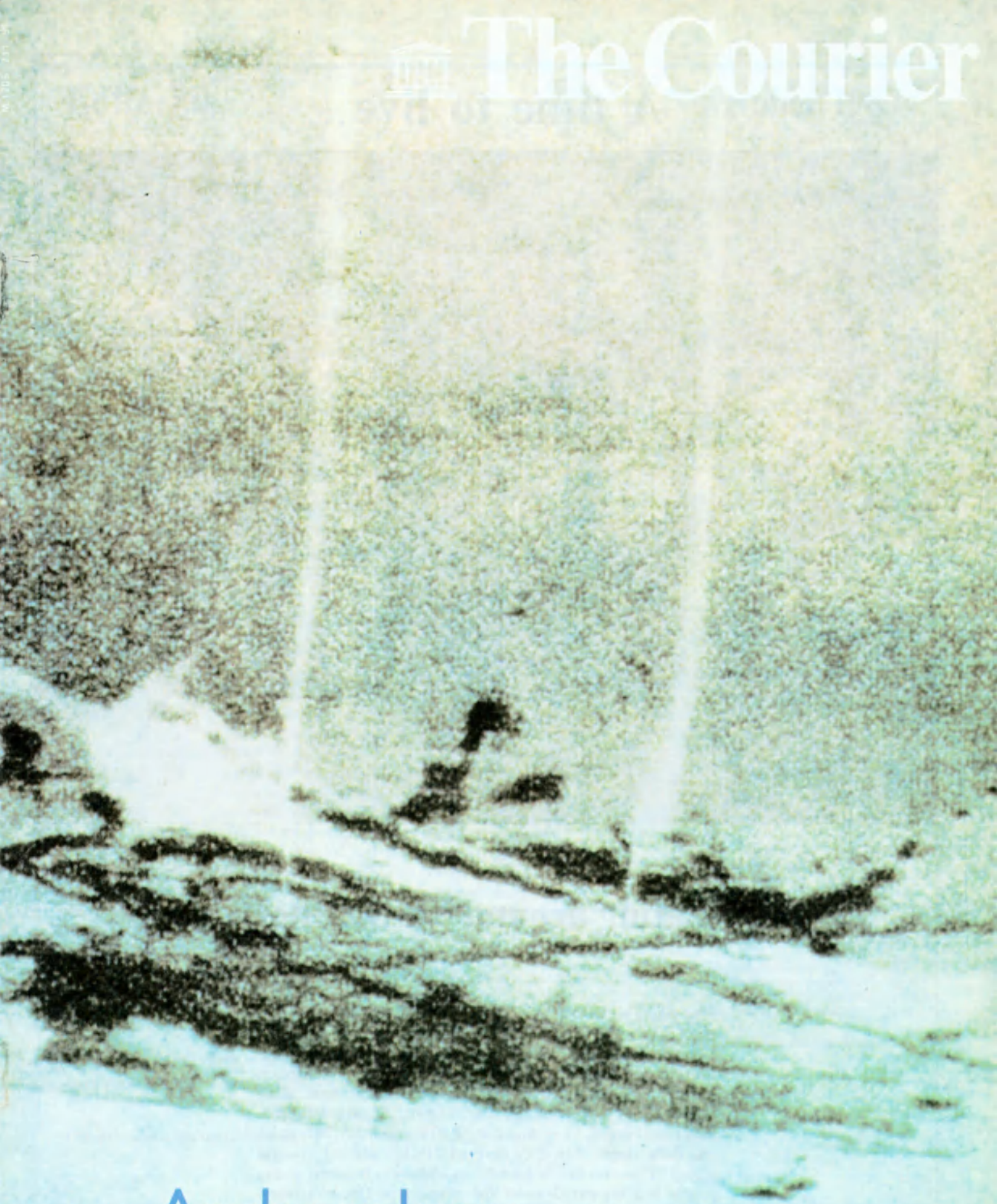
The Courier



Archaeology under water

A time to live...

Photo Unesco/Michel Claude

Roller-skating around the Mediterranean

Five young roller-skaters with an impressive sporting achievement to their credit being welcomed by the Director-General of Unesco, on their arrival at the Organization's Paris Headquarters on 9 September 1987. They had set off from Monaco on 13 July and roller-skated for 5,000 km in the summer heat, along often difficult routes through Italy, Tunisia, Algeria, Morocco, Spain and France. They skated some 90 km each day, except for one daily stage when they covered 216 km and set a world record. This exercise in friendly co-operation between young people was organized under the auspices of Unesco's International Fund for the Development of Physical Education and Sport (FIDEPS), as the first in a series of international sporting and cultural events designed to further the objectives of the Fund.

Editorial

Almost forty-five years ago, the French explorer Jacques-Yves Cousteau and the engineer Emile Gagnan invented the aqualung (Scuba), a self-contained underwater breathing device, and opened up a new era in the exploration of the ocean floor. Before the aqualung, divers were weighed down by heavy, cumbersome equipment which severely limited their underwater stamina and work capacity. With the aqualung vast areas of the sea floor became accessible to human curiosity—to marine biologists, to photographers, and to archaeologists.

Since that time underwater archaeology has made great strides. A number of spectacular discoveries, excavations and rescue operations (a selection of which are described in this issue) have captured the imagination of a wide public. Meanwhile, away from the limelight, great progress has been made in the development of underwater archaeology as a discipline on a par with land archaeology. This is a science which brings together not only professional and amateur archaeologists but sports divers, geologists, architects, surveyors and marine historians, as well as the geophysicists and electronic engineers who help to search the seabed and pinpoint remains through the use of remote sensing equipment. Underwater archaeologists are today adding to our knowledge of the past in many ways. Ancient wrecks are "time-capsules" which, when scientifically studied, can provide a microcosmic picture of life in the civilizations which produced them. On a larger scale, the collection, collation and interpretation of a growing mass of data accumulated from individual wrecks and underwater sites which are often not spectacular in themselves are throwing new light on ancient technologies and patterns of trade, changing sea levels, ancient settlements and migrations, helping us, in short, to understand human use of the sea and lakes over several millennia.

This issue presents a selection of reports on the activities of underwater archaeologists working in different world regions, in different marine environments, on different types of site, using different methods, on projects of different scales. The reports cover not only investigations of marine shipwrecks, but of submerged inland sites, as well as harbours, cities and even a vast landmass, now located underwater as a result of various kinds of natural occurrences. Finally, two articles reflect Unesco's concern about the protection of archaeological sites and the need for action to combat the looting of underwater sites and the growing illegal traffic in archaeological treasures.

Cover: A ghostly ship looms out of the past in this side-scan sonar image of the wreck of an early 19th-century Great Lakes sailing vessel with masts still standing. Sound pulses reflected from 70 metres down show the ship, which sank in 1813, in black, casting a white acoustic shadow that outlines her masts.

Back cover: A diver surveys a hull at a wreck-site off the coast of Gabon.

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Underwater archaeology, a new scientific discipline with a wide popular following

Plunging into

THE origins of underwater archaeology can be traced back to the time, about a century ago, when a handful of intrepid archaeologists began to use helmet diving methods or employ sponge divers to look at submerged ruins and wrecks. These methods were used on perhaps a dozen sites in all until the end of the Second World War, when the aqualung, a self-contained underwater breathing device invented by the French explorer Jacques-Yves Cousteau and the engineer Emile Gagnan, made it possible for scientists and explorers to work cheaply and easily in waters up to 50 metres deep.

Hundreds of books and magazine articles have now been written about underwater archaeology. In particular, in the last thirty years a number of underwater excavations have received massive publicity (see page 12). These finds, surveys and excavations have been vitally important, and have furthered the art and discipline of underwater surveying, stratigraphy, and the interpretation of ancient seafaring. Such major wreck excavations which have produced well-preserved artefacts form the high points of underwater archaeology.

However, to present another review of the high points of the last thirty years might suggest that underwater archaeology has become intellectually and spiritually dead, living off the grandeur of its achievements. The truth is that underwater archaeology has been spreading like wildfire. There are now many thousands of underwater sites

the past

by Nicholas Flemming and Mark Redknap

known throughout the world, ranging in age from 45,000 years to a few decades, from Stone Age quarry sites in Tasmania to American War of Independence gunboats; from the floor of the Mediterranean to Alpine lakes and sinkholes in Mexico and Florida. Hundreds of professional archaeologists spend at least part of their time supervising underwater sites, whilst thousands of amateur diving archaeologists assist the professionals in many dozens of countries.

Many developing countries now support scientific work on underwater archaeological sites ranging from the seventeenth-century Portuguese vessel off Mombasa (Kenya), and trade centres dating from the ninth to the twelfth century off Malaysia, to pre-European craft off Korea and Thailand, and early ports and wrecks off the southeast coast of Sri Lanka (see page 37). This increasing awareness of the cultural importance of archaeological sites in the maritime zone by governments and institutions is extremely encouraging.

The vast number of sites which are now known provide professional archaeologists with vital new opportunities. Whilst the sites are not all of equal value, and some are mundane, the accumulation of data means that experts can search for correlations, evolution and trends through time, spatial patterns and differences, links and causes. Instead of treating artefacts only as objects of beauty or technical achievement, the archaeologist can start to interpret them as parts of culture, trade, economics, politics, and patterns of living. Obviously the archaeologists working on the earlier excavations used comparisons with land sites to make such tentative deductions, but the sheer accumulation of information now means that much more sophisticated analysis can be attempted on the basis of comparison between underwater sites.

These vast assemblages of similar underwater sites of similar ages mean that we can start to understand how peoples and cultures related to the sea or lakes in each millennium and century. That is a grand objective. As the number and variety of sites has increased, the age barrier has been pushed further back in time.

In the 1950s the earliest known shipwreck was the Gelidonya Bronze Age ship at 1200 BC (some others were earlier than about 200 BC), and the earliest known harbours about 600 BC. The age of ship finds has only been pushed a little way back, with the discovery in 1982 of the fourteenth-century BC ship near Kas off the coast of southern Turkey (see page 12), but the number of known ships older than 2,200 years has increased significantly, filling the gaps.

The age of known harbours and coastal occupation sites has been extended dramatically, first with Bronze Age harbours (1500 BC) found in the late 1960s and early 1970s in Greece and Israel; then with Neolithic and Mesolithic settlements (5,000-10,000 years old) found in the Baltic, and off the coasts of Greece, Turkey, Israel and the United States; and most recently Palaeolithic artefacts, found in the North Sea, and off the coast of France, Italy and Greece, ranging in age from 10,000 to 45,000 years. We are now in a position to consider studying the whole sweep of the evolution of human culture in its relation to the sea over the last 40,000 years.

During the last Ice Age, from approximately 120,000 to 5,000 years ago, the sea level was lowered as much as 150 metres, as so much water was locked up in the form of ice in the great ice caps on the continents. As a result, most of the continental shelves of the world were dry, and Palaeolithic tribes could walk from Siberia to Alaska, from continental Europe to Britain, from the Soviet Union to Japan, and most of the way from Asia to Australia. Today underwater archaeology is contributing to our knowledge about these prehistoric migrations.

High standards of stratigraphic recording are now considered routine underwater. In the 1950s, Professor George Bass pioneered the techniques which enabled divers to maintain the same standards of recording as would be expected on land, producing accurate descriptions of deposits and using grids to produce precise site plans. Over the decades, improvements in electronic positioning, sonar imaging, and the use of underwater survey equipment and tape-recorders for fast on-site data collection, have improved the procedures, and made work faster. But the objective is always the same: to record the three-dimensional structure of a deposit, whether a wreck or an occupation site, so that the sequence of accumulation of artefacts and natural debris can be understood. This time-sequenced accumulation can then be unscrambled in reverse, so as to get as close as possible to the conditions and mode of use of the artefacts at the moment before deposition.

The stories presented on the following pages are a small selection of the many hundreds of underwater archaeological research projects at present underway in many countries. They range from large excavations centred on major museums to the excavations of modest wrecks by amateurs. They are typical of projects in the 1980s. Above all, they show a healthy level of energy, dedication to detail, and stimulating response to new ideas.

Where does underwater archaeology go from here? Firstly, we should perhaps be cautious and cast doubt on the theory that underwater archaeology has reached maturity. Conflicts between amateurs and professionals, between souvenir hunters and archaeologists, between treasure-salvors and those concerned with presenting and preserving the past for the benefit of present and future generations still create continuous problems. Nor have legislation and attitudes really evolved to contain the conflict. A great deal of educational effort, in the broadest sense, is needed to bring order.

The World Confederation of Underwater Activities (CMAS) is currently carrying out a survey of the underwater cultural heritage in an attempt to meet the need for an overall assessment of the present state of underwater archaeology and for greater exchange of this information (see box). Questionnaires on both marine cultural resources and inland underwater sites have been sent out by CMAS to 151 countries. Information on national inventories describing the numbers of underwater and marine artefacts in various countries, have been received from Europe, Africa, Asia and the entire Mediterranean littoral. The survey aims to produce a consultative document including specific recommendations for increased support for research.

There is a growing awareness that the underwater archaeological heritage belongs to the population at large, to the nation, to the community and that nobody has the right to destroy it or exploit it for private gain. If a wreck or city is too expensive to excavate and preserve in the dry, then it should be left and protected underwater. In parallel with principles applied on land in many countries, if social priorities demand the construction of a harbour, motorway, barrage, or oil well, then preventive archaeology should be carried out first.

Another important trend in underwater archaeology today relates to co-operation between amateurs and professionals. It has been suggested that tens of millions of people have an interest in archaeology, that there are two million or so sports divers, a few hundred professional archaeologists, and a few tens of professional treasure hunters. Many professional underwater archaeologists stress that their work would be impossible without amateur assistance.

Since there are now sports diving federations in over sixty-five countries, and most of them show serious interest in underwater archaeology, it is not surprising that the number of new sites reported to the authorities should be increasing rapidly. In the Mediterranean, for example, most known ancient wrecks are from areas where there are the most sports divers, in the south of France. Similarly, most Neolithic sites have been discovered off the coasts of Denmark, Israel and Florida, where sports divers and professionals have combined to search for them. Since sports diving is rather expensive as a hobby, it tends to spread progressively to more and more of the developing countries as they increase their level of technology and raise the economic standard of living. We can therefore expect a steady increase of new data from the coasts of Asia and Africa in the coming years. ■

NICHOLAS C. FLEMMING, *of the UK, is president of the Scientific Committee of the World Confederation of Underwater Activities. He has many years experience in archaeological diving on submerged terrestrial sites, and is the author of many articles and books on the subject. He is the co-editor (with P.M. Masters) of* Quaternary Coastlines and Marine Archaeology, Towards the Prehistory of Land Bridges and Continental Shelves, *published by Academic Press, London (1983).*

MARK REDKNAP, *British archaeologist specializing in Roman and medieval pottery, is secretary of the Archaeological Committee of the World Confederation of Underwater Activities. He has excavated widely both under water and on land.*

Photography is an essential tool for the underwater archaeologist who, like the excavator of any archaeological site, must record the locations of finds and make an accurate survey of the site. Stereophotogrammetry is today widely used to produce accurate site-plans from stereoscopic photos taken at different points along a frame. Right, a diving archaeologist sets up a camera mounted on a boom ready for stereophotogrammetry. Since it is generally impossible to encompass the whole area being excavated in a single photo, archaeologists fit a number of photos together like a jigsaw puzzle to give a general impression of the site. Below, photomosaic of the wreck of the 17th-century Swedish vessel *Kronan* in the Baltic (see article page 26). The main problems in photography under water are that light, colour and contrast are lost with increasing depth.

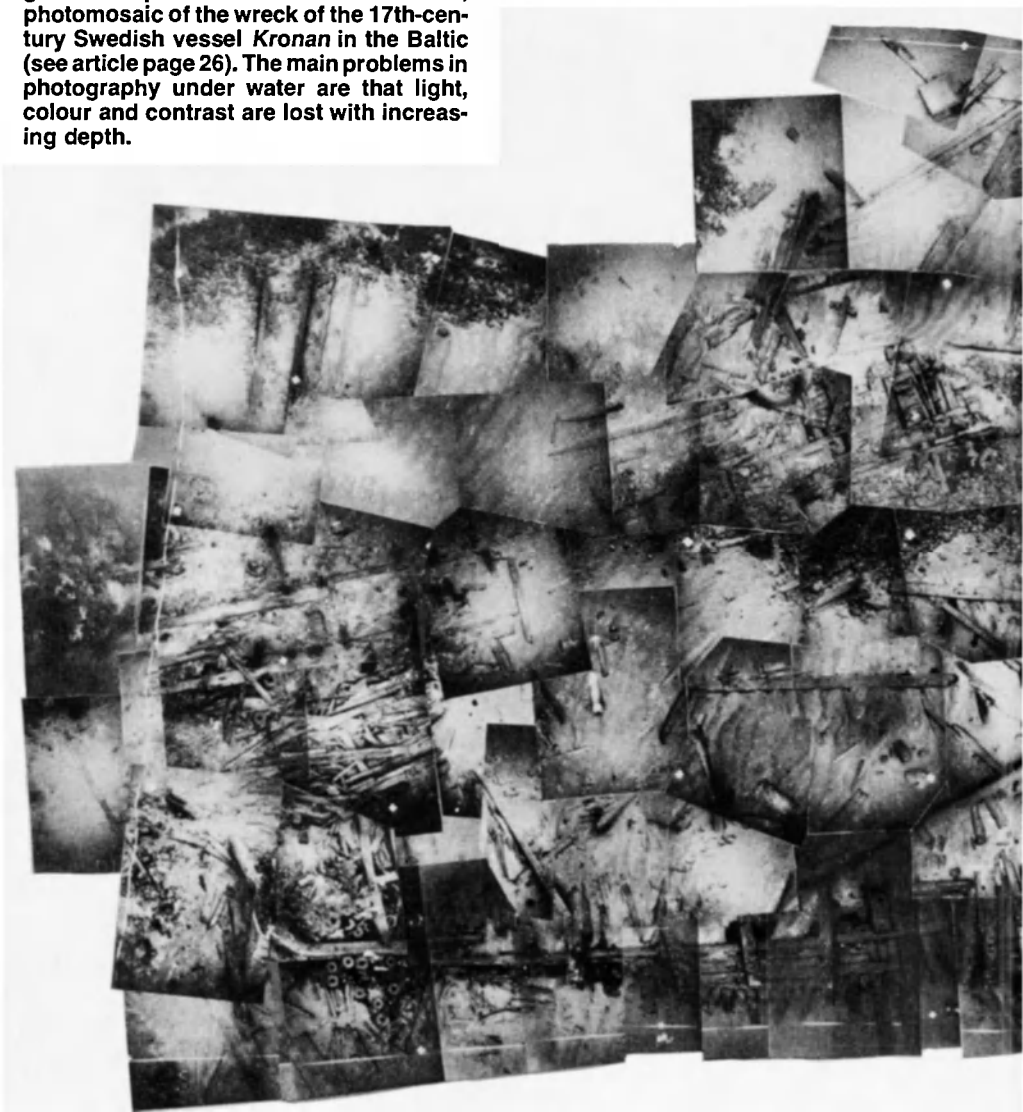

Photo Claude Rives © CEDRI, Paris

Photo © Kalmar County Museum, Sweden

An international survey of the underwater heritage

The Scientific Committee of the World Confederation of Underwater Activities (CMAS) is currently carrying out an international survey of the underwater cultural heritage. The survey, which is being prepared with Unesco support, will review marine cultural resources and inland underwater sites, mechanisms for their protection, shipwreck data bases and underwater cultural heritage inventories, ways of disseminating results, and the priorities for underwater archaeological research. The survey is designed to record submerged archaeological remains without giving away their locations.

