Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Navigational threats by derelict fishing gear to navy ships in the Korean seas

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ARTICLE INFO

Keywords:
Marine debris
Derelict fishing gear
Navigation
Propeller entanglement
Impact
Korea

ABSTRACT

This study assessed the impact of derelict fishing gear (DFG) on navigation. The Republic of Korea's navy (ROKN) recorded every case of approximately 170 naval ships associated with propeller entanglement by DFG from January 2010 to December 2015. The frequency of cases was 2.3 per ship and 397.7 (± 37.5) per year. The amount of DFG disentangled was 0.025 tons per ship and 10.0 (± 1.7) tons per year. The frequency temporally decreased whereas the amount increased over these six years. To disentangle propellers, 3.1 divers were needed on average per case. Propeller entanglement occurred in all local seas and some of these areas showed increases over time. Our study highlights that the impact of DFG on navigational threats has been persistent and ubiquitous and can potentially be reduced by preventing DFG in fishing areas, with a focus on improved management by fishermen and government and with more efficient retrieval of DFG.

1. Introduction

Derelict fishing gear has led to concern over the potentials to various aspects. It could kill target and non-target resources including endangered and protected species (i.e., turtles, seabirds, and marine mammals), alter the benthic environments (i.e., coral reefs and benthic fauna), cause navigational hazards, and impose economic loss to the relevant industries (Donohue et al., 2001; Macfadyen et al., 2009; NOAA, 2015; UNEP, 2016; Wilcox et al., 2015). The most common types of DFG refer to nets, lines, pots and traps from a variety of fisheries. Those can be lost, abandoned, or discarded in the marine environment due to too much gear, illegal fishing, gear conflicts, unconvenience and costs of shoreside disposal, and poor weather (Macfadyen et al., 2009). After introduction of synthetic materials to fishing gear in 20th century, DFG is likely to increase in the marine environment and has become a global issue to straight away tackle. Reliable information regarding the amount of DFG in the global ocean has not been estimated yet. However, at least in the Korean seas, the quantity of DFG accounts for 48.3% of total annual inflow of marine debris (44,081 tons among 91,195 tons per year) and DFG has been a most important debris type targeted by the governmental policy (Jang et al., 2014; Hong et al., 2015).

Navigational hazards and associated safety issues are some of the most unstudied outcomes of marine debris to date. The evidence remains limited (e.g., Takehama, 1990; Hall, 2000; Mouat et al., 2010) and is often times anecdotal (e.g., Wallace, 1990; Johnson, 2000; Cho, 2005) even though the seriousness of the potential threat has been well recognized (Macfadyen et al., 2009). Marine debris can cause navigational hazards to ships at sea due to entangled propellers and rudders, blocked water intakes, and collisions with floating objects. Entanglement of a ship's propeller can significantly reduce its stability and maneuverability (Macfadyen et al., 2009), which has the potential to put the ship's crew and passengers in danger, particularly when weather conditions are bad. This can, in turn, cause injury or death; but more often, this type of damage is associated with financial costs (Takehama, 1990; Hall, 2000; ten Brink et al., 2009; Macfadyen et al., 2009; Mouat et al., 2010; Watters et al., 2010; McIlgorm et al., 2011; Newman et al., 2015; UNEP, 2016). Takehama (1990) reported 32,848 incidents in Japan in 1985 of fishing vessel collisions with floating materials, cooling water intake clogging, and engine failure by propeller entanglement (data based on insurance payments to fishermen). The economic losses totaled about ¥ 4.4 billion in 1985 (Takehama, 1990). Hall (2000) surveyed harbor authorities around the UK and Ireland in 1998; the survey revealed 82% reported incidents and over 180 incidents involving fouled propellers, with an average cost per incident of £ 280 (£ 100–400) (USD in 2015). In 2008, the Royal National Lifeboat Institution (RNLI) undertook 286 rescues of fishing vessels that were experiencing propeller entanglement in Shetland. The cost of these rescues was between € 830,000–2,189,000 which included lifeboat station operation costs, such as training crews, lifeboat maintenance, and station maintenance (Mouat et al., 2010).

In the Republic of Korea (ROK) in 1993, a 110 GT ferry was involved in a serious fatality event in the western coastal area. The vessel capsized and sank, and 292 of 362 passengers died. The Korean

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http://dx.doi.org/10.1016/j.marpolbul.2017.04.006
Received 1 August 2016; Received in revised form 9 March 2017; Accepted 5 April 2017

Maritime Accident Investigation Agency reported that fishing rope caught in the shaft and propellers was one of the causes of the accident (Cho, 2005). Those threats have been ever-present not only for passengers but for all maritime crafts, such as those involved in shipping, fishing, recreational boating, and the navy. Unfortunately, this issue is still poorly understood due to a lack of information. This study is the first to quantify the impact of DFG on the navigational safety of active ships in Korea's territorial seas and its Exclusive Economic Zone (hereafter known as the Korean seas).

We analyzed the logs from the ROK Navy (ROKN) from the past six years, which describe regular naval ship hull cleaning, inspections of fractures, underwater welding when needed, and any conducted repairs (including the removal of DFG from the propellers when entanglement occurs within the Korean seas) None deteriorated into fatal accidents nor threatened loss of life or property were included in this study. Verifiable evidence from every single case has been compiled nationwide for years. These records are likely to provide good quality data for the present study on the impact of DFG on navigational hazards. The questions we sought to answer in this study are as follows: 1) How frequently are naval ships entangled by DFG? 2) Is the frequency (number of cases) decreasing or increasing? 3) Are there differences among local seas surrounding the Korean Peninsula or over the seasons? 4) How many divers and how much time is required for disentanglement? 5) How much potential economic loss is there from ship entanglement?

