

Chapter 17. Shipping

Contributors: Alan Simcock (Lead member) and Osman Keh Kamara (Co-Lead member)

1. Introduction

For at least the past 4,000 years, shipping has been fundamental to the development of civilization. On the sea or by inland waterways, it has provided the dominant way of moving large quantities of goods, and it continues to do so over long distances. From at least as early as 2000 BCE, the spice routes through the Indian Ocean and its adjacent seas provided not merely for the first long-distance trading, but also for the transport of ideas and beliefs. From 1000 BCE to the 13th century CE, the Polynesian voyages across the Pacific completed human settlement of the globe. From the 15th century, the development of trade routes across and between the Atlantic and Pacific Oceans transformed the world. The introduction of the steamship in the early 19th century produced an increase of several orders of magnitude in the amount of world trade, and started the process of globalization. The demands of the shipping trade generated modern business methods from insurance to international finance, led to advances in mechanical and civil engineering, and created new sciences to meet the needs of navigation.

The last half-century has seen developments as significant as anything before in the history of shipping. Between 1970 and 2012, seaborne carriage of oil and gas nearly doubled

(98 per cent), that of general cargo quadrupled (411 per cent), and that of grain and minerals nearly quintupled (495 per cent) (UNCTAD, 2013). Conventionally, around 90 per cent of international trade by volume is said to be carried by sea (IMO, 2012), but one study suggests that the true figure in 2006 was more likely around 75 per cent in terms of tons carried and 59 per cent by value (Mandryk, 2009). Not only has the quantity of cargo increased, the average length of voyages has also increased: between 2000 and 2013 the estimated amount of international seaborne shipments measured in ton miles increased by 65 per cent from 30,648 to 50,506 billion ton miles, while the total amount of international cargo rose by only about 50 per cent (UNCTAD, 2013). This growth in the average length of voyages has been largely in the carriage of coal, grain and ores.

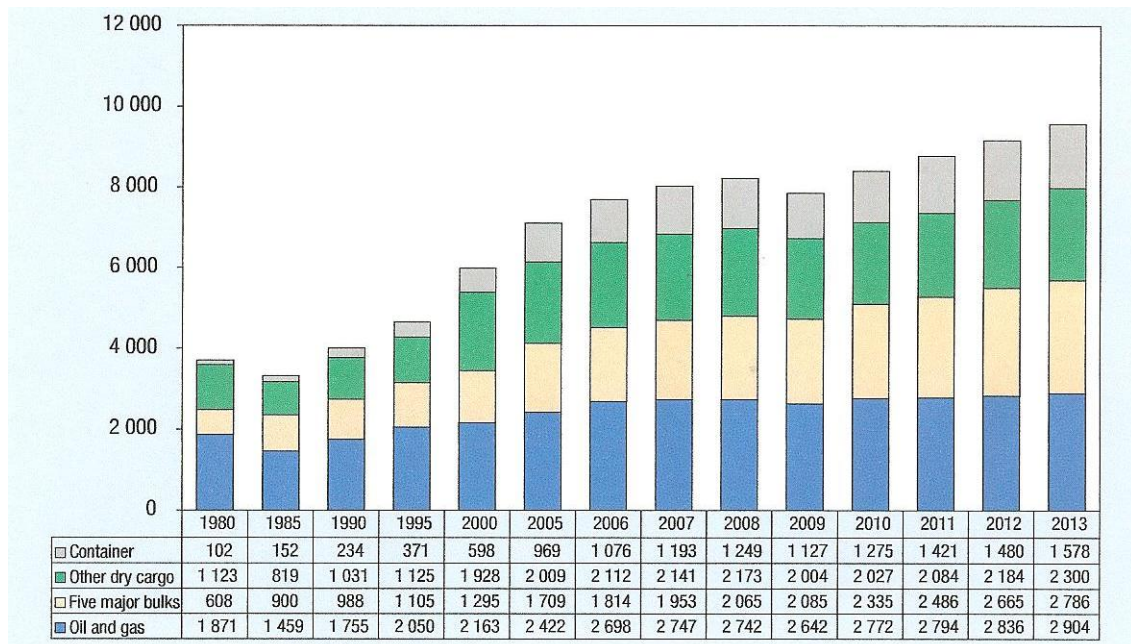
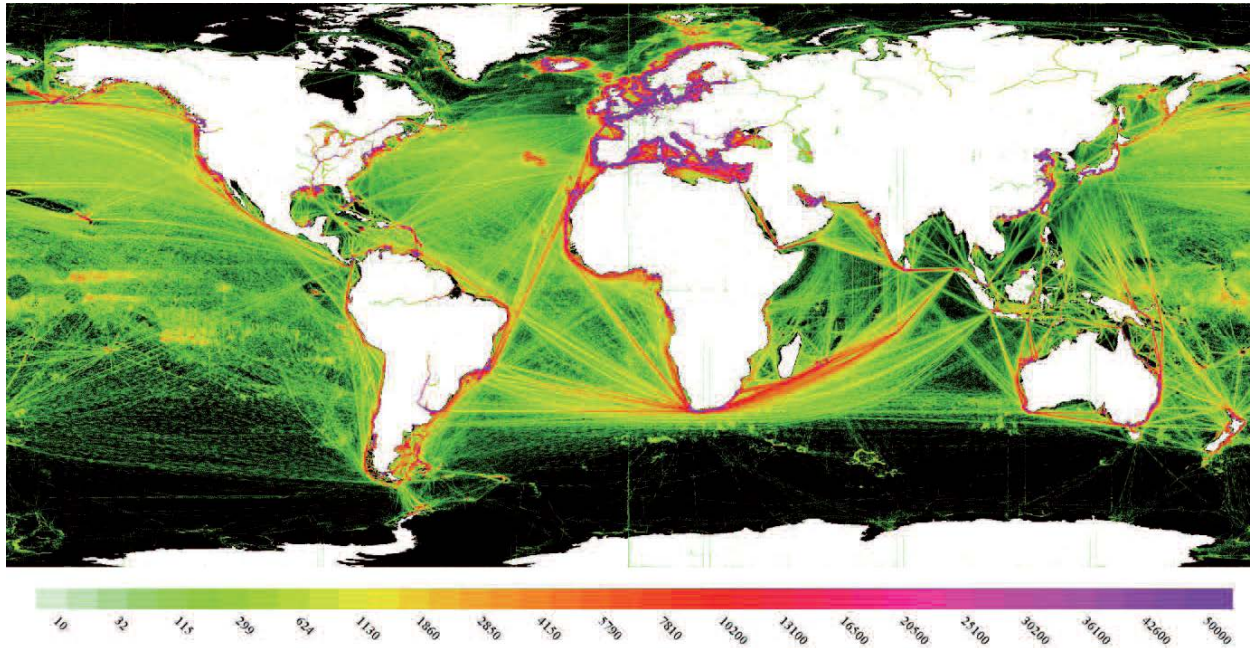


Figure 1. International Seaborne Trade: selected years 1980 – 2013. *Millions of tons loaded*. The “Five Major Bulks” are iron ore, grain, coal, bauxite/alumina and phosphate rock. “Other Dry Cargo” includes agricultural produce, metals, and forest products). Source: UNCTAD, 2013.

2. Nature and Magnitude of World Shipping Movements

2.1 Cargo traffic

Global shipping movements naturally mirror the world economy. The modern period up to 2008 therefore generally showed a steady increase. The economic crisis of 2008, not surprisingly, produced a drop in activity, but this was less than the drop in the world’s Gross Domestic Product, largely because of the continuing demand in eastern Asia for bulk movement of iron ore and coal (UNCTAD, 2013). Figure 1 shows the way in which world cargo movements are increasing. Figure 2 shows the distribution of total shipping movements around the world. The different main trades have substantially different distributions and patterns of sailings: the container routes are concentrated in the East/West belt around the southern part of the northern hemisphere and are very regular in their sailings, while both the five main bulk dry cargoes (iron ore, coal, grain, bauxite/alumina and phosphate rock) and the oil and gas trade are focused on the sources of these cargoes. Their sailings are also affected by changes in the market prices for these commodities. The carriage of bulk dry cargoes and oil and gas tends to have a higher proportion of return journeys in ballast. The mineral cargoes, in particular, have strong emphases on routes from Africa, South America, Australia and Indonesia to eastern Asia (Kaluza et al., 2010). Significant changes in maritime traffic routes could result from developments in extracting hydrocarbons from the earth: the growth of the shale gas industry of the United States of America, for example, is leading to major falls in United States imports, and growth of United States exports, with consequent changes in trade routes (EIA, 2014a).



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2. Global Network of Ship Movements (data 2012). Data derived from daily Automatic Identification System (AIS) messages recorded for each $0.2^\circ \times 0.2^\circ$ grid square. The coloured scale shows the number of messages recorded over the year for the grid squares. Source: IMO, 2014o.

For a long time there was an imbalance in cargo movements between developed and developing countries: cargo volumes loaded in the ports of developing countries far exceeded the volumes of goods unloaded. This reflected the difference in volume of exports from developing countries (dominated by raw materials) and their imports (substantially finished goods). As Figure 3 shows, over the past four decades a steady change has occurred: loadings and unloadings in the ports of developing countries reached near parity in 2012, driven by the fast-growing import demand in developing regions, fuelled by their industrialization and rapidly rising consumer demand.

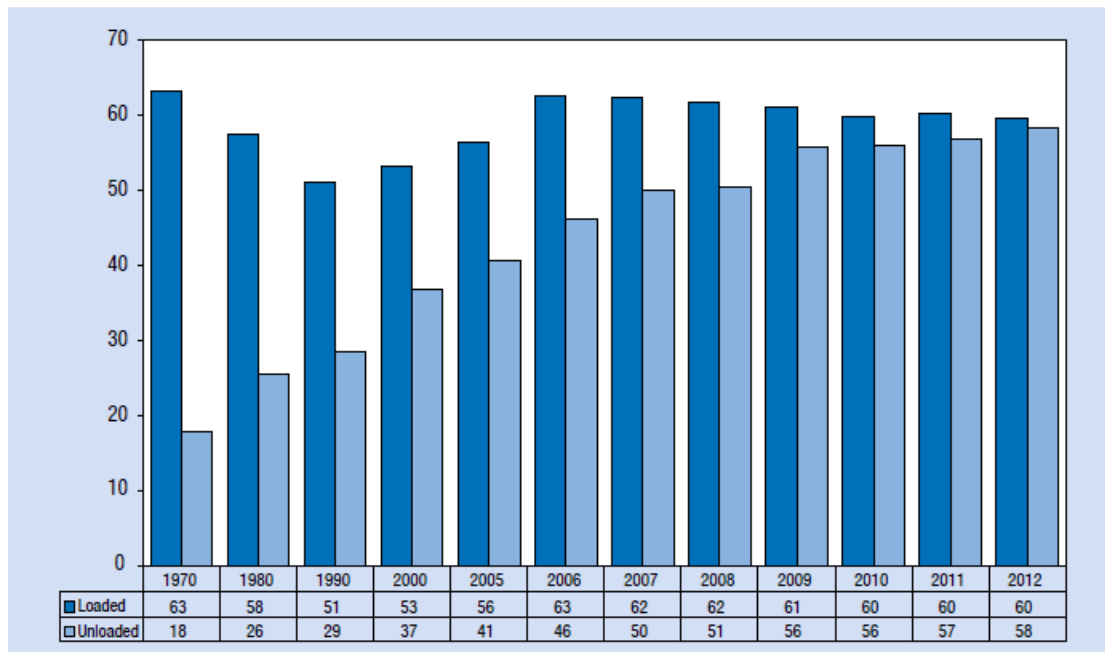


Figure 3. Cargoes loaded and unloaded in the ports of developing countries 1970 – 2012. Percentage share in tonnage of global loadings and unloadings. Source: UNCTAD, 2013.

General cargo transport has been transformed by the introduction of container shipping. Before 1957, when the first container shipment was made from Houston to New York in the United States, general cargo had to be loaded and unloaded package by package, with relatively long times needed to turn ships around, and high labour costs. The introduction of standardized containers (the Twenty-foot Equivalent Unit (TEU) and the Forty-foot Equivalent Unit (FEU)) enabled ships and ports to be constructed so that compatibility was not an issue. (Ninety per cent of current shipments are of FEU, but the TEU is widely used for statistical purposes) (Levinson, 2007). The convenience of being able to handle practically all forms of general cargo in this way is a major factor in producing the massive expansion of long-distance maritime transport. For a long time, growth in the volume of container traffic was three to four times the growth in world GDP (the average was 3.4 times over the period 1990–2005). A variety of factors now seem to be changing and some analysts suggest that the multiplier has fallen to only 1.5 times in 2012, and may continue at this level. This would imply that in future the global shipping industry would grow more slowly (UNCTAD, 2013). Table 1 shows how trade levels and the consequent distribution of container movements between parts of the world vary widely.

Table 1. Container movements on the 10 most heavily trafficked routes 2006.

Route	Number of TEU Movements ('000)
Far East to Far East	21,750
Far East to North America	13,764
Far East to North-West Europe	8,951
North America to Far East	3,950
Far East to Mediterranean	3,750
North-West Europe to Far East	3,571
Far East to the Persian Gulf and Indian Subcontinent	3,322
North-West Europe to North America	3,191
Latin America to North America	2,791
North-West Europe to North-West Europe	2,518

Source: Adapted from Mandryk, 2009.

Increases in the size of cargo vessels, and consequent efficiency gains, have been a major factor in enabling unit freight costs for containers, for oil and gas and for bulk traffic to be contained, thus encouraging growth in trade. It seems likely that the trend of increases in the size of vessels will continue. This trend is, however, constrained by the limitations on the size of vessels that ports can handle and by navigational choke-points. At present, three main choke-points constrain the size of vessels. These are the Panama Canal, the Suez Canal and the Straits of Malacca. The approximate maximum dimensions of vessels that can navigate these three passages are shown in Table 2. Vessels larger than these dimensions must seek alternative routes: around Cape Horn, around the Cape of Good Hope and around or through the Indonesian archipelago, respectively. These alternative routes add significantly to the costs of some of the main shipping routes, but may be offset by economies of scale in using larger vessels. Work is in progress to provide a new set of locks on the Panama Canal, which are expected to open in 2016, enabling ships within the “New Panamax” classification to pass through the canal (ACP, 2014). This is expected to result in significant changes in patterns of shipping between the Atlantic and Pacific. Proposals exist for a further canal through Nicaragua, which might (if completed) have even larger effects. Work has already started on expanding the Suez Canal. Subject to such changes and the emergence of alternative routes, the scope for efficiency savings from increasing the size of ships, and thus for containing costs, is likely to diminish, as the limits at the choke-points restrict further growth in the size of vessels.

Table 2. Choke-points in international shipping: maximum sizes of vessels.

Classification	Length	Beam	Draft	Air-draft (overhead clearance above water)	Approximate dead-weight tonnage ¹	Approximate Twenty-foot Unit (TEU) container capacity
Malaccamax	333-400 metres	59 metres	25 metres	Unlimited ²	300,000	15,000 – 18,000
Panamax	294.13 metres	32.31 metres	12.04 metres	57.91 metres	65,000 – 85,000	5,000
New Panamax	366 metres	49 metres	15.2 metres	57.91 metres	120,000	13,000
Suezmax	Unlimited	50 metres	20.1 metres	68 metres	120,000 – 200,000	14,500
<i>Largest current crude-oil tankers</i>	<i>415 metres</i>	<i>65 metres</i>	<i>35 metres</i>		<i>320,000 – 500,000</i>	
<i>Largest current container ships</i>	<i>400 metres</i>	<i>59 metres</i>	<i>16 metres</i>		<i>184,600</i>	<i>19,100</i>

Source: STH 2014.

The other source of potential increases in the deployment of larger vessels is the effects of climate change. As a result of the warming of the Arctic, it is becoming possible (at least in summer) to navigate between the Pacific and the Atlantic through both the North-West Passage (through the Canadian Arctic archipelago) and the Northern Sea Route (NSR - along the Arctic coast of the Russian Federation). These possibilities are currently only open to ice-class vessels. The extent to which larger vessels can be deployed depends on the routes that are feasible: Arctic shipping routes, especially the NSR, are subject to significant draft and beam restrictions (Humpert et al., 2012). Increases in the frequency and severity of northern hemisphere blizzards and Arctic cyclones may also limit the use these routes (Wassman, 2011). The *Nordic Orion* (75,600 dead-weight tons (dwt)) became the first commercial vessel to pass through the North-West Passage in October 2013 (G&M, 2014). The NSR has been used for Russian internal traffic since the 1930s. Some international transit traffic took place (with the aid of icebreakers) in the early

¹ Dead-weight tonnage (DWT) is a measure of how much weight a ship can safely carry. It is the aggregate of the weights of cargo, fuel, fresh water, ballast water, provisions, passengers, and crew.

² There are now proposals for a bridge across the Malacca Strait, which would introduce a limit.

