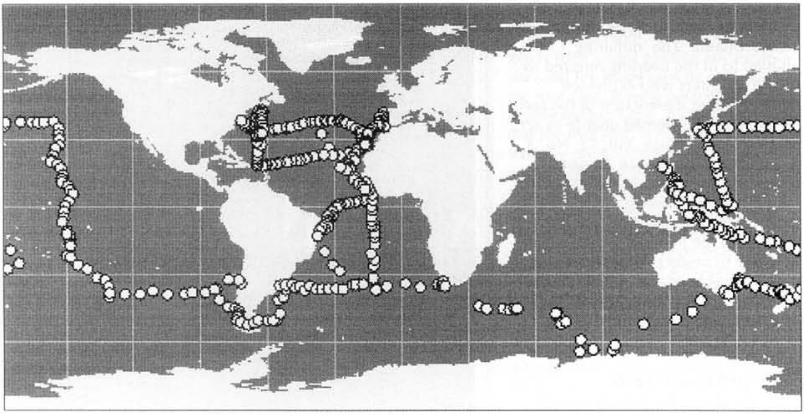

Figure 1 *Map of the 504* Challenger *Expedition stations generated by 'Hexacorallians* of the World'. Clicking on any point will display the data for that station (see Fig. 2).*

*Hexacorallians are members of cnidarian orders Actiniaria, Antipatharia, Ceriantharia, Corallimorpharia, Scleractinia, and Zoanthidea.

Expedition : Challenger Expedition 1873-1876		
Details for station 293		
From Expedition Report	**Chart title:** Tahiti to Valparaiso **This station occurs on chart(s):** 38 **Verbatim date:** November 1, 1875 **Start date:** 1875-11-01 **Latitude:** -38.93 **Longitude:** -104.92 **Depth:** 2025 **Depth units:** fathoms **Depth description:** **Bottom nature:** Globigerina ooze.	**Temperature surface:** 53.7 **Temperature bottom:** 34.4 **Temperature serial:** Y **Specific gravity surface:** 1.02522 **Specific gravity bottom:** 1.02573 **Sounding:** 438 **Method:** Trawled **Tools used:**
Environmental Data	• Environmental Summary • Time series Sea Surface Temperature One-degree weekly Reynolds SST Two-degree monthly Reynolds SST One-degree monthly Hadley SST	
Specimens	• 1 Specimen Observations	

Figure 2 *Information for station 293 in HoW.*

allows searching by expedition. To develop the prototype of the 'search by expedition' functionality, we entered into the database data on latitude, longitude, depth, date, gear, temperature and salinity for all *Challenger* stations (Fig. 2) and linked them to an interactive, clickable map. A user can view the track of the *Challenger* Expedition, and by clicking on a particular station can view a comprehensive record of all the hexacoral specimens that were collected at that station. We also display the expedition charts as published in the *Challenger Report*, and these, too, can be viewed on an interactive world map. We are now adding datasets for many more expeditions.

Census of Marine Life and OBIS

HoW is one of a growing number of biogeographic information systems that aggregate information on marine species. Others include FishBase (http://www.fishbase.org), which covers marine and brackish-water fishes, and CephBase (http://www.cephbase.org), for cephalopods (octopuses and squid). Until recently, scientists who were interested in studying the diversity and distribution of marine life would have to search many books and tediously analyze all the information they contain. More recently, they would have to search multiple databases. Either way, large-scale studies were difficult, because of the expense of data discovery, collection, and analysis.

OBIS, the Ocean Biogeographic Information System (http://www.iobis.org) was developed to facilitate the study of large-scale marine biodiversity. It acts as the data repository for the Census of Marine Life (http://www.coml.org), a global network of marine scientists in nearly 50 countries engaged in a 10-year initiative to assess and explain the diversity, distribution, and abundance of marine life and how it changes over time.

