

**Status of the coral reefs in and around
Komodo National Park
1996-1998**

monitoring report

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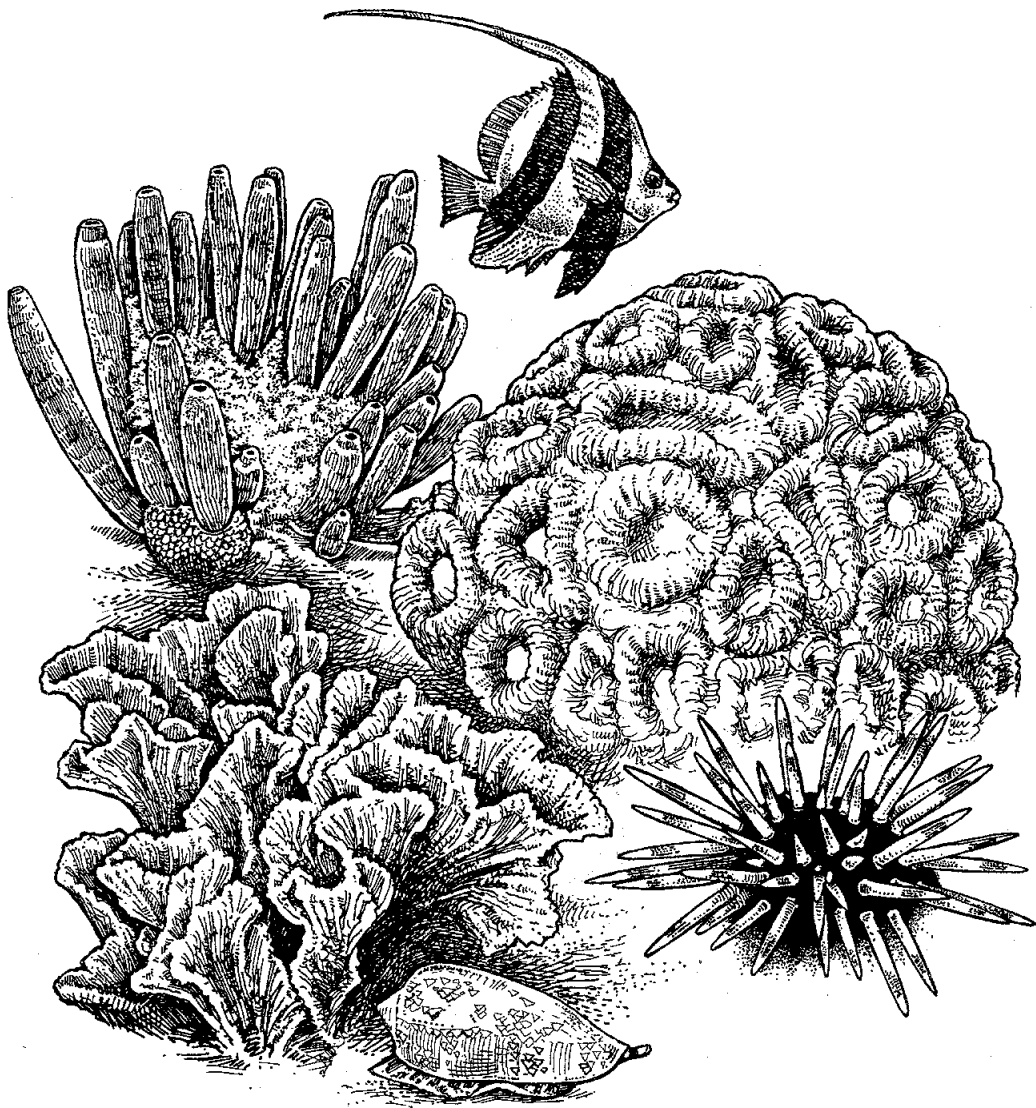
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1. INTRODUCTION: A LONG TERM MANAGEMENT PLAN FOR KOMODO NATIONAL PARK

In October 1996, a draft management plan was completed for the marine component of Komodo National Park (KNP), which was (and is still) seriously threatened by destructive fishing practices such as dynamite fishing, cyanide fishing, reef gleaning and plain overfishing. Destructive fishing practices destroy both the habitat (coral reefs) and the resource itself (fish and invertebrate stocks). The most important recommendations in the management plan are that destruction and harvesting of sedentary marine resources in KNP should be greatly reduced and that decision making, implementation and enforcement should be carried out in collaboration with the local communities.

