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Monitoring the Effects of the Solar I Oil Spill on the Benthic Infaunal Assemblages of the Taklong Island National Marine Reserve(TINMAR), Southern Guimaras, Philippines

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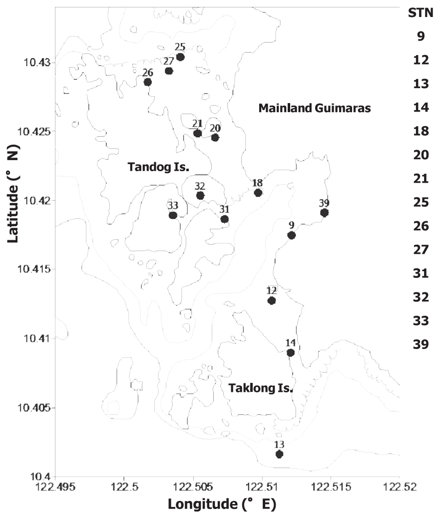
Abstract

The effects of the Solar I oil spill on the mean densities (ind.・m^{-2}) and species richness of the macrobenthic infaunal assemblages of the Taklong Island National Marine Reserve (TINMAR) were monitored. Time series comparisons in 14 stations sampled before (2002) the oil spill and after (2007-present) were made. A drastic decrease in densities (54%) and richness (63%), as well as the disappearance of oil-sensitive gammarid amphipods were noted right after the spill (Sept 2006), and are taken as clear direct impacts of the oil. A surge of densities, re-appearance of amphipods, and occurrence of polychaete larval stages during the first quarter of the two years of monitoring, on the other hand, suggest that recruitment took place and altogether further suggest that recovery is underway.

The MT Solar I oil spill on August 11, 2006 is considered as the largest oil spill incident in the Philippines. It released 200,000 to 300,000 liters of highly toxic bunker fuel, contaminating around 24 km^2 hectares of coastline and habitats in Guimaras, specifically affecting 1,100 hectares of the Taklong Island National Marine Reserve (TINMAR) (http://www.ndcc.gov.ph). The spread path of the spill is shown in Fig. 1. While a rapid assessment of the extent of its impact on marine habitats was initiated, there is a need for continuing monitoring because its effects on the organisms, especially on submerged, generally non-motile ones, may not be immediately detected.

The benthos comprise animals or plants living in, on, or in close association with the sea bed. Conventionally, these organisms are sub-divided on the basis of size, into micro-, meio-, macro-, and megafaunal components. The macrobenthos are the organisms retained on a 0.5-1mm sieve. This includes nematodes, polychaetes, bivalves, amphipods, and decapod crustaceans[1-3].

The benthic biota possess a number of important attributes that justify their inclusion in marine monitoring programs concerned with biological impact. They are generally sedentary and intimately associated with the seabed[4] which makes them reliable biological mirrors of any activity affecting the habitat. Furthermore, they respond to pollutant stresses[2,5-7] in varying sensitivities, thus making it possible to identify subtle effects of pollutants as reflected in changes in community structure[8]. The nature and time-scales of the earliest response to waste inputs of benthic organisms occur at various levels of biological organization, ranging from hours to days in the sub-cellular level, to seasons to years in the community level. Any change occurring in benthic communities due to waste discharge may thus be viewed as end-points of a hierarchical



STN	° North	° East
9	10.41749	122.51215
12	10.41276	122.51071
13	10.40165	122.51126
14	10.40900	122.51207
18	10.42057	122.50971
20	10.42456	122.50661
21	10.42487	122.50533
25	10.43039	122.50407
26	10.42857	122.50171
27	10.42938	122.50325
31	10.41865	122.50729
32	10.42036	122.50553
33	10.41893	122.50354
39	10.41912	122.51453

Fig. 1. Map and coordinates of stations fixed for the 2nd year of the long-term benthic community survey in Taklong Island National Marine Reserve (TINMAR), Guimaras, Philippines. Note: Station numbers follow those in the baseline information[13].

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sequence of adaptive or degenerative responses, and it is the nature and time scales of changes occurring at this level that are likely to be of greatest significance in terms of effects on other sources[4)]. In a review by Gray[9)], of a variety of known responses of benthic communities on stress, those which have been documented are reduced diversity, retrogression to opportunist species, and reduction in size.

The aim of the study was to investigate and monitor the effects of the Solar I oil spill on the mean density (ind·m^{-2}) and species richness of the macroinfaunal assemblages in TINMAR.

Materials and Methods

Field sampling for the long term monitoring of macrobenthic infauna in TINMAR was conducted bi-monthly in 14 stations (Fig. 1). Macrobenthic infauna were sampled using a corer (area = 57.78 cm^2) pushed into the sediment to a depth of 10 cm. Collected samples were preserved in 10% buffered seawater-formalin solution with Rose Bengal dye.

