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Some structural changes of seagrass meadows in Taklong Island National Marine Reserve, Guimaras, Western Visayas Philippines after an oil spill

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Abstract In August 2006, over 2 million liters of bunker fuel spilled from a sunken cargo vessel off Panay Gulf, Western Visayas Philippines. Floating oil found its way in the coastline of southern Guimaras including that of a marine protected area, Taklong Island National Marine Reserve (TINMR) (10º24' to 10º26'N, 122º29' to 122º31' E). Most shorelines adjacent to seagrass beds were heavily covered with bunker fuel for weeks before manual clean up were initiated. This study describes temporal changes in structure between 2 adjacent seagrass meadows within TINMR, one with extensively oiled shoreline (CALAPARAN) and the other visually unoiled (KALIROHAN). Seagrass features in TINMR sites were compared to a reference site (LAWI) ~15 km north off the oil spill path. All 3 sites have mixed species dominated by *Thalassia hemprichii*. Sampling of the seagrass meadows following the oil spill indicate impact in the meadows with oiled shoreline (CALAPARAN). These impacts included: (1) a decrease in seagrass cover and shoot density; (2) generally lower seagrass cover, shoot and blade densities, and above-ground biomass within a year after the oil spill when compared to the other 2 sites; (3) a lower mid-year peak in seagrass cover as part of a bimodal seasonal pattern; and (4) a prolonged decline in shoot and blade densities within a year of the oil spill compared to KALIROHAN.

Key words: Oil spill, seagrass, Guimaras

INTRODUCTION

The SOLAR 1 oil spill accident on August 11, 2006 caused much havoc and distress on the environment and people of southern Guimaras, Western Visayas Philippines. It reduced the scenic and educational values of the protected area in Guimaras, the Taklong Island National Marine Reserve (TINMR) as most of its white sandy beaches turned black overnight by stranded oil and made it impossible to carry out any activities nearshore as viscous bunker oil floated for weeks. Seagrass meadows are commonly found adjacent to white sandy beaches. An estimated 20 hectares of seagrass covered area is found in TINMR (Nievales, 1997 unpublished report).

Seagrass beds are considered one of the most productive natural ecosystems in the world (Phillips, 1978). They serve as nursery, refugia, breeding ground and home to many marine fishes, reptiles, and invertebrates with important economic, ecological and conservation value (in Thorhaug, 1986; in Walker & McComb, 1992). McManus et al. (1992) estimated some 20mT of fish, seaweeds and invertebrates may be harvested per km^2 per year in a seagrass bed. Seagrass beds help sustain the energy flow and biogeochemical cycling of nutrients and minerals, and ensure the continuity of the life cycle of biota shared with adjacent habitats like mangroves and coral reefs. In Guimaras, seagrass meadows serve as center of economic activity (e.g. shellfish gleaning, seaweed farming, sea cucumber collection and fishing using gill nets). These economic activities were hampered by the oil spill. There are few case studies in the tropics which looked at impacts of bunker fuel contamination on seagrasses. Having in mind these economic and ecological services of seagrass habitats, this study aims to explore how tropical seagrass meadows respond hydrocarbon contamination in the form of bunker fuel oil spill. The specific objectives are:

1) To compare the pre- and post-oil spill structure of a contaminated seagrass meadow;
2) To describe the temporal changes in structural properties of seagrass meadows within and outside of the area exposed to the oil spill.

METHODS and MATERIALS

Study sites

The Taklong Island National Marine Reserve (TINMR) (10º24' to 10º26'N, 122º29' to 122º31' E) was declared a protected seascape by Presidential Proclamation No. 525. It is situated in the southern end of Guimaras Island Province, Western Visayas, Philippines. To the east, west and south of TINMR is Panay Gulf, an extension of Sulu Sea and to the north is mainland Guimaras Island separated from it by a shallow soft bottom channel.

In this study, August 2006 was used as a timeline to separate pre- and post-oil spill changes in seagrass structure and properties in TINMR. Within TINMR, two neighboring coves with seagrass meadows were chosen, CALAPARAN and KALIROHAN. CALAPARAN has an estimated seagrass area of one hectare. It had a heavily oiled shoreline for at least three weeks. Four months after the oil spill, oil mixed with sand was still observed floating at high tide. KALIROHAN had no visible oil along its shoreline following the spill. It is located only 250 meters east of CALAPARAN. Outside of

Fig. 1. Location map of sampling stations in Guimaras, Western Visayas, Philippines.

