Philippine Journal of Natural Sciences Oil Spill Special Issue (2009) 33-42

Seagrass meadows in Southern Guimaras : Immediate Post-Oil Spill Status

Marie Frances J. Nievales

Division of Biological Sciences, College of Arts and Sciences,UP Visayas, Miagao, Iloilo

Abstract. The M/V Solar 1 Oil Spill damaged the ecology of southern Guimaras. Bunker fuel floated meters from shore for weeks hovering over critical ecological habitats including seagrass meadows.This study looked at the ecological status of seagrass meadows in the southern section of Guimaras Island immediately after the oil spill event; and, attempted to track temporal changes in monitoring stations exposed to varying degree of oiling to clarify potential short term responses of seagrasses. Nine (9) species in 6 genera of seagrasses were encountered in various meadows which included *Thalassia hemprichii, Enhalus acoroides, Halophila ovalis, H. minor, Cymodocea rotundata, C. serrulata, Halodule uninervis, H. pinifolia* and *Syringodium isoetifolium*. Majority of the meadows were mixed species assemblage with *T. hemprichii* generally as the dominant species. Poor seagrass cover (<5%) and sparse shoot density (<50 shoots/sqm) characterized monospecific beds dominated by *E. acoroides* along the channel (UP Channel) or protected muddy embayments (e.g. Alman, Panobolon Is.lee, Sabang). More open meadows are species-rich with good cover (≥60%) (e.g. Panobolon Is. front, Natunga Island). Shoots were densest (> 3000 shoots/sqm) in monospecific *Halodule* beds near estuaries (e.g. Igang, Alegria) with likely broadly fluctuating salinities.The meadow adjacent to the oiled shoreline with minimal clean up (i.e. CALAPARAN) had the least seagrass cover (17.4±1.4), shoot and blade densities (293±94, 948±203) and dry above-ground biomass (34.0±15.5) compared to less impacted meadows or the Reference Site between December 2006 to March 2007. In CALAPARAN, seagrass cover and shoot density were lower from 2 to 7 months after the oil spill event compared to its 2 weeks post oil spill or year ago levels. Seagrass stations within TINMR in November 2006, showed disturbingly high proportion of dying seagrass blades relative to the Reference Site or to more hydrodynamically open, impacted sites distant from the point source of the oil spill. These were clear suggestions of stress in oil-impacted seagrass meadows but must be distinguished from natural temporal fluctuations though longer term monitoring.

Keywords:

Introduction

The August 11, 2006 Solar 1 Oil Spill accident radically affected the ecological balance of the Taklong Island National Marine Reserve (TINMR). The accident threatened biodiversity, compromised ecosystem integrity and downgraded the academic, educational, research and economic values of species that are found in the protected area.

Seagrass beds are among the most productive natural ecosystems in the world and home to diverse marine life (Phillips 1978) which includes crustaceans, mollusks and echinoderms like sea cucumbers. In the tropics, they are found between mangroves and coral reef communities in the coastal zone. They can also form in lagoons of intertidal reef flats, They serve as important physical, biological and functional links between their two neighboring habitats in terms of energy flow, of biogeochemical cycling of nutrients and minerals, and of shared biota.

Seagrass meadows serve as habitat, nursery, feeding ground and refuge to diverse animals of ecological, economic and conservation values (Thorhaug 1986; Walker & McComb 1992). In the

---

* *Corresponding author:*
Division of Biological Sciences, College of Arts and Sciences University of the Philippines Visayas, Miagao, Iloilo, 5023 Philippines
Email address:

Philippines, UNEP (1995) reported over a thousand species from a trawl made within a meadow. The high productivity in seagrass systems could potentially supply 20mT in biomass of fish, invertebrates and seaweeds per sq.km. per year to small scale fishermen (McManus 1993). With favorable physical transport processes or biological agents, the potential value and influence of a seagrass bed as a carbon source exporter could extend seaward in the open ocean and/ or inland.

Inherent temporal dynamism in seagrass communities are long recognized (den Hartog 1970). With so much coastal development and re engineering taking place near or on seagrass beds, it would be interesting and challenging to know the extent of change man-made or aided perturbations on seagrass bed structure, function and natural dynamics. However, this requires prior documentation of baseline or control conditions through which changes may be tracked but more often “before-impact” scenarios are not readily available.

In the Philippines, there are significant literatures on seagrass natural dynamics (Fortes 1989 in UNEP 1995; Vermaat *et al*. 1995) and in response to perturbations e.g. sedimentation (Rollon *et al*. 1998), but nothing specific to hydrocarbon contamination in a scale which happened in southern Guimaras. Acknowledging the vital and critical contributions of seagrass meadows to the local economy and ecology, a rapid assessment was undertaken in southern Guimaras after the Oil Spill disaster with the following aims:

1. to do a profile of the ecological status of seagrass meadows in the southern section of Guimaras Island immediately after the oil spill event; and,
2. to track temporal changes in ecological conditions of selected sites exposed to varying degrees of impacts to oiling in order to clarify potential short term responses.

