



Science for Environment Policy

THEMATIC ISSUE:

Ship recycling: reducing human and environmental impacts

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EDITORIAL

Towards a safe, more sustainable future for ship recycling

The ship recycling industry — which dismantles old and decommissioned ships enabling the re-use of valuable materials — is a major supplier of steel and an important part of the economy in many countries, such as Bangladesh, India, Pakistan and Turkey. The recycling of scrap metals from ships also reduces the need for mining, an environmentally damaging practice. In this way, it is a vital part of the [circular economy](#) — which purports to minimise waste and recycle some materials infinitely.

However, mounting evidence of the impacts of current ship-recycling practices undermines the industry's contribution to sustainable development.

Most ships are run aground on tidal mudflats, a practice referred to as 'beaching', before low-paid workers dismantle them, often without protective equipment or heavy machinery; the Global Trade Union [IndustriAll](#) has described it as "the world's most dangerous job". The shipbreaking industry in South Asia has caused dozens of fatalities per year among workers — according to official statistics between 1983 and 2013¹, there were 470 fatalities in the Indian shipbreaking yards.

Moreover, some shipbreaking practices have highly concerning environmental and human impacts, releasing materials such as oil, asbestos and toxic paints into the local environment, and disrupting biodiversity. There have been local attestations of significant pollution to the surrounding environment and its resultant impacts on wildlife, farming and communities.

In 2015, 78% of total dismantled shipping tonnage in the world was beached, with European owners accounting for around one third. German and Greek owners beached 74% and 87% of their disposed vessels respectively, while Norwegian owners recycled 13 of their 17 end-of-life vessels in modernised facilities.

European ship owners actually control over 40% of the world's merchant fleet, with Greece the top ship-owning country globally. However, only 22% of vessels fly the flag of an EU Member State. This discrepancy relates to the use of 'flags of convenience': at the end of their life, ships are 'reflagged' (at low cost) in ship registries of countries with a poor record of implementing international legislation. As the [NGO Shipbreaking Platform](#) has shown, end-of-life 'flags of convenience' — which are hardly used while ships are operational — can be used to reduce costs and avoid

legislation intended to ensure environmental protection and workers' rights. These changes also disguise the real economic stakes in the ownership of a ship. Nearly 40% of all end-of-life ships beached in South Asia in 2014 were imported under flags with a particularly weak record of enforcing international law, such as Comoros, St Kitts and Nevis and Tuvalu. In 2014, only 7.7% of all beached ships (by gross tonnage) were still registered under an EU flag, although 32% were still under EU ownership. Indeed, almost 73% of the world's fleet is flagged in a country other than the country of beneficial ownership.

For these reasons, several bodies and mechanisms, including the UN's (still un-ratified) Convention for Registration of Ships (1986), have called for a more genuine link to be established between ownership and flag state, to avoid such evasion of responsibility — and to allow for effective enforcement via flag-state jurisdiction.

In total, [the world shipping fleet grew](#) by 42 million gross tonnage (GT) in 2014. However, overall growth rates in the industry have been slowing. The tonnage reported for demolition (22 million GT) has decreased since the record year of 2012, where at least 36 million GT were demolished. In recent years, the decrease in ship cargo has meant that many older vessels may be more financially viable as scrap. In addition, previously 'seaworthy' ships around the world are being retired earlier than ever. [UNCTAD notes that there is still an 'oversupply of tonnage'](#) in the market, and the age of scrapped ships is getting younger. This oversupply can be attributed to poor planning ahead of the global economic crisis, the introduction of stricter standards and the desire to upgrade ships with new high-tech, on-board technologies and modern architecture.

Such pressures all add to the need to establish a more competent, safe and sustainable global infrastructure to dismantle ships.



Tracking Hazardous Waste, Alang Shipyards (CC BY-NC-ND 2.0 Adam Cohn, February 2015, Flickr; www.flickr.com/photos/adamcohn/21296547418)

The [International Maritime Organisation's Hong Kong Convention 2009](#), intends to impose new requirements on ships from 'cradle to grave', covering issues around ship recycling on a global scale. However, only four of a required 15 states have ratified the convention (as of June 2016), while the combined gross tonnage of their fleets is far from the required 40% of the world's merchant shipping and they are far from possessing facilities able to recycle 3% of the gross tonnage of the signatory states annually. The [International Chamber of Shipping](#) has called the rate of uptake "[disappointingly slow](#)", and has released [transitional guidelines to help ship owners](#) to comply with the IMO Convention, ahead of enforcement — such as inventorying all hazardous wastes. Moreover, the Hong Kong Convention does not cover 'downstream' waste management, i.e. what happens to waste once it leaves the ship recycling facility.

More locally, the [EU Ship Recycling Regulation \(EC 1257/2013\) 2013](#) intends to ensure that shipbreakers provide evidence of pollution containment, as well as of adequate disposal facilities for hazardous waste. Owners of ships flying the flags of EU Member States will have to ensure that their ships are recycled in facilities included on a new approved list of facilities.

These will be progressive steps forward, relative to the current norm. However, both the IMO and EU frameworks remain based upon flag-state jurisdiction. Therefore, a critique remains that legislation based upon flag-state enforcement could have little effect if ships are 're-flagged' for convenience at end of life. Continuation of re-flagging practices would mean that neither

regulation could uphold a 'polluter pays' principle in every case, as they stand.

There is a clear need for ship owners to internalise the environmental and social costs created by breaking ships to some greater extent. Exact mechanisms to ensure greater responsibility are still being progressed; beyond legislation, levies, licenses, or a life-cycle ship-dismantling fund with costs borne by the ship owners have also been posited.

To return to those who currently bear the costs, many media images published on the subject of the ship yards appeal to public understanding of these issues: alternately the workers in appalling safety and environmental conditions on the beaches of South Asia, and the shipbreaking companies' more sterile, public-relations images of secondary plate-cutting zones. However, an ecological conflict of such global concern cannot be judged on images alone; detailed data is essential. In all the complexity of global perspectives, what is sometimes overlooked is the fact that precise research is already available, which might form a precipitant to meaningful action.

This Thematic Issue looks at the peer-reviewed science behind shipbreaking, by presenting a selection of recent research on the environmental and human impacts. The Issue also includes practical studies that examine the steps that ship designers and operators could take to have a constructive impact on current ship recycling methods.

Research carried out in Chittagong, Bangladesh notes that the concentration of toxic chemicals in the air, at several sites, was found to be above carcinogenic risk limits. Indeed, research has shown that ship-recycling workers can suffer from proportionally high rates of cancer, resulting in increased mortality. Another study traces asbestos-related cancer rates in Taiwanese shipbreaking workers, where a positive link is found between cancer incidence and exposure. As a result, the researchers recommend that any shipbreaking workers who may have been exposed to asbestos in the past have regular health checks in order to detect disease early. They also recommend legislation to ban all asbestos-containing products (which is still lacking in many parts of the world, including India), both in the workplace and general environmental settings.

Another study on pollution in India showed significantly higher levels of heavy metal and

petroleum hydrocarbons in sediment and seawater, compared to a control site — as well as increased numbers of pathogenic bacteria. The latter is a finding supported by evidence from another study, on the disruption of microbial communities near Alang–Sosiya, showing a high abundance of bacteria in polluted water samples, but their marked absence in the unpolluted control water. In another study, the researchers found 81 milligrams of small plastic fragments per kg of sediment, which, they say, is the direct result of shipbreaking. Another found that the area surrounding the Alang–Sosiya yards was found to be ‘strongly polluted’ with copper, cobalt, manganese, lead and zinc. This is supported by different researchers, operating in Chittagong, who conclude that heavy metal pollution is at an alarming stage and an urgent threat to marine life and biodiversity. They recommend establishing a separate area for shipbreaking activities, such as a dockyard, to mitigate damage to the coastal environment.

One researcher has explored the current and possible future status of shipbreaking in Bangladesh, with a particular focus on the outlook for workers. In each of the four possible scenarios, the workers come off worst: there is currently no best-case situation for the people who face the risk of accident, illness or death in the shipbreaking industry, or unemployment outside of it.

Shipbreaking seriously impacts the environment, but some methods are less damaging than others. A major ship-recycling centre, Turkey is the only OECD country to have an established shipbreaking industry. Turkey uses a modified ‘slipway recycling’ technique where ships are dragged onto a concrete slipway, which extends into the sea, before being dismantled. We summarise a study examining the environmental, health and safety issues surrounding the Turkish industry and its compliance with environmental regulations.

Researchers elsewhere estimate the costs of upgrading existing ship recycling facilities to more environmentally friendly, regulation-compliant standards. They conclude that the main barriers to a greener ship recycling industry lie in fear of job losses and a lack of strict regulations for ship owners or lenders in the second-hand shipping or scrap trade.

Another piece of research looks at the environmental impact of shipbreaking in a Portuguese ship recycling yard. Using a life-cycle assessment tool to model impacts for 23 different

types of ship over four scenarios, they conclude that ship recycling has negative environmental impacts, whatever the methods used — but that the impacts of ship dismantling are less damaging than abandonment or sinking. They recommend that the valorisation of parts to encourage their re-use, recycling and treatment can mitigate some of the impact.

The concept of ‘design for recycling’, where end-of-life hazards are considered early on during the shipbuilding design process, is posited by other research. This could involve identifying risks, such as toxic paints, or inefficiencies, such as oil tanks that must be manually cleaned before they can be recycled.

In another study, the researchers aim to estimate the environmental impact of the end-of-life phase of a ship compared to its overall life cycle — and another set of researchers reveal the carbon footprint and resources consumed in the cutting of steel plates. This research could help the design of technological solutions to reduce these emissions, such as removing surface coatings before cutting.

Most large transport industries, such as cars and aviation, have established component-listing schemes for manufacturing, whereas the shipping industry has no such standardised practice. An ongoing pilot project is being conducted with four shipping companies using a software system to help trace and track materials used in ship construction. The researchers conclude that the data could be used to encourage responsibility for the social and environmental effects of the materials used, from construction to recycling. A final study looks into ways that different interested parties (including environmentalists, the Indian authorities, shipping companies, ship recyclers and their workers) arrive at divergent conclusions regarding the costs and benefits — and ultimately, the legality — of recycling activities at Alang–Sosiya.

Given the current high human and environmental costs, it seems likely that ship owners and breakers, state mechanisms and international legislation will each need to continue to evolve and increase their cooperation to fill the gaps. The aim is that the operation of ship recycling facilities in a safe, environmentally sound and beneficial manner will, in the future, complement the circular-economy principles that hold great value for both this industry and global society.

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Read more about: [Air pollution](#), [Environment and health](#)

Chittagong ship recycling industry linked to carcinogenic air pollution

Dangerously high air pollution in the vicinity of shipbreaking yards has been detected by a recent study, where the concentrations of toxic chemicals in the air were found to be above carcinogenic risk limits (as set by the World Health Organisation). The research, carried out in Chittagong, Bangladesh, noted that shipbreaking activities and the subsequent processing and treatment of materials — particularly the burning of waste — result in emissions of persistent organic pollutants (POPs).

