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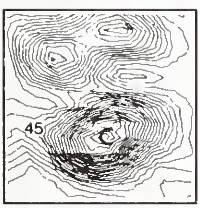
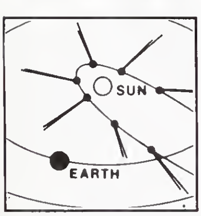
contents





profile

concerns

book reviews

The Cover: Concept by E. Kevin King. Color photo by John Porteous. Black and white photo of a Greek statue recovered off Riace, Italy.

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Introduction:

Marine Archaeology

by Peter Throckmorton

In looking back into the recent past, one is struck by the fact that a "great American maritime tradition" has disappeared in just a couple of generations. When I first went to sea in the 1940s, the backwaters of maritime America were filled with the hulks of 19th century sailing ships. Most men over 50 in the shipbuilding village in Maine where I spent boyhood summers had either built or sailed in sailing ships. Maritime lore was a part of everyone's lives – along with icehouses, work horses, and cutting up lots of cordwood with a buck saw.

Only a few people saw what was happening and attempted to preserve the last of what had been the driving force of our growth as a nation for much of its history. Sailing ships, along with their lore, disappeared in the same way as carrier pigeons and the buffalo – so fast that it took a generation before the general public knew it had happened. What had been a permanent part of our civilization disappeared before the academic community took much interest.

This is understandable when one considers that historic conservation in this country generally began in the 1930s. There was so much to do on land that there was no time for the sea until it was too late.

When I became a sport diver, in the early 1950s, I certainly had no idea that I would someday be using sport diving skills to study 19th century sailing ships. I simply did not believe that there was anything worth knowing about those ships that wasn't already known. For a couple of years on the GI bill as an anthropology student at the University of Hawaii, I supplemented my income by salvaging bronze propellers and by spear fishing. In those early days of sport diving, the rapid development of the aqualung offered a great range of exploration possibilities.

Two sport divers search for black coral in 130 feet of water off the coast of Cozumel, Mexico. (Photo by Ron Church, Photo Researchers)

If, at the time, I had been attending the University of Miami , rather than the University of Hawaii, there is no doubt in my mind that I would have become a searcher for Spanish gold rather than a salvor of bronze propellers. As it was, it took 6 years of diving before I made the connection that the skills that I had learned in diving could, and should, be applied to archaeology.

What, then, is archaeology? Grahame Clark, Professor of Archaeology at the University of Cambridge, England, defined it in his book *Archaeology and Society* (1939): "Archaeology may be simply defined as the systematic study of antiquities as a means of reconstructing the past . . ." Another Englishman, Glynn Daniels, defined archaeology as "the study and practice of writing the history of man from material sources . . ."

I am partial to the late Sir Mortimer Wheeler's definition that archaeology is the "art of digging up people." If people have left few records, or none, then it is obvious that the only way to learn about them is by digging up what they have left behind.

The techniques of digging are more or less the same whether one is digging paleolithic campsites, colonial settlements, or shipwrecks. In one sense, field archaeologists are as much analytical technicians as the investigator of aircraft accidents or homicide detectives. Confronted with a mystery, one draws on an assembly of generally recognized techniques in order to solve it.

All this seems simple enough. Yet, today's techniques of field archaeology began with the search by 19th century antiquarians in Europe and the Near East for ancient art treasures. This focus on art dampened the growth of archaeology as a tool for studying man. The archaeologists of most underdeveloped countries today are struggling to stem the tide of art objects flowing into the international art market. So they are more guardians of their countries' ancient art treasures than practitioners of the art of digging up people.

Edward Heath, a Brown University anthropologist, has estimated that in 1969 there were approximately 4,300 full-time tomb robbers in Costa Rica (population 1.5 million). He reported: "It is altogether possible that there are more part-time commercial archaeologists in a country the size of West Virginia, than there are academically trained (professional archaeologists) in the whole world . . ." Something like this is true in perhaps 50 countries.

Archaeology and archaeologist mean different things in different areas and disciplines. This is especially so in countries of the classical world, where archaeologists tend to be trained more in ancient literature and art history than in historical archaeology. The archaeological services of these countries tend to be curatorial, rather than research organizations.

The discovery early this century in the Mediterranean of a series of ancient shipwrecks with cargoes of classical statues led to the automatic association by the public in that part of the world of "undersea" with "treasure." Thus in first Italy and then Greece huge government-funded organizations were established for undersea archaeology. Interested parties promising the recovery of art treasures were the impetus for the creation of these government agencies.

In both Greece and Italy, these organizations accomplished little. In Italy, it was soon abolished, and, in Greece, it is now under heavy criticism in the press for inaction.

As a result, in both Italy and Greece, the sport-diving community has become alienated from the archaeological establishment. As the authorities can exercise little control, most sites in waters up to 150 feet have been looted. The same thing has happened in France and Spain, where perhaps 9 out of 10 underwater sites in reach of divers have been destroyed.

Turkey is an exception. For the last 25 years, George Bass, a founding member of the Institute of Nautical Archaeology (INA) at Texas A&M, has worked closely with Turkish authorities and with Turkish archaeologists. Bass's present spectacular Bronze-Age ship excavation (*National Geographic,* January 1985) is a result of 25 years of intelligent cooperation between INA and the Turkish Archaeological Service. In addition, sport diving is forbidden in Turkey and the ban is enforced.

The Question of Legislation

How then, does all this apply to the United States? The realization that shipwreck sites are important and are being destroyed by salvors and sport divers has led to legislation in many countries that attempts to protect sites. In some, this has been successful, mainly because the laws allow the participation of sport divers (Britain, Canada, the Scandinavian countries).

In countries where a legislative compromise between the authorities and the diving and salvage community has not been struck (Italy, Spain, Greece, and some parts the United States), the result has been destruction of the resource by divers and salvagers.

The literature of archaeology going back 200 years gives literally thousands of examples of excavation by archaeologists who at the time were practicing what was then state-of-the-art technology, but which would be condemned today.

Twenty-five states* now have shipwreck protection laws on the books. These generally allow salvagers to excavate sites, but force them to work under the supervision of state approved archaeologists. These laws have been challenged, namely in Texas and Florida, and salvors have won possession of dozens of important sites because courts have found that shipwreck sites come under admiralty jurisdiction. Recent legislation, which would put shipwreck sites under state antiquities jurisdiction rather than leaving them under Federal (admiralty) jurisdiction, passed the House as HR 3194, but was stopped in the Senate (as S 1504) by the opposition of Senator Paula Hawkins (R-Fla.). The bill's opponents won on the emotional issues of the salvager as a free entrepreneur! A new bill, HR 25, entitled the "Abandoned Shipwreck Act of 1985," was introduced at the first session of the new 99th Congress on January 3, 1985 (see page 9).

What then of programs that put archaeologists in charge of projects financed and organized by commercial salvagers? Unfortunately, there are no generally accepted research rules as applied to shipwrecks. Few archaeologists have the training needed to decide what is important and what is not in the infant discipline of the archaeology of shipbuilding and maritime commerce. This is not surprising when one considers that the first attempt at a scientific underwater excavation occurred in French waters in 1957.

As a result, today's archaeologists are under severe peer pressure. No one wants to go down in history as officiating at the destruction of a site that becomes important 20 years after it is studied, sampled, and destroyed with the consent of the attending archaeologist. The ethics of salvage archaeology have been discussed a great deal in recent years (see Ernestine Green, et al. 1984. *Ethics and Values in Archaeology*).

Many writers emphasize the importance of a research strategy as a way of making correct decisions as to what to excavate and how much excavation is required. Every archaeologist today who has worked in salvage archaeology has had to make

*Alaska, Arizona, Colorado, Florida, Georgia, Hawaii, Indiana, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Montana, New Hampshire, New York, North Carolina, North Dakota, Rhode Island, South Carolina, Texas, Vermont, Virginia, Wisconsin, and the Northern Mariana Islands. See Comparison of Laws, opposite page.

Comparison of State Laws Relating to Underwater Archaeology

State and Statute	Jurisdiction	Definition of Resource	State's Claim	Disposition of Artifacts	Penalties for Violations (Read less than [and/or] less than)
Alaska §41.35 (1977)	Land owned or controlled by the state, including tideland and submerged land.	Historic, prehistoric and archaeological resources.	Title to artifacts.	By permit.	$1,000 or 6 months, forfeit materials.
Arizona §41.841 (1982)	Lands owned or controlled by the state.	Ships and vessels at least 100 years old.	Regulatory authority.	Permit.	$500 or 6 months, forfeit materials.
Colorado §24.8 0.401—410 (1973)	Lands, rivers, lakes, reservoirs owned by the state or any of its subdivisions.	Historical, prehistorical and archaeological resources.	Title to artifacts.	Permit.	$500/30 days, forfeit materials.
Florida §267 (1982)	State-owned lands or submerged lands.	Sunken or abandoned ships.	Title to artifacts.	Contract payment.	$500/6 months.
Georgia §12.3 (1981)	Lands owned or controlled by the state or in the territorial Atlantic or navigable waters.	Ancient and abandoned ships.	Title to artifacts.	Permit, finder's fee.	$500/90 days.
Hawaii §6E (1976)	Lands or underwaters owned or controlled by the state.	Historic property, including underwater site.	Title to artifacts.	Permit.	$1,000.
Indiana §14.3.3.3-4 (1983)	Underwater.	Historic site, includes shipwreck.	Regulatory authority.	Permit.	$1,000/180 days.
Louisiana §41.1601 (1982)	Its tidelands, submerged lands and beds of its rivers and the sea.	All sunken or abandoned pre-20th century ships and wrecks of the sea.	Title to artifacts.	Contract, compensation.	$500/30 days.
Maine §27.373-378 (1982)	Any land or water area owned by the state, land beneath great ponds or navigable bodies of water and other submerged lands.	Physical entity worked or modified by human action.	Title to artifacts.	Permit.	$1,000.
Massachusetts §6.179-180 (1974)	Inland and coastal waters of the Commonwealth.	Sunken ships unclaimed for 100 years or valued at $5,000 or more.	Title to artifacts.	Permit, state option to purchase, permittee may retain 75 percent of value.	$1,000/6 months.
Michigan §299.51-54 (1982)	State-owned bottomlands of Great Lakes.	Water craft, including equipment, property, cargo.	Title to artifacts.	Permit disposition agreement, payment of salvage costs.	$100/90 days.
Minnesota §138 (1979)	Public lands or waters.	Objects of archaeological interest.	Title to artifacts.	License.	$3,000/1 year.
Mississippi §39.7 (1972)	Tidelands, submerged lands, rivers, the sea.	All sunken or abandoned ships, wrecks and cargo.	Title to artifacts.	Contract or permit, compensation.	$500/30 days.
Montana §22.3.421-442 (1981)	Upon or beneath the earth or underwater.	Object significant in history, architecture, archaeology or culture.	Title to artifacts.	Permit, provided for in permit.	$1,000/6 months.
New Hampshire §227.C (1981)	Bottom of navigable waters, great ponds, territorial waters.	Object significant in history, architecture, archaeology or culture.	title to artifacts.	Permit, disposition agreement up to 75 percent for permittee.	$1,000/6 months.
New York §14. (1982)	Underwater sites.	Property with significance in history, architecture, archaeology or culture.	Regulatory authority.	Permit.	Misdemeanor (at judge's discretion).
North Carolina §121.22-28 (1981)	Bottoms of navigable waters, one marine league into the Atlantic.	Shipwrecks, vessels, cargoes, tackle, underwater archaeological artifacts, unclaimed for 10 years.	Title to artifacts.	License, monetary fee, portion agreement.	Fine/2 years.
North Dakota §55.02,03,10 (1981)	Land or water areas owned or controlled by the state.	Historic or archaeological value.	Implied title to artifacts.	Permit.	$100 or 30 days, forfeit materials.
Rhode Island §42.45.1 (1977)	Bottoms of navigable waters, territorial sea.	Shipwreck, vessel, cargo, tackle, archaeological specimen, unclaimed for 10 years.	Title to artifacts.	Permits, compensation.	Bring or defend actions.
South Carolina §54.7.400 (1982)	Bottoms of navigable waters, one marine league into the Atlantic.	Sunken vessels, assemblages, artifacts.	Title to artifacts.	Licensee, compensation.	$10,000 or 2 years.
Texas §191.01 (1978)	Tidelands, submerged land, rivers and sea.	Pre-20th century ships and wrecks of the sea.	Title to artifacts.	Contract.	$1,000/30 days.
Vermont §22.701 (1978)	Underwater.	Shipwreck, vessel, cargo, tackle, archaeological specimen, unclaimed for 10 years.	Title to artifacts.	Permit, compensation.	$1,000/6 months, forfeit materials.
Virginia §10.145 (1983)	State-owned subaqueous bottom.	Shipwreck, vessel, cargo, tackle, archaeological specimen.	Title to artifacts.	Permit, fair share or cash value.	$1,000/12 months.
Wisconsin §27.012 (1973)	Water area owned by the state.	Man-made article, implement, item.	Title to artifacts.	Permit.	$100/90 days, forfeit materials.
Northern Mariana Islands P.L. No. 3-39 §11	Water surrounding the islands.	Artifact of historic or cultural significance.	Regulatory authority.	Permit.	$1,000/3 months.

Source: Subcommittee on Oceanography, Committee on Merchant Marine and Fisheries, U.S. House of Representatives, January 1985.

The Divers' Side

No amount of legislation is going to prevent looting of historical sites. Treasures and artifacts of commercial worth have been traded on the black market for centuries. What colonial powers didn't loot to stock their museums, private collectors bought from a network of fine arts procurers, ever-ready to turn a fast profit by exporting treasures of Pompeii, the Nile, or Grecian heritage.

What poorly conceived legislation can do is increase this black market by driving treasure hunters underground. In the present circumstances, they are already underwater. What I think legislation should do is strike a fair balance between two things:

1. The international interest in acquiring knowledge derived from historical shipwrecks.

2. The grand adventurous spirit that sets men and women out in quest of them.

To the myopic professor whose life is spent filing papers for government grants, competing with fellows for the glory of first publishing, the treasure hunter is at best a rogue. To the treasure diver who has spent 11 years seeking a shipwreck and, against all odds, finding it, then enduring the harshest of personal tragedies through the loss of a son, daughter-in-law, and a friend, the academic, bureaucratic and legalistic can represent a threat greater than the perils of the sea. Greed makes no distinction between the seeker of gold and the seeker of wisdom. In achieving their ends, the scientist and salvor both seek glory, and public acclaim, and riches, be it in the form of royalties from a book, a full professorship, or a handful of gold coins.

It is by taking advantage of the glory syndrome that this or any legislation can accomplish a worthwhile objective: To encourage the discovery of shipwrecks and preserve the evidence that will provide insight into history. If a person can find a shipwreck through personal genius, daring, and the expenditure of time and money and be assured that if they play by a just set of rules they will be treated fairly, then the treasure hunter will declare the find. The treasure hunter will eagerly pronounce it to the world and claim the glory. Make rules that treat a diver unfairly, brushing the finder of a shipwreck aside brusquely so another can claim it, then you will make the salvor a thief. The treasure diver will surely gobble up the gold, forsake the historical artifacts and excavate shipwrecks in a fashion designed to make the fastest possible getaway. Say no to the adventurer and discovery will stop altogether.

Legislation has not stopped Maya and Inca grave robbers, Egyptian tomb thieves, or traffickers in classical treasures from Italy or Greece. In all of these countries, strict archaeological protection laws have been in effect for many years.

No patrol force is equipped to police the sea. No government is prepared to foot the bill to search the seas then excavate and save each shipwreck found. Government should not be expected to pay for university grants, disfavoring free enterprise which [with] private funds can, under proper circumstances, accomplish the same thing.

Government must be as wary of the simple argument by academics that say, "Stop them, they are uneducated boors who are sacking the shipwrecks, pay us and let us do it" as the government must discourage the zealous treasure diver who would have the

hard decisions as to what to keep and what to sample and leave to the bulldozer.

However ruthless it seems, some sort of *triage* (the system employed in front-line military hospitals that decides who gets treated first) is necessary in salvage archaeology, in order to get the maximum benefit from limited resources. The Society of Professional Archaeologists' (SOPAS) Code of Ethics states (3.1a): "An Archaeologist shall respect the interests of his/her employer/client, so far as is consistent with the public welfare and this code and standards."

The salvager's situation is that he or she has been forced to hire an archaeologist. It is the responsibility of the archaeologist to see that nothing of potential research interest is destroyed, and that whatever is raised is properly studied. The archaeologist is bound by SOPAS code to not (1.2b): "Give a professional opinion . without being as thoroughly informed as might be reasonably expected."

First, the salvagers have invested a great deal of money. They want to get the goodies, sell them, and get out fast. From the archaeologist's point of view, fast is bad practice.

In my experience, the cost ratio between commercial salvage and archaeology is between 10 and 15 to 1 per man hour on the bottom. This is to say that excavations like the many done by George Bass's group at the University of Pennsylvania Museum and later by the Institute of Nautical Archaeology, both in the Mediterranean and

of the Coin

way clear to dynamite a wreck site to oblivion to get at the gold. When all the professional treasure divers, so called, are counted, the total would be very small. When the time these adventurers invest and the expenses they've had over the years is added up and compared to their finds, then most could earn better wages as a letter carrier, grocer, clerk, or fisherman.

In all of this, what about the ordinary person? The week-end diving enthusiast who dons mask, fins, and snorkel and sets out for a day's fun. What do they want?

It is they whom I represent best, both as the U.S. representative to the World Underwater Federation, CMAS, which is the United Nations of underwater activities headquartered in Paris and the representative of the Underwater Society of America, the U.S. national non-profit sport diving organization.

The average diver wants to enjoy the thrill of discovery by seeking, touching, and taking. If they've told not to take, they'll likely comply as long as they're told why. With shipwrecks in mind, there should always be some things the average sport diver can take and treasure even if it is only an old milk bottle from the forties found in a lake or a brass porthole ripped out of the side of some great lakes steamer polished bright so one can see a reflection in the brass. The artifact becomes a living room showpiece to the diver, a monstrosity that has to be cleaned to the non-diving spouse.

The sport diver wants fun. They want the freedom to hunt up souvenirs of the dive, a laudatory purpose, since more of them collect stuff that any self-respecting junkman would leave if the same item was abandoned in the gutter.

In all of the above, there is the flexibility in the oceans' bounty to accomplish the goal of proper legislation while preserving the spirit of its purpose.

Divers have a rare sense of esprit de corps, and a practical investment in the oceans and things maritime. It is they that benefit and they that lose after all. It is the diver that is most interested in shipwreck finds and marine artifact displays. They hold film festivals and artifact shows, swap tales and enjoy films about shipwrecks. Divers may also be the ones who rummage around and disturb things, but with proper guidance the harm can be minimized.

A law that satisfies the diver, the marine archaeologist, the treasure salvor and the conscience that says knowledge and artifacts of historical value should not be lost or destroyed is one which permits individuals to find shipwrecks, declare their finds, be licensed, if competent, to excavate them properly, and then let government buy any artifacts it wants for a fair price with the right of first refusal. After all what better way for a treasure salvor to realize a life's ambition, to be paid for the artifacts then be able to take grandchildren to see what was found with a little plaque bearing the finder's name in the Smithsonian.

Excerpts from a statement of John C. Fine, representing the Underwater Society of America, before the House Subcommittee on Oceanography, Committee on Merchant Marine and Fisheries, Sept. 27, 1983; testimony on HR 3194, Historic Shipwrecks.

elsewhere (in the United States at the *Defense* site in Penobscot Bay) cost little compared to commercial-type jobs, thanks to students and volunteers, the consequent few paid excavators, the donation of material and equipment, and the tax free status of the organizations involved. However, organizing such expeditions takes much more time than a commercial operation.

If excavating with volunteers and students in the manner of Bass and others is cheaper than a similar amount of time spent on a commercial operation, it must also be emphasized that the time ratio between salvaging and archaeology goes the other way. Bass has stated that the recovery of some wrecks has consumed less than 5 percent of the man hours required from the decision to excavate the site to the final publication of the results.

In most underwater sites, the actual recovery of artifacts consumes perhaps 20 percent of the expedition's field time compared with drawing, photographing, tagging and recording them (the purely archaeological part).

In short, the ratio in man hours of archaeology versus salvage is somewhere between 50 and 20 to 1. This contrasts with the cost ratio mentioned previously. In a context where commercial salvagers are required to pay for archaeology as a permit requirement, this leads to insoluble conflicts between archaeologists and salvors.

The Archaeologist's Side . . .

Historic shipwrecks are important cultural resources. The first factor to consider is that they are located on public land. As such they are a non-renewable public resource and should be managed for the best interest of the public at large. They are a part of our cultural heritage and should not be exploited for private gain.

The most important problem relative to historic shipwrecks today is that they fall under the judicial control of the admiralty courts. Because of the principle of marine peril, an appropriate concept for contemporary ships in distress or recently sunk, but a ridiculous legal fiction when applied to the long lost historic vessels, the courts persist in allowing and even encouraging the commercial exploitation of these resources. It has been suggested that wrecks might be left under admiralty jurisdiction but to be administered as cultural resources by the judges. This is not an appropriate role for the courts and one for which they are not qualified. Historic wrecks must be removed from the law of salvage and of finds. This is the critical first step and represents 85 percent of the present problem.

Having accomplished this, what is the best approach to managing the historic wrecks as cultural resources? The ideal might well be to plug them into the existing laws, regulations, and bureaucracy of the federal historic preservation process. However, in a time of severe fiscal constraints on the federal budget this may not be practical or possible. On the other hand, many states already have antiquities codes and cultural resource management programs which are attempting to protect and preserve historic shipwrecks. When the counterproductive actions of the federal admiralty courts are removed, the most practical course may be to allow the states to manage these resources in state waters. This is what I would suggest. This seems to be an ideal situation for management from the bottom up instead of from the top down.

Excerpted from a prepared statement by J. Barto Arnold III, Chairman, Advisory Council on Underwater Archaeology, delivered to the House Subcommittee on Oceanography, Committee on Merchant Marine and Fisheries, Sept. 27, 1983.

The conflict becomes even more difficult when one is working in the grey area of 18th and 19th century wrecks, where there is no consensus among archaeologists as to what is important and what is not. Or even any general understanding of the questions that need to be answered.

If the archaeologist decides that a salvage site needs to be meticulously (and expensively) studied, he comes almost automatically in conflict with his employer, the salvager who is perfectly at liberty to fire him and hire a more amenable archaeologist, who may, perfectly honestly, be prepared to say that the site in question does not require careful excavation.

The testimony before both the House and Senate subcommittees over HR 3194 and S 1504 (available through your local representative) exhibits the wonderful contrast between salvagers boasting about the high quality of the archaeology that they are performing, and the shrill disapproving voices of the legitimate archaeologists protesting in terms nobody seems to understand. Meanwhile, confusing the whole issue, is a pall of obfuscation raised by archaeologists in the salvagers' employ.

The Average Scuba Diver

Scuba sport diving has grown to be a multi-million dollar industry, which supports its own monthly magazines, thousands of commercial dive ships, and dozens of equipment manufacturers. A lot of the hype is based on the little guy's hope that, someday, he too will strike it rich. The population of skin divers is continually changing. The pattern seems to be that a few hard-core individuals stay with diving, turning into highly competent professionals, dedicated to the sport, while the less dedicated become bored and drop out after the first flush of excitement has passed. In my experience, the hard-core divers are generally decent, responsible people, who are genuinely interested in helping scientists in the sea, including archaeologists.

The general, average diver seems to be a member of middle-class America. My personal guess is that the average diver fits into the upper blue-collar, lower white-collar category. The majority are decent, law-abiding people, but probably not very knowledgeable about the disciplines of archaeology or anthropology. It is this group to

99TH CONGRESS
1ST SESSION

H. R. 25

Entitled the "Abandoned Shipwreck Act of 1985."

IN THE HOUSE OF REPRESENTATIVES

January 3, 1985

Mr. BENNETT (for himself and Mr. Wright) introduced the following bill; which was referred jointly to the Committees on Interior and Insular Affairs and Merchant Marine and Fisheries

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A BILL

Entitled the "Abandoned Shipwreck Act of 1985."

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE

SECTION 1. This Act may be cited as the "Abandoned Shipwreck Act of 1985."

FINDINGS

Sec. 2. The Congress finds that –

(1) States have the responsibility for management of a broad range of living and nonliving resources in State waters and submerged lands; and

(2) included in the range of resources are certain abandoned shipwrecks.

DEFINITIONS

Sec. 3. For purposes of this Act –

(1) The term "National Register" means the National Register of Historic Places maintained by the Secretary of the Interior under section 101 of the National Historic Preservation Act (16 U.S.C. 470a).

(2) The term "shipwreck" means a vessel or wreck, its cargo, and other contents.

(3) The term "State" means a State of the United States, the District of Columbia, Puerto Rico, Guam, the Virgin Islands, American Samoa, and the Northern Mariana Islands.

(4) The term "submerged lands" means the lands –

(A) that are "lands beneath navigable waters," as defined in section 2 of the Submerged Lands Act (43 U.S.C. 1301);

(B) of Puerto Rico, as described in section 8 of the Act of March 2, 1917 (48 U.S.C. 749); and

(C) beneath the navigable waters of Guam, the Virgin Islands, American Samoa, and the Northern Mariana Islands, including inland navigable waters and waters that extend seaward to the outer limit of the territorial sea.

(5) The terms "public lands" and "Indian lands" have the same meaning as when used in the Archaeological Resource Protection Act of 1979 (16 U.S.C. 470aa – 470ll).

RIGHTS OF OWNERSHIP

Sec. 4. (a) The United States asserts title to any abandoned shipwreck that is –

(1) substantially buried in submerged lands of a State;

(2) in coralline formations protected by a State on submerged lands of a State; or

(3) on submerged lands of a State when – ►

This bill, introduced on 3 January 1985, replaces a similar bill (S. 1504) that died in the Senate last fall, after having passed the House as H. R. 3194. At press time, the new bill had yet to pass in either chamber. The bill is sponsored by Charles E. Bennett (D.-Fla.) and Majority Leader Jim Wright (D.-Tex.)

(A) such shipwreck is included in or determined eligible for inclusion in the National Register; and

(B) the public is given adequate notice of the location of such shipwreck.

(b) The title of the United States to any abandoned shipwreck asserted under subsection (a) of this section is transferred to the State in or on whose submerged lands the shipwreck is located.PS9.5

(c) Any abandoned shipwreck in or on the public lands of the United States (except the Outer Continental Shelf) is the property of the United States Government.

(d) This section does not affect any right reserved by the United States or by any State (including any right reserved with respect to Indian lands) under –

(1) section 3, 5, or 6 of the Submerged Lands Act (43 U.S.C. 1311, 1313, and 1314); or

(2) section 19 or 20 of the Act of March 3, 1899 (33 U.S.C. 414 – 415).

RELATIONSHIP TO OTHER LAWS

Sec. 5. (a) The law of salvage shall not apply to abandoned shipwrecks to which section 4 of this Act applies.

(b) This Act shall not change the laws of the United States relating to shipwrecks, or other than those to which this Act applies.

(c) This Act shall not affect any suit filed before the date of enactment of this Act.

GUIDELINES

Sec. 6. To clarify that State waters and shipwrecks offer recreational and educational opportunities to sport divers and other interested groups, the Advisory Council on Historic Preservation, established under section 201 of the National Preservation Act (16 U.S.C. 470i), in consultation with appropriate public and private sector interests (including archaeologists, salvors, sport divers, historic preservationists, and State Historic Preservation Officers) shall publish, within six months after the enactment of this Act, advisory guidelines for the protection of shipwrecks and properties. Such guidelines shall assist States and the United States Government in developing legislation and regulations to carry out their responsibilities under this Act in such manner as will allow for –

(1) recreational exploration of shipwreck sites, and

(2) private sector recovery of shipwrecks, which is not injurious to the shipwreck or the environment surrounding the site.

Amend the title so as to read: "A bill to establish the title of States in certain abandoned shipwrecks, and for other purposes."

which the commercial treasure salvagers appeal when they plead that the proposed federal legislation would give states uncontested control over underwater sites, depriving them of their liberty. Their point of view is perfectly simple and quite understandable.

Confronted by archaeologists who disagree among themselves about what's important and what's not, and a "maritime preservation community" that has failed to agree on priorities, or even to convince the American public that maritime preservation is of any value, the divers tend to accept without question what they want to hear anyway. Finders keepers is the American way.

Joint Support Needed

The treasure salvagers as a group, in short, have convinced the large majority of divers that what they are doing is good, and they have convinced the courts that they have a right to the treasure at the expense of the heritage of humankind.

The cruel truth is that not one treasure-hunting group in the United States has done an excavation on a level with the work done commonly in the Mediterranean by Bass and others. They have not produced a single publication accepted by the scientific community. The system, common in most states, of imposing an archaeologist on treasure salvaging groups has failed to force these groups to do good archaeology.

Given the high cost of properly conducted ship excavations, it seems clear this can only happen with the support of everybody concerned – divers, archaeologists, and salvagers. Someone must set guidelines that are accepted by everyone.

It is a strange irony that although American institutions have led the world in shipwreck archaeology in the Mediterranean and elsewhere, this country, both in terms of national attitude and legislation, lags far behind the maritime nations of the world in protecting underwater antiquities.

Peter Throckmorton, who presently teaches marine archaeology at Nova University in Dania, Florida, has been referred to affectionately by one author in this issue as the "Godfather" of his profession. He is a marine surveyor working out of Maine and has participated in the excavation of many shipwrecks and harbor sites both in the United States and abroad.

Early Throckmorton

Men have been salvaging shipwrecks in the Mediterranean for centuries, but only in the past two decades has underwater archaeology entered into the picture. An American named Peter Throckmorton was the first person to realize the great archaeological potential of the many ancient shipwrecks in the Mediterranean and to do something about it. He was soon followed by others, such as Dr. George Bass of the University of Pennsylvania.

Throckmorton was fascinated by shipwrecks and archaeology as an adventurous young boy. After finishing high school, he studied archaeology in three different countries and traveled for years all over the world, diving in most of the Seven Seas.

In the spring of 1958, while visiting Istanbul, Turkey, he heard that a beautiful bronze bust of Demeter, the ancient Greek Goddess, dating from the fourth century B.C., had been discovered by a sponge diver near a place called Bodrum in southern Turkey. Naturally this excited his imagination and he was eager to dive in the same area, hopefully to make an important discovery on his own. Because of currency restrictions in Turkey it was impossible to import diving equipment and for days he searched in vain to buy or rent some, until he heard there was a diver-photographer living in Izmir, the main port of Aegean Turkey. Throckmorton rushed to Izmir and met Mustafa Kapkin, who shared many of the same interests he did — the sea, wrecks, and diving. Kapkin had been a fighter pilot in the Turkish Air Force and was then prospering as a commercial photographer. After Kapkin managed to borrow some homemade diving equipment from friends the two headed for Bodrum.

Bodrum was the center of the sponge-diving business in Turkey, as well as an important fishing center. After learning that the fisherman who had discovered the priceless Demeter bust was at sea they made friends with a rugged sea captain named Ahmet Kaptan. It took a considerable amount of persuasion to get him talking, but once they did, he continued for hours on end. He did not know the area in which the bust had been found, but he did know many areas where, he said, "The sea was so full of old pots that the fishing trawlers and sponge draggers had a hard time working." He mentioned one place called Yassi Ada, 15 miles from Bodrum, where there were two huge heaps of ancient pots, or amphorae, on the bottom in 20 fathoms about 50 feet apart. Only a week before, a trawler had brought up over 50 of the pots and they smashed them to pieces to prevent them from getting caught in their nets again.

Two days later, Throckmorton and Kapkin chartered a small boat and although the weather was miserable they induced the captain to take them to Yassi Ada. Throckmorton decided to make the first dive in order to locate the amphorae and then he and Kapkin would dive together. Apparently the boat captain did not know the exact location because Throckmorton was only able to find a few necks and sherds of amphorae. It was so rough when he climbed back aboard that the captain refused to stay in the area any longer and headed back to port.

That night while dining at a tavern on the waterfront, a sinister-looking man sat down at their table and identified himself as Captain Kemal Aras of the sponge-diving boat named Mandalinci. He admitted that one of his divers had found the Demeter bust, but claimed that there had not been anything else in the area and he had forgotten exactly where it was. After another all-night session of sea stories, Captain Aras invited them to accompany him and his crew for a month's cruise along the Anatolian coast where he claimed to know of many locations of old jugs.

The Mandalinci was a double-ended, sloop-rigged, 36-foot-long vessel with a decrepit auxiliary engine, which did not appear to be too safe. The boat was vastly overloaded with a massive air compressor, diving equipment, provisions for a month, and a large crew. Lashed to the mast base was an ancient amphora which was used for drinking water. Captain Aras explained that they were stronger built than the new ones, and, besides, they cost nothing since the divers picked them off the sea floor.

Their first stop was Yassi Ada and Captain Aras sent one of his divers down to locate a spot he wanted the two visiting divers to see. Ten minutes later the diver signaled that he had located the area and Throckmorton and Kapkin jumped, with snorkeling equipment, into water only 4 fathoms deep. On the bottom, snagging sponges with a hook, the helmet-diver was walking over a field of broken amphorae. Astonished by the scene before his eyes Throckmorton dove *down and shook the hand of the amazed sponge diver. The diver stared back, convinced the American must be crazy if he got excited over broken pots. When they returned to the surface for air, Captain Aras called them to come back on board, as he had more to show them. He moved the Mandalinci to a new area and minutes later Throckmorton was over the side wearing his scuba gear, following a helmet-diver to the bottom, 120 feet below. This time he saw a small mountain of intact amphorae, but before he could get a good look at the site, Captain Aras signaled for them to return to the surface because he had still another wreck to show them. The third wreck had carried a cargo consisting of large pot-bellied, almost round amphorae, unlike any Throckmorton had seen before. Mixed among the amphorae he sighted many pieces of encrusted iron and several anchors. Before darkness called a halt to the day's diving Throckmorton had seen six different ancient shipwrecks. The day had been frantic; their underwater cameras were not working well and Kapkin was busy arguing with Captain Aras most of the day, trying to convince him to stay long enough on one spot to permit them to properly survey it.*

During the next few days in the same area, Throckmorton and Kapkin dove on many other wrecks. They finally estimated that no fewer than 18 ancient wrecks had been lost on the reefs off Yassi Ada Island. Throckmorton realized that this area alone would be able to supply research material for many well-equipped expeditions for many years to come. He had kept abreast of everything happening underwater in the world and after diving on these wrecks he could not understand why nothing was being done in underwater archaeology, to which he vowed then and there to devote the rest of his life. Although he lacked a university degree, he had the necessary combination of talents with which he was sure he could do a good job: ample diving experience and a knowledge of archaeology. He was also a good seaman and knew a great deal about ships.

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Terms and Concepts Related to Marine Archaeology

by David R. Watters

The Editor selected the phrase *marine archaeology* as the title for this issue of *Oceanus*. Readers may wonder why *underwater archaeology*, a more widely known phrase, was not chosen. A glance at the issue's contents shows why marine is preferable. These articles all deal with subjects related to the ocean, but much of the research they discuss was not conducted underwater.

In the sense it is used here, marine archaeology is the more encompassing term, for it includes research that occurs on land or water. What unites the various aspects of marine archae-

A 5th century A.D. ship's figurehead from Belgium. (Photo from Archaeology Under Water, *by Keith Muckelroy)*

Connotations of Terms Related to Marine Archaeology		
Term (adjective)	Primary Meaning	Secondary Meaning
Aquatic	-living or growing in or on the water	-taking place in the water
Marine	-of or pertaining to the sea	-of or pertaining to shipping or maritime affairs; of or pertaining to sea navigation; nautical
Maritime	-located on or near the sea	-of or concerned with shipping or navigation
Nautical	-of, pertaining to, or characteristic of ships, shipping, seamen, or navigation	
Submarine	-beneath the surface of the water; undersea	
Underwater	-pertaining to, occurring, used, or performed beneath the surface of the water	

ology is that the subject matter under study relates, in some way, to salt-water (and brackish) environments and human use thereof.

Underwater archaeology is tied together by the fact that the cultural remains rest, and therefore must be investigated, under the water. This is irrespective of the kinds of materials being studied or of whether the water is fresh, brackish, or salt. Investigators may study sunken ships, towns, harborworks, or even isolated objects cast into the water, yet the common thread is that they are all submerged.

Put otherwise, marine archaeology encompasses research that revolves around a particular body of water, the ocean; underwater archaeology refers to the locale where research is conducted.

Related Terms

Other similar terms, such as *nautical, maritime, submarine, aquatic, shipwreck,* and *submerged sites archaeology,* pose additional problems with definitions and concepts. Some of these phrases relate to where materials are located, others to particular kinds of cultural materials or sites, and others to past activities or lifeways that are of interest to the researcher.

To differentiate or distinguish among these terms is no easy task because their connotations can overlap quite extensively. Moreover, it is not unusual for the same term to be used in different senses by various authors. And in this article, parallel problems of translating terms from foreign languages can be noted only in passing; it is worth mentioning two common Spanish phrases, *arqueología subacuática* and *arqueología submarina,** to give some idea of the complexities involved.

How so many terms, often imprecisely defined and overlapping in meaning, came to be used is an interesting study in its own right. Archaeological research has been conducted underwater for barely 30 years and its terminology is still being developed and standardized. To a great extent, the terms reflect the history of the development of underwater archaeology, the training and interests of various practitioners, and the different ways archaeology is perceived and categorized in different regions of the world.

*Aquatic archaeology, marine archaeology.

Underwater Archaeology

Underwater archaeology occurs in many aqueous environments, and so is not necessarily marine related. Cultural remains in lakes, rivers, reservoirs, sinkholes, and other freshwater bodies have been investigated. Some 20 years ago, the term "limnoarchaeology" was proposed (but not widely accepted) to label this research as the "freshwater counterpart" of ocean-based studies.

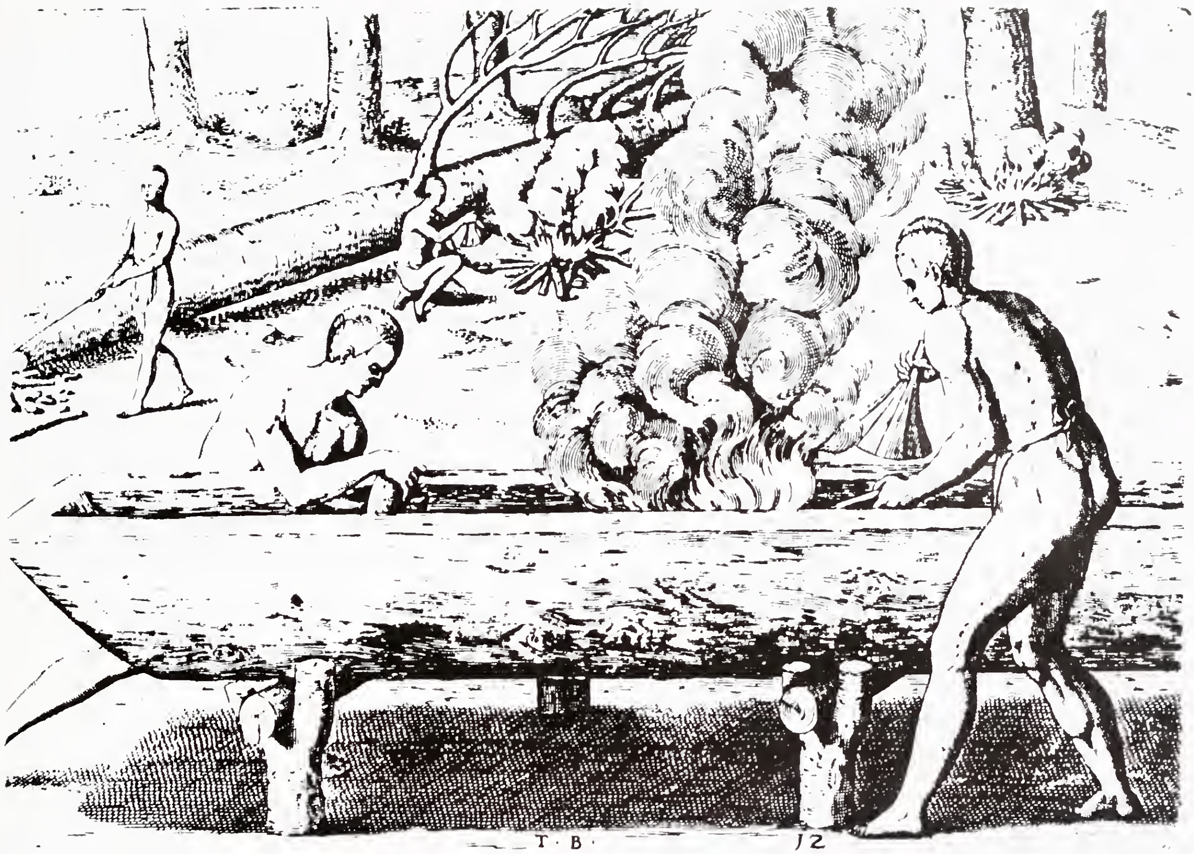
Archaeological techniques used to survey or excavate a site underwater are remarkably similar to those used on land. The differences are that the techniques are being practiced in the water and have been applied largely, but not exclusively, to watercraft, a class of cultural material rarely found on land.

Underwater archaeology is not an independent, unified, or distinct discipline but instead crosscuts many subdisciplines of archaeology and also relates to other disciplines, such as anthropology, history, and classical studies.

The situation for archaeologists working in North America is somewhat peculiar. Here, archaeology is traditionally divided into prehistoric and historic research. Prehistoric refers to study of Native American cultures. Historic archaeologists deal with European, African, and Asian groups that came to North America later, and with their descendants. Rarely does a North American underwater archaeologist have expertise in both historic and prehistoric studies.

Submerged Native American materials thus are in the province of prehistoric archaeologists, whereas European items found underwater fall to historic archaeologists. A person excavating a sunken Iroquois dugout canoe probably has little in common with someone working on a Confederate blockade runner.

The problem of classifying submerged cultural materials is evident elsewhere. The United



Theodor de Bry illustration, from 1590, of Virginia Indians making a dugout. (From A Briefe and True Report of the New Found Land of Virginia *by Thomas Harriot)*

Nations Convention on the Law of the Sea has two articles dealing with such remains. In both articles, references are made to objects that are "archaeological" as distinct from "historical." Tunisian delegates insisted on the inclusion of "historical" because of their concern that underwater materials from the more recent Byzantine era would not receive protection as "archaeological" objects.

Shipwreck and Nautical Archaeology

The public generally views shipwreck archaeology as synonymous with underwater archaeology. Indeed, much of the research into shipwrecks does involve vessels sunk in salt and fresh water. Occasionally, a vessel that originally was underwater may be exposed and excavated on dry land, as when a lake is drained or an enclosing cofferdam built, but these are rare circumstances.

Pioneering underwater research in the Mediterranean Sea on ships of the Greek, Roman, and Near Eastern civilizations has expanded in the last few decades to include watercraft from many time periods and geographic regions. In the Western Hemisphere, shipwreck archaeology has focused almost exclusively on historic vessels, although, in theory, it should include Native American watercraft.

Nautical archaeology is a broader term. It includes shipwrecks and cargoes but extends beyond to support facilities (harbors and ports), vessel construction techniques, water trade routes, navigation and exploration, and naval warfare. It also covers such unusual situations as ship burials (when vessels were buried, intentionally or otherwise, on land), which technically are not shipwrecks. In a sense, shipwreck archaeology refers to the specific category of object under study, whereas nautical archaeology is more theoretical and concerned with interpretation and explanation, such as understanding the seafaring tradition in relationship to seaborne trade patterns.

Maritime Archaeology

Maritime archaeology has a number of different connotations, being used by some authors in a sense that is similar to nautical archaeology, but by others as more akin to marine archaeology. When used by North American prehistoric archaeologists, it has a meaning quite different from that intended by their historic counterparts.

Prehistoric maritime archaeology involves research on Native American use of, interaction with, and adaptation to the ocean and its resources.

This includes migration and colonization, watercraft and navigation, procurement and exchange of marine resources, settlement patterns, and subsistence strategies. Evidence of maritime resources in coastal sites is shown by the remains of finfish, shellfish, marine mammals, and aquatic birds.

In maritime archaeology, oceanographic processes, such as fluctuating sea level, also are of interest, because they have modified coastal areas through time. In fact, the phrase "coastal archaeology" is preferred by some archaeologists who point out that peoples occupying coastal regions exploited terrestrial and riverine resources, not solely maritime ones.

There are underwater components of prehistoric maritime archaeology. They include watercraft and fish traps submerged in swamps or estuaries and objects cast into the sea for ceremonial or other reasons.

There are also early habitation sites on then-dry continental shelves that subsequently have been covered by rising seas. More recently, prehistoric sites have been flooded by reservoirs behind dams; being in freshwater, however, they technically do not fit into maritime or marine archaeology. Submerged, inundated, or drowned terrestrial sites are the terms used to distinguish these sites from underwater shipwrecks.

A Guide to the Ages

(All dates are for the starts of the phases.)

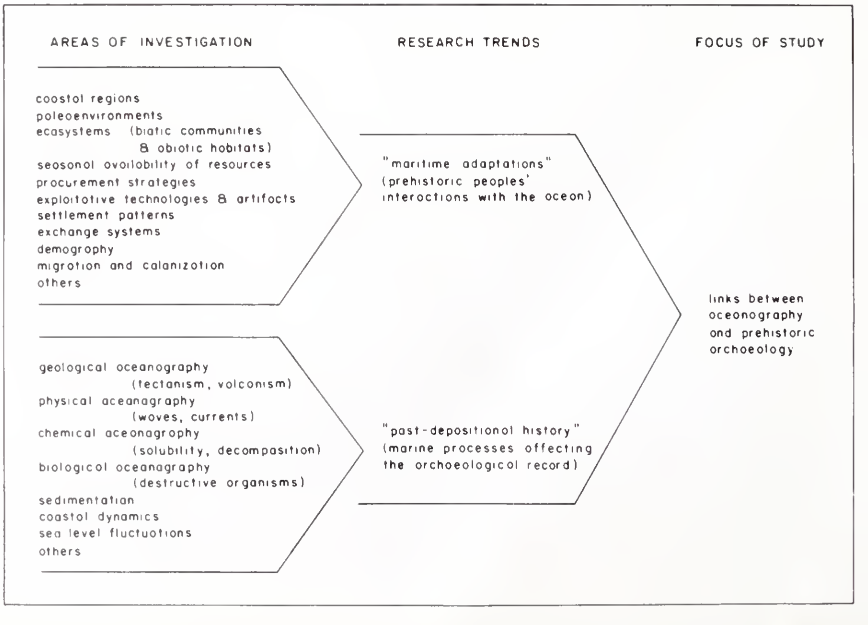
***Paleolithic* (Old Stone Age)**	
Early (or Lower) Paleolithic	**2.4 Myr ago**
Middle Paleolithic	**120,000 yr**
Late (or Upper) Paleolithic	**40,000 yr**
Epipaleolithic (or Mesolithic)	**18,800 yr**
***Neolithic* (New Stone Age)**	
Aceramic (potless) Neolithic	**10,600 yr**
Ceramic (with pots) Neolithic	**8,500 yr**
Chalcolithic (or Copper Age)	**8,000 yr**
Bronze Age	
Early Bronze Age	**6,000 yr**
Middle Bronze Age	**4,150 yr**
Late Bronze Age	**3,740 yr**
Iron Age	
Early Iron Age	**3,200 yr**
Full Iron Age	**3,000 yr**

The above terms are referred to by various authors throughout the issue. The dates indicated are the starting dates for each age, in years before the present. (After Timescale *by Nigel Calder)*

Agreeing to Disagree

A single phrase that is capable of serving as a catchword to encompass all facets of the diverse research previously noted has yet to be advanced and accepted. Because of the diversity in subject matter, research interests, theoretical approaches, cultures, time periods, and locations being studied, it is unlikely that one term ever will prove acceptable to all parties involved – perhaps with good reason.

