RESEARCH NOTES

Effects of the 26 December 2004 tsunami on littorinid molluscs near Phuket, Thailand

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A major effort is being undertaken to understand the effects of the December 2004 Indian Ocean tsunami on the marine environment.[1–4] The emphasis has been on coral reefs, which are subtidal and offshore of the areas that were most heavily affected by the tsunami. The greatest losses of human life and destruction of human infrastructure occurred in the intertidal and supratidal regions where the waves had the greatest destructive force after they broke. We seek to determine the effects of the tsunami in the upper intertidal region, where the effects might be greatest, by using littorinid molluscs as an indicator group.

An extensive 2002 survey of the distribution of littorinid molluscs at 50 sites in mangroves and on rocky shores in Thailand was recently published.[5] Six of the study sites were on the Andaman Sea coast in the area of Phuket, Thailand, one of the regions most heavily hit by the tsunami. These sites (Fig. 1) were resurveyed between 13 and 18 April 2005, 3.5 months after the tsunami, to determine qualitatively what damage had occurred.

Thirteen species of littorinids were recorded in the initial survey at the six sites; only seven species were recollected after the tsunami. The tsunami was not uniform, and depending on local topography affected the shorelines in different ways. The study sites included both rocky shores and mangrove areas (Table 1). Rocky shores at Kalim Beach and Nang Thong Beach were directly hit by the tsunami. While littorinid populations decreased considerably, the rocks themselves were not affected. At Nang Thong Beach the adjacent sandy shoreline was extensively modified (Figs 2, 3). The rocky shore of Mai ngarm Bay, Surin Island, has scattered mangroves (*Rhizophora apiculata* and *R. mucronata*). The shore was in the lee of the tsunami and there were no visible effects. A site at an extensive mangrove at Laem Mai Kaew was heavily hit by the tsunami and was unrecognizable after the event; all littorinids at the site had disappeared. It should be noted that the site was at the seaward fringe of the mangrove, which was affected by the tsunami. The trees rapidly dissipated the force of the tsunami and there were no obvious effects shoreward of the mangrove fringe. Mangroves at Pak Meng Beach and Ta la Beach were largely unaffected by the tsunami. Even where littorinid species were present after the tsunami, densities appeared to have decreased. Even in areas where there were no apparent effects of the tsunami on rocks or mangroves, some of the littorinids were washed off the rocks or trees. Population reductions were likely to have been caused by the tsunami. However, it has been three years since the initial surveys were undertaken at the sites. As population densities are naturally variable, the reductions could have been due to another cause. For example, substantial natural declines in the population of *Nodilittorina unifasciata* (Gray, 1826) at Waterman Bay, Western Australia occurred over a two-year period.[6]

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The fact that only seven of the 13 littorinid species originally found at the six study sites were present after the tsunami is not a cause for concern. The pattern found in the littorinids, as in the reefs, is of different effects in different areas. It is likely that more detailed studies would show that there are populations of the species remaining in the area that can recolonize areas affected by the tsunami. All of the species are widespread.[7–12] The species with the smallest known distribution, *Littoraria bengalensis*, was described in 2001, and is known from the west coast of Thailand and also from India.[11] All of the other species have much broader ranges. As far as is known, all of the littorinid species occurring on the west coast of Thailand have a planktonic larval stage, which will allow the ready dispersal of larvae into affected areas during the next spawning season. In summary, the immediate effects of the tsunami on littorinids in the Phuket area have been patchy, and it is likely there will be no major permanent changes to the distribution of species in the area.

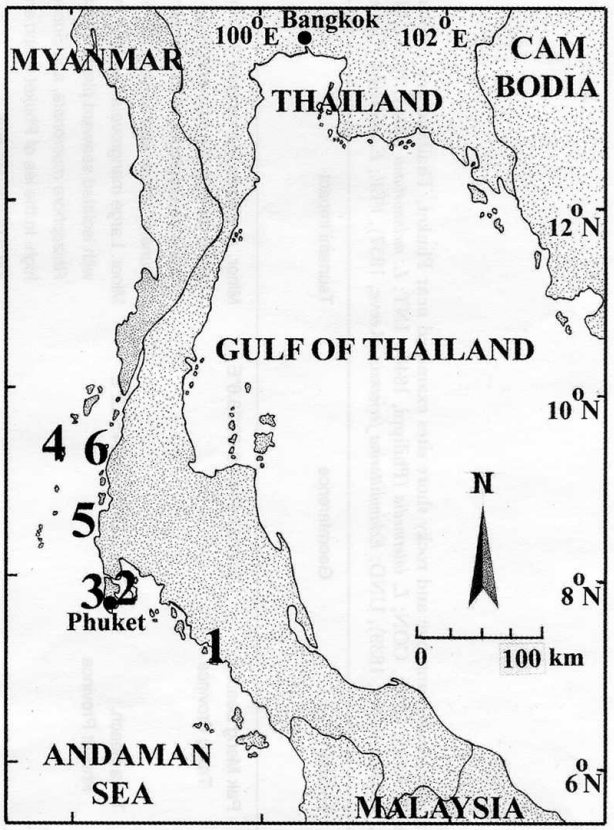

Figure 1. Map of Thailand showing the locations of study sites along the Andaman Sea coast. Site numbers are the same as on Table 1.

