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EX-USS KILLEN SITE INVESTIGATION AND BIOLOGICAL CHARACTERIZATION, VIEQUES ISLAND, NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

FINAL REPORT

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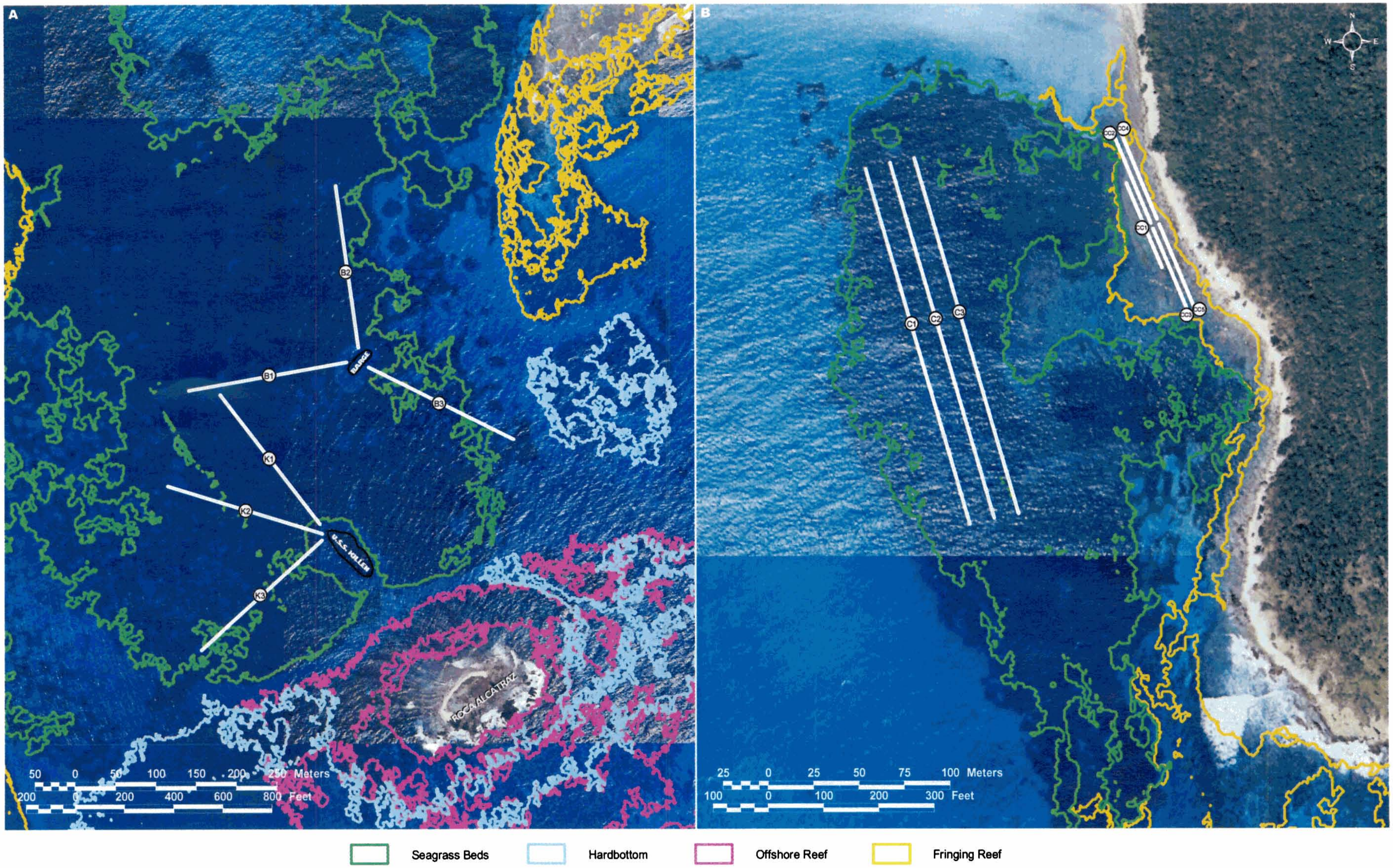

Figure 2. Transect locations in (A) area of wrecks, Bahia Salina del Sur, and (B) area of control site, Bahia Jalova

