# A characterization of marine debris in the Northeast Pacific deep ocean

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## Abstract

Marine debris is an ever-increasing global issue that has negative impacts upon both benthic and pelagic habitats in coastal and open-ocean areas. Little is known about marine debris in the deep-sea and few studies have looked specifically at marine debris in the deep ocean. Using MBARI's Video Annotation and Reference System (VARS), a video analysis and observation database, we review the types of marine debris in the Northeast Pacific from the US-Canadian border to the Gulf of California, with emphasis on Monterey Bay. Over 1,600 observations of marine debris in the VARS database provide insight into the types, sources, and potential impacts of debris in the deep sea. Our dataset reveals conduits for debris entering the deep sea and changes in type of debris over 22 years of observations in this region.

## Introduction

Anthropogenic marine debris is an increasing global issue that can have negative impacts in both benthic and pelagic habitats, and in coastal and open-ocean areas. Marine debris is introduced to marine environments via improper disposal or accidental loss, either at sea or on land, and is subject to wide dispersal by ocean currents and tides (Watters et al., 2010). Debris often sinks and accumulates on the seafloor, but due to the technical challenges and prohibitive costs of conducting research in the deep sea, little is known about how much reaches these habitats. In one of the few studies addressing this problem Galgani et al. (2000) performed a large-scale survey of marine debris off of the European coast and found the distribution to be extremely variable with greater amounts of large waste items found deep in submarine canyons due to stable conditions and decreased water movement. Even fewer studies have observed trends in marine debris accumulation over time (Barnes and Milner, 2005; Watters et al., 2010).

The Monterey Bay Aquarium Research Institute (MBARI) uses high-resolution video equipment to record over 300 remotely operated vehicle (ROV) dives per year at various depths up to 4,000 meters. Over the past 22 years, more than 17,000 hours of underwater video have been archived and managed as a centralized institutional resource. This video library contains footage of the biological, chemical, geological and physical aspects of the Monterey submarine canyon and other areas including the Pacific Northwest, Santa Barbara Basin, Central California seamounts, Northern California, Hawaii, and the Gulf of California. Here, we present a characterization of marine debris observed in this video archive, with an emphasis on the Monterey Canyon and surrounding area.

Figure 3. Examples of common marine debris observed on ROV video surveys. From upper left: plastic bag wrapped around a deep-sea gorgonian, aluminum can, rope and fishing net, glass bottle, tire with organisms living on and around it, paper, fishing float, plastic bag, and shoe with rockfish on it.

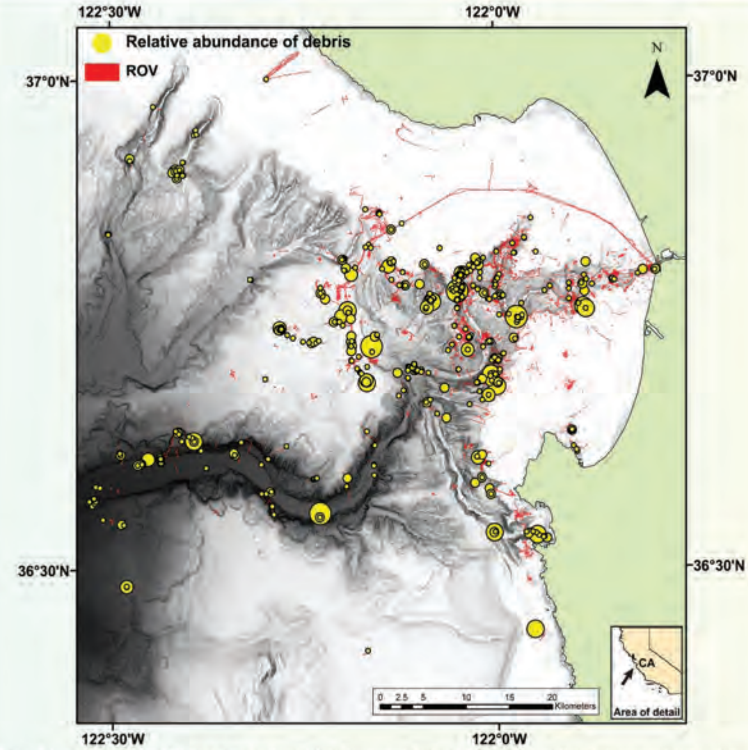


Figure 1. Locations of MBARI ROV dive tracks (red) and debris observations (yellow). The size of the yellow circles represents the relative abundance of debris found at that location.

