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Ocean Exploration : A Guide to Information Resources

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An overview and selective guide to the literature of ocean exploration is provided for reference, research and collection development purposes. Books, encyclopedias, bibliographies, databases and websites are identified and described. Both historical background and current information on the subject are covered.

KEYWORDS deep sea exploration, scientific expeditions, oceanographic research, marine science information

Running title : Ocean Exploration Information Resources

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The aim of this article is to provide an overview and a selective guide to the literature of ocean exploration as a starting point for reference, research and collection development. The topic is both of historical and current interest. For about two hundred and fifty years ocean exploring expeditions were sent out by European countries and by the United States to find new territory and to promote commercial and political interests. Unfamiliar waters were charted, biological specimens were collected, sea water samples were obtained and meteorological observations were made. These scientific activities were a sideline to the nationalistic purposes of the expeditions in the early nineteenth century, but by the late nineteenth and early twentieth centuries had culminated in the publication of multi-volume works reporting the results of ocean expeditions. These works contain the first identification of many new species of marine life and are beautifully illustrated by artists who were aboard the ships.

These historical works, such as the fifty volume British Challenger Expedition report, lay the framework for modern day ocean exploration. Because the ocean covers approximately seventy per cent of the earth's surface, its constantly changing environment impacts many human activities. Climate is regulated by the ocean, food is provided, oil and gas resources are obtained and pharmaceuticals are developed from marine plants and animals. Oceanographers have continued to advance the biological, chemical, physical and geological knowledge of the oceans through systematic investigation and documentation. Ocean exploration is international in scope, requiring the pooled resources of national governments and international scientific organizations. Computer-generated data sets can now be viewed online in real time and

remotely controlled submersibles are replacing older methods of on-site scientific collection as the field of marine robotics develops. A wide range of journals report the results of oceanographic research based on the exploration of newly discovered habitats, such as hydrothermal vents; increased knowledge of the ocean floor aids in the prediction of earthquakes and tsunamis; exploration of deep-water habitats may uncover sources of new drugs.

Ocean exploration is broadly interpreted here as scientific, as well as geographical discovery. The similarities and differences between ocean exploration and scientific research are outlined in a National Research Council Report which proposes a long-term effort to finance United States ocean exploration (*Exploration* 2003, 3-5). Books, encyclopedias, bibliographies, databases, websites and the collections of university libraries and marine research institutions are included. (A separate list of websites is provided at the end of this article). Information varies in level from that of the general reader to the specialized user. These works are appropriate for both undergraduate and research level collections. Authors have scientific backgrounds and their books are widely held in OCLC-member academic libraries. Favorable reviews appear in *Choice*, *Library Journal* and *New York Times Book Review*. Many titles are repeatedly cited in the bibliographies mentioned below.

Books

A good starting point for both the researcher and collection development librarian is Wust's authoritative article (Wust 1964). It is a review article written for the non-specialist that provides a chronological framework for the topic of ocean exploration by dividing its history

into four eras : the era of exploration (1873-1914); the era of national and dynamic ocean surveys (1925-1940); the period of new marine geological, geophysical, biological and physical methods (1947-1956); and the era of international research cooperation (since 1957). He notes that the progress of oceanography “depends on the results of the great oceanic expeditions, i.e. on the research work at sea, and the interpretation of data” (Wust 1964, 3). Extensive appendices include the literature on deep-sea research and its history, including expedition reports and selected journal articles; a list of deep-sea research vessels from 1873-1960; and charts of routes of twenty major deep-sea expeditions.

An overview of the history of oceanography is provided by Schlee. Starting with the early nineteenth century, the achievements of expeditions financed by the U.S., Britain, France, Germany and the Scandinavian countries are presented. The importance of the Challenger Expedition of Great Britain (1872-1876) which resulted in a 50 volume report, is emphasized. A 15 page bibliography is included (Schlee 1973). Similarly, Guberlet presents an historical summary of the important exploring expeditions, including the deep-sea diving vessels of Beebe and Cousteau (Guberlet 1964). Margaret Deacon covers the ancient world, Middle Ages, and Renaissance as background to seventeenth century ocean investigations. An excellent eighteen page bibliography of primary and secondary sources, lists of ships and expeditions, books and journal articles is included (Deacon 1997). In her later work, the influence of the Challenger Expedition on the subsequent development of marine science is examined in contributed chapters which cover the present status of scientific knowledge on the exploration of the sea floor, hydrothermal activity at mid-ocean ridges, ocean circulation, sea water composition and deep-sea biology (Deacon et al. 2001). Although the Challenger Reports are not yet fully

accessible online, a digitization project is underway at the University of Kansas Libraries, and some images, charts and maps are currently available (University of Kansas Digital Library Initiative). A listing of the botanical and zoological reports arranged in systematic order appears at the website 19thcenturyscience.org (Library of 19th century science).