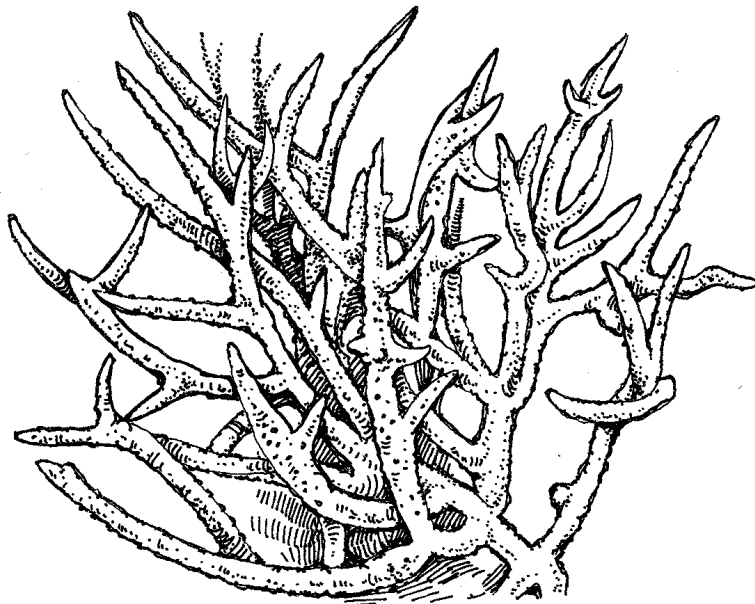
The objective of the Park management is "To protect the demersal and sedentary marine life forms of Komodo National Park, their ecosystems and their habitats, and to maintain the natural population and community structures of these life forms". Key modules in the management plan are:

- I. Design marine park zonation and specify regulations
- II. Promote implementation of cross-sectoral enforcement program with
 - a. Park Authorities
 - b. Police
 - c. Army
 - d. Fisheries Service
 - e. Local Government and Communities
- III. Involve local communities through:
 - a. community awareness program
 - b. participatory planning process
 - c. establishment of a local NGO
- IV. Work with business partners to develop alternative livelihoods in a variety of compatible enterprises such as:
 - a. eco-tourism
 - b. mariculture
 - c. pelagic fisheries
- V. Implement a comprehensive monitoring and research program which should generate the data needed for project evaluation and provide guidance towards the most desirable and effective interventions. Program sub-modules:
 - a. monitoring of the status of the coral reefs
 - b. monitoring of the status of commercially targeted fish populations
 - c. monitoring of fisheries resource utilization patterns
 - d. applied research and monitoring of the sustainability of proposed alternative livelihoods in mariculture
 - e. applied research and monitoring of the effectiveness of different methodologies to enhance coral reef rehabilitation

2. OBJECTIVE AND POTENTIAL MANAGEMENT RESPONSE

The objective of the coral reef monitoring program is to obtain information on spatial and temporal patterns in reef status and reef rehabilitation inside and outside the park, with special attention for the percentage of damaged coral. This monitoring program is an intensive survey of the coral reefs (185 locations) which enables mapping of damage by destructive fishing methods and other causes, and which will help to select sites for specific purposes (extra protection, research sampling sites, etc.). The coral reef survey will be repeated every second year to obtain feedback on the effects of management measures and on the rehabilitation of the reefs. A research project on reef rehabilitation will answer questions on the why's and how's of coral rehabilitation. Data have been collected and analyzed for 1996 and 1998.

Potential management responses to monitoring results include: a) Detailed update of the preliminary plan for zonation and regulations as drafted for the 25 years management plan (e.g., allocation of specific sites for dive-tourism, artisanal fisheries, full protection, or other purposes.) b) Adjustment of enforcement program in terms of effort allocation in space and/or time (adjustment of surveillance routine). c) Identification of locations and implementation of activities at places where active management is needed for reef rehabilitation. In some areas, reef rehabilitation seems to occur naturally and rapidly, whereas in other areas no rehabilitation is observed at all. In the latter cases, removing or altering the substrate (dead coral rubble) may be the key to reef rehabilitation.



3. THE MONITORING PROGRAM

One month of training is used to obtain standardization of the recording. All observers participate in the training program until they can estimate the percentage cover by habitat categories within 5% accuracy. Standard Under Water data sheets have been designed for data recording.

The total number of sampling sites is 185. All sampling sites have coral reefs and range in depth from 4 to 12 meters. All sites are surveyed by snorkeling (5 observations per site at 4 m deep) and by SCUBA diving (2 divers doing 5 observations at 8 m and 5 observations at 12 m deep respectively). The snorkeller and the divers are swimming 4 minutes for each observation. All observers work from one and the same speedboat. After each 4 minute swim, the observer records the estimated percentages (minimum step size 5%) of 4 habitat categories (totalling 100%):

1. hard coral live,
2. hard coral dead,
3. soft coral,
4. other (rock, sand, sponges, tunicates, algae, weeds, anemones, clams, etc.)

For each dive or snorkel-swim, the following information will also be recorded on the standard (UW) data sheets: date, site number, location (GPS), depth and name of observer. Each dive and snorkel-swim (including 5 observations) will take a total of about 30 minutes, including observing and recording. A total of fifteen observations per site (5 at 4m, 5 at 8m and 5 at 12 m) are recorded in a period of around 30 minutes, including observing and recording. The two divers which are working together on a particular day will rotate swimming depths so each diver will dive twice at 12 m and twice at 8 m (each diver makes a minimum of 4 dives per day during 2 or 3 days per week). Each dive will have a total bottom time of not more than 30 minutes and half an hour of rest will be taken between dives. The total daily dive effort per diver will therefore be at minimum 1 hour at 8 m and 1 hour at 12 m spread out over a period of about 5 to 6 hours. Divers and snorkellers will switch duties every day.

