



## Snow lines on shorelines: Solving Styrofoam buoy marine debris from oyster culture in Taiwan

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### ABSTRACT

Styrofoam buoy marine debris from oyster farming presents a tough management issue in Taiwan. It is an environmental externality but its associated environmental costs have long been neglected. In the pursuit of environmental sustainability, efforts by authorities have been made; yet the problem remains. In an attempt to enhance Styrofoam buoy marine debris management, this paper used document analysis, participative workshops and interviews to identify areas of concern regarding current management measures and propose recommendations. The results found that failure to impose buoy recovery, inevitable loss of buoys and unavailability of equally competitive, eco-friendly alternative buoys are major areas of concern. Built on the modes of governance (hierarchical, market and participative), the paper proposed recommendations, including enhancing farmer self-governance units' capacity to manage derelict fishing gear (DFG), strengthening Styrofoam buoy recovery, increasing farmers' awareness of DFG, developing eco-friendly buoys, instituting an ecolabeling program for Styrofoam-free oysters. The recommendations involve participation of farmers, decision makers and consumers and mostly rely on the government's initiation and support. The paper particularly highlighted the political sensitivity of a recommendation regarding phasing out the use of Styrofoam buoys and suggested it serve as a last resort and be practiced depending on fulfillment of circumstantial situations. Finally, the paper advised extra attention be paid on public participation in regulation-making, a mismatch between the scope of the problem and the jurisdiction of a local city and adaptive management, if any change to the status quo occurs.

### 1. Introduction

It is widely documented that marine debris, such as plastics and DFG, has detrimental impacts in many areas, including coastal aesthetics, beach experience, navigation safety, human health, marine wildlife, biological diversity, tourism, fisheries and ecological service systems (e.g., UNEP, 2009; Allen et al., 2012; Arthur et al., 2014; McIlgorm et al., 2011; Mouat et al., 2010; Mohamed Nor and Obbard, 2014; Chen, 2015; Campbell et al., 2016; Brouwer et al., 2017). In Taiwan, Styrofoam buoys are commonly used in shallow-water oyster culture. Buoys discarded end up on shore, causing DFG problems and leaving marked white lines on the west coast.

Styrofoam is made of foamed Polystyrene, often called expanded Polystyrene (EPS). It is a low density material but resistant to decomposition. Styrofoam buoy marine debris ruins coastal landscape, negatively impacts marine environments, deteriorates the esthetic value of beaches and reduce tourism (Lee et al., 2015). It also endangers navigation and causes gear interaction, and poses threats to marine life

through digestion of them. Styrofoam ingested can transfer chemical pollutants added during the production process or absorbed in the marine environment to biota through the food web (Tanaka et al., 2013). In addition, it was found that polystyrene microplastics interfere with energy uptake and allocation, reproduction, and offspring performance of oysters (Sussarellu et al., 2016).

A national beach cleanup operated by the Society of Wildlife in Taiwan in 2014, revealed that Styrofoam fragments are the second most common, only preceded by plastic pieces (SOW, 2014). A study found that Styrofoam fragments ranked as the number one among marine debris items found at Cijin beach during autumn and winter seasons (Liu et al., 2013). A related study further highlighted DFG problems caused by oyster farming (Liu et al., 2015). This indicates Styrofoam marine debris is serious in Taiwan and derelict Styrofoam buoys are a major source thereof, as shown in the images of buoys washed ashore (Fig. 1).

In fact, Styrofoam buoy marine debris is a problem occurring in places around the world where Styrofoam buoys are used in culture. For

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Fig. 1. Beached derelict Styrofoam buoys and fragments.

examples, Styrofoam buoys are used for oyster farming in Hiroshima Bay, Japan. A survey showed that foamed plastic fragments accounted for 99.5% of the total fragments collected at 58 sites along 48.6 km of coastline (Fujieda and Sasaki, 2005). Styrofoam buoys are also commonly used in the aquaculture in Korea. The oyster farming is concentrated mainly on the southern coast, where almost 90% of cultivation takes place. A rough estimate showed 1,800,000 buoys enter the ocean annually, although this has not been scientifically validated (Lee et al., 2015). Having a long history of oyster culture, Taiwan also faces a similar Styrofoam marine debris problem. This problem is an environmental externality of oyster farming; yet its associated environmental costs have long been neglected. In recent years, this issue has been highlighted in several public arenas, such as news media, social media (i.e., Youtube, Facebook) and various conferences. NGOs have harshly blamed governments for failing to take drastic actions to solve the problem (Liberty Times, 2017). Facing public concerns for this issue

and seeking environmental sustainability for oyster culture, governments have adopted management measures in recent years. However, the problem remains unsolved, indicating the current management framework is insufficient. This paper aims to enhance this framework so as to solve Styrofoam buoy marine debris. A perspective of ‘reduction at source’ is taken in this initiative. Specifically, reduction at source lies in reducing the number of Styrofoam buoys discarded at sea as well as reducing their use. The concepts of a problem-solving skill are used to structure this article (Liang and Zhang, 2010; Chen et al., 2016). Therefore, the paper first examines the root of this Styrofoam buoy problem in Taiwan's context, identifies areas of concern regarding current management measures and further proposes recommendations for future consideration.

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