“POPs...were found at their highest levels in sites near the shipbreaking yards”

In 2014, the Chittagong area accounted for 22% of shipbreaking activities worldwide. The industry employs over 100 000 adult workers, and there are an estimated 50 000 children involved in e-waste recycling — of which 40% occurs in shipbreaking yards. Chittagong city has a total population of around 4.5 million people, and the prevailing westerly winds mean that air is generally carried from the shipbreaking yards to the city.

The study, which is the first to measure POPs in ambient air in Bangladesh, took data from 23 sites in Chittagong’s residential and industrial areas and the shipbreaking yards to the north-west of the city. A total of 25 passive air samplers were used between the sites for 7 to 9 days in February 2013, after which the filters (polyurethane foam disks) were collected and analysed to reveal the pollutants that had been absorbed.

POPs including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) were found at their highest levels in sites near the shipbreaking yards, whilst dichlorodiphenyltrichloroethanes (DDTs) and short-chain chlorinated paraffins (SCCPs) were at their highest levels in urban areas. Readings for all these pollutants were high when compared to similar studies conducted in other parts of Asia. The toxic equivalent quotient (an air toxicity standard developed by the World Health Organisation) — for PAHs was above the World Health Organisation’s carcinogenic risk limit¹ at 18 of the 23 sites. The detection of DDT in urban areas may be from historic use,

but the researchers suggest it is likely evidence of recent or current (and therefore illegal) use. This is because the interpretation of the results, in terms of ratios between compounds that should degrade with different rates, indicates that concentration ratios have ‘recent’ signals.

It should be taken into account that the study was conducted during the dry season — at a time of year when annual air quality is at its worst in Chittagong. Throughout the sampling period, there was no rainfall (which helps remove particulate matter from the air) and the study was conducted at a busy time in the industrial calendar. For this reason, the authors recommend a follow-up study should be conducted in the wet season to give some insight into seasonal variability of the air quality in Chittagong.

The results of the study show that the effects of shipbreaking on air pollution are significant.

The levels of phenanthrene, a type of PAH, were higher in Chittagong than levels detected in the ambient air of Shanghai and in industrial areas of Taiwan. The researchers state that more must be done at an international level to prevent transport of hazardous waste, in the form of ships, from more economically developed countries to less developed countries, where international regulations on safe ship recycling may not be enforced.

Source: Nøst, T. H., Halse, A. K., Randall, S., Borgen, A. R., Schlabach, M., Paul, A., Rahman, A. & Breivik, K. (2015). High Concentrations of Organic Contaminants in Air from Ship Breaking Activities in Chittagong, Bangladesh. *Environmental Science & Technology* 49: 11372–11380. DOI: 10.1021/acs.est.5b03073.

¹WHO Air Quality guidelines for Europe http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

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Read more about: [Environment and health](#)

Asbestos exposure increases risk of cancer in ship recycling workers

Recycling ships for scrap is a known asbestos exposure hazard, yet this study is one of few to trace asbestos-related cancer rates in shipbreaking workers. The results, obtained from former shipbreakers in Taiwan, show higher rates of cancer overall, especially oesophageal and lung cancers.

“Although it is a recognised hazard, knowledge of the rates of asbestos-related disease among shipbreakers is lacking.”

Although awareness of the health risks of asbestos can be traced back to the early 1900s, the minerals continued to be used for decades afterwards. Asbestos use began to be restricted in the 1980s and it is now banned in 52 countries, yet approximately 125 million people worldwide are still exposed to it through their work environments. This includes those who work on ship recycling yards, as asbestos was used to provide thermal insulation in ships built in the 1960s and ‘70s.

There is now indisputable scientific evidence that inhalation of asbestos causes cancer, including lung cancer¹ and mesothelioma, a rare form of cancer which develops in the linings of the lungs or stomach. A number of studies of shipyard workers have clearly shown increased mortality due to cancer.

The ship recycling market hit a peak in the years following the financial downturn, bringing the issue of asbestos exposure to international attention. Although it is a recognised hazard, knowledge of the rates of asbestos-related disease among shipbreakers is lacking. Most studies have only assessed mortality which, while an important measure, does not record the many people with cancer who do not die from the disease (up to a third of sufferers).

Therefore, this study looked at the link between cancer *incidence* and asbestos exposure. The study focused on former workers of shipbreaking yards in Taiwan, a centre for shipbreaking between the 1980s and the end of the 1990s. The researchers used a matched-cohort study, which means many workers were

followed over time and ‘matched’ to similar individuals from the general population as a comparison.

Subjects were selected from a shipbreaking workers’ union, whose membership includes 70% of people employed in the industry in Taiwan, and of which they must have been a member since 1985. Workers were assigned to matched controls from the general population based on age, gender and living area. In total, 4 427 shipbreaking workers and 22 135 controls were followed.

The researchers used the same dataset to obtain cancer incidence for workers and the reference population: the Taiwan Cancer Registry, a record for new cancer cases, which was set up in 1979. The researchers assessed likely exposure to asbestos, differentiated by eight job titles: flame cutters, odd-jobbers, lifters, supervisors, knockers, sorters, drivers and administrators. The highest exposure job was flame cutter, and administrator the lowest.

The researchers calculated Total Exposure Potential (TEP) scores for the workers based on their job title and years of employment. They were grouped into three categories of high, medium or low exposure. Finally, the researchers calculated hazard ratios (the risk of getting cancer over the study time period, compared to the likelihood in the control population) for various types of cancer, by job category and exposure.

By the end of the 24-year follow up (2008), the researchers had collated data on 436

Source: Wu, W., Lin, Y., Li, C., Tsai, P., Yang, C., Liou, S. & Wu, T. (2015). Cancer Attributable to Asbestos Exposure in Shipbreaking Workers: A Matched-Cohort Study. *PLOS ONE*, 10(7): e0133128. DOI: 10.1371/journal.pone.0133128

1. One study reported that shipyard workers were at a higher risk of mortality from lung cancer by a magnitude of 26%.

cancer cases and 940 deaths. Analysis showed that shipbreaking workers had a significantly higher risk of developing cancer compared to the general population. There was a significant increase in hazard ratio for overall cancer, oral cancer and lung cancer in all three asbestos-exposure groups. Not only did the ship workers get cancer more often, they also got cancer younger. Furthermore, the relationship between cancer and asbestos exposure was dose-dependent — i.e. the more asbestos the ship workers were exposed to, the more likely they were to develop cancer.

Overall, the study confirms a positive link between cancer incidence and asbestos exposure among shipbreaking workers. As a result, the researchers recommend that any shipbreaking workers whom may have been exposed to asbestos in the past have regular health checks in order to detect disease early. They also recommend legislation to ban all asbestos-containing products (which is still lacking in many parts of the world), both in the workplace and general environmental settings.

“There was a significant increase in hazard ratio for overall cancer, oral cancer and lung cancer in all three asbestos-exposure groups.”



Shipbreaking Detritus on Beach, Alang India (CC BY-NC-ND 2.0 Adam Cohn, February 2015, www.flickr.com/photos/adamcohn/21505950505)

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Read more about: [Chemicals](#), [Marine ecosystems](#)

Pollutants at India's biggest ship recycling yard, including heavy metals and petroleum hydrocarbons, quantified

A study of the pollution caused by ship scrapping in Alang, India shows significantly higher levels of heavy metal and petroleum hydrocarbons in sediment and seawater, compared to a control site. The researchers also found reduced populations of zooplankton — a critical food source for marine biota — and increased numbers of pathogenic bacteria.

“Alongside the employment opportunities and notable contribution to the steel industry it provides, the industry has also polluted the region with substances including petroleum, asbestos, paint, glass wool and plastics.”

The beaches in Alang, on the western coast of India, have become the world's largest ‘graveyard’ for ships that have come to the end of their useful lives. The Alang shipbreaking yard, established in 1982, now recycles hundreds of ships every year and employs tens of thousands of people.

Alongside the employment opportunities and notable contribution to the steel industry it provides, the industry has also polluted the region with substances including petroleum, asbestos, paint, glass wool and plastics — many of which are persistent and harmful to humans and the environment. In addition, workers and local people have been known to dump domestic waste on the shore, leading to high concentrations of nutrients and bacteria.

To get a better understanding of the pollution problem along the Alang coast, this study quantified a number of pollutants. As a control site, the researchers used Piram, a nearby island that is in a more pristine condition and serves as a nesting site for endangered species, including turtles.

In total, the researchers took samples from four sites, two control sites (near shore and 10 km from the shore of Piram) and two sites at Alang (again, near shore and 10 km away). They collected seawater and sediment and analysed a number of parameters, including chemical and biological values (e.g. pH, oxygen levels and nutrient content), heavy metal concentrations, chlorophyll-a levels

(chlorophyll used in oxygenic photosynthesis — therefore an indicator of productivity), petroleum hydrocarbons, and numbers of bacteria, phytoplankton and zooplankton.

Concentrations of heavy metals, including iron, manganese, cobalt, copper, zinc, lead, cadmium, nickel and mercury, were significantly higher at the near shore station of Alang compared to the control site. The least-enriched metal was nickel, which was 25% higher at Alang than at the control site, while mercury was an astounding 15 500% higher at Alang than at the control.

Concentrations of petroleum hydrocarbons were 16 973% higher at Alang than at the control, and 53 900% higher at the near shore site of Alang than 10 km away. However, levels of chlorophyll-a were at much lower concentrations at Alang compared to at the control, and in some cases below detection.

Zooplankton showed considerable reductions in growth (up to 66%) at Alang compared to the control, but phytoplankton counts were slightly raised at Alang. Interestingly, the higher number of phytoplankton observed at Alang was not matched by an increase in chlorophyll-a levels (as expected, as chlorophyll-a is a measure of phytoplankton biomass). The researchers therefore conclude dead phytoplankton cells were likely included in the count, obscuring the fact that heavy metals and petrol reduced the productivity of phytoplankton in the region. The authors note that relationships between

Source: Tewari, A., Joshi, H., Trivedi, R., Sravankumar, V., Raghunathan, C., Khambhaty, Y., Kotiwar, O. & Mandal, S. (2001). The Effect of Ship Scrapping Industry and its Associated Wastes on the Biomass Production and Biodiversity of Biota in *in situ* Condition at Alang. *Marine Pollution Bulletin* 42(6): 461–468. DOI: 10.1016/S0025-326X(00)00185-5

numbers of phytoplankton and chlorophyll concentration vary and depend on many factors, including turbidity (cloudiness or haziness of water depending on the number of individual microscopic particles) and tidal range.

The total number of bacteria was 605% higher at Alang than the control site. Numbers of individual bacteria, including some pathogenic strains, were also higher; *E. Coli* and *E. Faecalis* were 349% and 394% higher at Alang than at the control, respectively. Coastal regions with high metal content and low salinity are thought to be less toxic to bacteria, which may explain why bacteria survived at higher levels in the seawater of Alang. Other factors include anthropogenic activities contributing bacteria to coastal seawater, including nearby latrines.

Such high bacterial content could pose health risks. According to the EU [Bathing Water Directive](#), coastal waters should contain no more than 500 units of *E. Coli* per 100 ml (and ideally no more than 250). At Alang, the researchers found over 1500 per 100 ml.

This study reveals how pollution caused by ship recycling and the surrounding industrial development can change local ecosystems — increasing numbers of potentially harmful bacteria and reducing ecologically important organisms, such as zooplankton. The researchers hope their findings inform protective regulations at Alang, and at similar sites worldwide.

