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The economic cost and control of marine debris damage in the Asia-Pacific region

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A R T I C L E I N F O

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A B S T R A C T

Oceans in the Asia-Pacific region are being impacted by increasing levels of marine debris, with many governments unaware of the extent that marine debris damages marine industries, the economy and the marine environment. We examine the economic costs associated with marine debris and present a simple marine debris cycle model to discuss the costs and benefits of prevention, clean-up and the benefits of using biodegradable materials. For the 21 economies of the Asia- Pacific rim we estimate that marine debris-related damage to marine industries costs US$1.26bn per annum in 2008 terms. Marine debris imposes an avoidable cost that can be reduced through policy implementation to economically optimal levels. Options to control debris, using regulations, technical intervention and market based instruments, may have a role. In this pollution policy area, additional economic cost data are required to inform governments on the most economical ways to control levels of marine debris.

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1. What is marine debris?

Industrialised society generates solid wastes in many forms, as goods are produced, transported, sold by retailers and used by consumers. Some of the waste finds its way to the oceans where it ends up as marine debris.[1] Debris is ubiquitous in the world's oceans, and is now recognised as one of the most insidious ocean pollution issues (Sheavly, 2005). While there are no certain statistics it is estimated that, worldwide, approximately 6.4 million tonnes of debris reach the ocean each year and that around 8 million items are discarded into the sea every day (UNEP, 2005).

According to Fanshawe and Everand (2002) the main types of debris found in the ocean are plastics (fragments, sheets, bags, containers), polystyrene (cups, packaging, buoys), rubber (gloves, boots, tyres), wood (construction timbers, pallets), metals (beverage cans, oil drums, aerosol containers), sanitary or sewage-related items (condoms, tampons), paper and cardboard, cloth (clothing, furnishings, shoes), glass (bottles, light bulbs), pottery/ceramic and munitions (phosphorous flares). Under the definition of marine debris, sewage is generally not considered marine debris, although they may be in association with each other.

Internationally as much as 80% of debris in the ocean is discharged from land-based sources (Sheavly, 2005; UNEP, 2005), including rivers and estuaries, storm-water discharges, industrial outfalls, land fill and tourist activities. Debris from ocean-based sources arises from the commercial fishing, shipping and oil sectors, and from recreational boating and military vessels (Allsopp et al., 2006).

In the Asia-Pacific region the status of marine debris/litter is monitored and documented by regional organisations and international clean-up initiatives (UNEP, 2008; NOWPAP, 2008 and ICC, 2008). Over the past 50 years, the nature of disposed waste has changed and organic materials, which once comprised the majority of discarded wastes, have largely been replaced by synthetic or plastic materials which are durable and may persist in the environment for many years (Sheavly, 2005; Allsopp et al., 2006). In addition, many synthetic materials are buoyant and can be transported over large distances, impacting on environments a long way from their point of origin. Increasingly it is being realised that derelict fishing gear (DFG) is part of ship sourced marine debris and damages marine life and habitat (Pooley, 2000; Kiessling, 2003; Wiig, 2004).

Much of the literature examines the prevalence and forms of marine debris and the impacts on fauna. To date, very few papers have addressed the costs that are imposed on society by marine debris. The effectiveness of control measures is usually examined

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[1] Marine debris, also known as marine litter, marine garbage and ocean debris, is defined for this study as, "any manufactured or processed solid waste material that enters the marine environment from any source whether on land or at sea" Coe and Rogers (1997).

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from a technical point of view and the economic benefits of removing marine debris are often assumed, but not normally measured.

2. The economic costs and impacts from marine debris

This paper examines the types of costs associated with marine debris and how they can be reduced through policy. The control of marine debris is examined identifying the different places where policy makers can intercept debris to control debris levels. We also present a simple model of the marine debris cycle and the theory of economic costs and benefits of prevention and clean-up. From this basis we then examine the issues involved in the control of marine debris in the 21 economies of the Asia-Pacific rim. An empirical estimate of the cost of damage from marine debris levels in this region is made and a range of policies and possible use of economic instruments is considered.

2.1. Economic costs

Economic costs are lost benefits to society. The economic impacts of marine debris can be measured by the diminished opportunities to exploit the marine environment for pleasure or profit (Faris and Hart, 1994). The different categories of economic costs of marine debris are as follows:

2.1.1. Direct economic cost

Those costs which arise from damage to an industry or to an economic activity, for example the costs of vessel downtime due to marine debris entanglement on a vessel propeller (Hall, 2000). In principle these costs are readily ascertained using market measures.

