Enhancing Reef Recovery in Komodo National Park, Indonesia: Coral Reef Rehabilitation at Ecologically Significant Scales

INTERIM REPORT: Project Installation

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For further background information and brief literature review regarding this project, please refer to the Proposal and December 2001 Interim Report and Monitoring Protocol.

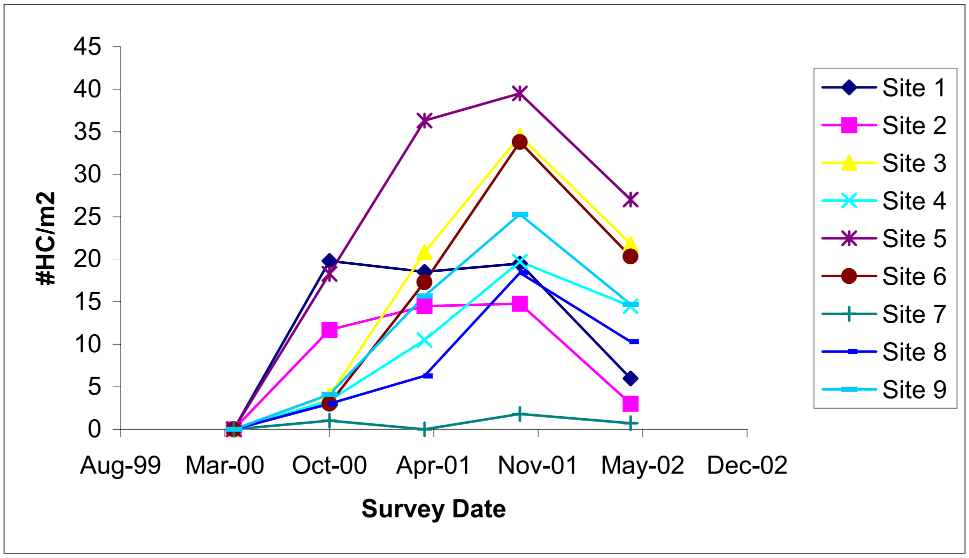
Introduction:

The natural and assisted recovery of coral reefs destroyed by dynamite or "blast" fishing in Komodo National Park, Indonesia was researched between 1998 and 2001. This study demonstrated the successful recruitment of hard corals to piles of inexpensive and locally available quarried rocks. This treatment is now being scaled up to cover ecologically significant portions of damaged reefs to re-create the large three dimensional reef structure that allows colonization by a full reef community of fish and invertebrates. Four different designs of rocks (parallel to prevailing current, perpendicular to prevailing current, complete coverage and rock piles) are being installed over a total of two hectares of rubble fields to test which method resists encroachment of rubble best to yield the best recovery per cubic meter of rock.

Activities During Second Visit:

Survey of Coral Recruitment to Rock Piles from Spring 2000:

Rock piles installed in Spring 2000 at nine rubble fields have been monitored twice yearly for hard coral (HC) and soft coral (SC) growth (Figure 1). This trip, an average of 13 coral colonies/m^2 were recorded, ranging from 1 HC/m^2 where soft coral growth is extensive along northern Rinca (Site 7), to 27 HC/m^2 along Karang Makassar (Site 5). Decrease in numbers of HC at Sites 1 and 2 is probably due to increased *Xenia* cover. The rocks at Pulau Mengyatan (Site 2) are also nearly buried by sand, and only two square meters of one pile are visible. Although the total number of hard corals has dropped at all sites since the last survey in October 2001, the sizes of the existing coral colonies appear to be increasing, so the overall percent cover of hard coral colonies is increasing. Sites chosen for large-scale rehabilitation have an average of 20 HC/m^2, which is considerably higher than the ambient recruitment to nearby rubble fields (4 HC/m^2). After only two years, ecologically and economically important fish and invertebrates such as grouper, *Trochus,* and *Octopus cyanea* have inhabited these piles.



Firgure 1. Average numbers of scleractinian recruits per square meter to large (0.5-2m^2) rock piles within the first two years based on six 1x1 m quadrats at each of nine rubble field sites in Komodo National Park. For site locations see Figure 1 in the December 2001 report.

Installation of New Rock Piles

Socialization:

The appearance of large piles and rows of rocks on rubble fields in KNP has sparked both curiosity and skepticism of people in Labuan Bajo. Supposed reasons for the rock treatments include abalone farming by TNC. Fishermen wonder whether it's safe to drive their boats near or over them. Although people think positively of the rehabilitation project when informed, they express their strong desire for The Nature Conservancy to increase communication with the public. Ron has prepared a one-page information sheet about the project to be translated into Bahasa Indonesia to be distributed throughout the park. A local TV station is preparing a short piece with Andreas that will include underwater video of the rock piles.

