

## Discovery of the Sea Grass *Halophila decipiens* (Hydrocharitaceae) in the Diet of the Hawaiian Green Turtle, *Chelonia mydas*<sup>1</sup>

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**Abstract:** The herbivorous Hawaiian green turtle (*Chelonia mydas* L.) has expanded its forage to include a newly reported sea grass species, *Halophila decipiens* Ostenfeld, that is closely related to the previously documented food item, *Halophila hawaiiiana* Doty & Stone. *Halophila decipiens* was first reported in Hawai'i in the literature in 2001, but our investigations have found it in reef specimens preserved from 1979 and in more recent samples from green turtle fore-stomachs. Its presence as a dietary item indicates that green turtles probably began utilizing this species after 1998. The status of *H. decipiens* as an indigenous species to Hawai'i, its effects on turtle pastures, and the adjustment of feeding behavior of *C. mydas* to the presence of a species abundant and available as a food source are discussed.

THE HAWAIIAN ISLANDS are particularly vulnerable to invasion by alien plants and animals and of primary concern is the conservation of threatened and endangered species, such as the herbivorous green turtle, *Chelonia mydas* L. The conservation of the green turtle in Hawai'i is of considerable importance and includes the protection of foraging habitats and the variety of species in the green turtle pasture ecosystems (Balazs 1980, Hirth 1997). The discovery of any new species in the green turtles' diet or habitat, such as *Halophila decipiens* Ostenfeld, which is closely related to a primary food item, *Halophila hawaiiiana* Doty & Stone, is important. This is especially the case if it is a native species with expanded distribution, or an alien species, because it

may have the potential to cause adverse effects on the natural forage of these animals.

The recent discovery of *Halophila decipiens* in the Hawaiian Islands (McDermid et al. 2002) prompted us to reexamine the fore-stomach, mouth samples, and fecal samples of green turtles we had collected from 1978 to 2001. Green turtles graze in a limited locality storing marine vegetation they eat in a fore-stomach or crop (Balazs et al. 1998). Upon necropsy of stranded turtles, the macerated food items in the fore-stomach and in fecal pellets can be identified and quantified, often to species (Russell and Balazs 2000). Turtles are natural collecting organisms, and it was largely from their fore-stomach and fecal samples that the distribution of the introduced red alga *Hypnea musciformis* (Wulfen) Lamouroux and its spread and utilization as food by *C. mydas* were determined for Hawai'i (Russell and Balazs 1994). Similarly, the introduction of the red alga *Acanthopora spicifera* (Vahl) Boerg into Hawai'i and its subsequent dispersal during the 1950s later created a widespread and abundant major food resource used by green turtles (Doty 1961, Balazs et al. 1987, Russell 1992).

It is reasonable to assume that we missed recognizing *H. decipiens* in earlier samples because it is so similar to *H. hawaiiiana*. The leaves of *H. decipiens* have serrations on the margins, are very fine and often difficult to see, and collapse upon drying. However, the

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leaf blades have distinctive abundant hairs on both leaf surfaces. There are neither teeth on the leaf margins nor hairs on the leaves of *H. hawaiiiana*. A reexamination of past samples for *Halophila decipiens* was valuable in determining the distribution and history of this species in Hawai'i. We report on the historical presence of *H. decipiens* in Hawai'i, hypothesize about its status as an indigenous or introduced species, and discuss its increased use by marine turtles as a food source.

#### MATERIALS AND METHODS

All green turtle forestomach, mouth, and fecal samples that contained *Halophila* that had been collected in Hawai'i since 1979 were thoroughly reexamined by microscope. Every leaf in every sample was examined to check for the presence of *H. decipiens* and *H. hawaiiiana*. Also included in the examination were pressed voucher specimens of *Halophila* fed to marine turtles in holding pens at the Hawai'i Institute of Marine Biology (HIMB), Coconut Island, Kāne'ōhe Bay, O'ahu.

#### RESULTS

The earliest record of *H. decipiens* in our collections was from pressed specimens collected in October 1979 at HIMB. In August 1979

large amounts of a robust *Halophila* (leaf blade length 20–30 mm, width 5–10 mm, and petiole length 10–20 mm) were gathered by hand from the reef at Lilipuna Pier, near Coconut Island, and fed to green turtles held in pens for aquaculture research at HIMB. *Halophila decipiens* was found to be palatable to these turtles. Three months later the area around and under the turtle holding pens was examined for the presence of this same *Halophila*, and voucher specimens of plants growing there were preserved by pressing them. These same locations were examined in August 2001, but no *Halophila* was present.

