Regulation of marine diversity in Bonne Bay, Newfoundland: Potential changes in benthic communities and their relation to the fishery

Pedro A Quijon & Paul VR Snelgrove

Biology Department & Fisheries Conservation Group

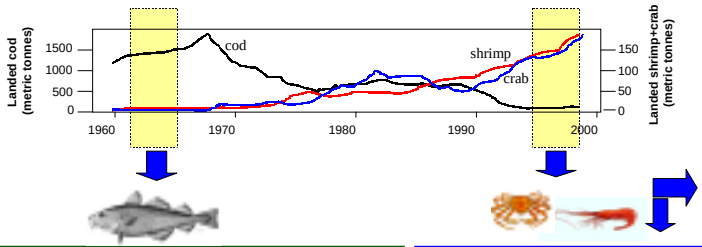
Memorial University of Newfoundland

Introduction

This review examines the effect of predation by fishery- related species on benthic communities from two points of view. First, we make inferences on the potential impact of a change in ecosystem top predators (from a previously cod dominated system to one now dominated by shrimp and crab). Second, we evaluate experimentally the role of shrimp and crab predation in a Western Newfoundland fjord.

Does a change on ecosystem's top predator influence the benthic community?

Figure 1. Long-term trends in cod, shrimp and crab. As cod collapsed, a switch in top predators was observed in the North Atlantic. Adapted with permission from Worm & Myers (Ecology 84, in press).



Scenario 1

The past: cod as top predator

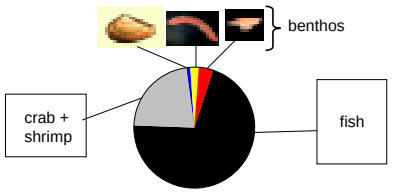


Figure 2. Cod diet. Different sources of data suggest that small benthic invertebrates represent < 8% (in wet weight) of the cod diet. Adapted from Hop et al. 1993. J.Fish Biol 43: 1-18.

But diet changes along life?

Predation on benthos is more prevalent in cod early stages, when individual feeding rates are relatively low. With age, feeding rates increase but cod prey mostly on fish, crab, and shrimp. Overall, benthos is only of secondary importance to cod diet and feeding.

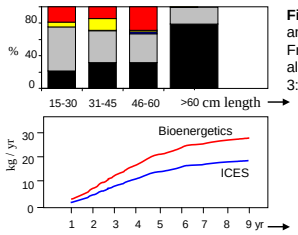


Figure 3. Cod diet and consumption. From Hansson et al. 1997. J Mar Sci 3: 107-14.

Scenario 2

The present: cod collapsed, shrimp + crab as top predator

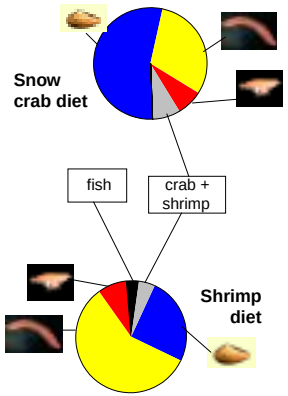


Figure 4. Snow crab and pandalid shrimp diet. Adapted from frequency of occurrence tables in Brethes et al. 1984 (Crustaceana 47: 235-244), and Weinberg, 1981 (Arch Fischerei wiss 31: 123-137), respectively.

In snow crab and shrimp diets, benthic invertebrates (polychaetes, molluscs, and peracarids) are all very important throughout the benthic phase.

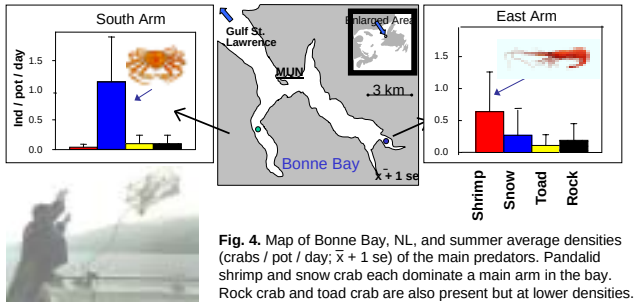
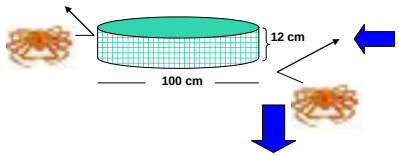


Fig. 4. Map of Bonne Bay, NL, and summer average densities (crabs / pot / day; $\bar{x}$ + 1 se) of the main predators. Pandalid shrimp and snow crab each dominate a main arm in the bay. Rock crab and toad crab are also present but at lower densities.

