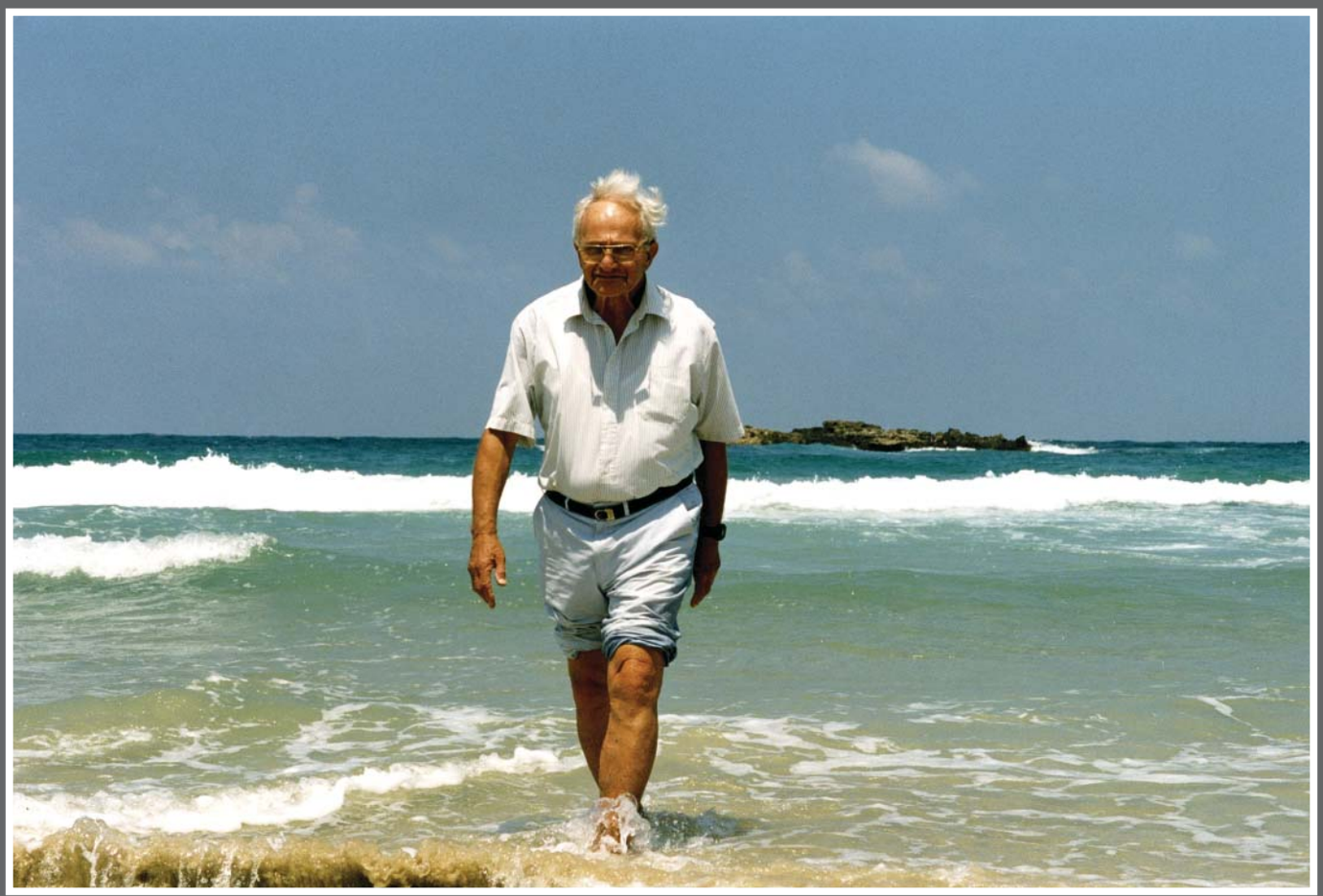
אוניברסיטת חיפה המכון ללימודי ים ע"ש ליאון רקנאטי

R.I.M.S. NEWS

UNIVERSITY OF HAIFA LEON RECANATI INSTITUTE FOR MARITIME STUDIES



Elisha Linder

1924 – 2009

REPORT NO. 35, 2009

Contents

Dear Friends,

In June 2009 Elisha Linder, the founder of the Leon Recanati Institute for Maritime Studies and the Department of Maritime Civilizations, passed away. This issue of the Newsletter is devoted to his memory.

Underwater archaeology is taking us back once again to the bay of Athlit (after the study of the Phoenician harbor – see R.I.M.S. NEWS 31 and 34) in the footsteps of Elisha Linder and Avner Raban, and to Dor South following another chance discovery (*Dor 2006*). These two projects were challenging and difficult, as we had to excavate in shallow water, and struggle with the open sea in the surf zone. This kind of work requires highly motivated, experienced and well-trained divers. The *Dor 2006* project, the first season of which was completed this year, has been recognized by the Israel Science Foundation, which has awarded a grant for the project for four years of research. The preliminary results have been presented at an international conference, and are summarized in the following pages. Two M.A. students of the Department of Maritime Civilizations have started their research on this shipwreck.

The 10th season of the combined underwater study project of the Universities of Ankara and Haifa, at Liman Tepe, Turkey, directed by Prof. Michal Artzy, took place last summer. Members of the Hatter Laboratory at the Recanati Institute contributed to the publication of Avner Raban's book, as well as to the Caesarea material and the Salvage Excavation Reports. A large excavation salvage project was carried out in cooperation with the Israel Antiquities Authority. Cooperation with the SCIEM 2000 Program of the Austrian Academy of Sciences and the University of Vienna on the Bronze Age Bichrome Ware and the Cypriot Imports in Northern Israel is continuing. A ground penetrating radar survey and an underwater survey are being carried out in the area of Tel Nami by Yossi Salmon, a Ph.D. student.

We have established a joint research project in underwater archaeology with the Faculty of Engineering and the Laboratory for Comparative Microarchaeology of the Department of Archaeology and Ancient Near Eastern Civilizations at Tel Aviv University. Research into several artifacts recovered from the sea is in progress, with significant results in course of publication.

Waterlogged artifacts from the sea, at present mainly from the Akko 1 Shipwreck, are being conserved in the Elaine Recanati Laboratory. Large timbers and small wooden artifacts, as well as leather items, are being conserved by two different methods: PEG 100% and freeze-drying. The conserved items will be exhibited in the Hecht Museum at the University of Haifa.

Dr. Ezra Marcus, together with Dr. Yosef Porath, are continuing the study of the finds from Tel Ifshar, in the Sharon plain, which are shedding important light on international maritime trade in the eastern Mediterranean in the 19th century BCE. This work and related studies (e.g., on Tel Akko) are supported by grants from the Israel Science Foundation, the German Israel Fund, the White-Levy Fund and the SCIEM 2000 Program.

Dr. Assaf Yasur-Landau is continuing the Tel Kabri archaeological excavation. This is a joint project with Dr. Eric Cline of the George Washington University, and is supported by the Institute for Aegean Prehistory (Philadelphia) and the National Geographic Society. In addition, Assaf is preparing for underwater excavations at the Phoenician harbor of Achziv, after a preliminary survey and obtaining seed money from the University of Haifa. His first Ph.D. student has started her research on the pottery from Kabri and its relation to maritime trade.

Dr. Dorit Sivan, the Head of the Department of Maritime Civilizations, is extending her research into sea level variation on Israel's coastline during the last 10,000 years, with emphasis on the last 2,000 years, and especially the Crusader period, based mainly on archaeological evidence. She is instructing an M.A. student, who has already presented her preliminary results at an international conference.

In marine biological activities, Prof. Spanier has initiated a new project of recording and studying the ecological and commercial effects of 'ghost nets'—fishing nets abandoned on the seabed. He is also continuing a three-year survey of the Israeli Mediterranean trawl fisheries, supported by a 3-year research grant from the Israel Ministry of Agriculture, with logistic support of the Fisheries Department of the Israel Ministry of Agriculture.

Dr. Dani Kerem is focusing on erecting the display of a 13.5 m-long skeleton of a fin whale calf that entered the Eilat-Ashqelon Oil-Pipe anchorage in February 2008, only to succumb after a few hours. Several research studies on the local population of the common bottlenose dolphin: social ecology, morphometry, genetics and toxicology, are in progress.

Dr. Dror Angel is conducting several basic and applied interdisciplinary research projects in marine and coastal ecology, including a NATO Science for Peace Program, a GIF project, an FP6 EU project, an FP7 EU project, and several projects with the Food and Agriculture Organization of the United Nations – all on various environmental, socio-economic and policy

implications of marine aquaculture. These are being carried out with students of the University of Haifa, the Ben Gurion University of the Negev, the Technion, the Inter-University Institute of Eilat, and foreign universities. A European Research project on climate change is being carried out in collaboration with Italian and Croatian partners, and helps support an M.A. student at the University of Haifa. Recently a research project for investigating the dense jellyfish blooms along the Israeli coast has been initiated as an M.A. project.

Dr. Nadav Kashtan is in the final stages of his work on the development of an intelligent mobile guide for museum visitors, as part of the Haifa-Trento scientific collaboration, and continues his research into ship motifs in classical literature, and the role of maritime cities in the ancient Mediterranean. Dr. Kashtan has established a B.A. program in conservation studies at the Western Galilee College, collaborating with the Recanati Institute on the aspects of waterlogged artifacts.

Prof. Sariel Shalev, together with Prof. Yossi Mart and Dr. Yaacov Kahanov, have established an analytical laboratory for the study of archaeological materials and sediments. The laboratory, which is financed by the Israel Science Foundation, with partial matching from the University of Haifa, is already active.

Dr. Daniella Bar-Yosef Mayer has been studying shells and beads from various prehistoric sites; and with Dr. Irit Zohar, has found that the oldest marine fishing in Israel probably started about 14,000 years ago.

Prof. Yossi Mart presented a series of lectures on the application of analog modeling to the geological history of the Middle East. He visited the Universities of Cambridge, Oxford, Southampton, and Manchester in England, Edinburgh and Aberdeen in Scotland, and the University of Western Brittany in France.

The results of these research projects are scientific publications, some of which are summarized in this issue. All these studies were made possible thanks to the staff, infrastructure, and maritime workshop of the Institute.

The activities of the Institute could not have been sustained without the generous and continuous support of the Recanati family, with the close involvement of Ariel Recanati and Elaine Recanati; Sir Maurice and Lady Irene Hatter, and other generous donors. We have also received donations from the Dead Sea Industries for the research study of the Molyneaux boat, and from Mr. Dov Shafir for an M.A. student who will study subjects in the spirit of Elisha Linder's heritage. These were matched by the Charney School and by the President of the University respectively. We are grateful to them all.

Yaacov Kahanov

The Leon Recanati Institute in full bloom

Remembering

Elisha Linder

1924–2009

Dr. Elisha Linder, the founder of maritime archaeological research and education in Israel, passed away peacefully in his kibbutz Ma'agan Mikhael on Sunday morning, 7 June, 2009, at the age of 85.

Elisha received his Ph.D. from Brandeis University in 1970. But even during his graduate studies he acquired a profound interest in maritime archaeology, which led him to establish, in 1961, the Undersea Exploration Society of Israel. With that Society he initiated archaeological surveys of ancient maritime sites in Israel, such as Achziv, Akko, Athlit, Dor, Caesarea, Yafo and Ashkelon along the Mediterranean coast, as well as Gezirath Fara'un and several other shipwreck sites in the Red Sea and in Lake Kinneret. In 1971 he joined the academic staff of the University of Haifa. In 1972 he founded the Department of Maritime Civilizations, and, concurrently, with the generosity and active support of Jacob Recanati, he founded the Leon Recanati Center for Maritime Studies.

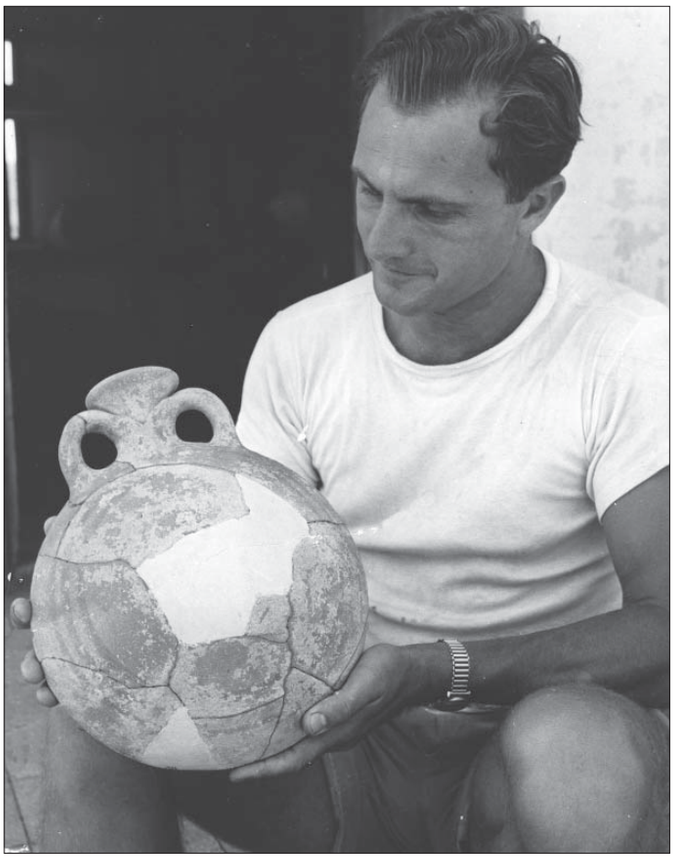
Early in his academic activity Elisha Linder realized that research and investigations of maritime material culture should be multidisciplinary, and experts in maritime archaeology and maritime history should cooperate closely with marine geologists, marine biologists and physical oceanographers to retrieve reliable information from the seafloor. To this end he built the Department of Maritime Civilizations academic curriculum to be multidisciplinary and interdisciplinary, and consequently he recruited for the Department not only archaeologists and historians, but also biologists and geologists, who cooperated closely in their teaching, in their tuition of their graduate students, and in their active research. Furthermore, Elisha insisted that all theses written in the Department will be multidisciplinary, and should require at least two advisors of complementing expertise. In this composite approach Elisha envisaged the development of these fields of science and was ahead of his time in comparison to, the then, general attitude to research.

Elisha Linder was deeply interested in the Phoenician, Hellenistic and contemporaneous shipping enterprises, and was fortunate to lead in-depth investigations of two outstanding finds in this field. The first was the discovery of a battering ram off Athlit, attributed to a Hellenistic galley that has not been discovered yet. Large rams were known from ancient paintings to be mounted on the bows of the warships of the ancient Mediterranean, but the 465 kg weight of the Athlit ram and the high quality of the bronze it was cast from, exceeded expectations. The ram is exhibited at the National Maritime Museum in Haifa and several replicas are exhibited in Museums around the world. Then, in 1985, a cargo vessel, dated approximately to 400 BCE, was fortuitously discovered at the beach of Ma'agan Mikhael, some 500 m from his own doorstep. During the following 15 years, Elisha guided the scientific salvage of the shipwreck, recording the shape of the vessel and its cargo, excavating it from the seafloor, and conducting its arduous conservation. He tutored several graduate students researching the wreck and led a complex, multidisciplinary expedition to explore the multifaceted aspects of ancient shipping, as well as the preservation of ancient vessels. He also succeeded in arousing the curiosity and interest of several benefactors who generously supported the enterprise of excavating, preserving and presenting the unique ancient vessel. Today the Ma'agan Mikhael ship is on display at the Reuben and Edith Hecht Museum in the University of Haifa.

Elisha Linder was a pioneer not only in maritime archaeology in Israel, but in his understanding that maritime research must be multidisciplinary, and experts from the numerous fields of oceanography should join together to thoroughly explore the ways in which man has been using the sea for transport, communication, trade and war. His contribution to maritime archaeology and *Humanistic Oceanography* has been internationally recognized repeatedly, and *Humanistic Oceanography* was indeed Elisha's real field of passion and expertise.

Yossi Mart

With the Rothschild family – inaugurating the first diving center at Caesarea Maritima, May 1965



In the Museum established by Elisha in Kibbutz Ma'agan Mikhael in 1966

Study cruise to Sicily 1976 with students from the Dept. of Maritime Civilizations

Studying 'Tanit' figurines found in Shavey Zion underwater excavation 1973

Side-scan sonar survey with Harold Edgerton

Akko underwater excavation, 1975

Receiving the Golden Trident Prize of the Italian Academy of Undersea Activities, 1989

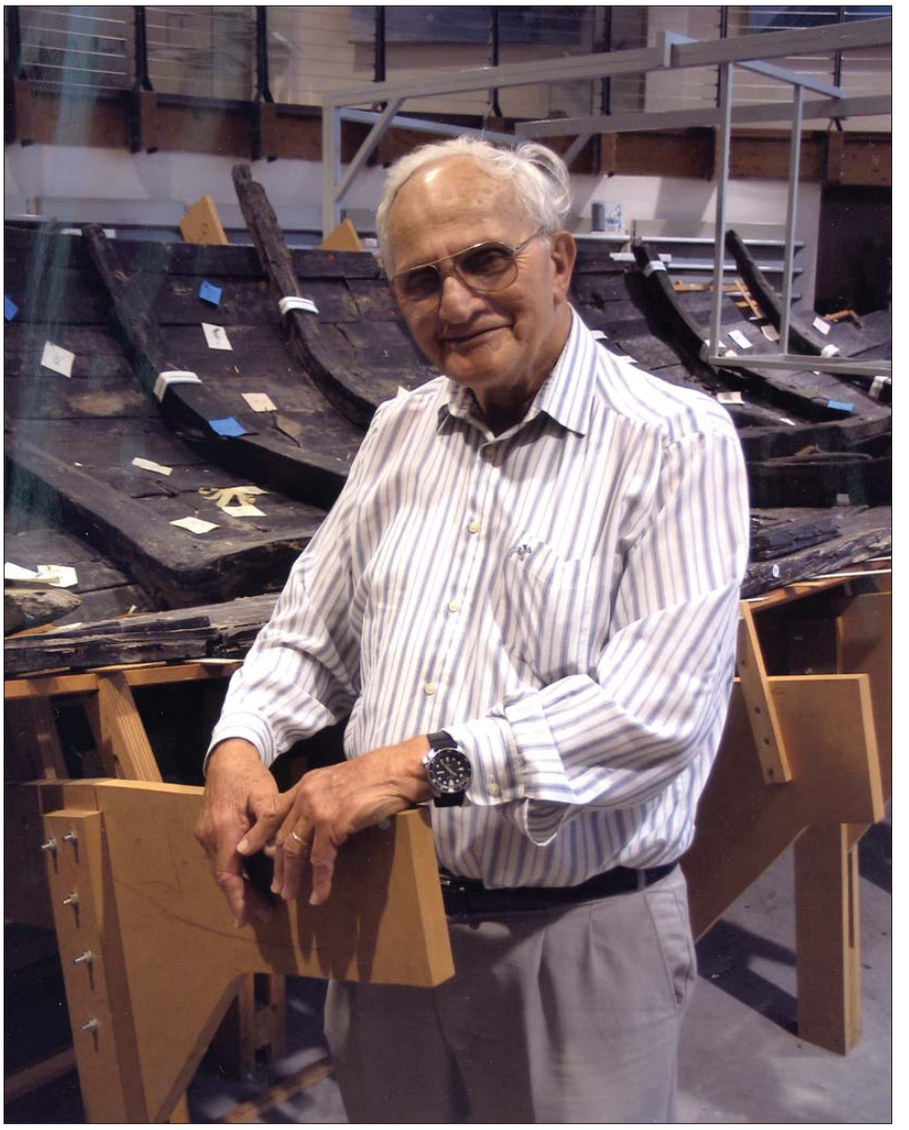
♦ Elisha's labor of love, which occupied him for more than twenty years, was the Ma'agan Mikhael ship, which is now exhibited in the Hecht Museum. It was during this period when I, as a student, met him. This project, from the underwater excavation to the retrieval, conservation, reassembly and exhibition in a purpose-built Museum, was the creation of a unique personality, who inspired and recruited students, staff, supporters and friends from all over the world. The close personal relationship between Elisha and Lord Jacobs, the benefactor of the Ma'agan Mikhael project (as well as other projects) and former Chairman of the Board of Governors of the University, were unique. The Ma'agan Mikhael ship is not only the jewel in the crown of the University of Haifa and its Maritime Studies, attracting international scientific recognition, but also an Israeli contribution to the World's heritage.

