Spiny lobster resources and opportunity for culture in post-tsunami Aceh, Indonesia

Conference Paper · December 2008

CITATIONS
4

READS
37

3 authors:

Alexander Tewfik
Wildlife Conservation Society
41 PUBLICATIONS **480** CITATIONS
SEE PROFILE

David Jonathan Mills
WorldFish
56 PUBLICATIONS **787** CITATIONS
SEE PROFILE

Dedi Supriadi Adhuri
Indonesian Institute of Sciences
49 PUBLICATIONS **416** CITATIONS
SEE PROFILE

Spiny lobster resources and opportunity for culture in post-tsunami Aceh, Indonesia

Alexander Tewfik, David Mills and Dedi Adhuri[1]

Abstract

In an effort to facilitate the restoration of livelihoods that reduce poverty and increase future resilience for the poor coastal communities of Aceh province, we investigated responses related to the pre-existing lobster fishery and the potential for lobster culture. Six species of spiny lobster endemic to the Indonesian archipelago (*Panulirus homarus, P. longipes longipes, P. ornatus, P. penicillatus, P. polyphagus* and *P. versicolor*) were identified through random sampling (August 2007 – September 2008) at landing sites in the district of Aceh Jaya. The great variety of benthic habitats (sand, pavement, rock and coral) and oceanographic conditions (clean oceanic water, continental run-off) in the area have combined to facilitate this high diversity. The largest mean carapace lengths and individual masses were represented by *P. ornatus* (89 mm, 817 g) and *P. polyphagus* (84 mm, 463 g) which also represented the smallest portions of the total catch, 6.1% and 1.8%, respectively. *Panulirus homarus* was the most frequently caught (34.9%) while *P. penicillatus* constituted the highest total mass (34.7%). Female to male ratios varied and were sometimes greatly biased towards males (*P. ornatus*, 0.42:1; *P. versicolor*, 0.48:1; *P. penicillatus*, 0.58:1). More than 36% of female lobsters landed were egg-bearing. Regression analyses revealed strong relationships ($R^2 > 0.81$) between carapace length and total mass for all six species despite small sample sizes for some. This is likely due to the unbiased population sampling through fishers who indiscriminately target all lobsters using bottom nets due to their high value. Prices for the largest size class (>300 g) of spiny lobster during 2008 ranged between Indonesian rupiah (Rp)120,000 (US$13) and Rp180,000 (US$20) per kilogram.

The presence of suitable habitats, observations of juvenile and adult spiny lobster in those habitats, the steady landings and the availability of a network of buyers and nearby markets (Banda Aceh, Medan, Singapore) have encouraged the design and deployment of experimental lobster puerulus (i.e. larva) collectors. Our puerulus collectors integrate some design elements from Australia (targeting *Jasus edwardsii*), use locally available artificial materials (light plastic fibre, outdoor carpet) and are built quickly (<2 hours) at a reasonable cost (<US$10). The materials and design attempt to mimic macroalgae and rock crevices. Twenty-eight collectors were randomly deployed in front of a fringing reef just north of an offshore island. Collectors were anchored in 5–6 m of water using reinforced concrete blocks, individually, paired or in quads approximately 1.0–1.5 m below the surface. The collectors appeared quite robust over the 6-month monitoring period (February–July). Although the collectors did facilitate the natural settlement of encrusting organisms and various shrimp, no spiny lobster pueruli were observed. We intend to proceed with design modifications and future deployments in other nearby areas and during other seasons. The deployment of such collectors on lift net (bagan) arrays, where lights are used for night fishing, will also be attempted. Finally, a detailed lobster fisher survey will provide better understanding of fishing and puerulus settlement patterns.

Keywords: aquaculture; puerulus collector; bagan; lift net

[1] The WorldFish Center, PO Box 500 GPO, 10670 Bayan Lepas, Penang, Malaysia
Email: <a.tewfik@cgiar.org>

