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Reef fish and coral assemblages at Maptaput, Rayong Province

Vipoosit Manthachitra[1] and Voravit Cheevaporn[2]

Abstract

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This study describes the structure of coral and fish assemblages of a group of small islands and pinnacles in the vicinity of Maptaput deep sea port, Rayong Province, Thailand during 2002. The coral and fish assemblages at Saket Island and nearby pinnacle, Hin-Yai, which are located less than 1 km from the deep sea port, had changed. Living coral cover in 2002 was 8% at Hin-Yai and 4% at Saket Island which decreased from 33% and 64%, respectively in the previous report in 1992. Numbers of coral species at Saket Island decreased from 41 species to 13 species. *Acropora* spp. that previously dominated the area had nearly disappeared. For fishes, a total of 40 species were found in 2002 the numbers decreased to only 6 species at Saket Island and 36 species at Hin-Yai. Fishes that dominated the area are small pomacentrids. After 1997, the conditions of coral and fish assemblages at Saket Island and Hin-Yai had markedly changed, whereas, the conditions found in the nearby area are much better. Sediment load from port construction was the primary cause of the degradation. This should indicate the adverse effect of sedimentation on coral and reef fish assemblages at Maptaput. Coral communities developed on rock pinnacles west of Maptaput deep-sea port are reported and described herein for the first time.

Key words : coral, reef fish, deep sea port, sedimentation

[1]Ph.D. (Marine Biology). Assoc. Prof., [2]Ph.D. (Marine Pollution Chemistry) Assoc. Prof., Department of Aquatic Science, Faculty of Science, Burapha University, Bangsean, Mueng Chon Buri, 20131 Thailand
Corresponding e-mail: vipoosit@bucc4buu.ac.th
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บทคัดย่อ

วิภูษิต มัณฑะจิตร และ วรวิทย์ ชีวาพร

ประชาคมปลาและปะการังบนกลุ่มปะการัง บริเวณมาบตาพุด จังหวัดระยอง

ว. สงขลานครินทร์ วทท. 2550 29(4) : 907-918

การศึกษาโครงสร้างประชาคมของปลาบนกลุ่มปะการังบริเวณเกาะและกองหินใต้น้ำ ใกล้พื้นที่ท่าเทียบเรือน้ำลึกและนิคมอุตสาหกรรมมาบตาพุด จัดหวัดระยอง ประชาคมปะการังและปลาบริเวณเกาะเสก็ดและหินใหญ่ที่อยู่ห่างจากท่าเทียบเรือประมาณ 1 กม ซึ่งพบปะการังมีชีวิตลดลงจากปี 2535พบ 62% และ 33% แต่ปี 2545 พบเพียง 4 % และ 8% และจำนวนชนิดของปะการังมีชีวิตลดลงจาก 40 ชนิดเหลือเพียง 13 ชนิด โดยปะการังเขากวางเดิมพบชุกชุมแต่เกือบไม่พบเลยขณะสำรวจ สำหรับปลาแนวปะการัง ปี พ.ศ. 2535 มีรายงานพบรวม 40 ชนิด แต่ปี 2545 บริเวณเกาะเสก็ดพบ 6 ชนิด แต่หินใหญ่พบ 36 ชนิด โดยพบปลาสลิดหินขนาดเล็กชุกชุมที่สุด สภาพของปะการังและปลาแนวปะการังเปลี่ยนแปลงไปตั้งแต่มีการก่อสร้างท่าเทียบเรือและนิคมอุตสาหกรรมบริเวณชายหาดตะกอนจากการก่อสร้างท่าเทียบเรือน่าจะมาจากสาเหตุของการเปลี่ยนแปลงนี้ กลุ่มปะการังบนกองหินใต้น้ำทางทิศตะวันตกของท่าเทียบเรือน้ำลึกมาบตาพุด ถูกรายงานและและอธิบายเป็นครั้งแรกจากการศึกษานี้

ภาควิชาวาริชศาสตร์ คณะวิทยาศาสตร์ มหาวิทยาลัยบูรพา ตำบลแสนสุข อำเภอเมือง จังหวัดชลบุรี 20131

Maptaput at Rayong Province was planned as a heavy industrial estate in the 1980s which was subsequently constructed in 1997 (UAE, 1998). Development was also conducted on a new land reclamation area that was done by seafloor dredging to facilitate building a plant and forming a turning basin for coal carrier boats. These activities have potential effect on the bottom topography and sedimentation in the adjacent area. Particularly, there are some small Islands (except Saket Island) and pinnacles which have never been studied before. Information on the distribution and status of coral reef assemblages in this area is important to provide a broad view and help in the assessment process of the impact that may occur after port operation. Saket Islands are the only area, within 10 km radius from Maptaput, where coral community was investigated (Sudara *et al.*, 1992). In fact, there are a number of near-shore pinnacles especially to the west of Maptaput. These near-shore pinnacles have never been explored and recorded as a part of the coral reef system in the East Coast of the Gulf of Thailand.