Some authorities have likened the search for an all-encompassing term to the classic cases of comparing apples and oranges or forcing the square peg into the round hole. The late Keith Muckelroy, a British underwater archaeologist, faced the classification problem in *Archaeology Under Water: An Atlas of the World's Submerged Sites.* His unique solution was to segregate "mobile" (ships) from "fixed" structures (towns, harbors, prehistoric sites) found under water. This has the



Aspects of maritime archaeology at several levels of investigation. These studies interrelate in a much more complex manner than shown here. (Reprinted from Watters, 1981) advantage of putting all apples together under "mobile" but leaves a wide variety of different oranges under "fixed."

A lack of consensus actually may be a positive rather than negative factor. The research does not constitute a unified or interwoven body of knowledge for it has a number of disparate elements that do not mesh well. Put otherwise, is there really any reason why sunken Roman ships, submerged colonial towns, shellfish remains in Native American sites, and prehistoric navigation techniques have to be neatly categorized? Just how much do they really have in common? Perhaps the appeal of this research, both to the specialist and the public, lies in the breadth and diversity of the subject matter, regardless of the somewhat baffling terms and concepts.

David R. Watters is Assistant Curator in the Section of Anthropology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania. From 1980 to 1982, he was a post-doctoral fellow in the Marine Policy and Ocean Management Program at the Woods Hole Oceanographic Institution.

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Additionally, readers should consult the *International Journal of Nautical Archaeology and Underwater Exploration* and the proceedings of the various Conferences on Underwater Archaeology (noted in Muche and Low's bibliography).

Ice Ages and Human Occupation

A bird's-eye view of the globe, showing the connections between the continents at times of low sea level during the Ice Ages, and the general directions of human migrations from East Africa over millions of years.

of

the

Continental

Shelf

by Nicholas C. Flemming

While the earliest continental ice sheets were gradually engulfing the mountainous landmass of Antarctica, in Africa an undistinguished species of ape was evolving into the species that we now call man. Examination of oceanographic cores and the dating of sediments from around Antarctica show that the ice began to form about 5 million years ago. Later, ice sheets up to 3 kilometers thick also covered Greenland, Canada, and Scandinavia, and extensive glaciers formed in the valleys of all the mountain ranges of the world. During the last 2 million years such vast accumulations of ice have covered the land and melted again about 20 times, each Ice Age lasting about 100,000 years.

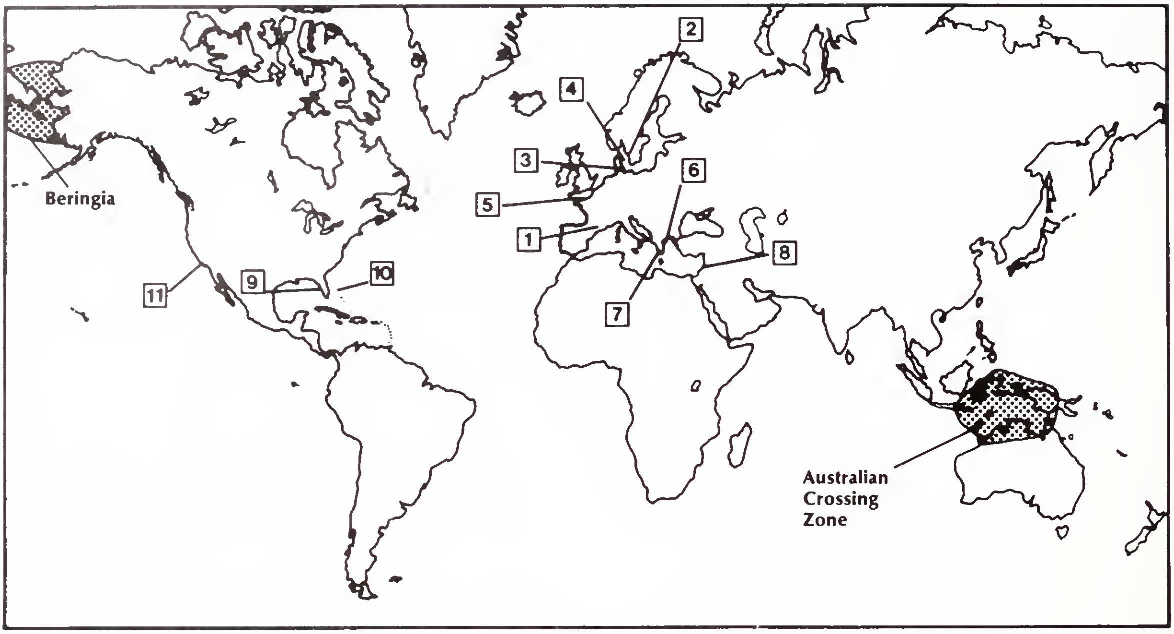
Discoveries of fossil bones, footprints, remains of tools, and food materials show that types of early men known as *Australopithecus* and *Homo erectus* had evolved in East Africa by 1.5 million years ago. The cultural and tool-making attributes of man are later found over a wider and wider area, encompassing Africa, most of Asia, and Europe, by about 1 million to 500,000 years B.P.*

During the long time span from 1 million years B.P. to 10,000 B.P., the human race colonized all the continents of the earth (with the exception of Antarctica) and most of the major islands. The dates of these colonizing migrations are not known, even approximately, although some of them involve crossing channels that are now wide sea straits, such as the Timor Sea and Celebes Sea between Indonesia and Papua New Guinea-Australia (which were one continent during the glaciations) or the Bering Strait between Siberia and Alaska. This spread of the human race across the globe is poorly understood, though it must be counted one of the most important processes in human history.

To illustrate the spread one can note traces of huts made of bone and pebble tools found in Siberia by Nikolai Dikov (of the U.S.S.R. Academy of Sciences at Magadan, Siberia), dating from

A diver making a survey of the shallowest part of Cootamundra Shoals, Australia, examines a coral. (Photo courtesy of Sirius Expedition)

*Before present, calculated from 1950 by scientific convention



Submerged sites that contained the remains of cultures older than 6,000 years before present. Site numbers and names are as follows: 1) Etang de Leucate; 2) Landskrona, Sweden; 3) Danish Archipelago; 4) Tybrind Vig; 5) Brittany coast; 6) Aghios Petros; 7) Franchthi Cave; 8) Mediterranean coast of Israel; 9) Little Salt Springs and Warm Mineral Springs, Florida; 10) Cape Canaveral; 11) La Jolla, California. The key inter-continental passages from Siberia to Alaska and Asia to Australia also are marked.

20,000 B.P., and rather similar remains in Alaska from later dates. In South America, human remains and tools are found dating from 13,000 B.P. Hearths, food remains, tools, and human remains have been found at widely separated locations in Australia dating from as early as 30,000 B.P. Japan was occupied well before 20,000 B.P.

There is controversy about the precise origins of the modern species of human, *Homo sapiens*, and the relations between the various preceding species or sub-species identified in Africa and Asia. Although this process of differentiation, evolution, and survival is a worthy subject for study, I do not wish to devote time to it here. For the purposes of this article we can view the human race as a single species, which evolves and spreads throughout the dryland surface of the globe in the course of about 1 million years. I wish to examine the mechanism and routes of that expansion, and the limits of the area which was inhabited.

Ice Age Sea Levels

Each time that the ice sheets reached their maximum extent, the additional volume of water extracted from the ocean was about 40 million cubic kilometers. This resulted in a drop of sea level of about 100 meters. The precise magnitude of sea-level drop relative to the land at each location is complicated by several side effects. In brief, the weight of ice itself depresses the earth's crust by about 1 kilometer in the immediate neighborhood of the ice, and the crust subsequently rises again when the ice melts. Conversely, the weight of water removed from all the oceans of the world causes the ocean floor to rise slightly, and it is depressed again when the water returns to the ocean. Since the crust and the underlying mantle are not perfectly uniform, the magnitude of these responses is not easily calculated. Additionally, the coast at all places in the world is subject to changes in altitude, relative to the center of the earth, as a result of the addition or removal of loads of sediment, and because of earthquakes or earth movements caused by forces arising within the earth, so-called tectonic movements.

Although we know that the sea fell and rose again with a periodicity of about 100,000 years, and through a range of about 100 meters, the variations locally are so great that the exact area of the continental shelf exposed at each place is difficult to calculate. For example, close to the ice sheet, the earth is forced down by more than the drop of sea level, so that the land floods as the sea level drops. Consequently, we have only approximate knowledge of what land was dry and at what time.

The Archaeological Problem

Archaeologists have been aware for several decades that the low sea levels created a larger living space for Stone Age tribes of the Paleolithic period (older than 10,000 years B.P.), and that migrations between continents and islands were promoted by the creation of land bridges or the narrowing of straits. To show how widely these ideas

Archaeological Periods

Geological Time	Geological Sub-division	Archaeological Period	Stone Tool Type	Years Before Present
HOLOCENE				3,000
		Bronze Age		5,000
		Neolithic		8,000
		Mesolithic	Microliths	10,000
PLEISTOCENE	Upper Pleistocene	Upper Paleolithic	Magdalenian	25,000
			Aurignacian	35,000
		Middle Paleolithic	Levolloiso-Mousserian	50,000
			Acheullian Flake tools	100,000
	Middle Pleistocene	Lower Paleolithic	Handaxe	250,000
				500,000
	Lower Pleistocene		Chopper tools first tools	3 million

Approximate beginning and end dates for the archaeological periods mentioned in the text. The terms refer to different styles and technologies for making flint tools. The transitions from one style to the next took place at different dates in different parts of the world. These dates are generally accepted for Europe and the Middle East.

are accepted I quote from Grahame Clark's *World Prehistory*, published in 1969: "The radiocarbon dating suggests that the Japanese islands were settled already during the Late Pleistocene, and this after all agrees very well with the fact that at the peak of glaciation (about 20,000 years B.P.) the main islands were joined to one another and to the mainland of east Asia by way both of Korea and of Sakhalin and the Amur Basin."

And again: "The territory of Siberia . . . owes its interest largely to its position in relation to the New World. . . .through this region the first immigrants must have passed on their way to America, presumably at a time when the land-connection was still intact."

And again: "There were periods during the Pleistocene when man could occupy most of Indonesia west of the Wallace line* without having to traverse open water. . . . Having once got to Australia by the use of some kind of boats or floats . . . which at the time of low sea level would have been joined to New Guinea on a broad front by the Sahul Shelf, there was nothing to prevent overland crossing to Tasmania, which was likewise joined to the mainland. The mere fact that sea passages were so narrow during the late glacial period makes it more likely that man first got into Australia at this time."

So if everybody agrees with this view, what is the problem? Let me quote Clark once again: "Mesolithic (about 10,000-6,000 B.P.) man could compensate for the reduction in animal grazing ground caused by the spread of forests, and that was by the development of fishing. Much of the evidence for this lies submerged by the rise of the ocean levels due to the continued melting of the ice-sheets."

*The Wallace line, first described by Alfred Wallace, marks the evolutionary break between Asia on one side and eastern Indonesia and Australia on the other.

In short, all competent archaeologists agree that the continental shelf must have been exploited in a general way for hunting and fishing, and in an explicit way to facilitate continent-to-continent migrations, but we have no direct evidence at all to support this, except that people arrived on the other side! It is implicit that they made the crossing by walking or use of simple craft at times of low sea level, but they could have made the crossing by use of more sophisticated craft over greater extents of water. Everybody agrees that the explanation is obvious, but we do not actually have any proof. This is rather unscientific; in fact, it is the Medieval view of knowledge. As Hilaire Belloc, a turn-of-the-century British humorist, said in his delightfully ironic poem about the microbe: "Let us never never doubt what nobody is sure about. Scientists, who ought to know, assure us that it must be so."

So everybody agrees what the answer ought to be, and everybody agrees that all the relevant data are buried beneath the sea. To continue my unscientific quotations, Mark Twain said (in reference to the weather), "Everybody talks about it, but nobody does anything."

But a few people have done something, and what they have found provides direct evidence that human beings did live on the continental shelf during the Palaeolithic, Mesolithic, and Neolithic periods, and that the remains of those cultures survived inundation by the oceans.

Mediterranean and Middle East

The work of Richard Leakey, Donald Johanson, and other biological anthropologists has shown that modern man originated in Africa more than 1 million years ago. The human expansion from Africa into Asia and Europe could have taken place entirely through the isthmus of Sinai, which has its narrowest point at the location of the present Suez Canal. When we use the terms expansion, or migration, we should not envision thousands of people with their flocks marching like a biblical scene from a movie. Rather, we must envision a gradual extension of hunting and seasonal migration patterns such that the boundary of the area occupied or used is moved on average less than one kilometer in a year.

Nevertheless, our understanding of these early years of human history is different if we presume that all human contact was through Suez, or if we assume that crossings could also take place across the southern end of the Red Sea; from Tunisia to Sicily and Italy; or from Morocco to Spain. Comparison of stone tool assemblages on each side of these channels indicates that there probably was direct contact across each strait tens of thousands of years ago, and that people were crossing the straits. As yet, there is no direct evidence from beneath the sea, but it is very important to find it. In the 1960s, this author explored a series of submarine caves off the southern tip of Gibraltar, down to a depth of 25 meters, and sport divers and off-duty military divers have now taken up the search. Other groups of divers are searching submarine caves around Malta.

The earliest evidence of exploitation of marine resources consists of layers of oysters, mussels, and limpets found at Terra Amata, near Nice, in the south of France. This is a land site, but it indicates that the occupants were collecting shells between 235,000 and 400,000 years B.P.

So far no signs of submerged habitation sites or hunting tribes have been found on the continental shelf immediately adjacent to the critical straits of the Mediterranean or Middle East. However, a large number of submerged Bronze Age and Neolithic sites have been found around the Mediterranean, and a few Paleolithic sites are now being explored by divers. These discoveries establish beyond any doubt that human occupation did take place below present sea level, and that the artifacts can survive the traumatic transgression of the high-energy surf zone.

Jean Guilaine, Director of the Center for Anthropology at Toulouse, France, and a team of distinguished colleagues have been working for 10 years on the mass of artifacts and food remains brought to the surface by a dredger working in the saltwater lagoon of the Etang de Leucate on the south coast of France. A Neolithic village was established at about 6,800 B.P. on a ridge of gravel brought down by the nearby river. The occupation level is now 4.5 to 6.0 meters below sea level. Archaeological analysis of recovered material shows that the people kept domestic animals, such as sheep and cattle, and that they hunted wild boar, deer, and birds. They collected shellfish and wild plants, and also caught deep sea fish. They used tools made of stone and bone, and made pottery, which they decorated by impressing the patterns of seashells into the wet clay. The excavators of this site concluded that coastal and maritime diffusion of Neolithic skills in food production took place on the now submerged continental shelf.

In 1981, two submerged Neolithic sites in Greece were surveyed and small test excavations made. At Franchthi Cave in the northern Peloponnese, John Gifford, Associate Professor of Anthropology at the University of Miami, and his team of divers worked in a water depth of 4.5 meters and cored the sea bed to a depth of 5.5 meters (10 meters below sea level). At two locations Neolithic pottery fragments, charcoal, and vegetable remains (dated to between 6,000 and 7,000 B.P.) were recovered from about 10 to 11 meters below present sea level. Lack of abrasion of the pottery, and lack of sorting of the associated sediments and vegetable remains suggests that there has been minimal transport or reworking of the deposit by waves, implying that the materials were deposited close to the shoreline of that time.

Farther north, the author worked with a team of divers from London University and the Greek Archaeological Eforiate of Volos to survey the sea bed around the tiny island of Aghios Petros in the Sporadhes. Although the sea bed at first seemed featureless and unvarying, we eventually identified an anomalous zone of 50 by 35 meters, and made some small test excavations of 1 meter squares. One 1 meter square excavated to a depth of 5 centimeters produced 123 pieces of goat and sheep bones, 347 sherds of Neolithic and Bronze Age pottery, 7 obsidian blades, assorted flakes of flint, chert, and quartz, and a primitive ceramic figurine. A further 1 meter square test produced almost identical results, even including another figurine. Embarrassed by the prolific haul, we then cut the test quadrats to 0.5 meters square. The results on a total of four more pits were similar, though proportionately smaller. The test quadrats were dug at depths below present sea level ranging from 3.8 to 8.8 meters. I concluded that there was a coastal settlement on the island, with trade communications with the mainland of both Greece and Turkey.

On the Mediterranean coast of Israel, Avner Raban and his colleagues at the University of Haifa (see page 59) have discovered numerous submerged sites of the Neolithic period, containing floors, pottery, hearths, burnt tree roots, tree trunks, and a host of associated materials. Most of the sites are in shallow water, less than 3 meters deep, on the gently sloping, sandy shore, but deeper sites may soon be found near the offshore ridges that run parallel to the shore. Most of the sites date from 6,000 to 7,000 B.P.

During 1984, the author visited Corfu to check on reports of Paleolithic implements being washed up by the sea. With the assistance of some local experts, we were able to find Levalloiso-Mousterian tools (from approximately 40,000 years B.P.) about 200 meters offshore, in 3 meters of water. Meanwhile, preliminary reports from Italy suggest that divers have found submerged caves and rock overhangs associated with flint tools nearly 100,000 years old.

Thus, the evidence from the Mediterranean shows that the continental shelf was occupied definitely to a depth 10 meters below present sea level, and over a time span of at least 40,000 B.P. to 6,000 B.P. That is the evidence. Venturing slightly into Hilaire Belloc country, one might suggest that the evidence is compatible with occupation at deeper levels and over longer periods.

Northwest Europe

The volume of Mesolithic and Neolithic village sites now discovered by divers in the shallow Baltic waters off Denmark and Sweden is so great that only the most important can be excavated in detail. Joergen Skaarup, a regional director of archaeology in Denmark, has worked with amateur scuba divers to map and recover artifacts from numerous submerged villages of the Mesolithic. A.S.H. Andersen, another regional director, excavated a Mesolithic settlement at Tybrind Vig off the island of Fyn which was occupied from 6,000 to 3,600 B.P. The remains included tools made of flint, wood, and antlers. There were a few sherds of pottery, leaves, fruit, seeds, and branches preserved in the underwater clay. The divers found the grave of a woman and child, and the scattered bones of at least four individuals. Most amazing of all, a perfectly preserved dugout canoe was embedded in the clay, 9 meters long, 0.65 meters wide, and cut from a single lime trunk. Nearby were oars, bows, and spears. Carbon-14 dating indicated an age of 5,700 years B.P.

On the stormy west coast of Scotland, the Hebrides are among the wildest islands of Europe. Sheltered by Islay, Colonsay, and other islands, Jura is relatively secluded. Mesolithic settlements there are associated with ancient raised shorelines, but the oldest sites at around 10,000 B.P. are so low that they can only be examined at low tide. The scattered flints seem to continue under the water, and divers are planning to expand the work to below low-tide level.

So the story continues around the coast of Brittany in France, and through the Channel Islands. Even from the sandbanks on the floor of the North Sea, the Dutch fishermen dredge up carved antlers and bones in their nets. When the sea level was lower, tribes migrated into Britain by walking across the North Sea as the ice sheets retreated.

Southeast Asia

Twenty thousand years ago when the sea level was about 100 meters lower than at present, Australia, Tasmania, and Papua-New Guinea were joined into a single continental landmass known as Greater Australia. All the islands of Indonesia were joined

The author snorkel diving on the Paleolithic site off Corfu. Flint tools and cores have been found between fallen slabs of conglomerate. (Photo courtesy of Kleinberg Photographic)

from Malaysia to Bali. From there to the east there were a number of channels that would have to be crossed if people or animals were to reach Australia. From the bones of so-called Java Man we know that humans reached that island about 1 million years ago, while recent discoveries in several parts of Australia show that the first Aborigines were well distributed in Greater Australia before 30,000 B.P. Sometime between these two dates, and probably later rather than earlier, humans crossed into Greater Australia, but exactly when and how is still a mystery.

Joseph Birdsell, Professor of Archaeology Emeritus at the University of California at Los Angeles, has presented maps and analyses estimating the degree of difficulty for each route through the eastern Indonesian Archipelago at times of low sea level. Whatever route was used, the journey to Australia must have included several sea channels, with one on the order of 50 to 80 kilometers in width. We are forced to the conclusion that Paleolithic tribes crossed sea channels of this width by boat, and that they did so in sufficient numbers to establish a permanent breeding population that could sustain itself in the face of all the hazards of the arid Australian climate.

Again we are in the land of Hilaire Belloc. "Scientists who ought to know assure us that it must be so. Oh let us never never doubt what nobody is sure about." But who made the sea craft that could cross the Timor Sea? When? How? Where did they leave from, where did they land? Why did they undertake such a voyage? (Indonesia seems so much more lush and fruitful than Australia.) And strangest of all, how did the peoples of 30,000 years ago have the technology to make such voyages? I am not suggesting anything wild about mysterious lost civilizations. I am just asking the blunt question: assuming a primitive culture using clumsy stone tools – of which examples have been found – how did they do it? The only fact we know is that they did.

The northwest continental shelf of Australia, the so-called Sahul Shelf, is a broad, undulating submerged landmass approximately 600 by 300 kilometers. Much of it is deep and sparsely surveyed. In 1982, with the support of a number of Australian and British institutions, and with financial support from the Australian Submarine Prehistory Research Foundation, I led an expedition to examine the Cootamundra Shoals, on the Sahul Shelf, 200 kilometers from Darwin. We did not immediately find human remains. The purpose of the expedition was to explore and describe the landscape of the shoals as it would have appeared when the sea level was about 60 meters below present sea level. This was the maximum depth to which we could descend on scuba.

We found that the shoals could indeed have been inhabited, and that the coastal environment would have provided food resources. The main land surface was about 34 meters below the present surface of the sea, and deep sinuous valleys wind between the banks, which are themselves fossil coral reefs. The reefs have been exposed many times to wind and rain at periods of low sea level, so that the landforms are a composite of reef-building, erosion, and rainwater solution. Several of the valleys have deep inland depressions showing internal drainage, probably associated with underground rivers.

Use of submarine television cameras, echo-sounding, and diving, revealed several submerged beach levels, while carbon-14 dating of fossil corals carried out by the Australian National University provided estimates of the rate of rise of sea level. Much more work is needed on the Sahul Shelf before we can have a chance of actually discovering the remains of human occupation, but at least we have established that Cootamundra Shoals is a good place to start.

Siberia to Alaska and the Americas

David Hopkins, Distinguished Professor of Quaternary Studies at the University of Alaska in Fairbanks, has devoted many years to the study of the ancient landmass that included eastern Siberia and Alaska, known as Beringia. Ecologically, this area was cut off from the rest of North America and Asia by ice sheets during times of low sea level.

There was dry land from Siberia to Alaska, the Bering Land Bridge, for most of the time from 80,000 to 14,000 years ago. Shallow episodes of flooding occurred at about 45,000 and 35,000 B.P. Cores from the land and the sea bed provide evidence for the pollen types at different dates, the sediment movements, and the stages of marine transgression or emergence. From the point of view of human occupation, the inhospitable nature of Beringia was not just because of the cold, but also the severe dryness for most of the time from 60,000 to 14,000 B.P. Pollen indicates a sparse tundra vegetation with dwarf birch widely distributed, and willow trees in the river floodplains.

The low-lying plains on the continental shelf were probably wetter than the highlands that can be studied on the present continents, and mammoth, horse, and bison ranged widely. Hopkins has documented a series of climatic and vegetation changes with increased rainfall during the marine transgression. As the waters of the Arctic Ocean flooded into the basin of the Chukchi Sea and joined to the Pacific, the last sill at the Shpanberg Strait, only 30 to 32 meters deep, was flooded at about 12,000 B.P.

The date and manner of the first human crossing of the Bering Land Bridge is, to put it mildly, controversial. This author does not intend to join the controversy, or even try to describe it. From land evidence most archaeologists agree that there was human occupation of Siberia by 70,000 years ago, and recent unconfirmed press reports suggest that Russian scientists have found much earlier remains during the past year. One uncontested occupation site in the United States is the Meadowcroft Rockshelter in Pennsylvania, which gives an earliest date of about 19,000 B.P. Suggestions for the most probable time of human entry into North America range from 20,000 to as much as 150,000 B.P.

Michael McBride, a conservationist and amateur archaeologist working in China Poot Bay, Alaska, has found intertidal remains of human occupation sites, and is planning to explore deeper using scuba gear. David Hopkins reports a single granite tool dredged up from the Bering Strait in a trawl, while Nikolai Dikov reports possible artifacts recovered from underwater by geological drills. These incomplete reports are the only suggestion so far that submerged materials might be found in Beringia. Further exploration is vitally important, especially in view of the extreme uncertainty about the date of first occupation of Alaska. Land evidence already indicates that the onset of the last Ice Age forced some people to migrate westward out of Alaska toward Siberia, so the evidence from beneath the sea might reveal movement in both directions.

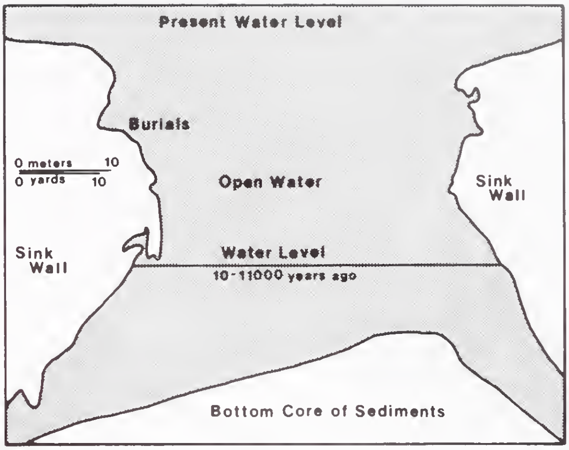
Early Paleo-Indian sites have been found below sea level off the southern coasts of the United States (see page 27). On the coast of Florida, Wilburn Cockrell, a marine archaeologist with the Florida Department of State, has recovered human bones and mammoth bones dating from 6,000 B.P. from a submerged site near Cape Kennedy. Near the Gulf Coast of Florida two flooded limestone caverns, Little Salt Springs and Warm Mineral Springs, have both been excavated by divers, and show Indian occupation down to 20 meters below present sea level and dates of 10,000 to 11,000 B.P. These excavations disclosed a rich variety of tools, seeds, bones, shells, pollen, nuts, human skulls, and even an oak boomerang. At the time of occupation of the caves the sea level would have been about 30 to 40 meters lower than at present, and the groundwater level in the caves proportionately lower than at present.

Underwater study of lithic culture sites in North America and especially in Beringia may contribute strongly to an understanding of early maritime technologies, and to the migration process itself. At the moment, the established finds are exciting in themselves, but no submerged site provides an earlier date than the best dated sites on land, and no submerged site has yet been found in the Bering Strait.

Conclusions

Ten years ago most geologists or archaeologists asked to give an opinion on the chances of finding Stone Age relics on the continental shelf would have rated the chances very low indeed, perhaps infinitely small. Since then a series of reputable publications have shown beyond doubt that lithic artifact sites are being found by divers off the coasts of many parts of the world, while amateur exploration and reports of work in progress suggest that the near future will produce deeper and older discoveries.

The area of the continental shelf is 5 percent of the entire area of the Earth, equivalent to a continent the size of North America. This continent was once available for exploitation by Stone Age peoples, and its exploitation contributed mightily to the growth of early technology, marine skills, the origins of seafaring and sea fishing, the origins of agriculture, and of civilization itself up to the start of the Bronze Age in the Middle East. It is unscientific to go on saying " This must have happened . . . ," "That must be so. . . ." Now is the time for earth scientists, oceanographers, and archaeologists to combine in the exploration of the drowned continent, and to obtain reliable scientific evidence. Above all, we need to know exactly where the shorelines were at each date with an accuracy of about 1.0 meter vertically, and 1,000 years in date. The discoveries of artifacts can then be related to the land and water masses of the time.



Cross section of Warm Mineral Springs, Florida. Paleo-Indian burials are located on ledges halfway down to the ground-water level at the time of occupation. (After Wilburn Cockrell)

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California Coastal Evolution and the La Jollans

by Patricia M. Masters

Humans have been living in southern California for at least 12,000 years, and during that time they have witnessed a series of retreating shorelines caused by rising sea level. Present-day sea level along the coast of California was reached only about 3,000 years ago, following a long period of climatic warming and melting of the polar ice caps. Since the climax of the last major worldwide glaciation, sea level has risen 120 to 150 meters (Figure 1).

New archaeological evidence is demonstrating an intensive and nearly continuous reliance by prehistoric people on Southern California's marine resources, not only on the mainland, but also on the Channel Islands. The evidence suggests that fishing and seafaring have occurred throughout the Southern California Bight for at least the last 8,000 years. Much of the new information comes directly from California's continental shelf, where an extraordinary number of artifact sites have been discovered.

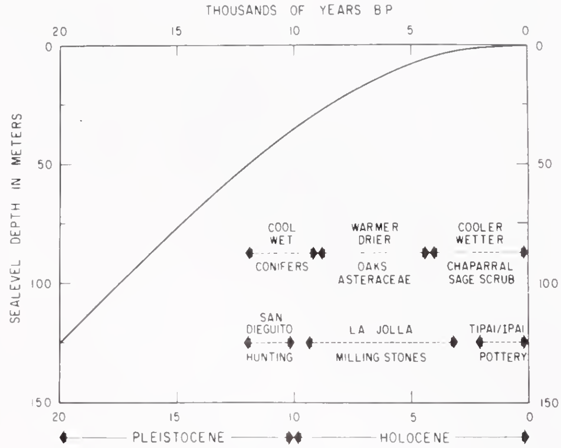

Figure 1. A generalized sea-level curve for southern California from the late Pleistocene through the Holocene. Also shown are the cultural and climatic successions. Years before present (B.P.) are calculated from 1950, as a scientific convention.

The Prehistoric Peoples

The earliest inhabitants of southern California were the San Dieguito, members of the widespread, big-game hunting tradition recognized throughout North America. There is no archaeological information on the coastal activities of the San Dieguito. But in the time range of 12,000 to 10,000 years B.P., when they occupied this region, the shoreline lay between 40 and 20 meters lower, and between 1 and 6 kilometers further seaward. If they fished or hunted along that earlier coastline, it is unlikely that we would find any evidence of it today.

Ethnographic information on later prehistoric peoples (described by the Spanish explorers, mission records, and living descendants) indicates a seasonal dependence on marine resources. Known shoreline usage zones extended along most of what is now the San Diego County coastline, which comprises about one quarter of the coast of the Southern California Bight. These

Figure 2. In the southern San Francisco Bay area, the Costanoans, shown here, used double-bladed paddles, as did the Chumash around the Santa Barbara Channel. (Watercolor by Louis Choris, 1816; taken from Levy, 1978)

peoples gathered marine foods with fishing spears, traps, and nets. They collected shellfish using a sharp stone as a prying tool; they also gathered edible seaweed and caught shorebirds. They made rafts and boats from reeds, and also manufactured dugouts from logs that washed down the then-large rivers in northern San Diego County.

From 9,000 B.P. to 3,000 B.P., in between the San Dieguito and late prehistoric cultures, southern California's most prominent culture flourished. Known to archaeologists as the Milling Stone Horizon, and to local residents as the La Jollans, these people left extensive shell middens, or refuse heaps, on the seabluffs and around the tidal lagoons of San Diego County. Today, as a result of urbanization, fewer than 10 percent of these sites remain.

Although we have no record of rafts or canoes, cultural remains dating from La Jollan times have been found on several of the Channel Islands (Figure 2). One shell midden on San Clemente Island has been dated to about 8,000 years B.P. This demonstrates that even in their earliest period, the La Jollans had the ability to navigate across wide stretches of open ocean. San Clemente Island is 75 kilometers from the nearest point on the mainland and 35 kilometers from Santa Catalina Island. Circulation in the bight would generally favor transit to San Clemente via Santa Catalina Island and then directly back to the mainland.

It is clear from their widespread shell middens that the La Jollans also were able to exploit bays, lagoons, and nearshore marine environments. These people thus represent the earliest marine-based economy (of a seasonal nature at least) known for California.

Between 9,000 and 3,000 years B.P., such coastal activities as fishing, collecting, and hunting necessarily took place on the now submerged continental shelf. If these coastal peoples established camps or permanent habitations on the exposed shelf, some of the artifacts found underwater in the Southern California Bight may be remnants of these economic and social activities.

Underwater Artifact Sites

Within the Southern California Bight, from Point Conception south to the international border, 110 submerged prehistoric artifact sites have been found — a density unparalleled anywhere else in North America (Figure 3). The finds range from a single artifact to multiple artifacts and, occasionally, to hundreds of artifacts.

Since 1979, sites along the San Diego County coastline have been extensively studied. Maps of the sites have been drawn based on published accounts and records from local museums and libraries, and personal on-site inspections conducted. In some localities systematic diving surveys have been used (Figure 4). Visual surveys of the bottom conditions in the vicinity of the submerged artifacts can yield valuable information on depositional and erosional features, which are essential clues to the nature of the sites.

There are two major concentrations of artifact sites, off La Jolla and off Point Loma (Figure 5). Both of these regions are headlands with sandstone exposed just offshore. There are almost no sandy sediments offshore, and the bare shelf supports forests of giant kelp.

At this point, it should be mentioned that the distribution of the sites is correlated with the amount of diving occurring in each area. Most commercial and sport diving focuses on the kelp beds and rocky reefs where abalone, fish, lobster, and sea urchins can be taken. The lack of a sediment cover also makes the artifacts more visible. So the discovery of artifacts probably does not provide a true picture of the prehistoric underwater sites along our coastline. The sites reported are simply the ones that can be seen.

The Mortars

Other than sheer numbers, the most striking characteristic of underwater artifact sites is the type of artifact found. Vessels, either mortars or shaped bowls, are overwhelmingly the most common artifacts reported. The mortars are formed on rounded cobbles, 15 to 20 centimeters in diameter, with a hemispherical or conical basin pecked into one surface (Figure 6). (Bowls are worked on both the interior and exterior surfaces.) Both bowls and mortars are manufactured from sandstone or mudstone cobbles, with a small percentage consisting of volcanic or granitic materials. Of the 42 underwater or intertidal localities in the southern part of the bight, 36 have been identified on the basis of mortar finds and two from bowls. Nine of the sites have yielded more than one mortar, with two localities accounting for hundreds (and by some accounts, thousands) of mortars.

The prevalence of this type of artifact from submarine localities may result from the fact that divers who have no archaeological training can

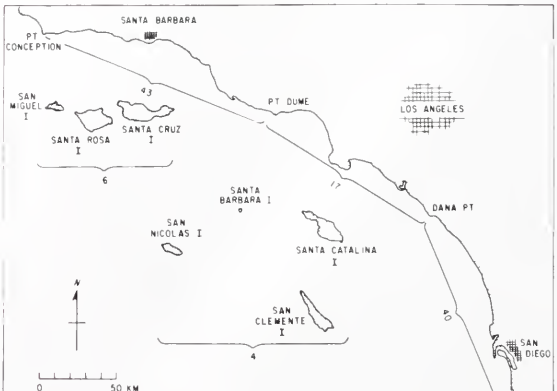

Figure 3. The Southern California Bight and Channel Islands. The number of underwater artifact localities is given for each area.

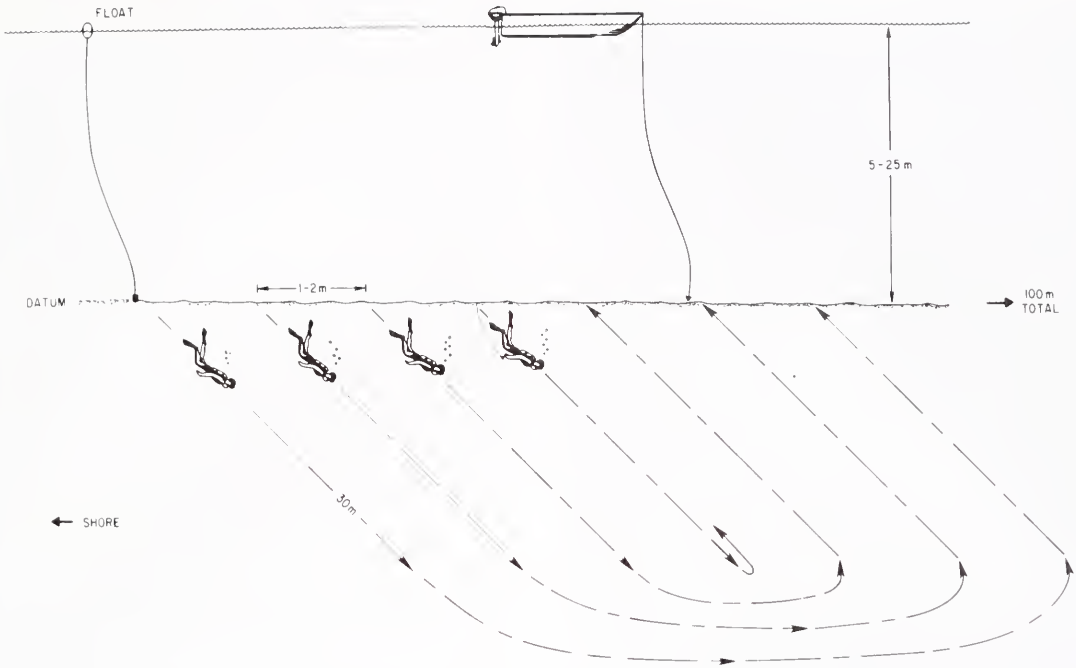

Figure 4. Diving plan for archaeological surveys. Divers are spaced at 1- to 2-meter intervals along a baseline anchored between two floats. A lead diver, at the far right, swims perpendicular to the baseline and unrolls a 30-meter line. The other three divers search the seafloor and remain in visual contact. On the return swing, all divers search and the lead diver stows the line as well. Up to 360 square meters can be covered this way.

recognize it easily. On the other hand, mortars are rarely reported in terrestrial archaeological sites, despite the availability of cobble outcrops in inland areas with long histories of occupation. In other words, the raw materials for fashioning mortars were available, but the terrestrial sites show little or no evidence of mortar manufacturing. Therefore we are realizing that in San Diego County, cobble mortars are definitely associated with the present continental shelf and reflect prehistoric activities on the exposed portion of the shelf or in nearshore areas.

In the northern part of the bight, cobble mortars have been found in Milling Stone Horizon sites on land. The type of vessel pictured in Figure 6a has been found in one site from Santa Barbara County dated to 4,600 to 4,800 years B.P. Another is reported from a site in Los Angeles County, dating to between 4,000 and 7,000 years B.P. Cobble mortars also occur in late prehistoric sites on the mainland; on Santa Rosa Island a mortar was dated to about 600 years B.P. These dates are very useful, since no underwater site has yielded datable materials as yet.

Mortars are used to grind up small bits of some material. The La Jollans may have used them in the preparation of food, pigments, or medicines. D. Travis Hudson, an archaeologist with the Santa Barbara Museum of Natural History and the first to systematically study the underwater artifacts from the Santa Barbara Channel, has cited an early ethnographic description from San Nicolas Island. An Indian woman was observed pounding dried abalone meat with a mortar and pestle. Various foods from marine vertebrates and invertebrates could have been dried and then similarly processed before being stored or consumed.

The bowls, of the so-called "flowerpot" form (Figure 6b), date from the Canalino period in the northern bight, 2,500 to 3,000 years ago. Hudson suspects a ceremonial purpose to their distribution since the Santa Barbara area (the area of their greatest concentration) was considered sacred by the late prehistoric Chumash. Various ethnographic accounts mention ceremonial discard of personal objects such as beads into the sea. John P. Harrington, an anthropologist who studied the Chumash in the early part of this century, described the Chumash practice of always carrying something aboard canoes that could be sacrificed to the sea, particularly if high winds arose.

Bowls have been found at two sites in the southern part of the bight – one off Santa Catalina Island and one in the La Jolla kelp beds. Both are from 11 to 12 meters below sea level, depths that also would have been below sea level in the late prehistoric period. The localities are too far from the present shore to have eroded out of an onshore site. Therefore, the bowls must have been dropped from canoes either accidentally or intentionally. The absence of other nearby artifacts in each case tends to support a ceremonial origin. Mortars are found at all depths, ranging from intertidal to more than 30 meters.

When all artifact localities in the southern bight are grouped by depth, four clusters appear (Figure 7). The intertidal sites are probably erosional features from nearby onshore sites and will not be considered any further here. The other three groupings are more interesting. At 2 to 5 meters in depth, there are a number of nearshore sites on rocky or cobble reefs; among these are two sites that yielded hundreds of mortars. Between 11 and 21 meters, kelp bed sites predominate. The third category, walls or ledges of the submarine canyons, overlaps in depth (but not location) with the kelp beds and includes one find at a depth of 31 meters. The submarine canyon heads are mapped in Figure 5.

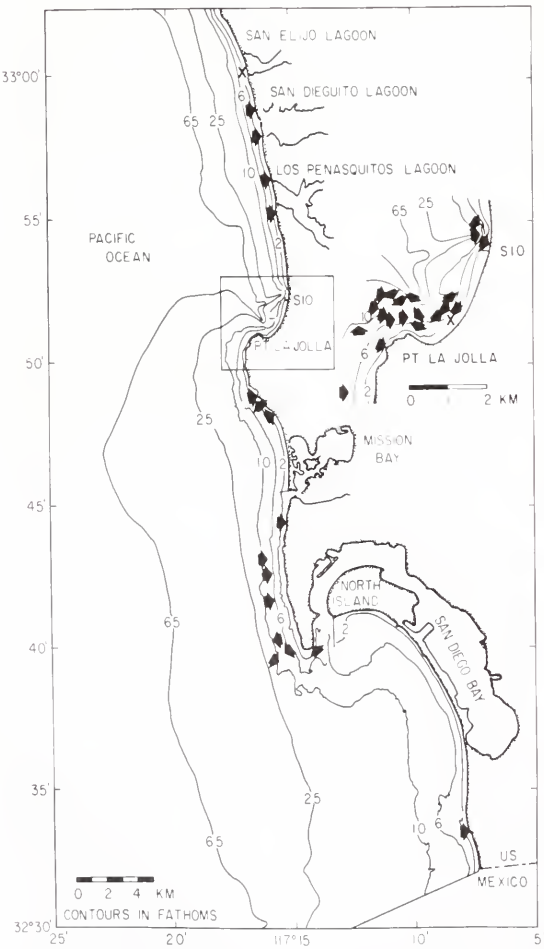

Figure 5. Map of the underwater artifact localities in southern San Diego County. The two major sites, at La Jolla Shores and Solana Beach, are marked by X's.

Interpreting the Underwater Sites

If the dates from the Santa Barbara and Los Angeles sites also apply in the southern region, then our local mortars may range in age from La Jollan through late prehistoric times. Certainly they should be no older than the earliest La Jollan sites since the San Dieguito were not known to have used any milling tools. The shoreline in early La Jollan times was probably 12 to 15 meters lower than it is today (Figure 5). In late La Jollan times, 3,000 to 4,000 years B.P., the shoreline lay 2 to 3 meters below present levels. Consequently, the only artifact localities that unequivocally qualify for drowned terrestrial sites are the nearshore reefs at 2 to 5 meters. The kelp bed sites and submarine canyon sites were not dry land during most of the La Jollan period. They probably resulted from losses during canoeing and fishing activities.

Other lines of evidence gained in the diving surveys support this interpretation. The kelp bed localities are all characterized by very similar bottom conditions: an exposed sandstone formation having an irregular surface pocked with small depressions and gullies in which thin veneers of

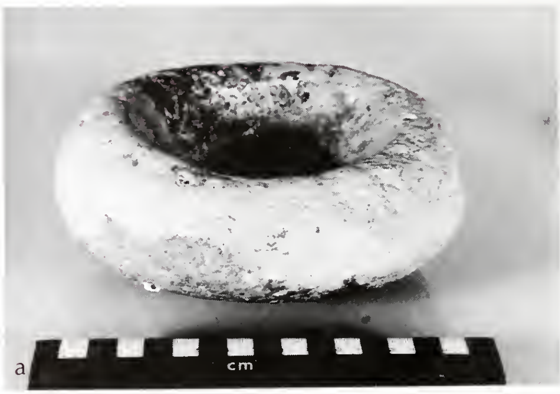

Figure 6. A cobble mortar a) and a shaped bowl b) from underwater sites.

sand collect. Scattered over this seascape are concretions* and rocks ranging in size from pebbles to boulders. Combined with water depths of 6 to 20 meters, these are ideal conditions for kelp growth. In late La Jollan times through the present, kelp beds have provided the best fishing of any nearshore shelf environment. This may explain the frequency of accidental or ceremonial losses from seagoing craft in these areas.

Another possible explanation for the kelp bed sites is that the mortars could be remnants of coastal sites prior to La Jollan times, when sea level would have been even lower. The sites, however, are found on what would have been an open, high-energy coastline during the rise in sea level. The shelf in this area is believed to have been dramatically affected by wave action about 9,000 to 10,000 years B.P. It is therefore unlikely that any cultural deposits would have remained in place from before the marine transgression.

The submarine canyon sites also may result from canoe losses, but another possible explanation is kelp rafting. To grow, young kelp plants must anchor to a solid substrate. Attachment can occur to the exposed sandstone seafloor or to smaller objects such as cobbles. Once the buoyancy of the giant alga overcomes the weight of the cobble, it is lifted off the seafloor and rafted away (Figure 8). Storms and high waves concentrate kelp (and anything attached) in the canyon heads, although some is washed up on the shore.

Human shoreline activities are the most reasonable explanation for the nearshore reef sites. During mid-to-late La Jollan times, the rocky reefs

*A harder, more resistant form of sandstone.