In the laboratory, sediment samples were sieved through a 500 μm mesh screen and stained organisms retained were hand-sorted, counted, and identified. Polychaetes were identified, whenever possible, down to the species level using various taxonomic literatures, such as Fauvel[10)], Fauchald[11)] and Higgins and Thiel[12)]. The rest of the macrofauna were identified only up to class or family level.

Time series comparisons were made between the 14 stations common among the present study, the pre-spill 2002[13)], and post-spill rapid assessment[14)]. ANOVA Single Factor was performed on the data set to test the significance of differences in mean density and species richness between sampling dates.

Results and Discussion

The overall mean density of macrobenthos from the 14 stations sampled quarterly for the second year of the long-term monitoring program is 11,008 ind·m^{-2} ± 11,150 (0 to 43,092). This is lower and more variable compared to the first year (14,676 ind·m^{-2} ± 9,281)[15)]. Comparison of density distributions among the four quarters (Figs. 2a-d) reveals generally low densities, with one or two outlying stations (e.g. stn 12 in March, stn 20 in May, and stn 27 in September and December) that account for the high variability. Moreover, patterns of density distributions show consistency with the first year, i.e. relatively northern stations have higher densities.

The time-series comparison of the four sampling periods is shown in Fig. 3. In this study, density was highest in March (16,369 ind·m^{-2}), providing further empirical evidence that recruitment takes place during the first quarter of the year, as shown in the 1st year of monitoring, where density was highest in the month of February 2007[15)]. As in 2007, there is a declining pattern observed in this study, with a drastic drop (2,820 ind.·m^{-2}) in September 2008. While there is a general observation of low densities in the second half of the year, it is also possible that decreased density in September 2008 is a vestigial effect of a disturbance brought about by a tropical

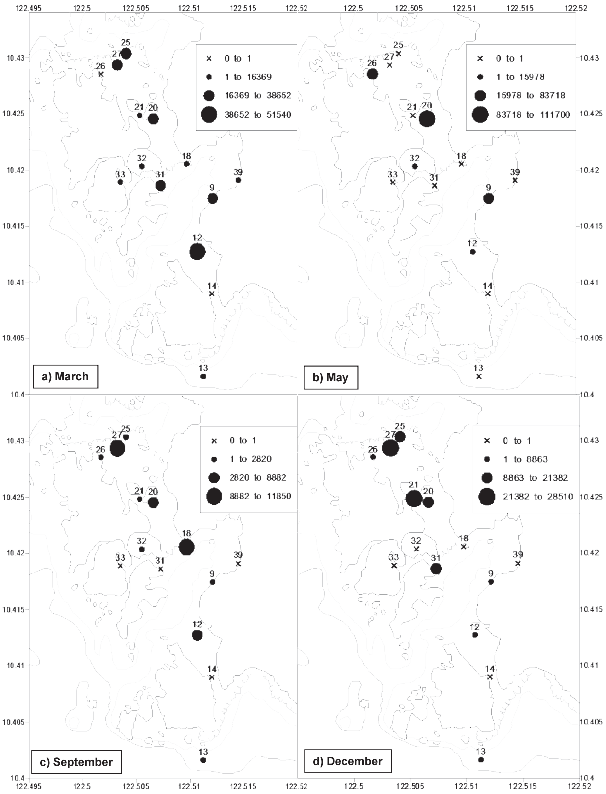

Fig. 2. Density (ind·m^{-2}) distribution of macrobenthos sampled quarterly in 14 stations in TINMAR, Guimaras, Philippines for the long-term monitoring program Year2 (Mar-Dec 2008).

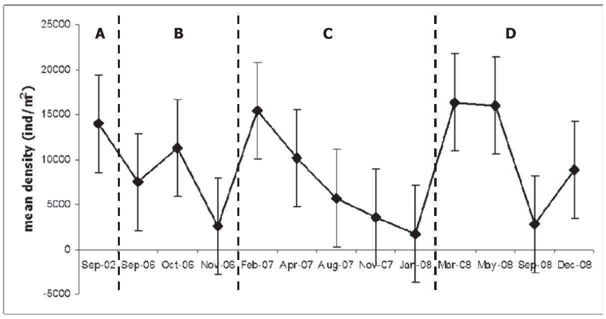

Fig. 3. Comparison of mean densities (ind·m^{-2}) of macrobenthos in 14 stations sampled in TINMAR for the following periods: (A) pre-spill, (B) rapid assessment, (C) Yr 1 monitoring, (D) Yr 2 monitoring.