Elisha's idea of studying and researching different aspects of 'Man and the Sea' from the maritime point of view was an innovative break-through. Elisha's inner drive never relaxed. With Edgerton, Link, Throck-morton, Flemming, Flinder, Pomey, Basch, Aharweiler,

Steffy, McGrail, Crumlin-Pedersen and Tzalas – the leading group of scholars in several disciplines, he anticipated similar modern enterprises by 40 years. This idea and its practical aspects became a source of worldwide admiration of Elisha and his activities. Elisha not only had the vision to establish an interdisciplinary department about 40 years before the terms 'interdisciplinary' and 'multidisciplinary' became popular and key words for academic studies and research; but also obtained academic backing and support from the Israeli archaeologists Benyamin Mazar and Yigal Yadin, and raised the financial means to establish the Center for Maritime Studies, now the Leon Recanati Institute for Maritime Studies.

Elisha made the first remote sensing survey of the harbor of Akko and its surroundings. He initiated the world's largest harbor excavation in Caesarea, introducing the scientific background with the help of Edwin Link, combined with the financial support of Baron Edmond de Rothschild. Avner Raban inherited the Caesarea project, and its continuation is another international success in scientific advancement and innovation.

Visiting College Station with J. R. Steffy and Yak Kahanov



In the Ma'agan Mikhael Ship Museum at the University of Haifa

Elisha created the first core of scholars and students, with whom he continued to realize his vision. He was respected worldwide, and among other awards received Italy's Franco Papo and Dioscuri Prizes, and the Trident of the Italian Academy, as well as the Israel and Bible Lands Percia Schimmel Award from the Israel Museum.

Elisha was our teacher and mentor. He opened our way to the study of 'Humanistic Oceanography', combined with the science he believed in. He never flagged; his spirit, initiation and vision encouraged many, including myself, who owe their careers to him and who are inspired to continue in his footsteps.

Yaacov Kahanov

The Amankila Hotel
Bali
Indonesia

July 5, 2009

My Dear Pnina,

It is with a heavy heart that I write this letter. I loved Elisha as I am sure many others did. He was the total inspiration for my work in Israel but that was nothing compared to his. The Ma'agan Mikhael ship and the museum will deservedly carry his name forever.

I recall so many good moments with him but none more exciting than the day he first walked into my office in London. He was such an exciting man to be with.

But, my dear Pnina, these memories which you share are just a small part of the wonderful man he was as father and husband. The sadness you and your family now share can only be softened by memories and time alone will help to ease your grief.

Evelyn and I send you and your family our deepest sympathy. We both hope we can meet with you again when we next come to Israel.

With fondest love,

Anthony

With Lord Anthony Jacobs

TEMPLE ANSHEI SHALOM
Rabbi Barry J. Konovitch
הרב יעקב ברוך קנוביץ

July 14, 2009

Mrs. Pnina Linder
Maagan Michael
37805
Israel

Dear Mrs. Linder,

My sincere condolences on the passing of your beloved husband Elisha.

I had the good fortune and honor of knowing him for a few short years and spending some inspirational time with him. I shared his enthusiasm for underwater archaeology and one of the highlights of my many visits to Eretz Yisrael was a dive we made in Tantura lagoon along with "Yak" on the underwater wrecks.

Elisha represented to me the great generation of the founding fathers of Israel. The true Chalutzim in the physical, intellectual and spiritual sense. I was honored to know him.

Sincerely,

Rabbi Barry J. Konovitch

Teaching at his kibbutz – Ma'agan Mikhael

Dear Yak,

Thank you for informing me so quickly of this quite sad news. I share your mourning and your sadness. You have lost a great figure, the founder of Israeli underwater archaeology, and more still, your mentor.

Elisha established the Center for Maritimes Studies and contributed to its international reputation. Maritime archaeology owes him some of its more beautiful discoveries; the Athlit Ram and the Ma'agan Mikhael wreck for example.

I will always remember Elisha's high stature which, in the meetings, exceeded all the others and his strong personality which impressed and influenced us all. He expressed to me his warm friendship since our first meeting in Italy, in Spoletto in 1972 (or 1973) and since then we regularly met all around the Mediterranean and elsewhere on the occasion of scientific meetings. Elisha invited me to Israel and I remember particularly his warm welcome at Kibbutz Ma'agan Mikhael where he was so happy and so proud to have discovered the wreck right in front of his house, like a symbol.

I join you all in this moment of sadness and will be with you, in thought, at the time of the funeral. I ask you my dear Yak to transmit to all my most sincere condolences and my saddened thoughts. I think of his wife and his family, hoping that this testimony may bring comfort to them.

Avec toute mon affectueuse amitié ,

Patrice Pomey

Dear Pnina,

I was very sad to hear from Yak Kahanov that Elisha had passed away. He was an inspiration to so many people, and it must be a terrible loss for your family.

Elisha first talked to me about underwater archaeology in Miami, I think, in about 1967. We met again in St. Paul Minnesota in 1972, and then at the CMAS World Congress in 1973. Always he was full of ideas and new discoveries and enthusiasm for exploration. At the CMAS conference he and other Israeli divers left quickly to return to Israel when the war started. Then, afterwards, he had that extraordinary idea of inviting me to come to Israel and organize a training course for soldiers injured during the war, it was my first visit to Israel, and an experience that I will treasure forever. It was inspiring for me to meet so many brave young men, and to enjoy for the first time the atmosphere and exuberance of life in Israel.

In 1975 Elisha invited me to work at the University, and so we began many years of collaboration in the study of the ancient ports and structures all along the coast of Israel. He started so many new projects: inspired so many people to follow his ideas; and encouraged so many publications. Underwater archaeology was truly shaped by Elisha's spirit during its formative decades.

Please accept the condolences and best wishes from myself and Jay to you and all your family.

With respects and best wishes and deepest sympathy,

Nic Flemming

Akko 1974. Diving course for disabled soldiers

Liman Tepe Underwater Excavations: A retrospective

Panoramic view of the Liman Tepe area (Photo: S. Breitstein)

The joint project of Ankara University and the Leon Recanati Institute for Maritime Studies of the University of Haifa has been ongoing since 2000.

Since we last wrote, some changes have taken place. Ankara University has inaugurated its own Research Center for Maritime Archaeology in Urla (ANKSÜM), and Dr. Vasif Sahoglu became its second director following in the footsteps of Prof. Hayat Erkanal. The Center has purchased diving and underwater excavation equipment similar to that our workshop has developed over the years. From 2006, we have used their equipment to carry out the underwater excavation instead of shipping our own.

Vasif Şahoğlu, Riza Tunçel and Levent Keskin have received their Ph.D.s. Dr. Şahoğlu is now serving as the director of Ankara University's excavation in the 2nd Millennium BCE site of Çesme, Dr. Ayşe-Gül Akalın is now the director of the Ankara University's excavations of *Erythraei.* Irfan Tuğcu and Sıla Mangalagulu Votruba are now advanced Ph.D. students. On the Israeli side – Beverly Goodman has received her Ph.D. (on a Liman Tepe related subject). Arad Haggi has now completed his Ph.D., Yossi Salmon is an advanced Ph.D. student and Gregory Votruba is a Ph.D. student in Oxford.

Based on the experience accumulated over the years, excavation logistics have improved significantly, including the implementation of a new system of running water from the pump to the dredgers, with the pump being located safely on the shore, instead of on a boat, and the water transferred to the dredgers with a special polyethylene hose bought for the purpose (Fig. 1). This new system is very convenient: setup and closure times have been shortened, and no working days are lost as in the past, due to waves flooding the boat and pump (see for instance: R.I.M.S. NEWS No. 30, pp. 20–21). The original research goal of the underwater excavation was to identify the harbor anchorage of the Bronze Age site of Liman Tepe, particularly that of the Early Bronze, when the site was equal to or larger than another Bronze Age site in the region – Troy. The likelihood of finding an artificial harbor of that period seemed problematic, since the earliest man-made harbors dated to a much later era.

Fig. 1. Laying out the pump hose on land (Photo: M. Artzy)

Geomorphological studies, carried out by Goodman and members of the team, located an area east of the Tel where there might have well been a natural bay used as a harbor during the Bronze Age period (Fig. 2). The results of the project to date include contributions towards understanding broader coastal processes during the Holocene, as well as recognizing harbor floors using integrated methodologies.

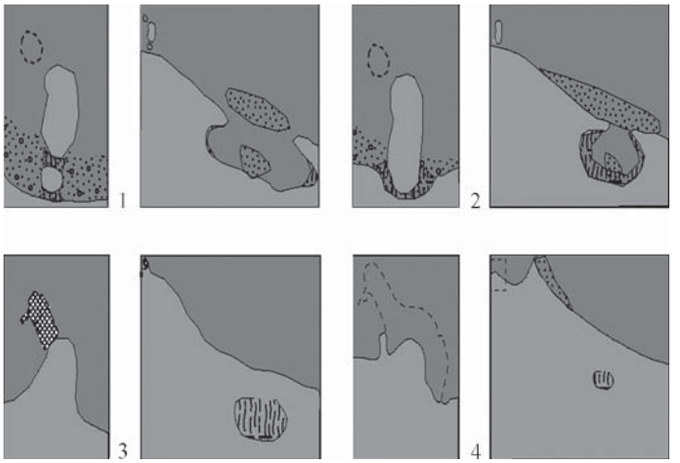


Fig. 2. Coastal changes: (1) EB I; (2) EB II; (3) Archaic; (4) Modern (Prepared by B. Goodman)

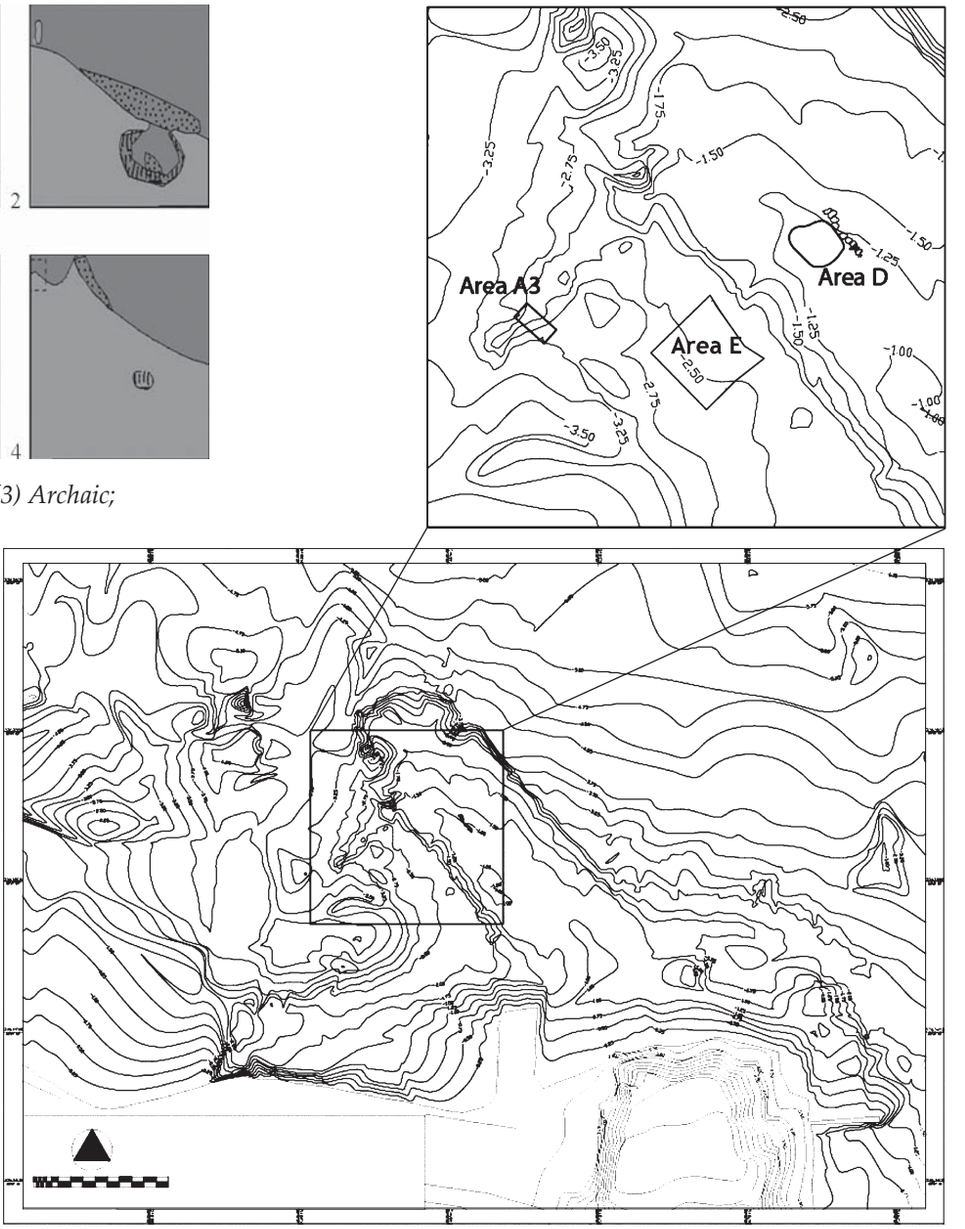


Fig. 3. Map of underwater areas at Liman Tepe (Prepared by Y. Salmon)

The presence of an ancient harbor feature was established. It is located in the area where a submerged tongue shaped feature, ca. 135 m long, joined almost perpendicularly a shorter extension of ca. 25 m long (Fig. 3). A clear harbor floor associated with it was located, the chronology of which began at least within the Archaic period (7th–6th century BCE).

A trench, Area A3 has been excavated ca. 3 m beneath the modern seafloor, which starts at ca. -3.0 m. The modern seafloor in the area of the trench consists primarily of sandy sediment and Posidonia grass (*Posidonia oceanica*). The sparse pottery sherds (primarily Medieval) found within this one-meter thick organic-rich layer indicate earlier seafloors, which were later covered by natural processes. Beneath this Posidonia-rich layer a ca. 1 m thick layer of primarily fine silt and mud sediment appears, which is assumed to be the siltation of the area. The lowest point of the silt is at the same level as the basal level of the mole stones (ca. -5.0 m). Beneath these stones and mud, starting at around -5.0 m, a second Posidonia-rich layer appears, displaying dense material culture of the late 7th and first part of the 6th centuries BCE on its surface and about 20 cm below it. The dating was reached by comparative typology of the fine ceramic wares, including sherds decorated with the 'Wild Goat' motif (Artzy, R.I.M.S. NEWS No. 30, pp. 20–21). This surface is an ancient seafloor, and the ubiquitous material culture is presumed to be the result of heavy harbor-related activity in the area. Sectioning of the breakwater-like extension of the sunken peninsula produced interesting results, although not as yet conclusive as to the dating of the structure.

In 2006, in addition to the ceramic finds, a wooden composite anchor arm was found. It was embedded at a 20 degree angle into the seafloor, exposed both on its upper face as well as its eastern side (Fig. 4). The arm portion is 97 cm long and has an encrusted metal conical 'tooth' at its deeper end, which is 19 cm long. The anchor arm

Fig. 4. Anchor arm in situ (Photo: G. Votruba)

exhibits slight tapering from 12 cm at its widest to 9 cm where the wood enters the metal. There is also slight natural curvature of the grain recognized in the upper end. Teredo worm damage to the anchor arm's upper end shows that it was exposed at the same elevation as the ceramics, and therefore is contemporaneous. The ^{14}C age of the wood is consistent with other dating methods.

The question remains as to which period should the massive *pithoi/dolia* remains, found at ca. -3.3 m (Artzy, R.I.M.S. NEWS No. 29, p. 22), be dated, or for that matter, what do they represent – the cargo of a boat, which sank after colliding with the partially submerged feature? Or was the feature in use during that time and the ceramics tumbled from it? Do parts of a *pithos/dolium* used alongside stones on the outer levels of the feature signify yet a third stratigraphical mark? Does a grey layer, possibly cement, belong to this third level? The partial sectioning produced interesting results, albeit not as yet conclusive as to the dating of the structure (Fig. 5).

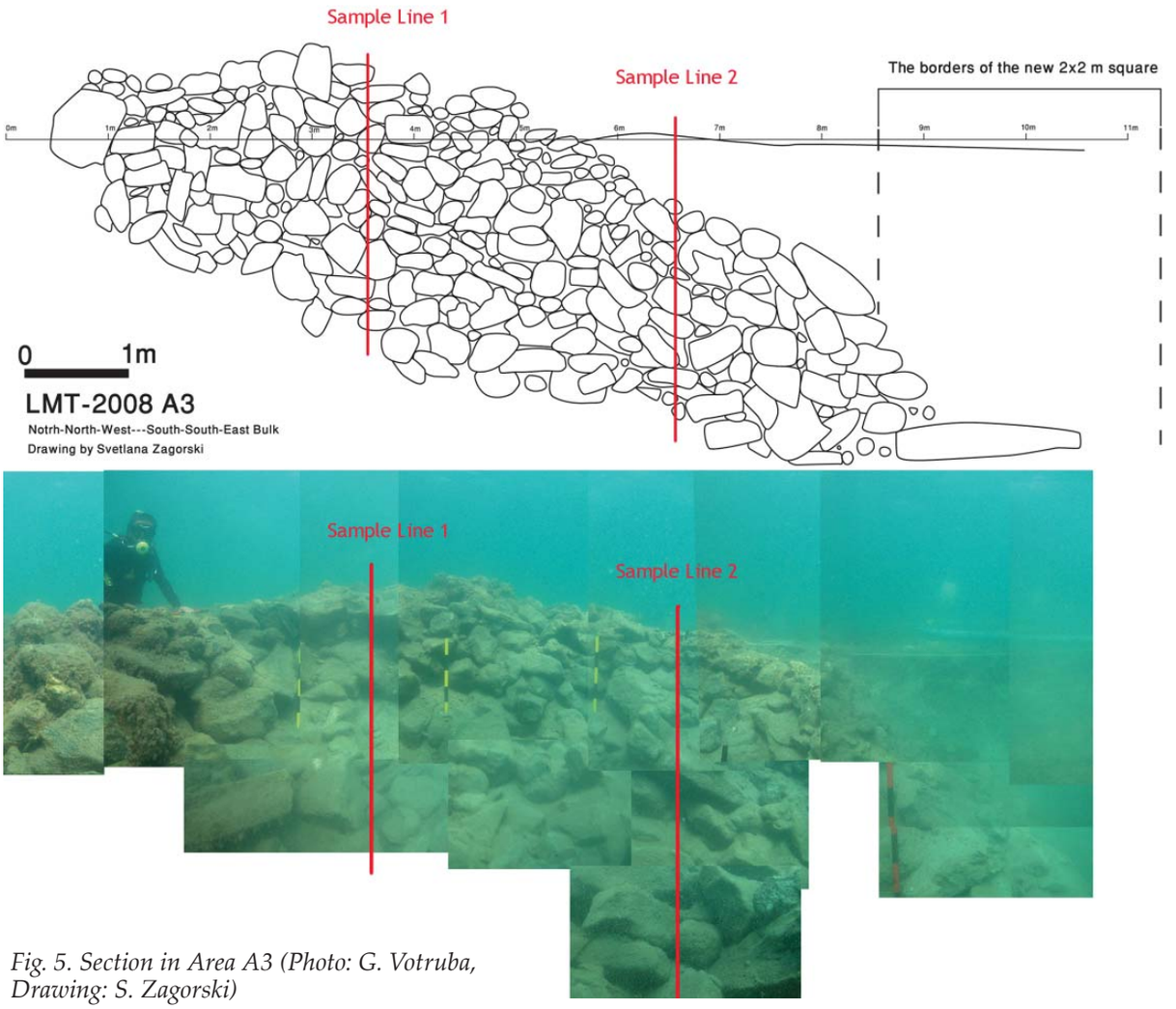


Fig. 5. Section in Area A3 (Photo: G. Votruba, Drawing: S. Zagorski)

Unlike the well-constructed artificial harbors in the eastern Mediterranean, such as Athlit and Tabbat el Hammam, built by Phoenicians, the harbors in the Aegean were less sophisticated and constructed by piling of rubble, probably because of their different environmental situations. The research to date at Liman Tepe/Klazomenae suggests that its harbor represents an early, if not the earliest, example of such a harbor.