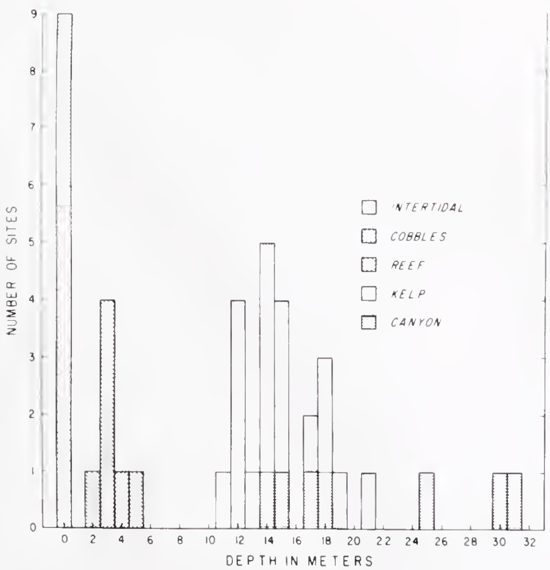

Figure 7. The distribution of underwater artifact sites by depth and terrain along the San Diego County coast.

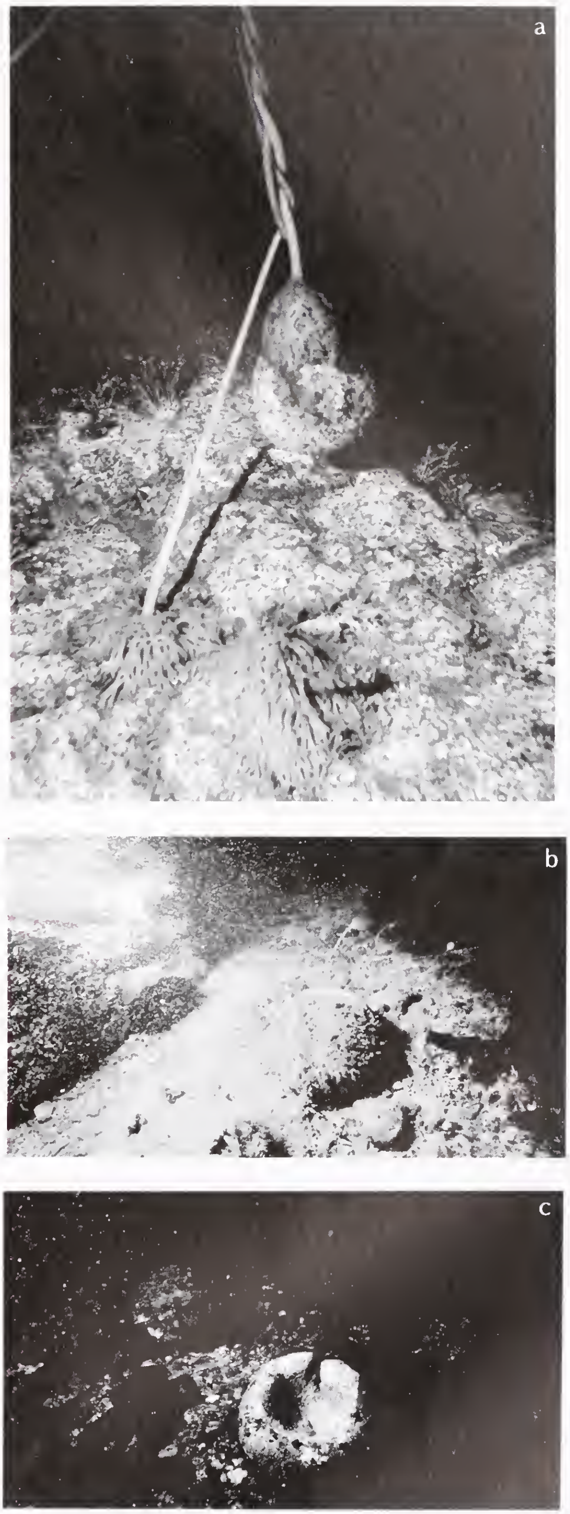

Figure 8. Kelp rafting of cobbles or mortars. a) A cobble is buoyed up by Nereocystis kelp off Monterey, California. b) A cobble mortar off the Point Loma headland in San Diego at a depth of 12 meters. Young kelp are attached. c) Same mortar inverted. (Photos courtesy of Ron McPeak)

Figure 9. A portion of the cobble reef at the La Jolla Shores site exposed by sand movement. Arrow marks a mortar in place at a depth of 3 meters.

were intertidal areas teeming with scallops, mussels, limpets, oysters, abalone, barnacles, starfish, and snapping shrimp. Shellfish collecting and processing would have taken place among these reefs. Most of these sites lie offshore of large midden or village sites, and many are near freshwater sources.

Two of these reef sites, at La Jolla Shores and Solana Beach, lie off the mouths of ancient or modern lagoons. They have yielded hundreds of mortars over the last 40 years. Today, the sites are visible in 3 to 6 meters of water when uncovered by seasonal sand movement. The La Jolla Shores site consists of extensive cobble patches intermixed with sand and lying on top of layers of peat and clay. Scattered among the cobbles are the mortars (Figure 9). At the Solana Beach locality, the mortars were found mingled with cobbles in a protected pocket of the reef. The La Jolla Shores site was probably a cobble spit deposited at the mouth of the now extinct lagoon. Estimates of the number of mortars go as high as 2,000 for the La Jolla Shores site, suggesting that it may have been a specialized manufacturing locale or factory site. With more than 100 mortars recovered from the Solana Beach reef site, it also probably was a mortar factory site.

Both sites are associated with extensive middens on the seabluffs above. The midden on the Solana Beach bluffs has never been professionally excavated or dated, but surveys indicate a La Jollan occupation. The bluff midden above the La Jolla Shores site has radiocarbon dates ranging from 1,270 to 4,770 B.P., indicating that it was a living site for both La Jollan and late prehistoric peoples.

Evolution of the San Diego County Coastline

The ecological zones of a coast are defined not only by climate but by physiographic and geological features. The interaction of sea-level changes with the physical features of our local coastline has recently been reconstructed for the last 120,000 years by Douglas L. Inman, Director of the Center for Coastal Studies at Scripps Institution of Oceanography (Figure 10a). As sea level first falls and then rises again, stream valleys go through a series of five changes. At the start of the cycle, streams have eroded valley floors to near sea level (Figure 10b, t_1). As sea level falls, water courses begin to cut into the former flood plains and exposed continental shelf (t_2) and eventually carve deep valleys (t_3). Because there is now a steeper gradient between the earlier watershed and the lowered sea level, streams have more energy and can move coarser sediments, such as cobbles or even boulders, to the new coast. Longshore transport by waves spreads the cobbles out.

When sea level begins to rise, the newly incised valleys are flooded and become bays. Large rivers rapidly fill their embayments, but the smaller

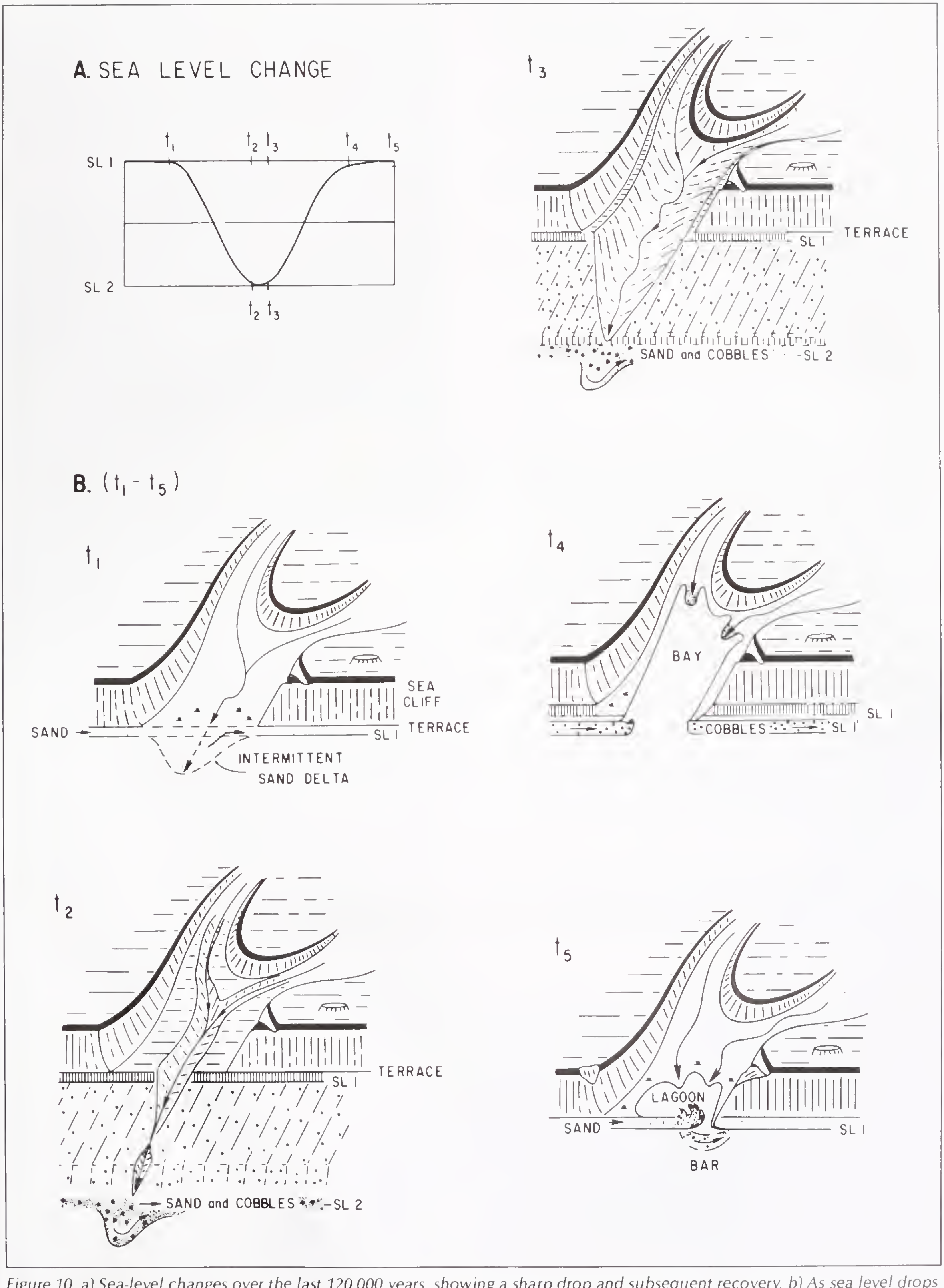

Figure 10. a) Sea-level changes over the last 120,000 years, showing a sharp drop and subsequent recovery. b) As sea level drops and then rises again, the geomorphology of stream valleys along the coast changes dramatically, with significant implications for coastal peoples.

streams deposit sediments only at the heads of the bays (t_4). This means that the outer coast is not receiving sediments to replenish its beaches. Yet storms and waves continue to pound the coast, so finer sediments are transported out of the area, leaving behind cobbles and other coarser materials that are worked into steep cobble beaches. As sea level rises further (t_4 to t_5), waves form cobble spits at the mouths of bays, and tidal lagoons and new salt marshes are created. Stream-borne sediments eventually fill in the lagoons, and the marine influence on their environments is essentially ended (Figure 11). The molluscan fisheries are rapidly wiped out. Only now are sandy sediments brought to the coast by streams; the demise of the lagoons coincides with the transformation from rocky to sandy beaches.

Prehistoric Peoples and the Evolving Coastline

Based on this reconstruction, the La Jollans came to the coast during t_4 times, near the end of the rapid Holocene sea-level rise. Embayments were teeming with marine life and vast cobble beaches edged the shoreline. After about 6,000 years B.P., sea level continued to rise, but more slowly, and bays began filling in. The underwater sites at La Jolla Shores and Solana Beach must date to between the formation of the cobble beds (6,000 to 7,000 years B.P.) and their submergence by the sea at about 4,000 years B.P.

Molluscan diversity and biomass declined rapidly with the closure of the lagoons and sand deposition along the shoreline, perhaps 3,000 years ago, as near-present sea levels were attained. The proportions of molluscan species in onshore middens reflect these changes. This transition may signal the terminal phase of the La Jollan culture because after 3,000 years B.P. the La Jollans disappear from the archaeological record.

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Figure 11. The La Jolla Shores area circa 1914, showing the remnant lagoon upper left and the early Scripps campus at the center.

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Prehistoric Man on Martha's Vineyard

by James B. Richardson III

Maritime archaeology is the study of human interaction with the ocean environment. Ocean resources have been a part of the economic system for more than 250,000 years in the Old World and for at least 10,500 years in the New World. Maritime archaeology involves research on human uses of ocean resources, as well as the study of geological, environmental, and oceanographic changes that have shaped cultures over the millenia.

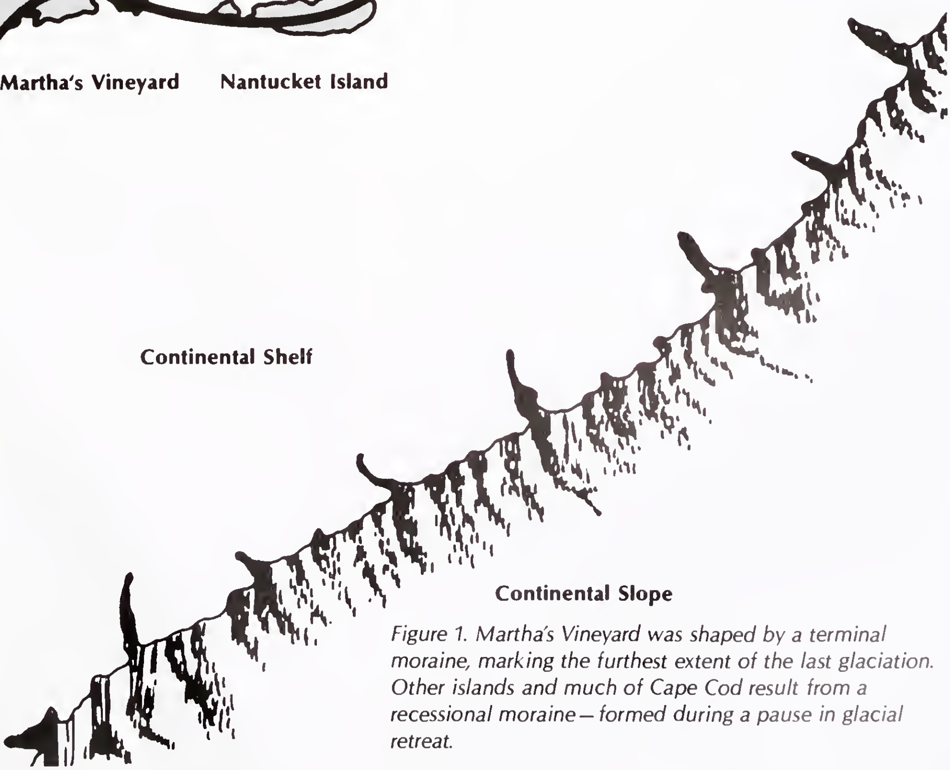

Figure 1. Martha's Vineyard was shaped by a terminal moraine, marking the furthest extent of the last glaciation. Other islands and much of Cape Cod result from a recessional moraine—formed during a pause in glacial retreat.

Unfortunately for maritime archaeologists, 17,000 years ago world sea level was much lower and the coastline was located many kilometers out from its present location. The continental shelf was part of the terrestrial environment. Thus, most evidence of the origins and development of maritime cultures prior to 5,000 years ago has either been destroyed or is situated underwater.

In 1981, the Section of Anthropology at the Carnegie Museum of Natural History initiated a long-term archaeological program of research on the 10,500 years of human adaptation to the changing landscape of the island of Martha's Vineyard, Massachusetts. One major question that this research addresses is when and how the early inhabitants of Martha's Vineyard began to include littoral and ocean resources into their hunting and gathering way of life.

The cultural chronology of New England is divided into three prehistoric periods: Paleo-Indian (10,500 to 9,000 B.P.), Archaic (9,000 to 3,000 B.P.), and Woodland (3,000 B.P. to European contact). Both the Archaic and Woodland periods are further subdivided into Early, Middle, and Late. The letters B.P. refer to before present, which by scientific convention is taken as 1950.

From Continent to Island

Until 5,000 years ago, Martha's Vineyard was an insignificant knoll on the exposed Atlantic continental shelf. The island was shaped by the Wisconsin ice sheet and by rising sea levels as the glacial ice retreated northward. The 91-meter-high backbone of the island was formed by the Buzzards Bay and Cape Cod Bay lobes of the Wisconsin glacial front,* which some 15,000 years ago rested on the northern half of the Vineyard (Figure 1). The glaciers left behind a V-shaped moraine with a flat outwash plain of sorted sands and gravels between the arms of the V.** The melting ice created a series of streams and rivers across the outwash plain. Ultimately, as the sea level rose toward the island, the stream and river valleys were flooded, forming the present ponds and lagoons.

During the later part of the Wisconsin Ice Age much of the water in the world's oceans was locked up in the continental ice sheets. Thus, 17,000 years ago, sea level was about 120 meters lower than at present. The continental shelf at that time was dry land stretching more than 100 kilometers south of the present southern shore of the Vineyard. The ice began retreating 15,000 years ago, and by between 14,000 and 13,000 B.P. its southern margin was north of Boston. By between 12,000 and 11,000 B.P., New England was essentially ice free. Human habitation began about 10,500 B.P.

There have been numerous estimates of the rate of the rise of sea level during the late Wisconsin and Holocene periods. One sea-level-rise curve for southeastern Massachusetts places sea level 12,000 years ago at 68 meters below its present level (Figure 2). Ten thousand years ago, at the beginning of the Holocene, the sea around the Vineyard was about 42 meters lower than at present; by 5,000 B.P. it was 10 meters lower than at present. The date of 5,000 B.P. is a crucial one, for it is at about this time that Martha's Vineyard truly became an island (Figure 3).

The island was larger than today, for during the last 5,000 years large areas have been submerged by the continued rise of the sea. Indeed, Martha's Vineyard is still shrinking as the result of the slow rise of sea level and coastal erosion. J. Gordon Ogden III, Professor of Biology at Dalhousie University, points to a radiocarbon-dated pine stump, located 6 kilometers off Katama Bay, which was killed by the rising sea at about 600 B.P. He believes the sea was then 2 meters lower. On the northwest corner of the island, a red maple stump, located in 1.2 meters of water, 20 meters offshore, was dated to 400 B.P. Ogden's study of the southeast corner of the island has demonstrated that between 1777 and 1969, the barrier beach receded by more than 880 meters. This is a loss of 4.6 meters per year because of the rise of sea level and the strong longshore currents that erode this coast. In addition to the erosion of the modern land surface, coastal archaeological sites and vacation homes are disappearing at an alarming rate.

The transgression of the sea across the continental shelf also may have had catastrophic effects on the evidence of prehistoric peoples' adaptations to the ocean. David G. Aubrey and Kenneth O. Emery, both scientists at the Woods Hole Oceanographic Institution, and Arthur L. Bloom, Professor of Geology at Cornell University, point to the fact that the landward migration of the coast has reworked the former continental shelf land surface to a depth of 10 to 18 meters, destroying much of the evidence for the presence of man in this area.

From Arctic to Temperate

The pollen sequences established by Ogden for Martha's Vineyard and by Marjorie J. Winkler (in a Master's thesis at the University of Wisconsin) for Cape Cod indicate that at 15,000 B.P. the exposed continental shelf supported a tundra type treeless vegetation composed of grasses. Spruce was the first tree to colonize this late glacial landscape and by 12,000 B.P. a boreal forest assemblage of spruce, alder, and jack pine predominated on the cape and the islands. At about 10,500 B.P. white and jack pine

*There are four named glaciations, of which the Wisconsin (lasting from 60,000 to 12,000 B.P.) is the most recent.

**Moraines are accumulations of rock, gravel, sand, and clay, deposited in place by glaciers. Outwash plains form when melting glacial waters carry sediments away from the glacier.

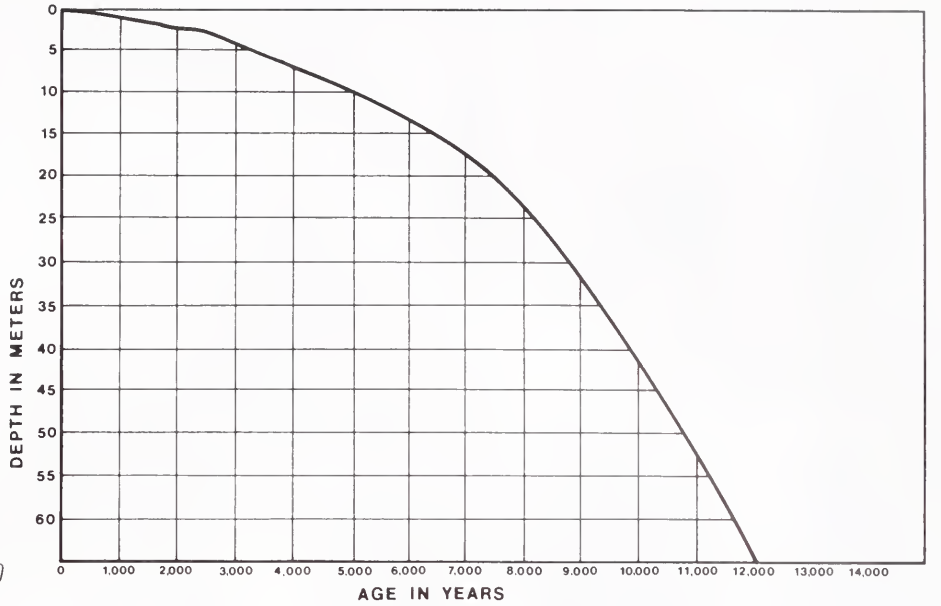

Figure 2. Approximate sea-level curve for southeastern Massachusetts. (Adapted from Oldale and O'Hara, 1980)

forests were prevalent and by 9,500 B.P. beech and oak trees appear in the paleobotanical record. Since 9,000 B.P. the vegetation of the islands and the cape has been similar to that encountered by the first European explorer, Bartolomew Gosnold, who visited the Vineyard in 1602 and described the island as having a high-canopied oak forest.

The resources that would have supported the early Indians changed as rapidly as the environment, and human culture had to continually readapt to new food sources as they either disappeared or became available for the first time. Fishing draggers have pulled up the teeth of mastodon and mammoth on the continental shelf off New England, New York, and New Jersey. Skeletons of these huge herbivores have been found in the eastern United States, but how extensively prehistoric peoples used this meat source is not known. In the western United States, these now extinct elephants were an important meat source for Paleo-Indian populations.

For the first several thousand years of human occupation of New England, the caribou was probably the major food source. Caribou bones have been found at the Bull Brook II site in eastern Massachusetts and at the Whipple site in southern New Hampshire, both dating to between 10,000 and 11,000 B.P. After the establishment of the temperate forest environment (around 9,000 B.P.), the modern range of fauna was exploited by man. The extensive lagoons, bays, marshes, and estuaries of the streams and rivers crossing the continental shelf would have provided terrestrial game, waterfowl, fish and shellfish, sea mammals, and plant resources.

Maritime Adaptations in New England

Until recently, many archaeologists felt that man's use of the sea did not occur until after 5,000 B.P. Shells do not appear in the garbage middens* that dot the New England coast until after 5,000 B.P., leading archaeologists to believe that the use of maritime resources is a late phenomenon throughout the eastern United States. Recent evidence, however, indicates that ocean resources were part of man's subsistence system between 10,500 and 5,000 years ago.

For example the catching of anadromous fish,** as well as freshwater species, can be traced back to before 10,000 B.P. The remains of anadromous fish have been found at the Neville site (8,000 to 3,000 B.P.) in southern New Hampshire and at the WEMCO site (8,735 B.P.) in the Connecticut River Valley of Massachusetts. Unidentified fish remains are present in the earliest levels of the Shawnee-Minisink site (10,640 B.P.) in New Jersey, at the recently discovered Brigham site (thought to date to 10,000 B.P.) in Maine, and at the John's Bridge site in Vermont (8,000 B.P.).

Netsinkers, the weights used to sink nets, were part of fishing technology by 8,000 B.P., and by 4,600 B.P. the famous Boylston Street fishweir in Boston Harbor was in operation. This wooden fish trap, located in a tidal bay that was filled during the mid-1800s, was uncovered during the construction of the Boston subway in 1913. Fishhooks and line weights called plummets date to 8,400 B.P. The toggle head harpoon, used to kill and then retrieve sea mammals, such as seals and walrus, dates to as early as 7,500 B.P. at the L' Anse aux Meadows burial mound in southern Labrador.

The evidence for shellfish exploitation prior to 4,000 B.P. is almost non-existent, but a submerged oyster midden in Penobscot Bay, Maine, has been

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*Rubbish heaps located near or under prehistoric dwellings.
**Anadromous fish are saltwater species, such as shad, alewife, and salmon, that spawn in rivers.

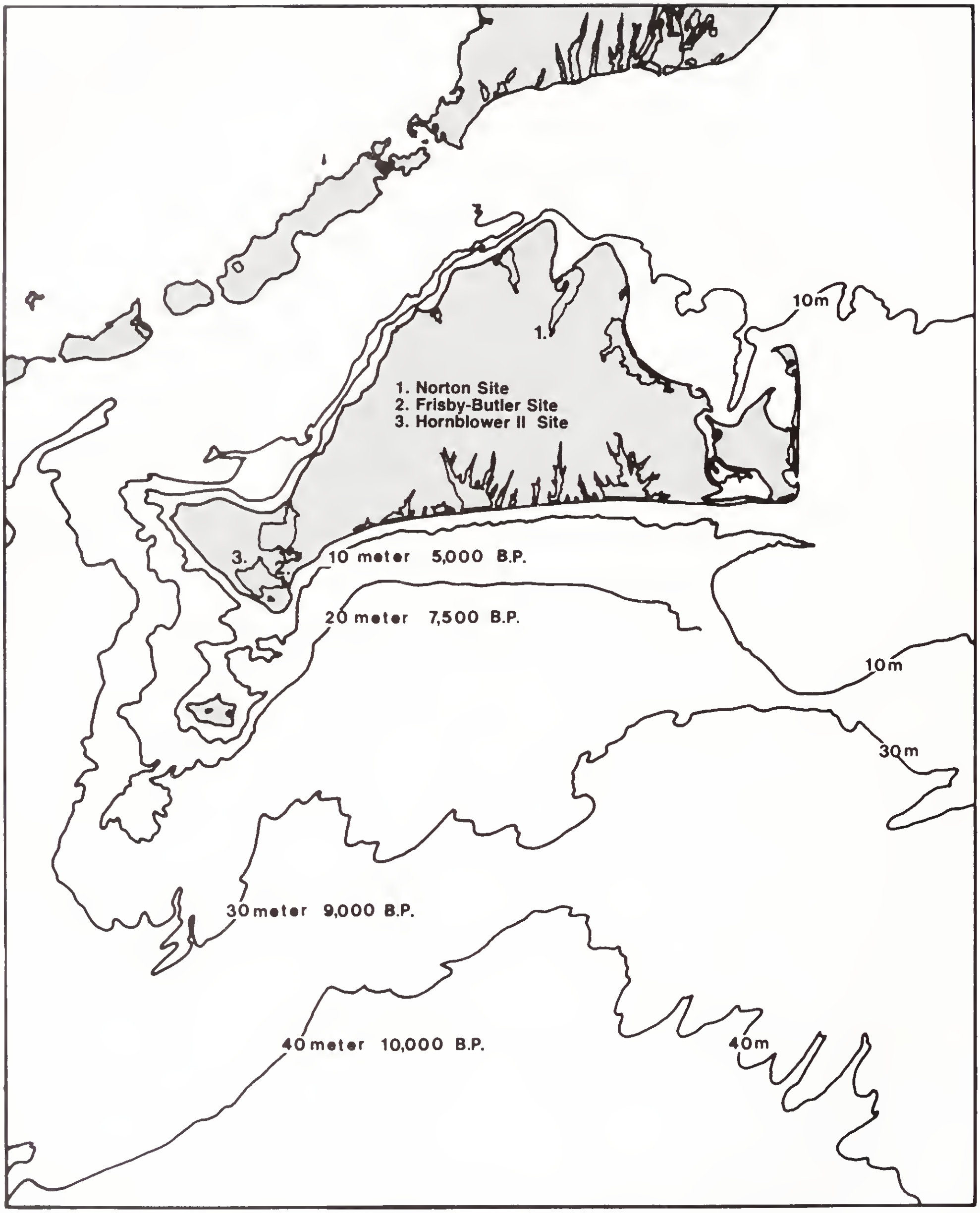

Figure 3. Bathymetric map of sea-level changes south of Martha's Vineyard for the last 10,000 years. The rising sea cut the island off from the mainland only 5,000 years ago. (Adapted from U.S. Department of Commerce map)

recently dated to 6,000 B.P. The earliest known shell midden above modern sea level in New England, at the Turner Farm site in Maine, has been dated to about 4,500 B.P. There the remains of swordfish, seals, small fish, and shellfish have been found. Since swordfish are deep-water species, these early Indians must have had ocean-going watercraft. Shellfish exploitation is more than 10,000 years old in Peru and Ecuador and probably as old along the Atlantic seaboard.

The evidence at hand clearly demonstrates that a well developed fishing technology was in place well before 4,000 B.P. Prehistoric peoples were not ignoring the edible riverine and ocean resources within their environment. By 4,000 B.P., numerous New England sites reflect the intensive harvesting of the bounty of the sea.

Martha's Vineyard

Only sparse evidence of human passing has been found on Martha's Vineyard from the Paleo-Indian and Early Archaic periods. The evidence for the Paleo-Indian period consists of one fluted and eight lanceolate spear points (Figure 4) from island collections. The locations where these nine points were found indicate that Paleo-Indians were hunt-

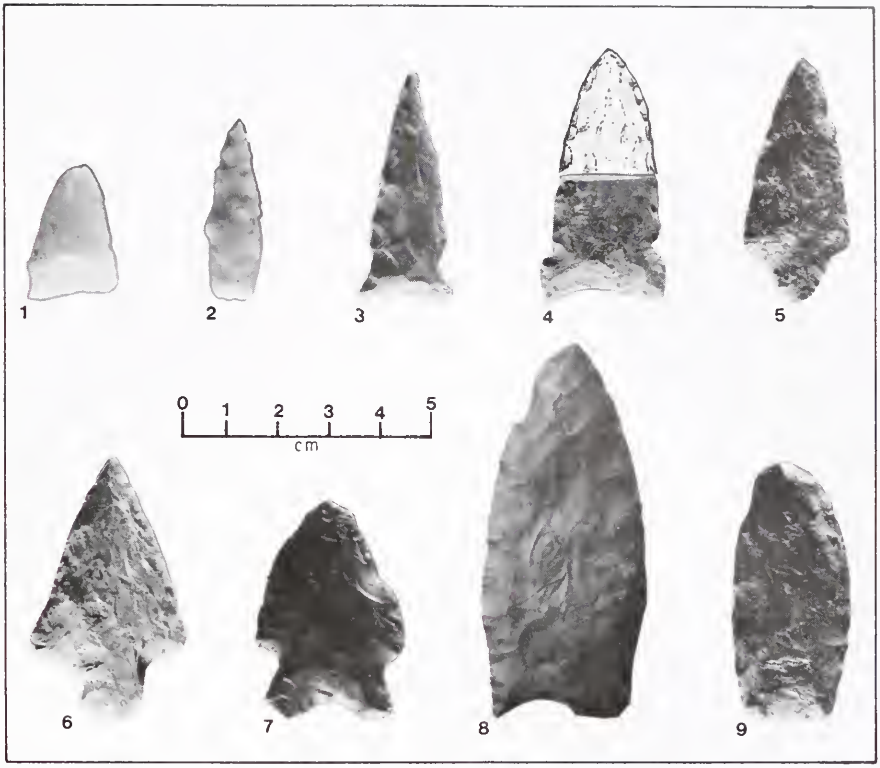

Figure 4. Spear and arrow points of the Paleo-Indian through Late Archaic periods. Late Archaic: 1) Squibnocket triangle, 2) Squibnocket stemmed, 3) Brewerton, 4) Otter Creek, Middle Archaic: 5) Stark, 6) Neville points. Numbers 1 through 6 all from the Norton site. Early Archaic: 7) bifurcate point from western Pennsylvania similar to those missing from the island. Paleo-Indian: 8) Lanceolate point of Pennsylvania yellow jasper from the head of Lagoon Pond, 9) fluted point from the Norton site. (Photo by Stanley Lantz)

ing at the heads of the stream valleys that once crossed the continental shelf. One of the lanceolate spear points in the collection of Ruth Redding, a retired schoolteacher and meticulous collector of prehistoric artifacts who lives on Martha's Vineyard, is made of Pennsylvania yellow jasper, suggesting widespread movements of these early hunters (Figure 4). A recent estimate by John R. Grimes, Associate Curator at the Peabody Museum of Salem, Massachusetts, of the Paleo-Indian population of southern New England places fewer than 1,000 persons in this vast region. Small wonder that there is scant evidence for their traversing across the Vineyard in their hunting pursuits.

Although there is no evidence for their use of maritime resources (only anadromous and freshwater fish remains have been found from this time period), Ogden has suggested that Paleo-Indians would not have ignored sea foods. The extensive lagoonal, marsh, and estuarine environments that surrounded Martha's Vineyard and Cape Cod supported marine fauna and Paleo-Indians may well have availed themselves of this resource. Robert N. Oldale, Geologist with the U.S. Geological Survey at Woods Hole, feels that further north, in the western Gulf of Maine, marine resources were very limited, and the Paleo-Indians were dependent upon terrestrial fauna. Throughout the northeast, Paleo-Indians' subsistence patterns took them over long distances in search of food. The marine resources of southern New England may well have been an integral part of their itinerary.

Archaic Exploitation

After the retreat of the glacial ice and the disappearance of the Paleo-Indian way of life, which included the hunting of now extinct animals and modern Arctic fauna (such as caribou) that retreated northward with the changing environment, the Early Archaic (9,000—8,000 B.P.) peoples adapted to more modern environments. One of the puzzles on Martha's Vineyard is the lack of almost any evidence of the Early Archaic peoples. There is only one reported Early Archaic bifurcate spear point type known from the Vineyard, and only 5 from Cape Cod, and none from Nantucket (Figure 4). Large numbers of these Early Archaic points are known from the Taunton area on the mainland. The apparent paucity of Early Archaic sites may be due to post-Wisconsin landscape alteration and coastal submergence.

The Middle Archaic (8,000—5,000 B.P.) is well represented on the Vineyard both in collections and in excavated archaeological sites. In the Norton site,* at the head of Lagoon Pond (excavated by E. Gale Huntington, a Vineyard historian and archaeologist who has done significant work with the Dukes County Historical Society), the lowest

*All sites on the Vineyard mentioned in this article are named after the landowner on whose property they occur.

level contained Neville and Stark points, the hallmark of the Middle Archaic in New England (Figure 4). The distribution of the Neville and Stark points at the heads of streams and rivers, now submerged in ponds and lagoons, suggests anadromous fishing. Further out on the continental shelf, these Early Archaic peoples probably were exploiting shellfish, the evidence of which remains buried or destroyed underwater.

Maritime Adaptations on Martha's Vineyard

Martha's Vineyard became severed from the mainland after 5,000 B.P., and it was then that the Vineyard finally began to resemble the island so prized by vacationers today. Numerous shell middens dating to the Late Archaic period (5,000—3,000 B.P.) have been found on the Vineyard.

The shell middens usually have four distinct levels or strata of occupation (Figure 5). The deepest level contains projectile points of the Middle Archaic Neville and Stark types as well as Otter Creek and Brewerton types from the Late Archaic. In this yellow-sand stratum at the Frisby-Butler and Hornblower No. II sites, bone fragments of white tailed deer, birds, and occasionally fish were recovered. These Indians were primarily terrestrial hunters at a time when sea level was still some 10 meters lower than now, and the coast one kilometer or so out from the sites.

At both sites, domesticated dog burials have been found dating to about 4,000 B.P. At the Frisby-Butler site, one of the earliest dog burials known for southeastern Massachusetts was found; the dog was an aged animal whose right front leg was broken (Figure 6). The owner did not kill his hunting partner, for the dog died some 6 months later of a bone infection and was then carefully buried. A Brewerton projectile point was found near the head of the dog.

The first people that can be truly labeled a maritime culture are the Squibnocket. The Squibnocket culture, defined by William A. Ritchie, State Archaeologist of New York Emeritus, is found in the third (second oldest) stratum at both the Hornblower II and Frisby-Butler sites (Figure 7). Extensive evidence of hunting and fishing was found. This includes the remains of white tailed deer, raccoon, fox, gray and harbor seals, a variety of waterfowl, ocean fish (including tautog, striped bass, Atlantic sturgeon, and scup), and shellfish (including scallops and quahogs). Small basin-shaped pits associated with Squibnocket artifacts and filled with scallop shells and thousands of fishbones leave no doubt that the Squibnocket people used maritime resources extensively.

Squibnocket technology included hunting with quartz, stemmed, and triangular arrow points; antler points; and weights for propelling spears with greater power. Fishing technology included notched, water-worn pebbles used as sinkers on fish and scallop nets; fishhooks; and sinkers to weight fishlines. Barbed harpoons were used for the hunting of seals and larger fish. The working of wood is attested to by the presence of adzes, celts (a kind of axe), and gouges. These may have been used to manufacture dugout canoes. Pestles were used to process wild plant foods.

Mixed hunting, fishing, shellfishing, and wild plant collecting continued to be the main economic system of Vineyard peoples from Squibnocket times to about 1,000 years ago, when domesticated plants were introduced, greatly expanding the food base. In 1602, when Gosnold visited the Vineyard, the Wampanoag Indian farmers numbered about 3,000 persons.

Figure 5. Profile of the south side of a square in the Hornblower II site showing the four levels of cultural occupation. Level one is a Woodland period level. Two, three, and four are Late Archaic levels. (Photo by author).

Figure 6. Dog burial from level 4 of the Frisby-Butler site. On the Vineyard, dogs were used for hunting, as pets, and sometimes for food. (Photo by author)

Figure 7. The Frisby-Butler site being excavated in 1981. All materials were screened to recover artifacts and diet information not found in troweling. (Photo by author)

During the 10,500 years that prehistoric Indians inhabited Martha's Vineyard, they were never isolated from cultural events and new technologies. Trade networks were well established by the Middle Archaic. For example, stone for the manufacture of artifacts or the artifacts themselves were traded to the Vineyard from far-off places. Onondaga chert from New York, Kineo felsite from the Moosehead Lake area of Maine, and Ramah chert from the Ramah Bay region of northern Labrador are found in Vineyard sites, reflecting the fact that the Indians of Martha's Vineyard were a viable part of an extensive trade network. The Martha's Vineyard prehistoric Indians were not "cast adrift" by the fact that they were inhabiting an island, but were an integral part of a wider cultural system in the northeast for 10,500 years.

The "Missing" 5,000 Years

In summary, research on maritime adaptations in New England is fraught with problems, not the least of which is the fact that much of the evidence from the first 5,000 years of use of ocean resources either has been destroyed or lies submerged on the continental shelf (Figure 8). From the data that now exists, however, it is clear that the potential of the ocean was exploited much earlier than the last 5,000 years that the terrestrial archaeological record has revealed.

The "missing" first 5,000 years hold the answer to our questions concerning when and how these early New Englanders made use of the bounty of the sea. Although actual faunal and technological evidence for the use of marine resources is scarce for the Paleo-Indian and Early and Middle Archaic periods, the evidence that we have strongly supports the view presented here, that ocean resources were an important part of man's economy during the first 5,000 years of habitation in New England.

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Figure 8. The Gay Head cliffs are eroding away rapidly. In several hundred years little may be left. (Photo by author)

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Above and below, Minature Ship fresco from *Excavations at Thera VI.*

Atlantis and

by James W. Mavor, Jr.

Catastrophe theory seeks to explain boundaries and other discontinuities in the cultural, biological, and geological record left in the soils and rocks of the Earth's crust. The causes of such circumstances may be either terrestrial or extraterrestrial events or both, sometimes of a rare or short-lived nature.

Catastrophe theory also seeks to explain or interpret ancient myths that appear to represent natural cataclysms couched in obscure language. Atlantis is such a myth.

Catastrophism, because it considers rare and short-lived events, is often perceived to be in conflict with uniformitarianism, a scientific theory that is the traditional basis of geology. Unifor-

Catastrophe Theory

mitarianism assumes that all past events are explainable by processes still at work on Earth, and that all natural laws are invariant.* Two generations ago, Sir William Dampier, late of Cambridge University, put the conflict into perspective: "the generalizations or laws [of nature] established by induction, even when universally accepted as true should be regarded only as probabilities."

The story of Atlantis, the legendary island nation, was told by Plato in his dialogues *Timaeus*

*See *Catastrophes and Earth History*, W.A. Berggren and J.A. Van Couvering, eds. 1984. Princeton University Press. Reviewed in *Oceanus*, Winter 1984/85.

and *Critias*. This is the only authoriative account, and Plato repeatedly asserted its historical basis. He wrote that his informant, Solon (an Athenian lawmaker, "wisest of the seven sages," who lived from 638 to 559 B.C.) brought the incomplete story from Egyptian priests at Sais, at the head of the Nile Delta.

According to Plato, Atlantis was a prosperous land having both natural resources and a flourishing maritime mercantile system. It was blessed with fertile soil, temperate climate, and great natural beauty. Art and architecture flourished there.

When the Earth was apportioned out among the gods, Poseidon received for his lot the island of Atlantis, and made his eldest grandson, Atlas, its first king. Over time, Plato explains, "the divine portion faded away, human nature got the upper hand," and the people of Atlantis became "full of avarice and unrighteous power." Zeus called on the gods to inflict an unspecified punishment on Atlantis "that they might be chastened and improve."

When Atlantis attacked the whole of Europe and Africa, including Athens, they were defeated by the Athenians. Afterward, both the Athenian warriors and Atlantis were destroyed. As Plato records the event:

> *There occurred violent earthquakes and floods; and in a single day and night of rain all your warlike men in a body sank into the earth, and the island of Atlantis in like manner disappeared in the depths of the sea. And that is the reason why the sea in those parts is impassable and impenetrable, because there is such a quantity of shallow mud in the way; and this was caused by the subsidence of the island.*

The story contains three major images – the nation of Atlantis declining into decadence, a glorious and victorious Athens, and a vividly described, devastating natural catastrophe.

The Minoan Atlantis

Of the many theories about the place and epoch of Atlantis as a historical entity, only one coincides with a scientifically verified and dated cataclysm that did in fact sink an island nation suddenly into the sea, and was accompanied by violent earthquakes and floods. This cataclysm occurred at the Greek island of Thera, later known as Santorini, which is an active volcano. About 1400 B.C., during the epoch in which the Minoan civilization occupied the southern Aegean Sea, an extremely violent volcanic eruption destroyed life on Thera and affected much of the eastern Mediterranean coasts. In its final paroxysm, the central part of the island collapsed into the sea (Figure 1).

In 1965, I was introduced to the identification of Atlantis with Thera by Angelos Galanopoulos, a seismologist at the University of Athens (see *Oceanus*, Vol. 12, No. 3, April 1966). In 1966, the Woods Hole Oceanographic Institution research ship *Chain* towed her seismic profiling array into the caldera of Thera and made profiles of the geological strata beneath bottom of the great basin, which is all that remains of the collapsed central part of the island (Figure 2). Within this caldera, the *Chain* passed close to the active volcano, Nea Kaimeni, which has grown nearly 2,000 feet out of the ancient magma vent since 1400 B.C. (see *Oceanus*, Vol. 13, No. 1, November 1966). We explored underwater ruins at several places along the coast, and I concluded that a land excavation would be the best way to find the archaeological remains that could prove the myth of Atlantis to be history.

In May and June of 1967, we began such a land excavation. Archaeologists Spyridon Marinatos and Emily Vermeule, and I, working in collaboration, discovered a Minoan town at Akroteri beneath the deep layer of volcanic ash which covers the island. The story of this adventure appears in my book, *Voyage To Atlantis*, published in 1969.

Of all the discoveries on Thera, the Minoan frescoes found at Akroteri most beautifully and fully reveal the culture that may have been Atlantis (Figure 3). They are the only nearly intact Minoan wall paintings preserved today. Practically all were discovered during the first six weeks of excavation in 1967.

Since 1967, the excavation has continued. Work is now under the direction of Christos Doumas, an archaeologist with the University of Athens, and many researchers have studied the archaeology and natural environment of the region in attempts to understand better the nature of the great eruption and its effects on society. There are some significant results from these more recent investigations:

> *1. The miniature fresco or wall frieze from Thera shows a 3,400 year old, eye-witness picture of three towns, a fleet of 20 Minoan ships and small craft in detail, a sea battle, and a coastal landing – probably in Africa. It also appears to show a nautical processional festival. Important features of ship design and handling (such as landing ramps, rigging details, presence of booms, and paddling technique), as well as details of building architecture, dress, and customs, hitherto unknown or only suspected from obscure renditions on seals or pottery, are revealed by this remarkable painting. Previously, it was thought that Minoan temples or sanctuary structures did not exist; the fresco provides the first clear evidence that they did. The clothing and ornamentation of individuals depicted show that some were from Africa. The curious stern structures, previously unknown, appear to be portable cabins for distinguished persons, carried*

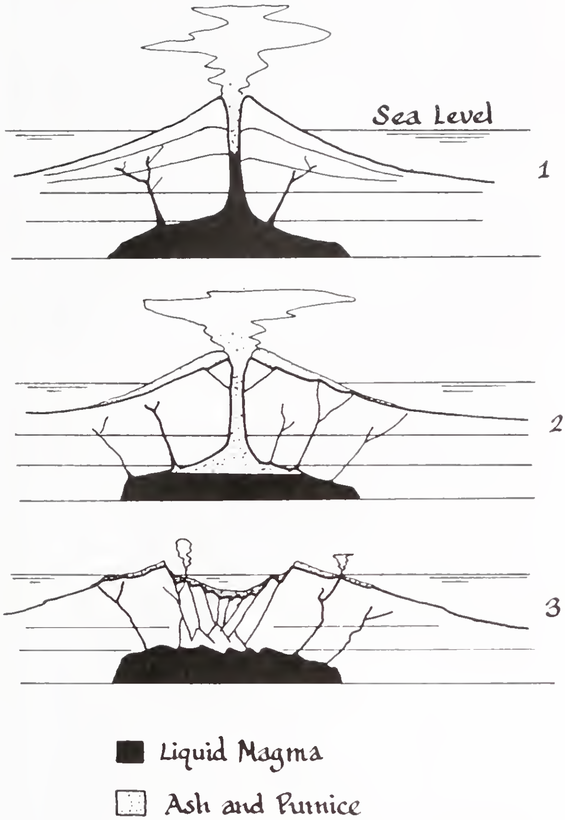

Figure 1. Volcanic eruption and collapse of Theran type of cone: 1) eruption, 2) partial voiding of magma chamber below volcano, 3) collapse of the unsupported cone into the empty magma chamber, creating a great water-filled caldera. (From Voyage To Atlantis, by J.W. Mavor, Jr.)

aboard much as cargo containers are on modern ships.

