Research Note

A prediction held true: first record of the non-indigenous Thrush Cowrie *Naria turdus* (Lamarck, 1810) (Gastropoda: Cypraeidae) in South Florida

The non-indigenous thrush cowrie *Naria turdus* (Lamarck, 1810), with its natural range in the eastern Indian Ocean and the Red Sea, apparently appeared in the greater Caribbean region in 2020. First records seemingly come from the island of Aruba where Mr. Leo Ros of the Aruba Shell Club photographed a living specimen of *N. turdus* in July of 2020 (Dekkers and Ros, 2022). Observations on Aruba were confirmed by A. Oleinik in September of 2021 (Oleinik, 2023). *Naria turdus* was recorded off Puerto Rico in 2021 (L. Ros, personal communication) and off Curaçao in 2022 (Dekkers and Ros, 2022). Next, live *N. turdus* specimens were photographed in shallow water near the island of Bonaire by Phil Gilette in April and by Ellen Muller in May of 2022 (Figure 1).

The occurrence of *Naria turdus* in the Caribbean was cursorily discussed by Leal (2022), who included occurrences from Venezuela and Costa Rica cited in iNaturalist (exact dates unknown) (https://inaturalist.ca/taxa/747581-Naria-turdus), who inquired: "The Thrush Cowrie's history of invasions and apparent adaptability makes one wonder where will it show up next." Oleinik (2023) provided details of the introduction of this non-indigenous species to the island of Aruba with discussion of the potential ways of the introduction. Dekkers and Ros (2022) compared the success of invasion of *N. turdus* to the Dutch West Indies with the success of the lionfish introduction to the Western Atlantic.

All three references outline the invasive success of the species in the Caribbean and suggested that we can expect *Naria turdus* to appear in Florida's coastal waters