Sudara *et al*. (1992) provided information on coral formation in the vicinity of Maptaput. After that Silpananthakul (1995) studied the condition of reef assemblages. Both studies, however, gave information on coral communities only at Saket Island. Sudara *et al.* (1992) reported the impact of land reclamation on coral communities of Saket Island pointing out that NW-Saket received the highest impact, where living coral covered < 5% of the sampling area. NE-Saket and Hin-Yai were also impacted from sediment but the coral community was still in good condition with living coral covering 61% and 33%, respectively. Sudara *et al.* (1992) also reported the richness of corals and fishes found in this area as 41 and 42 species, respectively. Silpananthakul (1995) reported that coral formation could be found on four areas around Saket Island and one area at the nearby pinnacle, Hin-Yai. The best-developed coral formation could be found at NE-Saket Island and NE-Hin-Yai where coral condition was also good when compared with other stations (24%). Relative area cover of living coral at Hin-Yai and NE-Saket was reported as 74% and 24%, respectively.

After Maptaput industrial estate and port had been launched in 1997, an environmental monitoring program on coastal environment including coral reefs was also carried out. The report in 1998 indicated that the condition of coral

communities at NE-Saket and NE-Hin-Yai was degraded as the relative area cover of living coral was ca. 20% with a restricted numbers of 4-5 coral lifeforms (UAE, 1998). However, in the vicinity of the deep sea port there is still an area where coral community might be developed but it has never been explored. The objectives of this study were to investigate the present status of coral reef fishes and coral habitat condition at Maptaput deep sea port and nearby area.

Materials and Methods

Coral and fish assemblages were evaluated on pinnacles to the east and west of the deep sea port at Maptaput, Rayong Province, Thailand during 2002 (Figure1). The study stations consisted of several groups of rock pinnacles that emerged from a sandy substrate. The 13 stations examined, varying in area from approximately 1500 to 50,000 m^2, were placed into four groups based on a relative distance from the Maptaput deep sea port. The closest two stations were within 0.5 km (Saket Island) while the most distant (Hin Ban-Pra) was approximately 11 km from Maptaput (Table 1).

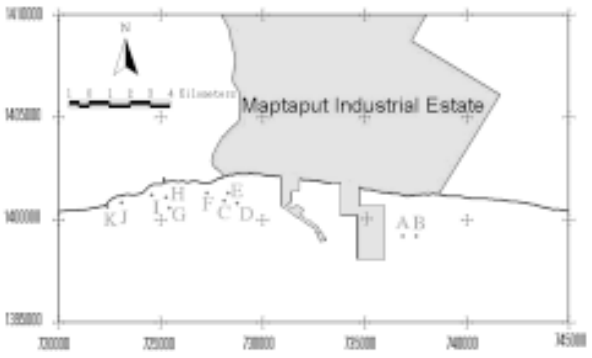

Figure 1. Map showing the study area at Maptaput, Rayong Province, Thailand during 2002. The letters represent the station as: A) Saket Island, B) Hin-Yai, C) Hin-Khong, D) Hin-Khong-Noi, E) Hin-Yuan, F) Hin-Khoa-group, G) Hin-Songpeenong, H) Hin-Payoon, I) Hin Zeek, J) Hin-Laem-Tean and K) Hin-Ban-Pra

Table 1. Details of coral formation on island and pinnacles at Maptaput, Rayong Province during 2002. (* side of the port)

Survey/Stations	Proximity to Maptaput (km)	Distance from land (km)	Coral community	Reef area (m^2)	Depth (m)	% Living Coral	Coral Species Richness	Fish Species Richness
1. Saket Island East (A1)	0.6 (East)*	2.3	Developed	Ca. 50,000	2	4.3	10	6
2. Saket Island West (A2)	0.5 (East)	2.3	Developed	Ca. 5,000	2	2.4	14	6
3. Hin-Yai (B)	0.6 (East)	2.2	Developed	Ca. 5,000	3	8.1	8	36
4. Hin-Khong North (C1)	6 (West)	1.6	Developed	Ca.30,000	3	12.4	29	32
5. Hin-Khong South (C2)	6 (West)	1.6	Developed	Ca.30,000	6	29.4	29	52
6. Hin-Khongnoi (D)	5 (West)	1.7	Non-developed	-	-	-	-	-
7. Hin-Yuan (E)	6 (West)	0.8	Non-developed	-	-	-	-	-
8. Hin-Khao gr. (F)	6.5 (West)	0.5	Non-developed	-	-	-	-	-
9. Hin-Song-Peenong (G)	8 (West)	0.8	Poorly developed	Ca. 2,500	-	-	5	-
10. Hin-Payoon (H)	8.5 (West)	0.6	Poorly developed	Ca. 2,500	-	-	5	-
11. Hin-Zeek (I)	9 (West)	0.3	Non-developed	-	-	-	-	-
12. Hin-Laem-Tean (J)	9.5 (West)	0.5	Developed	Ca. 1,500	1	47.3	13	21
13. Hin-Ban-Pra (K)	11 (West)	0.15	Non-developed	-	-	-	-	-