Books focusing on the expeditions mounted by individual countries include Torben Wolff's work which has a bibliography of books and articles on Danish marine research expeditions (Wolff 1967). *Spanish Scientists in the New World* follows expeditions along the west coast of Africa, the Caribbean and coastal areas of South America, many of which included scientific illustrators and mapmakers (Engstrand 1981). Spanish scientific reports went unpublished for the most part however, due to political upheavals and invasions, and were later found scattered in Spanish archives. The achievements of expeditions financed by the U. S. Navy in the nineteenth century are outlined by Ponko (Ponko 1974). Navy ships were used to advance commercial as well as scientific interests, such as collection of data and specimens, and charting of the ocean floor. Towards the end of the century the fuel requirements of steam-powered ships made voyages more expensive for the Navy to finance. Extensive notes and a bibliography of primary and secondary sources are included.

Several examples of the extensive literature on exploration in specific ocean regions are noted here. Schlee describes the deep-water research vessel *Atlantis* built in 1931 specifically for investigations in the North Atlantic by researchers at Woods Hole Oceanographic Institution (Schlee 1978). *Atlantis'* work on acoustic measurements for the detection of enemy submarines, and the collection of geophysical data for precise bathymetric charts was financed by the Navy. Also focusing on Atlantic Ocean oceanography, Winchester describes the findings

of expeditions from the sixteenth century through the present, as well as the founding of major oceanographic research institutions (Winchester 2010). Russian, German, Danish and U.S. expeditions in the Pacific Ocean from the seventeenth century to the present are covered by Benson and Rehbock. (Benson and Rehbock 2002). Extensive notes and bibliographic references are included.

Polar oceanographic explorations remain an area of general interest. In *Extremes : Oceanography's Adventure at the Poles*, contributed papers interweave scientific findings such as polar marine botany, sea ice research and ocean currents and the national ambitions of various nations in the Arctic and Antarctic (Benson and Rozwadowski 2007). Larson focuses on British Antarctic exploration describing the expeditions of Scott and Shackleton with their attendant physical hardships as well as their scientific findings. Extensive bibliographical notes for each chapter serve as a guide for research in this field (Larson 2011).

Held at irregular intervals, International Congresses on the History of Oceanography have issued publications of contributed papers on various aspects of oceanographic exploration. The Third Congress in 1980 includes articles on the role of instruments in the development of physical oceanography, the first deep ocean drilling, the development of marine chemistry until 1900 and marine industrial pollution (Sears and Meriman 1980).

During the 1960's and 1970's, deep sea diving in manned submersibles extended scientific boundaries and marine archaeological knowledge. Expeditions led by Jacques-Yves Cousteau and others are chronicled in *World Beneath the Sea* (World 1973), which includes an historical overview beginning with man's earliest efforts at ocean exploration. Bibliographical references and a detailed index are included. A U.S. Navy project, Sealab, demonstrated man's ability to

inhabit and explore the depths of the sea (Hellwarth 2011). Today, however, the development of remotely operated underwater vehicles has resulted both in eliminating human risk and reducing expense. A chapter on “Enabling Discovery,” published by the Ocean Studies Board of the National Academy of Sciences summarizes current work on various types of unoccupied vehicles. It emphasizes the need for increased funding so that remotely operated submersibles that can reach greater depths can be further developed (National Academy of Sciences 2009). Concentrating on the dramatic advances of the twentieth century, Kunzig treats such topics as seafloor spreading, plate tectonics and bioluminescence. The pioneering work of Robert Ballard includes discovery of hydrothermal vents and their unusual life forms in 1977, the remains of U.S. nuclear submarine *Thresher* in 1984 and of the RMS *Titanic* in 1985 via both manned and unmanned vehicles (Ballard 1995). A pioneer in the field of archaeological oceanography, active in public education and outreach, Ballard is now the Director of the Inner Space Center at the University of Rhode Island Graduate School of Oceanography. This facility transmits live data, audio and video feeds from research vessels accessible both to researchers and the general public (http://www.gso.uri.edu/files/u258/GSO_Profile11-18-11.pdf). The physical oceanographer, Walter Munk, reminisces about his work on ocean waves, currents, tides, tsunamis and ocean acoustic tomography in an oral history covering seven decades of ocean exploration (Storch 2010). Munk is Professor Emeritus of Geophysics at Scripps Institution of Oceanography, La Jolla, California.

Links to new books acquired by ten marine science libraries in the US and other countries are available at the website of the International Association of Marine Science Libraries and Information Centers (<http://www.iamslc.org/publications/new-book-lists>).