An informal meeting was held with Andreas and Yusuf to discuss the project's progress, difficulties, and goals. Socialization is the primary concern. They also wish to give a small tip to volunteer divers who help arrange rock piles and thus reduce number of speedboat days necessary to complete the arrangement.

Installation Process:

After the initial visit and review of rock installation in December 2001, recommendations were made to make the process more efficient, and many of these suggestions have been implemented or modified. Yusuf places a float on the location where the rocks should be unloaded, and the TNC speedboat helps the cargo boat anchor in two or more places to minimize drift from the target area. A snorkeler ensures that no coral or previous treatments are being damaged by this process. The TNK divers and speedboat often wait 1.5-3 hours at the site as the rocks are unloaded. A snorkeler and sometimes the speedboat help the cargo boat alter position as often as every ten minutes to streamline the rock-dropping process. If the rocks are unloaded properly and currents aren't too strong, four to five divers (two TNK plus two to three volunteers) can usually arrange 13 trucks of rocks in one dive. Four to six boat/diver days are needed to install each treatment. More dives are needed to arrange the rock piles and fewer dives are needed to arrange the complete coverage.

Placement

In general, the rocks are being installed next to the appropriate bamboo stakes according to the original plan. Exceptions are the rock piles and rows perpendicular to current in Padar, which has been discussed with Yusuf. Divers will be able to shift some of the rock rows, and shallower rock piles will be added. Future installations should continue to place rocks in the marked areas with the goal to continue (but not injure) the nearby live coral cover, a concept that was discussed during a meeting with Andreas and Yusuf, who have been coordinating the project.

Placement of treatments on slopes, in strong current, or on old rubble

One of the biggest challenges faced while rehabilitating blasted reef is the stabilization of existing rubble, a problem that is particularly difficult on steep slopes or in strong currents. Because slopes provide easy boat access to shallow reefs, a large portion of blasted reefs are on slopes, so it is important to find out which rehabilitation treatments work best on this aspect. Blasted reefs with strong tidal currents are challenging cases for conservation and rehabilitation because existing rubble not only rolls and prohibits new growth, it shifts and can bury or undercut nearby live coral. Treatments at sites with a steep slope (such as Karang Makassar) or high current (such as Padar) will help determine which treatments are most stable on a blanket of rubble, which resist encroachment of shifting rubble dunes, and which best reduces undercutting of nearby coral.

At Karang Makassar, the deepest rows of rock parallel to the current have already started to merge together. The heavy treatment appears to be sliding on the unstable rubble down the steep slope, and it will be interesting to see whether or not the rocks form a large stable row at some point. However, at Gililawadarat, the rows perpendicular to the current extend down a steep slope to 30 feet and appear to be maintaining shape. All configurations on slopes should be mapped on a regular basis, perhaps once or twice a year, with particular attention to depth.

Padar has the strongest currents of all of the rehabilitations sites, and also has good larval supply. Thus, this site is a logical place to assess treatment of high current sites with potential for rehabilitation. Large (about 1m tall) ridges of rubble shift and bury coral. Although soft coral appears to offer some stability to the shallower live reef, it is being undercut by erosion of rubble along the edge. Rubble and sand has started to build up (about 0.3m deep) next to some rock piles around the perimeter of the 25m x 25m treatment. However, current seemed noticeably weaker to divers between rock piles, and this treatment may form a refuge from currents that should continue to modify local flow (perhaps further enhancing coral settlement) once corals are established and heterogeneous structure increases.

Some concern was expressed that rubble might be too "old" to rehabilitate. Unfortunately, there is not an established method of judging rubble field age, other than weathering of rubble, and there are no existing comparisons or time lines. Although there has been blasting in Komodo for approximately 50 years and many reefs have probably been blasted all along, the blasting history of most sites is unknown. Most recent blast sites (such as those at Nusa Kode or at Tatawa Kecil, which are blasted since there's still reef and therefore fish there) are relatively small craters that are not amenable to the large-scale cargo-boat installation of rehabilitation treatments. Furthermore, given the current patterns, old rubble can easily move over new rubble. Also, as was determined in studies at North Sulawesi following blast craters of known age, the newly-blasted rubble doesn't look much different from the rubble in Komodo, other than that having less coralline algae. Therefore, it seems unlikely that a rubble field of new rubble would necessarily recover any faster or slower than one of older rubble. However, if there is only tiny rubble and sand (like at Pulau Mengyatan, Site 2), rehabilitation efforts are likely to be unsuccessful, as evidenced by the sharp drop in numbers of colonies on the Spring 2000 rock piles at that site.