2. Methods

We reviewed all of the cases of ROKN ships entangled by DFG for six years (2010–2015) within the Korean seas (Fig. 1). ROKN has operated about 170 ships, of which standard displacements range from 100 tons to 15,000 tons (Ahn and Oh, 2015). The ROKN Ship Salvage & Rescue Units (ROKN SSU) have deployed its units to four ROKN operation ports, and ROKN ships associated with DFG entanglements in mission areas have gone to the nearest SSU along coastal regions of the East Sea/Sea of Japan (ES), the Yellow Sea (YS), and the eastern (SSe) and western (SSw) South Sea (Fig. 1). In 2010, the SSU initiated the recording of information on every case of propeller and shaft entanglements from DFG (date of case, weight of DFG removed, diving time, and man power used for disentanglement, as well as photos of the cases), including routine inspection of ship hull fractures, rudder and propeller shaft repairs, removal of pipe contaminants, and underwater welding when needed (Fig. 2). Linear regression analysis was applied to test whether there was a significant increase or decrease in the frequency of cases and amounts of DFG removed each month over this period of time. A p-value of < 0.05 indicated statistical significance.

3. Results

3.1. Overall status and temporal trend of threat to navigation

The total number of cases in which propellers or shafts of ROKN ships were entangled by DFG was 2386 over six years (2010–2015), and the annual average was 397.7 (± 37.5), averaging 2.3 (± 0.2) cases per ship per year (Table 1). Each ship encountered DFG over the study period, with at least one entanglement per year. The weight of DFG removed from entanglements was measured to be about 60.1 tons in total, 10.0 (± 1.7) tons per year, and 0.025 (± 0.005) tons per case. Linear regression analysis revealed that the frequency of the entanglements decreased over the six-year period (from 465 cases in 2010 to 383 cases in 2015, $p < 0.05$) whereas the amount of DFG increased over the same period ($p < 0.01$).

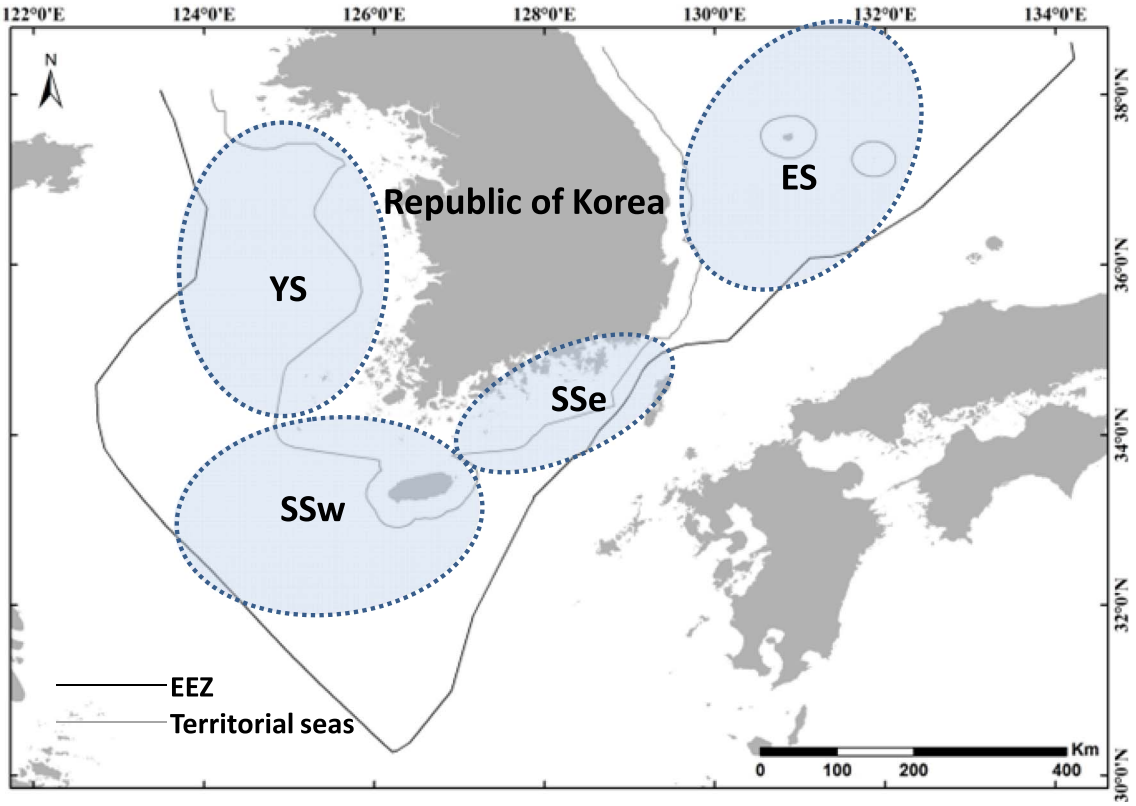

Fig. 1. Location of four service areas where derelict fishing gear (DFG) entangled in the propellers of Republic of Korea Navy (ROKN) ships was removed. Ships entangled by DFG were moved to the nearest ROKN Ship Salvage & Rescue Units (ROKN SSU) deployed port within the Korean seas. One ROKN SSU covers each shaded area; the boundary is not clearly defined (ES: East Sea/Sea of Japan, YS: Yellow Sea, SSe: Eastern South Sea, SSw: Western South Sea). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)