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Halophila stipulacea (Hydrocharitaceae): A recent introduction to the continental waters of Venezuela

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Abstract.–The occurrence of the introduced seagrass *Halophila stipulacea* (Hydrocharitaceae) is reported for Puerto Azul, Playa Mansa, Venezuela. This record documents range expansion to the Caribbean mainland, and first observation of male flowers, of this introduced seagrass, which until April 2013 was only reported at several Caribbean islands.

Keywords.–*Halophila stipulacea*, introduced species, seagrass, Venezuela, Caribbean.

Halophila stipulacea (Forskål) Ascherson is a dioecious tropical seagrass originally from the Indian Ocean and Red Sea. Since the 1920s the seagrass *Halophila stipulacea* invaded the eastern Mediterranean most likely through the Suez Canal (Lipkin 1975), after which it slowly expanded westward (Lipkin 1975). In 2006 it was found as far as Salerno, in western Italy (Gambi et al. 2008). Lipkin (1975) and Gambi et al. (2008) proposed anchors, fishing gear, or hulls of vessels as potential vectors of fragments of this species. In 2002, this species was found for the first time in the Caribbean, at the island Granada by Ruiz and Ballantine (2004), who hypothesized that it was introduced by yachts. Afterwards it was reported in Dominica and St. Lucia (Willette and Ambrose 2009), expanding rapidly along other Caribbean islands (Willette et al. 2014, Fig. 1). The rapid spread of this introduced species along the Caribbean islands most likely is aided by repeated patterns of human movement, by ships sailing from port to port, because the species is frequently found in harbors or anchorage sites (Willette et al. 2014). *Halophila stipulacea* has a wide physiological tolerance to changes in salinity, and in its native habit grows from 2-30 m depth, often forming dense monospecific beds (Lipkin 1977; Jacobs and Dicks 1985, Malm 2006, Short et al. 2007).

Venezuela has 3700 km of highly variable coastal waters suitable for the growth of seagrasses (Miloslavich et al. 2006). Seven species have been found along these coasts including *Thalassia testudinum* Banks ex König, *Syringodium filiforme* Kützing in Hohenacker, *Halodule wrightii* Ascherson, *Halodule beaudettei* (den Hartog) den Hartog, *Ruppia maritima* Linnaeus, *Halophila decipiens* Ostenfeld and *Halophila engelmanni* Ascherson (Ganesan 1989, Vera 1992, 2008). Here, we report for the first time the presence of *Halophila stipulacea* in continental Caribbean waters at Puerto Azúl, Vargas State, Venezuela, representing a further step in range expansion of the invasion of this species into the Caribbean.

Puerto Azúl Bay (10°37'12'' N and 66°44'21'' E) near the city of Naiguata, Venezuela has several wave-protected beaches, (Fig. 1). Playa Mansa, characterized by low hydrological activity has a depth of 1.5 m, transparent waters and sediments composed by fine grain sand and fine particulate organic matter. Salinity in this bay fluctuates from estuarine to marine depending on the Naiguata River discharge, and submarine springs are frequently found along the bay. The only native seagrass present is *Halodule wrightii* which is found as very sparsely isolated plants. Playa Mansa has a marina harboring mid-size ships and sailing boats coming from different

