

Environmental Projects Benefiting San Diego Bay

Project title:

Maintaining Healthy Eelgrass Beds: Fishes, Trophic Diversity, and Ecosystem Function

Introduction:

As the human population continues to expand, we are witnessing rapid changes in the environment due to anthropogenic impacts. One of these marked effects has been the global degradation and loss of seagrass habitats (Short and Wyllie-Echeverria 1996, Orth et al. 2006), including those within San Diego Bay (Browning and Speth 1973). It has been suggested that the wide-spread overexploitation of top predators (e.g. piscivorous fishes) in aquatic ecosystems could be indirectly contributing to the loss of seagrass habitats (Williams and Heck 2001). Eelgrass (*Zostera marina*), common to San Diego Bay, has been the most widely studied seagrass species throughout the world; however, relatively few studies have examined how small predators (such as fishes) influence the functioning of eelgrass ecosystems (Duffy et al. 2005), and to my knowledge, none have been conducted in a field setting. While eelgrass restoration and conservation are of great interest within San Diego Bay, the long-term success or failure of these efforts may be strongly influenced by trophic interactions such as grazing and predation.

Progress Report:

From July-September 2008, a species atlas (see attached list) was developed to facilitate the identification and quantification of preserved invertebrate samples (e.g. Amphipoda, Tanaidacea, Caridea, Brachyura, Annelida, Gastropoda, Cnidaria, Turbellaria, etc.). A library of voucher samples was also created to allow validation of invertebrate identifications derived from various texts (e.g. Light's Manual by Smith and Carlton). Two undergraduate research assistances were hired to help with the sorting and identification of all invertebrate samples (2007-8) and final analyses of eelgrass, algae, and fish samples.

Data from this work were compiled and presented in poster format at the 2008 annual meeting of the Western Society of Naturalists in Vancouver, British Columbia (see attached with acknowledgement of Port of San Diego in upper right-hand corner). The funded research project received an award for "Best Poster" based on format and content (e.g. experimental design, statistical analysis, conclusions and data summary).

The funded research project is 70% complete as of September 30, 2008. Though much work has been successfully completed, we have we found it important to further explore the feeding relationships of dominant fish and invertebrate taxa in San Diego Bay eelgrass in order to bolster



and better understand our findings from previous field experiments. During the next reporting period (October 1 – December 31, 2008), stable isotope analysis of eelgrass flora and fauna will be compared to stomach contents and the primary literature to verify feeding behaviors of invertebrates and fishes, and identify the relative importance of seagrass as a carbon source in the system. Additional fish collections will be used to better understand the composition of the microcarnivorous fish community, and the impacts a diverse assemblage of predators might have on the system.

This work will be conducted in collaboration with an undergraduate research assistant and will contribute, in part, to the completion of an undergraduate senior research thesis in Spring 2009. All analyses, literature review, and final writing of the project report will be completed in Spring 2009. The final master's thesis of Levi Lewis will be submitted in May 2009, followed by his graduation from San Diego State University. The funded research project is now scheduled to be 100% complete in May 2009 with the final report submitted to the Port of SD by June 1, 2009.

Invertebrate taxonomic key (summary)

TAXA	FAMILY	TAXA	FAMILY	
Amphipoda	Ampeliscidae	Polychaeta	Aoridae	
	Amphilochoidae		Capitellidae	
	Ampithoidae		Maldanidae	
	Aoridae		Nereidae	
	Caprellidae		Opheliidae	
	Corophiidae		Orbinidae	
	Dexaminidae		Phyllodocidae	
	Hyalidae		Polynoidae	
	Ischyroceridae		Serpulidae	
	Liljeborgiidae		Spionidae	
	Oedocerotidae		Syllidae	
	Phoxocephalidae		Terebellidae	
	Pleustidae		Unidentified	
	Podoceridae		Unk.R	
	Pontogeneidae		Sabellidae	
	Stenothoidae		Prosobranchia	
	Unidentified		Acmaeidae	
	Anomura		Paguridae	Calyptraeidae
			Unidentified	Columbellidae
	Arachnida		Unidentified	Conidae
Ascidia	Unidentified	Littorinidae		
Bivalvia	Mytilidae	Olivellidae		
	Unidentified	Unidentified		
Brachyura	Pectinidae	Pycnogonida		
	Tellinidae	Tanaidacea		
Copepoda	Canceridae	Paratanaidae		
	Grapsidae	Tanaidae		
Bryozoa	Majidae	Thalassinoidea		
	Portunidae	Unidentified		
Caridea	Unidentified	Unk.A		
	Bateidae	Unk.B		
Chaetognatha	Crangonidae	Unk.C		
	Hippolytidae	Unk.D		
Cnidaria	Unidentified			
	Anthozoa			
Copepoda	Hydroidea			
	Unidentified			
Cumacea	Calanoidea			
	Cyclopoidea			
Echinodermata	Harpacticoidea			
	Unidentified			
Isopoda	Unidentified			
	Anthuridae			
Mysidacea	Bopyridae			
	Idoteidae			
Nematoda	Sorolidae			
	Sphaeromatidae			
Nermertea	Unidentified			
	Unidentified			
Opisthobranchia	Unidentified			
	Aglagidae			
Ostracoda	Aplysiidae			
	Bullidae			
Platyhelminthes	Unidentified			
	Unidentified			


Fishes positively affect seagrass performance by mediating negative effects of grazing and fouling invertebrates

SAN DIEGO STATE UNIVERSITY
Black and red were the world

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INTRODUCTION

Seagrasses, common to bays and estuaries around the world, provide a myriad of ecosystem services and form productive habitats important to juvenile fishes and invertebrates. Algal blooms are known to smother and negatively affect seagrasses; however, small algae-grazing invertebrates (e.g. amphipods) can regulate such blooms¹. The influence of upper trophic levels on these dynamics, however, remains unclear.

