

## 5 VECTORS, SHIPPING AND TRADE

M L Campbell and C L Hewitt

Centre for Research on Introduced Marine Pests, CSIRO Marine Research, GPO Box 1538, Hobart, Tasmania 7001 Australia

### 5.1 INTRODUCTION

The link between introduction of exotic species into new bioregions and the release of ballast water from shipping is well documented (Smith and Carlton 1975; Carlton 1979; Carlton 1985; Simberloff 1986; Carlton *et al.* 1995; Ruiz *et al.* 1997; Shigesada and Kawasaki 1997). Despite the current recognition and acknowledgment of marine introductions via modern vectors, the historic movements of species by vessels may have led to the introduction of species prior to biological surveys. The historical movement of organisms was facilitated by wooden vessel hull fouling and boring, early mariculture (due to a lack of effective quarantine), and the discharge of semi-dry and dry ballast. Hewitt (1993; unpub. ms) further summarised the vectors into five groups: 1) hull fouling/boring; 2) mariculture; 3) dry and semi-dry ballast; 4) ballast water; and 5) intentional and unintentional (e.g. the aquarium trade) introductions. Changes in vessel design, engines and structural stability over time have resulted in reduced travel times. This may have led to an increase in the number of recent introductions.

#### 5.1.1 Vectors

Human mediated transport of species across biogeographic barriers is not new (Carlton 1979, 1985, 1992; Crosby 1986; Carlton *et al.* 1995; Carlton and Hodder 1995; Ruiz *et al.* 1997). The history of European expansion however is linked with the modern era of biological introductions (Crosby 1986; di Castri 1989).

##### *Hull fouling and boring*

Many fouling organisms (flora and fauna that attach to the hull of vessels), and boring organisms (fauna which bore into wooden hulls) are widely distributed with many species having near cosmopolitan, though often disjunct (e.g. present in harbours and ports) distributions. The fact that most biological surveys were conducted long after initial explorations and colonisation may have resulted in a redistribution of the world's fouling biota long before specimen collections, thus obfuscating the origins and true distributions of these species. The historic practice of careening a vessel in order to scrape the hull and replace rotten or damaged timbers may have significantly contributed to the inoculation of hull fouling and boring

species. Hull fouling continues to act as a modern vector for the introduction of numerous species (Coutts 1999; Gollasch and Leppakoski 1999). In contrast, boring organisms relied explicitly on wooden hulls of vessels. The advent of steel hulls reduced this vector to smaller recreational vessels. Similarly the development and use of various chemical based anti-fouling paints has acted to reduce these vectors (however see Coutts 1999).

##### *Mariculture*

Mariculture transplants into Port Phillip Bay have a limited history. The Pacific oyster, *Crassostrea gigas*, was transferred to the bay in 1955 from Tasmania, where it was originally introduced by CSIRO. As discussed in Chapter 8, the Victorian populations of the oyster appear to have failed, though recently a population was detected in Anderson Inlet (Coleman and Hickman 1986). The blue mussel, *Mytilus edulis*, has been extensively farmed in Port Phillip Bay since the 1970's. There is no indication that international imports of this stock have occurred.

##### *Dry and semi-dry ballast*

Ballast is required to stabilise vessels, providing trim and stability. When used properly, ballast provides a vessel with greater manoeuvrability and more efficient propulsion. Vessels too light on ballast can have a greater tendency to capsize, while vessels heavy on ballast may lose speed and labour under excess weight. Before the 1840's wooden vessels used dry ballast (rocks, shingle, cobble, sand, or alternatively cargo such as timber, iron, etc) but because ballast holds tended to accumulate water either with uptake of the ballast materials, through collection of bilge water, or through leaks in the wooden hulls, semi-dry conditions resulted leading to conditions similar to intertidal habitats. As discussed below, the discharge of dry ballast was significant during the 1800's, leading to regulations controlling its disposal during deballasting. Dry and semi-dry ballast has been implicated in the introduction of a variety of species (see Chapters 9, 10, 15, 16 and 18).

##### *Ballast water*

By the mid-1840's water ballast began to be used and became more common in the 1850's when colliers were able to hold the water in purpose built compartments (Carlton *et al.* 1995). Ballast water tanks started to become

integrated with the refinement of vessel designs. Although ballast water was used in the 1840's the complete change-over from dry/semi-dry ballast to water ballast occurred more than 100 years later, in the 1950's (Carlton *et al.* 1995). As discussed in depth elsewhere, ballast water is an active modern vector (Carlton 1985, 1992; Carlton and Geller 1993; Carlton *et al.* 1995; Williams *et al.* 1988) with numerous accounts of species introductions likely to have been the result of ballast water transfers (e.g. Carlton *et al.* 1990; Shushkina *et al.* 1990; Pollard and Hutchings 1990a, 1990b).

#### *Intentional and unintentional introductions*

A variety of intentional introductions other than for mariculture have occurred in Australian waters including stock enhancements and wild fisheries establishment (see Pollard and Hutchings 1990a, 1990b; Arthington and McKenzie 1997). Few of these intentional introductions have occurred in Port Phillip Bay. In contrast, numerous species are likely to have been transported and introduced unintentionally in association with mariculture activities (Pollard and Hutchings 1990b; see also Chapters 6, 7, 8, 9, 10, 12, and 13).

#### *Vessel design changes*

Wooden hulled sailing ships dominated world trade from the 14<sup>th</sup> century until late in the 19<sup>th</sup> century (1860's to 1870's). Ship designs changed significantly during this period. The common vessel in the 14<sup>th</sup> century was square-sailed with a single mast, commonly called a 'cog', used by seafarers since early history. The cog was replaced by the first truly ocean-going sailing ship, the caravel, which were used for early exploration. This exploration was largely motivated by the desire to find a sea route to the Indies and Cathay when the Ottoman Empire began blocking the land routes to the Orient (Macintyre 1972). By the middle of the 15<sup>th</sup> century, square-rigged carracks had replaced the caravel as the main trading vessel. Alterations and improvements to the square-rigged carrack focussed on warfare in the period ending with the Napoleonic Wars (1815). This produced a variety of ship types including the galleon; the 'pinnacle'; the frigate (with sloop rig); and the brigantines such as the 'snow', brig, galley, 'shebek', 'turuma' and 'udema' styles (Macintyre 1972).

Merchant ships were also being refined, with 'fluyt' ships, yachts and cat-built ships with a 'hooker' rig (e.g. Captain Cook's *Endeavour*) becoming common in the early 17<sup>th</sup> century (Macintyre 1972). By the 1800's, speed had become an important focus in ship design. Speed was necessitated by the Opium trade, where vessels needed to beat the monsoons on passage from India to Europe (Macintyre 1972). The faster vessels (mostly schooners) gradually became known as 'clippers' whose rig often denoted different vessel types such as the barque and barquentine.

The clipper sailing vessel eventually superseded older vessel designs to become the dominant worldwide trade vessel (Macintyre 1972). Clippers were softwood hulled sailing vessels (often copper-sheathed to aid against marine fouling and boring worms) capable of much greater speeds than experienced previously (Lubbock 1921; Macintyre 1972). The greater speeds were due to their design and the use of lighter wood (Lubbock 1921; Macintyre 1972). The new designs and speed afforded the Clippers the ability to sail different, faster routes, known as 'great circle' tracks and composite routes devised by the American 'wind expert' Maury (Lubbock 1921).

One traditional route to Australia was the Admiralty route where a vessel kept an eastward direction while heading south, rounding close to the Cape of Good Hope and then keeping north of the forties running their easting down (Lubbock 1921). This passage would take, on average, 120 days. In contrast, when using a Great Circle Track, the Liverpool to Australia (usually Melbourne) trip was reduced by 1,000 miles, with a timesavings of 20–30 days (70–80 days transit time) (Lubbock 1921; Bach 1976; Loney 1981). The Great Circle Track also reduced the number of intermediate ports (e.g. Port Elizabeth and St. Pauls Island) on the journey. Vessels would leave Liverpool and sail non-stop, out of sight of land until they landed at Cape Otway, en-route to Melbourne (Bach 1976). Because of this speed, clippers were goldrush vessels primarily used for passenger transport (Bach 1976).

By the 1860's softwood hulled clippers were showing their age and fragility. The softwood, once seen as a great advantage, was easily damaged and after a decade of use was becoming dilapidated. Softwoods were soon replaced by the new iron hull designs. Iron hulls initially began as an iron/softwood composite, having iron frames and timber planking (Macintyre 1972; Bach 1976). As techniques were refined, all-metal hulls became more common and were better suited to the long-distance carrying trade that began to flourish in the 1870's and 1880's (Bach 1976).

A second major change in vessel design was the introduction of steam power that resulted in increased speeds and an alteration of trade routes since vessels no longer had to rely on trade winds. Steam vessels began to appear in the cargo trade in the 1860's, becoming established by the 1870's due to the invention of the screw propeller (Macintyre 1972; Bach 1976; Fitchett 1980). Despite the advent of steam powered vessels, sailing vessels continued to dominate the passenger and cargo trades (especially the wool trade until 1880's) until the late 1890's (Macintyre 1972; Bach 1976). This was in part due to the depressed conditions in the world shipping industry in the 1870's (Bach 1976). Steam vessels

however, quickly became prime carriers of the mail because of their speed. The mail lines between Sydney and Britain took approximately 45 days via the Pacific route and 48 days via the Suez route by the end of the 1870's. By the 1880's, steam vessels were operating in the passenger trade and by the end of the century steam vessels had all but replaced sailing vessels on overseas routes.

Ship designs continued to be modified, as engine designs became more efficient allowing greater storage space and more speed (Fitchett 1980). By 1901 vessels were capable of travelling between London and Melbourne in 48 to 31.5 days (Bach 1976). Further engine modifications occurred in the 1920's with motor vessels replacing steam vessels and hence fuels changed from coal to oil (Dunn 1973). These changes greatly increased cargo space and lowered operating costs. During the 1920's, further changes that may have increased speed were ignored because of the generally held belief that to increase speed involved increasing length and draught. Many of the ports were capable of handling increased length but were too shallow for increased draught. Yet, the expected increase in draught was never fully realised. The next innovation was the diesel engine. From 1918 to 1939 a third of overseas tonnage entering Sydney and Melbourne was diesel powered (Bach 1976).

World shipping trades were reduced somewhat during World War I (WW I) and World War II (WW II), with a depression in shipping activity which never really vanished (Bach 1976). This depression halted the introduction of new vessel types, however the wars saw many vessel modifications that later became introduced onto the world-shipping scene. The first such modification was the bulk carrier, introduced into Australia by BHP for domestic interstate trade in 1943. During the 1950's, the bulk carrier was said to have saved the interstate shipping trade from extinction. Bulk carriers allowed a great increase of both wet and dry cargoes and again increased ship size. The 1940's also saw the development of the container ship developed to carry in the hull and on the deck standardised cargo containers, which meant that port equipment modified to handle containers could save time through better cargo handling practices.