2. The results of wider excavation reinforce the contention that Thera was a wealthy maritime nation fitting Plato's description of Atlantis. Discoveries have included the remains of extensive buildings of elegant design and construction (some with three stories), organized storage of trade goods, and imported quality pottery.

3. Additional analysis of deep-sea cores has shown that the ash fell in a direction more easterly than southerly and that little accumulated on Crete. Egypt was probably unaffected by ashfall. Minoan civilization was probably more strongly affected by the earthquakes and tsunamis that accompanied the Thera eruptions and collapse than by the ashfall.

4. Analyses of archaeological sites throughout the eastern Mediterranean, of how tsunamis move through the ocean, and of possible augmentation of the ocean waves by winds generated in the eruption have persuaded me that the Thera collapse was sufficient to produce an initial wave height at Thera of 100 to 200 meters, and enough coastal devastation at some distance to be remembered in several myths. Myths that are likely to have reflected these surges include the flood of Deucalion in Attica; the stranding of Jason's ship, Argo, in Tunisia; and the drowning of Pharaoh's army in Egypt.

5. Based on information available in 1967, I suggested that the Thera collapse, following a series of eruptions, took place sometime between 1450 and 1390 B.C. Since then, there has been much disagreement about the absolute date. Dates based on the concentration of a radioactive isotope of carbon, carbon-14, at sites in the Aegean occupying stratigraphic levels considered to date the destruction, have demonstrated an enigmatic spread of 500 years in either direction.

C. V. Hammer and others at the University of Copenhagen report one date quite independent of the carbon 14 dating process, derived from observing the residue of acid volcanic gases within the countable annual layers of snow in the Greenland ice sheet. There, the Thera eruption has been dated to 1388 B.C. plus or minus 50 years. A precise date for the Thera eruption is useful in comparing it with the dates of other events in historical records, archaeological evidence of catastrophe on Minoan Crete and elsewhere, and mythological accounts of disaster. There are indeed many accounts of disasters that appear to have been contemporary, as if a single cataclysmic event occurred about 1400 B.C.

Figure 2. Drawing of Thera showing archaeological sites and villages. (From Voyage To Atlantis, by J.W. Mavor, Jr.)

Figure 3. The Crocus-Gatherers Fresco from Akroteri, Thera (From Excavations at Thera VII, *1976, by S.P. Marinatos)*

Over the last 15 years, I have continued to believe that the source of Plato's Atlantis was indeed the Minoan culture and, specifically, that its decline and fall were primarily due to the eruptions on Thera. I would allow, however, that stories of other peoples, places, and cataclysms distant both geographically and in epoch may have been included in the story as recorded in Egypt. It is a delight, to those who mythicize, that evidence supporting a particular Atlantis theory often tends to encourage other theories, for many indeed can be correct at once. Two other theories to account for the legend of Atlantis have been proposed by Otto Muck and Immanuel Velikovsky. These focus on the catastrophic destruction of the island and have benefitted from new astronomical evidence, described later.

The study of catastrophism and the role of mythology in history has developed to the point where I would no longer group all second millenium B.C. near-eastern myths as consequences of the Thera cataclysm, but would discriminate between those which appear to represent vulcanism or flood alone and those that have a more astronomical character. This distinction leads to wider and more important considerations regarding the relationships between modern scientific speculations and cataclysmic myth in general.

Cataclysmic Myth

The Atlantis story is dominated by a lengthy description of life in Athens and Atlantis, with relatively little about catastrophe. However, there are four separate catastrophic images in Plato's *Timaeus:* the destruction of Atlantis; the flood of Deucalion in Attica, which probably was caused by tsunamis accompanying the collapse of Thera; and two allusions to cyclical astronomical events, couched in rather obscure language. In one of these, found in the twenty-second stanza of the *Timaeus* dialogue, Plato interprets the myth of Phaethon – a son of Helios, who loses control of the sun-chariot while crossing the sky and eventually is killed by Zeus and falls into the sea – as "a declination of bodies moving around the earth and in the heavens, and a great conflagration of things upon the earth recurring at long intervals of time." The confusion in the sky and destructive fire on earth may represent the aftermath of vulcanism. But, on the other hand, it could be a meteorite or asteroid impact. H.A.T. Reiche, Professor of Classics and Philosophy at the Massachusetts Institute of Technology, sees a more cosmic event, and identifies Phaethon's loss of control of the sun's chariot with the gradual displacement of the stars to the west, called the precession of the equinoxes.

In the account of the other astronomically originated catastrophe, also found in *Timaeus,* Plato cites the Egyptian priests: "And then, at the usual period, the stream from heaven descends like a pestilence, and leaves only those of you who are destitute of letters and education; and thus you begin all over again as children and know nothing of what happened in ancient times either among us or among yourselves." This seems to tell of the "literacy-gap" that followed the Minoan destruction, when there was no written language in the Aegean for 300 years. The pre-eruption linear scripts were eventually replaced by Archaic alphabetic writing from the Levant. Plato also alludes to possible extraterrestrial effects such as a meteor storm. These four images are not explicitly connected by Plato, but are indirectly joined by the fact that all are part of the tale told to Solon by the Egyptian priests.

In another dialogue, *Statesman,* Plato tells, again in obscure figures of speech, of an astronomical myth of ages past that parallels the myth of Atlantis. During the age of the god Kronos, "the primal nature being full of disorder got the upper hand, and due to some inherent quality of matter, the divine power let go and the Earth received a sudden impulse at both ends causing it to reverse its direction of rotation. The earth was shaken by a mighty earthquake and the sun and stars changed their course. The result was a great destruction of animals and man."

Reiche sees the age during which Kronos ruled as the mythological first age of the world, the Golden Age. He sees Plato's nation of Atlantis as a map of the southern sky presented in mythological and astrological language, with the capital of Atlantis equivalent to the bright star Canopus. About 4000 B.C., the Milky Way ceased to bridge the equinoctial points of the horizon because of the precession of the equinoxes.* This event he interprets as the end of Atlantis and the Golden Age,

*Equinoctal points are the two points on the horizon where the sun rises and sets on the spring and fall equinoxes. Precession of the equinoxes refers to the wobble of the earth as it rotates, which causes the positions of the stars to change over time, returning to their original positions every 26,000 years.

and the beginning of a cultural decline accompanied by calamities of flood and fire.

In recent years, catastrophe theory has evolved toward more serious consideration of such possibilities as the impact or near-miss of asteroids and comets. World-wide mythic images have played a vital role in this development. Scientific evidence and the results of myth interpretation make an uncomfortable mix, but the scholar of catastrophism must deal with both, for many of the theories flow from the mythology. Much progress has been made in squaring mythology with history, and the 19th century notion that myths of gods in the sky are entirely imaginative is gradually losing favor.

Astronomical Theories of Catastrophe

That the impact of asteroids and comets on earth may explain heretofore enigmatic discontinuities in the record is a possibility taken seriously by many geologists. The Cretaceous-Tertiary event of 65 million years ago, best known for extinction of the dinosaurs, coincided with the greatest vulcanism in geological history and with a period of rapid reversals of the earth's magnetic field. Luis Alvarez and his colleagues suggest that a large asteroid (6 to 14 kilometers diameter) collided with the earth and was injected into the atmosphere as pulverized rock at the end of the Cretaceous period. The mass extinctions of the paleontological record on land and beneath the sea at this time could be explained by the dust cloud from the asteroid suppressing photosynthesis or modifying climate.

Theories about extraterrestrial events as causes for natural catastrophes on earth within the past several thousand years are considered more speculative than similar explanations for events many millions of years ago. This may be attributable as much to human nature as to scientific evidence. Our criticism of ideas becomes more rigorous as we perceive them to affect us more.

A number of near-eastern myths describe events that may be separate from but contemporary with the eruption and collapse of Thera. The myths of combat between Zeus and Typhon, the Hurrian Song of Ullikummi, The Admonitions of an Egyptian Sage,* the Plagues of Egypt, and the Exodus may represent volcanic or extraterrestrial events. The Greek deluge of Deucalion, apparently of the second millenium B.C., and the floods of Noah and the Epic of Gilgamesh, apparently of the third millenium B.C., may refer to the effects of devastating astronomical events. The apocalyptic nature of the Revelations of St. John the Divine can also be interpreted as symbolic of natural catastrophe brought about by phenomena originating in the sky.

Other Theories of Atlantis

Among Atlantis theories, the mid-Atlantic ridge has been the favorite location. Otto Muck, in *The Secret of Atlantis,* published in 1976, speculated that an asteroid of 10 kilometers diameter impacted the earth between Puerto Rico and the mid-Atlantic ridge in 8500 B.C., thus setting off a chain of vulcanism and tectonics that caused the Azores plateau, previously a continent, to sink into the sea, leaving only the mountain tops exposed as the islands of the Azores. While the scientific evidence for such an event is very weak, Muck's detailed construction of the mechanics of the asteroid event is plausible and he makes a partial patchwork fit of the event to worldwide geological and climatic reconstructions and to mythology, including flood legends on both sides of the Atlantic.

Immanuel Velikovsky wrote only briefly on Atlantis, but in his opinion, it refers to a great island nation in mid-Atlantic sinking into the sea about 1400 B.C. as part of a worldwide cataclysm occasioned by the near passage of a very large comet. Both Muck and Velikovsky cite the opinions of geologists F.A. Melton and W. Schriever that the thousands of oval depressions on the Carolina coast, which have long axes aligned northwest to southeast and generally range from one-quarter mile to one mile in length, may have resulted from a meteorite shower or colliding comet.

New Evidence

Except for the Minoan-Thera thesis, attempts to locate Atlantis have been based primarily on mythology with weak scientific evidence. However, the comet theory of destruction, which has been around for at least two centuries, has gained substantial credibility through the work of astronomers Victor Clube of Oxford University and William Napier of the Royal Edinburgh Observatory. They argue that comets have passed destructively near the earth, and suggest that a multitude of myths could represent a comet that was observed world-wide during at least the 2nd and 3rd millenia B.C. and caused major convulsions on earth such as volcanic eruptions, fire, and flood. Clube and Napier suggest that several gods, including Zeus in Greece and Tiamet (Figure 4) and Ishtar in Babylonia, could have been associated with comets.

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*Hesiod wrote that Earth gave birth to Typhon — a hundred-headed, flaming monster. Zeus fought and killed him with thunder and lightning, and by heaving whole mountains onto him. The Song of Ullikummi, preserved on Hittite cuneiform tablets dated to 1300 B.C., describes Ullikummi's growth from deep underground into a giant pillar of diorite stone. The sun god ordered the storm god, Teschub, to destroy Ullikummi. Teschub fails, and Ullikummi sets out to destroy mankind. Older gods then cripple him by cutting off his feet, and Teschub finishes him off. An Egyptian papyrus (found at Memphis and dated to between 2300 and 1100 B.C.) entitled "The Admonitions of an Egyptian Sage," is the rational account by a horrified observer of drought, plague, darkness, and the breakdown of social structure.

Figure 4. Monster Timiat attacked by god Marduk with thunderbolt, possibly the impact on earth of a comet fragment. (Cylinder seal, courtesy of the British Museum).

The asteroid belt between Jupiter and Mars has been estimated to contain more than 1,000 asteroids in earth-intersecting orbits, which are collectively known as Apollo. Most of these could be de-gassed comets which have been captured by Jupiter and kept within our solar system. There is one known active comet, Encke, discovered in 1796, within the inner solar system. The orbit of the asteroid, Hephaestos, 10 kilometers diameter, discovered in 1978, and that of the Taurid meteor stream are so similar to that of Encke, that all three are probably fragments of a much larger comet.

Clube and Napier calculate that this very large comet entered our solar system from interstellar space about 20,000 years ago and spiraled in, over thousands of years, passing close to the earth many times before settling into a stable orbit around the sun. It would have been a spectacular sight on earth every time it appeared. The as-yet undetected, and now dead, dominant core of approximately 30 kilometers diameter may still exist in the Taurid meteor stream.

The period of this comet, originally long, would have become shorter on successive passages within Jupiter's sphere of influence, gradually becoming reduced to the present 3.3 year period of Encke. Comet Encke, which Clube and Napier suggest broke off from the larger comet about 3000 B.C., has an orbit that is inclined to Earth's orbit by only 6 to 12 degrees and wobbles in such a manner that a passage close to earth, at approximately the distance of our moon, is assured every 3,500 years (Figure 5).

This cosmic event, the passage of a great comet and its subsequent fragments near the earth, may have dominated the terrestrial environment for the past 20,000 years, producing fireballs, meteor swarms, and climatic changes. The most recent glaciation and the subsequent fluctuation in atmospheric temperatures may reflect the fragmentation record of the great comet, a record that is recoverable by backward projection of Taurid meteor orbits. Thus, a glaciation mechanism is proposed by Clube and Napier in which the cosmic dust flux controls climate. Dust deposition in the polar ice caps supports this theory, which contrasts with the theory of earth orbital variations as the cause of glaciations.* Clube and Napier estimate the effects of the impact of a comet fragment or a large Apollo asteriod of 10 to 20 kilometers diameter. If it penetrated the atmosphere intact and impact occurred on land, a crater of 200 to 400

*See The Earth's orbit and the ice ages by C. Covey, *Scientific American,* 250(2):58–66.

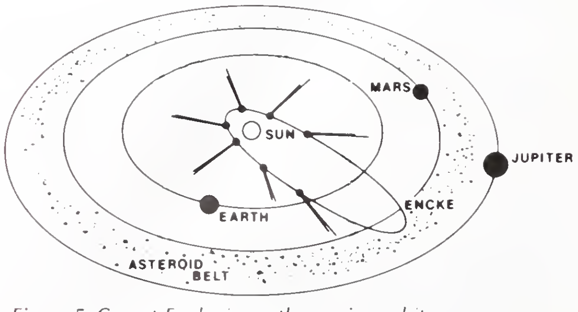

Figure 5. Comet Encke in earth-crossing orbit.

kilometers diameter would be created. If in the ocean, a shallower crater of 500 to 2,000 kilometers diameter would result. In either case, the earth's crust would be broken, exposing the mantle over a large area. This impact may have been part of a recurring episode of bombardment by asteroids as the solar system moves through the spiral arms of our galaxy. If so, a complex chain of interacting events – including sea level changes, climatic changes, violent tectonic episodes, magnetic field reversals, and mass extinctions – would take place, with time scales spanning the whole spectrum of geologic time from minutes to millions of years.

This plausible scenario as yet has no specific date, size, and composition of extraterrestrial objects, and no specific place of near passage or impact supported by astronomical, archaeological, or geological evidence. These can only be inferred from history and mythology. Nevertheless, an inviting circumstantial case is made.

While Clube and Napier conspicuously omit the Atlantis myth, they do marshall a multitude of other myths in support of their theory, which places a catastrophe at 1369 B.C. near Crete. This agrees well with archaeological dates for the Thera eruption and therefore supports not only an Aegean Atlantis theory, but also the notion that many near-eastern myths are records of the same event.

Conclusions

Scholars of comparative religion today generally agree that myths are not essentially imaginary, but rather the means and the mode of expression of ancient peoples, archetypes of which governed their conceptions of past, present, and future. With the acceptance of the idea that myth may be history, the interpretation of myth has changed into the determination of what an observer thousands of years ago actually sensed as distinct from the scientific record that has come down to us. The observer's interpretation of what he senses is colored by his preconceived notion of what he expects to sense based on his experience. Catastrophe theory as a tool to explain biological and cultural discontinuities of the past has blossomed among scientists who accept that extrapolation from the facts and methods of the recent past can be as limiting to thinking and imagination as belief in the existence of the Greek gods. Out of the marriage of scientific discipline and the creative interpretation of myth come the theories of earth history, stretching as far back as myths go, that most nearly approach observed reality. The myth of Atlantis has played a major role in the growing acceptance of both mythology as history and of catastrophe theory itself.

James W. Mavor, Jr., is an engineer turned anthropologist, and a member of Associated Scientists at Woods Hole, Inc.

Letter Writers

The editor welcomes letters that comment on articles in this issue or that discuss other matters of importance to the marine community.

Early responses to articles have the best chance of being published. Please be concise and have your letter double-spaced for easier reading and editing.

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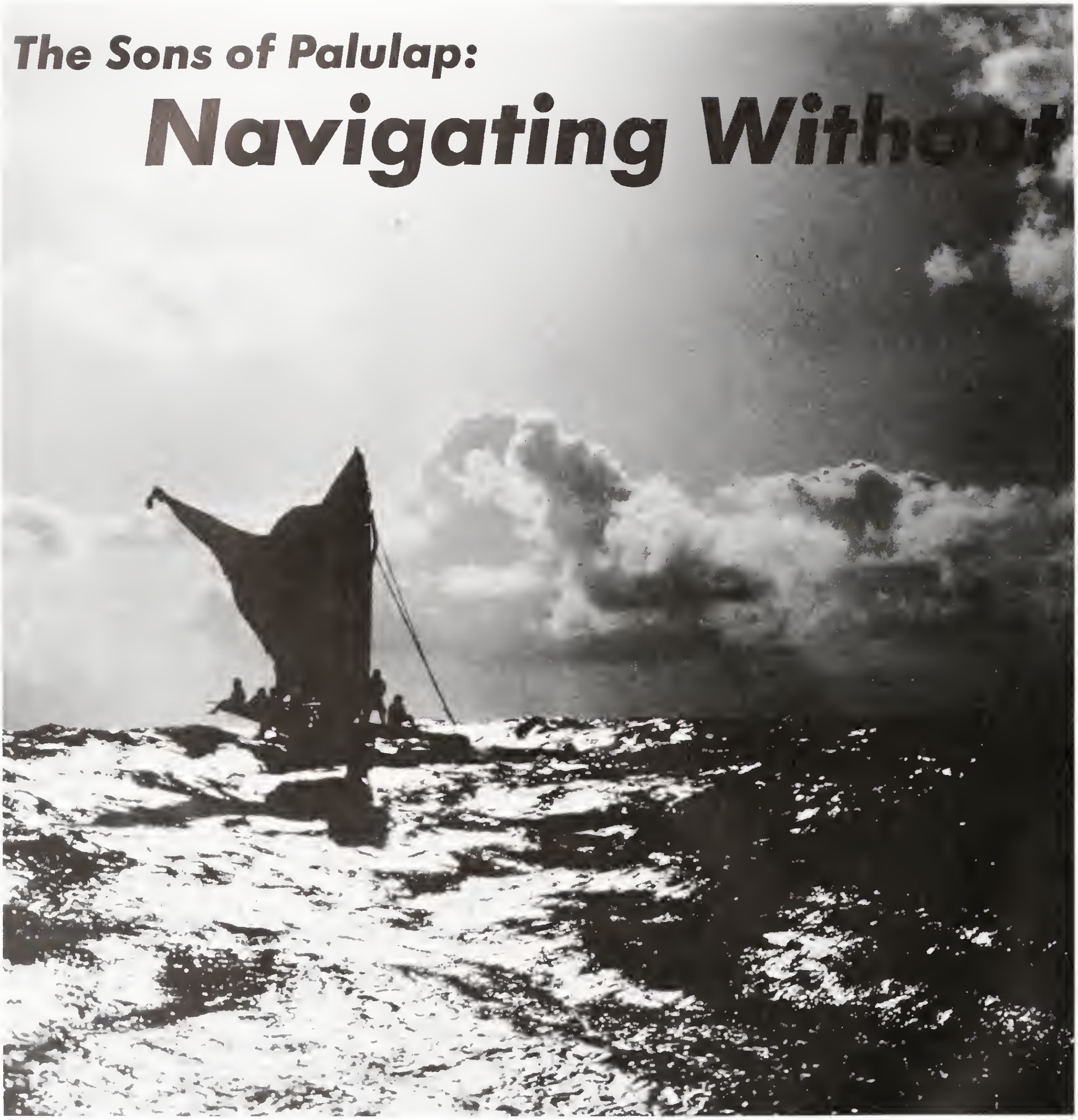


The Sons of Palulap: Navigating Without

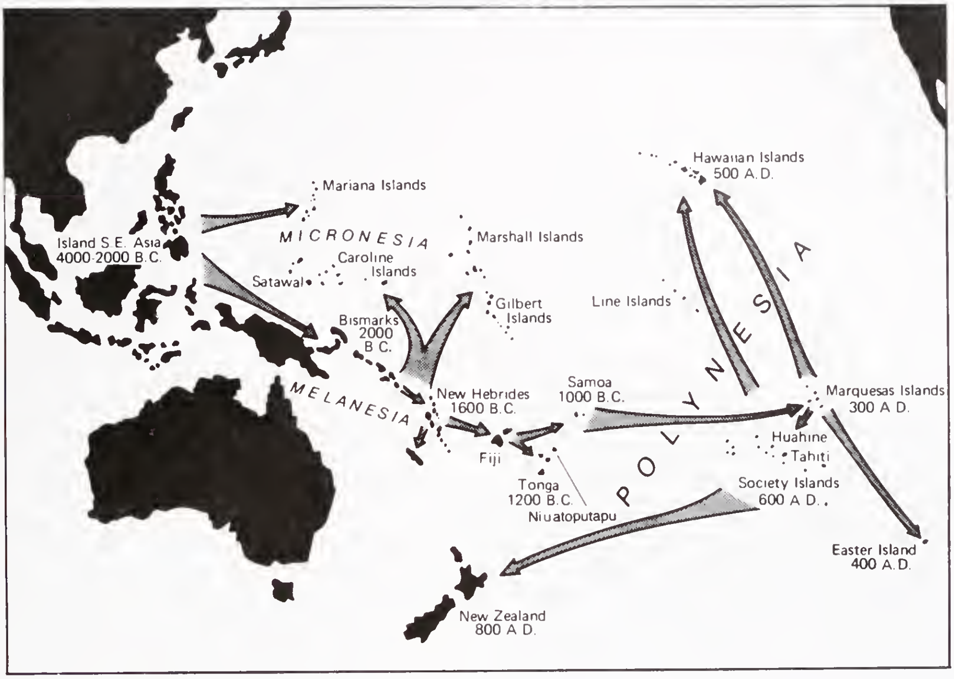
by Stephen D. Thomas

Darkness fell as the rain of another line squall hissed across the tropical Pacific. The stars were smudged out. Our navigator, Piailug, ordered us to drop the sail of our 30-foot outrigger canoe, *Suntory. White Horse,* our partner canoe, followed suit, and we settled down to endure the chilly, wet night.

Piailug estimated that we were just inside the *etak* of birds, the fishing grounds for seabirds from the island of Pikelot, our destination. There we drifted, waiting for morning, when the birds would fly out from their nesting sites and thus indicate the way to the island.

Two days before, our little fishing expedition had left Satawal, one of the most remote of Micronesia's Caroline Islands. Our purpose was to catch sea turtles, fish, and octopus for the 600 hungry Satawalese. We were led by Mau Piailug, one of the last of the *palu.* These Micronesian navigators pilot hand-hewn canoes without charts or instruments, guided only by the sea's signs of

Instruments in Oceania



*The Polynesians spread throughout the Pacific from the west in small sailing canoes like that shown opposite. (Map courtesy of Bernice P. Bishop Museum. Photo by author/*The Navigators*).*

land: stars, birds, and patterns of waves. Thousands of years ago Piailug's distant cousins, the Polynesians, probably used similar navigational techniques on their epic voyages of discovery to the Marquesas, Tahiti, Hawaii, Easter Island, and New Zealand.

As we lay hove to in Pikelot's *etak* of birds, squall after squall swirled around our canoes. The crew took turns trumpeting a conch shell to ward off rain. Despite the cold, between conch blasts I drifted in and out of sleep, until at long last, dawn crept across the empty sea. We mumbled the Hail Mary in Satawalese, made sail, and continued, worried because we saw no birds flying out to fish – birds that would guide us to our landfall. The ocean swells we had been steering by for the past two days were jumbled and confused by the shifting wind and rain. Nevertheless, Piailug could discern the swell coming from under *tan* (rising) Mailap (the star Altair). After about an hour, two sooty terns flew by, which gave us some encouragement, but by noon there was still no island. The sun came out, the sea grew calm, and we continued looking for land.

Finally, a sharp-eyed crew member spotted Moen, a deep-sea reef. Then we knew Pikelot lay east, under *tan* Mailap. At sunset, we spotted the tiny islet and, after paddling for several hours through a calm, quiet drizzle, we beached our canoes at about 3 A.M. It had taken 3 days to make the 60-mile passage from Satawal to Pikelot. If you took away the flashlights, the dacron sailcloth, the Winston cigarettes, and the prayers to the Virgin Mary, it could have been a voyage of a thousand years ago.

From Whence the Polynesians

"How shall we account for this Nation spreading itself over such a vast ocean?" Captain James Cook asked upon discovering the Hawaiian Islands in 1778. From New Zealand in the south, up through Tahiti and Easter Island to Hawaii in the north, he had found people whose languages, customs, canoes, dwelling houses, and social organizations were strikingly similar. Cook had discovered the Polynesians.

In the following two centuries, many hypotheses were forwarded in attempts to answer

Cook's question. One held that the Polynesians were the aboriginal inhabitants of flooded continents, forced to retreat to the mountain peaks by the rising sea. Another proposal was that ancient South American Indians sailed across the Pacific on balsa rafts to reach Polynesia. (In 1947, Thor Heyerdahl set out to test this hypothesis on the raft *Kon Tiki*.) Others held that the Polynesians were great seafarers who left their homeland in the western Pacific to colonize the Pacific islands. Surprisingly, modern research has shown this idea to be correct.

Southeast Asian Origins

Linguists have found that Polynesian languages are similar to those spoken in other parts of Oceania. Coconut, for instance, is *niur* in Malay, *niu* in Hawaiian, and *nu* in Satawalese. Eye is *mata* in Malay, *maka* in Hawaiian, and *mas* in Satawalese. Maylay, Hawaiian, and the languages of the Carolines (including Satawalese) probably are descended from a single tongue, the now-extinct Proto-Austronesian language once spoken in the islands of Southeast Asia.

Archaeologists have found a distinctive type of reddish earthenware pottery, called Lapita, at sites on New Guinea and the Bismark archipelago, the Solomons and New Hebrides, and all the way to Fiji, Samoa, and Tonga (see map). And on Huahine in the Society Islands, Yosi Sinoto of the Bishop Museum (Honolulu) made the spectacular find of two planks from an ancient Polynesian voyaging canoe buried in a mud slide 1,100 years ago. The rough adze marks and lashing holes on the planks show that they were hewn for a canoe almost identical to the one we sailed to Pikelot in 1984.

Ethnobotonists, studying how humans interact with plants, have determined that the ancestors of Polynesian crop plants – breadfruit, taro, and bananas – once grew wild in New Guinea and Southeast Asia. Now found on virtually all the islands in the Pacific, these plants must have been carried by early explorers intent on colonization.

From this confluent evidence, the following picture has emerged: Four to six thousand years ago a seafaring people left their homeland in the islands of Southeast Asia to wander down the Melanesian Islands and into the Pacific. Some sailed north to populate the Marshall, Gilbert, and Caroline islands. Others went east to Tonga and Samoa. Here they paused for nearly a thousand years, developing a uniquely Polynesian culture. Then, sometime between 200 B.C. and 300 A.D. at least one sea-going canoe with a cargo of crop plants and domestic animals made the passage from western Polynesia to the Marquesas. From there the Polynesians struck out into the whole of the central Pacific, to Hawaii, New Zealand, and Easter Island.

But how could they have done it? How could a race of primitive seafarers, without chart, compass, or sextant, using canoes lashed together with coconut fibres and driven by sails woven of pandanus leaves, find their way across thousands of miles of sea? To answer this question we turn to the contemporary navigators of Micronesia, the last practitioners of a way of sailing that evidently once flourished throughout Oceania.

Direction: The Star Compass

Any successful navigation system must allow a sailor to do three things: determine the direction to an objective, maintain that course at sea, and measure and compensate for displacement from the intended course caused by leeway, current, and steering error. Let's investigate Piailug's system and compare it to ours.

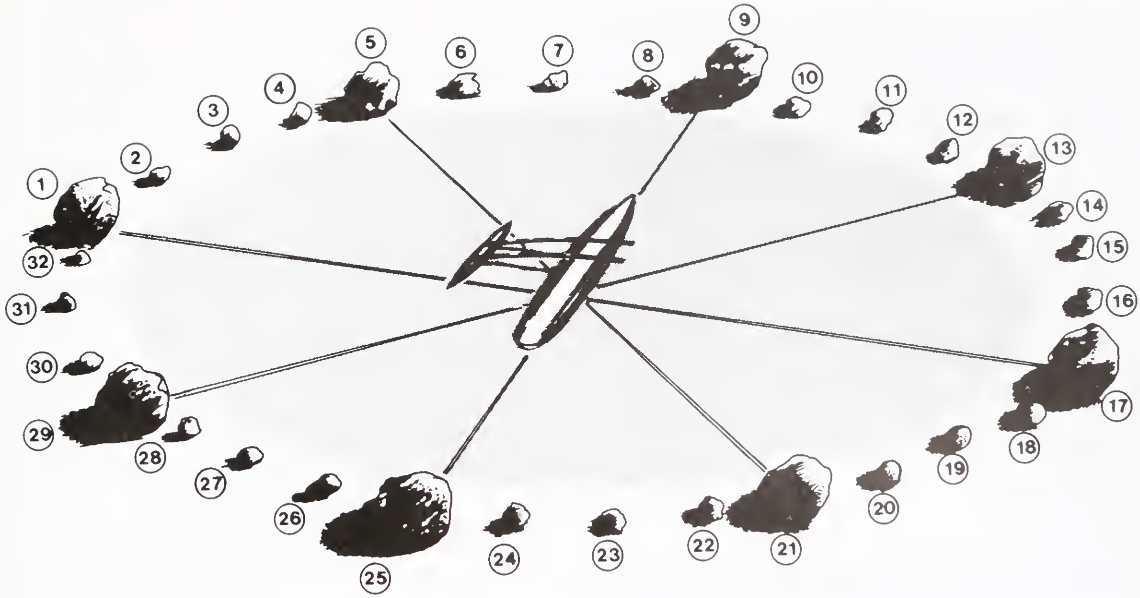
For the Western navigator, points along the horizon are marked and named by the compass: north, northeast, east, southeast, and so on. Note that the compass both names the directions and gives the navigator a means to maintain direction while sailing. But without a compass, how could one name the directions? Micronesian navigators use the rising and setting points of certain stars.

The stars wheel above us as if traversing the inside of an immense sphere. Among them, spatial relationships change very slowly, over eons. Thus the constellations of the ancient Greeks have the same configurations today. But more importantly, the stars rise and set in the same spots on the horizon – that is, their azimuths, or compass headings at rising and setting, remain the same as long as one does not drastically change latitude.

Watching the tropical Pacific sky evening upon evening, you always see Altair top the horizon just north of east, arc through the heavens, and set just north of west. Vega rises in the northeast and sets in the northwest; Shaula, in the tail of the constellation Scorpio, rises in the southeast to set in the southwest. Hovering in the north is Polaris, the North Star. Marking south is the Southern Cross in its upright position. Night after night you watch the stars. You notice that, although they rise four minutes earlier each evening, each star consistently breaks the horizon in its own place.

This is the basis of Piailug's system of navigation. At the age of five, Piailug began learning the stars from his grandfather, who placed 32 lumps of coral on a woven pandanus mat to represent the rising and setting positions of the 15 principal navigational stars and constellations. This is the "star compass"; the stars lend their names to the directions they denote.

To find the correct course to his objective, the Western navigator lays parallel rulers on his chart, one forming a line between his point of origin and his objective, and one indicating the true compass course to the objective on the compass rose printed on the chart. After correcting for magnetic variation, he can maintain that heading at sea by following his compass.



A device used to teach the principal navigational stars. In this excercise, the navigator places thirty-two lumps of coral in a circle on a mat. The canoe is used to help the student visualize himself at sea, always in the center of a web of "roads" reaching out to the stars. English names of the stars are: 1) Polaris, 2) rising Little Dipper, 3) rising Big Dipper, 4) rising Cassiopeia, 5) rising Vega, 6) rising Pleiades, 7) rising Aldebaran, 8) rising Gamma Aquilae, 9) Rising Altair, 10) Rising Beta Aquilae, 11) rising Orion's Belt, 12) rising Corvus, 13) rising Antares, 14) rising Shaula, 15) Southern Cross rising, 16) Southern Cross at 45 degrees, 17) Southern Cross upright, 18) Southern Cross 45 degrees setting, 19) Southern Cross setting, 20) setting Shaula, 21) setting Antares, 22) setting Corvus, 23) setting Orion's Belt, 24) setting Beta Aquilae, 25) setting Altair, 26) setting Gamma Aquilae, 27) setting Aldebaran, 28) setting Pleiades, 29) setting Vega, 30) setting Cassiopeia, 31) setting Big Dipper, 32) setting Little Dipper.

To maintain his course at sea, Piailug, with no compass, must follow the stars.* Instead of sailing east, he sails "under rising Mailap." At night, at the right time of year, Piailug simply points the bow of his canoe at the rising star to steer the course. But since the stars rise 4 minutes earlier each evening, Mailap may be either too high in the sky to be useful or may not have risen. So Piailug must know a score of lesser stars which follow the same "path" or "road" as the guiding star. Now, after 45 years of study, Piailug knows the entire nighttime sky. On a squally night he needs only an occasional glimpse of the stars to check his course.

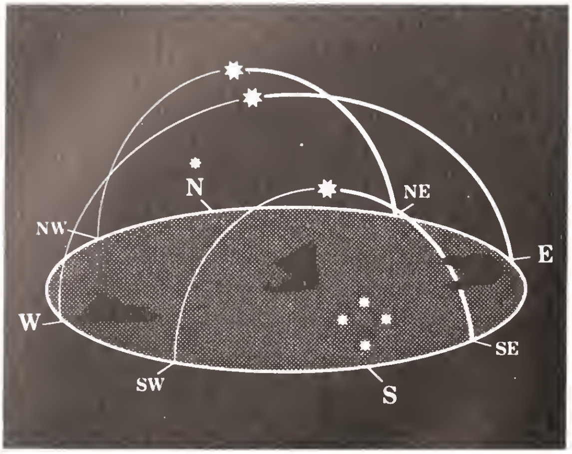
The *Palu* Chart Case: *Wofanu*

With a full chart case, the Western navigator can determine the course from one destination to any other. But with no charts or written language, the

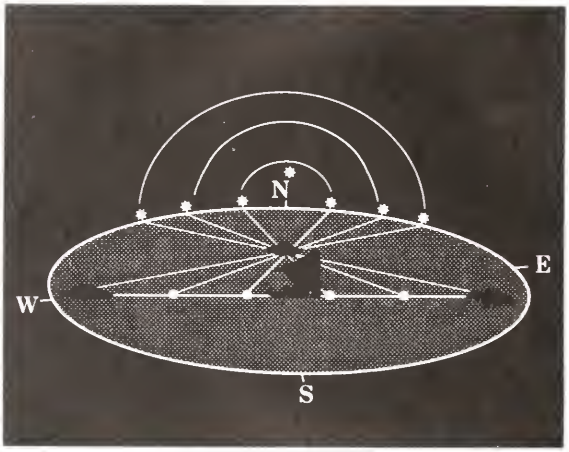
*Mau Pialug teaching the star compass to his sons. (Photo by author/*The Navigators*)*

palu must memorize the stars under which every island lies. This is called *wofanu,* literally "gaze at the island". Seated in a circle around their teacher – often relaxing with the alcoholic palm-sap

*The magnetic compass, according to the Satawalese elders, was introduced to Satawal by the German administration of Micronesia in the early part of this century. The Satawalese noticed that the face of the compass was divided into 32 points (instead of 360 degrees), corresponding exactly to their own star compass. So, with the points appropriately renamed, the compass was used to maintain direction at sea and did not affect the other portions of the Satawalese navigation system.



The star compass works because of the Earth's rotation, which causes stars to appear to rise in the east and set in the west. (Illustration courtesy of author)



By imagining lines through a reference island to the rising and setting points of defferent stars, a Satawalese navigator can monitor the progress of his canoe without charts. (Illustration courtesy of author)

drink *tuba* – students learn the web of star courses to and from every island in their world. The more *wofanu a palu* knows, the greater his voyaging range. An average *palu* knows *wofanu* for those frequently sailed passages around his home island. But a great navigator knows *wofanu* for all the islands in the Carolines. Piailug instructed me in *wofanu* for all these islands and then, to my amazement, added the star courses from Hawaii to California, South America, Tahiti, Samoa, Marquesas, Tuamotus, Cooks, Marshalls, Tonga, and Japan. These he learned from his grandfather. The star courses came "from long, long ago", although I suspect they were figured out by *palu* serving as sailors on European sailing ships late in the last century.

Though it is an impressive task, memorizing this long list of star courses is only a small part of what the *palu* must keep "inside the stomach", the traditional Micronesian seat of knowledge. Indeed, by mastering navigation, a man earns the highest rank he can achieve by his own efforts (that is, without being born into a chiefly clan). "My grandfather spoke of navigation," Piailug explained. "If you learn it you will have a name. You will eat the navigator's food. At sea you will have more power than a chief."

The Talk of Sailing

Having mastered the star compass and *wofanu,* the apprentice *palu* goes on to learn the "Talk of Sailing," a quiver of practical skills that allows *palu* to translate memorized lore into actual landfalls.

By day or on overcast nights, when the stars are not available as guides, the navigator must use other sea-signs to keep his bearings. Most important of these are ocean swells. Generated by distant winds, the long, low swells of the open ocean maintain constant direction as they march across the sea. When coming from only one direction, with the sea calm and the wind light, swells are easy to interpret. But when there are swells from two, three, or even four directions, topped with small, choppy waves generated by the local wind, the apparent result is chaos. Piailug and his colleagues can analyze the various component swells in what to us is the confusion on the sea's surface. To maintain his course at sea, Piailug keeps a constant angle between his canoe and the swells approaching from one direction.

Micronesians recognize eight swells, one from each octant of the star compass. During our voyage to Pikelot four of these swells were present; Piailug could readily distinguish the swell under Mailap, generated by the prevailing easterly tradewinds, from the three others that overlaid and obscured it. After some study (and with patience on Piailug's part) I could identify them as well.

On very dark nights, when there is no moon behind the clouds to light the sea, the *palu* must maintain his course by feeling the pitch and yaw of the canoe on the seaway. This technique, called simply "to feel," is the ultimate test of a *palu's* skill.

Compensating for Current

One of the most difficult problems facing a navigator is to measure the displacement from his intended course caused by current. Currents can be swift and variable in the central Caroline Islands; failure to measure them properly when leaving land or to apprehend a change while at sea is the primary reason navigators get lost.

The Western navigator measures current with a compass when first taking leave of land. Let's say he departs on an easterly course. After traveling a while, he sights back along his track to his point of departure. If it lies directly west, he knows he is not being pushed off course by a current. If the departure point lies south of west he knows a current is pushing him north. Conversely, if it lies north of west a current is pushing him south. Then, by plotting the intended course and the actual course

*Steering a Polynesian sailing canoe. Except for flashlights, modern sailcloths, Winston cigarettes, and prayers to the Virgin Mary, today's voyages are virtually identical to those of a thousand years ago. (Photo by author/*The Navigators*)*

on a chart of the area, he can measure the displacement caused by the current.

The Micronesian navigator does this with a different conceptual approach. When starting a voyage the *palu* takes a bearing on the island of departure just as it disappears beneath the horizon, a point known as "one tooth" since the island is a single tooth of land. Let's say his intended course is east – rising Mailap. If there is no current, the island will be under setting Mailap. However, if there is current the island will appear to move. If a current is pushing the canoe south, the island will move north to under the position of setting Paiifung or setting Ul. If a current is pushing the canoe north, the island will move south to under setting Paiiur or setting Uliul. The star under which the island has moved determines the course compensation the navigator must make. The Talk of Sailing includes specific course corrections for all permutations of wind and current for those voyages commonly made from Satawal.

Detecting current shifts when out of sight of land is much more problematic. The Satawalese have developed several methods for this situation. In calm weather, a navigator might drop a weighted line with a vane attached into the water. In anything other than flat calm, Piailug reads the shape and size of the waves. A short, steep sea indicates a current running counter to the direction of the swells. A longer, smoother sea means the reverse. Piailug also taught me to read the current by observing the whitecaps. If the current is setting in the direction of the wind and swell, the whitecaps smoothly and gently topple over and flow with the swells. If the reverse is true, the whitecaps peak up abruptly and appear pulled back from the wind.

Pookof

"What if you still can't tell what the current is doing?" I asked Piailug. He took my pencil and drew a rough chart of the seaway between Satawal and West Fayu.

"You have fish here," he solemnly explained. "You have bird here. If you see one you *know* you are not on the road to West Fayu."

Micronesian navigators believe that certain sea creatures – a species of flatfish, a pair of sea birds, a shark with special markings, or a pod of killer whales, to name a few – reside in specific places in the seas. According to legend, they were placed in the sea by Fanur and Wareyang, the two sons of Palulap, father of all navigators, to aid *palu* when lost. When one creature dies, another one of the same species and markings takes his place. One navigator explained: "The spirit gave us *pookof* because we don't have charts and sextants like the navigators from America."

All *palu* I queried claim to have sighted some of the creatures from *pookof*. I myself saw a billfish very near its prescribed location northeast of Satawal. Some creatures may inhabit specific areas because of prevailing conditions (such as the whales that feed in summertime on Stellwagen Bank, near the Boston Harbor approach buoy). Failure to sight a creature from *pookof* is not interpreted as a challenge to the validity of the system; it is simply taken to mean the canoe is out of visual range of the creature.

Etak: A Mental Plotting Method

Once he has set his course, a navigator must measure his movement along it. The Western navigator, measuring speed with instruments and having measured any displacement by current, keeps a running plot of his estimated position on a chart to model the progress of his vessel in relation to stationary land. He can check this dead reckoning position with sextant sights or by using an electronic system such as loran.

Without charts or instruments, the *palu* uses a mental plotting system called *etak*. He envisions the island of departure and the target island moving, unseen, beneath the horizon. A third island or reef off to one side of the course becomes his reference point. Imaginary paths radiate from the canoe through the reference point (never actually sighted) to the stars beyond, dividing the voyage into segments or *etak*. By visualizing the reference island moving under a succession of stars, the navigator mentally structures his voyage.

The first and last segments of a voyage are called the *etak* of sighting and the *etak* of birds. The length of the *etak* of sighting depends on the elevation of the island of departure. The *etak* of birds is the distance seabirds nesting on the island fly out to fish – generally about 18 miles. If uncertain of his bearings a navigator will pause at the *etak* of birds (as we did off Pikelot) to confirm the direction to land.

There are two noteworthy features about this system. Like its Western counterpart, dead reckoning, *etak* provides no independent confirmation of position once out of sight of land; it is a conceptual method that gives the *palu* a framework in which to model the course of his vessel and the factors acting upon it. Also, the Micronesian navigator envisions his canoe as stationary with islands moving around it, whereas the Western navigator pictures his vessel moving through stationary islands.

The Decline of Navigation

Satawal's remoteness and commercial insignificance shielded it from the West until after World War II. The Talk of Navigation was kept alive through the generations, handed from father to son, master to apprentice, in the broad, cool canoe houses. But the grip of tradition is loosening. For much of the year, the young Satawalese abandon the canoe-house classrooms of their fathers to attend a Western-style high school on distant Ulithi Atoll. There, they learn the customs and values of the West – a world view with little room for the fusion of teacher, fisherman, captain, and community leader that was the *palu*.

"My generation and the generation before me strove to learn navigation," Piailug explained. "But the young men don't care about it. They want to earn money. They go away to high school on Ulithi or college on Guam and often do not come back. They go to Yap, Palau, Ponape, and Saipan to find jobs."

In a way, this is in keeping with an ancient Pacific tradition. Perhaps the young captains who turned their canoes north, to leave their New Hebrides homeland and discover Micronesia, did so for the same reasons young men leave their islands today – to seek prosperity, to escape the strictures of a tightly organized society, and to behold new lands.

That a culture must change is the way of the world, but it weighs heavily on Piailug and his peers. They recognize a loss of more than just a set of navigational techniques: it is the loss of a way of life and a conception of the world. These men are the last living representatives of an unbroken tradition that began "before, before, before!" with Palulap, the great navigator. The Talk of Navigation has been handed down through the succession of his sons, the *palu*. It spun myth, magic, ethics, and practical knowledge into a seamless web, the center of which was navigation.

Once, after we had talked many hours, I asked Piailug how he felt about the Talk of Navigation. "I don't know about the others," he said, forcing his words out in a kind of pain, "but in my mind the Talk of Navigation is beautiful. Inside my body the same, I say the Talk of Navigation is beautiful."

Stephen D. Thomas became interested in non-instrumental navigation in Oceania after working as a yacht-delivery captain in the Pacific, Atlantic, and Mediterranean. He has made two trips to Satawal, where Mau Piailug adopted Thomas as a brother and instructed him in navigation.

Acknowledgements:

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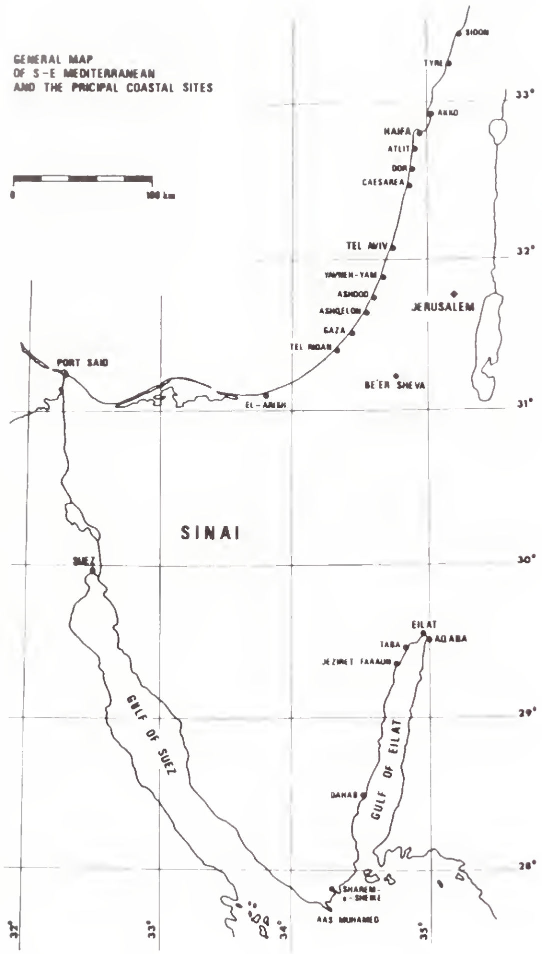
Marine Archaeology in Israel

by Avner Raban

Underwater research in Israel began one weekend in 1958 when a group of ex-Navy divers met at the Kibbutz Ma'agen Michael. These divers were called in by the fishermen of the kibbutz, who were led by the "keeper" of the local archaeology museum, Elisha Linder. The local museum, like its counterparts along the coastline, housed a collection of amphoras, stone anchors, and various clay vessels that had been salvaged from the sea bottom in the hauls of fishing nets. The curious "kibbutzniks" were eager to become divers, so that they could better reach the amphora sites dragged by their nets.