In the excavated harbor floor area, located immediately south of the breakwater, the activity seems to be limited to just the late 7th-or early part of the 6th centuries BCE, with no signs of later 6th, 5th or 4th centuries. The harbor seemed to have functioned only for a limited time before being abandoned. However, recent excavations by the Turkish team (directed by Prof. Erkanal) noted a possible 4th century BCE seafloor below the submerged tongue-shaped feature and south of the breakwater (Area E) – a different pattern, despite the proximity of the two areas.

In past seasons, remains of a wall were noted in a very shallow area on the tongue-shaped sunken peninsula. This prompted the excavation of the area named – D. The wall was tentatively dated to the 4th century BCE, mainly by the ceramics found in the marine conglomerate on which it seemed to be placed and in its vicinity. It is possible that this layer is contemporaneous with the construction of the causeway between the mainland and Karantina island by Alexander the Great or in his times (Fig. 6). This construction left a distinct change in the sediment record, and may have had major implications. Below this conglomerate layer, we came upon rubble containing hewn stones among which are some unusually large ones which had to be air-lifted and dragged from the area by the boats, as well as numerous broken ceramics dated by the fine wares to the last of the 7th and first part of the 6th centuries BCE (R.I.M.S. NEWS 30). In a very limited area we reached the layer below the rubble, but had to stop the excavation because of the danger to the divers.

Fig. 6. Location of (1) Liman Tepe (2); Karantina Island; (3) Causeway (Photo: G. Votruba)

Members of our maritime workshop have put forward a number of suggestions to deal with these hazards, but so far we have not been able to put them into effect. The questions as to the nature of the tongue-shaped peninsula are still of interest, and a few geological tests, planned to be carried out in the future, might give us some answers, without having to actually continue the archaeological excavations.

The harbor we have found functioned for a limited period, possibly as one of the harbors utilized by the inhabitants of Klazomenae for trade, especially in olive oil, for which it was famous. The question still remains – where harbors used earlier or later are located. A Roman harbor was found in Karantina island, but are there others? As research continues, near and around the modern harbor of Urla and Karantina island, these harbors and their accompanying installations could and should emerge. Geological work and mapping were carried out in the vicinity of the site in the years in which we did not perform any archaeological activities. In 2004 and 2005, the project concentrated less on underwater excavations, and more on surveying, above and under water, and studying the finds. Joe Boyce and a student, Gillian Krezoski, from McMaster University, with the help of the members of our team, Amir Yurman, Tamir Epstein and Greg Votruba did some side-scan sonar work, as did Beverly Goodman, as part of her Ph.D. under the supervision of Dr. Eduard Reinhardt. Yossi Salmon with the aid of Yossi Tur Caspa, continued the mapping of the underwater site and its vicinity. Noga Yoselevich and Sveta Zagorski worked on the material finds with the aid of Shai Eyal who worked on the fine ware for her M.A. thesis.

Concurrently with the geological and archaeological field work, extensive underwater terrestrial mapping, carried out by Yossi Salmon and members of the team, was undertaken to combine the underwater finds and topography with that of the present terrestrial one. The underwater survey was conducted using a combined system of Differential GPS and an Echosounder in the deeper areas; in the shallower areas – the depths were measured by a Total Station using reference points from the shore. The transfer zone was measured by both systems, for calibrating and creating a unified elevation and coordinate system (Fig. 3).

The 2009 season was dedicated to finishing the mapping, connecting the underwater map, including the excavated areas to the rest of the terrestrial site and its vicinity, and drawing sections of Area D (Fig. 7). Drawings of the remaining ceramics from the last season were completed, as was the photography. Permission was granted by the Turkish Culture and

Fig. 7. Re-measuring Area D (Photo: M. Artzy)

Museum Ministry authorities to sample the ceramics in order to analyze them by means of petrographic thin sections and possibly Instrumental Neutron Activation Analysis.

We were fortunate that Yossi Tur Caspa, who in the meantime has retired, joined us as the diving officer, friend and 'man for all seasons'. Unfortunately we were not lucky with the weather this season, so while the work in camp proceeded as planned, we were not able to collect all the data from the sea. Most problematic was the collection of geological data, especially in Area D. We hope to be able to do this in the future, and to complete the spatial and environmental pictures.

We wish to thank our hosts over the years – Prof. Hayat Erkanal and his crew for the opportunity of participating in this exciting joint Mediterranean project (Fig. 8). The project has been made possible by the financial contributions of Sir Maurice and Lady Irene Hatter and the Frankel Foundation.

Michal Artzy

Fig. 8. Team photo (Photo: Chronis Papanikolopoulos)

The Renewed Excavations at Tel Kabri and New Evidence for the Interactions between the Aegean and the Levant in the Middle Bronze II Period (ca. 1750–1550 BCE)

The Kabri Project

Tel Kabri is a 32 hectare site located in the western Galilee. It was the center of a Middle Bronze Age polity. Earlier excavations conducted at the site by Aharon Kempinski and Wolf-Dietrich Niemeier from 1986–1993 had revealed the remains of a palace dating to the Middle Bronze II period (ca. 1700–1550 BCE). Within the palace, Kempinski and Niemeier discovered an Aegean-style painted plaster floor and several thousand fragments originally from a miniature Aegean-style wall fresco. Kabri is one of only four sites in the eastern Mediterranean to have such Bronze Age Aegean-style paintings and may well be the earliest. There were also the first evidence in Israel for the presence of Aegean—either Minoan or Cycladic—art in a Canaanite palace.

A new project, co-directed by Assaf Yasur-Landau from the Recanati Institute for Maritime Studies and the Department of Maritime Civilizations at the University of Haifa and Eric H. Cline from The George Washington University, began at the site in 2003.

A geophysical survey in 2003, and our exploratory excavation season in 2005, enabled us to establish that the MBII palace at Tel Kabri is nearly twice as large as previously thought, probably 3,000–4,000 sq. m. rather than 2,000 sq. m. in area (Fig. 1). The 2006 and 2007 seasons were spent conducting a regional archaeological survey of MB I and MB II settlements throughout the western Galilee. It allowed us to reconstruct shifting settlement patterns, demography, and aspects of trade in the Kabri hinterland from its rise in Middle Bronze I to its demise at the end of the Middle Bronze II.

The 2008 and 2009 seasons of excavations within the Kabri palace yielded important information regarding the rise of Canaanite rulership at the site and its connections to the Aegean. Rich deposits of pottery and a series of floors excavated in Area DW revealed that the palace was first built during the MBI, some 200 years earlier than previously thought. Furthermore, deposits of wall plaster, some painted, have been found in clear stratigraphic contexts in both Area DW and DS, allowing us to revise the date of the appearance of Aegean-style art at the site. Some of the pieces, painted in black, yellow, red and bright blue, may well belong to a figurative fresco. These new findings of fresco fragments from the summer 2009 excavations call for a reevaluation of the interaction between the Aegean and the Levant during the second part of the Middle Bronze Age.

Fig. 1. Balloon photo of the excavation area in 2005

Interactions between the Aegean and the Levant during Middle Bronze II

The collapse of the Mari trading system, after the conquest of Mari by Hammurabi of Babylon (ca. 1750 BCE), following the Middle Chronology, or ca. 1664 BCE following the 'new Chronology', as well as the rise of the Hyksos in Egypt, and the transition to the Neopalatial period in Crete, must have created new challenges for interactions between Crete (as well as other parts of the Aegean) and the Levant. With the absence of any Egyptian threat, and before the rise of the Hittite Empire, the Amorite kingdoms of the Levantine littoral grew unhindered, and developed their own networks with Cyprus and the Aegean.

The apparent absence of MM III pottery imports and the rather small amount of LM IA/LH I pottery imports indicate that there was no Minoan intention to broaden the commercial activity to include Aegean goods aimed for the sub-elites of the east. Rather, the two conspicuous examples of Aegean-style frescos found at Kabri and Alalakh—identified by the use of the *buon fresco* technique, methods of plaster preparation similar to those in the Aegean, and the use of Aegean motifs—indicate the existence of inter-elite interactions.

However, the use of Aegean style and even symbolism does not necessarily mean the adoption of Minoan ideas, but rather the deliberate use of the foreign to further entirely local causes, demonstrations of the ruler's connection with far-away lands or an aspiration to belong to a more 'cosmopolitan' Mediterranean narrative.

At Tel Kabri, a frescoed floor was found in Hall 611 by Kempinski and Niemeier, within the ceremonial wing of the Canaanite palace built during the MB II period. It was decorated with a chequered design, with the division of the grid marked by red lines. Some squares were painted yellow, others were left white. Some squares were further decorated with marbling (stone imitation) design, while others were decorated with small dark-blue iris flowers and yellow crocuses. In addition, more than 2,000 tiny wall fresco fragments were found by Kempinski and Niemeier in and next to Threshold 698, located between Hall 611 and Room 740, where they had been reused as packing material. The fragments once belonged to an extensive miniature fresco, similar in style as well as in theme to that of the West House at Akrotiri on Thera/Santorini (Fig. 2). Fragments of grey sea, crescent-shaped boats, and white and reddish-brown rocks indicate that this was a coastal scene (Fig. 3). Fragments of architecture, reminiscent in style of the West House fresco, point to the existence of a coastal town. However, the date of the Kabri frescoes is problematic, and they may belong to anytime between the end of the 17th century BCE and the first half of the 16th.

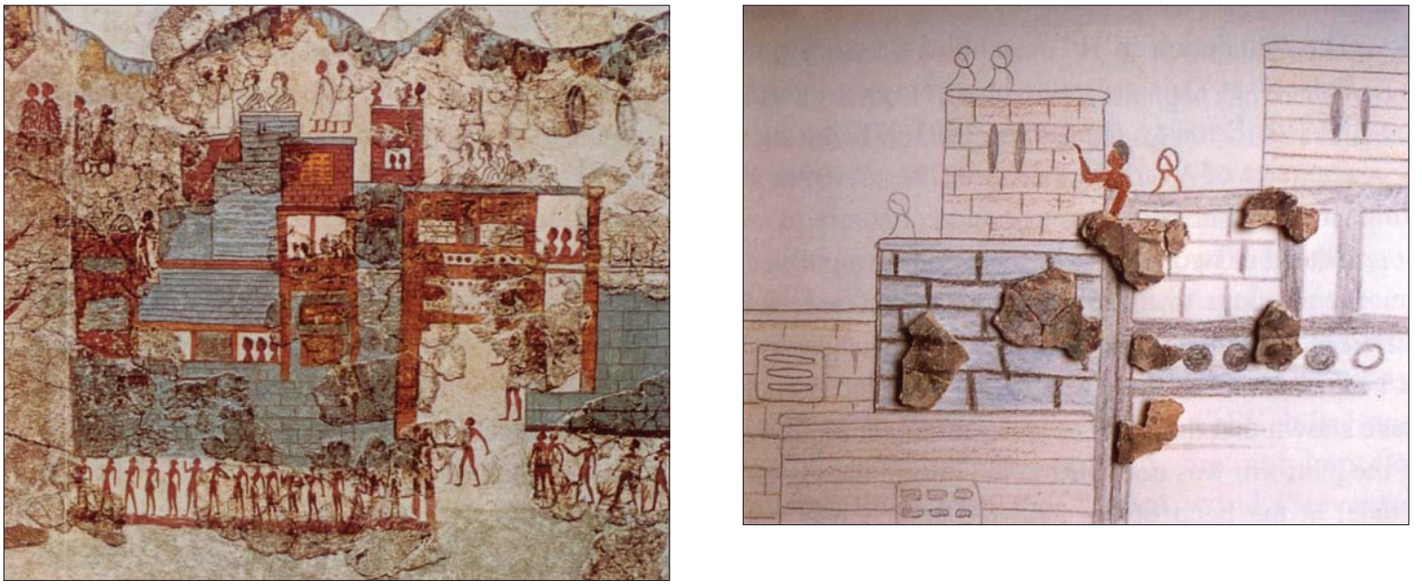


Fig. 2. The miniature fresco from the West House at Santorini (left) and fragments of the Kabri miniature fresco (right) (Photo after Niemeier and Niemeier 2002: Pl. XXX and XXXI)

Fig. 3. Fragments from the Kabri Fresco. Reconstruction by B. Niemeier and W. D. Niemeier; conservation by R. Pelta; photo: P. Shrago. After Cline and Yasur-Landau 2007, Pl. XXXVIIIa. The 2009 fragment added by N. Goshen

Elsewhere in the Levant, further indications for interactions with the Aegean during MBII take the form of two inscriptions: a pithos sherd found in a late Middle Bronze II context at the temple courtyard at Tel Haror incised with Cretan Hieroglyphic, and a stone basin from Lachish incised with Linear A signs, the latter locally made and thus indicating the presence of a literate Aegean person at the site. In addition, fresco fragments from the stratum VII palace of Yarim-Lim at Alalakh demonstrate Aegean influence. These were found in audience hall 5, as well as magazines 11–13, probably fallen from a large room (Woolley's *grand salon*) located above. The room 5 frescoes include grasses moving in the wind, as well as a bucranium frieze, possibly with a double ax—a motif with a strong

Minoan, and arguably even Knossian, ancestry. The *grand salon* fresco included a white design on a red background, the notched plume motif leading Niemeier and Niemeier to interpret the scene as a large griffin crouching on a rocky terrain, painted in a distinctively Aegean style. The hypothesized *terminus post quem* for the use of the palace is the destruction of Alalakh by Hattusili I, somewhere between 1625–1550 BCE, yet the frescoes themselves could have been painted anytime during the long life of stratum VII.

The discovery of additional fresco fragments at Tel Kabri – 2009 season

A highlight of the summer 2009 season at Tel Kabri was the discovery of more than 100 fragments of painted plaster in both Area D-West and D-South 1, from both a previously-unknown Minoan-style wall fresco with figural representations and a second Aegean-style painted floor.

In Area D-West, the area outside the external wall of the palace (673) was excavated, exposing the remains of what now appears to be a paved ceremonial road (2129) encircling the palace (Fig. 4). The paving of this road included many pieces of plaster, several painted, including one that in all likelihood belonged to the miniature fresco deposited inside the palace walls.

Fig. 4. Paved road outside the palace (Photo: E. H. Cline)

In Area D-South 1, the excavated area contained numerous walls, belonging either to the palace or to a nearby house or structure. Here there are at least two partially-exposed rooms, or perhaps one small room and a courtyard, lying to the north of Wall 3017 and another room presumably lying to the southeast. Scattered among pieces of restorable pottery were numerous fragments of painted wall and floor plaster, almost all of which were found lying face down on top of the crushed lime floor in this area (Fig. 5).

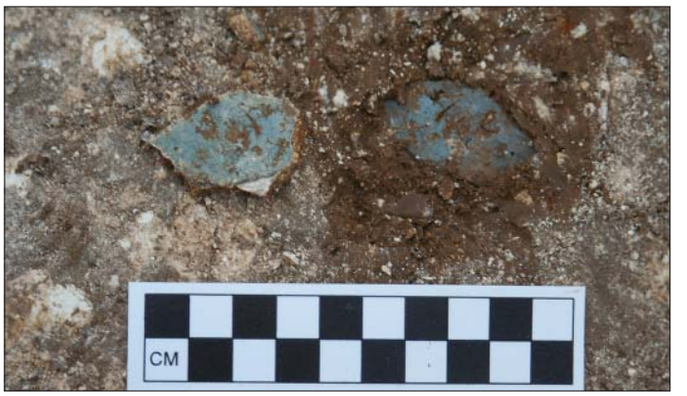


Fig. 5. Blue-painted fresco fragments revealed in area DS-1 (Photo: E. H. Cline)

One painted plaster floor fragment has an incised line separating a dark blue or grey band of paint from the white paint elsewhere on the piece, while other floor fragments have a white, highly polished surface. Additional floor fragments were painted solid red.

As for wall plaster, many pieces were painted with blue, some with a white image and black borders set against a blue background. It is possible that most belong to the same figurative painting. Some connecting fragments depict what appears to be a white wing on a blue background. This wing may belong to a bird, such as those found in the West house and Sector Alpha in Akrotiri, but also to a flying fish, such as the one found in Phylakopi on Melos, or even to a griffin.

Additional fragments were painted in red and yellow, some also against a blue background. A definitive description and photographs of these remarkable pieces must await additional conservation. However, we can already say at this time that these are, to date, the first wall paintings with a blue background found either at Tel Kabri or in all of Israel.

The meaning and chronology of Aegean art at Kabri

The 2009 season at Kabri doubled the number of Aegean-style paintings at Kabri, from two to four. This, as previously argued by us, reflects a deliberate strategy undertaken by the rulers of Kabri for impressing peers and attracting clients. The choice of Aegean art, perhaps a repeated choice reflected by at least four different Aegean-style paintings in the palace, was therefore deliberately aimed at demonstrating contacts which most other polities did not have, and was perhaps a manifestation of the rulers' aspiration to belong to a more 'cosmopolitan' Mediterranean narrative. This explanation may well account for the unique use of Aegean art and the absence of any sign of Canaanite or Syrian art at the palace, which challenges common perceptions about the political role of art in Canaanite rulership.

Our 2005 and 2008 excavations had previously suggested that the date for the Aegean-style paintings in the palace should be reconsidered. The fragments of wall fresco were found by Kempinski and Niemeier in and next to Threshold 698, located between Hall 611 and Room 740, where they had been reused as packing material. We suggested that the deposition of the fresco fragments was not the work of looters, as Kempinski and Niemeier suggested, but rather was conducted during a major renovation project within the lifetime of the palace.

Our new 2009 discoveries seem to support our belief that during this renovation the frescoed plaster was reused for various constructional purposes: some for the construction of Threshold 698, some for the paving of the external road, and some for the patching of floors in Area DS-1. As a result, while Aegean-style paintings adorned the penultimate palace of Kabri, the final phase of the palace was undecorated. Although considerable additional work is needed on the newly-found frescoes and their contexts, it may be suggested that they belong to the late 17th century BCE, or the earliest 16th century, thus being possibly as early as the Alalakh frescoes, if not older.

Acknowledgements

The project has been undertaken with support from the Institute for Aegean Prehistory, the National Geographic Society, and private donors, in addition to the co-directors' home institutions. Reports can be found at http://digkabri.wordpress.com/previous-results/.

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Assaf Yasur-Landau and Eric H. Cline

Dor 2006 Shipwreck – Report of the 2009 Excavation Season

The *Dor 2006* shipwreck underwater excavation season was held for three weeks in October-November 2009, by the Leon Recanati Institute for Maritime Studies at the University of Haifa. The shipwreck was discovered by a local fisherman, D. Abada, after a storm that exposed some of its timbers. Following his report, K. Raveh, A. Yurman and Y. Kahanov checked the finds, which gave the impression of being hull remains, including part of a mast.

As finding a mast from the Byzantine period is rare, it generated much interest. One of the questions is whether it is really a mast, and if so, would it be possible to determine if the ship had a lateen rig. In addition, this is the period of the 'transition in ship construction' from 'shell-first' to 'skeleton-first', and *Dor 2006* may perhaps contribute considerably to the information about the transition.

The excavation site is located 800 m south of Dor/Tantura lagoon, 100 m offshore, spread over an area of 11 m by 5 m, at a depth of 3–4 m. It is located in the surf zone, a fact that makes work possible only when the sea is calm (Fig. 1). Due to weather and sea conditions, it was possible to work only 11 days out of the three weeks, but in spite of this, the season was fruitful, with many achievements. By the end of the first week a large area of the shipwreck had been exposed, with sections of frames, planks, a stringer, the keelson(?), a mast (Fig. 2), and another vertical round timber adjacent to it. Ceramic sherds, iron nails, remains of a rope, and a woven mat or basket were also found. Just when the documentation started, a squall sprang up and the work had to be stopped. Following the subsequent storm, the site was covered by an additional 1.5 m of sand, and the work started from the beginning. At the end of the second day the northeastern part of the shipwreck was uncovered, while the southwestern part with the mast was still buried in the sand. After three days of work there was another storm, and sand covered the site again. At the end of the last week the work had been renewed, and the northeastern section of the shipwreck uncovered (Figs. 3–7).