Methods and Materials

A Study sites

Initially thirteen (13) sites were included in the rapid assessment running from east to west of the southern sectors of Guimaras Province between August to November 2007 **(Fig.1)**. Study areas included among others, a site in a marine turtle sanctuary (Sitio Lusay, LAWI, Jordan), several sites within a marine reserve (Taklong Island National Marine Reserve or **TINMR**, Nueva Valencia), and two Island stations (Panobolon and Natunga Islands). Lawi was eventually considered as the Reference Site because the spilled bunker fuel never reached this far based on reported satellite image taken of the oil spill path and corroborated by locals. The sites were classified as to relative degree of oil spill contamination of shoreline adjacent to meadows (**Table 1)**. After assessing these 13 sites, repeated surveys were carried out in 4 (marked in Table 1) namely, Calaparan and Kalirohan in TINMR, Panobolon Island, and Lawi. TINMR sites are about 15kms. south of the Reference Site (i.e. Lawi). Calaparan, TINMR had badly oiled shoreline and minimal clean up effort. Even 5 months after the oil spill, oil loosely bound in sand was still observed floating during high tide. Kalirohan is 250 meters away from Calaparan but with unoiled shoreline. The Panobolon Island station is 8kms. east of TINMR, had oiled shoreline but with clean up efforts. Transect positions were relocated by recording the coordinates using a Global Positioning System (GPS Garmin Model 76S) and also by staking ends of established transects for repeated surveys. The areal extents of the meadows in most sites were also ground truth using the GPS.

B. Ecological Survey of Macroflora

Macroflora assessment included plot method determination of seagrass percent cover, species composition, blade density per species, shoot density and above ground biomass. During the rapid assessment (i.e. first 3 months after the oil spill), one to three 50-m long transects were established either perpendicular to the shoreline for single transect or parallel to the shoreline if more. At the 4 repeatedly surveyed sites, three (3) 50 m transects were laid out parallel to shore and each other. Transects were spaced 25 m apart. In each transect, three (3) sampling points were chosen at about 25m intervals. Four 0.5m x 0.5 m plots (quadrats) were laid per sampling point. Each quadrat was divided into 25 grids (10cm x 10 cm per grid).

Seagrass cover was estimated in four 0.5 x 0.5m plots per sampling point based on the Saito-Atobe (1970) method. Shoot density was determined by counting all the shoots in 1 of 4 quadrats (=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. Relative abundances of the different species in a site were computed based on the total blades for all species sampled. Above ground seagrass biomass (AGB) was based on total harvest of seagrass shoots in 4 grids per sampling point. Harvested shoots were placed in pre labeled plastic bags and brought to the laboratory for wet and oven dried (between 60-70^{o}C until constant) weight determinations using a digital balance.

Results

There were 9 species in 6 genera of seagrasses seen in meadows in southern Guimaras

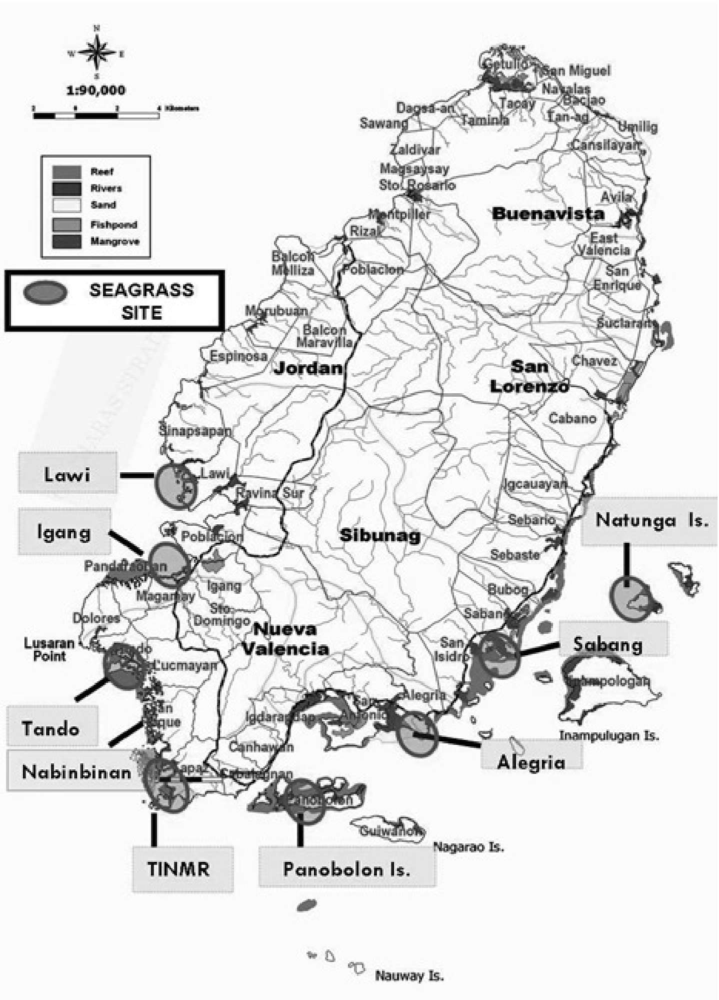


Figure 1. Surveyed sites in southern Guimaras between August to November 2006.

