In 2003, we made an exciting discovery during our excavations of an ancient harbor at Caesarea, Israel; shell and sediment deposits from an ancient tsunami. The harbor was built by Herod the Great at the end of the 1st c. BC. I had been conducting research since 1990 trying to determine what destroyed the ancient harbor and in 2003 we finally discovered part of the answer. Our collaborative research team, led by the late Dr. Avner Raban from the University of Haifa, and myself from McMaster University found the shell and sediment deposits. Radiocarbon dating and artifacts from the deposits indicated that the tsunami struck sometime in the 1st-2nd c. AD. We believe it was recorded in Talmudic sources (Shalem 1956) since it reports a tsunami striking the shore on December 13, 115 C.E. The force of the tsunami impacted Caesarea and Yavne, and its impact...
reached as far as Rome. An earthquake that destroyed Antioch (in modern Syria) probably triggered the tsunami which in turn affected the structural integrity of the harbor. At least, this was our working hypothesis, and the findings from this year have supported our theory.

At completion, two thousand years ago, the ancient harbor at Caesarea Maritima, on the Mediterranean coast of Israel, was a key center for maritime shipping; it is now an important submerged archaeological site. In 21 B.C., King Herod the Great, ruler of Judea, built an all-weather harbor at Caesarea, with a harbor structure that was a unique engineering feat for its time. The harbor breakwaters were built out from the coastline to the open sea, using a combination of hydraulic concrete and sandstone ashlars. The construction of the harbor breakwaters rapidly transformed the coastline from a high-energy beach environment to a quiet water lagoon. The harbor was completed in 10 B.C. and was described by Josephus Flavius (a Jewish historian) in A.D. 72-75.

Questions have arisen as to whether the harbor was destroyed shortly after construction, by an earthquake or was it through years of neglect and disrepair. The evidence that we uncovered indicated that the destruction was early, approximately 100 years after it was built, and much more rapid than previously thought. However, we still needed more data to isolate the size of the tsunami and its destructive force on the harbor and to confirm wave direction and its association with the Antioch earthquake. In order to collect more data on the tsunami, we needed to develop a new method for coring sediments underwater.

**Project Team**

The project was launched on May 17th, 2005 when team members travelled to Israel. Our team comprised of students and individuals with whom I had worked with in the past. I began working in my first undergraduate year on the underwater excavations at Caesarea in 1990, and worked my way up to co-director. During my career, I have also directed and worked on numerous underwater and coastal geoarchaeological projects in other parts of the Mediterranean and the Middle East. The team consisted of Beverly Goodman, my Ph.D. student from McMaster who is completing her dissertation on a Bronze Age harbor at Limen Tepe, Turkey and has worked with me for many years at Caesarea; Andrei Yakovenko, one of my new MSc students who has extensive dive experience as an instructor in the Red Sea; Jeremy Gabriel, an undergraduate student at McMaster, who was the newbie on the project having obtained his SCUBA certification just prior to coming on the expedition; Hendrik Dey, a PhD student at University of Michigan in Classical Archaeology, who also
worked on the project at Limen Tepe; and Andrew Lacovara, a friend since 1994, and a commercial diver with Stearns Engineering, who worked with me on many projects in the past decade. Andrew is the member that introduced and sponsored me into the Explorers Club in 2004. We were joined by our benefactor (who prefers to remain anonymous) who provided much of the funding for the project and has also worked with me at Caesarea since 1990. McMaster University provided funding for equipment.

Technical support was provided by the well-accomplished and professional team from the University of Haifa Marine Workshop directed by Steve Breitstein and assisted by Amir Yurman, who have decades of experience working underwater on archaeological as well as biological projects in the Mediterranean and the Red Sea. The project would not have been possible without the help of my collaborators, Professors Yossi Mart and Michal Artzy from the University of Haifa. Yossi Mart secured the use of the R/V Mediterranean Explorer from the Eco-Ocean Foundation and provided research funding and Michal Artzy obtained the necessary archaeological permits for the project.

