The following supplements accompany the article

Manatee grazing impacts on a mixed species seagrass bed

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Supplement 1. STUDY SITE

The study site was bordered on three sides by a dredged basin and was located near the western tip of a narrow spit of land vegetated with black and white mangroves (Fig. 2a). Depth increased gradually from the shoreline toward the basin. Depth in Area A on the shelf extending westward from the spit ranged from 90 to 115 cm, whereas depth in Area B along the northwest shore of the spit ranged from 50 cm nearshore to 130 cm offshore (Fig. 2a). While manatees are known to haul themselves up into extremely shallow seagrass beds to feed, they prefer waters greater than 50 cm (Lefebvre et al. 1999, J. Provancha personal observation).

Supplement 2. METHODS

Radio-telemetry. From 1991-1994, between 18 and 22 adult manatees were tracked annually on the Atlantic coast with satellite-monitored platform transmitter terminal (PTT) radio-tags (Deutsch et al. 2003). Of these, 8-13 tagged manatees annually visited the northern Banana River between 1991 and 1994. Each PTT generated a mean of 3.7 locations per day. We determined the density of radio locations in the northern Banana River for each year of our study.

Supplement 3. RESULTS

Radio-telemetry. Radio location densities also tended to be higher in Area 4 in late winter/early spring, from January 1991-October 1994 (Fig. S1). The relative density of telemetry locations was highest near our study site in March1992 (Fig. S2), which corresponds with the highest manatee count in the aerial surveys (Fig. 3). Manatee occurrence elsewhere in the northern Banana River continued through the summer and fall, but tended to drop off in Area 4, where our study site was located (Figs. 3 and S1).

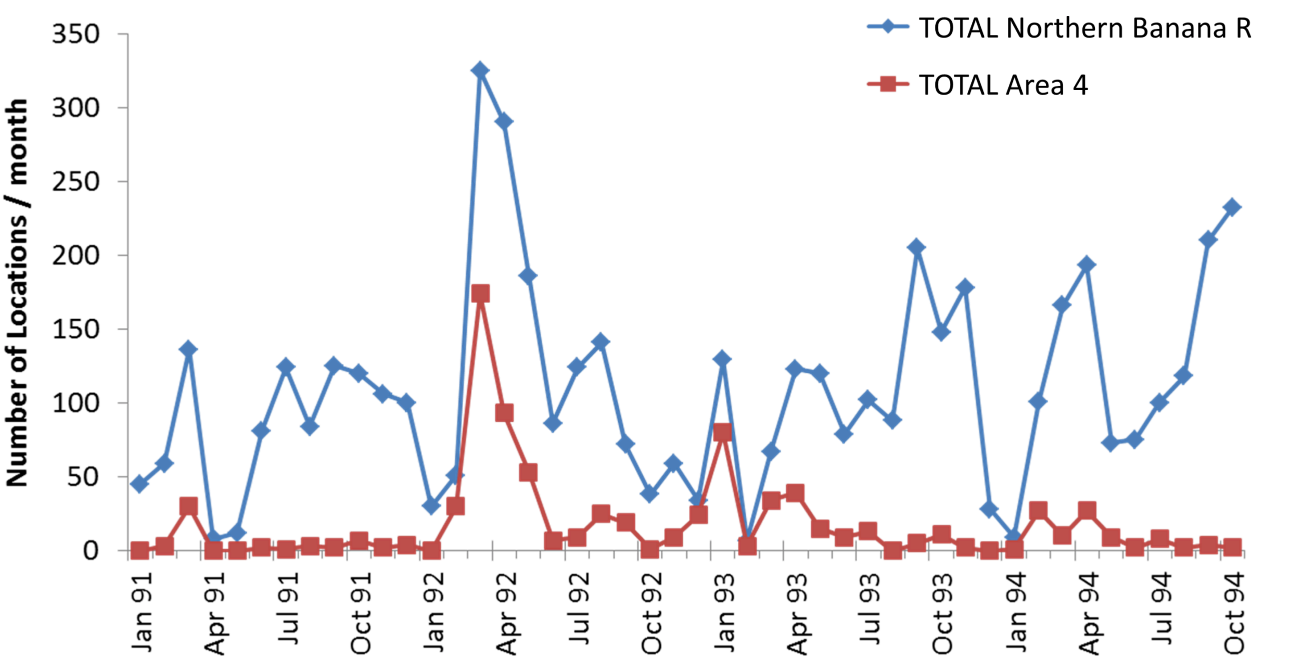

Fig. S1. Number of telemetry locations of manatees, Jan 91-Oct 94 (n = 8-13 per year), in the northern Banana River and in Area 4, where our study site was located. Source: USGS