which included *Thalassia hemprichii, Enhalus acoroides, Halophila ovalis, H. minor, Cymodocea rotundata, C. serrulata, Halodule uninervis, H. pinifolia* and *Syringodium isoetifolium*. Majority of the meadows were mixed species assemblage and often *T. hemprichii* was dominant (**Table 2**). Three to four species co-occur in the mixed zone. The areal extent of seagrass beds in eight (of 13) sites that were mapped totaled at least 20 hectares already**.**

Table 3 shows the ecological status per site. Poor seagrass cover (<5%) and sparse shoot density (<50 shoots/sqm) characterized monospecific beds dominated by *E. acoroides* along channel (UP Channel) or protected muddy embayments (e.g. Alman, Panobolon Is.lee, Sabang). Seagrasses were very abundant with good cover (≥60%) and species-rich in more open meadows (e.g. Panobolon Is. front, Natunga Island). Shoots were densest (> 3000 shoots/sqm) in monospecific beds near estuaries dominated by small sized genus, *Halodule* (e.g. Igang, Alegria). *Halodule* spp predominated in meadows with likely broadly fluctuating salinities like near or within estuaries (e.g. Igang, Alegria) and *E. acoroides* predominated in channels or in turbid protected embayments (e.g. Panobolon lee side, Alman, UP Channel).

The mean dry weight above ground biomass for all sites is **74 g DW per sqm** (from **Table 3** data). Monospecific or species-depauperate beds with low Margalef's Index of species richness (<1.0) were found in areas near river mouth or in silty/muddy, protected embayments (e.g. Igang, Alegria, Alman) and also along channels (e.g. UP Channel).

All post-oil spill ecological parameters were generally least in the meadow adjacent to the oiled shoreline with minimal clean up (i.e. CALAPARAN) compared to the other repeatedly monitored sites (**Fig. 2)** except for a brief(~one quarter) shoot density enhancement. More so, seagrass cover and shoot density were lower in March 2007 compared with August 2006 (this study) and March 2006 (Campos *et al.*, unpubl. NAGISA data) levels. In this same site, total blade count was not only lowest in Calaparan but this parameter continued to decline up to March

Table 1. Sites and degree of contamination (Note: [a] sites with repeated surveys)

SITE	INITIAL DEGREE OF OIL CONTAMINATION
1. Lawi[a]	Not Contaminated
2. Igang	Not Contaminated
3. Tando	HEAVY/SEVERE
4. Nabinbinan	Moderate
5. Alman	Moderate
6. UP Channel	Slight Moderate
7. Calaparan[a]	Moderate
8. Kalirohan[a]	None to very slight
9. Panobolon Is. Lee	None to very slight
10. Panobolon Is. Front [a]	Moderate
11. Alegria	Slight
12. Sabang	Slight
13. Natunga Is.	Slight

Table 2. Species composition, relative species abundance (%) and species richness in different study sites (data obtained between September to November 2006)

2007. The dominant species, *T. hemprichii*, composed less than 50% except in March 2007 in Calaparan but was generally over 50% in other sites. There was decrease in relative proportion of the climax species, *T. hemprichii* and *E. acoroides* and increase in the relative abundance of the small sized pioneer genus, *Halophila* by November/December in all sites **(Fig. 3)**. Seagrass stations within TINMR in November 2006, showed disturbingly high proportion of dying seagrass blades. The blades appeared burnt (i.e. yellowing and/or blackening) (**Fig. 4**).

Discussion

Seagrass meadows are highly productive and valuable ecosystems which provide “services” or functions with societal values (Zedler 2000). Seagrass beds may be feeding, nursery and breeding grounds,

Table 3. Ecological status of seagrass meadows in southern Guimaras surveyed between September to November 2006