Introduction

The catastrophic effects of the great Sumatra–Andaman earthquake and associated tsunami of 26 December 2004 were most severely felt by the poor coastal communities of Aceh province, Indonesia. These communities, variously engaged in fishing, farming and aquaculture, lost a significant proportion of the population and most of their livelihood assets (e.g. boats, fishing gear, tools, livestock) and supporting infrastructure (landing sites, markets) (Ananta and Onn 2007; Tewfik et al. 2008). The tsunami also severely damaged much of the coastal forest, fish ponds, agricultural lands and associated livelihoods as well as increasing the vulnerability to future extreme weather events and chronic sea-level rise. Examination of the impacts of this event across the Indian Ocean region highlights that systems with healthy natural environments and diversified livelihoods are more resilient to shocks and thus recover more quickly (Danielsen et al. 2005; Olsen et al. 2005). In an effort to facilitate the restoration of livelihoods that reduce poverty and increase community resilience[2] we investigated possible responses related to the pre-existing lobster fishery as well as the potential for the development of lobster culture. These activities included the compilation of biological details on local lobster populations in support of both the management of the capture fishery and future activities of puerulus collection and grow-out. Such work adds to broader efforts that include an array of habitat (e.g. mangroves) and livelihood (e.g. crab fattening, tilapia cage culture, postharvest) restoration activities as well as support to traditional and government resource-management bodies.

Study site, marine habitats and fisheries regulations

Aceh province lies at the western tip of Sumatra island and is surrounded by a range of nearshore habitats and substrates including mud, rubble, coral reefs and macroalgae beds with sand and pavement predominating on the north-east and south-west coasts, respectively (Long et al. 2006) (Figure 1). Our specific study area, in Sampoinet subdistrict, faces south-west towards the Indian Ocean within the district of Aceh Jaya (4°53'N, 95°24'W) (Figure 1). The dominant physical features of the nearshore area include the shallow and gently sloping (<1.4°) embayment (lhok) of Kruet (coarse sand and pavement bottom) and the island (pulo) of Raya. The discharge of the Kreung No River may have a strong influence on nearshore turbidity and benthos during certain times. The area around Pulo Raya is notable for its fringing reef habitat, including a number of hard-coral morphologies (3.5%: encrusting, massive, tabulate) as well as soft corals and sponges (together 1.3%), macroalgae (11.1%) and numerous rocky reefs (Long et al. 2006). Populations of spiny lobster (*Panulirus* spp., 32/ha) and reef-associated fish (coral trout, humphead wrasse, grouper, snapper and sweetlips) have been surveyed down to 15 m and constitute important fisheries resources in the study area (Long et al. 2006). In general, tsunami damage to coral and other subtidal habitats around Aceh is considered minimal (Baird et al. 2005). However, observations of a fine silt layer in sheltered locations of patch reef may be evidence of tsunami-related run-off. Such terrestrial materials may have long-term impacts that may be difficult to assess or predict given the lack of pre-tsunami data. Annual rainfall in the area is abundant (>2,500 mm), with two major seasons prevailing: wet (south-west monsoon from April to September), also associated with strong winds, rough seas and flooding; and dry (north-east monsoon from October to March) (Whitten et al. 2000). These two seasons, and related patterns of terrestrial sediment discharges and nearshore currents, often dictate the pattern of fishing activities and may also significantly influence the recruitment patterns of marine organisms (coral, lobster) to local benthic habitats. Local fisheries regulations are limited to: (1) restriction of specific fishing gears on specific grounds; (2) prohibition of destructive gears (e.g. cyanide, trawl, explosives); (3) prohibition of surface-supplied diving for lobster; (4) an obligation for outsiders to obtain permission to fish; and (5) prohibition of fishing on Fridays. Lobsters are exclusively caught using nets set on and around a variety of benthic habitats.

[2] Resilience is 'the potential of a system to remain in a particular configuration and to maintain its feedbacks and functions, and involves the ability of the system to reorganize following disturbance driven change' (Walker et al. 2002).

Lobster landings

Six species of spiny lobster endemic to the Indonesian archipelago (*Panulirus homarus, P. longipes longipes, P. ornatus, P. penicillatus, P. polyphagus* and *P. versicolor*) (see Figure 2) were identified through random sampling (August 2007 – September 2008) at landing sites in and around Lhok Kruet (Table 1). The general habitat preferences of Indo-West Pacific spiny lobsters of the equatorial zone are strongly influenced by hydrodynamics and turbidity and have been previously grouped as: 1. oceanic species in areas of strong surge (seaward side of coral or rocky reefs) and waters 'uncontaminated' by terrestrial run-off (*P. penicillatus*); 2. species strongly associated with coral reefs in