Exploring a current problem (second scenario)

Spatial differences in benthic community structure might be partially explained by differences in density and composition of the main benthic predators (Fig. 1). If that hypothesis is true, then experimental removal of the predators should change benthic communities compared to non-manipulated bottoms.

The approach: We tested this hypothesis by setting up field experiments at 30 m deep, in the two main arms of Bonne Bay.We monitored for changes at 0, 4 and 8 weeks. Three treatments were compared: exclusion, control and partial cages.



Deployment of cages and collecting of samples (7 cm diameter cores) was made by scuba diving.

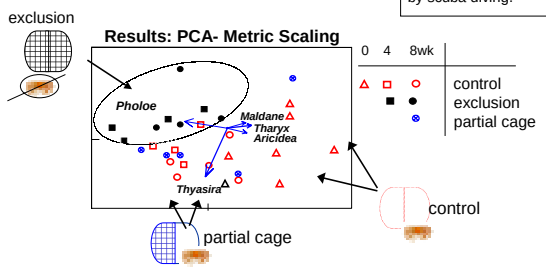


Fig. 5. Metric scaling plot of samples (South Arm shown only) after using PCA of Chord-Normalized Expected Species Shared (CNESS) similarity, and Gabriel Biplots (blue arrows) identifying the taxa that contribute most to between - sample differences. After 4 weeks, protected sediments (Exclusion cages, black symbols) separated from those exposed to predation (control + partial cages).

Field experiments showed that predation plays a role regulating benthic community structure, and identified species representative of sediments affected and protected from predation. One other question remained:

Which predators are actually contributing to that regulation?

One step further: predator contribution to the pattern

Laboratory experiments tested the impact of the three main predators: snow, toad, and rock crab. Intact infauna cores were collected and placed in cold circulating water tanks, exposed or protected from feeding by each crab.

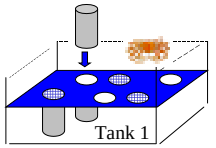
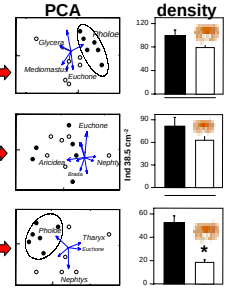


Fig. 6. Testing the effect of each benthic predator. Sediments were flush with a false bottom in a tank. Six cores were placed in each tank (3 protected, 3 exposed to predators), and four tanks were used per experiment. Each experiment lasted 4 days.

Fig. 7. Lab experiments: Protected (exclusion, black symbols) versus exposed (open) sediments, using different predators each time.



Overall, snow crab and rock crab are species that contribute to the patterns of benthic infauna observed in the field. A common species (the polychaete *Pholoe tecta*), was the most sensitive species in protected sediments in the lab and in the field experiments.

Conclusion

In the short term and at local scale, epibenthic predators regulate benthic community structure. In the long term, the composition of these predators is, and, has been modified by changes associated with the fishery (eg. Cod => shrimp+crab). It is reasonable to conclude that those changes introduced by the fishery will have indirect consequences for other components of the marine ecosystem. The benthic community, its composition and diversity are likely to be among these. More detailed analysis of the experiments described above will help to address the role of these species as ecosystem engineers.

Acknowledgements: The authors thank NSERC and the Fisheries Conservation Chair for funding. Special thanks to Bob Hooper, Patricia Ramey, Richard Haedrich, Mike (Kelly, Norris, Parson, and Rose) and the summer students of the Bonne Bay Field Station (MUN).