SITE	Estimated Area	COVER	Shoot Density	Blade Density	Above Ground Biomass	
	(ha)	(%)	(Shoots m^2)	(Blades m^2)	Wet (grams m^2)	Dry (grams m^2)
1. Lawi[a] (Sitio Lusay)	1.09	36.2	385	1272	949	121
2. Igang		35.7	1805	1400	165	
3. Tando		15.4	397	698	548	
4. Nabinbinan		20.8	560	739	1061	
5. Alman		1.4	24	136	2921	
6. UP Channel		0.4	32	50	795	
7. Calaparan[a]	1.00	21.0	404	1315	356	55
8. Kalirohan[a]	0.70	23.6	388	1342	480	59
9. Panobolon Is. Lee	1.83	1.0	28	197	116	50
10. Panobolon Is. Front[a]	13.05	73.6	860	921	172	86
11. Alegria	0.62	37.4	1715	3606	39	37
12. Sabang	1.50	2.5	61	293	122	110
13. Natunga Is.	0.71	60.0	759	1722	689	75

refuge and habitat for economically important marine invertebrate and vertebrate resources. The beds serve many functional roles largely because of the morphology of the dominant vegetation, the seagrasses. Their extensive underground rhizomes and roots keep coastal sediments stable and suppress resuspension of sediment particles while the vertical blades reduce current velocity. Blades filter and retain nutrients and accumulate organic matter within the system; and serve as substrate for epiphytes. The erect blade surfaces increase surface area on which metamorphosing meroplankton (only partly planktonic at certain stage of their life cycle) can attach, metamorphose, settle, grow and mature as benthos as in the case of sea urchins and sea cucumbers (Mercier *et al.* 2000).

The above mentioned functional characteristics of seagrass beds further highlight their unique role in maintaining connectivity and their interdependence with the other 2 adjacent tropical coastal habitats: reefs and mangroves. Seagrass beds allows a suitable substrate environment for mangrove propagules from adjacent communities to recruit locally thus enhancing retention of propagules. Furthermore, blades trap suspended particulate matter from land and/or mangroves or from sea and as a result, suspended organic particulate matter rain down into the bottom and enrich the sediment environment to fuel the food web (in Kirkman 1992). Settled sediments are bound by the underground extensive rhizomes and roots which minimizes resuspension of silt and its shoreward movement. This improves water clarity of adjacent coral reefs where reef building corals require clear water for its photosynthetic symbionts.

There are only few direct grazers on seagrass blades but the key to the high biodiversity of this ecosystem is its maintenance of a detritus based food chain and efficient recycling of nutrients from sediments to water column via seagrasses (Phillips 1978).

Ecological Status of Seagrass Meadows in southern Guimaras

The number of seagrass species encountered in southern Guimaras is over half of the total number of species reported in the country. Globally, there are about 60 seagrass species (Fonseca 1992) of which 20 species are in the East Asia region and 16 are found in the Philippines in meadows that are typically mixed species beds (Fortes, 1990; SEAGREM 1994; UNEP