Cost reductions became paramount during the 1940's and innovations such as Roll-On Roll-Off vessels (RO-RO), various forms of side loading ships, special purpose carriers for liquid chemicals and barge-carrying 'lash' (lighter aboard ship) ships (Bach 1976). The first full-cellular container ship service started in 1958, in Hawaii, with Australia starting to use such vessels in 1964. Container ships began making round trips between Britain and Melbourne in 1967. This container ship route was expanded in 1972 to include Europe, New Zealand and the east coast of North America. Further expansion of

container ship routes occurred in 1975. By 1972, bulk cargoes accounted for 73% of world trade. By mid-1973 tankers accounted for 40% of the world fleet, ore and bulk carriers for 24%, general cargo for 27% and fishing vessels for nearly 4% (Bach 1976). Lash vessels were first seen in Australia in 1973, where they operated between the west coast of North America and Australia, with Port Phillip being their first port of call (Bach 1976). With the increase in bulk carriers the purely passenger trade declined (from 40% in 1961-62 to 21% in 1967) because alternative methods of travel proved faster, cheaper and more comfortable.

From the 1970's on-wards many shipping innovations have occurred. The primary aim of these innovations was to reduce costs associated with cargo handling and increase profits through increased speed and cargo carrying capacity. Numerous types of vessels are on the oceans today. Carlton *et al.* (1995) was one of the first publications that attempted to classify vessel forms establishing three major divisions of vessels: passenger; cargo; and specialised.

## 5.2 TRADE ROUTES

The following historical account of Port Phillip Bay and the trade routes that developed during its history is by no means comprehensive, but aims to give an overview of the historical sequence relevant to biological invasions. The history of Port Phillip Bay is grouped into four periods, each associated with a significant shift in the shipping activities and routes. While it is recognised that Aboriginal history pre-dates this review, it is assumed that the likelihood of introductions of marine organisms was low during this period.

### 5.2.1 European exploration and colonisation

The history of European influence in Australia is relatively short (Crosby 1986). In 1768, the British lay claim to 'discovering' the Australian continent, despite previous European contact much earlier by the Spanish, Portuguese and French. Van Zanden (1997) discusses the European exploration by the Dutch explorer Willem Janszoon. Other reports suggest that the Portuguese landed within Port Phillip Bay in 1522 but did not settle the area (Priestley 1984) though this is considered to be unlikely by other historians.

The first recognised European activities in the region were sealing and whaling that operated in the Bass Strait since 1796 and often used Western Port as a home base (Shaw 1997). The sealers and whalers were primarily Americans who often had contact with vessels that traveled vast distances, such as from China (Shaw 1997). Contact with such vessels was not uncommon and as a consequence, the port and city of Launceston was founded in Tasmania in 1798 in order to capitalise the trade. The

East India trade used this route around Australia to their destination in Canton rather than a stopover in Sydney as it shortened the Europe-Australia leg by 700 miles (Bach 1976).

Although Western Port was frequented regularly, Port Phillip Bay was not subject to colonial exploration until the threat of French accession of land in Australia prompted the British to explore and establish Port Phillip. This threat originated from the French explorer Nicolas Baudin, who identified Western Port and surveyed the coast west of Cape Otway but failed to explore Port Phillip Bay (Leggett 1949; Shaw 1997). The fact that the Heads of Port Phillip Bay were treacherous may have added to the bay remaining unknown to colonial nations until the British entry of the heads in 1802.

The British 'discovered' Port Phillip Bay in February 1802 when John Murray on the *Lady Nelson* entered the heads (Shillinglaw 1972; Ruhen 1976; Loney 1981; Shaw 1997). In April, of that year Matthew Flinders entered the bay on the *Investigator* and anchored near Sorrento. The next vessel to visit the bay was the *Calcutta*, bringing English convicts and settlers in 1803 (Shillinglaw 1972; Bateson 1985). The journal of Reverend Robert Knopwood recounts the voyage of the *Calcutta* as it sailed the popular 'Cape of Good Hope' Admiralty route used by the British when travelling to Sydney (Shillinglaw 1972). Typically, vessels left from Portsmouth traveling to St. Helens, on the Isle of Wight, then Yarmouth Roads, Isle of Wight, anchoring at Santa Cruz roads, Tenerife, sailing on to St. Jago (Cape de Verde Islands), passing the equator and anchoring at Rio de Janeiro. If the vessel needed either repairs or re-supply this was conducted here. From Rio de Janeiro, the vessel would pass the Tropic of Capricorn and anchor at Simon's Bay in South Africa. Simon's Bay was often used as a layover in bad weather or for careening and repair. From Simon's Bay the vessel then passed through St. Pauls Island, anchoring 19 days later in Port Phillip. The *Calcutta's* original voyage to Port Phillip took 172 days and was disrupted by bad weather, which forced a 20 day stop-over at Rio de Janeiro and a 13 day stop-over at Simon's Bay. After arriving in Port Phillip a small settlement was established, which lasted for three months (1803-1804) before moving on to Hobart town (Shaw 1997). The next vessel to enter the Bay was the *Cumberland* in February 1803, which was the first vessel to sail around the entire bay and performed the first bay-wide biological survey (Loney 1981).

From 1803 until 1835, only three ocean-going western vessels were reported to have entered the Bay; two government vessels needing shelter during travel from Hobart to Sydney and one whaling vessel involved in whaling in the Antarctic. This may be an underestimation of visits during this time, as the Hobart built schooner

*Enterprize* regularly sailed between Sydney and Launceston, and was sold in 1835 to sail the Launceston-Melbourne route. However, historical records that were reviewed indicate that no further ocean-going vessels entered the bay (Shaw 1997).

In 1835 the Launceston settlers Batman and Fawkner settled at Indented Head and Melbourne, respectively, thus beginning the Port Phillip District. Although, it wasn't until 1836 that colonial settlement was 'officially' allowed. Captain Lonsdale landed on Port Melbourne beach in 1836, arriving from Sydney on the sloop *HM Rattlesnake*. He brought with him the barque *Stirlingshire* and the brig *Martha* (Priestley 1984; Shaw 1997). They carried stores, building materials, surveyors equipment, a detachment of 30 men, three surveyors with seven convicts each, two customs officers, four constables and a further 10 convicts to begin the building of the settlement (Shaw 1997).

During these early years, the first two marine trade routes were established: running from Launceston and Hobart to Port Phillip (Pemberton 1979; Wild 1950; Shaw 1997). This initial trade was established for passengers and shipment of livestock to Point Henry (Pemberton 1979; Priestley 1984). In 1835, a smaller intrastate run between Melbourne and Geelong began (at Point Wilson), which became permanent by 1839 (Pemberton 1979; U'Ren and Turnbull 1983). A trade route soon began operating between Sydney and Port Phillip. By 1839 the trade routes had extended to encompass interstate routes between Sydney, Hobart and South Australia; intrastate routes between Geelong and Melbourne and international routes to Great Britain and New Zealand (Pemberton 1979; Shaw 1997).

The East India Company's monopoly of British trade between the Cape of Good Hope and the Straits of Magellan limited trade between British colonies (Staples 1966; Bach 1976). For the first three decades of Port Phillip's existence, these restrictions prohibited all British ships not belonging to the company, nor enjoying special concessions granted by the company, from trading with any port within its prescribed limits (Bach 1976). The British East India Company lost much of its power during the Napoleonic Wars (1800-1815); by 1813 the company also lost the Indian commercial monopoly and by 1834 had become a purely administrative authority (Staples 1966). The British/China trade monopoly thus ended in 1834, when the restrictions were repealed in Parliament. However, the British Navigation laws restricting foreign competitors, remained in place (Bach 1976).

Trade in Port Phillip Bay was primarily British at this time, although trade with the East Indies, India (Madras and Calcutta), China and Hong Kong started to develop between 1835 and 1850 (Staples 1966; Bach 1976).

Britain used three main trading areas in the Indian Ocean Region: the Indian coastal waters; the Malay Peninsula and Archipelago; and the coastal waters of Australasia. Of these trading regions, there were six British territories (Bombay, Bengal, Madras, Singapore, Ceylon and New South Wales) and the Dutch East Indies (e.g. Batavia, Java, Moluccas spice islands, Dutch Timor, South Sumatra and Banca). These territories typically dealt with the metropolitan ports of London and Amsterdam. Britain considered inter-territorial, American and other European trade, as unimportant (Staples 1966). As a rule, British ships dealt with the larger ports (such as Singapore and Bombay), while coastal traders from the islands and smaller ports brought their trade to these larger ports. When British ships dealt with smaller ports such as Java, the smaller port would often record the transaction, however when arriving at the next larger port the vessels last port of call would be ignored and instead it would be recorded as arriving from its last large port (e.g. Australia) (Staples 1966). Thus, port records of shipping through the Indian Ocean Region during this period are imprecise and ship's logs must be consulted directly to determine the actual trading practices.

Trading activity was influenced by the availability of commodities from the Indian Ocean Region included tea (China and Java), sugar and coffee (Mauritius and Java), rice and tobacco (Java) and wheat (Chile) (Staples 1966; Bach 1976). Java and India quickly replaced many traditional commodity markets from the west of Cape of Good Hope, but manufactured goods continued to originate from European and North American markets. External factors such as the Java Wars (1825–1830) and the Opium Wars (1839–1842 and 1856) in China often affected exports from the Indian Ocean Region (Staples 1966). Trading activity suffered from the worldwide collapse of maritime trade from 1830–1833, proceeded by another depression in the 1840's (Staples 1966).

### 5.2.2 Immigration

The first British immigrants arrived in 1839, having been sent on from Sydney in the barque *Hope* (Pemberton 1979; Shaw 1997). This year also saw the first immigrant vessel that sailed directly to Melbourne: the *David Clarke* from overseas (Strahan 1994). During 1839, 11,500 immigrants from British ports (London, Liverpool, Plymouth and ports in Ireland and Scotland), made the 3–4 month trip to Port Phillip Bay. Immigrants went through the quarantine station at Point Ormond on arrival in Port Phillip and then moved on to Melbourne or Geelong (Shaw 1997).

During the increase in shipping between 1838 and 1839 a number of ships were lost to disasters (e.g. shoaling and sinking) inside Port Phillip Bay. These losses initiated the placement of buoys, channel markers and the building

of lighthouses. By 1840, Port Phillip and Geelong posted their first ballast and port regulations developed to control the discharge of dry ballast in order to prevent the creation of shoals and other shipping hazards (Thompson 1841; Kerr and Kerr 1979).

With the immigration of settlers came the establishment of port facilities. The first pier in Geelong (Stony Pier) was built in 1840, followed by the Steam Packet Wharf in 1847 (Holden and Loney 1969). Melbourne port facilities began with the left bank of the Yarra River used as a wharf (Ruhén 1976). By 1840, at least 52 overseas vessels had visited the bay, primarily by way of Sydney or Hobart (Thompson 1841; Ruhén 1976; Shaw 1997).