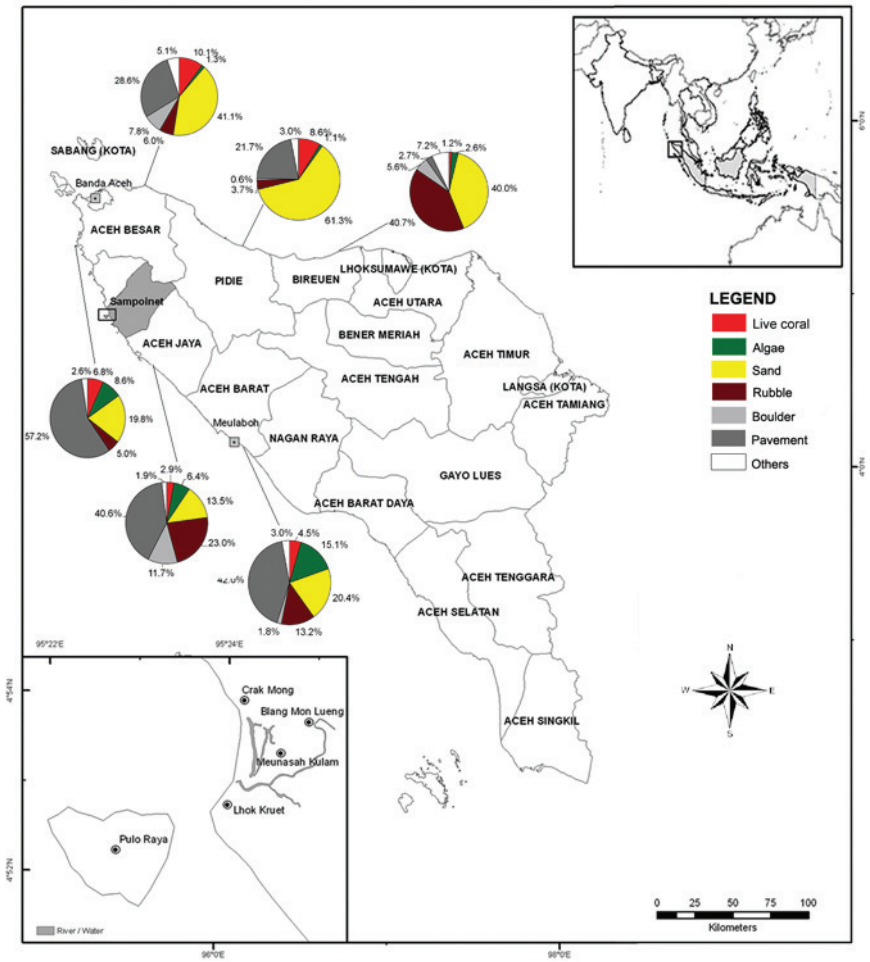

Figure 1. Map of Aceh province, Indonesia, showing its districts, including the study site located in Sampoinet subdistrict (grey area) of Aceh Jaya, and distribution of dominant nearshore benthic cover in surveyed districts. Inset top right: position of the main map within South-East Asia. Inset lower left: focal communities and permanent water bodies of the study area (detail of box in main map).

Notes: Benthic cover survey included over 550 transects (20 × 2 m) (Long et al. 2006). 'Others' category includes dead coral, soft coral and sponge. In the survey, Aceh Besar district was divided into north-east and south-west coasts.

areas sheltered from oceanic swells (*P. l. longipes* and *P. versicolor*); and 3. continental species found in coastal areas with soft sediments and variably influenced by terrestrial run-off (George 1974; Holthuis 1991; Coutures 2000). The continental species habitat niche may be further subdivided into: 1. lagoons dominated by silty bottoms and scattered coral (*P. ornatus*); 2. mixed sand/low terrestrial detritus substrates (*P. homarus*); and 3. areas where substrates are dominated by high levels of terrestrial detritus near discharges of rivers (*P. polyphagus*) (George 1974). The Bahasa Indonesian names for certain species—*P. homarus*, pasir (sand) lobster and *P. penicillatus*, batu (stone) lobster—may have evolved in fishing communities due to observations of strong habitat affinities. The great variety of benthic habitats (sand, pavement, rock and coral) and oceanographic conditions (clean oceanic water, continental run-off, strong currents) as well as the central position of the study site within the broader Indo-West Pacific region have likely combined to facilitate the high diversity of equatorial spiny lobster species we observed.