CMAS, which has also produced an International Code of Practice for Scientific Diving, is an international non-governmental organization which groups national bodies concerned with the training and safety of non-military and non-commercial divers involved in the fields of sport, photography, science, conservation, medicine, and the technology of diving equipment. Its Scientific Committee, established in 1970, includes representatives from bodies concerned with professional diving and has Commissions on biology and conservation, technology, geology and archaeology.

Already a number of sites of importance for marine archaeology have been included on Unesco's World Heritage List of properties of outstanding universal value. These sites are covered by the system of protection and international co-operation organized by the World Heritage Convention adopted by the General Conference of Unesco in 1972 (see the *Unesco Courier*, October 1987). They include the Great Barrier Reef (Australia), where a number of shipwrecks of historical interest are known, including that of *HMS Pandora* (see colour pages) which ran aground there in 1791. Also on the List are the island of Gorée (Senegal), the great classical cities of Carthage (Tunisia) and Leptis Magna (Libyan Arab Jamahiriya), and the ruins of Kilwa Kisiwani and Songo Mnara (United Republic of Tanzania), whence merchants once controlled a large proportion of trade in the Indian Ocean.

The Mediterranean, an underwater museum

by Anthony J. Parker

THE formative cultures of European history, especially the far-reaching Roman Empire, grew up around the Mediterranean Sea. They were thus involved with seafaring, fishing and seaborne commerce from the earliest times. Even in the seventh millennium BC, finds of obsidian and fish-bones in prehistoric settlements in Greece show that the sea was not an insuperable barrier.

In the classical period, cities such as Athens or Rome could not have survived without a regular supply of food and raw materials from overseas, brought by hundreds of sailing ships. An observer, gazing out over the Mediterranean from a cliff or a mountain top on a summer day some time in the last two centuries before Christ or the first two centuries of the Christian era, would have seen the blue sea dotted with sails.

The Mediterranean, though effectively tideless, and enjoying good visibility and calm weather for much of the summer, can still hold dangers for sailing ships. There are many low, sandy coasts which lack navigation marks and natural havens; there are also rocky, mountainous coasts where ships can be held up by contrary winds, or overwhelmed by squalls. Mediterranean currents, too, though they are scarcely noticed by modern, powered ships, are strong enough, if combined with other hazards, to place a small sailing ship in danger.

The magnetic compass was unknown to the classical world: ships navigated the Mediterranean by looking out for landmarks such as mountains, or by watching the stars at night. A sudden storm could therefore endanger the ship, not just if it were to be overwhelmed or made to leak, but by blotting out the sky or the horizon so that the ship sailed unawares into danger.

Small wonder, then, that there were many shipwrecks in classical Antiquity. The actual total number of ships lost is unknown—it must run into scores or hundreds of thousands—but the dangers of sailing (especially outside the best months of the year) were well known, and are mentioned by many writers, both Greek and Latin. Today, almost 1,000 shipwrecks of the classical and medieval periods have been discovered in the Mediterranean and the Black Sea; nearly all of these have been found by aqualung divers in the last forty years.

This body of information, which is continuing to grow at the rate of between fifty and a hundred new sites every year, offers great opportunities to archaeologists and historians to find out more about the commerce and economy of the ancient world. There are, of course, plenty of difficulties. The shipwrecked cargoes which survive for divers to discover do not, for the most part, include perishable goods such as corn, timber or cloth, which were certainly among the most important items of trade; not all wrecks are well preserved; some areas have not been thoroughly searched; all too many sites have been inadequately excavated, recorded, studied or published; and many divers are concerned only with collecting souvenirs or even making a profit out of selling their finds.

The special qualities of classical shipwreck sites are double—the overall view and the detailed insight. Since almost no statistics referring to seaborne trade survive from Antiquity, the hundreds of lost ships, even though they are individually very varied, can supply a kind of statistic. No master ever chose deliberately to wreck his ship, destroy his cargo and risk his crew's lives: shipwrecks are essentially a haphazard selection from the voyages which were made, though we do not (and cannot) tell whether the selection is really a meaningful sample.

The areas where shipwrecks have been found is one such statistic. The map on page 9 shows how they have been reported from most parts of the Mediterranean, but that the distribution is decidedly uneven. Many coastal areas, and most of the deep sea, have no wrecks at all; conversely, some areas, such as the south of France, which has one-fifth of all recorded sites, bulk disproportionately large because diving is popular in this area, there is a State underwater archaeology service, and most of the known sites have been published.

Another statistic which can be derived from the shipwreck reports is the periods at which voyages were most frequent. The great majority of known Mediterranean shipwrecks date from the Hellenistic and early Roman Empire periods. Knowledge of prehistory, and even of the colonizing and archaic centuries of Greek and Phoenician navigation, remains surprisingly undocumented. On the other hand, the statistics clearly show the revival of Mediterranean commerce in the sixth century AD. In the medieval period (after the Arab conquest of the seventh century AD) there were many changes in seaborne commerce, and so it is not surprising that wrecks of these centuries have rarely been reported.

In order to collect general statistics of this kind, one has to take into account all manner of wrecks, both well-preserved, where the ship's cargo and a good part of her hull lie on the sea-bed much as they came to rest on the day she sank, and mere scatters of broken pottery, often ground into tiny pieces by the waves and mingled with the remains of other cargoes lost at the same hazardous spot. Nor are all the published reports of wrecks of equal value: in fact, over a quarter of all recorded sites have been published only in very summary terms, such as "A Roman wreck two kilometres out to sea...". Figures and diagrams can reduce this very varied material to order for the historian, but there can be no doubt that it is well-preserved and fully-excavated wrecks that with their grouping of cargo, nautical equipment, personal pos-

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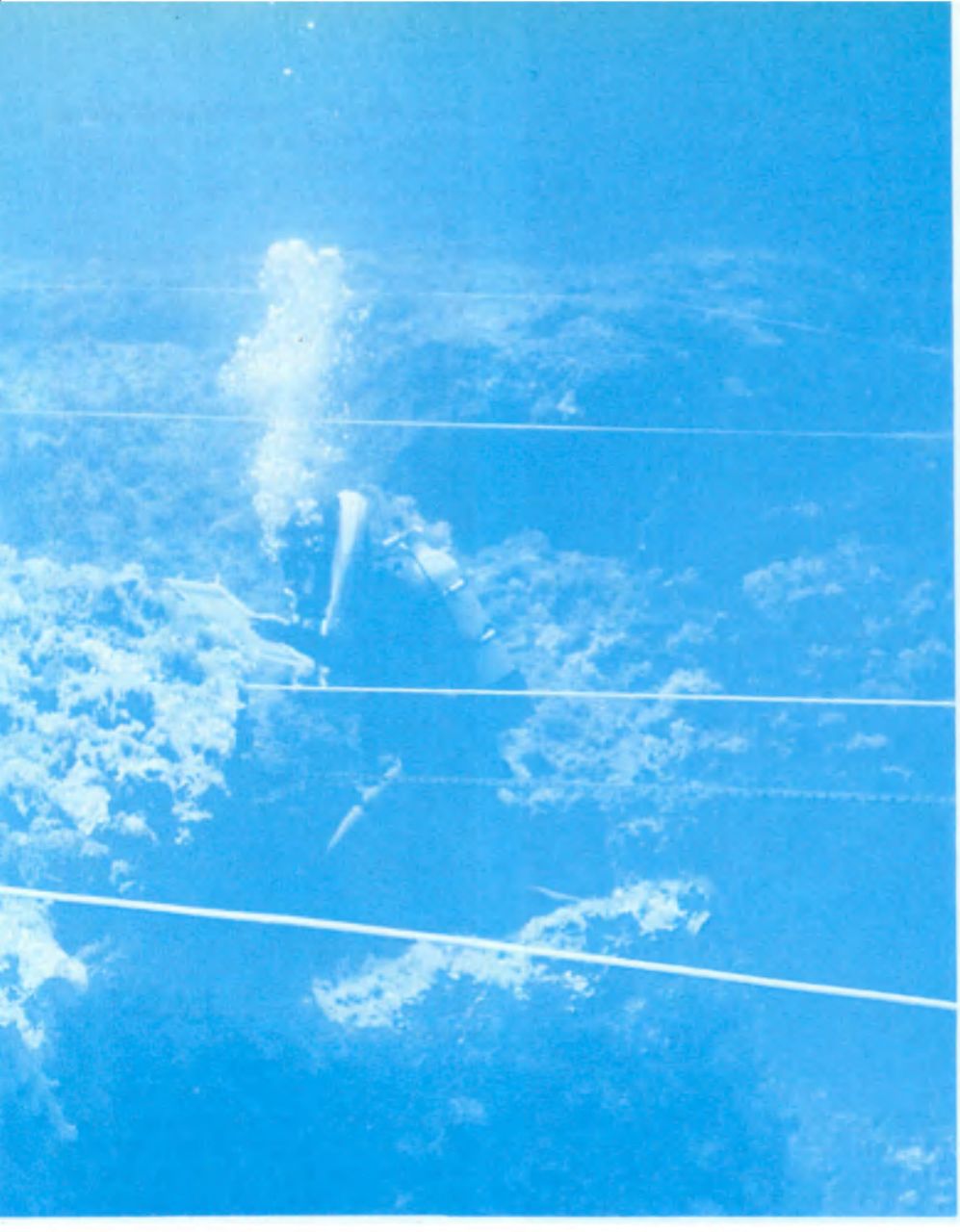
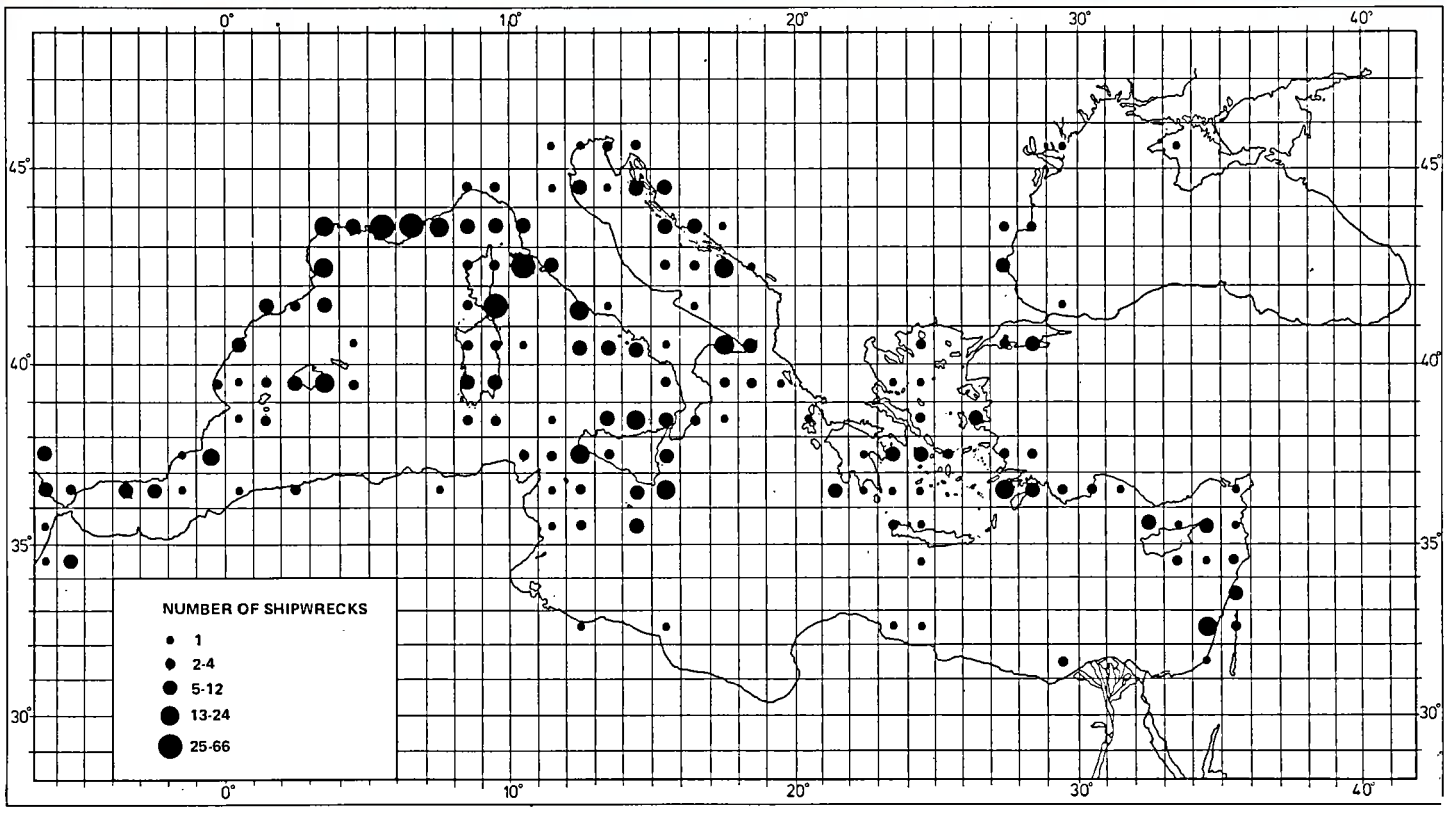


Surveying the site of a 4th-century-AD Roman wreck in the Mediterranean

Photo © University of Bristol, UK

Ancient shipwrecks in the Mediterranean and the Black Sea



Map © Elisabeth Indunì, University of Bristol, UK

CONTINUED FROM PAGE 8

sessions and hull timbers offer real gains to archaeology.

The people and objects on board a ship make up a very special group in any society, but we rarely have similar opportunities on land to catch a glimpse of people and artefacts frozen in the midst of their daily life. This "time capsule" aspect of ancient shipwrecks never fails to enthral divers, as weed, encrustation and sand are delicately stripped from the underlying deposits. Just one example could be cited—the Byzantine wreck of Yassi Ada, excavated by George Bass and Fred Van Doorninck, where the captain, Georgios, had meals cooked in a tiny stone-floored galley in the stern while his quite small ship sailed on with her cargo of anise-flavoured wine, slopping about in a job lot of second-hand jars. One could name many more details, and many other wrecks, which together make up a vivid and ever-growing tapestry of life in the ancient world.

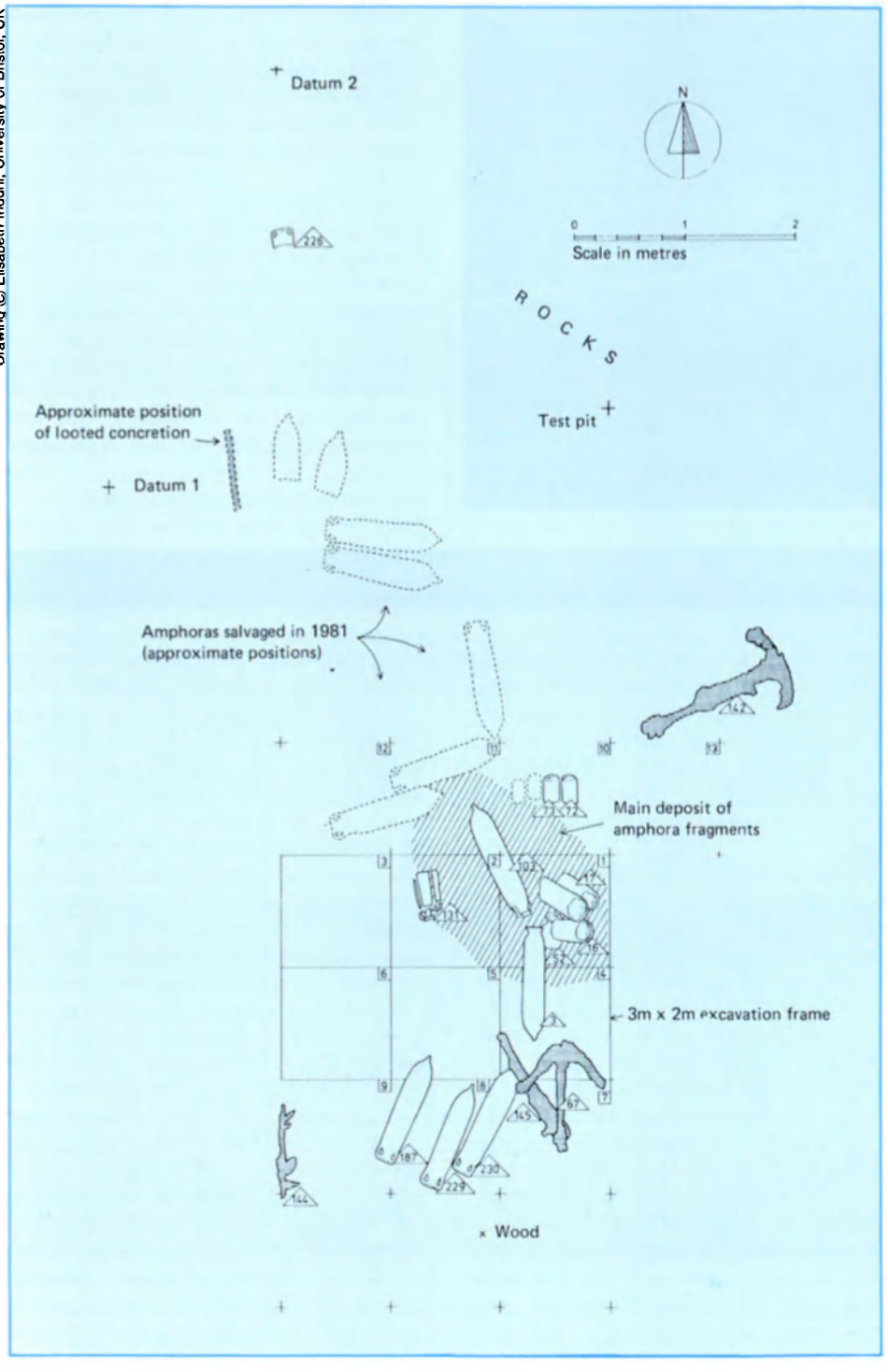
Gathering the threads of this tapestry, however, involves more than merely diving and collecting artefacts. Wreck-sites can only be understood if they are meticulously excavated, fully recorded on site, if the finds are carefully catalogued and conserved, and—most important of all—if enough time, effort and money are spent on making a thorough study of every aspect of the site. The Yassi Ada wreck is one of a mere handful of excavated wrecks which have been anything like properly studied and published.

