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Status of Mangroves Within Taklong Island National Marine Reserve, Nueva Valencia, Guimaras, Philippines : A One-Year Post Spill Monitoring Study

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Key words: Guimaras oil spill, mangrove monitoring, sublethal effect, litterfall production

Abstract

The M/T Solar I oil spill on August 11, 2006 in Guimaras, Philippines released more than 2 million liters of Bunker C affected the environmentally critical areas in Guimaras including mangroves. Acute effects involved massive mortality of mangroves that accounted to 0.932 ha in 2006. This paper reports the monitoring period of August 2007 until September 2008 among six stations within TINMR. Specifically, the study (a) monitored the monthly and annual litter fall production; (b) assessed the defoliation rate, production of new leaves, and standing leaves of selected trees; (c) measured the leaf size of the five species monitored, and (d) assessed the mangrove community structure annually. Litter fall productions among monitored species followed a unimodal pattern with peaks during dry season extending up to June except for *A. marina* that extends up to August. Litterfall production varied widely depending on local environmental conditions, productivity of individual species, and habitat-specific stresses. Hence, there is difficulty in extrapolating whether the low or high volume of litterfall from this study is solely attributed to the stress caused by oil spill. However, the community structure clearly showed a drastic reduction in density and stand basal area one year after the incident. Some trees of *R. apiculata, R. mucronata,* and *R. stylosa* contiguous to the deforested area showed a significant reduction in leaf size and canopy cover that reached up to a maximum of 54.5, 57.5, and 48.1% respectively. This reduction in leaf size could mean a decrease in total photosynthetic surface area and it appears to be a manifestation of a sublethal stress on mangrove trees. Propagules of *R. mucronata* found in Bagatnan adjacent to the deforested area showed deformities and necrosis towards the radicle portion. In addition, necrotic and highly-grazed leaves of saplings and wildings were prevalent in *R. stylosa* in Bagatnan site within the deforested area. These could be another indicator of chronic stress brought about by the residual oil in the sediments wherein their weakened state made them more vulnerable to r-selected species. Salient results of this study showed the overview of the apparently struggling mangrove habitat thus, further monitoring is needed to understand deeply the recovery processes, site stability and to evaluate further if remedial strategy will be needed.

Mangroves are valuable ecosystems for sustaining biodiversity in intertidal regions in tropical and sub-tropical areas. Their known ecological and economic significance are well established such as a spawning and nursery grounds for fish and they are considered as major exporter of organic matter into the sea. They also have the capacity to recycle nutrients, storage of organic matter, and the ability to sequester heavy metals and toxic materials.[1] However, they remain under constant threat arising from direct and indirect anthropogenic activities occurring upland (i.e. agriculture and urban run-off) and offshore (i.e. accidental oil spill). The M/T Solar I oil spill on August 11, 2006 off southern Guimaras released approximately more than 2 million liters of Bunker C affected the environmentally critical areas such as mangroves, coral reefs, and seagrass beds among others. The incident affected the 1,100 ha of Taklong and Tandog Island National Marine Reserve (TINMR) in Brgys. Lapaz and San Roque, Nueva Valencia where 37.51 ha of mangroves was greatly affected. Results of the first three months assessment showed a massive death of mangrove trees, saplings, and wildings that accounted to 0.932 ha only of the entire areas affected.[2] Among the 29 species affected, five showed mortality: *Avicennia marina*

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(0.03%), *Rhizophora apiculata* (0.16%), *R. mucronata* (0.26%), *R. stylosa* (0.46%), and *Sonneratia alba* (0.04%). However, the observed acute damage following the spill may be insignificant when compared to the longer-term chronic stress and sublethal effect induced on mangroves by the stranded and residual oil.

This study monitored the sub-lethal effects, responses, and recovery of the five mangrove species that showed mortality, and limited only in Taklong and Tandog Island National Marine Reserve (TINMR) in Brgys. Lapaz and San Roque, Nueva Valencia, Guimaras. Specifically, the study (a) monitored the monthly and annual litter fall production and its component over a year; (b) assessed the defoliation rate, production of new leaves, and standing leaves of selected trees; (c) measured the leaf size of the five species monitored, and (d) assessed the community structure annually.