1990s and the number of ships using the transit passage rose from four in 2010 to 71 in 2013 (Liu, 2010 and Economist, 2014). The route between Shanghai and Rotterdam via the NSR is approximately 4,600 km (about 40 per cent) shorter than the route via the Suez Canal, and would take 18–20 days compared to 28–30 days via the Suez Canal (Verny and Grigentin, 2009). Some estimates suggest that, in the longer term, up to 20 per cent - 25 per cent of global shipping movements could be affected by possible Arctic routes, which could offer up to 35 per cent savings in movement time and, hence, costs (Laulajainen, 2009). Others are more pessimistic, but can see some possibilities (Liu et al., 2010). The International Maritime Organization (IMO) has developed a new International Code for Ships Operating in Polar Waters (the Polar Code), covering both Arctic and Antarctic waters. The Code has been made mandatory under the International Convention on the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) through the adoption of relevant amendments to those Conventions, respectively in November 2014 and May 2015. The expected date of entry into force for the Code is 1 January 2017. Nevertheless, the requirements in the Code will need support through infrastructure such as improved charts and emergency response plans and waste-reception and other facilities capable of dealing with activities on a much larger scale than at present exists (COMNAP 2005, TRB 2012).

As well as the global, long-haul traffic, sea transport also carries much freight on shorter routes. Comparable statistics on this are difficult to find. Within Europe, a study for the European Commission in 1999 showed that 43 per cent of the total freight ton-miles within Europe (including both international and national traffic) were carried on short-sea journeys – an amount about the same as the ton-miles of road haulage. This high proportion was due to the fact that the average movement length by sea was much greater: the average sea movement was nearly 14 times that of the average road movement. Efforts are being made to increase the amount of freight carried on short-sea movements, in order to reduce both the pressure on roads and air pollution emissions (EC, 1999). Similar motives underlie the “America’s Marine Highway Program”, under which the United States is investing to increase the amount of short-sea freight movements along the Atlantic and Pacific coasts and from the Gulf of Mexico to the east coast (MARAD, 2014). Elsewhere, containerization is leading to rapid growth in short-sea coastal freight movements: for example, in Brazil, the volume of containers carried in coastwise traffic has grown between 1999 and 2008 from 20,000 TEU to 630,000 TEU (+3,050 per cent) (Dias, 2009). To a large extent, the scale of coastwise freight transport reflects the need to distribute more locally the large number of containers arriving in global movements in very large ships. Roll-on/roll-off ferries also play an important role in the more local movement of containers and other cargo, often combined with passenger traffic.

One specialised form of maritime transport that attracts concern in some quarters is the transport of radioactive materials. A wide range of materials need to be transported, from supplies for nuclear medicine to the components in the nuclear fuel cycle. Since 1961 the International Atomic Energy Agency (IAEA) has published advisory regulations on the safe transport of radioactive material, which are

generally adopted. Particular concern has been expressed about the shipment of used nuclear fuel for recycling. Since 1971, some 7,000 civil shipments of over 80,000 tons of used nuclear fuel have been reported, mostly to the reprocessing plants at Cap la Hague (France) and Sellafield (United Kingdom of Great Britain and Northern Ireland). These include 160 shipments (totalling 7,140 tons) from Japan to Europe (WNA, 2014). A 2011 survey of the transport of radioactive material in northern Europe confirmed that there had been no maritime transport accidents involving a release of radioactive materials (KIMO, 2011), and none have been reported since then (European Union, 2013).

2.2 Passenger traffic

Since the advent of large aircraft, maritime passenger traffic has effectively been confined to short-sea ferries and cruise ships. Every State with inhabited offshore islands too far offshore for the strait to be bridged has ferry services. States consisting of, or containing, archipelagos rely heavily on ferries for internal passenger transport. International passenger ferries are particularly important in the Baltic Sea, the North Sea and the Caribbean, where several States face each other across relatively short sea-crossings. Roll-on/roll-off ferries (where passenger vehicles and their passengers can make the journey together) have substantially aided the growth of short-sea passenger transport. Roll-on/roll-off ferries are also important for local freight movements, especially in Europe. Growth in passenger transport by ferries is governed mainly by improvements in the facilities and general economic growth in the countries concerned. Over the past decade, for example, the traffic on Greek passenger ferries has stagnated in the light of the Greek economic crisis, while traffic on passenger ferries in Indonesia and the Philippines has continued to grow substantially. Total ferry passengers worldwide in 2008 and its regional components are shown in Table 3.

Table 3. World ferry traffic volume and distribution 2008.

	Passengers	Cars	Buses	Freight vehicles
World traffic volumes (millions of journeys)	2,052	252	677	32
<i>Percentages of world total in each region</i>				
America and Caribbean	14.6	29.7	11.9	2.7
Baltic	10.9	33.7	38.6	24.3
Mediterranean	21.2	14.3	14.9	26.7
North Sea	4.4	7.5	32.4	31.7
Pacific	1.5	0.4	<0.1	1.5

Red Sea and Persian Gulf	3.7	0.5	0.9	0.2
South-East Asia	43.7	13.9	1.3	12.9

Source: Adapted from Wergeland, 2012.

2.3 Cruise ships

The other major sector of passenger maritime transport is cruise ships. Although maritime tourist travel can be traced back to 1837, and a substantial business developed, especially in the Mediterranean Sea in the 19th century (P&O, 2014), the modern cruise ship industry emerged in the 1960s and 1970s as a means of employing ocean-going passenger liners at a time when mass long-distance passenger air-travel was emerging and coming to dominate the long-distance passenger market. When the market demand became clear, specialized cruise ships began to be built, with less emphasis on speed than passenger liners, and more on space for entertainment and relaxation. The market has grown steadily and rapidly since then: the estimated numbers were 3,774,000 journeys in 1990 and 21,556,000 journeys in 2013 (Figure 4). The total turnover of the cruise market was estimated at 37.1 billion United States dollars (CMW, 2014). Growth has slowed somewhat since 2008, but has continued.

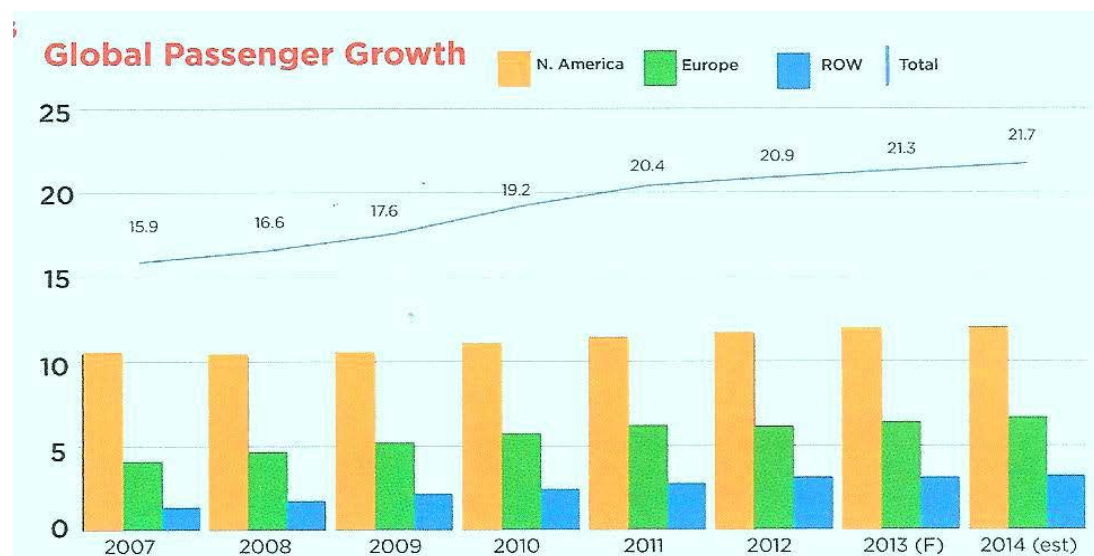


Figure 4. Growth in numbers of passenger cruise journeys 2007 – 2014.

(millions of journeys). Note: ROW is "Rest of the World" Source: CLIA, 2014.

Over half the market demand in 2013 was from the United States (51.7 per cent). The remaining demand is reported as 26.6 per cent from Europe, 3.6 per cent from Australia and New Zealand, 3.4 per cent from Brazil, 3.4 per cent from Canada and 11.3 per cent from the rest of the world. The main target areas in terms of itineraries and ship deployment for cruises in 2013 are reported as: the Caribbean (34 per cent), the Mediterranean (22 per cent), the rest of Europe (11 per cent),

Australia (5 per cent), Alaska (5 per cent), South America (4 per cent), Asia (3 per cent) and other areas (16 per cent) (CLIA, 2014).

There appears to be a trend towards larger vessels. In the Baltic Sea, the Helsinki Commission has calculated that the average number of passengers on the cruise ships calling at Baltic ports rose between 2006 and 2012 by 49 per cent, from 1,099 to 1,635 (HELCOM, 2014a).

2.4 The world fleet of ships

The size of the world's fleet of ships has been increasing rapidly in the period from 2000 – 2013 (Figure 5). The persistence of a high rate of growth after the economic crisis of 2008 is accounted for by the lead time between the ordering and delivery of vessels: 2012 was the first year since 2001 in which the tonnage of ships delivered fell below the tonnage delivered in the previous year (UNCTAD, 2013).

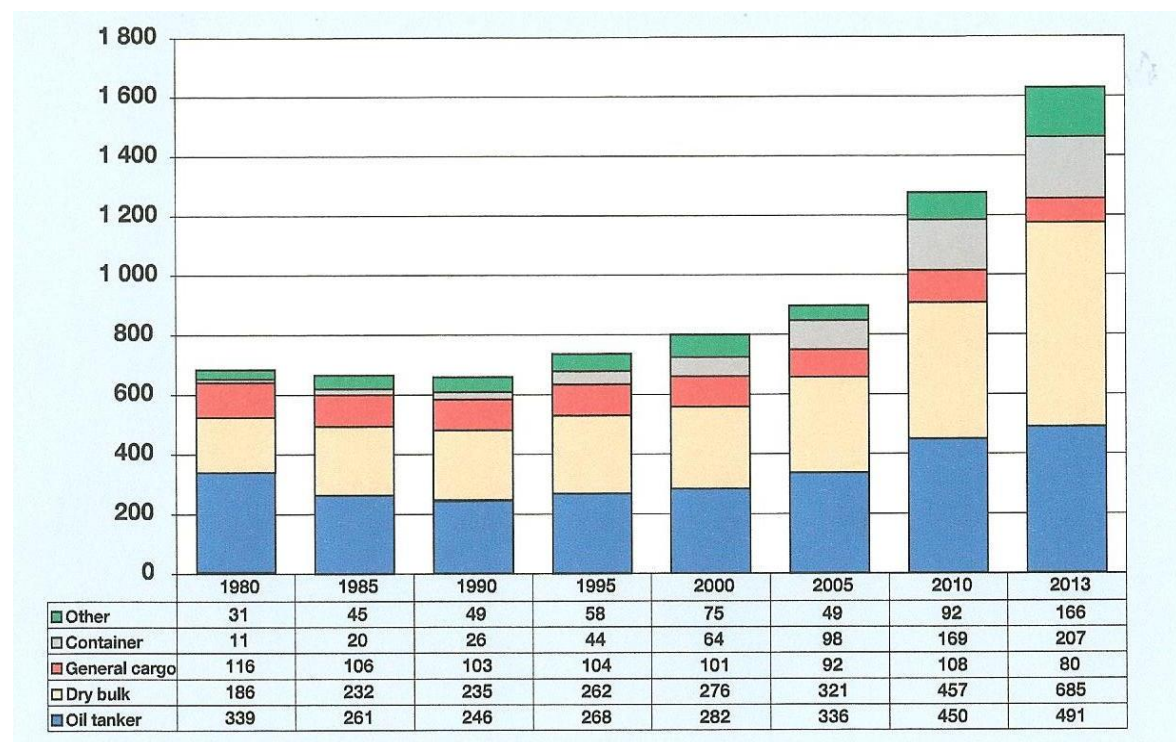


Figure 5. Total size of the world fleet of ships 1980 – 2013. Source: UNCTAD, 2013. Note: Figure 5. includes all propelled seagoing merchant vessels of 100 GT and above, excluding inland waterway vessels, fishing vessels, military vessels, yachts, and offshore fixed and mobile platforms and barges (with the exception of floating production storage and offloading units (FPSOs) and drillships).

The age profile of the world fleet has also been changing: by January 2013, 20 per cent of all seagoing merchant ships were less than five years old, representing 40 per cent of the world's deadweight tonnage. At that point, the average age (per ship) in January 2013 was 9.9 years for dry-bulk carriers, 10.8 years for container ships, 16.7 years for oil tankers, and highest for general-cargo ships (25 years) and the miscellaneous ships (22.6 years). The average ages of oil tankers and dry bulk carriers are lower because of the rapid increases in their numbers. The figure for oil tankers also reflects the phasing out of single-hulled oil tankers (UNCTAD, 2013).

The practice of registering ships in flag States other than that of the owner’s nationality has grown, particularly under what are called “open registries”, which (among other things) may not impose requirements on the nationality of officers or other crew. The proportion of vessels over 1,000 gross tonnage³ flying a flag different from that of their owner’s nationality has increased steadily from less than 41.5 per cent in 1988 to 73 per cent in 2013. In 2013, more than half the tonnage of the world’s ships was registered with four registries – Panama (21.52 per cent), Liberia (12.16 per cent), the Marshall Islands (8.60 per cent) and Hong Kong, China (7.97 per cent) (UNCTAD, 2013) (Figure 6). Because of the attractions of “open registries”, a number of States have created international shipping registers. These usually have less stringent requirements on the nationality of crew, but may not be open to ships trading solely within national waters.

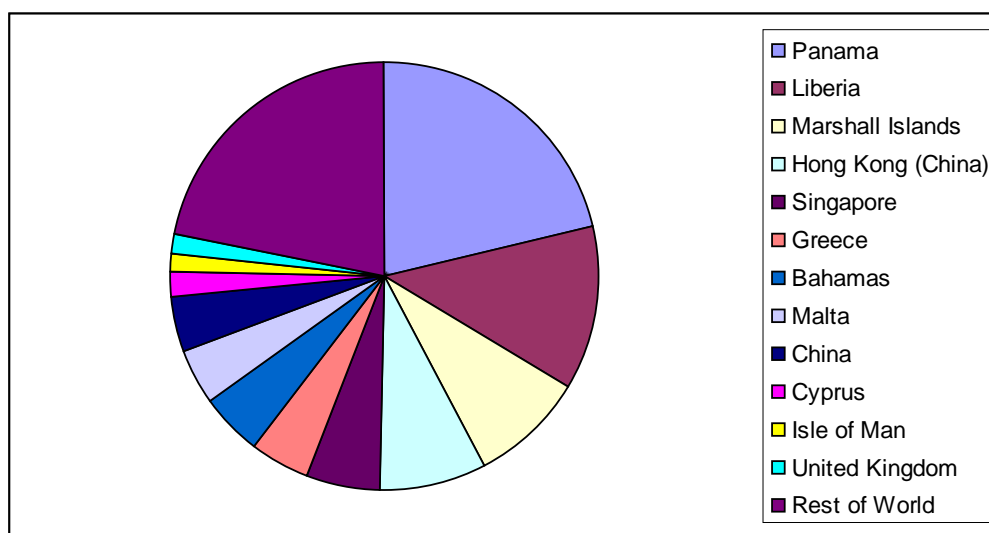


Figure 6. Share of the World’s Gross Tonnage by Registry 2013. (12 Registries with the largest gross tonnage on the register and the total gross tonnage of all other Registries). Source: compiled from UNCTAD, 2013).

The pattern of ownership of vessels varies widely between the registries. For example, among the 12 largest registries, some have negligible proportions owned or controlled by nationals. For others (China and Greece), the tonnage is predominantly controlled by nationals. Yet others have substantial, but not predominant, proportions controlled by nationals. This variable pattern is also found among all the other registries. Figure 7 shows the estimated spread of ownership and/or control for ships of over 1,000 gross tonnage between the 12 largest ship-owning States and the rest of the world. Owners from five countries (China,

³ “Gross tonnage” is a measure of “the moulded volume of all enclosed spaces of the ship” (International Convention on Tonnage Measurement of Ships, 1969) and is calculated from the volume of the ship multiplied by a reduction factor which increases with the size of the ship.

Germany, Greece, Japan, and the Republic of Korea) together account for 53 per cent of the world tonnage. Among the top 35 ship-owning countries and territories, 17 are in Asia, 14 in Europe, and 4 in the Americas (UNCTAD, 2013).