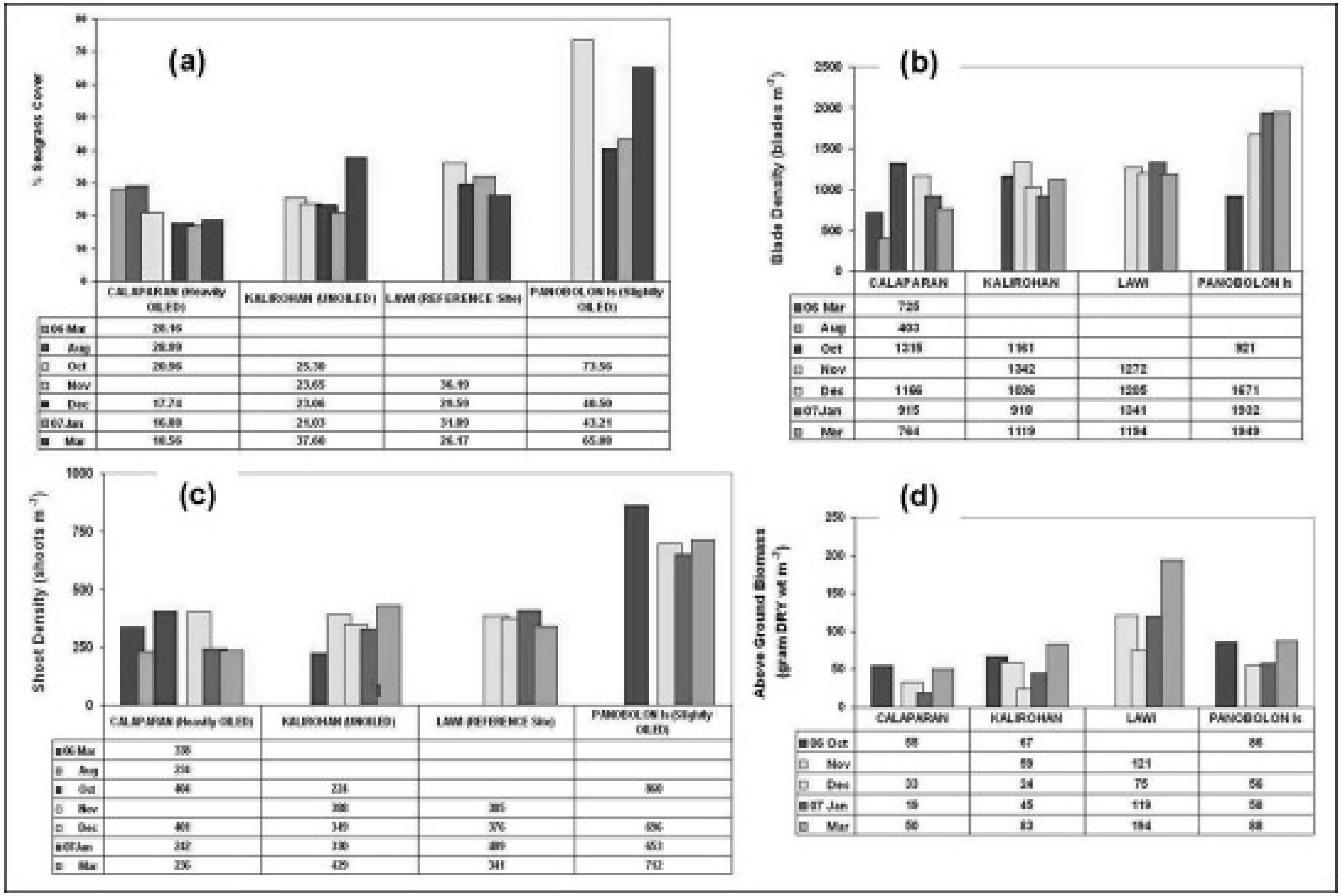
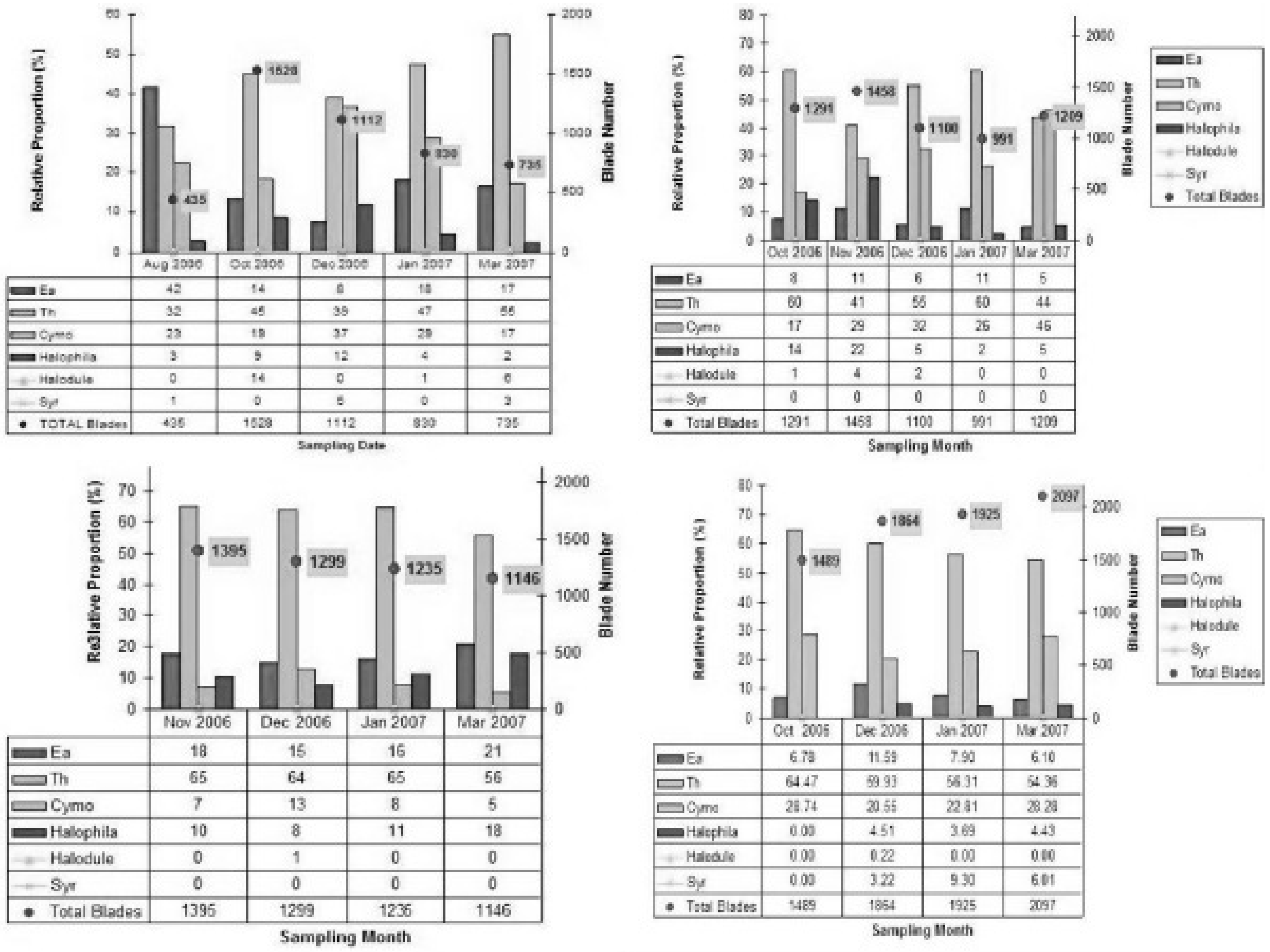


