Coral Reef Ecosystems and Resources of the Philippines

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INTRODUCTION

The educated layman may or may not have been introduced to corals and coral reefs in school. Today, however, he has probably been exposed to corals and coral reefs in real life or through the television screen. It is not uncommon to see the ornate skeleton of some corals in an aquarium, in a display window of jewelry and watches, or as part of a display of shellcraft in the home of a friend. What few of us may realize is that where such samples are seen, whether it be in the United States of America, in Europe, or elsewhere, chances are that the coral involved originated in the Philippines. As to the television screen, many have been exposed to documentaries involving marine life, including "The Coral Triangle" featuring our coral reefs (in which I served as the scientific adviser) and tourism or adventure clips which feature underwater scenes in the tropics.

But what is a coral? What has been referred to above generally applies to the stony corals, i.e., the coelenterates or cnidarians that secrete a calcareous, friable skeleton, usually white when separated from the living tissue. To a smaller number of us, coral may mean jewelry, usually pink or red and sometimes black. The sources of these precious corals are also coelenterates, but the animals are taxonomically distinct from the stony corals. Whether stony or precious, what we are often exposed to are the skeletons of colonial organisms long dead by the time we see their clean and sometimes polished remains.

Technically, most of the corals as the layman knows them belong the the Class Anthozoa or "flower animals" in the Phylum Cnidaria or Coelenterata. A few fall under the Class Hydrozoa, the best known being the fire coral of *Millepora*. The stony corals mostly belong to the largest order of anthozoans, the Scleractinia.

With few exceptions like the solitary mushroom coral whose polyp may reach a diameter of 25 cm, all the stony corals are colonial. Most of the scleractinians harbor symbiotic algae called zooxanthellae. Due to this mutualism, the stony corals are able to deposit significant quantitites of calcium carbonate as their housing or skeleton. The massive populations of the hundreds of species form geological structures that we term coral reefs, with contributions of other calcareous materials principally from algae, molluscs and echinoderms.

In terms of conservation, it is the coral reef as a unit that is of greater concern. A coral reef is a sizeable, living, calcium carbonate stucture in a shallow tropical sea supporting a diverse association of flora and fauna. Usually there is a complex sculpturing of high relief. It is to be stressed that a coral reef is a dynamic living structure, with both accretion and erosion of materials with a bias for the former, hence resulting in a net reef growth of a millimeter or so per year.

Of the associated organisms, the most obvious and the most important from an economic point of view are the fish. These are the objects of fisheries in addition to the edible invertebrates and the seaweeds that are found on reefs.

Besides organisms that are collected for food, there are those harvested for the live or dead ornamental trade, i.e., for aquarium or for decoration purposes. These include reef fish, corals and shells and other invertebrates for the live trade and corals and shells for the ornamental trade. But in addition to these, marine organisms are now being collected for studies in marine pharmacology. Novel compounds are being identified and extracted from various organisms which have medicinal potentials, including some of the conotoxins studied by Academician Lourdes Cruz with Dr. Baldomero Olivera and their colleagues.

One other use of corals has been to provide construction materials for roads, for churches of old and for new buildings. An excess of this activity could diminish one of the important functions of coral reefs which is shoreline protection. In some places, sandy beaches exist only because of the active growth of coral reefs offshore that serve as wavebreakers and that contribute sand particles to dynamic beaches. Without them, these beaches could erode and disappear.

Finally, more and more coral reefs are being appreciated for their aesthetic value. A pristine reef in a warm sea with myriads of colorful fish is truly a sight of unparalleled beauty. It is no wonder that more tourists from far and wide come to spend their holidays where good reefs are to be found.

RESEARCH

In the past two decades, coral reef research in the Philippines has taken virtually a quantum leap from what was almost purely taxonomic work to that whose breadth and quality are now almost at par with those in the most advanced scientific institution. The initial project in the mid-seventies (see following section) enabled local scientists to design and test various reef monitoring techniques. Contributions have been made to the international literature on suitable field techniques for detecting changes in coral reef structure (Gomez and Alcala 1984; Gomez 1984; and Yap 1984, 1986).