“...pollution caused by ship recycling and the surrounding industrial development can change local ecosystems — increasing numbers of potentially harmful bacteria and reducing ecologically important organisms, such as zooplankton.”



Ship being broken, Alang, Gujarat, India.

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Read more about: [Chemicals](#), [Marine ecosystems](#)

Micro-organism communities disrupted near world's largest ship-recycling yard

Pollutants have been shown to alter the structure of bacterial communities in the coastal waters around the Alang–Sosiya shipbreaking yard in north-west India. The research analysed sea water from two sites near Alang–Sosiya and from pristine sea water taken 10km from the coast. The results provide a clearer idea of changes to the microbial ecology near a large ship recycling yard.

“...contaminants that enter the seawater as a result of the recycling process can have a major impact on the marine environment — particularly on the microbial communities that play an important role in the nutrient cycles of local ecosystems.”

The Alang–Sosiya shipbreaking yard is one of the largest in the world, accounting for nearly half of shipbreaking and recycling activities worldwide. Although ship recycling reduces the pressure on metal resources such as iron and copper, contaminants that enter the seawater as a result of the recycling process can have a major impact on the marine environment — particularly on the microbial communities that play an important role in the nutrient cycles of local ecosystems.

The study took samples from two sites (one in Alang and one in Sosiya) during three different seasons: winter, summer and monsoon. The researchers assert the control seawater was not directly affected by anthropogenic activity, as it was taken 10km out from the Alang–Sosiya coast.

These samples were analysed to determine their chemical content, then diluted in series and introduced to a range of high-nutrient and low-nutrient agar preparations to develop microbial communities. One of the preparations, which used BHM (Bushnell-Hass Medium) agar, contained only petroleum hydrocarbons (such as benzene) as the carbon source, to determine whether organisms had locally adapted to surviving in a polluted environment.

For the purposes of identification, the DNA of the microorganisms was extracted and a 16S rRNA (ribonucleic acid) analysis was performed. This test is often used to determine if previously known or new microbes are present in a particular environment. The technique is widely used as a biomarker and in microbial ecology studies.

The results show that bacterial communities are altered as a result of human activities and waste

products, but also show an amount of seasonal variation in the bacterial counts. The bacteria in the vicinity of the ship-recycling yard were shown to be shifting from a *Gammaproteobacteria* (which was dominant in control samples) towards *Betaproteobacteria* and *Epsilonproteobacteria* classes — in general, towards bacteria that are known for their ability to degrade hydrocarbons.

Bacterial counts on the BHM agar, which contained petroleum-derived hydrocarbons, showed a strong difference between samples, with a high abundance of bacteria (ranging between 190 to 40,000 colony-forming units (CFU)/ml) on agar treated with samples from polluted waters and a markedly low abundance (35 CFU/ml) on unpolluted samples. The authors suggest that this could be due to the bacteria's adaptation to high concentrations of polycyclic aromatic hydrocarbons (PAHs), which the bacteria are exposed to as a result of the shipbreaking industry.

It is difficult to tell what proportion of contaminants measured in the study come directly from the shipbreaking industry, as large quantities of industrial and domestic waste flow into the Gulf of Khambat from many different river sources. However, a firm link was observed between anthropogenic pollutants in the coastal waters around Alang–Sosiya and the bacterial community structure. The control sample — 10km away from the two main sampling sites — which was labelled by the authors as ‘pristine seawater’, would be affected by this pollution from other sources.

Another potential benefit of this study is that the specific microbial biodiversity discovered on the site may be of use to those looking into the bioremediation of anthropogenic pollutants.

Source: Patel, V., Munot, H., Yogesh, S. S., Madamwar, D., (2014). Response of bacterial community structure to seasonal fluctuation and anthropogenic pollution on coastal water of Alang-Sosiya ship breaking yard, Bhavnagar, India. *Bioresource Technology* 161: 362–370. DOI 10.1016/j.biortech.2014.03.033

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Read more about: [Waste, Marine ecosystems, Sustainable development and policy assessment](#)

Small plastic fragments found in intertidal sediment from world's largest shipbreaking zone: over 80mg/kg of sediment

Plastic pollution is a threat to marine ecosystems, as plastics are persistent, toxic and can accumulate up the food chain. This study assessed the abundance of small pieces of plastic in Alang, India. The authors found on average 81 mg of small plastic fragments per kg of sediment, which they say is the direct result of shipbreaking.

“As expected, the highest amount of plastic fragments was found in the stations located at the centre of the yard, where shipbreaking activities are most intense.”

The waste generated by the shipbreaking industry is diverse, and includes asbestos, scrap paint, broken wood and an array of chemicals. However, the vast majority of marine waste (an estimated 40–50%) is made up of plastics. Plastics pose a particular challenge to the marine environment as they can drift between areas and are notoriously persistent. Although they do not degrade easily, plastics do eventually break down into smaller pieces, which can remain suspended in water or settle in sediments. Pieces smaller than 5 mm are commonly called microplastic. Plastic debris of this kind can have a significant negative effect on the health of marine ecosystems by reducing the amount of available oxygen in the water and accumulating up the food chain (bio-magnification). Microplastics were found to attract and transport hazardous chemicals, notably persistent organic pollutants, including polychlorinated biphenyls (PCBs) and dichlorodiphenyldichloroethylene (DDE), both of which may have adverse effects on animals (including humans).

Although many studies have attempted to quantify the plastic debris in marine ecosystems, none have looked specifically at shipbreaking yards. Addressing this knowledge gap, this study evaluated plastic pollution around the Alang shipbreaking yard in India, one of the world's largest shipbreaking zones due to its high tidal range, wide continental shelf, mud-free coast, gentle slope and firm seabed. The researchers built on [past](#) research conducted in the area to identify the small pieces of plastic present in the sediment between tide marks (known as the intertidal zone).

The researchers separated the shipbreaking yard into 10 sampling locations and quantified the microplastics at each location in 2004. Fragments were collected, evaluated under a microscope and identified using infrared spectroscopy (a technique measuring infrared light that is emitted, absorbed or scattered by objects to identify molecules). The plastics included polyurethane, nylon, polystyrene and polyester. The most abundant plastics were transparent plastic fragments such as polystyrene followed by nylon. Glass wool was the least abundant type of fragment. The individual weight of fragments varied from 15.8 mg for transparent plastics to 8.9 mg for glass wool. There were on average 81 mg of small plastic fragments found per kg of sediment. The least polluted stations were those located at the ends of the beach, 10 km away from the yard. As expected, the highest amount of plastic fragments was found in the stations located at the centre of the yard, where shipbreaking activities are most intense.

The major plastics identified by the study are commonly used in the construction of ships. The authors conclude that these fragments are likely to be derived from larger items used in the ships, which were then broken down into small pieces and accumulated in sediment. The researchers say the plastics they identified are unlikely to represent all of the shipbreaking-related materials present in the sediments at Alang and that more work is needed to understand their impact on marine ecosystems, but point out that their study is likely the first to describe and quantify small plastic pieces in intertidal sediments at Alang.

Source: Reddy, M. S., Shaik Basha, Adimurthy, S. & Ramachandraiah, G. (2006). Description of the small plastics fragments in marine sediments along the Alang–Sosiya ship-breaking yard, India. *Estuarine, Coastal and Shelf Science*, 68(3–4), pp.656–660. DOI: 10.1016/j.ecss.2006.03.018

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Read more about: [Waste](#), [Marine ecosystems](#)

Coast around Alang–Sosiya shipbreaking yard in India ‘strongly polluted’ with heavy metals

Alang–Sosiya shipbreaking yard in India is highly polluted with heavy metals, a study concludes. The researchers studied heavy metal contamination in sediments taken from the intertidal zone of the shipbreaking yard and compared them to a control site. The area was found to be ‘strongly polluted’ with copper, cobalt, manganese, lead and zinc.

“Although sites within the shipbreaking region were most heavily polluted with heavy metals, the authors also found some heavy metal enrichment in the control region.”

As well as re-using materials, the ship recycling industry generates a large amount of waste, including petroleum, persistent organic pollutants, bacteria and heavy metals. Metals are of particular concern due to their toxicity to marine biota and persistence in the environment.

This study evaluated the extent of heavy metal pollution at the Alang–Sosiya ship scrapping zone in India, a global shipbreaking hub with an estimated annual turnover of US\$ 1.3 billion (€1.19 million) (2003 data). The yard extends approximately 14 kilometres and contains almost 200 separate shipbreaking plots, which together dismantle approximately 10 000 tonnes of material each day. Only half of these plots are active; the remainder are dormant due to the low price of steel during the past year.

This paper built on a previous study¹ which showed concentrations of some heavy metals at Alang–Sosiya to be over between 25 and 15 500% higher than a nearby reference site. However, unlike that previous study, these researchers assessed the accumulation of heavy metals in the intertidal zone (the area between tide marks), where ships are broken down and a high degree of contamination can be expected.

The researchers assessed the concentration of heavy metals in two types of sediment: the bulk fraction (BF), which contains grains between

63 micrometres and 2 millimetres in size, and the fine-grained fraction (FF), which contains particles under 63 micrometres. Heavy metals tend to be found primarily in the latter fraction, where they are also more bioavailable and thus more likely to enter the environment.

Sediments were collected in 2002 from 10 stations along the coast, as well as from two stations at either end of the coast (5 km either side of shipbreaking zone). Reference samples were taken from a site 60 km south of the coast.

The researchers measured the total organic carbon content of the sediments as well as concentrations of heavy metals, including cadmium, cobalt, copper, chromium, iron, manganese, lead, nickel and zinc.

The amount of carbon stored in the sediment was higher at all stations in Alang–Sosiya than the control, which the researchers attribute to the domestic waste dumped by workers and nearby villagers. Carbon content was also high at the sites either end of the shipbreaking zone, which suggests carbon spreads along the coast in sediment.

Concentrations of heavy metals were up to four times higher at Alang than the end sites, and up to 19 times higher than the control site. Concentrations of heavy metals were also generally higher in FF sediments, which confirms that heavy

Source: Reddy, M. S., Basha, S., Sravan Kumar, V., Joshi, H. & Ramachandraiah, G. (2004). Distribution, enrichment and accumulation of heavy metals in coastal sediments of Alang–Sosiya ship scrapping yard, India. *Marine Pollution Bulletin* 48(11–12): 1055–1059. DOI: 10.1016/j.marpolbul.2003.12.011

*1. Tewari, A., Joshi, H., Trivedi, R., Sravankumar, V., Raghunathan, C., Khambhaty, Y., Kotiwar, O. & Mandal, S. (2001). The Effect of Ship Scrapping Industry and its Associated Wastes on the Biomass Production and Biodiversity of Biota in situ Condition at Alang. *Marine Pollution Bulletin* 42(6):461–468. DOI: 10.1016/S0025-326X(00)00185-5*

metals are bound more in this fraction than the BF fraction (due to its high surface area and the presence of organic materials).

Compared to previously reported concentrations for sub-tidal and marine sediments, all metals were more highly enriched in the intertidal sediment. This suggests that metals from ship recycling reach intertidal sediments first before being released into the sea.

Although sites within the shipbreaking region were most heavily polluted with heavy metals, the researchers also found some heavy metal enrichment in the control region. They say this is likely due to the presence of crystals rather than anthropogenic activities.²

2. Some naturally forming minerals also contain heavy metals. For example, haematite and magnetite crystals contain iron, and quartz crystals contain silicon. These can all be found naturally in sand.