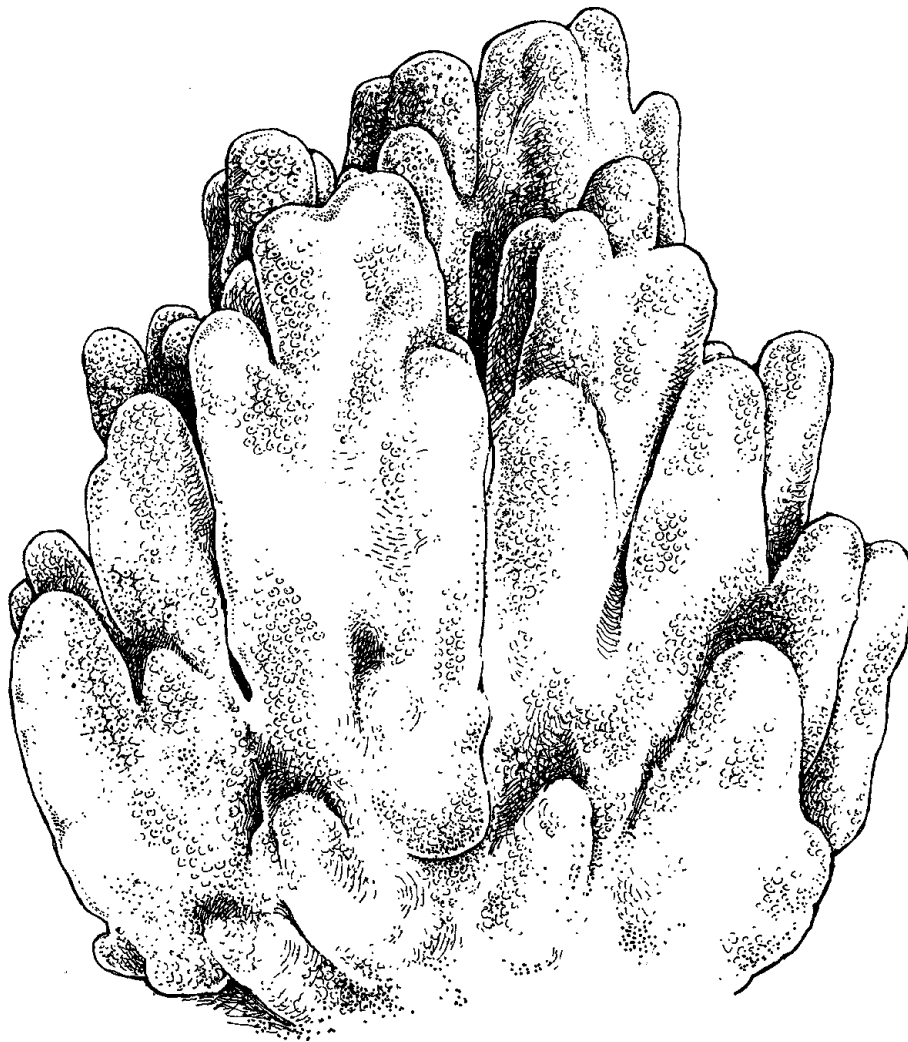
With a minimum of 12 sites covered per week and a minimum of two coral reef monitoring weeks each month, a minimum of 24 sites can be covered each month. The total survey should therefore not take longer than about 8 to 9 months. For the total of 185 sites, the resulting number of observations on reef status is 2775 per 2 years.

A hard coral mortality coefficient is calculated for each site with:

Mortality = $100 * (\% \text{ dead} / (\% \text{ live} + \% \text{ dead}))$

The mean percentages of all habitat categories and the mean mortality coefficients are calculated both for 5*5 square kilometer areas and for larger areas which are assumed to have different environmental conditions and different levels of impact from the fisheries. Results are also calculated over all 185 sites and separately for 'inside' and 'outside' the Park.

Means over areas (see maps) are calculated using as input the means over complete swims which include 5 observations each. For statistical analysis these means were arcsinus transformed (percentages), after which an analysis of variance was used to calculate the levels of statistical significance of differences over time.