In the course of time and further imrpovement of community structure methods, particular methodologies have been standardized and adopted for use on a broader geographic scale (e.g., Southeast Asia). A new generation of studies using these techniques has shed much light on broad distributional patterns of reefs and their associated assemblages, such as fish, in the Philippines (Gomez et al. 1989; Hilomen and Gomez 1989; Licuanan and Gomez 1989).

Research into the dynamics of these ecosystems initially focused on the nature of their recovery from physical damage, the most notable being blast fishing (Alcala and Gomez 1979; Aliño et al. 1985; Yap and Gomez 1989). Emphasis was given to this aspect because of its important economic as well as ecological implications.

Crucial parallel activities were the studies on coral growth, both on natural as well as artificial substrates (Alcala and Gomez 1979; Alcala et al. 1989; Yap and Gomez 1981; Alcala et al. 1982; Alcala and Gomez 1982; Gomez et al. 1982; Yap and Gomez 1984, 1985a; Gomez et al. 1985; and Yap et al. 1990). Many of these studies involved the use of coral transplantation as a tool for studying physiological responses of the organisms. Another goal of coral transplantation is with respect to the possible rehabilitation of damaged habitats.

STATUS OF PHILIPPINE CORAL REEFS

Concern for the status of Philippine coral reefs in part due to the reports of illegal gathering of precious corals in the Batanes Islands by foreign ships was translated into action in the second half of the seventies. The Marine Science Institute, which was

then the fledgling Marine Sciences Center that was without proper building space, was requested to submit a proposal for the assessment of Philippine corals. With the help of a few colleagues, I drafted the proposal for the "Investigation of the Coral Resources of the Philippines". In the execution of the project which went into three phases and spanned about five years, two other units of the University of the Philippines, viz., U.P. College Cebu and the College of Business Administration, and the Silliman University were involved as collaborators. Many publications resulted from this project, among them: Alcala and Gomez 1979; Gomez 1979; Gomez and Alcala 1979; Gomez and Añonuevo 1979; Gomez 1980; Alcala et al. 1981; Yap and Gomez 1981; Alcala and Gomez 1982; Alcala et al. 1982; Gomez et al. 1982; Gomez 1983; Maragos et al. 1983; Gomez and Alcala 1984; Yap and Gomez 1984; Alcala and Gomez 1985; Gomez et al. 1985 and Yap and Gomez 1985a.

As to the status of coral reefs, two papers viz., Gomez and Alcala (1979) and Gomez et al. (1981) gave the broad picture of the situation. The tabular results may be compared (Tables 1 and 2). The second table was first updated for 1982 by Yap and Gomez (1985b) and appears here as Table 3.

Since the end of the benchmark project, there has been no formal and systematic survey of Philippine reefs. The results have been adopted by both governmental and non-governmental organizations in recent years without any recognition of the source. In a sense, this has been gratifying and a good sign because they have been accepted and indeed corroborated by other observers.

In more recent years two ASEAN marine science projects have gathered some additional coral survey data for limited areas. These are the ASEAN/US Coastal Resources Management Project which focused on the western side of Lingayen Gulf and the ASEAN/Australia Marine Science Project: Living Coastal Resources. A summary table was included as Table 2 in Gomez (1989). The most recent data from the two ASEAN projects are compared to the old data in Table 4. It should be stressed that the method used for these other projects is different from the original method. Nevertheless, the results are comparable since they used percent live coral cover. If these results are combined in the old format, the result is Table 5, the status of Philippine coral reefs in 1991, assuming that the general condition of the reefs surveyed earlier has not changed significantly.

PROBLEMS

Stresses or problems that beset coral reef ecosystems are of two categories: natural and man-induced. A number of publications dealing with coral reef problems throughout the world have appeard. One such publication on human induced stresses edited by Bernard Saliat, appeared in 1987. I contributed to two chapters, one on dynamite fishing (Alcala and Gomez 1987) and one on other fishing methods destructive to corals (Gomez et al. 1987).

In a situationer on coral reefs of Southeast Asia (Gomez 1980), I outlined the problems of reefs in the region. That report was used as the basis of a paper on the coral reef degradation in Southeast Asia (Yap and Gomez 1985b).