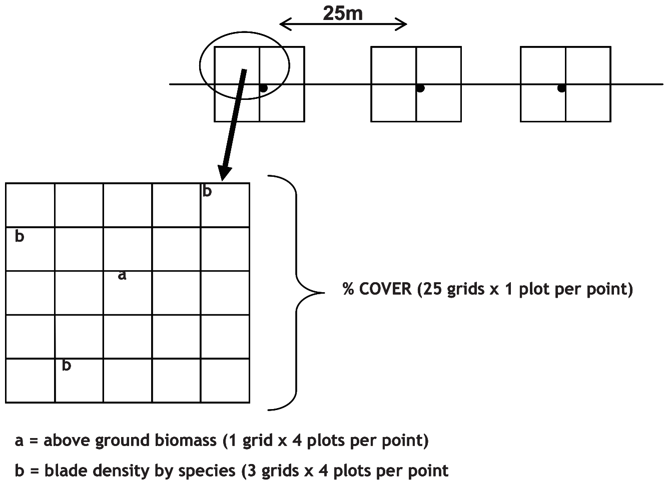


Fig. 2. Diagram of the ecological sampling strategy

the marine reserve, a cove with seagrass meadow in Sitio Lusay, LAWI (10º32'N, 122º31'E) was chosen as the reference site since satellite images showed fuel from SOLAR 1 never reached this area. LAWI is approximately 15 km to the north of TINMR and had 1.1 hectares of seagrass bed (Fig. 1).

Ecological Monitoring

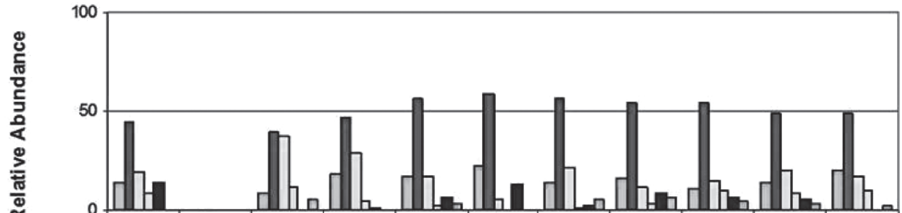
Seagrass assessment included plot method determination of seagrass percent cover, species composition, blade density per species, shoot density and above ground biomass. Three 50 m long fixed transects 25 m apart were established running parallel to shore in each site. Monthly to bimonthly ecological monitoring was conducted between August 2006 to March 2008 in CALAPARAN, which is a NAGISA seagrass site in the Philippines, and from October/November 2006 to March 2008 in KALIROHAN and LAWI.

In each transect, three sampling points were chosen about 25m apart. Four 0.5m x 0.5 m plots (quadrats) were laid per sampling point. Each plot was divided into 25 grids (10 cm x 10 cm per grid). Figure 2 shows the sampling strategy for the different ecological parameters. Seagrass cover was estimated in four plots per sampling point (i.e. m^{-2}) based on the Saito-Atobe method. Shoot density was determined by counting all the shoots in one plot (=25 grids) per sampling point. The species composition and mean blade density were determined by identifying the species and counting the total blades by species within 12 randomly chosen grids per sampling point. Above ground seagrass biomass (AGB) was based on total harvest of seagrass shoots in four grids per sampling point. Harvested seagrass shoots were placed in pre labeled plastic bags. These were brought to the laboratory for wet and dry weight (DW) determinations. To determine DW, samples were oven dried at 60-70℃ until weight was constant.

RESULTS

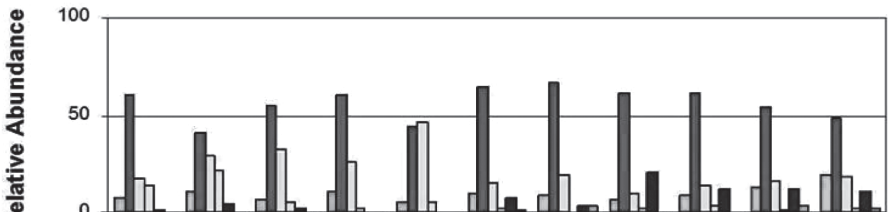
All three sites were mixed species meadows located in protected coves. A total of eight seagrass species were encountered in the 3 sites. The species were *Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata, C. serrulata, Syringodium isoetifolium, Halophila ovalis, Halodule uninervis and H. pinifolia*. *T. hemprichii* is the dominant species in all sites (Figure 3a-c).

a.