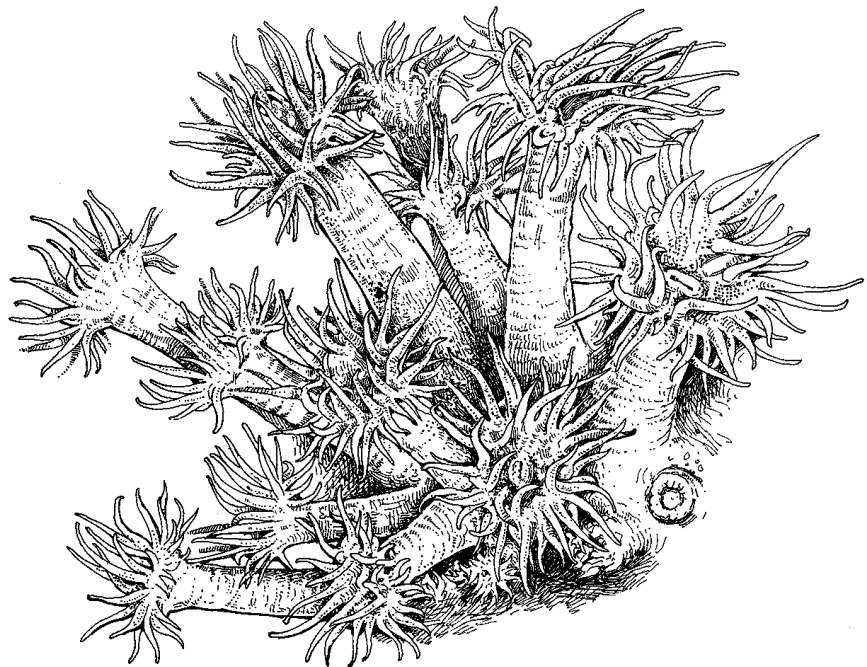
4. PRELIMINARY RESULTS

4.1 Summary

The overall means over 185 sites show that live hard coral cover has increased between 1996 and 1998 from 16 to 20%. Soft coral cover also showed a slight increase from 22 to 24% and the hard coral mortality coefficient decreased from 63% to 52%. The category of others remained almost constant with 35% in 1996 and 34% in 1998.

Inside Komodo National Park the live coral cover increased from 15% in 1996 to 19% in 1998. Outside the Park an increase was recorded from 17% to 23%. The coral mortality coefficient decreased inside the Park from 51% to 48% and outside the Park from 65% to 51%. Soft coral cover increased outside the Park but remained constant inside.

It can therefore be concluded that the overall destruction of the coral reefs in and around Komodo National Park has been stopped and that a slow rehabilitation (2% increase in hard coral cover per year) has started. This result is explained by the enormous decline in dynamite fishing in the area since early 1996. The results also show that rehabilitation is fastest near the center of protective activity, which is in the town of Labuan Bajo. Rehabilitation, on average is slower inside the Park, where many remote areas are still difficult to control.



4.2 Results per area

Levels of Significance:	P > 0.1	0
	0.05 < P < 0.1	*
	0.01 < P < 0.05	**
	P < 0.01	***

Area	Live Hard Coral Cover				Dead Hard Coral Cover			
	1996	1998	Diff.	Sign.	1996	1998	Diff.	Sign.
1. Labuan Bajo	15	24	+9	***	43	29	-14	***
2. Buffer Zone	16	21	+5	**	41	30	-11	***
3. KNP Rinca	14	18	+4	***	27	24	-3	0
4. KNP Komodo 17	21	+4		***	29	23	-6	**
5. KNP Padar 10	12	+2		0	17	19	+2	0
6. KNP NW	16	18	+2	0	22	18	-4	0
7. KNP South 16	21	+5		***	5	7	+2	**
8. Flores SW	8	13	+5	0	13	11	-2	0
9. Banta	28	27	-1	0	22	16	-6	*

Area	Live Soft Coral Cover				Other Cover			
	1996	1998	Diff.	Sign.	1996	1998	Diff.	Sign.
1. Labuan Bajo	12	17	+5	***	30	30		0
2. Buffer Zone	18	28	+10	***	25	21	-4	*
3. KNP Rinca	19	20	+1	0	40	38	-2	0
4. KNP Komodo	27	27		0	27	29	+2	0
5. KNP Padar	30	31	+1	0	43	38	-5	0
6. KNP NW	23	21	-2	0	38	43	+5	0
7. KNP South	29	30	+1	0	50	42	-8	***
8. Flores SW	19	15	-4	0	59	60	+1	0
9. Banta	23	31	+7	***	26	26		0

Area	Hard Coral Mortality Coefficient			
	1996	1998	Diff.	Sign.
1. Labuan Bajo	74	56	-18	***
2. Buffer Zone	71	55	-16	***
3. KNP Rinca	62	57	-5	**
4. KNP Komodo	60	51	-9	***
5. KNP Padar	47	54	+7	0
6. KNP NW	50	46	-4	0
7. KNP South	16	23	+7	*
8. Flores SW	50	46	-4	0
9. Banta	42	38	-4	0

5. CONCLUSIONS

Significant natural rehabilitation of the coral reefs has occurred between 1996 and 1998 in the following areas: 1. Labuan Bajo, 2. Buffer zone, 3. KNP Rinca, 4. KNP Komodo. Live hard coral cover also increased in KNP South, but so did dead coral cover, possibly by the destruction of other invertebrate live (very abundant in that area) which used to cover the old layers of dead coral. 'Other' cover has indeed decreased in this area. KNP South is a somewhat more remote area which is on the edge of the umbrella of protective activities. Coral rehabilitation is explained by a dramatic decline in dynamite fishing which was caused by a combination of enforcement, community awareness and a shift from low-income fishing for local markets (dynamited fish) to high-income fishing for export markets (live reef fish).

Soft coral cover increased in Labuan Bajo, the Buffer Zone and Banta Island. This increase in soft coral cover is mainly caused by *Xenia* spp. covering patches of coral rubble which resulted from dynamiting in the early nineties.

There was no natural rehabilitation of hard corals between 1996 and 1998 in the following areas: 5. KNP Padar, 6. KNP Northwest, 8. Flores Southwest and 9. Banta Island. In KNP Padar rehabilitation may be slow because of the fast currents around this Island (reducing success of coral recruitment?). Padar is in the middle of the protected area. KNP Northwest is a remote area which is difficult to protect against fishermen from Sumbawa. Banta Island is unprotected since it is outside the Park and outside jurisdiction of Labuan Bajo authorities. Banta lies in the NTB province and there is no marine law enforcement covering this island. The only 'protection' it receives is by frequent visits from dive boats and by community awareness work in coastal villages. Quite a few former dynamite fishermen from Sumbawa did change their practices in recent years due to clashes with enforcement patrols within the Park area. Flores Southwest lies outside the Park, is not covered by enforcement patrols and is only 'protected' by community awareness programs.

