QUARTERLY PROGRESS REPORT

Hovel and Regan: Eelgrass in San Diego Bay: Assessing Eelgrass Habitat Function for Recreationally Important Species

Funding dates: February 1, 2008 – August 31, 2011

Progress report date: July 2011(NOTE: new items are in RED text)

Summary of project:

The goal of this project is to enhance our knowledge of the function of seagrass as a habitat for recreationally important species in San Diego Bay (SDB). In SDB, eelgrass serves as a habitat for a variety of species such as juvenile giant kelp fish, barred and spotted sand bass, calico bass, and spiny lobster. Eelgrass may serve as an important refuge for these species, particularly in their juvenile stages, and eelgrass houses many small invertebrates that provide food. Despite the widely cited function of eelgrass as a nursery habitat for species such as these, critical information regarding the function of this habitat is missing. In this project we conduct experiments in SDB and in the new Coastal and Marine Institute Laboratory (site of the new Center for Bay and Coastal Dynamics) that are focused on the effects of eelgrass habitat structure on ecological relationships. These are intended to provide a more complete understanding of how eelgrass functions as a foraging and refuge habitat for organisms in SDB. We have integrated these experiments with a mathematical model that allows us to greatly increase the scope of the results. We also have to use our experiments and model to educate San Diego's youth about marine ecology and the importance of habitat in SDB. In addition to educational benefits for K-12 students, undergraduate, and graduate students, our results can benefit SDB by informing predictions of the consequences of eelgrass loss for SDB organisms, and will provide improved ability to restore seagrass in the event of habitat loss.

Expected results and progress:

The expected results listed in our proposal were:

1. Complete a field experiment in San Diego Bay that examines how seagrass habitat characteristics interact with predation to dictate the abundance and distribution of several seagrass-dependent species.
    - An experiment was completed in fall 2009 and the results were published by a master's student at SDSU in the peer-reviewed journal Oikos in 2010. This journal is a widely-read and respected journal of ecology. The reference is: Moore, E.C. and K.A. Hovel. 2010. Relative influence of habitat complexity and proximity to patch edges on seagrass epifaunal communities. Oikos 119: 1299-1311.

- We are conducting a new field experiment and continuing lab experiments that capitalize on the one described above and on our recent behavioral experiments that examine how habitat structure influences foraging decisions by fishes. This experiment involves examining how predation influences the abundance and diversity of small crustaceans on eelgrass blades, and ultimately how this influences the growth rates of eelgrass. This experiment is being done in collaboration with researchers working in other estuaries around the world (e.g. the US east coast, northern California, Alaska, and Europe). The general theme is to examine the impact that grazing epifauna (i.e. small crustaceans) have on eelgrass growth, by virtue of the fact that they consume epiphytic algae growing on eelgrass blades. We know from our Port of San Diego-funded experiments, however, that small fishes consume these crustaceans and that the density of eelgrass influences their foraging decisions. We are examining the influences of fish predation on crustaceans in the field in conjunction with an experiment on eelgrass and algal growth, and in the lab we are preparing to test how epiphytic algal growth on eelgrass blades influences predator-prey interactions involving fishes and crustacean grazers. This will provide information on both the functioning of eelgrass in San Diego's bays as well as the value of eelgrass as a habitat for fishes.

2. Complete laboratory experiments focused on the effects of organismal behavior on prey survival.
   - We have conducted three sets of lab experiments for the project, all of which were described in detail in our last progress report. Briefly, set 1 sought to determine how the structure of seagrass habitat influences the behavior of fish predators and their invertebrate prey during predator-prey interactions. We found that juvenile giant kelpfish detection rates of their shrimp prey decreased as the density of seagrass increased, but shrimp density modified this relationship. This means that prey density is as important, or more important to consider when assessing how seagrass habitat influences the foraging of juvenile fishes. This is the first experiment in seagrass habitat to quantify the relative effects of prey density and structure on fish foraging, an important function of seagrass nursery habitat. The work was carried out by an undergraduate honors thesis student and we have submitted the results to *Marine Ecology Progress Series*, a peer-reviewed marine biology journal. We have re-submitted our manuscript to the editor and are awaiting final decision about acceptance.
   - Our second set of experiments was carried out by three undergraduate students, including one representing Grossmont Community College via the SDSU BRIDGES program, conducted experiments in the summer of 2010 to provide more information on the effects of seagrass structure and prey density on juvenile fish foraging. These students used a wider range of seagrass structure and prey density than used in set 1, and quantified the same aspects of predator and prey behavior as in our previous experiments. Their results

corroborated those of the student who conducted our set 1 experiments. This was notable because it was important to determine if the same effects of habitat structure and prey density would be observed over wider ranges. These results were presented by the students at the annual Western Society of Naturalists conference in San Diego, CA in November 2010, which is an international conference on marine biology that is attended by approximately 600 marine biologists. These results also were presented in March 2011 at the annual Benthic Ecology Meeting in Mobile, Alabama, a conference on marine biology that is attended by approximately 800 professional and student marine ecologists. This lab experiment was accompanied by a field experiment conducted in the summer of 2010. The field experiment sought to determine whether the distribution of juvenile fishes is correlated primarily with seagrass structure or with the density of their prey. We used throw traps to sample discrete areas of seagrass habitat near Shelter Island in SDB, and we accompanied these samples with samples of epifaunal abundance and seagrass habitat structure. We processed these samples over the fall semester 2010 and now have completed our data acquisition for this field experiment. We are presently completing the analysis for these data.

