A characterization of marine debris in the Northeast Pacific deep ocean

Susan von Thun, Lonny Lundsten, Kyra Schlining, Linda Kuhnz, Brian Schlining, Lori Chaney, Nancy Jacobsen Stout, Judith Connor
Monterey Bay Aquarium Research Institute

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 sea. 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 1,400 observations of the debris in the VARS database provide insight into the types, sources, and potential impacts of debris in the deep sea. Our data 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 (Waters 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, Fiedler et al. (2008) performed a large-scale survey of marine debris off the European coast and found the distribution to be extremely variable with greater amounts of large debris 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 (Barouch and Miller, 2005; Waters et al., 2019).

The Monterey Bay Aquarium Research Institute (MBARI) uses high-end resolution video equipment to record over 300 remotely operated vehicles (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 Over the past 22 years, more than 17,000 hours of underwater video have been archived and managed as a centralized institutional resource.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, North Pacific, California, 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.

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 1,400 observations of marine debris in the VARS database were characterized using 16 broad categories, including:王朝, research equipment, fishing, clothing, other debris, glass, ceramics, manufactured wood, military debris, paper, rotenone, shipwreck, plastic, metal, fishing debris and unidentified debris items.

The observations were normalized by the effort within 50 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. New, 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.

The correlation of ROV depth and multi-beam bathymetry shows that the 20,672,561 grid cells used in this study's 48,581 grid cells have been visited and observed by MBARI’s ROV, or 0.56% of the seafloor in this area (Fig. 1). Debris was observed in 726, or 0.49%, of that area. More than half of the 1,619 observations of marine debris were classified as plastic and metal (Fig. 2). While the plastic category, 52% of the observations were plastic bags in the metal category, 49% were some type of can (i.e., aluminum, steel, or tin). Other abundant items were rope and unidentified trash. In Figure 3, we show examples of common debris items observed.

Currents move northward and southward 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 another matter downslope into the canyon. Additionally, strong currents in Monterey Bay may move debris from the uniform and relatively flat continental shelf to the canyon within the canyon system as 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 (Paul 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 (χ² = 0.361, p-value > 0.05). Most debris observations occurred on moderate slopes (5–28 degrees). Debris items observed at flat areas were likely caught on physical obstacles within the canyon system, such as canyon walls, rocky substrates, tugs, skags, whale falls, fish beds, and research equipment deployed on the seafloor. These high-relief features trap debris, acting as barriers to transporting the accumulation of debris. Within the Monterey Canyon, we observed higher concentrations of debris in the areas where the canyons meander (Fig. 5). While the relative frequency of plastic appears to increase over time with a noticeable increase in 2000 (Fig. 6), this could be due to increased number of plastic debris items entering the ocean. It is likely attributable to a production of a second MBARI vessel, R/V Thalassa, which increased the area and depths surveyed by MBARI. In addition, the relatively recent addition of high-definition cameras on both ROV makes 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.

References