CORAL REEF SURVEY KOMODO NATIONAL PARK 1998

DATE SITE (1-185) LOCATION E
S

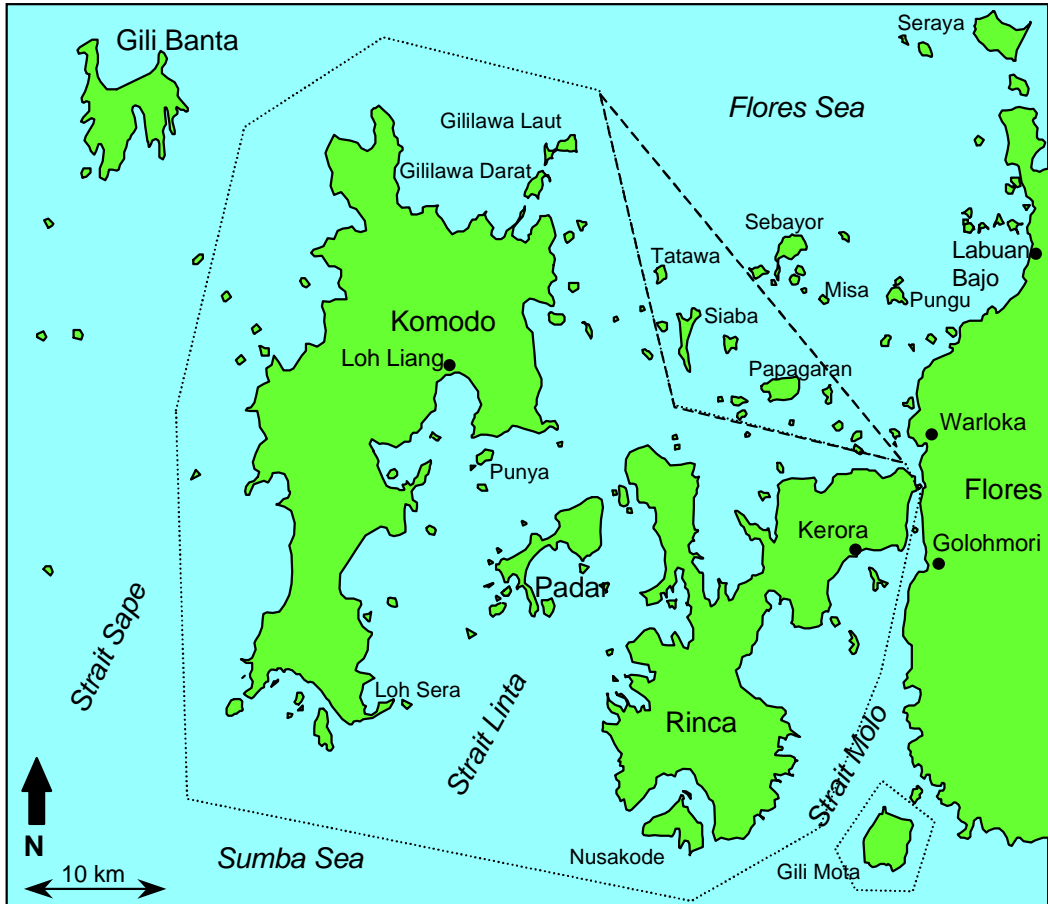
DEPTH (4,8,12): NAME:

PERCENTAGE (%) HABITAT CATEGORY PER OBSERVATION / SAMPLE

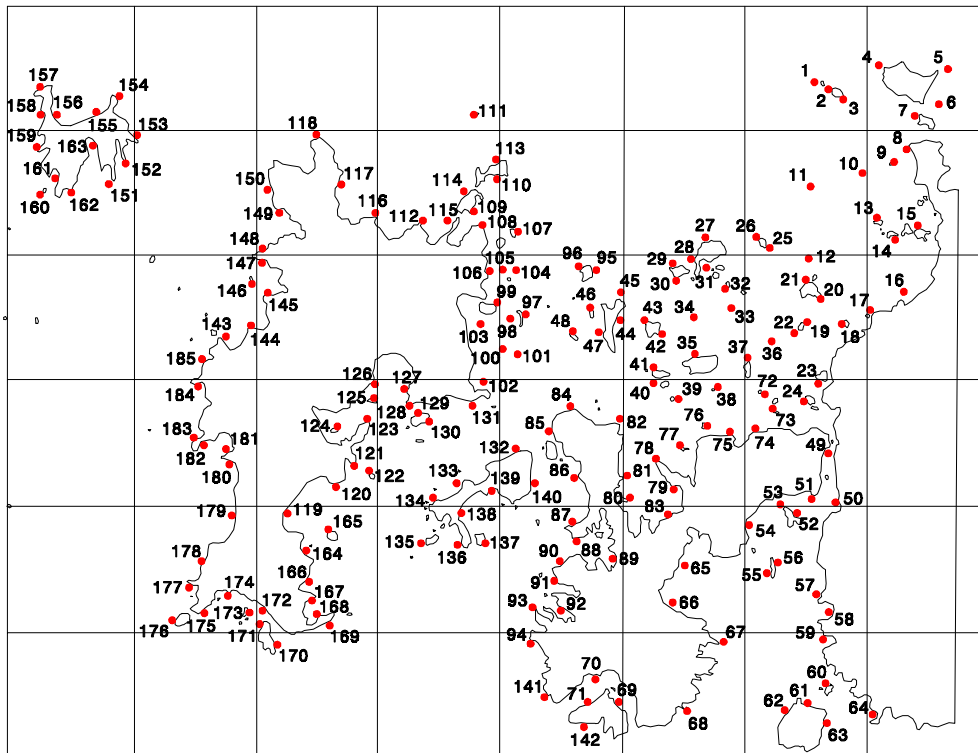
SNORKEL SWIMS: 5 OBSERVATIONS OF 4
MINUTES EACH

DIVES: 5 OBSERVATIONS OF 4 MINUTES EACH

HABITAT CATEGORY	OBSERVATION				
	1	2	3	4	5
HARD CORAL LIVE					
HARD CORAL DEAD					
SOFT CORAL					
OTHER = ROCK, SAND, ALGAE, ETC					



coral reef monitoring sites Komodo National Park

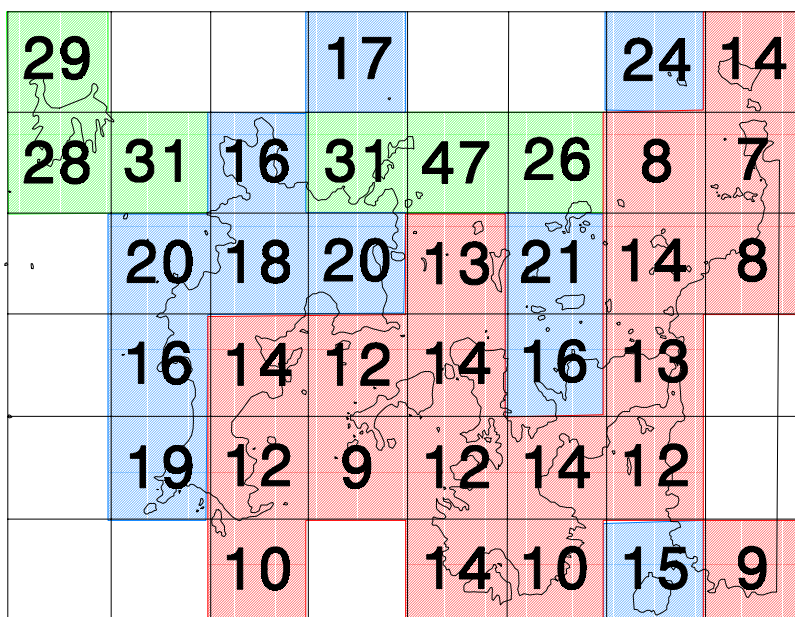


file: coordinates of coral reef monitoring sites
siteneu

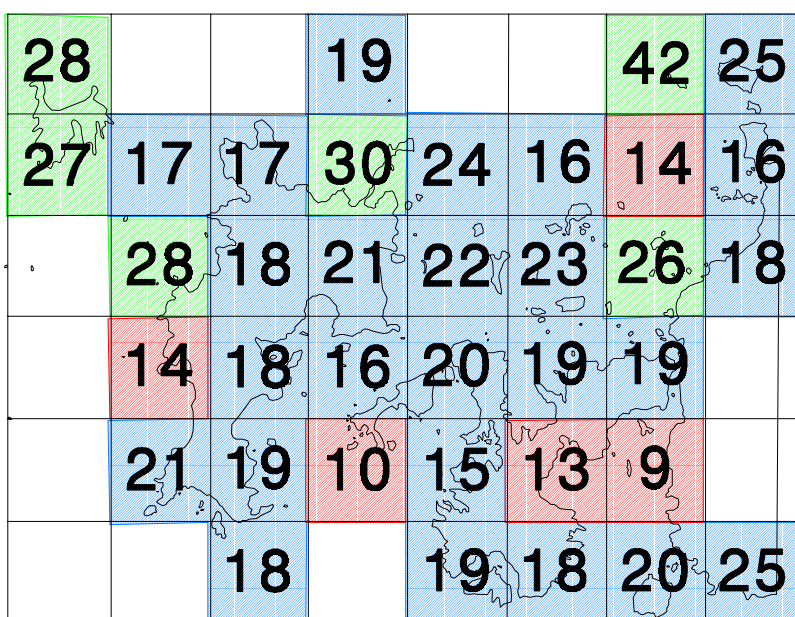
sitenum	south	east	sitenum	south	east
1	82316	1194775	51	83961	1194765
2	82332	1194815	52	84005	1194707
3	82400	1194828	53	83955	1194637
4	82241	1195018	54	84101	1194506
5	82270	1195310	55	84256	1194577
6	82404	1195244	56	84205	1194596
7	82492	1195173	57	84293	1194804
8	82594	1195121	58	84382	1194766
9	82666	1195070	59	84500	1194810
10	82667	1194954	60	84654	1194824
11	82715	1194764	61	84780	1194768
12	82975	1194756	62	84766	1194664
13	82882	1195006	63	84842	1194804
14	82942	1195086	64	84702	1195010
15	82879	1195147	65	84214	1194227
16	83115	1195145	66	84400	1194222
17	83215	1195000	67	84512	1194346
18	83273	1194867	68	84812	1194211
19	83288	1194765	69	84787	1193997
20	83165	1194775	70	84674	1193896
21	83090	1194765	71	84736	1193890
22	83320	1194709	72	83521	1194539
23	83503	1194754	73	83625	1194580
24	83554	1194721	74	83657	1194526
25	83000	1194530	75	83648	1194417
26	82947	1194513	76	83652	1194305
27	82916	1194370	77	83762	1194226
28	83036	1194234	78	83816	1194111
29	83050	1194221	79	83939	1194175
30	83108	1194232	80	83954	1194016
31	83102	1194307	81	83857	1194014
32	83107	1194413	82	83702	1193946
33	83241	1194413	83	84023	1194172
34	83263	1194314	84	83617	1193718
35	83338	1194404	85	83680	1193667
36	83360	1194584	86	83885	1193788
37	83442	1194545	87	84069	1193773
38	83522	1194402	88	84104	1193833
39	83601	1194247	89	84208	1193944
40	83516	1194185	90	84219	1193752
41	83465	1194112	91	84245	1193704
42	83322	1194112	92	84406	1193747
43	83300	1194038	93	84417	1193647
44	83266	1193969	94	84526	1193619
45	83147	1193976	95	83098	1193864
46	83223	1193831	96	83056	1193816
47	83331	1193858	97	83282	1193587
48	83321	1193759	98	83249	1193531
49	83839	1194799	99	83223	1193448
50	83963	1194834	100	83377	1193507