Figure 2. Temporal variations in ecological status of repeatedly monitored sites in southern Guimaras.(a) seagrass cover (b) blade density (c) shoot density (d) dry biomass



	Aug 2006	Oct 2006	Dec 2006	Jan 2007	Mar 2007
Ea	42	14	8	18	17
Th	32	45	39	47	55
Cymo	23	18	37	29	17
Halophila	3	9	12	4	2
Halodule	0	14	0	1	6
Syr	1	0	5	0	3
● TOTAL Blades	435	1528	1112	830	735

Sampling Date

	Oct 2006	Nov 2006	Dec 2006	Jan 2007	Mar 2007
Ea	8	11	6	11	5
Th	60	41	55	60	44
Cymo	17	29	32	26	46
Halophila	14	22	5	2	5
Halodule	1	4	2	0	0
Syr	0	0	0	0	0
● Total Blades	1291	1458	1100	991	1209

Sampling Month

	Nov 2006	Dec 2006	Jan 2007	Mar 2007
Ea	18	15	16	21
Th	65	64	65	56
Cymo	7	13	8	5
Halophila	10	8	11	18
Halodule	0	1	0	0
Syr	0	0	0	0
● Total Blades	1395	1299	1235	1146

Sampling Month

	Oct 2006	Dec 2006	Jan 2007	Mar 2007
Ea	6.78	11.59	7.90	6.10
Th	64.47	59.93	56.31	54.36
Cymo	28.74	20.55	22.81	28.28
Halophila	0.00	4.51	3.69	4.43
Halodule	0.00	0.22	0.00	0.00
Syr	0.00	3.22	9.30	6.01
● Total Blades	1489	1864	1925	2097

Sampling Month

Figure 3. Relative abundances of different seagrass species in repeatedly monitored sites: (a) Calaparan (b) Kalirohan (c) Lawi (d) Panobolon Island

Figure 4. Yellowing and blackening of seagrass blades 3 months after oil spill

1995).

Coastal topography and local hydrographic conditions likely influence seagrass bed development. Seagrass meadows in protected, muddy embayments, channels or near estuaries in southern Guimaras were poorly structured and were of low diversity and well-structured and species rich in more open, intertidal environment. Mixed species assemblage meadows is likely indicative of a stable, healthy, well developed seagrass meadow while low species richness values may represent either emergent seagrass communities or periodically disturbed beds that limit seagrass recruitment and expansion. In multi species beds, there is a mix of tall and short species that physically enhances the topographic complexity of the meadow, creates more niches and enables the ecosystem to trap and support a more diverse assemblage of organisms.

Above-ground (leaf) biomass is reflective of primary production of the ecosystem. The range of mean dry weight above ground biomass (37-121) falls within that reported by Rollon and Fortes (1989 in Fortes 1990) of seagrass communities in the Philippines but less than half of what was reported for meadows in Bolinao, Pangasinan NW Philippines (224 g DW per sqm in Duarte & Chiscano 1999). There is hardly any baseline information with which to compare the above ground biomass data obtained in this study. This ecological parameter is influenced by the blade size of the predominant species, seagrass cover and shoot density. Intuitively, areas that are well covered, with high shoot density and dominated by larger species will be expectedly high in above ground biomass. High seagrass biomass but not species richness supports more diverse fish communities. This emphasizes the shelter and refuge values of seagrasses for most fishes in meadows (UNEP 1995).

The rapid assessment reveals changes and apparent constancy of meadow features. Tando was the largest bed reported by Babaran *et al.* (1996) with 35.7 hectares a decade ago, and showed a wide range of seagrass cover from (<10-80%). This study reports poor seagrass cover in a station surveyed in Tando (only 15%) while shoot density appeared to have been enhanced (400%). Yet, there was little change in biomass (606 g per sqm in Babaran *et al.* 1996 vs 548 g wet weight per sqm., this study) suggestive of habitat fragmentation and possible shifts in composition and/ or relative abundances of species.

Panobolon Island fronting the Guimaras Strait had the most extensive meadow (> 13 has.) among 8 sites that were mapped in this study. Meadow features seem to have been enhanced after ten years with the highest seagrass cover (76%, this study) among all sites and also among the most species rich (s=7 spp). Ten years ago, best percentage seagrass cover reported in Panobolon Island was ~50% with 4 species (Babaran *et al.* 1996).

