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Tragedy of the unwanted commons: Governing the marine debris in Taiwan's oyster farming



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ABSTRACT

Marine debris is a pollution problem on a global scale, which causes harm to marine ecosystems and consequently results in profoundly negative influences on mankind. This type of pollution can originate from various activities such as leisure and tourism, fishery, land-based sources, and vessels, etc. In this study, it was found that derelict fishing gear (DFG) produced by oyster farming activities is being dispersed along the southwestern coast of Taiwan, consequently reducing the leisure quality and coastal amenities. In order to understand the current problem of DFG, related stakeholders were invited to undergo qualitative interviews to observe the stakeholders' perceptions pertaining to DFG pollution and their opinions on subsequent mitigation measures. The results of the interviews were then used to explore management issues pertaining to DFG, as well as the trans-boundary pollution problems caused by DFG based on the theory of environmental resource governance and scales of management jurisdiction. Finally, suggestions were provided to effectively reduce the DFG pollution from oyster farming, including the strengthening of environmental education and propagation, sustaining management and monitoring of marine debris by the government, using policy tools, and applying solid waste management principles.

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1. Introduction

The sources of marine debris are diverse. They can be transferred through ocean currents to various coastal regions, polluting nearby seawaters and coasts [1–3]. Marine debris reduces the aesthetics of the beaches and also results in many undesired environmental consequences, such as increasing adverse health risks, causing significant ecological changes, threatening marine wildlife, leading to loss of biodiversity and inflicting losses on the fishery sector [4–7]. In the context of marine debris, plastic produces the most profound damage because it does not biodegrade. Plastic debris has gathered into a considerable area in the North Pacific and presents a great area of influence [8–11]. Taking into account the problems caused by marine debris, numerous countries have begun to investigate, monitor, and formulate policies and strategies to mitigate these problems [12].

Among the type of marine debris, derelict fishing gear (DFG) originating from fishery activities is a problem that is increasingly of concern. DFG refers to fishing gear that has been abandoned, lost or otherwise discarded and this problem has existed ever since fishing began [13,14]. Although fishing gears mainly applies to fishing rather than fish farming, the Food and Agriculture

Organization (FAO) includes derelict equipment from aquaculture in DFG category due to their potential contribution and for greater control of this type of marine debris [13]. In a comprehensive marine debris monitoring program conducted in the United States, results show 17.7% of beach litter originated from the ocean, including fishing nets, fishing lines, ropes, fish baskets, floats and buoys and traps and pots [15]. Oigman-Pszczol and Creed noted that fishery-related debris represented 46% of total marine litter found in the subtidal benthic environment in Brazil [16]. The impact of DFG includes continued catching of living resources [17–21], interactions with threatened species [22–25], physical impacts on the benthos [26–30], and causing navigational hazards [31,32]. In this study, qualitative research was conducted to explore the trans-boundary pollution of DFG in Taiwan's Oyster Farming. Various stakeholders' perceptions pertaining to DFG pollution and their opinions on subsequent mitigation measures were analyzed in order to better understand the current problem of DFG pollution. Results were then used to develop suggestions for the improvement of the current DFG conditions.

2. Background of the pollution from oyster farming in Tainan, Taiwan

Oyster farming is a crucial shallow water industry that can be dated back to more than 300 years ago during Dutch colonial

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period. The main species of oyster farmed in Taiwan is the Pacific oyster (*Crassostrea gigas*) [33]. Major oyster farming areas in Taiwan are located in Hsinchu, Changhua, Yunlin, Chiayi Counties, and Tainan City, as shown in Fig. 1. This aquaculture is a critical source of income for fishermen. Several culture methods have been practised to produce the Pacific oysters in Taiwan, including bamboo stake method, horizontal rack method, raft-string culture, and floating raft culture [33,34]. The oyster farming in Tainan employs the floating raft culture system to grow oysters, in which the rafts are supported by polystyrene foam (PSF) floats to maintain buoyancy. Every year after the harvest of oysters, the torn culture rafts and PSF floats are discarded on the sites.

In a previous litter survey at Cijin beach in Kaohsiung City, considerable amounts of fragmented PSF were observed [35] (see Fig. 1). In addition, pieces of derelict rafts from oyster farming were occasionally identified as well. Most of the PSF fragments at Cijin beach can be recognized as fragments broken off from the PSF floats used in oyster farming. According to an official fishery statistics report [34], the oyster fishery closest to Cijin beach is approximately 50 km to the north, specifically, the shallow coastal mariculture located in Tainan City. The pollution caused by DFG was not only present near the oyster farms located in Tainan City, but also caused pollution along the southwestern coast of Taiwan in Kaohsiung. However, the coastal authority in Kaohsiung has no jurisdiction over the DFG pollution originating from Tainan. In response to the pollution problems caused by DFG and the complaint from Kaohsiung City's government as well, Tainan City established the *Ordinance for Shallow Water Oyster Farming*

Management. This DFG problem, nonetheless, cannot be alleviated even though regulations have been enforced.