Review of rocks already installed:

The rocks installed as of the end of May 2002, with the dates of installation, are given below in Table 1. The total number of trucks of rocks delivered to a site is given in parentheses.

Table 1. Dates of rocks installed at each site. Total number of trucks of rocks installed is given in parentheses. * Denotes treatments that were considered completed but should be extended with more rocks to meet original size goals.

	Rock Piles	Complete Coverage	Rows Parallel to current	Rows perpendicular to current
Papagarang		12/8/2001; 3/10, 3/22, 4/9/2002 (43)*		4/23, 5/6, 5/8, 5/28/2002 (51)
Padar	12/12/2001; 3/3, 3/20, 3/25, 4/7, 4/21/2002 (65)*		3/8, 3/20,5/18, 5/20, 5/22/2002 (62)	
Gililawadarat	4/15, 4/29, 5/14/ 2002 (39)			12/4, 12/10/2001; 4/5, 5/4, 5/16/2002 (45)*
Karang Makassar		4/17, 4/19, 5/3, 5/16, 5/30/2002 (62)*	12/6, 12/14/2001, 3/6, 3/18, 4/3/2002 (55)	

Treatment sizes

Maps of rocks installed (except perpendicular rows at Padar) have been prepared to monitor both initial placement as well as integrity of shape once established (Figures 2 and 3). A map of the rows perpendicular to the current at Padar was not prepared because of time constraints and because the rows may be shifted. Close-up figures that include specific dimensions of rocks appear at the end of this text as Appendices.

“Completed” treatments installed so far are smaller than target coverage and have received fewer than the 60-70 allotted truckloads of rocks (Table 2). Rows are shorter and piles are fewer than planned. Installation priority should be given to completing these arrangements as soon as possible to minimize damage to the new colonizing community. Timely installation is also necessary so that colonization rates can be monitored consistently.

Table 2. Dimensions of treatments compared to target dimensions. Numbers in yellow are current treatment dimensions. Numbers in blue are total square meters that should be added to meet original size goals. See plan maps to determine where to extend.

Location	Design	Length	Width	Total	Site Totals
Padar Utara	full coverage	15	11	165	
Padar Utara	Piles	80	20	1600	
		25	25	625	975
Padar Utara	parallel spurs	30	25	750	
Padar Utara	perpendicular spurs	30	25	750	
TOTAL PADAR					3265
Papagarang S.	full coverage	12.5	12	150	
		13	7	91	59
Papagarang S.	Piles	35	35	1225	
Papagarang S.	parallel spurs	20	20	400	
Papagarang S.	perpendicular spurs	20	20	400	
		20	15	300	100
TOTAL PAPAGARANG					2175
Gililawadarat	full coverage	20	10	200	
Gililawadarat	Piles	80	15	1200	
		50	15	750	450
Gililawadarat	parallel spurs	50	15	750	
Gililawadarat	perpendicular spurs	50	15	750	
		50	13	650	100
TOTAL GILILAWA					2900
Karang Makassar	full coverage	10	20	200	
		10	10	100	100
Karang Makassar	Piles	50	30	1500	
Karang Makassar	parallel spurs	25	30	750	
Karang Makassar	perpendicular spurs	25	30	750	
		20	20	400	350
TOTAL K. MAKASSAR					
GRAND TOTAL					11540

Qualitative Description of Rock Colonization:

Algae and animals have already started to colonize rocks that were installed less than five months ago. A few small hard coral recruits are already visible on rock piles at Padar, and qualitative assessment of rocks at other sites revealed the presence of coralline algae, turf algae and tunicates. Non-diver stationary video was taken at treatments installed in December 2001 (Gililawadarat- parallel to current; Karang Makassar-perpendicular to the current; Padar- rock piles; Papagarang- complete coverage) as well as on nearby untreated rubble. Each comparison showed higher fish numbers and diversity at the rocks than around the rubble. Fish on rubble fields (primarily small schools of parrotfish and surgeonfish) appeared transient. Fish at rock treatments, on the other hand, spent more time in the frame and some appear to be using the rocks as refuge. Fish observed include grouper, damselfish, surgeonfish, parrotfish, Moorish idols, anthias, *Chromis*, and fusiliers.

