**An abundant sand-flat meadow of *Halimeda lacrimosa* M.Howe off Bermuda, a species previously unknown in the island flora**

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The wreck of the former 1st Bermuda Volunteer Rifle Corps (B.V.R.C.) WWI troop transport vessel *Louise* (Fig. 1A) was discovered in 2014 at a depth of 14-15 m a quarter mile off Fort St. Catherine's on St. George's I., Bermuda (Fig. 1B; 32˚23'43.08"N, 64˚42'21.60"W). After decommissioning from the B.V.R.C., the *Louise* was used privately as a lighting vessel and then as a watering ship in Bermuda before taking on water and sinking offshore in Murray's Anchorage (Figs 1B, 1C) probably at some time in the 1930s (Teddy Tucker, pers. comm. 2014). The *Louise* lies just shoreward of the Narrows shipping channel on the north coast that runs between St. George's, the Dockyard on Ireland I. North and Hamilton Harbour on Bermuda I. (Fig. 1B). The discovery of the wreck brought us (CF, PR) to its resting place in September 2015 where a meadow of *Halimeda lacrimosa* M.Howe, *Caulerpa mexicana* Sonder *ex* Kützing and *Udotea flabellum* (J.Ellis & Solander) J.V.Lamouroux was discovered surrounding the sunken vessel (Fig. 1D, IE). We revisited the site in August 2016 to ensure that *H. lacrimosa* was still present and to confirm its relative abundance in the area surrounding the *Louise*. Interestingly, although there are four species of the genus *Halimeda* known abundantly in shallow and deep waters surrounding the islands [*H. discoidea* Decaisne, *H. incrassata* (J.Ellis) J.V.Lamouroux, *H. monile* (J.Ellis & Solander) J.V.Lamouroux and *H tuna* (J.Ellis & Solander) J.V.Lamouroux], *H. lacrimosa* had never been collected in Bermuda prior to now. Three other species of *Halimeda* [*H. opuntia* (Linnaeus) J.V.Lamouroux, *H. scabra* M.Howe and *H. simulans* M.Howe] were reported as members of the local flora in the past (Schneider 2003) but likely are misidentifications of the above species as recent collections and observations on historical vouchers have failed to verify these records.

When Howe (1909) described *Halimeda lacrimosa* in the Bahamas from the shallow subtidal to depths of 20 m, he stated that depth "perhaps accounts for the rarity with which it has been collected." The turn of the 20th century was a time when collectors relied on dredging and storm drift to provide specimens from beyond shallow waters. Its habit as a species impregnated with calcium carbonate composed of globose to tear-shaped (lacrimiform, obovoid) segments forming its branched axes (Fig. 1E) would seem to preclude this species from casual drifting any distance from the sand-flat habitats where its fibrous holdfasts are embedded in calcareous sediments. In her world monograph of the genus *Halimeda*, Hillis (1959) described the distribution of *H. lacrimosa* as Florida, the Greater Antilles and Bahamas and noted that the "restricted distribution of this species may be partly accounted for by the ease with which such small specimens are overlooked." She echoed Howe (1909) when mentioning that this species "commonly occur[s] in relatively deep water where it is more difficult to make representative collections" (Hillis, 1959). Most recently, Littler & Littler (2000) noted that the nominate variety of this species was found in depths to 61 m in their marine flora of the Caribbean. The newly collected specimens perfectly fit the description of the overall morphology and microscopic anatomy of *H. lacrimosa* (Howe, 1909; Hillis, 1959; Taylor, 1960; Hillis-Colinvaux, 1980).