The weekend meeting spawned the Undersea Exploration Society of Israel (UESI). Linder offered the ex-Navy divers an opportunity to continue diving on the weekends for pleasure as civilians while teaching them the basic theories and practices of archaeology. He had secured the money necessary for diving gear and survey equipment from various industrialists and owners of ship companies. The society was soon attracting scientists with diving experience and a host of volunteers from settlements along the coast.

These Roman statuettes were found in waters near Hof Hacarmel. The largest is less than 15 centimeters tall.



In the summer of 1960, a small research vessel, the *Sea Diver*, crossed the Atlantic, mooring off the ancient port of Caesarea. The *Sea Diver* was built and specially equipped for underwater archaeological research by her owner and designer Edwin Link. The vessel, at Link's command, served as a floating base for trial excavations at Caesarea, a harbor that through the ages has disappeared beneath the waves.

This project not only utilized scuba divers, but also gave volunteers of the UESI their first chance to participate in a project fully equipped with all the latest innovations in underwater research. Because of bad weather and malfunctioning gear, the expedition experienced only 9 to 10 days of underwater work during the entire summer. Yet, it was an opportunity for the group to experience the potential of underwater excavation and also taught members something about cooperating in international projects. UESI divers would later participate in important wreck excavations at Yassi-Ada in Turkey, in the Strait of Messina, and off Kirenia in Cyprus.

One of the "godfathers" of underwater archaeology, Peter Throckmorton (see page 2), was invited to guide an underwater survey along the northern Israeli coastline for a few weeks. Thus, UESI members had an opportunity to learn from the most eminent person in the field at that time.

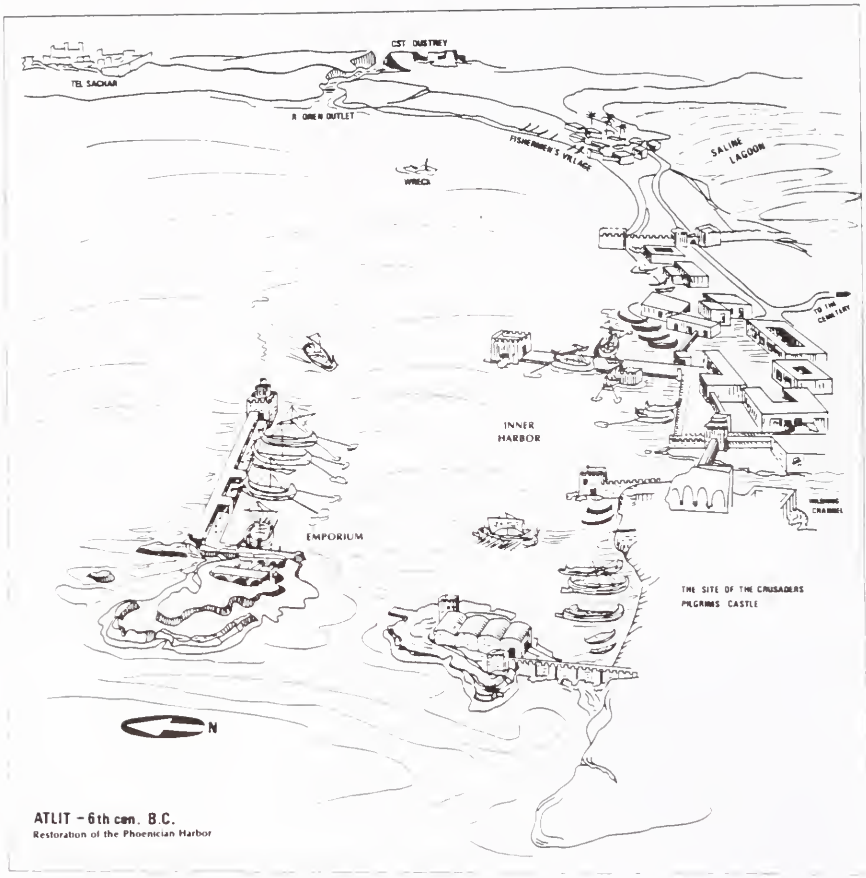
Potential Recognized

All this activity created an awareness among the public as well as among the archaeological community of the potential that underwater research held. This yielded two results. The UESI was asked to join the Israel Exploration Society, which allowed the young organization to systematically explore the near-shore sea bottom within the IES framework. Meanwhile, fishermen, aware of the various findings of UESI, soon perceived that there was a better profit in treasure hunting. The end result was that more and more fishermen turned away from spear-fishing for groupers or harvesting sponges and focused on hunting for man-made objects, such as amphoras and metal statues.

In 1964, the Israel Exploration Society carried out a field survey along the coast of Haifa, and continued south to the Crusader Pilgrim's Castle at Atlit. The divers of UESI, following close behind, uncovered approximately 20 wreckage sites, a few submerged prehistoric settlements, and, last but not least, an intact Phoenician harbor – completely unknown and perfectly preserved – at Atlit.

The detailed survey of that harbor was soon followed by a larger project. In 1965, the Israeli government decided to build an adequate breakwater for the Arab fishermen of Akko. To reduce expense, it was to be built on top of the ancient breakwater – the main feature that allowed Akko to serve as a major port for more than 2,000 years. Although losing a public campaign against this plan, UESI members tried to extract as much data as possible; as they dove, heavy cranes dropped large stone blocks near their heads. However, the data gathered, the experience gained in excavating submerged structures, as well as information acquired from the ancient sea walls, allowed for a team of underwater archaeologists from the British Sub Aqua Club as well as experts from Oxford to develop a new proton magnetometer. At the same time, Harold Edgerton came to work with us, bringing his sub-bottom profiler (a low-frequency sonar device that was nicknamed mud penetrator) and the experimental version of his side-scan sonar instrument. Utilizing these electronic sea bottom searching devices, two full-scale surveys were performed off Ashdod and Caesarea.

The Six Day War in 1967 between Israel and Arab forces opened a new territory for the UESI. The Red Sea always had been a "Promised Land" for marine archaeologists in Israel, who were accustomed to fighting the murkiness and the surge of the Mediterranean and who were frustrated by a



Artist's reconstruction of the Phoenician harbor at Atlit.

total lack of deep-water wreckage sites along Israel's Levantine coastline. The narrowness of the Strait of Tiran (the southern entrance to the Gulf of Aqaba), the off-shore coral reefs with the sheer drops at their base, the year-round good weather, calm seas, and perfect visibility were all factors contributing to ideal working conditions. Even the tedious task of surveying for wreckage sites was alleviated. King Solomon's fleet of Ophir, Roman ships that sailed to Arabia Felix, and other ships holding cargoes with riches from ports of the Indian Ocean were all there waiting to be exposed.

A full-scale expedition was soon organized to a little off-shore island named Jezirat Pharaun. The strait between the island and the mainland was crisscrossed by Edgerton's mud penetrator, while a mixed group of divers from England and the UESI investigated selected subbottom anomalies. Soon it became clear that broken amphoras of the Byzantine era (some 1,500 years before present [B.P.]) were under 2.5 to 3 meters of loose sand produced by disintegrating corals from the fringing reefs. Assuming the rate of deposition to be more or less fixed through the millenia, one would have to look for anomalies of Solomonic age under 6 to 8 meters of sand. Such anomalies actually were recorded by Edgerton, but they tended to be buried too deep in the sand for the airlifts and other excavating tools of the expedition.

Another frustration resulted from the annual growth rate of stone-hard corals, which are capable of settling on any firm base underwater. These corals would grow as much as 4 to 5 centimeters each year, creating such thick stone forests over ancient wrecks that the odds of detecting Biblical relics would be almost nil. In fact, even a 500-year-old excavated Arab wreck had a coral coating of more than a meter in thickness. Between the years 1969 and 1973, several other wrecks were excavated and all were found to be but a few hundred years old. There was not even a single item from the pre-Christian era.

While the volunteers of UESI took up the challenge of exposing old wrecks in the Red Sea, Linder began a public campaign for academic recognition of multidisciplinary underwater exploration as a valid subject to be taught in the universities. In 1972, the University of Haifa agreed to establish a Center for Maritime Studies with a charter to promote the study of all aspects of human activities in the sea. Two years later, a group of graduate students was admitted to the

Department for the History of Maritime Civilizations.

The People of Dor

The history of the Israeli coastline, which is straight for the most part with only a few bays, is one of radical social changes. On the one hand, there were times when it served as a main stopover port for ships bound from the East and the Indian Ocean to the Mediterranean markets of Greece, Rome, and, during the Middle Ages, most of Europe. On the other hand, there were centuries of oblivion, when ports were deserted and the dominant empire tried to keep out foreign vessels. This has been the case for most of the time since the Crusaders were turned out of Akko in 1292, till our century. This fact kept many of the ancient harbors from being rebuilt in the later periods. On the Israeli coast, there are more well-preserved remnants of ancient marine structures than elsewhere in the Mediterranean. This unique situation has made the study of ancient harbors of prime importance among the research activities of the Center for Maritime Studies.

Of these port settlements, Dor is most interesting. It was first settled some 4,000 years ago on what was then the tip of a peninsula. The people of this town took advantage of the fact that there was an inner lagoon on one side of their town. They either artificially connected it to the sea via a submerged outlet, or kept the natural passage from a river siltfree by diverting floodwaters further south to protect the lagoon. Preventive measures of a similar character and of the same period have been detected in half a dozen port sites both north and south of Dor. These data are indicative of the understanding these people had of coastal processes. It also shows the amount of work they would undertake to create safe inner harbor basins.

Toward the end of the Bronze Age, a new military force emerged in the Near East—"the Sea People" (or literally translated from Egyptian and Ugaritic texts: Those who came from beyond the Great Green). While most historians believe these Sea People caused the total collapse of the entire Bronze Age civilization and political unities in the Levant, including the Hittite empire and the Canaanite Kingdoms of Ugarit, Byblos, Sidon and Tyre, the Biblical stories tell us about only one of these people — the Philistines.

According to the Bible, the Philistines were good warriors, and the first to possess weapons made of iron. They are thought to have controlled the rural parts of the country. Yet, there is not a single reference to their maritime activities. A unique Egyptian papyrus, known as the "Story of Wenamun," mentions the fact that another group of Sea People, known as the Sikuly (probably the same people who first colonized Sicily), were the inhabitants of Dor. These Sikulians also were known as pirates, according to a Ugaritic text. Yet, recent excavations, at the shoreline of Tel Dor, disclosed that they also were harbor engineers.

During the 13th to 12th centuries B.C., the people of Dor used stone-made landing stages, quays, and flanking sea walls built of carefully cut large blocks that were accurately placed in the water with their shorter sides facing the sea. This building technique, known as headers masonry, consumed a great deal of labor because only a small percentage of leveled surfaces could comprise the face of the wall. Yet, it was also very durable and perhaps the best technique to prevent the sucking effect of retreating waves from pulling individual blocks off the structure. The dragging between two neighboring ashlars* in this building system is so great that no mortar or other fastening measures are necessary.

The data from Dor are the first indication that the Sea Peoples were not pirates, mercenaries, or wanderers, but rather carriers of high technology in building and marine engineering. In searching for a possible source for their technical knowledge and maritime heritage, one must go back to Minoan Crete, as well as to the Aegean Bronze Age cultures that disappeared long before the Greeks of the classical period reached literacy.

There even may be more to it: the greatest maritime nation of the Iron Age was Phoenicia. It is generally thought that its maritime and technological heritage was brought to the Levant by the offspring of older Canaanites. But new evidence suggests that it may have been an influx of Minoan Sea People whose ideas merged with those of the local experts in seaborne trade — the old people of Sidon and Tyre.

This reconstruction of historical events based on archaeological data from harbor sites tends to be supported by the studies of ships that were built in this region during the same period. Encounters between bulky Canaanite merchant vessels with a rigid square rig and swift Aegean long and narrow galleys brought experiments with a new loose-foot sail that allowed vessels to tack closer to the wind. In addition, new ship designs brought a variety of specialized vessels for both coastal shipping and the ocean-going merchant trade, as well as fighting ships furnished with a battering ram and more than one deck.

Atlit, about 10 miles south of Haifa, is one site where some perfect archaeological remnants of the Phoenician maritime know-how have been found. This harbor was probably built during the seventh century B.C. as a trade port by Phoenicians from Sidon. They chose the north side of a natural, rocky promontory in the lee of two rocky islets. One quay was built on the lee side of the north islet. At its foot, on the rocky bottom under 1.5 to

*Square building stones.

2 meters of water, a 40-meter-long, vertical wall of carefully laid ashlar headers was built. From the north tip of this quay, eastward, a free standing mole* was installed on the rocky sea bottom. In places, where the sea bottom was covered with sand, a "pillow" of coarse gravel and pebbles was laid as a base to protect the structure from being undermined by currents.

The mole itself was about 10 meters wide with both sides consisting of vertical blocks 2.0×0.5×0.6 meters, laid very accurately next to each other without the aid of mortar or any other fastening devices.

The core of the structure was composed of carefully organized ashlar blocks of similar size. The mole was more than 140 meters long and had a rectangular tower at its tip, where the sea bottom is about 5 meters deep. The other section of the harbor was at the north shore of the low tombolo** that connected the promotory to the main shore line. Along this shore, another quay of ashlar headers was laid, and, from its eastern tip northward into the sea, a 100-meter-long mole similar to the first one was placed on the sea bottom.

The opening between the two mole heads faced east and though it was too wide to be closed by chains or even to keep out waves, its orientation gave storm surge a maximum fetch of only a few hundred meters. The narrow gap between the two rocky islets served as a washing channel that kept the harbor basin silt free. The off-shore section of the harbor was used as an emporium – an international mooring place and trading base. Being separate from the in-shore part of the harbor, there was less opportunity for foreign crews to raid the town or storage places on the shore.

The same concepts and technologies have been found at the ancient harbor of Akko. There, the anchorage at the lee side of the promontory had to be protected by a free-standing breakwater in order to keep off the surge of the southwestern winter storms. The Phoenicians of Tyre, who held the city for some centuries, probably built such a structure when their Persian patrons chose the place as a base for Cambyses's expedition to Egypt in the thirties of the sixth century B.C. The main breakwater was built as a mole in the same technique as the one at Atlit.

Beyond the entrance to the Akko harbor, some 60 meters east of the tip of the breakwater, there is now a medieval structure locally called "The Tower of Flies." Not covered by modern breakwaters, the submerged base of the tower once apparently served as an offshore docking area for foreign ships in transit along the coast.

The Sea People and the Phoenicians represent a maritime civilization with coastal

Diver salvaging a Phoenician amphora from a wreck site north of Akko.

strongholds on sites detached from inland territories. These sites were open to the sea and to the maritime routes. The harbors had no defending sea walls. The artifacts found in these sites are from all over the Mediterranean, illustrating the international character of their trade as well as the eclectic nature of their culture.

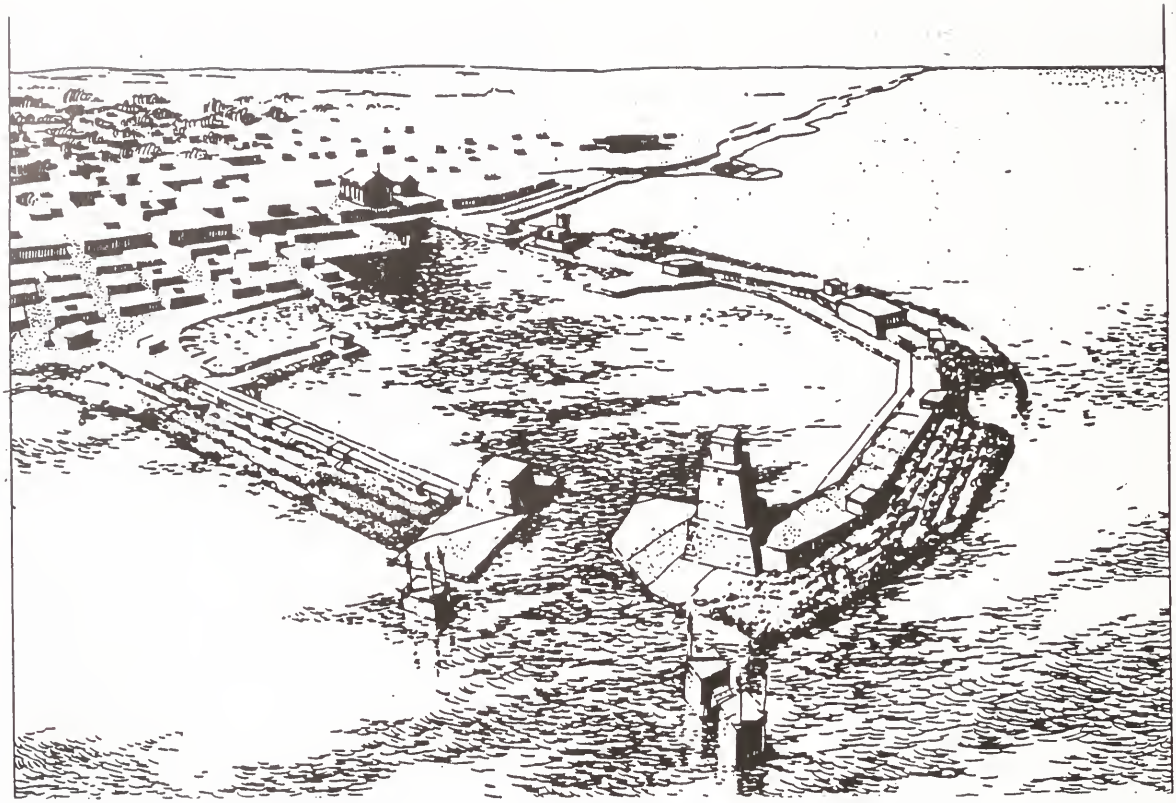
The Harbor at Caesarea

In 1975, the theoretical question of whether or not the straight delineation of the Mediterranean coast of Israel is the result of a tectonic fault line gained immediate relevancy. That year, the United States considered selling a nuclear power plant to Israel. The quantities of water needed for cooling the reactor dictated that its location be on the shore.

The government, recalling our earlier reports about frozen flows of molten lead in the sunken parts of the ancient harbor of Caesarea, asked us to carry out an archaeological study to determine whether there was a displacement of the sea bottom at Caesarea after the completion of the

*A mound or massive work formed of large stones or earth laid in the sea as a pier or breakwater.

**A sand or gravel bar connecting an island to the mainland or another island.



Artist's reconstruction of the great Herodian harbor of Caesarea.

harbor. Josephus Flavius, the Jewish historian, 1,900 years earlier wrote:

> *Now King Herod observed a place near the sea, which was very proper for containing a city, and was before called Straton's Tower...and what was the greatest and most laborious work of all — he adorned it with haven that was always free from the waves the sea... The king, by the expenses he was at, and the liberal disposal of them, overcame nature and built the haven larger than that at Pireous and it had towards the city a double station for the ships. It was of excellent workmanship: and this was more remarkable for its being built in a place that of itself was not suitable to such noble structures, but was brought to perfection by materials from other places, and at very great expenses. This city is situated in Phoenicia, in the passage to Egypt, between Jaffo and Dor, which are lesser maritime cities, and not fit for havens, on account of the impetuous southwest winds that beat upon them, which rolling the sands that come from the sea against the shores do not admit of ships lying in their station; but the merchants are generally forced there to ride at their anchors in the sea itself. So Herod endeavored to rectify this inconvenience, and laid out a compass toward the land as might be sufficient for a haven, wherein the great ships might lie in safety;*

Two divers survey the remains of a Roman merchantman at Caesarea.

and this he effected by letting down vast stones into 20 fathoms of water, most of them being 50 feet in length, and 9 in height and 10 in breadth, and some still larger. But when the haven was filled up to that depth, he enlarged that wall which was thus already extant above the sea, till it was 200 feet wide; 100 of which had buildings before it, in order to break the force of the waves, whence it was called Prokumatia, or the first breaker of the waves; but the rest of the space was under a stone wall that ran around it. On this wall were very large towers . . . There was also a great number of arches where mariners dwelt. There was also before them, a quay (or landing place), which ran round the entire haven, and was a most agreeable walk to such as had a mind to that exercise; but the entrance or mouth of the port was made on the north quarter, on which side was the stillest of the winds of all this place . . . At the mouth of the haven were on each side three great Colossi, supported by pillars, where those Colossi that are on your left hand as you sail into the port are supported by a solid tower; but those on the right hand are supported by two upright stones joined together, which stones were larger than that tower which was on the other side of the entrance
(Antiquities, *XV: 334—338;* War, *I: 411*—413).

This may be the most detailed description of an ancient harbor to have survived. The harbor was built with a master plan over a 12-year period (22—10 B.C.). Since 1980, the excavation project has been carried out by the Caesarea Ancient Harbor Excavations Project (CAHEP), which links the Center for Maritime Studies with the universities of Colorado (at Boulder), Maryland, and Victoria (British Columbia).

Every summer, more than 100 diving volunteers come from all over the world to Caesarea to be directed by a large staff of marine archaeologists, diving technicians, marine engineers, and architects. It is probably the largest underwater excavation project of its kind.

Though the work is far from completed, 10 seasons have yielded data that not only verify Flavius's testimony, but add surprising information about the sophistication of harbor technology at that time. It was the first protected basin that was artificially encompassed by free-standing breakwaters that were not based on any headland, natural bay, or off-shore reef. The breakwaters were designed in such a way that their internal side was wide enough to accommodate storage places and mooring facilities along their entire length. To protect the breakwater, the harbor engineers added an additional breakwater — a rather simple and narrow sea wall some 30 meters away from the main breakwaters. This subsidiary structure was just above the water level, high enough to block the waves' energy from the main breakwater.

Caesarea represents a culmination of 25 years of marine archaeological exploration and research in Israel. The project encompasses land and underwater excavations and includes sampling of biota, minerals, and sediments for laboratory analysis. The results will help determine environmental changes, land-sea relations, marine engineering techniques, and harbor technologies. There are wrecks with and without preserved hulls at Caesarea. There are lost anchors and metal objects. . . .

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The above report does not attempt to cover all the marine archaeological projects carried out in Israel, or even all those carried out by the Underwater Exploration Society of Israel and the Center for Maritime Studies. There have been important excavations of Arab wrecks in the Red Sea, Phoenician cargoes of wine containers and clay figurines, hoards of bronze objects and helmets of Babylonian origin, Byzantine wrecks, and more.

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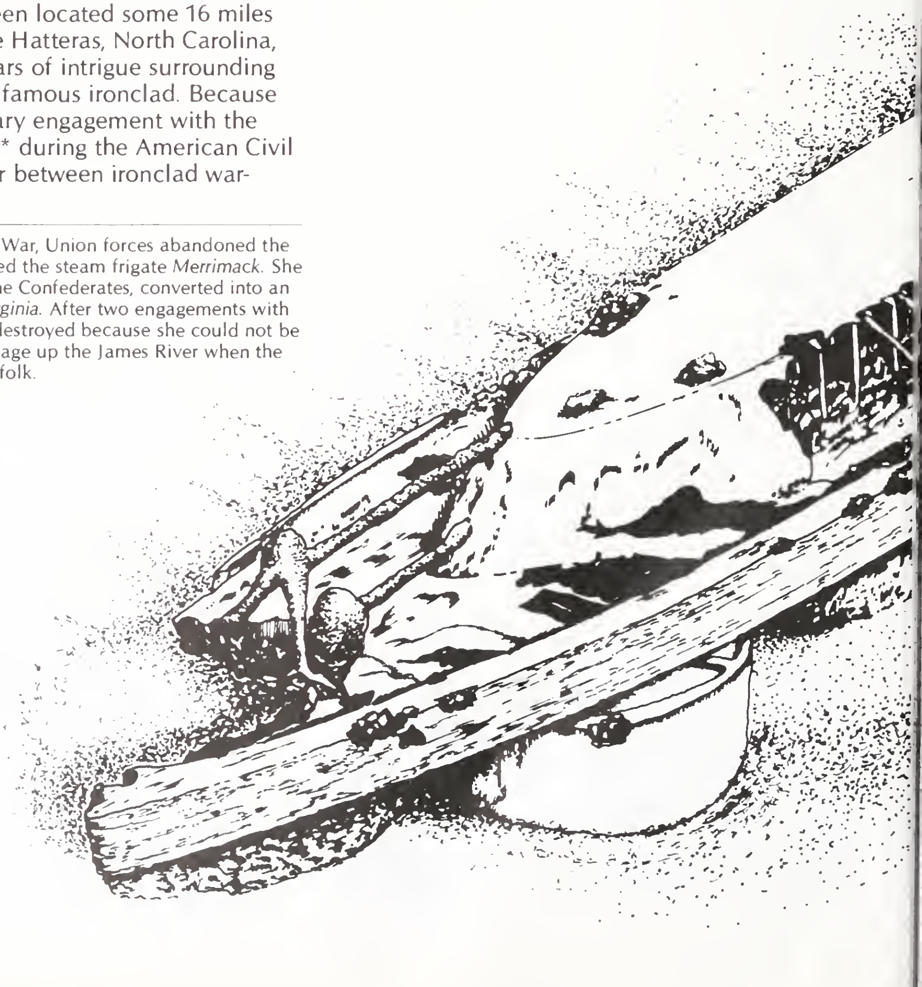
The Monitor National

by Edward M. Miller

The confirmation in 1974 that the wreck site of the *USS Monitor* had been located some 16 miles south-southeast of Cape Hatteras, North Carolina, ended more than 25 years of intrigue surrounding the whereabouts of the famous ironclad. Because of the *Monitor's* legendary engagement with the *Merrimack (CSS Virginia)** during the American Civil War (the first battle ever between ironclad war-

*At the beginning of the Civil War, Union forces abandoned the Norfolk Navy Yard and scuttled the steam frigate *Merrimack*. She was subsequently raised by the Confederates, converted into an ironclad, and renamed the *Virginia*. After two engagements with the *Monitor*, the *Virginia* was destroyed because she could not be lightened sufficiently for passage up the James River when the Confederates abandoned Norfolk.



Marine Sanctuary

The Monitor *lies inverted on its displaced turret, placing severe stress on the major longitudinal support, the port armor belt.*

ships), and its subsequent loss in heavy seas a short while afterwards, the discovery of the wreck was generally regarded as a "prize" by the various groups looking for it. The U.S. Navy, in 1953, formally had abandoned the vessel, relinquishing all claims to the wreck so as not to impede private interests in the search for the vessel. As a result, numerous competing groups sought to locate the ironclad in what the Navy Supervisor of Salvage referred to as the "Great *Monitor* Sweepstakes."

Soon after the *Monitor* was found an intense debate arose over what should be done with it. Arguments spanned a spectrum, from those calling for immediate recovery to establish salvage claims, to those calling for the wreck to be left undisturbed.

National Marine Sanctuary Program

Soon after discovery of the *Monitor,* officials of concerned government agencies and universities determined that, because of the site location, the wreck was beyond the jurisdiction of the State of North Carolina and that existing federal laws did not protect the site. The need for such protection was dramatically underscored by a press report of a dredging attempt to recover artifacts that same month.

As a result, there was a consensus agreement that provisions under a newly established law, Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, afforded the best protection for the wreck. Subsequently, the site was nominated by the governor of North Carolina, and, after a process of review and public hearings, was designated as the nation's first marine sanctuary by the Secretary of Commerce on January 30, 1975, the 113th anniversary of the vessel's launching.

Title III of the Marine Protection, Research, and Sanctuaries Act of 1972 authorizes the Secretary of Commerce, with Presidential approval, to designate ocean waters from the shoreline to the edge of the continental shelf, including the Great Lakes, as marine sanctuaries for the purpose of preserving their distinctive conservation, recreational, ecological, cultural, and aesthetic values. This was interpreted to include historic or cultural remains of widespread public interest, such as the *Monitor.* The National Marine Sanctuary Program is managed by the Sanctuary Programs Division of the National Oceanic and Atmospheric Administration (NOAA). The protection of a historic shipwreck within this general management framework used for other fragile, living marine resources, such as coral reefs and fish habitats, provides a sound scientific basis for learning how to treat shipwrecks – an important, yet little understood, marine resource.

Historic Shipwrecks as Marine Resources

Throughout history, the ship has been one of the largest and most complex machines produced by man. As such, the ship and its contents present a discernable "finger print" of the society that produced it and can reveal a great deal of information about the people who constructed and operated it.

A ship and its contents were specifically selected for a narrowly defined purpose and designed to be self-sufficient and to maintain a shipboard community for extended periods of time. Decisions made by the builders on design, selection of materials, and method of construction paint an accurate picture of their technology and industry, while the ship's contents reveal a great deal about their economy, society, and culture.

Few individuals can fully appreciate the type of commitment and the level of investment in terms of time, effort, knowledge, and money often required to record, excavate, and secure the physical recovery, conservation, and long-term curation of material from underwater sites. Any project considering the recovery of a historic shipwreck should carefully study the Scandinavian experience with the *Wasa* and the recent British experience with the *Mary Rose,* and compare them to the U.S. experience with the *Cairo.*

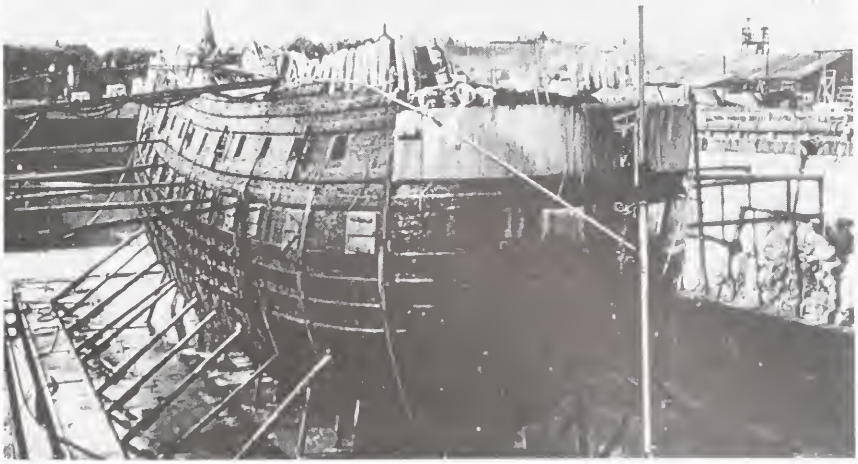
The *Wasa* is a remarkably well-preserved 1628 Swedish warship recovered intact from Stockholm Harbor in 1961. This project serves as a model for all ship recovery projects. It was the first large-scale project attempted, and, as a result, much of the present technology for the conservation of submerged materials derives from it.

Many decisions on the *Wasa* project were made without the full knowledge of what the consequences would be in terms of results or final costs. Several important lessons can be learned from this project.

First, once the decision is made to recover, there must be total commitment to conservation in terms of sufficient financing. Economic factors should not be allowed to determine when the conservation process is complete. Second, a project of this magnitude requires support from the general public as well as from government institutions. Lastly, the preservation of the ship equates to perpetual care and maintenance, if the ship is to be a lasting artifact. The *Wasa* has been undergoing conservation treatment for more than 25 years.

A more recent example is the 1545 Tudor warship *Mary Rose* recovered in 1982 from 40 feet of water near Portsmouth, England. What started in 1965 as archaeological explorations to survey, record, and if possible, identify an unknown anomally using amateur divers turned into a 17-year effort to completely document, excavate, and finally recover the remaining ship structure at a cost of nearly $7 million, supported largely by private donation.

The *Mary Rose* project is a management model because it demonstrated the need for strong management to control all aspects of the project, including archaeology, conservation, engineering, museology, and a host of other supporting



The 17th century Swedish warship Wasa *was recovered from Stockholm harbor in 1961. Today it is a major historical attraction.*

disciplines and specializations, the most important being fund raising.

The highly publicized and exciting work of the discovery of *Mary Rose* artifacts and the recovery of the hull is completed. Now efforts are concentrated on sustaining the project through the lengthy conservation and display phases, estimated to take another 20 years.

From the archaeological perspective, it seems unfortunate that only the relatively short, high-risk recovery phase is sufficiently spectacular to generate the crucial money and enthusiasm. In comparison, the slow toil, long-term effort, and considerable expense of adequate recording, conservation, and formal publication appear lack-luster. As a result, these efforts receive little public attention, and, in many cases, lack the necessary planning and support.

A lamentable example of poor planning is the case of the *USS Cairo*, a Civil War gunboat discovered virtually intact and well-preserved in 1956 near Vicksburg, Mississippi. The best intentions (motivated by local pride and enthusiasm over the find), combined with a lack of continuity of personnel to create a catastrophic loss of information and material in archaeological and historical terms. Poor planning for the recovery resulted in the wreck being torn apart during the lifting operations. This was later compounded by failure to plan for conservation and a shortfall of anticipated funding. Although the National Park Service has done an admirable job of "salvaging" what otherwise would have been a complete loss, the "Hardluck Ironclad" is a mute reminder of what can happen to an ill-conceived and hastily executed ship recovery project.

The principal danger to the surviving archaeological record, in most instances, is from excavators and salvors who, in the process of uncovering material, disrupt the tenuous equilibrium between preservation and deterioration. This awareness places great emphasis on the need for planning that encompasses not only the engineering of recovery, but also the conservation, curation, and display of recovered artifacts. It too often is the case that damage in the recovery and treatment phases exceeds all previous damage suffered by the object.

The greatest benefit from studying the previous projects is that they form an essential data base of collective knowledge, maturing attitudes, and developing experience on how to properly treat historic shipwrecks. A shipwreck should not be excavated just because it is discovered. How is the decision made? Who should be involved? What minimum standards of historical and archaeological documentation should be required? How should the projects be financed?

How the essential cooperation between various government agencies, different professionals, and amateurs is elicited, and the crucial outside support is orchestrated, so that the collective "project" succeeds, is a harmonious melody that has so far eluded authorities in the United States. The difference in the results between the *Cairo* and *Mary Rose* projects was not a matter of luck, but rather a matter of design through policy, management, and planning.

The National Marine Sanctuary Program is building on the experience of these past projects, hoping to provide similar elements of success for the management of the *Monitor* National Marine Sanctuary, both as a suitable requiem to the "little cheesebox-on-a-raft" and to serve as a national model for the treatment of historic shipwrecks, thus adding another first to the already long list of firsts for this famous ironclad. As such, the concentration is not on the question of the recovery of the vessel

The Monitor's *anchor was recovered in 1983.*

per se, but on the process of arriving at the decision of what should be done with the shipwreck, recognizing that the answer to the first question lies in the understanding of the second.

Conflicting Viewpoints

Since the first discovery of the *Monitor* in 1973 and its subsequent designation in 1975 as the nation's first National Marine Sanctuary, many conflicting viewpoints have been expressed about the ultimate disposition of the wreck.

As the result of interaction between a great number of people, a philosophical basis has emerged on how to deal with the site. The fundamental premise is that the *Monitor* is an archaeological site, and, because of the ship's historical significance, and the public interest in it, the project warrants careful and deliberate planning so that a maximum return and benefit can be derived for the American public. In addition to maintaining site integrity for scientific research, equal emphasis has been placed on maintaining intact recovered artifacts, documentation, and other *Monitor*-related materials in a single collection for researchers and the public.

A national conference in 1978 considered the fundamental question of what *should* be done with the *Monitor*, in contrast to what we *can* or *want* to do. Thus significant emphasis was placed on the process of decision making so as to insure the maximum benefit for the American people, without degrading the historical and archaeological value of the site. This same approach was recommended for other historic shipwrecks, including the USS *Tecumseh, Brown's Ferry,* and other vessels both known or yet to be discovered.

Additionally, there was general consensus that more research and information about the environment and its impact on the material condition of the wreck were necessary before any decision could be made about the ultimate disposition of the *Monitor*, if it is to be treated in a scientific and technologically sound manner.

It was recommended that the consideration of what *should* be done with the *Monitor* be continued, accompanied by a research program consisting of assessments and evaluations structured to determine the technical and fiscal feasibility of management options ranging from non-disturbance of the site to complete recovery of the wreck. The objective of this research is to determine what the condition of the wreck is so as to avoid decisions based on speculation.

Monitor Hull Is in Peril

Since the designation in 1975, NOAA has sponsored three major expeditions to the sanctuary. The most extensive investigation occurred in 1979 when a team of archaeologists conducted 49 dives in 26 days from a lock-out submersible.* The major accomplishment was the completion of a test excavation to collect archaeological samples and engineering data to evaluate the extent of the archaeological record and the condition of structural members buried by bottom sediments. The test excavation was conducted in the deepest water to date in the United States.

The experience gained in working in 70-meter depths has been extremely rewarding in terms of developing new approaches and tools for deep-water archaeology. Additionally, the information collected by the diver/archaeologists first hand is vastly superior to the quality and quantity of remote methods currently available today.

The results of the static equilibrium analysis are perhaps the most germane to our understanding of the interaction of the wreck with the environment. This study concluded that sections of the armor belt and adjacent exterior hull may be stressed close to their ultimate strength, and already show indications of yielding.

A corollary study that compiled and analyzed what is presently known about the effects

*A submersible that allows divers to enter and exit at the bottom of the ocean.

of the environment on the rate of deterioration concluded that the *Monitor* is continuing to deteriorate from natural galvanic corrosion because of its continued exposure to the marine environment. Unlike historic shipwrecks well-preserved by a protective covering of marine sediments, the *Monitor* has been exposed in a highly corrosive environment because of the relatively high temperature, oxygen content, and current velocity at the site.

This dynamic type of environment – as opposed to one that is static and anoxic and therefore conducive to preservation of materials – adversely affects the structural fabric of the wreck by two mechanisms. The relatively high velocity of the currents above the site transport abrasive bottom sediments that erode the protective encrustation built up by the by-products of corrosion. Normally, these by-products tend to gradually decrease deterioration over time. As a consequence, exposed surfaces receive less protection from the insulating effects of corrosion by-products than would be expected.

This adverse mechanism is compounded by the continuous flow of relatively warm, highly oxygenated sea water. This water supplies ions that "feed" the corrosion reaction with the detrimental effect of accelerating the rate of corrosion of exposed material compared to similar material buried by bottom sediments. Thus, the natural environment at the site has been a major factor in the extensive structural deterioration of the wreck for more than 120 years.

These findings indicate that the remaining structure of the vessel may soon collapse, an indication made more likely by the stress of resting on the displaced turret. More than a half of the existing structure is presently being supported above the bottom by the gun turret. Because of the structural weight imposed on the longitudinal support members, there is a high probability that the structure will collapse in the near-term.

Such a collapse would substantially increase the rate of deterioration for the remaining parts of the ship by exposing newly fractured material surfaces to the corrosive environment. Additionally, the collapse of the intact structure would diminish both the archaeological and historical value of the site.

This threat is being evaluated and future research efforts will attempt to measure precisely the residual strength and degree of strain in critical structural members. Whether or not any reasonable action can be taken to mitigate this threat is presently unknown. Several options are being assessed. A 1984 NOAA report concluded that the option of "no action" did not appear to be justifiable in the *Monitor* case because it risks the eventual loss of the cultural resource that the Sanctuary was established to protect. The strategy to date though has been successful in that the *Monitor* still lies intact and protected within the Sanctuary.

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The Institute of Nautical

The Program and the Port Royal Project

by D.L. Hamilton

While there has been interest for decades in the investigation of sunken shipwrecks, ports, and even townsites, underwater archaeology has had difficulty in being accepted as a legitimate extension of archaeological research. One reason for the fact that many archaeologists refuse to take underwater archaeology seriously is that few of them dive; therefore, in their opinion, the investigation of sunken shipwrecks and other underwater sites is not being approached scientifically.

It was not until the excavation in 1960 of a Bronze Age shipwreck at Cape Gelidonya, Turkey, by George Bass, then a graduate student at the University of Pennsylvania and now head of the graduate Nautical Archaeology Program at Texas A&M University, that standard archaeological excavation controls and documentation were applied to an underwater shipwreck excavation. Thus began the long – and continuing – battle to make underwater archaeology a legitimate field of study. The Cape Gelidonya excavation established minimal standards for all shipwrecks.

In 1974, Bass resigned his position at the University of Pennsylvania and established the American Institute of Nautical Archaeology. In 1979, American was dropped from its name to reflect the international character of its endeavors. The Institute of Nautical Archaeology (INA) is a nonprofit, scientific, and educational organization whose purpose is to gather knowledge about the past from the physical remains of maritime activities and to disseminate this knowledge through scientific and popular publications, seminars, and lectures. At first, the institute was headquartered on Cyprus, but the war there between Greek, Turkish, and Cypriot factions forced it to relocate to the United States. In 1976, INA affiliated with Texas A&M at College Station, Texas, although it remains an independent entity.

INA and Texas A&M then established the first academic graduate program in nautical archaeology in the United States, within its Department of Anthropology. Presently, the nautical archaeology program at Texas A&M leads to a Master of Arts Degree in Anthropology; a doctoral program is planned, to begin in the fall of 1985.

Students enrolled in the nautical archaeology program are given core courses in classical history, the history of seafaring, the history of ship construction, ship reconstruction, historical archaeology, and artifact conservation.

Bass and Frederick vanDoorninck teach courses on the history of seafaring, while Richard Steffy teaches courses on ship construction and reconstruction. This author teaches courses on historical archaeology and artifact conservation, and directs the summer field school at Port Royal, Jamaica. In addition, a variety of related courses are offered in the Departments of Anthropology, History, and Geography. All of the graduates of the Master's program come out with a sound background in nautical archaeology, but it is the association of the academic program with the research projects of the Institute that makes the program at Texas A&M unique.

A continuing, symbiotic relationship exists between INA and Texas A&M. The University

Continued on page 74

Archaeology at Texas A&M

The Search for the Caravels of Columbus

by Roger C. Smith

As the quincentennial celebration of the discovery of the New World approaches in 1992, popular and scholarly interest in European maritime exploration is experiencing a revival on both sides of the Atlantic. Just as in 1892, when the 400th anniversary of Columbus's first voyage was observed, new evaluations and interpretations of the Age of Discovery will add to our understanding of this crucial turning point in world history. But, while historians, cartographers, novelists, and biographers have written countless works about the explorers and their accomplishments, archaeologists have only just begun to investigate the tangible remains of mariners who gave us a true world geography for the first time.

Perhaps the most complex and mysterious factors that propelled Medieval Europe into the vanguard of a maritime renaissance were technological adaptations, such as oceangoing ships and precise navigational devices. Yet experts in the evolution of sailing craft know more about Greek and Roman ships than they do about the vessels commanded by da Gama, Columbus, and Magellan.

While models of famous discovery ships exist in museums, and "replicas" have crossed the oceans, all are based on hypothesis since no documented example of an Iberian caravel or *nao* has yet been found and studied. And, although these ships represented the "Mercury space capsules" of a long line of transoceanic vessels, their constructional details and rigging methods are poorly understood. No architectural plans exist and only a few vague illustrations on old charts and documents are left behind as a paltry legacy of their role in the transformation of the globe.

Relatively few caravels of discovery are known to have been lost at sea compared with other long-range sailing craft. This may partially explain why these ships were almost always chosen by Portuguese and Spanish mariners of discovery, and is a testimony to the vessel's reliability in deep water and maneuverability close to shore. And, we know from the narratives of early voyages of exploration that those caravels that were lost either disappeared during storms at sea or crashed on unfamiliar reefs.

His Last Two Ships

Of the many shipwrecks thus far discovered and partially excavated in the New World, only three fragmentary sites – one on Molasses Reef in the Turks and Caicos Islands, another at Highborn Cay in the Bahamas, and a third in Bahia Mujeres in Mexico – appear to date from the first decades of the 16th century. Although these sites presently are under investigation, and are producing valuable new data on ships of this period, their exposed situations in shallow reef environments have not favored preservation of the most crucial portions of their complex organization – their hulls.

However, hidden beneath the soft sediments of St. Ann's Bay on the north coast of Jamaica, there are not one, but two documented examples of caravels of discovery. The last two ships to be commanded by Christopher Columbus, *Capitana* and *Santiago*, are recorded as having been gently run aground in this tranquil sheltered lagoon. Not only are they nautical monuments to the world's best known explorer, but, to archaeologists, they

Continued on page 75

provides INA with office facilities, financial support, and, of course, student researchers, while the Institute provides graduate students with research and training opportunities on the various projects that it supports in the Mediterranean and the Caribbean. Over the years, a number of students have directed INA projects.

Present INA projects in the Mediterranean include an 11th century Islamic or Byzantine shipwreck, a 16th century Ottoman wreck, and a Bronze Age shipwreck. In the Caribbean, INA is sponsoring the excavation of a 16th century Spanish shipwreck in the Turks and Caicos Islands, the search for two of Columbus's caravels in Jamaica, and the excavation of the 17th century city of Port Royal on the same island. Students are involved in all the research projects, but the Port Royal one is more closely integrated into the academic program than the others because it is the site of the summer underwater archaeology field school.

The Port Royal Project

In 1980, Jamaica approached INA about a cooperative project on the underwater sections of Port Royal. The proposal was accepted. From the beginning, the project has been a cooperative effort between INA, Texas A&M, and the Jamaican government. One reason for enthusiastically accepting the research program was the opportunities that we saw for offering a field school on underwater archaeology at the site. Few archaeological sites in the world are as well suited for teaching underwater archaeology students the techniques of underwater mapping, documentation, and excavation; laboratory processing and conservation; and analysis of archaeological materials. Since the first field school in 1981, more than 50 students across the United States have enrolled and earned academic credit in the course.

A Little History

Port Royal, Jamaica, is an extremely interesting site. The mere mention of its name conjures up visions of buccaneers, pirate ships, and adventure on the high seas. Jamaica, which was discovered by Columbus on his second voyage in 1494, was a relatively unimportant Spanish possession with a small population through the first half of the 17th century. This situation changed as a result of Oliver Cromwell's plan to expand England's presence in the Caribbean. In 1655, Cromwell set about to secure a power base in the Spanish New World territories by sending out a force, under the dual command of Admiral Penn and Robert Venables, to carry out his "Western Design." The English were unsuccessful in their attempt to capture Hispaniola; so, in a last-ditch effort to salvage the undertaking, they sailed to Jamaica and gained control of the island's south coast. All Spanish resistance was eliminated by 1660.