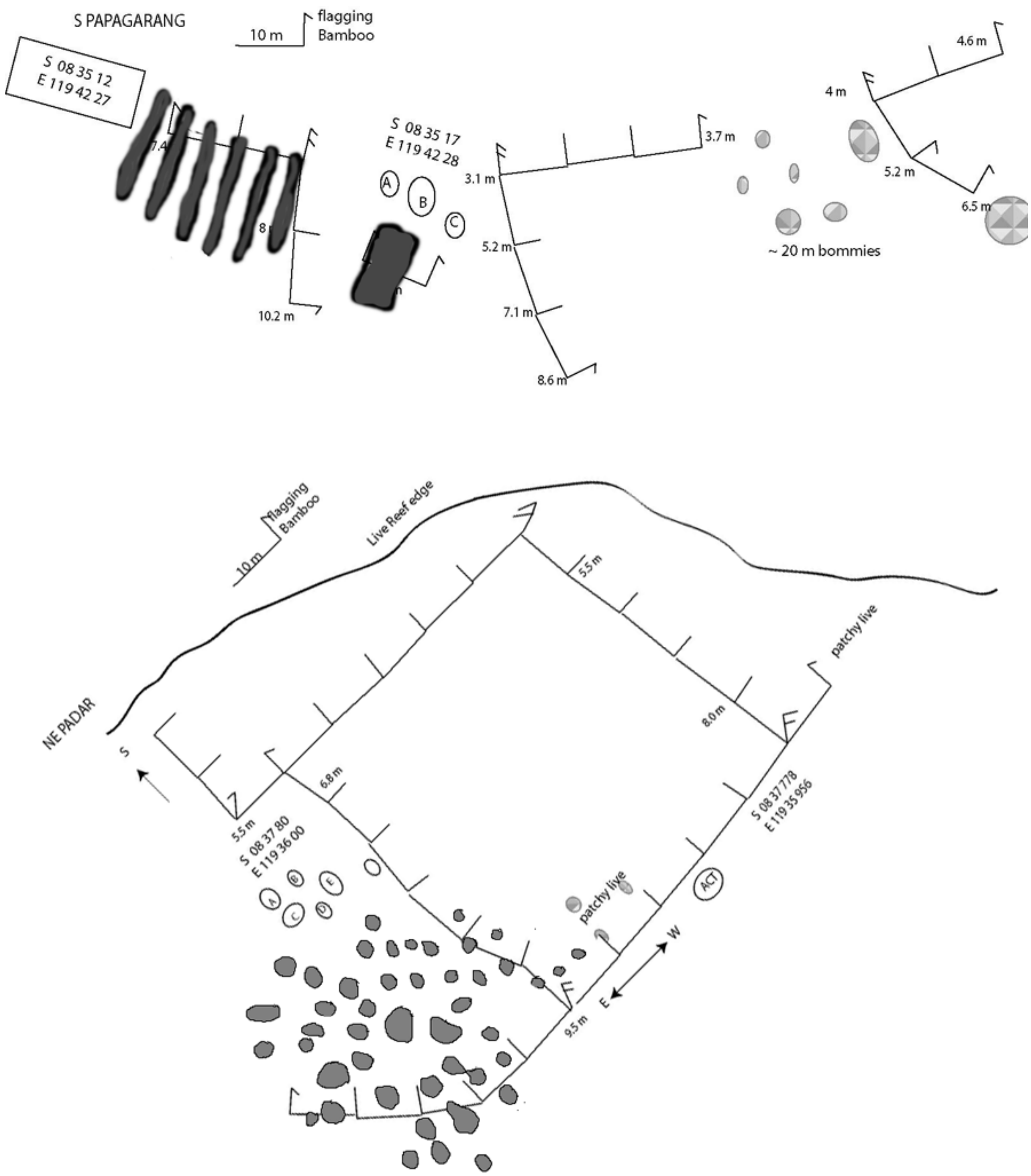


Figure 2. Rocks already installed Papagarang (top) and Padar (bottom- missing rock rows perpendicular to the current) by May 2002. Please see Appendix 1 for close-up views and dimensions.

