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The Relationship Between Fish Abundance and Algal Biomass in a Seagrass–Drift Algae Community[a]

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George R. Kulczycki[b], Robert W. Virnstein, and
Walter G. Nelson[c]
Harbor Branch Foundation, Inc., RR 1, Box 196, Fort Pierce, FL 33450, U.S.A.

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Repetitive seine and monthly drop net samples taken in a seagrass bed in the Indian River, Florida, indicate that significant relationships exist between the abundances of both the code goby *Gobiosoma robustum* and the gulf pipefish *Syngnathus scovelli* and drift algae biomass. We suggest that drift algae provides a refuge from predation which increases in effectiveness with increased algal biomass, and that this interaction, in concert with habitat preference and food availability, is responsible for the relationships observed.

Introduction

Large clumps of unattached drift algae are a prominent feature of some seagrass ecosystems and, in addition to the seagrasses themselves, may provide food, habitat and shelter for macrobenthic animals (Eiseman & Benz, 1975; Hooks *et al.*, 1976; Cowper, 1978; Heck, 1979; Heck & Thoman, 1981; Gore *et al.*, 1981). However, most studies of seagrass macroinvertebrates have given little consideration to macrofaunal–drift algae associates (e.g. Brook, 1975; Young *et al.*, 1976; Young & Young, 1977, 1978).

Heck & Whetstone (1977), Gore *et al.* (1981) and Stoner (1980) have shown that macroinvertebrate abundance and species diversity may in some cases be linked to macrofloral biomass in seagrass communities. Although a variety of fishes may also be found associated with drift algae in seagrass, little has been reported on the relationship of fish to drift algal biomass. Since these fishes may prey on the invertebrate macrofauna associated with drift algae, such a fish–algae relationship may be highly important in understanding the trophic and population dynamics of macroinvertebrates in seagrass beds when drift algae is present.

This study reports on the relationship between drift algae biomass and the abundance of two fishes commonly found associated with drift algae in seagrass beds, the code goby

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[a] Contribution No. 212 of the Harbor Branch Foundation, Inc.

41 [b] Present address: 1) Florida Department of Environmental Regulation, 2) 2745 S.E. SE Morningside Boulevard, Port St. Lucie, FL 33452, U.S.A.

[c] Present address: Environmental Protection Agency Marine Science Center, Newport, Oregon 97365, U.S.A.

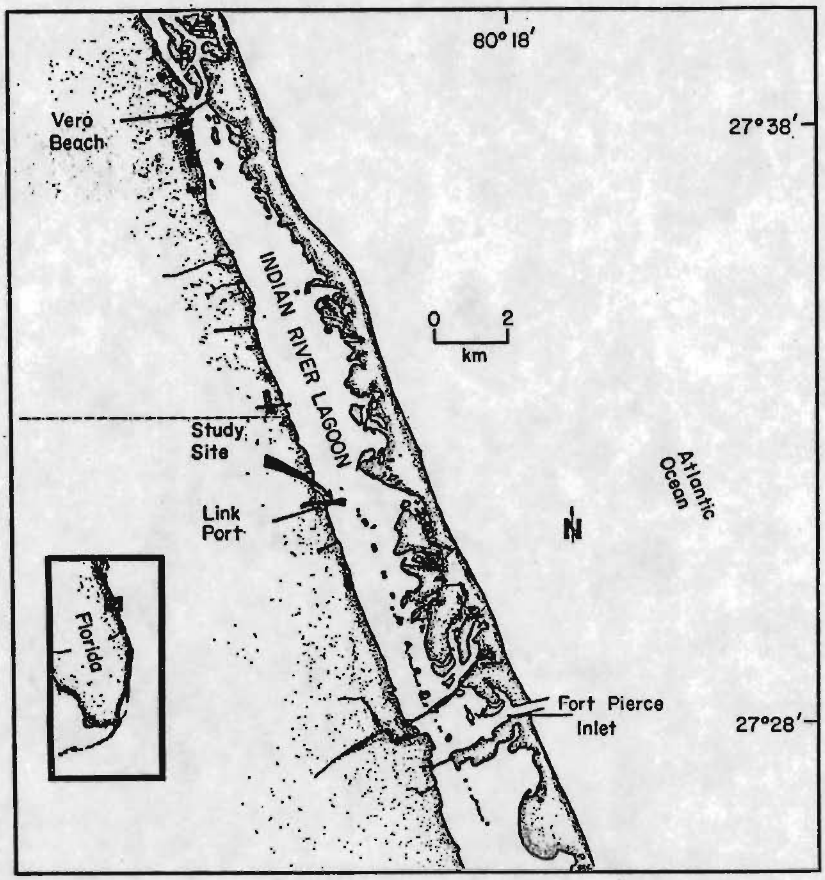

Figure 1. Map of the Indian River, Florida, showing the location of the Link Port study area.