sitenum	south	east	sitenum	south	east
101	83352	1193545	151	82732	1191895
102	83532	1193425	152	82641	1191956
103	83304	1193419	153	82549	1192007
104	83029	1193545	154	82412	1191919
105	83058	1193500	155	82447	1191830
106	83114	1193430	156	82499	1191700
107	82958	1193546	157	82381	1191650
108	82923	1193418	158	82499	1191610
109	82856	1193366	159	82600	1191602
110	82731	1193493	160	82805	1191668
111	82438	1193360	161	82715	1191643
112	82883	1193160	162	82800	1191720
113	82663	1193454	163	82592	1191808
114	82738	1193331	164	84180	1192697
115	82889	1193285	165	84110	1192777
116	82908	1192991	166	84300	1192707
117	82752	1192828	167	84353	1192722
118	82557	1192707	168	84428	1192746
119	84041	1192626	169	84466	1192771
120	83912	1192825	170	84529	1192569
121	83848	1192893	171	84442	1192518
122	83834	1192930	172	84424	1192533
123	83660	1192938	173	84409	1192461
124	83695	1192836	174	84356	1192401
125	83602	1192956	175	84422	1192280
126	83532	1192969	176	84468	1192187
127	83530	1193101	177	84335	1192245
128	83613	1193104	178	84235	1192292
129	83639	1193113	179	84045	1192420
130	83693	1193190	180	83841	1192397
131	83600	1193400	181	83796	1192364
132	83797	1193516	182	83741	1192325
133	83904	1193341	183	83735	1192276
134	83970	1193244	184	83561	1192273
135	84126	1193227	185	83455	1192230
136	84155	1193316			
137	84123	1193416			
138	84082	1193348			
139	83924	1193452			
140	83874	1193626			
141	84729	1193678			
142	84866	1193850			
143	83329	1192408			
144	83300	1192458			
145	83175	1192525			
146	83124	1192472			
147	83036	1192508			
148	82927	1192558			
149	82828	1192549			
150	82728	1192516			

