

Ingestion of Marine Plastic Debris by Green Turtle (*Chelonia mydas*) in Davao Gulf, Mindanao, Philippines

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Marine plastic debris is a global problem that is threatening marine biodiversity. Different marine organisms have been exposed to the lethal and sub-lethal effects of this problem. Sub-lethal effects include reduced fitness due to reduced feeding, reduced reproductive output, limb amputation, and exposure to diseases and toxic materials, while lethal effects include drowning, gastro-intestinal blockage, and stomach rupture. Marine turtles are very vulnerable to these effects since these organisms actively ingest plastic mistaking it as prey. This adds stress to the declining population of marine turtles. On 17 April 2015, a dead adult female green turtle was recovered in Brgy. Lapu-lapu, Agdao, Davao City, Philippines. Necropsy showed that several plastic materials caused blockage in the pyloric end of the stomach which may have caused the turtle's mortality.

Key words: Davao gulf, Green turtle, plastic debris, plastic ingestion, pollution

INTRODUCTION

Marine plastic debris is considered a threat to marine biodiversity. The effects of plastic on marine organisms range from sub-lethal to lethal. Sub-lethal effects include reduced fitness due to reduced feeding and stomach capacity, vulnerability to predators, reduced reproductive output, limb amputation, exposure to diseases and toxic materials adsorbed to plastics that may cause physiological irregularities. On the otherhand, several studies have reported that plastic has caused mortality to marine species by drowning, gastro-intestinal blockage, and stomach rupture among others (McCauley & Bjorndal

1999; Plot & Georges 2010; Hirai et al. 2011; De Stephanis et al. 2013; Lavers et al. 2014). Aside from its direct impacts to individual marine organisms, plastic can also have ecological effects that may indirectly affect various marine animals. Plastic is known to introduce alien species, altering the community structure and possibly food web simplification (Katsanevakis et al. 2014; Pham et al. 2014).

The ubiquity of plastics in the marine environment means that exposure of different marine organisms to these pollutants is high. An increasing trend in the number of marine species directly affected by plastic, through entanglement and ingestion, has been observed (Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF

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2012.). This can be a result of the increasing encounters that occur between marine species and plastic debris found in the world's oceans (González-Carman et al. 2014). The amount of plastic production in the 1950's was around 1.5 million tons. In 2012, the global plastic production have reached 288 million tons, of which 0.1% is estimated to become marine plastic debris (Eriksen et al. 2014). Resistance to degradation due to the durability of plastics have allowed it to accumulate in the world's oceans over the years and plastic in the ocean has been estimated to be from 35,000 tons to 268,940 tons or 5.25 trillion plastic particles (Cózar et al. 2014; Eriksen et al. 2014). Although this can be an underestimation, it can be considered a big pollution problem.

Among the different marine organisms affected by plastic debris, marine turtles are one of the most vulnerable (Schuyler et al. 2015). All of the seven marine turtle species have been reported to ingest plastic debris (Kühn et al. 2015). One possible cause of plastic ingestion by marine turtles is the visual similarity of the material to their natural prey, specifically jellyfish, thereby making marine turtles actively ingest this material (Schuyler et al. 2014b). Reports on marine turtle mortalities caused by plastic ingestion can affect its population dynamics (Lazar & Gračan 2011), posing a new challenge to turtle conservation.

The Philippines is considered to be one of the "hottest" biodiversity hotspots in the world (Myers et al. 2000) and marine plastic pollution poses additional threat to

its biodiversity (e.g. nutrient enrichment, sedimentation (Abreo et al. 2015) and overfishing (Nañola et al. 2010)). With a fast growing economy, increased usage of plastic will inevitably lead to the increase in plastic deposition in the marine environment (Lebreton et al. 2012; van Sebille et al. 2012). Moreover, plastic pollution is observed to be higher in densely populated areas where there are increased anthropogenic activities (Ryan 2013). In 2012, global plastic production was at 288 million tons using the conservative estimate of Eriksen et al. (2014). This translates into at least 288 thousand tons of plastic becoming marine debris. Human dependence on plastic has caused the increasing production of the material (Andrady and Neal 2009). Plastic debris will inadvertently impact marine species in the environment as a result. Davao City, which is one of the urban centers of the Philippines, is situated alongside the Davao Gulf. The potential of its population (over one million) contributing to marine plastic debris is great. This study reports the first case of plastic ingestion by a marine turtle in Davao Gulf, Mindanao, Philippines.