Gobiosoma robustum (Ginsburg) and the gulf pipefish *Syngnathus scovelli* (Evermann and Kendall). The fish abundance–drift algae biomass relationship for these two species is examined both on a daily basis for 18 days and by monthly day and night samples for 1 year.

Study area

This study was conducted in a seagrass bed located on the west side of the Indian River, Florida, immediately north of a spoil jetty of the Link Port channel of the Harbor Branch Foundation (Figure 1), and is an area which has been extensively studied (Young *et al.*, 1976; Young & Young, 1977, 1978; Gore *et al.*, 1981). These shallow (~1 m deep) seagrass beds are composed largely of *Halodule wrightii* and *Syringodium filiforme* with occasional patches of *Thalassia testudinum*.

Sporadic and patchy accumulations of drift algae occur at the Link Port study area. In a study of a nearby (8 km to the south) seagrass area within the Indian River, Benz *et al.* (1979) identified 63 species of drift algae. Dominant species were *Acanthophora spicifera*, *Chondria tenuissima*, *Dictyota dichotoma*, *Hypnea cervicornis* and *H. musciformis*. At the Link Port site, several species of *Gracilaria* were usually prominent in the drift algae samples.

Methods

For sampling fish and drift algae on a daily basis, a 3·2-mm mesh, 15-m bag seine was used. A single seine haul was taken daily (08.00 h) over the same 10×30-m area for 18 consecutive days (13–30 October 1975).

From April 1976 to March 1977, monthly samples were taken using three 3·2-mm mesh, 10-m^2 drop nets (Gilmore *et al.*, 1978). Nets were set up 60–70 m apart and left raised for 1 h before tripping. After a net was dropped, a rigid 3·2-mm mesh seine which spanned the interior of the drop net was passed through the closed off area five times to collect the contents. For each monthly sample, three drops were made during the morning (10.00–11.00 h) and three drops were made that night (1 h after sunset).

Fish were sorted from the algae and the algae was weighed (wet weight). Because considerable quantities of drift algae were often collected in the seine collections (up to 11 kg), wet weight was determined after the algae were allowed to drip dry for 8 h.

Because correlations of fish abundance with algal biomass between sampling dates were low (r positive, but $\leqslant 0{\cdot}5$), data were also analysed by 2×2 tests of independence with the G-test of significance (Sokal & Rohlf, 1969) to examine whether fish abundance and drift algae biomass tended to move in the same or different directions from sample date to sample date, i.e. whether an increase in algae biomass was accompanied by an increase in fish abundance.

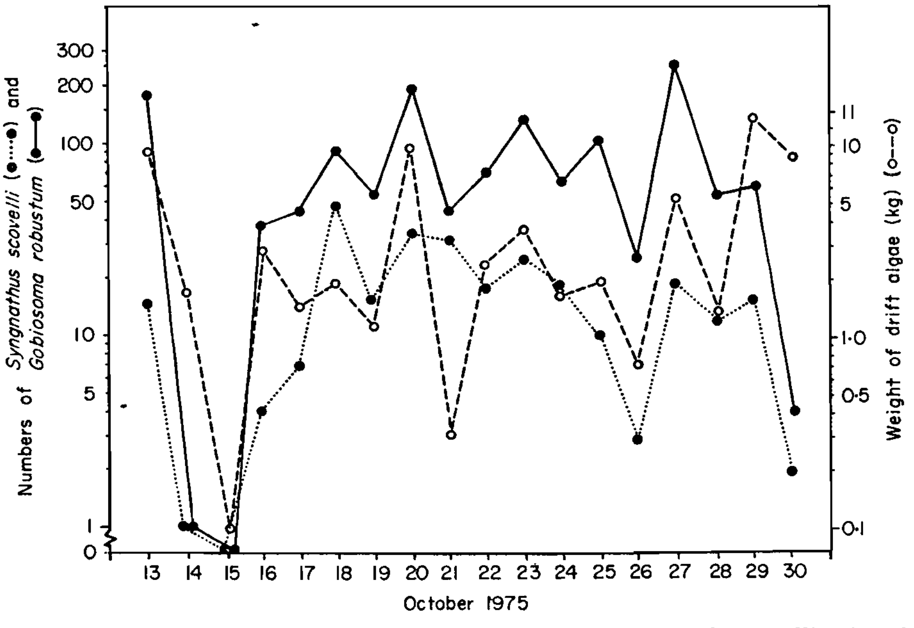

Figure 2. Total numbers of *Gobiosoma robustum* and *Syngnathus scovelli* and total drift algae biomass (wet weight, kg) collected from the same area by seine hauls over an 18-day period. Note the vertical axis is a log scale.