Percentages live hard coral cover in KNP 1996

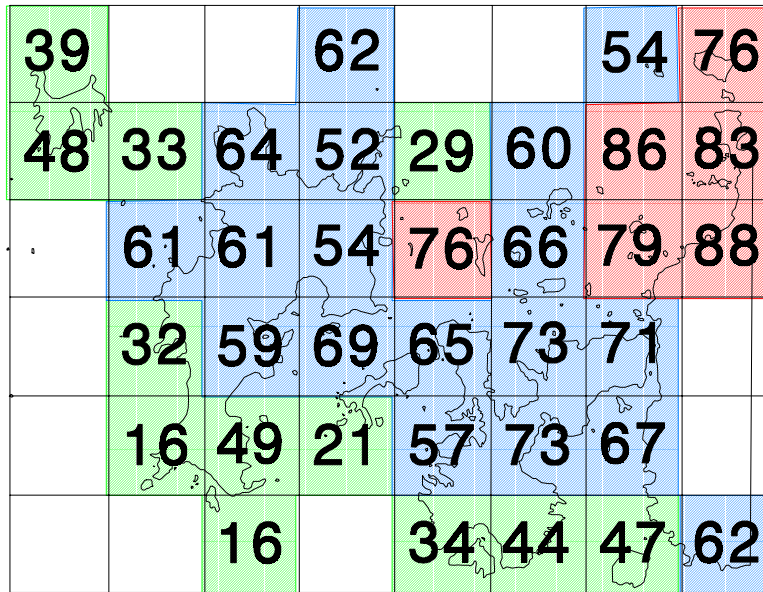


Percentages live hard coral cover in KNP 1998

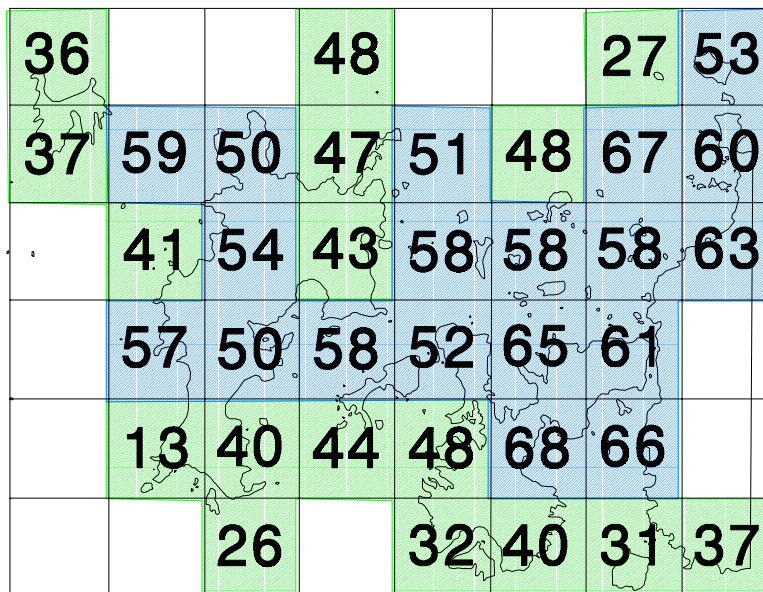


- less than 15% live hard coral cover
- 15% to 25% live hard coral cover
- more than 25% live hard coral cover

Mortality index reef building corals in KNP 1996



Mortality index reef building corals in KNP 1998



- 75% or more of hard coral is dead
- 50% to 75% of hard coral is dead
- less than 50% of hard coral is dead

file:
result96

hardlive mean

29	ERR	ERR	17	ERR	ERR	24	14
28	31	16	31	47	26	8	7
ERR	20	18	20	13	21	14	8
ERR	16	14	12	14	16	13	ERR
ERR	19	12	9	12	14	12	ERR
ERR	ERR	10	ERR	14	10	15	9

harddead mean

19	ERR	ERR	28	ERR	ERR	28	45
25	15	27	34	19	40	46	36
ERR	31	29	24	42	40	50	55
ERR	8	21	26	26	42	33	ERR
ERR	4	11	3	15	38	24	ERR
ERR	ERR	2	ERR	7	8	13	14

mortality index

39	ERR	ERR	62	ERR	ERR	54	76
48	33	64	52	29	60	86	83
ERR	61	61	54	76	66	79	88
ERR	32	59	69	65	73	71	ERR
ERR	16	49	21	57	73	67	ERR
ERR	ERR	16	ERR	34	44	47	62

soft coral mean

21	ERR	ERR	31	ERR	ERR	17	10
24	34	23	12	17	15	15	13
ERR	24	28	27	22	16	7	5
ERR	20	33	25	32	11	11	ERR
ERR	25	41	35	30	4	18	ERR
ERR	ERR	48	ERR	35	25	22	34

other cover mean

31	ERR	ERR	24	ERR	ERR	30	31
23	20	34	22	17	18	32	45
ERR	25	25	28	24	23	29	33
ERR	56	32	38	28	32	42	ERR
ERR	52	35	53	42	44	46	ERR
ERR	ERR	40	ERR	45	59	51	44

file:
result98

hardlive mean

28	ERR	ERR	19	ERR	ERR	42	25
27	17	17	30	24	16	14	16
ERR	28	18	21	22	23	26	18
ERR	14	18	16	20	19	19	ERR
ERR	21	19	10	15	13	9	ERR
ERR	ERR	18	ERR	19	18	20	25

harddead mean

16	ERR	ERR	18	ERR	ERR	16	29
16	25	17	27	25	15	28	23
ERR	20	21	15	30	32	36	31
ERR	19	19	22	22	35	30	ERR
ERR	3	13	8	14	29	17	ERR
ERR	ERR	6	ERR	9	12	9	15

mortality index

36	ERR	ERR	48	ERR	ERR	27	53
37	59	50	47	51	48	67	60
ERR	41	54	43	58	58	58	63
ERR	57	50	58	52	65	61	ERR
ERR	13	40	44	48	68	66	ERR
ERR	ERR	26	ERR	32	40	31	37

soft coral mean

27	ERR	ERR	35	ERR	ERR	20	16
34	34	20	20	35	29	24	16
ERR	23	29	37	27	24	15	9
ERR	16	29	29	39	15	18	ERR
ERR	27	29	30	26	8	13	ERR
ERR	ERR	38	ERR	31	29	27	25

other cover mean

29	ERR	ERR	28	ERR	ERR	22	31
23	24	46	24	17	41	35	45
ERR	30	32	27	22	21	23	42
ERR	51	34	33	20	30	33	ERR
ERR	49	39	52	45	50	61	ERR
ERR	ERR	37	ERR	40	40	45	34

