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Underwater Paleontology: Recovery of a Prehistoric Whale Mandible Offshore Georgia

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Abstract

During the fall of 2006, scientific divers from University of Georgia, Athens (UGA) and the National Oceanic and Atmospheric Administration (NOAA) were conducting a reconnaissance dive at JY reef approximately 20 nautical miles offshore Georgia. During this dive, a large subfossil bone was discovered partially embedded in the reef. On subsequent dives, loose sand was removed from around the bone and a small section was recovered. This bone fragment was carbon dated to approximately 36,000 years before present. However, since the bone was determined to be much larger than originally thought; not readily recoverable; and would require extensive excavation, a bottom disturbing permit was required. After approximately one year of discussions with multiple state and federal agencies, the United States Army Corps of Engineers issued a permit for excavation. Excavation began in the summer of 2008 and involved cutting through fossilized shell beds before reaching softer, but hard packed silt. Divers worked diligently with hammers, chisels and knives to cut away the overburden and carefully remove the sediment immediately around the bone. After numerous dives, the bone was recovered in sections totaling approximately 1.5 m in length. The bone has been visually identified as a North Atlantic Gray whale mandible. Ongoing work including visual study and DNA extraction is being conducted to verify the species. A joint UGA and Emory University team is currently working to professionally restore the bone and prepare it for display.

Keywords: scientific diving, marine paleontology, gray whale, prehistoric, baleen whale

Introduction

Researchers from The University of Georgia, Athens (UGA) and National Oceanic and Atmospheric Administration (NOAA) have been studying the surficial geology, invertebrate and vertebrate paleontology and the effects of erosion at Gray's Reef National Marine Sanctuary (GRNMS) and nearby JY reef for several years. GRNMS is located approximately 36 km east of Sapelo Island, Georgia and is home to a vibrant live-bottom community (Figure 1). Unlike tropical carbonate reefs, Gray's Reef is composed of dolomitic sandstone outcrops with upward relief of 2 to 3 m (Hunt, 1974). This geologic structure has been determined to be approximately 2 to 3 million years before present (ybp) (Huddleston, 1988). Considerable attention was brought to Gray's Reef during the 1960s and 1970s as the extent of the live-bottom habitat was documented. It was the realization that Gray's Reef was such a unique marine environment that it was designated as one of NOAA's national marine sanctuaries in 1981. Since then, NOAA has been charged with protecting Gray's Reef from exploitation and abuse.

JY reef is located approximately 18 km north of GRNMS and is also a very active live-bottom community (Figure 1). Unlike the reef structure at GRNMS, JY reef is actually an ancient shell bed

mostly comprised of large, coldwater scallops (*Placopectin magellianicus)* that once thrived offshore Georgia between 32,000 and 40,000 ybp (Garrison *et al*, 2008). Structurally, the shell bed at JY reef is considerably less stable than the outcrops at GRNMS. The shell bed is lightly cemented from the seafloor down to approximately 0.3 to 0.5 m after which it is more readily eroded. Bottom currents sweeping along the reef have undercut the softer layers of the shell bed leaving the harder cemented shell bed as exposed ledges. It is not uncommon to find sections of ledges that have broken and fallen to the seafloor.