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Table 1. Details of mangrove and rocky shore sites examined near Phuket, Thailand and littorinid species present. Key: *Littoraria bengalensis* Reid, 2001, BEN; *L. carinifera* (Menke, 1830), CAR; *L. conica* (Philippi, 1846), CON; *L. intermedia* (Philippi, 1846), INT; *L. melanostoma* (Gray, 1839), MEL; *L. pallescens* (Philippi, 1846), PAL; *L. scabra* (Linnaeus, 1758), SCA; *L. strigata* (Philippi, 1846), STR; *L. undulata* (Gray, 1839), UND; *Echinolittorina feejeensis* (Reeve, 1857), FEE; *E. trochoides* (Gray, 1839), TRO; *E. vidua* (Gould, 1859), VID; *Peasiella roepstorffiana* (Nevill, 1885), ROE.

Site	Location	Georeference	Tsunami impact	Pre tsunami		Post tsunami	
				Survey date	Species present	Survey date	Species present
1	Pak Meng Beach, Trang Province	7°27'37.6"N; 99°20'23.6"E	Minor. *Avicennia marina* grew 3–5 m high in a small area along the side of a seaward canal. There was no change in the physiography of the shoreline caused by the tsunami, which was weak in this area.	6 Dec 2002	CAR, BEN, STR	15 Apr 2005	BEN
2	Ta la Beach, Phuket Province	8°1'10.8"N; 98°24'51.2"E	Minor. Large mangrove area along the mouth of a canal with isolated seaward plants, mostly *Avicennia marina, Rhizophora mucronata*, and *Sonneratia griffithii* 5–7 m high. In the lee of Phuket Island and not hit by the direct force of the tsunami.	7 Dec 2002	PAL, STR, BEN	15 Apr 2005	PAL, STR, BEN
3	Kalim Beach, Phuket Province	7°54'11"N; 98°17'53.6"E	Major. Rocky intertidal outcrop at northern end of a sand beach on the exposed side of Phuket Island. Heavily hit by the tsunami.	7 Dec 2002	UND, TRO, VID, FEE Abundant	15 Apr 2005	UND, TRO Numbers reduced
4	Mai ngarm Bay, Phangnga Province	9°26'27.7"N; 97°52'48.5"E	Minor. Rocky shore on an offshore island, with scattered *Rhizophora apiculata* and *R. mucronata*, in the lee of the tsunami.	20 Apr 2002	TRO, VID, ROE, UND, INT, SCA, PAL	18 Apr 2005	TRO, VID, UND, SCA
5	Nang Thong Beach, Phangnga Province	8°38'14.9"N; 98°14'56.6"E	Major. Small rocky outcrop on a long sandy beach near a small tidal channel. Severely affected by tsunami, with all houses destroyed and over 1000 people killed. It has since been bulldozed clean. Tidal channel removed by the tsunami.	8 Dec 2002	UND, TRO, VID	14 Apr 2005	TRO
6	Laem Mai Kaew, Ranong Province	9°27'58.5"N; 98°26'13.9"E	Major. Extensive mangrove about 800 m from the sea, including *Finlaysonia maritima*, *Ceriops decandra* and *Aegialitis rotundifolia*. Open coast; all infrastructure destroyed and extensive loss of human life. Post-tsunami seaward portion of the mangroves destroyed and unrecognizable.	3 Sep 2002	CAR, MEL, BEN, CON, PAL	14 Apr 2004	None

Figure 2. View of the site at Nang Thong Beach before the tsunami.

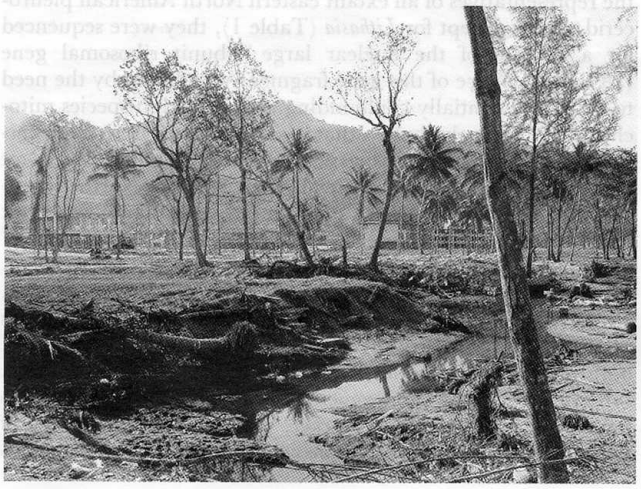

Figure 3. View of the site at Nang Thong Beach after the tsunami.

The pattern of differential effects of the tsunami is in agreement with the picture emerging of damage on coral reefs. Only four days after the tsunami an international effort was undertaken to assess impacts on coral reefs on marine national parks in the Andaman Sea area of Thailand.[1,2,4] Analysis of 174 reef sites revealed that nearly two-thirds (61%) had no or very low (defined as 1–10%) impacts. Only 13% of the sites had a heavy impact, in which >50% of the reef was affected. Similarly, the northern islands of the Seychelles, which were most exposed to the tsunami had the greatest damage. Southern islands, which were in the lee of the northern islands, were less affected. Within this pattern reefs with underlying granite were less affected than those with a carbonate base.[3]

The results on the effect of the tsunami on molluscs of coral reefs in the Phuket area are similar to those presented here for littorinids.[13] Very little direct evidence was found of damage to mollusc populations on the reefs as a result of the tsunami. Visible effects were restricted to two areas. In regions where large *Porites* bombies were overturned there were undoubtedly some losses due to debris being thrown about in the water. Molluscs living in or attached to the upturned coral are likely to die over time as they are no longer in their proper habitat. In some heavily affected areas, portions of the populations of intertidal species of molluscs such as nerites and muricids were washed off the rocks and died. Accumulations of dead shells of these species were found in the sand at the base of the granite rocks. As with the intertidal littorinids examined in this paper, portions of the nerite and muricid populations survived even at heavily affected sites.

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