## Methods

Using MBARI's Video Annotation and Reference System (VARS), a video analysis and observation database (Schlining and Jacobsen Stout, 2006), we reviewed the types of marine debris observed in MBARI's ROV video archives from August 1988 to December 2010. Over 1,600 observations of marine debris in the VARS database were characterized using 16 broad categories, including: abandoned research equipment, battery, clothing, other fabric, glass, concrete, manufactured wood, military debris, paper, rope, rubber, ship wreckage, plastic, metal, fishing debris and unidentified debris items.

The observations were normalized by dive effort within 50m$^2$ grid cells where ROV surveys have been conducted. These normalized data were mapped in ArcGIS and show relative abundance of debris observed on ROV dives. Normalized observation data were also used to plot types of debris over time. Raw, non-normalized data were used to plot commonly observed debris across the database. A chi-square test was conducted to determine if debris was randomly distributed with respect to slope.

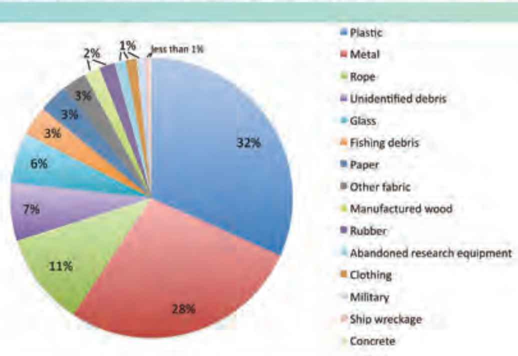


Figure 2. Percentage of total marine debris observations by category.

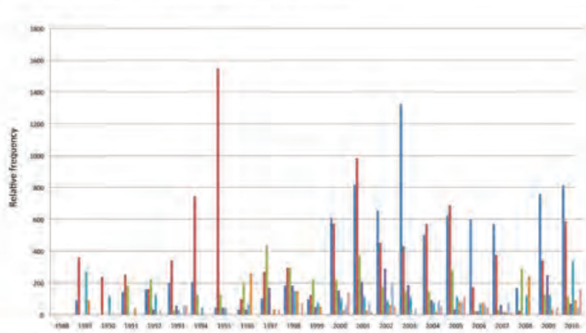


Figure 5. Relative frequency of debris observations by category normalized by ROV effort over time. Note, category colors match above figure.

## Results and Discussion

The correlation of ROV depth and multi-beam bathymetry shows that of the 20,672,561 grid cells used in this study, 48,581 grid cells have been visited and observed by MBARI's ROVs, or 0.56% of the seafloor in this area (Fig. 1). Debris was observed in 726, or 1.49%, of that area. More than half of the 1,630 observations of marine debris were categorized as plastic and metal (Fig. 2). Within the plastic category, 53% of the observations were plastic bags. In the metal category, 63% were some type of can (i.e. aluminum, steel, or tin). Other abundant items were rope and unidentifiable trash. In Figure 3, we show examples of common debris items observed.