In the Mediterranean, as elsewhere, wrecks are threatened with destruction from commercial development and casual looting. Portable artefacts such as amphoras are hard to protect by legislation and policing, and often the only way to save a site from destruction is to excavate it as soon as possible.

There are some wrecks, however, which are easier to protect, at least from casual depredation, and they are also often spectacular sites on which to dive. These are the remains of marble and building stone cargoes. At Rome the demand for fine stone with which to construct or finish off buildings had to be met by importing marble and granite from Greece, Turkey, Egypt and other distant parts of the Empire. Naturally, some stone-carrying ships failed to reach their destination, and their cargoes lie lost and abandoned along the sea-routes of the Mediterranean. To swim under water among the great blocks of stone is an aesthetic and an evocative experience.

Let us hope that these sites can be left as they are, with some protected status and with a guardian boatman in charge, to serve as exciting and instructive underwater monuments which tourists (with aqualungs, snorkels or even glass-bottomed buckets) can view, just as (in another dimension) they might visit the Colosseum or the Parthenon on land. ■

ANTHONY J. PARKER, *of the UK, is lecturer in Roman archaeology at Bristol University. He is the author of a forthcoming comprehensive review of pre-16th-century wrecks in the Mediterranean.*



Drawing at left is an example of site-mapping as practiced by underwater archaeologists. It shows the wreck of a small Roman merchant ship which ran aground on the beach of Randello, on the south coast of Sicily, around AD 300, while carrying a cargo of sardines preserved in brine and stored in amphoras. Almost 1,700 years later, in 1982, the wreck was excavated by a team of archaeologists from British universities, with the help of the man who found it, Dott. Giovanni D'Andrea, and the assistance of the Sicilian authorities. Analysis of fish-bones in the amphoras revealed that the sardines had "been processed in a permanent, professional fish-factory", writes Dr. Anthony Parker. "The clay and shape of the amphoras point to the Sado estuary of Portugal as the place where this was done; in the ruined Roman town of Troia, at the mouth of the estuary, batteries of fish-salting tanks can still be seen. The salt-pans of the Sado are traditionally renowned for the fine flavour of their salt, and a century ago the fishermen of the area were recorded as using boats and nets for catching sardines in a way which is extraordinarily like not only what we know of Roman fishing in general but also what can be inferred from the Randello sardine bones."

A Roman freighter yields its secrets

The Madrague de Giens wreck

by André Tchernia

Photo © Chéné-Réveillac, CNRS-University of Provence, France

Part of the cargo of amphoras carried by the Roman merchantman wrecked off the south coast of France near La Madrague de Giens.

FOR eleven years, from 1972 to 1982, diver-archaeologists of the Archaeological Institute run jointly in Aix-en-Provence (France) by the University of Provence and the National Centre for Scientific Research (CNRS), pitched camp each summer in a pine wood overlooking the sea on the southern shore of the Giens peninsula, some thirty kilometres east of Toulon.

A Roman wreck had been discovered near the little fishing port of La Madrague de Giens in 1967, and since it was lying at a reasonable depth—18 to 20 metres—and had not, like so many others, been pillaged by looters, it was chosen as the site of the first truly scientific underwater excavation carried out in France on a considerable scale. Three years of work were planned: little did we know, at the time, that the wreck would prove to be one of the two or three largest ancient ships whose remains have ever been found under the sea.

The method adopted is easier to describe than it was to implement, given the nature of our equipment and changing conditions at sea. It meant extricating the objects carefully and completely using an air pump, without moving any one of them before its position had been recorded; attaching clearly visible numbers to all the amphoras and other important objects; carrying out a stereoscopic photographic coverage of the area explored; raising to the surface the objects thus identified, and continuing to probe, level by level, as far as the hull. Lastly, we carefully examined the hull itself and dismantled parts of it in order to determine how it had been constructed.

The ship was wrecked some time around 70-60 BC. It was carrying a cargo of wine from Italy—to be precise, from the region of Terracina: we know the location of the workshop where most of the amphoras in the cargo were manufactured. It measured nearly 40 metres in length, and could carry 7,000 or 8,000 amphoras, which gave it a tonnage of 350 to 400 tons: a respectable capacity for any traditional sea-going vessel as late as the nineteenth century.

But we did not find so many thousands of amphoras on the sea-bed. Firstly because, on its last voyage, the ship was not fully loaded with wine. An extra cargo, consisting of crates of black glazed pottery, had been packed on top. Secondly, and above all, because we were able to establish that divers—probably professionals—had come to salvage the sunken cargo shortly after the wreck, and had raised to the surface at least half of the amphoras. There were two consistent pointers to this. The wreck is strewn with large stones; a geological study has shown that they very probably came from the peninsula itself, or from the opposite coast adjoining the town of Hyères. These are the stones used by skin divers in order to plummet more quickly to the sea-bed, as sponge divers have done for centuries throughout the Mediterranean.

Furthermore, scrutiny of photographs and plans produced during the excavation reveals beyond a shadow of doubt that, despite the displacement of the cargo during and after the wreck, while three layers of amphoras are still in place on the port side, there is only one layer to starboard. In some places there are even holes in the cargo, and one or two isolated amphoras have remained embedded in the volcanic sand which, to aft, was used both as ballast and to hold the amphoras in place, whereas those next to them were hoisted on board the boat used as a base by our predecessors in Roman times.

Studying the hull called for the most spectacular measures. In order to examine the keel and take samples from it, it was necessary to dig a tunnel under the hull and to use underwater chain-saws. The fragments removed were taken apart and studied trenail by trenail on land, then reassembled exactly as before and returned to their place in the wreck.

The most important finding was the confirmation that the strongly curved hull profile and the depth of the keel would certainly have prevented the ship from drifting very much and would have enabled it to sail to windward. The elaborate form of the hull would have compensated for the large, non-specialized sails of ancient ships and given it speed. Forward, an inverted stem and a bobstay piece added the finishing touches to the ship's nautical qualities.

Patrice Pomey drew up a detailed plan of the hull and superimposed it on a much later picture of a ship represented on a Tunisian mosaic. The proportions are exactly the same: the upward sweep fore and aft begins at exactly the same point, and the bilge pump and the masts are in the same positions. From this we must draw three important conclusions: that this mosaic, and probably many others, represent ancient ships with much more realism and accuracy than might be supposed; that the missing parts and the sails of the Giens wreck must have been similar to those on the mosaic; and that this type of ship was built to a virtually identical pattern for more than three centuries.

Five years after the end of the excavation, an exhaustive study of the results is still far from complete. Further observations will be made. It is a pity that no other way of preserving this great sailing ship of Antiquity could be found than covering it with sand again and leaving it buried where we had found it. ■

ANDRE TCHERNIA, *of France, is assistant director of the sciences of man and society at the National Centre for Scientific Research (CNRS). In 1967 and 1968 he served as France's first director of research in underwater archaeology. With Patrice Pomey he directed, under the auspices of the CNRS, the excavations of the Madrague de Giens shipwreck from 1972 to 1982.*

Ten great discoveries

On this double page and overleaf we present a selection of discoveries and achievements of underwater archaeology in the last two decades which have attracted widespread publicity and have contributed to the growing popular interest in the underwater heritage.

One of the Riace statues shortly after being recovered from the sea
Photo Giansanti © Sygma, Paris

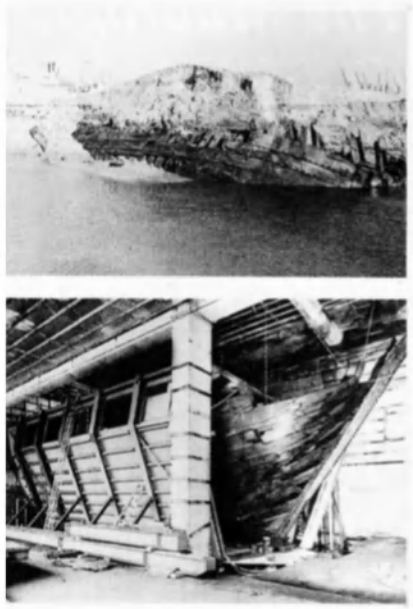
ITALY
The Riace warriors

In August 1972, a Roman skin-diver discovered two large bronze statues representing human figures near Riace on the Calabrian coast of southern Italy. He immediately informed the archaeological authority for the area, and the statues, about 2 metres high and weighing over 150 kilos, were recovered from the sea-bed and brought back to land. Authentic examples of classical Athenian art, it is thought that they may have belonged to a group of 11 statues intended to decorate the temple at Delphi. Some specialists believe that they are the work of the great Greek sculptor Phidias who, with his pupils, carved the frontispiece and friezes of the Parthenon in Athens. After some 2,000 years of immersion, the restoration of these masterpieces of 5th-century-BC Greek art proved a long and painstaking job. The statues were X-rayed to provide a picture of their internal structure and the thickness of their different parts in order to choose appropriate restoration materials. Research revealed that metals other than bronze were used for certain parts of the statues. The teeth and eyelashes of one of the figures are in silver, lips are of copper, ivory was used for whites of the eyes and vitreous paste and amber for the iris. The statues are now preserved at the Magna Graecia Museum in Reggio di Calabria, where they were shown to the public for the first time 7 years after being discovered. (See Unesco Courier, November 1981)

Map Jack Kelly, courtesy *Archaeology* Vol 38, 4 © Archaeological Institute of America 1985

TURKEY
'Metal biscuits with ears'

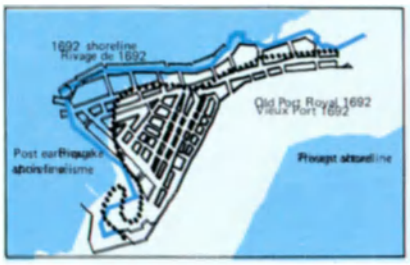
This was how a young sponge diver described the objects he had spotted lying on the sea-bed, in the autumn of 1982, less than 100 m from his home village of Kas. For the experts from the Bodrum Museum of Underwater Archaeology, this image recalled the copper ingots recovered in 1960 from a shipwreck at nearby Cape Gelidonya. The US archaeologist George Bass and his team from the Institute of Nautical Archaeology of Texas A & M University, who had studied the Gelidonya wreck, immediately launched plans to excavate the site, which has pushed back knowledge of the shipbuilding techniques of Antiquity as far as the Bronze Age. The copper ingots found in the Kas wreck resemble an ingot depicted in an Egyptian tomb at Thebes dating from 1350 BC (copper was combined with tin to make the bronze from which the era takes its name). The discovery of a miniature seal, no larger than a button, with markings similar to those used by ancient Greek merchants, suggested the origin of the vessel. Among the finds in the wreck are many precious objects in gold, pottery, amphoras from Canaan, Mycenae and Cyprus, as well as cobalt-blue glass ingots, the earliest glass ever found, probably intended for making jewellery or goblets. The wreck is still giving up its rich cargo, and the remains of the hull will perhaps supply vital information on the type of ships in use at the time of the Trojan Wars.



Photos © Deutsches Schiffahrtsmuseum, Bremerhaven, Fed. Rep. of Germany

FEDERAL REPUBLIC OF GERMANY
Conserving the Bremen Cog

When the harbour at Bremen on the Weser estuary in the Fed. Rep. of Germany was dredged in 1962, engineers uncovered a 14th-century merchant vessel or "Cog" preserved in the mud (top). The wreck was rescued with a view to research and conservation. The raising of the Cog, the *Wasa* and the 5 Viking ships from Roskilde Fjord confronted museum conservators for the first time with the problem of preserving huge objects made of waterlogged, soft, old wood. Scientists discovered that such timbers could be protected against the distortions caused by shrinkage which would inevitably occur as they dried by impregnation with a water-soluble wax, polyethylene glycol (abbreviated PEG). After the Cog had been reconstructed from some 2,000 pieces of timber (a task which took 7 years), a conservation tank was built around it so that it could be immersed in a PEG solution (above). Today visitors to the German Maritime Museum at Bremerhaven can see the resubmerged vessel through windows in the tank, where it will be immersed for many years. Controlled drying will then take place and the tank will function as a huge controlled climate chamber.



Map Reinhardt and Cavanagh, courtesy *Archaeology* Vol. 37, 1 © Archaeological Institute of America 1984

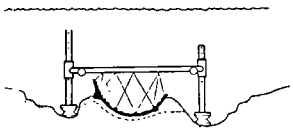
JAMAICA
Port Royal—a submarine Pompeii

Shortly before noon on 7 June 1692, the bustling life of Port Royal (Jamaica) ended in a violent earthquake and tidal wave. Within minutes, nine-tenths of the great Caribbean trading centre lay beneath the waters of what is now Kingston Harbour. Since then many divers have explored its ruins, but not always with the controls and documentation demanded by modern archaeology. In 1978 a plan of collaboration between the Government of Jamaica and the Institute of Nautical Archaeology of Texas A & M University was established, and a thorough research programme was initiated. There are hundreds of submerged buildings to be excavated, offering a wealth of architectural data and artefacts, and work will continue for years to come. A vast quantity of brass, pewter, silver, iron, glass, pottery and wood objects have already been brought to the surface to be restored and studied. The X-ray of one find, an encrusted watch, has revealed the time at which the earthquake struck.

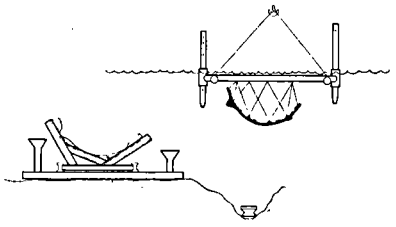
UNITED KINGDOM
Tudor life at sea

On a calm summer day in 1545, as a French invasion fleet lay at anchor off Portsmouth, King Henry VIII's flagship, *Mary Rose,* sailed into her final battle. Probably as a result of poor handling and overloading, she heeled over and sank, so close to the shore that the king, watching her go down, is said to have heard the cries of the drowning sailors. On 11 October 1982, 437 years later, the surviving starboard hull structure of the 700-ton vessel was raised to the surface (see drawings) and towed into Portsmouth harbour as the climax of a great rescue operation which had begun in the late 1960s when maritime archaeologists located the wreck. A survey and exploration programme was carried out by volunteer divers, scientists and archaeologists until 1979, and then the contents of the ship were removed and its structure fully recorded. Divers brought up 17,000 artefacts representing almost every aspect of Tudor life at sea. The internal structural timbers of the hull were dismantled and taken ashore. After being raised in a protective steel cradle, the *Mary Rose* was taken to a special dry dock in Portsmouth dockyard. Today visitors can view the hull, like a giant cutaway model towering to the height of a 4-storey building, and watch the work underway to replace many of the timbers removed during the years of underwater excavation (top right). When this work is complete long-term conservation can begin. The hall in which the ship is preserved is kept at 95 % humidity. The hull is sprayed with chilled water to prevent degradation and uncontrolled drying.

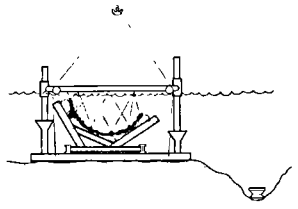
Photo © Mary Rose Trust, Portsmouth, UK



The hull ready for lifting with wires attached to tubular steel lifting frame



The hull in suspension from the lifting frame being transferred underwater to a support cradle



The cradle with the hull ready to be lifted into the air and placed on a barge to be towed ashore

Drawings © Mary Rose Trust, Portsmouth, UK

Photo © Pablo Bush Romero

MEXICO
The sacred well of Chichén-Itzá

Underwater archaeology began in Mexico with the exploration of the *cenote* (sacred well) of Chichén-Itzá (left), a freshwater well with a diameter of 68 m and a depth of 22 m to the surface of the water, itself 14 m deep. The Mayan civilization, a highly developed pre-Hispanic culture of Meso-America, worshipped water deities, and votive offerings were thrown into the well in their honour. The first, unsuccessful, attempt to explore it was made in 1881 to 1882 by the French antiquarian Désiré Charnay. In 1904, Edward H. Thompson, the first United States consul to Yucatán, organized two seasons of diving work to dredge the well, recovering archaeological treasures (jade figures, stone sculptures, gold and copper discs, remains of human skeletons), which went to the Peabody Museum in Harvard University, USA. Other salvage attempts were carried out at later dates. The most recent explorations took place in 1967 to 1968, under the direction of Dr. Piña Chan, of the National Institute of Anthropology and History, Mexico. The team employed various methods, such as lowering the water level almost 4 m and chemically clarifying the water. The divers used the most advanced techniques, and all the artefacts recovered, which will be preserved in museums in various parts of the country, will be studied and classified by specialists from the Institute.

Full-scale replica of a Viking ship from Roskilde Fjord
Photo © Viking Ships Museum, Roskilde

DENMARK
Viking dragon ships

Five Viking sailing ships scuttled over 900 years ago at the entrance to Roskilde Fjord, near the village of Skuldelev in Denmark, were discovered in the late 1950s during underwater excavations organized by the Danish National Museum. In 1962, a cofferdam was built round the site which was pumped free of water so that the wrecks could be excavated as if on land. After lengthy conservation treatment the ships were painstakingly reconstructed. The remains were those of 2 warships of different size, 2 merchant ships, and a smaller vessel, perhaps a ferry or a fishing boat. The larger warship seems to have been at least 30 m long with provision for 26 pairs of oars. Such a longship, designed for speed and manoeuvrability, could have carried up to 60 warriors as well as its crew, and would have been a pillar of Danish maritime power a thousand years ago. One of the merchantmen is almost certainly a *knarr*, a type of broad-beamed ocean-going craft which was described in the Icelandic Sagas and formed the backbone of Viking trade. The Roskilde find provided archaeologists with a unique opportunity in northern waters to study ships built at the same time but for different purposes.