Fig. 1. General view of the site (Photo: J. B. Tresman)

Fig. 2. The mast (Photo: R. Navri)

Fig. 3. One of the two containers used as a mobile field base (Photo: D. Cvikel)

Documentation included direct measurements, hand drawings and photography. WEB points were fixed, but the task was not completed due to sea conditions.

The tree species of the frames were identified by Prof. N. Liphschitz of Tel Aviv University as *Ulmus campestris* and *Quercus cerris*. Other tree species identified were *Pinus nigra*, *Pinus brutia*, and *Cupressus sempervirens*. The origin of these trees is the eastern Mediterranean and western Turkey.

Results of six ^{14}C analyses of wood and rope samples by the Institute of Particle Physics in Zurich, ETH, dated the shipwreck to 460–580 CE, the Byzantine period.

Planks were measured. All planks were well worked, and carpenters' tool-marks were discernable. Some of the components were made from half-logs, similarly to the contemporary Yassiada, Pantano Longarini, and Tantura F shipwrecks.

Preliminary dimensions of frames were taken: average sided was 10.6 cm, average molded was 14.5 cm, and average room and space was 26.1 cm. The diameter of the mast at the deepest accessible point was 26.1 cm.

Preliminary measurements indicate a hull with larger scantling dimensions than other hulls excavated in Dor lagoon. No signs of edge fastenings were found anywhere in the planking, specifically no mortise-and-tenon joints. It is suggested that *Dor 2006* was built based on frames, like other contemporary shipwrecks found at Dor.

There is still much information to be gathered, and many interesting questions to be answered in coming seasons, especially about the mast.

Rika Navri

Fig. 4. Fighting the waves in the surf zone (Photo: J. B. Tresman)

Fig. 5. Taking the metal frame out of the water (Photo: J. B. Tresman)

Fig. 6. Working till sunset when sea condition permitted (Photo: R. Marlar)

Fig. 7. Last-minute briefing before entering the water (Photo: D. Cvikel)

Overseas Expedition: The Underwater Excavation of the *Jeanne-Elisabeth* (Maguelone 2)

A violent storm during the night of 14/15 November 1755 drove the *Jeanne-Elisabeth* ashore on the Mediterranean coast of France, near the Île de Maguelone, about 65 nautical miles west of Marseilles. The merchantman, loaded with a cargo of about 200 tons of wheat, and a secondary freight of cochineal balls, was sailing from Cadiz to Marseilles. The *Jeanne-Elisabeth* was also carrying piasters, and sailed under a Swedish flag to avoid the possibility of being attacked by the British.

The well-preserved remains of the *Jeanne-Elisabeth* were discovered in 2007 by chance, during a survey aiming at locating the remains of a near-by late 19th century shipwreck. The shipwreck was designated Maguelone 2, and the first season of underwater excavation took place in the following year. Following archival and archaeological study, it became certain that these were the remains of the *Jeanne-Elisabeth*.

The excavation and research of the shipwreck is directed by Patrick Grandjean, with the collaboration of Marine Jaouen, both of the Département des Recherches Archéologiques Subaquatiques et Sous-Marines (DRASSM, Ministry of Culture), and Dr. Eric Rieth, director of research at the Centre National de la Recherche Scientifique (CNRS) and head of the Département d'Archéologie Navale at the Musée National de la Marine, in charge of the architectural study of the ship. In September 2009 the author was privileged to join the second season of underwater excavation of the shipwreck.

The remains of the *Jeanne-Elisabeth* are about 27 m long, with the bow facing north. The hull had split into two along the keel, which allowed excavation between the two decks. The shipwreck lies under layers of sand and compact clay, and the maximum depth this season was 8 m. The excavation was conducted from the diving vessel *Shadok*, using two small powerful Honda water pumps and dredgers. Two Zodiacs were used as safety boats. The *Shadok* and the Zodiacs anchored in the marina of Palavas, about 2 nautical miles north-east of the excavation site. Each working day, divers and equipment were loaded on the *Shadok* and taken to the excavation site. The day ended only after all the dive gear, diving vessel and boats were thoroughly washed, and all equipment was stored on land.

The expedition team was composed of 10–15 highly experienced divers (Fig. 1), who made 1–2 dives a day each, each dive lasting about one and a half hours. During the author's stay, documentation by direct measurement and drawing was carried out by Christelle Chouzenoux, Andrea Poletto, Marine Sadania, Magali Veyrat, and the author, under the close supervision of Dr. Eric Rieth, and photography, both underwater and of artifacts on land, by Philippe Groscaux (CNRS). All divers were under the strict control of the dive supervisor Jean-Michel Minvielle. Daily ship-handling routine was conducted by Laurent Borel, Guy Charleux, Michel Khripouchine, and Patrice Pitsch.

Fig. 1. Group photo of the excavation team (Photo: P. Groscaux)

During this season some of the ship's fittings were found, among them two iron anchors, an anchor cable and a diverse variety of ropes. Part of the windlass has also survived. Many interesting objects were found in the excavated section. These included weapons and ammunition: fusils, fusil and pistol lead shot, swords; leather objects, such as a book cover and a single shoe; glass and ceramic ware; and a great deal of wheat. In addition, two metal cauldrons and a wooden box containing well-preserved kitchen utensils have been recovered.

The well-preserved shipwreck of the *Jeanne-Elisabeth* presents us with a unique opportunity for the excavation and study of an 18th-century merchantman. Underwater excavation makes possible the study of details that traditional non-archaeological sources, such as ships' drafts, historical documents and iconography, can rarely disclose.

It was an educational and enriching experience, and the author is most grateful to Dr. Eric Rieth and Patrick Grandjean for their kind invitation, and for their generous hospitality and personal attention. The author would also like to thank her dive mates for their warm support.

Deborah Cvikel

Between Continents – 12th International Symposium on Boat and Ship Archaeology

The 12th International Symposium on Boat and Ship Archaeology, organized by Prof. Nergis Günsenin of Istanbul University, was held from 12th to 16th October 2009, at the Suna and İnan Kıraç Foundation Pera Museum in Istanbul, Turkey. The symposium was naturally inspired by the Yenikapı excavation project in the Byzantine (Theodosian) harbor of Istanbul, where 34 shipwrecks have been found and excavated. This is an outstanding archaeological enterprise, which has put underwater archaeology and the study of ship construction in a new light. The Yenikapı excavation site is larger than any previous major project: Pisa, Olbia, Jules-Verne, Roskilde, Dor and Mainz. An introductory visit to the Yenikapı site was organized before the conference sessions, guided by Dr. Ufuk Kocabaş.

The Symposium was attended by participants from 24 countries, who presented 52 lectures, 25 posters, and 9 documentary and amateur films. Many new projects were introduced, and new participants, among them students, presented their work and research. Prof. George F. Bass opened the conference with a comprehensive review entitled *Shipwreck Archaeology in Turkey: A Brief History*. The following sessions dealt with ship construction, Ottoman shipbuilding, and Mediterranean, Black Sea, and northern European ships and seafaring. A special session was dedicated to the Byzantine ships at Yenikapı. Sessions were dedicated to experimental archaeology and research methods. Closing remarks were made by Prof. Patrice Pomey, who remembered Lionel Casson, Elisha Linder and J. Richard Steffy, who passed away since the previous ISBSA in Mainz. Throughout the various sessions, while maintaining a friendly atmosphere, the participants did not hesitate to comment, criticize or ask difficult questions, demonstrating the necessity of maintaining a high scientific level.

Fig. 1. Group photo of participants

The Israeli presenters at the conference were Dr. Yaacov Kahanov, M.A. student Eyal Israeli, and Ph.D. student Deborah Cvikel, all of the Leon Recanati Institute for Maritime Studies at the University of Haifa. Eyal Israeli presented a paper, co-authored with Yaacov Kahanov, *Tantura E: Hull Construction Report*. Their presentation discussed the surviving components of the hull, as well as construction elements, which place Tantura E as an additional example of the completion of the transition in ship construction from shell-first to frame-based in the Mediterranean in the local Early Islamic period. Deborah Cvikel presented *The Akko 1 Shipwreck: The Archaeological Find and its Historical Context*, a 19th century shipwreck, which is the subject of her Ph.D. dissertation. Akko 1 is the wreck of an auxiliary naval vessel or small warship, involved in one of the naval campaigns in Akko at the first half of the 19th century.

A visit to the Naval Museum, followed by a tour on the Bosphorus and a dinner, was arranged by the organizers, and enabled the participants to socialize and discuss subjects raised during the sessions in a relaxed atmosphere. At the end of the conference an optional two-day excursion to Amasra was organized, guided by Nergis Günsenin and Hüseyin Çoban. A group of about 20 participants (Fig. 1) visited several shipyards along the Black Sea coast, where wooden ships and boats are built by traditional methods, as well as the castle and the archaeological museum, and enjoyed warm and welcoming Turkish hospitality.

The participants from the University of Haifa are most grateful to the organizers for the well planned and organized conference, and for their hospitality and personal attention. We now look forward to the 13th Symposium, which will be held in Amsterdam in 2012.

Deborah Cvikel

Advanced Workshop for Ground Penetrating Radar Data Processing

In July, Yossi Salmon was invited to participate in the Advanced Workshop for Processing Ground Penetrating Radar Data (GPR processing, post-processing and imaging) in Pontevedra, Spain. This provided a chance to meet the developers of the GPR imaging software 'GPR slice v6', to discuss and to solve problems of data processing, and to suggest improvements to the imaging software. Most of the participants were researchers from Europe and the USA, who combine geophysics and archaeology.

The workshop addressed four issues: 1. A technical reconnaissance survey of all available GPR systems and their data formats. The participants handled problems raised in different GPR systems, extracting spatial data, such as markers and survey wheel/cart data, and GPS records. 2. Signal processing, where the participants dealt with the application of several filters for geophysical data, and the advantages and disadvantages of using it in archaeological applications. Velocity analysis models and their implementation on migration processes were discussed. 3. Problems of combining multiple 3D surveys using spatial correction techniques. The participants were introduced to various methods of correcting multiple 0 (zero) positions, correcting staggering noises that usually result from small location errors, and also correcting mosaic noises caused by various ground conditions between different areas of a survey and different equipment settings. 4. 3D computer representation and modeling. The participants dealt with vector imaging techniques, geographic and static corrections and overlay analysis, and were also introduced to available medical software applications that can be used in GPR data processing.

Y. Salmon's participation in this workshop was made possible due to the kind financial support of the Sir Maurice and Lady Irene Hatter Laboratory, the Leon Recanati Institute for Maritime Studies and the Department of Marine Geo-Science, Charney School of Maritime Sciences, University of Haifa.

Joint Geo-archaeological Project, Stavnsager, Denmark

In summer 2008, Y. Salmon conducted a GPR pilot at the site of Stavnsager in Denmark, as part of a joint geo-archaeological project led by Associate Professor Chris Loveluck of Nottingham University (UK), Associate Professor Karen Høilund Nielsen of the Institute of History and Civilization, University of Southern Denmark, and archaeologist Reno Fiedel of the Cultural Historical Museum of Randers (Denmark). This project allowed the testing of some components of the GPR equipment now housed in the Hatter Laboratory at RIMS, purchased with the help of a grant from the Israel Science Foundation. The site of Stavnsager is partly excavated, and has been investigated with multiple geophysical and geochemical methods, which presented the opportunity of comparing the GPR results with the results of magnetometry, resistivity, chemical analytical tests of soil samples, and exposed archaeological features. This allowed Y. Salmon to evaluate the scope of contribution of the GPR survey in the overall analysis of the archaeological site in more controlled conditions. A pilot GPR survey was conducted in several locations at the site and its surroundings, in order to trace the boundaries of the ancient river-shoreline, the location of the anchorage of the site, and to examine the possibilities of tracing ancient waterlogged wooden remains with GPR. An enormous amount of fire-cracked stones, located along the ancient river, have tentatively been suggested by Chris Loveluck to be waste after steam-bending of ships' planks. A series of test transections was carried out in chosen locations, with 400 MHz and 900 MHz antennas, measuring the velocity of the radar waves in the sub-terrain. Based on these measurements, a velocity model was created in order to calculate the depth of the different buried features. Some of the transections were conducted above exposed archaeological features in order to outline them on the reflection profiles, and as a means to use them as future references to similar features. In addition, five areas were chosen for spatial 3D grid analyses using survey lines at 0.5 m spacing. Two of the grids had been previously surveyed by magnetometer and chemical soil analyses. The results of the 3D grids show that the large features that had been detected by the magnetometer survey were also detected by the GPR. In Grid A, at Hørning Church, the approximate depth and volume of an earlier Viking Age church were

delineated. Other features, not visible in the magnetometer survey, were detected by the GPR as the stone foundations of a presumed medieval building.

The results obtained from the transection tests show that the 400 MHz antenna detects natural geological features and separates them from cultural layers in which larger features, such as pit houses or pits, are embedded, but it fails to detect post holes; whereas the 900 Mhz antenna successfully detected smaller features, and in some cases postholes 20 cm in diameter. Despite its general limited penetration energy, the results obtained by the 900 MHz antenna appeared to be good, as it also manages to detect the deep geological features at the site.

At the end of September Y. Salmon was invited to present the results of the GPR pilot in a meeting called 'Non-agrarian Settlements and Integrated Survey and Excavation Strategy', held at the Cultural Historical Museum of Randers, Denmark. His participation in the meeting was made possible by the kind financial support of the Cultural Historical Museum of Randers.

15th European Association of Archaeologists Annual Meeting Riva del Garda, Italy

In mid-September, Y. Salmon presented a poster in the 15th EAA (European Association of Archaeologists) Annual Meeting, held in Riva del Garda, Italy, in a session dedicated to underwater archaeology and spatial technology in archaeology. Preliminary results of the geo-archaeological research project of the site of Nami (which is part of his ongoing Ph.D. research, supervised by M. Artzy and L. Conyers), were presented.

The regional project of Tel Nami has been a target of intense interdisciplinary research since the 1970's. Studies of seven seasons of excavations under the direction of M. Artzy, and preliminary geological/geomorphological field studies, are now nearing conclusion. The results reveal evidence of interesting interactions between Man and the forces of nature during the second millennium BCE, and probably also on the Levantine coast. During the 2nd millennium BCE, the region of Tel Nami underwent various geomorphological processes, changes in sea level, establishment of urban settlement, desertion, and later re-habitation towards the end of the period, in the shape of a small cultic sanctuary and a necropolis.

The traditional path of research includes an expansion of the archaeological excavations and geo-archaeological fieldwork into larger areas. Another method which is now available can be carried out on the basis of theoretical and practical advances in landscape archaeology. New survey techniques that incorporate spatial analyses, GIS analyses, geo-chemical surveys and remote sensing methods, allow the sampling of a larger area, and based on the results, a smaller area can be chosen for excavation – being more likely to answer research questions (Fig. 1). In this conference, Y. Salmon presented the preliminary results of a Ground Penetrating Radar survey, an underwater survey, and the mapping of the archaeological and geomorphological features that allowed the depiction of a possible setting of an anchorage from the second millennium BCE (ca. 4000 BP).

Yossi Salmon

Fig. 1. Field work at Tel Nami – operating the GPR and Total Station (Photo: M. Artzy)

SUMMARIES OF THESES SUBMITTED TO THE DEPARTMENT OF MARITIME CIVILIZATIONS, 2008–9

The Population of Bottlenose Dolphin (*Tursiops truncatus*), Bottom-Trawl Catch Trends and the Interaction between the Two along the Mediterranean Continental Shelf of Israel

General Introduction

The present research assesses the relationship between two top predators in the marine food web, the common bottlenose dolphin *(Tursiops truncatus)* (hereafter CBD), and the bottom-trawl fleet, the main marine fishing industry in Israel, in the framework of the complex relationship between mankind and the sea (Figs. 1, 2). Free-ranging coastal communities of CBD have provided prime research opportunities in the field of cetacean social ecology at several marine localities around the world. Several longitudinal studies of this type have been conducted in the central Mediterranean Basin, notably in the Adriatic and the Ionian seas, but none in its easternmost reach, the Levantine Basin. The biological resources in this basin are limited, since the level of primary production, and accordingly the supported food web, is low. The setting where these two top predators exploit the same benthic niche in an ultra-oligotrophic body of water sets the scene for competition for limited resources. Competition may first be assessed indirectly by conducting social behavioral research on the CBD population, with emphasis on the relationship with the bottom-trawlers. This kind of data may be complemented by following the fish catch trends, particularly where there is evidence of over-fishing. Then, the question of alleged fisheries/CBD competition could be addressed more directly by comparing features of the CBD diet and the bottom-trawl catch. A straightforward comparison could be made between the composition of stomach contents of stranded carcasses and by-caught animals and that of the catch, or inferences may be made by performing stable isotope analysis on CBD tissue and the tissues of its potential prey. General attributes of the diet of dolphins are reflected through the stable isotope composition of their body carbon ($\delta^{13}C$) and nitrogen and ($\delta^{15}N$) values, respectively. The $\delta^{15}N$ of tissues provides a powerful tool for determination of the trophic relationships among organisms and the trophic position within the food-web. The $\delta^{13}C$ is useful to the study of diet through its use as a tracer of sources of primary productivity, and thus the feeding niche. Primary producers vary in their isotopic C signatures according to their origin (e.g., terrestrial versus aquatic, benthic versus pelagic).

Fig. 1. Bottlenose dolphin (Tursiops truncatus) (Photo: A. Scheinin)

Fig. 2. Trawler in action (Photo: A. Scheinin)

Aims

The first aim of this research was to reveal the different ecological aspects of the local CBD population. Then, following the primary assumption of competition between bottom-trawl fishery and the local CBD popula-

tion, it was important to "know the enemy" and to determine whether the bottom-trawl fishery was over-utilizing the benthic habitat. Finally, CBD diet-based methodologies and analysis of the composition and trophic level of the fish catch were employed in order to explore the existence and degree of competition.

Common Bottlenose Dolphin Population

Materials and methods

The source of information was based on half-day dedicated coastal surveys which took place sporadically between 1998–2002 and systematically from 2003 to 2007. Navigational and weather conditions data were collected throughout the surveys, and within the sighting, group size and composition as well as behavioral and photo-identification materials were recorded.

Results and conclusions

A total of 232 surveys were performed between 1998 and 2007, covering over 3,000 km of trackline, along the central Israeli coastline. CBD was the only species sighted. The overall encounter rate increased significantly when searching around bottom-trawlers (Table 1).

	Total	Standard mode	Trawler mode
Search time (h)	378.9	338.7	40.2
Searching distance (km)	3007.7	2488.0	519.7
Number of sightings	54	26	28
Mean (±SD) duration (h) of searching bout (t-detectability)	7.02 (±11.29)	13.03 (±14.00)	1.44 (±1.31)
Mean (±SD) distance (km) covered before sighting (d-detectability)	55.7 (±79.23)	95.7 (±98.8)	19.0 (±18.03)
Mean encounter rate (groups/100km effort)	1.91	1.13	5.65

Table 1. Summary of overall effort, sightings and detectability between the years 2003–2007

The coastal CBD population prefers depths >40m; the bottom-trawl fleet works mostly between the 35 and 55 m depth contours. Most births occur during the warm months. Mean group size was 5.7 ± 6.9, significantly larger in spring (7.5) than in summer (3.4).

The sighting frequency was independent of season, suggesting a year-round and year-to-year stability of population size in the study area, estimated at 360 individuals. As for composition, there appears to be a small resident nucleus in the study area, of around 20 animals out of 155 individually identified animals. The cumulative discovery curve is still steadily increasing (Fig. 3), suggesting an 'open' population.

Sighted groups were mainly engaged in foraging behavior, series of long dives interrupted by short periods of ventilation at the surface, either while following bottom-trawlers or without much horizontal movement. Of 23 dolphins sighted four times or more, all were observed at least once foraging behind a bottom-trawler, suggesting

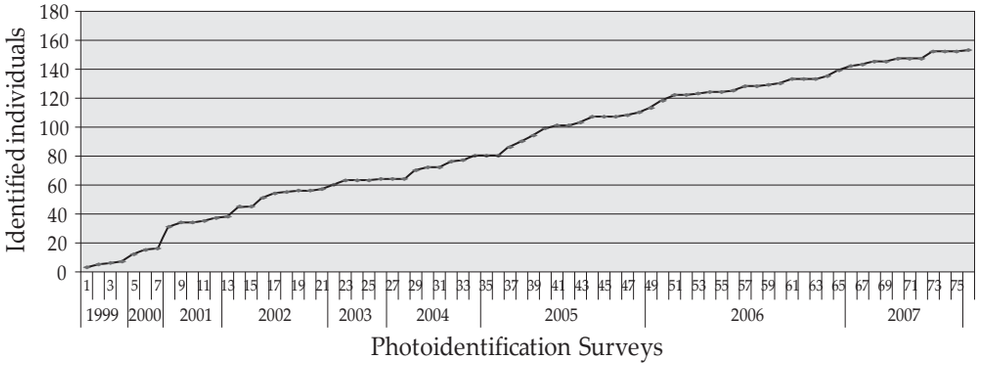

Fig. 3. Discovery rate of new individuals over time

behavior common to all members of the resident population, rather than a specialty of some members, as described in other parts of the world.