Immigration was high in 1841 and 1842, however the depression in 1843 resulted in few migrants arriving in Port Phillip. This shortage of migrants resulted in a shortage of labour in the settlement. To overcome this shortage the Melbourne Immigration Society brought over Tasmanian men for labour in Melbourne and Geelong (Shaw 1997). Immigration continued to rise and fall with a general decline in numbers occurring after 1847. Between 1846 and 1851 local and international immigration increased the population by 32,000. In the 1840's immigrants usually came by way of Sydney or Hobart on the *Clonmel*, *Seahorse* or *Shamrock* (Bach 1976).

Fewer new trade routes were opened, an exception being the development of a bay-wide shipping service, trade with Manila and occasional trade across the Pacific (Bach 1976; Pemberton 1979; Shaw 1997). The Manila trade supplied Australia with sugar, coffee, cordage, cigars and hats (Bach 1976). This trade followed the route to Manila via Sydney and the Torres Strait, returning around the west via Cape Leeuwin and returning to Melbourne (Bach 1976). Concurrently, trade with Calcutta expanded to include: sugar, silk, rice, canvas sacks, hemp, rum and horses.

A Pacific trade began by the late 1840's, catering for the demand of Newcastle coal in California (Bach 1976). Occasional trade for exporting whaling products was also occurring with various islands (still considered to be part of Australia at this time) and South America (Bach 1976). In 1849 the British Navigation laws were repealed, allowing foreign competitors to challenge the British monopoly (Bach 1976).

As mentioned earlier, the Opium Wars (1839–1842 and 1858) affected shipping in Australia. As a British colony, Australia was involved in these conflicts through the supply of enlisted of men and the use of vessels. The outcome of the first war was the Treaty of Nanking, which ceded Hong Kong to Great Britain and opened other Chinese ports to British residence and trade (Wallbank *et al.* 1992). The

French and Americans were soon (1844) afforded the same provisions as the Nanking Treaty. The outcome of the 1856 Opium War was the Treaty of Tientsin. This treaty again opened new ports to trading and allowed foreigners with passports to travel in the interior (Lubbock 1967; Wallbank *et al.* 1992). Thus, until the Opium Wars, Chinese ports had restricted trade and access with foreign vessels.

Convicts started to arrive in Port Phillip during the 1840's. Port Phillip received 13 convict ships between 1803 and 1849. The first convict ship was the *Calcutta*, which arrived in 1803. After the *Calcutta*, convict ships were not seen in Port Phillip until 1844. The majority of convict ships came by way of Hobart (e.g. *Sir George Seymour* in 1845; *Stratheden* in 1846; *Marion* in 1848; *Anna Maria* in 1848; *Eden I* in 1849 and *Adelaide* in 1849) although two vessels came directly via the Cape of Good Hope (*Hashemy* in 1849 and *Randolph* in 1849; Bateson 1985). Often convict voyages would take between 102 to 168 days. Convict shipping ceased by the end of the 1840's to Port Phillip, and by 1852 for Tasmania and New South Wales due to a reduction in labour shortages (Bach 1976).

### 5.2.3 The Gold Rush

In 1850, the Port Phillip District separated from New South Wales (NSW) and became Victoria. An announcement of gold at Clunes was made in 1851 shortly after separation. Gold was suspected at Castlemaine as early as 1838 but an announcement of the Clunes' goldfind in 1849 was suppressed until Victoria had separated from NSW (Shaw 1997). Meanwhile, the wool industry was also expanding, becoming Geelong's mainstay industry until the present (Wild 1950). Australian wool began export to Britain in 1839 (Kerr and Kerr 1979) and became one of Britain's biggest imports, its value exceeding that of cotton (Staples 1966).

The population of Victoria swelled from < 40,000 to 416,000 in five years after the announcement of gold (Bach 1976; Wild 1950). Immigrants came from England, Scotland, Ireland, China, Wales, Germany, United States, France, Italy, Spain, Poland, Denmark, Norway, Sweden and India to try their luck on the goldfields (Thompson 1841). Routes used to travel to Australia were still largely based on Great Circle Tracks, with vessels traveling via the Cape of Good Hope, Cape Horn or trans-Pacific.

Port facilities expanded with the incoming populace. Developments in Geelong included: the devotion of the Hutton wharf to ballasting vessels; the Yarra pier was built in 1852; Cunningham pier was built in 1855, only to be replaced in 1864; the Moorabool Street Pier was built (it fell into disuse in 1938 and was demolished in 1949); a magazine jetty at Limeburners Point was built in 1856; the Geelong yacht Club was established; and the bar across Corio Bay was dredged for the first time in 1856 from 10 to 13 feet (Wild 1950; Holden and Loney 1969).

The expansion of the mail service due to the gold rush was an essential service enabling immigrants to keep in contact with their homelands. The initial mail run, using the Peninsular and Oriental (P & O) Company's ships, operated from Singapore to Sydney by way of Western Australia (King George Sound) and started in 1852. A second mail contract for every alternate month to Australia via the Cape of Good Hope was tendered to the Australian Royal Mail Steam Navigation Company (Bach 1976; Fitchett 1980). P & O were offered a continuing contract at the completion of their first term in 1858 that extended their run to Aden, Mauritius, Point de Galle in Ceylon until 1866 (Bach 1976). Although the mail run had existed for many years, it was not until 1880 that a direct service began from Melbourne to Britain (Jackson 1996). The first trans-Pacific steamer service also began in 1866, running from Panama to Sydney by way of Tahiti.

Coastal shipping (domestic inter- and intra-state) expanded rapidly with the great influx of population. Steamers and sailing vessels conducted a large passenger trade between Launceston and Melbourne (Bach 1976). A run between capital cities began with 15 steamers operating by the end of 1853. Services had extended to the north with vessels travelling from Sydney to Curtis Bay and Rockhampton and returning as far south as Melbourne by 1860. A southern service also began that ran from Sydney to Two Fold Bay (Eden), to Melbourne and on to Tasmania. Melbourne's coastal shipping also extended out to Wilson's Promontory in the West and east to the Gippsland coast (Bach 1976).

The goldrush led to an increase in the number of vessels abandoned in ports and on beaches. Some abandoned ships were dismantled and others put to use as coastal lighters and prison hulks (Ruhen 1976; Loney 1981). The ship *Lysander* was one such vessel. Abandoned by her crew, it was converted by the government into a prison hulk (Loney 1981). Between 1852 and 1855 five prison hulks (*Success*, *Sacramento*, *Deborah*, *Lysander* and *President*) became a common sight on the shores of Hobson's Bay (Loney 1981; Strahan 1994). This was largely due to the failure of the tickets-of-leave system (adopted after the Tasmanian and Norfolk Island prisons had been abandoned) in controlling prisoners (Strahan 1994).

One of the changes seen in the 1850's was the development of a Conference System. Shipping services became divided into two categories (Conference and Tramp). Conference shipping was concerned with regular voyages on a specific route, while Tramp shipping had no specific schedule or route. Conference shipping carried both passengers and cargo, in accordance with a guaranteed usage of particular routes resulting in a scheduled timetable. Tramp shipping tended toward bulk cargoes of a single type, in order to occupy the majority of the ship's carrying capacity.

By the end of the gold rush years, the townships of Melbourne and Geelong had greatly expanded, yet their ports were still lacking many services. For example, no graving dock was available in Melbourne until the 1860's (Cook 1958). A small slipway existed on the river in Melbourne, one small slipway existed at Williamstown and a floating dock also existed at Williamstown. All vessels drawing more than 8.5 feet had to anchor outside the mouth of the Yarra and lighter their cargo ashore (Bach 1976).

#### 5.2.4 Modern shipping

From 1860 until the early 1900's, the majority (93%) of total tonnage in Australian waters (and worldwide) was British. Despite the majority of shipping under the British flag, foreign vessels commonly entered Port Phillip. For example, the US Confederate Navy's ship, *Shenandoah* visited Melbourne in 1865. The *Shenandoah* was repaired at the Williamstown slip and took on food, water and recruited 42 Melbournians to aid in the US Civil War (Cook 1958; Crompton 1993; J Cossum pers. comm.). A direct trade route between New Zealand and Melbourne began in 1860. This trans-Tasman route provided a service to Otago and Canterbury, expanding in 1873 to include Bluff, Otago, Lyttelton, Wellington, Nelson, Greymouth and Hokitika (Pemberton 1979). This direct service transported troops to New Zealand for the Maori Wars (which lasted on and off for 12 years), then subsequently transported diggers (Australian Army) to the Otago goldfields in late 1862. A regular service between Sydney, Nelson, Wellington and Dunedin was established subsequently (Bach 1976). Since the 1849 abolishment of the British Navigation Laws many foreign (British, French, German, Italian, Norwegian and American) steamship lines began to operate in Melbourne (Priestley 1984).

Coastal trade continued to develop, with P & O running a service from Melbourne to Albany by way of Adelaide in 1862. Services also ran from Melbourne to Geraldton, with extensions to Shark Bay and Carnarvon until 1927. The interstate trade continued to grow in the 1860's, with Gippsland being the most significant (Bach 1976). Melbourne started to lose some of its importance because of competition with roads and the development of other more competitive ports on the coastline. With this decline, Melbourne became aware of the problem of having its city upstream. Two choices to improve their situation were either to leave the ships in the bay and transport the cargo to the city or to create a waterway to the city. A decision was finally made in the 1870's; the ships would be taken to the city.

The Port of Geelong continued to develop and upgrade their facilities. Limeburners jetty was replaced in 1866 with a wooden jetty. In 1889, Station Pier (originally known as Railway Pier) had been deepened and was thus

opened to steamer vessels and vessels with large draughts (Kerr and Kerr 1979). In 1893 the Geelong Channel was finally opened, allowing more vessels into Corio Bay (Wild 1950). This was a long awaited event, with the bar across Corio Bay often being blamed for the fewer vessels that visited Geelong (Kerr and Kerr 1979; Wild 1950).

The Suez Canal opened in 1869 creating a second route for vessels traveling from England to Australia and vice versa. Prior to the opening of a waterway, vessels could take cargo to the Suez, unload and move the goods across Egypt to the port of Alexandria, once again load goods onto vessels and depart for northern destinations; this route was risky and time consuming (Staples 1966; Fitchett 1980). The British mail lines particularly favoured this practice, with P & O keeping this service going, even after the canal opened, although it was more costly. Contrary to popular belief, the Suez only shortened the Cape of Good Hope route to Australia by 900 statute miles and was used primarily because it cut almost 4,400 miles off the route to India, China, Singapore and Malaysia (Fitchett 1980).

A new trade route opened to the west coast of North America in 1870 (Pemberton 1979). This trans-Pacific route went from Melbourne to Honolulu, onto Vancouver, down to Seattle, Tacoma, Portland, San Francisco and Los Angeles before returning to Melbourne and was run by the A.S.N. company (Bach 1976; Pemberton 1979). The Fiji to Britain service ended in 1874, with the A.S.N. Company stepping in to re-establish a route between Sydney and Fiji. This route was maintained until 1928 (Bach 1976). A China trade was explored in the 1870's, however it was decided that little profit could be made and the idea of a service was shelved (Bach 1976). In 1875, the Suez Canal was deepened, although it was still shallower than the entrance into Port Phillip Bay (the Rip). By the end of the 1870's the mail lines from Sydney to Britain took approximately 45 days via the Pacific and approximately 48 days via the Suez (Bach 1976).

