Fig. 1 **a** Rock piles 1 year after installation in rubble field in Komodo National Park. **b** Coralline algae and scleractinian recruits on rocks: *Seriatopora guttatus* (?) 40 mm wide *between calipers*; encrusting *Acropora sp. lower left* (*arrow*)

Pilot study suggests viable options for reef restoration in Komodo National Park

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Among the many threats currently facing coral reefs in Southeast Asia, dynamite or "blast" fishing ranks as perhaps the most immediately and extensively damaging in many areas (Erdmann 2000). Although illegal, blast fishing is widely practiced and can result in high yields and profits. In addition to rupturing the swim bladders of the targeted fish, the homemade ammonium nitrate fertilizer and kerosene bombs also shatter the hard coral skeletons. Even in areas where successful management programs have decreased the incidence of blast fishing, large fields of unconsolidated dead coral fragments remain.

Komodo National Park, located in eastern Indonesia between the islands of Sumbawa and Flores, has had relatively effective enforcement of the ban on blast fishing since 1996, due largely to patrolling efforts led by the Nature Conservancy. Without intervention the rubble fields in the Park are likely to have long, potentially indefinite recovery times because new coral recruits are buried or abraded by the moving rubble, especially in areas with strong currents (Fox et al. 2001).

Reef restoration is an option to consider because of the lack of stable substrate for coral establishment (Edwards and Clark 1998). Most of the artificial reef technologies currently employed are not applicable due to the limited financial resources of developing countries or are primarily fish-aggregating devices that do little to enhance coral recruitment. Transplantation, which can be expensive and labor-intensive, was not considered, because most reefs around Komodo are not recruitment limited.

A pilot study was begun in 1998 to test three inexpensive, low-tech, and locally available substrate stabilization methods: netting pinned to the rubble, cement slabs, and piles of quarried rock. The rock piles were most successful, and larger-scale trials were initiated in April 2000 (Fox et al. 2001). Three (or more) 0.5–2.0 m^3 rock piles were installed at each of nine rubble field sites throughout the Park (Fig. 1).

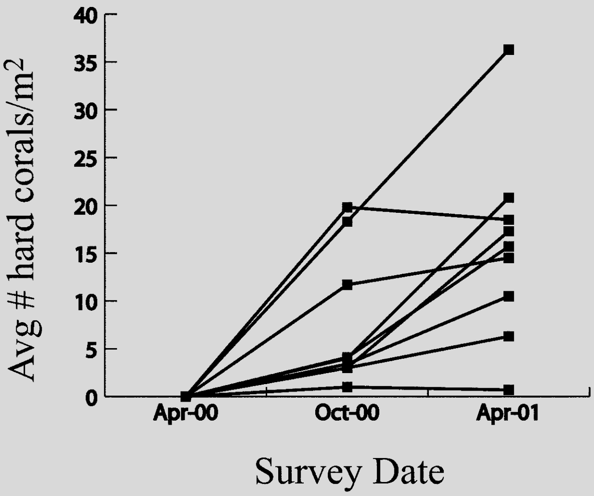

Fig. 2 Average numbers of scleractinian recruits per square meter to large (0.5–2 m^3) rock piles within the first year, based on six 1×1-m quadrats at each of nine sites in Komodo National Park. Standard errors of the mean ranged from 0.4 to 2.7 for October 2000, and from 0.3 to 6.4 for April 2001

Table 1 Mean numbers of hard coral colonies (per m^2) and standard errors of the mean at each of nine sites, based on six 1×1-m quadrats per site, surveyed in October 2000 and April 2001

Site no.	Average October 2000	Average April 2001	SEM October 2000	SEM April 2001
1	19.8	18.5	3.0	3.4
2	11.7	14.5	1.7	3.5
3	4.0	20.8	0.7	4.3
4	3.4	10.5	1.6	1.9
5	18.3	36.3	2.7	6.4
6	3.0	17.3	0.8	2.4
7	1.0	0.7	0.4	0.3
8	3.0	6.3	0.6	1.2
9	4.1	15.7	1.0	2.4

The piles were surveyed for scleractinian recruits in October 2000 and April 2001 using six 1×1-m quadrats (Table 1). Coralline algae and other encrusting organisms colonized the rock piles quickly, and within 1 year there were many hard coral recruits 2–4 cm in diameter (Fig. 1, inset). Thus far, the rock piles have been resistant to shifting and burial by rubble and sand. There are an average of 15.7 scleractinian recruits per m^2 (± 1.65 SE, $n = 54$), although the range across the sites is wide, from an average of $0.7/m^2$ to $36.3/m^2$ ($n = 6$; Fig. 2). During the same time period, there was no significant increase in natural coral recruitment in unstable rubble fields. The approximate cost of this method is US\$5–10/m^2, an order of magnitude less than many other restoration schemes.

While more extensive analyses are currently in preparation, these initial results are encouraging and suggest the potential of rehabilitating reefs in areas that were damaged in the past but now are effectively managed.

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