The Eco-Ocean Foundation is an environmental non-profit organization (NPO) in Israel launched by Andreas Weil. The ultimate goal of Eco-Ocean is to generate and maintain a healthy marine environment in the Eastern Mediterranean and parts of the Red Sea and Western Indian Ocean. Eco-Ocean's 21 m research vessel (R/V) Mediterranean Explorer (Med Explorer), was brought to Israel in August, 2004 and is equipped for marine research, with wet and dry labs, and an aft deck working area with crane and winches. The boat can accommodate 11 people including researchers and crew. The vessel is also outfitted for diving with an onboard compressor and air-bank. The crew of the Med Explorer Danny Shaffer (Skipper) and Etai Katzman (Chief) provided extensive experience and expertise for the expedition.

The Research

With the team assembled in Israel on Tuesday May 17th, I along with Jeremy and Andrei began assembling and testing the coring equipment for the project. Beverly was already in Israel enjoying a Fulbright Scholarship for studies at the University of Haifa. The following two days were spent purchasing, and then fitting, all the components of the coring equipment at the marine workshop located at the National Maritime Museum in Haifa. We worked very closely with Steve and Amir to develop the coring methodology for the project. There were many components to the equipment from the air-bank which powered the pneumatic hammer to drive the cores, to lift bags which pulled the cores out of the sediment, and scuba equipment to get us to the seabed. We needed to purchase hoses and specialized pieces of equipment needed to be made. The coring methodology that we were developing drew upon collective years...
of coring experience and work underwater. The success of the coring methodology was the basis for the whole project; if it didn’t work we faced total failure of the project. I had anticipated that it would take time to develop the corer and plans as we envisioned on paper would not work with the first attempt. Trying to develop a new piece of equipment without field testing is risky, there are always problems that you never anticipate that can foil any well-conceived plan. Add water and you double the frustration. We had hoped to test the coring apparatus before we left, but due to delays in obtaining the necessary parts, we were not able to test the corer before the project.

Another aspect of the project was the diving, which allowed us to take the sediment cores underwater. Recreational scuba diving on warm water Caribbean reefs is often a pleasurable experience. However, conducting research underwater is an entirely different endeavor. One needs a well-conceived plan before entering the water, anticipating all contingencies, or the operation can quickly turn into chaos. Not only did we have to consider the safe operation of scuba equipment and life-support system, but we needed to accomplish complex tasks underwater. The dive team must be well-trained, since communication with hand-signals is often difficult and everyone must know exactly what needs to be accomplished and how. Attempting a new method, like underwater coring, added another dimension of stress; you can conduct dry-land training, however, it can never replicate the underwater realm. We also had to contend with the element of time; we can’t stay underwater forever, and tasks need to be completed efficiently and quickly. If you stay too long at depth you will need to decompress. Most of the diving would be at depths that would not require decompression, and we used Nitrox, a gas with variable amounts of oxygen and nitrogen to extend our stay on the bottom. However, in the deepest coring location at 100ft, the required bottom times would necessitate some decompression. Decompression adds another element of risk to working underwater; we couldn’t simply surface if we had a problem, we needed to solve our problems underwater and gradually surface to avoid getting bent. So, careful planning was required; one needed to know the quantity and type of gas to breath during the dive, the amount of reserve in case of difficulty, and on the deep dives, we needed to carry back-up systems. So, I knew the team members level of dive training and their limitations and planned accordingly.

Once we had all the gear assembled for loading on the Sunday, we spent the weekend testing scuba gear and picking up our last two team members Hendrik and Andrew from the airport. The Monday was spent loading and stowing the equipment on the R/V Med Explorer.