Materials and Methods

Study area

Studies were conducted in Taklong and Tandog Island National Marine Reserve (TINMR) in Brgys. Lapaz and San Roque, Nueva Valencia, Guimaras from August 2007 to September 2008. There were six stations (5 oiled and 1 unoiled) established namely; Sitios Bagatnan, Pototan, and Tuguisan; and Taklong Island in Lapaz; Tandog Island in San Roque, and an unoiled site in Taklong Island that served as reference site (Fig. 1). The site in Tandog Island is classified as an overwashed mangrove type and had a mean salinity of 35 ppt with slight fluctuation throughout the year. Distinguishing characteristics is the mono-specific stand often dominated by *Rhizophora* species. The forests were formed on small islands or projections from land masses (peninsulas) with intense daily tidal flushing. The high flushing rates do not allow the formation of strong salinity gradients nor accumulation and aggregation of the soil or of nutrients, a factor that lead to a succession of species toward the interior.[3] The other sites were classified as fringing mangrove type with a minimum of 30 m stretched from seaward to landward and salinity varied widely from 8 to 35 ppt throughout the year. This type is characterized by a strong horizontal gradient in turbulence and tidal amplitude. Energy derived from tides and waves decays rapidly inland where tidal flooding is further reduced by the rise in the mangrove floor. Toward the outer edge of the fringe where greater energy levels prevail, the large heavy seedlings of *Rhizophora* become established. Inland this wave and tidal energy dissipates, and in the higher, less flushed parts of the fringe, *Avicennia* becomes the dominant species.[3]

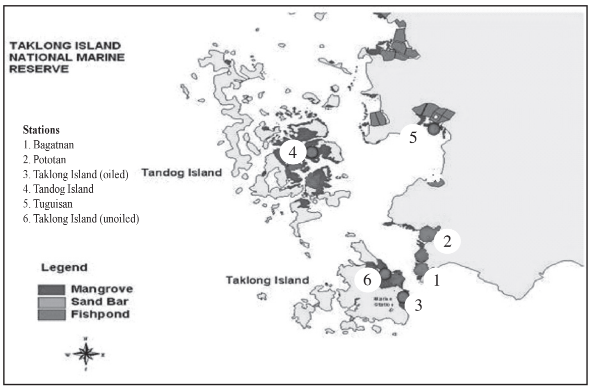

Fig. 1. Monitoring sites.

Litter fall production and plant condition

Three mature trees with comparable height and girth for every species monitored (species that showed mortality) were selected and leaf traps made of B-net 54 with PVC pipe frame were set up. Litter fall were collected monthly and sorted into leaves, fruits/propagules, flowers, stipules, twigs, and debris (carcasses), dried for 72 hours at 80 ^{0}C, and weighed. For shoot tagging, nine shoots per species of tree were tagged in the upper canopy position using a parachute cloth (same tree where leaf traps were set up). Leaf size (length and width in cm) and internode length (in cm) were measured for every tagged leaf. For saplings and wildings, six shoots were tagged, and leaf size and internode length were measured. Monthly shoot observations of trees, saplings, and wildings were scored through counting of standing stock of leaves per shoot, appearance of new leaves, and defoliation rate. Several shoots died during the study both accidentally and natural causes, in which case missing shoots were replaced with new ones. Other plant stress indicator monitored were the timing of reproductive season, deformities in the fruits or propagules, reduction of canopy cover, and prevalence of necrosis on leaves as vulnerability indicator to insects and or microorganisms.

Forest structure

Monitoring plots with an area of (10x10 m) 100 m^2 were established in six stations within the marine reserve. There were three plots established from each site and the mangrove community structure inside the plot was assessed annually following English et al., 1994.[4]

Results and Discussion

Litter fall production

Litter fall production (in g.m^{-2}) was measured in five affected sites and in one reference site from October 2007 to September 2008. Litter fall productions among monitored species showed a unimodal pattern with peaks during dry season extending up to June except for *A. marina* that extends up to August (Figs. 2-6). This peak would imply the physiological response of mangroves wherein they tend to reduce transpiration during dry periods by thinning their canopy through frequent shedding-off of their leaves. The same pattern was reported in Australia for *R. stylosa*[5] and for *R. stylosa* and *A. marina*[6] while in India, *A. marina* litter production was high in the post monsoon period and low in the pre-monsoon period.[7] Duke et al. stressed further that this pattern appears to be a modal response to rainfall with low net production in periods of relatively high and low rainfall, and maximal net leaf production during periods of moderate rainfall.[5] This implied that periods of unusually high or low rainfall might cause mangrove stands to be more vulnerable to further disturbance such as oil pollution.

