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Anchors away? The impacts of anchor scour by ocean-going vessels and potential response options

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ABSTRACT

Shipping is critical to global trade and anchoring is a long-held practice for safe and effective ship operations. While it is well established that anchoring or mooring of small recreational vessels has physical impacts on the seafloor and associated biota, the impacts of larger ships on seafloor environments has received little attention. This is, however, an increasingly pressing issue as world trade increases and shipping impacts on valuable yet vulnerable marine environments escalate. Using a case study in south eastern Australia this article highlights the multifaceted issues surrounding the anchoring of large ocean-going vessels. How these activities interact with marine environments is explored, with emphasis on the significant uncertainty surrounding impacts on seafloor biota. Finally, a range of potential response options to mitigate the effects of anchoring are provided.

1. Introduction

It is common practice for ships to lie at anchor while waiting to access port facilities. Anchoring reduces fuel consumption and emissions as well as inhibiting drift of vessels toward land, submerged features or other vessels, thus minimising the risk of groundings and collisions. Nevertheless, vessels at anchor pose a risk to the seafloor and its biota. A ship's anchor can shift, and its mooring chain swing across the seabed, causing abrasion of the seafloor and damage to benthic ecosystems; this phenomenon is known as 'anchor scour'. These threats are ill-understood and little acknowledged, as is the challenge of identifying how anchor damage might be mitigated.

Anchoring occurs in offshore areas where there are multiple coincident and potentially conflicting activities and stakeholders, as well as jurisdictional complexities. Here, the multifaceted nature of the issue is outlined and multidisciplinary approaches that may afford solutions are considered. Our discussion is structured in four parts. First, the scale of anchoring is contextualised in terms of global trade patterns. Second, an Australian case study is used to highlight the scale of anchoring and the complex institutional-legal issues that influence its practice. Third, consideration is given to deep-water assemblages of marine organisms that exist in locations where anchoring takes place and which are likely to be impacted by anchor scour, although we acknowledge limitations to knowledge in this area. Finally, potential prevention or mitigation strategies are considered including the need to resolve conflict among stakeholders given that anchoring bears the hallmarks of a collective action dilemma.

2. Anchor scour – a hidden cost of global trade

International shipping is a fundamental driver of global prosperity. Over 80% of global trade by volume is carried by sea, with a global fleet of more than 68,000 cargo-carrying vessels [49]. The scale of this multi-billion dollar global industry has escalated rapidly in recent decades in keeping with sharply increasing global trade. Indeed, ocean transport by volume has almost tripled since 1990 (Fig. 1). This trend appears set to continue with further significant growth predicted. Indeed, it has been estimated that sea borne trade will increase a further three fold by 2060 [44]. The dramatic growth in global trade is in part driven by the increasing size of modern vessels which enables shipping costs to remain low [50].

The escalating numbers and size of ships has led to concerns about how modern ocean-going vessels interact with the natural

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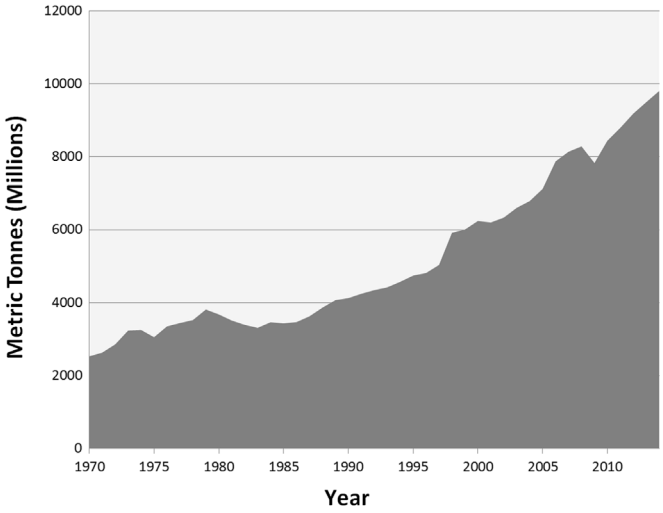

Fig. 1. World seaborne trade in volume (metric tonnes/millions) between 1970 and 2014. Sourced from UNCTAD stats (2015) (accessed 21/3/2016) based on total goods unloaded.

environment. Some environmental impacts associated with the shipping industry are well established. For example, vessels produced an estimated 2.2% of the world's CO_2 emissions in 2012 [19], and produce significant sulphur emissions [50]. Concerns have also been raised about international trade as a vector for marine invasive pests via ballast water or hull fouling [20] and a source of contamination from biofouling agents or spillages [18,25]. Vessels may also contribute to light and noise pollution [23], particularly when at anchor in coastal waters awaiting an opportunity to dock.