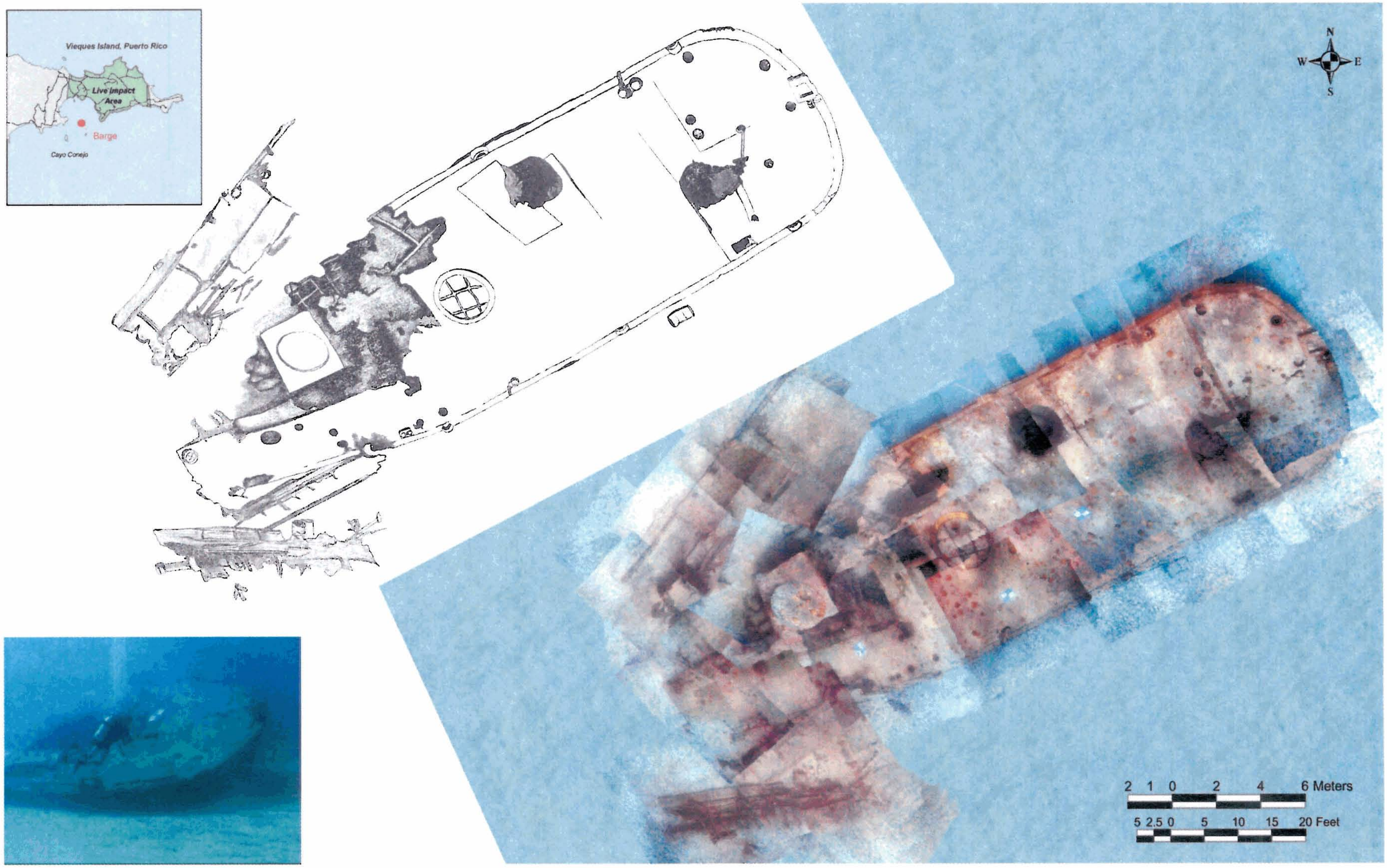

Figure 4. Sketch and photomosaic of a barge sunk as a target in Bahia Salina del Sur, Vieques Island, Puerto Rico