Individual species may differ in the conditions that produce heavy litter.[8] Moreover, productivity may also vary from habitat to habitat, and habitat-specific stresses like aridity and nutrient condition and including stress from oil spill. For instance, the offset trend for *A. marina* is mainly attributed to its reproductive season. Its flowering season culminates on March while fruits or propagules starts to fall-off on June to August which constitutes a significant component of the litter that reached up 58% of the total litter on these months. A review of available literature on litterfall production appeared to be dependent on local conditions, species composition, and productivity of individual species (Table 2). For instance, litterfall production of *R. apiculata* in southern Thailand had a lowest rate prevailed in May/June and had trimodal peaks[9] in contrast to this study. Monthly litter fall production of *A. marina* ranges from 15.2 ± 30.5 g.m^{-2} to 162.2 ± 46.5 g.m^{-2} (Fig. 2) with a mean of 64.3 ± 28.1 g.m^{-2}. The minimum value was ob-

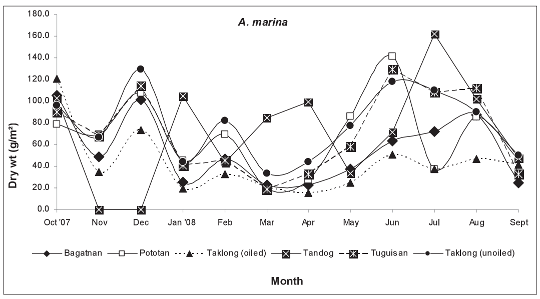

Fig. 2. Litter fall production of *A. marina* from October 2007 to September 2008.

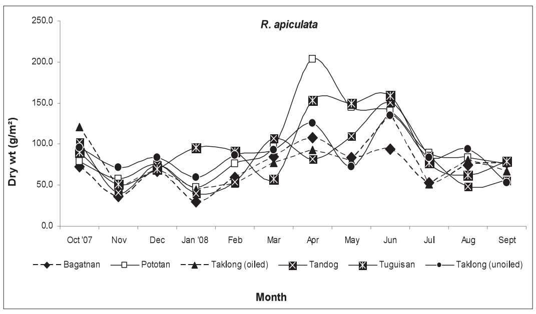

Fig. 3. Litter fall production of *R. apiculata* from October 2007 to September 2008.

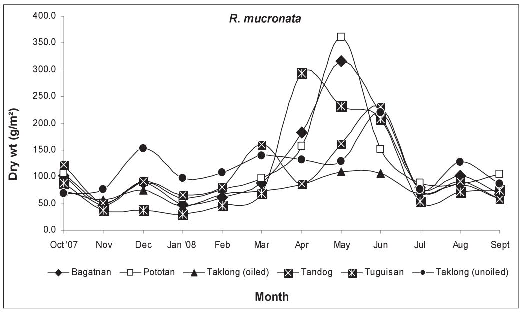

Fig. 4. Litter fall production of *R. mucronata* from October 2007 to September 2008.

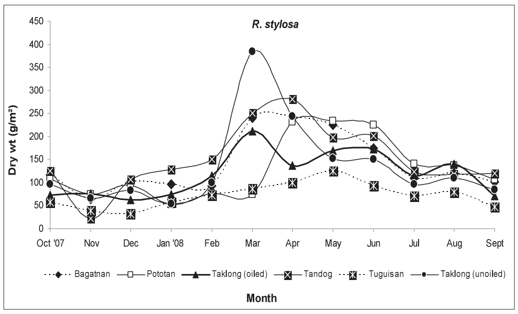

Fig. 5. Litter fall production of *R. stylosa* from October 2007 to September 2008.

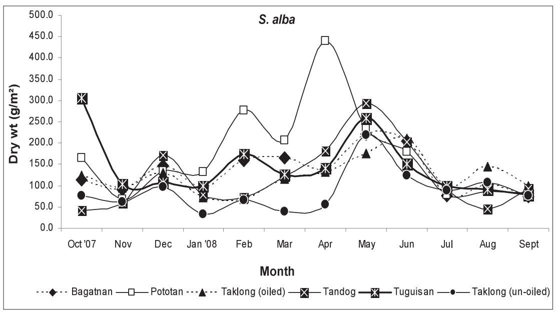

Fig. 6. Litter fall production of *S. alba* from October 2007 to September 2008.

Table 1. Component weights (dry weight in g.m^{-2}) of annual litter fall of the five species monitored from October 2007 to September 2008. Debris includes insect frass and litter of other species fallen into the leaf trap. Total litter did not include the weight loss to herbivory.