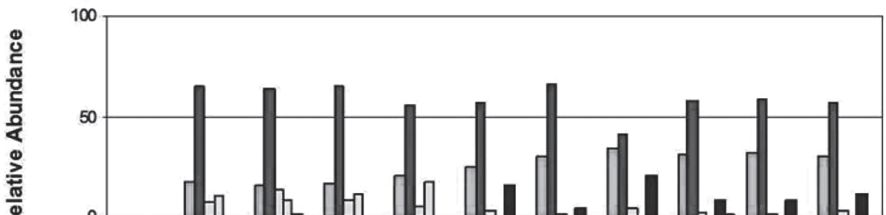
	Oct '06	Nov	Dec	Jan '07	March	May	July	Sep	Nov	Jan '08	March
Enhalus	14		8	18	17	23	14	16	10	14	21
Thalassia	45		39	47	56	58	56	54	54	49	49
Cymodocea	19		37	29	17	6	21	12	14	21	17
Syringodium	9		12	4	2	0	2	3	10	8	10
Halophila	14		0	1	6	13	2	9	7	6	0
Halodule	0		5	0	3	0	5	6	4	3	3

b.



	Oct '06	Nov	Dec	Jan '07	March	May	July	Sep	Nov	Jan '08	March
Enhalus	8	11	6	11	5	9	9	7	9	13	19
Thalassia	60	41	55	60	44	65	66	61	61	54	48
Cymodocea	17	29	32	26	46	15	19	10	14	16	18
Syringodium	14	22	5	2	5	2	0	2	4	2	2
Halophila	1	4	2	0	0	8	3	20	12	12	11
Halodule	0	0	0	0	0	1	3	0	0	3	2

c.



	Oct '06	Nov	Dec	Jan '07	March	May	July	Sep	Nov	Jan '08	March
Enhalus		18	15	16	21	25	30	34	31	32	30
Thalassia		65	64	65	56	57	66	41	58	59	56
Cymodocea		7	13	8	5	3	1	4	2	1	3
Syringodium		10	8	11	18	0	0	0	0	0	0
Halophila		0	1	0	0	15	4	21	8	8	11
Halodule		0	0	0	0	0	0	0	1	0	0

Fig. 3. Relative abundance of different seagrass species by site
a. CALAPARAN b. KALIROHAN c. LAWI (reference site).

There was no visual account of seagrass blades being smothered or covered with oil in meadows within the marine reserve. However, oil stranding on shoreline adjacent to the seagrass bed in CALAPARAN which is a NAGISA site was documented.

There were observed differences in structural properties and dynamics of the seagrass meadow that was heavily impacted (CALAPARAN) compared to benchmark data and relative to the properties of a neighboring meadow (KALIROHAN) with unoiled shoreline or to the reference site (LAWI). Mean seagrass cover in CALAPARAN declined for two successive years compared to its pre-oil spill level measured in March 2006 (Campos W. *et al*. unpublished data). Prior to the spill, mean seagrass cover was 28.2%. A year after the oil spill, mean seagrass cover was 18.6% and, two years after the

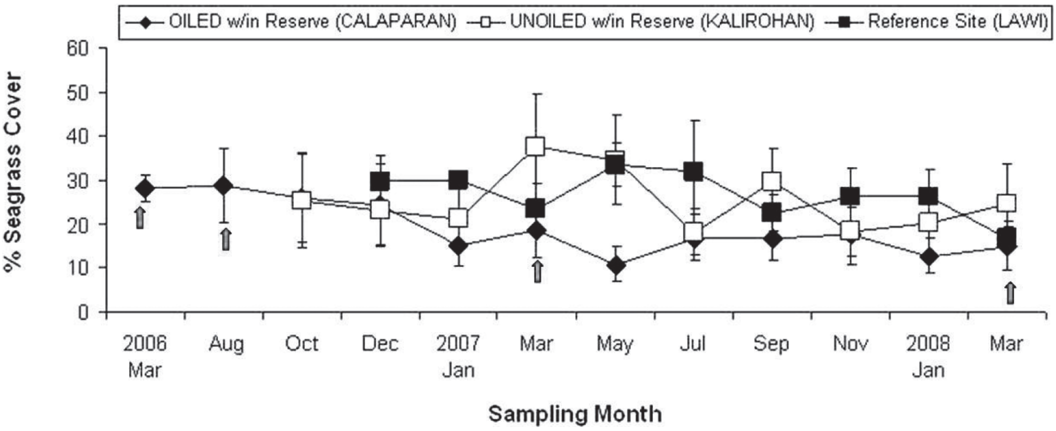


Fig. 4. Temporal change in seagrass cover (% cover +/- se) in 3 sites. Arrow shows seagrass cover pre- and post-oil spill in heavily oiled site, CALAPARAN. *Note*: March 2006 sourced from W. Campos