A diver examines a Neolithic site (4000 BC) in Lake Zürich.
Photo © Dr. Ulrich Ruoff, Zürich

SWITZERLAND
Lake-floor archaeology

The archaeological wealth of lakes and other inland underwater sites is much less well known than that of sites located in or near the sea. In Switzerland and its neighbouring countries important discoveries have been made from lake settlements built on piles and dating mainly from the Neolithic period and the Bronze Age (from the end of the 5th century to the beginning of the 1st century BC). In the last 20 years excavations in Lake Zürich, one of the most important centres of these lacustrine settlements, have brought to light Stone Age and Bronze Age axe helves, ladles, flint knives, looms, archery bows, wooden boxes, scraps of netting and textiles, balls of yarn and other finds providing valuable information about prehistoric technology. Four years ago the ground plan of a late Bronze Age house was discovered at a spot where volunteer divers had previously found a collection of small Bronze Age vessels. Today this cultural heritage is in great danger due to construction work on the shoreline, dredging to accommodate shipping, and increased wave erosion in the shore area as protective reeds are removed.

The preserved and reassembled hull of the 2,300-year-old Kyrenia Ship
Photo © M.L. Katzev, Arlington, Vt., USA. Kyrenia Ship Project

CYPRUS
The Kyrenia wreck

Discovered by a sponge-diver, a 4th-century-BC amphora carrier lying in about 30 m of water near the harbour town of Kyrenia, Cyprus, began to be surveyed and excavated in 1968 by a team led by Michael L. Katzev of the University of Pennsylvania. Thus began a programme of conservation and research which has continued for almost two decades and culminated in the building of Kyrenia II, a full-scale, sailable replica of the ancient Greek merchantman (see page 23). The Kyrenia Ship, writes Katzev, "represents the best preserved hull of the Classical Greek period ever found. About 60 per cent of her total area and more than 75 per cent of her representative timbers survived to be recorded in meticulous detail. Five years went into raising the hull piece by piece, preserving it in polyethylene glycol, then mounting it for exhibition in a handsome sandstone gallery of the Crusader Castle at Kyrenia". Its cargo included some 400 amphoras, as well as crockery, millstones, iron ingots, and the remains of nearly 10,000 almonds.

Photo © Wasa Museum, Stockholm

Richly decorated stern of the Wasa. *In the middle, the Swedish national coat-of-arms.*

SWEDEN
Raising the *Wasa*

In 1961, the Swedish warship *Wasa* was raised from the bottom of Stockholm harbour, where she had sunk at the start of her maiden voyage in 1628. This huge vessel, displacing about 1,300 tons and measuring 70 m from stem to stern, was apparently unstable and capsized in 35 m of water. She was remarkably well-preserved: she had not suffered damage from long service at sea, she had not run aground, and, lying at the bottom for three centuries, she had not been damaged by ice or currents nor attacked by wood-destroying marine organisms. The wreck, rediscovered in 1956 by an amateur marine archaeologist and historian, Anders Franzen, is an outstanding testimony to 17th-century naval architecture and life in Sweden. An unprecedented rescue operation was mounted which lasted from 1957 to 1961. The salvaged ship was housed in a special hall where the correct temperature and humidity could be maintained, and sprinklers were installed to prevent premature drying out of the wood. Treatment of the waterlogged timbers was carried out by a system of pipes and nozzles by which every part of the ship was sprayed for more than 10 years with a solution of polyethylene glycol (PEG). By the late 1970s, more than 6 million people had already visited the museum to see this major addition to Sweden's cultural heritage.

Technology and the marine archaeologist

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, USA, 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 raises 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 whose performance would match or exceed those being used at land sites. That goal generally has been achieved.

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 in which that equipment is used.

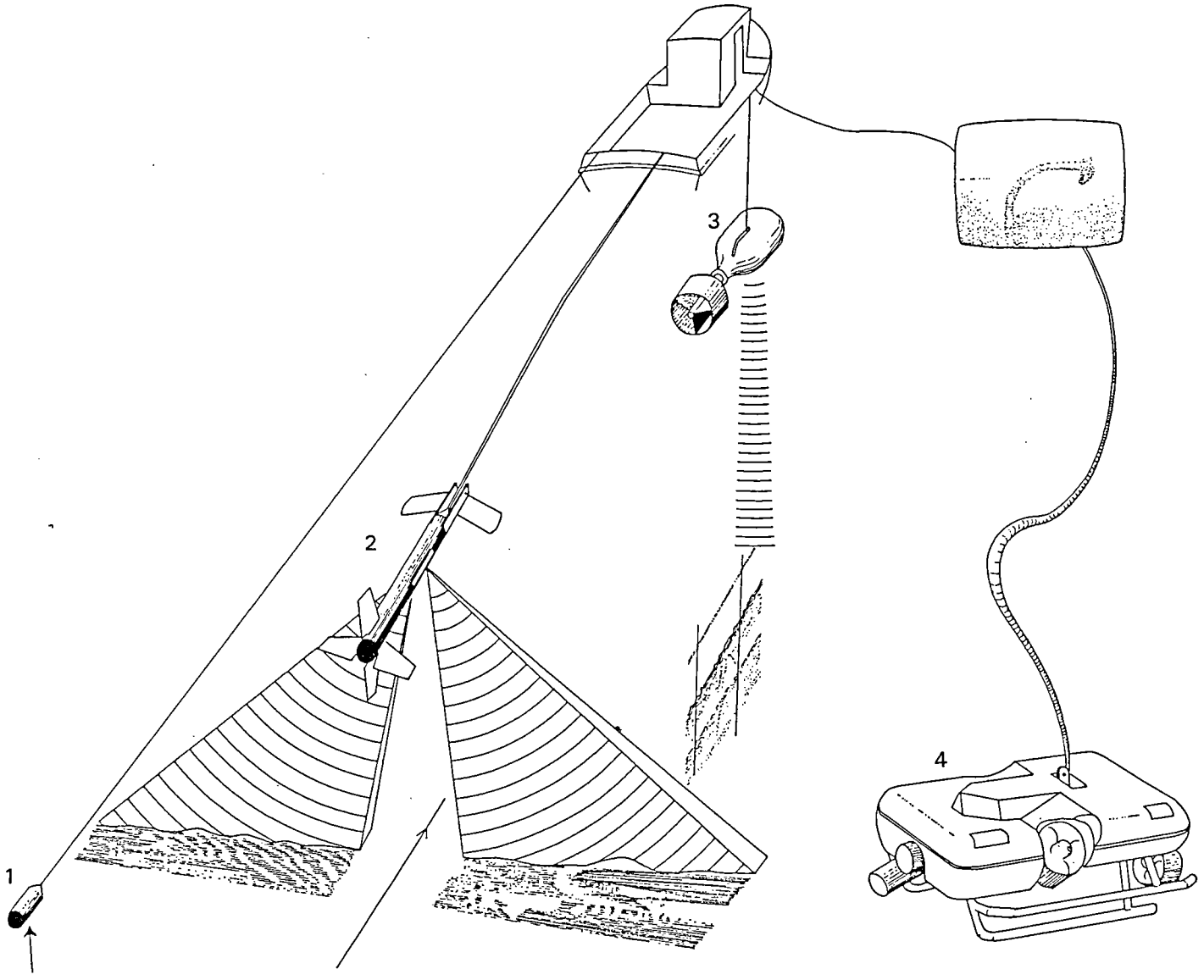
The question of technique should come into play as soon as a project is conceived. One factor in the initial planning of a job is the selection of the appropriate technology. And, even if the proper equipment is selected, all efforts may fail if it is not used properly. For example, running a sonar search 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 is playing an increasingly important role in finding shipwrecks and other sites and in carrying out the excavation and providing documentation.

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 most commonly used instruments for searching in the oceans are the side-scan sonar, the sub-bottom profiler, and the magnetometer. These generally can be called high tech. Other methods, just as good, fall under the categories low tech, no

The manned deep-water submersible *Alvin,* of the Woods Hole Oceanographic Institution (USA), with its mother ship, *Atlantis II.* In 1986 *Alvin* explored the wreck of the *Titanic* 4,000 metres beneath the North Atlantic. Much advanced technology is available for marine archaeology but its use on a routine basis is often limited because of prohibitive costs.



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 sea floor 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 sea floor 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 sea floor, similar to an aerial photograph. A side-scan can produce an image of the sea floor more than 300 metres out on both sides of the tow path.

Side-scan sonar produces a detailed graphic image of the *surface* of the sea floor. Areas of rock, sand, mud, or other material can be distinguished. If an archaeological site leaves some visible trace on the sea floor, 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 sea floor. 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 sea floor 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.

Drawing shows 4 methods of geophysical surveying under water. (1) The *proton magnetometer* detects variations in the earth's magnetic field, which is distorted by objects of a ferrous nature such as cannon, iron shot or steel hulls. (2) *Side-scan sonar* detects variations of projections above the sea-bed. A "fish" towed behind the boat transmits a fan-shaped beam of acoustic energy perpendicular to its path, and rock outcrops, sandwaves, wrecks and other projections are recorded on a continuous graph (see front cover). (3) The *sub-bottom profiler* is an acoustic transmitter which sends out into the sea-bed sound pulses which bounce back from underlying strata or buried objects. All 3 devices, when used simultaneously, can detect objects lying on or below the sea-bed and distinguish ferrous and non-ferrous anomalies, thus helping archaeologists to distinguish early timber structures from later metal wrecks. (4) Another system is the *Remotely Operated Vehicle (ROV).* Equipped with low-light videos and cameras, such highly manoeuvrable unmanned submersibles are connected to a mother vessel by a cable through which they receive electricity and commands from their human pilot and transmit pictures and data.

Photo © Courtesy Texas Antiquities Commission

A mosaic of X-ray photos of a concretion helps to guide a technician in the process of chipping off the overlay from iron artefacts recovered from a 16th-century shipwreck off the coast of Texas, USA.

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 the 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 is generally towed behind the search vessel, although for some shallow-water operations magnetometer sensors have been mounted on a 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 metres, a site with scattered iron anchors and cannon at 80 to 100 metres, an isolated iron cannon at 30 metres, and an individual small iron object at 3 to 5 metres. 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 structures, artefacts, or associated minerals. 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 unfavourable 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 of such material may be on a site. Bronze cannon, for example, cannot be detected.

With all 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 is also needed to return to any contacts found with the search instruments.

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 be more widely used. Satellite images have already 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 aircraft. 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 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 have

already performed television and photographic inspections of several sites. One-atmosphere diving "suits" 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.

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.

A new mapping system is currently 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 centimetre, 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 is 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, analysing and displaying information on artefacts 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 co-ordinates 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 fieldwork is one that should show rapid development in the next few years. ■

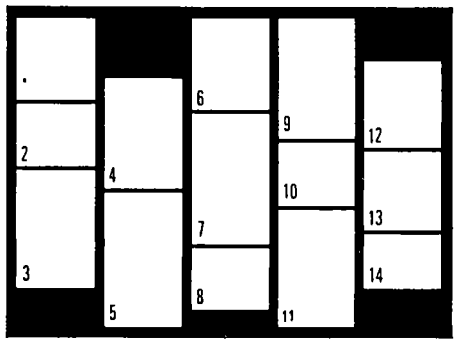
CHARLES MAZEL, *of the USA, is an ocean engineer who is technical director of the non-profit Maritime Archaeological and Historical Research Unit, based in Maine. He is presently a consultant on ocean survey and electronics projects and is developing new equipment for underwater photography. This article was first published in* Oceanus *magazine (vol. 28, no. 1, Spring 1985) published by the Woods Hole Oceanographic Institution, Massachusetts.*

Colour page opposite

A sunken ship is a "time capsule" of life at sea, frozen at a moment in the past. These 3 photos show a silver pocket watch recovered by Australian archaeologists from the remains of HMS *Pandora*, which foundered on Australia's Great Barrier Reef on 29 August 1791 with the loss of 35 men. *Pandora* had been sent to Tahiti in 1790 by the British Admiralty to capture the mutineers who had seized HMS *Bounty* the previous year and "bring them to condign punishment". She went down on her return voyage to England with 14 mutineers manacled inside a deckhouse cell.

The watch, thought to have belonged to the ship's surgeon because it had a second hand useful for taking a patient's pulse, was brought up in a wet container. An X-ray showed that most of its works were still intact. It had stopped at 12 minutes and 20 seconds past 11. *Pandora* sank at 6:30 A.M. and so the watch may have been stopped by the shock of impact when the ship hit the reef the night before or by rising waters when she began to fill. Remarkably preserved, the watch was conserved and restored by Jon Carpenter, conservator of the *Pandora* expedition, and rebuilt nearly to working condition (below right) by an antiquarian watchmaker, Hugh Whitwell.

Centre colour pages



Photos on this double page spread show some of the processes and techniques of underwater archaeology today, from surveying and excavation to conservation.

1. Laying down the line. Before excavations can take place, an accurate survey of the site is made to record archaeological material and the environmental situation. Site planning before and during excavation is usually done with the aid of a site grid made using poles or line (see also photo page 28).

2. Making measurements. Detailed site plans often involve measuring the position of objects by taking the distance at right angles to the main grid line. The diver at right is carefully noting the distances.

3. By swimming along lines strung between two fixed points, divers can inspect the sea-bed for archaeological material. Intensive surveying and plotting with recovery of selected items for dating evidence can identify new sites worthy of further investigation.

4. Underwater vacuum cleaners called airlifts are commonly used to remove sediment from the site. They come in all sizes. The equivalent of the wheelbarrow on land, they should only be used to remove sediment and not the evidence embedded in it.

5. The rim of a pot gradually appears as divers carefully remove the topmost layer of sediment with a vacuum hose. The diver's hand is the most sensitive working tool of all.

6. Drawing underwater is done with an ordinary pencil on a sheet of underwater drawing film. Meticulous records need to be made of archaeological sites under water just as on land, since all archaeology is destructive. Once the excavation is complete the only record is that produced on paper and film.

7. Stereophotogrammetry (making plans by computer from stereophotographs) may be used to produce a 3-dimensional record of parts of a site or even of complete hulls.

8. Underwater archaeologists are not solely concerned with shipwrecks. They also explore sites once occupied by prehistoric man in inland waters or submerged on the continental shelf. Here, divers record data and prepare to recover a mastodon tusk from a North Florida river.

9. Archaeologists and divers working at great depths face the danger of decompression sickness, commonly known as "the bends", which can kill or paralyse. Photo shows a submersible decompression chamber (SDC) used at Yassi Ada (Turkey) in the late 1960s by George Bass and a team from the University of Pennsylvania. By allowing four divers at a time to decompress, the SDC permitted longer daily dives.

10. A diver uses a pneumatic saw to cut off a piece of the hull of a wreck off Gabon for study ashore.

11. Air-filled bags are used for raising heavy objects to the surface.

12. Deep water sites are now becoming accessible thanks to technological developments in the field of off-shore engineering. Here, a diver clad in a revolutionary "wearable" submarine. Such equipment circumvents decompression problems.

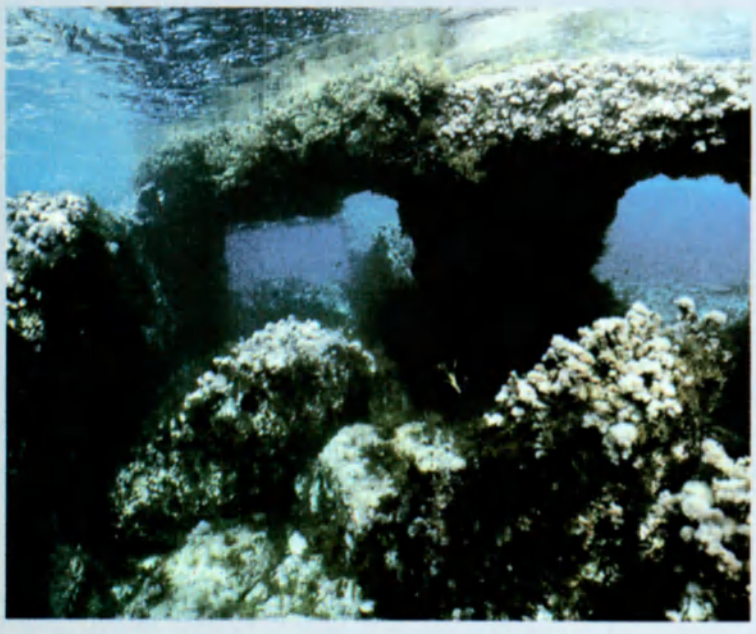
13. The Bremen Cog. Reassembly of this medieval ship from about 2,000 pieces of waterlogged timber took 7 years.

14. Inside the hull of the *Sohar*, a full-size replica of a medieval Arab ship (see photo story page 23). The workmen are using mops dipped in vegetable oil to preserve the coir (rope made of hand-twisted coconut fibres) used to lash the ship's timbers together.







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Modern replicas of ancient vessels

The sea trials of full-scale replicas of a number of ancient ships have successfully demonstrated the seaworthiness of early craft as well as contributed to our knowledge of naval construction techniques and the art of navigation. (1) In 1987, for the first time in over 2,000 years, a trireme of the Greek navy cut through the waters of the Mediterranean. The trireme, a reputedly invincible, fast and manoeuvrable warship with three tiers of oarsmen on each side, was fundamental to the naval strength of Ancient Greece. The modern replica, named *Olympia*, was built in a Greek naval shipyard to a design by a team of British researchers. As no remains of a trireme have ever been found, the designers relied on descriptions by classical writers, surviving illustrations of the ships, and experience gained from other ancient shipwrecks. The warship, 37 m long and over 5 m broad, displaces 1.5 m of water for 45 tons weight and is armed with a bronze ram at the bow. She soon showed her paces, reaching a speed of 7 knots in her first sea trials, propelled by a crew of almost 200 rowers. Use of the trireme will lead to a better understanding of the tactics employed by the Ancient Greek fleet. The *Sohar* (see colour page left) is a replica of an 8th-century Arab trading ship or *boom*. In this vessel, with a crew including 8 Omani seamen, navigator Tim Severin made a 7-month voyage of almost 10,000 km, from Muscat to Canton, following the route of Sindbad, the legendary Arab sailor and hero of *The Thousand and One Nights*. (2) Tim Severin uses an early Arab navigation instrument, the *kamal*. A wooden rectangle pierced by a knotted string, the *kamal* is a kind of sextant for calculating latitude from the position of a selected star above the horizon. (3) The *Kyrenia II*, an authentic replica of a Greek merchantman which went down off Kyrenia (Cyprus) 2,300 years ago, is the culmination of a 20-year research programme carried out on the wrecked ship under the direction of the Institute of Nautical Archaeology (INA). The Kyrenia Ship (see also page 14) is the best preserved vessel of its period yet found. Thanks to knowledge gained during the long and painstaking reconstruction of the ship, which can be seen today in the city of Kyrenia, a replica was built in a Greek shipyard, using ancient techniques. The 14-m-long *Kyrenia II* has already made several successful voyages.