Coral assemblage was present at 6 of the 13 stations but one of the six stations had overall very poor condition with living coral cover less than 20% (Manthachitra, 1994). Therefore, data were collected at 5 stations: 1) Saket Island - East, 2) Saket Island-West, 3) Hin-Yai-East, 4) Hin-Khong-South, and 5) Hin-Laem-Tean (Figure 1).

Coral species and distribution at each station were examined along 3-4 replicate transects approximately 10-15 m apart and each 30 m in length on the upper reef slope of the reef (3 meters below mean sea level) parallel to the shore line. SCUBA divers recorded all coral species and other benthic lifeforms along each transect. Coral and benthic lifeforms were expressed as a percentage of the area surveyed. Data were analyzed using one-way ANOVA to test the difference in area cover among stations. When significant difference was detected by ANOVA, Student-Newnam-Keuls was employed. The relationships between the percentage of living coral cover and the distance to the Maptaput was analyzed using linear regression analysis. The condition of coral assemblages was classified by the proportion of living coral: dead coral as proposed by Manthachitra (1994).

Fish species and abundances were recorded using a visual census technique (English *et al.*, 1997). Censuses were conducted on the same coral transects. Along each transect, SCUBA divers identified, counted and recorded fishes within the range of approximately 5 m either side of the transect. Small and cryptic species such as gobies and blennies were also identified and recorded but enumeration was avoided.

Fish assemblage structure of 5 stations; 1) Hin-khong North, 2) Hin-Khong South, 3) Hin-Yai East, 4) Saket Island East, and 5) Hin-Laem-Tean, were analyzed using discriminant function analysis (Quinn and Keough, 2002). Only those species whose contribution to abundance was > 5% of total abundance (23 species) were used in the analysis. The abundance values were Ln-transformed and the data matrix centered to reduce the effect of a few dominant species but focus more on common species. Angular interpretation was, thus, used to interpret the ordination plot produced by discriminant function analysis. Discriminant functions are lists of the coefficients showing how much each original variable contributes to each new derived variable. In this case, each function represents species of fish that have the greatest varience in the function. Other parameters of fish communities are presented in terms of total abundance, species richness, Shannon-Wiener diversity index and evenness index (Pielou, 1984). All of the fishes presented in this study were used in these analyses.

Results

Corals. Species lists for coral were carried out on all stations that had coral formation. Species pool of corals found in the study area was at least 35 species (Table 2). Hin-Khong had the highest richness of corals with the presence of 29 species, while Hin-Song-Peenong and Hin-Payoon had lowest species richness with the presence of only 4-5 species.

Quantitative assessment of the condition of coral assemblages could be done only at 6 stations; Hin-Laem-Tean, Hin-Khong North and South, Hin-Yai, Saket Island East and West, because of poor visibility (< 2 m) and poor coral assemblage development. There were significant differences ($p<0.05$) in living coral among stations. According to Student-Newman-Keuls test, stations could be separated into 3 groups as follows: 1) East and West of Saket Island, Hin-Khong and Hin-Yai North 2) Hin-Khong South and 3) Hin-Laem-Tean. Living corals at all stations occupied less than 50% of the area. There was a trend that living coral cover decreased with closer proximity to Maptaput. Saket Island had the lowest coverage (2.4% - 4.3%) of living coral (Figure 2). The percentage cover of living coral at the six stations where visibility allowed for quantitative assessment increased linearly with distance from Maptaput. This relationship was described by the regression:

$$C_l = 4.2\ D_m \quad (r^2 = 0.92^*, n = 6).$$

Table 2. Species list of corals found at Maptaput, Rayong Province during 2002.