Species	Component wt. (g.m^{-2})	Bagatnan	Pototan	Taklong Is. (oiled)	Tandog Is.	Tuiguisan	Taklong Is. (unoiled)
A. marina	Leaves	454.3	498.8	351.4	399.3	496.1	637.2
	Fruits	72.1	19.1	24.5	121.4	62.4	96.5
	Twigs	47.1	146.0	58.3	58.7	82.5	38.9
	Stipules	-	-	-	-	-	-
	Flowers	-	-	-	-	-	-
	Debris	84.1	148.6	82.8	126.5	209.0	125.0
	Total litter fall	**657.6**	**812.4**	**517.0**	**850.6**	**850.0**	**940.4**
R. apiculata	Leaves	520.3	684.4	602.9	607.0	601.2	778.3
	Fruits	39.4	166.4	24.4	67.5	210.3	20.0
	Twigs	101.3	137.5	149.9	84.3	175.3	113.2
	Stipules	77.9	83.1	74.6	97.7	54.2	80.6
	Flowers	26.4	37.3	15.0	58.5	38.2	40.2
	Debris	74.2	61.2	53.4	35.9	57.3	21.2
	Total litter fall	**839.5**	**1170.0**	**920.1**	**950.8**	**1136.5**	**1053.5**
R. mucronata	Leaves	732.5	818.1	670.3	792.1	478.5	1063.3
	Fruits	393.5	183.7	5.6	68.0	353.0	143.3
	Twigs	34.4	83.6	53.4	98.5	126.2	63.8
	Stipules	85.8	87.3	79.2	113.4	44.9	106.9
	Flowers	75.6	103.7	48.4	50.0	20.9	20.5
	Debris	76.4	152.3	47.5	155.3	219.9	17.9
	Total litter fall	**1398.2**	**1428.7**	**904.4**	**1277.4**	**1243.5**	**1415.7**
R. stylosa	Leaves	930.8	975.5	852.9	927.2	563.2	878.1
	Fruits	346.2	133.8	193.7	557.5	78.9	485.7
	Twigs	138.6	74.2	125.2	101.0	27.5	47.9
	Stipules	144.1	145.4	140.8	122.8	65.0	144.1
	Flowers	56.0	96.8	36.3	45.2	101.3	26.8
	Debris	70.7	128.2	68.5	71.6	101.3	40.9
	Total litter fall	**1686.3**	**1553.9**	**1417.3**	**1825.3**	**861.4**	**1623.5**
S. alba	Leaves	1010.1	1029.0	911.3	942.3	1083.8	630.1
	Fruits	81.5	405.6	153.7	197.3	189.1	124.2
	Twigs	326.2	274.2	266.4	171.6	309.0	166.6
	Stipules	-	-	-	-	-	-
	Flowers	10.7	72.4	11.9	40.1	20.8	3.5
	Debris	159.7	299.5	120.8	101.0	131.2	122.7
	Total litter fall	**1588.2**	**2080.7**	**1464.1**	**1452.4**	**1733.9**	**1047.2**

served in Taklong (oiled) in April while the maximum value was observed in Tandog Island in July. The total dry weight of litter collected for a year was shown in Table 1. Annual litter production of *A. marina* ranged from 517.0 ± 155.1 g.m^{-2} (Taklong, oiled site) to 940.4 ± 155.1 g.m^{-2} (Taklong, unoiled site) with mean of 771.3 g.m^{-2} and leaves made up the bulk of litter fall comprising 61.9% of the total dry weight. This annual production is relatively lower compared to 3.65 t ha^{-1} yr^{-1} in New Zealand,[10] 3.10 t ha^{-1} yr^{-1} in Jervis, Bay NSW Australia,[11] and 6.28 t ha^{-1} yr^{-1} in Embley River, Australia.[12] For *R. apiculata,* monthly litter fall ranged from 29.7 ± 23.2 g.m^{-2} to 203.7 ± 45.0 g.m^{-2} (Fig. 3) with mean of 84.3 ± 10.8 g.m^{-2}. The minimum value was observed in Bagatnan in January while the maximum value was observed in Pototan in April. Annual litter production ranged from 839.5 g.m^{-2} in Bagatnan to 1170 g.m^{-2} in Pototan with a mean of 1011.7 ± 129.7 g.m^{-2} and leaves made up the bulk of litter fall comprising 62.8% of the total dry weight. This annual production is comparable to

Table 2. Review of available literatures on litterfall production.