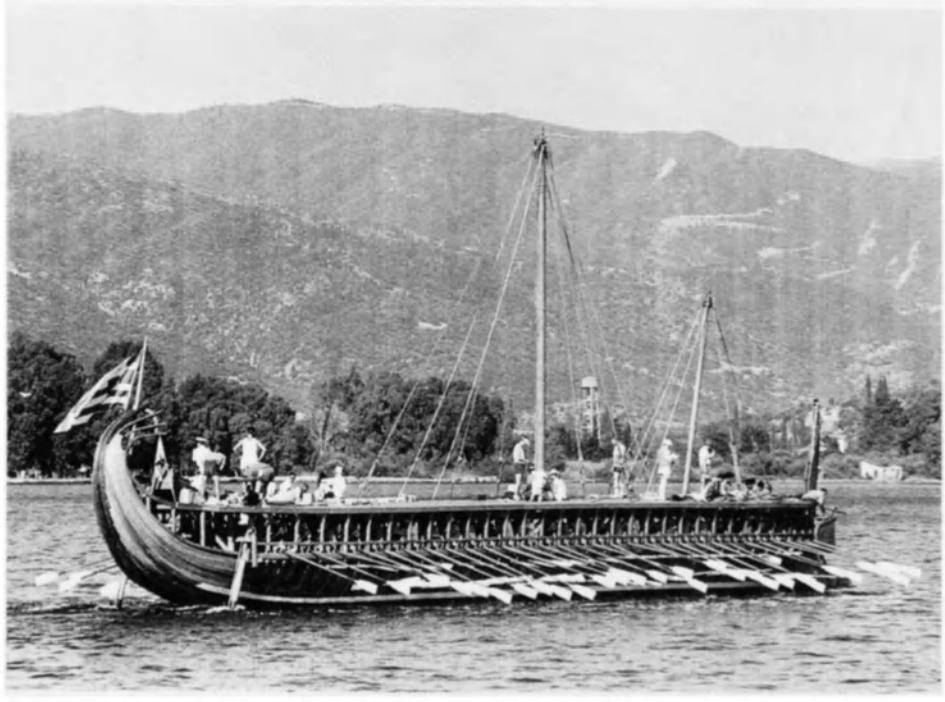

Photo Graham Wood © Times Newspapers Ltd., London

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Photo Richard Greenhill
© Tim Severin-Sindbad Voyage

Photo © M.L. Katzev, Arlington, Vt., USA-Kyrenia Ship Project

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Colour page left

Above: *Sohar*
Photo Richard Greenhill © Tim Severin-Sindbad Voyage

Far left: a Roman warehouse in the western dock of the submerged harbour of the ancient city of Apollonia, Libyan Arab Jamahiriya (see page 38).

Left: central quarter of Apollonia and the harbour
Photos © André Laronde

Law and the underwater heritage

by Lyndel V. Prott
and Patrick J. O'Keefe

AN international consensus is developing that States should take special steps to ensure the protection of their underwater heritage. Apart from international agreements by which States have undertaken actively to ensure the protection of the cultural heritage generally, such as the European Convention on the Protection of the Archaeological Heritage; Unesco Convention for the Protection of Cultural Property in the Event of Armed Conflict; Unesco Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property; Unesco Convention Concerning the Protection of the World Cultural and Natural Heritage; OAS (Organization of American States) Convention on the Protection of the Archaeological, Historical and Artistic Heritage of the American Nations, there is also a Unesco Recommendation which deals specifically with the underwater cultural heritage. This is the Recommendation on International Principles Applicable to Archaeological Excavations (1956). It applies to "any research aimed at the discovery of objects of archaeological character" whether on land "or on the bed or in the subsoil of inland or territorial waters of a Member State".

The Recommendation includes some detailed provisions on the control of excavations, the admission of foreigners for archaeological work, the keeping of a central register of important sites, the formation of collections, disposal of finds, rights and duties of the excavator, documentation of excavations and the suppression of clandestine excavations. The Recommendation, according to the Constitution and Rules of Procedure of Unesco, obliges Member States of Unesco to implement it and to report the methods taken to give effect to it. European and other States bordering the Mediterranean should also be aware of a major initiative of the Council of Europe to strengthen legal protection of the underwater cultural heritage in the European and Mediterranean areas.

In studying all these materials, States may not only feel a responsibility or an obligation to legislate promptly on this issue, but will also find guidance as to the type of provisions that should be included.

There are two legislation schemes which have been very widely used to provide permanent legal protection: these are, first, the extension of general antiquities legislation to underwater finds and, second, the drafting of special legislation solely to cover submarine antiquities (meaning those under the sea) or other antiquities under water where these are significant. Certain schemes have been based on the extension of other types of legislation to cover the underwater cultural heritage: most of these appear to have some disadvantage.

The major advantage in having specific legislation on the underwater cultural heritage is the practical one of easy accessibility. For the most part, those who do damage to shipwrecks are divers, fishermen or employees of oil or cable-laying companies involved in underwater operations. Many of these have little legal knowledge.

Divers, both amateur and professional, and particularly those interested in shipwrecks, are often said to be of independent character, resourceful and sceptical of authority. They come from a variety of backgrounds, from the highly educated to the lowly. Nevertheless, they have a common tendency to regard what they find under water as their own, a product of their skill and effort and something that only they can work on, by whatever means they consider fit. It is important to seek their co-operation and not to arouse their resentment.

On the other hand, fishermen in most cases do damage by dragging their nets along the sea bottom, scattering surface remains and obliterating sites, as well as raising objects in their nets. In recent years, the surveying and trenching of the sea floor for pipelines or cables has led to the unintentional discovery of many wrecks. It is important that such finds be reported and identified, and requirements to that effect should be written into every national permit system.

Philippines law provides that any accidental discoveries made "in the course of agricultural and engineering works, mineral and marine explorations" shall be reported and further work immediately suspended. Norway and Thailand have also expressly created a duty to report for such operators. In all cases, the best protection of the underwater cultural heritage lies in education and in persuasion of the diver, fisherman, oil worker or cable layer of the cultural value of what is found or noticed. This will be done most easily if reference can be made to a single piece of legislation which is easily accessible physically and associated by name: one in which rights and duties are set out concisely, without ambiguity or the need to refer to other legal provisions.

The extension of general antiquities legislation to the underwater cultural heritage is an alternative which has been adopted by some States which already have comprehensive legislation on land antiquities (e.g. Greece and Turkey). There is no legal reason why the cover provided by general antiquities legislation should not be as strong: the advantages of specific legislation are, as we have mentioned, practical ones.

There are a number of other States that have not made the extension specifically but whose system of classification and protection would be suitable to cover important finds. Such an extension of existing legislation would not, however, ensure accessibility and publicity. Nor is this pattern of action helpful where general antiquities legislation is not so well developed.

Although many States have comprehensive legislation to protect the underwater cultural heritage, and even those that do not have other legislative weapons in hand to protect them from the spoliator, the cultural authorities should not become complacent. Many will recognize that there are much stronger provisions that could be—and should be—included in their national legislation. This is an urgent task for all national cultural authorities in countries where the underwater cultural heritage is under threat. There are two other important tasks which would increase legal protection: one, the signing of international agreements on this subject; the other, the requiring of all those working on the seabed for any purpose to observe and report finds of interest. The best level of protection will be achieved by a judicious blend of strong legal provisions and an effort to make people everywhere aware of the incalculable value of the cultural inheritance of man. ■

LYNDEL V. PROTT *is Reader in International Law and Jurisprudence at the University of Sydney, where her husband,* **PATRICK J. O'KEEFE,** *is Senior Lecturer in Law. They are co-authors of a report for the Council of Europe on legal protection of the underwater cultural heritage (1978), and are currently engaged on a major project to collect, analyse and comment on national and international laws on the protection of the cultural heritage round the world. The results of their research will eventually be published in 5 volumes, the first of which,* Law and the Cultural Heritage, *appeared in 1983 (Professional Books, Abingdon, UK). The above article is an extract from "Law and the underwater heritage", a chapter which they contributed to* Protection of the Underwater Heritage, *a collective work published by Unesco in 1981.*

Looting of ancient shipwrecks is widespread. How can it be stopped?

The amphora war

MORE than 2,000 years ago, Greek and Roman galleys sailed the Mediterranean Sea loaded with goods for trade or soldiers for conquest. Today, off the coasts of Italy, Spain, and France, hundreds of these ancient shipwrecks, sunk for centuries, are being pirated by clandestine salvagers and deep-sea divers. In the past twenty years in France alone almost 400 shipwrecks from the Greek and Roman eras have been found. All but three had been pillaged before being discovered by the authorities.

The statues, art works, precious metals and amphoras found on these ships supply an international market of private buyers. The publicity surrounding the volume of this trade, soaring prices, the aggressive promotion by auction houses, and continued record-breaking sums have done much to promote this illegal traffic. And it has led to violence. Rival gangs are known to have burned each other's boats, and over twenty divers, some very experienced, have been found dead due to dangerous clandestine working conditions in deep water or outright murder. In the South of France they call it the Amphora War.

For hundreds of years, men tried to invent ways of getting to sunken ships with little or no success. With the invention of the scuba tank, a practical solution was found.

It was one of the inventors of the scuba tank, Jacques Cousteau, who excavated the first ancient ship from the sea floor. In 1954, diving down 60 metres off the Grand Congloué island in the Mediterranean near the city of Marseilles he found an ancient Roman shipwreck sunk in the second century BC. Two thousand amphoras were discovered on the ship. Cousteau's divers simply raised them to the surface and drew no plans of the site, but this first expedition led to the birth of underwater archaeology.

On land, wholesale plundering of ancient artefacts had been going on since the eighteenth century. Today, treasure hunters spend more time searching under the sea than on land.

In France, the police responsible for enforcement of the laws protecting underwater archaeological sites are under the authority of the Customs Service. With a fleet of 20 boats, 12 helicopters and 3 aeroplanes, the Customs agents regularly patrol the areas of known underwater archaeological sites. Aircraft spottings are reported to patrol boats that are equipped with radar and armed with sub-machine guns. But, as Commandant Rivière, head of Customs from the Mediterranean coastline from Italy to the Spanish border and the island of Corsica, has pointed out, ". . . The fight to prevent the pirating of underwater wrecks is only a small part of our activity because our main job is aimed against drugs and terrorists.

"Guarding underwater archaeological wrecks is very difficult because there are a lot of wreck sites and it is impossible to put a Customs officer on every site, and if you are not there to catch someone red handed bringing up an artefact, then most probably the pirate cannot be prosecuted."

The major problems facing the preservation of ancient shipwreck sites are the expense of an excavation, the tedious weeks at sea, around-the-clock security to protect the site from pirates, and the health dangers of decompression from repeated deep-water diving. Since diving can be done only seven months a year off the coast of France, unfinished excavations must be buried in hundreds of tons of sand to protect them from pirates during the winter months, and then painstakingly uncovered the following year before new work can begin. ■

This text has been extracted from the script of a new video programme entitled Amphora War. *A Unesco-Cross Communications Europe co-production, the 26-minute video reviews the question of piracy of amphoras and other artefacts off the coast of southern France and the measures being taken by Unesco for the protection of the underwater heritage. For further information about the video, which exists in English and French versions, please apply to: Division of Audiovisual Productions, Unesco, 7 Place de Fontenoy, 75700 Paris.*

Investigation of a 17th-century man-of-war in the Baltic

by Lars Einarsson

THE Swedish man of war HMS *Kronan* ("The Royal Crown") was lost in battle off the coast of south-east Sweden on 1 June 1676. Her keel had been laid in 1665 and she had been launched in 1668, entering service four years later in 1672. The first three-decked ship built in Sweden, she displaced 2,140 tons. Her length was 55 metres, and she carried 126 cannons. At the time of the disaster her crew consisted of approximately 850 men.

In the mid-seventeenth century, Sweden was a great power with the general strategic ambition of controlling the Baltic Sea and the shores around it, thus creating a closed inner sea—a "Mare Claustrum". In 1675 the Swedish provinces on continental Europe were attacked by Brandenburg. In the same year, war broke out between Denmark and Sweden, and in the spring of 1676 the Swedish navy set sail for the southern Baltic in order to find and destroy the Danish fleet which was ravaging the Swedish islands.

The first battle between the enemy fleets was fought between the islands of Bornholm and Rügen during the night of 25 May. In spite of the Swedish superiority in numbers, the Danes escaped, and were a few days later joined by a Dutch squadron. The Dutch became a Danish ally to prevent Sweden gaining total control of the Baltic.

The Swedes had acted in confusion during the battle, and consequently the king ordered the fleet to seek battle closer to the Swedish mainland, hoping that a possible disaster could be avoided if the ships could seek refuge in Swedish ports.

On the morning of 1 June 1676, the Swedish fleet, over sixty ships strong, was sailing northwards in a southwesterly gale along the coast of Oland. Off the village of Hulterstad, the *Svärdet* ("The Royal Sword"), the flagship of the second squadron, fired a gunshot either as a signal to call the fleet closer together, or as a request to turn against the enemy who were closing up from behind.

Without responding to the *Svärdet*'s shot, the *Kronan* turned with the wind without taking in sail. Suddenly, the ship heeled

Jewels from the Crown

over and began to capsize. The crew tried desperately to pull the guns in through the gunports, but in vain. The ship capsized, and shortly afterwards was shaken by an explosion in which the starboard side was blown to pieces. Within a few minutes, the *Kronan* had sunk with the loss of 800 lives. Only forty men survived the disaster.

The wreck of the *Kronan* caused total confusion in the Swedish fleet. Only a few ships remained to continue the battle, among them the *Svärdet,* which fought heroically for several hours before being set on fire by a fireship. The result of the battle was disastrous for the Swedes: the loss of the two largest ships in the Swedish navy and 1,500 seamen.

In the 1950s, Anders Franzen began a programme to find twelve Swedish men-of-war sunk in the Baltic in the sixteenth and seventeenth centuries. Franzen had realized that because of climatic and other natural conditions, the Baltic is a treasure-house for the underwater archaeologist.

First of all, the Baltic is within the continental shelf area and only parts of it are deeper than 100 metres. Both the coastal waters and large areas of the sea bottom are accessible for ordinary diving—up to a depth of 50 metres. Secondly, wood-destroying organisms such as shipworm (*Teredo navalis*) are less prevalent than in warmer, saltier waters such as the Mediterranean. In fact the whole of the Baltic is free of damage by shipworm.

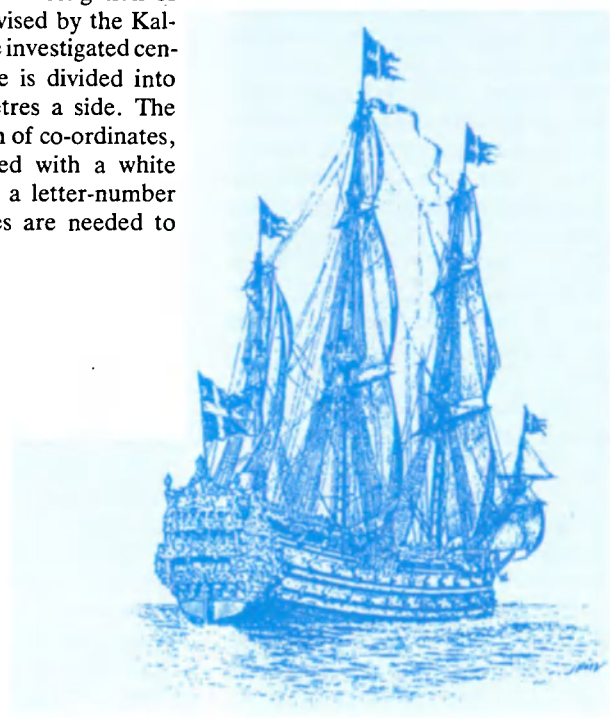
In 1956, Franzen discovered the *Wasa* in the waters of Stockholm harbour where she had sunk at the start of her maiden voyage in 1628. After an unprecedented rescue operation the *Wasa* was raised from the sea-bed and towed away to a museum site in 1961 (see page 14).

In 1980, after making a systematic survey including the use of side-scan sonar, proton-magnetometer and low-light television, Franzen and his team discovered the *Kronan* just over 6 nautical miles off the east coast of Oland, at a depth of 26 metres.

The first sight which met the divers was that of a broken wreck, not a *Wasa.* But the sediments of the site would later prove to contain thousands of artefacts originally belonging to the crew, representing a seventeenth century in miniature encapsulated and deep frozen at noon on 1 June 1676.

In 1981, archaeological investigation of the *Kronan* began, supervised by the Kalmar County Museum. The investigated central area of the wrecksite is divided into twenty squares of 10 metres a side. The squares comprise a system of co-ordinates, each corner being marked with a white cross and identified with a letter-number combination. These codes are needed to

Pieces of richly carved woodwork are among the most notable finds made during excavations of the *Kronan*. Left, a cherub from the admiral's quarters photographed as it lay among the wreckage. Above left and right, another wooden cherub from the *Kronan*.



Right, artist's impression of the *Kronan*. The drawing, by Admiral Jacob Hägg, was made in 1906.

Excavating and documenting the port side of the *Kronan*, which lies flat on the seabed. The plastic grid divided into squares enables the location of objects to be precisely recorded. Upright forms in background are broken deck-beams.

describe the location of a recovered object and are also helpful in photographic and search-work.

A further refinement in excavation is the use of a portable plastic grid, divided into squares. The grid as a whole is fitted into the general system of co-ordinates before excavation is begun, and then makes the work of describing the location of recovered artefacts easier. This method is used in combination with triangular measuring and has proved to be efficient at this stage of the excavation.

The actual excavation work is done with an airlift, a sort of underwater vacuum cleaner. It uses compressed air to draw up the sediment, thus revealing objects and parts of the ship, by preventing everything from being obscured in a cloud of mud. The divers pick up the objects recovered in this way, while the sediment, sand and gravel drawn up with the compressed air are sieved on deck, so that smaller objects are also recovered.

Important aids in the underwater documentation process are waterproof sketching equipment, underwater cameras and—perhaps most important—an underwater video camera. Documenting the excavations with low-light video is a very convenient method of obtaining maximum input of immediate visual information at a relatively low cost. Communication between divers and the surface is carried out by diver telephone.