Figure 6. Underwater view of the barge bow (Bahía Salina del Sur, Vieques Island, Puerto Rico)

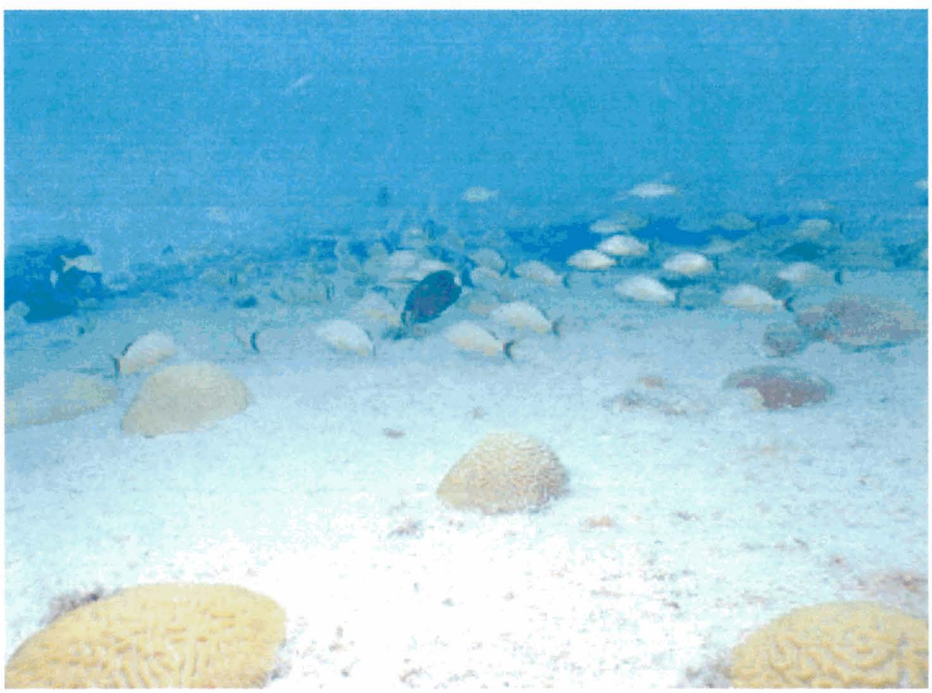

Figure 7. Corals growing on the barge deck (Bahía Salina del Sur, Vieques Island, Puerto Rico)

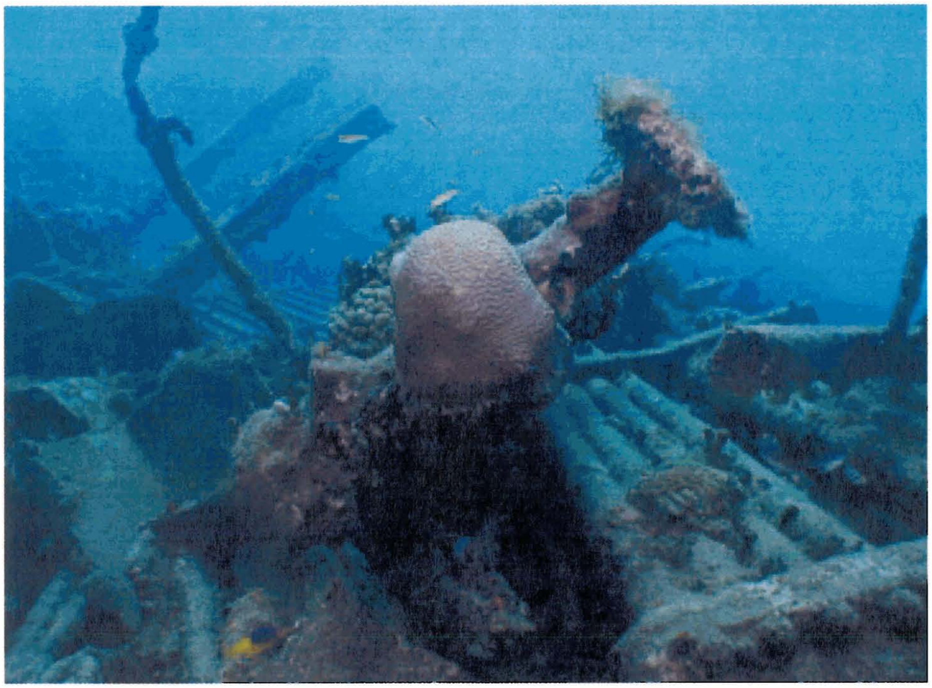

Figure 10. Coral growing on the Killen (Bahía Salina del Sur, Vieques Island, Puerto Rico)

