CEST 2019

16th International Conference on Environmental Science and Technology

Rhodes, Greece, 4 to 7 September 2019

Benthic litter density maps through low-cost underwater towed video camera surveys. An integrated approach

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Abstract

The marine environment is the final recipient and digester of litter. Floating and benthic litter constitute the majority of litter items in the marine environment while both remain quite unexploited due to their demand in high-cost and time-consuming surveys. In this paper we propose an integrated approach for assessing in detail the spatial distribution and composition of benthic litter in coastal environments, through the use of underwater towed cameras. The method is showcased in Syros Island, Cyclades, Greece where benthic litter density maps revealed benthic litter sources and environmental drivers controlling their spatial distribution and general pathways.

Keywords: benthic litter assessment, underwater towed video camera, Syros Island.

1. Introduction

Towed Underwater video camera (TUC) surveys constitute a widely accepted way for benthic litter assessment (TGML/JRC guidance on monitoring marine litter in European seas, 2013), but still much development must be reached before they can be standardized. During LIFE DEBAG project (LIFE14 GIE GR/001127), effort has been put to implement a reliable methodological scheme to assess benthic litter densities in shallow coastal waters through low cost means, such as a simple towed camera and a GPS, operated through a small opportunity vessel, conducting regular survey lines achieve full data coverage in the surveyed area. Seafloor litter surveys are considered a challenging task, partially due to field work peculiarities but mostly due to the increased data processing demands. Herein, an integrated video benthic litter data processing approach is proposed to extract safe benthic litter density maps by accurately geolocating, scaling and classifying litter in underwater video footage.

2. Methodology

In detail, processing of seafloor video footage involved:

• Rough georeferencing of the video snapshots by pairing them to GPS fixes based on time records of both the video and the GPS in UTC time.

• Fine georeferencing via layback (horizontal tow-camera to vessel distance) compensation. Although the cable out of the tow camera is known during all stages of the field-work, its exact position cannot be readily known as along-track sea currents and vessel speed changes alter the cable-out needed to reach a certain depth. We resolve this by finding landmarks (e.g. targets and sharp material changes) visible in both the Side-Scan Sonar backscatter maps and the video snapshots. This way the position where the camera actually was during the survey is assessed for a number of occurrences where landmarks exist, and the layback is approximated for all the mid-distances via interpolation in the time domain. Attention has been payed to finding landmarks arranged throughout the whole tow-camera survey lines, so that layback could be accurately approximated for the whole survey.

• Narrowing data down to the effective survey-lines. In order to better approximate the actual seafloor area that has been visually inspected as to be able to estimate reliable litter densities, any parts of the survey lines that corresponded to poorer quality video or different than the desired distance of the towed camera from the seabed were excluded from further analysis.

• Litter detection and classification. This was the most important and time-consuming part of the data analysis que, during which all litter items that have been recorded in the video were manually detected and classified. Classification was performed using the dedicated TGML/JRC guidance document on monitoring marine litter in European seas (2013). The modified protocol used included more than 14 litter types that can be clearly visible in the video footages, but it also included dedicated types for hardly recognized items (e.g. “potentially bags” and “potentially sheets”) as well as “unrecognized” litter items.

• Elementary statistical analysis of the litter abundances and their type/ material composition on the seafloor.

• Spatial analysis of the benthic litter types on the seafloor as to make an estimation of the true litter densities accounting for the actual surveyed seafloor area and constructing interpolated litter density models for the full survey area. Spatial analysis of the benthic litter types on the seafloor led to drawing conclusions about the local litter load on the seafloor as well as about any features that acts as trap of specific types of litter, such as bathymetric depressions and seagrass patches. This step involved various sources of uncertainty, including the true area of the inspected seafloor, which mainly depends on the towing height of the camera above the seafloor and the viewing angle. Normally this issue is treated by using scaling underwater lasers, but in our case a more low-cost, yet reliable solution, was sought. The camera was kept at about the same height above the seafloor for the whole survey and indicator litter items (i.e. plastic bottles) of known sizes were frequently used in the data processing stage to make a reasonable approximation of the seafloor area viewed. Other issues regarded the treatment of any areas that have been inspected more than once, where multiple instances of the same litter item should be regressed to unity. After litter items have been converted to litter densities along the underwater camera transects, a kriging spatial interpolator was employed to produce full coverage heat-maps of litter densities of the surveyed area. The above analyses have been performed to estimate the seafloor litter densities of: (a) all litter items resting on the seafloor and (b) of plastic bags from super-markets and retail shops.