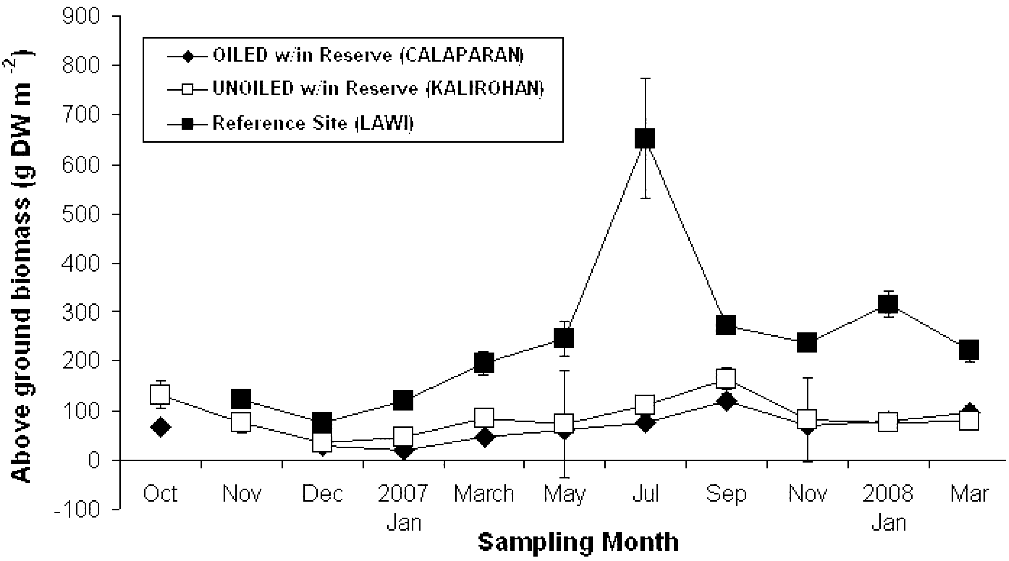


Fig. 5. Above ground biomass (g DW m^{-2} +/- se) in 3 sites from October/November 2006 to March 2008.

spill, mean seagrass cover was 15%. In most months after the oil spill, seagrass cover was lowest at CALAPARAN (Figure 4). The seasonal pattern in seagrass cover was bimodal with early to mid- and end of the year peaks. CALAPARAN and KALIROHAN had peaked in March and September though the early peak in the former was slight. In LAWI, the peaks occurred later in May to July and November to January. Seagrass cover ranged from 11% to 29% in CALAPARAN, 18% to 38% in KALIROHAN and 17% to 34% in LAWI.

Above ground biomass was consistently lowest in CALAPARAN five months after the oil spill and for the next 10 months (January to November 2007) (Figure 5). The pattern was unimodal in all sites. The unimodal pattern was very pronounced in and occurred earlier in LAWI (July 2007) compared to either KALIROHAN and CALAPARAN (September 2007). Biomass ranged from 21 to 120 g DW m^{-2} in CALAPARAN, 34-164 g DW m^{-2} in KALIROHAN and 75-652 g DW m^{-2} in LAWI. For the duration of study, the monthly mean biomass was highest in LAWI with 245 ± 51 g DW m^{-2} (se). This value was nearly three-fold that of KALIROHAN (87 ± 11 g DW m^{-2}) and four-fold of CALAPARAN (66 ± 9 g DW m^{-2}).

Much like seagrass cover and biomass, mean blade density was least in CALAPARAN. The lowest mean blade density occurred in CALAPARAN in May 2007 and followed a prolonged decline in mean blade density which ran from January 2007 until May 2007. Of the neighboring TINMR sites, greater blade density was observed in KALIROHAN (even relative to the reference site). The seasonal pattern in blade density appeared stable with bimodality in LAWI (January and May peaks) while unimodal in KALIROHAN (September peak) and CALAPARAN (November peak) (Figure 6).