storm in June 2008, with Panay as the hardest hit area. This occurrence may have heightened the physical mixing of the water column and lowered the salinity by means of increased rainfall (Fig. 4)[16], consequently altering the ambient conditions with which organisms are adapted to. It was observed that while oil pollution sensitive gammarid amphipods disappeared in September 2006[14], they have remained present in September 2008 (Table 1). As in the case of the Amoco Cadiz oil spill, there was a remarkable decrease in the number of amphipod species (e.g. members of the gammaridean family Ampeliscidae) that was well correlated with the pollution[17]. Furthermore, it has been demonstrated repeatedly in experimental studies that amphipods are more sensitive to hydrocarbon pollution than are polychaetes or decapods[17,18]. Moreover, bivalves, which are also considered to be relatively k-selected organisms, even showed an increase in mean density from 236 $\text{ind}\cdot\text{m}^{-2}$ in September 2006[14] to 251 $\text{ind}\cdot\text{m}^{-2}$ in September 2008. Thus, the oil spill affected the macrobenthic community in a target-specific manner (i.e. alteration of the species composition) while a naturally occurring phenomenon such as a tropical storm may have reduced abundances without affecting the macrobenthic composition.

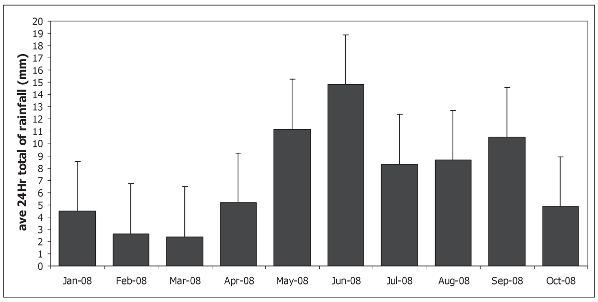

Fig. 4. Monthly average rainfall (mm) from a 24-hour observation for Jan-Oct 2008. Source: National Mango Research and Development Center Weather Station, Jordan, Guimaras.

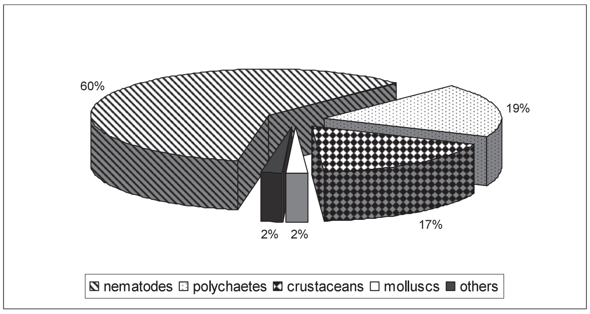

Fig. 5. Relative composition of major macrobenthic groups in the 14 stations sampled in TINMAR for the long-term monitoring program Year2.

Nematodes dominated the macrobenthic community with a 60% relative composition, followed by the polychaetes (19%) and the crustaceans (17%) (Fig. 5). Albeit there is no marked shift in community composition, in the 1st year of monitoring, polychaetes dominated the macrobenthic composition, followed by the nematodes. The shift in dominance observed in this study could not be accounted at present, however, polychaetes and nematodes are normally co-dominants, and this shift may just be a part of the natural variability of generation times of these organisms.

Conclusions and Recommendation

An increase in macrobenthic density, the consistent surge in densities in the first quarter of the year, both interpreted as indications of recruitment, and the reappearance of hydrocarbon-sensitive gammarid amphipods all suggest that recovery is underway. Moreover, the occurrence of a tropical storm in June 2007 illustrated the difference in effects of a natural phenomenon to that of an oil spill event. With the former, there is only reduction in abundances, while the latter further alters the species composition. The study of the intertidal macrobenthic community is recommended to complement results for the subtidal community.

Acknowledgments

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Table 1. Relative composition of the top 10 macrobenthic infauna in TINMAR across all sampling periods of the long-term monitoring program year2.