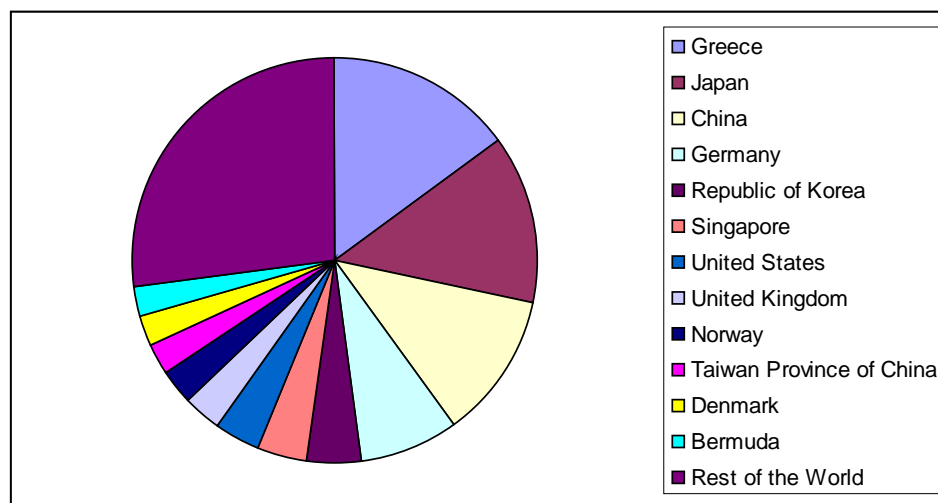


Figure 7. Spread of the control/ownership of vessels of over 1,000 gross tonnage between the 12 largest fleets and the rest of the world 2013. Source: compiled from UNCTAD, 2013.

2.5 Ship safety

Whether ships are carrying passengers or cargo, the main aim is that the ship should reach port safely at the end of the voyage. In the 1960s, concern about the numbers of collisions of ships, the damage that they could inflict on the environment, the risks to the lives of those on board and the economic effects of losses led to the development of various recommendations on methods of navigation in areas with high levels of shipping activity. In 1971, the IMO Assembly adopted the principle of compulsory measures for ships' routing under the SOLAS Convention, of which the scheme in the Dover Straits was the first (IMO, 2014c).

The IMO has now established some 152 ships' routing measures around the world. These include Traffic Separation Schemes (which require ships going in opposite directions to stay in designated lanes), Inshore Traffic Zones (designated areas landward of a traffic separation scheme for coastal traffic), Deep-Water Routes (routes which have been accurately surveyed for clearance of sea-bottom and submerged objects), and Areas To Be Avoided (areas in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships, or by certain classes of ships). In addition, a number of Governments and port authorities have established similar schemes, particularly in the approaches to major ports (UKHO, 2014). The importance of ships' routing measures can be seen from the straits linking the Black Sea and the Mediterranean. A 2004 study showed that the majority of the accidents in the period 1953 to 1994 were collisions between two or more ships; after the introduction of a traffic separation scheme in 1994, the majority of the accidents were groundings or strandings (Akten, 2004).

In addition to the ships' routing measures adopted by IMO, the IMO has designated, on the proposal of coastal States, Particularly Sensitive Sea Areas (PSSAs) in their exclusive economic zones, where associated measures to protect the environment can be approved. Fourteen such areas have so far been designated. Eight establish Areas to be Avoided (ATBA), six impose mandatory reporting requirements on some or all ships (MSR), four include Traffic Separation Schemes (TSS), two impose a ban on any ship anchoring in a specified area, and one imposes a mandatory deep-water route (DWR). In addition, two recommend the use of pilotage and two recommend the use of an established two-way route. Three of the areas (the Great Barrier Reef, Malpelo Island and the Paracas National Reserve) are linked to areas designated as World Heritage Sites (see Chapter 8 – Cultural Ecosystem Services from the Ocean). The 14 areas, the States proposing them, and the additional protective measures adopted are (in the order of their designation):

- (a) Great Barrier Reef (Australia, 1990) (for measures see (h) below);
- (b) Sabana-Camagüey Archipelago (Cuba, 1997, ATBA);
- (c) Malpelo Island (Colombia, 2002 – ATBA);
- (d) Marine area around the Florida Keys (United States, 2002 – ATBA, mandatory no-anchoring areas);
- (e) Wadden Sea (Denmark, Germany, Netherlands, 2002 – DWR);
- (f) Paracas National Reserve (Peru, 2003 – ATBA);
- (g) Western European Waters (Belgium, France, Ireland, Portugal, Spain and the United Kingdom – MSR);
- (h) Extension of the Great Barrier Reef PSSA to include the Torres Strait (Australia and Papua New Guinea, 2003 – MSR, two-way route, recommended pilotage);
- (i) Canary Islands (Spain, 2004 – ATBA, TSS, MSR, recommended routes);
- (j) Galapagos Archipelago (ATBA, MSR, recommended routes);
- (k) Baltic Sea (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden, 2004 – TSS, DWR, ATBA, MSR);
- (l) Papahānaumokuākea Marine National Monument (USA, 2007 – ATBA, MSR for all USA ships and all other ships over 300 gross tonnage, recommended reporting for other ships);
- (m) Strait of Bonifacio (France and Italy, 2011 – MSR, recommendation on navigation);
- (n) Saba Bank (Caribbean Netherlands, 2012 – ATBA, mandatory no-anchoring area) (IMO, 2014d).

Work continues to improve the safety of navigation, including through on-going improvements to charts, electronic aids to navigation and other navigation services. Such improvements have played a significant part in achieving the reductions in shipping casualties described in this chapter (IMO, 2014e).

The combined effect of all these measures has been to achieve a steady reduction in the number of ships lost at sea, with environmental, social and economic benefits: less pollution of the sea, fewer lives lost and less disruption of trade. Over the long term, in 1912, the casualty rate was about 1 in 100 ships from a fleet of about 33,000 ships; in 2009, the casualty rate was about 1 in 670 ships from a fleet of about 100,000 (Allianz, 2012). The following graph (Figure 8) shows how the number of ships lost has decreased over the past decade to 2013. (However, more recently, casualties to ships carrying refugees may affect the picture).

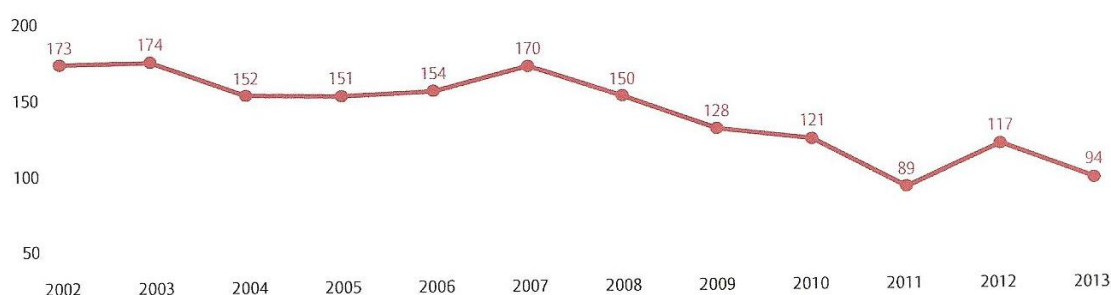


Figure 8. Number of ships over 1,000 gross tonnage lost 2002 – 2013. Source: Allianz, 2014 (based on Lloyd’s List Intelligence Casualty Statistics).

As for the locations of these events, they are naturally concentrated on the main shipping lanes. As Table 4 shows, 30 per cent of the losses between 2002 and 2013 were in the waters off eastern Asia.

Table 4. Shipping losses over 1,000 gross tonnage by sea area

SEA AREA	2002 - 2013	2013
South-East Asian Seas (the waters off southern China, Viet Nam and the eastern coasts of the Malaysian peninsula and Thailand, the coasts of Brunei Darussalam and Sarawak (Malaysia) and around Indonesia and the Philippines and Singapore)	296	18
Eastern Mediterranean and the Black Sea	215	17
North-West Pacific (the waters off northern China, Japan, the Korean peninsula and the Pacific coast of the Russian Federation)	207	9
The North Sea, the English Channel, other waters around the Britain and Ireland, and the Bay of Biscay	135	8
The Persian Gulf and its approaches	96	6
South-West Atlantic	82	5
Western Mediterranean	73	4
Wider Caribbean	51	3
Western Indian Ocean	51	3

SEA AREA	2002 - 2013	2013
Bay of Bengal	50	3
Eastern seaboard of the United States	45	0
Other parts of the world	372	18
Total Losses worldwide	1,673	94

Adapted from Allianz, 2014 (based on Lloyd's List Intelligence Casualty Statistics).

In the late 1990s a series of disasters involving ships not covered by the IMO Conventions and their requirements prompted IMO to undertake action as part of their Integrated Technical Cooperation Programme to help States in various regions to develop codes to improve the standard of shipping in those regions. By 1999, States in Asia, the Caribbean and the Pacific agreed codes for non-Convention ships, which many States have incorporated into their legislation. Draft regulations have been developed for Africa, and the IMO has been assisting some States to use these as a basis for improving the safety of ships operating in their waters. Much work still remains to be done, because the infrastructure and skilled personnel needed to implement the regulations are often not available (Williams, 2001). Even where regional codes have been adopted, they do not apply to vessels under 15 – 24 metres (depending on the region). Concern therefore remains in many parts of the world (especially Africa) about improving the safety of small vessels – for example, a 2012 study showed that 70 per cent of the shipping incidents between 1998 and 2011 reported in South Africa involved small ships or fishing vessels (Mearns et al., 2012).

3. Socioeconomic aspects of shipping

3.1 Profitability of the world fleet

The profitability of ferries and the carriage of cargoes within a State (“cabotage”) will depend very heavily on local circumstances. Many States subsidize ferries to offshore islands from general taxation in order to remove the disadvantages which those living on such islands would otherwise suffer. Restrictions on which ships may carry out cabotage (which can be restricted to ships flying the national flag of the State within which the carriage takes place) can significantly affect the profitability of routes. States may also intervene to make cabotage more profitable in order to encourage cargo traffic to use sea routes rather than land routes, in order to reduce pressure on roads or the need to build or improve them.

The profitability of international traffic, particularly on intercontinental routes, is, on the other hand, very much a matter of the global shipping market. Long-distance cargo capacity is largely traded on a global market, which is focused on certain cities with well-established local shipbroking networks. Among these are Amsterdam, the Netherlands; Athens (Piraeus), Greece; Copenhagen, Denmark; Hong Kong, China;

London, United Kingdom of Great Britain and Northern Ireland; New York, United States; Oslo, Norway; Shanghai, China; and Tokyo, Japan. This market covers both ships operated principally by those who own them, and ships whose owners generally expect to charter them out to other firms to operate. Ships can easily switch between these categories, depending on the levels of supply and demand in the market. Since the level of activity in global shipping is closely linked to the level of global trade within the four main markets of oil and gas, the main bulk cargoes, containers and general cargo, the levels of supply and demand of shipping in the market will likewise fluctuate. Extended periods of growth in global trade encourage ship-owners to invest in new capacity – even more so if growth causes demand to outstrip supply significantly, as happened at some periods over the past two decades. 2001 to 2012 saw the longest sustained growth in the size of the world fleet in history, with record deliveries of new vessels year after year. Additions to capacity will also be caused by investment in new vessels which can operate more efficiently, usually because they are larger. The entry into service of such improved vessels will cause other vessels to be cascaded down the markets. Mismatches between increases in capacity and growth in global trade will lead to overcapacity and falls in freight rates and consequent drops in profitability. Likewise, if global demand drops because of economic recessions, the long lead-time for new shipping means that capacity will continue to grow from deliveries of vessels ordered at a time of growth, thus enhancing the effects of falls in demand (UNCTAD, 2013).

The drop in global trade from the 2008 global recession led to serious drops in freight rates, especially for container ships. For container ships, recovery in trade in 2011 did not immediately lead to better freight rates, in view of the large increases in new capacity. Measures such as slowing voyages (which both saves fuel and uses more capacity) and transferring capacity from east-west routes (where trade remained low) to north-south routes (where trade was growing) meant that in 2012 container freight rates recovered. For tankers carrying oil, gas and chemicals, the position has been similarly poor, with rates over 2009 – 2013 roughly half those of the peak of early 2008. For bulk carriage of coal, grain and minerals, rates over the same period have been only 10 per cent - 30 per cent of the peak 2008 rates. In 2012, a survey revealed that 21 carriers of the top 30 that publish financial results reported an overall operating loss of 239 million dollars in 2012, with only seven carriers turning in positive results (UNCTAD, 2013).

Overall, the pattern has been one of bigger ships offered by fewer companies. Although, in general, the level of service for cargo carriage by regular sailings, as shown by the UNCTAD Liner Shipping Connectivity Index, has improved over the past decade, the result of concentrating cargo in bigger vessels owned by bigger companies has been to reduce the level of competition. In 2004, 22 countries were served by three or fewer carriers: in 2013, 31 countries were facing this situation (UNCTAD, 2013). In 2013, three of the largest container shipping lines proposed collaboration in the scheduling of sailings and allocation of cargo to sailings, while retaining separate sales and pricing systems. These proposals were not accepted by all States and have now been dropped. However, in 2014, the shipping companies involved in those proposals and other companies formed two alliances. Some in the

shipping industry believe that further arrangements may be proposed (SCD, 2014, Lloyds List, 2014).

In recent years, passenger cruise ships have suffered some bad publicity, with the loss of the *Costa Concordia* and a number of other adverse events. However, all the major cruise lines have been reporting profits. Across the industry, profits per passenger were reported to grow by nearly 18 per cent between 2011 and 2013, from 157 dollars to 185 dollars (Statista, 2014).

4. Seafarers

4.1 Numbers of seafarers

Worldwide, there are just over 1.25 million seafarers. Only about 2 per cent of these are women, mainly in the ferry and cruise-ship sectors (ITF, 2014). Their origins are shown in Table 5.

Table 5. Broad Geographical Origins of Seafarers 2010.

Origin	Officers	per cent	Ratings	per cent
Africa / Latin America	50,000	8	112,000	15
Eastern Europe	127,000	20	109,000	15
Far East	184,000	30	275,000	37
Indian Sub-Continent	80,000	13	108,000	14
OECD Countries	184,000	29	143,000	19
Total - All National Groups	624,000	100	747,000	100

Source: BIMCO/ISF, 2010.

Although there are many uncertainties, a recent survey by the Baltic International Maritime Council Organization and the International Shipping Federation indicates that the industry will most probably face a continuing shortage of qualified crew (and particularly of officers) when shipping markets recover. There is also a high wastage rate of qualified crew leaving the industry, and this contributes to potential shortages (BIMCO/ISF, 2010).

4.2 Conditions of work for seafarers

Because ships and those who work on them are operating in a world market, and are frequently (and, in international shipping, usually) not operating within the State under whose flag they fall, international action to regulate the pay and conditions of seafarers has been a major concern of the International Labour Organization (ILO) since its foundation in 1919. In 2006, the ILO adopted the Maritime Labour Convention (MLC) as the “fourth pillar” of international maritime law (alongside SOLAS, the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended (STCW), and MARPOL). The MLC embodies “all up-to-date standards of existing international maritime labour Conventions and Recommendations, as well as the fundamental principles to be found in other international labour Conventions”. The MLC entered into force on 20 August 2013 and, by June 2014, had been ratified by 61 States representing 80 per cent of global shipping tonnage (ILO, 2014).

The MLC continues and restates a unique system for setting recommended minimum wages for seafarers from all countries. A Subcommittee of the ILO Joint Maritime Commission (with representation of Governments, seafarers and ship-owners) has agreed on an increase in the minimum monthly basic wage figure for able seafarers to 592 dollars (7,104 dollars a year) from 1 January 2015 and to 614 dollars (7,368 dollars a year) from 1 January 2016 (ILO 2014)

The pay of officers is determined by the market. However, there are noticeable differences between pay rates, depending on the national origin of the officers concerned. A global survey in 2012 showed the following pattern of salaries (Table 6).

Table 6. Pay of ships’ officers in United States dollars a year

ORIGIN	JOB TYPE			
	Master Mariner	Chief Engineer	Chief Officer	Second Engineer
Asia	111,422	102,740	74,319	72,996
Eastern Europe	109,627	104,448	74,653	81,125
Western Europe	138,320	104,628	90,273	81,871

Source: compiled from Faststream, 2012

Because seafarers can find themselves in foreign ports without many of the support services available to land-based workers, the rights under the MLC on such issues as enforcing arrears of pay are very important. In addition, a survey based on 3,480 cases presented to the Legal Committee of the IMO strongly suggested that the rights of seafarers, as set out in the IMO/ILO “Guidelines on fair treatment of

seafarers in the event of a maritime accident”, are often subject to violation. Among the views expressed were that the survey showed a need to keep up pressure for better implementation of the Guidelines, and that seafarers were more exposed to criminal proceedings than many other workers (UNCTAD, 2013).

4.3 Safety of seafarers

There are difficulties in obtaining a clear picture of the deaths and injuries suffered by seafarers. In this context, it seems necessary also to consider deaths and injuries suffered by those working at sea in the fishing industry, since these have similar causes. In 1999, a study looking at 19 major shipping administrations over the period 1990 – 1994 concluded that casualties arising from disasters involving merchant vessels were grossly underreported, and in addition failed to address mortality from all other causes of death at sea (Nielsen, 1999). In 2013, when the Secretary-General of IMO launched the Accident Zero Campaign, he noted that the available statistics are neither accurate nor comprehensive, and suggested that there is a need for an official global statistical base (Sekimizu, 2013). The statistics quoted by the IMO Secretary-General showed the following pattern of deaths (Table 7) as far as they could be ascertained:

Table 7. Pattern of Deaths of Seafarers 2008 - 2012

Year	Deaths of seafarers
2008	1,942
2009	2,395
2010	1,501
2011	1,095
2012	1,051

Source: Sekimizu, 2013.