METHODOLOGY

On 17 April 2015, a deceased green sea turtle (*Chelonia mydas*) was recovered in Brgy. Lapu-lapu, Agdao, Davao City (Figure 1). Necropsy was performed to determine

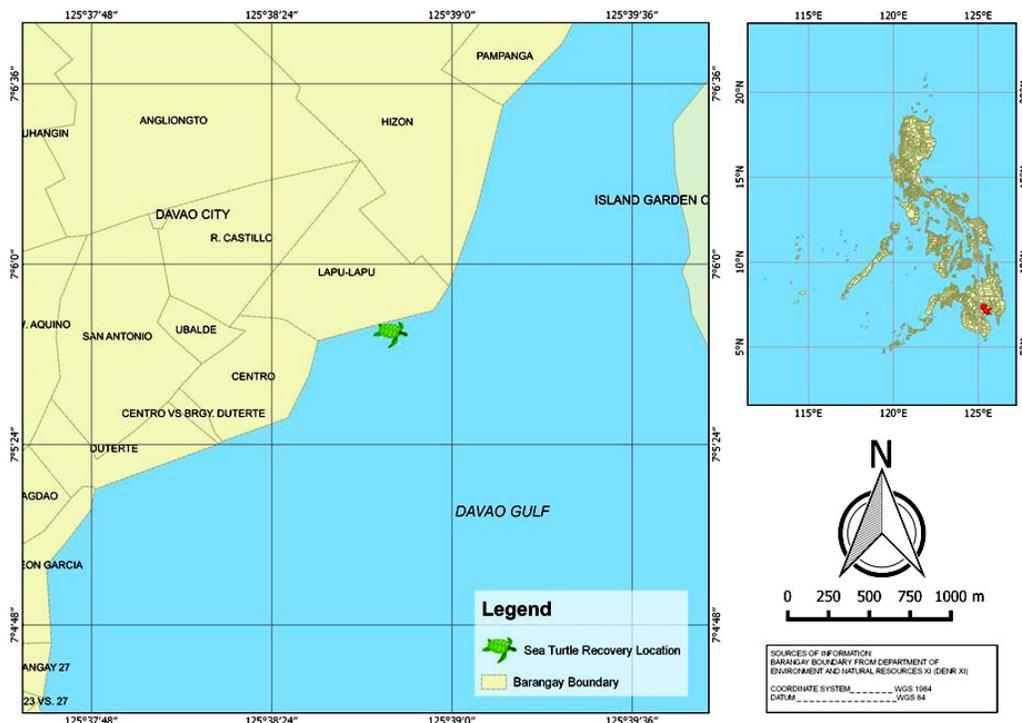


Figure 1. Map of Davao City showing the location of the recovered green turtle.

the cause of death. Morphometric measurements were taken and external morphology was checked for physical injuries. Further, the digestive tract was opened and checked for lacerations and other damages that may have caused the death of the sea turtle. Gut contents were collected, washed with freshwater, air dried, and analyzed. Anthropogenic debris was later isolated from food remains and other organic debris. In this study, only anthropogenic debris was analyzed and then categorized by type and color.

RESULTS AND DISCUSSION

Globally, marine turtle population is declining (Table 1) due to different anthropogenic activities that impacts their habitat. Threats to marine turtle population includes overfishing for human consumption, accidental catch (by-catch), collision with vessels and marine pollution, among others (Bagarinao 2011; González-Carman et al. 2014; Poli et al. 2014). This same trend is observed for marine turtle populations in the Philippines (Meylan and Donnelly 1999). The decline in marine turtle population prompted the formation of the Pawikan Conservation Project, a government conservation effort to address the dwindling marine turtle population of the country (Trono 1991).

The *C. mydas* that was recovered was an adult female (Figure 2) with a curved carapace length (CCL) of 47.63 cm and a curved carapace width (CCW) of 45.72 cm . The sea turtle did not exhibit any external injuries, nor did it exhibit signs of malnutrition and disease. Further, no injuries, such as lacerations, were observed in the digestive tract of the sea turtle. The stomach contained undigested sea grass (approx. 1 kilogram wet weight), remains of 2 squid beaks, and plastic materials (Figure 3).