Results

Of the 55 species of fish collected during the 18-consecutive-day sampling period, the abundance of two species, the code goby *Gobiosoma robustum* and the gulf pipefish *Syngnathus*

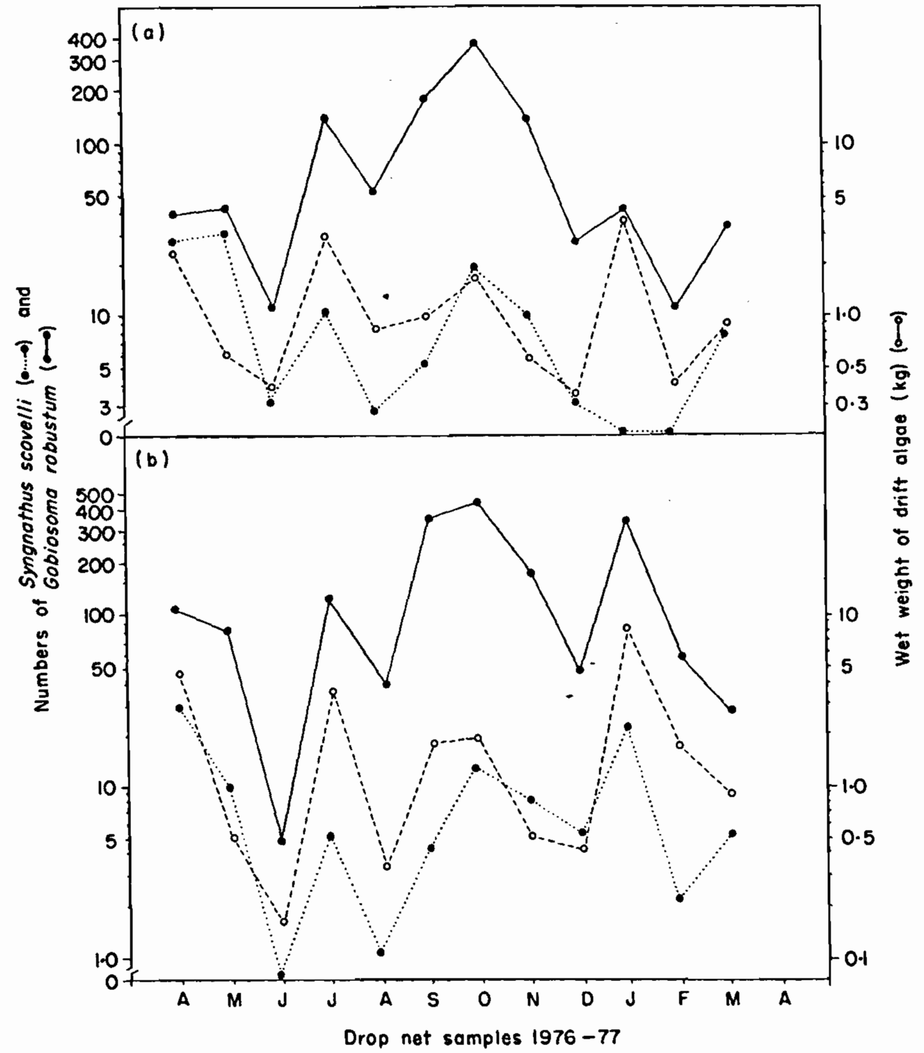

Figure 3. Total numbers of *Gobiosoma robustum* and *Syngnathus scovelli* and total drift algae biomass (wet weight, kg) collected from (a) day and (b) night drop net samples over 1 year. Note the vertical axis is a log scale.

scovelli, showed significant ($P<0{\cdot}05$) relationships between the direction of change in number of individuals and wet weight of drift algae (Figure 2). Over the 18-day sampling period, with almost every increase or decrease in drift algae biomass, there was a corresponding increase or decrease in the number of *G. robustum* and *S. scovelli*. Drift algae was obviously not depleted, but rather was replenished daily (by tidal current, wind, etc.); the largest algal biomass occurred in the 17th collection.

Over the 13 months of drop net sampling, similar significant relationships between the direction of change in *G. robustum* abundance and drift algae biomass were seen in both day and night samples (Figure 3). For *S. scovelli*, a significant relationship was observed for the night samples, but the day samples showed only a marginal relationship ($0{\cdot}05<P<0{\cdot}1$) between direction of change in abundance and biomass. This day–night difference resulted from the fact that no *S. scovelli* were captured during the day in January and February 1977, although they were present at night. The reason for this difference in day–night abundance is unknown but may be related to the high concentrations of the filamentous brown alga *Giffordia mitchelliae* in day samples at this time.