The largest mean carapace lengths and individual mass were represented by *P. ornatus* (89 mm, 817 g) and *P. polyphagus* (84 mm, 463 g). *Panulirus polyphagus* also represented the smallest portion of the total catch in both number of individuals and total mass landed, followed by *P. ornatus* (Table 1). The smallest mean carapace length and individual

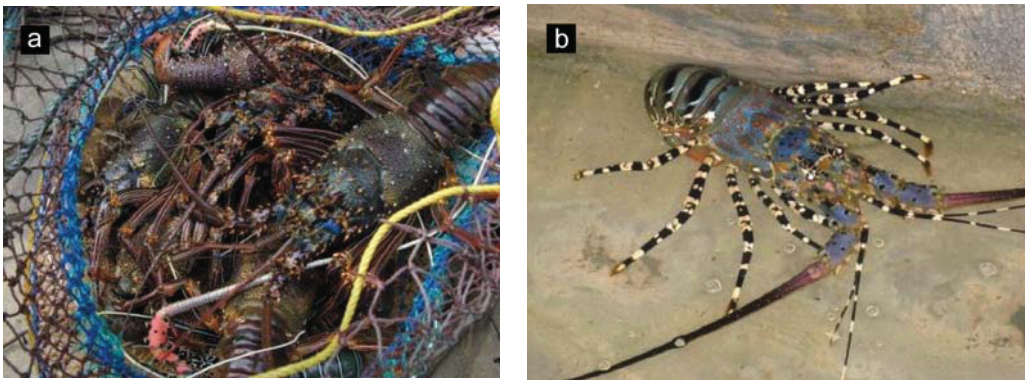

Figure 2. (a) Single fisher landing of *Panulirus longipes longipes*, *P. penicillatus* and *P. versicolor*; (b) *P. ornatus* in an onshore holding tank

Table 1. Summary of *Panulirus* spiny lobster data collected at Lhok Kruet, Aceh Jaya, Aceh Province (August 2007 – September 2008)

Attribute	*P. homarus*	*P. longipes longipes*	*P. ornatus*	*P. penicillatus*	*P. polyphagus*	*P. versicolor*
Total sampled	251	88	17	203	9	152
Mean CL (mm)	66	59	89	74	84	67
Min. CL (mm)	32	37	42	34	52	37
Max. CL (mm)	106	95	129	138	120	123
Total mass (g/individual)	281	223	817	388	463	261
Total mass caught (%)	31.1	8.7	6.1	34.7	1.8	17.5
Total individuals caught (%)	34.9	12.2	2.4	28.2	1.3	21.1
Females (%)	45.4	53.4	29.4	36.9	44.4	32.5
Egg-bearing (%)	24.6	61.7	40.0	40.0	25.0	32.7
CL at 50% maturity (mm)[a]	73	55	107	74	101	77
Min. CL at maturity (mm)[a]	45	44	92	46	101	43
Average price (US$/kg)[b]	19.90	14.50	20.15	13.40	16.40	16.30

[a] Mature females were considered as those in egg-bearing state
[b] Mean value for largest size class (>300 g) (January – November 2008)
Note: CL = carapace length; Min. = minimum; Max. = maximum

mass was found for *P. l. longipes* (59 mm, 223 g). Individuals of *P. homarus* were the most frequently caught (34.9%) while *P. penicillatus* constituted the highest total mass caught (34.7%). Sixty-one per cent of the total catch was landed during the north-east monsoon period (October – March). This may simply be due to fishers switching to other marine resources (reef-fish, small pelagics) during the south-west monsoon. Total mass frequency distributions for the four most commonly landed species may indicate disproportionate impact on the larger size classes given the broad range of lobsters targeted using nets (Figure 3). Females often accounted for less than half of the catch, which was sometimes greatly biased towards males (*P. ornatus*; *P. versicolor*) and may be of a particular concern for *P. penicillatus*, which represents a significant portion of the total catch (Table 1). More than 37% of all female lobsters landed and almost 62% of female *P. l. longipes* were egg-bearing. Most egg-bearing females were landed during the north-east monsoon period (63%) with peaks occurring in April and October (Figure 4).

The fisheries-dependent data collected in this study are considered quite representative of the wild population. This is due to the fact that fishers indiscriminately target all lobsters using small mesh bottom nets due to their high value regardless of size.