OBIS is an international effort to draw together accurately identified, geo-referenced information on marine animals and plants and serve that information through a single, searchable, on-line interface. It provides a user with query tools for searching one or more of its data-providers simultaneously by variables such as taxon, location, depth, and date of specimen collection, plus various environmental parameters. The results can be visualized by a variety of mapping and data modelling services. Because the results of an OBIS query are specimen observations that are taxonomically and geographically resolved, the OBIS mapping and data-modelling tools allow a user to examine species in the context of their environments using physical, chemical and biological oceanographic data (cf. Fig. 3).

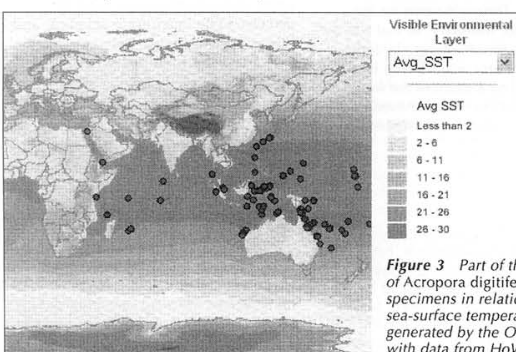

Figure 3 *Part of the global map of* Acropora digitifera *coral specimens in relation to average sea-surface temperature, generated by the OBIS mapper with data from HoW.*

While OBIS allows searches of species occurrences across multiple databases, it is not itself a database. Instead, when someone uses the OBIS query system, member databases are queried, and the information is put in a common format. The databases that serve data to OBIS do not all contain the same type of information in the same format; they are simply able to communicate with OBIS in a common protocol or language. This allows the proprietors of each database the freedom to structure data in the way they find most useful, as long as their system supports the OBIS schema. For instance, the earliest version of HoW was created mainly as a tool for taxonomists and therefore it includes a great deal of information on scientific names, their synonymies, and bibliographic sources. Other marine life databases began as collections of specimen photographs, and some are repositories for museum collection information. However, as long as each can provide well identified, geo-referenced species observations, it can provide data to OBIS.

Challenger Stations On-Line

The first 48 volumes of the *Challenger Report* are much like individual biogeographic information systems because most volumes contain one or more chapters on a subset of related species – such as the corals or the cephalopods. However, the final two volumes of the *Challenger Report* provide a list of species collected at each station. Indexes across species observations by geographical location are very valuable to scientists studying biodiversity, but they are unusual for expedition reports, probably because they require a great deal of tracking and cross-referencing.

The general practice for a marine expedition on which a large number of specimens are collected is for the specimens to be shipped to experts around the world for identification, and for the experts to publish their results in peer-reviewed journals. For some expeditions (e.g. *Challenger)*, taxonomic experts publish their results in a series devoted to the expedition so at least the information is in one place; for others, the results are published in a variety of outlets. However, because those who identify specimens are typically experts in only a few taxa, each publication focusses on a particular taxon, so it is difficult to get a comprehensive picture of the species that might inhabit each place sampled, and so get a sense of the ecology. HoW used the final two volumes of the *Challenger Report* as a model for a system to query marine biogeographic information systems by station. Now it is possible to find, through HoW, which hexacoral species were collected at which *Challenger* stations. With the station data for the *Challenger* Expedition now on line, we are working on the station data for other expeditions.

We hope that, in the future, other marine biogeographic information systems will contain specimen observations tied not only to locality, but also to the expedition and station where the specimen was collected. Those developing such databases need not go through the keyboarding we did to capture the locality and physical attributes for each *Challenger* station (data that are available for download from the HoW website). Nor is it necessary for those data to be incorporated into another database: records for cephalopods collected on the *Challenger* Expedition were entered into CephBase, along with the *Challenger* station number for each, but the details for a station can be obtained by CephBase from HoW through an interactive link. This, too, is a prototype for what we envision will be a service of OBIS: OBIS will have all expedition data and charts, so that any dataset served through the OBIS portal could be searched for records from any expedition station. So a trawl full of deep-sea animals that had been dispersed to taxonomists around the world could be reconstituted virtually, enabling us to know not only where *Challenger* collected (say) sea anemones, but also what shrimps, sea stars, flatworms, etc. lived in the same place as the anemones, thereby providing important ecological information about each site sampled as well as information on individual species.