Correlations of fish abundance with drift algae biomass were low and not significant between months ($r=0{\cdot}24$ for *G. robustum* and 0·39 for *S. scovelli*). This low between-month correlation is at least partly due to patterns of fish reproduction that may be unrelated to drift algae abundance. For example, the number of *G. robustum* in September, October and November was much greater than predicted by drift algae biomass (see Figure 3). This difference is largely due to an influx of large numbers of juvenile *G. robustum* at this time, similar to the situation in Tampa Bay (Springer & McErlean, 1961). For example, in our April 1976 drop net samples, there was only one *G. robustum* <20 mm; in October there were $691 \leqslant 15$ mm (R. G. Gilmore, unpublished data). These abundant smaller fish presumably require less space and are more closely packed in the drift algae. This huge change in abundance due to reproductive pattern temporarily overshadowed the fish–algae relationship and caused the between-month correlation to be low.

When the three day and three night drops were considered as six separate replicates (day–night differences were non-significant for both species), fish–algae correlations within-months in April and November–January were significant ($P<0{\cdot}05$) for both species. During these months, the mean within-month correlation was 0·90. Correlations were also significant for *G. robustum* in July (0·96) and for *S. scovelli* in May (0·92), October (0·89) and March (0·83). Overall within-month correlations were significant for both species (0·63 for *G. robustum* and 0·57 for *S. scovelli*).

Discussion

In relating macroinvertebrate abundance and species richness to plant biomass in tropical seagrass systems, Heck & Whetstone (1977) proposed four possible explanations of the positive correlations of abundance and biomass they observed. These were based on (1) food availability, (2) reduction of fish predation, (3) increased living space and (4) additional nearby habitats. The fourth, additional habitats, is mainly a mechanism relating to species richness, not abundance. The other three, however, offer possible explanations for the relationship observed between densities of *G. robustum* and *S. scovelli* and drift algae biomass in the present study.

Both food availability and increased living space relate to population resource limitation. Increases in drift algae biomass may result in increases in either or both food and space, allowing larger population sizes to be supported if either resource is limiting. Even if space is not limiting and the drift algae habitat is not saturated with fish, a positive correlation would be expected simply if the fish utilized the habitat, even non-preferentially. Stoner & Livingston (1980) collected the banded blenny, *Paraclinus fasciatus*, in trawl samples on both bare sand bottoms and *Thalassia* seagrass meadows only when clumps of red algae were present. They attributed this relationship to habitat preference by the fish. Additionally, the drift algae may serve as a transport and dispersal mechanism.

Larger individuals of both *G. robustum* and *S. scovelli* feed primarily on amphipods, which generally occur in low densities (1974–77 mean 500 m^{-2}) in *Halodule* seagrass beds at this site (Nelson *et al.*, 1981). *G. robustum* >18 mm and *S. scovelli* >35 mm ate exclusively amphipods (26 and 11 guts analysed, respectively). In drift algae, however, it is not likely that amphipods constitute a limiting resource for *G. robustum* and *S. scovelli*; a 600-g sample of drift algae collected by dip netting contained 6300 amphipods and an abundance of possible alternative food items such as copepods, isopods, gastropods and juvenile shrimps.

Perhaps more important than living space or food availability is protection from predation on *G. robustum* and *S. scovelli* by piscivorous fishes which occur in the Indian River (Gilmore, 1977). Among these species, *G. robustum* has been found in the guts of the grey snapper *Lutjanus griseus* (Stark & Schroeder, 1971; P. H. Hastings, personal communication) and of the spotted sea trout *Cynoscion nebulosus* (Springer & Woodburn, 1960; Tabb, 1961). Both *G. robustum* and *S. scovelli* probably are also consumed by other fish predators. Greater abundances of these fishes were found in cages which excluded large fish predators than in uncaged controls (unpublished data), suggesting that abundance is affected by predation. However, this response may simply be a behavioral response to cover; the intensity of predation on *G. robustum* and *S. scovelli* has not been shown to be high.

Heck (1979) found seven times the invertebrate abundance in a temperate seagrass community (with high algal biomass) than in a tropical seagrass community (with little or no drift algae) and partially attributed this difference to the extra protection from predation provided by the algal clumps. Increased habitat complexity is known to reduce predation rates by fish on invertebrate prey (Vince *et al.*, 1976; Nelson, 1979; Heck & Orth, 1980; Heck & Thoman, 1981; Stoner, 1981, and personal communication), and we expect it would similarly affect rates of predation by piscivorous fish on their prey.

At our Link Port site, in spite of the winter defoliation of the seagrasses, there is no evidence of a concomitant decline in *G. robustum* and *S. scovelli* abundance, suggesting either that drift algae, not seagrass, is the preferred habitat or that it is an equally acceptable alternative habitat of these two fishes. Experiments are needed to separate the importance of habitat preference, food availability, and predation in order to demonstrate why these species are so abundant in drift algae. We suggest that increased drift algae biomass may provide additional refuge for *G. robustum* and *S. scovelli* and may be responsible for the observed relationship between fish abundance and drift algae biomass.

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