There was a 30% reduction in shoot density in CALAPARAN from the pre-oil spill level (March 2006) but this was short term (< one year after oil spill). CALAPARAN had the lowest shoot density values among sites from 5 to 10 months post-oil spill. Thereafter, shoot density at CALAPARAN roughly equaled its pre-oil spill level and approached mean values in KALIROHAN and LAWI (Figure 7). Shoot density pattern was unimodal in LAWI and CALAPARAN though the high values of these two sites did not coincide (May in LAWI and October to December in CALAPARAN). The

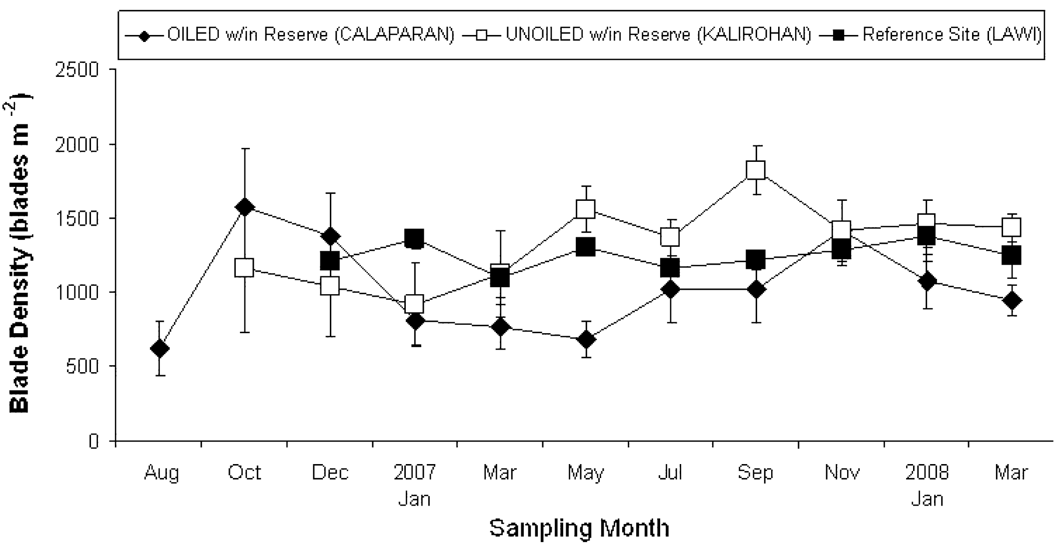


Fig. 6. Blade density patterns (blades m^{-2} +/- se) from October 2006 to March 2008.

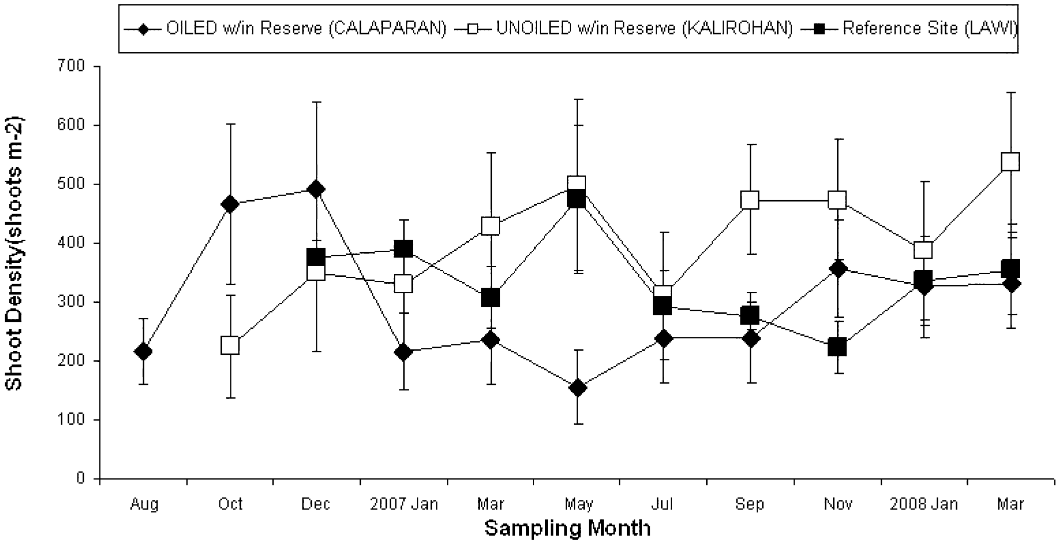


Fig. 7. Shoot density (shoot per m^{-2} +/- se) patterns from March 2006 to March 2008 with arrows indicating pre- and post-oil spill levels in the heavily impacted site, CALAPARAN. *Note*: March 2006 sourced from W. Campos

pattern in KALIROHAN looked bimodal with enhanced levels in March/May and September/November. Shoot densities ranged from 156 to 491 shoots m^{-2} in CALAPARAN; 220 to 538 shoots m^{-2} in KALIROHAN; and, 222 to 475 shoots m^{-2} in LAWI.