Among the different marine turtle species, *C. mydas* has been observed to have increased their likelihood to ingest



Figure 2. Carcass of the *Chelonia mydas* recovered in Davao City.



Figure 3. Stomach contents of the recovered *Chelonia mydas*.

plastic from 30 % in the 1980's to 50 % in 2012 (Schuyler et al. 2014a). As shown in Table 2, among the plastic materials ingested by the recovered *C. mydas*, the most common were plastics that were soft and transparent (33.3 %) and white plastics (33.3 %) (Figure 3). Studies have

Table 1. Status of Marine Turtles.

Common name	Scientific name	IUCN status	Population trend
Loggerhead Turtle	<i>Caretta caretta</i>	Endangered	-
Hawksbill Turtle	<i>Eretmochelys imbricata</i>	Endangered	Decreasing
Kemp's Ridley Turtle	<i>Lepidochelys kempii</i>	critically endangered	-
Olive Ridley Turtle	<i>Lepidochelys olivacea</i>	Vulnerable	Decreasing
Flatback Turtle	<i>Natator depressus</i>	data deficient	-
Leatherback Turtle	<i>Dermochelys coriacea</i>	Vulnerable	Decreasing
Green Turtle	<i>Chelonia mydas</i>	Endangered	Decreasing

Source: The IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org>. Downloaded on 11 June 2015.

Table 2. Plastic Ingested by Marine turtle recovered in Brgy. Lapu-lapu, Agdao Davao City.

Plastic Color	No. of Pieces	Percentage (%)
Transparent/translucent	5	33.3
White	5	33.3
Blue	2	13.3
Gray	2	13.3
Multicolored	1	6.6

shown that marine turtles are able to distinguish color and this ability affects their food selection behavior (Swimmer et al. 2006). Moreover, a study conducted by Schuyler et al (2014b) showed that *C. mydas* favor ingestion of soft plastic that is translucent and/or transparent. The high amount of soft and transparent plastic that was ingested by the individual could be a result of the turtle mistaking it for a prey (e.g. jellyfish) (Schuyler et al. 2012). Aside from transparent plastic materials, the individual also ingested plastic materials of different color (Figure 5) and a five centavo replica (Figure 6). Given that marine turtles are

visual feeders, ingestion of the coin replica is not a result of active food selection. The plausible reason could be that it was ingested accidentally. Marine organisms, such as dolphins and whales, ingest plastic accidentally with their prey (Di Benedetto & Ramos 2014). Since plastic marine debris is ubiquitous, its distribution overlaps with foraging areas of marine organisms (Williams et al. 2011). Plastic marine debris is known to be found floating in the water column and are also abundant in sea floors, both of which are utilized by *C. mydas* (Schuyler et al. 2014a). This could mean that the presence of plastic in their foraging areas increases the likelihood of accidentally ingesting the plastic materials (Sigler 2014). High frequency of ingested plastic was observed by Gonzalez-Carman (2014) in the guts of marine turtles that were found to have core foraging areas overlapping with areas having high concentration of marine plastic debris. This can also be the plausible reason for the ingestion of plastic with other colors.

The plastic debris was not found to have caused any lacerations or damages in the digestive tract of the individual. The lack of sharp and hard plastics may be a plausible explanation for the lack of internal injuries.



Figure 4. Transparent plastics found in the digestive tract of *Chelonia mydas*.

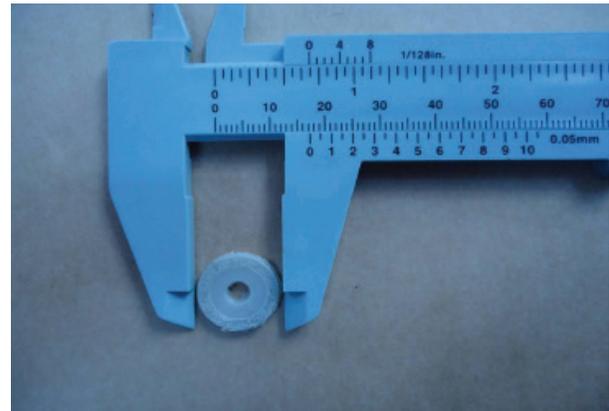


Figure 6. five centavo replica recovered from the digestive tract of the *Chelonia mydas*.



Figure 5. Colored plastic materials recovered from the digestive tract of *Chelonia mydas*.