Species	Saket Island	Hin-Yai	Hin-Khong	Hin-Laem-Tean	Hin-Song-Pee-Nong	Hin-Prayoon
1. *Pocillopora damicornis*	+	+	-	-	-	-
2. *Acropora valvida*	+	-	+	-	-	-
3. *Acropora* sp.	-	-	+	-	-	-
4. *Acropora hyacinthus*	*	-	*	-	-	-
5. *Acropora robusta*	*	-	*	-	-	-
6. *Astreopora myriopthlma*	-	-	+	-	-	-
7. *Porites lutea*	+	+	+	+	+	+
8. *Goniopora djiboutiensis*	+	-	+	-	-	-
9. *Pavona decussata*	-	-	+	+	-	-
10. *Fungia fungites*	-	-	+	-	-	-
11. *Fungia echinata*	-	-	+	-	-	-
12. *Lithophyllon edwardsi*	-	-	+	-	-	-
13. *Galaxia astreata*	-	-	+	-	-	-
14. *Galaxia fascicularis*	-	-	+	-	-	-
15. *Hydnophora microconos*	+	+	-	-	-	-
16. *Favia pallida*	+	-	+	+	+	+
17. *Favia favus*	+	-	+	+	+	+
18. *Favia matthaii*	-	-	+	-	-	-
19. *Barabattoia amicorum*	-	-	+	+	-	-
20. *Favites abdita*	+	+	+	+	+	+
21. *Favites halicora*	-	-	+	-	+	+
22. *Favites chinensis*	+	+	-	-	-	-
23. *Goniastrea retiformis*	+	-	+	-	-	-
24. *Goniastrea aspera*	-	-	+	-	-	-
25. *Platygyra daedalea*	+	+	+	+	-	-
26. *Platygyra sinensis*	+	+	+	+	-	-
27. *Platygyra pini*	+	+	+	+	-	-
28. *Montastrea curta*	-	-	+	+	-	-
29. *Oulastrea crispata*	-	-	+	+	-	-
30. *Diploastrea heliopora*	-	-	+	-	-	-
31. *Plesiastrea versipora*	+	-	-	+	-	-
32. *Leptastrea transversa*	-	-	+	-	-	-
33. *Cyphastrea serailia*	-	-	-	+	-	-
34. *Echinopora lamellosa*	-	-	+	-	-	-
35. *Turbinaria peltata*	-	-	+	-	-	-
Species richness	14	8	29	13	5	5

Remark + present, - absent, * dead skeleton

Where C_l is the percentage of living coral cover and D_m, is the distance, in km, from Maptaput deep sea port (Figure 3).

The pattern of coral species richness differs slightly from that of area cover as Hin-Khong was the highest numbers of coral species, 29 species (Figure 4). Only 2 species of corals were found at every station: Porites lutea and Favia abdita. Two species found at all stations except at Hin-Yai were *F. pallida* and *F. favus*.

Numbers of coral species were greatest at Hin-Khong station with 29 species (Table 2). Saket

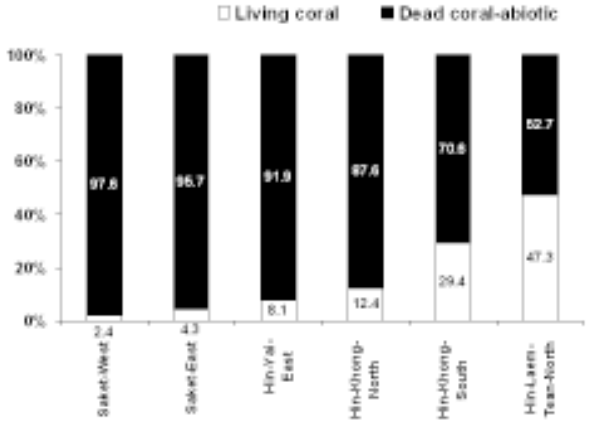

Figure 2. Area cover of living coral and dead coral-abiotic on the coral assemblage at Maptaput during 2002

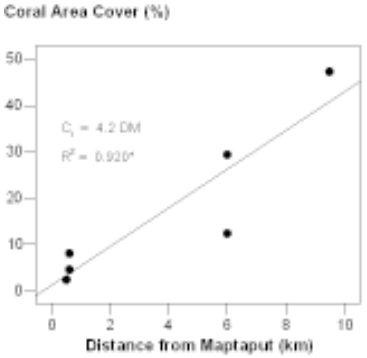

Figure 3. Relationships between distance from Maptaput (DM) and coral area cover (C) found on the coral assemblage at Maptaput during 2002

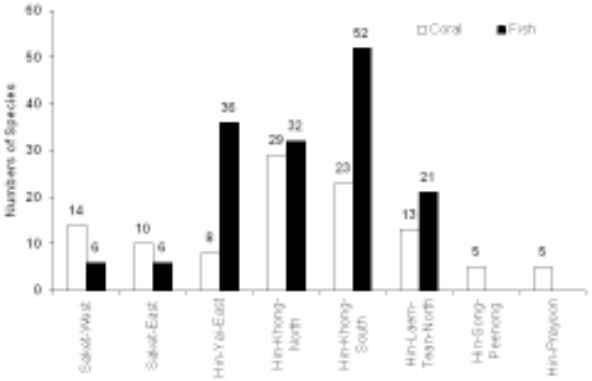

Figure 4. Species richness of corals and fishes found on the coral assemblage at Maptaput during 2002.