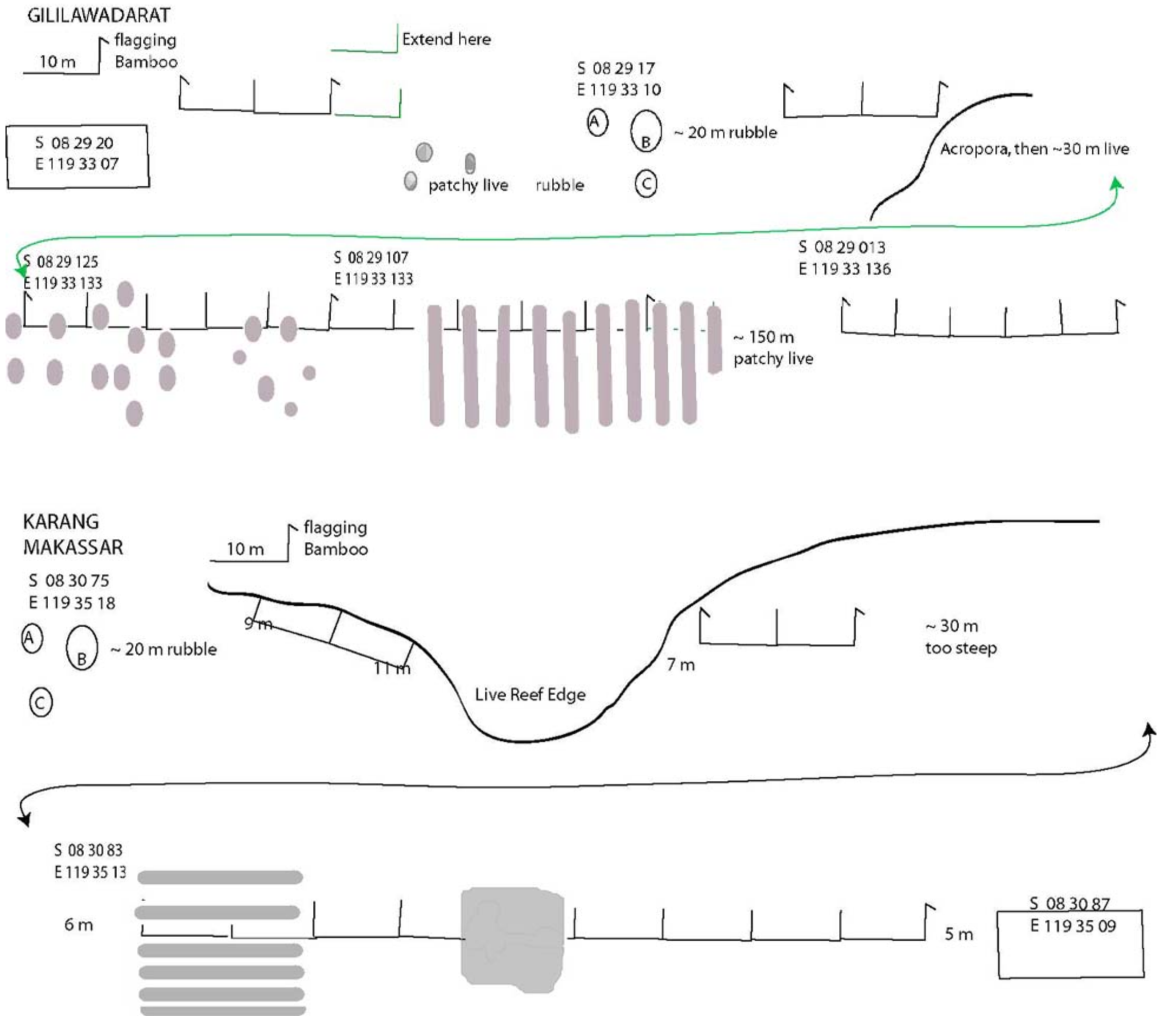


Figure 3. Rocks already installed at Gililawadarat (top) and Karang Makassar (bottom) by May 2002. Please see Appendices 2-4 for close-up views and dimensions.

Expenses (Boat Use, Trucks and Exchange Rates)

The Indonesian Rupiah has strengthened (now 8,800 Rp/USD up from 10,000 Rp/USD in December 2001), which reduces the spending power of the project by over ten percent (loss of about $4800). The target cost for the cargo boat (1.5million Rp/ day) has not been met because of rising fuel costs. A boat has been located that drops 250 truckloads per month (10 trips of 12 or 13 trucks each) for 2 million Rp per trip. Given this current arrangement, the rocks will be installed after seven months rather than twelve, and some of the funds lost to exchange rate and boat costs are recovered (although the project will still cost about an additional $2000 from the calculations in December 2001). However, this still leaves a “cushion” and it is not anticipated that the project will go over budget.