The divers use only dry-suits, meaning they wear insulating overalls under their diving suits and remain dry. This prevents the diver from being exposed to the cold waters of the Baltic, which seldom exceeds 8°C at this depth. This is a most important safety measure.

Diving time at a depth of 26 metres with compressed air is relatively limited. Each diver does two descents a day, with an effective diving time of from 50 to 70 minutes, depending on whether decompression in water is being used.

When the excavations began in 1981, the first method used was to dig test-pits in strategic areas of the wreck-site, in order to determine the area of the find and the ship's constructional elements. The archaeologists immediately realized that a tremendous number of artefacts were preserved in the sediment and, thanks to the wood-preserving conditions of the Baltic, noticed the remarkable richness of the exposed parts of the ship. *Kronan* clearly offered a unique opportunity to study life on board a big seventeenth-century battleship.

In 1984, after three seasons of excavations, a new method succeeded the test-pit

Photo © Kalmar County Museum, Sweden

Plate and jugs from the *Kronan*

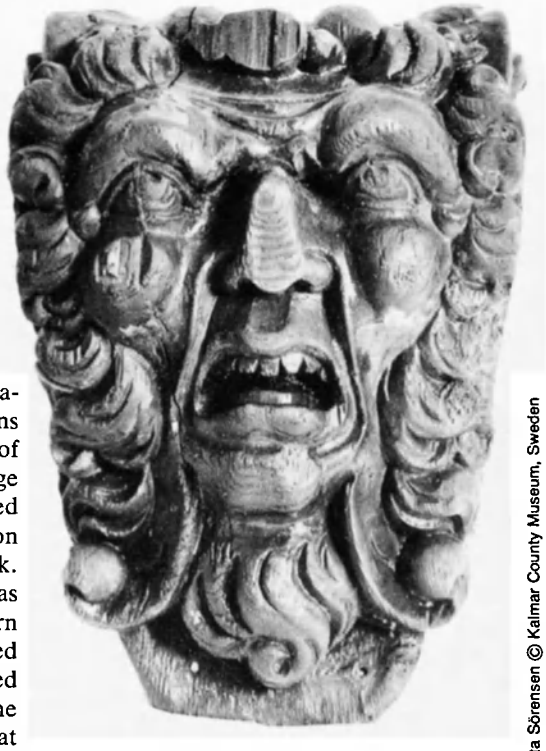


Photo Gösta Sörensen © Kalmar County Museum, Sweden

This carved wooden head was placed on the sterncastle of the *Kronan* to frighten the enemy.

method. Continuous, systematic excavation starting from identified constructions on the port side began. The choice of method was based on the knowledge obtained from the previous tests, which led to a theory concerning the deterioration process and the present state of the wreck. At the time of the disaster, *Kronan* was heading north in a strong south-western gale. The ship turned with full sails, heeled over on her port side, capsized and turned around in the wind. This is proved by the ship's position on the sea-bed. The great explosion in the powder-storage room must have blown the entire starboard side away, since this was the direction of the shock-wave. The vessel probably broke athwartships at this stage, forward of the main mast, which explains the absence of the bow. Thus, approximately two-thirds of the length of the port side, from the stern forward, is preserved.

After the explosion, *Kronan* sank rapidly. When she reached the sea floor, she immediately rested on her port side. This is indicated by *in situ* findings of internal port side sculptures, originally decorating the walls of the admiral's quarters, astern on the upper gun-deck. The sculptures were originally nailed to the wall with iron nails, which rusted away soon after the shipwreck. The sculptures still remain in their original positions.

One consequence of this must be that the external sculptures of the port side stern castle are also likely to be still in their original positions, embedded in the anaerobic, glacial clay. We hope that future excavations will prove this.

Since she was the first three-decked ship ever built in Sweden, *Kronan* is likely to show unique constructional details. Some interesting features have already been observed. However, the outstanding asset of *Kronan* is the tremendous richness of the artefacts found on her. As of 1986, approximately 15 per cent of the area of the wreck-site had been excavated. More than 12,000 artefacts have been salvaged. They range from everyday utensils, personal belongings, weaponry, navigational instruments, sculpture, and musical instruments to a medicine chest and the largest find of gold coins ever made in Sweden.

Perhaps the most interesting finds are the sculptures which are in remarkably good condition. One can still see in detail how the artist has shaped the piece of wood with his tools. The relatively gentle conservation process of freeze-drying ensures that the original features of the wooden sculptures remain. The reconstruction of the sculptural features of the *Kronan* is one of the greatest achievements of the investigation.

Since the excavation began, a *Kronan* exhibition has been open to the public at the Kalmar County Museum. More than 200,000 people have seen the exhibition so far.

Apart from the main archaeological purpose of the *Kronan* investigations, the site has also become a melting pot for international underwater archaeology. Each year marine archaeologists from different countries and institutions are invited to take part in the work and exchange experiences. The Baltic in general, and *Kronan* in particular, offer a unique opportunity for underwater archaeological work under extremely good conditions. ■

LARS EINARSSON *is curator of the Kalmar County Museum, Sweden, and chief archaeologist of the* Kronan *project.*

Photo N. Aukan © Kalmar County Museum, Sweden

The Convention on the Law of the Sea and marine archaeology

Adopted on 30 April 1982 by the United Nations Conference on the Law of the Sea (by 130 votes to 4, with 17 abstentions) the Convention on the Law of the Sea lays down rules for all parts and virtually all uses of the oceans. Articles 149 and 303, the texts of which are given below, relate specifically to archaeology.

Article 149
Archaeological and historical objects

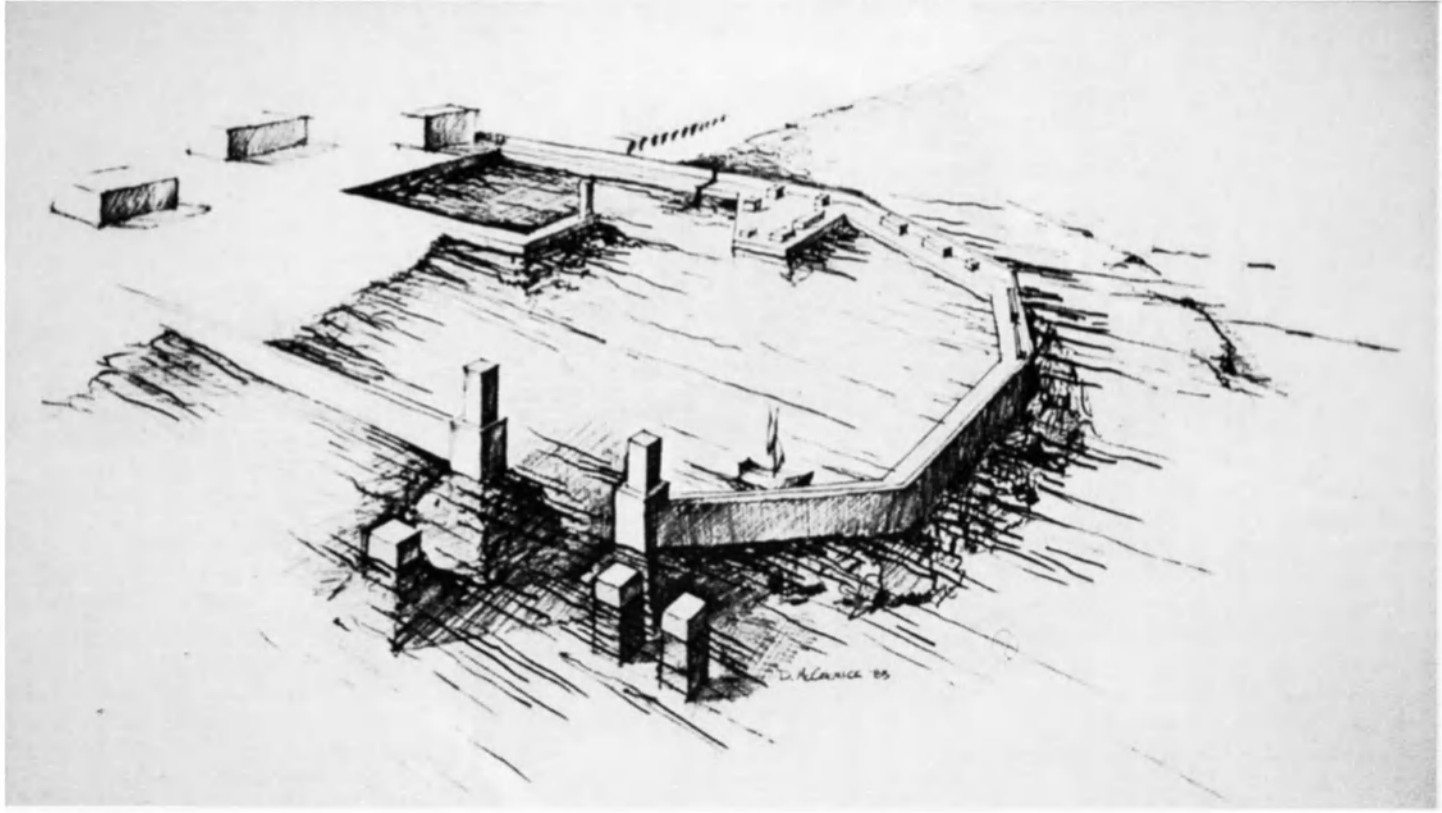
All objects of an archaeological and historical nature found in the Area* shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and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

Article 303
Archaeological and historical objects found at sea

1. States have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose.
2. In order to control traffic in such objects, the coastal State may, in applying article 33, presume that their removal from the sea-bed in the zone referred to in that article without its approval would result in an infringement within its territory or territorial sea of the laws and regulations referred to in that 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 objects of an archaeological and historical nature.

* **Article 1**
Use of terms and scope
1. For the purposes of this Convention:
(1) "Area" means the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction;

** **Article 33**
Contiguous zone
1. In a zone contiguous to its territorial sea described as the contiguous zone, the coastal State may exercise the control necessary to:
(a) prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea;
(b) punish infringement of the above laws and regulations committed within its territory or territorial sea.
2. The contiguous zone may not extend beyond 24 nautical miles from the baselines from which the breadth of the territorial sea is measured.



Drawing © S. Gianeti

Painting by J. Robert Teringo © 1987 National Geographic Society, Washington, D.C.

Ancient Caesarea, now submerged beneath the Mediterranean, was an amazing feat of engineering

Herod's great harbour

by Avner Raban

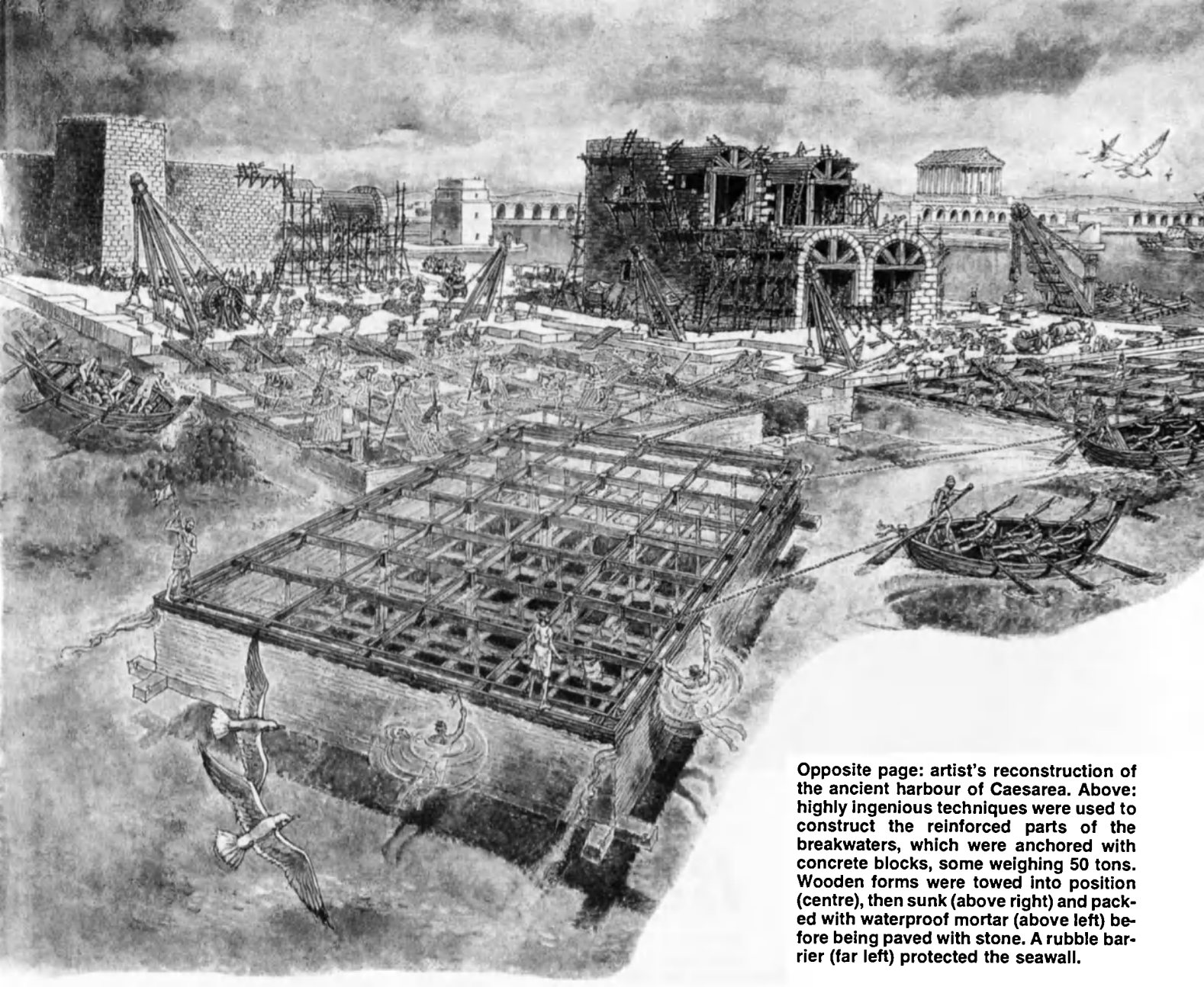
'NOW King Herod observed a place near the sea, which was very proper for containing a city, and was before called Strato's Tower. ... and what was the greatest and most laborious work of all, he adorned it with a haven that was always free from the waves of the sea. ... The king, by the expenses he was at, and the liberal disposal of them, overcame nature and built the haven larger than at Piraeus 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 expense. 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 south-west winds that beat upon them, which rolling the sands that come from the sea gainst 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 endeavoured to rectify this inconvenience, and laid out a compass towards the land as might be sufficient for a haven, wherein the great ships might lie down in safety; and this he effected by letting down vast stones into twenty fathoms of water, most of them being fifty feet in length, and nine in height and ten in breadth, and some still larger. But when the haven was filled up to that length, he enlarged that wall which was thus already extant above the sea, till it was two hundred feet wide; one hundred of which had buildings before it, in order to break the force of the waves; but the rest of the space was under a stone wall that ran around it.

The name of Pilatus (Pontius Pilate), the Roman procurator who tried Jesus Christ, is carved on this stone found at Caesarea. It may once have been affixed to a temple.

Photo Bill Curtsinger © 1987 National Geographic Society/Photo Researchers

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."

These words were written almost 2,000 years ago by the Jewish historian Josephus Flavius and constitute what may be the most detailed description of an ancient harbour. In 1975 this hidden wonder of ancient hydraulic technology began to be studied by the Centre for Maritime Studies of the University of Haifa, and since 1980 the project has been carried out by the Caesarea Ancient Harbour Excavations Project, with the participation of the universities of Colorado, Maryland and Victoria (British Columbia). Every summer, over one hundred diving volunteers from all over the world, directed by a large staff of marine



Opposite page: artist's reconstruction of the ancient harbour of Caesarea. Above: highly ingenious techniques were used to construct the reinforced parts of the breakwaters, which were anchored with concrete blocks, some weighing 50 tons. Wooden forms were towed into position (centre), then sunk (above right) and packed with waterproof mortar (above left) before being paved with stone. A rubble barrier (far left) protected the seawall.

archaeologists, diving technicians, marine engineers and architects take part in what may be the largest underwater excavation of its kind.

Though the work is far from being completed, it has already yielded scores of data that not only verify Josephus' testimony but add surprising facts about the standards of harbour technology of that time. Not only was this the first protected basin to be artificially encompassed by free-standing breakwaters not based on any headland, natural bay or off-shore reefs, but those structures were so designed that their internal side was properly protected from the splash of breaking storm waves to accommodate mooring facilities for their entire length.

The main breakwaters were built in a unique combination of carefully laid huge ashlar blocks fastened with iron clamps (held by molten lead that was poured into grooves at the edges of the ashlar blocks when they were already in place under the water) and artificial hydraulic conglomerate that slowly solidified within double walled wooden caissons that were lowered to their proper position by the careful addition of a specially blended mixture of hydraulic concrete made of lime, red soil, and volcanic pumice, in between the double wooden walls.