Figure 7. Feces of recovered *Chelonia mydas* with plastic debris.

Commonly, marine organisms that ingest plastic suffer from lacerations or rupture in parts of its digestive tract which can lead to the organism's demise (Gregory 2009). Although plastics failed to cause digestive tract damage that could have killed the individual, the plastics were found to have impacted its intestines through blockage. Aside from large plastics found to have been lodged in the pyloric end of the stomach, smaller plastic materials were also found in the large intestine embedded in the feces (Figure 7). Although sea turtles are capable of excreting small plastic materials (Tomás et al. 2002), accumulation of these small plastic materials can cause blockage in the digestive tract. Blockage of the digestive tract is a leading cause of mortality for marine organisms that ingest plastic materials resulting commonly in emaciation and severe starvation of the organism (McCauley & Bjorndal 1999; Lazar & Gracan, 2011). In the present case, the individual that was recovered did not exhibit signs of starvation or malnutrition. Necropsy finding suggests that the individual was feeding, as indicated by the presence of partially digested seagrass in the stomach. The amount of plastic found in its digestive tract was not enough to cause false satiation that could lead to decrease food intake that would further lead to starvation and emaciation. Although the complete blockage of the digestive tract of the recovered *C. mydas* could have caused its death, it cannot be confirmed. The lack of signs of emaciation of the individual could be an implication that its death is caused not by malnutrition or less absorption of nutrients. Studies showed that marine plastic debris has the ability to accumulate toxic materials through adsorption (Hirai et al. 2011; Rochman et al. 2014). Moreover, these adsorbed toxic materials and the materials that are part of the plastic during production, can be mobilized from the plastic once exposed to surfactants in the guts of animals making it available for absorption (Engler 2012). Aside from this, the study by Carson et al. (2013) showed that microorganisms also thrive in marine plastic debris and those microorganisms can affect the marine organisms that may come in contact or ingest the plastic debris with microorganisms (Arbelo et al. 2012).

CONCLUSIONS AND RECOMMENDATIONS

Plastic in the marine environment has been documented to have caused mortality to different marine organisms. The ubiquity of these materials in the marine environment coupled with its increasing number can have negative implications to marine biodiversity. In this study, the first incidence of mortality of a green turtle (*C. mydas*) due to plastic ingestion in the Philippines was recorded. The intestinal blockage that the plastics caused in the distal part

of the stomach could have probably caused its demise. A further study might be conducted on these plastic ingestion incidents (e.g. histopathology studies) to understand the interaction between marine organisms and marine plastic debris. The amount and distribution of plastic marine debris in the Davao Gulf should also be determined, as well as the core foraging areas of these turtles since studies have shown that the overlap of plastic distribution and foraging habitats can increase plastic ingestion incidence (González Carman et al. 2014).

REFERENCES

- ABREO NAS, MACUSI ED, CUENCA GC, RANARA CTB, CARDONA LT, ARABEJO GFP. 2015. Nutrient Enrichment, Sedimentation, Heavy Metals and Plastic Pollution in the Marine Environment and its Implications on Philippine Marine Biodiversity: A Review. *IAMURE International Journal of Ecology and Conservation* 15(1):111-167
- ANDRADY AL, NEAL MA. 2009. Applications and societal benefits of plastics. *Philos Trans R Soc Lond B Biol Sci* 364(1526):1977–1984. doi:10.1098/rstb.2008.0304
- ARBELO M, BELLIERE EN, SIERRA E, SACCHINNI S, ESPERÓN F, ANDRADA M, RIVERO M, DIAZ-DELGADO J, FERNÁNDEZ A. 2012. Herpes virus infection associated with interstitial nephritis in a beaked whale (*Mesoplodon densirostris*). *BMC Vet Res* 8(1):243. doi:10.1186/1746-6148-8-243
- BAGARINAO T. 2011. The sea turtles captured by coastal fisheries in the Northeastern Sulu Sea, Philippines: Documentation, care, and release. *Herpetol Conserv Biol* 6(3):353–363.
- Carson, H.S., Nerheim, M.S., Carroll, K. a., Eriksen, M., 2013. The plastic-associated microorganisms of the North Pacific Gyre. *Mar. Pollut. Bull.* 75:126–132. doi:10.1016/j.marpolbul.2013.07.054
- CÓZARA, ECHEVARRÍA F, GONZÁLEZ-GORDILLO JI, IRIGOIEN X, UBEDA B, HERNÁNDEZ-LEÓN S, PALMAAT, NAVARRO S, GARCÍA-DE-LOMAS J, RUIZ A, FERNÁNDEZ-DE-PUELLES ML, DUARTE CM. 2014. Plastic debris in the open ocean. *Proc Natl Acad Sci USA.* 111(28):10239-10244. doi:10.1073/pnas.1314705111
- DE STEPHANIS R, GIMENEZ J, CARPINELLI E, GUTIERREZ-EXPOSITO C, CAÑADAS A. (2013). As main meal for sperm whales: Plastics debris. *Marine pollution bulletin* 69(1): 206-214. doi:10.1016/j.marpolbul.2013.01.033