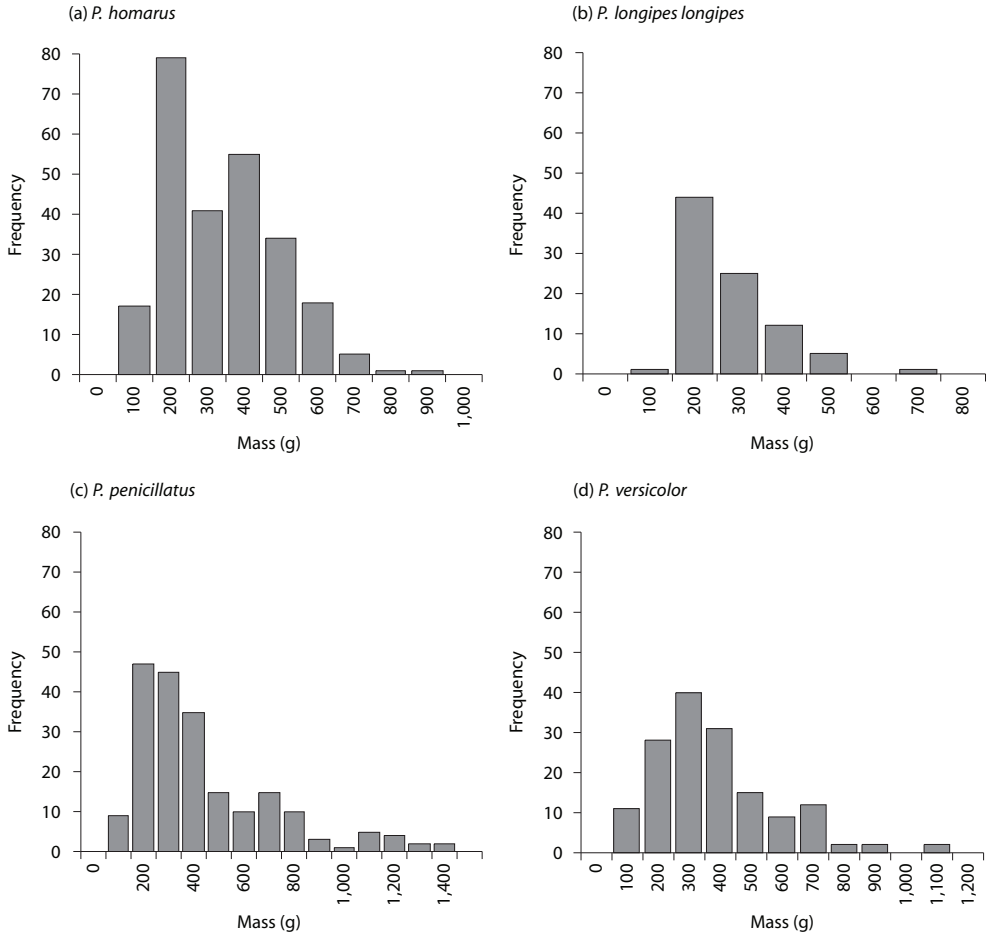

Figure 3. Total mass (g) frequency distributions for the most commonly landed species of spiny lobster at Lhok Kruet, Aceh Jaya, Aceh province: (a) *Panulirus homarus* (*n* = 251), (b) *P. longipes longipes* (*n* = 88), (c) *P. penicillatus* (*n* = 203) and (d) *P. versicolor* (*n* = 132)

Such fishing practices result in landings of small juveniles, egg-bearing females and a by-catch of other low-value crustaceans (e.g. *Carpilius maculatus*) that are usually discarded. After being landed, lobsters are weighed and sold to local buyers who may hold them for several days in floating pens or onshore in concrete ponds (Figure 5). When a sufficient number of lobsters has been accumulated, they are rolled in clean sand and packed live in cardboard boxes with frozen bottles of water. Land transport to markets and export points in Banda Aceh (120 km away) may take 4–5 hours depending on road conditions. Prices for the largest size classes (>300 g) in premium condition (live, undamaged) during 2008 ranged between rupiah (Rp)120,000 (US$13) and Rp180,000 (US$20) per kg (Table 1). A number (approximately 11%) of non-palinurid lobsters (e.g. *Parribacus antarcticus*—kipas hitam) is also landed and constitutes the lowest-value portion of the lobster catch (Rp25,000 or US$2.50/kg).