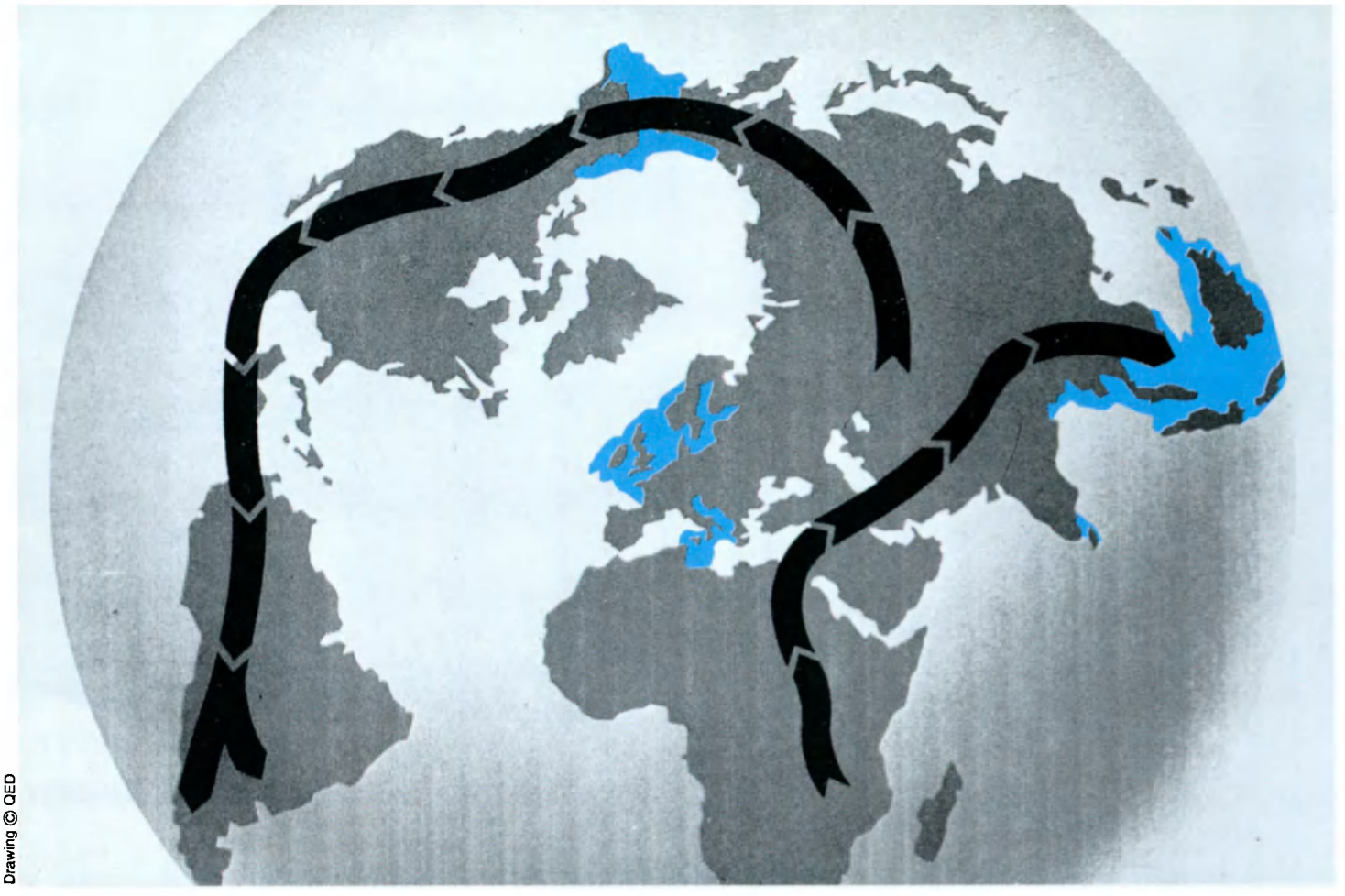
In order to save building material in the construction of the submerged part of the breakwater (the total volume of the underwater base must have been around 200,000 cubic metres) the caissoned blocks and the ashlar walls were installed only at the external, internal, midsection and cross-sections of the breakwaters, with hollowed compartments of 20 x 30 metres left for the sea to fill with wave-carried sand. In this way, after a few years, the filled sections could be paved and built on.

Other sophisticated measures were taken in order to prevent what seems to be the constant problem of all modern protected basins along this coastline, silting up and the deposition of sand. This natural process was prevented by the creation of a constant current through the harbour entrance. This current was initiated by a series of channels through the stem of the main breakwater. These channels would have an opening just above the highest tide, so there would be only an inflow of silt-free water generated by each incoming wave-front. The flow in the channels could be controlled by sluice-gates to satisfy the demand for an efficient washing current.

The archaeological proof that this system was properly working was deduced from the thin layer of fine silt with Herodian pottery sherds all over the harbour bottom which represents a sandfree basin during the time when the harbour was intact and functioning. The same kind of layer, with an abundance of clay vessels and other small finds dating from the Roman period, was found just outside the harbour entrance. It was over 1.5 metres thick and had been swept there by the outflowing current.

Technologically, the Caesarea project is the culmination of twenty-five years of marine archaeological exploration and research. It encompasses land and underwater excavations and includes sampling of bio-species, minerals and sediments for laboratory analysis. The results will contribute to knowledge of ancient environmental changes, land-sea relations, ancient marine engineering and harbour technologies. ■

AVNER RABAN *is Executive Chairman of the Centre for Maritime Studies at the University of Haifa.*



Drawing © QED

Beringia

A prehistoric 'intercontinental highway' between Asia and America

by Nikolai N. Dikov

During the last 2 million years, vast accumulations of ice covered extensive parts of the Earth and melted again about 20 times, each Ice Age lasting around 100,000 years. Each time that the ice sheets reached their maximum extent, the additional volume of water extracted from the ocean was about 40 million cubic kilometres. This resulted in a drop in sea level of about 100 metres.

Archaeologists have been aware for several decades that the lower sea levels during the Ice Ages created a larger living space for Stone Age tribes of the Palaeolithic (over 10,000 years ago), and that migrations between continents and islands were promoted by the creation of "land bridges" or narrow straits. Marine archaeologists are now studying submerged prehistoric sites on the continental shelf and have established beyond doubt that human occupation did take place below the present sea level. Study of "land bridges" may shed new light on one of the most important (and still poorly understood) processes of human history, the colonization of the Earth's continents by early man after his evolution in East Africa 1.5 million years ago. In the following article, a Soviet specialist, Nikolai N. Dikov, describes one of these land bridges, the ancient landmass known as Beringia which in prehistoric times stretched from Siberia to Alaska.

UNLIKE the mysterious Atlantis, Beringia actually existed. Like Atlantis, it was submerged by the sea. This happened gradually about 10,000 years ago, as the huge glaciers of the last great Ice Age melted. The level of the Pacific Ocean rose as much as 200 metres at that time, and the vast depression between Chukotka and Alaska was inundated. Since then, the waters of the Bering and Chukotkan seas and of the Bering Strait, which joins them, have intermingled here.

The honour of making the definitive discovery (in the 1960s) of this huge land-mass which is now under water belongs to the U.S. geologist David M. Hopkins, although the actual term "Beringia" was first used by a Soviet palaeozoologist, Petr P. Sushkin,

View of the globe showing connections between the continents at times of low sea level during the Ice Ages, and the general directions of human migrations over millions of years.

in 1925, and as long as 200 years ago a Russian academician, Stepan P. Krasheninnikov, had a general idea that there was some such land route between Asia and America.

Subsequent scientific investigations confirmed the existence of Beringia and enabled us to chart the course of its rivers and lakes and to get an idea of what its climate and its fauna and flora must have been like. It was a flat plain, woody in the south, and with tundra and steppes in the north, where herds of mammoths and bison, wild horses and reindeer grazed.

Curiously enough, Beringia appeared above water more than once during the Ice Ages, when much of the world's water became concentrated in sheets of ice and as a result extensive shallows along the coasts (shelfs) became dry land. Glacial and interglacial periods alternated, and when the temperature rose, the ice melted and a strait appeared between Asia and America, where there had previously been dry land.

At the beginning and end of the Ice Ages, each of which lasted several thousand years, there was a fairly wide bridge of land between the west and east parts of the sheet of ice. In these periods, too, there was a direct route by which animals and people could migrate from Asia to the interior of America, which was covered with glaciers. The main interest that Beringia holds for archaeologists lies in the question of the original settlement of America from Asia.

In the silt that has accumulated at the bottom of the sea, archaeologists expect to find tracks of Stone Age men who passed through on their way from Asia to America. Underwater operations are to begin very soon, but for the time being intensive archaeological prospecting and excavation work is being done on the approaches to the submerged land of Beringia, in Chukotka, Kamchatka, and Alaska. These investigations are giving us some idea of the stages in the migration of populations through Beringia and of the nature of their culture. They are also helping us to work out our strategy for the underwater archaeological searches that are to be undertaken, which will take account of the topographic and stratigraphic characteristics of the ancient sites that have been discovered in the immediate approaches to Beringia.

Systematic searching was begun by the author of this article in 1961, after he had worked out a programme for archaeological investigations in the north-east with a view to solving the problem of the peopling of America. The excavations carried out so far have revealed a large number of Palaeolithic sites in Kamchatka and Chukotka, which are now the basic source of information for our study of the peopling of America through Beringia.

Every year brings fresh evidence that this region, which was subsequently cut off from the centres of ancient civilization, was at that time not a backward, outlying part of the world but one of its great highways which, with Beringia, formed a wide bridge between what are now Asia and North America.

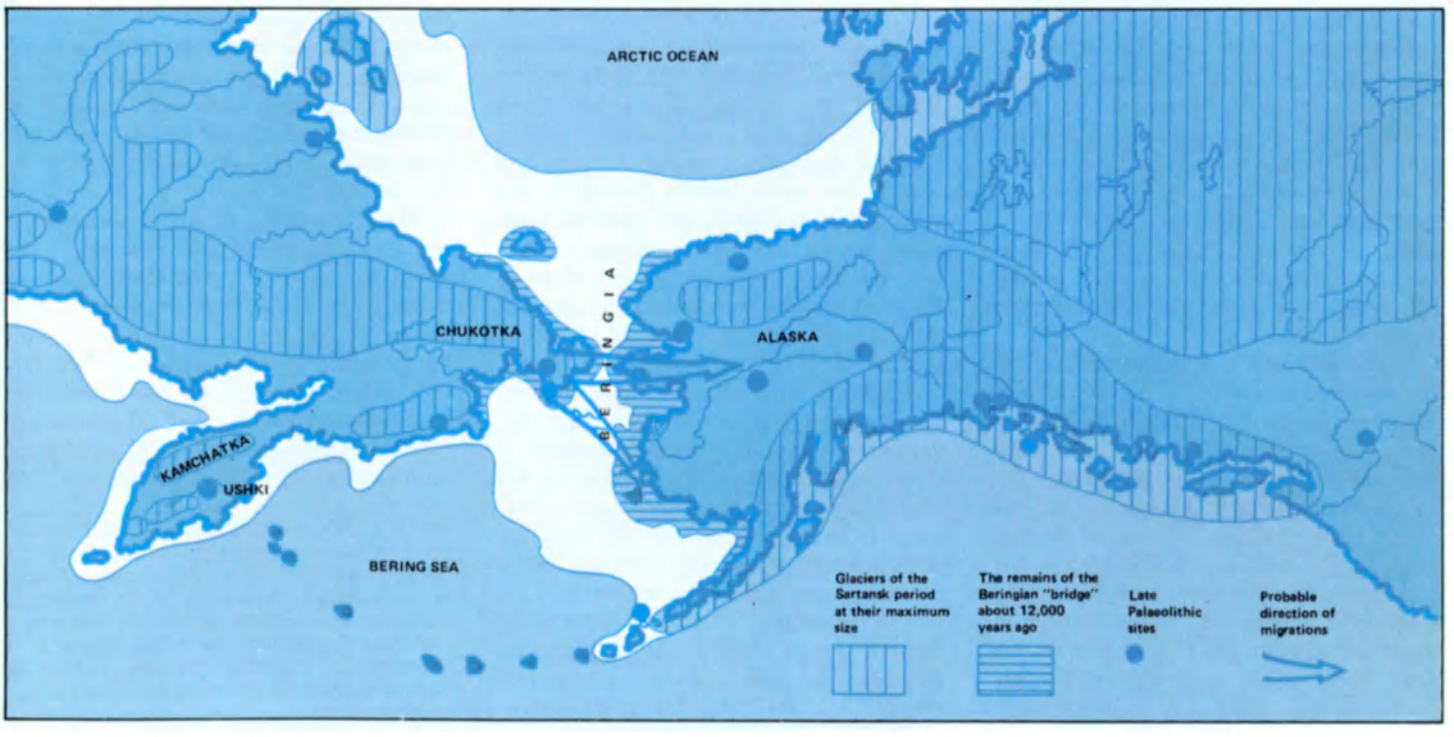
Data obtained by Soviet and U.S. archaeologists enable us to distinguish, with different degrees of precision, four stages in the peopling of Beringia.

The first stage is as yet in many respects hypothetical, but logically necessary. It appears to correspond either to the penultimate Ice Age, known as the Ziryansk Ice Age (70,000-50,000 years ago) or to the beginning of the last Ice Age, known as the Sartansk Ice Age (28,000-20,000 years ago). This is the stage to which we may attribute both extremely ancient relicts that have been found in America, including roughly chipped pebbles, and what appear to be prototypes of these ancient relicts which have been found at sites in the Soviet Far East in Chukotka and elsewhere.

The second stage, which is also largely hypothetical, corresponds to the period between 14,000 and 20,000 years ago when Sartansk glaciation was most extensive and Beringia itself reached its maximum size. At this stage, its tundra-steppes, which were populated with megafauna, were a single natural zone, cut off from its surroundings by glaciers to the west and east and by the relatively warm Pacific Ocean to the south.

In this closed-in region it was probably some time before there was any differentiation between the two cultural zones—the continental zone, where huge mammals were hunted in the tundra-steppes, and the north Pacific zone, near the coast, where hunters, of whom little is known as yet, exploited the sea's resources in a sporadic fashion. Technologically, this was still a united zone with a relatively uniform culture.

The third stage, which is quite clearly defined, corresponds to the dispersal to the western approaches of Beringia, in Kam-



View of the excavations (foreground) of the Ushki Palaeolithic site in Kamchatka. Around photo, stone implements unearthed on the site.

chatka, of the early Ushki culture, which is dated around 13,000-14,000 years ago and possibly earlier, judging by palaeo-magnetic dating. From this period on we can make fairly definite assertions about the cultural connections between Asia and America by way of Beringia—and also, perhaps, about population migration, when we think of the astonishing resemblance of Ushki stemmed bifacial stone points for missiles to those found in sites in the State of Washington, in the north-west of the USA.

This was the last period when cultural connections and perhaps population migrations were possible entirely over dry land, because up to the beginning of the thirteenth millennium Beringia was not divided by a strait. The north-west coast of North America could also be used to get from Beringia to America, which was covered with glaciers, for at that time the glaciers had somewhat diminished in volume and were no longer a hindrance to population migration along the Pacific coast, particularly for populations which engaged in hunting, fishing and gathering, as in the early Ushki culture.

The fourth and much more clearly defined stage corresponds to the very end of the Sartansk Ice Age (12,000-10,000 years ago). It is connected with the further erosion and ecological reconstruction of Beringia—the broadening of the strait between Chukotka and Alaska, the gradual swamping of the tundra-steppes and the reduction of the diversity of species and the number of megafauna. The main flow of migration to Beringia did not pass by the north route in the direction of Yakutia (although this cannot be entirely excluded) but by a south Pacific route in the direction of the northern part of what is now the Soviet Far East.

Here there came into being a new culture which was based on fishing and bison-hunting and could readily adapt to the new ecological conditions. This was the Late Ushki culture, which has been extensively studied in Kamchatka. It is characterized by large settlements, at the largest of which some thirty dwellings have already been excavated. These dwellings are quite different from the large double tents of the early Ushki culture.

There are also marked differences in stone implements. As well as the bifacial leaf-shaped non-stemmed points of missiles, forms of ornament much favoured by the Aleutians and the Eskimos have been found. A domestic dog burial has already been found, that of a dog like a husky. It is one of the most ancient burials in the Palaeolithic. Wedge-shaped cores are commonly found. They are yet another indication that there is a certain affinity between the Ushki culture and the Denali culture in Alaska, where the latter played its part in the formation of the proto-Eskimo Aleuts.

When the proto-Eskimo Aleuts reached the southern part of Beringia, they developed sea hunting more and more intensively. A factor that facilitated this was the considerable diminution in the size of Beringia (starting about 12,000 years ago). A strait gradually appeared, and boats had to be used to reach the eastern side.

The Palaeolithic sites in Chukotka may be seen as intermediary stopping places on the way from Kamchatka to Beringia and beyond it to America. The same wedge-shaped cores and bifacial weapon points have been found in them as in the Late Ushki culture in Kamchatka and the Denali culture in Alaska. This shows that population movement direct from Chukotka to Alaska took place 12,000-10,000 years ago, when Beringia began to get considerably smaller, until finally there was a strait where it had once been.

Underwater archaeologists working in the submerged land of Beringia can expect to make fascinating discoveries. They can use the latest diving equipment available on vessels such as the *Academician Nesmeyanov*, which is registered at the Far East Department of the USSR Academy of Sciences. This vessel is equipped with the latest apparatus including a system for the adaptive training of divers and remote control by television communication. It can carry out underwater operations at a depth of up to 300 metres.

As to the method of carrying out underwater investigations, what we have said about the pattern of the distribution of ancient sites in the parts of Beringia that were not submerged suggests that it would be advisable to begin—possibly by drilling—near the mouths of the river beds that have been found on the shelf. The success of these investigations is bound to be of great international scientific importance. ■

NIKOLAI NIKOLAEVICH DIKOV *is a corresponding member of the USSR Academy of Sciences and director of the archaeology, history and ethnography laboratory of the North-East Scientific Research Institute of the Academy's Far East Department. He is the author of 7 monographs, including "Ancient Culture of North-East Asia" (2 volumes) and over 150 scientific papers.*

Reports from 6 countries

SPAIN
Exploring a 'ships' graveyard'

Photo © M. Martín-Bueno, Saragossa

In August 1987, during an extensive underwater archaeological operation off the "Coast of Death", Galicia, a team of 20 archaeologists discovered the wreck of a ship which had taken part in a naval expedition sent by King Philip II of Spain against England. Many of the ships, which set sail from Seville and Lisbon, were wrecked in October 1586 during a violent storm off Cape Finisterre. The archaeologists made 600 individual dives and spent a total of 800 hours under water at a maximum depth of 25 metres. The excavation and recovery of some of the remains, which were located with the aid of magnetometers and uncovered by airlifts, was no easy task since the artefacts had fused together and were covered with concretion. The wooden wreckage had distintegrated, but it proved possible to recover a large anchor, some stone projectiles, a large quantity of small arms ammunition, and numerous coins (left), as well as pottery and personal accessories. Work in this veritable "ships' graveyard" is to continue for several years.

Manuel Martín-Bueno
Professor of archaeology,
University of Saragossa.
Director of the "Finisterre 87" expedition

THE NETHERLANDS
Archaeology in muddy waters

If beauty is in the eye of the beholder, maritime archaeology in The Netherlands cannot be called beautiful. Eyesight is often superfluous to the diver, who is confronted with absolute darkness or a shimmering opaque green micro-world in which the shapes and features of structural remains and differences in soil texture can be felt but can hardly ever be seen. Practically blinded, the diver feels his way and digs like a mole—although his method of excavation differs greatly from the one followed by that destructive creature.