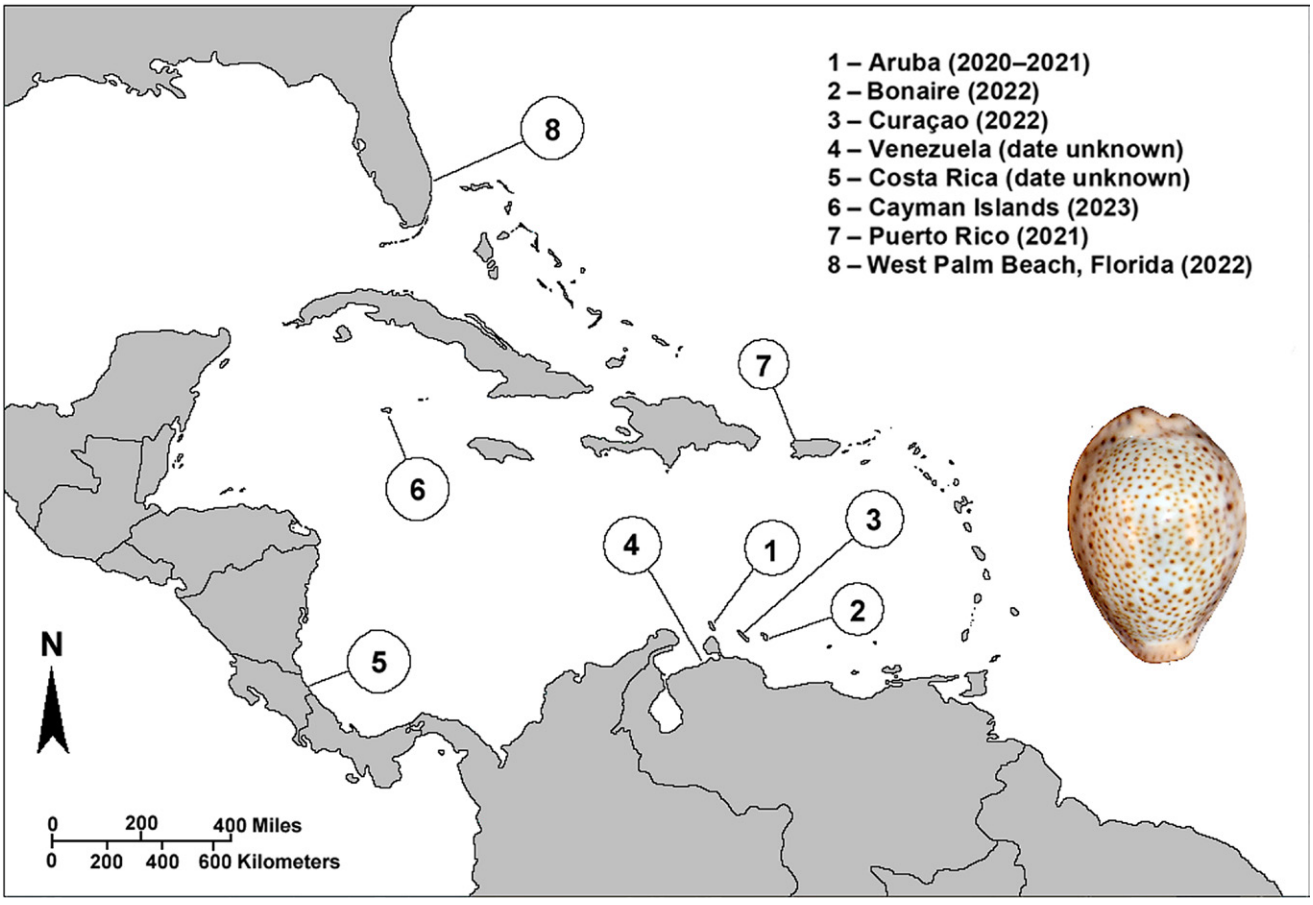

Figure 1. Known distribution of *Naria turdus* in the Western Atlantic and the year it was recorded in each locality.

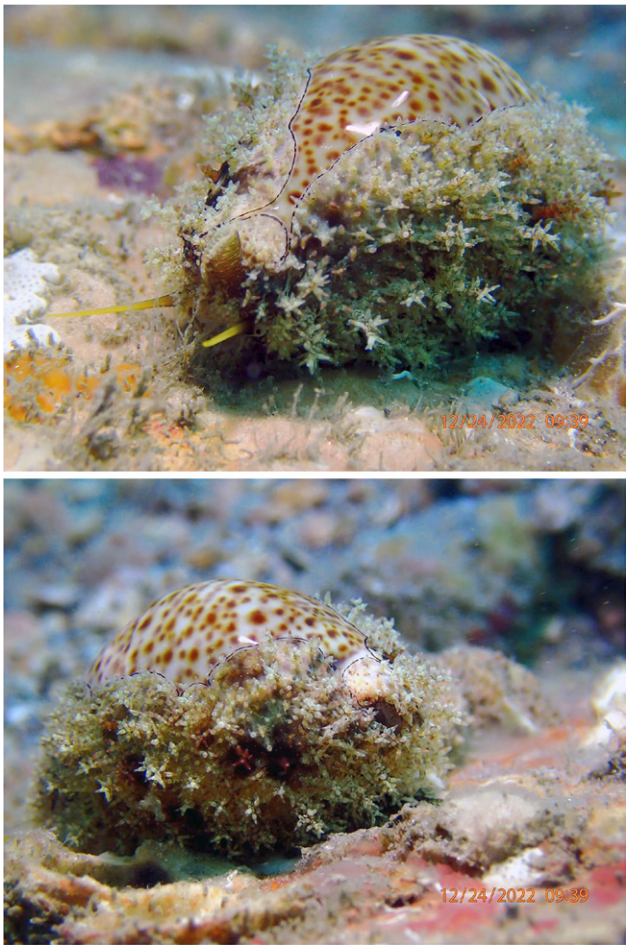

Figure 2. Underwater photographs of the *Naria turdus* in the Lake Worth lagoon, in the vicinity of the Phil Forster Park. Photos were taken on December 24, 2022 by Nuch Uthairat.

in the near future[1]. That "near future" had arrived on December 24, 2022, when live *N. turdus* (Figure 2) was photographed underwater by Nuch Uthairat in Lake Worth Lagoon (LWL), in the vicinity of the Phil Foster Park, 900 Blue Heron Blvd, Riviera Beach, FL 33404, approximate coordinates 26°46′59.06″ N; 80°02′31.13″ W (Figure 3). That is the first record of this species in U.S. coastal waters. As per Uthairat's observation, the approximate size of the mollusk was roughly 2 × 1 inch (about 50.8 × 25.4 mm), quite large for the species, and strongly suggesting that the observed specimen was an adult individual. Given the estimated time of the first introduction to the island of Aruba in 2019–early 2020 (Oleinik, 2023), and assuming that the range expansion occurred without further introduction events along the "route", it took *N. turdus* about two years to reach Florida.