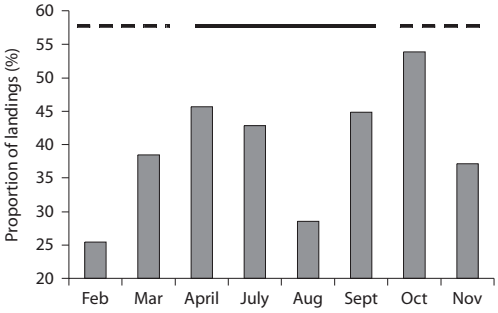

Figure 4. Occurrence of egg-bearing females (n = 122) amongst all female spiny lobsters caught (n = 341) between April 2007 and September 2008. Bold horizontal line indicates north-east (dashed) and south-west (solid) monsoon periods when 63% and 37%, respectively, of egg-bearing females

Puerulus collector testing

The presence of suitable habitats and associated observations of lobster, dependence on lobster-generated income for some households and the availability of a network of buyers and nearby markets (Banda Aceh, Medan, Singapore) have encouraged the design and deployment of experimental puerulus (i.e larva) collectors (Figure 6). Such collectors may facilitate local grow-out options presently being trialled elsewhere in Indonesia (Jones 2007) and well practised in Vietnam (Tuan and Mao 2004). Our puerulus collectors integrated design elements from Australia (Phillips et al. 2001; Mills and Crear 2004), used locally available artificial materials (light plastic fibre, outdoor carpet) and were built quickly (<2 hours) at a reasonable cost (<US$10) (Figure 6a). The materials and design attempt to mimic macroalgae settlement for pueruli and crevices to shelter recently settled juveniles as well as providing appropriate substrate for other invertebrates that may serve as food for early lobster life-history stages. Twenty-eight collectors were randomly deployed over the fringing reef just north of Pulo Raya (Figure 1). Collectors were anchored in 5–6 m of water using steel-reinforced concrete blocks individually, paired or in quads approximately 1–1.5 m below the surface (Figure 6b). The collectors appeared quite robust over the 6-month deployment period (February–July). One year after deployment, fouling as well as damaged or missing floats caused the collectors to sink before being removed from the water. Although the collectors did facilitate the natural settlement of encrusting organisms and various shrimp, only a single juvenile *Scyllarides squammosus* slipper lobster was observed during four monitoring events (Figure 6d).

Future work

Our lobster landings data collection program revealed that *P. homarus* (pasir lobster) and *P. penicillatus* (batu lobster) are the most important species caught. These species appear not to associate directly with coral habitats but rather on sand bottoms or rocky reefs in more oceanic or turbid water conditions, respectively (George 1974). Therefore, the deployment of our collectors over coral reefs may have possibly limited our target range to coral-dependent species (*P. l. longipes, P. versicolor*). The limited period of the collector monitoring (February – July) may have missed peak puerulus settlement periods. Given the importance of lobsters to local communities and potential livelihood opportunities through grow-out, we intend to proceed with collector design variants, future deployments and more frequent monitoring. Future deployments will take place over various habitats, and during various seasons as well as from lift net (bagan) arrays (Figure 6e). Deployment from

bagans, operated by lobster fishers, will benefit from being in a secure location that can be easily monitored and moved to other locations. The use of bagans as puerulus collector platforms also eliminates the need for individual collector anchor systems and benefits from bagan lighting traditionally meant to attract small pelagics during night-fishing operations. A detailed lobster fisher survey is also underway and should provide a more complete understanding of fishing patterns, observations of puerulus settlement and attitudes on the prospect of culturing and management of the lobster fishery. Finally, the long-term success of lobster seed collection and development of lobster grow-out may be well suited to the experience of local people who already practise short-term, postcapture lobster care (Figure 5) and other types of aquatic husbandry (tilapia, milkfish).

References

Ananta A. and Onn L.P. 2007. Aceh: a new dawn. Institute of Southeast Asian Studies: Singapore.

Baird A.H., Campbell S.J., Anggoro A.W., Ardiwijaya R.L., Fadli N., Herdiana Y., Kartawijaya T., Mahyiddin D., Mukminin A., Pardede S.T., Pratchett M.S., Rudi E. and Siregar A.M. 2005. Acehnese reefs in the wake of the Asian tsunami. Current Biology 15, 1,926–1,930.

Coutures E. 2000. Distribution of phyllosoma larvae of Scyllaridae and Palinuridae (Decapoda: Palinuridea) in the south-western lagoon of New Caledonia. Marine and Freshwater Research 51, 363–369.