Bottom-Trawl Fishery

Materials and methods

Sources of information for assessing the bottom-trawl fishery effort and catch trends were the annual reports by the Israeli Department of Fisheries for the years 1949-2006. The author was involved in the collection of data for the annual publications of 2004–2006.

Results and conclusions

Fishing effort showed an overall increasing trend from 1949-2006, with a transient decrease in the 60s. Effort is not the sole determinant of the catch; fishing efficiency is another. New technologies, such as radar, sonar, and satellite navigation tools (GPS), have been introduced to enhance efficiency, and these had developed during the six decades of data collection. Also, stronger engines and propeller nozzles improved the towing capabilities of the boats, and new fishing nets with larger vertical opening and better rigging had been introduced. When analyzing the time-trend of the overall annual fished biomass (catch) in units of kg per fishing day per boat (catch per unit effort – CPUE), the effect of the increased efficiency does not become evident, and should be kept in mind. Until the mid-50s, the CPUE showed a significant increase, and since then the trend has reversed. The data from the 50s also shows that CPUE was effort-independent, suggesting that fish abundance did not set catch limits, thus allowing an increase of the fleet without affecting CPUE. In the 60s, 70s and the beginning of the 80s, effort and CPUE were constant, suggesting a possible equilibrium between the fishery and the fish stock. This, however, may have only been a fictitious stability, with improvement of technology and use of new fishing grounds (e.g. north Sinai) compensating for over-fishing and dwindling stocks. In the late 80s and 90s, the effort had increased significantly over that of the 60s to mid-80s, but the CPUE had decreased. Mullidae (goatfish) is a bottom-dwelling fish family, which had been a major target family for the local bottom-trawl fishery during these years. The graph of CPUE against time for the Mullidae (Fig. 4) shows a decreasing trend, very similar to that of the overall catch. The decreasing time-trend was demonstrated for most bottom-dwelling commercial fish families.

Penaeidae (shrimps), currently the second most important family in the gross income of the bottom-trawl catch, shows an increasing time-trend of the CPUE. This might be a case of disturbance-tolerant species, for which bottom-trawling creates new habitats, while their relatively short life cycle enables them to recruit in the face of growing fishing effort. Fishing down the marine food web is a worldwide phenomenon in which the composition of the catch is shifted away from predators (high trophic level) to plankton-eaters (low trophic level). A basic assessment for the Israeli bottom-trawl fishery catch data suggests a similar trend, even though there is a significant increase with time of the high trophic level catch. The latter could be the result of increases in the CPUE of high trophic level families, such as the Sphyraenidae. One explanation for this increase is the higher vertical opening of the nets and the more powerful engines which have enabled the fishers to improve their catch on this semi-pelagic fast swimming species. Another reason may be the regional proliferation of the Lessepsian migrant, *Sphyraena chrysotaenia*, which did not oust the local species, but has become an important component of the catch.

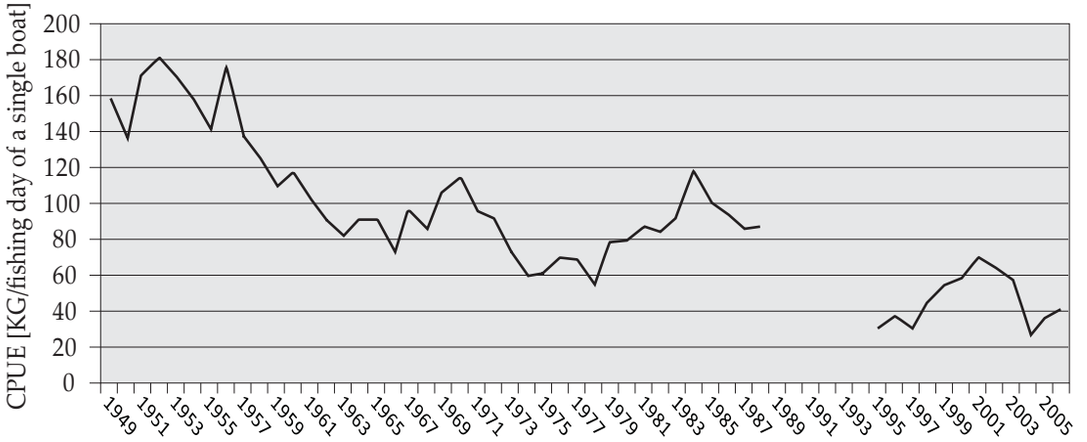

Fig. 4. Mullidae family: Mean annual catch per unit effort (CPUE) by the Israeli bottom-trawl fleet between 1949 and 2006

Comparing CBD Diet to Bottom-Trawl Catch

Materials and methods

The data-base included carcasses of beached and/or by-caught CBD: 7-8 such cases are available annually on average. Twenty-three animals had stomach contents which were pooled for comparison with the bottom-trawl catch. Muscle samples of CBD and of commercial fish and invertebrates were analyzed for stable isotopes ($\delta^{15}N$ and $\delta^{13}C$).

Results and conclusions

The diet of CBD along the Israeli coastline was mainly composed of fish; cephalopod prey was less important, and shrimp remains were not found. These findings matched results from the Western Mediterranean. The estimated annual food consumption of the local CBD population was found to be very similar to the annual bottom-trawl catch, setting the ground for potential competition.

However, when comparing the proportion of different fish families in the CBD stomach contents to the local trawl-fishery catch, Sparidae (sea bream) was the only family showing equal frequencies between the potential competitors. Most members of this family have a relatively low commercial value. Also, the most prevalent prey item of CBD was the Balearic conger *Ariosoma balearicum*, a non-commercially important fish. The overall comparison suggests that the local CBD population and the local bottom-trawl fishery fleet do not target the same items, and as such are not in direct competition. The stable isotope analysis has shown a similar trend. When subtracting the estimated trophic enrichment factor from the $\delta^{15}N$ value of the CBD, the resulting $\delta^{15}N$ value turns out to be lower than that of most commercial species, again suggesting that the local CBD population and the local bottom-trawl fishery fleet are actually exploiting different levels of the food-web.

General Discussion

The CBD occurs in a wide variety of habitats world-wide. The existence of several populations in near-shore areas, where they are relatively easily accessible for researchers, makes the CBD the best-studied cetacean. However, there are a limited number of long term studies on CBD in the Mediterranean Sea. This dissertation is the first step in establishing a long-term study on the CBD in the easternmost Mediterranean – a population living in ultra-oligotrophic waters, and showing a worrying dependence on the local bottom-trawl fleet. On one hand, the CBD obtains an easy meal from the bottom-trawl net; on the other hand, over-exploitation of the benthic resources harms the CBD directly and indirectly, and by-catch in the trawl-net is a major cause of death in the local population. Is the practice of foraging around and inside the net just a manifestation of an intelligent predator taking advantage of an easily accessible source of food, or is the population motivated by a necessity arising from the scarcity of food in its natural marine environment? Their intelligence is uncontested; their ability to adapt is also well documented. Therefore it is reasonable to believe that they have learned to consume these easy meals. However, some facts, emerging from the present research, hint at nutritional stress. The local CBD population forages most of the day, similarly to a population studied in the Adriatic, were food limitation was suggested, and unlike CBD populations studied in the UK, USA and Australia. Thin dolphins are frequently observed in the study area. This is seemingly mainly related to the lesser insulatory demands during the warm period, with a resultant decrease in blubber thickness to allow cooling of the body. However, judged by lower catch rates during the warm period, the contribution of nutritional stress, accentuating the thermoregulatory effect, cannot be ruled out.

Operational Conclusions

At this stage of the research, drawing operational conclusions concerning the local CBD population is problematic, due to lack of information prior to 2005. However, the strong evidence for over-fishing by the bottom-trawl fishery over the last six decades, combined with the continuous and cumulative damage to the sea-bed inflicted by the trawling process, strengthens the need for better fishery regulation and enforcement. Such regulations will benefit the fishers and the CBD population in the long run. The world-wide accepted regulation involves upper limits on effort, enforcement of maximal catch quotas and establishment of sea refuges (also known as marine protected areas) with no-catch or with spatially and/or seasonally restricted catch. Such biological reservoirs can enrich the entire surrounding marine ecosystem.

Suggested Further Research

* Continue the longitudinal research on the local coastal CBD population, and extend it to the northern and southern parts of the coast as well as to deeper western parts of the continental shelf and the slope.
* Derive more accurate population size estimates by means of distance sampling and mark-recapture techniques.

* Define the home range of members of the local CBD population by satellite tagging.
* Define the preferred habitat by use of generalized additive models.
* Monitor in real-time the foraging activity of CBD around the trawl nets by combined visual and acoustical devices.
* Further investigate and quantify the phenomenon of fishing down the marine food web in Israel by using the Echopath software.
* Create a complete food web model of the Israeli coastline, including the fisheries. This will enable a better understanding of the competition and will provide a scientific basis for establishing fishing regulations and dolphin conservation measures.

Aviad P. Scheinin (Ph.D.)
Advisors: Dr. D. Kerem and Prof. E. Spanier

Aspects of the Dynamics of Fish Populations and Fishery Management in the Mediterranean Coastal Waters of Israel

Fishery management is directed toward sustainable exploitation of fish resources in the oceans and seas. In this framework, fishery managers must control fish populations in such a way that stocks will be renewed yearly for the benefit of present and future generations.

There are various approaches to fishery management. Not long ago most were directly aimed at the fish populations, without paying adequate attention to the marine ecosystems that sustain these populations, and no consideration of the impact of fishing operations on these ecosystems. Until recently, fishery managers' interests were focused on the dynamics of the fish populations of the target species and the direct effects of fishing operations on those populations. However, this approach has recently changed dramatically, and has become holistic, attempting to estimate the overall effects of the relationships between man and his environment. Present management approaches are aimed at the diverse impacts of fishery operations on the sea, with all the implications involved. This new attitude in fishery management is called the 'Ecosystem approach to fisheries'.

To adopt this approach and to follow its objectives, several tools are needed. The first and most basic of these is knowledge. Fishery managers look for as many avenues as possible to gather data and information on the dynamics of fish populations, the relationships between these populations and the marine ecosystems that sustain them, and on the interrelationship between fishing operations and these two variables.

To obtain this tool, there is a need for an ongoing monitoring of the fish populations and the influence of the fishing activities on fish resources and the marine ecosystem. Furthermore, research should be carried out on different biological and ecological aspects of the complex relationships between fish stocks, fishing operations and the ecosystems that sustain both. Additional means needed are diverse types of management tools, together with new techniques which are being developed to provide solutions to the new challenges raised by the expansion of ecological, biological and technical knowledge. Fishery managers must choose from the wide variety of tools, while taking into account all available data and information on their fisheries and their effects on the marine environment. All this while considering that preserving the ecosystem will lead to sustainable fishing management. In addition, the adoption of this approach will yield the desired aspiration of society today to save the marine environment, its diversity and its complex ecosystems. However, these steps should be taken cautiously and in moderation, since our knowledge of oceanic ecosystems is, after all, still very limited.

The present study attempts to promote the adoption of the Ecosystem approach to fisheries in Israel.

The first chapter in this dissertation aims to provide Israeli fishery managers with knowledge of the fish populations exploited along the Israeli Mediterranean coast, and to focus on one of their unique aspects – Nanism (dwarfism).

The second chapter deals with a very important management tool – selectivity of the fishing equipment. This chapter introduces an attempt to increase the selectivity of the least selective fishing method of all fishing techniques – trawling. Increased selectivity refers to the overall population of fish found in the fished environment, and not only to those of commercial value.

The third chapter attempts to clearly and directly reveal if Marine Protected Areas (MPAs) can serve as a local tool within the overall Israeli fishing management concept, since MPAs have become an important tool in the Ecosystem approach to Fisheries.

Nanism: the aspect of dwarfism is relevant when managing fisheries along the Israeli coast. Gaining knowledge and characterizing the resources we would like to manage, including size distribution, is of upmost importance when choosing the right tools to implement limitations on fishing operations and fishing equipment.

The hypothesis in this research ('Levantine Nanism') is that fish in the south-eastern Mediterranean are of smaller body size than their conspecifics of the same age and sex from the central and western Mediterranean. This phenomenon has been suggested several times in the past, by several researchers for different taxonomic groups, but has never been proved quantitatively until the present research.

The research presented here proved for the first time, systematically, quantitatively and conclusively, that the phenomenon of Levantine Nanism does exist at least for one of the most commercially important species in the Mediterranean, the red mullet, *Mullus barbatus*. A systematic comparison was made between red mullet of the same age and sex from the Israeli fishing grounds and from the fishing grounds off the coast of Sicily, in the central Mediterranean. Fish age was determined by otolith readings (Fig. 1). It was found that red mullet from Israel aged 1 year and older are significantly smaller than their conspecifics of the same age and sex from Sicily (Fig. 2). The difference between the two populations is explained by the theory by which in variable and unpredictable conditions (of food supply in the present study in the oligotrophic Levantine basin) the adaptation of the population is for *r* selection, where development is fast, reproduction is early, and body size is relatively small.

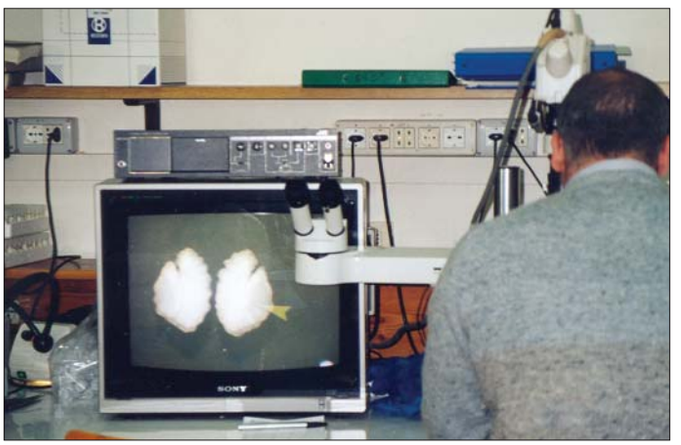

Fig. 1. Age determination of the red mullet, Mullus barbatus, in the nanism study, using otolith readings (seen on the monitor of the double station binocular)

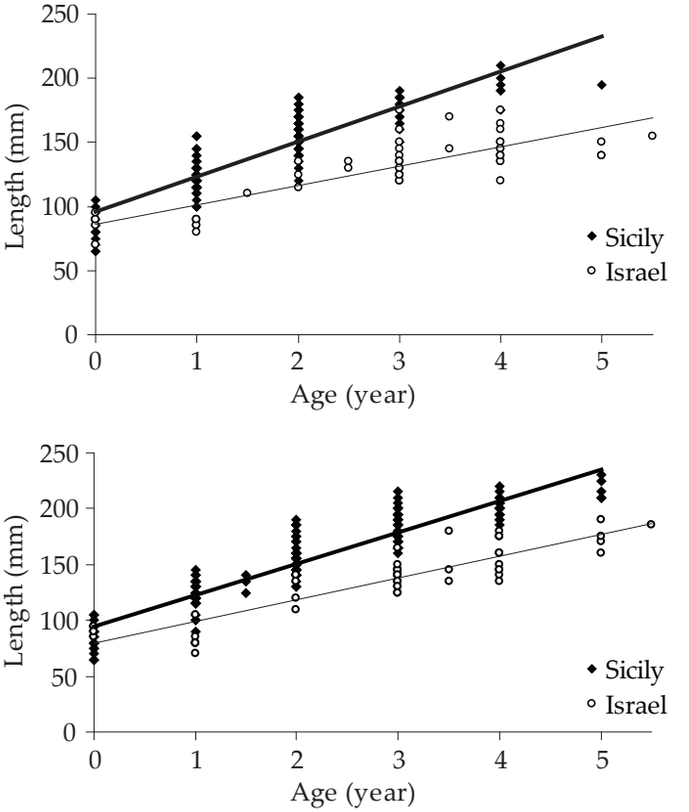

Fig. 2. Growth patterns in red mullet, Mullus barbatus; males (top) and females (bottom), from Israel and Sicily. Curves represent regression lines for prediction of length by age

Selectivity: Over-exploitation of fish populations has led fishery managers to seek ways of increasing the selectivity of fishing equipment. The most problematic fishing operation in this context is trawling, which is deemed to be the least selective method of all techniques permitted for operation in Israeli fishing grounds.

One of the negative effects of trawling is the capture of fish with small body size that are either juveniles of commercial, or specimens of non-commercial species, which are discarded. The selectivity aspect is very relevant for fishery management in this context, since it is desired to exclude from the trawl catch young fish that have not yet performed at least one reproduction cycle.

This aspect should be examined in relation to the Nanism phenomenon which is associated directly with body size.

Increasing the selectivity of a multi-species trawl fishery was considered to be an extremely complex task, yet a very simple and effective tool is demonstrated in the present study. Fishing operations were conducted using commercial trawlers with the original crews. A small experimental 'escape window' made of square

mesh netting was attached to the trawl net cod-end, and a collecting net that recaptured the escaping fish was connected over the escape window (Fig. 3). A comparison of the length distribution of fish taken from the collecting net, after they had passed through the 'escape window', and those taken from the cod-end of the main net was conducted. It was demonstrated that a relatively small, 50x50 cm, escape window can release as much as 40% of all small fish specimens. Since the Mediterranean trawl fishery is a multi-species industry, and involves fish species with diverse body shapes, some commercial fish, including some narrow and elongated commercial specimens, also got away through the escape window. These fish with commercial value constituted about 12% of the catch of the collecting net (Fig. 4). Further investigations are necessary, as soon as possible, to optimize the dimensions and mesh size of the escape window. Furthermore it is essential to monitor the survival ability of the escapees after going through the complex process of capture and escape from an operating trawl net. The results of these investigations are critical in order to implement the obligatory use of this selective device within the framework of the Israeli commercial trawl fishery industry.