Location	Species	Litter prod'n (t ha^{-1} yr^{-1})	Reference
Guimaras, Philippines	*A. marina*	0.52-0.94	This study
	R. apiculata	0.84-1.17	
	R. mucronata	0.90-1.42	
	R. stylosa	0.86-1.82	
	S. alba	1.05-2.08	
Australia	*R. stylosa* (oiled)	0.99-1.21	Duke et al., 1999[5]
	R. stylosa (control)	0.52-0.84	
South Thailand	*R. apiculata*	1.38	Bunyavejchewin et al., 1998[9]
Peninsular, Malaysia	Mixed forest	1.40-1.58	Sasekumar and Loi, 1983[18]
Papua New Guinea	Mixed forest	1.43	Leach and Burgin, 1985[19]
New Zealand	*A. marina*	3.65-8.10	Woodroffe, 1982[10]
Southern Quintana Roo, Mexico	*R. mangle*	2.61	Navarrete and Oliva, 2002[20]
*Gazi Bay (Kenya)	*R. mucronata*	0.02	Slim et al., 1996[15]
	C. tagal	0.01	
*Jervis, Bay NSW (Australia)	*A. marina*	3.10	Clarke, 1994[11]
	A. corniculatum	2.10	
*Guyana (South America)	Mixed forest	17.71	Chale, 1996[21]
*Teacapan-Ague Brava Lagoon, Mexico	Mixed forest	14.71	Flores-Verdugo et al., 1990[22]
*Bermuda (North America)	Mixed forest	9.40	Ellison, 1997[23]
*Bonny estuary (Nigeria)	*R. racemosa*	8.46	Abbey-Kalio, 1992[24]
	A. africana	6.41	
	Laguncularia sp.	8.18	
*South Africa	Mixed forest	4.50	Steinke and Ward, 1990[25]
*Andaman Islands (India)	Mixed forest	7.10-8.50	Mall et al., 1991[26]
	B. gymnorrhiza	5.11-7.09	Dagar and Sharma, 1993[27]
	R. apiculata	8.08-10.30	Dagar and Sharma, 1993[27]
*Mandovi-Zuari Estuary (India)	*R. apiculata*	11.70	Wafar et al., 1997[14]
	R. mucronata	11.10	
	S. alba	17.00	
	A. officinalis	10.20	
*Fly River Estuary (New Guinea)	Mixed forest	8.00-14.00	Twilley et al., 1992[28]
*Matang mangal (Malaysia)	Mixed forest	3.90	Gong and Ong, 1990[7]
*Embley River (Australia)	*R. stylosa*	12.23	Conacher et al., 1996[12]
	C. tagal	5.39	
	A. marina	6.28	
*Australia	*A. marina*	15.98	Bunt, 1995[6]
	R. stylosa	23.69	
	C. tagal	12.90	

* adapted from Kathiresan and Bingham, 2001[8]

1.38 t ha^{-1} yr^{-1} in South Thailand[9] and relatively lower to 8.08 t ha^{-1} yr^{-1} in Andaman Islands, India,[13] and 11.7 t ha^{-1} yr^{-1} in Mandovi-Zuary Estuary, India.[14] For *R. mucronata,* monthly litter fall ranged from 29.5 ± 23.3 $g.m^{-2}$ to 361.0 ± 103.2 $g.m^{-2}$ (Fig. 4) with mean of 106.5 ± 16.5 $g.m^{-2}$. The minimum value was observed in Tuguisan in December while the maximum value was observed in Pototan in May. Annual litter production ranged from 904.0 $g.m^{-2}$ (Taklong, oiled site) to 1415.7 $g.m^{-2}$ (Taklong, unoiled site) with mean of 1278.0 ± 198.4 $g.m^{-2}$ and leaves made up the bulk of litter fall comprising 59.9% of the total dry weight. This annual production is relatively higher compared to 0.02 t ha^{-1} yr^{-1} in Gazi Bay, Kenya[15] and lower compared to 11.1 t ha^{-1} yr^{-1} in Mondovi-Zuary Estuary, India.[14] For *R. stylosa,* monthly litter fall ranged from 22.4 ± 21.5 $g.m^{-2}$ to 384.3 ± 115.6 $g.m^{-2}$ (Fig. 5) with mean of 124.6 ± 28.2 $g.m^{-2}$. The minimum value was observed in Tandog Island in November while the maximum value was observed in Taklong (unoiled site) in March. Annual litter production ranged from 861.4 g.m^{-2} (Tuguisan) to 1825.3 g.m^{-2} (Tandog Island) with mean of 1494.6 ± 338.6 g.m^{-2} and leaves made up the bulk of litter fall comprising 58.1% of the total dry weight. This annual production is comparable to the field oiling experiment by Duke et al.[5] in Australia that ranged from 0.99-1.21 t ha^{-1} yr^{-1} for oiled site and slightly higher to their control site (0.52-0.54 t ha^{-1} yr^{-1}), however lower compared to 12.23 t ha^{-1} yr^{-1} in Embley River, Australia[12] and 23.69 t ha^{-1} yr^{-1} in Australia.[6] For *S. alba*, monthly litter fall ranged from 32.3 ± 33.1 g.m^{-2} to 440.2 ± 133.1 g.m^{-2} (Fig. 6) with mean of 130.1 ± 28.5 g.m^{-2}. The minimum value was observed in Taklong Island (unoiled) in January while the maximum value was observed in Pototan in April. Annual litter production ranged from 1047.2 g.m^{-2} (Taklong Is., unoiled) to 2080.7 g.m^{-2} (Pototan) with mean of 1561.1 ± 342.3 g.m^{-2} and leaves made up the bulk of litter fall comprising 60.5% of the total dry weight. This annual production is lower compared to 17 t ha^{-1} yr^{-1} in Mandovi-Zuari Estuary, India.[14] The reproductive components of the five species were expected to be highly variable indicating that each species has a unique reproductive phenology.