Island followed with 13 species. At Hin-Laem-Tean 13 species were found. At each of the remaining three stations eight or fewer species were found. Species richness tended to increase linearly with distance from Maptaput. The relationship was statistically significant and described by the regression:

$$S_i = 3\ DM \quad (r^2 = 0.66^*, n = 6)$$

Where S_i is the coral species richness and DM, is the distance, km, from Maptaput deep sea port (Figure 5).

Coral reef fish. There was a total of 67 species found in the study area (Table 3). Species

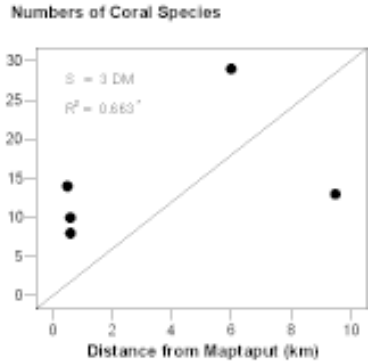

Figure 5. Relationships between distance from Maptaput (DM) and coral species richness (S) found on the coral assemblage at Maptaput during 2002.

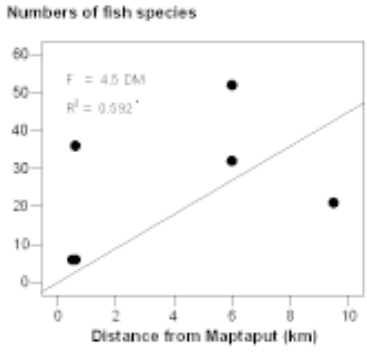

Figure 6. Relationships between distance from Maptaput (DM) and fish species richness (F) found on the coral assemblage at Maptaput during 2002.

Table 3. Abundance of coral reef fishes at Maptaput, Rayong Province during 2002 (mean ± standard error/150 m.^{2})

Species/Study stations	Saket Island-West	Saket Island-East	Hin-Yai-East	Hin-khong-North	Hin-khong-South	Hin-Laem Tean
1. *Abudefduf bengalensis*	-	0	13±3	10±4	18±3	4±1
2. *Abudefduf sexfasciatus*	-	0	32±10	0.8±0.6	17±16	14±6
3. *Abudefduf vaigiensis*	-	0	10±7	0.6±0.6	2±2	0
4. *Abudefduf sordidus*	-	0	0	0	0.2±0.2	0
5. *Amblyglyphidodon curacao*	-	0	4±3	2±1	1±1	0
6. *Amphiprion perideraion*	-	0	1±1	0	0.4±0.4	0
7. *Cheiloprion labiatus*	-	0	0	0	0.2±0.2	0
8. *Neoglyphidodon nigroris*	-	0	0.4±0.4	0.2±0.2	0	0
9. *Neoglyphidodon melas*	-	0	0	0	0.2±0.2	0
10. *Plectroglyphidodon lacrymatus*	-	0	0.2±0.2	0.8±0.6	0	0
11. *Pomacentrus cuneatus*	+	7±4	58±14	114±25	220±34	8±4
12. *Pomacentrus chrysurus*	+	9±3	0.2±0.2	11±4	12±5	15±4
13. *Pomacentrus moluccensis*	-	0	0.4±0.4	0	0.2±0.2	0
14. *Pomacentrus tripunctatus*	-	0	0	0	0	5±3
15. *Neopomacentrus filamentosus*	+	46±46	220±82	10±6	690±336	12±10
16. *Neopomacentrus cyanomos*	-	0	140±91	0	0	0
17. *Neopomacentrus anabatoides*	-	0	0	100±63	650±384	0
18. *Neopomacentrus bankieri*	-	0	0	0	2±2	0
19. *Stegastes obreptus*	-	0	3±1	2±1	4±1	0
20. *Chaetodon octofasciatus*	-	0	3±1	4±2	7±2	0.8±0.4
21. *Chelmon rostratus*	-	0	0	0.4±0.4	1±1	0.8±0.4
22. *Halichoeres chloropterus*	-	0	1±1	4±1	7±2	1±1
23. *Halichoeres nigrescens*	-	4±3	33±12	7±3	11±3	8±2
24. *Halichoeres purpurescens*	-	0	0	0	0.2±0.2	0
25. *Halichoeres marginatus*	-	0	0	0	0	0.2±0.2
26. *Hemigymnus melapterus*	-	0	0	0.2±0.2	0.4±0.2	0
27. *Labriodes dimidiatus*	-	0	0.4±0.4	0	0	0
28. *Scarus ghobban*	-	0	0.4±0.4	0	1±1	0
29. *Cephalopholis boenak*	+	0	0.4±0.4	0.6±0.4	4±1	0.6±0.4
30. *Cephalopholis formosfa*	-	0	2±1	0.2±0.2	2±1	0.4±0.2
31. *Cephalopholis cyanostigma*	-	0	0.4±0.4	0.4±0.4	0	0
32. *Epinephelus merra*	-	0.6±0.6	0	0	0.6±0.2	0.2±0.2
33. *Plectopomus maculates*	-	0	0	0	0.2±0.2	0
34. *Lutjanus fulviflamma*	-	0	4±4	0.4±0.4	5±5	0
35. *Lutjanus russelli*	-	0	2±2	0	20±20	0
36. *Lutjanus argentimaculatus*	-	0	0	0	0.2±0.2	0
37. *Lutjanus vitta*	-	0	0	0	0.6±0.4	0
38. *Caesio cunning*	-	0	61±25	0	26±17	0
39. *Pterocaesio tile*	-	0	71±59	0	0	0
40. *Siganus corallinus*	-	0	0	2±2	0	0
41. *Siganus javus*	-	0	0.8±0.5	0	0.6±0.4	0.2±0.2
42. *Siganus guttatus*	-	0	31±13	0	7±6	0
43. *Siganus virgatus*	-	0	0	0	0.4±0.4	1±1