Marine Protected Areas: The fishery yield in the Mediterranean, including along the Israeli coast, has significantly decreased in recent years. This is due, among other reasons, to overfishing and the relatively high percentage of small fish in the trawlers' catch. Populations of commercial species and those of non-commercial species dwelling in the same habitats

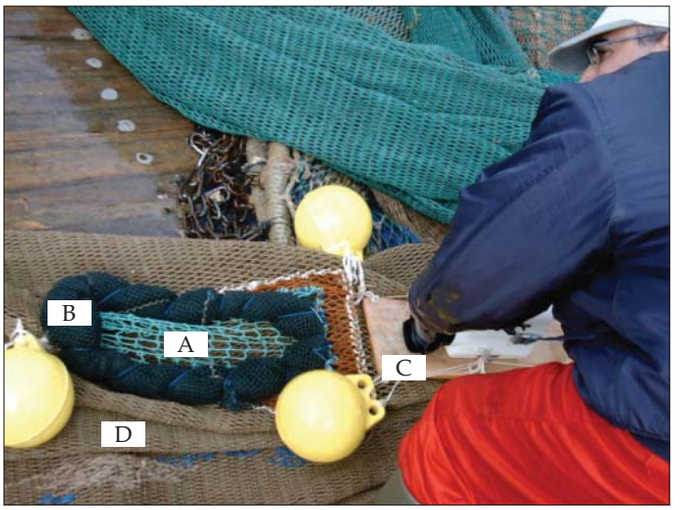

Fig. 3. Selectivity study: the 'escape window' (A) composed of square mesh netting attached to the trawl net cod-end (B), and the underwater documenting video camera (C). The collecting net (D) that recaptured the escaping fish, connected over the escape window, is folded to enable video recordings

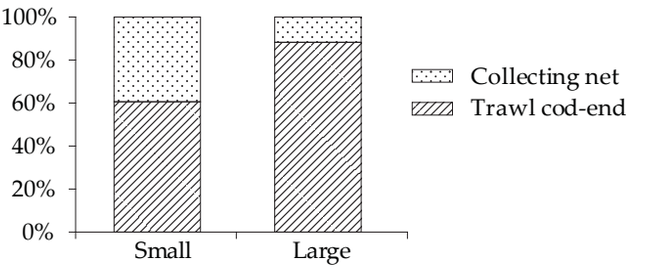

Fig. 4. Selectivity study: Percentage of large (at least 110 cm total length) and small (less than 110 cm total length) escaping fish recaptured in the collecting net (top of the histograms), and the trawl net (bottom of the histogram)

are affected. Marine protected areas (MPAs) that can serve, among other purposes, as sanctuaries for reproductive populations, are used as important fishery management tools at many sites in the World's oceans. To date MPAs do not exist in Israel. However, a military zone, where fishing has been completely forbidden for many years, can be considered an MPA. The present study referred to this military zone (the closed marine area off the village of Athlit) as an MPA. The objective of this facet of the study was to compare by fishing operations, the fish sampled in this MPA and those caught in the adjacent unprotected and intensively-fished control area north of the MPA. The sampling was performed with long lines using the same commercial fishing vessel, operating with the same professional crew, on the same dates and time frame, and with the same equipment. The yield was sorted and identified, and species richness, diversity and biomass were calculated for both areas. Results indicate that despite seasonal variations and those apparently associated with sea states, the number of fish species was always higher in the protected area than in the unprotected one (by 1.3–7 times) as well as the biomass (by 2.9–43.7 times) and the Shannon-Weiner Diversity Index (by 1.1–2.01 times) (Fig. 5). In most samples the number of specimens was also higher in the MPA. It is worthwhile mentioning that representatives of the groupers, family Serranidae, fish of high commercial value, such as the golden grouper, *Epinephelus costae*, the white grouper, *Epinephelus aeneus*, the dusky grouper, *Epinephelus marginatus* and the comb grouper, *Mycteroperca rubra*, some of which are on the IUCN Red List of threatened species, were significantly more common in the MPA catch. Mean number of species, mean number of specimens, mean biomass and mean biomass/fish were respectively 5, 11.7, 28.9 and 2.1 times higher in the MPA than in the control area. These findings point to the potential of establishing MPAs in Israel. The results correspond with those of studies on

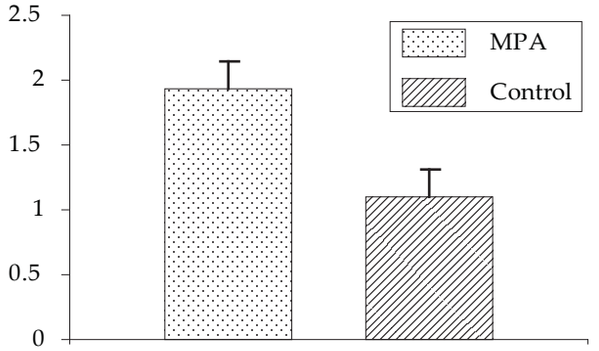

Fig. 5. The study of a Marine Protected Area (MPA): Mean Shanon-Weiener species diversity index in the MPA (left histogram) and in an unprotected control area (right histogram)

MPAs in other places. In the protected area there was a significant improvement in all indicators, pointing to the healthy conditions of the ecosystem compared to the control area. These findings will enable fishery managers and those responsible for nature protection in Israel to promote a decision to implement MPAs along the Israeli coast. MPAs which include the various marine habitats typical to our coasts – rocky, sandy and muddy, will serve as a most valuable tool for fishery management in our Mediterranean coast, as well as nature reserves in their own right, protecting all natural assets within their boundaries.

The present study deals with various aspects associated with fishery management along the Mediterranean coast of Israel. Moreover, some of the recommendations are operational for the improvement of fishing management along the Israeli coast, thus including Israel as one of the countries that embraces the Ecosystem Approach to Fisheries.

These recommendations incorporate further immediate study of selective trawl nets in order to implement a selective component in trawl equipment to reduce the discard in Israeli trawl fisheries.

At the same time, the present work recommends accelerating the official process which has already begun, between the Department of Fisheries, the Ministry of Agriculture, and the Israel Nature & National Parks Protection Authority, to plan and establish Marine Protected Areas along the Israeli Mediterranean coast, for better fishery management, and as a way to preserve the marine environment.

Adopting the recommendations of this study, together with present management tools and those adopted earlier and not yet implemented (such as a seasonal recess of the Israeli trawl fleet in the summer months), could improve fishery management in Israel. These improvements could upgrade Israeli fisheries to the standards acceptable in Western communities, and support the desire of Israeli fishermen and Israeli society as a whole to preserve the Mediterranean fishery for present and future generations.

Oren Sonin (Ph.D.)
Advisor: Prof. E. Spanier

Typical catch from the control area

Harbors in Phoenicia, Israel and Philistia in the 9th–7th Centuries BCE: Archaeological Finds and Historical Interpretation

This is a study of Iron Age II anchorages and harbors in the Levant, and the interaction between the Phoenician cities where these were located and the main economic and political centers. The maritime trade of the 9th–7th centuries BCE is examined through the distribution of anchorages and harbors along the Levantine coast, the origins and development of marine construction, and in the port-cities' relations with the superpowers, especially the Assyrians. It utilizes historical as well as archaeological records from surveys and excavations, both old and modern.

The influence and pressures exerted by regional kingdoms such as Aram-Damascus and the Northern Kingdom of Israel over the port-cities is also examined. The questions asked include whether military force or diplomatic and commercial ties lay at the heart of these kingdoms' trade relations with the port-cities. In particular – did the Kingdom of Israel seek direct control over the port-cities by developing her own naval force and merchant fleet, or was trade secured by diplomatic and commercial agreements with the professional seamen known as 'the Phoenicians', from the various port cities (and at times competitive entities), such as Sidon and Tyre? Further examined is how these relations changed following the Assyrian conquest of the region.

Knowledge of the Phoenicians is based on the Old Testament and the writings of Josephus Flavius, who wrote his histories many centuries after the period described in the Old Testament. However, new evidence does not support these opinions. Firstly, the dissemination of Phoenician trading-posts around the Mediterranean began in the 9th century BCE. Secondly, according to radiocarbon dating, the artificial Phoenician harbor at Athlit was built at the end of the 9th century or early 8th century BCE. These facts indicate that the apogee of maritime trade was several decades later than the trading between Tyre and the United Kingdom of Israel described in the Old Testament, and which is traditionally attributed to the 10th century BCE. Other than Old Testament references, and the Hellenistic and Roman writings based thereon, there is no evidence to suggest any expansion of maritime trade during the 10th century BCE, nor the existence of Hiram I of Tyre.

The archaeological component of this research focuses on findings from the Athlit harbor (Figs. 1–3) and a comparative study of anchorages and harbors that were in use in the eastern Mediterranean during the Iron II period. Athlit is the most complete example of Phoenician harbor construction discovered in the Mediterranean to date. The harbor was built during

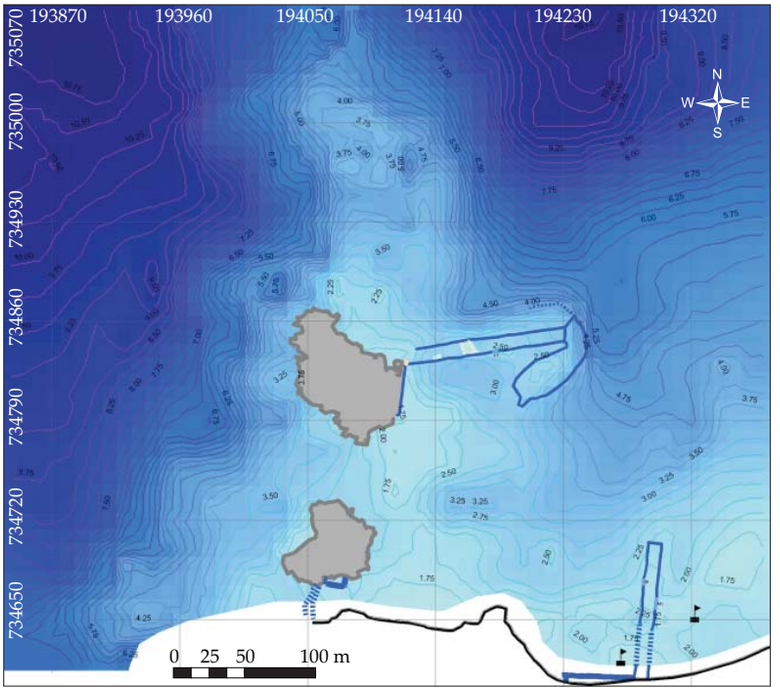

Fig. 1. A new map of Athlit Phoenician harbor based on recent excavations (Prepared by H. Cohen)

Fig. 2. Coring in the shallow water of the harbor (Photo: M. Artzy)

Fig. 3. Divers drawing remains of a possible storage area on the southern island (Photo: A. Yurman)

Iron Age II, before the Assyrian occupation of the region, and it eventually fell out of use at the end of the local Persian era. There are no remnants of any later construction over the Phoenician facility at Athlit, in contrast with other Phoenician ports, such as Sidon and Tyre. The study of Athlit harbor has therefore provided invaluable information on the positioning and planning of harbor facilities in the Levant, and the maritime construction techniques of the Phoenicians. The survey of anchorages and harbors extends from El Mina in the north to Tel Reqeish in the south. Findings from previous archaeological studies at the various sites have been assessed. The different types of construction at each site were compared, to determine whether there were any significant developments at the sites during the transitions from the Late Bronze Age to Iron Age I and from Iron Age I to Iron Age II, as well as any further changes after the Assyrian occupation.

It emerges that the decline, if not the demise, of Ugarit at the middle, or a little later, of the 13th century BCE was concurrent with major changes in a number of other anchorages, including those at Tell Abu-Hawam, at the base of the Carmel Ridge, and Maroni (Tsaroukkas), in Cyprus, which ceased functioning. With the destruction of Ugarit, at the close of the 13th century and during the early 12th century BCE, some harbors in the vicinity ceased to function, including the anchorage at Tel Nami and Ras Shamra itself, although other harbors and sites continued to be active, among them: Ras Ibn Hani, Sidon, Tyre, Akko and Dor. The most significant geopolitical consequence of Ugarit's decline was the shift of the center of Levantine maritime trade to the port-cities of southern Phoenicia, with Sidon and Tyre at the forefront.

It has been assumed that the maritime building technique of using 'headers' was introduced to the Levant from the Aegean and Crete, and passed on to the Phoenicians by the so-called 'Sea Peoples'. This assumption continued to be entertained despite the absence of any clear evidence that the 'Sea Peoples' had developed a maritime tradition in the region. For instance, to date no remnants of any artificial harbor facilities have been discovered in the Philistine coastal cities, such as Ashkelon and Gaza. Neither were they built in the two cities boasting the best natural features for the placement of harbors, namely Jaffa and Yavne-Yam. Sites north of Jaffa are those at which artificial harbors are first noted. This study proposes that in fact the maritime construction technique involving the use of headers was developed from the terrestrial usage in the eastern Mediterranean. The terrestrial technologies were then adapted to marine usage (Fig. 4) by Phoenician builders, and then exported to the western Mediterranean.

Finds from the underwater excavation at Athlit lead to the conclusion that the incorporation of perpendicular moles in harbor construction, such as the one proposed at Dor, was not developed prior to Iron Age II. During the course of the 9th century BCE, the Phoenicians transferred the dry-land 'Pier and Rubble' construction technique, in use since the Bronze Age, to the sea for the purpose of mole construction. Development of this type of mole allowed deep harbors to be artificially created for the first time. These harbors had year-round protection from weather conditions. Furthermore, larger vessels could now be accommodated, thereby increasing trade capacity. This expan-

Fig. 4. Athlit harbor. The inner header wall at the northern mole (Photo: S. Breitstein)

sion of Phoenician trade, and the introduction of larger and more cumbersome vessels, led the Phoenicians to establish a navy for the protection of the merchant fleet. Accordingly, the introduction of perpendicular moles and deep harbors, and the resulting growth in Phoenician trade, had geopolitical implications in terms of the Phoenician presence in the Mediterranean. This included, in particular, the expansion of the sphere of Phoenician trade to the western Mediterranean, and the strengthening of Tyre's control over new sources of raw materials in these areas.

Besides Athlit, three other deep harbors from the early period of artificial harbor-building have been identified. The first two of these are the harbors of Sidon and Tyre, where due to continuous occupation and utilization, up to the present time, it has not been possible to precisely date the Iron Age II harbor facilities. A third and smaller harbor is that of Tabat el-Hamam in northern Syria, which probably served as the port of ancient Simyra/Ṣumur-Tell Kazel. Its moles are very similar to those at Athlit, and it was probably constructed at a similar period.

As mentioned above, there were some changes in the locations of regional anchorages as a result of the weakening of Ugarit at the close of the Late Bronze Age. However, the design and planning of most of the anchorages along the Levantine coast remained consistent throughout the Iron Age. These featured the exploitation of small natural bays and construction of quays parallel to the coastline. The four deep harbors: Tabat el-Hamam, Sidon, Tyre and Athlit, served larger vessels whose cargo was either unloaded directly to shore, or onto smaller vessels (lighters) which then carried the goods to other shallower harbors along the coast. This model of maritime trade was also used in the Roman era, where a number of Imperial deep harbors, such as Caesarea, Alexandria, Puteoli, and Portus, were used primarily for the trade in wheat. The same model continued in use throughout most of the Middle Ages.

There was no major fluctuation in the number of anchorages and port-cities operating along the coast of Israel from the beginning of the Iron Age until the Assyrian occupation. The main development during the period preceding the Assyrian occupation was the

construction of the deep harbor at Athlit on the Carmel coast. The construction of perpendicular moles during Iron Age II allowed the Phoenicians to build deep-water harbors, such as Tabat el-Hamam, Sidon, Tyre and Athlit. The moles allowed the Phoenicians to build vessels with greater drafts and capacities. An example is the northern mole at Athlit harbor, whose eastern edge was built at a depth of about 6 meters (Fig. 1).

Traditionally, Dor has been regarded as the Kingdom of Israel's principal Iron Age harbor. However, Dor's main harbor situated at the south of the city is shallow, and would not have accommodated vessels with deep drafts. Additionally, from the 10th century BCE, access to the city from the harbor was blocked by a wall, and there are no signs of any further construction in any of the bays around Dor until the Persian era. The idea that Dor served as the Kingdom of Israel's main harbor is essentially based on references in the Old Testament, rather than on any archaeological evidence.

To date no harbors or anchorages built during this period, and which feature perpendicular moles such as those at Athlit, have been discovered. Following this period, this technique came back into usage during the Persian and Hellenistic eras, at sites such as Akko, and Amathus in Cyprus.

The period of Assyrian domination along the coast was marked by the construction of fortresses at locations which would have been unsuitable for harbors. While the Phoenician ports were established at carefully chosen sites, the Assyrian fortresses were built on sandy beaches, at the mouths of streams or along dry-land trade routes. Archaeologically, these policies are demonstrated in the establishment of fortresses on straight sandy beaches that would have been unsuitable anchorages. Examples of such fortresses are at Ashdod-Yam and Tel-Kudadi.

The building of these fortresses along the coastline is indicative of the political change that occurred with the ascent of Tiglath-Pileser III to the throne, and his policies toward the port-cities. After the Bronze Age, the port-cities were left in relative freedom by the ruling city-states and empires of the day, who would not generally employ military force to control them. No doubt, there was a concurrent dependence of the rulers on the northern Canaanite seamen who monopolized seafaring know-how. For instance, the Egyptians and Hittites in the Bronze Age, and the Northern Kingdom of Israel in Iron Age II, achieved access to sea-trade by diplomatic and political, rather than military, means. On the contrary, from the reign of Tiglath-Pileser III and under the subsequent Assyrian rulers, a strategy of conquering and controlling the port-cities was implemented, with ensuing direct power over maritime trade.

Up to the mid-8th century BCE, Tyre administered a trade network facilitated by political alliances with regional kingdoms such as the Northern Kingdom of Israel. While the Northern Kingdom of Israel and Aram-Damascus tended to be occupied by trivial disputes with one another over farmland and trade routes, they refrained from seizing control of the port-cities by force. This was due to their reliance on Phoenician expertise and maritime tradition in operating the harbors and vessels.

With the rise of Tiglath-Pileser III to power, the Assyrian policy toward the port-cities changed. Assyria was determined to secure direct control over the ports and maritime trade, employing military force to this end. Assyria's control in this period can be seen, for example, in the forbidding of Tyre to trade with Egypt or Philistia, and by their replacing Tyre with Sidon as the principal Phoenician port-city.

The relationships between Assyria and Tyre were complicated by the Assyrian dependency on Tyre's trade network, and by the Tyrian merchants' influence over Tyrian maritime policy. This is evident in the Asarhaddon-Baal pact which was sealed shortly after the conquering and sacking of Sidon. It is likely that one of the main objectives behind the pact was Assyria's immediate need of a key port in Phoenicia. There are two main parts to the pact: 1. Tyrian vessels were granted access to the harbors and anchorages along the Assyrian-occupied coastline. Those previously under Sidon's control were now transferred to Tyre. 2. Regulation of Tyre's trading and defined property rights that were applied to the harbors and anchorages.

Assyria's pressure on Tyre and the Phoenician cities, which began in the mid-8th century BCE, and the increasing threat from Greek domination of long-distance maritime trade-routes, eventually led to the disengagement of Carthage from Tyre, and the creation of a distinct economic and political system in the western Mediterranean. With the expansion to the West came the diffusion of the special harbor building technique which had, as is shown in this study, originated in the eastern Mediterranean following local tradition, rather than one imported to the area from the West by the enigmatic 'Sea Peoples'.

Arad Haggi (Ph.D.)
Advisors: Profs. M. Artzy and I. Finkelstein

Dor 2001/1 Wreck – Evidence for the Transition in Shipbuilding Construction: A Characteristic of Socio-Economic Changes in the Byzantine Empire in the 5th-6th centuries CE

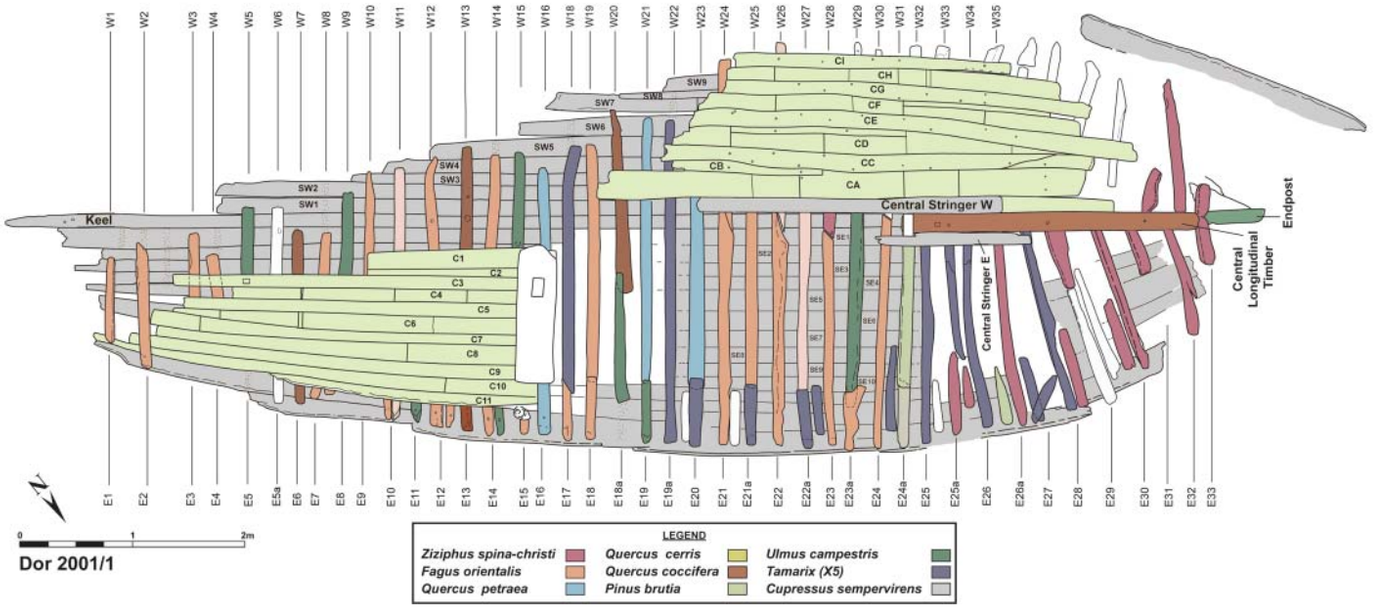

Fig. 1. The ship at the final stage of excavation (C. Brandon, S. Haad)

This study analyses the *Dor 2001/1* shipwreck, found during a survey in Dor lagoon, Israel. Its remains were found about 70 m offshore, close to Tafat Island, oriented roughly north-west/south-east, adjacent to the lagoon's navigation channel. It was at a depth of 1 m, buried under 1.8 m of sand. The total length of the find was 11.5 m, and its maximum width was 4.5 m (Fig. 1). The hull remains include sections of the keel; false keel; endpost; false endpost; 42 frames (floor timbers, half-frames and futtocks); 29 strakes, among them a chine strake and two wales; 21 ceiling strakes, among them a clamp and two foot-wales; a central longitudinal timber, two central stringers and part of the mast-step assemblage (Fig. 2). The shipwreck was excavated underwater for five seasons, from 2002 to 2006. It was dated by ^{14}C and wiggle matching, to the beginning of the 6th century CE, which was the Byzantine period in this area.