Additionally, there is abundant evidence that the mooring chains of recreational or small (< 50 m) commercial vessels can have dramatic impacts in shallow water environments, especially seagrass habitats. The production of circular mooring scars denuded of virtually all surface biota is well documented in these habitats [8,13] and recovery for some key habitat-forming species may be extremely slow [26]. It can be anticipated that large vessels at anchor also pose a threat to the marine environment; anchors on the largest vessels may weigh in excess of 25 t [16]. Anchors hold vessels fast in combination with the weight of the chain lying on the seabed [16]. Consequently, anchor chains for large vessels are often extremely heavy with individual links weighing between 60 and 200 kg [16], particularly for vessels anchoring on wave-exposed coasts with high dynamic loads on their anchoring systems [1]. The length or 'scope' of chain deployed is determined by the holding ground (bottom type), depth of water and the prevailing sea conditions [16]. The 'scope' is usually between three and seven times the water depth, with most ship masters preferring a scope greater than five [16].

In contrast to shallow water habitats, which have received scientific scrutiny, there is poor understanding of how large vessels at anchor interact with marine biota at depths beyond those easily sampled with SCUBA. This is a submerged and therefore largely hidden impact of shipping (Fig. 2). Sampling becomes logistically difficult and expensive beyond 30 m and usually requires remote sampling technologies [35]. Consequently, there is a general lack of awareness of the threats that anchoring may pose to the marine environment, arguably stemming from a limited understanding of the diversity and importance of the environments under threat (see below). This is illustrated by the fact that neither the International Maritime Organization – the UN agency charged with the global standard-setting for maritime safety, security and the environmental performance, nor the environmental code of practice developed by the International Chamber of Shipping makes mention of anchor scour [17,21].

3. Anchoring in south eastern Australia: a case study

As an island nation Australia is heavily reliant on shipping with 99% of trade by volume being carried by sea [4]. Australia's ports receive more than 26,000 ship visits annually supporting a $200 billion industry [39]. The economic reliance on commodities is reflected in the percentage of global trade shipped from its ports. Coal exports from Australia account for 29% of the world's coal transported by ship [6] 56% of the world's iron ore [42] and 9% of global grain exports [6]. Australia's eastern seaboard is a focal point for Australia's resource rich industries. Ports in the Sydney region (the Ports of Newcastle, Sydney, Botany Bay and Wollongong) distribute a large portion of Australia's commodities. The most recent figures available for Sydney Ports (2011–2012 financial year for Sydney Harbour and Port Botany combined) record 2141 ships visits trading 30.7 million tonnes. Reports for Wollongong's Port Kembla (2012–2013) document 946 ship visits for a total trade volume of almost 29 million tonnes [29]. While the Port of Newcastle, the world's largest coal port registered almost 160 million tonnes of trade in 2014 and 2170 ship visits in this period [30].

New South Wales (NSW) offers an attractive area in which to focus a case study. In addition to busy ports, there are challenging jurisdictional issues surrounding Port limits as well as complex issues of jurisdiction and responsibility shared between State and Federal authorities. Fortunately, deep-water assemblages near Sydney have received attention by biologists; this research highlights significant knowledge gaps for key habitat-forming organisms on deep reefs and their recovery following disturbance. These challenges are explored below.

3.1. Anchoring practices in New South Wales

Many of the vessels entering NSW ports lay at anchor while awaiting their turn to dock. Environmental conditions experienced on the NSW coastline include highly changeable winds, a strong south-flowing western boundary current (the East Australian Current) and large swell associated with storm systems originating in the southern ocean. These conditions cause vessels to swing on their anchor chains. Such changes in vessel position appear as anchoring arcs, visualised with AIS (Automatic Identification System) vessel tracking data made available by the Australian Maritime Safety Authority (AMSA) (Fig. 3). These data also confirm that vessels often remain at anchor for several days. The average is more than four days in waters adjacent to Port Kembla and nearly three days at the Port of Newcastle (Table 1), although some vessels remain at anchor for as long as almost 32 days. Two substantive points can be discerned from the AIS data. First, the scale of the anchoring arcs identified is substantial; some exceed 500 m in diameter. Here it can be noted that only part of the anchor chain will come into contact with the seafloor, something that is dependent on the depth of water and load placed on the anchoring system [3]. Second, there is evidence that some areas of sea bottom have experienced repeated scouring over the three years of data examined. It should be noted that many anchorages, including Port Kembla and Newcastle, have been receiving vessels for decades.

3.2. Complex jurisdictional challenges in NSW

Australia claims a territorial sea extending seawards to 12 nautical miles (M) from baselines along the coast, consistent with the United Nations Law of the Sea Convention [48]. Australia's constituent states and territories such as NSW have principal