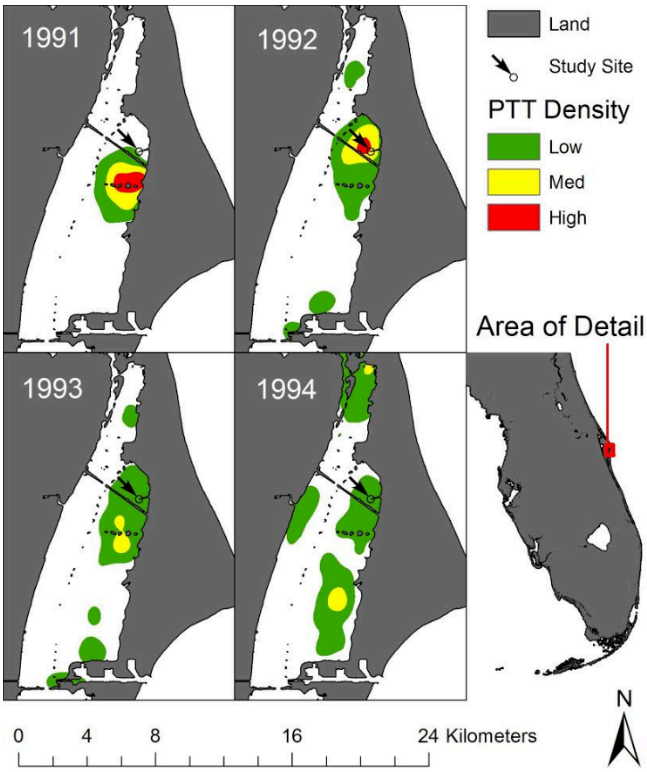

Fig. S2. The relative density of telemetry locations of manatees in the northern Banana River in: 1991 (n = 8 manatees; 1000 locations), 1992 (n = 13 manatees; 1450 locations), 1993 (n = 11 manatees; 1274 locations), and 1994 (n = 8 manatees; 1875 locations).

Densities less than 20 locations km^{-2} are not shown.

Low = >20, <60 PTT locations km^{-2}
Medium = >60, <100 locations km^{-2}
High = >100 locations km^{-2}

Supplement 4. DISCUSSION

(a) *Comparison of seagrass biomass at other sites in the IRL.* Biomass data from three other studies of mixed *Syringodium filiforme* and *Halodule wrightii* beds in the IRL during approximately the same time period (1988-1995) were generally similar to mean biomass in our open plots by Summer 1993 (our Summer 1991 and 1992 means were considerably lower; Table 2). Hanisak (2001) collected biomass and shoot count data at a site approximately 150 m east of our B open plot. For 'potentially grazed' (not exclosed) *S. filiforme*, mean total biomass values ranged from 30 (Hanisak 2001) and 28 (this study in Fall 1990 and Summer 1993) in the northern Banana River, 49 (Lefebvre et al. 1999) in Hobe Sound and Jupiter Sound at the southern end of the lagoon), to 62 g dry weight m^{-2} (Gallegos & Kenworthy 1996), average of two sites in the central lagoon. Mean total biomass of 'ungrazed' *S. filiforme* was 147 (Lefebvre et al. 1999), compared with a mean of 167 g dry weight m^{-2} in this study in Summer 1993 (Table 2).

For 'potentially grazed' *H. wrightii*, mean total biomass values ranged from 119 (Hanisak 2001), 95 (Gallegos & Kenworthy 1996), 92 (this study in Summer 1993, Table 2), to 20 g dry weight m^{-2} (Lefebvre et al. 1999). The lower mean for Hobe and Jupiter sounds (20 g dry weight m^{-2}) likely reflects the fact that those samples were taken in recent manatee grazing locations (determined by aerial observation and confirmed by site visits), and thus is more comparable to mean values for our open plots in Summer 1991 and 1992: 11 and 22 g dry weight m^{-2}, respectively. Mean total biomass of 'ungrazed' *H. wrightii* in Hobe and Jupiter sounds was 44 (Lefebvre et al. 1999) and 53g dry weight m^{-2} in our exclosed plots in Summer 1993 (Table 2).

The strongest seasonal effect we observed was for *S. filiforme* and *H. wrightii* shoot counts which were significantly higher in summer than spring; *S. filiforme* shoot counts were also significantly higher in fall than spring (Table 1). This is consistent with Hanisak's findings (2001) at a nearby site. We observed significantly higher total biomass in fall than spring for both *S. filiforme* and *H. wrightii* (Table 1), which is similar to Hanisak's (2001) results for *S. filiforme* however, he observed somewhat lower *H. wrightii* biomass in the fall than summer or spring.

(b) *Perturbation unrelated to manatee grazing*. The most likely organisms responsible for the perturbation inside both of the exclosures were fish (possibly red drum [*Sciaenops ocellatus*], which were abundant in the study area) and sting rays (*Dasyatis say* and *D. sabina*). The first author observed a sting ray feeding in the hole left behind after removal of a biomass core. *D. say* was the most abundant ray collected from 1975-1978 (Snelson & Williams, 1981) and1982-1986 (Schmid et al. 1988), and was frequently observed in our study area. Cownose rays (*Rhinoptera bonasus*) have been implicated in destruction of *Zostera* beds in Chesapeake Bay (Orth 1975) and have been collected in the Mosquito Lagoon (Snelson & Williams 1981) and central Indian River (Schmid et al. 1988), but have not been reported in the Banana River. Green sea turtles (*Chelonia mydas*) were not present in the Banana River during our study years, and sea urchins and horseshoe crabs (*Limulus polyphemus*) were not observed. Gilbert & Clark (1981) concluded that the formation and growth of sandy patches in a *Syringodium* bed in the northern Indian River were caused by horseshoe crabs.

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