The “Ave Maria” site in Babaran *et al.* (1996) is the closest to “Lawi” site in this study since Ave Maria Island is situated just about in front of the meadow in both. However, there could be a mismatch in the actual site or zone within the meadow surveyed as the dominant species do not correspond. In the “Ave Maria” station monitored by Babaran *et al,* (1996) ten years ago, the small sized *Halodule pinifolia* characteristic of the upper zone was dominant. In the “Lawi” site of this study, *Thalassia hemprichii* and *E. acoroides* were co-dominants and these are much bulkier, climax species typical of the lower zone in mixed species seagrass meadows (UNEP 1995). The co-dominance of these climax species accounts for the high above ground biomass in Lawi.

Two of the sites within TINMR, i.e. Calaparan and Kalirohan, re-surveyed post-oil spill appeared degraded over time. This was more severe in Calaparan compared to Kalirohan. The seagrass meadow shrunk by 70% in Calaparan and by 30% in Kalirohan while seagrass cover decreased by 53% in Calaparan and 34% in Kalirohan (Nievales 1997, this study). *Thalassia hemprichii* persisted as the dominant species in both meadows. It must be noted however, that the shrinkage in Calaparan may be partly seasonal. During the rapid assessment, the brown seaweeds, *Sargassum* spp were found abundant and reproductive (Nievales & Noro 2006 unpubl data). In contrast, the survey ten years ago was undertaken during the warm months when these seaweeds were just beginning to grow. Kalirohan, while barely 300 meters away north of Calaparan does not form extensive seasonal proliferation of *Sargassum* (pers. observ).

Post-Oil Spill Habitat injury

When the Solar 1 Oil spill happened in August 2006 much of its 2.1 million liters of bunker fuel cargo became stranded on shorelines south of Guimaras. While there was no visible oil coating and smothering of seagrass vegetation observed when surveys were initiated, the white sand shoreline adjacent to seagrass meadows were badly affected.

The most extensive seagrass meadows in Guimaras (Babaran *et al*. 1996; this study) were those with shorelines that were visually classified to be moderately-to severely-affected by the M/V Solar 1 oil spill. These are Tando, the Taklong Island National Marine Reserve (TINMR) and Panobolon Island. Further, considering the ecological and economic values of seagrass meadows, these facts magnify whatever negative impact(s) the oil spill event may have.

There are contrasting reports on direct injury to seagrasses (Dean *et al*. 1998), seaweeds (Stekoll & Deysher 2000) as well as on macrofauna (Mignucci-Giannoni 1999) from oil spills. Bleaching and death of the surfgrass, *Phyllospadix* followed oil spills along the coasts of California, Washington and Alaska, USA while *Thalassia* beds were reportedly severely affected after oil spill events in Puerto Rico and Panama (var. authors cited in Dean *et al* 1998). In contrast, data showed no severe damage on eelgrass (*Zostera marina*) affected by separate oil spill events in Brittany coast of France and in San Francisco, USA. Also, in the Exxon Valdez oil spill in Alaska, the eelgrass, *Zostera* suffered slight injury which did not persist after a year. Injury was in terms of lowered shoot density and decreased number of flowering shoots but that the population recovered two years after the oil spill event (Dean *et al* 1998).

Indications of disturbance to seagrass meadow as a result of the M/V Solar 1 oil spill accident became evident in comparing pre- and post-oil spill ecological conditions of impacted sites or relative to natural dynamics of unimpacted sites. As this study revealed, short term monitoring of ecological parameters e.g. seagrass cover, shoot density, blade density and above ground biomass was least in the meadow adjacent to the oiled shoreline with minimal clean up (i.e. Calaparan) compared to the other sites. Add to this was the decline in cover and shoot density from year ago level suggesting degradation.

There was an apparent short-term enhancement of shoot density observed in Calaparan immediately after the oil spill. This is in contrast to short term decreased shoot density observed of crude oil contamination from the EXXON Valdez oil spill on *Zostera* beds in Alaska (Dean *et al*. 1998) but similar to the “greening phenomenon” or large increases in annual and ephemeral seaweed species in the temperate latitudes after an oil spill as a consequence of reduction in herbivore populations (Kingston *et al*. 1997 in Stekoll and Deysher 2000). Yet, while there was enhanced shoot growth after oiling, this was not translated to increased seagrass cover. One reason for this could be the change in relative abundances among species such as the observed decrease in proportion of the climax species, *T. hemprichii* and *E.acoroides* 2 & 4 months after initial assessment and increase in the relative abundance of the small sized pioneer genus, *Halophila*. Notable, too, was the fact that the relative blade abundance of the dominant climax, canopy species, *Thalassia hemprichii* (Rollon & Fortes 1990; Vermaat *et al*. 1995) in Calaparan was consistently below 50% except in March 2007 while in Lawi (Reference site) and in the less impacted sites, this dominant species was often over 50%.

A seasonal (November to January) decline in cover was observed in all sites regardless of impact coinciding with longer emergence during daytime spring low tides (Fortes, 1990). However, while recovery was subsequently observed in other sites, seagrasses in Calaparan responded poorly.