A Harbour Trust was eventually established in 1876. One of the first issues to be addressed was the extension and deepening of the piers at the river entrance upstream wharves. Secondly, the port facilities needed to be moved upstream. In 1878, Sir John Coode recommended that docks be set up as close as possible to railways and the commercial area of the city. This was agreed to by the Harbour Trust in 1883 and work began by the 1890's.

The first of the Boer Wars began in 1880-1881 due to the repressive policies of the British Governor of the Cape. The South African Boer Republics revolted against the annexation of the Transvaal and the Orange Free State and secured limited self-government. Tensions between the Boers and British were further aggravated when gold and diamonds were discovered in the Transvaal. Once

again, the British policies created an untenable situation leading to the Boers attacking the Cape Colony and Natal in 1899. This second war lasted until 1902. During this time, services to the Cape colony were disrupted. Australia was obliged to send troops and provide vessels (such as the White Line's *Medic*) in aid of the British. This disrupted coastal and international shipping, with many coastal vessels requisitioned to transport soldiers (Bach 1976). Merchant shipping was re-routed through the Suez or around Cape Horn (South America), to avoid the dispute, with the Cape of Good Hope route being re-established after the completion of the second war.

The 1880's saw the establishment of many direct trade routes to Melbourne. As mentioned earlier, one of the first direct routes to be established was that of the Melbourne/Britain mail service. This was followed in 1881 with routes to Fiji, Papua New Guinea, New Britain and New Ireland (Pemberton 1979). Direct services to the European continent and India also began (Bach 1976; Priestley 1984). In 1883 a French Line, Messageries Maritimes, operated a direct shipping link between Europe and Melbourne, which was soon followed by a German Line in 1887 (Bach 1976). The India direct service began in 1889 and ran from Melbourne to Colombo, onto Madras and finally to Calcutta before returning (Pemberton 1979). Intrastate trade also expanded to a Lakes Entrance/Melbourne tourist service. This service saw a slump during the 1890's but had recovered by 1900 and continued to service the Lakes Entrance until the 1930's (Bach 1976).

As the amount of traffic increased, the diversity of vessel types visiting Port Phillip Bay also increased. It was soon realised that the entrance was too shallow for many vessels to safely negotiate the Rip. Between 1881 and 1883 the reef at the Rip was blasted to deepen the entrance channel. The Suez was still shallower than the Rip and hence deepening did not have to be excessive. However, plans to increase the depth of the Suez to 33 feet (11 m) by 1920 led to a long term channel plan (Bach 1976). Plans for future deepening and widening of the Rip were made with the first stage to increase the entrance draught implemented in 1901–1903. By 1913, vessels of 38 feet (12.6 m) draught began using the Cape route and had trouble entering the bay since the Rip was blasted to a maximum depth of 33 feet (11 m). Two additional blastings in 1916 occurred. However, more blasting was implemented in 1943 to deepen the Rip to 43 feet (14.3 m). By 1969 the Rip was considered safe for vessels with a draught of 38 feet (12.6 m) to enter (Bach 1976).

Expansion of shipping services continued in the 1890's. A second direct service to New Zealand and a trans-Pacific route to Canada began in 1893. By 1898 a steamer service to Singapore had also started and Japan

and China were also linked with Australia (Bach 1976; Pemberton 1979). Port maintenance in Melbourne began with the completion of the 96 acre Victoria Dock in 1892, first used in 1893 (Bach 1976; Kerr and Kerr 1979). A depression (probably linked to the Boer War and increased tonnage) once again hit the port, holding up much of the work on wharfage until 1903. The Princess Pier was opened by 1915. Port improvements continued into the 1920's with a rebuilt Station Pier opened in 1922 and the Ferguson Street Pier in Williamstown opened in 1927 (Priestley 1984).

By the turn of the century, voyages from London to Melbourne had been reduced from 48 days to 31.5 days. The emphasis on the Cape of Good Hope trade route had diminished, with the majority of Australian wool, meat, fruit and butter being exported via the Suez Canal (Bach 1976). In 1913 the Cape route was still used by 75% of the regular British steamers outward bound to Australia. However, on the return journey 32% went by way of the Cape of Good Hope, 28% carried on around Cape Horn and 40% used the Suez Canal (Bach 1976). A brief direct service to Calcutta began in 1902. This was followed in 1905 with a steamer service to Norfolk and Lord Howe Islands and the New Hebrides (Pemberton 1979). Eight years after the Boer War, an extended service was established to South Africa, via Mauritius that visited Delagoa Bay, Durban, East London and Capetown (Pemberton 1979). A service to Japan began in 1912, however this service and others were soon curtailed by WWI (Pemberton 1979; Priestley 1984).

The Federation of the Australian States occurred in 1901 with celebrations around Australia. Melbourne celebrated in typical fashion, hosting foreign ships from around the world. Vessels such as the American *USS Brooklyn*, the Russian *Gromoboi*, the German ships *Kormoran* and *Hansa*, the Netherlands Navy's *Noordbrabant*, the Royal Australian Squadron with the flagship *Royal Arthur* and HM ships *St. George*, *Juno*, *Ringarooma*, *Wallaroo* and *Mildura* all visited Melbourne to help with the celebrations. The entire US "White Fleet" visited Melbourne in 1908 and again in 1921 (J Cossum pers. comm.).

Up until 1914, two routes operated from England to Australia: the Suez Canal and Cape of Good Hope. In 1914, a third route began across the Atlantic, through the Panama Canal and onto Australia, across the Pacific (Fitchett 1980). In 1914, six lines (Aberdeen Line, Blue Funnel Line, Orient Line, P & O Line, P & O Branch Line and White Star Line), with 42 vessels were operating along these three routes (Fitchett 1980). Aberdeen, Blue Funnel, P & O Branch and White Star operated on the Cape of Good Hope route, whilst the Orient and P & O operated via the Suez (Fitchett 1980). Each line offered



different ports of call: The Aberdeen Line's usual route called at: Sydney and Melbourne, Australia; Durban and Capetown, South Africa; and Plymouth and London, England. The Blue Funnel Liners called at Sydney, Melbourne and Adelaide, Australia; Durban and Capetown, South Africa; Liverpool and Glasgow, UK. P & O Branch called at Sydney, Melbourne and Adelaide, Australia; Durban and Capetown, South Africa; and London, whilst the White Star liners ran via Sydney, Melbourne and Albany, Australia; Durban and Capetown, South Africa; Plymouth, London and Liverpool, UK (Fitchett 1980).

The First World War began in 1914 and lasted until 1918. Unlike other wars (Napoleonic, Maori, Opium and Boer), WWI interrupted trade across the globe. Similar to WWI, WWII had major influences on Australian and global shipping routes and services. Vessels were requisitioned (such as the *Esperance Bay (2)*, *Jervis Bay* and *Indarra*) by the Australian and British governments, which halted intrastate and interstate shipping trades activities (Dunn 1973; Bach 1976; Fitchett 1980). Defence force personnel were sent to war, leaving a depleted work force. Coastal shipping remained under the wartime control system until 1947. Immigration again escalated with an exodus of refugees in the pre- and post-war era. Australia took in the largest proportion of displaced persons, with 75,000 refugees coming to Victoria between 1935 and 1954 (Strahan 1994).

In a bid to reduce Australia's reliance on foreign shipping, after WWI, the government introduced state owned/state controlled fleets (such as the Australian Commonwealth Line and the Aberdeen and Commonwealth Line Ltd). This was unsuccessful, resulting in the fleets being sold to foreign investors during the 1920's (Bach 1976; Fitchett 1980). A new shipping depression had begun triggered by excessive tonnage. This depression lasted from 1918 to 1939. During this depression tramp shipping suffered the most (Bach 1976). Although a depression was occurring, new services continued to develop. In 1921 a service to Java and Singapore via Sourabaya and Samarang began (Pemberton 1979). This service was later (1935) extended to Hong Kong and Saigon.

In 1932, the Australian Navigation Act provisions were relaxed allowing overseas vessels to operate in the interstate tourist trade (Bach 1976). This further directly opened up Australia to vessels that had operated in other bioregions. Other changes soon took place on the Australian port scene. For example, timber decking on wharves was phased out as reinforced-concrete decks replaced the old timber decks. Dry docks were established in the Yarra and at Williamstown. The emergence of the bulk carriage vessels, after WWII, required the development of specially constructed berths, with

sophisticated equipment. The berths also required dredging and approach channels needed widening and deepening (Bach 1976). By 1969, Victoria and Appleton Docks catered for vessels up to 31 feet (10.3 m) draught and Port Melbourne Pier and the oil terminal at Williamstown catered for vessels up to 37 feet (12.3 m) draught (Bach 1976).

World trade and shipping tonnage expanded greatly after 1948. Australian trade developed East Asian markets, particularly Japan. North American routes also expanded while the traditional European and British trades have been lost. Major services to Japan in 1969, included vehicle-deck and container lines (Bach 1976; Pemberton 1979). A Japanese passenger trade also began in 1962 (Pemberton 1979). Three container lines between the East Coast of North America using offset-ramp ships started in 1969 (Bach 1976). By 1972, trade services included a container ship route between Europe and Australia. This new service traveled via the Cape of Good Hope to Australia and then went on to New Zealand and back to Europe via the Panama Canal and the East Coast of the USA (Bach 1976). A trans-Pacific service to the West Coast of the USA was also operating. By 1975, a new container ship service to the Philippines, South Korea, Hong Kong and Kaohsiung had begun (Pemberton 1979). A service to Malaysia also began in 1977.

Rationalisation and specialisation had saved the coastal shipping industry in the 1960's. This rationalisation saw the disappearance of the small, short-haul intrastate coaster and specialised passenger liners and the development of the Coastal Shipping Commission, which instigated the Coastal Shipping Agreement Act (Bach 1976). New interstate services also started with the 1959 Melbourne to Devonport passenger ferry, a four-weekly service in 1960, from Melbourne to Mackay, Townsville and Cairns, a general-cargo service between Melbourne and Launceston, in 1961 and a Fremantle to Melbourne container ship service in 1964. Other services started but soon halted. For example, the Melbourne to King Island supply run started in 1954 and stopped in 1963, resulting in King Island having to rely on Tasmania for its supplies.

With the commencement of many new lines and services, some ended. In 1928, the Fiji service started in 1881 halted. 1961 saw the end of the Tasman service and the New Guinea service ended in 1968 (Pemberton 1979). Pacific services operated by Burns Philps halted in 1970, while services to the West Coast of North America expanded.

With the development of new vessel types and improved engines, travel time has been reduced. In 1969 a line operating between Melbourne, Sydney, Brisbane and four Japanese ports took only 28 days to complete a round-trip. Port facilities have had to undergo more refurbishment's to cope with the new vessel designs.