- Set 3 experiments have been completed by Kelly Tait, an MS student in the Hovel lab, in outdoor mesocosms provided with flow-through seawater from San Diego Bay. These experiments are designed to determine how seagrass structure influences habitat selection behaviors by epifaunal organisms (grass shrimp) and juvenile fishes. Organisms are provided with choices of simulated eelgrass habitat within mesocosms (dense eelgrass or sparse eelgrass). After an initial set of selection experiments in which only habitat is the only factor, we add a predatory threat to determine if this results in a change in habitat selection. In a third experiment we add food to determine whether this motivates organisms to change their preferred habitat. Our results suggest that shrimp and fishes prefer dense to sparse eelgrass (which coincides with results from the field experiments in objective 1), but that an increased threat of predation reverses this preference for shrimp, but not for fish. Instead, fish remain within dense seagrass even if large predatory fishes are there, but they move much less and take on a vertical orientation to better hide behind seagrass blades. This lab experiment is being accompanied by field experiments within seagrass habitat at Shelter Island that are designed to determine if habitat selection by prey organisms under natural conditions mirrors that seen in the laboratory under more controlled conditions. We are finding that grass shrimp movement from seagrass is higher when predatory threats are present, but only when seagrass density is sparse. Under high seagrass density, grass shrimp prefer to remain hiding in eelgrass rather than moving and exposing themselves to predators. We also are seeing more movement at night, suggesting that grass shrimp may move among seagrass patches at night when visually-oriented predators cannot hunt for them. Set 3 experiments were presented by Kelly Tait at the annual Western Society of Naturalists conference in San

Diego, CA in November 2010, as well as the Benthic Ecology Meeting in Mobile, Alabama in March 2011. Kelly also defended her master's thesis in May 2011 and now is working on her manuscript for submission to a peer-reviewed journal.

3. Complete a revised version of our predator-prey model using information gleaned from field experiments that predict the consequences of eelgrass loss for SDB, meet with Port personnel to describe the scope of our findings, and submit recommendations for conservation and restoration of eelgrass in SDB based on our findings.
   - In June 2008 and 2009, PIs Hovel and Regan revised the existing initial mathematical model of how predator and prey organisms interact in eelgrass habitat and how this is influenced by habitat structure. The overall goal is to determine what factors lead to the highest success of juvenile fishes, which constitute mesopredators in seagrass beds (i.e., those animals that hunt for prey, but also are hunted as prey). In 2008, the primary upgrade to the model was the inclusion of habitat complexity (e.g. shoot density and relative biomass) into the digital "landscapes" within which our digital "organisms" interact. In 2009 the PIs incorporated a much more extensive behavioral repertoire for predator and prey organisms into the model. Prey have preferences for particular habitat types (e.g. dense seagrass, or patch edges) based on results from the field experiments from objective 1. Predator and prey behaviors change with eelgrass structure, based on the laboratory experiments conducted already, and those presently being completed. As the final data are coming in from lab and field experiments, we are refining the behavioral repertoires of the organisms in our model, and using the model to test hypotheses about the success of fishes in seagrass nursery habitats. This eventually will provide a more accurate prediction of how seagrass structure influences nursery habitat function for juvenile fishes.

4. Complete a program in which SDSU graduate students and faculty teach K-12 students in two local afterschool programs about the value of SDB habitats for marine species and the value of using mathematical tools to study marine animals.
   - We have conducted a variety of exercises with the Ocean Discovery Institute (formerly Aquatic Adventures) to educate underrepresented youth about marine ecology, the value of marine habitats, and mathematical modeling. The group has visited the Coastal and Marine Institute Laboratory to conduct an experiment examining how habitat influences predator-prey interactions. This simple experiment quantified how the efficiency of hunting for small fishes changes with the addition of habitat structure into experimental arenas. Second, we have conducted two instructional sessions in the SDSU Biology Department's computer laboratory, in which students used our mathematical model to perform an experiment on predator-prey interactions in simulated seagrass habitat. The students were given a short lecture to introduce the concept of modeling, and they then

followed instructions to build their own mathematical model in NetLogo. This simple model allowed the students to create a world in which predator and prey organisms interact, and in which habitat can be added or removed to act as a protective area for prey. Finally, the students used our full model for seagrass habitat to test how changing the behaviors of the organisms influenced the effectiveness of seagrass nursery habitat.