*Halimeda lacrimosa* would appear to be a species unlikely to have been recently introduced to Bermuda. Globose and tear-shaped segments shed from this species (Fig. 1F) are found several inches deep in the calcareous sediments that lie in the sand flat surrounding the *Louise* suggesting that this species may have been living here for a significant period of time. Furthermore, as this species is currently known only in lower latitudes of the western Atlantic at a minimal distance of

ca. 1100 km from the nearest island in the Bahamian archipelago (Britton, 1918) and mostly is collected in deeper waters, it would seem equally unlikely that it would inadvertently be picked up in ballast water of modern ocean-going vessels. Container and cruise ships generally arrive in Bermuda from the east coast of the US and not from southern waters where *H. lacrimosa* is known to occur. Over geologic time, *H. lacrimosa* could have been entangled with pelagic *Sargassum* in the Greater Antilles during storm activity and then distributed north to Bermuda via the Gulf Stream. Alternatively, and probably less likely, it could have been brought north inadvertently at some time from the 1700s to the early 1900s when there was a brisk commercial trade between Bermuda and the Caribbean by tall ships using a ballast of rocks collected from near-shore environments. In any case, we speculate that *H. lacrimosa* has been present historically in Bermuda, until now remaining undetected by earlier collectors due to its current location and depth as well as this species' unsuitability for inshore drift. Calcareous sediments comprise a sprawling sand flat in the Bermudian atoll lagoon on the north coast called Murray's Anchorage, and the *Louise* is found immediately shoreward of the Narrows Channel (Fig. 1B) where the North and South Channels diverge. Prior to the discovery of the *Louise*, there would have been little reason for recreational divers or marine biologists to visit the disturbed habitat where it was recently discovered. Here, the water is murky due to sediment kicked up by large ocean-going vessels (Fig. 1C) and the current is extremely challenging, running against itself at different depths at the same time.

Until now, this sand flat in this area would have looked like thousands of other hectares in the lagoon where the sediment is so deep that hard-bottom areas are not exposed, unable to form isolated patch reefs commonly found closer to the outer atoll and to the west in the lagoon (Garrett *et al*., 1971). By virtue of their greater biotic diversity, patch reefs would more often have been visited by diver collectors than the sand-covered lagoonal habitats. The first author has collected on patch reefs in the atoll lagoon over the past quarter century, but never on sand flats within Murray's Anchorage in a search for siphonous green algae growing on the sediment as these would presumably have been similar to those found readily in shallower locations around the islands. In effect then, the discovery of the *Louise* has led to the detection of a species unknown in Bermuda, a species important in contributing to the surrounding calcareous sediment.

The recent collections of this *Halimeda lacrimosa* in Bermuda represent a new northern extension of the distribution for this subtropical western Atlantic species previously known only from the areas outlined by Hillis (1959) mentioned above. This is the second species of *Halimeda* newly reported in Bermuda since the first author began floristic work in the islands more than three decades ago. *Halimeda discoidea* Decaisne, a species with relatively large segments, was first discovered in 2005 in a shallow, protected bay area off St. David's Island (Schneider & Lane, 2007). Perhaps this species represents a recent introduction to the islands based upon its relative abundance in Dolly's and Cocoa Bays, as previous workers (Taylor & Bernatowicz, 1969) had collected in these environments but failed to uncover this presently obvious species (Schneider & Lane, 2007). It is a *Halimeda* with large, broad plates and an overall large size (to 23 cm tall) that would be difficult to overlook but could have been present in much less abundance in the mid-20$^{th}$ century and only recently has become an abundant life form in the Smith Sound region off St. David's Is. We have noted that *H. discoidea* has, since its first discovery, spread into St. George's Harbour in the area of the Town Cut Channel, but has yet to be collected on the outer coast. The newly discovered *H. lacrimosa* appears to be limited to deep water in Bermuda as local habitats have been heavily collected for marine algae over the past 150 years (Schneider 2003) and it has never been found in shallower waters.