Of these, about 10 per cent were in the fishing sector, 40 per cent in domestic shipping and 50 per cent in other categories, including international shipping. Statistics on serious injuries to seafarers are even less easily established.

Over the past three decades, acts of piracy and armed robbery have re-emerged as serious risks to seafarers. Much attention has been focused on such attacks on shipping in waters off eastern Africa, but reports show that the problem is more widespread. In the last three years, action against attacks off eastern Africa appears to have had some success, but attacks elsewhere are also of concern - especially in the South China Sea area, the location of over half the incidents reported in 2013. The statistics cover reports of alleged piracy (outside the territorial sea) and armed robbery at sea in the territorial sea and port areas (Figure 9). Of the 132 attacks reported in 2013 in the South China Sea area, 70 per cent allegedly occurred while

the ship was in port. Worldwide, 17 per cent of the attacks were reported to involve actual violence against the crew (IMO, 2014a).

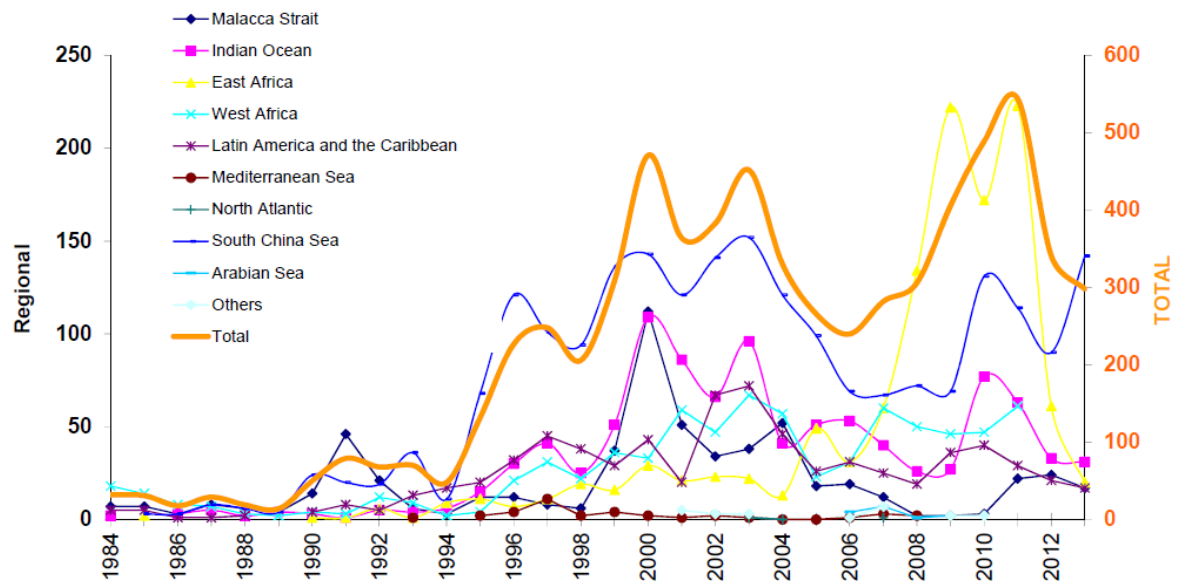


Figure 9. Reports of Alleged Acts of Piracy and Armed Robbery Committed or Attempted 1984 – 2013. Source: IMO, 2014a.

4.4 Safety of Passengers

There are several aspects to the safety of passengers on board passenger ships. The aspect on which most attention has been focused by the international community, since at least the *Titanic* disaster in 1912, is protection against incidents involving ships on international voyages. Although (as with deaths and injuries to seafarers) there are problems in establishing the relevant statistics for deaths of, and injuries to, passengers, there seems to be little doubt that the number of incidents involving passenger ships on international voyages, and the consequent harm to passengers, is small and has fallen steadily: 13 passenger vessels were lost in 2002 as compared to six in 2013 (Allianz, 2014). A second aspect of passenger safety is that of passenger ferries on domestic voyages. Although, again, statistics are limited, the IMO Secretary-General has drawn attention to the fact that in the 2½ years from January 2012 to June 2014, 2,932 lives were lost in domestic passenger ship accidents around the world. The third main aspect of passenger safety is the accidents and other events of a kind that have nothing to do with the failure of vessels: these cover not only medical emergencies, but also crimes committed by crew or other passengers, and people falling overboard. The size of modern cruise ships (with up to about 5,000 passengers and 2,500 crew) means that this kind of event is as likely to happen on a ship as in a small town. However, investigation and follow-up are a matter for the flag State of the vessel. Statistics on these aspects of passenger safety are not consistently collected. However, because of the large proportion of cruise trips that start in its territory or involve its citizens, the United States since 2010 has required reporting these incidents to the Federal Bureau of Investigation (FBI) for,

among others, cruises starting or ending in its ports. The reports show 130 reports of alleged serious crimes in 2011 – 2012 (Rockefeller, 2013).

5. Links to other industries

5.1 Shipbuilding

The steady growth in the numbers and size of vessels of all kinds resulted in record levels of ships being on order in 2008: the dead-weight tonnage (dwt) on order grew by between 50 per cent (general cargo) and 1000 per cent (bulk carriers) to a total of around 600 million dwt. The economic crisis of 2008 resulted in a rapid decline in new orders, and as a consequence many shipyards are thought likely to have to reduce employment. Over the decade from 2002 to 2012, there have been major changes in the location of shipbuilding: in 2012, China (41 per cent), Republic of Korea (33 per cent) and Japan (18 per cent) produced about 92 per cent of all new dwt tonnage; six years earlier in 2006, China had been producing only about 15 per cent, about the same as the European shipyards taken together. The Philippines also has a growing shipbuilding industry: 3 per cent of global dwt completed in 2012. Eastern Asia has thus become dominant in the global shipbuilding market (UNCTAD, 2013).

5.2 Ship-breaking

The ship-breaking industry has likewise become more concentrated. In 2012, 70 per cent of all gross tonnage reported as sold for demolition was sold to ship-breaking yards in Bangladesh, India and Pakistan; 22 per cent was sold to ship-breaking yards in China and 3 per cent to yards in Turkey, leaving only 5 per cent being sold to the rest of the world (UNCTAD, 2013). The ship-breaking industry has given rise to concerns about both the impact on the workers employed and the effects on the marine environment (see Chapter 20). An ILO expert group described it as very hazardous for the workers and presenting many threats to the environment, with major difficulties in enforcing regulations (ILO, 2003). The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships was adopted in 2009. To enter into force, this requires ratification by 15 States representing 40 per cent of the gross tonnage of the world fleet and the combined maximum annual ship recycling volume of these States constituting not less than 3 per cent of the gross tonnage of their combined fleet. However, at the end of 2014, only three States representing 1.98 per cent of world tonnage had ratified it (IMO, 2014b). From the start of 2015, the IMO will implement, in coordination with the Government of Bangladesh, a project aimed at enhancing the standards of health, safety and environmental compliance of ship recycling in Bangladesh.

5.3 Bunkers

Ships need to burn fuel to move, and there is therefore a substantial world-wide industry delivering ships' bunkers (as ships' fuel is named). Estimates of total

worldwide fuel consumption by ships vary: calculations in the IMO Greenhouse Gas study based on a bottom-up approach using data on ship movements from Automatic Identification Systems (AIS) show a total consumption of about 327 million tons per year in 2011, compared with a figure of 254 million tons a year based on top-down data on sales of bunkers (IMO 2014o). This compares with an estimate by the United States Energy Information Agency of around 164 million tons a year (EIA, 2014b). In 2010, this represented about 1.5 per cent of the world's total primary energy supply (OECD, 2014). Most of the bunkers are residual fuel oil – that is, the fuel oil that remains after lighter fractions have been removed for other uses. As a consequence, it often has high sulphur content and presents other problems (such as the need to heat it before it can be pumped to the engines). Restrictions are being introduced on bunkers, in order to combat air pollution from ships (see below). Much of the delivery of bunkers takes place in the larger ports, especially those situated near navigational choke-points. Singapore is the world's leading port for the supply of ships' bunkers (MPA, 2014).

5.4 Marine insurance

Alongside the maritime transport industry, a major industry has grown up to insure ships and their cargoes while they are in transit. This is an important component of maritime transport, since cargo owners, ship owners, crew and the rest of the world (including the marine environment) can easily be damaged by ship accidents. A means of ensuring compensation is essential. Many States require a valid insurance certificate as a precondition of entry to their ports: for example, this is a requirement in all European Economic Area States (EC, 2009). The annual premium income worldwide of the marine insurance industry was estimated at 28,930 million United States dollars (excluding the offshore energy industries, whose insurance is often included in marine insurance figures, because it is provided by the same firms). The premiums on cargoes and freight costs represented 18,139 million dollars (62.7 per cent) of this business, the ships themselves 8,563 million dollars (29.6 per cent), and 2,228 million dollars (7.7 per cent) the cost of insurance against causing damage to the marine environment. In addition to the commercial insurance of ships, cargoes, freight costs and environmental risks, many ships are entered into Protection and Indemnity Clubs (P & I Clubs). These are non-profit associations of ship owners, which cover their members against other risks not covered by the marine insurance policy. These clubs are financed by calls on members. In 2013, the total of calls from P & I Clubs was estimated at 3,630 million dollars (Seltmann, 2014).

An important element of these insurance arrangements is the inspection of ships by independent surveyors. These inspections are organized by Classification Societies, which also lay down construction standards for ships that are consistent with the legal requirements of the States with which the Classification Society works. Registration by a Flag State, as well as obtaining insurance, is normally conditional on a Classification Society issuing a certificate that the ship meets the standards laid down for its class. There are over 100 Classification Societies in the various parts of the world. The major Classification Societies formed, in 1961, the International Association of Classification Societies (IACS), which currently consists of 12 member

societies and has adopted common approaches to the task of classification through the development of unified rules, requirements and interpretations— for example, the Common Structural Rules for Tankers and Bulk Carriers 2006 (IACS, 2014).

6. Pathways by which shipping impacts on the marine environment and the nature of those impacts

Shipping's impacts on the marine environment can be divided into the catastrophic and the chronic. Catastrophic impacts on the marine environment result from disasters involving the ship, and may lead to its total loss: for example, collisions, fires, foundering and wrecks. Chronic impacts are those that result from the day-to-day operation of ships, without calling into question the ship's integrity or continued functioning (Donaldson, 1994). Both are important, and both are addressed by very similar methods, including by ensuring the safe construction of vessels and their safe operation through construction standards, safe navigation methods, and the proper training and deployment of the crew.

Figure 2 highlights the way in which major shipping routes pass through certain choke-points: among the more significant are the Malacca and Singapore Straits, the Strait of Hormuz, the Bab al Mandab at the entrance to the Red Sea, the Suez Canal, the straits linking the Black Sea and the Mediterranean, the Sound and the Belts at the entrance to the Baltic Sea, the English Channel and the Straits of Dover, and the Panama Canal. Concerns about chronic effects are therefore greatest in these areas, because it is there that those effects are most concentrated.

Catastrophic events produce the most serious impacts on the marine environment, as well as being very serious from the point of view of the crew and any passengers and in their economic impact. As explained above, the combined effect of efforts under a number of international conventions has been to reduce steadily the number of ship losses and other catastrophic events.

6.1 Combined impacts of catastrophic events and chronic inputs to the ocean from ships

For most of the major threats to the ocean from shipping, MARPOL provides the technical specifications for preventing and reducing the threats. It was adopted in 1973, adapted in 1978 to facilitate its entry into force, and entered into force for the provisions relating to oil and noxious liquids in bulk in 1983. Since then, it has developed over time (as explained below), both by strengthening the requirements and by bringing into force regulations relating to additional fields. Other international conventions also address threats to the marine environment arising from ships (see also below).

Effective implementation and enforcement of the requirements of these international conventions are crucial.

6.2 Oil

Oil spills from shipping have a wide range of impacts. Catastrophic discharges of large amounts of hydrocarbons will produce large oil slicks with consequentially massive impacts. Smaller slicks will have lesser impacts, but may be equally serious if they are repeated frequently. The impacts range from covering seabirds with oil (which can lead to death), through killing and tainting fish and shellfish and making the stock of fish farms unusable to covering beaches and rocky shores with oil (which can adversely affect tourism). In specific cases, problems can be caused for industries that rely on an intake of seawater (such as marine salt production, desalination plants and coastal power stations) and coastal installations (such as marinas, ports and harbours) (ITOPF, 2014a). In summarising general experience with oil spills, the study on the environmental impact of the spill of 85,000 tons of crude oil in the 1993 *Braer* catastrophe (Ritchie et al., 1994) drew attention to three important features of major oil spills:

- (a) There is an initial, very serious impact, usually with extensive mortality of seabirds, marine mammals, fish and benthic biota and coastal pollution;
- (b) In many circumstances, however, marine ecosystems will recover relatively quickly from oil spills: crude oil loses most of its toxicity within a few days of being spilled at sea, mortality of marine biota declines rapidly thereafter, sub-lethal effects are of limited long-term significance and marine ecosystems recover well where there are nearby sources of replacement biota;
- (c) Nevertheless, the local circumstances of an oil spill will be very significant. The impact on seabirds, marine mammals and sessile biota will obviously be worse if the spill occurs in areas where they are present in large numbers at the season when the spill occurs – the location of breeding and nursery areas and migration routes and other regular concentrations being particularly important.

The ambient temperature is one of the local circumstances that are most significant for the duration of the impact and the timing of recovery. In warmer areas, the bacteria that break down hydrocarbons are more active, and the effects will disappear more quickly. In spite of the size (about 1 million tons) of the discharges (not including the airborne deposits from the burning of a further 67 million tons), the effect on the coasts of Kuwait and Saudi Arabia of the discharges from oil wells during the Gulf War in 1991 was largely disappearing within 18 months. These coasts had largely recovered within five years. However, oil appears to have persisted in salt marshes and at lower depths in the lower sediments as a result of their anaerobic condition (Readman et al., 1992; Jones et al., 1994; Otsuki et al., 1998; Barth, 2001). In colder areas, on the other hand, bacterial activity is much lower, and the effects of oil spills persist much longer. The impact of the *Exxon Valdez* disaster, in which 35,000 tons of oil were spilt in 1989, was still measurable 20 years later (EVOSTC, 2010).

Local circumstances will also determine the appropriate response to an oil spill. In relatively calm water, it is often appropriate to contain an oil spill with floating booms and use skimmers to retrieve as much oil as possible. With such equipment,

it is possible to recover a large proportion of the spill – two-thirds of the 934 tons spilt from the *Fu Shan Hai* in the Baltic in 2003 were recovered (HELCOM, 2010). The other major approach is the use of chemical dispersants. Opinion is divided on the appropriateness of using them: some States regard them as appropriate in many cases, depending on the meteorological circumstances, the local environment and the nature of the oil spill; other States regard them as unacceptable (for examples, see the different opinions in BONN, 2014).

The problem of pollution from oil was the starting point of MARPOL, and the rules to prevent it are in its Annex I. The Annex covers the construction of oil tankers, their operation, what discharges of oily water are permitted, the equipment that must be used and the record-keeping required about any discharges. These requirements have been strengthened over time. In particular, it requires the phasing out of single-hulled oil tankers by, at the latest, 2015.

MARPOL Annex I not only prohibits any discharge into the sea of oil or oily mixtures from any ships in the waters around Antarctica, but also provides for the designation of Special Areas, in which more stringent limits on the discharge of oily water apply. As a counterpart to the designation of Special Areas, coastal States in a Special Area must be parties to MARPOL and must provide appropriate reception facilities for oily waste (see also Chapter 18 - Ports). An important feature of Special Areas is that the maximum permitted level of oil in water discharged is 15 parts per million. In a number of States, the legal system considers that any visible slick on the sea surface must have been caused by a discharge above this level (for examples, see NSN, 2012). Special Areas have been designated, and are in force, in the Mediterranean Sea, the Baltic Sea, the Black Sea, the “Gulfs Area”⁴, the Antarctic Area (south of 60°S), North-West European Waters and Southern South African waters. Three further areas have been designated, but are not yet in force because the coastal States have not all notified IMO that adequate reception facilities are in place: the Red Sea, the Gulf of Aden and the Oman area of the Arabian Sea (IMO, 2014f).

In some parts of the world, special measures have been introduced to reduce oil pollution. Aerial surveillance, supplemented and guided more recently by the use of satellite surveillance, has been used in North-West Europe. Coupled with an effective programme of prosecutions of owners and masters of ships observed unlawfully discharging oil, this has led to decreases over the last two decades in the numbers of oil spills, both in absolute terms and in terms of numbers of oil spills observed per hour flown (BONN, 2013; HELCOM, 2014). In the Mediterranean, pilot projects of this kind have been undertaken (REMPEC, 2014). Canada also has set up similar surveillance programmes, using both aerial and satellite surveillance (Canada, 2011).