Currents move near-shore sand from points near Santa Cruz and Monterey to the middle of the bay, where they are then carried into the Monterey Canyon. Frequent turbidity flows occur in the canyon, carrying large volumes of sediment and other matter deeper into the canyon. Additionally, strong currents in Monterey Bay may move debris from the uniform and relatively flat continental shelf to areas within the canyon system where it accumulates on high-relief physical barriers. If debris were randomly distributed throughout the study area, one would expect debris observations to occur on all ROV dive tracks and in similar abundance. However, our mapped observations show debris accumulating within the various canyons in the study area, thus canyons do appear to act as conduits transporting anthropogenic debris downslope as is the case with sediment transport (Paull et al., 2005). A chi-square test was conducted to determine if the debris was randomly distributed with respect to slope (Fig. 4). The null hypothesis—that the random distribution and the measured distribution of debris are the same—was rejected (df = 2, $\chi^2 = 0$, $\chi^2(0.05) = 5.99$, p = > 0.5). Most debris observations occurred on moderate slopes (6–28 degrees). Debris items observed on flat areas were likely caught on physical obstacles within the canyon system, such as canyon walls, rocky outcrops, talus slopes, whale-falls, clam beds, and research equipment deployed on the sea floor. These high-relief features trap debris, acting as barriers to transport resulting in the accumulation of refuse. Within the Monterey Canyon, we observed higher concentrations of debris in the areas where the canyon meanders (Fig. 1).

The relative frequency of plastic appears to increase over time with a noticeable increase in 2000 (Fig. 5). While this could be due to an increased number of plastic debris items entering the ocean, it is likely attributable to acquisition of a second MBARI vehicle, ROV Tiburon, which increased the area and depths surveyed by MBARI. In addition, the relatively recent addition of high definition cameras on both ROVs made it possible for smaller debris items (such as plastic bags) to be identified.

The Monterey Bay region is one of the most well-studied areas of the world's deep ocean. Yet, in 22 years of exploration, MBARI has observed less than 1% of the region's seafloor. Our study suggests that debris accumulated most often in canyons and on other physical barriers. Much like the concentration of pelagic debris in the North Pacific Gyre (Moore et al., 2001), it is likely that there are high-relief areas on the deep seafloor where much of the debris accumulates. With vast areas of the deep sea remaining unexplored, we expect that the amount of anthropogenic debris far exceeds the observations made in this study.

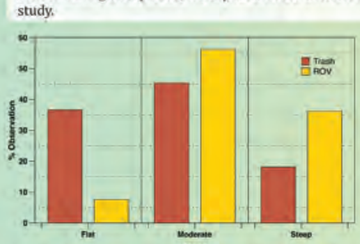


Figure 4. The percentage of observations of debris and ROV effort by slope category where 0-6° = flat, 6-28° = moderate, 28-90° = steep.

## Action Items

The impact of marine debris in deep seafloor habitats on biological communities is largely unknown. Further surveys with an emphasis on categorizing interactions between man-made items and organisms will provide insight into the types of debris that can have a negative effect on organisms. Studies such as this should be shared with the broader research community and public and policy makers in an effort to increase awareness and funding for surveys in other ocean basins. Efforts should also be made to standardize methods for tracking and reporting observations of debris during marine expeditions.

Deployment of ROV Ventana

Barnes, D. K. A. & Milner, P. 2005 Drifting plastic and its consequences for sessile organism dispersal in the Atlantic Ocean. Mar. Biol. 146, 815 – 825.

Galgani, F. et al. 2000 Litter on the sea floor along European coasts. Marine Pollution Bulletin 40, 516 – 527.

Moore, S.L., Lencaster, M.K., Weisberg SB. 2001. A comparison of plastic and plankton in the North Pacific central gyre. Marine Pollution Bulletin. 42:12, 1297-1300.

Paull, C.K., P. Mitts, W. Ussler III, R. Keaten and H. Gary Greene. 2005. Trail of sand in upper Monterey Canyon: Offshore California. Geological Society of America Bulletin. 117:1134-1145.

Schlining, B., Jacobson Stout, N., 2006. MBARI's video annotation and reference system. In: Proceedings of the Marine Technology Society/Institute of Electrical and Electronics Engineers Oceans Conference, Boston, MA, pp. 1–5.

Watters, D. L., M. M. Yoklavich, M. S. Love, and D. M. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60:131-138. doi: 10.1016/j.marpolbul.2009.08.019.