Soon after the conquest, Port Royal was established as a defensive fortification at the tip of a long sand spit that separated Kingston Harbor from the Caribbean. The town, however, soon achieved much greater significance. Between 1655 and 1692, Port Royal evolved into the largest and most economically important English town in the New World.

The period between 1660 and 1671 was the age of officially sanctioned buccaneers for which the city is so notorious. Jamaica was at this time

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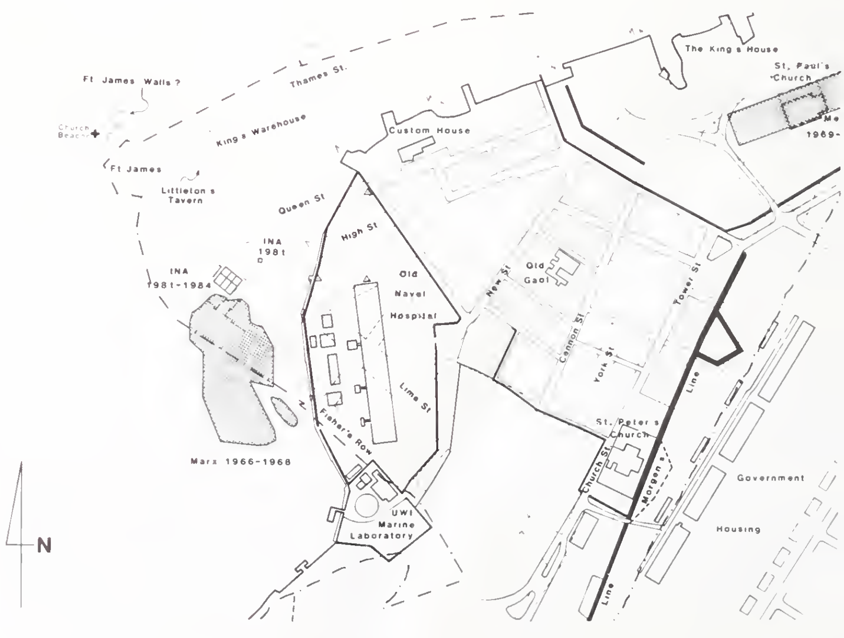

The Port Royal harbor area, showing present features (solid lines) and former features (dashed lines).

represent the opportunity to study the characteristics of vehicles that brought two independent corners of the earth together for the first time.

To this end, the Institute of Nautical Archaeology at Texas A&M University is conducting a search for the lost caravels in conjunction with the government of Jamaica. A team of archaeologists and students from both countries has been headquartered at the historic plantation of Seville on the shore of the enclosed bay. Once the site of the first Spanish settlement on the island, *Sevilla la Nueva,* the government-owned land is administered by the Jamaica National Trust, which hopes to establish a national historic park. The cooperative effort to pursue the abandoned caravels began in 1982, combining traditional disciplines of archaeology and history with modern advances in electronics and marine geology. Collections of archival documents, coupled with geophysical and artifactual data, have begun to peel back the layers of time at St. Ann's Bay, providing clues to the whereabouts of the vessels' buried remains.

The circumstances that brought the aging Admiral to the north coast of Jamaica almost five centuries ago, and the dramatic events that followed rate among the most fascinating in the annals of exploration. Storms and shipworms forced the remnants of Columbus's fourth and final expedition into this small bay, where the men were marooned for more than a year in make-shift huts aboard the two grounded vessels before rescue came. The story of this unexpected exile is filled with hardships, illness, and mutiny, as well as a heroic canoe voyage to seek help, and a clever ruse involving a lunar eclipse to impress local Indians.

The castaways finally were rescued; although their leader never returned to Jamaica, his son Diego established the town of *Sevilla la Nueva* adjacent to the site of the abandoned hulks. Discovery in the 1930s of buried portions of the ruined Spanish settlement on a modern sugar plantation called Seville confirmed St. Ann's Bay as the location of Columbus's island exile.

In 1982, we began conducting preliminary test cores for clues to shoreline accretion in the last 500 years. A survey network of 30-meter grids was established along the present-day beach and offshore into the lagoon. With the assistance of Gordon Watts of East Carolina University, which also has a program in nautical archaeology, we began systematic magnetometry coverage both on shore and inside the bay using a small boat. Charles Mazel of Klein Associates (see page 85), joined us with a prototype sub-bottom sonar device to investigate the soft silt at the bottom of the lagoon. Buried anomalies detected by the instruments were plotted on a survey plan and marked for reference in the field.

Coring Tool Used

To investigate these targets, a long probe powered by low pressure air was to penetrate the sediments. John Gifford of the University of Minnesota helped to devise a 3-inch coring tool to recover samples of sediments and artifacts from layers encountered by the probe. Coring conducted both on the beach and underwater produced the first tangible evidence of cultural material, and allowed us to discriminate between archaeological deposits and natural features, such as ancient coral formations and outcroppings of rock.

Two discreet layers of artifacts and associated debris were found under the seabed near an old English wharf. Coring and test excavation found them to be anchorage middens comprised of ballast, bones, and discarded maritime trash from ships anchored at the Seville plantation to take on cargos of sugar in the first and last decades of the 18th century.

Core samples from one anomaly in particular contained – aside from ballast, glass, and ceramics – a fortuitous clue: a wooden treenail of the kind used to fasten ship's planking. To test this location further, we used an aluminium culvert 4 feet in diameter and 5 feet high, several of which were donated to the project by Kaiser Bauxite of Jamaica, which also transports our equipment to and from the island free of charge. Positioned over the anomaly, the cylinder acted as a miniature caisson for limited excavation, or a giant coring tube, within which an archaeologist could dig through sediments in a traditional manner.

Silt in suspension was removed by a water dredge with a screened outfall; as the contents of the caisson were emptied, it sank lower and lower into the seabed. Under almost 2 meters of sand and silt, well-preserved hull frames and planking of an old shipwreck began to appear. Although only a small window to the site had been opened up, the integrity of the wreck had not been disturbed , except to extract diagnostic materials for analysis. The contents of the caisson and ship's hull indicated a small English sailing ship from the mid-18th century, but its state of preservation suggested that even older sites, such as the Columbus caravels, would be similarly protected under the soft seabed.

In this way, we began to identify and eliminate each anomaly, deciding to expand the survey in 1983 to a dense area of modern mangroves toward the western portion of the bay. The operation required cutting trails through the overgrowth in order to continue the uniform grid network and take readings with a hand-held magnetometer. Farther to the east, an offshore anomaly associated with a shallow sandbar was in-

Continued on page 77

dependent on the buccaneers for protection from the Spanish because of the absence of a suitable English naval presence in the Caribbean. It also received great wealth in plunder from Spanish colonies and ships attacked by the buccaneers and freelance pirates of the day. The buccaneer era was a short-lived but very colorful period. It was not effectively controlled until Henry Morgan, formerly one of the most active pirates working out of Port Royal, was knighted by King Charles II and returned to Jamaica as the lieutenant governor.

After 1670, Port Royal became the trade center of the Caribbean, particularly in the realm of sugar and raw materials. At its height the city had an estimated population of 6,500, and as many as 2,000 buildings. This prosperity came to a sudden and frightful end. On June 7, 1692, at approximately 11:30 a.m., a severe earthquake shook the city. Approximately 60 percent of it sank into the harbor. An estimated 2,000 persons were killed by the earthquake and a subsequent tidal wave. Another 2,000 to 3,000 citizens died of disease in the days following the disaster. Salvage and outright looting began almost immediately in the city, continuing off and on for years.

The Present Work

What was left of the city remains today as a poor fishing village situated at the tip of the long sand spit, still exposed to the fickle nature of the elements. The city has survived the turmoil and ravages of time, but its primary significance to archaeology is that in its submerged and buried depths lies one of the world's largest collections of undisturbed, 17th century English artifactual material. Only a small portion of the former city has been investigated archaeologically, and much research remains to be done.

Most excavations to date have concentrated on the submerged portion of the city; only a small amount of the early field work was conducted by professional archaeologists with the controls and documentation demanded by modern archaeology. In 1956 and 1959, Edwin Link (the submersible designer), for example, excavated in the area of the King's warehouse and Fort James. In 1960, Norman Scott, a diver, worked around Fort Carlisle; and from 1965 to 1968, Robert Marx (the author of several books on shipwrecks) directed a very extensive excavation in the southwestern part of the sunken city, in the area of the fish and meat markets between Lime Street and the former harbor. With the exception of Marx's work, little is known about the excavations or the recovered materials.

When INA in 1981 accepted the Jamaican invitation to excavate at Port Royal, there had not been an excavation in the sunken city since Marx's work in 1968. The new INA/TAMU excavations were undertaken about 50 feet to the north of Marx's excavation in an area that faces onto Lime Street near Fort James. Initially, we were concerned about whether conditions in the harbor were good enough to conduct well-controlled excavation. In the area excavated, we found that visibility was normally 4 to 10 feet, enabling the excavation team to take underwater photographs, plot the location of artifacts within a 10-foot metal grid frame, maintain good stratigraphic control, and prepare detailed drawing of all features. In this particular area, the 17th century city is buried under 1 to 5 feet of sediments. We quickly reached the conclusion that the excavations could be carried out in much the same way as on land, using similar techniques and tools.

Since work is taking place in depths of less than 20 feet, all excavation diving is done on hookah – that is with the air being supplied through a diesel run air compressor mounted on a barge above the divers. Scuba gear is used only on the wider-ranging surveys of the harbor. A water dredge is employed as the main excavation tool at the site. Other standard archaeology tools, such as mason's trowels, line levels, and measuring tapes are used to maintain stratigraphic and horizontal controls.

The divers swim out from the sea wall to the excavation area where the project barge is anchored. For safety, the barge is tended at all times by one or two crew members who keep watch over the divers, the water pumps that operate the dredge, and the air compressor, which provides air to from 4 to 6 divers working one of the three daily 3-hour work shifts.

During the first excavation season in 1981, an intact brick floor was encountered a couple of feet below the sediments in the harbor. During the next three summers, the excavations were expanded across the floor until, at the end of 1984, six rooms of a large multi-room brick structure were completely excavated. Work is continuing on the analysis and conservation of the vast number of artifacts recovered during the excavation of the building.

By 1992 (the tricentennial of the sinking of Port Royal), the archaeological excavations will have contributed significantly to our understanding of the bustling and sometimes notorious activities of the town. A by-product of this knowledge will be the nautical archaeologists who receive their initial training as students at the site.

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intensively surveyed. A computer contour map, produced from our field data by Jim Baker of Texas A&M, demonstrated what the magnetic readings looked like on paper. Their size, configuration, and characteristics made the anomaly a likely candidate for the lost caravels, especially when viewed in a 3-dimensional projection showing the magnetic gradients and peaks in relief. A transect of cores through the sandbar produced only fragments of brick and ballast and sand. Pinpoint cores in areas of highest magnetic intensity indicated that the buried feature did not extend deeply into the sediments. Visual inspection of the area was hampered by turbulence on the shallow sandbar.

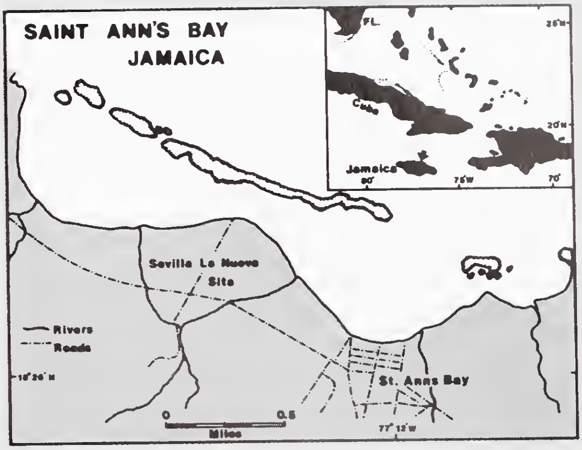
18th Century Wrecks Found

By the end of the second season, we had completed a large area of the coastline, from the western mangrove area to the sandbar anomaly on the eastern side of the bay. Other shipwreck sites had turned up as well, including one that appeared to be eroding from shallow water near the beach. Its structural components and related artifacts indicated a small island vessel from the late 18th century. The site may be the remains of the *Fly*, which wrecked at anchor during a hurricane in 1791. Other wrecks, such as a salt trader from the Turks and Caicos Islands, and a ship loaded with sugar cane milling apparatus, were discovered, but none from the 16th century.

Our survey efforts during the first two seasons had avoided an area near the old English stone wharf because of its accumulation of colonial and modern trash. The objective of the third season was to determine what was under the wharf, since it appeared to have been built on top of an older Spanish structure. Piers and wharfs often were built on top of beached ships; their ballast represented a convenient load of foundation rocks. In this case, the initial waterfront property chosen by Columbus may have been put to good use by later Spanish and English inhabitants of St. Ann's Bay.

An aluminium caisson was inserted alongside the stone wharf, and a test excavation carried out in arbitrary levels of 25 centimeters, with all cultural material sorted and bagged in lots according to their depth. Gradually, the worm-eaten tops of two wooden pilings began to emerge from the mud. Further excavation revealed the top of a smaller and cruder piling, which may have been part of the original wharf construction.

We began to collect a stratigraphic assemblage of artifacts going back in time from the present through colonial days: English trade ceramics; fancy glass stemware; rum and wine bottles; beef, pork, and turtle bones; sailor's buttons and culinary implements; slave-produced pottery, and roof tile and brick fragments – all attesting to the variety of commerce conducted across the plantation's wharf in the last three centuries. Oyster



shells of a nontropical variety reflected the North American colonial connection; Pacific money cowries found their way via Africa to the West Indian sugar plantations along with the slaves they helped to purchase.

The work in Jamaica continues at the present time: at the end of the third season, the excavation had reached a 17th-century horizon – a period that is not well understood in the historical picture of Jamaica. Already, the variety of sites and materials discovered at St. Ann's Bay is helping to fill in the chronology of maritime trade to the overseas plantations.

In pursuit of Columbus's caravels, we have unearthed a cross-section of nautical history, which will hopefully aid in the establishment of the planned national historic park and its interpretation to the public. But our main objective is to reach the buried 16th-century horizon, and locate the last two ships commanded by Christopher Columbus.

Roger C. Smith is Director of the Caravels Project at the Institute of Nautical Archaeology at Texas A&M University.

Legal and Regulatory Issues in Marine Archaeology

A clay figurine of the Phoenician goddess Tanit. (Photo courtesy of Avner Raban)

by Dean E. Cycon

The last year has seen a tremendous number of important underwater archaeological finds around the world. These finds include the oldest vessel ever uncovered (off Turkey), an ancient battle fleet (off Egypt), and possibly a famous pirate ship (off Cape Cod, Massachusetts). As underwater archaeology grows in professional stature, and amateurs and professionals alike seek to uncover the secrets locked beneath the waters of the world, there has been a deepening concern among nations that priceless treasures and irreplaceable history are threatened with destruction or dislocation. In response, many nations have enacted legislation to regulate archaeological activities off their shores.

In some nations, the extent of jurisdiction and the regulatory mechanisms are quite clear, thereby affording the archaeologist a firm understanding of national ownership claims and the requirements for acceptable activities. In others, jurisdiction and control may be ill-defined or nonexistent, leaving the archaeologist at great personal and financial risk. It is imperative, therefore, prior to any significant commitment of resources to an underwater project, that the laws and regulations of the host nation be well researched, and that all necessary requirements be met.

In exploring the often murky waters of underwater cultural resource regulation, three interrelated areas must be examined. First, the physical perimeters of national jurisdiction must be determined relative to the location of the underwater site. In many areas of the world, jurisdiction over waters may be subject to dispute, thereby embroiling the underwater archaeologist in an undesirable international political battle. Certain locations in the South China Sea and the Caribbean present this situation. Even within undisputed areas of national jurisdiction, the distance of the site from shore may determine the scope of the national claim.

The second area to be examined is the theory of governance over the actual site (as opposed to the superadjacent waters). The host nation may claim full ownership of the artifacts on the basis of their historical significance to the development of the nation or its culture. It may not

A diver explores a modern wreck site. (Photo by Ron Church, Photo Researchers)

claim ownership but retain varying degrees of control over the archaeological expedition under traditional maritime laws, commerce regulations, or cultural protection regimes. Thus, the theory of governance underlying a national regulatory approach may determine whether an expedition's work is viewed as an attempt to plunder a nation's past for personal profit, as an attempt to increase the world's understanding of older cultures, or as an ordinary economic activity.

The third related area concerns the administrative mechanisms through which nations implement their authority and control over underwater archeological activities. These would include identifying the agency or agencies with oversight authority, and complying with specific permitting requirements that range from determining who may perform underwater archaeology to what happens to artifacts.

Perimeters of Jurisdiction

Underwater archaeologists must be concerned with three jurisdictional areas: 1) territorial seas and contiguous zones, 2) continental shelves and exclusive economic zones (EEZ's), and 3) international waters.

Territorial seas range from the three nautical miles claimed by the United States, Britain, Singapore, and Belgium to a 200-mile zone decreed by many Latin American (including Brazil, Ecuador, and Nicaragua) and some African nations. Table 1 demonstrates the range of territorial sea claims. Within territorial seas, a nation exercises full sovereign rights, and therefore has complete authority to regulate underwater archaeological

Table 1. Examples of Territorial Sea Claims.

Distance from shore-baseline (Nautical Miles)	Nation
3	**United States**
	Fiji
4	**Norway**
	Finland
6	**Greece**
	Dominican Republic
12	**China**
	Colombia
15	**Albania**
20	**Angola**
30	**Congo**
50	**Tanzania**
	Macao
70	**Mauritania**
100	**Gabon**
150	**Senegal**
200	**Argentina**
	Somalia

activities in whatever manner it deems appropriate.

In some nations, authority within portions of territorial seas has been delegated to sub-national political units. In the United States, for example, coastal states have exercised jurisdiction over "underwater archaeological resources" within three miles from shore, based largely on the transfer of ownership of the coastal seabed from the federal to the state domain under the Submerged Lands Act of 1953. Similar delegations exist in Australia, Yugoslavia, Canada, West Germany, and Malaysia.

Following the 1945 Truman Proclamation on the continental shelf, many coastal nations joined with the United States in asserting jurisdiction and control over subsoil and seabed natural resources of the continental shelf. A decade later, the international community formally endorsed this concept by enacting the Geneva Convention on the Continental Shelf. In 1969, the International Court of Justice held that the doctrine of coastal state control of the continental shelf for natural resource exploitation had become part of customary international law, and was therefore available to all nations, regardless of whether or not they had signed the Geneva Convention. It is not clear whether this doctrine, which applies to the "mineral and non-living resources of the seabed and subsoil" of the shelf, encompasses shipwrecks, inundated sites, or other objects of antiquity. The sparse legislative history that exists on the subject indicates that it does not. In preparation for the Geneva Convention, the International Law Commission (ILC) noted:

> *It is clearly understood that the rights in question do not cover objects such as wrecked ships and their cargos (including bullion) lying on the seabed or covered by the sands of the subsoil.*

During the discussions at Geneva in 1958, the notion that sunken vessels should be included among the "resources" subject to coastal state jurisdiction was again rejected. Yet present national practice regarding this issue is varied.

Based, in large part, upon the comments of the ILC, the United States Fifth Circuit Court of Appeals in *Treasure Salvors, Inc. v. The Unidentified, Wrecked and Abandoned Sailing Vessel,* 569 F.2d 330 (1978), rejected the federal government's claim of ownership of an ancient Spanish galleon found by divers. The court held that U.S. jurisdiction over the continental shelf did not encompass ownership of shipwrecks of any vintage. Although legislation has been introduced in Congress several times to alter this situation, to date the United States has no direct control over such objects.

Several nations, however, have specific legislation declaring jurisdiction over man-made objects on the continental shelf. This jurisdiction is apparently predicated on the claim that objects of archaeological significance are national (if not natural) "resources," and therefore are appropriate subjects for jurisdiction under customary international law. Cyprus first claimed the right to control exploitation of antiquities on the continental shelf when it ratified the Geneva Convention in 1974. Similarly, Seychelles considers antiquities to be among the non-living resources on the continental shelf over which the government exercises sovereign rights for the purposes of exploration, exploitation, conservation, and management. Under the Historic Shipwrecks Act of 1976, the Australian Minister for Home Affairs has authority to declare shipwrecks or other objects on the continental shelf to be historic, and thereby subject to acquisition by the government. Norway has declared management authority to protect shipwrecks and other items of historical interest discovered during petroleum exploration activities on the continental shelf.

During the 1979 United Nations Conference on the Law of the Sea (UNCLOS III), seven Mediterranean-area nations* attempted unsuccessfully to include objects of archaeological and historical significance within the definition of natural resources of the continental shelf.

Two other jurisdictional concepts have been applied to afford coastal states control over archaeological resources beyond territorial seas. In 1981, Morocco became the first nation to assert national administrative authority over archaeological work within 200 miles of its shores under the exclusive economic zone principle. Other members of the international community thus far have resisted application of the EEZ principle to what have been termed such "cultural," as opposed to economic, interests. Member states of the Council of Europe are presently considering adoption of a parallel concept to augment coastal state authority in the EEZ:

*Greece, Italy, Malta, Portugal, Yugoslavia, Tunisia, and Cape Verde.

a 200-mile "cultural protection zone." The purpose of this zone is only to enable coastal states to exercise control over activities (such as oil and gas exploration, pipe laying, and site disturbance by untrained persons) that might threaten the integrity of underwater sites.

In international waters, the historic rule regarding control over ancient shipwrecks and other archaeological resources has been "finders, keepers." Nations have been traditionally without authority to regulate either the search for or the recovery of objects in these waters. Nor have many states sought such authority. As a practical matter, the depth of most international waters and the lack of adequate technology rendered the subject largely academic. This situation changed dramatically during the 1970s, with the rapid development of deep-sea sensing and mineral extraction technology. As a result, Greece and Turkey introduced proposals before the UNCLOS attendees to declare "all objects of archaeological or historical value in the area beyond the limits of national jurisdiction" to be "part of the common heritage of mankind." Exploration and recovery activities would be subject to management by the International Seabed Authority.

After several years of debate, the following article was submitted for ratification as part of the Draft Convention:

> *Article 149. All objects of an archaeological and historical nature found in the Area shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin.*

This regime presents a multitude of problems that will prevent its implementation for a long time – if it will ever come into being at all. The most obvious problem is that the Convention itself is years away from entering into force as a binding instrument of international law.* Nor will the regime stated in Article 149 be considered part of the customary body of international law because it is such a radical departure from the existing rules of freedom on the high seas. Moreover, the text itself is unsatisfactory. First, there is no definition of what constitutes "objects of an archaeological and historical nature." And, as we shall see, nations employ a wide range of definitions in their national regulatory approaches. Second, unlike the original proposals, the Draft article does not indicate who is to perform or manage the exploration, examination, or recovery of these objects. It is also difficult to envision how the objects would be preserved for the benefit of mankind as a whole. Public museum display would nominally satisfy this criterion; but which country would have the honor? Where would we display Greek statues carried by a Roman vessel in the Assyrian trade?

A second section in the Draft Convention, Article 303, authorizes a degree of coastal state jurisdiction over removal of archaeological objects in the contiguous zone:*

> *1. States have the duty to protect archaeological objects and objects of historical origin found at sea, and shall cooperate for this purpose.*
> *2. In order to control traffic in such objects, the coastal state may, in applying Article 303, presume that their removal from the seabed in the area referred to in that article without the approval of the coastal state would result in an infringement within its territory or territorial sea of the regulations of the coastal state referred to in that article.*

Thus, signatory nations do not have jurisdiction to regulate underwater archaeological acitivities *per se*: rather, such actions are only subject to regulation insofar as they infringe on other areas over which the country has jurisdiction (for example, customs, fiscal, and sanitary regulations). The impact of this roundabout extension of jurisdiction is significantly reduced in the remaining paragraphs of the Article:

> *3. Nothing in this article affects the rights of identifiable owners, the law of salvage or other rules of admiralty, or laws and practices with respect to cultural exchanges.*
> *4. This article is without prejudice to other international agreements and rules of international law regarding the protection of archaeological objects and objects of historical origin.*

These qualifications will exempt a large part of the underwater activities that affect archaeological objects.

It is safe to say that the "finders, keepers" regime of international waters will remain in effect for many years, even though the first steps toward restructuring that arrangement have been taken.

Theories of Governance

Within the areas of their jurisdiction, coastal states assume varying degrees of authority and control over their underwater archaeological heritage. The regulatory regime employed reflects the national perception of, and attitude toward, the objects that

*As of February 15, 1985, only 15 nations had ratified the Convention. The United States has stated that it will not do so.

*The contiguous zone extends from shore to a maximum of 12 miles. In this zone, coastal nations have limited jurisdiction to prevent infringement of customs, fiscal, or sanitary regulations within the territorial sea. The Draft Convention extends the contiguous zone to 24 miles, in recognition of the fact that most states have expanded their territorial seas to 12 miles and beyond.

Table 2. Examples of Nations Claiming Ownership of Submarine Antiquities.

Belize	Kuwait
Brunei	Libya
Bulgaria	* Malaysia
China	Mexico
Costa Rica	New Zealand
Cyprus	Norway
Denmark	Poland
Dominican Republic	Romania
Ecuador	* Saudi Arabia
* Gibraltar	Spain
Greece	* Sudan
Haiti	* Sweden
Hong Kong	* Syria
Hungary	Taiwan
Iceland	Tanzania
Iraq	Tunisia
* Israel	* Turkey
Italy	Venezuela
* Kenya	

*Indicates states with provisions for renunciation of national ownership.

lie on its seabed. Broadly speaking, there are two competing theories of governance: historicist and commercialist.

In a growing number of nations, submarine antiquities are perceived primarily for their significance to national historical development, or their innate beauty or artistry. Governments that perceive submarine antiquities in this manner are likely to legislate national ownership.* This theory of governance cuts across the political and social spectrum, as is apparent from Table 2, which lists nations claiming ownership of archaeological resources.

Of course, actual ownership of artifacts is not an end in itself. There are certainly political, aesthetic, and other valid reasons to retain for national display objects of extreme beauty and rarity, as well as a representative sampling of more common articles. However, once the less significant objects have been studied in their archaeological context and all relevant information obtained, it may not be necessary to retain national ownership. Therefore, several nations provide for renunciation of national ownership rights in these circumstances (see Table 2).

National ownership of submarine antiquities may also occur through two legal devices: compulsory acquisition after discovery, and the right of first refusal. In the former situation, nations such as Australia, Brazil, India, Indonesia, Morocco, Saudi Arabia, and Senegal have legislated that the finder or possessor of an object of archaeological importance may be compelled to sell to the appropriate national authorities. In the latter, the country will not disturb the private ownership of antiquities unless the owner wishes to sell. At that point, the nation has the pre-emptive right to purchase the object or to prevent the sale to others. Nations having this type of authority include Colombia, Cuba, Italy, and Lebanon.

A second theory of governance elevates the economic risk to the finder above the national significance of the submarine antiquity, and generally considers the objects to be the property of those who have put forth the time, energy, and capital to locate them. The principal form this theory takes is through the branch of maritime law known as salvage. Salvage can be described as *a service voluntarily rendered in relieving property from an impending peril at sea by a person under no legal obligation to do so.* Prior to the advent of archaeological protection regimes for submarine antiquities, any recovery of objects from the sea would conceptually be a salvage. This regime still obtains in the federal waters of the United States and the Union of South Africa. Traditionally, an award for salvage service consisted of payment from the original owner or from the sale of the goods recovered. The amount of payment would be based upon the skill of the salvor, the degree of danger involved, and other factors. Modern salvors of underwater antiquities have sought, and often received, court-awarded title to the objects themselves.

Britain regulates underwater archaeology on a similar basis – through the maritime law of wreck. This regime traditionally has been utilized to award title or offer compensation, without consideration of "peril," to persons who have recovered objects lost at sea or washed on shore. In order to encourage the recovery (and disclosure) of historic wreck items, the finder is entitled to 100 percent of the net proceeds from the sale of the items by the Receiver of Wreck (but only 75 percent of the value of ancient coins).

The commercialist theory of governance has been criticized as inappropriate for the regulation of underwater archaeological activities. The theory is based on economics, and encourages not only the search for submarine antiquities but also their rapid recovery. Yet the archaeological significance of an object may be contextual and its physical relationship to its surroundings may be of great importance. Thus a tension exists between the need for slow, patient, contextual analysis of objects, and the economic impetus of salvage and wreck regimes. Some federal courts in the United States have addressed this criticism by incorporating archaeological preservation and protection into the requirements for proper salvage. It is too early to tell whether such efforts will be sufficient to insure the archaeological integrity of underwater sites and related artifacts, and to satisfy the time expedient of the commercial salvor.

*In the United States, where there is no federal legislation, several states have claimed title to submarine antiquities within waters under state jurisdiction.

Although the commercialist theory places primary emphasis on the economic nature of underwater archaeological activities, an exception may be made wherein the object is of great historic significance. For example, the United States in 1975 declared the remains of the first turreted Civil War ironclad, the *U.S.S. Monitor*, to be a marine sanctuary under the Marine Protection, Research and Sanctuaries Act of 1972, (see page 66). Western Samoa and Tasmania (Australia) also have used this method to protect important underwater sites.

Administrative Mechanisms

The need for a specialized and visible system of organization for archaeological administrative services was recognized in 1956 by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Although much progress has been made in this regard, nearly 30 years later national administrative mechanisms remain scattered among different departments and regulatory arrangements. It is often difficult for the well-intentioned marine archaeologist to know which door to enter.

General authority over archaeological activities may be vested directly in a Ministry or Department, such as Culture (France, China), Tourism (Jordan, Libya), Education (Turkey), Home Affairs (Australia) or Environment (Britain, Denmark*). Yet underwater activities may not fall under the statutory definition of archaeology, and administrative jurisdiction may be unclear. This situation exists in several Latin American nations, where the Ministry of the Navy effectively exercises this jurisdiction.

Not only might it be difficult to locate the agency with jurisdiction within a system, but it also might be hard to figure out what constitutes an antiquity. Most define antiquities for the purpose of jurisdiction through a two-part test. The first part concerns the nature of the object – it must have archaeological, artistic, scientific, or historical interest or significance. Almost all old objects under the sea are of such "interest"– but are they significant? In either instance, local authorities tend to have a great deal of discretion, and will probably claim jurisdiction on this basis. In very few nations will appeal of an administrator's decision in this area be successful – if even permitted.

The second part of the test concerns age, which may be determined by a "fixed" or "moving" date. In the former, a cut-off date having some national significance may be employed. In Brunei, for example, "antiquities" refers to any object of archaeological or historical interest manufactured prior to January 1, 1984. Both Israel and Jordan use 1700 A.D. as a fixed date, but authorize the appropriate Minister to include significant objects made later. Under the moving date system, objects that have been underwater for more than a specified number of years are eligible. The most common is 100 years, although the period ranges from 30 years (Micronesia) to 500 years (Yemen Arab Republic). Other nations using moving dates include Kuwait (40 years), Malta (50 years), and Saudi Arabia (200 years).*

Regulation of underwater archaeological activities by national agencies ranges from general oversight under salvage laws to strict and pervasive licensing regimes. Licensing regulations may significantly impact the efficiency and effectiveness of an expedition. Such regulations usually address the purpose of the expedition, funding prerequisites, composition of the team, output controls, and other aspects of projects. Permits and licenses granted in most jurisdictions are subject to revocation for a number of reasons. Permits may be granted for only one year (Hong Kong, Jordan, Kenya, and the Soviet Union) or several (Cyprus, India, and Pakistan). Renewal is generally predicated on adequate progress. A lack of diligent pursuit of the project or noncompliance with permit requirements may lead to revocation or nonrenewal. In Malaysia and several American states (Nevada and Arizona), permits may be cancelled at the discretion of the appropriate administrative officer.

In certain jurisdictions, only activities for a particular purpose are permitted. Honduras only allows archaeological sites to be worked for "scientific investigation." Several nations limit exploration and excavation to activities that are performed for the benefit of reputable museums, universities, or other scientific institutions (Greece, Lebanon, and Mauritania). Others require assurances that the expedition is financially supported by a reputable archaeological or scientific society (Fiji and Kenya). Additional funding concerns may involve minimal annual license fees or more significant bonding requirements to insure observance of license conditions or funding for site restoration and preservation (India, Italy, Jordan, and Pakistan). Many jurisdictions require preparation of full expedition budgets (Cyprus, Hong Kong, and South Korea) or disclosure of sources of financial support (Peru and South Korea).

Some nations demand thát particular research specialities be represented on the team. Libya, for example, requires an architect and an epigraphist, while Saudi Arabia requires a surveyor and a draftsman. Other composition requirements include state review of team members' credentials (Turkey, Jordan, and Peru), and inclusion of nationals as state representatives (Bahrain, Iraq, and

*National authority is divided in these nations. In Britain, wreck authority is vested in the Department of Trade. In Denmark *in situ* archaeology is under Environment, but excavation activities are under the Minister of Culture. In contrast, France has a separate bodies for land and water archaeology, but both are within the Ministry of Culture.

*American states use different moving dates: South Carolina (50 years), Massachusetts (100 years), and North Carolina (10 years). Louisiana uses a fixed date (pre-20th century).

Syria) or as active members of the team (Columbia, Honduras, and Mauritania). The expedition is usually required to pay the salaries, board, and other expenses of local participants.

Other permit requirements may address site inspection, regular reporting (daily, interim, and annual), program scheduling, and acceptable recovery and preservation methodologies.

The most economically and professionally significant regulation of an expedition involves control of output. This includes regulation of publicity and publication, and ultimate disposition of artifacts.

Several nations require prepublication review and other controls on media releases. Libya requires permission for any release of information to newspapers or other media. Honduras requires written permission, and includes speeches, interviews and symposium presentations among the dissemination forms subject to control. In Turkey, drawings and photographs of archaeological works may not be used for commercial purposes.

In 1956, UNESCO recommended that nations reserve copyright and priority of publication to the excavator. Although many states follow this, several authorize national publication if the permittee fails to publish within a specified period of time. In Libya, the permittee must publish within two years. Saudi Arabia and Kuwait require publication within five years. Israel guarantees exclusive publication rights for 10 years, but requires publication within five. Honduras, however, retains the right to publish the preliminary report, and to translate and publish the final report without payment of copyright fees. Honduras, Pakistan, and Portugal also require prepublication review of the final report. Failure to publish may also result in a denial of permit renewals or new permits for other sites (Jordan and the Soviet Union) or forfeit of bonds or other security (Pakistan and Sudan). These nations recognize that publication may be the only means of preserving archaeologically significant finds once a site has been disturbed. In light of the low publication rate of archaeological expeditions (around 50 percent), some publication requirements seem quite justified.

Although many nations claim title or authority over submarine antiquities, presentation of artifacts is one of the compensation and reward possibilities available to underwater archaeologists. This generally occurs where similar items already exist in national collections, or where the objects are of limited significance. Chile awards up to 25 percent of the artifacts recovered from the site. Saudi Arabia, Syria, and Pakistan will offer some artifacts on the condition that they must be displayed in museums or scientific institutes. A more common means of compensating a finder is to award a percentage of the market value of the find, ranging from a third (Lebanon and Thailand) to a half (Greece and France). In Massachusetts, a finder of an "underwater archaeological resource" is entitled to 75 percent of the value of the find.

Conclusion

Modern archaeologists involved in underwater activities must deal with more than inundated sites and sophisticated equipment. As we have seen, they must be able to locate and understand the relevant legal and administrative regimes that control such activities in the host nation. As daunting as this may seem, it is absolutely essential to the success of the archaeological endeavor.

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Technology for Marine Archaeology

by Charles Mazel

"Davy Jones Meets the Computer." "High Tech Treasure Hunt." These headlines from articles on recent finds of important shipwrecks are signs of the growing role of sophisticated equipment in the location and excavation of historic underwater sites. The privateer *De Braak,* lost in 1798 with a fortune in treasure reported aboard, was found just off the shore of Lewes, Delaware, by side-scan sonar. The site of what is probably the pirate vessel *Whidah,* sunk on the outer shore of Cape Cod in 1717, was located by magnetometer. In both cases, precision navigation played a vital role.

The applications of technology go far beyond the search phase of any project. Sites must be excavated carefully, with precise mapping and recording of the locations of all objects found. Underwater work poses difficulties unlike those encountered on land. Besides the obvious problem of breathing, there are limitations in communications, visibility, and movement, to name a few. One of the early tasks of modern marine archaeology was to develop tools that would match or exceed those being used at land sites. That goal generally has been achieved.

Transfer of Technology

How does technology, sophisticated or otherwise, get into the archaeological field? Marine archaeology budgets tend to be small and usually insufficient to fund independent development of new instruments. The field has to depend on other means to bring in new tools.

Most sophisticated search and navigation instruments are primarily used by oil companies or the government. Fortunately, throughout these instruments' development, there have been individuals at various companies who have taken an interest in marine archaeology, donating equipment and services for projects around the world.

Archaeology has been traditionally a profession for non-technical (in the engineering sense) people, but that is starting to change. A good worker in any field knows his tools, and those tools are becoming increasingly complex. Archaeologists are becoming more familiar with the capabilities and limitations of available technology and are finding ways to apply these tools in the field.

Finally, there are those individuals who have both engineering skills and an abiding love for archaeology. In their spare time, they participate in archaeological projects, bringing with them the knowledge they have obtained in other fields.

Technology and Technique

Just because a search or site mapping operation uses all the latest electronic gizmos and computer-controlled whatsits does not mean that it is going about the project in the right way. Proper technology should not be confused with proper technique. Technology is just the hardware, electronic or otherwise, that is used for the job. Technique is the *way* that equipment is used.

The question of technique should come into play as soon as a project is conceived. One factor in the initial planning of a job is the selection of the appropriate technology. And, even if the proper equipment is selected, all efforts may fail if it is not used properly. For example, running a sonar search with inadequate navigational control is poor technique and could lead to failure.

The right way to go about a project is to a) succeed, and b) spend as little money and time as possible in doing so. Both too much and too little technology can be a problem. Without proper technique, success becomes a matter of luck. Proper selection of tools and methods are playing an increasingly important role in finding shipwrecks and other sites and in carrying out the excavation and necessary documentation.

Search

Research. The role of research as the first phase in any search project cannot be overemphasized. The inexpensive hours spent in libraries and archives can save many expensive and difficult hours searching on the water. A survivor's report that "the wreck is located in two fathoms of water, two leagues south of the river mouth" may sound like a good lead until the researcher learns that a "league" has meant different things in different times and places, and the river mouth, not to mention the position of the beach itself, may have moved a great distance in the time since the original disaster. A serious student of the art will learn much about the history of how one measures time, distance, and position.

The time spent tracking down clues, many times into blind alleys, is well spent. Robert Stenuit, author and diver, is said to have spent 600 hours in the library and only 1 hour on the water in his successful search for the *Girona,* a ship of the Spanish Armada lost off the west coast of Ireland in 1588. Robert Marx, a well-known historian of shipwrecks and an archaeologist, spent years conducting research in the archives of Seville before embarking on a successful career of locating underwater sites both for treasure and history.

Search technology. The most commonly used instruments for searching in the oceans are the side-scan sonar, sub-bottom profiler, and magnetometer. These were primarily developed for commercial and military applications but are suitable for many missions in the sea. They generally can be called high tech. Other methods, just as good, fall under the categories low tech, no tech, and plumb luck. The great majority of finds have resulted from methods as simple as talking to local sponge divers, or spending long hours in a small boat with a hand-operated coring device.

Side-scan sonars and sub-bottom profilers are acoustic devices that use sound waves to produce a hard-copy, graphic record of the seafloor and underlying sediments. Both instruments are portable and utilize battery power. They can be operated from small boats, thus making it possible to mount search operations in difficult or remote locations.

In the side-scan sonar, a torpedo-shaped "towfish" transmits pulses of high frequency sound (50 to 500 kilohertz) out to both sides. The pulses are transmitted in a narrow beam in the horizontal plane, giving good resolution, and a broad beam in the vertical plane, providing wide coverage. Sound is returned to the sonar from the texture of the seafloor and by reflections from targets. The returns from successive pulses are printed side by side on the paper record, producing a very detailed view of the seafloor, similar to an aerial photograph. A side-scan can produce an image of the seafloor more than 300 meters out on both sides of the tow path.

Side-scan sonar produces a detailed graphic image of the *surface* of the seafloor. Areas of rock, sand, mud, or other material can be distinguished. If an archaeological site leaves some visible trace on the seafloor, it can be found by side-scan sonar. If a wreck is relatively intact, the sonar image may be clear enough to allow identification from the sonar record alone. In some cases, indirect indications, such as a difference in material type, may be enough to point to a site location even if no portion of the wreck itself is exposed. A side-scan sonar unit cannot detect sites that are completely buried beneath the seafloor. Extremely rocky or irregular bottoms can make it hard to interpret sonar returns.

The sub-bottom profiler utilizes low-frequency sound (3.5 to 12 kilohertz) to penetrate bottom sediments. A pulse of sound is directed vertically down into the bottom. At each interface between different types of sediment layers some of the sound energy continues on and some is reflected. As the device is towed along, a cross-sectional view of the seafloor is generated, showing the different layers and the underlying bedrock. If there are buried hull remains, they can show up as a localized reflection below the bottom.

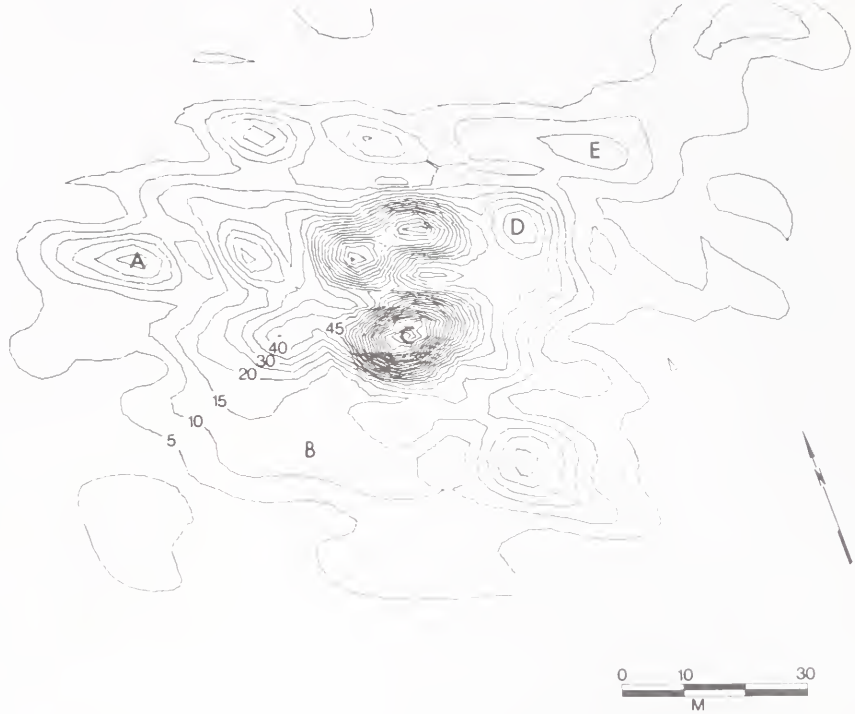
A sub-bottom profiler can be used to locate sites that are completely buried. Since it looks directly down, it covers only a narrow path underneath the search vessel. This makes it an inefficient tool for general searching. The sub-bottom profiler can be used effectively to help define the site limits and geology once the primary location is found by other means.

In some cases, a magnetometer should be used either instead of or along with a side-scan sonar or sub-bottom profiler. The magnetometer is a passive device that measures the strength of the local magnetic field. It has been the primary search tool for treasure hunters and others looking for Spanish vessels in the New World, where most wrecks are broken up and buried in sand or coral.

The spinning Earth behaves much like a bar magnet, with a north and south magnetic pole. At any point on the Earth there will be some natural magnetic field strength, influenced by the local geology. Concentrations of ferrous material – such as iron anchors, cannon, or ships' fittings – will alter that field, producing what is termed a magnetic anomaly (or variation). It does not matter whether the iron material is buried or exposed. The shape and size of the anomaly give clues to the mass of iron producing it and the depth of burial.

The unit of measurement of magnetic field strength is the *gamma.* The Earth's natural magnetic field ranges from 30,000 to 60,000 gammas, depending on your location. Modern magnetometers can detect anomalies in the local field of less than 1 gamma. Although there are several types of magnetometer available (cesium, rubidium, flux-gate), the one most commonly used for marine search applications is the proton precession magnetometer. These units are relatively small, simple, and robust and are well suited to field operations.

A magnetometer consists of a sensor, a chart recorder, an interconnecting cable, and a power supply. The units are portable and are easily adapted to virtually any search vessel. The sensor generally is towed behind the search vessel, although for some shallow-water operations magnetometer sensors have been mounted on a



A computer drawn magnetic contour map of what is believed to be the 16th century wreck of the San Sebastian. *The peak at A is attributed to a single, large, iron anchor.*

boom on the bow of a small boat or even suspended from a helicopter. A boat that is not made out of steel is preferred, but any vessel can be used if there is enough cable to get the magnetometer out of the influence of the vessel's own magnetic field.

The strength of an object's magnetic field decreases with the *cube* of the distance from the object. This means that the magnetometer sensor must be towed relatively close to the object in order to detect it, depending of course on the amount of metal involved. As a rough guide, a large steel wreck can be detected at a range of 120 to 180 meters, a site with scattered iron anchors and cannon at 80 to 100 meters, an isolated iron cannon at 30 meters, a non-ferrous vessel with only small amounts of ferrous material at 10 to 15 meters, and an individual small iron object at 3 to 5 meters. Skilled operators are able to use magnetometer readings to put a marker buoy directly on top of the source of an anomaly.

Magnetometers are useful for finding any site that has iron structure, artifacts, or associated materials. Since it does not matter whether or how deeply the material is covered, magnetometers are particularly appropriate for locating vessels that are buried or located in areas that are unfavorable for sonar searching.

Magnetometers are not able to detect non-ferrous materials, so it is necessary as part of the research process to determine whether and how much such material may be on a site. Bronze cannon, for example, cannot be detected.

Some areas of the world are more magnetically active than others. On the Florida coast and in the Caribbean, for example, the background magnetic field is uniform; anomalies show up well against the quiet background. In parts of northern New England, on the other hand, intrusions of iron-bearing rocks make the magnetometer readings variable and difficult to interpret.