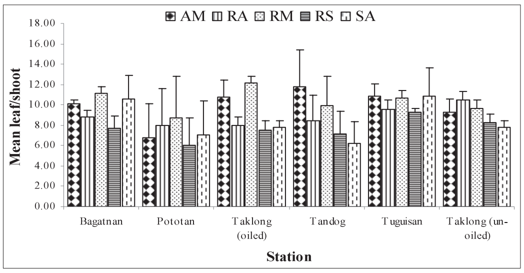

Fig. 7. Mean standing leaves per shoot (± s.d.) from October 2007 to September 2008.

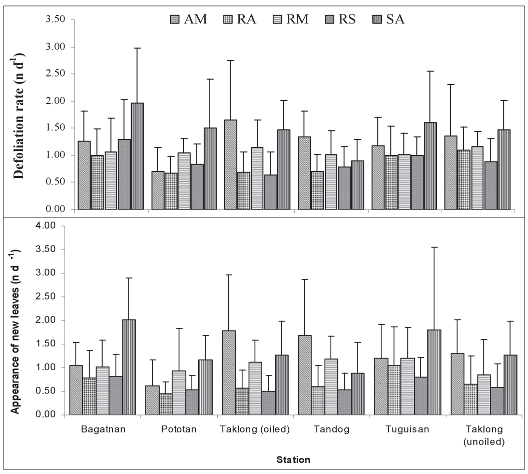

Fig. 8. Proximate defoliation rate per month (± s.d.) and rate of appearance of new leaves per month (± s.d.) of monitored trees from October 2007 to September 2008.

Plant condition

Average standing leaves per shoot range from 7 to 11 leaves (Fig. 7) while appearance of new leaves and defoliation rate were almost equal (Fig. 8) with slight fluctuation relative to monthly climatic condition. This is the expected condition in

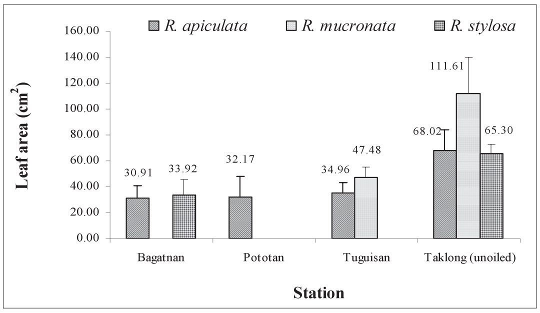

Fig. 9. Leaf area (cm^2) of some trees showing reduction in canopy cover (± s.d.).

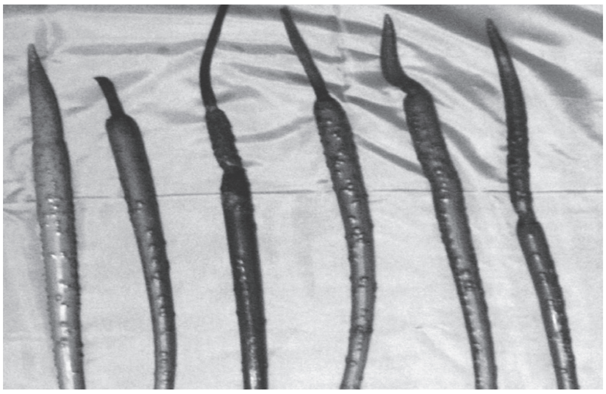

Fig. 10. Propagules of *R. mucronata* showed deformities towards the radicle portion.