Figure 11. Drums on the Killen (Bahía Salina del Sur, Vieques Island, Puerto Rico)

Figure 8. Drums in the barge (Bahía Salina del Sur, Vieques Island, Puerto Rico)

Figure 9. Sediment aprons surrounding the barge and the Killen (Bahía Salina del Sur, Vieques Island, Puerto Rico)

5.0 DISCUSSION

5.1 DRUMS ON THE WRECKS

A recent broad survey of metals and explosive compounds in fish and shellfish collected at the Killen and barge sites revealed that the 55-gallon drums on the Killen and the barge were and continue to be unlikely sources of contaminants on the surrounding marine biota (ATSDR 2002). No shellfish nor fish collected at the Killen site contained concentrations of metals or explosive compounds that would be a health hazard to humans consuming fish or shellfish captured either at the Killen or the barge site. As discussed below, rather than being used to store hazardous substances, the drums found on the wrecks were most likely used for target stabilization and for reserve buoyancy.

The USS-Killen was one of 175 Fletcher-class destroyers built during World War II. The current condition of the wreckage indicates that the starboard and port sides of the hull have collapsed, falling outward for most of their lengths. The hull has essentially split apart, widening the overall width of the ship. The once vertical portions of the hull have fallen outward and now lie flat on the seafloor. With an original beam of 39.7 ft (12 m), the width of the wreckage is now 71 ft (22 m). The two boilers, which in Fletcher-class destroyers are located below the main deck, are now the highest points on the wreckage above the seafloor. The bow portion of the ship has completely broken up and has collapsed inward. Large parts of the bow have split apart and have fallen or folded over in areas.

The configuration of the Killen as it now lays on the seafloor indicates that it had been modified prior to being sunk as a target. The bulk of above decks superstructure appears to have been removed. The wreckage lacks any artifacts resembling weaponry, indicating that all the ship's armament, including all five of the five-inch gun turrets and the two top-mounted torpedo launchers, had been removed. The missing superstructure includes the two smoke stacks, the conning tower and bridge structure, and all other deck housings (i.e., structures located on the main deck).

A good deal of the steel from the main deck flooring also seems to be missing. From examination of the photomosaic image of the Killen wreckage site, it appears that most of the main decking over the engine and boiler rooms was absent at the time the ship was sunk. In the top-down view of the wreckage, the components of the engineering rooms are clearly visible, and no sign of the main deck plates can be seen. Portions of the main decking from the bow area just forward of the first boiler room may have been in place at the time of sinking, but it is difficult to verify just how much was present. Pieces of decking plates can be seen scattered over the rubble at the bow.

Several components of the ship's engineering rooms (boiler and engine rooms) may also have been removed prior to the Killen's use as a target. Fletcher-class destroyers have four completely sealed engineering rooms: two boiler rooms (fire rooms) with two boilers apiece as well as two engine rooms containing the steam turbines (one per room), reduction gear units (one per room), backup diesel engine (one per ship), and other control equipment and machinery (including generators for the ship's electric power). As the photomosaic image (Figure 5)—illustrates, two boilers from the fore boiler room and both the fore and aft turbines, seem to be missing.

Considering the alterations made to the Killen prior to sinking, the presence of the 55-gallon drums could very likely have been used as ballast to redistribute the weight of the modified target ship. With the amount of superstructure, armament, and heavy engineering components that were missing from the Killen when it was sunk, the added ballast weight may have been necessary to stabilize the target vessel during towing to it's the site and during the time it was a target. The ship's fuel and water storage holds may also have been filled with seawater to provide the ballast needed for stabilization, yet additional weight may have been necessary due to the highly reduced tonnage of the modified configuration of the Killen. Removal of various engineering components may have unbalanced the ship causing it to list to one side or the other. If drums were used for ballast, they were most likely filled with sand or seawater.