(to be continued)

Table 3. (Continued)

Species/Study stations	Saket Island-West	Saket Island-East	Hin-Yai-East	Hin-khong-North	Hin-khong-South	Hin-Laem Tean
44. *Kyphosus vaigiensis*	-	0	0	0	0.2±0.2	0
45. *Scolopsis monogramma*	-	0	0.4±0.4	0.2±0.2	0.2±0.2	0.2±0.2
43. *Scolopsis ciliatus*	-	0	1±1	2±2	0	0
47. *Scolopsis margaritifer*	-	0	0	0	0.2±0.2	0
48. *Scolopsis vosmeri*	-	0	0.2±0.2	0	0.6±0.6	0
49. *Atule mate*	-	0	5±5	0	0	0
50. *Monodactylus argenteus*	-	0	0.2±0.2	0	2±2	0
51. *Sphyraena obtusata*	-	0	0	0	4±4	0
52. *Moolgarda seheli*	-	0	0	0.2±0.2	0	0
53. *Upeneus tragula*	-	0	0	0.2+0.2	1±1	0.2±0.2
54. *Cheilodipterus artus*	-	0	0	6±4	0	0
55. *Cheilodipterus quinquelineatus*	-	0	0	0	34±29	6±6
56. *Apogon cooki*	-	12±12	44±23	2±2	10±10	0
57. *Apogon cyanosoma*	-	0	0	0	2±2	0
58. *Archamia fucata*	-	0	0	0	126±97	0
59. *Pempheris oualensis*	-	0	15±6	21±18	7±4	4±4
60. *Valenciennea muralis*	-	0	0	0	1±1	0
61. *Ptereleotris* sp.	+	0	0	20±20	140±57	0
62. *Ptereleotris microlepis*	-	0	0	0	2±2	0
63. *Sargocentron rubrum*	-	0	3±2	0.2±0.2	0	0.4±0.4
64. *Tylosurus crocodilus crocodiles*	-	0	0	0.6±0.6	0.4±0.4	0
65. *Spartelloides gracilis*	+	0	0	0	0	0
66. *Echenius naucrates*	-	0	0	0	0.2±0.2	0
67. *Diodon liturosus*	-	0	0	0	0.2±0.2	0
Mean Total abundance		79±41	768±229	323±100	2042±507	84±11
Species richness	6	6	36	33	52	21
Eveness		0.703	0.654	0.566	0.475	0.778
Diversity index		1.26	2.344	1.962	1.877	2.368

Remark + present, - absent

richness of fishes at each study station had a slightly different pattern as compared to coral species richness (Figure 4). The stations with the highest richness were Hin-Khong South (52 species and 2042±507 individuals, mean±standard error), Hin-Yai (36 species and 768±229 individuals) and Hin-Khong North (33 species and 323 ±100 individuals), respectively. Fish species richness was lowest at Saket Island with a total of 9 species found. Indeed, a total of 60 species was encountered at Hin-Khong-South and Hin-Yai with 24 species being common to both. Overall, richness was least at Saket Island with 6 species, the station closest to Maptaput. At Hin-Laem-Tean, which is the station furthest from Maptaput but closest to the shore, 21 species were found which is lower than Hin-Khong. Species richness tended to increase linearly with the distance from Maptaput. The relationship was statistically significant and described by the regression:

$$F_i = 4.5\ DM\ (r^2 = 0.59^*, n = 6)$$

Where F_l is the fish species richness and DM is the distance, km, from Maptaput deep sea port (Figure 6).

Table 4. Results of the discriminant function analysis on reef fish assemblages found at Maptaput, Rayong Province during 2002.