- DI BENEDITTO APM, RAMOS RMA. 2014. Marine debris ingestion by coastal dolphins: What drives differences between sympatric species? *Mar Pollut Bull* 83(1): 298–301. doi:10.1016/j.marpolbul.2014.03.057
- ENGLER RE. 2012. The Complex Interaction between Marine Debris and Toxic Chemicals in the Ocean. *Environ Sci Technol* 46(22):12302–12315.
- ERIKSEN M, LEBRETON LCM, CARSON HS, THIEL M, MOORE CJ, BORRERO JC, GALGANI F, RYAN PG, REISSER J. 2014. Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. *PLoS One* 9(12):e111913. doi:10.1371/journal.pone.0111913
- GONZÁLEZ CARMAN V, ACHA EM, MAXWELL SM, ALBAREDA D, CAMPAGNA C, MIANZAN H. 2014. Young green turtles, *Chelonia mydas*, exposed to plastic in a frontal area of the SW Atlantic. *Mar Pollut Bull* 78(1):56–62. doi:10.1016/j.marpolbul.2013.11.012
- GREGORY MR. 2009. Environmental implications of plastic debris in marine settings--entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Philos Trans R Soc Lond B Biol Sci* 364(1526): 2013–2025. doi:10.1098/rstb.2008.0265
- HIRAI H, TAKADA H, OGATA Y, YAMASHITA R, MIZUKAWA K, SAHA M, KWAN C, MOORE C, GRAY H, LAURSEN D, ZETTLER ER, FARRINGTON JW, REDDY CM, PEACOCK EE, WARD MW. 2011. Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. *Mar Pollut Bull* 62(8):1683–1692. doi:10.1016/j.marpolbul.2011.06.004
- IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org>. Downloaded on 11 June 2015.
- KATSANEVAKIS S, WALLENTINUS I, ZENETOS A, LEPPÄKOSKI E, ÇINAR ME. 2014. Impacts of invasive alien marine species on ecosystem services and biodiversity : a pan-European review. *Aquat Invasions* 9(4):391–423. doi:10.3391/ai.2014.9.4.01
- KÜHNS, REBOLLEDO ELB, FRANEKER JA. VAN. 2015. Deleterious Effects of Litter on Marine Life. In: *Marine Anthropogenic Litter*. Switzerland: Springer International Publishing p.75–116. doi:10.1007/978-3-319-16510-3
- LAVERS JL, BOND AL, HUTTON I. (2014). Plastic ingestion by flesh-footed shearwaters (*Puffinus carneipes*): Implications for fledgling body condition and the accumulation of plastic-derived chemicals. *Environmental Pollution* 187:124-129. doi:10.1016/j.envpol.2013.12.020
- LAZAR B, GRAČAN R. 2011. Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea. *Mar Pollut Bull* 62(1):43–47. doi:10.1016/j.marpolbul.2010.09.013
- LEBRETON LCM, GREER SD, BORRERO JC. 2012. Numerical modelling of floating debris in the world's oceans. *Mar Pollut Bull* 64(3):653–661. doi:10.1016/j.marpolbul.2011.10.027
- MCCAULEY SJ, BJORNDAL KA. 1999. Conservation implications of dietary dilution from debris ingestion: Sublethal effects in post-hatchling loggerhead sea turtles. *Conservation Biology* 13(4):925-929. doi:10.1046/j.1523-1739.1999.98264.x
- MEYLAN AB, DONNELLY M. 1999. Status Justification for Listing the Hawksbill Turtle (*Eretmochelys imbricata*) as Critically Endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian Conserv Biol* 3(2):200-224.
- MYERS N, MITTERMEIER RA, MITTERMEIER CG, DA FONSECA GAB, KENT J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403(6772):853–8. doi:10.1038/35002501
- NAÑOLA CL, ALIÑO PM, CARPENTER KE, 2010. Exploitation-related reef fish species richness depletion in the epicenter of marine biodiversity. *Environ Biol Fishes* 90(4):405–420. doi:10.1007/s10641-010-9750-6
- PHAM CK, RAMIREZ-LLODRA E, ALT CHS, AMARO T, BERGMANN M, CANALS M, COMPANY JB, DAVIES J, DUINEVELD G, GALGANI F, HOWELL KL, HUVENNE VAI, ISIDRO E, JONES DOB, LASTRAS G, MORATO T, GOMES-PEREIRA JN, PURSER A, STEWART H, TOJEIRA I, TUBAU X, VAN ROOIJ D, TYLER PA. 2014. Marine litter distribution and density in European seas, from the shelves to deep basins. *PLoS One* 9(4):e95839. doi:10.1371/journal.pone.0095839
- PLOT V, GEORGES JY. 2010. Plastic debris in a nesting leatherback turtle in French Guiana. *Chelonian Conservation and Biology* 9(2):267-270. doi:10.2744/CCB-0857.1
- POLI C, LOPEZ L, MESQUITA D, SASKA C, MASCARENHAS R. 2014. Patterns and inferred processes associated with sea turtle strandings in Paraíba State , Northeast Brazil. *Brazilian J Biol* 74(2):283–289.
- ROCHMAN CM, HENTSCHEL BT, THE SJ. 2014. Long-term sorption of metals is similar among plastic types: Implications for plastic debris in aquatic environments. *PLoS One* 9(1). doi:10.1371/journal.pone.0085433
- RYAN PG. 2013. A simple technique for counting marine debris at sea reveals steep litter gradients