The metals found at the highest concentrations at Alang were iron (137 990 parts per million), zinc (1222 ppm) and manganese (4643 ppm). By developing an index of geoaccumulation for the metals, the researchers were able to describe contamination in comparison to background levels.

Contamination with three metals — manganese, lead and zinc — along the Alang-Sosiya coast was described as ‘strong to very strong’. Some metals were almost 100 times more enriched compared to their natural, background levels. Overall, the authors describe heavy metal enrichment at Alang-Sosiya as ‘relatively high’.

“Contamination with three metals — manganese, lead and zinc — along the Alang-Sosiya coast was described as ‘strong to very strong’.”



Alang Ship Breaking Beach, Gujarat India (CC BY-NC-ND 2.0 Adam Cohn, February 2015, Flickr; www.flickr.com/photos/adamcohn/21514474481)

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Read more about: [Chemicals](#), [Marine ecosystems](#)

Marine biodiversity under threat from high levels of heavy metal pollution in Bay of Bengal

Bangladesh's economy is heavily dependent on ship recycling. However, the shipbreaking industry is polluting the Bay of Bengal, an area of high biodiversity. This study measured trace metals in sediments around the area, concluding that heavy metal pollution is at an alarming stage and an urgent threat to marine life.

"The wastes from scrapped ships, including oils and persistent organic pollutants (POPs), enter the Bay of Bengal."

In 2012, over 1250 ocean-going ships reached the end of their useful life and were [broken down for parts](#)¹. However, very few were recycled sustainably. Due to lower health and safety standards and less stringent environmental regulations, countries with developing economies host the majority of the industry. [Asia demolished over 90% of vessels by weight in 2013](#)², with major ship recycling centres in Bangladesh, China, India and Pakistan.

The Chittagong ship recycling industry was born in the 1960s and today this coastal area in Bangladesh is a major ship recycling centre. The industry, which scraps a large proportion of the world's ships, is of huge importance to poverty-stricken Bangladesh, employing around 25 000 people and offering indirect employment to a further 200 000.

However, in recent years, Bangladesh has come under criticism due to its practices, which are causing harm to the environment and human health. Ships are broken down directly on the beach (a practice known as 'beaching'), allowing harmful contaminants to enter the coastal environment.

The Bangladesh coastal environment is highly dynamic and ecologically diverse with critical terrestrial and aquatic habitats such as mangrove forests, seasonally and permanently inundated wetlands and tidal flats. These enriched ecosystems are at risk due to environmental impacts and

human intrusion. The wastes from scrapped ships, including oils and persistent organic pollutants (POPs), enter the Bay of Bengal. This, the world's largest bay, is home to a range of marine life, including many endangered and vulnerable species, and pollution has been identified as one of three major transboundary issues affecting its marine ecosystem.

This study prioritised metal pollution around the ship recycling areas. Although some metals are needed for the ecosystem to function, when heavy metals accumulate in aquatic habitats they can reach toxic levels because they are not biodegradable. Metals eventually become incorporated into the bottom sediment where organisms living there (benthic organisms) can accumulate them. Heavy metals also have an impact on organisms higher up in the water.

Recorded level of cadmium (Cd) and copper (Cu) were high enough to impact hatching and increased fish mortality in the sea area around shipbreaking areas. The impact of a higher level of mercury (Hg) has delayed development in molluscs; and lead (Pb) has caused a loss of breeding capacity in sea birds in the Chittagong coastal area. The researchers measured heavy metals in the sediment at four sites along the 10 km shipbreaking strip in Chittagong. They also measured levels at a nearby unpolluted site.

The researchers measured levels of:

Source: Siddiquee, N. A., Parween, S., Quddus, M.M.A. & Barua, P. (2012). Heavy Metal Pollution in Sediments at Ship Breaking Area of Bangladesh. In: *Coastal Environments: Focus on Asian Coastal Regions*. India: Springer: 78–87. DOI: 10.1007/978-90-481-3002-3_6. Originally published in 2009, in the *Asian Journal of Water, Environment and Pollution* Vol. 6 (3): 7–12.

1. <http://www.shipbreakingplatform.org/main-aspects/problems-and-solutions/>
2. http://unctad.org/en/PublicationsLibrary/rmt2014_en.pdf

“...the authorities should use a separate area for the shipbreaking activities, such as a dockyard, to mitigate damage to the coastal environment.”

- **Iron:** Maximum concentration was 41 361 micrograms (μg) per gram of sediment, while the lowest concentration (3393 $\mu\text{g}/\text{g}$) was lower than that of the unpolluted marine sediment. The average value was 27 370 $\mu\text{g}/\text{g}$, which concurs with previously published values from Chittagong. The researchers, however, note that the concentration of iron may not be significantly affected by anthropogenic input, as it can fluctuate naturally, is abundant in the earth's crust, and is an essential nutrient for aquatic organisms.
- **Manganese:** This metal is biologically important and has low toxicity. However, even the lowest level found at the polluted site (1.8 $\mu\text{g}/\text{g}$) was significantly higher than the unpolluted sediment (1.17 $\mu\text{g}/\text{g}$) — the standard of the [Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection](#) (GESAMP).
- **Chromium:** Distribution of this metal in the shipbreaking area was very complex in nature and its concentration did not follow any regular pattern of distribution. Average concentrations in affected and control sites were below the maximum value recommended by the [International Atomic Energy Authority](#) (IAEA) (77.2 $\mu\text{g}/\text{g}$).
- **Nickel:** Levels (average of 33 $\mu\text{g}/\text{g}$) were below the IAEA threshold (56 $\mu\text{g}/\text{g}$).
- **Copper:** At some sites, levels were above the recommended value of 33 $\mu\text{g}/\text{g}$, which could increase mortality in fish.
- **Lead and cadmium:** Levels of lead and cadmium were approximately 6.5 and 8.5 times higher than the levels recommended by the [Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection](#) (GESAMP), respectively.
- **Mercury:** Levels of mercury in polluted sites were an astounding 94 times higher than the recommended concentration. This is a major concern, as methylmercury is a nervous system toxin and a significant threat to human and environmental health³.

Of greater concern were:

- **Zinc:** Concentrations (average 112 $\mu\text{g}/\text{g}$) were higher than the IAEA recommended level of 95 $\mu\text{g}/\text{g}$, and higher than in marine sediment from other parts of the world, the researchers assert. Levels of just 0.1–1 $\mu\text{g}/\text{g}$ of zinc in soft water are lethal to all fish species.

Researchers suggest that fishery resources in the coastal area of Chittagong seem to be affected by the shipbreaking activities as revealed by increased fishing efforts, reduced catch per unit effort (CPUE) per boat/day and reduced species diversity. The researchers say that this decrease of catch and availability of fish is not only due to pollution, or destruction of fish larvae, but also due to other factors such as an increase of the number of boats and demand for fish.

The researchers conclude that heavy metal pollution in this area is at an ‘alarming’ level. They suggest shipbreaking is a serious environmental hazard and that if the industry is to continue in Bangladesh, efforts must be made to minimise the pollution. For example, they say the authorities should use a separate area for the shipbreaking activities, such as a dockyard, to mitigate damage to the coastal environment.

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Read more about: [Sustainable development and policy assessment](#), [Environment and health](#)

The future for Bangladeshi ship recycling: a critical scenario analysis

A large proportion of ships are recycled on the beaches of developing countries in Asia. This study considers shipbreaking in Bangladesh, using critical scenario analysis to explore different futures for the industry and its workers. The paper suggests that a radical shift in socioeconomic and political structures is needed to enable environmentally sound practices while retaining employment opportunities for local people.

“...ships are driven ashore at high tide (a practice known as ‘beaching’) before being broken up by workers who often lack basic safety equipment and are at risk not only from industrial accidents, but from long-term inhalation of carcinogenic toxins such as asbestos.”

Shipbreaking has become a cornerstone industry in south Asia, partly as a result of increasing environmental awareness and regulations on hazardous waste disposal in more developed nations. It is economically beneficial and often simpler (in regulatory terms) to send ships to Asia rather than to dismantle them in Europe. However, ship-recycling practices are rudimentary and often unsafe.

In the shipbreaking yards of Bangladesh for example, ships are driven ashore at high tide (a practice known as ‘beaching’) before being broken up by workers who often lack basic safety equipment and are at risk not only from industrial accidents, but from long-term inhalation of carcinogenic toxins such as asbestos. The beaching process is also highly toxic to the marine environment, leaving traces of oil, asbestos and persistent organic pollutants on beaches. These factors, alongside the wide use of child labour, has led Western governments and NGOs to condemn the practice of beaching and to implement international controls such as the [Basel Convention](#) to prevent it.

This paper explored the current and possible future status of shipbreaking in Bangladesh, with a particular focus on the outlook for workers. The shipbreaking industry involves many different stakeholder groups, perspectives and complex economic connections. In order to approach the complex issues and uncertainty surrounding the future of shipbreaking, the author

applied scenario analysis — a framework for investigating complex and ambiguous business issues. Scenario analysis involves challenging conventional thinking in order to generate possible futures and begins by identifying the driving forces (e.g. political, economic or social factors) that will affect the issue. In this case, the driving forces were the effectiveness of global regulation and commitment to ‘green practices’ in Bangladesh.

Following a broad comprehensive review of published literature on the subject¹, four scenarios were developed:

- **Global Cooperation:** Global regulation combined with national commitment (best case)
- **World Divided:** Global regulation without national commitment
- **Bangladesh Goes Alone:** National commitment without global regulation
- **Business-as-usual:** Failure of both global and national control and commitment (worst case)

The impact on and response to each scenario was estimated for major stakeholder groups, including yard workers and owners in Bangladesh, yard workers in other developing nations, consumers and ship owners in the developed world and NGOs.

Source: Cairns, G. (2014). A critical scenario analysis of end-of-life ship disposal. *Critical perspectives on international business* 10(3):172–189. DOI: 10.1108/cpoib-10-2012-0049.

1. Including academic literature, grey literature, commercial, governmental and non-governmental publications.

The researcher says the ‘best case’ scenario of effective global regulation and a new ‘green’ industry in Bangladesh may not be viewed positively by all stakeholders, as it is not likely to provide employment for the thousands of current workers. If there is global regulation but no commitment in Bangladesh, investment will likely go elsewhere, also causing job losses. As many of the current workers have had few education opportunities and come from rural areas of Bangladesh where there are few alternative job opportunities, many have protested against such changes. Although there is the potential for safer and higher paid jobs in a new ‘green’ industry, the researcher says this could only involve a minority of the current workers.

Similarly, ship owners may oppose the change, as they would be responsible for the cost of safe and environmentally friendly disposal. The cost would translate into higher shipping costs and thus higher commodity costs for producers and consumers, which may not be desirable in the competitive global market.

The paper concludes that — regardless of the future status of the industry — the situation for the majority of workers in Bangladeshi shipbreaking yards is unlikely to change. The author suggests that, with no commitment to or investment in alternative employment, there is no best case situation for the workers who face the risk of accident, illness or death in the present industry, or unemployment outside of it. In all four scenarios modelled, the workers fare the worst, and have little power to change their situation.



