The Nursery Role of Seagrass Beds

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COMMENTARY

THE NURSERY ROLE OF SEAGRASS BEDS.—
Seagrass meadows are usually thought to serve
as essential "nursery grounds" for a wide va-
riety of species in coastal waters, including
many economically important finfish and shell-
fish (see, for example, reviews by Thayer et al.,
1984; Zieman and Zieman, 1989; Bell and Pol-
lard, 1989). Many of these fish and inverte-
brate species are spawned offshore and pass
through a series of larval stages on the shelf
before moving into coastal waters as larvae or
postlarvae. They then make the transition
from a planktonic to a benthic existence by set-
tling into seagrass habitats.

Seagrass species are among the most pro-
ductive plants known, and they frequently sup-
port animal densities many times those on
nearby unvegetated substrates (Virnstein et al.,
1983; Orth et al., 1984; Summerson and Peter-
son, 1984; Williams et al., 1990; Hutchings et
al., 1991; Kirkman et al., 1991; and the reviews
cited above). Textbooks and review articles
commonly report that the great amount of
food potentially available to juveniles, usually
thought to be in the form of seagrass detritus
and epiphytic algae, together with the protec-
tion from predators provided by seagrasses, ex-
plains why such large numbers of animals are
typically associated with seagrass habitats (e.g.,
Thayer et al., 1984; Zieman and Zieman,
1989).

However, the database that would allow an
evaluation of whether seagrass meadows actu-
ally provide more available food for juvenile
fish and shellfish is actually quite small. One
simple way to evaluate this proposition is to
compare the growth rates of individuals inhab-
iting vegetated and nearby unvegetated sub-
strates. The expectation is that growth rates
will be highest in seagrass, owing to the greater
food supply available there. We are aware of
only a relatively small number of studies that
have experimentally tested this hypothesis.
They frequently employ the use of field enclo-
sures, and include studies of fish (Sogard,
1992; Nadeau, 1991; Nadeau and Heck, un-
publ. data), shrimp (Heck et al., unpubl. data),
brachyuran crab (Perkins-Visser et al., 1996),
bivalve mollusk (Peterson et al., 1984; Peterson
and Beal, 1989; Coen and Heck, 1991; Irlandi
and Peterson, 1991; Irlandi and Mehlich,
1996), and gastropod mollusk (Ray and Stoner,

1995) growth. These studies have frequently
come to different conclusions regarding the ef-
fect of seagrass on growth rates.

There are, however, many studies that have
investigated the protection that seagrasses
might provide various species of invertebrate
prey from their predators (e.g., Nelson, 1979a;
Coen et al., 1981; Heck and Thoman, 1981;
Stoner, 1979, 1982; Summerson and Peterson,
1984; Leber, 1985; Heck and Wilson, 1987;
Main, 1987; Ryer, 1987). There are few studies
using small fish as prey (e.g., Lascara, 1981),
although there are many reports of the protec-
tive role of vegetation for freshwater fish spe-
cies (cf. the review in Heck and Crowder,
1991). These studies, in contrast to those of
the effect of seagrass on growth rates, have usu-
ally come to very similar conclusions regarding
the role of submerged aquatic vegetation
(SAV) as protection from predators, although
there are a small number of exceptions.

Below, we search for some generalities in
these studies regarding the "nursery role" of
seagrasses in providing both abundant food
and protection from predators. We rely heavily
on our own work (both published and as yet
unpublished) and studies by other U.S. scien-
tists. Consequently, our conclusions should be
strictly applicable only to eastern North Amer-
ica, although we believe that they may have
broader relevance.

GROWTH RATES

Invertebrates.—In the past 2 decades, the
growth rates of suspension-feeding northern
quahogs (*Mercenaria mercenaria*) in seagrass and
in nearby unvegetated substrates have been
compared many times. Much work has been
done on this commercially important species
in North Carolina by Peterson and colleagues
(Peterson et al., 1984; Peterson and Beal, 1989;
Irlandi and Peterson, 1991; Irlandi and Meh-
lich, 1996). Conclusions have varied, with dif-
ferent studies finding enhanced, equal, or re-
duced growth in seagrass compared to that on
unvegetated substrate (e.g., Peterson and Beal,
1989). Similarly, in the northern Gulf of Mex-
ico, variable responses of hard clam growth to
the presence of seagrasses have been found,
with positive, negative, and nonmeasurable ef-
fects on quahog growth (Coen and Heck,
1991; Wilson, 1991; Coen et al., unpubl. data).

Studies of another commercially important
suspension feeder, the bay scallop (*Aequipecten*

irroratus), have also produced mixed results regarding the effects of SAV on growth rates. In the northern Gulf of Mexico, growth rates of tethered scallops were greater at the edges of seagrass beds than in their interiors or on unvegetated sand (Bologna and Heck, unpubl. data).

The commercially important herbivorous gastropod *Strombus gigas* (the queen conch) grows at faster rates in seagrass than on sand at medium and larger sizes (11 and 22 mm shell length, respectively) tested, but smaller conchs (5 mm shell length) grow more rapidly on unvegetated sand (Ray and Stoner, 1995).