DISCUSSION

There are many "services" with societal values that are provided by seagrass meadows (Zedler, 2000). The varied ecosystem services that seagrass meadows provide are possible because of the properties and morphology of the dominant vegetation. Massive die-offs of eelgrass (*Zostera marina*) in the 1930s due to the "wasting disease" demonstrated how structural changes could affect the integrity of the seagrass ecosystems and negatively impact associated fauna (in Orth *et al.*, 2006). In the tropics, seagrass beds have definite trophic and life cycle linkages with adjacent coral reefs and mangrove resources that further highlight the need for an integrated and holistic approach in the management of tropical coastal systems so as to conserve this inherent connectivity in functions, processes and energy budgets.

At least half of the total 16 species reported in the Philippines, can be found in TINMR. The three sites in this study are mixed species meadows typical of most seagrass beds in the Philippines (Fortes, 1990; 1994; 1995). The temporal oscillations observed in this study reveal seasonality (Fortes, 1995; Lin & Shao, 1998). Within the context of these seasonal patterns, oil contamination appears to have had a negative impact on seagrass at CALAPARAN as evidenced by reduction in seagrass cover, shoot and blade density, and above ground biomass. These changes were apparent within a year or so after the oil spill event. The seagrass meadow began to show some signs of recovering roughly one year after the spill. However, seagrass cover and above ground biomass remained low in the oil affected meadow nearly two years after the oil spill relative to its pre-oil spill level and to a reference site. The lowered biomass is significant as shelter and refuge values of seagrasses for important fishes associated in seagrass beds have been correlated with high seagrass biomass (Fortes, 1995).

The effects of oil contamination on mixed species intertidal Philippine seagrass meadows on a scale of the August 2006 oil spill in southern Guimaras may be more complex and long term. Thus, there is need to continue monitoring to identify long-term patterns and gauge if recovery is occurring and, if so, how long it will take for full recovery.

Acknowledgment

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LITERATURE CITED

Fortes, M.D. 1990. Seagrasses: A resource Unknown in the ASEAN Region. ICLARM Education Series 5. 46p. International Center for Living Aquatic Resources Management, Manila, Philippines.

______ 1994. Management of Seagrass and Mangrove Ecosystems in the Philippines. In: Seagrass Resources in Southeast Asia, Technical Papers for Advanced Training Course/Workshop in Seagrass Resources, Research and Management (SEAGREA) Philippines, pp 106-109.

_____ 1995. Seagrasses of East Asia, Environment and Management Perspectives, RCU/EAS Technical Report Ser. #6 UNEP 79 p.

Lin, H-J. and Shao, K.T. 1998. Temporal changes in the abundance and growth of intertidal *Thalassia hemprichii* seagrass beds in southern Taiwan, Biol. Bull. Acad. Sin. 39. 191-198.

McManus, J.W., Nanola, C., Reyes, R. and Kesner, K. 1992. Resource ecology of the Bolinao Coral Reef System. ICLARM Studies and Reviews 22, 117 p.

Nievales, M.F.J. 1997. Marine Resource Assessment of Taklong Island National Marine Reserve, Guimaras. (Final Report to UPFI). 18 p.

Orth, R.J., Carruthers, T.J. B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W, Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, J.W., Olyarnik, S., Short, F.T., Waycott, M. and Williams, S.L. 2006. A global crisis for seagrass ecosystems. Bioscience 56 (12): 987-995.

Phillips, R.C. 1978. Seagrasses and the Coastal Marine Environment. Oceanus 21 (3): 30-40.

Thorhaug, A. 1986. Review of seagrass restoration. Ambio 15 (2): 110-117.

Walker, D. and McComb, A.J. 1992. Seagrass degradation in Australian coastal waters. Marine Pollution Bulletin. 25: 191-195.

Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology and Evolution 15 (10): 402-407.