Shipbreakers with Steel Beam, Alang Shipyards (CC BY-NC-ND 2.0 Adam Cohn, February 2015, Flickr; www.flickr.com/photos/adamcohn/20863228643)

Although none of the scenarios presented here are a predicted, likely future, the findings do identify important issues and perspectives to consider when discussing how richer-world shipping companies dispose of their redundant vessels and how developing countries engage in ship recycling.

“...with no commitment to or investment in alternative employment, there is no best case situation for the workers who face the risk of accident, illness or death in the present industry, or unemployment outside of it.”

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Read more about: [Resource efficiency](#), [Waste](#), [Environment and health](#)

The Turkish shipbreaking industry: review of environmental, health and safety issues

Turkey is a major ship recycling centre and is the largest OECD member country with a significant ship recycling industry. In this 2008 study, published before the adoption of both the Hong Kong Convention and the EU Ship Recycling Regulation, researchers reviewed the environmental, health and safety issues surrounding the Turkish shipbreaking industry, its compliance with environmental regulations, and ability to claim 'green recycling'.

"Turkey is the tenth largest steel producing country in the world. Its steel industry is dependent on scrap iron, a proportion of which (1-2%) comes from ships broken down at one site."

Shipbreaking — the dismantling of old and non-functional ships, or those which cost more to keep in operation than to scrap — enables the re-use of valuable materials. It enables the financial viability of the shipping sector, is a major supplier of steel and a critical part of the economy in many developing countries. In environmental terms, recycling of scrap metals from ships reduces the need for mining, which uses primary energy, generates greenhouse gas emissions and damages the earth's surface. However, shipbreaking has its own environmental impacts, which this study explores in the context of Turkey.

Shipbreaking is an important industry for sustainable production. However, its potential is currently limited due to the hazardous contaminants found on board ships, which can be harmful to workers and the natural environment. Regulations are essential to control these effects and, since 2004, old ships have been considered to be a form of toxic waste by the Basel Convention¹. The researchers discuss a trend for converting shipbreaking yards into areas for construction and repair occurring across Europe and Asia, and warn that regulations — such as those in the Basel Convention which include actions aimed to improve occupational safety, occupational health and environmental protection — may cause shipbreaking to become restricted to countries with developing economies.

Turkey is the tenth-largest steel producing country in the world². Its steel industry is dependent on scrap iron, a proportion of which (1–2%) comes from ships broken down at one site: Aliğa, in the Aegean Region, west Turkey. This is a major ship recycling site; 4% of the World's global ship fleet was scrapped here between 1994 and 2002, making it one of the top five recycling countries in the world.

Shipbreaking has been taking place in Aliğa since 1976. It is near a number of steel works that use the scrap iron and steel as raw material and there are no major tides in the area, facilitating ship dismantling.

Ships are broken down there following 'modified slipway recycling'. Slipway recycling is used in areas with lower tidal ranges. It involves dragging a ship onto a concrete slipway, which extends into the sea. In the modified form of slipway recycling that occurs at Aliğa, vessels are brought ashore before the vessel is cut from the bow and 600–800 tonne sections are cut off and pulled onto an on-shore cutting area. Smaller sections and equipment are later removed by cranes. As the shore ground contains densely packed soil, vehicles and cranes can operate close to the vessel.

This process generates solid and liquid waste, as well as atmospheric pollutants. A study

Source: Neşer, G., Ünsalan, D., Tekoğul, N. & Stuer-Lauridsen, F. (2008). The shipbreaking industry in Turkey: environmental, safety and health issues. *Journal of Cleaner Production* 16(3): 350–358.
DOI: 10.1016/j.jclepro.2006.08.018.

1. 'Technical guidelines on environmentally sound management of full and partial dismantling of ships'. See: <http://www.basel.int/Portals/4/Basel%20Convention/docs/meetings/sbc/workdoc/techships-e.pdf>
2. Chamber of Mechanical Engineers of Turkey (2005) Report on the Turkish iron and steel industry

conducted in the seawater around the Aliğa yard took samples from a location near to the shipbreaking yard, at four different times of year — February, June, April and October. The research revealed high levels of aluminium, iron, cadmium, nickel, zinc, fluoride, nitrates and phosphates. Extremely high levels of heavy metals were found and, along with fluid wastes, were identified as the main polluters of the coastal area. The study also found that levels of fluoride were higher than normal — attributed to the shipbreaking industry.

In terms of regulation, Turkey is a member of the [Basel Convention](#) on hazardous waste. As an [Organisation for Economic Co-operation and Development](#) (OECD) member country, Turkey is able to recycle ships under the EU Waste Shipment Regulation which prohibits exports of hazardous waste to non-OECD countries.

The Aliğa yard is also regulated by Turkey’s Ministry of Transportation, which requires measures to prevent pollution caused by shipbreaking. In 2004, a regulation, published by the Undersecretariat for Maritime Affairs, reiterated the importance of hazardous waste disposal as stated in the Basel Convention. According to these regulations, companies that do not comply with the preventive measures of the Basel Convention (such as the cleaning of toxic contents from the ship before recycling takes place) will not be allowed to perform shipbreaking. The researchers make recommendations for future enforcement of this regulation, including inspection methods to ensure environmental protection and health and safety outcomes are achieved.

“Slipway recycling is used in areas with lower tidal ranges. It involves dragging a ship onto a concrete slipway, which extends into the sea.”



Naparima: Oil/Chemical tanker on its way from Liverpool to Aliğa (Turkey)(CC BY 2.0 Smabs Sputzer April 2015, Flickr; <https://www.flickr.com/photos/10413717@N08/17050545968/>)

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Read more about: [Waste](#), [Resource efficiency](#), [Sustainable consumption and production](#)

Costs estimated for upgrading ship recycling to environmentally friendly standards

A 2013 study has estimated the costs of upgrading existing ship recycling facilities to more environmentally friendly, and regulatively compliant, standards. The research focuses on alternatives to the 'beaching' method of shipbreaking, widely criticised for its environmental impact and safety record.

"Partly because of the lack of safeguards, beaching is cheaper and currently more profitable than more environmentally friendly methods of ship recycling."

Beaching — running end-of-life ships aground on tidal plains for ease of dismantling — has been widely criticised for both its human and environmental record.

For example, for its lack of safeguards to protect against, prevent or contain discharges or emissions of hazardous substances to sea and the surrounding environment. This study only considered the upgradability of other methods of recycling (piers and slipways). It did not, however, consider whether upgrading beaching facilities was feasible.

A medium-sized crude oil tanker is made of around 15 000 tonnes of steel, with a scrap value of around six million USD (5.38 million). Adding to this the value of recycling the many other components, such as electrical devices and lifesaving equipment, makes recycling end-of-life ships a potentially profitable business.

Partly because of the lack of safeguards, beaching is cheaper and currently more profitable than more environmentally friendly methods of ship recycling. This is a problem that many nations, regulators, organisations and NGOs are working to address, aiming to improve standards.

Dry dock recycling is a costly, but more sustainable alternative to beaching. This is when the ship is sailed into a dock and the water pumped out, leaving the ship in a dry environment. While it is better for the environment, as there is less pollution to surrounding waters, it is an underused technique because of its cost.

A study commissioned by the United Nations Environment Programme (UNEP), published in 2013, has attempted to identify cost-effective, environmentally sound alternatives to beaching and to estimate the costs of upgrading other facility types to environmentally sound management standards.

To do this, the study first identified the most current (as of 2012/13) regulations and proposed regulations (and their drivers) for environmentally sound ship recycling. This included, for example, the regulations from around the world.

These formed a base for identifying the components of environmentally sound management practice. This included elements such as identification and documentation of hazardous materials, equipment and yard facilities required for safe dismantling and handling of hazardous materials, and the use of quality assurance schemes.

This was followed by a review of currently used ship recycling methods and an assessment of existing recycling nations to identify countries where a suitable 'model' facility might easily be established.

Using all of this information, the researchers examined the costs associated with upgrading each example case of existing non-beaching facility to environmentally sound and safe ship recycling. The costs to upgrade to environmentally sound management were estimated for a model facility depending on its individual circumstances. The main model facility is assumed to have a 100 000 LDT

Source: United Nations Environment Programme (UNEP) feasibility study for ship dismantling. <http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-SHIPS-WHITEP-2013ShipDismantlingStudy.English.pdf>
Litehautz Maritime Environmental Consultancy, 2013.

“...the main barriers to a greener ship recycling industry lie in fear of job losses; a lack of strict regulations for ship owners or lenders in the secondhand shipping or scrap trade; and problems linked to the selection of verified ship recycling yards.”

(light displacement tonnage — i.e. the weight of water displaced by the ship without cargo, fuel, passengers, crew etc.) dismantling capacity per year. To compare upgrade requirements for smaller facilities, a cost analysis for 25 000 LDT and 50 000 LDT is included. The researchers identified four different examples for analysis.

1. Upgrade of existing pier breaking yards: Pier breaking takes place in harbours or rivers, often located in sheltered and calm waters, making containment and remediation measures easier, limiting the potential for release or dispersal of hazardous waste. This method is used in yards in the Yangtze in China and in some Turkish yards.
2. Upgrade of existing slipway breaking yards: ships are sailed against the shore or a concrete slipway extending into the sea. The ship is dismantled by removing pieces with a mobile crane onshore, or from barges while dragging the ship up on the shore as it is lightened, providing better opportunities to control spillages.
3. Upgrading an existing basic pier area to compliant pier breaking.
4. Upgrading an existing basic harbour area to slipway breaking.

For each case, the authors also considered the costs associated with different sizes of facility, capable of handling ships of small, medium and large sizes.

The costs for upgrading were, in the order of large (1 000 LDT), medium (50 000 LDT) and small (25 000 LDT) facilities: (Case 1) 9.5 (€8.52), 3.9 (€3.50) and 1.9 (€1.70) million US dollars; and (Case 2) 21 (€18.84), 12.9 (€11.57) and 7.5 (€6.73) million US dollars.

Costs for upgrading both basic piers and slipways to environmentally friendly breaking yards were very similar. Case 3, basic piers, was the most versatile upgrade, because it does not

place any demands on the site, costed in the region of 23.9 (€21.44), 14.3 (€12.83) and 9.5 (€8.52) million US dollars, depending on size. Basic slipways (Case 4) was costed in the region of 24.9 (€22.34), 14.8 (€13.28) and 9.7 (€8.70) million US dollars, again depending on size.

The differences in cost between different sizes of facility were almost directly proportional to the amount of concrete for construction/upgrading of facilities and heavy machinery needed. The main concrete costs were in the construction of areas to contain spillages.

Other operational measures, of equal importance to the upgrade process, had far less financial impact.

Costs for basic infrastructure, such as access roads, quays and downstream waste processing and handling facilities were not included in the cost estimates.

Ports suitable as Case 1 were identified in areas of India, China and the Dominican Republic. For Case 2, the authors state that a wide range of ‘domestically oriented locations’ across the world would be suitable for smaller facilities, with a larger site identified in Mumbai, India.

Cases 3 and 4 could be applied more or less anywhere in the world where there is an existing port or slipway, the researchers say.

