RESEARCH NOTE

EFFECTS OF PINNA CLAMS ON BENTHIC MACROFAUNA AND THE POSSIBLE IMPLICATIONS OF THEIR REMOVAL FROM SEAGRASS ECOSYSTEMS

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Seagrasses are widely distributed throughout the world’s oceans and are among the most productive and economically important of all ‘ecosystem engineers’. They provide habitat structure to coastlines that would otherwise consist of bare sand, and deliver significant ecosystem services not offered by seagrasses. Although Pinna clams—also known as ‘razor clams’, ‘razor fish’, ‘razor shells’ and ‘pen shells’ (Fig. 1A)—are habitat-forming bivalves that occur within seagrass meadows in many of the world’s oceans. In Lake Macquarie (New South Wales), Australia’s largest coastal lake, local residents and recreational users of the Lake have called for eradication of Pinna clams from seagrass meadows, because of the hazard they pose to swimmers. Their broad posterior margins are razor-sharp—hence the name ‘razor’—and, throughout the summer, a considerable number of swimmers require hospitalization after standing on the clams. ‘Razor—and, throughout the summer, a considerable number of swimmers require hospitalization after standing on the clams’. While Pinna clams—also known as ‘razor clams’, ‘razor fish’, ‘razor shells’ and ‘pen shells’ (Fig. 1A)—are habitat-forming bivalves that occur within seagrass meadows in many of the world’s oceans. In Lake Macquarie (New South Wales), Australia’s largest coastal lake, local residents and recreational users of the Lake have called for eradication of Pinna clams from seagrass meadows, because of the hazard they pose to swimmers. 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Fig. 3A). Whereas there were marginal effects of seagrass presence on the number of infaunal taxa (seagrass $F_{1,16} = 4.00$, $P = 0.06$), the number of infauna was higher in the presence of seagrass than in its absence (Fig. 3A). The total abundance of infaunal individuals was also higher in the presence of seagrass ($F_{1,16} = 6.38$, $P = 0.02$; Fig. 3B). There were no interactions

Figure 1. A. One valve (inside view) of a cleaned Pinna sp. shell taken from Lake Macquarie (NSW, Australia). B. An experimental plot showing a transplanted Pinna sp. with surrounding seagrass removed. C. A goby (Parablennius intermedius) peering out of a nonliving Pinna sp. shell.

Figure 2. Diagram of study site showing the 10 locations where Pinna sp. populations where surveyed (density and length). Point Wolstoncroft was also used for the manipulative experiment.
between Pinna sp. presence and seagrass presence. Both seagrass presence ($F_{1,16} = 3.43, P = 0.08$) and Pinna sp. presence ($F_{1,16} = 2.34, P = 0.14$) had marginal effects on sediment organic content in natural assemblages (Fig. 3C). Organic content was lower in the presence of seagrass than in bare sediments and was also slightly lower in the presence of Pinna sp. than in its absence (Fig. 3C).

At this same site, we conducted a manipulative, fully-crossed factorial experiment (Fig. 4), whereby we manipulated the presence and absence of Pinna sp. and seagrass cover (no removal, above-ground cover removal, total removal) and monitored the response (via changes in abundance and species richness) of benthic macro invertebrates and fish (assessed via visual census) at three points in time (after 1 week, 2 months and 5 months).
Pinna sp. treatment did not have independent or interactive effects on the abundance of associated species (Fig. 5B). Of the 16 fish species observed, the horned blenny (Parablennius intermedius) was the only species found to be affected by Pinna sp. treatment; this species was found to be significantly more abundant in dead clam shells ($F_{2,144} = 6.26; P < 0.001$; Fig. 1C), regardless of the habitat type in which these shells were situated. Similarly, Munguia (2007) found that dead pen shells (Atrina rigida) provide shelter for egg-laying fishes that did not appear to be offered by the surrounding seagrass.

Seagrass cover was highest in the no-removal treatments, intermediate in the above-ground-removal treatments and lowest in the complete-removal treatments (seagrass treatment $F_{2,105} = 233.82, P < 0.001$; Fig. 5A). The number of associated benthic macroinvertebrate species varied by sampling date when all treatments were pooled ($F_{3,144} = 3.06, P = 0.03$; Fig. 6), but there was no effect of seagrass treatment ($F_{2,144} = 1.99, P = 0.14$) or Pinna sp. treatment when sampling times were pooled ($F_{2,144} = 2.15, P = 0.12$). The total abundance of associated benthic macroinvertebrate species (monitored via visual censuses, see Supplementary Material) in our experimental plots also varied by sampling date ($F_{3,144} = 5.89, P < 0.001$; Fig. 6). In addition, there was a significant effect of seagrass treatment ($F_{2,144} = 7.04, P = 0.001$; Fig. 5B), with highest abundances in the above-ground-removal treatment, regardless of Pinna treatment (Fig. 5B). This effect was largely due to the response of the common gastropod species, Batillaria australis (seagrass treatment $F_{2,144} = 5.87, P = 0.003$) which had greatest abundance in the seagrass above-ground removal treatment (Fig. 5C).

Overall, this study suggests there are very small effects of Pinna sp. on local associated fauna that are not offered by seagrass meadows alone. The only substantial effect observed was that the presence of dead Pinna sp. shells significantly increased the abundance of horned blennies. This demonstrates, from an ecological point of view, that Pinna sp. clams are not functionally redundant in terms of facilitating biodiversity when seagrass is present. However, is the positive effect that these clams have on a single, nonthreatened fish species enough to outweigh proposed council actions to remove razor clams from popular swimming areas? This is a complex issue. With regards to the possible impacts on associated fauna, it is our opinion that removal of razor clams is unlikely to lead to any major impacts on horned blenny populations within Lake Macquarie. We should also point out that Pinna sp. probably support epiphytic communities (which we did not quantify) not found within seagrass (Munguia, 2007; Munguia & Miller, 2008).

That said, the main concern of removals could be the impacts on Pinna sp. populations themselves. Pinna sp. occur as metapopulations, with irregular dispersal (Burns & Smith, 2011). After settlement, growth of Pinna sp. recruits is rapid; they reach c. 260 mm in length during the first 2 years, which corresponds with the time of highest predation risk, and then grow about 35 mm per year thereafter (Butler & Brewster, 1979). This life-history strategy makes Pinna sp. dependent on the ‘storage effect’, whereby maintenance of populations is ‘stored’ in the adult population as a result of their long adult life (Butler et al., 1993). This means that populations are only stable if the longevity of adult populations is maintained, and that increases in adult mortality can cause localized population collapses (Katsanevakis, 2009). Localized removal of Pinna sp. could have serious detrimental consequences for persistence of the species within Lake Macquarie, especially given that their abundance was found to be highly variable among sites within the Lake.

**Figure 5.** The effects of seagrass removal (no removal vs above-ground removal vs above- and below-ground removal) and Pinna treatment (live Pinna, dead Pinna, or no Pinna) on seagrass percent cover (A), associated species abundance (B) and Batillaria australis abundance (C).
Further work is needed to identify possible ‘source’ and ‘sink’ populations, which could be achieved through analysis of the genetic structure of populations, combined with hydrodynamic modelling to assess connectivity among populations.

SUPPLEMENTARY MATERIAL

Supplementary Material is available at Journal of Molluscan Studies.

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REFERENCES