Geelong has expanded from eight to 17 piers in 1979, with further refurbishment occurring in the 1990's. Whilst Port Melbourne had 106 piers by 1952; 73 of these were upriver. Docks such as Webb, Victoria and Swanson were deepened and expanded in the 1960's to cope with overseas vessels, container-ships and RO-RO vessels (Kerr and Kerr 1979; Priestley 1984). Larger docks and repair facilities have been slow to develop, with many large vessels needing to be repaired elsewhere than Australia (usually in Indonesia) (Bach 1976).

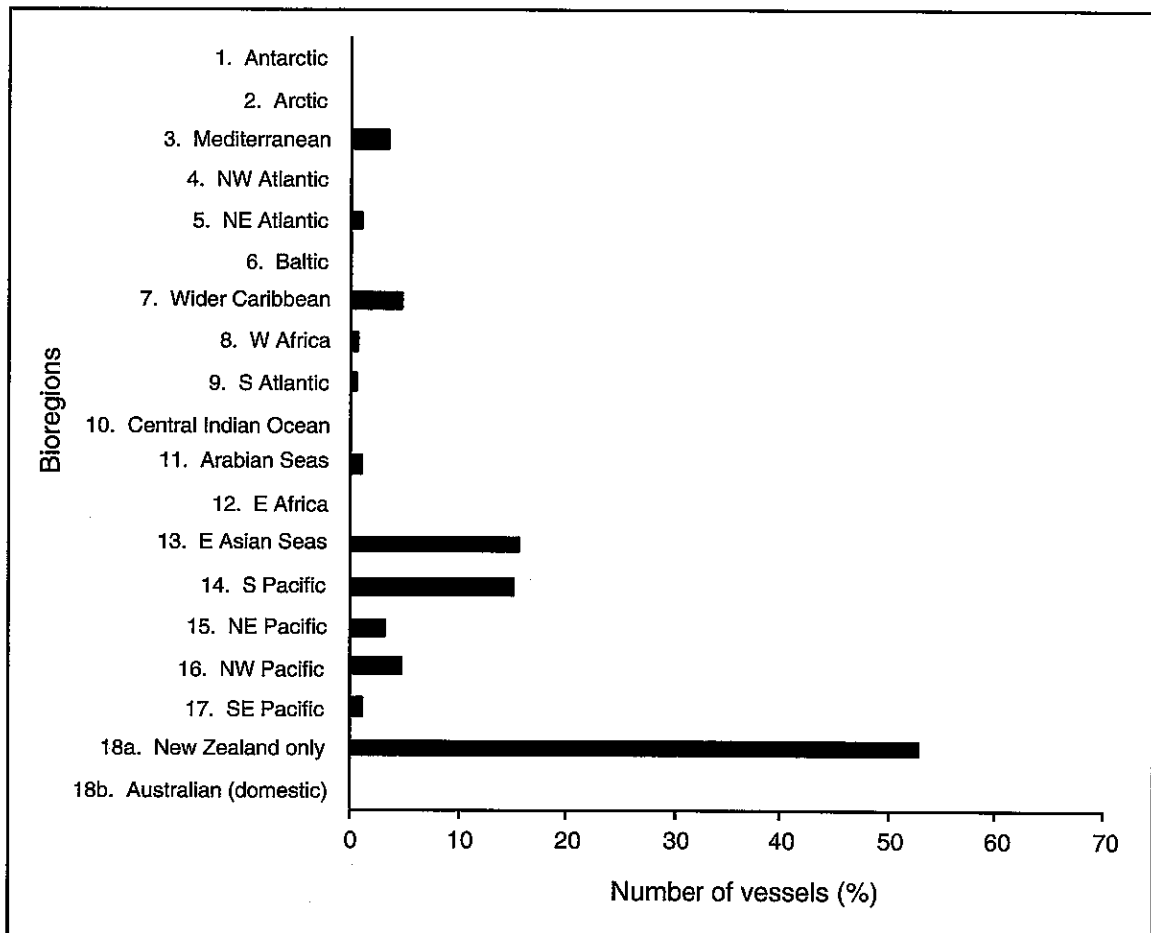
### 5.3 CURRENT TRADE PATTERNS

Two of Victoria's largest shipping ports are located in Port Phillip Bay: Melbourne and Geelong. Annually, both these ports see numerous international (670) and domestic (2,323) vessels, with an estimated 2.5 million tonnes (832,000 international and 1.7 million domestic tonnes) of ballast water being received, between August 1994 to July 1995 (Walters 1996). The Port of Melbourne is Australia's largest general cargo/container port and receives the second highest quantity of ballast water in Victorian ports (Walters 1996). Geelong deals principally with bulk and specialist cargo, such as petroleum and bulk

grain. The primary vessel types have shifted from grain to petroleum vessels, which discharge low amounts of ballast. Presently, Melbourne and Geelong deal with different trades and hence different vessel types, cargo types and quantities, and amounts of exports and imports. All these factors influence the actual quantity of ballast discharged (Walters 1996).

Using the data provided by Walters (1996), for 1994 and 1995, the Port of Melbourne received vessels from 14 bioregions (see Chapter 2 for bioregion descriptions; Figure 2.1). The vast majority (50%) of traffic was trans-Tasman. New Zealand, the East Asian Seas (15%) and the South Pacific (14.5%) comprised 79.5% of all international traffic into Melbourne (Figure 5.1). The remaining 20.5% of international traffic was with the Wider Caribbean, the South Pacific, the Mediterranean, the North East Atlantic, the Arabian Seas, the South East Pacific, West Africa, South Atlantic, the North West Atlantic and the Baltic. The Central Indian Ocean, East Africa, Antarctic and Arctic are the only bioregions that do not directly contribute to inbound traffic in the port of Melbourne.

Domestic vessel traffic (2,110 domestic visits) into Melbourne was more prolific than international traffic



**Figure 5.1.** The Port of Melbourne trade (1994 and 1995) with bioregions 1–18 (after Kelleher *et al.* 1995; see Chapter 2 for discussion of bioregions, Figure 2.1).

(541 international visits). Domestically, 30.5% of inbound traffic originated in Western Australia, followed by Queensland (25.0%), New South Wales (16.7%), Tasmania (13.9%), South Australia (11.1%) and other Victorian ports (2.8%) (Walters 1996).

Unlike Melbourne, only a small percentage of Geelong's traffic deals with containerships (Port of Geelong Authority 1995; Walters 1996). Data from Walters (1996) shows that the majority (66%) of Geelong's traffic was with four bioregions: South Pacific (24%); North West Pacific (18%); East Asian Seas (13%); and the Wider Caribbean (11%) (Figure 5.2). The remaining 44% of traffic was with the Arctic, Mediterranean, North East Atlantic, West Africa, Arabian Seas, North East Pacific, New Zealand and domestic Australia (Figure 5.2). Seven bioregions (Antarctica, North West Atlantic, Baltic, South Atlantic, Central Indian Ocean, East Africa and South East Pacific) were not represented in this data, however they may have had contact with Geelong, via vessels visiting other domestic ports before entering Geelong. Thus, the last port of call would be registered as domestic, not international.

The largest proportion of visits into Geelong was domestic (214 domestic visits versus 129 international

visits; Walters 1996). Geelong domestic visits contrasted vastly with Melbourne; with New South Wales (28.5%) and other Victorian ports (27.1%) providing the majority of traffic, followed by Tasmania (17.8%), Western Australia (10.7%), Queensland (10.3%) and South Australia (5.6%; Walters 1996). This reflects the different trade commodities that each port deals with. Geelong's main imports are crude oil and petroleum products (61%), fertiliser (12%), grain (11%), raw materials for aluminium smelting (5%) and woodchips (5%) (Port of Geelong Authority 1995; Walters 1996). For example, a large percentage of petroleum products came from Western Australia and all aluminium-smelting products are from Western Australia (Port of Geelong Authority 1995).

The latest shipping data available (1996 and 1997) are shown in Figures 5.3 and 5.4, and was provided by the Victorian Channels Authority (A Blott pers. comm.). Data for Geelong was unavailable. During 1996 and 1997, the Port of Melbourne received vessels from 13 bioregions (Figure 5.3) and exported to 12 bioregions (Figure 5.4). The vast majority of this traffic is trans-Tasman. This trend has not changed since 1994 and 1995. Inbound traffic to Melbourne came primarily from domestic

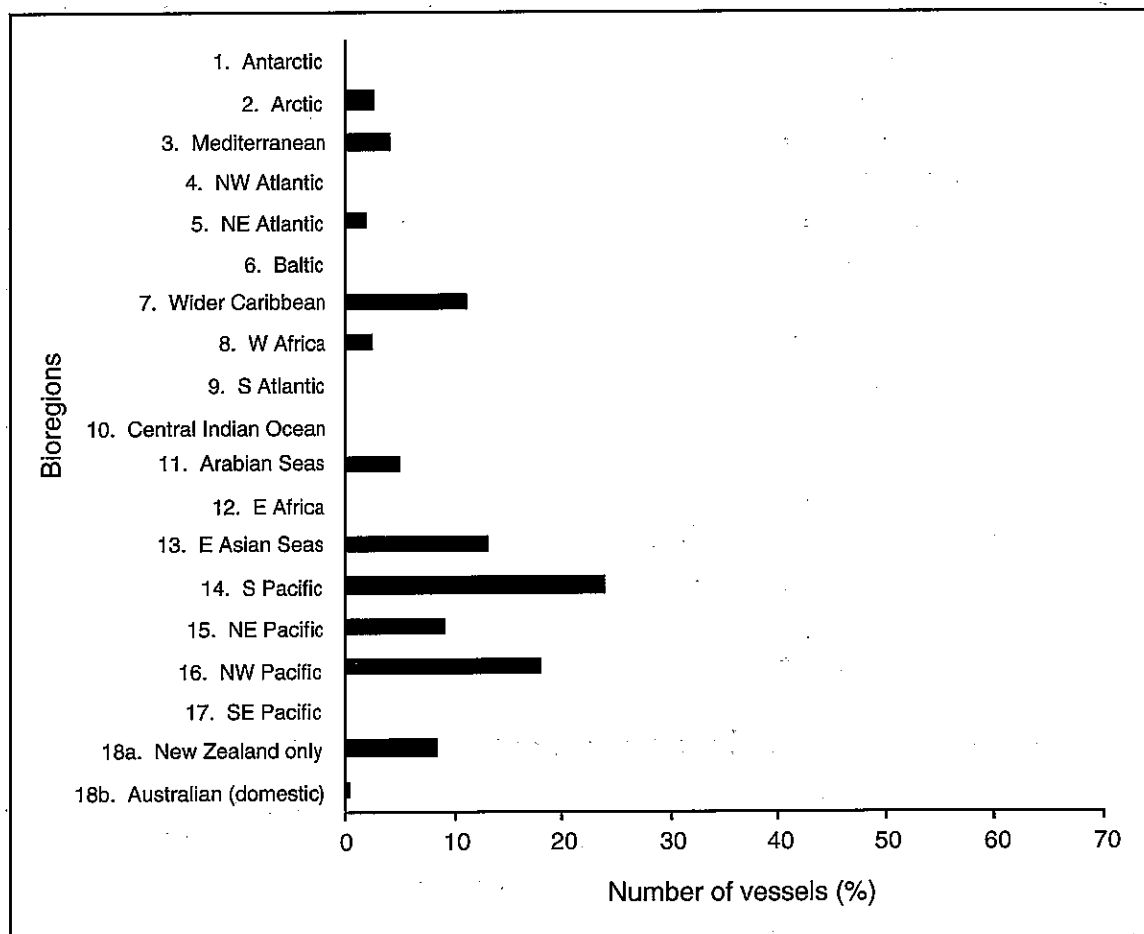


Figure 5.2. The Port of Geelong trade (1994 & 1995) with bioregions 1-18 (after Kelleher *et al.* 1995; see Chapter 2 for discussion of bioregions, Figure 2.1).