Appendix 1: Papagarang: Rows or rocks perpendicular to prevailing current and complete rock coverage. All treatments here are between 0.75-1m high.

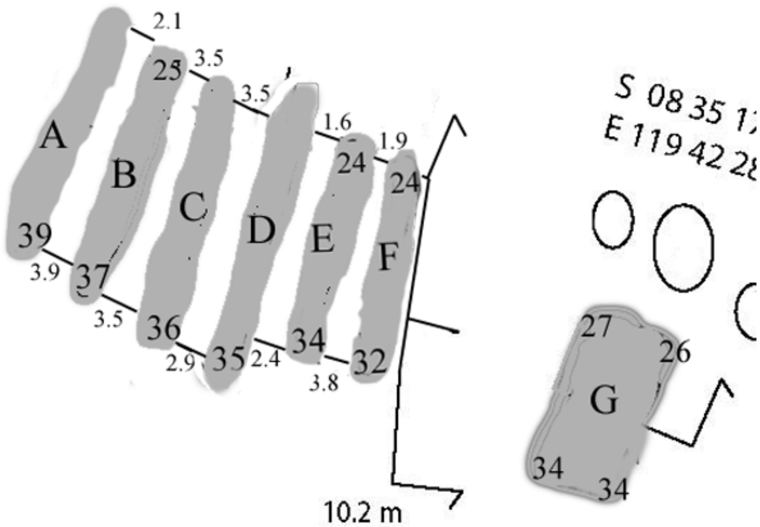


Figure 3.1: Close-up map of rows and complete coverage showing distances (m) between rows and depth

Table 3.1: Dimensions of rows and complete coverage (m) are given in the table below

	A	B	C	D	E	F	G
Length	13.8	13.7	13.2	15.7	12.1	12.6	13.0
Width (top)	2.1	1.6	1.7	1.4	1.7	2.0	7.2
Width (bottom)	1.8	1.5	1.8	1.3	1.7	1.4	6.5

Appendix 2: Gililawadarat Rock Piles (batu gunung)