As to actual problems of Philippine coral reefs, one of the earliest publications was the proceedings of a forum on natural resources management (Gomez 1979). Hence, what I need to say here is a distillation of previous work. A broader treatment of Philippine corals was prepared subsequently by Alcala, Gomez and Yap (1987).

It is probably not very relevant to discuss natural stresses on corals except to say that in general, our reefs have developed through some eons of typhoons and volcanic activity, and they have shown that they have the resilience to survive these events. Areas that are unsuitable for reef growth simply have no reefs to speak of. For an idea of how typhoon-damaged reefs recover, see Alcala and Gomez (1990) and Alcala et al. (1986). The recent eruption of Mt. Pinatubo may provide an opportunity to study the effects of the volcanic ejecta on Zambales reefs.

In Yap and Gomez (1985b) we listed siltation, fisheries-related destruction, collection of building materials, tourism, collection of reef invertebrates and other pollutants as the major causes of coral reef degradation. Details may be seen from that paper or from Alcala et al. (1987). A broader review of marine environmental problems in the region is provided in Gomez (1988b).

Every once in a while, I take the opportunity to reflect on these problems. Coral reef science and concerns for conservation in the Philippines have now broadened a great deal in contrast to those two decades ago. There are now dozens of investigators and activists taking up the cause of coral reefs. I am therefore now somewhat away from the frontlines, so to speak. This has allowed me to have a broader perspective.

If asked what the major problem of the coral reef is, I would probably say it is the pressure of human populations. A visit to any fishing village situated near a reef will demonstrate the situation very well. There are, in the first instance, just too many fishermen. They overfish the reefs and even if they use non-destructive fishing gear, the coral reef ecosystem in question is stressed. This stress is exercised from the bottom to the top of the reef. The pressure is especially heavy on the reef flats or tops of reefs. Here, at practically every low tide, reef gleaners comb the area for anything edible and marketable. Hence, accessible reef flats become less diverse and less productive from overharvesting and from trampling.

If you superimpose on the pressure of sheer numbers the destructive practices of some fishermen, then the reefs really regress. Blast fishing, muro-ami and the use of poisons all have more lasting negative impacts on the reefs.

With the possible exception of man-induced siltation, there is no greater stress on our reefs than population pressure.

MANAGEMENT

In view of all the problems alluded to above, what management measures might be recommended to conserve coral reefs? The most obvious is for this government and for each citizen to do something about our population problem. The details of how that might be done are beyond the scope of this paper.

Since the above is a broader and longer term approach, I should like to mention a management measure that could be adopted with great effort. From my perspective, the only way to save our reefs and restore their productivity is by limiting access to them. It is recognized that this will be no mean task. But if nations can agree to adopt the concept of the Exclusive Economic Zone among them, it should be possible to think in terms of exclusive economic zones among geographic or political units within the country.

A start is being made with the establishment of marine parks (cf. Gomez et al. 1984). Marine parks and marine reserves are beginning to be recognized in the country. We need many, such as the reefs of global significance (Gomez 1988a). However,

they can serve only as limited replenishment areas for neighboring habitats.

What I would like to see happen is for each reef to be under the management of an identifiable authority at the municipal or barangay level. Such an authority should be empowered to determine the number of fishermen allowed at any one time as well as the gear used. It would regulate the catch in terms of amount, size of individuals and kinds of species caught. Furthermore, it would exercise the authority to close a fishery or an area during certain times of the year.

Such an authority would obviously need much power and credibility. The power can come from the people themselves or from the government. The credibility would have to be cultivated and there must be inputs from scientists who would determine the biological basis for the regulations.

Table 1. Summary of Reef Survey Data ("Coral Cover" includes both soft and hard corals.)