A large number of the drums may have been empty and sealed to provide added buoyancy to certain compartments of the target ship. A fully intact enemy warship (which the Killen was presumably simulating) would have had the ability to tightly seal various compartments and rooms of the vessel when under attack. This prevents the ship from sinking if it were hit. Due to the degree of modification the Killen seems to have undergone prior to sinking, she may have lost the ability to securely seal off her fore, mid, and aft compartments to make them independently watertight. The added air spaces located within the sealed drums may have simulated the ability of an enemy vessel to seal off watertight compartments to slow or indefinitely delay its sinking. A slowed sinking would also have extended the Killen's usefulness as a surface target. The empty sealed drums seem to have been placed in areas of the ship where they could not get loose and float away from the sinking vessel (e.g., in the bow). The destruction of the bow and hull during or since the time of the ship's sinking has left many of these drums exposed.

The other portion of the ship that would have contained empty, buoyant drums would have been the stern section, which is currently missing from the main Killen wreck site and its location is unaccounted for at this time. Upon examination of the dimensions and physical characteristics of the Killen and other Fletcher-class destroyers, the strong possibility arose that the barge may very likely be the missing stern section of the Killen. The wreckage of the Killen as measured on the seafloor is 67 m (220 ft) in length. In contrast, the total stem to stern length of Fletcher-class destroyers is 115 m (376.5 ft). Around 48 m (156 ft) of the ship's length is missing from the wreckage at this site. The aft-most region now seen at the Killen wreck (the southeast end; Figure 5) is a portion of the aft engine room, which on Fletcher-class destroyers is around 34 m (111 ft) short of the stern end of the ship. The barge as measured on the seafloor is 37 m (120 ft) in length. The difference in lengths of the "missing section" and the barge is relatively small (3 m, 9 ft) and can be accounted for by the fact that the aft bulkhead of the Killen engine room is missing (i.e., the aft engine room is not complete) and the open end of the barge has a jagged edge, making exact measurements difficult. Many other characteristics of the barge and the stern section of a Fletcher-class destroyer match up as well, such as the measurements of the beam at the stern of the Killen and the width of the barge, the distance from the gunwale to the bottom of the hull at the stern of a Fletcher-class destroyer, as well as other elements such as distances between various deck features. Furthermore, resting along the southern side of the barge wreck is a long and cylindrical structure resembling a drive shaft, which would be unrelated to a barge. The reason for the separation of the stern from the rest of the Killen is unknown and can only be speculated upon.

5.2 SUBMERGED AQUATIC VEGETATION (SEAGRASS)

Sand aprons (halos) surrounded both the Killen and the barge. Halos of non-vegetated areas are typical around significant reef structures, be they natural or anthropogenic. Halos are natural rather than symptomatic of environmental distress. Herbivorous reef fishes typically graze on SAV located closest to the reef (shelter from predation) causing a barren area (halo in the case of this study) along a reef margin (Randall 1965). This was clearly illustrated by two patch reefs and associated halos located approximately 120 m north of the barge site.

The submerged aquatic vegetation (SAV) surrounding the wrecks did not vary in terms of species composition, frequency of occurrence, species abundance, or species density as a function of distance from the wrecks. Using *T. testudinum* (one of the two most abundant seagrasses), we verified that there were no significant differences between near-field (within 40 m of a wreck) and far-field samples (170 to 200 m away from the wreck). Further, the population characteristics (diversity, abundance, and density) of the SAV at the control site were comparable to what we found around the wrecks. Further, the SAV around the wrecks did not exhibit signs of environmental distress.

5.3 FISHES

At all three study sites (i.e., control, Killen, and barge), the results are quite clear: the coral reef, Killen wreck, and barge wreck all support a much greater diversity and abundance of reef fishes than the surrounding seagrass habitat. Coral reefs are well known for their tremendous species diversity and abundance, not only of reef fishes, but other taxa as well (e.g., invertebrates). This faunal profusion is a function of habitat complexity. Simply put, habitats of low spatial complexity (e.g., seagrass meadows) do not offer the opportunities for niche divergence that habitats of high spatial complexity (e.g., coral reefs) do. The potential for trophic and spatial partitioning is higher in habitats of greater spatial complexity.