Over the past forty years, there have been substantial reductions in the scale of marine environmental problems from oil pollution. As Figure 10 shows, after the amount of oil transported by sea started to recover from the effects of the 1974 price increases, the amount transported (measured in ton/miles) has steadily

⁴ The “Gulfs Area” is the sea area between the Arabian Peninsula and the Asian mainland.

increased. At the same time, the number of recorded spills of more than 7 tons has steadily decreased. Forty-six per cent of the spills between 7 and 700 tons between 1970 and 2013 occurred as a result of collision or grounding and 26 per cent as a result of hull or equipment failure or fire or explosion. For spills of over 700 tons in that period, 63 per cent were the result of collision or grounding and 28 per cent of hull or equipment failure or fire or explosion. In both cases the remaining causes were unidentified (ITOPF, 2014a, UNCTAD, 2012).

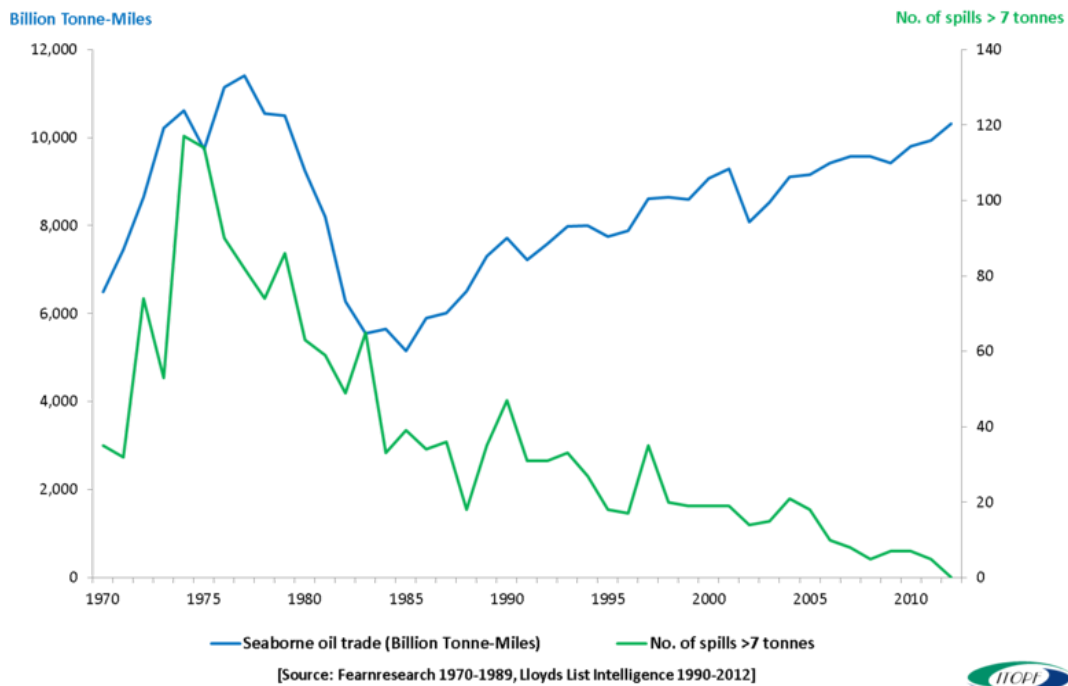


Figure 10. Seaborne oil trade and number of tanker spills of more than 7 tons 1970 - 2012. Source: ITOPF, 2014b.

As Figure 11 shows, a similar decrease is observed in the amount of oil involved in these oil

spills.

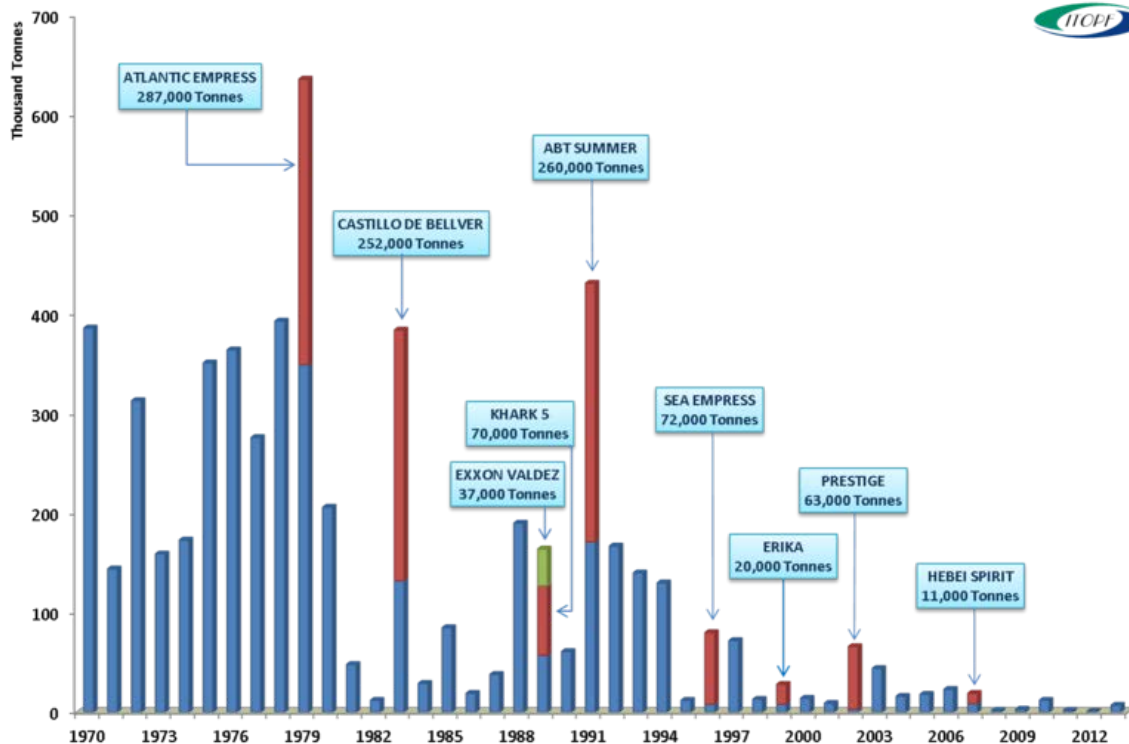


Figure 11. Quantities of oil in spills of more than 7 tons in the years 1970 – 2013. (with notes of the major recent oil spills and their sizes). Source: ITOPF, 2014b.

Nevertheless, a significant problem remains, especially near major shipping routes. A study has shown that even low levels of oil fouling in Magellanic penguins appear to be sufficient to interfere with reproduction (Fowler et al., 1995). One way in which the extent of the remaining problem can be seen is from observations on shorelines of the proportion of the dead seabirds found there which have been contaminated by oil. Diving seabirds are very sensitive to oil pollution: once such a bird is polluted with oil, it is likely to die from hypothermia and/or inability to forage. In the MARPOL North-Western Europe Special Area, the proportion of common guillemots (*Uria aalge*) stranded near the major shipping routes in the southern North Sea was about 40 per cent in 2010, compared with about 4 per cent around the Orkney Islands (OSPAR, 2010). Similar reports have been made about the oiling of seabirds in other areas with high levels of shipping: in the MARPOL Southern South Africa Waters Special Area, studies note that, on the basis of the proportion of the population that has been affected, the African penguin is considered to have suffered more from oiling than any other seabird species globally (Wolfaardt, 2009; Garcia-Borboroglu et al., 2013). In the Straits of Malacca, there is a serious problem with illegal discharges of oil: during the five-year period from 2000 to 2005, there were 144 cases of oil spills into the sea; of this number, 108 cases were due to illegal discharges from ships (BOBLME, Malaysia, 2011). In the waters around south-eastern South America, used both by coastwise local shipping and large vessels travelling between the Atlantic and Pacific Oceans, a study showed that between 1980 and 1994 some 22,000 adult and some 20,000 juvenile Magellanic penguins

(*Spheniscus magellanicus*) were being killed each year by oil from discharges from ships passing through the foraging areas for their colonies on the coast (Grandini, 1994). Happily, the solution adopted in 1997 of requiring coastal shipping to follow routes further out to sea may have reduced this problem: over the years 2001 – 2007, the number of oiled penguins observed annually was around 100 (Argentina, 1998; Boersma, 2008). However, other reports are less optimistic (see Chapter 36B). Further north, on the Atlantic coast of Canada, there are also reports of substantial numbers of seabirds being killed by oil. A conservative estimate is put at 300,000 birds a year, with appreciable effects on the populations of species commonly suffering this fate (Canada, 2011).

Effective response to oil spills requires a good deal of organization and equipment. The international framework for this is provided by the 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention). This entered into force in 1995, and 107 States are now parties. The IMO plays an important role in coordination and in providing training (IMO, 2014g). Coastal States have to bear the capital cost of establishing adequate response capability, but may be able to recover operational costs if and when that capacity is deployed to deal with an oil spill. Developing countries can have difficulties in mobilising the resources for investment in the necessary facilities (Moller et al., 2003).

Major oil spills can cause serious economic damage to a wide range of people and enterprises. After the 1967 *Torrey Canyon* disaster, many States sought to make it easier for those suffering economic damage to obtain reparation. The 1969 International Convention on Civil Liability for Oil Pollution Damage and the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution aimed to achieve this. These Conventions were revised in 1992 and the revisions came into force in 1996. By July 2014, 115 States were parties to both the 1992 Conventions, and 24 States have become parties to a supplementary protocol providing for additional compensation if the damage exceeds the limits of the 1992 Convention. The economic effect of the Conventions is basically to transfer the economic consequences of an oil spill from the coastal State to the States in which undertakings receive cargoes of oil. This is done either through the insurance costs which the cargo carriers have to incur and include in the costs of the voyages or (to the extent that the damage exceeds the amount insured and the coastal State participates in the funds) through the contributions paid to the funds by those that receive oil cargoes and are located in the States parties.

6.3 Hazardous and noxious substances and other cargoes capable of causing harm

Oil is not the only ship's cargo capable of causing damage. Much depends on the quantities involved – large quantities of nearly any cargo can have an adverse impact, at least on the local environment. SOLAS and MARPOL require precautions against damage from a range of other cargoes, including through requiring compliance with the International Maritime Solid Bulk Cargoes Code, the International Maritime Dangerous Goods Code, the International Code for the Safe

Carriage of Grain in Bulk and the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk.

Data on marine pollution incidents involving hazardous and noxious substances are scarce (FSI, 2012). A 2010 study looking at 312 reported incidents of this kind between 1965 and 2009, mainly in the North Atlantic, concluded that reports had become much more frequent since about 2000, with the advent of the internet. It found that about 33 per cent of the cases involved bad weather or structural damage, 30 per cent collision or grounding, 11 per cent fire or explosion and only 6 per cent failures in loading or unloading. Only about half the cases involved discharges into the sea. The three most common substances involved were iron ore, sulphuric acid and caustic soda (Cedre, 2010).

The increased use of containers means that a substantial amount of hazardous or noxious substances is being carried in containers. In 2010 a group of container owners set up a voluntary system to report incidents involving containers, such as fires and spillages, with a view to analysing the data to see if any patterns emerged which could be useful for risk reduction. The Container Notification Information System now covers about 60 per cent of all container slot capacity. Data on the number of incidents have not yet been published, but some preliminary conclusions have been announced: nearly 50 per cent of incidents involved containers where the contents had been mis-declared; 75 per cent of incidents involved hazardous or noxious cargoes; no particular global pattern of loading ports emerged from the incidents, but incidents appeared to be higher with containers packed in June, July and August (CINS, 2014).

Containers lost overboard are another source of potential pollution from hazardous and noxious substances. Some estimates have suggested that the numbers of such containers could be in the thousands annually. However, the World Shipping Council, based on a survey to which 70 per cent of the global container shipping capacity responded, estimated in 2011 that about 350 containers are lost overboard each year, excluding mass losses of 50 or more containers as a result of a major ship disaster. If those mass losses are included, the number of containers lost rises to about 650 a year out of about 100 million carried annually (WSC, 2011). On the other hand, it must be remembered that even one container lost overboard can have a lasting and widespread effect on the marine environment: a container holding 28,800 plastic yellow ducks, red beavers, blue turtles and green frogs was lost in 1992 in the middle of the Pacific. The toys have been washed up not only all around the Pacific, but also as far away as the Hebrides in the United Kingdom in 2003 (Ebbesmeyer, 2009).

Following on from the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), a protocol dealing with preparedness and response to incidents involving hazardous and noxious substances was adopted in 2000. This follows the same model as the OPRC Convention. It came into force in 2007, but so far only 33 States have become parties. Efforts to set up an international agreement to deal with compensation for liability and damage from hazardous and noxious ships' cargoes were started as long ago as 1984. A convention was agreed in 1996 but, despite further efforts, no scheme is yet in force

to provide international support where a hazardous or noxious cargo causes economic damage.

6.4 Sewage

The problems from the discharge of sewage (in the narrow sense of human and animal urine and faecal waste) from ships are the same as those for similar discharges from land, which are discussed in Chapter 20. Basically, the problems are the introduction of nutrients into the sea, and the introduction of waterborne pathogens. Away from land, the oceans are capable of assimilating and dealing with raw sewage through natural bacterial action. Therefore, the regulations in Annex IV to MARPOL prohibit the discharge of sewage into the sea within a specified distance of the nearest land, unless ships have in operation an approved sewage treatment plant. (IMO, 2014j).

In summary, discharge of sewage into the sea outside a Special Area is permitted:

- (a) When a ship has in operation an approved sewage treatment plant to meet the relevant operational requirements (these are broadly similar to the performance of an effective secondary sewage-treatment plant on land);
- (b) When a ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land;
- (c) When a ship is discharging sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land (MARPOL Annex IV as in force from 2005).

Because of the problems of eutrophication described in Chapter 20, the amendments to MARPOL Annex IV by IMO in 2011 introduces the Baltic Sea as a special area under Annex IV and adds new discharge requirements for passenger ships while in a special area. In effect, when adequate reception facilities are in place, passenger ships capable of carrying more than 12 passengers may only discharge sewage if nitrogen and phosphorus have been removed to specified standards. (MEPC, 2012).

“Grey water” (that is, waste water from baths, showers, sinks, laundries and kitchens) is not covered by MARPOL Annex IV. Some States (for example, the United States in respect of Alaska) have introduced controls over the discharge of sewage and grey water from larger passenger ships putting into their ports because the local conditions (in Alaska, particularly the water temperature) make the breakdown of any contaminants it may contain quite slow (EPA, 2014a). Furthermore, some States, particularly small island developing States, have difficulties in managing sewage discharged ashore from cruise ships and from the large numbers of such ships visiting their ports. These challenges for small island developing States are discussed further in Chapter 25.

6.5 Garbage

There is no doubt that a substantial part of the marine debris considered in Chapter 25 originates from ships. The damage to the environment from this marine debris is described in that chapter. This debris is constituted by waste from the normal operations of the ship that is thrown overboard. All the serious (and not entirely understood) consequences of marine debris described in that chapter therefore apply to this chronic form of discharge from ships. Because of the large numbers of passengers that they carry, cruise ships generate a high proportion of the garbage generated at sea – in 1995, the United States National Research Council estimated that cruise ships produced 24 per cent of the solid waste generated on board ships, although they represented only 1 per cent of the world fleet (NRC, 1995). Because of the scale of the challenge, most large cruise ships now incinerate on board each day a high proportion of the waste that they generate (75 to 85 per cent of garbage is generally incinerated on board on large ships (EPA, 2008)).

Annex V to MARPOL seeks to eliminate and reduce the amount of garbage being discharged into the sea from ships. Although the Annex is not a compulsory part of the requirements of MARPOL, 15 States, with combined merchant fleets constituting no less than 50% of the gross tonnage of the world's merchant shipping became parties to enable its entry into force on 31 December 1988. Experience showed that the requirements in the original version of Annex V were not adequately preventing ships' garbage from polluting the sea. United Nations General Assembly resolution 60/30 invited IMO to review the Annex. This was done and a revised version entered into force in 2013. Alongside this, IMO adopted guidelines to promote effective implementation. The revised Annex V prohibits generally the discharge of all garbage into the sea, with exceptions related to food waste, cargo residues, cleaning agents and additives and animal carcasses. It also provides for Special Areas where the exceptions are much more restricted. The Special Areas comprise the Mediterranean Sea, the Baltic Sea, the Black Sea, the Red Sea, the "Gulfs" area⁵, the North Sea, the Antarctic area (south of 60°S) and the Wider Caribbean Region (including the Gulf of Mexico and the Caribbean Sea) (IMO, 2014h).