The researchers conclude that the main barriers to a greener ship recycling industry lie in fear of job losses; a lack of strict regulations for ship owners or lenders in the secondhand shipping or scrap trade; and problems linked to the selection of ratified ship recycling yards. The forthcoming [European List](#)¹ (expected to be published at the end of 2016) of ship recycling yards will establish a list of ship recycling facilities both within Europe and the rest of world, which meet the requirements from the new ship recycling regulation.

1. <http://ec.europa.eu/environment/waste/ships/list.htm>

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Read more about: [Waste](#), [Marine ecosystems](#), [Sustainable development and policy assessment](#)

Constituent materials more important than weight or class for environmental impact of shipbreaking, but valuation methods differ greatly

When broken down, ships can release hazardous substances into the environment. This study investigated the environmental impact of shipbreaking in one of Europe's few ship recycling yards, based in Portugal. The results reveal large differences between assessment methods and show that environmental impact depends on composition rather than size or class.

"...at least 85% of the materials removed from merchant vessels were recycled. The proportion of recycled materials was lower for military ships, but it was still the most significant final destination for materials."

Although all shipbreaking sites have an environmental impact, these issues are more commonplace at sites in south Asia, such as Bangladesh, Pakistan and India, which host the majority of the global industry. Europe makes a relatively small contribution, dismantling just 3% of ships globally (by weight). In the [OECD](#), there are registered shipbreakers in, for example, Italy, Spain, Turkey and the UK.

There are similar concerns throughout the global industry. A European Commission green paper '[On better ship dismantling](#)'¹ revealed that the industry produces millions of tonnes of materials of environmental concern such as oil, paint and asbestos — and that radical industrial change is needed to lessen the high human and environmental costs as soon as possible. Following this paper, the Commission adopted a [comprehensive regulation on ship recycling](#)² to reduce the negative impacts associated with ships flying EU Member State flags.

This study focused on the Portuguese industry. Although Portugal has a small shipbreaking industry (accounting for just 0.1% of all companies related to maritime activities in

2001), it is diverse and dismantles many different types of ship. The researchers, who were part-funded by the European Commission³, set out to determine the environmental impact of dismantling these different ships, using data collected from an environmentally certified (according to norm [NP EN ISO 14001:2004](#)) dismantling yard in Lisbon.

The researchers collected information on the amount and type of materials removed from 23 different types of ship: 18 merchant vessels (including nine transportation ships, three fishing vessels and six auxiliary ships) and five military ships. The researchers assessed the proportions of seven groups of materials in each ship: ferrous materials (e.g. steel), non-ferrous metallic materials, glass, wood, dangerous solid substances, dangerous liquid substances and 'undifferentiated' materials. For most ships, ferrous materials were the major constituents; however, wood accounted for 60% of the gross tonnage of the fishing vessels.

The researchers also assessed how many of the materials were recycled, as opposed to being re-used or sent to landfill. They found at least 85% of the materials removed from merchant vessels

Source: Carvalho, I., Antão, P. and Soares, C. G. (2011). Modelling of environmental impacts of ship dismantling. *Ships and Offshore Structures* 6(1–2):161–173.
10.1080/17445301003776233

1. http://ec.europa.eu/environment/waste/ships/pdf/com_2007_269_en.pdf

2. <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013R1257>

3. MARSTRUCT (Network of excellence in marine structures) was supported by the European Commission under the Sixth Framework Programme. See: <http://www.mar.ist.utl.pt/Marstruct/index.aspx>

“...this research also shows that the weight of a ship or its class does not directly correlate with environmental impact. Instead, the types and relative amounts of constituent materials are more important.”

were recycled. The proportion of recycled materials was lower for military ships, but it was still the most significant final destination for materials.

Using this data, the researchers modelled the environmental impact for the different ships and under four scenarios: dismantling of the ship (the current, ‘real world’ scenario), total recycling of the ship (a fictitious scenario, in which all materials are recycled), ship [abandonment](#), and ship sinking. They used the life cycle assessment tool [SimaPro](#) to conduct the analysis, alongside four different environmental impact assessment methods.

The researchers deemed that two of the four assessment methods used were sufficient to assess environmental impact. The first approach, eco-indicator 99 (H), was developed by the [Dutch Ministry of Infrastructure and the Environment](#) and measures human health, ecosystem quality and resource impacts. The second, [IMPACT 2002+](#), measures cumulative toxicological risk and ecosystem impacts associated with emissions. As well as the categories measured by eco-indicator 99 (H), it also estimates climate change impact.

Both methods reported environmental impact in units called points, specifically millipoints (mPt). 1 mPt represents the yearly environmental load of one average European inhabitant. These units allowed comparison between ships and methods.

There was a vast difference in the scale of the values calculated by the two methods; the environmental impacts calculated by eco-indicator 99 (H) were 1000 times higher than the IMPACT 2002+. The researchers suggest these could set upper and lower limits for environmental damage. They highlight that the methods are based on different assumptions and that they weigh various factors differently, which makes a direct, quantitative comparison difficult. However, it is possible to compare the relative ranking of influencing factors.

According to eco-indicator 99 (H), ecosystem quality impacts were the greatest for all ships, while for IMPACT 2002+, human health impacts were the largest (with the exception of some military ships, for which climate change impacts were the most significant).

Most importantly, although the two methods generated substantially different results and assessed different environmental issues, both showed that impact did not correlate with gross tonnage or class. Instead, the relative proportion and types of materials were more important. Of the different ship classes, merchant and military vessels were the worst performing; their maximum values of environmental impact were around twice that of the fishing and auxiliary vessels.

Comparison of the four scenarios showed that full recycling had similar environmental impacts to the dismantling (current) scenario. This is perhaps to be expected, given that around 60–100% of materials removed from ships are recycled already. Abandonment and sinking also had similar impacts, although these were higher than those generated by recycling and dismantling, confirming the environmental benefits of recycling.

Ship recycling has negative environmental impacts, whatever the methods used, but the impacts of ship dismantling are shown to be less than abandonment or sinking. The researchers assert that the valorisation of parts, via the re-use, recycling and treatment of the materials and equipment removed from ships can mitigate the impact. They also note that the ship-dismantling scenario did not contribute to depletion of the ozone layer (as assessed by the IMPACT 2002+ method). Importantly, this research also shows that the weight of a ship or its class does not directly correlate with environmental impact. Instead, the types and relative amounts of constituent materials are more important.

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 Read more about: [Resource efficiency, Sustainable production and consumption](#)

Design for recycling: a route to green ship recycling

Ship recycling, at the end of a ship's useful life, aims to make the industry more environmentally sustainable and is a major source of employment in developing countries. However, there are associated health, safety and environmental concerns. This study argues these concerns are due to inappropriate design and explains how 'design for recycling' can reduce the costs and risks of ship recycling.

"...to address the negative impacts of ship recycling properly, hazards must be considered during the design process."

The final stage of a ship's life cycle — recycling — is essential for renewal of the shipping fleet. On average, 96% of the ship can be recycled or reused¹. The re-use of increasingly scarce materials also reduces the burden that shipping places on natural resources, improving the environmental sustainability of the industry.

Ship recycling also supports the developing economies of several countries, such as Bangladesh, China, India, Pakistan and Turkey, which together represent 97% of the world's ship recycling capacity. However, current recycling practices can have negative social and environmental impacts. Ships contain toxic materials such as asbestos and heavy metals, which many ship recycling hubs do not have the infrastructure to treat, generating health and safety concerns for workers and contaminating the natural environment.

Awareness of the risks of ship recycling was first raised in the early 1990s, leading the [International Maritime Organization](#) (IMO) to adopt the Hong Kong Convention for the Safe and Environmentally Sound Recycling of Ships in 2009. More recently, the EU has published a [Ship Recycling Regulation](#)², which aims to reduce the negative impacts caused by recycling Member State-flagged ships.

The researchers of this paper argue that, to address the negative impacts of ship recycling

properly, hazards must be considered during the design process. 'Design for recycling', a concept which involves identifying the recycling challenges during the design stage, has already been successfully applied in the automobile industry. In the context of ships, it could involve identifying hazards, such as toxic paints, or inefficiencies, such as oil tanks that must be manually cleaned before they can be recycled.

Their basic principle is for ship designers to ensure that recycling is as safe, efficient and environmentally friendly as possible. Not only would this prevent or reduce the use of materials such as asbestos, PCBs (polychlorinated biphenyls), heavy metals and oils (e.g. residual fuels) that could be a threat to workers and the local environment during dismantling, it would also reduce risk throughout the ship's life cycle, decreasing risks to builders and crew members.

The concept has three key objectives: providing an accurate inventory of hazardous materials, reducing or replacing hazardous materials, and making the ship easy to dismantle. The latter could be achieved by using techniques such as standardisation of all parts and equipment on every ship to make it easier to identify the components of end of life ships for potential reuse, remanufacturing or recycling.

Other techniques for ease of dismantling would be to include properly designed lifting

Source: K.P. Jain, J.F.J. Pruyne & J.J. Hopman (2014). Influence of ship design on ship recycling — Proceedings 2nd International Conference on Maritime Technology and Engineering. *Maritime Technology and Engineering*. ed. Guedes Soares, C.; Santos, T.A. London, UK : CRC Press – Taylor & Francis Group: 269–276. DOI: 10.13140/2.1.1517.3127

1. McKenna, S.A, Kurt, R.E & Turan, O. (2012). A methodology for a 'design for ship recycling' in *The Environmentally Friendly Ship*: 28-29 February 2012, RINA HQ, London. Royal Institution of Naval Architects, London, pp. 37–44, International Conference on the Environmentally Friendly Ship, London, UK, 28-29 February 2012.
 2. <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013R1257>

supports for handling dismantled structural parts to minimise accidents due to falling components. The key objectives could be incorporated into design rules through IMO codes, for example.

However, there are concerns about the impact that implementing these changes would have on the costs of building and operating ships. To deal with these additional costs, the researchers suggest the expense of creating inventories of hazardous materials be borne by the ship owner (as in the ‘polluter pays’ principle). They also say costs should be calculated for different replacement materials and design changes in order to identify the most affordable options.

The researchers say the negative impacts of ship recycling presently undermine the industry’s contribution to sustainable development.

Within this paper, the researchers describe a method, with techniques for efficient ship dismantling, to reduce these negative impacts by improving ship design and, ultimately, to achieve cost-effective, green ship recycling.

“...the researchers suggest the expense of creating inventories of hazardous materials be borne by the ship owner (as in the ‘polluter pays’ principle).”



Shipbreaking Operation at Alang, Gujarat India (CC BY-NC-ND 2.0 Adam Cohn, February 2015, Flickr; www.flickr.com/photos/adamcohn/20882968384)

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Read more about: [Resource efficiency, Sustainable production and consumption](#)

Environmental impact of recycling metals from ships: a life cycle assessment

Life cycle assessment (LCA) can measure the environmental impact of the different stages of a ship's life cycle, from design to dismantling. This assessment focused on the impact of recycling the metal parts of a ship and did not consider the crucial impact of the hazardous materials present on board. The results showed that re-use of metals had environmental benefits, but overall these were small compared to the environmental impact of other stages, such as operation.

“This study aimed to estimate the environmental impact of the end-of-life phase compared to the overall life cycle of a ship.”

Global trade is dependent on seaborne transport — over two thirds of goods worldwide are carried by ships. However, the amount of seaborne transport has decreased recently. Following the 2008 financial crisis, demand for the transport of goods fell and ships on the world's oceans reached overcapacity. Many older vessels were decommissioned and scrapped, generating business for the ship recycling industry.