Figure 5. Short-term lobster holding systems: (a) floating pen off Lhok Kruet; (b) concrete pen using closed circulation with (c) simple biological filtering (coral rubble) system (Samatiga, Aceh Barat, see Figure 1 for location)

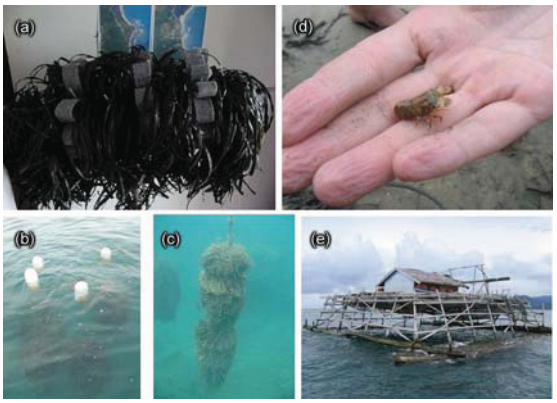

Figure 6. Puerulus collectors: (a) newly constructed; (b) anchored quad of collectors with surface floats; (c) collector after 12 months in situ; (d) juvenile *Scyllarides squammosus* (slipper lobster) retrieved from collector after 12 months and (e) lift net (bagan) array set north of Pulo Raya

Danielsen F., Sørensen M.K., Olwig M.F., Selvam V., Parish F., Burgess N.D., Hiraishi T., Karunagaran V.M., Rasmussen M.S., Hansen L.B., Quarto A. and Suryadiputra N. 2005. The Asian tsunami: a protective role for coastal vegetation. Science 310, 643.

George R.W. 1974. Coral reefs and rock lobster ecology in the Indo-West Pacific region. International Coral Reef Symposium 1, 321–325.

Holthuis L.B. 1991. Marine lobsters of the world. Food and Agriculture Organization of the United Nations (FAO) species catalogue volume 13. FAO: Rome.

Jones C. 2007. Improving lobster grow-out and nutrition in Nusa Tenggara Barat—a feasibility study. Australian Indonesian Partnership, Australian Centre for International Agricultural Research: Canberra, 23 pp.

Long B.G., Hamdani A., Andrews G., Courboules J., Ibros Z., Sinaga M., Scott P.J.B., Siregar A. and Mansyur K. 2006. Aceh nearshore atlas and draft marine zonation plan. Marine and Coastal Resources Management Project (Asian Development Bank Loan No. 1770-INO – Department of Fisheries, Indonesia): Jakarta.

Mills D. and Crear B. 2004. Developing a cost-effective puerulus collector for the southern rock lobster (*Janus edwardsii*). Aquacultural Engineering 31, 1–15.

Olsen S.B., Matuszeski W., Padma T.V. and Wickremeratne H.J.M. 2005. Rebuilding after the tsunami: getting it right. Ambio 34, 611–614.

Phillips B.F., Melville-Smith R., Cheng Y.W., Rossbach M. and Bourque B.J. 2001. Testing collector designs for commercial harvesting of western rock lobster (*Panulirus cygnus*) puerulus. Marine and Freshwater Research 52, 1,465–1,473.

Tewfik A., Bene C., Garces L. and Andrew N.L. 2008. Reconciling poverty alleviation with reduction in fisheries capacity: boat aid in post-tsunami Aceh, Indonesia. Fisheries Management and Ecology 15, 147–158.

Tuan L.A. and Mao N.D. 2004. Present status of lobster cage culture in Vietnam. In 'Spiny lobster ecology and exploitation in the South China Sea region: proceedings of a workshop held at the Institute of Oceanography, Nha Trang, Vietnam, July 2004', ed. by K.C. Williams. ACIAR Proceedings No. 120, 21–25. Australian Centre for International Agricultural Research: Canberra.

Walker B., Carpenter S., Anderies J., Abel N., Cumming G.S., Janssen M., Lebel L., Norberg J., Peterson, G.D. and Prichard R. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conservation Ecology 6, 14. At: <http://www.ecologyandsociety.org/vol6/iss1/art14/>. Accessed 24 June 2009.

Whitten T., Damanik S.U., Anwar J. and Hisyam N. 2000. The ecology of Sumatra. The Ecology of Indonesia Series, volume 1. Periplus Editions: Hong Kong.