With all of these search tools, it is vital to have precision navigation. That is the only way one can know that the entire search area has been covered with a reasonable degree of accuracy. It also is needed to return to any contacts found with the search instruments. A typical search usually turns up a large number of targets or anomalies that must be investigated by divers. The better the navigation, the less time it takes to find and identify each contact. This is especially true in water with poor visibility, where a diver can be just a few meters from a target and not see it.

Archaeologists have a variety of navigation tools at their disposal, depending on the search location and accuracy needed. In United States coastal waters the LORAN-C system maintained by the Coast Guard provides repeatability within about 10 meters, which is enough for many types of searches. Microwave positioning systems provide repeatable "fixes" within 3 meters or less. In addition, there are navigation systems that utilize orbiting satellites to fix positions.

Site Mapping

Careful documentation of underwater sites is perhaps the most important part of an excavation project. The aim of any project is to learn something about the past – be it trade patterns among cultures, characteristics of shipboard life, or shipbuilding techniques. Analysis of the finds from any site can take many years after the actual excavation. During the analysis, innumerable questions arise. The only way to answer them is to refer to the original excavation records. Assemblages or associations of artifacts can be more important than the artifacts themselves. The archaeologist has to know exactly where every item comes from on a site.

Before beginning excavation, the archaeologist has to know the extent of the site. A careful magnetometer survey can be done to construct a contour chart showing the location of all iron remains. Underwater metal detectors can be used to locate metal artifacts, although their detection range is limited to a few meters even for large masses of metal.

George Bass, Director of the Institute of Nautical Archaeology at Texas A&M University, pioneered the development of underwater site mapping techniques in his work on Mediterranean shipwreck sites dating to as early as the Bronze Age. Working at depths of more than 30 meters, divers were limited in the amount of time they could spend on the site, so it had to be well spent. Bass first used careful tape measurements from grid frames, supplemented by photographs, to construct site plans. He later used stereophotogrammetry very successfully, despite the advice of "experts" who said that he could not run the required equipment on the uninhabited island off the Turkish coast that was the expedition's home base.

During the years from 1960 onwards, Bass's group has either developed or tested a wide range of equipment for working on sites. His group invented the "underwater telephone booth" that permits divers to stand with their heads in a trapped bubble of air so that they can talk with other divers or with the surface. They used a research submersible to investigate sites in 100 meters of water and mapped them in just a few passes using stereo photography. Many of the techniques developed are in common use worldwide, while others continue to be developed to meet the needs of particular sites.

Where poor visibility restricts photography, measurements have to be made in other ways. Tape measures are standard equipment for underwater sites, but how they are used may depend on the particular site. Divers can make their initial measurements in the easiest way for the local terrain and then use small calculators to convert the raw data to rectangular coordinates. This makes working on slopes or along the curved hulls of ships much easier.

Another approach is to either take the water away or improve the visibility. In some cases, cofferdams are used to surround shallow water sites so that archaeologists can work "in the dry." In Virginia, John Broadwater of the Virginia Research Center for Archaeology, built a cofferdam around a Revolutionary War vessel in the York River. Large pumps circulated the trapped water through filters in order to improve visibility.

Each site presents new problems and challenges depending on the state of preservation of the site; environmental factors, such as bottom material, slopes, visibility, and currents; and the budget. Marine archaeologists are increasingly turning to technology to meet these challenges in a cost-effective manner. Publications and conferences serve to spread the word of new techniques through the archaeological community.

The Future

The future is already here in terms of available technology. Computers, submersible vehicles, satellite mapping systems, and the like are in widespread use. It is their application to marine archaeology that is somewhat lagging. In large measure, this can be attributed to the prohibitive cost of using these systems on a routine basis.

The major change in search technology is likely to be an increasing success rate for site location. The basic technology is in a relatively advanced state of development. Continued advances will be made in selecting the best equipment for a job and carrying out the search properly. As the equipment and techniques are refined, they will play an important role in site identification, as opposed to simply site location.

Aerial and satellite imaging, whether by photography or multi-spectral imaging, will see more application. Satellite images already have disclosed previously unknown reef structures and sandbars that might contain shipwreck sites. Shipwrecks can sometimes be seen in high-altitude photographs. Photography using optimized film/filter combinations could maximize water penetration and bottom contrast.

Pulsed lasers are being used experimentally to make hydrographic measurements from airplanes. As the technology advances, it will become possible to survey large areas of the bottom at previously unheard of rates. Anomalies will be found that are caused by shipwreck sites.

The possibility of finding shipwrecks in deep water has been recognized since the 1960s. Under the right conditions, wood and other organic materials suffer little deterioration at great depths. The War of 1812 vessels *Hamilton* and *Scourge* in Lake Ontario and the *Breadalbane* near Beechey Island in the Canadian Arctic prove this point. They were found in 100 meters of water by side-scan sonar, in a remarkable state of preservation.

The future will see continued progress in the ability to locate such sites. More importantly, technology will provide the means to investigate such sites more efficiently. Unmanned, remotely operated vehicles already have performed television and photographic inspections of several sites. One-atmosphere diving "suits," such as the JIM and WASP, now commonly used in the offshore oil industry, provide the archaeologist with direct access to sites at ever-increasing depths, with no danger of decompression sickness. Lock-out submersibles have brought archaeologist-divers to the site of the *Monitor* in 70 meters of water (see page 66).

Improvements also continue to be made in the ability to document sites rapidly and accurately. New film and camera technologies make it easier to obtain high-quality photographs for documentation.

There is a new mapping system that is presently undergoing field trials. It promises to greatly reduce the time needed to make measurements. The system uses acoustic signals to replace measuring tapes. The diver holds a wand-like device wherever he wants a measurement. When he pulls a trigger, acoustic pulses travel out to receivers at carefully surveyed locations. The travel time of the pulses is converted into a distance measurement by a computer on the surface, which then calculates the location of the point in space. To achieve the necessary accuracy of less than a centimeter, the system must continually measure and adjust for the speed of sound in the water. The equipment is compact and portable. The system is so fast and accurate that the diver can sign his name on the computer screen simply by holding down the trigger and "writing" with the wand.

As computers become smaller, cheaper, and more powerful, they are increasingly being used in the field of underwater archaeology. This not to say that archaeologists have not been using computers. University mainframe computers have been used for a number of years for archaeological database management — storing, sorting, analyzing, and displaying information on artifacts and sites. The data are brought in from the field on standard reporting forms. Recently, however, more and more archaeologists have been taking either terminals or small computers into the field so that data can be sent back to the mainframe computer over telephone lines on a daily basis.

With the advent of portable, battery-powered microcomputers, field uses are starting to go far beyond simple cataloguing tasks. Underwater measurements can be entered into the computer on site to be converted into useful coordinates for immediate plotting or display on a graphics screen. This provides both on-the-spot error checking and a tool for site planning. The role of computers as an integral part of archaeological field work is one that should show rapid development in the next few years.

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Profile Sir George Deacon

Portrait by Charles Kerins

British Oceanographer

by Margaret Deacon

When the idea emerged that I should write a profile of my father for *Oceanus,* I rather lightly agreed, assuming that I would have the benefit of his help and encouragement throughout. Unfortunately, this was not to be. Without warning, on 14 November 1984, my father suffered a heart attack and was admitted to the hospital. He did not appear to be seriously ill, so we were not unduly alarmed, but after two days he suddenly became much worse and died.

George Deacon made a name for himself both in the field of ocean circulation through his study of the Antarctic water masses and in the history of British oceanography as founding director of the National Institute of Oceanography.

My father was born George Edward Raven Deacon, on 21 March 1906, in the city of Leicester, in the English Midlands. He was and remained English to the core, though this did not stop him enjoying travel and cooperating with people of different nationalities and races. He was insular in the best sense of the word.

His parents were devout Nonconformists – George Raven Deacon and his wife Emma, née Drinkwater. They made considerable sacrifices to give their two children the best education open to them.

Deacon's boyhood was not all hard work. Besides the routine of school and chapel and helping his father who was a keen gardener, there were long walks and bicycle rides in the then largely unspoiled Leicestershire countryside. After elementary school, at the age of 11, both Deacon and his sister Grace won scholarships to the Newarke Secondary School, but in 1919 all boys and masters moved to the newly founded City of Leicester Boys' School. Many masters had only recently returned from active service in World War I. They combined ability with outstanding personality, none more so than A.G. Carpenter, the mathematics master who encouraged Deacon's potential in this subject and who remained a close friend of the family until his death, in his nineties, not many years ago.

In the small sixth form, Deacon received almost private instruction in mathematics, physics, and chemistry, and it was chemistry, taught by another great influence, C.V. Smith, that he decided to read at university. After passing the necessary qualifying examinations – he was proud of a distinction in history in the Senior Oxford Local Examination (C.P. Snow took the exam at the same time) – Deacon won a scholarship to King's College, London, in 1924, with the aim of becoming a teacher.

He was offered the post of chemist and he could not resist the challenge of working on board a small ship in Antarctic waters.

The honors course in chemistry at King's took two years. Deacon found his lecturers, Professors Allmand and Smile, H.W. Cremer, and C.S. Salmon, remarkable men. Allmand also gave a very popular course on the history of chemistry. Deacon obtained a first-class honors degree in 1926, a year after his sister Grace had been the first student to achieve a first in mathematics at Leicester University. He went on to study for a diploma in education and again had teachers of high caliber, including John Dover Wilson, the Shakespearian critic. Deacon found time to do some research and published his first paper, in the *Journal of the Chemical Society*. Characteristically, he never mentioned this but the opportunity was open for him to stay on at university for postgraduate work. Almost certainly he did not do this because he felt the time had come for him to earn his own living and to help his parents financially instead of being helped by them.

Off for the Antarctic

Jobs were not easy to come by in 1927. My father made many applications before being appointed lecturer in chemistry and mathematics at Rochdale Technical School in Lancashire. He enjoyed the work but, after having long ceased to expect to hear anything about his application, he was offered the post of chemist by the Discovery Committee, and he could not resist the challenge of working on board a small ship in Antarctic waters. He used to say jokingly that the desire to go to sea arose when, as a boy, a promised boat trip across the River Humber was called off. Friends and relatives advised against; there was an element of risk, no pension rights, and no security of employment. But the college released him. On Christmas Eve, 1927, he set sail from Portsmouth in the Royal Research Ship *William Scoresby* – into a gale in the Bay of Biscay which left him with a permanent distaste for tinned pineapple.

The *William Scoresby* also was provisioned with salt beef and pork, and lime juice (to combat scurvy). There was no refrigerator. The ship was only 123 feet long. But Deacon was fortunate in finding himself working under D.D. John, who became a lifelong friend. On arriving in South Georgia, he also met J.W.S. Marr, now known for his pioneering work on krill, who remained a colleague and valued friend until his premature death in 1965.

The purpose of the Discovery Committee was to study the life history of Antarctic whales and to collect information that might be used to regulate the whaling industry and prevent the whales' extermination in Antarctic waters, as had already occurred on traditional hunting grounds. The pattern of whaling altered so much during the 1920s that in fact this had already become impossible for one nation to achieve unilaterally. Land-based whaling stations were being replaced by ships, and pelagic whalers came in at the end of the decade. In response to this, the Discovery Committee, on the advice of their scientific director Stanley Kemp, built the fully powered R.R.S. *Discovery II,* launched in 1929 to investigate the sub-Antarctic islands where the whaling stations, and the Committee's early work, had been concentrated. Meanwhile, in South Georgia, under F.C. Fraser, zoologists crossed from the marine station to Grytviken to study whale catches while Deacon and others sailed in the *William Scoresby* to sample the surrounding seas.

It was almost essential in those days for a physical oceanographer to be a chemist so that he could measure salt (by titration), oxygen, phosphate, and nitrate content, and other properties of sea water. Deacon had been shown how to do this before leaving home but there had been no opportunity for him to learn about the wider applications of such work, and indeed little attention had been paid to this aspect of oceanography in Britain. As he learned about the more recent advances in his field through reading the papers of Scandinavian and German oceanographers, he began to understand how oceanographical measurements could be applied to the study of water movements and their influence on plankton distribution.

Deacon returned home in the spring of 1929, joining other colleagues based in a hut on the grounds of the Natural History Museum. Meanwhile, the *Discovery II* was beginning her long career, making measurements and collecting samples at such a rate that my father had to go out again in the summer of 1930 to assist the hydrologists on board. This time Kemp was in charge of the scientific work and Deacon came to have the highest regard for him, both as a scientist and as a leader. After sailing from Cape Town to South Georgia via Bouvet Island, encountering heavy ice, they visited the South Sandwich, South Orkney, and South Shetland Islands and the west coast of the Antarctic Peninsula. During the few months at home after the voyage, Deacon was able to complete an account of the hydrology of the South Atlantic Ocean (published 1933) before sailing again in September 1931.

The Discovery was diverted to the Bay of Whales in the Ross Ice Barrier to search for the American explorer Lincoln Ellsworth and his pilot . . .

In April 1932, the *Discovery II* left Cape Town on a winter circumpolar voyage. Her captain was W.M. Carey, with Dilwyn John as Chief Scientist. The memory was of a long haul in conditions that were difficult but not as bad as they had anticipated, rather than of any moment of danger, though sometimes there was no other ship within a thousand miles. They reached Punta Arenas safely in October and did further work in the Falkland sector before completing the winter circumnavigation of the continent, the first ship to carry out such a voyage, in 1933.

For Deacon, the voyage had provided the opportunity of showing that the Antarctic convergence (the sharp boundary between the Antarctic and subantarctic surface waters) noticed by earlier workers, was a continuous phenomenon extending right round the continent. During 18 months spent at home, these and other results were incorporated in his *Report on the Hydrology of the Southern Ocean* (published in 1937), which was to remain for many years the standard work on the origin and distribution of the Antarctic water masses. He was later awarded the D.Sc. (Doctor of Science) on the basis of published work.

In 1935, he went out again but the *Discovery* was diverted to the Bay of Whales in the Ross Ice Barrier to search for the American explorer Lincoln Ellsworth and his pilot Hollick Kenyon who disappeared while flying across Antarctica. They were found at Little America, where my father had the experience of being for a few seconds the only man on the continent – he was last into the boat. Ellsworth left behind a woolly hat that my father took home and wore for gardening.

Work was again interrupted in January 1937 when a survey party was stranded in the South Shetlands and found only after an arduous search. My father always said he would have liked to have his Antarctic years all over again. The life was hard and dangerous at times but the variety of experience and good companionship made it enjoyable.

A Time of Expansion

When Deacon got home, the Discovery Investigations' future looked increasingly uncertain. But his career was decided by the outbreak of war, when he joined the Admiralty anti-submarine research establishment at Portland. The following spring he married my mother, Elsa Jeffries, whom he met when she was working in the Discovery office. When seagoing became impossible because of enemy action – my father's office was destroyed by a bomb on a Sunday morning – they moved to the Clyde, where I was born.

My father worked on underwater sound until 1944. In that year, he was elected a

Fellow of the Royal Society, perhaps the highest distinction open to a British scientist. He was also invited to lead a new unit being set up at the Admiralty Research Laboratory at Teddington to study sea waves. Its members included N.F. Barber, K.F. Bowden, D.E. Cartwright, H. Charnock, J. Darbyshire, M.S. Longuet-Higgins, C.H. Mortimer, M.J. Tucker, and F. Ursell, all of whom were to become distinguished in oceanography. On the technical side, F.E. Pierce and N.D. Smith made notable advances in the design and construction of oceanographic instruments. By applying spectrum analysis to records of wave heights made on the coast of Cornwall, they were able to distinguish between the different wavelengths present and to pinpoint their sources in storms sometimes thousands of miles away.

New work followed on waves and tides, magnetic and electrical effects of tidal streams, and microseisms. These results, together with the growing feeling that more permanent arrangements for research into physical oceanography in Britain were long overdue, led to the setting up in 1949 of the National Institute of Oceanography— with my father as director.

Funds were scarce and it was not until 1953 that the Institute moved to a site of its own, an empty wartime Admiralty building in the grounds of King Edward's School, Witley, Surrey. It was to investigate all the principal branches of oceanography and drew its staff not only from the Admiralty group but also from former Discovery Investigations personnel. The *Discovery II* and *William Scoresby* were purchased for their use. It was a time of enthusiasm and expansion.

Work continued on waves and on recording them from shore, ships, and buoys, leading to improvements in forecasting. Studies were made of storm surges and other long waves and of factors that influence mean sea level. J.C. Swallow's neutrally buoyant floats disclosed the unsuspected character and variability of deep water movements in the ocean. Topographical, magnetic, and seismic studies of the sea floor contributed to the development of the new theories of ocean spreading and plate tectonics. New instruments and techniques were developed for the study of marine geology and geophysics, of which perhaps the best known is the long-range, narrow-beam sonar designed to obtain pictures of the deep sea floor (GLORIA).

Biological work partly focused in early days on Antarctic problems, particularly the life history of krill, but gradually emphasis shifted to other areas where new ideas and techniques could be more readily employed. In 1962, a new ship, the *Discovery*, was commissioned in time to take part in the International Indian Ocean Expedition.

When I wrote in my first draft of this profile that my father had spent these years in administration, he strongly disagreed with my wording. He said that the Institute ran itself. For him, it was a time of wider interests— instead of concentrating on his own research. As someone recently observed, his method was to get the best people he could to work there and leave them "to get on with it."

The *New Scientist* described my father as "one of the true enthusiasts of science, totally convinced of the importance of his subject and totally dedicated to improving its position. Ever since the Institute was set up, he has worked tirelessly to make it a success, and there is no question that its present high reputation throughout the world [is] due. . .to his. . .ability to lead. . . a happy ship."

But these years, outwardly so successful, also brought my father much sadness. My mother's long illness, followed by her death in 1966, was bravely borne by them both. Additionally, he had deep misgivings over the wisdom, and the propriety, of the decision to end the Institute's charter and bring it under the control of the Natural Environment Research Council (NERC). He believed that shifting decision-making away from those most closely involved with scientific work would destroy the flexibility needed to promote new ideas and that this was in the best interests neither of the science nor the nation. Subsequent events gave him no cause to modify his opinion. These two separate griefs remained with him for the rest of his days, but the tone of his mind was naturally optimistic and he never allowed himself to become embittered.

Deacon's term as director ended in 1971. He was knighted on his retirement, but it was inconceivable to him to give up oceanography. He held an NERC Fellowship for some years and was grateful to his successors at the Institute of Oceanographic Sciences (as it soon became) for giving him a small room on the top floor, with superb views over the surrounding country. He continued to work there regularly until his last illness. Below his windows were the grounds of King Edward's School, a charity dating back to the reign of King Edward VI, of which he had been a governor since 1958. At his last meeting, he was told of the decision to name a playing field Deacon's Field in his honor. He also represented the Royal Society on the governing body of Charterhouse School for many years.

It would be inappropriate in a profile like this to list my father's scientific awards and the various societies, committees, and organizations both national and international, on which he served. He continued to be active in many of them after retiring and enjoyed continuing associations with King's College, where he was a fellow and visiting professor, and with the University of Swansea. He was awarded honorary doctorates by the Universities of Leicester and Liverpool.

One task that he found most congenial was organizing a four-month course on the physics of the oceans and atmosphere at the International Centre for Theoretical Physics at Trieste in 1975. Speaking only a few words of Italian, he nevertheless appeared perfectly at home in these unusual surroundings, and found the contact with students and visiting lecturers highly stimulating.

Delightful Rambles

We did not very often travel abroad together, except to congresses on the history of oceanography. At meetings, my father conscientiously attended sessions, but he deviated from this rule a couple of months before his death and climbed Snowdon during a Challenger Society meeting at Bangor. Sightseeing with him on days off had a character all its own; we had delightful rambles off the beaten track in Italy, southern France, Scotland, and elsewhere. On a cycle ride once around Martha's Vineyard with Dave Cartwright we were caught in a torrential rain and rescued, first by a van driver who insisted on taking us back to the ferry and then by the unforgettable hospitality of Henry Stommel and his wife Elizabeth. Two years later, we followed Jim Crease and Ray Pollard along the "finest trail in Canada" (rather muddy) to see the tide race into the Bay of Fundy.

Family holidays were never regular events, but both my parents loved walking and the countryside. In the later years, my father and I explored some of the coasts and hills of England and Wales and, when I moved for a time to Edinburgh, we had two memorable holidays in the West Highlands and the Lake District.

But what I shall probably remember best were more recent visits to the Isle of Man. The offer by friends of the use of their house in Ramsey introduced us to this haunt of fishing boats and yachtsmen. The lofty moorland, coastal walks, and beaches completed our ensnarement and we returned annually for several years.

At home, we walked in the surrounding varied countryside of heathland, Weald, and downland in the differing seasons, taking with us visiting relatives or guests from overseas.

During his last few years, my father could not manage long distances and was perhaps even more inclined to climb a fence marked "private" if it stood between him and where he wanted to go. In other ways, he did not slow down at all. He was always quite happy to drive me to a meeting in central London – and to find his way there when I was quite lost. He still enjoyed looking after his large garden and it was this that over the years provided his principal opportunity for relaxation, if not of the most restful kind. He was happiest up a ladder, chopping down a tree, or gumming up our slate roof, long past its prime.

He was happiest up a ladder, chopping down a tree, or gumming up our slate roof . . .

In retirement, my father turned again to the Antarctic, looking at old data in the light of new material. He enjoyed traveling to meetings, though he always grumbled beforehand, but it was the rare opportunities of seagoing that gave him the greatest pleasure. In 1975, he went with Ted Foster in the USGS ice-breaker *Glacier* to the Weddell Sea. The cruise ended prematurely when the *Glacier* was damaged going to assist another ship and the scientists were taken off. The first we heard of it was when one of the more sensational British daily papers rang up the Institute inquiring about "British scientist adrift in Antarctic," conjuring up visions of him floating on the ice like Shackleton. Two days later, the scientist himself arrived by air, highly disgruntled about his trip being cut short.

In 1979, he was again in southern waters with the *Discovery*. Never greatly troubled by seasickness, he found that advancing age cured the condition completely. Others on board had slightly mixed feelings when he invariably told them what readings would be before they could look at their instruments. He always came back from such trips looking 20 years younger.

When a colleague recently asked advice on a future *Discovery* voyage, he replied "I'd like to come." After I married, finding television palled, he characteristically taught himself to type and wrote a book, *The Antarctic Circumpolar Ocean*, published by Cambridge University Press. It arrived the day before he was taken ill.

With increasing years, and possibly sense, I came to appreciate more fully my father's sterling qualities – honesty, integrity, kindness, modesty and common sense. He was straight-forward, yet a man of opposites. In many ways he was conservative – disliking change, and preferring old ways, old friends, and old clothes. But he showed few signs of age himself and was happy in the company of young people. He maintained to the full his capacity to enjoy life, to meet a challenge, to be interested, and to help people. His sense of adventure never flagged, nor his ability to inspire others, and his death was a shock to all who knew him. He leaves a gap which cannot easily be filled.

concerns

Poor Fish of Redondo!:

Managing the Galápagos Waters

by J.M. Broadus

"Poor fish of Redondo! In your victimized confidence, you are of the number of those who inconsiderately trust, while they do not understand, human nature."– Herman Melville, The Enchanted Isles

In recent years, there has been a world-wide explosion of tourism concerned with wildlife, wildlife areas, and scenic beauty. For the nearly 8,000 residents of the physically inhospitable Galápagos Islands, virtually isolated 1,000 kilometers to the west of mainland Ecuador, this is a promising development. For the archipelago's unique natural systems, however, it could be ominous.

Confined to small "colonized" areas on four of the archipelago's 16 islands, and surrounded by arid national parklands and the Pacific Ocean, the Galápagos people are hard pressed for a livelihood. As a source of employment, tourism services have already surpassed traditional farming and fishing activities in economic importance. Annual tourist visits to the Galápagos recently have grown to nearly 20,000, from about 4,500 in 1970, but their benefit to local inhabitants is limited. Most tourism revenues – an average visit costs about $2,500 – are captured by travel agencies before the tourists reach the islands. The bulk of the visitors tour the islands on four ships (each carrying 50 to 90 passengers) operated by continental tour companies. Only about a third are served by small (under 15 passengers) local converted fishing boats.

Nowhere is the heterogeneity of biological adaptive responses more apparent than on oceanic islands, and the Galápagos long have provided an important laboratory for studies of comparative evolution. The striking occurrence and variation of birds, plants, and reptiles have distinguished the archipelago as a unique ecosystem, recognized by Darwin during his historic visit in 1835. Darwin described the islands' mystical appeal: "Considering the small size of these islands, we feel the more astonished at the number of their aboriginal beings, and at their confined range. Seeing every height crowned with its crater, and the boundaries of most of the lava-streams still distinct, we are led to believe that within a period, geologically recent, the unbroken ocean was here spread out. Hence, both in space and time, we seem to be brought somewhat near to that great fact – that mystery of

Photo by Ivon Pires

A close-up of an ancient-looking Galápagos marine iguana.

appearance of new beings on this earth."

Visitors are Pilgrims

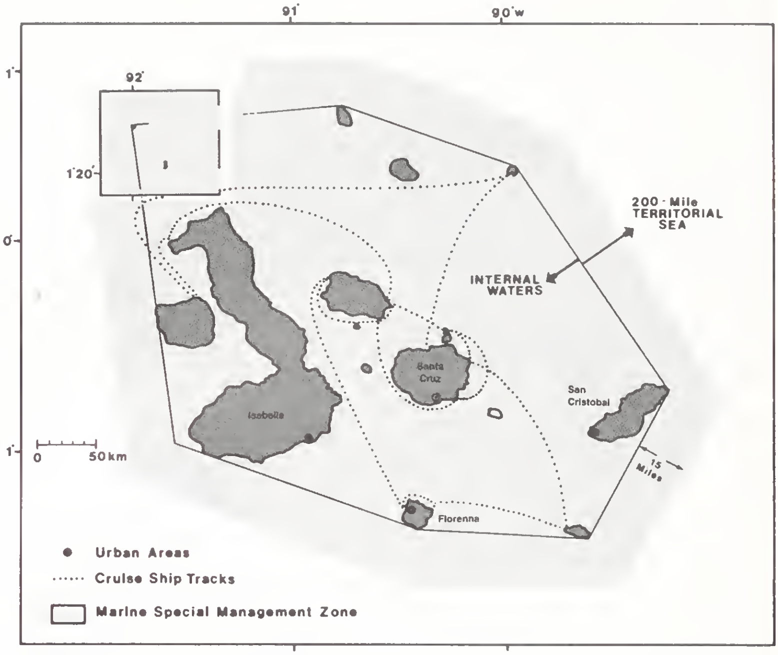
Visitors to the Galápagos Islands are in a sense more pilgrims than tourists, as noted by my colleague, Arthur Gaines, a marine science advisor at the Woods Hole Oceanographic Institution (WHOI). Tourists as well as scientists come to observe the biota and other natural features of the islands, and they exercise a sensitivity and care approaching reverence in their interactions with the natural environment. However, if there were to be an influx of too many tourists, then a rapid degradation in the natural asset that attracts the visitors would seem inevitable. For those dependent on income from outsiders, the goose that lays the golden egg will have ceased to lay if not to live.

Significant progress in protecting the archipelago was made by the government of Ecuador in 1959, when it created the Galápagos National Park. The park includes about 90 percent of the islands' land area. The Charles Darwin Research Station, a small installation established on Santa Cruz Island in the early 1960s by the Charles Darwin Foundation and the government of Ecuador, provides support with scientific information and technical advice. The islands also have been designated a "Natural Heritage of Mankind" by the United Nations Educational, Scientific, and Cultural Organization, but the practical significance of this status is not clear.

Unfortunately, the Galápagos National Park has been struggling through a series of severe budgetary crises, and the Charles Darwin Station is plagued with both financial and political uncertainties. Many individuals who have worked to assure protection of the islands' natural systems are apprehensive about what position the new government of Leon Febres Cordero will take concerning the islands. Composed of business-oriented conservatives, the Febres Cordero administration is expected to pursue environmental policies similar to those of the Reagan administration, or at least to weigh economic considerations more heavily in tradeoffs with environmental values.

Ecuador's new Director of Tourism recently announced plans to intensify efforts for growth in Galápagos tourism, suggesting that annual visits might be expanded fivefold. The resulting national uproar led to this statement on December 7, 1984, by Ecuador's Ministry of Foreign Relations: "The policy of the Government of Ecuador is always in favor of the preservation, protection, and maintenance of the environment of the Galápagos Islands and its wealth of flora and fauna." The extent to which this policy will be maintained and implemented remains to be seen. There can be little doubt, however, that the National Tourism Authority expects to play an increased role in management of Galápagos affairs.

Although national policy for the terrestrial area of the Galápagos Islands stresses protection of the natural environment, no comprehensive policy exists for the Galápagos marine area. Thus, there is an opportunity for the establishment of special management provisions that would preserve the natural habitats as well as traditional uses of this important marine area.



Under one proposed management concept for the Galapalgos, all internal waters and a 15-mile marine buffer zone would be designated as a marine special management area.

Hues as Yet Unpainted

The complex Galápagos marine environment is still poorly understood. G.M. Wellington, whose works are the only comprehensive reference on marine life and habitats of the Galápagos, stresses that much remains to be learned about this distinct biogeographic province, which is characterized by:

- *High diversity* – a rich and varied flora and fauna compared to other marine insular environments in the eastern Pacific.
- *High degree of endemism* in the marine biota – around 25 percent of most groups occur nowhere else on Earth.
- *Complex and unusual system of oceanic currents* – cool currents, upwelling areas, and water masses of different origins transporting bioelements from tropical and subtropical regions of the American continent as well as from the Indo-Pacific region.
- Unusual mixed biogeographic affinities – strong phyto- and zoogeographical affinities with the tropical and subtropical American continent, with many elements representing the Peruvian/Chilean and West Pacific provinces.

- *Large diversity of habitats and highly complex marine communities* relative to other insular marine areas in the eastern tropical Pacific. The variety of geomorphologic characteristics offer a high density of marine habitats isolated from the continent, comprised of rocky, vertical cliff face, mangrove, sandy beach, lagoon, embayment, and hypersaline panne habitats.

- Critical importance to a large number of terrestrial organisms that depend on the marine environment for survival. Darwin Station marine biologist Gary Robinson writes, "Many of the fantastic animals, such as the penguin, fur seal, sea lions, flightless cormorant, waved albatross, and marine iguana – not to mention the large array of seabird species – are directly dependent on the marine environment for their existence." Of 57 resident bird species in the Galápagos, 27 depend on the surrounding ocean.

- *Pristine quality* – little altered by man compared with most marine areas in the world.

- *Scientific importance* – the available evidence indicates that the Galápagos marine environments may offer opportunities for basic biological studies comparable to those of the terrestrial environment. Wellington stresses, "The underwater life and habitats of the Islands certainly offer opportunities equal to those of the terrestrial areas to observe and understand the structure and function of insular ecosystems and to learn about the processes of evolution."

Herman Melville, on his visit to these "Enchanted Isles," was enthralled by the marine life in the clear waters around Roco Redondo: "Below the waterline, the rock seemed one honey-comb of grottoes, affording labyrinthine lurking-places for swarms of fairy fish. All were strange; many exceedingly beautiful; and would have well graced the costliest glass globes in which goldfish are kept for a show. Nothing was more striking than the complete novelty of many individuals of this multitude. Here hues were seen as yet unpainted, and figures which are unengraved."

An increasing number of modern-day visitors are attracted to the Galápagos for snorkeling, diving, or swimming expeditions to see the same sights described by Melville and others. While scuba equipment and dive tours have become increasingly accessible, there is no mechanism for the regulation and control of such activities, nor is there a system for ensuring the safety of diving visitors or responding to accidents should they occur. Increasing use of Galápagos waters also raises questions about the growth and control of more traditional water sports, such as spear and sport fishing, sunbathing, recreational boating, and waterskiing.

A 1982 consultant's report on reformulation of the management plan for the Galápagos National Park states that "the importance of including a marine area in the national park as soon as possible should be underlined." It adds that the national park as presently composed cannot maintain the insular ecosystems of the Galápagos until it includes the marine component. The report urged such action "at the earliest possible opportunity." In 1981, a high-level Ecuadorian government commission also recommended inclusion of marine areas within the national park as a matter "of the greatest urgency."

A marine component for the Galápagos National Park has been envisaged since at least 1973. Over the last decade, however, little progress has been made toward its establishment, and opposition has been expressed on several points. As currently written, the National Parks and Reserves Law of Ecuador clearly prohibits the removal of any organisms from a national park. This would presumably apply to numerous traditional and economically important activities, such as the *bacalao* fishery. Further, there are serious questions about effective control and administration of an extensive marine area. National park officials have stated that they cannot effectively manage a marine extension at current manpower and support levels.

The desirability of incorporating meaningful local input into the planning of a marine special management area, along with the advantages of assuring traditional artisanal uses in the area, cannot be stressed too strongly. Indeed, protection of traditional uses can be a prime objective in creating such reserves and is a common feature of a number of marine parks worldwide.

The traditional fisheries of the Galápagos have been studied by Conner Bailey, a rural sociologist at WHOI, who has concluded that the existing artisanal fisheries do not represent a serious threat to the marine environment around the islands. These long-established fisheries provide significant employment opportunities to island residents; banning fishing within the Galápagos Islands would create considerable hardship. Because of the potential dangers to important endemic species, however, the introduction of new technology and gear must be approached with caution.

The status of lobster and black coral resources is less clear and requires further scrutiny. The activities and effects of industrial tuna operations in Galápagos waters also require further study.

The steep drop-offs around the cactus studded Corona del Diablo are popular but treacherous diving spots. (Photo by Arthur Gaines)

The relatively undisturbed quality of this marine area is actually one justification for its inclusion as a special management area or reserve. It represents an opportunity to preserve a still unspoiled marine area before it becomes subjected to heavy stress.

On pragmatic grounds, it is unclear whether a marine reserve would generate large economic benefits beyond those already accruing from the existing park. Development of additional opportunities to dive and view natural marine phenomena could attract more visitors to the islands who would appreciate and respect the fragility of the environment. Such development also could help spread tourist visits over a greater number of sites and so reduce pressure on existing visitor sites.

Laws and Regulations

The laws and regulations affecting the Galápagos marine area have been analyzed by Ivon Pires, an international legal scholar at WHOI's Marine Policy and Ocean Management Center. Under Ecuador's 1981 Forestry and Conservation Law and its 1983 regulations, the designation of new natural areas is determined by the Ministry of Agriculture through its National Forestry Program (PRONAF). In addition to providing for the establishment of national parks and ecological or biological reserves, the new Ecuadorian law also permits the creation of recreation, hunting, and fisheries areas. This allows not only recreation and scientific research activities, but also the rational development and utilization of Galápagos wildlife so as to benefit local communities or commercial operations. These activities must not damage existing species and resources. This thus could represent a flexible legislative umbrella under which to organize a broadly acceptable, special marine-management area in the Galápagos.

Because of the importance of the marine area to the integrity of terrestrial Galápagos habitats, it would seem important that the national park play an influential role in the formation of policies, regulations, and management rules of procedure, no matter what options are pursued. Even in the face of severe resource constraints, the Galápagos National Park has been exceptionally successful. It has received worldwide recognition as a model to be emulated.

Ecuador's Navy has considerable experience in regulating maritime activities. It seems likely that practical jurisdiction in the special management area would be left with the Navy, however else the area is designated administratively. Effective administration, in any case, will require a high degree of interagency cooperation.

On the question of boundaries and zonation, a 2-nautical-mile band has been proposed that would encompass much of the archipelago's 200-meter isobath and thus more than 90 percent of the marine fauna and flora of the islands. A major difficulty that arises with such specific boundary widths, however, concerns control and enforcement. Inclusion of all the archipelago's internal waters in the special management area could greatly simplify administrative coordination and reduce enforcement costs. In addition, it has been noted that while the 2-nautical-mile zone would provide protection for nearly all the Galápagos marine life associated with coastal habitats, it would not necessarily provide protection for migratory marine mammals, such as whales and sea lions, or for seabirds.

Conference Proposed

At this time, however, no proposal for the Galápagos marine area appears to be moving forward. The situation is on hold. Given fishermen's opposition to the idea of a "marine park" and the severe financial restraints imposed by Ecuador's external debt, the problem now seems to be uncertainty about just what steps to take next.

The Charles Darwin Foundation is currently engaged in a fund-raising drive that should significantly strengthen the research station's future capabilities and security. The new director of the Darwin Station, Gunther Reck, is a marine biologist, and a marine biology lab has been added to the station's facilities.

At WHOI, a group of marine management specialists at the Marine Policy and Ocean Management Center are designing and pursuing cooperative studies with Ecuadorian counterparts on issues related to a special marine management area. This work has been funded by a grant from the Tinker Foundation. If additional supplementary funds can be found, and if there is sufficient interest in Ecuador, a broad-based conference might be organized there to address in detail the question of the Galápagos marine area's future. Such a conference could serve several purposes: to focus attention on the problem; to facilitate mutual education; to ease remaining conflicts or misunderstandings among interested parties; and to begin formulation of concrete proposals for further action.

The ingredients for progress in devising appropriate management provisions for the Galápagos marine area seem to be in place. This pristine area is of great scientific interest and of vital importance to the archipelago's terrestrial organisms. A scientific research station is already on the scene and functioning, and the station's marine research capabilities have been upgraded. A new national government is turning its attention to the situation, which commands broad public interest. A national park is a major presence onshore, and the Navy already maintains an administrative and enforcement structure in the archipelago. The Galápagos Islands themselves enjoy high international visibility. If a comprehensive management program cannot be devised and successfully implemented for this watery treasure, we must surely be pessimistic about what can be achieved for other such marine areas elsewhere in the world.

J.M. Broadus, Social Scientist, Marine Policy and Ocean Management Center, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

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concerns

WIDECAST:
Help for Caribbean Sea Turtles

Whether one defines conservation as preservation, or as management for sustained utilization, the six species* of sea turtles in the Caribbean and the Gulf of Mexico are in need of stringent conservation measures. The Kemp's ridley turtle is poised on the brink of extinction – it is estimated that fewer than 1,000 breeding pairs are left. The other species are either endangered or threatened because of overharvesting and habitat destruction. Those who hunt the turtles for meat, eggs, and tortoise shell face the prospect that their children and grandchildren may not be able to carry on the same traditions practiced by their forefathers.

Sea turtles and their eggs have been exploited by all the inhabitants of the Caribbean. Turtle bones have been found in Indian mounds and near ancient villages. Although the Indians probably used sea turtles for thousands of years without creating stress on the resource, European colonization and the development of foreign markets for turtle soup and tortoise shell quickly reduced the numbers of the once-plentiful Caribbean turtles.

The Europeans, and the Africans later brought over as slaves, hunted turtles to help provision ships and early settlements. Sea turtles could be kept alive in a ship's hold for weeks, providing fresh meat on exploratory voyages. Nesting females and their eggs were easy prey for inhabitants of the new settlements. In later years, sea turtles from throughout the Caribbean were exported to England and continental Europe for tortoise shell (highly valued for making jewelry) and calipee (used in making turtle soup).

The green turtle, Chelonia mydas, one of six species commercially exploited in the Caribbean and Gulf of Mexico. The pace of industrial and agricultural development is reducing foraging and nesting areas. (Photo by Karl H. Maslowski, Photo Researchers)

Sea turtles are not as heavily exploited now as in the past, partly because their numbers have been reduced to the point where commercial exploitation cannot be sustained. Even with greatly reduced hunting pressure, however, the populations show little sign of recovering. A new stress that could drive them to extinction even if hunting were stopped altogether is affecting their lives.

As direct exploitation of turtles declined in the present century, the pace of industrial and agricultural development in the Caribbean increased dramatically, destroying sea turtle foraging and nesting areas both directly and indirectly.

Rapid development, spawned by population growth and burgeoning tourism, has led to increases in domestic sewage and

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*The green turtle, *Chelonia mydas*; the hawksbill, *Eretmochelys imbricata*; the loggerhead, *Caretta caretta*; the leatherback, *Dermochelys coriacea*; the Kemp's ridley, *Lepidochelys kempi*; the olive ridley, *L. olivacea*.

creases in domestic sewage and industrial waste discharges. Even in places where development has not had much of an impact yet, it can be expected to increase along with economies and populations. Thus, the beaches, reefs, mangroves and sea grass beds all face potential effects from construction, oil spills, siltation (as a result of agricultural development), waste disposal, and increased boat traffic. These could damage vital fisheries and destroy much of the aesthetic value that makes the region so attractive to tourists, in addition to the detrimental stresses they would create for sea turtles.

A Model For Other Areas

The problem now emerging in sea turtle management — that of recovering a previously over-exploited resource in the face of habitat destruction — is likely to be applicable to other living marine resources as the global human population continues to expand. So that future generations can rely on the sea for their livelihood, we must now learn to use our living resources without exceeding their capacity to remain renewable. To do this, nations must be willing to cooperate in conserving and managing the ocean's living wealth.

Sea turtles can serve as a case study for the development of methods to ensure international cooperation in preventing the further decline of depleted living resources, in restoring them to former levels of abundance, and in maintaining them for sustained use. The potential benefits of such a methodology are immense, but protecting Caribbean sea turtles and their habitats also provides more immediate benefits, even beyond the protection of six endangered or threatened species.

The Caribbean's mangrove forests, sea grass beds and coral reefs are important habitats for crustaceans, mollusks, and finfish, as well as for sea turtles. Fisheries resources are extremely important to both developing and industrialized nations. Wise management of more economically important species, such as lobster or conch, demands that the foraging, breeding, and nursery habitats be protected. The Caribbean's coral reefs, clear near-shore waters, and pristine beaches, needed by foraging, breeding, and nesting sea turtles, also attract nearly 100 million tourists each year. The rapid development of facilities to house, feed, and entertain tourists should not be allowed to destroy the beauty that first attracted them to the Caribbean. Thus, the protection of sea turtles and their habitats should be seen as part of an over-all plan to enable other species to flourish as well.

Alternative Approaches

There are obviously several options for managing and recovering sea turtle populations. The usual approach is for each country to attempt to manage sea turtles on its own by passing fisheries laws that protect turtles during specified seasons or prohibit the capture of turtles under a specified size. This approach was used by the Bermuda Assembly as early as 1620, and similar laws have been passed by other countries as recently as the 1970s. Unfortunately, although such laws may provide some relief, the protection afforded is rarely sufficient to enable the populations to recover.

Sea turtles do not recognize national boundaries. Those that feed in one country's waters may nest on another nation's beaches. Furthermore, they can travel through the waters of several different countries on their way to nesting or foraging areas. Even if one nation seeks to protect "its" turtles, neighboring or even distant nations can allow "their" turtles or eggs to be heavily exploited. When each nation has what it believes to be a reasonable quota for harvesting "its" turtles, the combined quotas may impose great stress on the turtle population. And harvest quotas and size restrictions do not address the threat of habitat destruction from coastal development. Once the turtles are gone, each nation will have lost a valuable resource and a national treasure.

Some Caribbean governments recognized the need for international cooperation in protecting sea turtles as early as the beginning of the 20th century. However, little has been done in the last 85 years to achieve it. There are many forms that cooperative efforts might take, as indicated by recent multilateral maritime agreements.

Multilateral agreements may be global in their extent, such as the 1982 United Nations Conference on the Law of the Sea, or on a regional basis, enabling nations that share the same resources to manage them in common. For example, representatives of the Organization of Eastern Caribbean States (OECS)* met at Castries, St. Lucia (30 July – 4 August, 1984) for a workshop on the Harmonization and Coordination of Fishery Regimes. Among other items, they proposed a moratorium on the taking of sea turtles and their eggs. If enacted, such a moratorium would certainly have beneficial effects on sea turtles, even though it would not ameliorate detrimental effects from development and alteration of habitats. Additionally, the proposed moratorium cannot protect any OECS turtles that wander into other areas of the Caribbean. Thus, while global agreements may be too large in scope, smaller regional agreements may be too small. What is needed is a more comprehensive set of management plans, covering a wider geographic area and addressing habitat protection as well as direct exploitation.

Since 1974, the United Nations Environment Program (UNEP) has sought to protect the marine environment through its Regional Seas Program, which calls for cooperation in reducing pollution and conserving living marine resources. UNEP's Wider Caribbean Region includes the Gulf of Mexico, the Caribbean Sea, and those parts of the Western Atlantic within 200 nautical miles of the Bahamas and Florida (south of 30 degrees North), down to the northern border of Brazil. Thus, it includes the eastern Central American nations, all of the Caribbean island nations (Greater and Lesser Antilles), the northern countries of South America, Mexico, and the United States.

In 1983, about half of the Wider Caribbean countries were involved in drafting and adopting the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (see *Oceanus* 27(3):85-88). In a resolution adopted along with the convention, they called for the preparation of a draft "protocol on specially protected areas and wildlife." Non-governmental organizations (NGOs) were encouraged to prepare proposals for submission, reflecting an increased recognition of NGO expertise in environmental affairs. The request for NGO involvement led concerned sea turtle scientists and conservationists to form a new NGO called WIDECAST.

*OECS member states: Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts/Nevis, St. Lucia and St. Vincent. Representatives from Anguilla, Barbados, and the British Virgin Islands also attended the workshop.

Table 1. WIDECAST Recovery Team Members
Francisco Palacio (Colombia – Chairman, 1984–1985)

Argelis Ruiz Guebara (Panama)	John Fuller (Antigua)
Jaques Fretey (France)	Ricardo Mier Ayala (Mexico)
Molly Gaskin (Trinidad & Tobago)	Jorge Luis Piñero Piñero (Puerto Rico)
Maria Teresa Koberg (Costa Rica)	Nat B. Frazer (U.S.A.)
Peter C. H. Pritchard (U. K.)	Sally Ray Murphy (U.S.A.)
Ex officio:	James I. Richardson (Director, Secretariat)
	Milton Kaufmann (Coordinator)

The WIDECAST Proposal

WIDECAST stands for the *Wid*er *C*aribbean *S*ea *T*urtle Recovery Team and Conservation Network. The recovery team is an international, non-governmental, volunteer group of 11 sea turtle scientists and conservationists dedicated to recovering depleted sea turtle populations throughout the Wider Caribbean to their former levels of abundance (Table 1). To do this, they have agreed to work with government officials and with other NGOs to write a "Wider Caribbean Sea Turtle Recovery Action Plan," as well as individual action plans for each of 38 political entities in the Wider Caribbean, including Bermuda and Brazil. Coordination is provided by a Secretariat located at the University of Georgia's Institute of Ecology.

The WIDECAST effort will ensure that each country is presented with an action plan that is formulated as part of a Caribbean-wide, coordinated effort at sea turtle conservation and management. The individual plans will contain recommendations to each government for conserving and managing the sea turtles under its jurisdiction, within the context of the Wider Caribbean. Plans will address both the protection of sea turtles and their eggs during the breeding and nesting seasons as well as protection of foraging and nesting habitats.