“Burnt” blades (yellowing, blackening) was only observed in Calaparan and Kalirohan in TINMR. This was pointed out as likely normal occurrence that may be attributed to highly intense light and longer emersion period in December to January (Estacion J. pers. comm..). Interestingly, however, other sites with no contamination (e.g. LAWI) or with more open coastal morphology though contaminated (Natunga and Panobolon Islands) but were equally exposed to prolonged emersion during low spring tide, only exhibited heavy epiphytism but not the conspicuous yellowing and burnt appearance.

Stressed Ecosystem

Clearly, there are indications of stress on the ecology of seagrass meadows as a result of the oil spill. There is need for longer term monitoring to help quantify the extent and degree of disturbance that may be attributed to oil spill against background natural annual or inter annual variations imposed by other factors. For instance, phenological events are cued to a suite of environmental factors that influence intra-annual fluctuations in biomass production (UNEP 1995). This alone, calls for at least a year long monitoring program. Further, “delayed” injury or delayed detection of injury was mentioned by Stekoll & Deysher (2000) which makes long term monitoring of ecologically sensitive coastal habitats like seagrass meadows a necessity. Finally, the Solar 1 Oils Spill disaster is an opportunity for tropical ecologists to understand better how tropical systems like seagrass beds respond to this specific impact, how resilient is the system, if and when recovery happens, and how best to rehabilitate it.

Acknowledgements

Funds for this research was provided by the UPV Oil Spill Research Program (OSRP). The field support of R.Sibonga, J.Moleta, J. Mosura, V. Basco, J. Gajo, A. Gargalicana and A. Margallo; research staff at Ocean Bio and Marine Bio Labs under Dr. WL Campos and A dN Campos, respectively; field volunteers; GIS work provided by G. Azares ; lab. assistance of W de la Cruz, D Urfilla, SS Laminero & D Gomez; access to space and facilities in Cell & Devtal Bio Lab of Dr. JS Geduspan; UPV MBS in Taklong Island under Station Head Prof. NGYunque; other Bio Sci facilities in Miagao campus headed by Prof. MSF Katalbas, Chair Bio Sci Div, are all very much appreciated.

Literature Cited

Babaran, R.P., Ingles, J.A., Zamayla, M.E., and Martinez, R.T. 1996. The seagrass ecosystem of Guimaras province. In: Babaran RP & Ingles JA (Eds.), Philippine Coastal Marine Habitats at Risk: A case study of Guimaras Island. UP Press,Quezon City, Philippines. 161- 200.

Chen, J 2003. Overview of sea cucumber farming and sea ranching practices in China. SPC Beche de mer Info Bull No 18; 18-23.

Dean, T.A., Stekoll, M.S., Jewett, S.C., Smith, R.O. Hose, J.E. 1998. Eelgrass (*Zostera marina* L.) in Prince William Sound, Alaska: Effects of the Exxon Valdez Oil Spill. Mar. Poll. Bull. 36, 201-210.

Den Hartog, C. 1970. The Seagrasses of the World. North-Holland, Amsterdam.

Duarte, C.M. Chiscano, C.L. 1999. Seagrass biomass and production: a reassessment. Aqua Bot. 65;159-174.

Fonseca, M. 1992. Restoring seagrass systems in the United States. In: Thayer, GW (Ed.), Restoring the Nations’s Marine Environment. 79-109.

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

Kirkman, H. 1992. Large scale restoration of seagrass meadows. In: Thayer, W.G. (Ed.), Restoring the nation’s environment. A Maryland Seagrant Book, College Park, Maryland, 111-140.

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.

Mercier A, Battaglene SS, Hamel J-F. 2000. Settlement preferences and early migration of the tropical sea cucumber *Holothuria scabra*. J. Exp. Mar. Biol. Ecol. 249: 89-110.

Michio, K., Kengo, K., Yasunori, K., Hitoshi, M., Takayuki, Y., Hideaki, Y., and Hiroshi, S. 2003. Effects of deposit feeder *Stichopus japonicus* on algal bloom and organic matter contents of bottom sediments of the enclosed sea. Mar. Poll. Bull. 47, 118-125.

Nievales, M.F.J. 1997. Marine Resource Assessment of Taklong Island National Marine Reserve, Guimaras, unpublished. 18.

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

Saito,Y., Atobe, S. 1970. Phytosociological study of intertidal marine algae. I. Usujiri Benten-Jima, Hokkaido Bull. Fac. Fish. Hokkaido Univ. 21;37-69.

SEAGREM, 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 (SEAGREM) Philippines, 106-109.

Stekoll, M.S., Deysher, L. 2000. Response of the dominant alga *Fucus gardneri* (Silva) (Phaeophyceae) to the Exxon Valdez oil spill and clean up. Marine Pollution Bulletin 40; 1028-1041

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

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

Vermaat, J.E., Fortes, M.D., Agawin, N.S.R., Duarte, C.M., Marba, N., Uri, J.S. 1995. Meadow