Providing adequate waste reception facilities in ports and ensuring that those facilities are used is important. The provision of waste-reception facilities in ports is considered in Chapter 18. However, it should be noted here that small island developing States face major problems in establishing adequate port waste-reception facilities (Corbin, 2011). The greatest effort to promote use of waste-reception facilities has been in Europe, by requiring ships to deliver garbage on shore before leaving port, and removing any economic incentive to avoid doing so. Under this approach, with a few exceptions, all ships are required to deliver their garbage to the port waste-reception facility before leaving port, and the cost of such facilities is to be recovered from ships using the ports, with all ships (again with some exceptions) contributing substantially towards the cost of those facilities, whether or

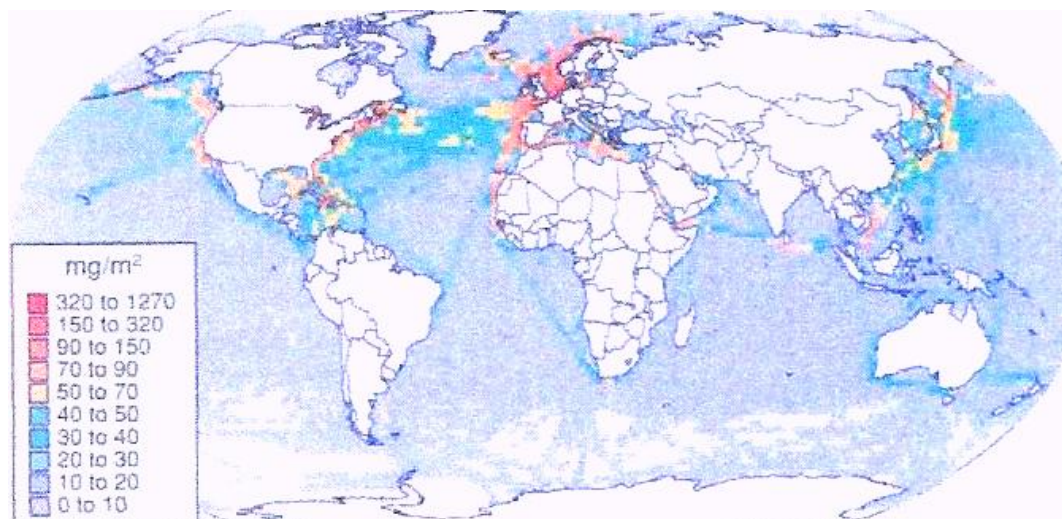
⁵ The sea area between the Arabian Peninsula and the mainland of Asia.

not they made use of them (European Union, 2000). This substantially removes any economic advantage from not using them. This has resulted in a significant (about 50 per cent) increase between 2005 and 2008 in the amount of garbage delivered on shore in European Union ports (EMSA, 2010).

As the OECD pointed out in its 2002 report: “Illegal discharge of wastes at sea often takes place away from shorelines and under cover of night. These two factors make it difficult for port and coastal States to detect acts of pollution, and/or positively identify the polluting vessel” (OECD, 2002). As said in Chapter 25, more information is needed.

6.6 *Air pollution*

Since the replacement of sail by steam and then diesel, ships have been making emissions to the air. By the early 1990s it was becoming apparent that, in some parts of the world, emissions of nitrogen oxides (NO_x) and sulphur oxides (SO_x) from ships were becoming a serious element in air pollution for coastal States with heavy shipping traffic in their coastal waters (OSPAR, 2000). Even short-term exposure to NO_x produces adverse respiratory effects, including airway inflammation, in healthy people and increased respiratory symptoms in people with asthma. It also reduces resistance to respiratory infections (Knelson et al., 1977; Lee, 1980; EPA, 2014b). Airborne NO_x is also a substantial source of nitrogen inputs into coastal waters, and can thus contribute to excessive levels of nutrients (OSPAR, 2010: see also Chapter 20). Exposure to SO_x likewise weakens resistance to respiratory infections, and is linked to higher rates of mortality in humans. It is also a contributor (with land-based emissions) to acid rain, which can harm forests and fresh waters (Greaver et al., 2012). SO_x emissions from ships have been worsening for decades, as a result of the increasing restrictions on the levels of sulphur in hydrocarbon fuels used on land: as restrictions have reduced the extent to which fuel oils with higher sulphur content can be used on land, so such fuel oils have become more attractive for use at sea, because there were no restrictions and the reduced demand on land lowered the price. NO_x and SO_x, together with volatile organic compounds (VOCs), can also react in sunlight to produce smog, which affects many major cities: for coastal cities, emissions from ships can contribute to this problem (EPA, 2014c). In addition, shipping was seen as a further source of chlorofluorocarbons and other substances which were contributing to the depletion of the ozone layer, and thus increasing ultraviolet radiation on the earth’s surface (GESAMP, 2001). Estimates in 1997 of total global NO_x emissions from shipping suggested that they were equivalent to 42 per cent of such emissions in North America and 74 per cent of those in European OECD countries, and that total global SO_x emissions from shipping were equivalent to 35 per cent of such emissions in North America and 53 per cent of such emissions in European OECD countries. The global emissions of both NO_x and SO_x were concentrated in the northern hemisphere (Corbett et al., 1997) – see Figure 12 for SO_x. Emissions from shipping have therefore been seen as a significant contributory source of air pollution in many parts of the world.



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 12. Estimated annual emissions of SO_x from ships 1997. Source: Corbett et al., 1997.

In 1997 a new annex to MARPOL (Annex VI) was adopted to limit the main air pollutants contained in ships' exhausts, including NO_x and SO_x. It also prohibits deliberate emissions of ozone-depleting substances and regulates shipboard incineration and emissions of VOCs from tankers. Following its entry into force in 2005, it was revised in 2008 to reduce progressively up to 2020 (or, in the light of a review, 2025) global emissions of NO_x, SO_x and particulate matter, and to introduce emission control areas (ECAs) to reduce emissions of those air pollutants further in designated sea areas (IMO, 2014n). These requirements can be achieved either by using bunkers with lower sulphur content (which may have higher prices) or by installing exhaust scrubbers. Some shipping companies have announced fuel surcharges to meet extra costs which they attribute to the new requirements (Container Management, 2014).

6.7 Anti-fouling treatments

Ships have always been at risk of marine organisms (such as barnacles) taking up residence on their hulls. This increases the resistance of the hull in its passage through water, and thus slows its speed and increases the fuel requirement. With fuel being around half the operating cost of a vessel, this can be a significant extra cost. Historically, the response involved taking the ship out of water and scraping the hull. Because of the inconvenience and cost of this, various treatments developed, mostly involving the application copper sheeting or copper-based paints. In the 1960s, organic compounds of tin were developed, which were shown to be very effective when applied as paints to ships' hulls, with the tin compounds leaching into the water. The most effective was tributyl tin (TBT) (Santillo et al., 2001). By the late 1970s they were commonly used on commercial and recreational craft from developed countries. In the late 1970s and early 1980s, oyster (*Crassostrea gigas*) harvests in Arcachon Bay, France, failed. Subsequent research identified that TBT was the cause. At the same time, research in the United Kingdom showed that TBT was an endocrine disruptor in a marine whelk species (*Nucella lapillus*) causing

masculinisation (imposex) in females and widespread population decline. Bans on TBT on boats less than 25 metres long first started in the 1980s. In 1990, the IMO recommended that Governments should eliminate the use of antifouling paints containing TBT. This resolution was intended as a temporary restriction until the IMO could implement a more far-reaching measure. The International Convention on the Control of Harmful Anti-fouling Systems on Ships was adopted in 2001. This prohibited the use of organotin compounds as biocides in anti-fouling paints. This Convention came into force in 2008, and has been ratified by 69 States, representing 84.41 per cent of the gross tonnage of the world's merchant fleet (IMO, 2014j). There are the typical enforcement problems with this Convention. There is also a legacy problem in that dry docks and port berths may have deposits of old anti-fouling paint in the sediments on their bottoms. As and when this sediment has to be removed, disposal into the sea will be a problem, since it may remobilise the TBT remains.

6.8 Wrecks

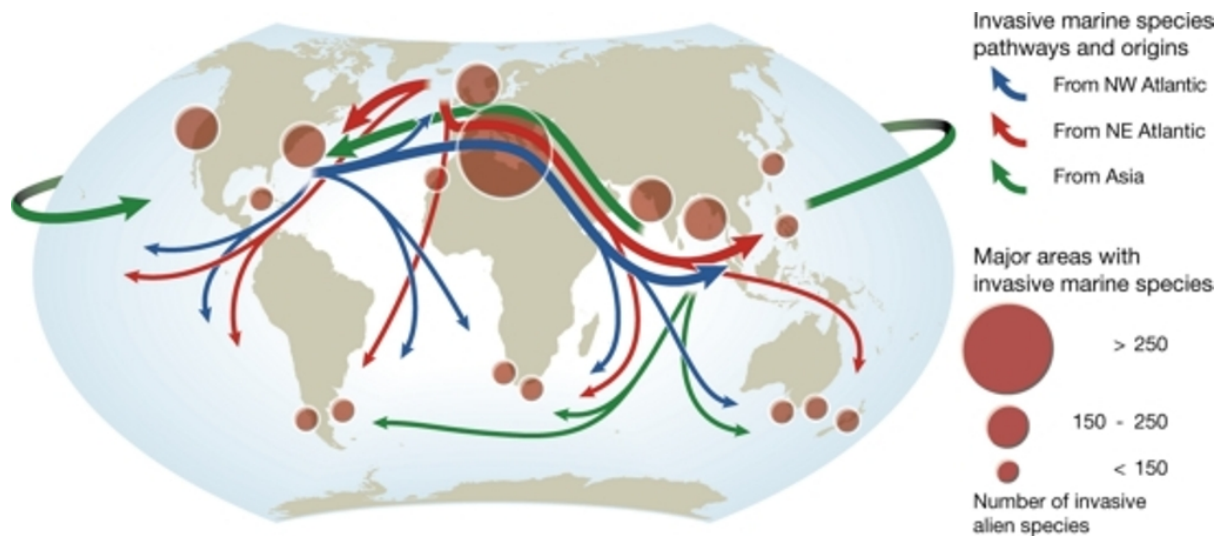
The seabed is littered with the remains of shipwrecks, some dating as far back as the second millennium BCE. The main impact on the marine environment comes from more recent wrecks, since the introduction of fuel oil as the source of the motive force. Such more recent wrecks will usually contain bunkers, which will eventually leak, and become a new source of oil pollution of the sea. Likewise, cargoes may present dangers of pollution from oil or hazardous substances. There are a number of other problems: first, and depending on its location, a wreck may constitute a hazard to navigation. Secondly, substantial costs are likely to be involved in the location, marking and removal of hazardous wrecks. The Nairobi International Convention on the Removal of Wrecks, 2007, aims to resolve these and related issues. It sets out rules on how to determine whether a wreck presents a hazard, makes the owner of the ship liable for costs of removal and marking (subject to the rules on limits for liability for marine damage) and requires compulsory insurance to cover such costs for ships registered in, or other ships entering or leaving, States parties to the Convention. The Convention will enter into force in 2015. So far there are 12 contracting States, representing 13.84 per cent of the gross tonnage of the world's merchant fleet (Bray et al, 2007; IMO, 2014).

6.9 Invasive species

Invasive non-native species are a major and growing cause of biodiversity loss. They can cause health problems, damage infrastructure and facilities, disrupt capture fisheries and aquaculture and destroy habitats and ecosystems. In some cases, the transport by shipping is clear. For example, in 1991 and 1992, the bacterium that causes cholera (*Vibrio cholerae*) was found in ballast water from five cargo ships in ports in the United States along the Gulf of Mexico (McCarthy, 1994). In other cases, it can be inferred. There are two main ways in which ocean shipping transports invasive species: as attachments to hulls, and in ballast water that has been taken up and discharged by ballasting operations during the stages of a voyage.

So far, the International Union for the Conservation of Nature (IUCN) has identified 84 non-native invasive marine species which have appeared in marine habitats outside their natural distribution (GISD, 2014). A separate review (Molnar et al, 2008), using a wide range of reports (not all peer-reviewed), identified 329 marine invasive species, with at least one species documented in 194 marine eco-regions (84 per cent of the 232 marine eco-regions worldwide used in the review). The main groups of species listed were crustaceans (59 species), molluscs (54), algae (46), fish (38), annelids (worms) (31), plants (19), and cnidarians (sea-anemones, jellyfish, etc) (17). The review found 205 species with detailed shipping pathway information. Of these, 39 per cent are thought to have been, or likely to have been, transported only by fouling of ships' hulls, 31 per cent in ballast water, and 31 per cent by one or other of these routes. Some regional reviews have also identified high numbers of non-native species: for example, 120 in the Baltic Sea and over 300 in the Mediterranean (Zaiko et al., 2011).

Another review of reports of cases of invasive species (Williams et al, 2008) found several estimates of economic damage in the range of millions of US dollars to the localities where the invasive species had been studied. Figure 13 shows a summary of the scale of transfers between origins and destinations (Nelleman, 2008).



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 13. Major pathways and origins of invasive species infestations in the marine environment. Source: Nelleman et al, 2008.

The scale of these problems led to international efforts to address the pathways through ships' ballast water and biofouling. In 1991 the IMO Marine Environment Protection Committee (MEPC) adopted guidelines for preventing the introduction of unwanted organisms and pathogens from ships' ballast water and sediment discharges. In 1993, the IMO Assembly followed this up by asking the MEPC to review the guidelines with a view to developing an international convention and, in

1997 invited States to use the guidelines to address this problem. More than fourteen years of negotiations were needed to develop the 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments (the BWM Convention). The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. States parties can take additional measures subject to specified criteria and guidelines. The MEPC completed the work of developing the guidelines in 2008. The basic requirements of the BWM Convention are the ballast water exchange standard and the ballast water performance standard. Ships performing ballast water exchange must do so with an efficiency of 95 per cent volumetric exchange of ballast water. Ships using a ballast water management system must meet a performance standard based on agreed numbers of organisms per unit of volume. The BWM Convention requires acceptance by 30 States representing 35 per cent of the gross tonnage of the world merchant fleet before it can enter into force. By November 2014, 43 States representing 32.54 per cent of the tonnage of the world merchant fleet had accepted it. It therefore seems likely to enter into force fairly soon (IMO, 2014j, IMO, 2014k).

The Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (Biofouling Guidelines) were adopted in July 2011. The Biofouling Guidelines are intended to provide a globally consistent approach to the management of aquatic organisms on ships' hulls, and represent a decisive step towards reducing the transfer of invasive aquatic species by ships. In addition, biofouling management can improve a ship's hydrodynamic performance and, therefore, be an effective tool in enhancing energy efficiency and reducing air emissions. In October 2012, the IMO supplemented the Biofouling Guidelines with Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft, less than 24 metres in length.

6.10 Noise

The marine environment is subject to a wide array of human-made noise from activities such as commercial shipping, oil and gas exploration and the use of various types of sonar. This human activity is an important component of oceanic background noise and can dominate in coastal waters and shallow seas. Long-term measurements of ocean ambient sound indicate that low frequency anthropogenic noise has been increased, primarily due to commercial shipping, both as a result of increases in the amount of shipping and as a result of developments in vessel design (particularly of propellers), which have not prioritised noise reduction. Shipping noise is centred in the 20 to 200 Hz frequency band. Noise at these low frequencies propagates efficiently in the sea, and can therefore affect marine biota over long distances. Baleen whales use the same frequency band for some of their communication signals. A variety of other marine animals are known to be affected by anthropogenic noise in the ocean. Negative impacts for least 55 marine species (cetaceans, fish, marine turtles and invertebrates) have been reported in scientific studies. The effects can range from mild behavioural responses to complete avoidance of the affected area. A 1993 study concluded that "low-frequency noise

levels increased by more than 10 dB in many parts of the world between 1950 and 1975,” corresponding to about 0.55 dB per year. A 2002 study indicated an increase of approximately 10 dB over 33 years (about 0.3 dB per year). Subsequent measurements up to 2007 confirmed this but suggest that, in some places at least, the subsequent rate of increase has slowed or stopped. It is generally agreed that anthropogenic noise can be an important stressor for marine life and is widely regarded as a global issue that needs addressing (NRC, 2003, Tyack 2008, Andrew et al., 2011, UNEP 2012).

6.11 Enforcement

The effectiveness of the internationally agreed rules to protect the marine environment from the adverse effects of shipping depends to a large extent on the extent of enforcement. There are important economic aspects to the ways in which this enforcement is carried out. The United Nations Convention on the Law of the Sea (UNCLOS) gives flag States, coastal States and port States a range of powers to enforce internationally agreed rules and standards. For port-State control, ports are often competing with their neighbours. This makes it economically important for the port-States to be certain that their enforcement actions are not disadvantaging the competitive positions of their ports. Port-State inspection is, therefore, carried out in many regions in accordance with memorandums of understanding between the States of the region. Memorandums of understanding (MoU) have been set up covering most ocean regions: Europe and the north Atlantic (Paris MoU – 27 States); Asia and the Pacific (Tokyo MoU – 19 States and territories); Latin America (Acuerdo de Viña del Mar – 15 States); Caribbean (Caribbean MoU – 14 States and territories); West and Central Africa (Abuja MoU – 14 States); the Black Sea region (Black Sea MoU – 6 States); the Mediterranean (Mediterranean MoU – 10 States); the Indian Ocean (Indian Ocean MoU – 17 States); and the Riyadh MoU (part of the Persian Gulf – 6 States). These port-State inspection organizations publish details of the results of their inspections, which can have economic significance for ship operators, since cargo consignors tend not to want to use shipping lines which have a poor performance.