Most of this business went to Asia, where over 90% of ships are scrapped¹. In countries such as India and Bangladesh, ships are often dismantled under harsh working conditions and with few environmental protection measures. Many ‘scrapyards’ are simply beaches, where ships are pulled ashore and manually disassembled.

Due to the human and environmental cost of such practices, international agreements have been launched to improve management of ships at the end of their useful life, including the [Basel Convention](#), [Hong Kong Convention](#) and the more recent [EU Ship Recycling Regulation](#).

This study aimed to estimate the environmental impact of the end-of-life phase compared to the overall life cycle of a ship. The researchers first performed a literature review of existing ship LCA studies. They found that many studies have been published in the past 15 years, but few focused on end-of-life. A number of

assessment tools have also been developed, such as the ‘Tool for Environmentally Efficient Ship Design’, developed as part of the [Energy Efficient Ship project](#)². This tool aids decision making during design to reduce energy consumption and environmental impact, and was used by the authors of this study.

Based on the findings of the literature review, the researchers developed their own end-of-life assessment approach, using a simplified model that takes into account all three phases of the ship life cycle (building, operation and scrapping). The model was created with the product sustainability software [GaBi](#) and assessment was performed based on [ISO 14040 guidelines](#). The model was based on one ship with a mass of 5 000 tonnes (without cargo). The impact assessment focused on the metal components of the ship (mainly steel), which were assumed to contribute 75% of its overall mass. The authors describe this as a ‘first screening’ of the environmental impacts of ship recycling and did not assess the impact of environmental contamination with hazardous substances, but say they hope to do so in future work.

Two scenarios for scrapping were evaluated, with different approaches to recycling. The first scenario represented *general recycling* of the metals, separated into ship body and machinery. This assumes general recycling of steel for other industries. In the second scenario, the researchers

Source: Ko, N., Gantner, J. & Wehner, D. (2015). Life cycle assessment of ships with special consideration of ship scrapping. *Matériaux & Techniques*, 103(1), p.101. DOI: 10.1051/mattech/2015002.

1. M. Sarraf, F. Stuer-Lauridsen, M. Dyoulgerov, R. Bloch, S. Wingfield, R. Watkinson, *The Ship Breaking and Recycling Industry in Bangladesh and Pakistan*, The World Bank. Washington, DC, 2010.
2. *The Energy Efficient Ship (TEES) project was funded by the European Commission under a cooperative research contract. See: http://cordis.europa.eu/project/rcn/46334_en.html*

looked at the impact of *re-using metals*, for example, putting machinery in a new ship. Any materials that cannot be re-used are recycled as in the first scenario.

The contribution of the end-of-life phase to the overall environmental impact of the ship (in each scenario) was evaluated using five categories: impacts on climate (global warming potential), impacts on plants and soil (acidification potential), impacts on soil and water (eutrophication potential), impacts on the lower atmosphere (photochemical ozone creation potential) and energy use (primary energy demand). The researchers used the [CML impact assessment methodology](#)³, developed by [Leiden University](#).

Scenario two (re-use) had greater environmental benefits compared to general recycling (at least 23% (in terms of impacts on soil and plants through acidification, based on a re-use rate of 20%) and up to 101% (for impacts on the lower atmosphere, based on a 60% re-use rate). However, when the researchers compared the environmental impact of all the life stages, they found that the ship's working life (operation stage) has the greatest impact.

End-of-life causes the least environmental damage of all stages, but at best could only compensate for half of the environmental damage caused by ship building. Overall, it had less than 1% influence on environmental impact, suggesting that other stages of the life cycle may be more important for making environmental gains. However, the researchers say recycling may have a more significant impact via categories not measured in this study, such as [resource efficiency](#).

The scenarios assessed here show that ship recycling is environmentally beneficial. However, this study did not consider economic and social factors, such as the economic value of ship recycling for poorer countries, or the impacts of exposure to hazardous materials. As the project develops, the researchers hope to use their model to evaluate the environmental, economic and social impacts of ship designs, in order to optimise sustainability in the ship building industry.

“...when the researchers compared the environmental impact of all the life stages, they found the ship's working life (operation stage) has the greatest impact.”

3. <http://www.universiteitleiden.nl/onderzoek/onderzoeksoutput/wiskunde-en-natuurwetenschappen/cml-cml-ia-characterisation-factors>

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Read more about: [Resource efficiency](#), [Chemicals](#)

Resource use and pollutant emissions due to ship recycling in India

The Alang shipbreaking yards in India recycle almost half of all end-of-life ships worldwide. The major activity at the yards is plate-cutting, used to recover steel from ships. This process consumes nearly 29 kg of oxygen and 7 kg of liquefied petroleum gas (LPG) and emits almost 22 kg of CO₂ per 1 km-long cut with a 1 mm depth. This study reveals the carbon footprint and resources consumed in the cutting of steel plates. The method used to derive these findings could be adapted to ship dismantling yards worldwide.

“EU-funded researchers investigated the pollution associated with the cutting of steel ‘plates’, an important process for recovering steel from ships.”

India is home to the world’s biggest ship recycling zone, which accounts for almost half of all ships recycled worldwide. Every year at the Alang shipbreaking yards in western India, over 350 ships are broken down and recycled.

There are many benefits to the ship recycling industry in India. It generates materials that can be re-used or recycled — for example, it provides raw materials for nearby steel mills (almost 2% of all steel produced in India comes from ship recycling). This reduces the need for mining and thus reduces pressure on natural resources. Ship recycling is also a local source of employment — the industry in India alone is estimated to employ around 60 000 people.

However, the process is also hazardous for workers and pollutes the coastal environment. In this study, [EU-funded](#)¹ researchers investigated the pollution associated with the cutting of steel plates, an important process for recovering steel from ships.

Like most shipbreaking yards, plate cutting is the major operation that takes place at Alang; almost 70% of the manual workforce is dedicated to the process. Here, plates are cut manually using handheld devices called Oxy-LPG torches. The researchers estimated the resources used and pollution generated by this process, in an effort to better understand the associated health, safety and environmental concerns.

The researchers developed an input–output framework which, alongside extensive field data, was used to estimate inputs of labour, oxygen and fuel, and outputs of CO₂ and paint.

The results suggest that approximately four hours are spent cutting plates, per 1 km of length and 1 mm depth, while the total time spent on plate-cutting (including supporting activities such as moving the plates) is double that. The results further showed that approximately 6.2 kg of LPG (liquefied petroleum gas) and 28.5 kg of oxygen is used for each 1 km long and 1 mm deep cut.

Ships contain significant amounts of paint on their hull surfaces, which can chip off during loading, transport and cutting of steel plates. Per 1 km length/1 mm depth of plate cut, 0.9 kg of paint is emitted to the atmosphere and 1.34 kg is deposited to intertidal sediments, the researchers say. Related CO₂ emissions were even higher, at 21.77 kg.

These are average values, and the researchers note that the rate of plate-cutting may vary based on factors such as the experience of the cutter. They also say that plate cutting is not the only source of air and sediment pollution due to ship recycling, and therefore the outputs described in the study probably represent an underestimate.

However, the researchers describe their results as ‘fairly accurate’ and say they will aid efforts to make ship dismantling greener. Furthermore, the approach used to generate their results could be applied to shipbreaking yards worldwide.

The emissions factors presented here could also help to design technological solutions to minimise health and safety risks and protect the environment. For example, scrapping the surface coating before cutting the steel plate could

Source: Deshpande, P.C., Kalbar, P.P., Tilwankar, A.K. & Asolekar, S.R. (2013). A novel approach to estimating resource consumption rates and emission factors for ship recycling yards in Alang, India. *Journal of Cleaner Production* 59: 251–259. DOI: 10.1016/j.jclepro.2013.06.026.

¹ *Dismantling of Vessels with Enhanced Safety and Technology (DIVEST)* is funded by the European Commission under its Seventh Framework Programme. See: http://cordis.europa.eu/result/rcn/54389_en.html

reduce the toxic gases generated by plate-cutting. Although there is a cost associated with adopting such new technologies, they are important in the light of international regulations (such as the [Hong Kong Convention](#) and the more recent

[EU Ship Recycling Regulation](#)) and in the long-term will help ship recycling yard owners to attract clients looking for green ship recycling yards.

“The emissions factors presented here could also help to design technological solutions to minimise health and safety risks and protect the environment.”



Shipbreakers with Acetylene Gas. Alang, Gujarat, India. (CC BY-NC-ND 2.0 Adam Cohn, February 2015, Flickr; www.flickr.com/photos/adamcohn/21484274655)

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Read more about: [Resource efficiency](#), [Waste](#), [Sustainable development and policy assessment](#)

Ship manufacturers encouraged to keep track of materials

An inventory of materials used in ship construction could minimise waste and increase ships' recycling rates and resale value, according to the Sustainable Shipping Initiative (SSI). Although extra data management would be required on the part of suppliers, manufacturers and owners, it would help make the industry more efficient and future-proof with regard to developments in international legislation on ship building.

"...a greater focus on material use may lead to improvements, not only in recycling but also in initial ship design."

Over 90% of international goods are traded by sea. Whilst other large transport industries, such as cars and aviation, have established component listing schemes, the shipping industry has no similar standardised practice. This is despite the fact that ships are often constructed with valuable materials, such as lengths of flexible cabling, and can contain hazardous materials, including asbestos. Recording material use in cars has allowed toxic components, such as chromium-6, to be stringently regulated, reduced and, where necessary, stored safely.

In an effort to change the status quo in shipping, the SSI worked with a variety of businesses and academics to investigate how ships could be better designed, built, dismantled and re-used. Recording the use of materials was identified as a major area which would have an impact at all stages of a ship's life cycle. This data could be used to instil responsibility for the social and environmental effects of the materials used during a ship's lifespan — from construction to recycling.

Pilot projects and consultations with four major shipping companies were initiated. Two of these companies used Hewlett-Packard's [Compliance Data Exchange](#) (CDX) software system to help trace and track materials used in ship construction. This system helps manufacturers to collect, analyse and report data from all levels of the supply chain. Supplementary research from the University of Strathclyde analysing the waste streams of 1 000 vessels from five years of recycling data was used to highlight ongoing trends.

During the pilot projects there was reluctance from within the industry regarding material tracing and tracking. It was seen as a very time-consuming and costly activity; there were no immediate incentives; manufacturing trade secrets could be breached; and the CDX software had to be adopted not only by manufacturers, but also by those along the supply chain.

Despite these reservations, the pilot projects demonstrated that the process was feasible — in total, data was collected for over 96% of the materials in the ships that were part of the project.

Several positive effects of the inventory process were identified. Having a database of materials makes it easier to report in line with existing environmental regulations, and protects against future changes in requirements. The data could instil responsibility in the industry for the social and environmental effects of the materials used during a ship's lifespan — from construction to recycling. Lastly, the process also encourages transparency, which could lead to greater competition and suitable partnerships in the supply chain as well as in ship recycling. The pilot projects are ongoing, but the aim is to create a well-defined set of reporting guidelines so that these practices can be adopted more widely. This would help ships to comply with recent [European Regulation 1257/2013](#)¹, which states that an inventory of hazardous materials must be kept on board any ship entering an EU port. The researchers add that a greater focus on material use may lead to improvements, not only in recycling but also in initial ship design.