Location	No. with Total No. of Stations	No. with Excellent (75-100%) Coral Cover	No. with Good (50-74.9%) Coral Cover	No. with Fair (25-49.9%) Coral Cover	No. with Poor (0-24.9%) Coral Cover
LUZON					
1. La Union	8	0	1	2	5
2. Zambales	4	0	0	1	3
3. Pangasinan	11	0	4	4	3
4. Bataan	6	0	3	2	1
5. Batangas	38	1	7	12	18
6. Mindoro Occidental	13	1	2	6	4
7. Mindoro Oriental	31	1	8	15	7
8. Palawan	5	0	3	2	0
Subtotal	116(100%)	3(2.5%)	28(24.2%)	44(37.95)	41(35.4%)
VISAYAS					
9. Bohol Island/Islets	22	0	8	7	7
10. Cebu Province	57	3	15	18	21
11. Negros Island	100	4	24	37	35
12. Siquijor Island	31	0	9	9	13
13. Guimaras Island	32	8	8	11	5
Subtotal	242(100%)	15(6.2%)	64(26.4%)	82(33.9%)	81(33.5%)
MINDANAO					
14. Zamboanga del Norte	8	0	3	2	3
15. Aliquay Island	8	2	3	2	1
16. Selinog Island	7	0	0	1	6
Subtotal	23(100%)	2(8.7%)	6(26.1%)	5(21.7%)	10(43.5%)
TOTAL	381	20	98	131	132
Percentage	(100%)	(5.2%)	(25.7%)	(34.5%)	(34.6%)

Table 2. Status of Philippine coral reefs - 1981: 619 Stations in Four Categories of Living Coral Cover - Excellent (75-100%), Good (50-74.9%), Fair (25-49.9%) and Poor (0-24.9%)

LOCATION	No. of Stations	EXCELLENT		GOOD		FAIR		POOR	
		No.	%	No.	%	No.	%	No.	%
LUZON									
1. Albay	9	0	0	1	11.1	5	55.6	3	33.3
2. Bataan	10	0	0	0	0	0	0	10	100.0
3. Batangas	25	0	0	6	24.0	11	44.0	8	32.0
4. Cagayan	4	0	0	2	50.0	2	50.0	0	0
5. Camarines Norte	13	0	0	1	7.7	7	53.8	5	38.5
6. Camarines Sur	2	0	0	0	0	2	100.0	0	0
7. Cavite	9	0	0	0	0	6	66.7	3	33.3
8. Isabela	3	0	0	2	66.7	1	33.3	0	0
9. La Union	5	0	0	1	20.0	2	40.0	2	40.0
10. Marinduque	5	0	0	0	0	4	80.0	1	20.0
11. Mindoro Occidental	31	1	3.2	8	25.8	15	48.4	7	22.6
12. Mindoro Oriental	11	1	9.1	2	18.2	4	36.4	4	36.4
13. Palawan	49	6	12.2	17	34.7	20	40.8	6	12.2
14. Pangasinan	37	0	0	8	21.6	14	37.8	15	40.5

Table 2. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
15. Quezon	4	0	0	2	50.0	2	50.0	0	0
16. Zambales	12	0	0	2	16.7	3	25.0	7	58.3
Subtotal	229	8	3.5	52	22.7	98	42.8	71	31.0
VISAYAS									
1. Antique	12	2	16.7	10	83.3	0	0	0	0
2. Bohol	22	0	0	8	36.4	8	36.4	6	27.2
3. Cebu	51	5	9.8	13	25.5	19	37.2	14	27.4
Hilutangan Island	4	0	0	1	25.0	0	0	3	75.0
Mactan Island	15	1	6.7	3	20.0	3	20.0	8	53.3
Olango Island	7	0	0	1	14.3	2	57.1	2	28.6
Sumilon Island	4	0	0	3	75.0	0	0	1	25.0
4. Iloilo	64	9	14.1	18	28.1	27	42.2	10	15.6
5. Leyte	12	0	0	0	0	6	50.0	6	50.0
6. Negros Occidental	18	1	5.6	2	11.1	5	27.8	10	55.6
Refugio Island	4	0	0	1	25.0	1	25.0	2	50.0
7. Negros Oriental	98	5	5.1	20	20.4	41	41.8	32	32.6