A coral reef is one of the best examples of a natural habitat with high spatial complexity. Reef environments, however, are patchily distributed, and there are large areas in tropical regions that are not characterized by coral reefs. When an artificial reef is introduced into an area of relatively low spatial complexity, the diversity and abundance of fishes and other reef organisms increase as animals are attracted to the structure (Bohnsack et al. 1994). Artificial reefs may be deliberate (e.g., sunken concrete structures), accidental (e.g., shipwrecks), or incidental (e.g., oil rigs). The positive effect of artificial reefs on the diversity and abundance of fishes was certainly evident at the Killen and barge study sites.

5.4 CORALS

Despite the fact that the vessels were sunk in the middle of a large seagrass area, they were able to function as productive artificial reefs for coral. Hard coral density (col/m^2) and diversity on the wrecks were not statistically different from what was found at the reef control site. Nevertheless, we observed reef building coral colonies to be significantly larger at the wreck sites. The barge deck supported in excess of 300 massive coral colonies, mostly symmetrical brain corals (*D. strigosa*), grooved brain corals (*D. labyrinthiformis*), and massive starlet corals (*S. siderea*). The photomosiac of the barge clearly shows the abundance of these coral heads (Figure 4). What was not visible in the photomosaic were the ever present lesser starlet coral (*S. radians*) colonies. In addition to the mature coral colonies, there were literally thousands of juvenile corals (mostly *S. radians*) disseminated across the barge deck. The Killen wreck also contained numerous juvenile corals and hemispherical coral heads. These growth and colonization characteristics were definitely absent from the reef control site. The higher abundance of corals on the wrecks suggested that the artificial reef was a more suitable environment for successful coral recruitment and growth. Between the two wrecks, we found 18 of the 29 coral species known to occur at the eastern end of Vieques Island (NSRR 2002). We did not witness obvious signs of massive bleaching, abundant coral diseases, or physical destruction at either study site. Further, there was no evidence of any recent impacts on the wrecks and their coral biota that would have been caused by inner range activities (e.g., physical impacts or ordnance).

Sedimentation, algal cover, and type of substrate all influence the success hard corals have in colonizing a substrate (Bagget and Bright 1985; Sorokin 1995). Compared to the control fringing reef site, the wrecks were advantageous in many ways to hard corals. The wrecks allowed hard corals to settle on three-dimensional substrates well removed from sedimentation by coarse or fine sediments of the bay. Furthermore, the complexity of the Killen wreck in particular offered a tremendous number of locations and total hard substrate area for hard corals to colonize. The higher abundance of fishes (many of which were grazers) on the wrecks than the control site explained in part the lower algal cover on the wrecks. The active grazing of algae by fishes adds to the competitive success of hard corals competing for colonization space. Grazers also impact coral recruits and adult coral colonies. Yet, despite the potentially negative impacts of reef fishes on hard corals, the wrecks (particularly the barge) have supported significant coral growth over time (approximately 30 years since the sinking of the wrecks). Interestingly, flat surfaces of the wrecks (the barge deck and remains of the Killen bow deck) and not the more contorted or perhaps protected parts of the wrecks supported the most impressive coral formations. This went against the accepted notion that coral recruits will develop on the underside of recruitment plates (e.g., terra cotta plates or quarry tiles) and in areas protected from predators (Bagget and Bright 1985; Gleason 1999). One other possible advantage of the three-dimensionality of the wrecks was a local increase of oxygenation induced by the wrecks, acting as barriers to water circulation. As we conducted our work on the wrecks we noted perceptible changes in water current speed in areas where large structures obstructed and consequently accelerated water transport at their edges; the accelerated transport possibly oxygenated the water locally.

The wrecks supported coral populations similar to the reef control site. We accept the null hypothesis that the biota on the wrecks, when compared to the surrounding habitat, was no different than what would be seen in a natural environment. Therefore the analyses of the coral data showed that the wrecks and their contents did not have negative impacts on the coral reef ecosystems developing on the wrecks. Rather, the wrecks acted as productive artificial reef habitats.

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