Encyclopedias

Hamilton's two volume encyclopedia is an indispensable basic reference for the subject area of marine exploration. Brief alphabetically arranged entries, short sidebars of background information, lists of recommended sources, and longer topical articles are among its features. Strong on biographical information, the encyclopedia includes a list of web sites and a detailed index (Hamilton 2011).

Other encyclopedias cover the entire field of oceanography. Ellis' work serves as a useful one volume reference source (Ellis 2000) , while *Encyclopedia of Ocean Sciences* is a six volume compendium with numerous contributions on the results of oceanographic expeditions (Steele et al. 2001). *Interdisciplinary Encyclopedia of Marine Sciences*, a three volume work. includes a directory of research institutions and centers, as well as lists of suggested readings and pertinent websites accompanying many articles (Nybakken et al. 2003).

Bibliographies

The literature of deep-sea research presented by Wust (Wust 1964) is extended by several other bibliographies and lists of oceanographic expeditions. Estok and Boykin include reports of oceanographic, hydrographic and polar expeditions, as well as related secondary sources held by 26 academic and research libraries (Estok and Boykin 1976). A comprehensive list of names of oceanographic expeditions and research vessels has been compiled at the Scripps Institution of Oceanography (Helms 1977). An index to ships and expeditions involved in marine exploration from the 18th to mid 20th centuries was compiled at the University of Washington

(Selected 1972). The holdings of the library of the New Zealand Oceanographic Institute are found in Maciver's bibliography (Maciver 1979). An index to 19th century reports of explorations printed in United States government documents was compiled in 1899 and reprinted in 1969 (Hasse 1899). *A Handlist of Source Books on the History of Oceanography* is an unannotated list which includes basic texts, symposium and congress proceedings, biographies, and articles and books on research institutions (Mills 2000). Additionally, the bibliographies included in many of the books cited above are helpful resources.

Databases and Websites

Specialized databases providing access to research in scholarly journals are available primarily through institutional subscriptions and must be accessed through library catalogs or library web pages. Two comprehensive sources are *Aquatic Sciences and Fisheries Abstracts*, and *Oceanic Abstracts*.

To access free databases of government-funded research, <http://www.science.gov> serves as a link to all U.S. government scientific and technical websites. These include the National Sea Grant Library, and the U.S. Environmental Protection Agency's *Science Inventory*. (<http://www.epa.gov/si>). *Avano*, a search engine offering free and full-text access to marine and aquatic sciences resources, as well as other scientific fields, includes links to the archives of many oceanographic research institutions (*Avano*).

A comprehensive, annotated list of both U.S. and international web guides, portals, data sources, satellite data, oceanographic research institutes and large-scale international projects is provided by David Mattison (Mattison 2003a, 2003b). In "Marine Science Resources : Starting

Points for Researchers and Students” (Fritzler, 2005) the author covers the websites of international organizations, academic societies and organizations and includes descriptions of their missions and activities.

Oceanographic Institutions

The websites of individual oceanographic institutions describe their histories, scientific programs, news of current research activities and available free information resources. Some may have links to their institutions’ digital repositories.

Directory of Source Materials for the History of Oceanography is arranged by country and lists institutions holding original source material for the history of oceanography, 1600-1950. Documents, data, written archives, apparatus, and collections of geological and biological samples are included. Names of ships, expeditions, and persons are indexed (McConnell 1990).

An eleven page alphabetical listing with links to the websites of university marine programs, government sponsored marine research institutions and programs, and marine research stations, laboratories and institutes worldwide has been compiled by Open Seas Instrumentation, Inc., a manufacturer of oceanographic equipment (<http://www.openseas.com>). Among the U. S. institutions included are Scripps Institution of Oceanography, University of Rhode Island Graduate School of Oceanography, and Woods Hole Oceanographic Institution.

Conclusion

Over 90% of the world ocean and ocean floor are still unexplored and “great discoveries remain to be made there” (Kunzig 2000, 2). Public interest in the subject is high : the discovery of the *Titanic*, observation of hydrothermal vent life, development of increasingly sophisticated deep submergence vehicles, and reports of satellite observations of the ocean are covered in the popular media. We need to understand the ocean because of its influence on human life. The development of deep-sea vehicles has led to finding new life forms that derive energy from hydrogen sulfide; new sources of oil and gas; and marine organisms that may contain anti-cancer substances. Submarine geological investigations have led to the theory of plate tectonics that has furthered knowledge of the forces that shape the earth. Autonomous underwater vehicles are able to record seafloor mapping data over extensive territory. Both the historical background and current information on these topics that affect both human and animal life on earth are covered in the print and online sources described and cited here.

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