Table 2. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
Apo Island	5	0	0	5	100	0	0	0	0
8. Siquijor	31	0	0	9	29.0	9	29.0	13	41.9
Subtotal	347	23	6.6	94	27.1	123	35.4	107	30.8
MINDANAO									
1. Misamis Occidental	9	0	0	0	0	4	44.4	5	55.6
2. Misamis Oriental	1	0	0	0	0	0	0	1	100
3. Zamboanga del Norte	18	1	5.6	3	16.7	6	33.3	8	44.4
Aliquay Island	8	2	25.0	3	37.5	2	25.0	1	12.5
Selinog Island	7	0	0	0	0	1	14.3	6	85.7
Subtotal	43	3	7.0	6	14.0	13	30.2	21	48.8
TOTAL	619	34	5.5	151	24.4	234	37.8	200	32.3

Table 3. **Status of Philippine coral reefs - 1982: 619 Stations in Four Categories of Living Coral Cover - Excellent (75-100%), Good (50-74.9%), Fair (25-49.9%) and Poor (0-24.9%)**

LOCATION	No. of Stations	EXCELLENT		GOOD		FAIR		POOR	
		No.	%	No.	%	No.	%	No.	%
LUZON									
1. Albay	9	0	0	1	11.1	5	55.6	3	33.3
2. Bataan	10	0	0	0	0	0	0	10	100.0
3. Batangas	25	0	0	6	24.0	11	44.0	8	32.0
4. Cagayan	4	0	0	2	50.0	2	50.0	0	0
5. Camarines Norte	13	0	0	1	7.7	7	53.8	5	38.5
6. Camarines Sur	2	0	0	0	0	2	100.0	0	0
7. Cavite	9	0	0	0	0	6	66.7	3	33.3
8. Isabela	3	0	0	2	66.7	1	33.3	0	0
9. La Union	5	0	0	1	20.0	2	40.0	2	40.0
0. Marinduque	5	0	0	0	0	4	80.0	1	20.0
1. Mindoro Occidental	31	1	3.2	8	25.8	15	48.4	7	22.6
2. Mindoro Oriental	11	1	9.1	2	18.2	4	36.4	4	36.4
3. Palawan	49	6	12.2	17	34.7	20	40.8	6	12.2
4. Pangasinan	37	0	0	8	21.6	14	37.8	15	40.5

Table 3. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
15. Quezon	4	0	0	2	50.0	2	50.0	0	0
16. Zambales	12	0	0	2	16.7	3	25.0	7	58.3
Subtotal	229	8	3.5	52	22.7	98	42.8	71	31.0
VISAYAS									
1. Antique	12	2	16.7	10	83.3	0	0	0	0
2. Bohol	22	0	0	8	36.4	8	36.4	6	27.2
3. Cebu	64	6	9.4	14	21.9	27	42.2	17	26.6
Hilutangan Island	4	0	0	1	25.0	0	0	3	75.0
Mactan Island	15	1	6.7	3	20.0	3	20.0	8	53.3
Olango Island	7	0	0	1	14.3	2	57.1	2	28.6
Sumilon Island	4	0	0	3	75.0	0	0	1	25.0
4. Iloilo	64	9	14.1	18	28.1	27	42.2	10	15.6
5. Leyte	12	0	0	0	0	6	50.0	6	50.0
6. Negros Occidental	18	1	5.6	2	11.1	5	27.8	10	55.6
Refugio Island	4	0	0	1	25.0	1	25.0	2	50.0
7. Negros Oriental	98	5	5.1	20	20.4	41	41.8	32	32.6

Table 3. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
Apo Island	5	0	0	5	100	0	0	0	0
8. Siquijor	31	0	0	9	29.0	9	29.0	13	41.9
Subtotal	360	24	6.6	95	26.4	131	36.4	110	30.6
MINDANAO									
1. Misamis Occidental	9	0	0	0	0	4	44.4	5	55.6
2. Misamis Oriental	1	0	0	0	0	0	0	1	100
3. Zamboanga del Norte	18	1	5.6	3	16.7	6	33.3	8	44.4
Aliquay Island	8	2	25.0	3	37.5	2	25.0	1	12.5
Selinog Island	7	0	0	0	0	1	14.3	6	85.7
Subtotal	43	3	7.0	6	14.0	13	30.2	21	48.8
TOTAL	632	35	5.5	153	24.2	242	38.3	202	32.0