Naria turdus is a benthic gastropod of the family Cypraeidae, reaching about 38 mm (1.5 inches) at the adult stage. Shell coloration consists of diagnostic dark brown spots on a light-grey dorsal shell surface background. Additionally, the mantle of *N. turdus* exhibits characteristic papillae (Figure 2). *Naria turdus* is a generalist herbivore, apparently capable of survival on a wide variety of food items. The species thrives on coral reef habitats in its native range (Burgess, 1985: 211). Egg capsules are attached to hard substrates and undergo a pelagic larval stage. The duration of the larval stage is unknown. Details on the reproductive capabilities, egg-capsule attachment, and pelagic larvae are discussed in Oleinik (2023). Given the heightened likelihood of larval settlement in a tropical/sub-tropical habitat in this species, the locality where it was recorded in Florida is hardly accidental. LWL is Palm Beach County's largest estuary, spanning 20 miles from PGA Boulevard in the North to Boynton Beach Bridge at Ocean Avenue in the South and separated from the Atlantic Ocean by a succession of barrier islands. Ocean waters flow into LWL through 2 inlets and mix with freshwater entering the lagoon through three major flood canals. Consequently, the salinity regime in LWL is strongly influenced by episodic freshwater flows from the drainage canals, and ranges from freshwater to hypersaline. Other controlling factors and processes include saltwater inflows from the ocean through the Lake Worth and South Lake Worth tidal inlets. Freshwater inflows combined with marine processes operating at tidal, meteorological, and seasonal time scales determine the overall salinity regime within LWL. The Atlantic Intracoastal Waterway runs the entire length of the lagoon, roughly parallel to the shoreline. The specific area around Phil Foster Park (Figure 3), although initially being mostly man-made through dredging of canals and spoil piles, was restored in the 1990s under the guidance of the SE Florida Environmental Resources Management. Corals and coral-reef associated organisms grow on hard structures at LWL (Florida Museum, 2023).

The Lake Worth Inlet, which is in close proximity to the site separating Singer and Palm Beach Islands (Figure 3), is 800 feet (243.8 m) wide by 35 (10.6 m) feet deep, 0.7 miles (1126.5 m) long,. It is intermittently dredged, featuring jetties on the north and south sides (Figure 3). The mean tidal range in the Atlantic Ocean at Palm Beach is 2.8 feet, and the spring tide range is 3.3 feet, with average tidal-current velocities of 3 miles or less per hour, as measured at the Lake Worth Inlet jetty (Eden, 1958). Later measurement by South Florida Water Management District (SFWMD) yielded a range of flood tide-current velocities from 0.25 to 1.25 knots. The estimates of the saltwater prism flushing rate through Lake Worth inlet is 9.32×10^8 ft^3/tidal cycle of salt water or approximately 26,391.3 m^3/tidal cycle (U.S. Army Corps of Engineers, 2016). Large volumes of ocean water regularly entering the inlet from the Straits of Florida have the potential to carry abundant marine planktonic organisms, including pelagic larvae of benthic mollusks.

The area of the LWL between the Peanut Island and the Phil Foster Park, in the immediate vicinity of the Lake Worth Inlet (Figure 3) is a local biodiversity hotspot

[1]Oleinik (2023) was accepted for publication prior to the finding of *N. turdus* in Florida.