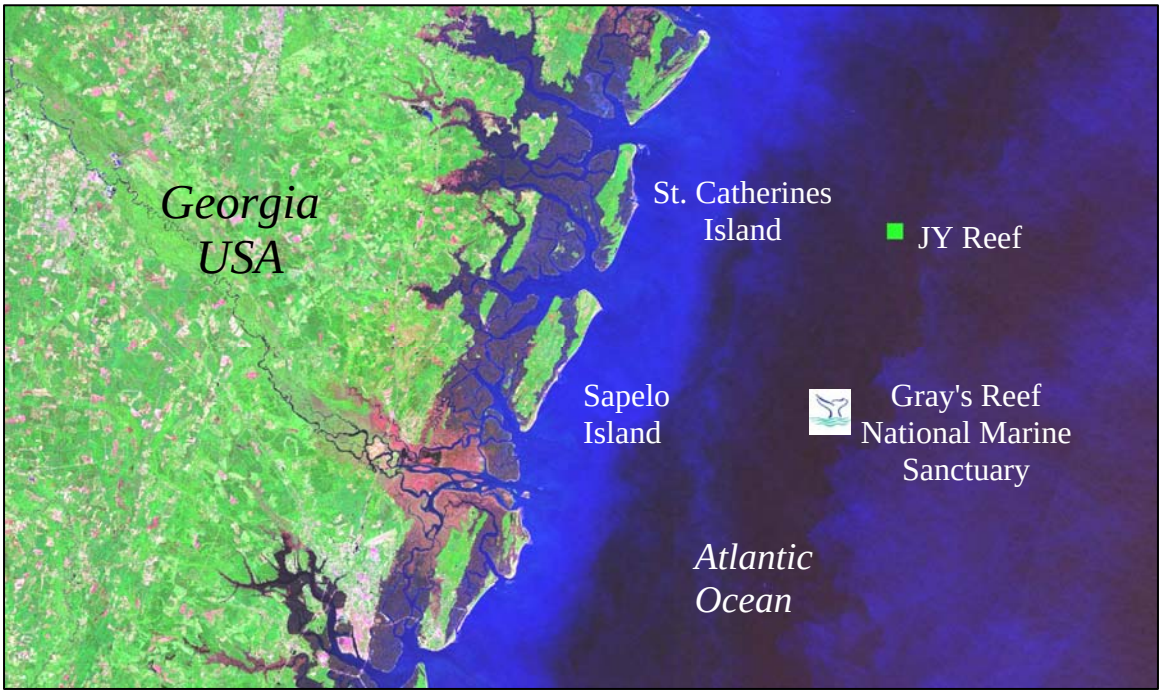

Figure 1. Study area offshore Georgia, USA

The Discovery

As a result of the erosional process, objects long buried in the reef are slowly being exposed. Over the years, small bone fragments have been recovered from JY reef, but most were not identifiable. One discovery that has been identified was a rostrum of a bottlenose dolphin (*Tursiops truncatus*). Some larger bone fragments and whale vertebrae have also been recovered from the JY reef area, but still were not readily identifiable. It was not until August 2006, that a large subfossil bone was discovered partially protruding from under a ledge at JY reef. Loose sand was swept from the bone and revealed a long, slightly curving bone mostly embedded in the compacted silt and shell. The bone appeared to continue into the reef structure, but no definite concept of the actual length could be determined. In order to evaluate the find, light excavation was performed to determine the approximate size of the bone and possible identification. As a result of this process, it was determined that the bone did extend solidly into the reef bed. Also, due to the cross-sectional view of the now partially exposed bone, it was suspected that the bone was that of a baleen whale such as the Right whale, known to frequent the reef's waters. During inspection of the bone, a small fragment was recovered and was sent to the Center for Applied Isotope Studies (CAIS) at UGA to be dated by accelerator mass spectrometry (AMS). This bone fragment was determined to be approximately 36,000 ybp. This date fit well with the dates already determined for the shell bed and also documented that the bone had been buried relatively quickly after the whale's death.

Permit and Excavation

Since it was determined that the bone would need extensive excavation into the reef bed for recovery, a permit would be required before work could continue. Multiple federal and state agencies were contacted in regard to permits. It was determined that due to the age of the bone and its state of mineralization; it no longer fell under the National Marine Fisheries (NOAA) jurisdiction. Also, the bone was too far offshore to fall under the Georgia Department of Natural Resources jurisdiction. Finally, after much debate, it was determined that the United States Army Corps of Engineers (USACE) would be the permitting agency so a permit was granted for bottom disturbing activities. By the time a permit was in hand, most of the 2007 diving season had passed so very little excavation could be accomplished. It was also determined that it would be better for the bone to remain buried during the winter months to prevent marine growth from attaching to the exposed bone and to avoid potential deterioration due to storms. The site was marked by a 1 m metal rod and the bone was recovered by loose sand.

Starting in June 2008, serious efforts were directed towards excavating the bone. Once again, divers from UGA, NOAA, Georgia Institute of Technology (GT), and Georgia Southern University (GSU) descended upon the bone site. Due to the small excavation site only two divers could effectively work without interfering with one another. However, sufficient divers were on hand to work the excavation in teams. When one dive team returned to the surface, the next team would descend to the excavation site. The digging tools were left on the bottom until the last dive of the day when they would be brought to the surface and rinsed with fresh water. Nitrox 36% gas and dive computers were used for all dives which provided added safety and shorter surface intervals. Each dive team was able to achieve 3 dives in a day for a total of 12 person-dives. A typical dive only lasted approximately 30 minutes due to heavier than normal air consumption while digging. Also, NOAA regulations required that divers leave the bottom with 1000 pounds per square inch (psi) pressure remaining in their scuba tank and that each diver return to the surface vessel with 500 psi.