- between the Straits of Malacca and the Bay of Bengal. *Mar Pollut Bull* 69(1):128–136. doi:10.1016/j.marpolbul.2013.01.016
- SCHUYLER QA, WILCOX C, TOWNSEND KA, WEDEMEYER-STROMBEL KR, BALAZS G, VAN SEBILLE E, HARDESTY BD. 2015. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. *Glob Chang Biol* 22(2): 567–576. doi:10.1111/gcb.13078
- SCHUYLER Q, HARDESTY BD, WILCOX C TOWNSEND K. 2012. To eat or not to eat? Debris selectivity by marine turtles. *PLoS One* 7(7):e40884. doi:10.1371/journal.pone.0040884
- SCHUYLER Q, HARDESTY BD, WILCOX C, TOWNSEND K. 2014. Global analysis of anthropogenic debris ingestion by sea turtles. *Conserv Biol* 28(1):129–39. doi:10.1111/cobi.12126
- SCHUYLER QA, WILCOX C, TOWNSEND K, HARDESTY BD, MARSHALL NJ. 2014. Mistaken identity? Visual similarities of marine debris to natural prey items of sea turtles. *BMC Ecol* 14(1):14. doi:10.1186/1472-6785-14-14
- SIGLER M. 2014. The Effects of Plastic Pollution on Aquatic Wildlife: Current Situations and Future Solutions. *Water Air Soil Pollut* 225(11):1-9. doi:10.1007/s11270-014-2184-6
- TOMÁS J, GUITART R, MATEO R, RAGA JA. 2002. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean. *Mar Pollut Bull* 44(3):211–216. doi:10.1016/S0025-326X(01)00236-3
- TRONO RB. 1991. Philippine Marine Turtle Conservation Program *Mar Turt Newsl* 53:5–7. Retrived from www.seaturtle.org/mtn/PDF/MTN53.pdf. on 28 Nov 2015.
- VAN SEBILLE E, ENGLAND MH, FROYLAND G. 2012. Origin, dynamics and evolution of ocean garbage patches from observed surface drifters. *Environ Res Lett* 7(4):044040. doi:10.1088/1748-9326/7/4/044040
- WILLIAMS R, ASHE E, O’HARA PD. 2011. Marine mammals and debris in coastal waters of British Columbia, Canada. *Mar Pollut Bull* 62(6):1303–1316. doi:10.1016/j.marpolbul.2011.02.029