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Economic and environmental perspectives of end-of-life ship management

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ABSTRACT

The economic feasibility and environmental impacts of three examples of end-of-life management options were analyzed with a cost–benefit analysis and an environmental life cycle assessment. The economics of ship recycling methods depend on various parameters such as the market price of reclaimed materials, ship purchase price, environmental and work safety regulation fees, labor costs, and overhead costs. Standard recycling methods are typically used in the U.S., EU, China, and Turkey. The example of recycling the USS Forrestal, showed that standard ship recycling methods can be profitable. Standard ship recycling methods must follow strict regulations, and therefore, can only release negligible amounts of hazardous substances into the environment. In addition, the reclaimed materials from standard ship recycling methods provide various life cycle environmental benefits. Substandard recycling methods, such as beaching, used in southern Asia countries, allow shipyard owners to outbid standard method recycling companies and remain profitable due to a lack of enforced environmental regulations. The non-compliance with environmental regulations, allows these substandard methods to release a large amount of harmful substances into the environment. The reefing option is neither economically viable nor completely safe for the environment, but it could improve the local economy and underwater habitats for local sea life.

1. Introduction

Globally over one thousand ships each year reach the end of their useful life which equates to around 20 million tons of potentially recyclable materials (ECORYS Transport, 2005; Patrizia Heidegger, 2015). The required high quality nature of ship materials leads to higher profitability when those materials are resold, especially steel (Hossain et al., 2010). Common ship materials include liquid quenched and tempered steels, wrought copper alloys, titanium and titanium alloys, aluminum, and lead (DNV-GL Consulting, 2003). Further specifications on the quality of ship materials can be found in a report published by ASTM (ASTM, 2013). Electronic equipment can often be reused or deconstructed for their precious metals, while high quality steel can be recycled into anything from more ships to construction equipment.

The ship breaking industry is expected to be prosperous as the number of ships being manufactured around the globe is continually increasing (Tor Svensen, 2014). Although there is a great potential for both economic and environmental benefits from ship recycling, there are some barriers that exist within the current system. The most profitable shipbreaking methods are also the most dangerous to both worker safety and the environment. In some areas of the world such as the United States, Europe, China, and Turkey, strict regulations dictate how ships should be dismantled and recycled (Reid and Cavalieri, 2011). An in-depth review of the U.S. regulations can be found in a report published by the Environmental Protection Agency (EPA) (U.S. EPA, 2000). The guide outlines the EPA and Occupational Safety and Health (OSHA) regulations for removal and disposal of asbestos, polychlorinated biphenyls (PCBs), bilge and ballast water, oil and fuel, paint, metals, and ship machinery. In other areas of the world; such as Bangladesh, India, and Pakistan, there are facilities utilizing substandard methods which do not comply with international regulations (Patrizia Heidegger, 2015). The lack of enforced regulations allows for the safety and well-being of the workers and the environmental impacts to be completely ignored (Andersen, 2001; Krueger, 2001). Many of the ships being recycled today were constructed with materials that are now known to be toxic. Environmental impacts during the life cycle of shipping have

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been studied and negative health impacts and premature mortality of the shipping related particulate matter (PM) were reported (Dalsøren et al., 2010; Paxian et al., 2010; Wang et al., 2007a,b). The practice of dismantling a ship is very complex and dangerous due to the handling of toxic materials and flammable fluids that are part of various equipment and tools on a ship (Kaiser and Pulsipher, 2009).

Recently, there have been great strides to develop more effective regulations that prevent ships from being sold to substandard shipbreaking facilities. In 2009, maritime experts met at the Hong Kong Convention to develop standards for recycling practices aimed to minimize the negative effects of ship breaking on the welfare of workers and the environment (Chang et al., 2010; IMO, 2009). As of now this regulation is complete and adopted by International Maritime Organization (IMO). It is currently waiting for the tonnage and number of flags condition to be met in order to come into force (Lloyd's Register, 2011). Ships to be recycled using standard shipbreaking methods should mirror the technical guidelines for environmentally sound management as published by the Basel Convention in 2003 (UNEP, 2003) and EU regulations on ship recycling which entered into force on 30 December 2013 (European Commission, 2013). The EU regulations are similar to the Hong Kong Convention for the safe and environmentally sound recycling of ships which has yet to be entered into force internationally (ABS, 2014). With this recent trend, the currently substandard ship breaking facilities will have to undergo a complete overhaul due to the emerging regulations and increasing global awareness of environmental issues to be able to stay in business.