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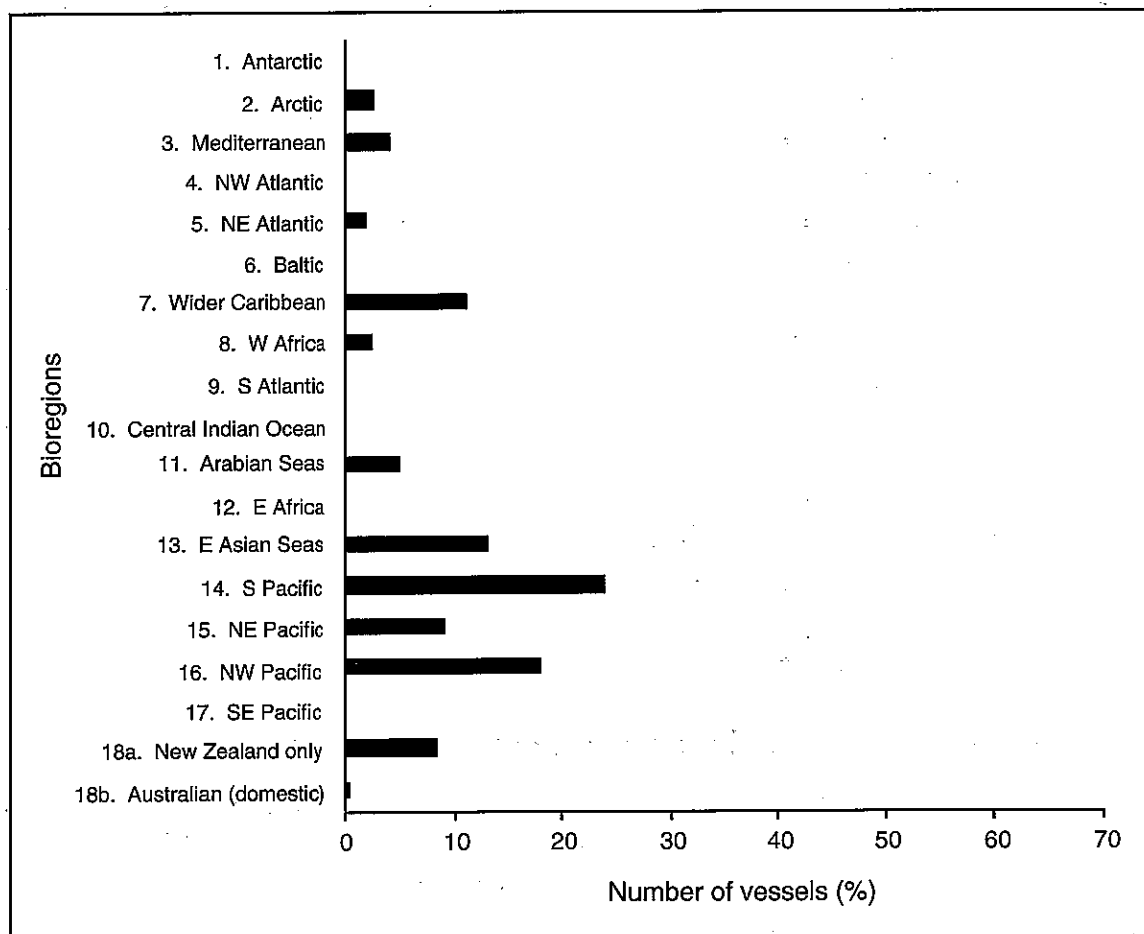


Figure 5.2. The Port of Geelong trade (1994 & 1995) with bioregions 1-18 (after Kelleher *et al.* 1995; see Chapter 2 for discussion of bioregions, Figure 2.1).

Australia (82.1%). Of the remaining bioregions, 90% of traffic were with the bioregions of New Zealand (55.5%), the South Pacific (19.7%) and the East Asian Seas (14.9%). The remaining 10% of inbound traffic originated from the Antarctic, North West Pacific, North East Pacific, South East Pacific, East and West Africa, the South Atlantic, North East Atlantic and Mediterranean and the Wider Caribbean bioregions (Figure 5.3). This pattern is similar to the 1994 and 1995 shipping data.

As well as receiving exotic species, Port Phillip Bay is capable of infecting other bioregions. Current trade (1996, 1997) indicates that 85.2% of traffic goes to domestic ports in Australia (A Blott pers. comm.). Of the international visits, 52.1% goes to New Zealand, 23.2% to the east Asian seas, 10.2% to the northwest Pacific and 9.2% to the south Pacific. The remaining bioregions receive only 14.5% of Melbourne's traffic (Figure 5.4). Information on export traffic during 1994 and 1995 was unobtainable. However, the similarity between 1994 and 1995, and 1996 and 1997 inbound traffic suggests that export traffic may also have been similar, over these periods.

Of the 19 worldwide bioregions (Kelleher *et al.* 1995; see Chapter 2, Figure 2.1), Port Phillip Bay has received

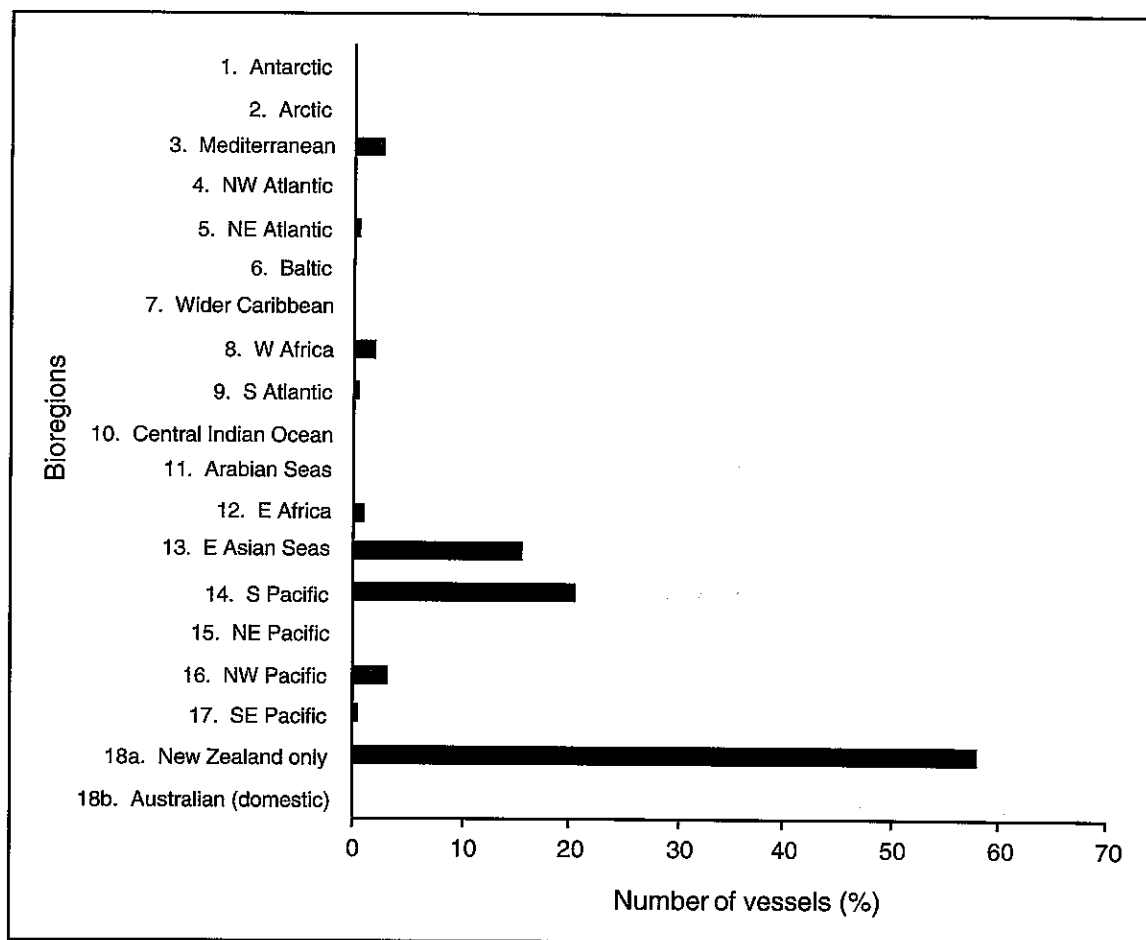
exotic species from all but one bioregion: Antarctica. The majority (60%) of introductions originate from the combined bioregions of the Atlantic, the Mediterranean and Baltic Sea. The Pacific region has contributed 17% of introductions and the Central Indian Ocean, South Pacific, East Asian and Arabian Seas have combined contributions of 7%, with the remaining bioregions (New Zealand, Arctic and Cosmopolitan bioregions) contributing the final 16%.

## 5.4 WATERWAYS AND PORTS

### 5.4.1 Maintenance and management

Maintenance of port areas includes activities such as dredging, development of new wharves and piers, demolition of old wharves and piers, cleaning facilities and land reclamation. These activities are managed by several interests including port authorities, management groups, and the Victorian Channel Authority.

Dredging facilitates vessel access and maintains safe passage within a region. A number of channels within Port Phillip Bay are continually dredged, maintaining access into Geelong, Melbourne and into the bay. The port areas are also dredged to maintain berth depths. Port



**Figure 5.3.** The Port of Melbourne current trade (1996 and 1997) with other bioregions 1–18 (after Kelleher *et al.* 1995; see Chapter 2 for discussion of bioregions, Figure 2.1).

dredging practices have been demonstrated to play a role in the local translocation of introduced species within a port environment (Carlton *et al.* 1990). Early dredge tailings from Port Phillip Bay were dumped inland, with taxonomists seizing the opportunity to document the marine flora and fauna found in the spoil (Wilson 1894). In recent times, dredge spoil is dumped within the bay in areas considered suitable for such activities.