Acknowledgments

Development of HoW has been funded largely by US NSF grants DEB95-21819 and DEB99-78106 in the Partnerships to Enhance Expertise in Taxonomy program, and supplements in the Research Experience for Undergraduates program. Additional funding was provided by US NSF grant OCE00-03970 in the National Oceanographic Partnership Program. The Challenger Project was funded by a grant from the University of Kansas as part of the Digital Library Initiatives.

Steven Perry and **Daphne Fautin** are at the Dept of Ecology and Evolutionary Biology, and the Natural History and Biodiversity Research Center, University of Kansas (Emails: smperry@ku.edu and fautin@ku.edu)

Concrete boats

The raising of a quizzical eyebrow was suggested by the 'sic' that followed 'concrete' in 'Now, there's a funny thing ...' in the last issue of *Ocean Challenge* concerning the creation of offshore cities using concrete tanks for buoyancy. In fact ferro-cement boats were patented by the French in 1855 and they remain one of the most favoured methods for the amateur construction of boats that are more than 25 feet long. The technique is particularly popular in Britain where craft constructed in this manner are referred to as 'concrete' boats. The method involves building a frame for the hull from steel rods and tubes which are bent to shape to form the ribs and stringers and then covered by several layers of wire netting. The netting is held to the steel frame using twists of wire and is built up in layers until it reaches a thickness of a few inches. Then a team of labourers and some skilful plasterers coat the hull with cement (which must be accomplished in a single day) and allow it to dry slowly in a controlled manner over several days to avoid cracking. (I speak from experience. I was one of the labourers when a friend built a 38ft-long sailing boat in 1972. May I never push as many wheelbarrow-fulls of cement across a garden in a single day ever again.)

Concrete floating structures played a central role in the D-Day landings during the Second World War. Two artificial harbours were created by towing concrete barges across the English Channel to form breakwaters and docks for the British and American forces at Omaha Beach and Arromanche. The code name for the secret plan was 'Mulberry' so that was the name given to the structures. Unfortunately the mulberry near Omaha Beach was destroyed by a storm in the week after D-Day but the other survived and was in constant use by both forces for several months.

Alan Elliott
Menai Bridge

Well, I had (sort of) heard of concrete ships built during World War II, but had forgotten. Your letter provides a fascinating summary of how concrete can be excellent for ship-bulding, and of course it can provide suitable 'floats' for any offshore housing planned in future years.
John Wright

Fishermen are not pests

I hesitate a little to write, but thought I should voice a note of concern. I always read *Ocean Challenge* avidly, and think it has come along greatly from its origins. However, I am worried by some of the 'editorial' that appears under News and Views. In the last issue (Vol.12, No.3), under 'Iceland to save cod by culling whales', you have the phrase 'Fishermen see seals and whales as pests, but from the point of view of the marine environment the real pests are the fishermen themselves ...'

I think this is a bit strong. *Ocean Challenge* should reflect objective science, not personal feelings. Many organizations work very hard to include 'stakeholders', such as fishermen (or more correctly fishers) in discussions concerning marine science. While we personally may hold opinions as members of society, as scientists shouldn't we restrict public comments to scientific aspects of ecological impacts of the fishing industry, rather than labelling fishermen as 'pests'?

I have seen the personal effort and concern with which scientists from this institute enter into long, protracted, heated and stressful negotiations with fishermen, trying to explain the science behind stock assessment and the ecosystem approach. Our colleagues deserve our support in their attempts to reach out to the fishing community, and do not need the misunderstanding that could be caused by ill-judged comments. As happened in Canada, fishing communities in north-eastern Scotland are coming under pressure because of what they perceive to be inaccurate science, and things are very tense between scientists and fishermen just now.

You are in danger of opening up *Ocean Challenge*, and the Challenger Society, to criticism from an industry that feels itself under attack from scientists. You may also anger fishery scientists who perceive academia and the physical sciences as naive in terms of how to deal with the fishing industry. As a member of the Society of 20 years standing (and formerly on the Editorial Board), I believe we need to be more objective in publications such as the magazine, and News & Views should stick more clearly to science issues. Please do not turn *Ocean Challenge* into an opinion-led magazine,