Table 4. Status of Philippine coral reefs - based on surveys by three projects

SOURCE	No. of transects Stations	EXCELLENT (75 - 100%) No.	%	GOOD (50 - 74.9%) No.	%	FAIR (25 - 49.9%) No.	%	POOR (0 - 24.9%) No.	%
Yap and Gomez (1985b)	632	35	5.5	153	24.2	242	38.3	202	32.0
ASEAN - Australia MSP:LCR*	103	4	3.9	32	31.1	46	44.6	21	20.4
ASEAN - US CRMP	40	-	0	18	45	17	42.5	5	12.5

* Source: Unpublished data from the ASEAN-Australia Marine Science Project: Living Coastal Resources

Table 5. **Status of Philippine coral reefs - 1991**

LOCATION	No. of Stations	EXCELLENT		GOOD		FAIR		POOR	
		No.	%	No.	%	No.	%	No.	%
LUZON									
1. Albay	9	0	0	1	11.1	5	55.6	3	33.3
2. Bataan	10	0	0	0	0	0	0	10	100.0
3. Batangas	35	0	0	13	37.1	14	40.0	8	22.9
4. Cagayan	4	0	0	2	50.0	2	50.0	0	0
5. Camarines Norte	13	0	0	1	7.7	7	53.8	5	38.5
6. Camarines Sur	2	0	0	0	0	2	100.0	0	0
7. Cavite	9	0	0	0	0	6	66.7	3	33.3
8. Isabela	3	0	0	2	66.7	1	33.3	0	0
9. La Union	5	0	0	1	20.0	2	40.0	2	40.0
10. Marinduque	5	0	0	0	0	4	80.0	1	20.0
11. Mindoro Occidental	31	1	3.2	8	25.8	15	48.4	7	22.6
12. Mindoro Oriental	66	4	6.0	11	16.7	33	50.0	18	27.3
13. Palawan	71	7	9.9	23	32.4	29	40.8	12	16.9
14. Pangasinan	53	0	0	18	34.0	19	35.8	16	30.2

Table 5. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
15. Quezon	4	0	0	2	50.0	2	50.0	0	0
16. Zambales	12	0	0	2	16.7	3	25.0	7	58.3
Subtotal	332	12	3.6	84	25.3	144	43.4	92	27.7
VISAYAS									
1. Antique	12	2	16.7	10	83.3	0	0	0	0
2. Bohol	22	0	0	8	36.4	8	36.4	6	27.2
3. Cebu	64	6	9.4	14	21.9	27	42.2	17	26.6
Hilutangan Island	4	0	0	1	25.0	0	0	3	75.0
Mactan Island	15	1	6.7	3	20.0	3	20.0	8	53.3
Olango Island	7	0	0	1	14.3	4	57.1	2	28.6
Sumilon Island	4	0	0	3	75.0	0	0	1	25.0
4. Iloilo	64	9	14.1	18	28.1	27	42.2	10	15.6
5. Leyte	12	0	0	0	0	6	50.0	6	50.0
6. Negros Occidental	18	1	5.6	2	11.1	5	27.8	10	55.6
Refugio Island	4	0	0	1	25.0	1	25.0	2	50.0
7. Negros Oriental	98	5	5.1	20	20.4	41	41.8	32	32.6

Table 5. Continued

LOCATION	No. of Stations	EXCELLENT No.	%	GOOD No.	%	FAIR No.	%	POOR No.	%
Apo Island	5	0	0	5	100	0	0	0	0
8. Siquijor	31	0	0	9	29.0	9	29.0	13	41.9
Subtotal	360	24	6.7	95	26.4	131	36.4	110	30.5
MINDANAO									
1. Misamis Occidental	9	0	0	0	0	4	44.4	5	55.6
2. Misamis Oriental	1	0	0	0	0	0	0	1	100
3. Zamboanga del Norte	18	1	5.6	3	16.7	6	33.3	8	44.4
Aliquay Island	8	2	25.0	3	37.5	2	25.0	1	12.5
Selinog Island	7	0	0	0	0	1	14.3	6	85.7
Subtotal	43	3	7.0	6	14.0	13	30.2	21	48.8
TOTAL	735	39	5.3	185	25.2	288	39.2	223	30.3

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