The Victorian Channels Authority regulates this. Offshore (onto the continental shelf) dredge spoil dumping must meet legislative requirements specified within the Commonwealth Environment Protection (Sea Dumping) Act 1981 and is administered by the Environment Protection Group of Environment Australia. This legislation also follows the ANZECC Sea Dumping Guidelines (ANZECC 1997). At present, offshore dumping of dredge materials does not occur in Port Phillip Bay (C Gibbs pers. comm.). Typically, dredge spoil is disposed of at the Port Phillip Spoil grounds (marked on all nautical charts for Port Phillip Bay) (C Gibbs pers. comm.). Spoil grounds also exist for the recent deepening of the Geelong channel; both in Corio Bay and an outer spoil ground in Geelong Arm (C Gibbs pers. comm.).

Maintenance dredging has been highlighted as a high-risk activity with the potential to re-distribute species such as *Sabella spallanzanii*, *Corbula gibba*, *Theora lubrica* and cysts of toxic dinoflagellates in Australian coastal and estuarine waters.

Port enhancement activities (e.g. maintenance dredging, berth development and revetment construction) create disturbed and novel habitats that may lead to increased invasion success. Many introduced species appear to require some form of disturbance in order to enter an existing native community (Fox and Fox 1986). For example, *S. spallanzanii* is known to rapidly colonise recently cleared or newly submerged hard surfaces (Clapin and Evans 1995; C Hewitt pers. comm.; Chapter 16). Port maintenance activities may influence the establishment of some encrusting or fouling species within Port Phillip Bay by clearing a space that may be colonised by ballast water or hull fouling organisms.

Hull cleaning activities of both large, commercial vessels and smaller recreational, either in-water (brush cart cleaning) or drydock, can lead to the inoculation and establishment of exotic species. A number of slipway facilities and one drydock facility exists in Port Phillip

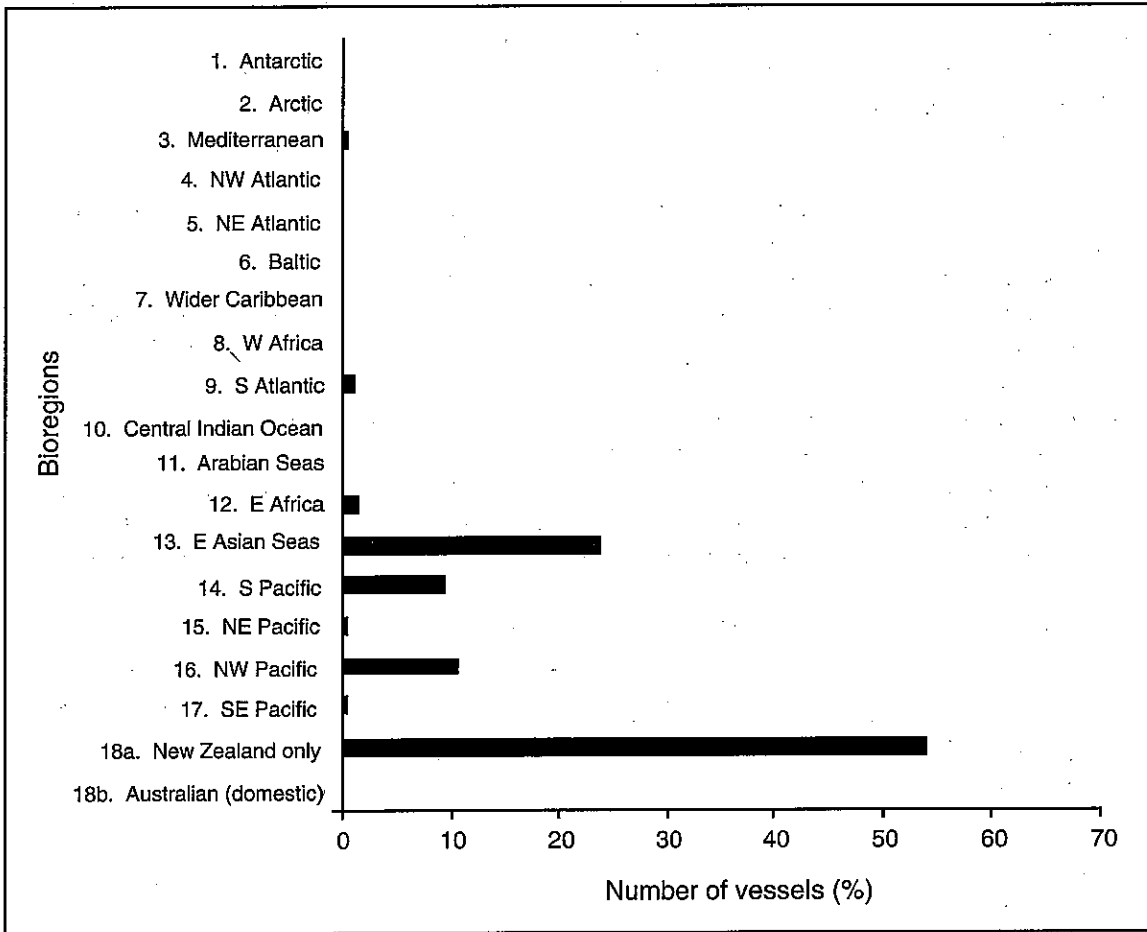


Figure 5.4. The Port of Melbourne current trade (1996 and 1997) to other bioregions 1–18 (after Kelleher *et al.* 1995; see Chapter 2 for discussion of bioregions, Figure 2.1).

(Table 5.1). All are involved in hull cleaning and painting (especially the smaller marina's, such as Runaway Bay marina) and others are involved in construction and refit activities. State environment legislation exists to ensure that debris from drydock hull cleaning (Williamstown and the Rippleside slipways) is correctly disposed (Walters 1996). Yet invariably, cleaning of vessels result in inoculation into the port environs. In 1995, only 2% of vessels in Australia, conducted in-water cleaning of hulls at Port Melbourne, with 14% of these vessels using the Geelong port (Walters 1996). Restrictions on in-water cleaning are becoming common, with authorities (both Australian and international) trying to dissuade this practice (Walters 1996). Only two of the drydocks and slipways in Port Phillip Bay deal with international traffic, Wagland and Williamstown. However, Wagland floating dock closed 5–6 years ago, leaving the Williamstown Transfield facilities as the only facility dealing with vessels that have had likely international experience.

In recent years, Geelong has implemented an environmental monitoring study (EMS) to manage the port's operations and ensure compliance with its environmental commitments. Before commencing dredging activities, plans are submitted and must receive approval, both planning and ministerial. The dredging periods are preceded by a 12-month environmental monitoring program and followed by a further five year monitoring period (Port of Geelong Authority 1995). Development of wharves and piers must also be approved and environmental studies must be done. Port Melbourne has a similar EMS in place to ensure environmental commitments are maintained (C Gibbs pers. comm.). The Victorian Environmental Protection Authority also provides environmental monitoring throughout the bay (C Gibbs pers. comm.).

In addition to port maintenance, the operation of mariculture facilities in waterways near port facilities may increase the likelihood of introduced species becoming established and spreading. Mariculture practices have the potential to transfer exotics species from one region to

another (Hewitt and Martin 1996). Many exotic species such as *Turritopsis nutricula*, *Sabella spallanzanii* and *Asterias amurensis* are associated with mussel lines and hence transfer of these lines from one region to another will facilitate redistribution of these species. Portarlington and Beaumaris Bay are aquaculture regions within the bay that both have a number of established exotic species (see Chapters 2 and 14). The transfer of mariculture equipment is of prime concern and has been implicated in the transfer of organisms within and between local, national and international regions (Chew 1990; Grizel and Héral 1991; Carlton 1992; Utting and Spencer 1992).

#### 5.4.2 Ballast practices

Heavy 'dry' materials (such as sand, boulders, and chain) were originally used for ballast. Thompson (1841; see also Kerr and Kerr 1979) reported that as early as 1840, dry ballast discharge regulations existed in Port Phillip.

*"Melbourne, April 15, 1840*

*The harbour-master of Port Phillip draws the attention of all commanders of vessels proceeding either up or down the harbour of Port Phillip to the Act (Wm. IV., No. 6) prohibiting, under heavy penalty, the discharge of ballast overboard in any of the channels leading to the harbour.*

*Should any vessel happen to ground on the banks of the channels, while passing through them, it is required that the longboat shall be got out, and that the ballast or other heavy materials should be landed at high-water mark on the adjoining nearest reef.*

*Notice is hereby given that the harbour-master has orders to proceed against any party who may after the publication of this notice transgress from the above regulations.*

*By order of*

*C. J. LA TROBE."*

Although these regulations were more concerned with the creation of shipping hazards, it was the beginning of ballast regulations within the Port Phillip region. Dry

**Table 5.1.** Drydock and slipway facilities operating in Port Phillip Bay.

Facility	Vessel origin	Operational status
Williamstown drydock (commercial)	International & domestic (Navy)	+
Victoria slipways (commercial)	Domestic	+
Appleton Dock slipways	Domestic	+
Wagland floating dock	International	-
Duke and Oars slipways (x2)	Domestic	+, -
Anne St. slipways	Domestic	+
Rippleside slipways (commercial)	Domestic	+
Mordialloc Creek slipways	Domestic (fishing fleets)	+
Moonee Ponds slipways	Domestic	+

ballast began to be replaced by water ballast in the mid 1840's (Carlton 1985; Carlton *et al.* 1995) and as early as 1908 ballast water was recognised as a potential vector for marine organisms (Carlton 1985). Dry and semi-dry ballast has been implicated in the transfer of numerous species (Carlton 1989; Carlton 1992; Mills *et al.* 1993) such as the New Zealand porcelain crab, *Petrolisthes elongatus* (King 1997) and possibly corophiid amphipods, such as *Corophium acherusicum* and *C. sextonae* (Storey 1996; see Chapter 16).

Ballast water can be carried in dedicated ballast water tanks and in empty cargo holds, which are modified for such purposes (Walters 1996). Ballast discharge is associated with the loading and unloading activity of the vessel while at berth. If a vessel loads a large volume of cargo only (e.g. ore carrier), it will discharge ballast water to maintain trim. Vessels that both load and unload cargo (e.g. container vessel) at berth require minimal ballasting. Thus, the type of vessel and its capacity to load and/or unload cargo controls the potential discharge of ballast water (Walters 1996). Presently in Australia, AQIS manages ballast water from international vessels. However, there are no standard ballast regulations for coastal shipping in Australia (ENRC 1997).

