Mechanisms of trophic cascades in a rocky intertidal zone: why predator removal is a “Pisaster disaster” for macroalgae

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Introduction

Trophic cascades exist when predators indirectly influence the structure of plant or algal communities. There are at least three mechanisms of trophic cascades:

• Density mediated indirect interactions (DMIs): predators eat herbivores, reducing herbivore density and thus grazing pressure.

• Trait mediated indirect interactions (TMIIs): predators scare herbivores, causing them to modify foraging or habitat choice.

• Competition effects: predators consume prey that compete for resources with species at lower trophic levels.

In this study, we examine trophic cascades in the mid to upper rocky intertidal zone at Schoolhouse Beach (Sonoma Co., CA). We compare trophic structure and molluscan grazer behavior in the presence and absence of the “keystone” predator Pisaster ochraceus (Paine 1969) in order to determine if and how Pisaster indirectly influences the macroalgal community.

Hypothesis: Pisaster indirectly increases overall macroalgal abundance (particularly that of taxa preferred by grazers) through DMIs, TMIIs, and competition effects.

Methods.

• Biweekly Pisaster removals from 12 boulders, beginning 4 years ago.

• 12 boulders with no Pisaster removed.

• Boulders partitioned into 8 faces: high/Pisaster and N/S/E/W.

• Census, during spring low tides in July:

  • Mytilus, barnacles, macroalgae, and bare rock (percent cover).

  • Molluscan grazers (density per m²).

• Five partitioned compartments.

• One empty or w/ one Pisaster.

• Three with Ulva, plates covered w/ diatoms, 5 Tegula.

• One with Ulva, diatom plates, no Tegula.

Community effects of Pisaster removal

Overall: Mytilus cover, algal cover

High

Low

Pisaster present

Pisaster removed

Figure 4. Pisaster density on high and low faces (n=48) of boulders with Pisaster present or removed.

Indirect effects: less pref. macroalgal abundance

High

Low

Prey Item # Eaten

Sm. barnacles 80

Mytilus 49

Tea 7

Porphyra 6

Nucula 3

Mopalia spp. 2

Littorina spp. 0

Lottia spp. 0

Prey Item # Eaten

Table 1. Stomach contents of 61 Pisaster removed from boulders. 70 other Pisaster had no stomach contents.

Grazer foraging response to Pisaster

Methods.

• Tanks with running seawater (1 cm deep, 0.5 L/min flow)

• Five partitioned compartments (15 x 20 x 25 cm).

• One empty or w/ one Pisaster.

• Three with Ulva, plates covered w/ diatoms, 5 Tegula.

• One with Ulva, diatom plates, no Tegula.

Figure 8. Experimental setup: Pisaster scent flows to Tegula in compartments with diatom plates and Ulva.

Discussion

• Pisaster indirectly affects macroalgal communities. With Pisaster present, less preferred macroalgae are more abundant.

• Indirect effects on macroalgae (and grazers) are largely due to reduced competition for space. With Pisaster present, algae and grazers inhabit space otherwise occupied by Mytilus.

• DMIs cannot explain the indirect effects. Pisaster does not deplete grazers through consumption; grazer densities are actually the same or higher when Pisaster is present.

• TMIIs may contribute to indirect effects. Grazer feeding response to Pisaster (Fig 9) could temper herbivory, despite high grazer densities.

• Summary: A keystone predator can influence competition between (not just within!) trophic levels, causing indirect effects on primary producers & consumers.

• Further study

  • Expanded feeding trails with Tegula, Lottia, and Littorina. Does Pisaster’s presence alter feeding rates/preferences?

  • At low tide, Pisaster is almost exclusively low on boulders (Fig 4). So why are the trophic effects so much stronger up high?

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