Overall		Mar-08		May-08		Sep-08		Dec-08	
Taxa/Species	%	Taxa/Species	%	Taxa/Species	%	Taxa/Species	%	Taxa/Species	%
nematode	59.66	nematode	59.04	nematode	71.37	nematode	67.22	nematode	37.28
tanaid	8.47	tanaid	10.33	tanaid	10.59	bivalve	8.89	*Exogone sp.*	10.07
Exogone sp.	4.16	gammarid	4.40	*Magelona sp.*	3.33	*Exogone sp.*	6.11	*Magelona sp.*	4.95
gammarid	2.67	harpacticoid	3.64	*Paraonis/Paraonides*	1.76	*Eusyllis sp.*	3.89	gammarid	4.24
Magelona sp.	2.35	*Exogone dispar*	3.06	*Exogone sp.*	1.67	ostracod	2.78	tanaid	3.89
harpacticoid	2.21	*Dorvillea sp.*	2.49	bivalve	1.57	gammarid	1.67	*Aricidea sp.*	3.53
bivalve	1.57	cumacean	1.34	*Aricidea sp.*	1.47	*Nematonereis sp.*	1.67	Capitellidae	3.36
Aricidea sp.	1.49	Paraonidae	1.24	ostracod	1.27	*Dorvillea sp.*	1.11	harpacticoid	2.65
ostracod	1.32	ostracod	1.15	calanoid	0.88	*Questa sp.*	1.11	*Heteromastus sp.*	2.30
Dorvillea sp.	1.21	*Syllis sp.*	1.05	harpacticoid	0.78	*Autolytus sp.*	0.56	*Paraonis/Paraonides*	2.30
								cumacea	1.94
Sum	85.09		87.75		94.71		95.00		76.50
N	56		14		14		14		14
Mean Density (ind·m^{-2})	11008		16369		15978		2820		8866
SD	11150		16730		32663		4136		9465

References

1) Nybakken, J.W. (1997). Marine Biology: An Ecological Approach 4th Ed. Addison-Wesley Educational Publishers Inc., USA.
2) Gray, J.S. (1981). The Ecology of Marine Sediments: An Introduction to the Structure and Function of Benthic Communities. Cambridge University Press.
3) Steele, J.H. (1974). The Structure of Marine Ecosystems. Harvard University Press, Cambridge, Massachusetts.
4) Rees, H.L., C. Heip, M. Vincx, and M.M. Parker (1991). Benthic communities: Use in monitoring point-source discharges, in "Int'l Council Explor. Sea Tech. Rep. No. 16". Copenhagen, Denmark.
5) Bilyard, G.R. (1987). The value of benthic infauna in marine pollution monitoring studies. *Mar. Pollut. Bull.,* **18**:581-585.
6) Hartley, J.P. (1982). Methods for monitoring offshore macrobenthos. *Mar. Pollut. Bull.,* **13**:150-154.
7) Pearson, T.H. and R. Rosenberg (1978). Macrobenthic succession in relation to organic enrichment and pollution of the environment. *Oceanogr. Mar. Biol. Ann. Rev.,* **16**:229-311.
8) Gray, J.S., K.R. Clarke, R.M. Warwick, and G. Hobbs (1990). Detection of initial effects of pollution on marine benthos: an example from the Ekofisk and Eldfisk oilfields, North Sea. *Mar. Ecol. Prog. Ser.,* **66**:285-299.
9) Gray, J.S. (1989). Effects of environmental stress on species rich assemblages. *Biol. J. Linn. Soc.,* **37**:19-32.
10) Fauvel, P. (1953). Annelida: Polycheta, in "The Fauna of India including Pakistan, Ceylon, Burma and Malaya". Allahabad, p. 507.
11) Fauchald, K. (1977). The Polychaete Worms. Definition and keys to the Orders, Families, and Genera. Natural History Museum of Los Angeles County. The Allan Hancock Foundation. *Univ. of S. Calif. Sci. Ser.,* **28**:1-188.
12) Higgins, R.P. and H. Thiel (1988). Introduction to the study of meiofauna. Smithsonian Inst. Press, Wash. D.C.
13) Nacionales, E.B. and W.L. Campos (2004). Macrobenthic assemblages in Taklong Island National Marine Reserve, Southern Guimaras. *UPV J. Nat. Sci.,* **9**(1):30-44.
14) del Norte-Campos, A.G.C. and E.N. Nacionales (2008). Assessment of the impact of the Solar 1 oil spill on the infaunal assemblages of southern Guimaras, Philippines. *Mar. Res. Indonesia,* **33**(2):213-220.
15) del Norte-Campos, A.G.C and G.E. Genito. Monitoring the Effects of the Solar I Oil Spill on the Benthic Infaunal Assemblages in Southern Guimaras, Philippines. *UPV J. Nat. Sci.* (submitted).
16) National Mango Research and Development Center (NMRDC) Weather Station. Monthly Weather Observation (January-October, 2008).
17) Dauvin, J.C. (1982). Impact of Amoco Cadiz oil spill on the muddy fine sand *Abra alba* and *Melinna palmata community* from the Bay of Morlaix. *Estuarine, Coastal and Shelf Science,* **14**:517-531.
18) Elmgren, R., S. Hansson, U. larrson, B. Sundelin, and P.D. Boehm (1983). The "Tsesis" oil spill: acute and long-term impact on the benthos. *Mar. Biol.,* **73**:51-65.