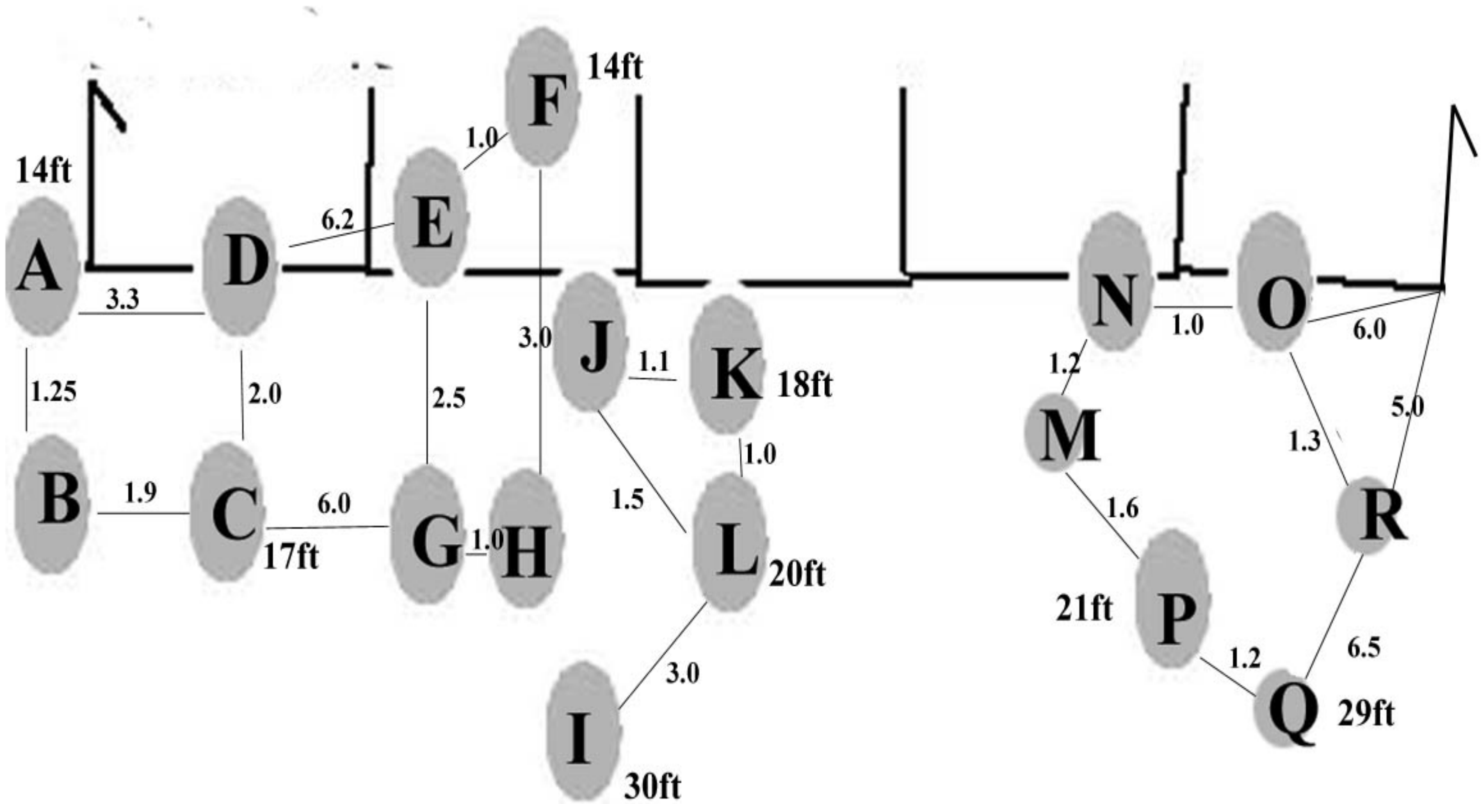


Figure 2.1: Close-up map of rock piles showing distances (m) between rock piles and depth

Table 2.1: Dimensions of piles (m) and depths (ft) of rock piles are given in the table below

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Length	2.35	2.60	2.65	2.80	2.40	3.00	2.90	1.30	3.00	2.90	2.80	2.40	1.70	2.30	3.30	3.60	2.40	2.40
Width	1.65	2.40	2.10	1.80	2.70	3.90	2.70	3.90	2.40	2.70	2.70	1.80	1.70	2.10	3.10	3.20	2.10	1.70
Height	0.85	0.85	0.85	1.10	0.90	1.40	0.95	1.10	0.70	0.95	0.75	0.70	0.70	0.70	0.90	0.85	0.70	0.60
Depth	14	17	17	13	14	14	20	20	30	18	18	20	19			21	29	21

Appendix 3: Gililawadarat Spur and Groove Perpendicular to the prevailing current

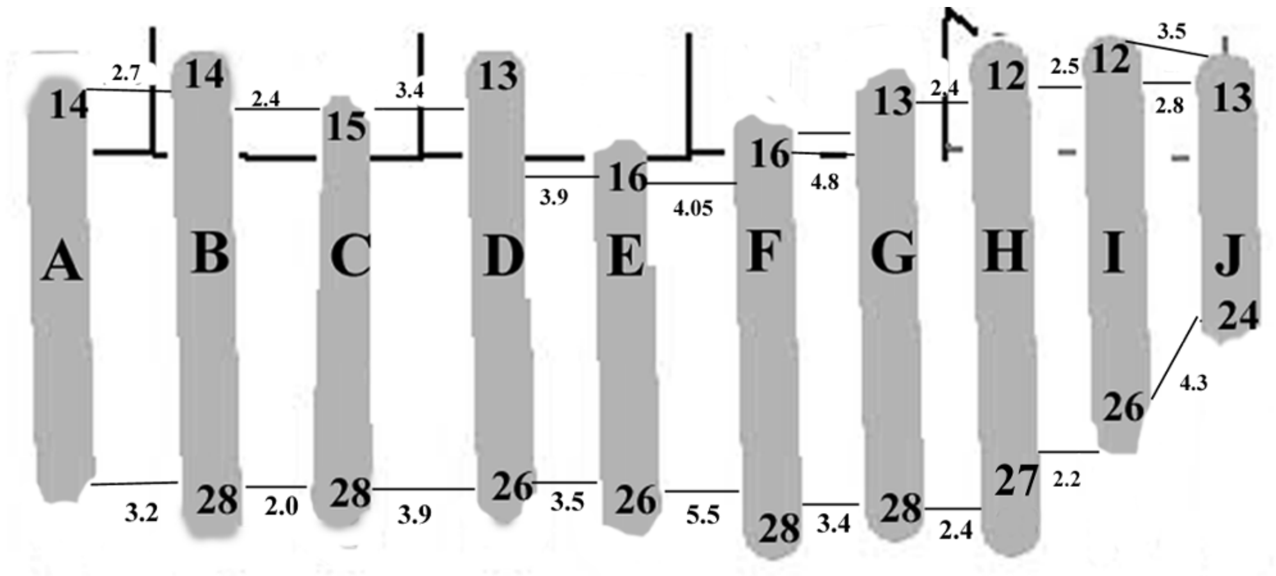


Figure 3.1: Close-up map of rows of rocks. Depths (large numbers at the top and bottom of rows) and distances (m) between rows are shown.