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	420.188	76.4	76.4	.999
2	92.758	16.9	93.2	.995
3	29.840	5.4	98.6	.984
4	7.464	1.4	100.0	.939

Species diversity and evenness of fish had slightly different patterns from total abundance and species richness. It was found that Hin-Laem-Tean has the highest diversity and evenness (2.37 and 0.78) but low abundance and richness. There were 3 dominant species of fishes found at every study station (i.e. *Neopomacentrus filamentosus, Abudefduf bengalensis* and *Pomacentrus cuneatus.* There were 4 species; *Cephalopholis boenak, C. formosa, Scolopsis monogramma,* and *Pempheris oulensis,* found at all stations except at Saket Island.

Total abundance followed a similar pattern with the largest number of fish at the southern station at Hin-Khong with over 2000 fish/150 m^2 and the lowest of about 80 fish/150 m^2 at the Saket Island and Hin-Lean-Taen stations. Few species were numerically dominant at any station with the relative number tending to vary inversely with richness. Thus, at the most species-rich station, Hin-Khong, only 8 and 12% of the species had abundances more than 5% of the total. In contrast, at the least specious station, Saket Island, five of the six species were found at more than 5% of the total.

Assemblage structure of fishes was represented by fish abundances more than 5% of the total. On this basis, 23 of the total of 67 species were analyzed by discriminant function analysis. Three groups of fish assemblages were recognized by the analysis with the first two functions accounting for 93.3% of total variance (Table 4 and Figure 7). The first assemblage included Saket Island and Hin-Laem-Tean stations and was characterized by low species richness, 2- 6 species, and low total abundances of about 80 fish/ 150 m^2.

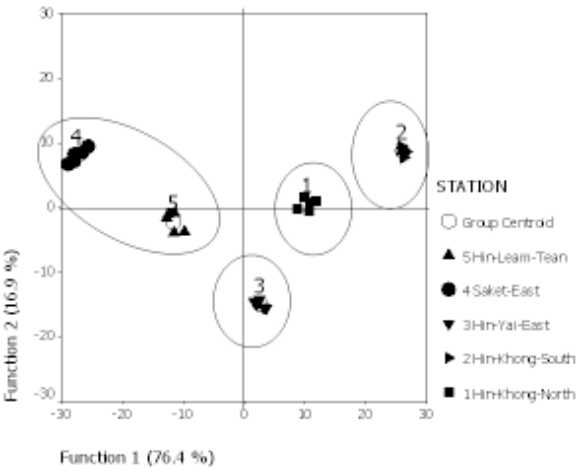

Figure 7. Ordination plot from the result of the discriminant function analysis of coral reef fish assemblages at Maptaput during 2002.

Common species in group 1 were small damsel fishes; *Pomacentrus chrysurus, P. cuneatus* and *Neopomacentrus filamentosus,* wrasses; *Halichores chloropterus* and *H. nigrescens* and a small grouper, *Epinepherus merra*. The second group included Hin-Khong North and Hin-Yai had modulated species richness and total abundance with 33 species and 300 fish/150 m^2. Numerically dominant species in this group included *Abudefduf vaigiensis, P. cuneatus* and *Lutjanus fulviflamma, Siganus corallinus* and *Moolgarda seheli*, which were uncommon in the area and were found only at these stations. The third group consisted of Hin-Khong south and had the highest richness and total abundance at 52 and 2000 fish/150 m^2, respectively. Fish that characterized this group were *Pomacentrus cuneatus, Pomacentrus chrysurus,*

Table 5. Area cover (%) of living and dead coral and species richness of corals and fishes found at Saket Island and Hin-Yai during 1992-2002

Saket-West	92[1]	95[2]	Sep 97[3]	Dec 97[3]	Mar 98[3]	Jan 02[4]
Living coral (%)	62	74	60	30	30	2.4
Dead coral (%)		15	45	45	96	
Coral species richness	19	-	17	5	5	14
Fish species richness	40	-	-	-	-	6
Hin-Yai						
Living coral (%)	33	24	60	30	30	8.1
Dead coral (%)	-	-	15	45	45	92
Coral species richness	12	-	17	5	4	8
Fish species richness	29	-	-	-	-	36

[1]**Sudara *et al.* (1992),** [2]**Silapananthakul (1995),** [3]**UAE (1998), and** [4]**This study**

Neopomacentru filamentosus, Halichoeres nigrescens and *Epinephelus merra*.

Discussion and Conclusion

The only previous records of coral assemblage in the Maptaput area were confined to Saket Island and Hin-Yai (Sudara *et al.*, 1992; Silapananthakul, 1995). This study provided information of coral assemblages found at these and recorded new stations within the Maptaput area. All of the new coral assemblages in this area were located close to coastline, ranging from 300 m to 5 km. The impact of sediment was high because these stations were surrounded by shallow muddy bottom (UAE, 1998). Generally, the condition of coral assemblages was poor. It is suspected that these coral assemblages received impact from sedimentation during and after port construction since 1990.