Out of the 61 turtle samples that contained *Halophila* collected between 1978 and 2002, eight samples included *H. decipiens* and the other 53 contained *H. hawaiiiana*. The samples containing *H. decipiens* from green turtles were all found after 1998; an additional four were from plants collected in the wild. *Halophila decipiens* was found in samples from widely separated locations on O'ahu (Table 1): Hanauma Bay, Magic Island Lagoon, Iroquois Point, 'Āina Haina, Kahalu'u, and near the Ahu o Laka sandbar in Kāne'ōhe Bay (Figure 1). Samples were also taken from the island of Hawai'i and Midway Atoll. *Halophila decipiens* was not mixed with *H. hawaiiiana* in any of the turtle samples or in the reef collections except in a single reef sample 8 m

TABLE 1  
Locations of *Halophila decipiens* in Green Turtle and Reef Samples

Date	Location	Origin
15 October 1979	Kāne'ōhe Bay, Coconut Island, O'ahu	Reef sample, 2 m depth
28 January 1998	Iroquois Point, O'ahu	Forestomach necropsy
13 November 1998	'Āina Haina, O'ahu	Forestomach necropsy
16 November 2000	Midway Atoll <sup>a</sup>	Forestomach flush, MT no. 56
17 November 2000	Midway Atoll	Forestomach flush, MT no. 60
14 November 2000	Midway Atoll	Forestomach necropsy
11 April 2001	Hanauma Bay, O'ahu	Forestomach necropsy
24 April 2001	Kahalu'u, Kāne'ōhe Bay, O'ahu	Forestomach necropsy
02 June 2001	Ahu o Laka, Kāne'ōhe Bay, O'ahu	Forestomach necropsy
23 June 2001	Magic Island Lagoon, O'ahu	Reef sample, 4 m depth
09 September 2001	North Kohala, Hawai'i Island <sup>b</sup>	Reef sample, 24 m depth
13 September 2001	Midway Atoll	Reef sample, 8 m depth

<sup>a</sup> Midway Atoll is located 2100 km northwest of O'ahu in the Hawaiian Archipelago.

<sup>b</sup> Hawai'i Island is located 250 km southeast of O'ahu.



FIGURE 1. Locations of samples on O'ahu that contained *Halophila decipiens*.

deep at Midway Atoll (15 September 2001) where *H. decipiens* and *H. hawaiiiana* leaves were found together in equal amounts.

An examination of the samples we collected from Magic Island Lagoon in the summer of 2001 confirmed the presence of *Halophila decipiens* at that location. The size range of 10 leaves from *H. decipiens* from Magic Island Lagoon was 12.0–17.4 mm long and 3.7–5.7 mm wide, with a petiole length of 3.2–7.0 mm. Hartog (1970) gave a range of 10–25 mm for blade length, 3–6 mm for blade width, and petiole length of 3–15 mm. All other characteristics of the plants fit the description for *H. decipiens* given by Hartog (1970).

#### DISCUSSION

The scattered distribution of *H. decipiens* in widely separated locations of the Hawaiian

Archipelago (e.g., Midway, O'ahu [shown in Figure 1], and Hawai'i Island) reported in this paper and McDermid et al. (2002) is evidence that there is no easily identifiable focal point of introduction. Species that have been introduced usually have a focal point from which they spread (Elton 1958). There was no indication that it was introduced to the HIMB area, because it was not established in the lagoon near the research laboratories before being taken there from Lilipuna Pier to feed turtles, a distance of only 0.5 km. There is not enough evidence to speculate as to how *H. decipiens* may have come to the Hawaiian Islands, but given its broad, scattered distribution, it has probably been in the Islands at a low level and has most likely been overlooked (as we overlooked it) rather than introduced.

It is not surprising that *Halophila* was present at Lilipuna Pier and HIMB in 1979

but does not occur there today. *Halophila* absence, especially after such a long period of time, is not necessarily a direct indication of grazing pressures, pollution, or human perturbation. *Halophila* species are very fragile vascular plants, and their roots only penetrate the substrate a few millimeters (Hartog 1970). This leaves them vulnerable to many disruptive conditions, and little is known about their physiology, durability, growth dynamics (Herbert 1986), or persistence in any specific location (Phillips and Meñez 1988).

*Halophila decipiens* usually occurs in deeper water (Phillips and Meñez 1988), separate from and not in direct competition with *H. hawaiiiana*. The presence of *H. decipiens* in shallower water, however, provides a more readily available food source than plants growing 24 m deep because turtles will be able to dive and surface to breathe with less effort. Furthermore, *H. decipiens* is not known to displace other sea grass species, so it has likely not been nor will be a threat to *H. hawaiiiana*.

The implication is that because *H. decipiens* was not found mixed with *H. hawaiiiana* in turtle samples, the turtles were feeding on these two species in sufficiently separated locations that they were not eaten at the same time. The increased presence of *H. decipiens* in turtle samples after 1998 indicates that the abundance of *H. decipiens* in shallower water has just recently increased sufficiently enough for turtles to find and utilize in their diets. As *H. decipiens* becomes more abundant in Hawai'i it can provide a more important food resource for green turtles (Phillips and McRoy 1980). Concomitantly, as the green turtle population in Hawai'i continues to increase and expand its range, *H. decipiens* will offer an additional source of forage possibly similar to what occurred in Hawai'i following the introduction of *Acanthophora spicifera* and *Hypnea musciformis* (Balazs et al. 1987, Russell and Balazs 1994, 2000).

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