2.1.2. Indirect economic impacts

Those costs which arise indirectly, for example marine debris spoiling sites for new tourism development investment, or marine life ingesting plastic waste impacting on fish health and humans. Marine debris is a type of pollutant and can lead to the loss of economic opportunities (Ofiara, 2001). Should ambient marine debris levels remain high in a given tourist area, it may threaten new private sector investment in hotel developments if the potential of the area to attract tourists has been compromised by marine debris (McIlgorm et al., 2009).

The indirect costs of impacts from marine debris can have both market and non-market values. Non-market values can be scenic values, or the values placed on the marine environment, or marine life forms impacted. The presence of debris in seawater reduces recreational values, impacts bird and marine life and also lessens the ecosystem value of the oceans.

2.1.3. Debris impacts

Marine debris impacts activities both at sea and on the shoreline. Debris impacts are most readily seen on beaches where municipal authorities have to clean beaches to regain their amenity. Beach access has a value and several economic studies have evaluated the costs of the loss of beach access. Kirkley and McConnell (1997) propose an example: suppose that Beach A, which involves $50 in travel cost per visit, is closed because of marine debris; consumers now switch to visiting Beach B which offers identical recreational benefits, although it is further from the city and involves a $55 travel cost. The cost of the marine debris is the extra $5 per beach visit, whereas the economic impact may well be zero: the original $50 travel expenditures – on fuel, food, accommodation – continue and the extra $5 expenditure is simply diverted from some other part of consumers' budgets. The economic loss to the whole economy in this example consists of the relative change in values by consumers using a substitute beach.

Marine debris also causes damage to ships and leisure craft by entangling vessel propellers and increasing maintenance, repair costs and ships' downtime (Hall, 2000). Shipping and fishing industries experience damage from plastic and rope entanglement of propellers/bow thrusters, leading to stern tube seal damage and vessel flooding in extreme cases (Hall, 2000). Such impacts are more prevalent in smaller vessels and to outboard motors where gear box damage is evident (McIlgorm et al., 2009).

All marine vessels have bilge coolant hull fittings for entry and exit of engine cooling water and these are often impeded by plastics, causing engine overheating and damage. In Japan, Takehama (1990) found fishing vessels in the 5 to 20 Gross Tons size class, had the highest frequency of accidents with floating objects affecting engine cooling systems and entanglement of foreign material in propellers. Many of the costs associated with this damage occur in the form of vessel delays and increased vessel repair and maintenance costs. Only a few incidents lead to vessel loss (Cho, 2005).

Marine debris impacts on marine life causing damage to a range of wildlife including, sea birds, marine mammals, fish and turtle species and even plankton (Laist, 1987, 1997; Moore et al., 2001). Ingestion of plastics significantly impacts bird, turtle and fish populations (Allsopp et al., 2006) affecting the health of these populations and potentially reducing the value of ecosystem goods and services.

Derelict fishing gear (DFG) is considered a distinct debris category impacting fish populations through nets impeding fish by ghost fishing and by derelict fishing gear covering fish habitat areas (Laist, 1997; Raaymakers, 2007). DFG often floats in the water column and has received significant publicity in the Midway Islands where it is accumulated by the North Pacific Ocean Gyre (Moore et al., 2001; Allsopp et al., 2006).

Internationally coastal states face marine debris coming ashore which requires clean-up measures to be taken, often at the expense of the local municipal level of government. How do we control marine debris and at what cost?

3. Control and prevention of marine debris

The control of marine debris is part of the waste management process in society, but tends to be only one of many waste issues for land-based waste management agencies. Marine debris has a life cycle history as shown in Fig. 1. Prevention of debris going into the sea from land sources, can be controlled by land waste management systems. When debris enters water courses, estuaries and the

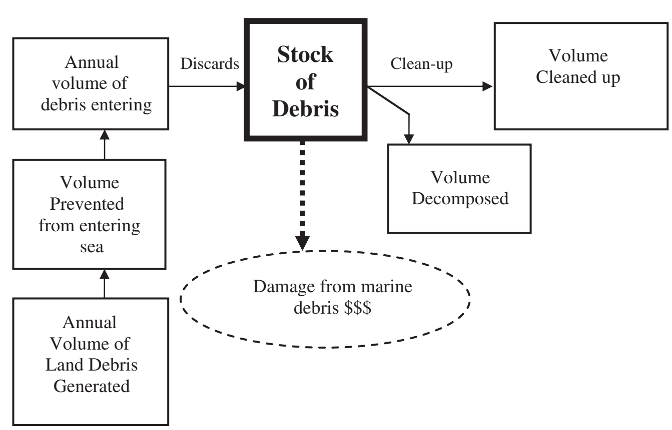

Fig. 1. A conceptual stock flow diagrammatic overview of marine debris (not to scale).

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