The first objective towards excavation was to remove part of the overhanging ledge covering the bone (Figure 2). This was accomplished by utilizing a hand-held slide hammer equipped with a spade chisel. The slide hammer allowed divers to remove large sized sections (~30 cm diameter) of the reef at a time. Since much of the overhanging reef had live growth attached, the removed sections were carefully placed on the seafloor below the ledge next to a large reef ledge that had broken away years before. Divers continued to cut the ledge back to an existing hole near the ledge foundation. Approximately 40 dives spread out over many days were required to cut the ledge back to the foundation allowing the divers to access the buried bone. Next, the shell bed foundation had to be cut back in an area estimated where the bone would extend. This was accomplished by an assortment of hand tools including hammers, chisels, knives and small picks. Due to the cemented nature of the shell bed, the reef surface down to approximately 0.5 m required the hammer and chisel. Work was relatively slow at this point with pieces no bigger than ~5 cm diameter being removed at a time. With depth, the digging became easier and the small hand pick was carefully utilized. Once the excavation reached a level just above where the top of the bone was estimated to start, digging was limited to knives and chisels primarily used as scrapers. The divers were careful to scrape the compacted silt and shell along the side of the bone and to stop frequently to allow water clarity to improve and to inspect their progress. As the bone became exposed, it was noticed that it unexpectedly curved westward requiring more excavation of the hard reef foundation. Once the overburden for the newly projected bone position had been removed, the divers were able to carefully remove the compacted silt and shell along the length of the bone without disturbing it. In all, a total of 124 dives were logged by 9 divers to accomplish the complete excavation.

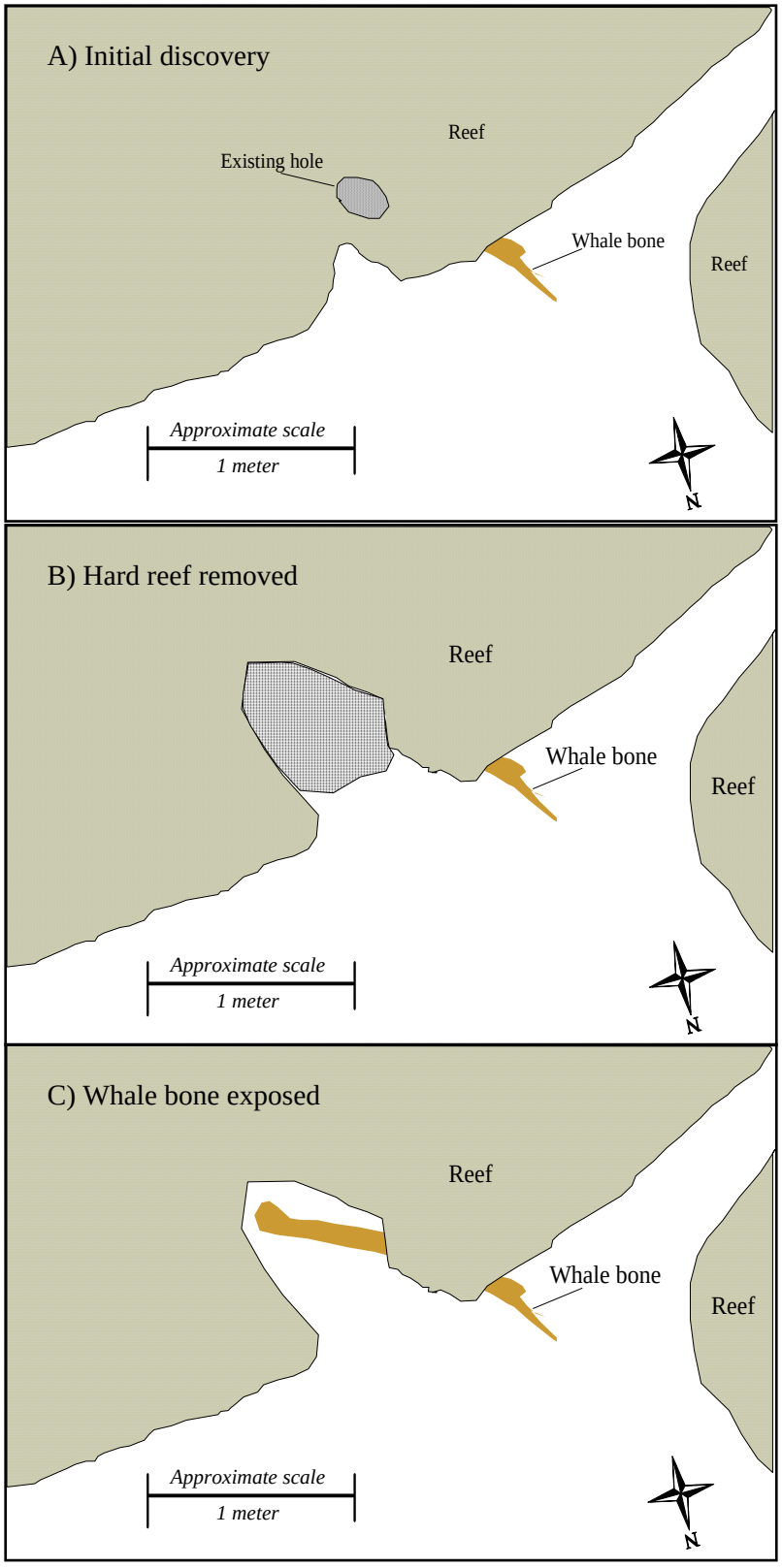

Figure 2. Excavation site showing a) initial discovery, b) hard reef removed and c) whale bone exposed.