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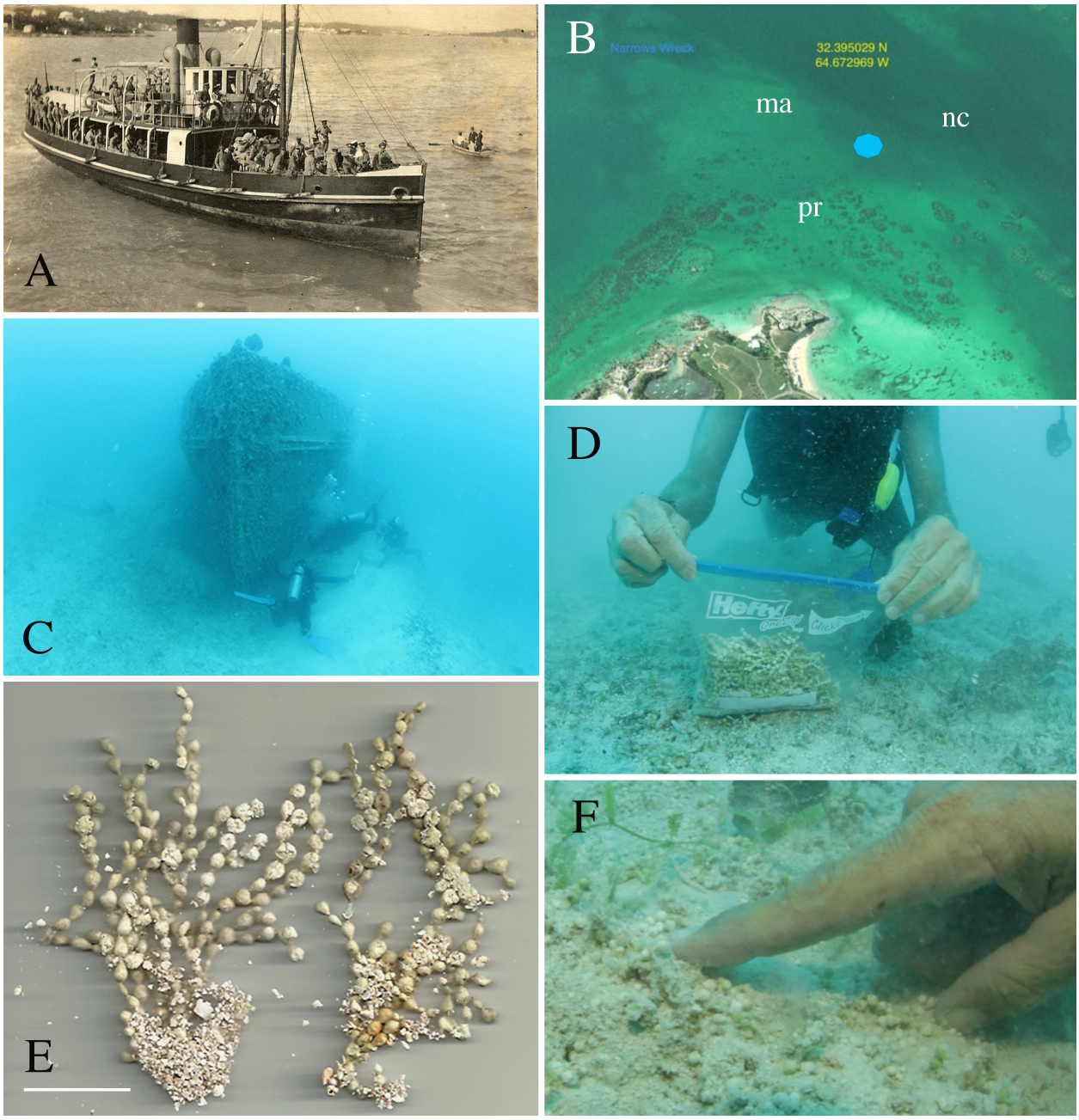


Fig. 1A. The *Louise* carrying 1st Bermuda Volunteer Rifle Corps WWI troops in Bermuda, May 1915 (from the Teddy Tucker Collection). Fig. 1B. Location of the wreck of the *Louise* (blue dot) off Ft. St Catherine's inside the Narrows Channel (nc) to the north of shallow water patch reefs (pr) and surrounded by Murray's Anchorage (ma). Fig. 1C. Bow of the *Louise* at Murray's Anchorage. Fig. 1D. *Halimeda lacrimosa* M.Howe from sand-flat area. Fig. 1E. *Halimeda lacrimosa*, scale bar = 3 cm. Fig. 1F. Detached segments of *Halimeda lacrimosa* on sediment surface. Underwater photographs: P. Rouja.