Table 3.1: Dimensions of rows (m)

	A	B	C	D	E	F	G	H	I	J
Length	10.9	12.7	9.0	10.1	8.7	10.0	12.4	12.2	10.7	7.5
Width (top)	1.9	1.9	2.1	1.7	1.8	2.3	1.9	2.0	1.8	1.5
Width (bottom)	1.9	2.2	2.3	1.3	1.5	2.7	1.4	2.4	1.2	2.0

Appendix 4: Karang Makassar Groove and Spurs parallel to current.

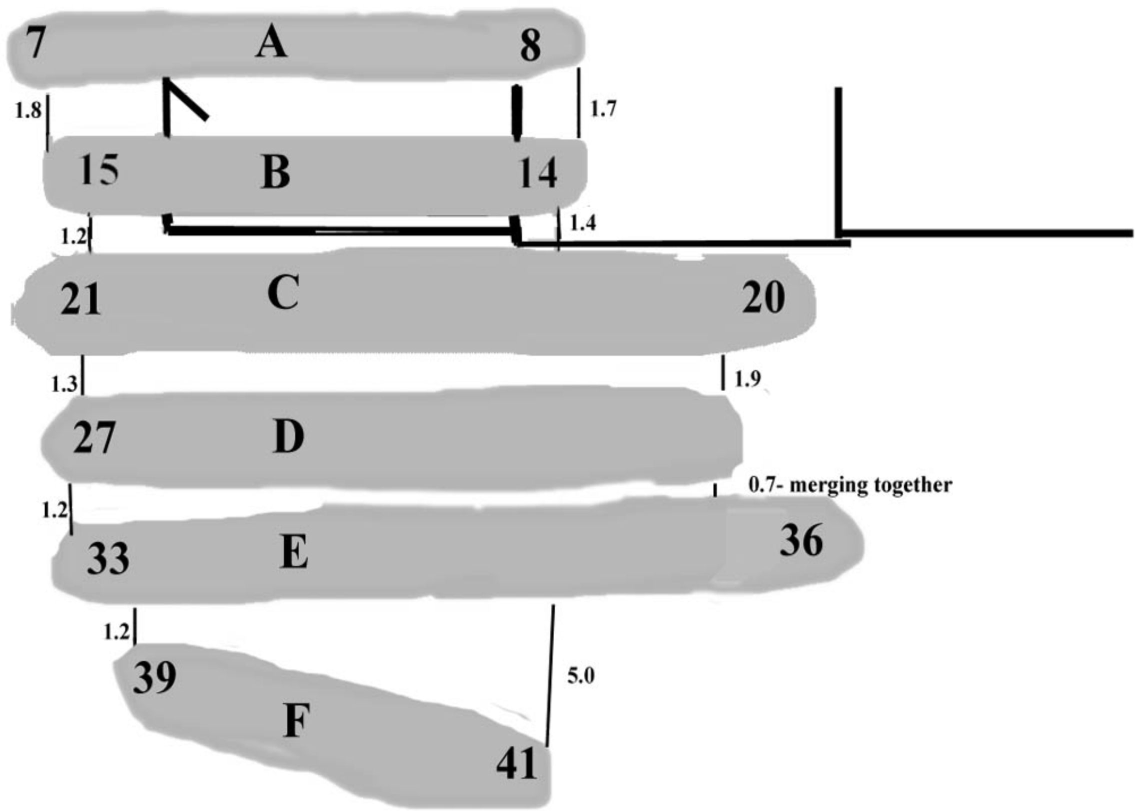


Figure 4.1: Close-up map spurs showing distances (m) between rock piles and depth (ft)

Table 4.1: Dimensions of rows (m)

	A	B	C	D	E	F
Length	16.8	15.6	19.1	17.4	23.0	6.8
Width (left)	1.7	2.2	2.7	2.4	2.4	2.5
Width (right)	1.4	3.1	1.8	1.7	2.4	2.0

Complete coverage is: 8.9-10.4m wide, 9-11m long, 0.4-0.9m tall