3. Research methods

Qualitative interviews were conducted to examine stakeholders' perceptions of the marine debris problems of Taiwan; in particular, perceptions of the DFG pollution originating from oyster farming that has subsequently resulted in the trans-boundary pollution in different cities on the southwestern coast of Taiwan. By observing the opinions of stakeholders from various perspectives, reasons for the current DFG pollution can be explored. Interviews can be conducted in the form of structured, semi-structured, or open-ended interviews. In this study, a semi-structured interview method was adopted, in which a set series of questions was presented to the interviewees, but the interviews were conducted in a conversational manner to maintain openness, allowing the interviewees to provide their personal opinions [36]. During the interviews, the flexibility of the questions was maintained. Besides occasionally and appropriately reminding the interviewees of key points, the entire interview process was conducted in a relaxed and easy manner to encourage the interviewees to provide even more personal opinions but simultaneously maintain the course of the interview [36].

The stakeholders selected in the interview in this study were the fishers involved in oyster farming or the governmental officers related to the management of DFG (Fig. 2). The interviewees can be categorized into 5 distinctive groups, namely academia, governmental

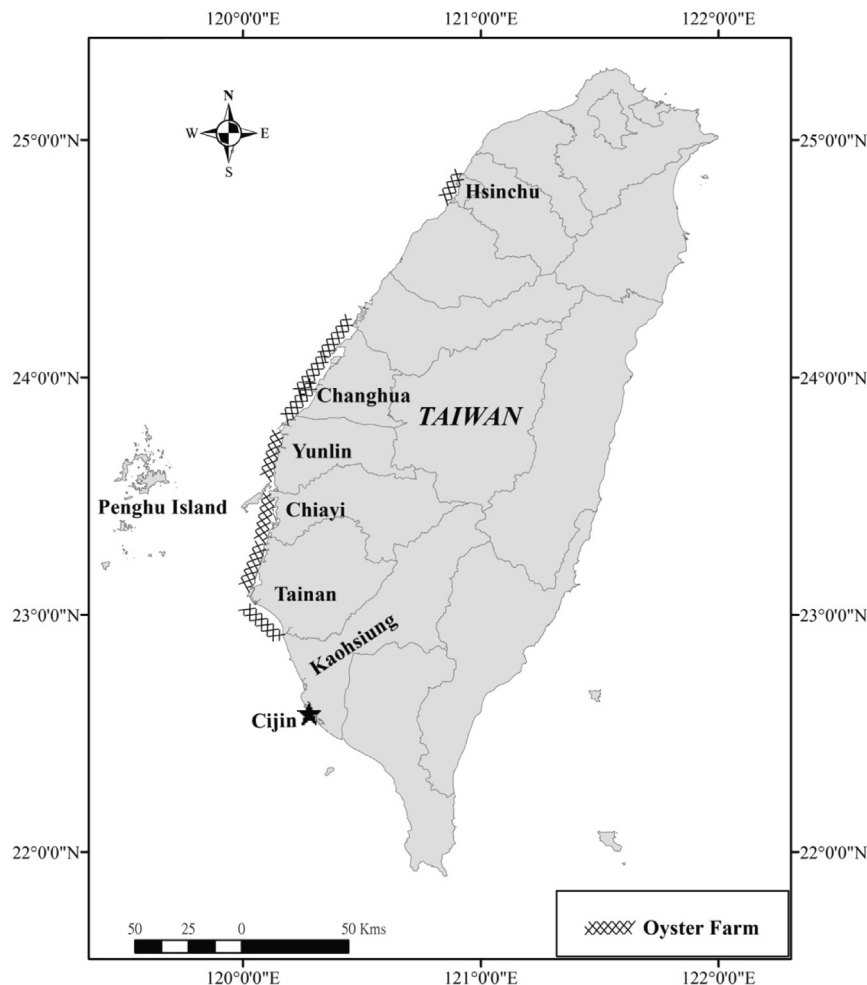


Fig. 1. Major oyster farming areas in Taiwan. Cijin beach is the site for marine debris survey as in [35], where trans-boundary pollution of DFW was observed.

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