Data for the economic and environmental impact analysis of ship recycling are limited. In addition, there are lots of differences for markets between commercial ship and naval vessel recycling. The main goal of this study is promote the benefits of studying the end-of-life ship management options with the economic cost–benefit analyses and life cycle thinking approach. The scope of this study is to provide a framework which can be utilized for future ship recycling research. This paper surveys the current options for end-of-life ship management and analyzes the economic feasibility and the environmental impacts of each option. The social perspective for end-of-life ship management and the needs for an integrated system approach for managing end-of-life ships are reviewed in Section 5.

2. Survey of end-of-life ship management options

This paper discusses two categories of ship breaking methods, standard and substandard. Methods in the standard category are considered capable of adhering to international and local regulations that protect worker safety and minimize the risk for environmental damage. Methods in the substandard category are considered unable to meet such regulations based on the inherent environmental dangers and risks to worker safety associated with each particular method. Four major countries dominate the ship breaking market as shown in Fig. 1. In 2013, Asian ship breaking facilities processed 92% of the tonnage of the dismantled vessels, out of a world total of 29 million tons (Miroux, 2014). Bulk carriers, oil tankers, and container ships accounted for 44, 20, and 18 percent of the tonnage of demolished vessels respectively. Bangladesh, China, India, and Pakistan have the greatest market share for demolition in bulk carriers, gas carriers, container ships, and oil tankers respectively.

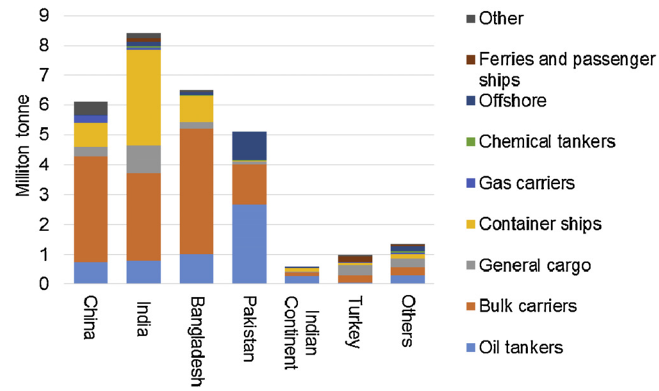

Fig. 1. Global ship recycling activities by country and ship type in year 2013.

The most common end-of-life ship management option is recycling. There are four main methods of ship recycling that vary in cost, safety, and environmental impact. The landing method (or non-tidal beaching), used in Turkey, is a standard method similar to beaching except the ship is hauled up onto a concrete slipway which makes any spills easier to contain and clean up but is not the safest method (Litehauz, 2013). A mobile crane is typically used to remove parts of the ship. Alongside (or pier-side breaking) is a standard method used in China, EU, and the U.S., that secures the ship to a dock in sheltered water. This method uses a crane to remove parts of the ship until it can be lifted out of the water. When spills occur, the pollution goes straight into the water which affects the local area but can be contained and cleaned up eventually (Andersen, 2001). Dry-dock ship breaking is a standard method used in China, the U.S., and EU (U.S. EPA, 2000). This method is the safest from an environmental perspective but also the most expensive. The ship is moved into an enclosed area which is sealed off and drained. Once the ship is dismantled by crane, the area is cleaned and re-flooded for the next ship (Lloyd's Register, 2011). Dry-docking is a slower method than alongside which means it has a lower annual capacity for breaking ships. Beaching is a substandard method used in Bangladesh, India, and Pakistan where ships are brought up onto mudflats during high tide, once the tide recedes the ship is grounded and hundreds of workers manually cut pieces off the ship and load them onto a lorry for additional transportation (Demaria, 2010). This manual labor can be done very cheaply and the safety of the workers in this method is largely ignored. In addition, any spills of hazardous materials are left on the mudflats to be swept away once the tide rises again (Jansen, 2014). As an alternative to recycling for end-of-life management, ships could be sunk to create artificial reefs after being removed of hazardous materials (George et al., 2006).

2.1. *Standard ship recycling*

Standard ship recycling refers to recycling of ships via the landing method, alongside method, or dry docking method. This option is typical for many U.S. military ships (NAVSEA, 2005). Ships that undergo this option are completely stripped of all equipment, materials and contaminants, dismantled and then all recyclable materials are sold. Breaking these ships is an extremely labor intensive process. The standard ship recycling facility operates under strict regulation for ship recycling to ensure the workers' safety and proper disposal of all types of toxic materials removed from recycled vessels (Kaiser and Pulsipher, 2009). All standard ship recycling activities are capable and should comply with strict regulations from the Environmental Protection Agency (EPA) and other maritime organizations. Working under such strict requirements means that facilities are only able to break a few ships per year, but they do so with much less hazard for the environment, workers, and surrounding population. These regulations demand that all yards separate hazardous and non-hazardous waste and have appropriate storage units available before the ship hull is cut up. Fig. 2 shows the simplified view of the decommissioning process for standard method shipyards. Hazardous wastes are separated