Attention to the implementation of international rules and standards demands qualified inspectors to undertake the various controls. Most port-State control inspectors have qualified through service on board ships. A demand for more inspectors may well be in competition for the same pool of staff, which (as noted above) may be itself inadequate for the primary task of crewing ships if the steady growth in shipping activity continues.

7. Significant environmental, economic and/or social aspects in relation to shipping (including information gaps and capacity-building gaps)

This section summarises the most significant elements from the foregoing sections.

Shipping is a vital component of the world economy. As the world economy has become increasingly globalized, the role of shipping has become more important. The economic crisis of 2008 produced some reductions in the levels of shipping, but those have recovered and growth has resumed, though not at quite the previous rate. Shipping has provided means for many States rich in primary resources to export those resources, and for many States that are developing their economies to export their products. Gradually, the balance of the tonnage of goods loaded in developed and in developing countries is becoming more equal. Increasing human wealth will therefore continue to be a driver in increasing the scale of shipping that is needed.

The pressures that shipping imposes on the environment are significant and widespread. In total they represent a significant contribution to the cumulative pressures that humans are imposing on the rest of the marine environment, and that is affecting the harvest from the sea and the maintenance of biodiversity. The pressures are particularly concentrated at certain choke points where shipping routes crowd through narrow sea-passages, e.g., straits or canals. Those pressures are also diverse – some result from shipping disasters, and some are chronic (oil discharges, loss of containers, garbage, sewage, air pollution, noise, anti-fouling treatments of hulls, transport of invasive species). Over the past 40 years, global rules and standards have been developed to regulate most of these. Steps are now being taken to make the enforcement of these rules and standards more uniform throughout the world.

However, there is still a significant number of States and territories that have not been able to become parties to the various international conventions and agreements that embody these rules and standards. These States and territories need to build the capacities which will enable them to commit themselves to implementing these rules and standards. The necessary skilled staff and facilities will also be needed to implement those rules and standards. Although the IMO and other international organizations have programmes to support such capacity-building, there are still gaps.

There are signs that, at least in some regions, the implementation of these global rules and standards and other local measures is helping to improve the status of the marine environment. The overall number of ships lost at sea has continued to decrease, and in some areas oil discharges seem to have declined. But there is a continuing growth in shipping. Unless the everyday pressures generated by shipping can be steadily reduced, the continuing growth in shipping will lead to increased pressure on the ocean. Even if all ships can meet the standards of the best, increased numbers and tonnage of shipping will eventually increase the pressures on the environment.

However, in many parts of the world, coastal States do not have adequate plans to respond to maritime casualties. Such plans often require substantial investment in plant and equipment and the training of personnel. The resources for such investment are sometimes lacking.

From the social aspect of shipping, it is noteworthy that Africa and South America are underrepresented in the labour force. The divergence between the genders is

even more noteworthy, with only an estimated 2 per cent of the maritime labour force being female. It is also noteworthy that there are significant differences in the levels of pay of ships' officers depending on their national origin.

Current reports suggest that there is an adequate labour force to provide the crews of the current levels of shipping. If (as is expected) the amount of world shipping continues to grow, crew shortages may develop. Skilled staff will also be needed to enforce the internationally agreed rules and standards, and this demand may be competing with those for ships' crews.

The entry into force of the 2006 Maritime Labour Convention in 2013 was a major step forward in ensuring the provision of decent working and living conditions for seafarers. Capacities will need to be built for its enforcement.

There is a gap in the information available on deaths of, and injuries to, seafarers. This information is essential for ensuring that they have decent working conditions and for reducing the numbers of seafarers' deaths and injuries. Likewise, the information available on the deaths of, and injuries to, passengers does not appear to be adequate to support policy development in this field, although such information as is available does not suggest that this is a major problem.

References

- ACP (2014). Autoridad del Canal de Panamá –
<https://www.pancanal.com/eng/pr/press-releases/2014/06/25/pr514.html>
(accessed 4 July 2014).
- Akten, Nekmettin (2004). Analysis of Shipping Casualties in the Bosphorus, *Journal of Navigation*, vol. 57, issue 03.
- Allianz Global Corporate & Specialty (2012). SE with Cardiff University, Safety and Shipping 1912 to 2012.
http://www.agcs.allianz.com/assets/PDFs/Reports/AGCS_safety_and_shipping_report.pdf (accessed 22 July 2014).
- Allianz Global Corporate & Specialty (2014) SE, Safety and Shipping Review.
<http://www.agcs.allianz.com/insights/white-papers-and-case-studies/shipping-review-2014/> (accessed 22 July 2014).
- Andrew, R.K., Howe, B.M., and Mercer, J.A. (2011). Long-time trends in ship traffic noise for four sites off the North American West Coast, *Acoustical Society of America*, 129, 642.
- Argentina 1998 – Prefectura Naval Argentina, Ordenanza No 13/98 (Rutas de los buques que transportan hidrocarburos y sustancias nocivas líquidas en granel en navegación marítima nacional), 8 January.
- Barth, H. (2001). The coastal ecosystems 10 years after the 1991 Gulf War oil spill (unpublished)
http://www.uni-regensburg.de/Fakultaeten/phil_Fak_III/Geographie/phygeo/downloads/barthcoast.pdf
(accessed 21 June 2014).
- BIMCO/ISF (Baltic International Marine Council and International Shipping Federation) (2010). Manpower 2010 Update: The Worldwide Demand for and Supply of Seafarers.
https://www.bimco.org/en/News/2010/11/~/_media/About/Press/2010/Manpower_Study_handout_2010.ashx (accessed 20 June 2014).
- BOBLME Malaysia (2011). Bay of Bengal Large Marine Ecosystem Project, Country report on pollution – Malaysia -
<http://www.boblme.org/documentRepository/BOBLME-2011-Ecology-07.pdf>
(accessed 17 March 2014).
- Boersma, P. Dee (2008). Penguins as Marine Sentinels, *BioScience*, vol. 58, No. 7.
- BONN (2013). Bonn Agreement, Annual report on aerial surveillance for 2012
<http://www.bonnagreement.org/eng/html/welcome.html> (accessed 31 May 2014).
- BONN (2014). Bonn Agreement, Counter-Pollution Manual
<http://www.bonnagreement.org/eng/html/welcome.html> (accessed 31 May 2014).

- Bray, S. and Langston, W.J., *Tributyltin pollution on a global scale - An overview of relevant and recent research: impacts and issues*, WWF, Godalming.
- Brazil (2013). Marinha do Brasil - Diretoria de Hidrografia e Navegação, Manual de Utilização do Sistema de Tarifa de Utilização de Faróis.
<https://sistuf.dhn.mar.mil.br/arquivos/manual.pdf> (accessed 20 June 2014).
- Canada (2011). Environment Canada, Birds oiled at Sea. <http://www.ec.gc.ca/mbc-com/default.asp?lang=En&n=C6E52970-1> (accessed 20 April 2014).
- Cedre (2010). Centre de documentation, de recherche et d'expérimentation sur les pollutions accidentelles des eaux. *Bulletin de information du Cedre No 27*, 2010 (ISSN 1247-603X).
- CINS (Container Incident Notification System Organization) (2014). *Liner 'Cargo Incident Notification System' growing up*.
<http://www.containerownersassociation.org/news/370-liner-%E2%80%98cargo-incident-notification-system%E2%80%99-growing-up.html> (accessed 31 May 2014).
- CLIA (Cruise Lines International Association) (2014). *State of the Cruise Industry Report*. <http://www.cruising.org/sites/default/files/pressroom/Infographic.pdf> (accessed 5 July 2014).
- CMW (Cruise Market Watch) (2014). *Growth*.
<http://www.cruisemarketwatch.com/growth/> (accessed 8 July 2014).
- COMNAP (Council of Managers of National Antarctic Programmes) (2005). *International Coordination of Hydrography in Antarctica: Significance to Safety of Antarctic Ship Operations*, XXX Antarctic Consultative Meeting, New Delhi, 2007 (HCA7-INF5).
- Corbett J.J., and Fischbeck, P.S. (1997). Emissions from Ships, *Science*, vol 278, 1997.
- Container Management (2014): "Maersk announces Low-Sulphur Surcharge". (<http://container-mag.com/2014/10/09/maersk-announces-low-sulphur-surcharge/> accessed 10 December 2014).
- Corbin, C. (2011). Protecting the Caribbean Sea from marine-based pollution: lessons from the MARPOL Annex V Special Area Designation, In *Technical Proceedings of the Fifth International Marine Debris Conference March 20–25, Honolulu, Hawai'i, USA* (Ben Carswell, Kris McElwee, and Sarah Morison, eds), National Oceanic and Atmospheric Administration, Technical Memorandum NOS-OR&R-38, 2011.
- Dias, M. (2009). *O Desenvolvimento do Transporte de Contêineres na Cabotagem Brasileira*, in www.antaq.gov.br/portal/SeminarioCabotagem.asp (accessed 4 July 2014).
- Lord Donaldson of Lymington (1994): Safer Ships, Cleaner Seas: Report of Lord Donaldson's Inquiry into the Prevention of Pollution from Merchant Shipping (Command Paper Cm 2560), Her Majesty's Stationery Office, London, United Kingdom.
- Ebbesmeyer, C. and Scigliano, E. (2009). *Flotsametrics and the Floating World: How*

- One Man's Obsession with Runaway Sneakers and Rubber Ducks Revolutionized Ocean Science*, Collins, London (ISBN. London Collins (ISBN: 9780061971150).
- EC (European Commission). (1999). *The Development of Short Sea Shipping in Europe: A Dynamic Alternative in a Sustainable Transport Chain*, (COM(1999) 317 final).
- EC (European Parliament and the Council of the European Union) (2000). Directive of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues. (Directive 2000/59/EC as amended).
- EC (European Parliament and the Council of the European Union) (2009). Directive of 23 April 2009 on the insurance of shipowners for maritime claims (Directive 2009/20/EC).
- Economist (2014). Polar bearings, *The Economist*, 12 July 2014.
- EIA (USA Energy Information Administration) (2014a). U.S. *Natural Gas Imports and Exports 2013* - <http://www.eia.gov/naturalgas/importsexports/annual/> (accessed 10 July 2014).
- EIA (USA Energy Information Agency (2014b), *International Energy Statistics – Consumption of Residual Fuel Oil for Bunkering* (<http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=66&aid=13>) (accessed 20 October 2014).
- EMSA (European Maritime Safety Agency) (2010). Horizontal Assessment Report – Port Reception Facilities (*Directive 2000/59/EC*), 2010. <http://ec.europa.eu/transport/modes/maritime/consultations/doc/prf/emsa-report.pdf> (accessed 6 June 2014).
- EPA (USA Environmental Protection Agency) (2008). Cruise Ship Discharge Assessment Report, (*document EPA842-R-07-005*).
- EPA (USA Environmental Protection Agency) (2014a). *Sewage and Graywater Standards Development* http://water.epa.gov/polwaste/vwd/sewage_gray.cfm (accessed 14 August 2014).
- EPA (USA Environmental Protection Agency) (2014b). *Nitrogen Oxides – Health* <http://www.epa.gov/oaqps001/nitrogenoxides/health.html> (accessed 21 July 2014).
- EPA (USA Environmental Protection Agency) (2014c). Southern California Air Quality <http://www.epa.gov/Region9/socal/air/index.html> (accessed 21 July 2014).
- EU (2013). European Union, *Report from the Commission to the European Parliament, the Council and the European Economic and Social Committee on the implementation by the Member States of Council Directive 2006/117 EURATOM on the supervision and control of shipments of radioactive waste and spent fuels* (COM(2013) 240 final).
- EVOSTC (Exxon Valdez Oil Spill Trustee Council) (2010). Status of Injured Resources and Services. <http://www.evostc.state.ak.us/index.cfm?FA=status.injured> (accessed 20 June 2014).
- Faststream (Faststream Recruitment Ltd) (2012). *Maritime Salary Review*.

- http://www.faststream.com/faststream_recruitment_news/2012_maritime_salary_review/ (accessed 20 May 2014).
- Fowler, G.S., et al. (1995). Hormonal and Reproductive Effects of Low Levels of Petroleum Fouling in Magellanic Penguins (*Spheniscus Magellanicus*), *The Auk*, vol. 112, section 2.
- FSI (IMO Sub-committee on Flag State Implementation) (2012). Casualty Statistics and Investigations – report by IMO Secretariat, IMODOCS FSI 20/5/4.
- G&M (2014). A reality check on the North-West Passage “boom”. *The Globe and Mail*, Toronto, 7 January.
- Garcia-Borboroglu, P., Boersma, P.D., Reyes, L.M. and Skewgar, E. (2013). *Petroleum Pollution and Penguins: Marine Conservation Tools to Reduce the Problem*. Paper presented at the annual meeting of the International Marine Conservation Congress, George Madison University, Fairfax, Virginia. http://citation.allacademic.com/meta/p296486_index.html (accessed 30 June 2014).
- GESAMP (2001). Joint Group of Experts on the Scientific Aspects of Marine Pollution, *A Sea of Troubles*. Arendal, Norway (ISBN 82-7701-019-9).
- GISD (2014). International Union for the Conservation of Nature, *Global Invasive Species Database*. <http://www.issg.org/database/species/search.asp?sts=sss&st=sss&fr=1&x=12&y=9&sn=&rn=&hci=8&ei=-1&lang=EN> (accessed 25 November 2014).
- Gandini, P., Boersma, D., Frere, E., Gandini, M., Holik T., and Lichtschein, V. (1994). *Magellanic Penguins (Spheniscus magellanicus) Affected by Chronic Petroleum Pollution along the Coast of Chubut, Argentina*. *The Auk*, Vol. 111(1), 20-27.
- Greaver, T.L., Sullivan, T.J., Herrick, J.D., Barber, M.C., Baron, J.S., Cosby, B.J., Deerhake, M.E., Dennis, R.L., Dubois, J-J.B., Goodale, C.L., Herlihy, A.T., Lawrence, G.B., Liu, L., Lynch, J.A., and Novak, K.J. (2012). Ecological effects of nitrogen and sulfur air pollution in the US: what do we know? *Frontiers in Ecology and the Environment*, Vol. 10, No. 7. 365-372.
- HELCOM (Helsinki Commission) (2010). Ecosystem Health of the Baltic Sea 2003–2007: HELCOM Initial Holistic Assessment, *Baltic Sea Environment Proceedings No. 122*. Helsinki (ISSN 0357 – 2994).
- HELCOM (Helsinki Commission) (2014a). *2013 HELCOM overview on port reception facilities for sewage in the Baltic Sea area and related trends in passenger traffic* (HELCOM document 4/16/Rev 1).
- HELCOM (Helsinki Commission) (2014b). Annual report on illegal discharges observed during aerial surveillance 2013. <http://helcom.fi/Lists/Publications/HELCOM%20report%20on%20illegal%20discharges%20observed%20during%20aerial%20surveillance%20in%202013.pdf> (accessed 12 July 2014).
- Hildebrand, J.A. (2009). Anthropogenic and natural sources of ambient noise in the ocean *Marine Ecology Progress Series*, Vol 395.

- Humpert M., and Raspotnik, A. (2012). *The Future of Arctic Shipping*, The Arctic Institute. <http://www.thearcticinstitute.org/2012/10/the-future-of-arctic-shipping.html> (accessed 25 July 2014).
- IACS, (International Association of Classification Societies) (2014). *Classification Societies - What, Why And How?* http://www.iacs.org.uk/document/public/explained/Class_WhatWhy&How.PDF (accessed 20 October 2014).
- IAEA (International Atomic Energy Agency) (2008). Security in the transport of radioactive material, Vienna, *IAEA Nuclear Security Series No. 9* (ISBN 978–92–0–107908–4).
- ICS (International Chamber of Shipping) (2014). *World Seaborne Trade* <http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade/world-seaborne-trade> (accessed 3 July 2014)
- IEA (International Energy Agency) (2014). *Key World Energy Statistics 2014*, Paris.
- ILO (International Labour Organization) (2003). Safety and health in shipbreaking: Guidelines for Asian countries and Turkey, *ILO 2003* (MESHS/2003/1).
- ILO (International Labour Organization) (2014). Press Release – “ILO body adopts new minimum monthly wage for seafarers” 28 February 2014 - http://www.ilo.org/global/about-the-ilo/media-centre/press-releases/WCMS_236644/lang--en/index.htm (accessed 31 May 2014).
- IMO (International Maritime Organization) (2012). International Shipping Facts and Figures – Information Resources on Trade, Safety, Security, Environment. <http://www.imo.org/KnowledgeCentre/ShipsAndShippingFactsAndFigures/TheRoleandImportanceofInternationalShipping/Documents/Internationalper cent20Shippingper cent20-per cent20Factsper cent20andper cent20Figures.pdf> (accessed 17 April 2014).
- IMO (International Maritime Organization) (2013). IMO Instruments Implementation Code (III Code) (IMO document A 28/Res 1070).
- IMO (International Maritime Organisation) (2014). Special areas under MARPOL. <http://www.imo.org/OurWork/Environment/Pollution/Prevention/SpecialAreasUnderMARPOL/Pages/Default.aspx> (accessed 21 June 2014).
- IMO (International Maritime Organization) (2014a). Reports on Acts of Piracy and Armed Robbery against Ships - Annual Report – 2013 (MSC.4/Circ.208 1 March 2013⁶) http://www.imo.org/OurWork/Security/SecDocs/Documents/PiracyReports/208_Annual_2013.pdf (accessed 31 May 2014).
- IMO (International Maritime Organization) (2014b). Ships’ Routing <http://www.imo.org/OurWork/Safety/Navigation/Pages/ShipsRouting.aspx>

⁶ The document is dated 1 March 2013, but states that it contains the information for the year ending 31 December 2013.