PURPOSE: to explore the importance of microcarnivorous fishes in the functioning of a seagrass ecosystem.

Figure 1. Study Site in SD Bay



I used a caging experiment in San Diego Bay, CA (Fig. 2) to manipulate the abundance of small fishes and evaluate their effects on invertebrates, algae, and eelgrass (*Zostera marina*).

Figure 2. Predicted Trophic Interactions

Fishes

↓

Grazes

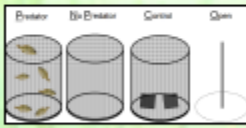
← Algae

← Seagrass

HYPOTHESIS: Fishes reduce invertebrate biomass, thus allowing algae to exhibit unregulated growth, ultimately having negative indirect effects on eelgrass performance (Fig 2).

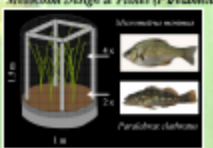
METHODS

Figure 3. Treatments



- Predator enclosures (P): I added 4 dwarf perch (*Micropogonias undulatus*) and 2 jay fish (*Paralichthys caudivittata*) of size 90–110 mm (Fig. 4).
- Predator enclosures (NP): all fishes removed and excluded.
- Control cages (C): four windows cut to allow predator access.
- Open plots (O): unmanipulated; marked with a single PVC pole.

Figure 4. Mesocosm Design & Fishes (P treatment)



All cages were constructed of a rigid internal PVC frame covered by a cylindrical barrier of 5 mm clear plastic mesh (Fig. 4)

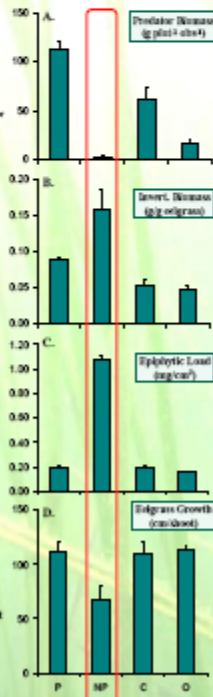
RESULTS

- Treatments installed May 30-June 1; experiment completed on August 22-24 (12 weeks).
- Results analyzed by one-way blocked ANOVA ($F_{3,35}$) $\alpha = 0.05$.
- Tukey HSD test used for multiple comparisons.
- **Rectangle** indicates significant effects of fish exclusion.

• **Initial samples** revealed no sig. treatment differences (not shown).

• **Final results** indicated strong effects of predator exclusion:

Figure 5. Response to Experimental Treatments



A. Predator Biomass (g plant⁻² above)

Treatment	Predator Biomass
P	~115
NP	~15
C	~65
O	~25

B. Invert. Biomass (g g seagrass)

Treatment	Invert. Biomass
P	~0.09
NP	~0.16
C	~0.05
O	~0.04

C. Eelgrass Growth (cm/week)

Treatment	Eelgrass Growth
P	~115
NP	~75
C	~115
O	~115

• Cages effectively manipulated predator biomass (Fig 5A; data from scuba surveys).

(Low values in open plots likely due to direct avoidance; not fish avoidance predator biomass)

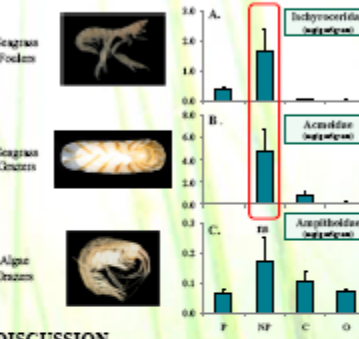
• Invertebrate biomass doubled when fishes excluded (Fig. 5B)—fishes exerted strong influence on invertebrate community.

• Large epiphytic loads (fouling) occurred when fishes excluded (Fig. 5C). Visual inspection and old analysis indicated fouling dominated by invertebrate tube-masses (i.e. *post algae*).

• Eelgrass growth 45% reduced when fishes excluded (Fig. 5D).

• Growth reductions in seagrass likely due to direct consumption and/or smothering of eelgrass by abundant epifauna (Fig. 6).

Figure 6. Effects of Predators on Biomass of Dominant Invert. Groups



A. Tachyrodites (mg eelgrass)

Treatment	Tachyrodites
P	~0.4
NP	~1.8
C	~0.1
O	~0.1

B. Acrostichus (mg eelgrass)

Treatment	Acrostichus
P	~0.1
NP	~0.4
C	~0.1
O	~0.1

C. Amphipods (mg eelgrass)


Treatment	Amphipods
P	~0.1
NP	~0.2
C	~0.1
O	~0.1

DISCUSSION

Contrary to my hypothesis, these results indicate:

- 1) Unregulated invertebrate productivity may have adverse effects on seagrasses either by direct consumption or by fouling mechanisms similar to algal overgrowth.
- 2) Consequently, microcarnivorous fishes may benefit seagrasses by regulating the biomass of these potentially harmful invertebrates (Fig. 6A,B), while not significantly affecting algae-growth (Fig. 6C) known to promote seagrass performance. These interactions are summarized in Fig. 7.

Figure 7. Indirect effects of fishes on eelgrass



ACKNOWLEDGEMENTS

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¹Hogler, A.B., Terada, E.J., Rodriguez, L.F., and Wilcox, D.L. 2004. Evidence of direct grazing and indirect (herpetivore) control on epiphyte-free Pacific Bay. *Mar. Ecol. Prog. Ser.* 262: 27-38.