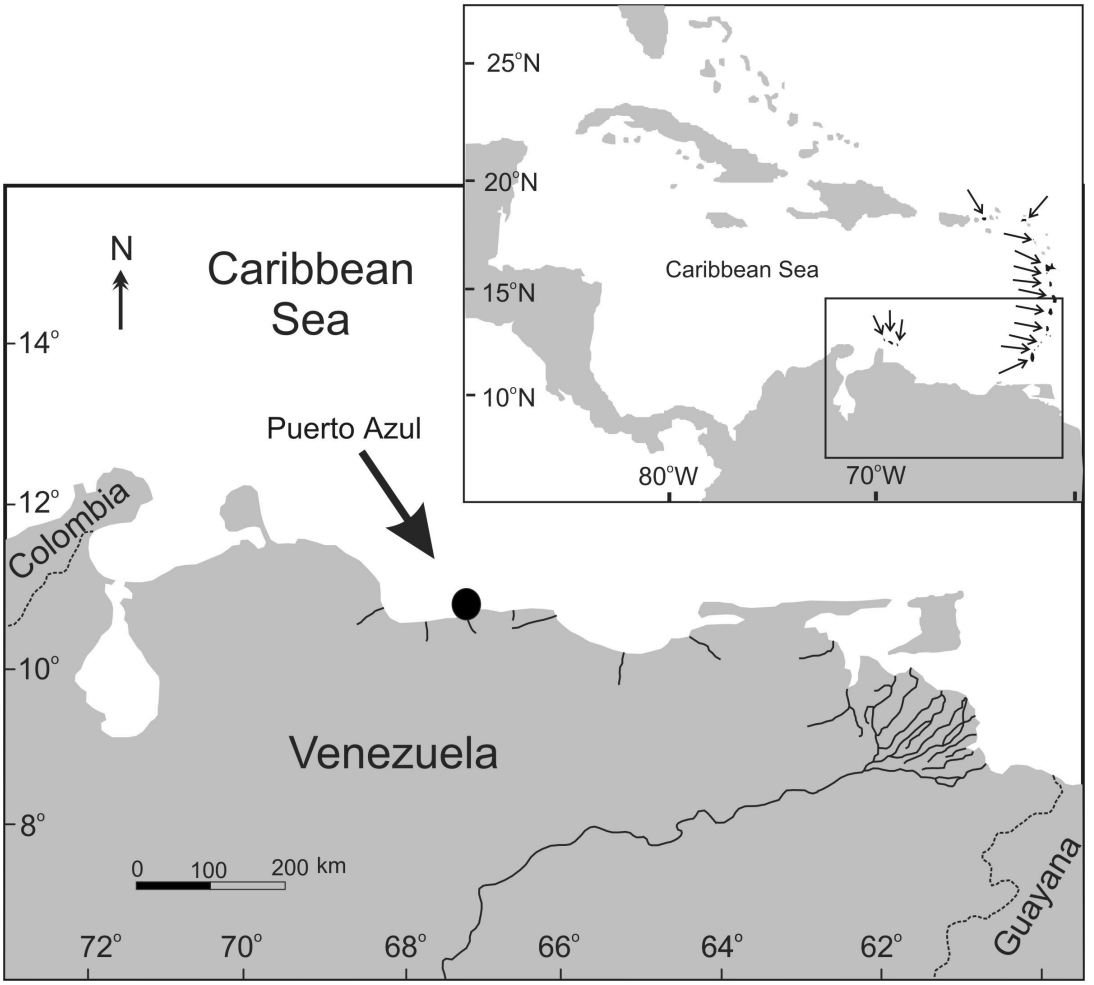

Fig. 1. Map of the continental Venezuelan Caribbean coast showing the site where *Halophila stipulacea* was found. The locations of *H. stipulacea* at the Caribbean islands (from Willette et al. 2014) are indicated with arrows.

Caribbean islands or Florida. Surveys of benthic subaquatic vegetation were conducted in April 2013 along a 200 m transect parallel to the coast. Seagrass samples were taken haphazardly by hand and maintained in a cooler until processed in the laboratory. The specimens were cleaned and preserved in a 4% formaldehyde seawater solution. Identification of the species followed Den Hartog (1970).