The next day we were finally ready to start; that snowy February day in Hamilton when I sketched the plan for the corer seemed far away, as I gently rolled on the waves on the Med Explorer off Caesarea. Finally, after all my careful planning, everything was coming together and I was eager to start. We spent the morning getting the coring equipment ready for testing; everyone was briefed on the approach and in the afternoon we set off to test the corer. Unfortunately, what followed was a week of trial and error, with more error than I had anticipated.
The first problem was the weather. I had anticipated that the end of May and early June would be a perfect time for the project. In the past 13 years of experience at Caesarea, this was a time where we could expect a higher probability of having calm conditions. However, this year, the temperatures were unseasonable cool and windy. This made our life on the surface difficult, and in the shallow areas wave surge gave us trouble.

But on that first day the weather was the least of our worries, the coring apparatus as carefully designed on paper just didn’t work. We couldn’t get enough penetration with the pneumatic hammer and trying to hold the corer upright underwater wasn’t possible. So back we went to the harbor, and our the way, we devised some modifications which we began working on right away.

For the next two days we modified and improved the coring system which began to function as planned. However, once it was working and we were successfully coring at 50ft water depth, a major equipment failure occurred. When things go bad, there is always something to blame on an underwater project. If it isn’t the equipment, it’s the weather.... We had moved forward, but slowly, and we were running out of time.

The failure occurred with the chisel that connected the pneumatic hammer to the core tube. The hammer and chisel were designed for construction and breaking pavement, and not for taking sediment cores underwater. However, we were adapting it for our purposes by designing a coupler to join the chisel to the end of our aluminum core tubes. The force of the hammer on the core tube would pound it into the sediment; which we would later pull out with lift bags. However, we did not anticipate that the hardened-steel chisel would fail at the junction with the coupling due to the force of hammering. Luckily, there was enough chisel left to use it again, and we managed to find a local machine shop to fix the problem. We made some minor modifications to our coupling, and we were back to work. But the part didn’t last long, our modification didn’t solve the problem, and the chisel broke again. Now the big problem, there wasn’t enough chisel to use it again, and a new chisel was not available in Israel. Luckily, I had ordered two chisels, but unluckily I had left one behind in Canada. I remember telling Andrei my student. “We won’t need this” and tossed it on a shelf while packing.

I placed a phone call to Charlene, my assistant at McMaster University, described the chisel, and where it was in my laboratory, and requested an overnight FEDEX to the research vessel. The chisel arrived and on Sunday, with one week left, we now needed to fabricate a new adaptor. Again, we modified the design to try and solve the problem. We returned to the machinist, sheepishly with broken chisel and adaptor in hand and begged for help. Some loud discussions in Hebrew, some shrugging of shoulders, and we got an estimate for sometime the next day. The next day came and went without
the adaptor being finished; we were a small job at the end of a long list. By now, the expedition members became worried that the coring device would never work, training, money, expertise - all would be in vain.

With only a few days left, the machine shop came through; the adaptor was finished! We quickly finished the core that we started at 50ft water depth and got close to 10ft of penetration into the sand; everything worked flawlessly and it looked as if we had solved the problem. We had two days left, with a core a day that would give us three. Still not bad, I thought, if everything continued to work.... We tried at 100ft water depth, got medium penetration because of the substrate, then tried at 70 ft and got a 7ft core. In the end, we recovered two great cores; but not the 10-15 cores that I had envisioned at the beginning of the project.

Cutting the cores open on the last day was probably the most exciting. For the two-weeks we had been focussed on obtaining the cores, but now I hoped they would contain the data that I needed. Opening the cores released the pent-up frustration of the previous weeks. We found tsunami deposits similar to those we had found near the harbor; so we now knew the tsunami affected the seabed at least 3000 ft from shore. We were also able to get a direction of the wave from the orientation of the shells in the tsunami deposit, which indicated the wave likely came from a W-NW direction fitting with the description of the ancient earthquake at Antioch.

The most important discoveries will be made from further analyses in the controlled environment of the laboratory. The fieldwork is always the tip of the iceberg, and even if it can be frustrating, the memories of the fieldwork carry us through to the next project. Waiting until next year will be difficult, and although we have moved forward, we will no doubt face new challenges in our quest to understand more about Herod’s Harbor at Caesarea.

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