Juvenile [50–70 mm total length (TL)] brown shrimp (*Penaeus aztecus*), a commercially important penaeid shrimp often closely associated with seagrass meadows (Zimmerman and Minello, 1984a, 1984b; Zimmerman et al., 1990), usually showed no significant difference in growth rate among living or artificial seagrass or unvegetated substrates (Academy of Natural Sciences of Philadelphia, 1992, 1993, 1995a, 1995b; Heck et al., unpubl. data). These unpublished studies differ from previous studies that found growth of shrimp (up to 59 mm TL) to be greater in marsh vegetation (*Spartina alterniflora*) than on nearby unvegetated substrate (Zimmerman and Minello, 1984b).

Growth rates of juvenile blue crabs (*Callinectes sapidus*), which are closely associated with seagrasses in their early juvenile stages (cf. Orth and Von Montfrans, 1987; Thomas et al., 1990), have been shown to be significantly greater in seagrass than on unvegetated substrates in both field and laboratory experiments (Perkins-Visser et al., 1996).

Fishes.—Sogard (1992) used field enclosures to compare the growth rates of three species of fishes on eelgrass and on nearby unvegetated substrates. These species were eelgrass specialists to varying degrees: winter flounder occurs on all types of substrates but is most frequently found on sand; tautog (*Tautoga onitis*) is primarily found in vegetated habitats, including both eelgrass and macroalgal-dominated substrates; and naked goby (*Gobiosoma bosc*) is found in structured habitats such as seagrass beds and oyster reefs and is much more common in seagrass than on unvegetated substrate (Sogard, 1992). Sogard's (1992) results showed that only the tautog grew at significantly greater rates in seagrass than on unvegetated sand.

In similar types of experiments with juvenile red drum (*Sciaenops ocellatus*), Nadeau (1991) found no significant difference in growth rates

between vegetated and unvegetated substrates, despite the fact that early juvenile red drum are closely associated with seagrass beds (Holt et al., 1983). Furthermore, enclosure experiments with spotted sea trout, a species also closely associated with seagrass habitats, showed significantly greater growth in seagrass on one occasion (Heck and Nadeau, unpubl. data) in Alabama waters, but not when the same experiments were done in Texas with living and artificial seagrass and unvegetated substrate (Academy of Natural Sciences of Philadelphia, 1992, 1993, 1995a, 1995b; Heck et al., unpubl. data).

PROTECTION FROM PREDATORS

Although there are differences in the details of predation studies, virtually all attempts to investigate the effect of seagrass biomass on predator success rates have found that seagrass does significantly reduce predation risk (cf. review of Heck and Crowder, 1991). This is true of laboratory studies using both living and artificial seagrasses (e.g., Nelson, 1979a; Heck and Thoman, 1981; Coen et al., 1981; Main, 1987; Ryer, 1988), as well as field studies using caging (Leber, 1985) and tethering techniques (Heck and Thoman, 1981; Heck and Wilson, 1987; Wilson et al., 1987, 1990; Heck and Valentine, 1995). These studies have used primarily crustacean prey (amphipods, shrimp, anomuran and brachyuran crabs) and fish predators, although other prey taxa have been used (sea urchins; Heck and Valentine, 1995), and crustacean and fish predators are also presumed to be involved in some field studies (Heck and Wilson, 1987; Wilson et al., 1990). We are aware of only a few studies that have used fish as prey (Lascara, 1981; Rozas and Odum, 1988), but the results of these studies appear to be consistent with those of studies using invertebrate prey in finding that vegetation reduced predator effectiveness.

There is uncertainty about the amount of vegetation required to produce a significant decline in predator effectiveness and about the shape of the relationship between vegetation biomass and predation rate (cf. Nelson and Bonsdorff, 1990; Heck and Crowder, 1991). However, we are aware of one study (James and Heck, 1994) that showed no significant reduction in predation success rates as vegetation abundance was increased. This study used a predator with an "ambush" foraging mode, and this "exception to the rule" had previously been predicted (Heck and Orth, 1980a).

SYNTHESIS

We conclude that the evidence for the role of food in the seagrass "nursery paradigm" is less compelling than the role of seagrass as shelter from predation. There are no obvious differences in seagrass "nursery function" between invertebrates and vertebrates. To date, only those taxa very closely associated with seagrass appear to show elevated growth rates in the presence of vegetation, and this is not without exception. However, relatively few species have been tested, and relationships between growth rates and the identity and abundance of seagrass species present have not yet been fully explored. In fact, much of our own work, as cited here, is still unpublished. We think it likely that a more complex set of relationships will be identified when additional studies are completed.

In contrast, studies of a wide variety of invertebrate prey taxa have shown the beneficial effects of seagrass presence on avoidance of potential fish predators. There is much less evidence for the effects of seagrass as protection for small fishes from their predators, but existing results are in accord with studies on invertebrates. At present, it appears that the provision of shelter is by far the best documented and most important "nursery function" of seagrass meadows.

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