Fig. 11. Necrotic and grazed leaves of *R. stylosa* leaves.

stable and sustaining condition. Some trees of *R. apiculata, R. mucronata,* and *R. stylosa* contiguous to the deforested area showed a significant reduction in leaf size and canopy cover that reached up to a maximum of 54.5, 57.5, and 48.1% respectively (Fig. 9). These trees were considered to be the "survivor" that suffered from partial defoliation characterized by death of pneumatophores and prop roots and with few leafy shoots. This reduction in leaf area would mean a decrease in total photosynthetic surface area. Cintron et al. explained that the condition of the leaves appears to be a sensitive sublethal stress on mangrove trees.[16] Leaves are the loci of energy capture in the system, but the ability to maintain an optimum leaf area index is determined by the ability of trees to concentrate and transport nutrients and freshwater to the leaves. This ability is dependent upon proper root function that is influenced in turn by site conditions and is reduced by environmental stressors particularly oil. Cintron et al. further explains that stressors like oil have initial acute effects at which time structure is lost and the system decays.[16] If the stressors persist, the system deteriorates further and the new structures develop and exhibit a reduced vigor, reflecting the persistent energy drain on the system often resulted to mortality.

Propagules of *R. mucronata* found in Bagatnan adjacent to the area where massive death of mangroves showed deformities and necrosis towards the radicle (tip) portion (Fig. 10) which could result in the inability or failure of settlement since embryonic roots arise from this part of propagules. Necrotic and highly-grazed leaves of saplings and wildings were prevalent in *R. stylosa* in Bagatnan within the deforested area (Fig. 11). This could be another indicator of chronic stress brought about by the residual oil. Their weakened state made them more vulnerable to insects, pests, fungi, and other r-selected species.

Mangrove community structure

Stems per hectare (n ha^{-1}) reduced dramatically one year after the incident (Fig. 12). This is attributed to numerous numbers of dead plants observed within the area. Tree density (n ha^{-1}) particularly in Bagatnan site dropped significantly from 2006 to 2007 (Fig. 13). This site had largest deforested mangrove area within TINMR three months after the oil spill.[17] Sapling density (n ha^{-1}) also reduced in all sites except in Bagatnan which showed slight improvement (Fig. 14). This increased in density of saplings in Bagatnan site however could not be translated immediately as sign of recovery. Saplings maybe able to survive for certain period of time until all their food reserve are exhausted. Wilding density (n ha^{-1}) on the other hand dropped significantly in all sites (Fig. 15). Saplings and wildings are considered as natural regeneration potential; however, this fluctuation in densities over a period of one year may signify instability of the oil impacted areas. Stand basal area (m^2 ha^{-1}), showed a marked reduction in Bagatnan, Tandog site, and Taklong (oiled site) while a slight increase in Tuguisan site (Fig. 16). Species diversity using the Shannon-Weaver index of diversity (H') showed a slight change among sites indicating that there was no change in terms of species

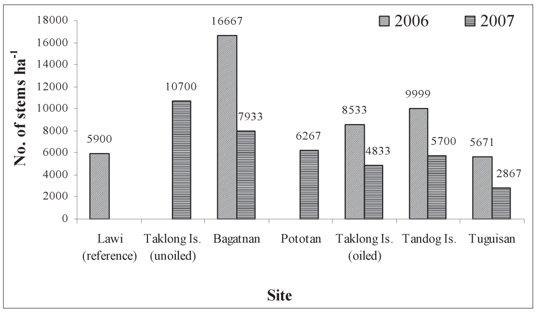

Fig. 12. Stems per hectare (no. of tree, sapling, wilding ha^{-1}) of monitored sites in 2006 and 2007.

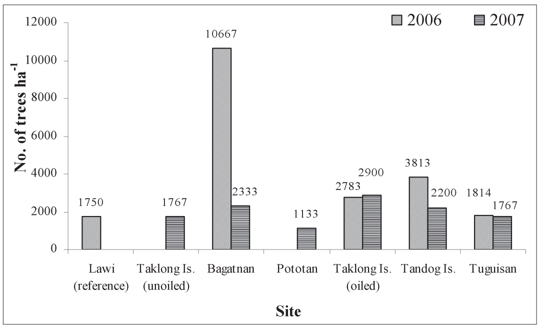

Fig. 13. Tree density (no. of trees ha^{-1}) of monitored sites in 2006 and in 2007.