Whale Bone Recovery, Assembly, and Identification

Once the entire bone was exposed, the original intent was to slide a board under the bone, secure it and bring it up intact. However, upon close inspection of the bone, it was determined that it had vertical fractures that divided it into roughly thirds. Between the fractures and low visibility when the bottom sediments were disturbed, the decision was made to bring the bone up in sections. It was anticipated that bringing the bone up in sections would insure the least amount of potential damage to the bone. Prior to removal, high-definition video was collected of the bone *in situ* to document its position on the seafloor and for reference upon reassembly. After filming the whale bone, each section was carefully removed and placed in a mesh bag. A line was attached to the bag and a float was inflated to send the line to the surface. Personnel on the NOAA vessel were standing by to retrieve the float and haul in the bone sections. After several dives, the entire bone was now onboard the NOAA vessel. The bone fragments were carefully packed in wood crates for transport back to Athens.

As soon as the whale bone arrived in Athens, the fragments were placed in fresh water to dissolve the chloride salt crystals from inside the bone. The fragments were soaked for approximately two months with the water periodically replaced before being removed and laid out to air dry. Once dried, the bone fragments were assembled (Figure 3). Since the bone had been well preserved and held in place by the surrounding sediment, most of the pieces had a very good fit. The recovered bone measured 1.5 m in length and weighed approximately 22 kg. It was clear that the bone was that of a baleen whale mandible, but further investigation would be required to determine the species. Pictures were taken of the mandible and sent out to cetacean experts for review.

Figure 3. Whale bone dry-fitted for identification.

The consensus was that this was a Gray whale mandible (*Eschrichtius robustus)*, extinct from the Atlantic Ocean since the seventeenth century (Mead and Mitchell, 1984). It was very fortunate that the articulating end or condyle of the mandible had been recovered. That along with the distinctive curve of the mandible was essential for a positive identification. Unlike other whales, the Gray whale feeds in shallow, very productive benthic ecosystems (Nerini, 1984). It has a unique mandible adapted to perturbating bottom sediments and then filtering the benthic organisms (Berta *et al*, 2006). Once identified as a Gray whale, the mandible was added to the Georgia Museum of Natural History collection (27372) and also listed on the Cetacean Distributional Database (STR15264).

The Gray whale has the unusual distinction of first being characterized by fossil remains in Europe (Bryant, 1995). Researchers had discovered the subfossil bones, but a living specimen was no longer found off the European coast. It was not until researchers reviewed whaler's logs that written descriptions of the Gray whale were identified. These logs described the Scrag whale which closely fit the Gray whale (Dudley, 1725). In the logs, the whalers commented that the Scrag or Gray whale was a coastal whale that had high quality oil which made it a highly prized catch (Mead and Mitchell, 1984). Also, since the Gray whale was found along the coast, shore whaling practices were employed (Sayers, 1984). This practice allowed smaller vessels from shore to catch the whales and haul them back to shore for processing.

Very few Gray whale remains have been discovered along the North American eastern coast. This discovery marks the first Gray whale remains to be discovered offshore Georgia. Previously discovered Gray whale remains ranged from New York to Florida with the oldest coming from the Chesapeake Bay, Virginia at approximately 10,000 ybp (Mead and Mitchell, 1984). Since the Georgia Gray whale mandible was dated at approximately 36,000 ybp, it is now the oldest recorded specimen found along the United States eastern coast. Older Gray whale specimens have been found in Europe, Japan, and the North American west coast dating as old as the Pliocene age (Barnes and McLeod, 1984; Hiroto *et al.*, 2006). It is anticipated that continued exploration at the discovery site will yield more Gray whale remains. Future plans call for a systematic sweep of the JY reef area looking sand-ward away from the reef outcrop. It is thought that much of the remains has most likely been eroded from the shell bed and may be scattered in the sand away from the outcrop. Limited exploratory excavation will also be attempted to determine if further remains lie beneath the shell bed.

Research in progress includes the extraction of DNA from the mandible. Samples from the mandible have been sent to McMasters University in Canada to extract DNA. Once extracted, the DNA will be sequenced with known Gray whale DNA to provide positive identification. UGA and Emory University's Carlos Museum in Atlanta, Georgia have agreed on a joint understanding that allows the museum to use the mandible as a teaching tool. In the process, the bone will undergo professional conservation and assembly by the museum's staff and student interns. The final outcome will be a quality museum piece ready for display. Upon completion, a suitable display location will be selected that will allow high visibility for this unique discovery.

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