3. Results

During the LIFE DEBAG project, six seafloor litter surveys were implemented, using underwater towed cameras, in Ermoupolis harbor basin. The total seafloor coverage surveyed was more than 405 hectares. 36 hours of underwater video has been acquired, corresponding to 72 km of survey lines onboard small opportunity vessels. A total number of 3675 litter items have been identified and classified in those videos, of which 314 (8,5%) were plastic bags from super-markets and retail shops.

By far, the most abundant litter type on Ermoupolis seafloor is plastic drink bottles, accounting for 22.6% of the detected litter items, followed by paper-cardboard (11.7%) and large industrial object such as metallic ones (9.5%) and tires-belts (9.2%). Plastic bags were the fifth most abundant seafloor litter type, having a 7.8% share in the total seafloor litter items.

Assessment of the actual litter densities in the bay of Ermoupoli clearly exhibited the size of the problem, with Ermoupolis' bay having a mean litter density of 211 items/hectare (5 times higher than that of other surveyed bays of the Island). Density maps were produced for each sampling period while in Figure 1 a characteristic schematic interpretation of benthic litter fluxes at Ermoupolis Harbor is provided. This reveals in detail the prevailing litter sources, bathymentric traps of high litter abundances and general litter pathways.

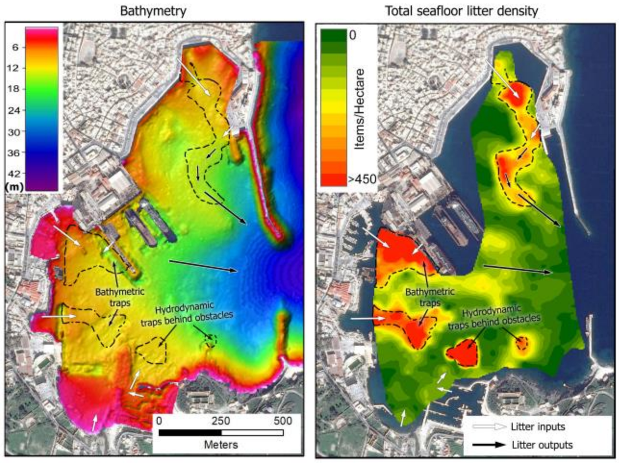

Figure 1. Schematic interpretation of benthic litter fluxes at Ermoupolis Harbor basin, Syros.

4. Discussion

The spatial distribution of benthic litter densities on the seafloor is a cumulative effect of litter sources' intensities and natural drivers like wind/wave and current conditions. Making safe interpretations about the exact spatiotemporal distribution of benthic litter requires good knowledge of the local above-mentioned natural drivers combined with data assimilation through mathematical modelling, which was out of the scopes of this paper. Here, towed camera surveys aided in the creation of benthic litter density maps that reveal litter accumulation hot-spots on the seafloor. Those are well correlated to specific seafloor morphological features, like bathymetric depressions and seaweed beds or high intensity litter sources, such as by high traffic harbor docks, ship routes, marinas and shipyards.

It was revealed that plastic bags on the seafloor are about 3 times more than the equivalent on the beaches, and plastic bottles' about 20 times. This implies that although the seafloor is considered as the final recipient and digester of marine litter, those are sorted according to their buoyancy, shape and material and they are shared at different percentages between the sea surface (potentially ending on the beaches), the water column and the seafloor.

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