The conditions of coral and fish assemblages at Saket Island and Hin-Yai during the past 10 years are summarized in Table 5. There was a trend of deterioration in the condition of coral reef assemblages because of the sedimentation. Those corals and fishes remaining were low in number of species and abundance. Sudara *et al.* (1992) found 40 species of fishes at Saket Island but only 6 species were found in the current study. In contrast, fish species were found in increased numbers at Hin-Yai, from 29 to 36 species. This might indicate the faster recovery of fish than coral assemblages. The impact from sedimentation also covered the western side of the port. The impact on coral assemblages is higher than that on fish assemblages. That was also no sign of coral recovery.

Recently, the north end of Saket island has developed a long sand dune extending from the island to the mainland. This sand dune had buried some parts of the coral assemblages at NE-Saket. Sudara *et al.* (1992) found the sedimentation rate to be highest at NW-Saket (752 mg/cm^2/day) while a lower rate was detected at Hin-Yai and NE-Saket (25.5 and 47 mg/cm^2/day respectively). These sedimentation rates, however, and all over the stress limit for corals. Rogers (1990) reviewed the responses of coral reefs and reef organisms to sedimentation and pointed out that the level of sedimentation rate and suspended sediment for reefs not subject to stresses are < 10 mg/cm^2/day and 10 mg/l. Above these levels the reefs will be subject to chronic stress. Thomas and Ridd (2005) classified the sediment accumulation rate levels and suspended solid concentration corresponding to impact zone on coral reefs. Thus 10-20 mg/cm^2/day and 15-30 mg/l are in transition condition while levels above this indicate severe condition. UAE (1998) reported that during the construction

in 1998 that the sedimentation rate at Saket Island was 190-200 mg/cm^2/day while at Hin-Khong it was 30-31 mg/cm^2/day. Both areas had sedimentation rate exceeding the severe condition but Saket Island had remarkably higher sedimentation rate than Hin-Khong.

Sudara *et al.* (1991) reported the influence of sediment on coral growth at the inner Gulf of Thailand. Sedimentation rate ranged from 0.3 to 6.25 mg/cm^2/day and suspended solids in water 0.6-8.4 mg/l were found to coral growth. Dodge and Vaisnys (1977) reported the influence of dredging in terms of sedimentation and turbidity on coral population and growth pattern. Theyfound living corals in the impact area decreased when compared with control stations. The impact on coral population was described as decreasing numbers of younger colonies. This indicated that younger colonies are less resistant to sedimentation and turbidity than older colonies. Chansang *et al.* (1981) reported the main cause of damage on reefs in the Bang Tao Bay, Phuket was sedimentation. They mentioned that the corallimorphs are abundant in the Bang Tao Bay because they can resist the effect of sediment better than hard coral. At Saket Island, however, corallimorphs had not been seen. Neil (1990) showed the potential stress on coral from suspended sediment at a concentration of 1,093 mg/l and deposition at 32.8 mg/cm^2/day causing moderate stress to reef flat corals together with re-suspension and deposition of sediment by reef walkers. Neil (1990) mentioned that sediment concentration and frequency of disturbance are major factors contributing to the impact on corals. Rogers (1983) found that light illumination on reefs at 15-20 m depth was reduced from 30% to less than 1% because of siltation. The effects on coral less capable of sediment rejection, *Porites astreoides*, were loss of zooxanthellae and death. For corals those are capable of rejecting sediment, such as *Madracis mirabills*, their calcification rate decreased by 33%. Rogers (1983) reported that natural sedimentation rates on coral reefs are variable but generally less than 10 mg/cm^2/day

Rogers (1990) pointed out the effect of sediment on recruitment where in high sediment environment the settlement of coral will take place on the vertical plane rather than the horizontal plane. And where sediment is very high, coral larvae cannot successfully colonize. Recruitment of reef organisms is very important for the recovery of the coral reef ecosystem after heavy sedimentation due to the effect from land reclamation. The recovery can take place only at the level of sedimentation less than stress level. If the impact from sedimentation still exists, coral assemblages may completely degrade. Toress and Morelock (2002) illustrated the negative log linear relationships between sedimentation rate and linear extension rate of three Caribbean massive corals. Sedimentation rate of 100 of mg/cm^2/day could reduce the linear extension rate by around 50%.

At Saket Island and Hin-Yai, the impact from sediment was pointed out in 1992. However, in 2002 there was no sign of coral recovery at Saket Island and Hin-Yai. The impacts from prolonged sedimentation on larvae transport is the major suspect. If the impact from sedimentation still exists, the coral community may be completely degraded. From the observation, there was sediment deposit on coral at the west side of the island. It is necessary to be aware that any activities leading to increased sediment load may completely deteriorate these coral communities.

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