The main purpose of the research was to identify the method by which the hull was built, and then to place it along the sequence of changes in shipbuilding construction that occurred during the 1st millennium CE. The study of the hull remains of the *Dor 2001/1* wreck proved beyond doubt that most of the frames were nailed to the keel, there were no planking edge-joints, the planking was nailed to the frames with caulking material in the seams, and there were several longitudinal reinforcements, including a central longitudinal timber. This led to the conclusion that it was built 'frame-based'. The use of this building method was already assumed during the excavation, but in order to prove it beyond any doubt, a 2-m section was removed from the hull. The section was made at the widest part of the wreck, in order to include as many wood components as possible. The laboratory work indeed confirmed the initial hypothesis, and the suggested sequence of construction is as follows: the endposts were joined to the keel, most of the frames were nailed to the keel, the planking was nailed to the frames from the outside, caulking material was inserted into the seams from the outside, and finally various longitudinal reinforcements were installed.

Based on the analysis of the wreck's details, an attempt was made to reconstruct the hull lines of the original ship and test their characteristics. The original vessel had a length of 16.9 m from stem to sternpost, a

Fig. 2. View of the eastern side of the Dor 2001/1 shipwreck (Photo: I. Grinberg)

5.4 m beam and a 2.5 m depth. The frames amidships formed a flat-bottomed section, converging towards the endposts. The weight of all the timber components was estimated to be about 12.5 tons, and together with the steering, mast, rigging, crew and basic supplies, it is estimated to have been about 15.5 tons, without cargo. In light of the estimated 2.5 m depth, a freeboard of 1 m, would leave a 1.5 m draft. With such a draft, the original vessel is estimated to have carried about 35 tons of cargo. Altogether at a draft of 1.5 m, fully loaded with cargo, the estimated displacement of the vessel could have reached 50 tons.

Since there were no remains of mast, sail or rigging in the archaeological find, it was necessary to assume the shape of the sail. In light of recent views, which posit that the lateen sail had spread throughout the Mediterranean by the middle of the 1st millennium CE, it is assumed the vessel carried a lateen sail. The sail was estimated to have been about 73 m^2 in area, based on the suggested hull lines and the wetted area at 1.5 m draft, and comparative studies. The reconstruction calculations suggest that the vessel had good sailing stability, and even in 5–6 Beaufort winds, fully loaded, it could have heeled to an angle of 23° and still sail safely.

In order to understand the importance of the change in construction, attention must be drawn to the debate regarding the 'transition in ship construction' and its date. During the 1st millennium BCE and most of the 1st millennium CE, ships were built using the 'planking-first'/'shell-first' method. In this sequence of construction, the planks were joined to the keel and to each other either by mortise-and-tenon joints locked with wooden pegs, or by sewing. Only after the planking was joined, were the transverse supports, i.e. the frames, installed. Thus, the shape of the hull was dictated and determined by the longitudinal lines of the planking, which were the source of its strength. The 'shell-first' method was very reliable, producing a very strong and tight hull, but the building process was prolonged and expensive, since it required a highly professional shipwright's crew and much building material, and the maintenance of such a vessel was difficult and costly.

Several excavations of shipwrecks in the Mediterranean dated to the 1st millennium CE have yielded clues regarding a shift in the building method, when shipbuilders started to rely less on the joints between the planking. The space between the mortise-and-tenon joints grew, and eventually they were no longer pegged. In the new building method, 'framing-first'/'skeleton-first', the hull was based on transverse components. The sequence of construction was that frames were first nailed to the keel, and then the planking was nailed to each frame by iron nails. This system did not require as much building material as the previous one, and the manpower could have been less professional. The entire process was faster and cheaper, and maintenance was easier. Until recently, the first wreck documented as being built completely by the 'skeleton-first' method was the *Serçe Limanı* wreck, found off the coast of Turkey, dated to the beginning of the 11th century CE.

Such a change was not the product of a shipwright's chance invention. The field of ship construction is very conservative, and technological changes are extremely slow, because they have an immediate effect on the stability of the ship and its sailing characteristics. Therefore, such a change is usually a by-product of different factors, such as economics, which leads to the economic issues of ship ownership at that period. In order to investigate this, the secondary goal of the research was to study the socio-economic reason for such a change. The study makes extensive use of one of the few historical documents dated to this period, which deals with boats and their ownership – a collection of 57 laws regarding their owners, *navicularii* in Latin, in Book 13 of the Theodosian Codex.

The Codex, compiled during the 5th century CE, contains all the rules issued by Emperors on both parts of the Later Roman Empire, divided into main topics. The Codex had been translated into English, but in this research the original Latin text was translated into Hebrew, and the rules were analyzed in light of the maritime sphere. The translated text deals with the *navicularii*: landowners who were obliged to provide the state with ships, and were in charge of their construction, maintenance and operation, in order to supply food to the population of the capitals and to the army.

They either deal with the special privileges that were awarded to the *navicularii* in order to allow them to fulfill their obligations, or with the maneuvers they employed to lighten their financial burden. The interest of the state in awarding certain privileges was to enable them to provide valuable services which the state depended on, since it hardly had a fleet of its own. This was the reason it defended them from various local governors. Despite this, the financial burden grew heavier, and the *navicularii* sought ways of lowering their costs. The hypothesis put forward in this study is that one of these ways, which is implied in several of the rules, was to cut down building expenses of ships, by building smaller, cost-efficient ships using a faster and cheaper building method, such as the 'frame-based' construction.

The main find in the wreck, besides the hull itself, was a cargo of 96 stones, stacked in two layers of three to seven adjacent rows (Fig. 3). All of them were slightly trapezoidal voussoirs, and were about the same size, with average dimensions of 57x28x18 cm. Each stone weighed about 60 kg., which means that the total amount which was found is estimated at about 5.5 tons. Petrographic analysis of several stones identified them as *kurkar* (coarse calcareous sandstone), from the vicinity of the site, probably from the Habonim-Dor ridge. The shape in which the stones were chiseled and their size suggest that they were building stones, destined for an unknown project. They were transported by ship, since it was much easier to convey loads by sea than by land. The local identification of the *kurkar* might be linked to one of the main livelihoods of the Byzantine population in this area – the *kurkar* quarries.

In addition to the stones, a large and varied pottery assemblage was recovered from the wreck, mostly dated to the Byzantine period, 5th–7th centuries CE. They were mostly body sherds, severely damaged, with relatively few indicative fragments of Cypriot and African red-slip bowls, cooking pots, strainer jugs, Gaza storage jars, Palestinian bag-shaped jars, Beth-Shean bag-shaped jars, and Yassi Ada jars. All the pottery was above the wreck, above and between the stones, very few pieces lay directly on the hull, and none can be described as *in situ*. Nevertheless, it is important to point out that most of the pottery assemblage corresponds to the dating of the shipwreck by ^{14}C and wiggle-matching, and there is a high chance that at least some of it belonged to the ship's original cargo.

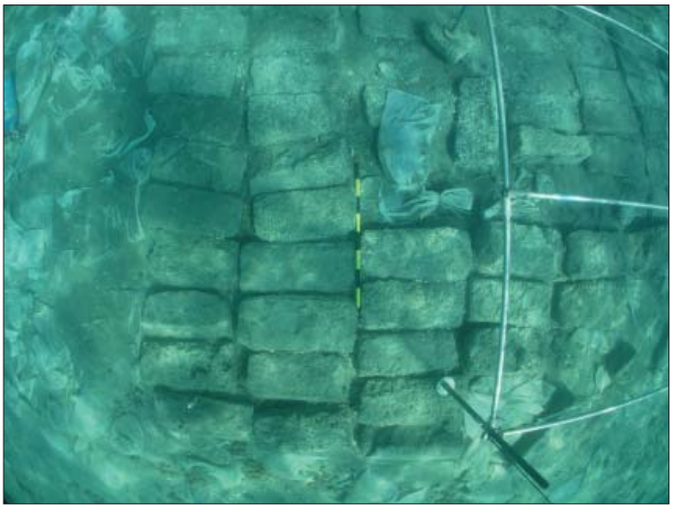

Fig. 3. The cargo of stones before removal (Photo: S. Breitstein)

The presence of the wreck in the lagoon is closely tied to the fact that it is one of the very few natural anchorages along the Israeli coast. Throughout the history of the settlement at Tel Dor, which began in the middle of the 2nd millennium BCE, one of the main factors for its commercial success was the convenient nearby anchorage. The archaeological research of the Tel, and the historical documents, all imply that the site ceased being populated in the Byzantine period, and served only as a military post. However, excavations of the south-eastern slopes of the Tel discovered the remains of a residential quarter dating to the Byzantine period. Identified among the remains was a basilica, which according to Christian beliefs, hosted the remains of several saints and a piece of the rock of Golgotha. The *Dor 2001/1* is the earliest known wreck belonging to a group excavated at Dor lagoon, most of which show features of the change in ship construction methods. The combination of all the archaeological information mentioned above, together with comparative study of several later wrecks (mostly off the coast of France, and two wrecks from Istanbul), with evidence from north-west Europe, suggests that the 'transition in construction' occurred in the Mediterranean about 500 years earlier than previously believed. In this aspect, it is easy to see the importance of *Dor 2001/1* as a pioneering wreck. The new translation and reconsideration of the historical text of the codex resulted in a new interpretation of the archaeological finds. This research indicates that this shift in technology was subject to ideological economic factors, leading to major changes in shipbuilding in the middle of the 1st millennium CE.

Hadas Mor (Ph.D.)
Advisors: Dr. Y. Kahanov and Prof. Z. Rubin (deceased)

The Sea of Galilee Fish Market 1996 to 2006

Fishing in the Sea of Galilee has great significance for the economy of the region. Its importance began during ancient times: the New Testament reveals the lifestyle of the Sea of Galilee fishermen at the beginning of Christianity. For example, the story of the miracle of the bread and fish appears three times: in the Gospels of Matthew (Chapter 14: 13–21), Mark (Chapter 6: 30–44) and John (Chapter 6: 1–15). According to this story, Jesus performed a miracle and fed 5,000 people with two loaves of bread and five fish "...and they were filled". The miracle occurred as evening was falling, in the north-western area of the Sea of Galilee. The Gospel of John (Chapter 21: 10–17) describes Peter catching 153 fish in one cast of his net in the same place. This area was known to be very rich in the local St. Peter's fish, *Sarotherodon galilaeus* (Fig. 1), before the diversion of the saline water from the springs of Ein Nur from the Sea of Galilee, and thus the description of Peter's catch fits well with our knowledge of the Sea of Galilee at that time.

Such narratives are also to be found in the Talmud. These describe life around the Sea of Galilee, mostly in terms of the daily struggle by Jewish fishermen to cope with the observation of the Biblical commandments, side by side with their fishing activities. The accounts of Josephus, who described the Jewish uprising against the Romans, also illustrate the events occurring around the Sea of Galilee at that time, and depict prolific fishing activity around the towns of Tiberias and Magdala, as well as the battles between the fishermen and the Romans on the Sea of Galilee. After the Roman period, there was a decline in the status and importance of the Sea of Galilee, until the establishment of the British Mandate, which began instituting fishing and ensuring its continued existence. Thus, in 1921 the British Mandatory government declared that only those holding government licenses were allowed to conduct commercial fishing activities in the Sea of Galilee. Among other initiatives to promote fishing, the Mandatory Government appointed Dr. Ricardo Bertram (on behalf of the Haifa Fishing Officers' Bureau, which was part of the British Mandate Government administration) to examine the state of fishing in the Sea of Galilee in the early 1940's. The report submitted by Dr. Bertram included a description of the state of the fish and fishing, and recommendations for action and legislation. The report was completed in November 1944, and attested to the difficult situation of fishing and to the necessity of preserving the quantity of fish, fast becoming extinct. It stated that the pressure of fishing must be reduced by minimizing the number of licenses and limiting the number of fishermen. Bertram's report still serves as the basis for fishing regulations in the Sea of Galilee.

The present study is interdisciplinary, combining economic and biological aspects. The biology is concerned with the fish themselves, and the natural factors (biotic and abiotic) affecting them and their populations. The economics examines the fish's monetary value and the importance of this sector to the economic welfare of the region. The aim of the study is to examine the state of affairs of the commercial fish market in the Sea of Galilee during the past decade, in order to construct an economic model based on supply, demand and prices. The importance of the present study is in developing scientific tools which can act as a basis for making decisions relating to the Sea of Galilee fish market, its management, and the degree of importance of each taxon of fish to the Sea of Galilee and to the total fish catch.

Fig. 1. St. Peter's fish, Sarotherodon galilaeus (Photo: D. Darom)

Study Results

– The Sea of Galilee fish market is not stable, and is subject to many changes. This is evinced by the sharp fluctuations in revenue, ranging between a maximum of about NIS 12 million in 1996, to a minimum of about NIS 4.4 million in the years 2001 and 2003. This fluctuation between the highs and lows expresses a decrease of about 66% in revenue. Since 2003, there has been a rise in revenue, and in 2006 the total revenue was about NIS 8 million.

– The Sea of Galilee is a minor supplier of fish, and is influenced by regional problems. During the past decade, it has produced an average of 5% of the total

catch of fish in Israel. This is small compared with the extensive aquaculture sector, which supplies 70% of production. Assuming that fish consumption per person in Israel is about 10 kg/year, the Sea of Galilee supplies 0.2 kg per person/year, while the bulk of fish consumption (5.8 kg per person) comes from imports. The fishing sector in the Sea of Galilee is considerably influenced by regional changes, which affect the entire fishing market. Therefore, it is incorrect to examine the events in the Sea of Galilee in isolation from external factors.

– Due to their relatively small proportion of the total catch of fish in Israel, the price of Sea of Galilee fish is affected by the prices of aquaculture fish, imported fish, and regional crises. It is not the Sea of Galilee fishermen who set the price of their fish, but rather they accept the price set by the wider market. Price is a major influence on the amount of fish caught in the Sea of Galilee, so that when the prices are high there is a greater motivation to fish. For example, a rise of 1% in the average price of Sea of Galilee fish increases the catch by about 4.5%. The price fluctuates throughout the year, following consumer demand, especially during the Jewish High Holidays. However, this increased demand is not always compatible with fish reproduction and growth rate.

– A fisherman's decision to fish is dictated by considerations of economic profitability. When the market price is too low, the revenue from fishing does not cover costs, and the fisherman will not fish (if he has an alternative source of income, a fisherman will not go fishing even when there is a profit to be made, if it is lower than that from the alternative source). This contradicts a common assumption that the fishing effort is at a maximum, and that Sea of Galilee fishermen will try and catch any fish whose size approaches commercial range. This erroneous assumption ignores the fact that the incentive to fish is dictated by economic considerations.

– Analysis of the different influences on Sea of Galilee fish shows that price has a positive effect on the amount of fish in the Sea of Galilee, especially *Sarotherodon galilaeus*. This effect is lower for other species of fish, such as the blue tilapia, *Oreochromis aureus*, the thinlip mullet, *Liza ramada*, the flathead grey mullet, *Mugil cephalus* and the large scale barbell, *Barbus canis*. There is also a strong association between extensive aquaculture sites and the Sea of Galilee. A rise in prices, as well as an increase in the supply of *Sarotherodon galilaeus* from extensive aquaculture, causes a sharp decrease in the catch from the Sea of Galilee. Fish stocking of *Sarotherodon galilaeus* increases the catch, but has little effect on the *Oreochromis aureus* and other species of tilapia. The number of fishermen affects the amount of fish in the Sea of Galilee.

– Comparing the Sea of Galilee to a company which produces fish, it is obvious it has a negative marginal output, wherein any further fishing causes a decrease in the company's revenue, since it interferes in some way with the overall production. Without specifying numbers here, it is apparent that lately there has been an increase in incidents of deliberate fish poisoning, stemming from disputes between fishermen, and related to a fish shortage and the desire to earn a living. Undoubtedly, the Sea of Galilee is yielding a negative marginal output. Only by minimizing the number of active fishing boats will this situation be amended.

Recommendations for Increasing Revenue from Sea of Galilee Fish

Fishing for larger fish

The situation in the Sea of Galilee is different from that in extensive aquaculture sites, where the cultivator has both fixed and variable maintenance costs, and his interest is to sell the fish with the smallest maintenance time and at the highest price. Letting fish grow to a larger size does not involve any cost, since the fish feed off natural food found in the lake, and of course, there is no supervision, checking, or any other costs. This means that fish body mass growth does not entail any expenses, and may greatly increase the revenue, so that if fish are caught at double their weight, the price increases in proportion, as do the fishermen's profits.

Fine-tuning the distinction between Sea of Galilee fish and extensive aquaculture fish

The Sea of Galilee's great advantage is that its fish feed off natural food and enjoy a relatively clean habitat closely suited to their needs, in contrast to the situation in extensive aquaculture, where the fish are fed with food chosen for them, and they cannot change their habitat. This means that there is a certain health benefit in Sea of Galilee fish, which can be turned into a marketing tool and a consumer preference modifier.

Supervision and information dissemination

All the above, as well as any other actions to be implemented in the lake, including the prevention of criminal activities, have no chance of being carried out without an efficient supervisory mechanism. Today, supervision suffers from a significant shortage in manpower and means of enforcement, and a lack of motivation on the part of the existing supervisory staff.

Reducing the number of fishing licenses

As mentioned above, fishing is now in a state of low, perhaps even negative, marginal output. This means

that the number of fishing licenses in the Sea of Galilee must be substantially reduced in order to ensure that the remaining fishermen can earn their living. The possibility of stipulating that a fishing license is issued only on condition that no laws are violated should be examined, as it may act as a further incentive for obeying the law.

Increasing stocking

The origin of some of the Sea of Galilee fish is cultivated fingerlings from outside the Sea of Galilee, which are released into the lake at minimal cost. The silver carp, *Hypophthalmichthys molitrix*, *Liza ramada* and *Mugil cephalus* are not native to the Sea of Galilee, and outside of stocking, they cannot reproduce in it, unlike the stocked *Sarotherodon galilaeus* which join the reproductive population of the Sea of Galilee. In recent years, *Liza ramada* and *Mugil cephalus* have captured a major part of the Sea of Galilee market. These fish are in great demand, and so maintain a good price level. Adding fingerlings to the Sea of Galilee will increase the amount of fish caught per year and increase the revenue, provided, of course, that this is done within the ecological limitations of the Sea of Galilee.

Study follow-up

Despite the small portion the Sea of Galilee holds in the national fish market, and in spite of its relatively small size compared with the marine territory which borders our country, we have discovered very little. There is room for further investigation of Sea of Galilee fishing on many levels. Among others, the quantitative relationship between the fish and the water quality, and the effect of increasing the amount of stocked fish on the quality of lake water, need to be explored. The relationship between stocking with *Sarotherodon galilaeus* and the catch, and that between the Sea of Galilee fish market and fish markets in the Mediterranean, also need further study. It might also be worthwhile examining the profitability of executing reforms by which fishermen pay a tax in exchange for marketing and supervision services.