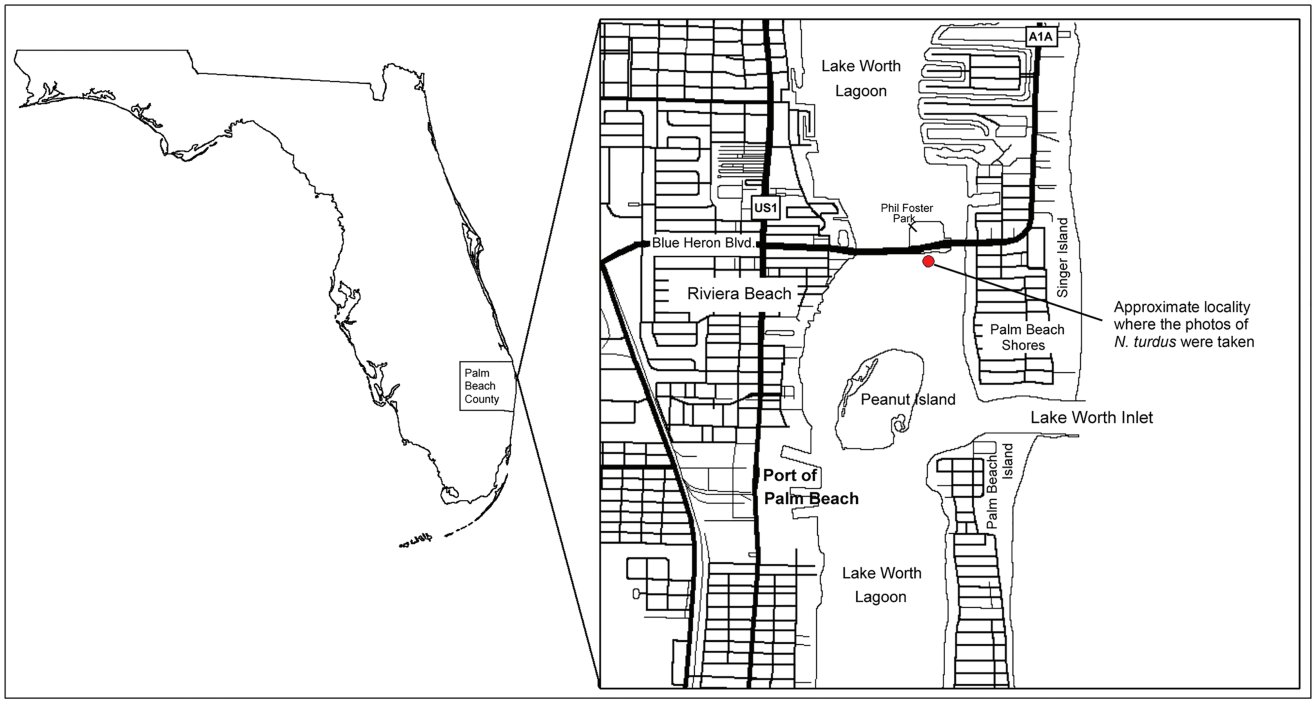

Figure 3. Locality map of the area where first *Naria turdus* (Lamarck, 1810) was recorded in South Florida

that, in addition to a rich fauna of fish, corals, crustaceans, echinoderms, and marine plants, is home for 761 species of mollusks, with at least 184 species of bivalves and 474 species of gastropods (JaxShells.com, 2023).

An alternative factor that may have contributed to the introduction of the *N. turdus* in that area of the LWL is its relatively close proximity to the Port of Palm Beach. The Port of Palm Beach, located in Riviera Beach, Florida, is a full-service marine port offering a variety of cargo and cruise services. The port processes 2.5 million tons of cargo and 700,000 cruise passengers annually (https://www.portofpalmbeach.com/). Large cargo ships, including cruise liners and cargo vessels of various kinds, are capable of carrying ballast water and organisms attached to the submerged portion of the vessel as hull fouling. Ballast water may contain planktonic larvae, hull fouling may include attached egg capsules.

The possibility that introduction could have happened as a result from the aquarium trade is very slim, as *N. turdus* is not a species that is collected and traded for that purpose. At least one website dedicated to coral reef life indicates that "there are no reports (...) that this animal has been kept in captivity successfully." (www.reeflex.net/tiere/13855_Naria_turdus.htm) Not enough data is yet available to assess any potential effects of the introduction of *N. turdus* on the native LWL cowrie population around the Phil Foster Park and the Peanut Island.

Possible impacts in terms of potential food competition can be expected to affect similar-sized *Naria acicularis* (Gmelin, 1791) and *Luria cinerea* (Gmelin, 1791), which co-occur in parts of the newly established range of the introduced species. *Naria turdus* and its locally native counterparts *N. acicularis* (Gmelin, 1791) and *Luria cinerea* (Gmelin, 1791), are, like most shallow water cowries, herbivorous or sponge grazers (Pawlik and Deignan, 2015). On the other hand, larger *Naria turdus* can be an attractive prey for healthy octopus populations in that area of the LWL. Although Burgess (1985: 211) does mention that *N. turdus* in the Indian ocean prefers habitats where "live corals are found", this is definitely not the case in the western Atlantic. Very shallow water, rubble, and sandy bottom with large rocks seem to be the preferred conditions. Some live corals may occur in the area, but not in any appreciable numbers.

Potential effects of the introduction would probably be similar to those discussed for Aruba by Oleinik (2023). The current status of the species can be defined as "non-indigenous", rather than "invasive", because the exact effects on the local biota are yet unknown.

The introduction of *Naria turdus* in the western Atlantic raise a number of questions about this particular species. The area of the eastern Indian Ocean and Red Sea include at least 13 species of the genus *Naria* (Lorenz, 2017). All these species have planktonic larvae and most are common in assorted nearshore habitats. The key question is what exactly made *N. turdus*, among many other similar species, so successful in expanding its natural biogeographic range halfway around the world and securing a firm foothold in the western Atlantic. More detailed research on the ecology, reproductive, and survival strategies of this remarkable species are needed so we can better understand the

dispersal potential and capabilities of marine mollusks species in an ever-changing oceanic realm.

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