15 A BAY-WIDE SURVEY FOR INTRODUCED SPECIES IN PORT PHILLIP BAY 1995–1996

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15.1 INTRODUCTION

Thirty-three years have passed since the last extensive (benthic and fouling) bay-wide survey of Port Phillip Bay (Port Phillip Bay Environmental Study, Phase One, 1968–1971) although additional work has been conducted by the Victorian Marine and Freshwater Resources Institute (MAFRI, formerly the Victorian Fisheries Research Institue: VFRI) and the Museum of Victoria (MoV). In the intervening period a number of introduced species have become abundant (e.g. *Asterias amurensis, Corbula gibba, Musculista senhousia, Sabella spallanzanii* and *Undaria pinnatifida*), in some cases experiencing increases of up to 400% (Wilson *et al.* 1996, 1998). These species have the potential to directly impact native flora and fauna or alter critical components of ecosystem function such as nutrient cycling (see Chapter 17).

All surveys in Port Phillip Bay have had intrinsic problems including limited spatial and habitat coverage, and unidentified and misidentified specimens due to either a poor knowledge of the phyla or a lack of experienced taxonomists (a situation that still exists for some groups). This has resulted in differential taxonomic resolution between phyla and an inability to obtain definite collection/identification dates, which in turn has hindered the deduction of accurate introduction dates (see Chapter 18). In addition, both collectors and researchers differentially sampled taxanomically, spatially and temporally. Thus, rare or hard to sample species were often missed and may not have been represented in records until later.

The recent results from partial re-surveys (Wilson *et al.* 1996, 1998) indicate that introduced species are more prevalent and potentially more widespread than 33 years ago. This may be due to an increase in shipping activity (and hence ballast water and hull-fouling) resulting in more introduced species inoculations into Port Phillip Bay. Alternately, the lack of comprehensive surveys targeting those regions and habitats most likely to have received introductions may have resulted in poor baseline resolution. As discussed in Chapter 1, the second phase of the CRIMP Port Phillip Bay study was to undertake a targeted field survey to rigorously sample the benthic fauna for introduced and cryptogenic species, and to place the results in the context of evaluations conducted by the taxonomic consultants (Chapters 6–13).

15.2 BASELINE BIOLOGICAL SURVEYS

Early biological surveys of Port Phillip Bay (in the 1800's) provided baseline information of the diverse taxa within this region. Studies by Harvey (1847, 1855, 1858–1863, 1869), Sonder (1852, 1853, 1880) and Wilson (1886, 1889, 1890, 1892, 1894, 1895) described the algae of the bay and helped provide the impetus for the formation of the Council of the Royal Society of Victoria. Similarly, knowledge of the fauna, specifically crinoids, sponges (Porifera), hydroids, algae and bryozoans was expanded via systematic biological surveys performed by Wilson, Agardh, Carpenter, Hickson, Spencer, Dendy and Pritchard among others (Anon 1890, 1892, 1894, 1895). The impetus for these collecting activities was bought to an end in 1895, with the death of J B Wilson.

Chapter 4 provides a summary of the surveys that have occurred since the mid-1950's. These surveys have recorded a number of introduced (Table 15.1) and cryptogenic (Table 15.2) species although most at the time were not recognised as introduced. For these surveys, complete species lists can be obtained from: Burn (1966), Clark (1966), Edmonds (1966), Macpherson (1966a, 1966b), Miller (1966), Naylor (1966), Pope (1966), Ralph (1966), Squires (1966), Womersley (1966), Cutress (1971), Griffith and Yaldwyn (1971), King *et al.* (1971), Knox and Cameron (1971), Southcott (1971), Utinomi (1966), Vigeland (1971), Watson and Utinomi (1971), Port of Melbourne Study (1979), PPES (1968–1971), Black (1971), Light and Woelkerling (1992), Poore (1992), Wood and Beardall (1992), Coleman (1993), Magro *et al.* (1996), Officer and Parry (1996), Wilson *et al.* (1996) and Chidgey and Edmunds (1997). Due to incomplete identifications and poor taxonomic resolution in specific taxa, additional introductions may have been present but remained undetected.

15.3 MATERIALS AND METHODS

The CRIMP survey was performed using methods outlined in Hewitt and Martin (1996; see Chapter 2). The sampling regime was designed to cover a variety of areas, concentrating on the shipping ports of Melbourne and

Table 15.1. Introduced species collected in previous surveys of Port Phillip Bay. Surveys listed are (1) Port Phillip Study (1957–1963); (2) Port Phillip Bay Environmental Study, Phase 1 (1968–1971); (3) Port Melbourne Study (1976–1977); (4) Corio Bay (1987) and (5) Port Phillip Bay Environmental Study (1991–1996). + denotes species collected during survey; ++ denotes species recognised as introduced at time of collection.