Eyal Ofir (M.A.)
Advisors: Profs. E. Spanier and U. Ben Zion

Methods for Preservation of Cetacean Skeletons for Reference Collections, Research and Display

This study is a review and hands-on examination of preservation methods of cetacean skeletons, with the aim of recommending the optimal method, applicable in local conditions.

Animal skeletons are a rather important research constituent in the fields of morphology, ecology and population genetics. In addition, they serve as didactic accessories and impressive exhibit items in natural history museums. In recent decades, there has been a global increase in the scope of cetacean research, resulting in a growing need for collection and preservation of their skeleton specimens.

Unlike the preservation of terrestrial animals, the preservation of cetacean skeletons constitutes a challenge for the professionals, with problems deriving from their unique anatomical and physiological features: The structure and composition of bones, their size and their high fat content – all affecting the quality of long-term preservation.

In Israel, since the sixties of the last century, with the development of the Tel Aviv Zoological collection, a few dozen cetacean skeleton parts have been preserved. This activity eventually ceased, by the end of the 1980s. Since 1995, a few other skeletal items were collected and preserved by IMMRAC (Israel Marine Mammal Research and Assistance Center), sponsored academically by the Recanati Institute for Maritime Studies, the University of Haifa, and have been kept in the latter institute. The recent growth of cetacean research at the University of Haifa has increased the awareness of the importance of collecting and preserving these specimens, and of maintaining a proper and inclusive cetacean skeletal collection. The means of establishing such a collection are examined in this study.

Cetaceans are a mammalian order, which by a unique evolutionary process have become entirely marine. The transition into the marine environment is evident by adaptations, which – among others – have affected the structure of bones and skeleton. Among the latter are included: the atrophy and the total disappearance of hind limbs, the transformation of the forelimbs into flippers and marked modifications in skull morphology. Also, as a result of the skeleton losing its body-mass supporting function and due to

buoyancy considerations – a radical change in bone structure ensued, i.e. reduction of dense cortical bone and inclusion of a fatty texture in an expanded spongy matrix. One chapter of this study is dedicated to the evolution in skeleton structure, stressing implications for preservation.

There is a surprising number of historical and archaeological evidence of man's exploitation of cetaceans, starting with the use of bones and fat in ancient cultures, and up to their industrial use since the 18th Century and onwards. Utilization of skeletal parts included structural support for dwellings, fabrication of tools, extraction of fat and actual burning material. Another chapter in this study reviews the use of cetacean bones throughout history.

Scientific interest in cetaceans started in mid 20th century, and together with the development of science, emphasis was put on the need to build taxonomically ordered collections. The leading collections worldwide can be found in universities and museums of natural history.

In Israel there are twelve species of cetaceans, including two species of baleen whales and ten species of toothed whales. Around two hundred cases of beached specimens were recorded between the years 1993 – 2008. Most specimens in the collections in Israel originate from beached individuals or ones accidentally caught by fishermen, and are stored at the Universities of Tel Aviv and Haifa (IMMRAC collection). The Tel Aviv collection includes specimens from the years 1960 – 1990, whereas the Haifa collection includes specimens since 1995. Several specimens also exist in the Hebrew University collection, the Oranim College and the Haifa Zoo. A description of the collections in Israel, and worldwide, is included in the third chapter. A preliminary catalog of the existing Israeli specimens, and a detailed description, down to the level of separate bones, of the IMMRAC collection, were compiled by the author.

The fourth and main chapter of this study recounts the author's personal experience in preservation methods and in preparation of display items. The unique cetacean skeletal structure and the high content of fat set a challenge for the preservation process, which should result in a long lasting product, accessible for research, odorless and visually aesthetic.

This study examines the scientific and applied knowledge on the subject of preserving cetacean skeletons, comparing personal experience in several currently recommended methods, in order to recommend a combination of techniques, suitable for the climatic conditions and constraints of Israel. During the comparison, we examined quantitatively the effectiveness of different methods for removing soft tissues and extracting the fat from the skeletons. The comparison and final grading of the various methods was based on several parameters: the state of the specimen at the completion of the preservation process, and again, after a varying period of up to two years; the duration of the preservation process and the accrued costs (manpower and materials) of the technology.

Personal experience also included producing exhibit items "from corpse to display". This experience included the preparation of a complete skeleton of a common bottlenose dolphin (*Tursiops truncatus*), reassembled according to customary worldwide guidelines. This was followed by the preparation of an original exhibit, a transparent cast of a common bottlenose dolphin's flipper, around its bony elements – a combination of old and innovative techniques.

For all preservation methods examined in this study, common among curators all around the world, it turned out that the hot Israeli climate is an advantage for the relatively rapid preservation of specimens. The use of soft tissue decomposition catalysts, such as compost and horse manure, is cheap and effective. In addition, the hot climate allows the use of other methods of tissue removal by scavenging organisms such as dermestide beetles. Unlike cold countries, the climate in Israel enables the use of this method outdoors for a large part of the year. This process, too, is cheap – though lengthy. Careful, controlled boiling is suitable for preservation under time constraints, mainly in adult specimens.

Quantitative examination of the relative effectiveness of two common fat-extraction materials – ammonia and acetone – did not reveal a significant difference between them. The main difference that does exist between these two techniques is the higher cost of acetone in the volumes required to immerse all but the smallest specimens. Damage to bones which may occur following bleaching by hydrogen peroxide (mainly for displays), causing many cetacean preservers in leading institutions to avoid its use – was not proved in the quantitative toughness tests conducted in this study. The efforts related to the existence of a permanent scientific collection, i.e. skilled paid personnel, beach mobility, materials and tools, laboratories and large storage space, as well as continuous maintenance, require a clear definition of objectives. Defining the nature of the collection is critical in issues such as preference of species and parts to preserve and the desired range of ages and sizes. All these may influence the activity of preservation, beginning with the stage of collecting animal data on the beach and up to the challenges of maintaining speci-

mens for a long time in a comparative collection and on educational displays.

Reviewing the inventory of cetacean specimens in the collections of Israeli research institutes as well as in neighboring countries indicated that only a few species are represented by entire skeletons.

Of the 200 specimens beached and accidentally caught in Israel during the last decade, skeletal elements of less than a quarter were properly preserved.

Our review also indicates that currently IMMRAC appears to be the only research body in the eastern Mediterranean with the potential to build and maintain an adequate reference base of cetacean samples necessary for both scientific research and didactic needs. Materializing this challenge requires that the institute invest heavily in the allocation of space, the required equipment and the training of skilled and experienced personnel (Fig. 1).

Fig. 1. Assembling a dolphin skeleton for exhibition (Photo: J. J. Gottlieb)

Eliana Ratner (M.A.)
Advisors: Drs. D. Kerem and N. Kashtan

Sponge Ecology: Historical Aspects and Recent Findings from the Mediterranean Coast of Israel

The present interdisciplinary study of sponge ecology combines historical and ecological topics, examining ancient descriptions of sponge habitat with modern ecological tools.

In Antiquity, sponges were harvested due to their unique capacity to retain liquids and expel them when squeezed. As a result of the constant demand for, and the widespread use of, sponges in ancient times, considerable knowledge was accumulated regarding their natural history.

Today 'bath sponges' are gaining renewed popularity in 'natural-goods' stores, but they hardly have other direct uses. On the other hand, numerous sponge species are a natural source of substances with anti-inflammatory, antibacterial, antitumor, antifouling and other properties, which could be utilized by the pharmaceutical and other industries. The demand for these substances has led to a growing interest in sponge ecology.

In the past, knowledge of habitat conditions was vital for successful harvesting of sponges with desired qualities. Such knowledge, if recovered from ancient texts and properly analyzed, may serve as a launching point for modern research. Moreover, the knowledge of habitat preferences of sponges may be utilized towards their cultivation.

The main objectives of the present study were: 1. To find information on sponges in the works of Ancient Greek and Roman authors, and analyze these records. 2. To examine factors affecting sponge distribution and habitat preferences.

Descriptions of sponges were located in the works of four Ancient Greek authors and four Ancient Roman authors. Among the main findings are passages from the works of Aristotle (384–322 BCE, *History of Animals* 548a 36–40) and Pliny the Elder (23–79 CE, *Natural History* 9.69), dealing with various aspects of sponge ecology, in particular the descriptions of undersea caves as a preferred habitat for sponges.

The ancient descriptions of sponge habitat served as the starting point for the field study on the influence of water motion and irradiance intensity on sponge distribution. The encrusting sponge *Batzella inops* (Fig. 1) inhabits both well-illuminated and dimly-lit habitats and served as the focus of this study. The working hypothesis was that this sponge would be more abundant in habitats with low water motion and dim light, such as submerged caves.

B. inops has been shown to contain molecules with specific inhibitory activity on calcineurin and caspase enzymes, which could be used to produce immunosuppressant drugs. Hence, the knowledge of the

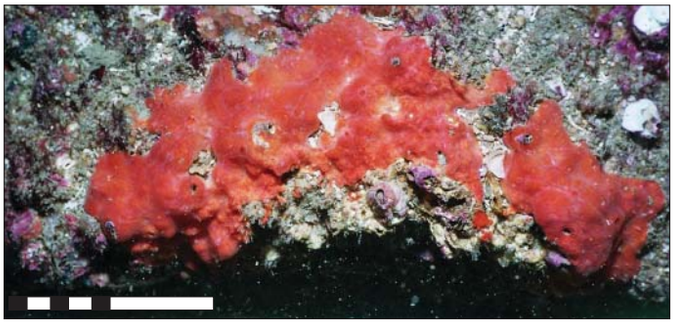

Fig. 1. The sponge studied – Batzella inops (Photo: P. Nemoy)

sponge's habitat preferences could contribute toward successful cultivation of this sponge and the harvest of biomedically important chemicals.

The field study was performed on a kurkar ridge (~10 m depth) approximately 1 km west of Nahariya, along the northern coast of Israel. Water motion (measured by the gypsum dissolution method) was significantly weaker inside submerged caves than outside, and irradiance levels (measured by means of an underwater PAR irradiance sensor) inside the caves diminished to less than 0.5 % of the external irradiance. The local distribution of *B. inops* was examined by means of visual and photography surveys and sponge abundance was determined by quadrate (40x40 cm) sampling. The sponge was considerably more abundant inside submerged caves than outside them. In order to test the hypothesis that submerged caves are a preferred habitat for this sponge, reciprocal transplantation of *B. inops* inside and outside a cave was performed. Contrary to expectations, the health of sponges transferred from external boulder surfaces into the cave deteriorated significantly compared to those transferred from inside the cave to the external environment.

Although several factors, such as the short duration of the experiment and the low number of replicates (several sponges were lost following severe underwater scouring events) could have had a significant bearing on the results, some interesting conclusions emerged from the transplantation experiment. Among these is the hypothesis of a heterogeneous population of *B. inops*. It is possible that the sponge population consists of sponges that are able to thrive in both internal cave and exposed conditions, as opposed to sponges adapted exclusively to the exposed boulder conditions. Another interesting finding was that the population of *B. inops* that was studied harbored photosynthetic symbionts. Individual sponges exhibited photosynthetic activity two months after being transferred from the illuminated exposed boulder surfaces into the dimly-lit cave, indicating that the symbionts remained active within

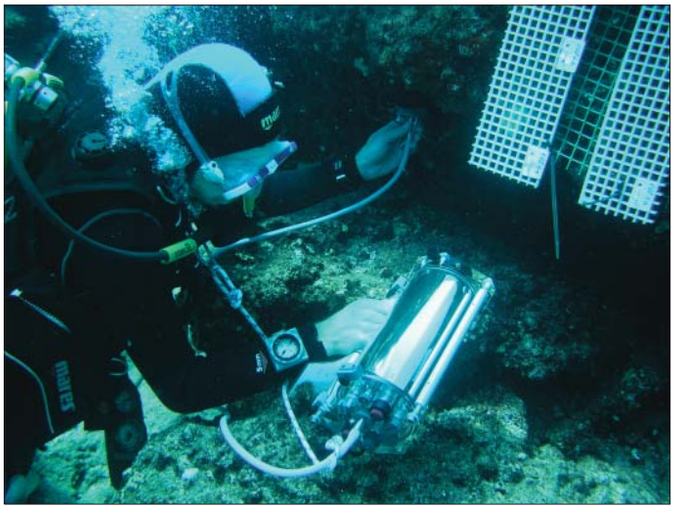

Fig. 2. The activity of photosynthetic sponge symbionts being estimated in situ by PAM fluorometry (Walz, Germany. Photo: P. Nemoy)

the sponges. These results suggest that the irradiance inside the cave, although very low, was sufficient to maintain the photosynthetic activity of the sponge symbionts (Fig. 2).

Though the effects of irradiance and water motion on *B. inops* could not be separated, this work offered new insight into the ecology of this still poorly known species. These findings call for further investigation, such as:

* Field experiments involving separation of factors (e.g. exclusion experiments) should be performed in order to reveal the separate influences of irradiance and water motion on sponge distribution. In addition, laboratory experiments under controlled conditions of irradiance and hydrodynamics should be performed in order to corroborate the field data.
* Controlled experiments should be performed in order to reveal the possible effects of biotic factors, such as grazing or intra – or inter-specific interactions on the distribution of *B. inops*.
* The nature and the role of photosynthetic, as well as other symbionts of *B. inops*, should be elucidated.
* The existence of different morphotypes of the sponge, which are adapted to different environments, should be investigated.

The data generated in this study may be applicable to sponge aquaculture – a lucrative field in light of the large number of bioactive chemicals that are produced by sponges and used in the biomedical industry.

Philip Nemoy (M.A.)
Advisors: Drs. D. Angel and N. Kashtan

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(Photo: Y. Bachar)

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Publications

The Harbor of Sebastos (Caesarea Maritima) in its Roman Mediterranean Context

Avner Raban

Artzy, M., Goodman, B., Gal, Z., (eds.)
BAR International Series 1930, 2009, 222p.

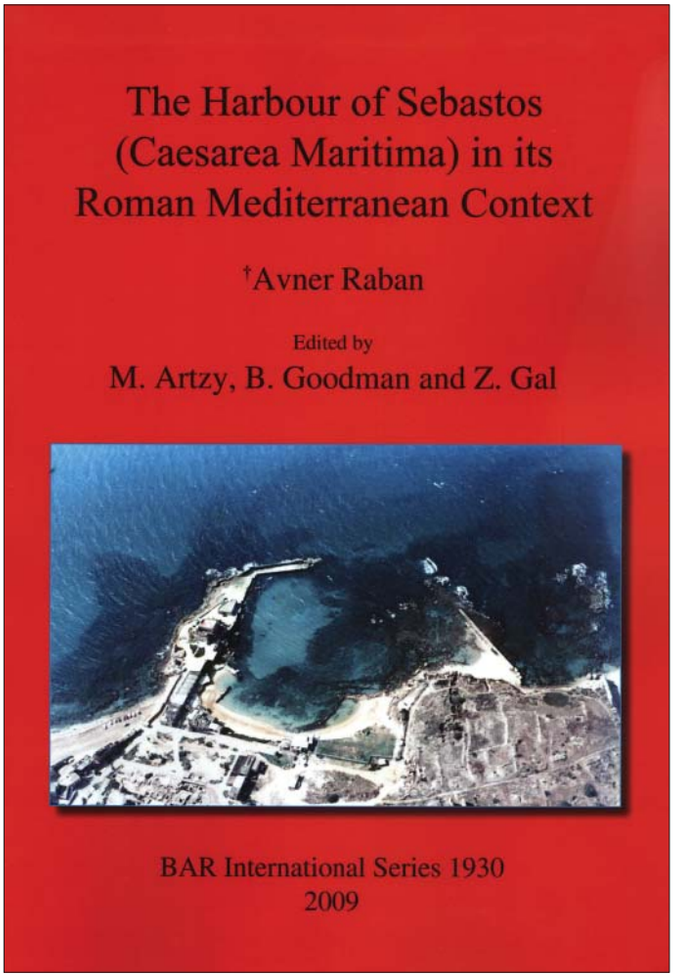
In the fall of 2003, following summer underwater excavations at the harbor of Sebastos (Caesarea Maritima) and the harbor of Clazomenae/Liman Tepe, Turkey, Prof. Avner Raban started a sabbatical year in Oxford. He chose Wolfson College and Oxford University for its proximity to what he considered to be the best libraries. His main task was to prepare a manuscript on Caesarea, not necessarily a technical book on the excavations of Caesarea Maritima, the largest and most demanding project he had ever undertaken in his professional career, but more of a personal study. This was to be a more general overview of Herod's harbor in Caesarea within the Mediterranean context of the Roman period, addressing questions as to why Herod decided to build the harbor there, why he wished it to be so large a harbor (which was no doubt a major financial burden during its construction), how it was built, the technology, the materials, the concept, how all this was achieved, and how the harbor fit within the context of the periods in which it functioned.

Avner's dream of a more general book on the harbor, in context of the Mediterranean world, did not materialize during his lifetime. He passed away very suddenly on the 11th of February, 2004 in London. A partially completed draft of a manuscript was found among his files. The draft arrived with the hard disk of the computer he used, and a copy of it was given to me.

Avner's draft manuscript needed more work than I had anticipated when I first volunteered, along with others, to oversee its preparation for publication. Several sections were very much in preliminary less-than-draft form. After some initial uncertainty as to how to approach the publication, I decided that the chapters Avner had envisioned would be retained and no others were to be added.

As is, the manuscript contained a wealth of material both on the harbor of Caesarea itself as well as its context in comparison to other Mediterranean harbors, especially in the Roman period. I retained his ideas as they had been expressed, although at times I had to put some order into his musings, which I am sure would have been rectified had he prepared the book for publication himself. The bibliography was problematic since Avner was very well read and had visited many libraries but didn't always supply clear bibliographical citing. I could not revisit these libraries and if there are still inconsistencies, I ask the reader to be forgiving. I did my best to find all the right articles and books. It was not always easy to understand what Avner meant in his writing. I tried to keep Avner's ideas intact as I attempted, I hope successfully, to make them understandable and approachable. I hope this did not hamper his personal style, which should still be evident in the final version of the manuscript.

My own background in coastal and anchorage sites, especially those from the second and early first Millennia BCE along the Carmel coast, did not quite prepare me for dealing with Roman harbors, but being in the same academic department and institute and sharing field experiences with Avner, encouraged me to undertake this project as a tribute to him.



Unfortunately, Avner did not live to dedicate this manuscript. Yet I am sure that his wife Dina, his children, Rowee, Smadar, Haggai and Ido, their spouses, his grandchildren and his beloved kibbutz, Ramat David in the Jezreel Valley, were all on his mind when he listened to Classical music, a constant companion, as he worked in Oxford on the unfinished draft of Sebastos, Caesarea Maritima and his beloved Mediterranean.

The Leon Recanati Institute took upon itself to continue the scientific publication of one of Avner's extensive land excavations, namely, the important inner harbor of Caesarea Maritima (Area 'I').

Aknowledgements:
The publication of the book was made possible by the Sir Maurice and Lady Irene Hatter Laboratory, which I head, as well as some private donations; the Rector of the University of Haifa, Prof. Yossi Ben-Artzi, a friend of Avner's, and the Faculty of Humanities. Thanks are due to Zvi Gal and Beverly Goodman for their great help with the editing; Chris Brandon who prepared the figures and helped with the illustrations; Michal Oren-Paskal who helped with the figures and bibliography; Svetlana Zagorski and Noga Yoselevich – graphics, settings and preparation for print; Nira Karmon, Yossi Tur-Caspa, Rachel Pollak, Shalom Yanklevitz, John Oleson, Bob Hohlfelder, Ken Holum, Joe Boyce, and others who helped with the figures.

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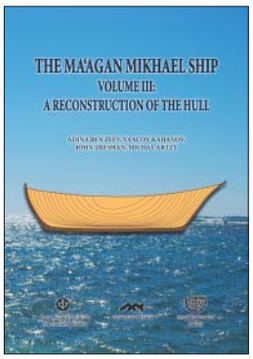

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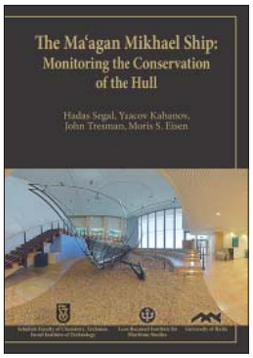

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