## 5.5 REFERENCES

- ANZECC (1997). *Environmental Assessment of the Sea Disposal of Dredged and Excavated Materials*. ANZECC Sea Dumping Task Force.
- Arthington, A. H. and McKenzie, F. (1997). *Review of Impacts of Displaced/Introduced Fauna Associated with Inland Waters*. Australia State of the Environment, Technical Paper Series, Canberra. 69 pp.
- Bach, J. (1976). *A Maritime History of Australia*. Book Club Associates; Sydney. 481 pp.
- Bateson, C. (1985). *The Convict Ships 1887-1868*. Brown, Son & Ferguson; Glasgow. 421 pp.
- Carlton, J. T. (1979). *History, Biogeography and Ecology of the Introduced Marine and Estuarine Invertebrates of the Pacific Coast of North America*. Ph.D. Dissertation. California, University of California, Davis, USA. 904 pp.
- Carlton, J. T. (1985). Transoceanic and interoceanic dispersal of coastal marine organisms: The biology of ballast water. *Oceanography and Marine Biology Annual Review* 23: 313-371.
- Carlton, J. T. (1989). Man's role in changing the face of the ocean: Biological invasions and implications for conservation or near-shore environments. *Conservation Biology* 3: 265-273.
- Carlton, J. T. (1992). Dispersal mechanisms: A conceptual framework. pp. 13-45. In: Rosenfield, A. and Mann, R. (eds.). *Dispersal of Living Organisms into Aquatic Ecosystems*. Maryland Sea Grant Publication; College Park, Maryland. 471 pp.
- Carlton, J. T. (ed.) (1998). Ballast Water: Ecological and Fisheries Implications. *Rapport des Recherches Collectives No. 224*. Conseil International pour l'Exploration de la Mer; Copenhagen, Denmark.
- Carlton, J. T. and Geller, J. B. (1993). Ecological roulette: the global transport of non-indigenous species. *Science* 261: 78-82.
- Carlton, J.T. and Hodder, J. (1995). Biogeography and dispersal of coastal marine organisms: experimental studies on a replica of a 16<sup>th</sup>-century sailing vessel. *Marine Biology* 121: 721-730.
- Carlton, J. T., Reid, D. M. and van Leeuwin, H. (1995). *The Role of Shipping in the Introduction of Nonindigenous Aquatic Organisms to the Coastal Waters of the United States (other than the Great Lakes) and an Analysis of Control Options*. Report No. CG-D-11-95. National Technical Information Service; Springfield, Virginia 22161.
- Carlton, J. T., Thompson, J. K., Schemel, L. E. and Nichols, F. H. (1990). Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. I. Introduction and dispersal. *Marine Ecology Progress Series* 66: 81-94.
- Carlton, J. T., Thompson, J. K., Schmel, L. E. and Nichols, F. H. (1990). Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. I. Introduction and dispersal. *Marine Ecology Progress Series* 66: 81-94.
- Chew, K. K. (1990). Global bivalve shellfish introductions. *World Aquaculture* 21: 9-22.
- Clapin, G. and Evans, D. R. (1995). The status of the introduced marine fanworm *Sabella spallanzanii* in Western Australia: A preliminary investigation. *Centre for Research on Introduced Marine Pests Technical Report No. 2*, CSIRO Division of Fisheries, Hobart. 34 pp.
- Coleman, N. and Hickman, N. (1986). Pacific oyster found in Victoria. *Australian Fisheries* June 1986: 8-10.
- Cook, A. C. (1958). Birth of dockyard facilities at Williamstown. *Port of Melbourne Quarterly* 11 (4): 42-50.
- Coutts, A. D. M. (1999). *Hull Fouling as a Modern Vector for Marine Biological Invasions: Investigation of Merchant Vessels Visiting Northern Tasmania*. M.S. Thesis. Bell Bay, Australian Maritime College, Australia. 286 pp.
- Crompton, B. J. (1993). *The Confederate States Steamship Shenandoah in Melbourne*. Melbourne.
- Crosby, A. W. (1986). *Ecological Imperialism: the Biological Expansion of Europe, 900-1900*. Cambridge University Press; Cambridge. 368 pp.
- diCasteri, F. (1989). History of biological invasions with special emphasis of the Old World. pp. 1-3. In: Drake, J. A., Mooney, H. A., diCasteri, F., Groves, R. H., Kruger, F. J., Rejmanek, M., and Williamson, M. (eds.). *Biological Invasions: A Global Perspective*. SCOPE 37. John Wiley & Sons; New York. 525 pp.
- Dunn, L. (1973). *Merchant Ships of the World in Color 1910-1929*. Macmillan; New York. 215 pp.
- ENRC (1997). Ballast water and hull fouling in Victoria. *Parliament of Victoria Environment and Natural Resources Committee*. Victorian Government Printer; Melbourne. 319 pp.
- Fitchett, T. K. (1980). *The Long Haul. Ships on the England-Australia Run*. Rigby; Adelaide. 95 pp.
- Fox, M. D. and Fox, B. J. (1986). The susceptibility of natural communities to invasion. pp. 57-66. In: Groves, R. H., and Burdon, J. J. (eds.). *Ecology of Biological Invasion*. Cambridge University Press; London. 166 pp.
- Gollasch, S. and Leppakoski, E. (1991). *Initial Risk Assessment of Alien Species in Nordic Coastal Waters*. Nordic Council of Ministers, Copenhagen. 244 pp.
- Grizel, H. and Héral, M. (1991). Introduction into France of the Japanese oyster (*Crassostrea gigas*). *Journal de Conseil International pour l'Exploration de la Mer* 47: 399-403.
- Hewitt, C. L. and Martin, R. B. (1996). Port surveys for introduced marine species - background considerations and sampling protocols. *Centre for Research on Introduced Marine Pests, Technical Report No. 4*, CSIRO Division of Fisheries, Hobart. 40 pp.
- Holden, R. H. and Loney, J. (1969). *Early Shipping in the Port of Geelong*. Marine History; Geelong.
- Jackson, S. (1996). *Victorian, 1996 Year Book*. Australian Bureau of Statistics. No. 108.
- Kelleher, G., Bleakley, C. and Wells, S. (1995). *A Global Representative System of Marine Protected Areas. Volumes 1-4*. The Great Barrier Reef Marine Park Authority; The World Bank; and The World Conservation Union (IUCN). Washington, USA.
- Kerr, C. and Kerr, M. (1979). *Port Phillip Bay*. Rigby; Melbourne.
- King, R. (1997). *Systematic Relationships between Tasmanian and New Zealand Populations of Petrolisthes elongatus (Crustacea: Anomura: Porcellanidae)*. B.Sc. Honours Thesis. University of Melbourne, Victoria. 37 pp.
- Leggett, G. R. (1949). The birth of Melbourne's port. *Port of Melbourne Quarterly* 2 (1): 12-50.
- Loney, J. (1981). *Ships in Corio Bay, Geelong, 1840-1980*. Neptune; Geelong. 222 pp.
- Lubbock, B. (1921). *Colonial Clippers*. Brown, Son & Ferguson; Glasgow, Scotland. 384 pp.



- Lubbock, B. (1967). *The Opium Clippers*. Brown, Son & Ferguson; Glasgow, Scotland. 392 pp.
- Macintyre, D. (1972). *The Adventure of Sail*. Ferndale editions; London. 256 pp.
- Mills, E. L., Leach, J. H., Carlton, J. T. and Secor, C. L. (1993). Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. *Journal of Great Lakes Research* 19(1): 1–54.
- Pemberton, B. (1979). *Australian Coastal Shipping*. Melbourne University; Melbourne. pp. 46 – 60, 207–230.
- Pollard, D. A. and Hutchings, P. A. (1990a). A review of exotic marine organisms introduced to the Australian region. I. Fishes. *Asian Fisheries Science* 3: 205–221.
- Pollard, D. A. and Hutchings, P. A. (1990b). A review of exotic marine organisms introduced to the Australian region. II. Invertebrates and algae. *Asian Fisheries Science* 3: 222–250.
- Port of Geelong Authority. (1995). *Annual Report. 1994–1995*. Geelong, Victoria, Australia. 48 pp.
- Priestley, S. (1984). *The Victorians: Making their Mark*. Fairfax, Syme & Weldon; Sydney.
- Ruhen, O. (1976). *Port of Melbourne, 1835 – 1976*. Cassell; Melbourne. 324 pp.
- Ruiz, G. M., Carlton, J. T., Grosholz, E.D. and Hines, A. H. (1997). Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent and consequences. *American Zoologist* 37: 621–632.
- Shaw, A. G. L. (1997). *A History of the Port Phillip District. Victoria after Separation*. Miegunyah; Melbourne. 334 pp.
- Shigesada, N. and Kawasaki, K. (1997). *Biological Invasions: Theory and Practice*. Oxford University Press; Oxford. 205 pp.
- Shillinglaw, J. J. (1972). *Historical Records of Port Phillip. The First Annals of the Colony of Victoria*. Heinemann; Melbourne. 225 pp.
- Shushkina, E. A., Nikolaeva, G. G. and Lukasheva, T. A. (1990). Changes in the structure of the Black Sea planktonic community at mass reproduction of sea gooseberries *Mnemiopsis leidyi* (Agassiz). *Oceanology* 51: 54–60.
- Simberloff, D. (1986). Introduced species: A biogeography and systematic perspective. pp. 3–24. In: Mooney, H. A. and Drake, J. A. (eds), *Ecology of Biological Invasions of North America and Hawaii*. Springer-Verlag; New York. 321 pp.
- Smith, R. I. and Carlton, J. T. (1975). *Light's Manual. Intertidal Invertebrates of the Central California Coast*. 3<sup>rd</sup> edition. University of California; Berkeley. pp. 1–26.
- Staples, A. C. (1966). Maritime trade in the Indian Ocean, 1830–1845. *University Studies in History* 4 (4): 84–120.
- Storey, M. (1996). *Native and Introduced Species of the Genus *Corophium* (Crustacea: Amphipoda) in Southeastern Australia*. B.Sc. Honours Thesis. University of Melbourne, Victoria, Australia. 81 pp.
- Strahan, L. (1994). *At the Edge of the Centre. A History of Williamstown*. Hargreen; Williamstown. 489 pp.
- Thompson, J. (1841). *Kerr's Melbourne Almanac and Port Phillip Directory for 1841*. Lansdown Slattery; Mona Vale.
- U'Ren, N. and Turnbull, N. (1983). *A History of Port Melbourne*. Oxford; Melbourne.
- Utting, S. D. and Spencer, B. E. (1992). Introductions of marine bivalve molluscs into the United Kingdom for commercial culture – case histories. *ICES Marine Science Symposia* 194: 84–91.
- Van Zanden (1997). *1606 Discovery of Australia*. Rio Bay Enterprises; Perth, Australia. 135 pp.
- Wallbank, Taylor, Bailkey, Jewsbury, Leiws and Hacket (1992). *Civilizations past and present. A short history on the Opium Wars*. <http://mojo.calyx.net/~schaffer/heroin/opiwar1.html>
- Walters, S. (1996). Ballast water, hull fouling and exotic marine organism introductions via ships – a Victorian study. *Environmental Protection Authority*; Melbourne. 144 pp.
- Wild, D. (1950). *The Tale of a City: Geelong, 1850 – 1950*. Cheshire; Melbourne.
- Williams, R. J., Griffiths, F. B., van der Waal, E. J. and Kelly, J. (1988). Cargo vessel ballast water as a vector for the transport of non-indigenous species. *Estuarine, Coastal and Shelf Science* 26: 409–420.
- Wilson, J. (1894). List of dredging stations at and near Port Phillip Heads. *Proceedings of the Royal Society of Victoria* 25: 261–263.