- (accessed 8 July 2014).
- IMO (International Maritime Organization) (2014b). Hong Kong Convention
<http://www.imo.org/about/conventions/listofconventions/pages/the-hong-kong-international-convention-for-the-safe-and-environmentally-sound-recycling-of-ships.aspx> (accessed 10 July 2014).
- IMO (International Maritime Organization) (2014c). Summary of Status of Conventions
<http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>, (accessed 12 July 2014).
- IMO (International Maritime Organization) (2014d). Particularly Sensitive Sea Areas
<http://pssa.imo.org/#/intro> (accessed 31 May 2014).
- IMO (International Maritime Organization) (2014e). International Convention on Oil Pollution Preparedness, Response and Co-operation 1990
[http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-\(OPRC\).aspx](http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-(OPRC).aspx) (accessed on 31 May 2014).
- IMO (International Maritime Organization) (2014f). Carriage of Chemicals by Ship.
<http://www.imo.org/OurWork/Environment/PollutionPrevention/ChemicalPollution/Pages/Default.aspx>
(accessed 31 May 2014).
- IMO (International Maritime Organization) (2014g). Prevention of Pollution by Garbage from Ships.
<http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Pages/Default.aspx> (accessed 31 May 2014).
- IMO (International Maritime Organization) (2014h). Prevention of Pollution by Sewage from Ships.
<http://www.imo.org/OurWork/Environment/PollutionPrevention/Sewage/Pages/Default.aspx>
(accessed 7 June 2014).
- IMO (International Maritime Organization) (2014j). Prevention of Pollution by Sewage from Ships.
<http://www.imo.org/OurWork/Environment/PollutionPrevention/Sewage/Pages/Default.aspx> (accessed 7 June 2014).
- IMO (International Maritime Organization) (2014k). Water Management.
<http://www.imo.org/OurWork/Environment/BallastWaterManagement/Pages/Default.aspx> (accessed 20 November 2014).
- IMO (International Maritime Organization) (2014l). Status of Conventions.
<http://www.imo.org/About/Conventions/StatusOfConventions/Documents/Status%20-%202014.pdf> (accessed 28 November 2014).
- IMO (International Maritime Organization) (2014m). Special areas under MARPOL.
<http://www.imo.org/OurWork/Environment/Pollution/Prevention/SpecialAreas>

- UnderMARPOL/Pages/Default.aspx (accessed 21 June 2014).
- IMO, (2014) – International Maritime Organization, Prevention of Air Pollution from Ships.
(<http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx> accessed 3 December 2014).
- IMO, (2014) – International Maritime Organization, *Third IMO Greenhouse Gas Study 2014*.
- IOPCF (International Oil Pollution Compensation Funds) (2013). Annual Report.
http://www.iopcfunds.org/uploads/tx_iopcpublications/annualreport2013_e.pdf (accessed on 31 May 2014).
- Irons, David B., et al (2000). Nine Years after the "Exxon Valdez" Oil Spill: Effects on Marine Bird Populations in Prince William Sound, Alaska, *The Condor*, vol. 102, No. 4.
- ITF (International Transport Workers Federation) (2014). Women Seafarers
<http://www.itfseafarers.org/ITI-women-seafarers.cfm> (accessed 1 July 2014).
- ITOPF (International Tanker Owners Federation) (2014a). Information and Statistics.
<http://www.itopf.com/knowledge-resources/data-statistics/statistics/> (accessed 30 May 2014).
- ITOPF (International Tanker Owners Federation) (2014b). Oil Tanker Spill Statistics 2013.
http://www.itopf.com/fileadmin/data/Documents/Company_Lit/OilSpillstats_2013.pdf (accessed 30 May 2014).
- Jones, D.A., et al (1994). Intertidal recovery in the Dawhat ad-Dafi and Dawhat al-Musallamiya region (Saudi Arabia) after the Gulf War oil spill. *Courier der Forschungs-Institut Senckenberg*, vol 166.
- Kaluza, P., Kölzsch, A., Gastner, M.T. and Blasius, B. (2010). The complex network of global cargo ship movements. *Journal of the Royal Society: Interface*, (7).
- Kendall, Steven J., Erickson, W.P., Lance, B.K., Irons, D.B. and McDonald, L.L. (2001). Twelve Years after the Exxon Valdez Oil Spill. *The Condor*, Vol. 103, No. 4.
- KIMO (Kommunenenes Internasjonale Miljøorganisasjon) (2011). *The Transport of Nuclear Materials by Sea in Northern Europe*. Lerwick (United Kingdom), 2011.
- Knelson, J.H. and Lee, R.E. (1977). Oxides of Nitrogen in the Atmosphere: Origin, Fate and Public Health Implications. *Ambio*, vol. 6, No. 2/3.
- Laulajainen, R. (2009). The Arctic Sea Route. *International Journal of Shipping and Transport Logistics*, vol. 1(1).
- Lee, S.D. (ed.) (1980). *Nitrogen Oxides and their Effects on Health*. Ann Arbor Science Publishers, Michigan.
- Levinson, Marc. (2008). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton (ISBN 9781400828586).
- Liu, Miaoqia and Kronbak, Jacob. (2010). The potential economic viability of using the Northern Sea Route (NSR) as an alternative route between Asia and Europe.

Journal of Transport Geography, vol. 18, Issue 3.

Lloyds List, 2014. CMA CGM, UASC and China Shipping unveil rival to 2M, G6 and CKYHE, Tuesday 09 September 2014.

Mandryk, W. (2009) (Lloyd's Marine Intelligence Unit), *Measuring global seaborne trade*. International Maritime Statistics Forum, New Orleans.
http://www.imsf.info/papers/NewOrleans2009/Wally_Mandryk_LMIU_IMSF09.pdf (accessed 10 July 2014).

MARAD (2014) USA Department of Transportation, Maritime Administration, America's Marine Highway Program.
http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm (accessed 20 June 2014).

MARPOL (1973/78). The International Convention for the Prevention of Pollution from Ships. United Nations *Treaty Series*, vol. 1340, I-22484.

McCarthy, S.A., Khambaty, F.M., (1994). International dissemination of epidemic *Vibrio cholerae* by cargo ship ballast and other nonpotable waters. *Applied Environmental Microbiology*, Vol 60, 7.

Mearns, K., Olivier J. and Jordaan M. (2012). Shipping Accidents along the South African Coastline.
http://www.academia.edu/537251/Shipping_Accidents_Along_the_South_African_Coastline (accessed 20 June 2014).

MEPC (IMO Marine Environment Protection Committee) (2012). Resolution MEPC.227(64), IMO Document MEPC 64/23/Add.1, Annex 22.

MLC (International Labour Organization) (2006). The Maritime Labour Convention.
http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:91:0:::P91_SECTION:MLC_A5 (accessed on 2 July 2014).

Moller, T.H., Molloy, F.C. and Thomas, H.M. (2003): Oil Spill Risks and the State of Preparedness in the Regional Seas. *International Oil Spill Conference Proceedings*: Vol. 2003, No. 1, pp. 919-922.

Molnar, J.L., Gamboa, R.L., Revenga, C., and Spalding, M.D. (2008). Assessing the Global Threat of Invasive Species to Marine Biodiversity. *Frontiers in Ecology and the Environment*, Vol. 6, 9.

MPA (Maritime and Port Authority of Singapore) (2014) *Bunkering*.
http://www.mpa.gov.sg/sites/port_and_shipping/port/bunkering/bunkering.page (accessed 20 October 2014).

Nelleman, C., Hain, S., and Alder, J. (Eds) (2008). *In Dead Water – Merging of climate change with pollution, over-harvest, and infestations in the world's fishing grounds*. United Nations Environment Programme, GRID-Arendal, Norway.

Nielsen, D., and Roberts S. (1999). Fatalities among the world's merchant seafarers (1990–1994). *Marine Policy*, Volume 23, 1.

NRC (USA National Research Council (1995)). *Clean Ships, Clean Ports, Clean Oceans: Controlling Garbage and Plastic Wastes at Sea*. National Academy Press:

- Washington, DC, 1995.
- NRC (USA National Research Council - Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals (2003)). *Ocean Noise and Marine Mammals*. National Academies Press. Washington (DC) USA.
- NSN (North Sea Network) (2012). *North Sea Manual on Maritime Oil Pollution Offences*. London, (ISBN 978-1-906840-45-7).
- OECD (Organization for Economic Cooperation and Development) (2003). *Cost Savings Stemming from Non-Compliance with International Environmental Regulations in the Maritime Sector*.
[http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/DOT/MTC\(2002\)8/FINAL&docLanguage=En](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/DOT/MTC(2002)8/FINAL&docLanguage=En) (accessed 7 June 2014).
- OSPAR (OSPAR Commission) (2000). *Quality Status Report on the North-East Atlantic*. London, 2000 (ISBN 0 946956 52 9).
- OSPAR (OSPAR Commission) (2010). *Quality Status Report 2010*, London (ISBN 978-1-907390-38-8).
- Otsuki, A., Abdulraheem, M.Y., and Reynolds, R.M. (eds) (1998). *Offshore Environment of the ROPME Sea Area after the War-Related Oil Spill – Results of the 1993-94 Umitaka-Marun Cruises*, Tokyo 1998 (ISBN 4-88704-123-3).
- P&O (2014). *Peninsular and Oriental Steam Navigation Company, Our History*.
<http://www.poheritage.com/our-history> (accessed 6 July 2014).
- Rall, David P. (1974). Review of the Health Effects of Sulfur Oxides. *Environmental Health Perspectives*, Vol. 8.
- Readman, J.W., Fowler, S.W., Villeneuve, J.-P., Cattini, C., Oregioni B., Mee, L.D. (1992). Oil and combustion-product contamination of the Gulf marine environment following the war. *Nature*, 358.
- REMPEC (2014). Regional Marine Pollution Emergency Response Centre for the Mediterranean, Illicit Discharges.
http://www.rempec.org/rempec.asp?theIDS=2_161&theName=PREVENTION&theID=8&daChk=2&pgType=1 (accessed 12 July 2014).
- Ritchie, W., and O'Sullivan, M. (eds). (1994). *The Environmental Impact of the Wreck of the Braer*, Scottish Office Environment Department. Edinburgh (ISBN 07480 0900 0).
- Rockefeller (2013). Staff Report Prepared For Senator John D. Rockefeller IV, Chairman, USA Senate Committee On Commerce, Science, And Transportation, Cruise Ship Crime. <http://www.lipcon.com/files/cruise-ship-crime-consumers-have-incomplete-access-to-cruise-crime-data.pdf> (accessed 20 July 2014).
- Santillo, D., Johnston, P., Langston, W.J. (2001). Tributyltin (TBT) antifoulants: a tale of ships, snails and imposex. In: Harremoës P, Gee D, MacGarvin M, Stirling A, Keys J, Wynne B, et al., eds *Late Lessons from Early Warnings: The Precautionary Principle*. Environment Issue Report, no. 22., European Environment Agency, Copenhagen.

- SCD (Supply Chain Digest) (2014). <http://www.scdigest.com/ontarget/14-07-23-3.php?cid=8310> (accessed 26 July 2014).
- Sekimizu, K. (2013). Address of the Secretary-General of the International Maritime Organization at the Opening of the Fifty-Sixth Session of the Sub-Committee on Fire Protection, 7 January 2013
<http://www.imo.org/MediaCentre/SecretaryGeneral/Secretary-GeneralsSpeechesToMeetings/Pages/FP-56-opening.aspx> (accessed 31 May 2014).
- Sekimizu, K. (2014). Address of the Secretary-General of the International Maritime Organization at the Opening of the Ninety-Third Session of the Maritime Safety Committee, 14 May 2014.
<http://www.imo.org/MediaCentre/SecretaryGeneral/Secretary-GeneralsSpeechesToMeetings/Pages/MSC93opening.aspx> (accessed 30 June 2014).
- Seltmann, A. (2014). *Global Marine Insurance Report 2014*. International Union for Marine Insurance
http://www.iumi.com/images/gillian/HKfromHH/20140922_1200_Seltmann_As trid_FactsFigures_corr.pdf (accessed 23 May 2014).
- Statista Inc. (2014) <http://www.statista.com/statistics/204563/cruise-revenue-expenses-and-profit-per-passenger-worldwide/> (accessed 21 July 2014).
- STH (2014). Ship Trade House – Types of Vessel.
(<http://shiptradehouse.com/vsotypes> accessed 22 May 2015).
- Stebbing, A.R.D. (1985). Organotins and water quality – some lessons to be learned, *Marine Pollution Bulletin*. 16 (10).
- TRB (Transportation Research Board) (2012). *Safe Navigation in the U.S. Arctic - Summary of a Conference*, Seattle.
<http://onlinepubs.trb.org/onlinepubs/conf/CPW11.pdf> (accessed 3 July 2014).
- Tyack, P.L., 2008. Implications for Marine Mammals of Large-Scale Changes in the Marine Acoustic Environment. *Journal of Mammalogy*, 89(3), 549–558.
- UKHO (United Kingdom Hydrographic Office) (2014). *Annual Summary of Notices to Mariners 2014*. Taunton (ISBN 978-0-70-773-2138).
- UNCLOS (1982). United Nations Convention on the Law of the Sea, United Nations, *Treaty Series*, vol. 1833, No. 31363.
- UNCTAD (2012). United Nations Conference on Trade and Development, *Liability and Compensation for Ship-Source Oil Pollution: An Overview of the International Legal Framework for Oil Pollution Damage from Tankers - Studies in Transport Law and Policy - 2012 No. 1*, New York and Geneva.
- UNCTAD (2013). Secretariat of the United Nations Conference on Trade and Development (UNCTAD), *Review of Maritime Transport 2013*, New York and Geneva (ISBN 978-92-1-112872-7).
http://unctad.org/en/PublicationsLibrary/rmt2013_en.pdf
- UNEP (United Nations Environment Programme) (2012). Convention on Biological

- Diversity, Subsidiary Body on Scientific, Technical and Technological Advice, Scientific Synthesis on the Impacts of Underwater Noise on Marine and Coastal Biodiversity and Habitats (SBSTTA document 16/INF/12).
- USMA (USA Maritime Administration) (2014). *Marine Highway Fact sheet*.
http://www.marad.dot.gov/documents/AMH_Fact_Sheet_V11.pdf (accessed 7 July).
- Verny J. and Grigentin, C. (2009). Container shipping on the Northern Sea Route. *International Journal of Production Economics*, 122.
- Wergeland, T. (2012). Ferry Passenger Markets. In *The Blackwell Companion to Maritime Economics* (Wayne K. Talley, ed.).
<http://onlinelibrary.wiley.com/doi/10.1002/9781444345667.ch9/summary> (accessed 2 July 2014).
- Williams, I. and Hoppe, H. (2001). Safety Regulations for Non-Convention Vessels – The IMO Approach.
http://www.imo.org/blast/blastDataHelper.asp?data_id=18002&filename=Safety.pdf (accessed 20 June 2014).
- Williams, S.L. and Grosholz, E.D. (2008). The Invasive Species Challenge in Estuarine and Coastal Environments: Marrying Management and Science, *Estuaries and Coasts*, Vol. 31 (1).
- WNA (World Nuclear Association) (2014). Transport of Radioactive Materials.
<http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Transport/Transport-of-Radioactive-Materials/> (accessed 1 July 2014).
- WNA (World Nuclear Association) (2014). Transport of Nuclear Fuels.
<http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Transport/Transport-of-Radioactive-Materials/> (accessed 7 July 2014).
- Wolfaardt, A.C. et al. (2009). Review of the rescue, rehabilitation and restoration of oiled seabirds in South Africa, especially African penguins *Spheniscus demersus* and Cape gannets *Morus capensis*, 1983–2005, *African Journal of Marine Science*, Volume 31, Issue 1.
- WSC (World Shipping Council). (2011). *Containers Lost at Sea*.
http://www.worldshipping.org/industry-issues/safety/Containers_Overboard__Final.pdf (accessed 31 May 2014).
- Zaiko, A., M. Lehtiniemi, A. Narščius, and S. Olenin (2011). Assessment of bioinvasion impacts on a regional scale: a comparative approach. *Biological Invasions*, Volume 13, Issue 8, 1739-1765.