Source: Simpson, P. (2014). *Closed loop materials management*. Sustainable Shipping Initiative, www.ssi2040.org/what-we-do/work-streams/clmm/

1. <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013R1257>

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Read more about: [Waste](#), [Resource efficiency](#), [Environment and health](#), [Sustainable development and policy assessment](#)

Perspectives on shipbreaking: economic, social and environmental impacts at Alang–Sosiya

The Alang–Sosiya shipbreaking yards in India highlight the inequalities and opportunities of global waste management. The yards, which recycle retired ships from more economically developed countries, have dramatically altered the ecosystems and social structures of the local area. A study looking at stakeholder perceptions analyses different positions on the social and environmental impacts of the yards.

“In the Alang–Sosiya ship-yards, waste — whether it is hazardous or not — is usually released into the sea, burnt on site or dumped in surrounding areas where other industries also operate, such as farming fields.”

The first ship was beached in this region of north-east India in 1983 but, by 2012, Alang–Sosiya accounted for 95% of India’s ship recycling — at a time when India in turn accounted for nearly half of the world’s ship recycling. Nearly 180 Alang–Sosiya ship recycling yards operate out of a 12km-long coastal strip, with a cumulative processing capacity of approximately 3.5 million tonnes/year.¹

This study, which combines data from interviews, official documents, media coverage, legal analysis and direct observation by the researcher, investigated the ‘political ecology’ of the area in 2009, focusing on the distribution of benefits and burdens among shipping industry stakeholders.

Semi-structured or in-depth interviews with 64 respondents were conducted with local villagers, farmers, fishers, shipbreaking entrepreneurs, workers, political and administrative authorities, legal experts, academics and activists. Interviewees were selected to represent a broad spectrum of interests and knowledge regarding shipbreaking. Focus groups were also led with fishers, farmers and workers. Special focus was given to the ‘Blue Lady’ legal case at the Indian Supreme Court during 2006 and 2007.

The study poses the problem of the Alang–Sosiya ship waste being released into the sea, burnt on site or dumped in surrounding areas where other industries also operate, such as

farming fields. Fishing is the main livelihood of an estimated 10 000 people in the area, but fish monitored in the area have been found to contain dangerously high levels of heavy metals and, according to local fishers, the diversity and quantity of catches was diminishing. Local people also reported respiratory and skin problems from burning waste, and that oxen and cattle have died from eating waste. Those living close to the operation yards are affected by noise pollution.

While land and labour costs have increased in the area, villagers reported that quantity and size of crops have decreased and several wells had been abandoned as the water is no longer seen as fit for consumption. However, new business and employment opportunities have also arisen in trade, transportation and retail after the arrival of the yards.

The paint flakes and chips from ships’ hulls have been found to contain several toxic heavy metals — iron, copper, zinc, lead, tin, chromium and cadmium. Plate-cutting workers on the sites are exposed to elevated levels of heavy metal pollutants emerging from the combustion of this paint during the course of open-air plate cutting², and heavy metals can also contaminate a surrounding ecosystem.

The Indian ship-recycling industry has taken some positive steps to reduce work-related fatalities and accidents, such as improvements in the technology used (e.g. cranes instead of manual lifting), security (e.g. asbestos

Source: Demaria, F. (2010). Shipbreaking at Alang-Sosiya (India): An ecological distribution conflict. *Ecological Economics* 70: 250–260. DOI: 10.1016/j.ecolecon.2010.09.006.

*1. & 2. Updated data from Deshpande, P. C., Tilwankar, A. K. and Asolekar, S. R. (2012) A novel approach to estimating potential maximum heavy metal exposure to ship recycling yard workers in Alang, India. *Science of the Total Environment* 438 (Nov): 304-11.*

“Workers on the shipbreaking yards are predominantly seasonal migrants from poorer neighbouring states who reside in vulnerable housing nearby, and are thus exposed to the pollutants in the surrounding environment. They generally worked 12 hours per day, 6 days a week, with a pay of between three and seven US dollars (€2.64-6.15) per day (in 2009).”

chambers, although the researcher found these were not used). However, the industry always uses the beaching technique and significant improvements cannot take place until a dry dock is used. Official data reported 470 fatalities between 1983 and 2013³. Workers on the shipbreaking yards are predominantly seasonal migrants from poorer neighbouring states who reside in vulnerable housing nearby, and are thus exposed to the pollutants in the surrounding environment. They generally worked 12 hours per day, 6 days a week, with a pay of between three and seven US dollars (€2.64-6.15) per day (in 2009). Workers also reported the use of force by the local police to suppress sporadic strikes disputing pay, safety and working conditions.

The second part of the study looks at a case study of an ocean liner, the *Blue Lady* (former *SS France*), at the Indian Supreme Court in 2006–2007, to illustrate the valuation decisions made at each stage of the ship disposal process — and to interrogate the way different stakeholders understood the industry’s costs and benefits.

Ships that are to be retired are sometimes sold to brokers and buyers who temporarily acquire ownership of the end-of-life vessels, a system that may allow the original owners to bypass liabilities and regulations.

In the case of the *Blue Lady* ocean liner, which contained 1 250 tons of asbestos, ownership was transferred multiple times en route to the Alang–Sosiya yards. An estimate of 17 million euros was quoted to decontaminate part of the in-built asbestos in Germany, after which the ship owner decided instead to dispose of the ship. The Malaysian mother company sold it through a Bermuda-based subsidiary to a Liberian company for only \$10 (€8.82) (the real price was estimated at \$15 (€13.23) million). Despite the applications of Indian environmental activists, the ship was sold to one Indian shipbreaking company, which sold it to another, and the ship was beached at Alang–Sosiya and allowed to be dismantled.

The case of *Blue Lady* was taken to the Indian Supreme Court due to the health and

environmental risks it posed. The position of the shipbreaking industry representatives was that shipbreaking is a ‘green’ industry as it saves non-renewable resources and does not produce solid waste. It was also represented as an economic opportunity as it employed people, returning good quality steel to the domestic market, and raising government funds in the form of customs duties, income and sales taxes. The main issue was seen as the occupational hazards and not the environmental impacts.

This perspective came into sharp contrast with that of the environmental justice activists, who represented the arrival of the ‘toxic’ ship as hazardous waste which was non-compliant with international law. The ‘polluter pays’ principle was invoked in a call for decontamination prior to export, transparent pollution monitoring and proper waste removal.

The Indian authorities took a similar view to the shipbreakers: emphasising the public, economic and environmental benefits of the practice, and stating that hazardous substances are managed safely, and that the ships are not ‘hazardous waste’.

In 2007, the head of nearby Sosiya village filed an application on behalf of 12 *sarpanches* (village heads) and 30,000 people who lived within 1 to 25km of the shipbreaking yard. The applicants opposed the dismantling of the ship because of the damage it would do to the recycling workers’ and villagers’ health and to the local environment on which many people depended (most of the population consists of farmers and fishers). They noted that Indian shipbreakers did not have the technology to dispose of the estimated 1 000 tons of asbestos safely, and that the floating oil near the coast was forcing local fishers to fish beyond 5 or 6 kilometres out to sea.

Permission was granted in 2007 by the Supreme Court to dismantle *Blue Lady* in Alang–Sosiya, citing that it would employ 700 workers and bring 41 000 tons of steel to India, and relieve the pressure from mining activities. The adverse effects on the

3. Obtained from the Gujarat State Industrial Safety and Health Department, Ahmedabad, 15 May 2014. Sabu, G. (2014) *Workers of Alang-Sosiya*. *Economic & Political Weekly XLIX* (50): 52-59.

ecology and environment were considered to be hardships fairly balanced by a project of public utility; sustainable development was interpreted as positive economic benefit at the national scale.

The researcher notes that the court did not quantify costs and benefits, nor conduct a multi-criteria evaluation, either of which might have included long-term environmental impacts and the cost of human health and lives. Common across all perspectives, the lack of technology was seen as a barrier to safe industrial practices.

The international regulations for ship recycling which could have prevented *Blue Lady* from reaching Alang–Sosiya⁴, prompt the question of what EU policymakers should do to ensure that international shipping conventions are upheld.

The forthcoming [European List](#) intends to ensure a safe final destination for European ships. Owners of ships flying the flag of European Member States will have to ensure that their ship is only recycled in facilities that are on the European List — i.e. the facilities will have to comply with strict requirements, particularly in regard to removing hazardous materials. A first version of the European List will be published before 31 December 2016, and it will be regularly updated by the European Commission. The EC will also issue guidelines on the requirements for ship recyclers and independent verifiers certifying the yards.

However, the researcher states that the issue of foreign (non-EU) flagged ships still needs to be addressed. In 2007, ‘developed countries’ controlled about 65.9% of the world’s DWT (deadweight tonnage, or how much mass a ship is carrying), ‘developing countries’, 31.2%, and ‘economies in transition’, the remaining 2.9%. The five top ship-owning economies together controlled 54.2% of the world fleet. Fleet ownership, however, does not always reflect ship registration. Foreign flagged ships accounted in 2008 for 67% of the world total, most of them registered in the so-called ‘states of convenience’ such as Panama and Liberia. In 2004–2005, 82.5% of the ships dismantled at Alang–Sosiya Shipbreaking Yard (India) used a flag of convenience. Flags of convenience allow under-invoicing, can result in evasion of import tax, and facilitate ship owners’ access to the shipbreaking market.

The researcher also mentions several recommendations for improving the global environmental effects of ship recycling, such as requiring ship owners to pay a deposit throughout a ship’s life, which would eventually be spent on proper dismantling in a dry dock, under safe conditions, rather than beaching. This deposit could then become a requirement for entry at any harbour (for example, in the European Union, regardless of their flags), to ensure sustainable practices across national borders.

“The forthcoming European List intends to ensure a safe final destination for European ships. Owners of ships flying the flag of European Member States will have to ensure that their ship is only recycled in facilities that are on the European List — i.e. the facilities will have to comply with strict requirements, particularly in regard to removing hazardous materials.”

4. Under Article 9 and the Basel Ban amendment of the Basel Convention, as the transfer of ‘hazardous waste’ from an OECD country to non-OECD country, this could be seen as illegal traffic.

Further reading

You may also be interested in reading the following publications from Science for Environment Policy.

News Alert articles

Remaking and revaluing ships sent for demolition (December 2010)

A recent study has examined how ships no longer economical to run are broken apart, reassembled and made into goods of new value, such as furniture, in Bangladesh. There are strong concerns about working conditions for those who work in this industry and shipbreaking yards have recently been closed as they are considered hazardous. However, this study draws a valuable lesson from ship breaking in that 'things are but temporary configurations of material', which can, potentially, be endlessly reassembled, under safe conditions.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/221na4_en.pdf

Thematic Issues

Exploring the Links Between Energy Efficiency and Resource Efficiency (June 2015)

Energy efficiency is at the centre of EU policy for achieving a fundamental transformation of Europe's energy systems by 2030. This Thematic Issue reveals the complexity of the issue of energy efficiency, its links with resource efficiency and the wide range of factors influencing it, from technology to social practices.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/energy_efficiency_and_resource_efficiency_links_49si_en.pdf

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