Specimens of *Halophila stipulacea* from Puerto Azúl, Playa Mansa, are small plants with a thin creeping rhizome, from which at each node a long unbranched hairy root of 4-5 cm and foliar shoots emerge. The foliar shoots have a pair of elongated ellipsoid, approx. 5 cm long, delicate leaves with 1 cm long petioles and slightly serrated margins. The leaves have a marked central vein with 11-18 cross veins emerging at angles between 45-60° joining intramarginal nerves at the leaf edges. Conspicuous (1-1.5 cm long) colorless scale leaves cover the petioles of the leaves and the horizontal rhizome (Fig. 2). While most specimens in the study area were vegetative, some plants had male flowers. *Halophila stipulacea* occurred in a patch approximately 3 m^2 with large plants covering almost 90% of the substratum. Adjacent to this large patch, developing patches of younger plants (~ 1 m^2) were found (Fig. 3).

The arrival to Venezuelan waters may be

Fig. 2. *Halophila stipulacea* herbarium specimen from the Playa Mansa, Puerto Azúl, Venezuela.

attributed to frequent boat traffic between Puerto Azúl, Playa Mansa and some Caribbean Islands. The fact that the first sighting of the species is near the marina supports this hypothesis, and is consistent with other registrations of this species in port and anchoring areas at the Caribbean islands (Willette et al. 2014). This site has been subjected to various disturbances in the last 15 years that may have facilitated the establishment of *H. stipulacea* (Negron 1999). After a period of heavy rain in 1998, the Playa Mansa beach was overloaded with mud and rocks from adjacent mountains covering any previous subaquatic benthic vegetation. In order to recover this important touristic site, the beach was dredged 8 years ago and thereby creating potential new habitat for colonization of the introduced species (Negron 1999). Newly introduced species may become especially invasive in human-induced disturbed areas (Williams 2007) with potential detrimental effects to native seagrass beds. For example, the spread of an introduced strain of the green macroalgae *Caulerpa taxifolia* (M. Vahl) C. Agardh in the Mediterranean was facilitated by pre-existing conditions of instability of the native *Posidonia oceanica* seagrass beds (Occhipintli and Savini 2003). In the Caribbean, the introduction of *H. stipulacea* may not necessarily be harmful everywhere, considering its ample physiological tolerances it may establish at formerly unoccupied habitats by native seagrasses. Or alternatively, it may form an understory of well-established native seagrass beds, providing diversification of habitat. Lipkin (1975) suggested that in the Mediterranean it only occurred in habitats in which competition with native seagrass species may be non-existent or weak (Lipkin 1975). In the Caribbean Islands, this species forms dense monospecific mats in in areas with highly variable environmental conditions or poor water quality (Ruiz and Ballantine 2004, Willette et

Fig. 3.. Aerial view of Playa Mansa, Puerto Azúl *Halophila stipulacea* patch.

al. 2014), however, in these areas it may also displace native species such as *Syringodium filiforme* (Willette and Ambrose 2009, Willette et al. 2014).

The spatial colonization by fragments with a well-defined patch surrounded by smaller patches, as found in Playa Mansa, may indicate further expansion as has been found in other invading clonal organisms such as *Caulerpa taxifolia,* (Ruesink and Collado-Vides 2006). The lack of sexual reproduction is also a trait of many introduced species that in their native range may reproduce sexually, as is known for *H. stipulacea* (Malm 2006). The clonal growth strategy might explain the colonization success of this species in the absence of sexual reproduction, including the West-ward expansion in the Mediterranean where, similar to the present study, only male flowers have been found (Gambi et al. 2008). Current-mediated transport from the islands to the Caribbean mainland, although not impossible now that the species has increase its expansion to further islands (Willette et al 2014), was not very likely due to the strength (13 cm s^{-1}) and westward direction of the prevailing Caribbean Current in Venezuela and Columbia basins (Richardson 2005); further, the first occurrence of the species in a marina suggest that ships and sailing boats might have functioned as the major vector. Now that this species has been established on the Caribbean mainland, colonization of coastal environments through small leaps of fragments transported on near-coastal currents and local countercurrents is likely, in addition to human-mediated vessel transport. Further monitoring of the spread of this species, its habitat requirements and its impact on the local seagrass communities is urgently required.

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