Obviously, the small recovery team cannot decide what is best or even desirable for each of six species of sea turtles under 38 different jurisdictions. Therefore, WIDECAST recruited a network of more than 100 individuals and organizations to assist in this enormous task. Network participants include governmental officials, conservationists, scientists, and private citizens throughout the Wider Caribbean. They provide vital information on the specific problems that sea turtles face in their countries. They also help to determine which solutions are applicable, practical, and likely to succeed in each country, given its particular socio-economic environment.

At their third meeting in Caguas, Puerto Rico (24-26 January 1984), the team set about researching and writing the recovery action plans. More recently, at the fourth meeting (Panama City, Panama, 9-12 October 1984), the WIDECAST team reviewed a draft outline for the "Wider Caribbean Sea Turtle Recovery Action Plan" and approved detailed drafts of individual action plans for Trinidad and Tobago, Costa Rica, French Guiana, and Guadeloupe. Additional drafts are scheduled to be presented at the fifth meeting in March of 1985 in Guadeloupe.

The Wider Caribbean Region, with the addition of Bermuda and Brazil, constitutes a natural grouping of states that together can manage and recover their sea turtle populations. The initial impact of WIDECAST has already encouraged conservationists to plan similar conservation networks for manatees in the Caribbean and for sea turtles in the Eastern Pacific.

Nat B. Frazer, Research Fellow, Marine Policy and Ocean Management Center, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

book reviews

The Geology of the Atlantic Ocean **by K.O. Emery and Elazar Uchupi. 1984. With 21 charts (available separately). Springer-Verlag, New York, Berlin, Heidelberg, Tokyo. 1,050 pp. $98.00.**

This book – eight years in the making – is a synthesis of what is known to date about the Atlantic Ocean. Written primarily for geologists and geophysicists of the shipboard, theoretical, teaching, and industrial varieties, it combines new and old data on biological, chemical, geological, and physical processes to arrive at a broad understanding of the shape, composition, and history of the oceans. While the authors have concentrated primarily on geology in the Atlantic, there is reference throughout to pertinent new findings in other oceans and on land.

The book, a hefty 1,050 pages with a bibliography of 5,000 entries, is divided into eight sections. In the preface, the authors explain their organization:

"The first chapter, *Exploration,* attempts to show the fragile beginnings and strong sequential accumulation of knowledge about ocean geography and seafaring. The long chapter on *Physiography* is a continuation of Exploration but mainly in a vertical rather than a horizontal sense; we consider a description of ocean-floor features with deductions about origin derived from shapes and relations with each other to be necessary [prior to] introduction of subsurface geological and geophysical processes. Equally pertinent is introduction of the Earth's deeper-seated physical composition and inferred processes in *Internal Igneous Structure;* this information extends the knowledge of ocean-floor (and continental) topography and composition to origins and changes with time.

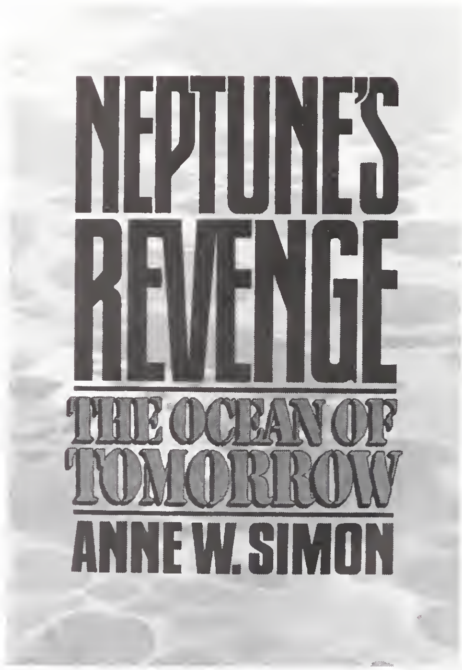
"The chapter on *Syn-Rift Supersequence and Crustal Boundary* deals mainly with the history of the crust of the Atlantic and the nature of its junction with adjacent continental crusts, augmenting the information from previous chapters. Next is [a] long chapter on *Drift Supersequence* that describes the sediment layers deposited on oceanic and continental crusts and the broad control over them exerted by biological, chemical, and physical processes. Much more knowledge about the environmental controls on sediments is available for surface sediments than for deeper ones because of their easier access, and these matters are the subject of *Sediment Provenance and Properties.*

"In *Evolution of the Ocean Floor,* the contents of all previous chapters are brought together, summarized, and considered in an ocean-wide context without need for digressions concerning origins of component features. Finally, many of the characteristics of the ocean water, its organisms, and bottom materials, are important for the well being of mankind that lives on land rather than on or in the ocean itself; this is the content of the final chapter, *Interfaces Between Ocean and Man."*

The authors note that the sequence of chapters is intended to trace the history of the ocean floor in an integrated way, not in the usual textbook fashion by scientific disciplines. There are 399 figures accompanying the text. This book, along with its accompanying charts, should prove an invaluable reference source for all oceanographers and people with a serious interest in the development of our planet.

Paul R. Ryan,
Editor

***Neptune's Revenge: The Ocean of Tomorrow* by Anne W. Simon. 1984. Franklin Watts, New York, N.Y. 223 pp. $15.95.**



Wake up, people, to the vulnerable state of the oceans. This is the message and purpose of *Neptune's Revenge.* Noble as is the cause, the vehicle is flawed. For although the country is supposedly ripe for a "Silent Spring of the Oceans," as this book is billed, *Neptune's Revenge* is disappointing in both style and content.

Ms. Simon is on the right track: nothing on this planet is so vast as to escape the touch of the enormous human population, not even the oceans. We have believed immense equals infinite – in other words, the oceans were thought so vast that no matter what we did we could not harm them or their superfluous resources. Of course that's not true, and today we are seeing the effects of our taking, using, exploiting, and ignoring. Enormous fish populations have all but disappeared; man-made chemicals are found in the remotest parts of the oceans; and that modern mega-giant, the energy industry, is busily searching beneath the waves for petroleum. Not without cause, of course – the historical and economic reasons for energy exploration in the seas are quite sound.

However, Ms. Simon is no Rachel Carson. I had a hard time getting through even the first chapter. The writing is often schlocky, blatantly attempting to tug our heartstrings. The combination of melodrama with science is unfortunate – the author does not allow facts to speak for themselves, but rather supplies interpretations that demand specific reactions. This insults the reader, as well as filling up space that might better have been used to explain some of the more difficult concepts presented. Strangely, the book's purpose is stated in an aside. Facts and ideas about particular subjects are presented higgledy-piggledy, jumping around without apparent structure among natural sciences, ancient history, and Ms. Simon's own brand of philosophy. As well, the analyses are simplistic, such as in the story of the Atlantic salmon, which proceeds from 14th-century England to 20th-century America in two sentences. I was surprised to read that ". . . Caesar's legions discovered the fish swarming in the rivers of Gaul, named it

Salmo salar, Salmo from the Latin to leap, *salar* from the Latin root for salt." Okay, maybe the Romans did use binomial nomenclature, but hadn't the Gauls already noticed all those fish? According to my dictionary, the Latin *salmo* was borrowed from the Gaulish for "the leaping fish." (Of course, dictionaries are notoriously in disagreement on these matters.) This criticism may seem picayune, but *Neptune's Revenge* is rife with similar difficulties.

This book has many, many problems with language. Terminology is ill-used and arguments confusing, as is the hodge-podge of tenses, and there is an excessive use of incomplete sentences – a device best left to fiction. There is a resounding over-simplification of scientific material. In short, the book reads as if it was not edited.

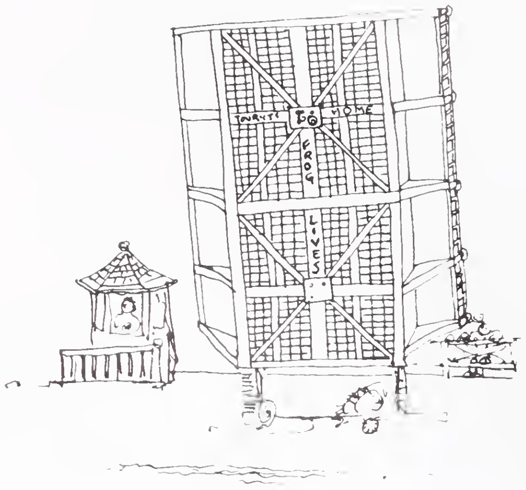
Since I began the chore of reviewing *Neptune's Revenge*, many people have informed me that it has gotten good reviews elsewhere. Why this is is a mystery to me. I cannot accept that every book with an environmentalist message will get a good review simply by virtue of its message. Perhaps other reviewers are less aware of the condition of the oceans and are so astounded by the general drift of this book that they overlook problems of style and factual discrepencies. It seems to me, though, that any reader moderately informed about marine biology would object to such sentences as "Every drop of ocean water contains a microscopic speck that is alive." Those who know nothing of marine biology will be completely confused, for this does not refer to the spirit of the water droplet, but to plankton.

Certainly the country needs to be awakened to the plight of the oceans, which ultimately is our own plight. If the seas, the ancient spawning grounds of life, are exploited and polluted to death, there no doubt will be a revenge. This is after all a very small planet, and by changing it as we have, we have also assumed responsibility for it – whether we want it or not. It's just too bad that *Neptune's Revenge* so poorly states the case.

Elizabeth Miller,
Assistant Editor

David's Landing by Judith Benét Richardson. 1984. Woods Hole Historical Collection. Woods Hole, Mass. 155 pp. $8.95.

You may not think of Woods Hole as a center for literary effort. *People* magazine has not yet discovered this Cape Cod, Massachusetts village in its annual summer quest celebrating the *glitterati* of Provincetown and Martha's Vineyard. But in sheer tonnage, pagination, or simply destruction of our nation's forests, Woods Hole certainly outdoes more



An illustration by Molly Bang from David's Landing.

celebrated climes. Granted, though, most Woods Hole authors write for an audience of ten picky colleagues scattered around the globe. What I am waiting for is a Woods Hole novel that captures this unique, little village the way Steinbeck captured Monterey, California.

Until that novel is written we have an excellent substitute. *David's Landing* is a children's book that offers a warm, insightful view of science, scientists, their families, and Woods Hole. It is altogether fitting that *David's Landing* is a children's book and that its denouement revolves around the outcome of the Maushope's Landing school's annual science fair.

The fictitious Maushope's Landing is of course Woods Hole and the allegory is perfect. Woods Hole is nothing if not a vast science fair where hundreds of adults are turned loose to fiddle with computers, dabble with electrodes, and experiment with animals with the same curiosity a child has with his first microscope.

Like Maushope's Landing, Woods Hole resides at the end of an economic pipeline that emanates from Washington. If federal administrations change, or a field goes out of vogue, or a source of funding dries up, then a scientist, a lab, or even an institution may go under. No matter how interesting the field or elegant the research, if the powers that be dictate that it's no longer necessary, it ends.

In *David's Landing*, David and his schoolmates are faced with a similar dilemma. A cost-conscious school committee no longer sees a need for the Maushope's Landing village school. David's scientist father, slowly coming out from behind his *Scientific Americans* and a failed marriage, and David mold a new understanding as they team up to save the school. David's father discovers his son and David gains understanding and respect for his father's science.

It is not surprising to learn that *David's Landing* is an inside job. The author, Judith Benét Richardson, is the wife of Woods Hole Oceanographic Institution scientist Philip Richardson. The illustrator, Molly Bang, grew up as a Marine Biological Laboratory kid. The book is beautifully designed by another local resident, Diane Jaroch. *David's Landing* is published by the Woods Hole Historical Society whose excellent first book, *Woods Hole Reflections,* made this one possible. All parties deserve congratulations.

I am not going to reveal whether David's iguana wins the black dog contest, if Frog lives, or if the blue meanies from the Falmouth School Committee succeed in closing down the school. Suffice it to say that I recommend the book to all children and anyone else who wants to understand the strange ways that things happen in Woods Hole.

Bill Sargent,
Woods Hole, Massachusetts

Books Received

Biology

***Advances in Marine Biology: Volume 21*, J.H.S. Blaxter, Frederick S. Russell, and Maurice Yonge, eds. 1984. Academic Press, New York, N.Y. 233 pp. + xi.$55.00(U.S.); £32.50(U.K.).**

This volume contains two essays: Recent developments in the Japanese oyster culture industry by R.F. Ventilla, and Marine toxins and venomous and poisonous marine plants and animals by F.E. Russell. Ventilla discusses the characteristics and larval development of the oyster; the techniques for and problems of its culture; and the production, harvesting, and marketing of oysters in Japan. He concludes with a discussion of the future potential of the Japanese cultured oyster. In the second essay, Russell provides a general introduction to marine toxins, including an outline of relevant folklore. The remainder of the work is organized according to taxonomy, with separate discussions of the toxins and venom of Protista, Porifera, Cnidaria, Platyhelminthes, Rhynchocoela, Annelida, Arthropoda, Bryozoa, Echinodermata, and Mollusca.

***Perspectives on Coral Reefs*, D.J. Barnes, ed. 1983. Published for the Australian Institute of Marine Science by Brian Clouston Publisher, Manuka, A.C.T., Australia. 277 pp. $19.95.**

A collection of 19 review papers written by participants in the Australian Institute of Marine Science's workshop on coral reefs held in August 1979. At the workshop, it was determined that scientific investigation of coral reefs would benefit from an interdisciplinary approach. This book was conceived as a means of communication to the scientists concerned. Three general areas are covered: reef geology, reef growth, and reef biology.

***The Lobster: Its Life Cycle* by Herb Taylor. 1984. Revised edition. Pisces Books, New York, N.Y. 96 pp. $8.95.**

This colorfully illustrated treatise on lobsters was written with the curious amateur biologist in mind. The author extensively researched the material with professional lobster-biologists, and includes an excellent collection of color photographs. Lobster is a posh food that never loses its appeal despite its price; this book explains the complexities and intricacies of the life of the animal. Perhaps knowledge of the lobster's life cycle will help people better appreciate their dinner meat.

***The Gray Whale,* Eschrichtius robustus, Mary Lou Jones, Steven L. Swartz and Stephen Leatherwood, eds. Illustrations by Pieter Arend Folkens. 1984. Academic Press, Orlando, Fla. 600 pp. + xxiv. $75.00.**

The sole member of family Eschrichtiidae, the gray whale is considered by many researchers to be the most primitive surviving baleen whale. It frequents coastal waters and is often seen from shore; it is important aesthetically, economically, and as a species of scientific interest. In four sections, this book covers: evolution, fossils, and subfossil remains of gray whales; historical relationships between man and gray whales and exploitation of these cetaceans; demography, distribution, and migration; and the biology and behavior of gray whales. There are lots of tables, photographs, and drawings; the book should appeal to sociologists and historians as well as to biologists, ecologists, and whale buffs.

***The Mollusca. Volume 7: Reproduction,* A.S. Tompa, N.H. Verdonk, and J.A.M. van den Biggelaar, eds. 1984. Academic Press, Orlando, Fla. 486 pp. + xix. $70.00.**

The essential features of reproduction for the Prosobranchia, Basommatophora, Stylommatophora, Opisthobranchia, Bivalvia, and Cephalopoda. This volume is meant to accompany Volume 3 (Development) of *The Mollusca.* Because molluscs are well suited as experimental animals for the study of many reproductive phenomena, the information in this book should be useful to all those interested in comparative reproductive zoology. Research problems in sex determination, cytology, gamete biology, larval ecology, evolutionary biology, and other areas are discussed.

***So Excellent a Fishe: A Natural History of Sea Turtles* by Archie Carr. 1984. Revised edition. Charles Scribner's Sons, New York, N.Y. 280 pp. $15.95.**

This edition includes a new epilogue on important recent developments in sea-turtle research and conservation; as well, there are many new black-and-white photographs. It is mainly a natural history, focusing on the mysteries that surround sea turtles, especially their ability to navigate across up to a thousand miles of open ocean between feeding and nesting grounds. The author (who directs the green turtle research program at Tortuguero, Costa Rica) presents his ideas on turtle navigation and other unanswered questions about sea turtles, such as where do the turtles go when they hatch? He describes the *arribada* – when tens of thousands of ridley turtles nest on a short beach – and pleads for the conservation of these endangered and threatened species.

***Coastal Waders and Wildfowl in Winter*, P.R. Evans, J.D. Goss-Custard, and W.G. Hale, eds. for the British Ornithologists' Union. 1984. Cambridge University Press, New York, N.Y. 331 pp. + x. $54.50.**

This book was produced after a 1981 meeting of European ornithologists concerned with coastal birds' feeding requirements and behavior. It is meant to help both planners concerned with coastal wetlands and researchers interested in the problems discussed, by presenting a mixture of reviews, reports on the progress of long-term studies, and specific reports. The topics that define the sections of the book are: bird populations' use of feeding areas, including the influence of food resources and the birds' social behavior at these sites; and the significance of specific areas on the Palaearctic-African migration routes of waders.

***Methods for the Study of Marine Benthos*, N.A. Holme and A.D. McIntyre, eds. 1984. Second edition. IBP Handbook Number 16, Blackwell Scientific Publications, Boston, Mass. 386 pp. $44.00.**

This handbook was written for three kinds of workers in marine benthic studies: the newcomer to the field, the isolated worker without access to large libraries, and those in related disciplines. Full of practical information and well referenced, it remains an excellent sourcebook for all those studying the sea bed. It includes chapters on the design of sampling programs, sediment analysis, techniques for the study of macrofauna, meiofauna, and phytobenthos, and a final chapter on energy-flow measurements. This second edition reflects both technical advances and changed attitudes toward understanding and monitoring benthic processes and communities.

Diving

***The Decompression Workbook: A Simplified Guide to Understanding Decompression Problems* by George S. Lewbel. 1984. Pisces Books, New York, N.Y. 61 pp. $5.95.**

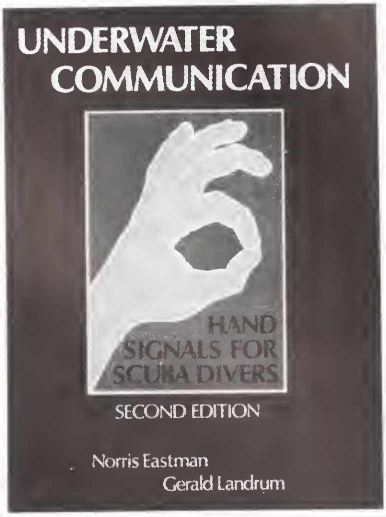
This book is designed to help sport divers completely master decompression tables. It is a self-teaching text in four sections. The first three are: basic concepts with simple, one-dive problems; repetitive dive concepts and two-dive problems; and three- and four-dive problems. The fourth section, on decompression dives, deals with special problems such as fast ascents and other potentially dangerous situations. *The Decompression Workbook* can be used with any set of dive tables based on the U.S. Navy air decompression tables.

***Living and Working in the Sea* by James W. Miller and Ian G. Koblick. Illustrated by William Boggess. 1984. Van Nostrand Reinhold, New York, N.Y. 446 pp. + xiv. $32.95.**

Periodically the notion of humans taking up habitation on the sea floor enjoys a spurt of popularity. This book traces the progress of actual attempts to create sea-floor human habitats, including Sealab, Hydrolab, Conshelf, and many others. It gives a brief history of diving, explains how underwater habitats are designed and constructed, describes their working technology and scientific capabilities, and includes excerpts from aquanauts' personal accounts of their experiences. There is practical information on food and water management, carbon dioxide and odor removal, medical and psychological considerations, and more. A look at the future of underwater habitats concludes the book.

***Underwater Communication: Hand Signals for Scuba Divers* by Norris Eastman and Gerald Landrum. Illustrations by Anne B. Burnley. 1984. Second edition. Princeton Book Company, Princeton, N.J. 48 pp. $3.95.**

This booklet does exactly what it proclaims: depicts (via line drawings) hand signals for use by divers underwater. Very briefly, the book explains why and how to learn hand



signals. There are 130, divided into six categories: fundamental and instructional, emergency and safety, environmental, marine life, numerical, and fingerspelling. A study guide contains typical diving "conversations" for students to practice with; a teaching guide lists ten commands useful for efficient underwater instruction.

***Sport Scuba Diving in Depth: An Introduction to Basic Scuba Instruction and Beyond* by Tom Griffiths. 1985. Princeton Book Company, Princeton, N.J. 270 pp. $14.50.**

An instuctional book emphasizing diving fun and safety. Part one is on the "basics"– equipment, underwater physics and physiology, and the diving environment. The second section is on safety and scuba rescue; thirdly is "beyond the basics," a section on dive planning, repetitive diving and no-decompression tables, maintenance of equipment, underwater communications, continuing underwater education, and specialty diving. Each chapter is followed by review questions.

Environment/Ecology

***The Living Planet: A Portrait of the Earth* by David Attenborough. 1984. Little, Brown and Company, Boston, Mass. 320 pp. $25.00.**

The story of Earth's surface and its colonization by living organisms, written concurrently with the filming of the BBC television series of the same name (sequels to an earlier series and book entitled *Life on Earth*). The author surveys the ways in which modern life-forms, including survivors of ancient groups and representatives of newly-evolved ones, survive in various Earth environments. He writes in a style reminiscent of a travelogue, and explains or omits scientific terms; scientific names of organisms are included only in the index (each alongside the appropriate common name). The book is beautifully illustrated with large color photographs.

***The Alaskan Beaufort Sea: Ecosystems and Environments*, Peter W. Barnes, Donald M. Schell, and Erk Reimnitz, eds. 1984. Academic Press, Orlando, Fla. 466 pp. + xvi. $39.00 (U.S.); £ 30.50(U.K.).**

As Alaskan oil industrialists sought to expand their Prudhoe Bay operations out into the Beaufort Sea, large biological and physical studies of the region were undertaken, managed by NOAA and its Outer Continental Shelf Environmental Assessment Program and funded by the Minerals Management Service. Additional studies by state and local governments added to the growing collection of facts and ideas about the Alaskan Beaufort Sea. This volume collates much of this multidisciplinary information. Following the introduction, the book contains papers on the physical environment of the Beaufort Sea, biological interactions in the region, and the impact of the petroleum industry there. The information is generally applicable to all the seas surrounding the Arctic Ocean.

***Living with the Louisiana Shore* by Joseph T. Kelley, Alice R. Kelley, Orrin H. Pilkey Sr., and Albert A. Clark. 1984. Duke University Press, Durham, N.C. 164 pp. $22.75(hardcover); $9.75(paperback).**

The Louisiana shoreline is varied, beautiful, and endangered. Human population pressure and natural processes are causing an accelerated rate of change along the shoreline, with parallel increases in problems. This little book carefully sets forth guidelines for coastal users in Louisiana. There is information on buying and building, land use practices and the law, and the dynamics of coastline change. Numerous diagrams and black-and-white photographs illustrate important concepts. Four appendices cover what to do during and how to prepare for a hurricane; federal, state, and local agencies involved in coastal development; references; and a field trip guide to Grand Isle and vicinity.

***Sea Cliffs, Beaches, and Coastal Valleys of San Diego County: Some Amazing Histories and Some Horrifying Implications* by Gerald G. Kuhn and Francis P. Shepard. 1984. University of California Press, Berkeley, Calif. 193 pp. + xi. $22.50.**

In San Diego County coastal erosion and shoreline development have been documented extensively. This book, an analysis of historical documents, photographs, and scientific literature, puts the situation in plain form before the public, to benefit future planning in the San Diego region. One important finding of the analysis is that the rate of erosion is nearly impossible to predict. The book has two parts, one describing the area, methods of study, and climatic history of San Diego County, and the other describing the coastal history in geographical sequence, from San Onofre to Coronado and Imperial Beach. There are many photographs, a geological timetable, glossary, and extensive reference list.

***Marine Ecological Processes* by Ivan Valiela. 1984. Springer-Verlag, New York, N.Y. 546 pp. + x. $34.00.**

A textbook for beginning graduate and advanced undergraduate students. The author attempts to depict the evolving nature of ecology by covering interdisciplinary topics relevant to marine ecology. Recent references, especially reviews, are provided to help students delve into specific interest areas. Chapters 1 through 7 cover physiological and populational levels of biological organization; chapters 8 and 9 discuss how populations relate to each other and their environments; chapters 10 through 12 are on the chemistry of organic matter and nutrients in marine ecosystems; and chapters 12 through 15 discuss how the structure of marine ecosystems can be maintained.

***Antarctic Ecology*, Volumes One and Two, R.M. Laws, ed. 1984. Academic Press, Orlando, Fla. 850 pp. plus subject index. $55.00 and $75.00, respectively.**

These volumes outline the challenges and opportunities in Antarctic ecology, a very youthful division of a young science. Volume One addresses the ecology of the inhabited regions of Antarctica – the two percent of the continent not covered with ice – including contributions on the terrestrial environment, terrestrial plant biology, terrestrial microbiology, invertebrates and ecosystems, introduced mammals (everything from rats and mice to pigs, sheep, and mink), and inland waters. Volume Two is concerned with the biota and processes of Antarctic marine ecosystems. The chapters are on the marine environment, marine flora, benthos, zooplankton, fish, seabirds, seals, whales, marine interactions, and conservation of Antarctica and its inhabitants.

***Methods in Marine Zooplankton Ecology* by Makoto Omori and Tsutomu Ikeda. 1984. John Wiley & Sons, New York, N.Y. 332 pp. + xiii. $44.95.**

A comprehensive guide, applicable to studies of small organisms and the larval stages of larger animals such as fish and molluscs. After an introduction to plankton, the text is arranged in a practical order, with chapters on sampling, fixation and preservation of samples, observation and identification, processing and measurements, rearing and culture, feeding, respiration and excretion, productivity, and distribution and community structure. Each method is described in detail, including a discussion of its inherent problems. The book should be a useful guide for both students and workers in the experimental study of zooplankton.

Fisheries

***The Cod: A Saga of the Sea* by Albert C. Jensen. 1984. Second edition. Deep Sea Press, Inglis, Fla. 186 pp. $7.95.**

This book traces the history of the Atlantic cod and its impact on American life from Viking times to the present. The author is a fisheries biologist, fisheries manager and teacher. Well-researched and authoritative, the book is also very readable; hard facts about cod are laced with amusing, thoughtful

anecdotes. The chapters are on history, legend and custom, natural history, the varieties of cod, development of the fishery, the role of cod in the discovery and settlement of America, cod fisheries today, research, and conservation. Finally, there is a brief update on management efforts since the first edition was published in 1972. Of interest to all fish eaters, this book could be specially useful to teachers of biology and social sciences.

***Scallop and Queen Fisheries in the British Isles* by James Mason. 1983. Fishing News Books, Farnham, Surrey, England. 144 pp. $6.90.**

Based on a series of lectures given by the author as the 1980 Buckland Professor of Economic Fish Culture (United Kingdom). Scallops and queens (pectinids) are a fascinating group that in recent years has become quite important economically. The book ranges over many topics, from the historical symbolism of scallops and the history of scallop fisheries, to the biology and behavior of pectinids, their capture, handling, marketing, and cultivation, and conservation of wild stocks.

***Atlantic Fisheries and Coastal Communities: Fisheries Decision-Making Case Studies*, Cynthia Lamson and Arthur T. Hanson, eds. 1984. Dalhousie Ocean Studies Program and Institute for Resource and Environmental Studies, Halifax, Nova Scotia. 252 pp. + x. Price unknown.**

These case studies examine some of the differences among the producer-processor -government relationships of various fisheries. The studies are meant to illuminate the processes of fisheries decision-making. The use of stock-assessment information, the extent to which discretionary authority is applied, and the ability of special-interest groups to alter policy, are among the inputs to fisheries decisions discussed. The editors hope to awaken those involved in fisheries decision-making to the sometimes unexpected consequences of their actions.

***1984 World Record Game Fishes: Freshwater, Saltwater, and Fly Fishing*. 1984. International Game Fish Association, Fort Lauderdale, Fla. 320 pp. $7.95.**

An update of world records in game fishing for all-tackle, line, and tippet class categories for more than 150 fresh- and salt-water species. This publication includes articles on worldwide tag and release programs, sportfishing for sharks, and other topics, and it has diagrammatic instructions for tying fishing knots.

Marine Policy

***Ocean Uses and Their Regulation* by Luc Cuyvers. 1984. John Wiley & Sons, New York, N.Y. 179 pp. + x. $29.95.**

Information on the economic, political, and legal aspects of ocean utilization. In eight chapters, this book introduces and describes the physics, geology, chemistry, and biology of the oceans; reviews principal oceanic uses and resources (food, minerals, waste disposal, navigation, and ocean energy); and discusses the law of the sea. Finally, the author points out instances in which problems of pollution, overfishing, and unregulated mining are likely to arise, and explains how proper management can prevent the misuse of the sea and its resources.

***The Emerging Marine Economy of the Pacific*, Chennat Gopalakrishnan, ed. 1984. Butterworth Publishers, Boston, Mass. 256 pp. + ix. $39.95.**

There are 18 distinguished contributors to this book, with topics in four parts: Introduction (by Arvid Pardo); ocean energy and mining; fisheries and agriculture; and ocean resource management and policy. This anthology was selected from the many papers pesented at the International Conference on Ocean Resource Development in the Pacific, held in Honolulu, October 1981. The book is meant for policy analysts, administrators, researchers, and academicians, and examines the Pacific's resources and their management on local, national, and international levels.

***United States Arctic Interests: The 1980s and 1990s*, William E. Westermeyer and Kurt M. Shusterich, eds. 1984. Springer-Verlag, New York, N.Y. 369 pp. +xviii. $35.00.**

Burgeoning resource-development activity has catalyzed economic, strategic, political, and social change in the U.S. Arctic. This book presents the contributions of participants in an "Arctic workshop" held in Woods Hole in May 1983. The contributions cover the gamut of U.S. concerns in the Arctic, from the perspectives of industrialists, policymakers, and others. Topics include: hydrocarbons, Alaskan mineral resources, living resources, effects of development on the Inupiat, the role of science, environmental quality, resource conflicts, and issues from local/regional, federal/state, and international perspectives. Security issues, U.S.-Canadian cooperation, and future prospects are also considered.

Physical Sciences

***Archaean Geochemistry: The Origin and Evolution of the Archaean Continental Crust*, A. Kroner, G.N. Hanson, and A.M. Goodwin, eds. 1984. Springer-Verlag, New York, N.Y. 286 pp. + x. $30.50.**

Advances in isotopic methods and their application to Precambrian rocks, and the recognition that some of the oldest terrains retain primary igneous and sedimentary textures and even geochemical characteristics, have led to many new studies of early Precambrian terrains. This volume summarizes issues in Archaean geochemistry addressed during the nine-year Geological Correlation Programme. Topics include the accretion history of Earth, composition of the primordial mantle, greenstone belt evolution, and others. There are new data on regions in the U.S.S.R., China, and India. Each article contains its own table of contents and abstract, and each is extensively referenced.

***Sea Bed Mechanics* by J.F.A. Sleath. 1984. Wiley Ocean Engineering Series, John Wiley & Sons, New York, N.Y. 335 pp. + xx. $44.95.**

Aspects of fluid flow near the sea bed: currents carrying pollutants; dissipation of wave energy; ripple and dune formation; sediment transport. Much of the information in this book was available previously only in technical reports. Solutions to certain problems are offered, along with an extensive bibliography and other information that should help design and civil engineers and students with design calculations for sea bed engineering problems. To balance coverage between steady and oscillatory flows, each chapter except that on sediment properties has three parts: one on waves alone; one on currents alone; and one on the combined action of currents and waves. The chapters cover basic wave and current theory; fluid velocities and pressures near and in the sea bed; bed forms; bed friction, energy dissipation, and forces on bodies on or near the bed; and sediment properties and transport.

General Reading

***The Dark Abyss of Time: The History of the Earth and the History of Nations from Hooke to Vico* by Paolo Rossi. Translated by Lydia G. Cochrane. 1984. The University of Chicago Press, Chicago, Ill. 338 pp. + xvi. $35.00.**

This is the first translation (Italian to English) of this work by the historian of ideas, Paolo Rossi. In it he describes the impact on European thought of the discoveries that challenged biblical chronology. During the 17th and 18th centuries, Westerners came to realize the immensity of time. Rossi recounts the heated debates partaken of by theologians and biologists, geologists and philologists, that led to the foundation of the idea of evolution. An intriguing book for historians and pracitioners of science and philosophy.

***How to Survive on Land and Sea* by Frank C. Craighead and John J. Craighead, revised by Ray E. Smith and D. Shiras Jarvis. 1984. Fourth edition. Naval Institute Press, Annapolis, Md. 412 pp. + xxiv. $14.95.**

Covering survival skills for environments on both land and sea, this book would be invaluable to stranded adventurer or downed airline passenger alike. Such topics as swimming through burning oil, jumping from heights, dealing with bugs and parasites, dressing game, and obtaining water from banana tree stumps are included. As might be expected with such a wide-ranging book, its weight reduces its usefulness in the field.

***Greenhouse Effect and Sea Level Rise: A Challenge for This Generation,* Michael C. Barth and James G. Titus, eds. 1984. Van Nostrand Reinhold, New York, N.Y. 325 pp. + xiii. $24.50.**

While scientists are still arguing about the magnitude of impending global warming, *Greenhouse Effect and Sea Level Rise* looks at the practical implications of such a trend. Focusing on coastal areas, the book includes information on the economics of sea level rise, coastal geomorphology, land use planning, and the effects of rising seas on hazardous waste sites in coastal areas. The book also covers how predictions of sea level rise are made and the range obtained by various estimates.

***A Passion to Know: 20 Profiles in Science,* Allen L. Hammond, ed. 1984. Charles Scribner's Sons, New York, N.Y. 240 pp. + xii. $15.95.**

These profiles were first published in *Science 85* magazine. The people portrayed are not ordinary scientists; impossible to stereotype, nevertheless they all are driven to an unusual degree by a "passion to know." They are or were investigators into everything from astrology to zoology, including Margaret Mead, Frank Oppenheimer, Barbara McClintock, Charles Darwin, and many others. Good reading for anyone intrigued by science and scientists, this book should be a source of inspiration to high-school and college-age would-be scientists.

***Geophysical Data Analysis: Discrete Inverse Theory* by William Menke. 1984. Academic Press, Orlando, Fla. 260 pp. + xii. $42.50.**

Inverse theory is a set of methods used to extract inferences about the world from physical measurements. Fitting a straight line to data is a simple application; tomography, a more sophisticated one. There are different theories for physical properties with discrete parameters (matrix equations) and continuous functions (integral equations). This book is an introduction and as such only deals with discrete inverse theory, in which parameters either are truly discrete or can be approximated so. The theory is within the reach of most beginning graduate students and many college seniors. There are four parts: general background and review of concepts from probability theory; the solution of linear problems with Gaussian statistics; non-Gaussian, non-linear problems; and examples of application with a discussion of numerical algorithms for doing these problems on a computer.

***Proceedings of the Joint Oceanographic Assembly 1982: General Symposia.* 1983. Canadian National Committee/Scientific Committee on Oceanic Research, Ottawa, Ont. 189 pp. 189 pp. + viii. $25.00 Canadian.**

The 1982 Joint Oceanographic Assembly was held at Dalhousie University, Halifax, Nova Scotia. This publication contains a selection of papers from the Assembly's general session. The papers are grouped into four topic areas: major advances in oceanography, the ocean and climate, ocean resources (fish), and paleoceanography. Abstracts of the poster sessions, reproduced on microfiche, are included in a pocket.

***Upstream: A Voyage on the Connecticut River* by Ben Bachman. 1985. Houghton Mifflin Company, Boston, Mass. 217 pp. + ix. $15.95.**

The Connecticut River begins in a tiny pond in northern New Hampshire, just a few hundred yards from the Canadian border, and ends in Long Island Sound after a journey of some 400 miles. In this book, the author describes his discovery of the river. He journeyed up from outside its mouth to its headwaters, traveling by canoe, tugboat, train, and on foot. He writes of wildlife and human life, the physical causes of the river, and man's effects on it throughout our long history of relationship.

Ships and Sailing

***The Ships and Aircraft of the U.S. Fleet* by Norman Polmar. 1984. Thirteenth edition. Naval Institute Press, Annapolis, Md. 559 pp. $29.95.**

This volume describes the U.S. Navy in the mid-1980s as the fleet undergoes a large peacetime buildup. Compared to past editions, this one gives increased coverage to naval aviation, electronics, nuclear weapons, the Marine Corps, Rapid Deployment Force, Navy and Marine organization and personnel, and shipyards. All in all there are 31 chapters, from "State of the Fleet" through "Electronics;" five appendices on the Coast Guard, NOAA, advanced technology ships, shipyards, and a reading list; and indices of ship names, classes, and designations. The book is generously illustrated with black-and-white photographs.

***A Seaman's Guide to the Rule of the Road: A Programmed Text on the International Regulations for Preventing Collisions at Sea, 1972 with Amendments in Force from 1983. 1983.* Third edition. Naval Institute Press, Annapolis, Md. 457 pp. +xvi. $13.95.**

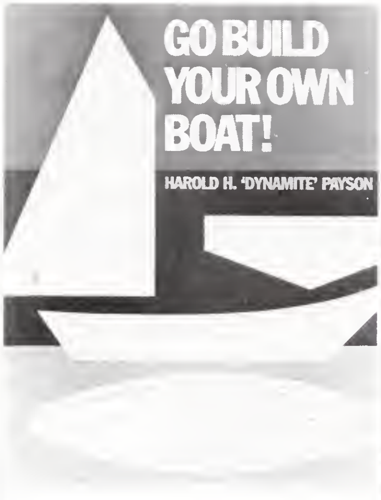
A small, programmed learning guide designed for the British Royal and Merchant Navies, this book teaches the international regulations for preventing collisions at sea and is meant to be used in conjunction with sea-going experience. A general knowledge of sea-terms is assumed. The instructional portion covers definitions, steering rules, day-time recognition of vessels in special circumstances, night-time recognition, conduct in narrow channels and in restricted visibility, rules for vessels under sail, radar and the rules, and requirements for good seamanship and special circumstances. An appendix covers miscellaneous subjects, and a special section contains the International Regulations for Preventing Collisions at Sea, 1972, with amendments in force from June 1983.

***Boatbuilding Techniques Illustrated* by Richard Birmingham. 1984. International Marine Publishing, Camden, Maine. 312 pp. + viii. $28.50.**

Not a description of how to build a boat, but an aid to troubleshooting for boat builders: the methods, materials, and tools best suited to the job. Preliminary chapters discuss setting up a boat-building project – is it from scratch, a kit, or a restoration? A bibliography, with subjects arranged parallel to the text, is included for those needing more detailed information.

***Go Build Your Own Boat!* by Harold H. 'Dynamite' Payson. 1983. Van Nostrand Reinhold, New York, N.Y. 114 pp. + x. $25.50.**

A how-to book for boat builders, with information on every step from blueprints to launching. Boat design and the phases of construction are discussed, from setting a scale and making a model to making the full-sized craft. The book has three parts, "Building to Your Own Design," "The Pleasures and Perils of Plywood," and "A Miscellany of Simple Solutions." Each chapter is illustrated with lots of photographs and drawings. A glossary defines terms.



***Heavy Weather Guide* by William J. Kotsch and Richard Henderson. 1984. Second edition. Naval Institute Press, Annapolis, Md. 399 pp. + xi. $21.95.**

The science of predicting marine weather and the art of seamanship in rough weather are combined in this updated edition to provide all sorts of sailors with a readable guide to coping with storms at sea. Tropical storms – typhoons, cyclones, and hurricanes – and other kinds of storms are explained, along with vessel design for heavy weather, safety gear and storm preparation, and vessel handling during a storm. There are many charts, drawings, and photographs, and a series of essays by various sailors describing their experiences with heavy weather. A list of information sources, and conversion tables and factors are included.

***The Last Sailors: The Final Days of Working Sail* by Neil Hollander and Harald Mertes. 1984. St. Martin's Press, New York, N.Y. 142 pp. + xiv. $19.95.**

The days of deep-water sail are numbered, and the authors of this book set out to record the final days of working sail by crewing on junks, trading schooners, barges, and other sailing vessels. Along with the vessels and their fittings the authors document the way of life of the working sailor. Eight types of sailing vessel are covered: the Windward Islands schooner, Brazilian *jangada,* Chilean *lancha chilota,* Egyptian *aiyassa,* Sri Lankan *oruwa,* Bangladeshi *shampan,* Chinese junk, and Indonesian *pinisi.* Many excellent black-and-white photos and a color insert illustrate the text.

***Historic Ships of San Francisco* by Steven E. Levingston. 1984. Chronicle Books, San Francisco, Calif. 124 pp. + iv. $8.95.**

A guide to the vessels of the National Maritime Museum of San Francisco, moored at the foot of Hyde Street there. This book begins by outlining San Francisco's long maritime history and detailing the foundation of the museum. It then focuses on the five ships you may board and tour at the museum: the square-rigger *Balclutha,* sailing schooner *C.A. Thayer,* ferryboat *Eureka,* liberty ship *Jeremiah O'Brien,* and World War II submarine *Pampanito.* Also covered is the *Alma,* a scow schooner; briefly described are steam-tug *Hercules* and paddle-wheel tug *Eppleton Hall* (these last three may be viewed from the pier). Altogether, these ships form one of the greatest historic fleets in the country and represent more than 100 years of maritime heritage.

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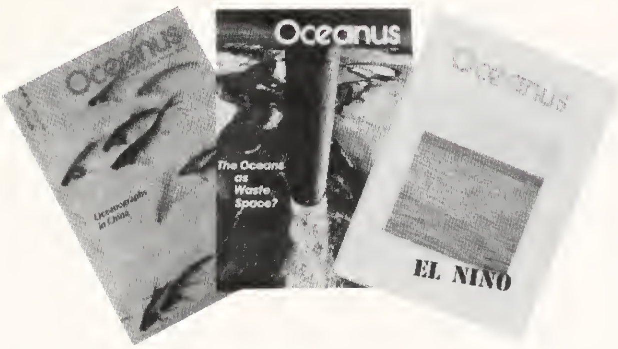

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Issues not listed here, including those published prior to Spring 1977, are out of print. They are available on microfilm through University Microfilm International; 300 North Zeeb Road; Ann Arbor, MI 48106.

- **The Exclusive Economic Zone** Vol. 27:4, Winter 1984/85—An assessment of the options open to the United States in developing its new Exclusive Economic Zone.
- **Deep-Sea Hot Springs and Cold Seeps,** Vol. 27:3, Fall 1984—The biology, geology, and chemistry of hydrothermal vents and sulfide seeps. Other articles on the exploration of lose vent sites and the funding of oceanographic research.
- **El Niño,** Vol. 27:2, Summer, 1984—A comprehensive exploration of the El Niño phenomenon, the oceanic temperature anomaly blamed for abnormal weather worldwide during 1982 and 1983. Articles cover the ocean/atmosphere connection, positive effects of El Niño, its effects on the Earth's rotation, and much more.
- **Industry and the Oceans,** Vol. 27:1, Spring, 1984—Positive uses of the oceans, including genetic engineering, and salmon ranching. Also, a new article on marine science in China, and a history of the Naples Zoological Station.
- **Oceanography in China,** Vol. 26:4, Winter 1983/84—Comprehensive overview of the history of marine studies in China, including present U.S.-China collaboration, tectonic evolution, aquaculture, pollution studies, seaweed-distribution analysis, the changing role of the Yangtze River, and the administrative structure of oceanographic programs.
- **Offshore Oil & Gas,** Vol. 26:3, Fall 1983—Historical accounts of exploration methods and techniques, highlighting the development of seismic theory, deep-sea capability, and estimation models. Also covers environmental concerns, domestic energy alternatives, and natural petroleum seeps.
- **Summer Issue,** Vol. 26:2, Summer 1983—Articles cover the effects of carbon dioxide buildup on the oceans, the use of mussels in pollution assessments, a study of warm-core rings, neurobiological research that relies on marine models, the marginal ice zone experiment, and career opportunities in oceanography. A number of "concerns" pieces on the U.S. Exclusive Economic Zone round out the issue.
- **Seabirds and Shorebirds,** Vol. 26:1, Spring 1983—Feeding methods, breeding habits, migration, and conservation.
- **Marine Policy for the 1980s and Beyond,** Vol. 25:4, Winter 1982/83—The problems of managing fisheries, the controversy over ocean dumping, the lack of coordination in U.S. Arctic research and development, military-sponsored oceanographic research, the Law of the Sea, and international cooperation in oceanographic research.
- **Deep Ocean Mining,** Vol. 25:3, Fall 1982—The science and politics of mining the deep ocean floor.
- **Summer Issue,** Vol. 25:2, Summer 1982—Contains articles on how Reagan Administration policies will affect coastal resource management, a promising new acoustic technique for measuring ocean processes, ocean hot springs research, planning aquaculture projects in the Third World, public response to a plan to bury high-level radioactive waste in the seabed, and a toxic marine organism that could prove useful in medical research.
- **Summer Issue,** Vol. 24:2, Summer 1981—The U.S. oceanographic experience in China, ventilation of aquatic plants, seabirds at sea, the origin of petroleum, the Panamanian sea-level canal, oil and gas exploration in the Gulf of Mexico, and the links between oceanography and prehistoric archaeology.
- **The Oceans As Waste Space,** Vol. 24:1, Spring 1981—A debate over the appropriateness of ocean disposal.
- **Senses of the Sea,** Vol. 23:3, Fall 1980—A look at the complex sensory systems of marine animals.
- **Summer Issue,** Vol. 23:2, Summer, 1980—Plankton distribution, El Niño and African fisheries, hot springs in the Pacific, Georges Bank, and more.
- **A Decade of Big Ocean Science,** Vol. 23:1, Spring 1980—As it has in other major branches of research, the team approach has become a powerful force in oceanography.
- **Ocean Energy,** Vol. 22:4, Winter 1979/80—How much new energy can the oceans supply?
- **Ocean/Continent Boundaries,** Vol. 22:3, Fall 1979—Continental margins are being studied for oil and gas prospects as well as for plate tectonics data.
- **The Deep Sea,** Vol. 21:1, Winter 1978—Over the last decade, scientists have become increasingly interested in the deep waters and sediments of the abyss.
- **Sound in the Sea,** Vol. 20:2, Spring 1977—The use of acoustics in navigation and oceanography.

Psalm 107

23 They that go down to the sea in ships, that
do business in great waters;
24 These see the works of the Lord, and his
wonders in the deep.
25 For he commandeth, and raiseth the stormy
wind, which lifteth up the waves thereof.
26 They mount up to the heaven, they go down
again to the depths: their soul is melted because
of trouble.
27 They reel to and fro, and stagger like a
drunken man, and are at their wits' end.
28 Then they cry unto the Lord in their trouble,
and he bringeth them out of their distresses.
29 He maketh the storm a calm, so that the
waves thereof are still.
30 Then are they glad because they be quiet; so
he bringeth them unto their desired haven.