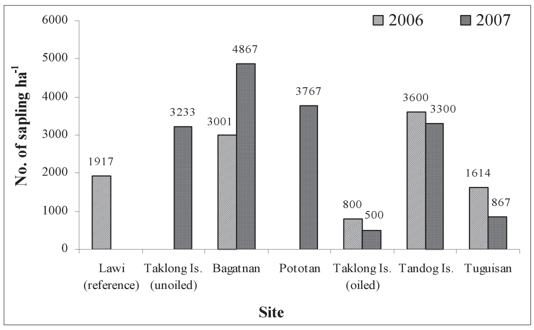

Fig. 14. Sapling density (no. of saplings ha^{-1}) of monitored sites in 2006 and in 2007.

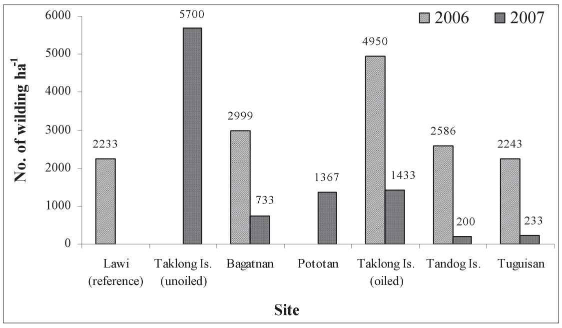

Fig. 15. Wilding density (no. of wilding ha^{-1}) of monitored sites in 2006 and 2007.

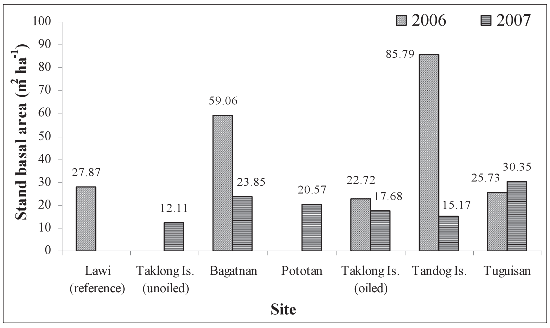

Fig. 16. Stand basal area (m^2 ha^{-1}) of monitored sites in 2006 and 2007.

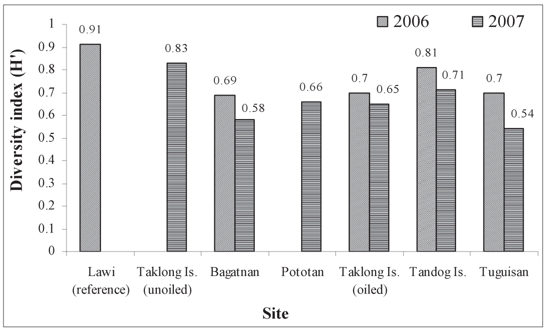

Fig. 17. Shannon-Weaver index of diversity of monitored sites in 2006 and in 2007.

composition (Fig. 17). The same species were recruited in the area that tends to re-establish or rehabilitate naturally the deforested area.

Conclusion and Recommendation

Litter fall productions among monitored species followed a unimodal pattern with peaks during dry season extending up to June except for *A. marina* that extends up to August. This peak would imply a modal response of mangroves to rainfall wherein they tend to reduce transpiration during dry periods by thinning their canopy through frequent shedding-off of their leaves. In comparison with available literatures, the result of this study varied widely. This would mean that volume of litterfall production varied significantly from habitat to habitat and depends on local environmental conditions, species composition, productivity of individual species, and habitat-specific stresses. Hence, it's difficult to extrapolate yet whether the low or high volume of litterfall production from this study is solely brought about by the stress caused by oil spill. However, results on community structure clearly showed the drastic reduction in density of trees, saplings and wildings, and stand basal area one year after the oil spill. Appearance of new leaves and defoliation rate were almost equal with slight fluctuation relative to monthly climatic condition. Some trees of *R. apiculata, R. mucronata,* and *R. stylosa* contiguous to the deforested area showed a significant reduction in leaf size and canopy cover. These trees suffered from partial death and with few leafy shoots per branch. This reduction in leaf size would mean a decrease in total photosynthetic surface area and appears to be a manifestation of a sublethal stress on mangrove trees. Propagules of *R. mucronata* found in Bagatnan adjacent to the deforested area showed deformities and necrosis towards the radicle portion that may result in the inability or failure of settlement since embryonic roots developed from this part of propagules. Necrotic and highly-grazed leaves of saplings and wildings were prevalent in *R. stylosa* in Bagatnan within the deforested area and this could be an indicator of chronic stress brought about by the residual oil in the sediments wherein their weakened state made them more vulnerable r-selected species. The observed sublethal stress on mangroves only gave overview of the apparently struggling mangrove habitat. Thus, further monitoring is needed to understand deeply habitat condition and stability and to determine if other remedial strategies are needed in the future.

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