The survey of a shipwreck discovered near the harbour of the medieval town of Medemblik illustrates how underwater archaeologists in The Netherlands work in such conditions. Maximum visibility on the site was about 0.5 metres. An accurate drawing of the remains protruding from the bottom was prepared in the following way. Pins were set out in a rectangle, the longitudinal side of which was parallel to the main axis of the ship. The pins were spaced exactly 3 metres apart. They were connected by strings, thus forming a grid. This grid was simply an aid for orientation, no measurements being taken from the lines. Trilateration measurements were taken from each set of two pins (see drawing bottom right). The measurements and all other data were recorded by speaking into a tape recorder. A pencil was only used to note certain specific details. In this way trilateration was carried out in confined areas, approximately square in shape and the resulting drawings were fitted into a general plan which provided an "overview" of this barely visible site.

Next, three trial trenches were dug perpendicular to the main axis in order to establish the midships, forward and aft sections of the hull, and to provide a relatively clear picture of the construction of the ship. With little work done on site a maximum of information was retrieved.

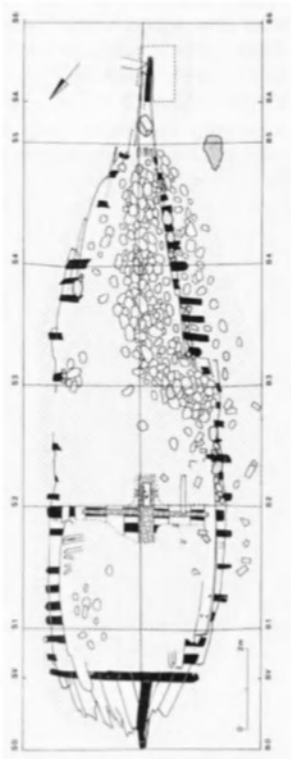
The find is of great interest from the point of view of shipbuilding techniques and traditions. It combines features of the medieval cog with distinct differences in construction. The underwater survey and trial excavation have shown that the ship dates from between the Middle Ages and modern times—a transitional period for the building of big ships.

There are no plans for extended excavation of the site. Its importance has been assessed and it can and will be kept as it is, an object for scientific research in the distant future. Why, it might be asked, wait so long if the site is so interesting? There are good reasons for this.

Firstly, much of the scientific research on sites in the reclaimed land of the Zuiderzee and on ships such as the Bremen Cog has not yet been published. Only when it is shall we get a clear picture of what is known and of the gaps in our knowledge. Only then will it be possible to formulate up-to-date hypotheses which can be tested on sites that have been preserved and protected.

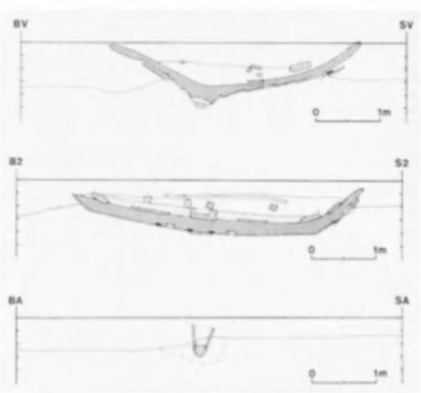
Another reason is that there are many more sites than can be tackled scientifically at present. Whenever protection is feasible we should thus limit our curiosity to a good survey.

Thijs J. Maarleveld,
Co-ordinator of underwater archaeology,
Government of The Netherlands

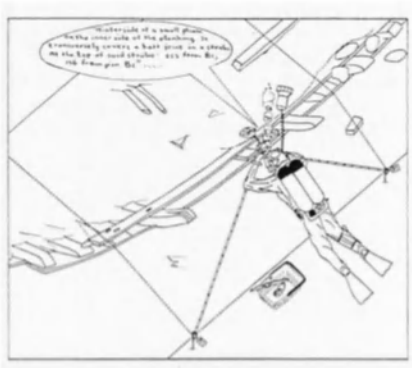


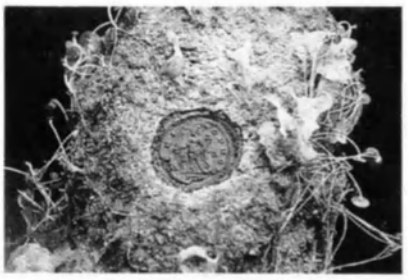
Drawings © T.J. Maarleveld

Left, plan of the wreck-site, with (below) sections of the trial trenches.



Below, trilateration measurements being carried out on the Medemblik wreck. All information was spoken into a tape recorder.





Top, detail of coin bag with 4th-century-AD Roman coin.
Above, fishbones preserved in resin.
Photos © C.R.A.S.A., Sardinia, Italy

ITALY
The Lazzaretto wreck, Sardinia

The Underwater Archaeology Research Centre of Sassari and Alghero (CRASA) in Sardinia is an association of scuba divers which works in close collaboration with the Sardinian archaeological authorities and employs the scientific expertise of a professional underwater archaeologist during excavations.

Its most important operation has been the complete excavation of the remains of a small Roman round ship which sank in the fourth century AD at Lazzaretto cove near Alghero. The wreck lay about 40 metres offshore at a depth of only 2.5 metres. Excavations were carried out for 2 seasons in June 1985 and June 1986.

Although the archaeological work has only just finished, we may already begin to draw some conclusions. The ship was loaded with preserved fish (in brine or dried) and *garum* (fish sauce) stowed in amphoras produced in northern Africa or southern Spain. One important find was a number of coins in a leather or cloth bag completely transformed by concretions. This small bag must have been affixed to its possessor's waist. One of the coins became detached from the rest and left a perfect impression on the concretion, enabling us to conclude that it is a *follis*, struck during the reign of the Emperor Licinius and issued in AD 315-316. The shipwreck was caused by a southwesterly gale, but we cannot exclude an act of piracy.

Edoardo Riccardi
Scientific Director, Lazzaretto project

A diver positions a measuring scale during excavation of the wreck of an 18th-century Dutch freighter found by sports divers off the coast of Norway. Each year sports divers locate many new archaeological sites.

Photo © Nils Aukan

NORWAY
Amateurs are welcome

Ever since its birth in the early 1960s, Norwegian marine archaeology has depended heavily on the participation of amateur divers, and the museums co-operate closely with the Norwegian Diving Association. Local diving clubs have formed marine archaeology groups whose members specialize in such fields as underwater photography, drawing, and surveying. The museums contact the groups when they need assistance. Projects are usually carried out during the summer holidays and the divers are unpaid, although they receive compensation for the use of their personal diving equipment as well as travel and lodging expenses.

One important wreck that has been surveyed and worked on by amateur divers is a medieval hulk dating from about AD 1450, which has been found in southern Norway. Its cargo seems to have consisted of flagstones, sarcophagus lids, and round copper ingots. Fossils in the limestone flag-stones indicate that they came from a quarry outside the town of Tallin in Estonia. The wreck was excavated by sports divers under the supervision of the Norway Maritime Museum during 1986 and 1987.

Torstein Ormoy,
Norwegian Diving Association

MEXICO
Sacred wells and Spanish galleons

Although objects were being recovered from the sacred well of Chichén Itzá as early as the end of the 19th century (see page 12), it is only relatively recently that systematic exploration began of Mexico's important underwater heritage of pre-Hispanic votive offerings and other objects in inland waters and its maritime colonial heritage of Spanish vessels and their cargoes. In 1980 a Department of Underwater Archaeology was created as part of the National Institute of Anthropology and History (INAH), the federal institution with responsibility for the protection, investigation and conservation of the country's archaeological heritage.

One important project undertaken by the Department began when a group of U.S. sports divers who were exploring the Cayo Nuevo reef in the Bay of Campeche discovered several iron cannon and an anchor, as well as a bronze cannon with 16th-century inscriptions and emblems which particularly attracted their attention. In 1979 the INAH began work on the site with the Institute of Nautical Archaeology at Texas A & M University, and since then other objects have been retrieved from this 16th-century shipwreck and the remains of an 18th-century wreck have been located. The 16th-century bronze cannon is today preserved in a museum in the city of Campeche.

Half Moon Spring in San Luis Potosí State, a spring into which offerings were thrown in pre-Hispanic times (above all between AD 600 and 900) is the site of another project sponsored by the Department. Unfortunately, the spring's popularity with divers has encouraged looting, and thousands of objects have been removed without any control or record.

In 1984 the Department launched a project on "Aids to pre-Hispanic navigation on the east coast of the Yucatán peninsula". The aim is to locate and analyse offshore structures such as lighthouses which might have aided navigation in pre-Hispanic times.

Finally, the Department has embarked on the preparation of an atlas of all Mexico's submerged sites of archaeological interest, both inland and at sea.

Pilar Luna Erreguerena,
Department of Underwater Archaeology, National Museum of Anthropology, Mexico City

Hauling aboard a 16th-century iron cannon, Bay of Campeche, Mexico

Photo © Pilar Luna Erreguerena

SRI LANKA
Coins and cannon

Owing to its geographical position in the Indian Ocean, centrally situated in the sea lanes linking the Near East and the East Indies, Sri Lanka has been an important landfall for seafarers ever since ancient times, when it was known as Taprobane to the Greeks and Romans, Serendib to the sea-farers of old Arabia, and the "land without sorrow" to the Chinese. The great Chinese traveller Cheng Ho made several visits to the island in the early years of the fifteenth century as part of his explorations of the "Western Oceans".

There is no doubt that there are wrecks in Sri Lankan coastal waters dating from the period of European expansion into South Asia. An expedition to the Great Basses reef in the early 1960s, the first real attempt at the archaeological exploration of a wreck off southern Sri Lanka, produced finds including some 350 pounds of silver coin, a bronze cannon and flintlock pistols. Post-expedition analysis established that the coins came from Surat, the cannon may have been British, and the ship may have been built in Southeast Asia. More recently, important studies have taken place on the traditional *Madel Paruwa* or sewn boats, drawing attention to the need for research on the ethnographic material relating to the Sri Lankan maritime heritage.

In late 1986 an exploration of two reported wreck sites was organized as part of a feasibility study on the marine archaeological potential of Sri Lanka. The first took place in Galle harbour, 115 km south of Colombo. Galle, dominated by the massive ramparts of the Portuguese and Dutch fort in which the city is contained, is bounded on the east by Mount Rummaswela, which has a perennial fresh water spring. Folklore relates that this fresh water source was used by vessels in Antiquity. A scatter of artefacts including local and imported pottery was found. The second site, approximately 2 km west of Colombo, was identified by local divers some years ago, at a depth of 20 metres, and was assumed to be the location of two jettisoned cannon. The 1986 survey identified two more cannon and it has been suggested that they are probably of a seventeenth-century type used for merchant service. These limited explorations showed that a coherent maritime archaeology programme is called for, and as a result a joint "Sri Lanka Maritime Heritage Project" between the Sri Lanka Department of Archaeology and the University of London has been prepared.

Prasanna Weerawardane
Department of Archaeology, Sri Lanka

Photo Unesco/Kyodo News

A sea-going vessel of a kind which would have plied the Indian Ocean in the 8th or 9th century AD. Detail from a low-relief carving at the Buddhist temple-sanctuary of Borobudur (Indonesia).

The Bodrum Museum of Underwater Archaeology, Turkey, houses important displays of the remains of five scientifically excavated shipwrecks from Antiquity. Below, 1:20 scale diorama of the excavation of a 4th-century-AD Roman shipwreck at Yassi Ada (near Bodrum, in south-west Turkey), carried out during the late 1960s. Several modern underwater search techniques were used for the first time during this excavation.

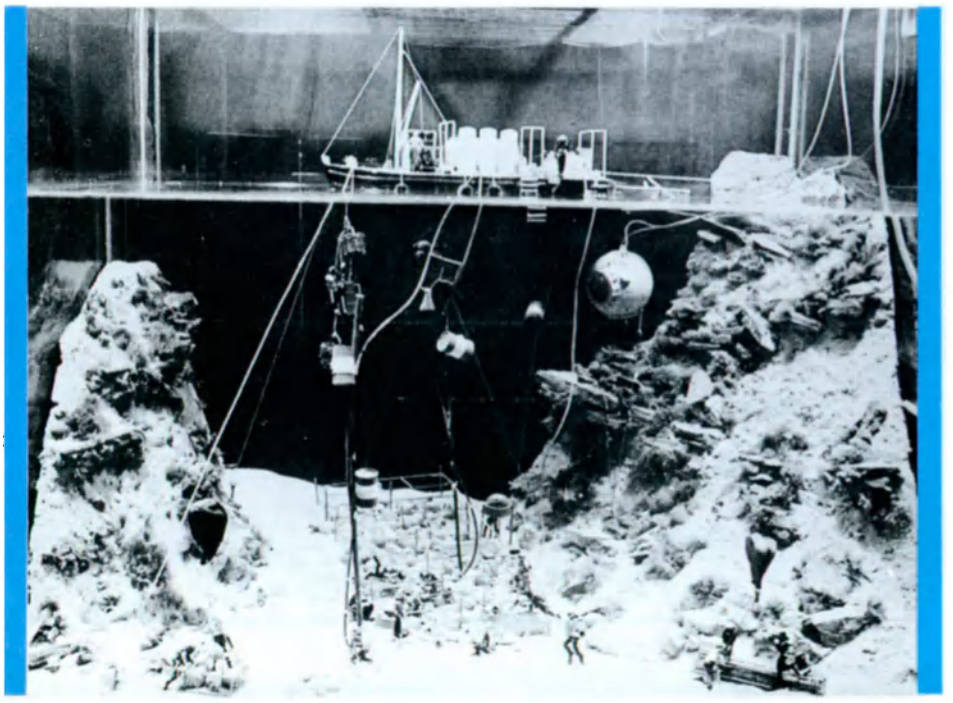


Photo © Bodrum Museum, Turkey

Below right, this Chinese celadon jar *(Ch'ing-pai* type) with carved dragon handles is thought to date from the 14th century. It comes from a shipwreck off Shinan (Republic of Korea) that has been excavated and studied since 1976 by archaeologists from the Cultural Properties Preservation Bureau, Seoul. Examination of artefacts found on the wreck, notably almost 9,000 pieces of celadon and around 4,500 porcelain objects, should throw light on the history of Chinese porcelains and of international sea trade in the Middle Ages. Right, Chinese coins *(Chi-dai T'ung-bao)* found at the Shinan site. They were minted in the early 14th century and were legal tender in Japan and other countries in the region, as well as in China. The finds confirm that this ancient Far Eastern shipwreck is perhaps the richest ever found, both in terms of the value of the cargo as well as for the information it provides on traditional naval construction techniques in this region.

Photos © Kim Tae-byok

Apollonia, a model port of Antiquity

RECENT discoveries made in the submerged ancient harbour of Apollonia (see colour page 22) by the French Archaeological Mission to the Libyan Arab Jamahiriya were featured in an exhibition held at Unesco's Paris headquarters from 3 to 15 June 1987. The exhibition, produced by Unesco's Division of Cultural Heritage, also highlighted the results of major projects for the study, safeguard and presentation of the Libyan Cultural Heritage carried out as a result of co-operation between Unesco, the Department of Antiquities of the Libyan Arab Jamahiriya, and the Archaeology Department of the University of Manchester (UK).

Located on the northeast Libyan coast, Apollonia has been described as "a textbook example of an ancient harbour." It was the port, and originally a dependency, of the great inland city of Cyrene, which was founded around 631 BC. In the first century BC, it became a city in its own right. Today the ancient harbour installations are submerged because of subsidence that has occurred all along this part of the Libyan coastline.

The harbour was formed of two linked sandstone islets joined to the shore by natural breakwaters. Today these islets are 300 metres offshore. An extraordinary range of buildings and other structures has been discovered, including the best preserved set of slipways in the Mediterranean, a well-preserved piscina or fish tank, and the remains of warehouses including grain-storage silos cut into the rock.

The French Mission, directed by Professor André Laronde and working in co-operation with the Archaeological Service of the city of Arles, has carried out a systematic survey of submerged structures and wrecks and other material recently located in the eastern dock. The wreck of a merchant ship, originally about 25 metres long, has been discovered. Apart from its wooden structure, the wreck has also yielded ship's tackle and the remains of a cargo have been found nearby.

Another wreck contained terra-cotta bowls with ornamentation in relief, known as "Megarian" ware, which come from the coast of Asia Minor, together with Rhodian amphoras for transporting wine. The stamps on the handles make it possible to date this material and consequently the whole cargo to about 180 BC. Underwater exploration has also produced an abundance of undecorated ceramic ware, most of it locally made, which gives an idea of the accessories of everyday living. A bronze candelabrum head from the beginning of the Roman period bears witness to trade with southern Italy in the first century BC, while a gold coin (*solidus*) from Constantinople shows that trading relations were still being maintained at the time the Arabs arrived in Libya. ■

Acknowledgments

We regret that owing to a last-minute technical error, the September issue of the *Unesco Courier* devoted to the Baroque was printed without a note expressing our gratitude to the French art critic and former Unesco staff member Michel Conil Lacoste for his help in preparing that issue. The Editors also wish to acknowledge their indebtedness to *Le Baroque*, a monumental work by the French author Yves Bottineau, published by Editions Mazenod, Paris, 1986.

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Forty years of cultural action

The *Unesco Courier,* which was first produced in 3 languages, is now published in 34 languages worldwide, in addition to Braille editions in 4 languages. In the early days, its circulation was a few thousand; today hundreds of thousands of copies are printed and the magazine is read by over 3 million people of all ages and on all continents. In its forty years of existence the *Unesco Courier* has won for itself a unique position on the international cultural and publishing scene. In the words of its Editor-in-Chief, Edouard Glissant, "the editions of the *Courier* produced in 34 languages not only represent an outstanding publishing achievement, they constitute above all an irreplaceable instrument for mutual enrichment and international understanding, without being either bland or partisan".

To mark these "40 years of cultural action", the *Courier*'s Paris staff organized an exhibition about the magazine which was held at the Georges Pompidou Centre, Paris, from 9 September to 5 October 1987. A series of display panels retraced in words and pictures the history and achievements of a magazine which, in the words of Unesco's Constitution, has always sought to "construct the defences of peace in the minds of men" by developing understanding between peoples and cultures.

The exhibition, which will later tour France and other European countries, was accompanied by a series of films about Unesco's work, one of which has as its theme the cover designs of the *Courier.* On 10 September four writers associated with Unesco and with the magazine took part in a poetry reading at the Pompidou Centre: the Arab poet Adonis, deputy permanent representative of the Arab League to Unesco; the Martinican poet Edouard Glissant; the French poet Alain Lévêque, senior editor of the French edition of the *Courier;* and Henri Lopès, Congolese novelist and Unesco's Assistant Director-General for Culture and Communication.

A fortieth anniversary issue of the *Unesco Courier* will be published in 1988.

Group photograph taken at Unesco's Paris Headquarters on 23 April 1987 during a meeting of Editors of the **Unesco Courier**

Photo Unesco / Salvaro