Taxa	Species	Previous surveys				
		1	2	3	4	5
Algae	*Antithamnionella spirographidis*					+
	Cladophora sp. (possibly C. prolifera)					+
	Deucalion levringii					++
	Medeiothamnion lyalli					++
	Polysiphonia brodiaei					+
	Polysiphonia pungens (senticulosa)					+
	Schottera nicaeensis					++
	Sorocarpus micromorus					+
	Stictysiphon soriferus					++
Dinoflagellate	*Alexandrium catenella*					++
	Gymnodinium mikimotoi					+
	Gymnodinium pulchellum					+
Cnidaria	*Amphisbetia operculata*	+				
	Ectopleura crocea	+				
	Halecium delicatulum	+				
	Obelia dichotoma (australis)	+				+
Annelida	*Boccardia proboscidea*					+
	Euchone sp.			+		+
	Myxicola infundibulum	+	+	+		
	Pseudopolydora paucibranchiata			+		+
	Sabella spallanzanii					++
Mollusca	*Corbula gibba*				+	++
	Janolus sp. (possibly *J. hyalinus).*	+				
	Musculista senhousia				+	+
	Okenia sp. (possible *O. plana)*	+				
	Theora lubrica	+	+	++	++	++
Arthropoda	*Carcinus maenas*	:		: :		
	Pyromaia tuberculata					++
Bryozoa	*Aetea anguina*	+				
	Bowerbankia spp.	+				
	Bugula neritina	+				
	Celleporella hyalina	+				
	Conopeum reticulum	+				
	Fenestrulina malusii	+				
	Membranipora membranacea	+				
	Scruparia ambigua	+				
	Scrupocellaria scrupea	+				
	Scrupocellaria scruposa	+				
Ascidacea	*Ascidiella aspersa*	+			+	
	Botryllus schlosseri			++		
	Ciona intestinalis	+		++		
	Styela clava			++		++
	Styela plicata	+				

Geelong. For ease of discussion the bay was divided into five regions: 1) Port Melbourne; 2) Geelong Arm; 3) the Heads; 4) the Eastern Shore and; 5) the Middle Bay (Figure 15.1). Regions 1 and 2 are the main port areas, regions 3 and 4 are recreational and commercial fishing areas and region 5 is dominated by shipping channels and markers. Four surveys were conducted over spring 1995 and summer 1995/1996.

The consultants contracted to review known introductions within Port Phillip Bay (see Chapter 2) provided a target species list of introduced and cryptogenic species. (Chapter 2, Table 2.2). The CRIMP survey sampling efficiency was evaluated by comparing survey detection against the target list. Collected algae, dinoflagellates and phytoplankton were not identified or targeted in this survey, although the algae and dinoflagellates are listed on the target list.

Table 15.2. Cryptogenic and possibly introduced species collected in previous surveys of Port Phillip Bay. Surveys listed are as in Table 15.1; + denotes species collected during survey.

Taxa	Species	Previous surveys				
		1	2	3	4	5
Algae	*Acinetospora crinita*	+	+			+
	Bryopsis plumosa	+	+			+
	Centroceras clavulatum					+
	Ceramium flaccidum					+
	Ceramium rubrum					+
	Chaetomorpha aerea					+
	Chaetomorpha linum					+
	Colpomenia peregrina					+
	Colpomenia sinuosa	+	+			+
	Cutleria multifida	+	+			+
	Dictyota dichotoma		+			+
	Enteromorpha compressa		+			+
	Enteromorpha intestinalis		+			+
	Feldmania globifera	+				+
	Feldmania lebelii					+
	Gelidium pusillum					+
	Kuckuckia spinosa					+
	Leathesia difformis					+
	Nemalion helminthoides					+
	Petalonia fascia					+
	Petrospongium rugosum					+
	Pilayella littoralis					+
	Polysiphonia subtilissima					+
	Pterocladia capillacea	+				+
	Punctaria latifolia					+
	Scytosiphon lomentaria		+			+
	Sphacelaria fusca					+
	Ulva lactuca		+			+
	Ulva rigida					+
Arthropoda	*Caprella equilibra*			+		
	Elminius modestus	+	+			
Bryozoa	*Celleporaria albirostris*	+				
	Parasmittina trispinosa	+				

The numerous studies of Port Phillip Bay have resulted in considerable amounts of information being collected on the bay. However, the sampling strategies performed in each survey are not directly comparable due to different sampling intensities, site locations and habitats, sampling methodologies and because many taxonomic groups from previous surveys were not identified beyond taxa level. Because of this, no comparative statistical analyses with the CRIMP data is possible (K Haskard pers. comm.), although some descriptive statistics are used in section 15.6.2 below.

15.4 RESULTS

Based on historical information, bay-wide and the Port of Geelong (see Chapter 14; Currie *et al.* 1998) surveys there are at least 855 species currently in Port Phillip Bay, and potentially there are 191 are introduced, cryptogenic or possibly introduced species (Appendix A, Table A7).

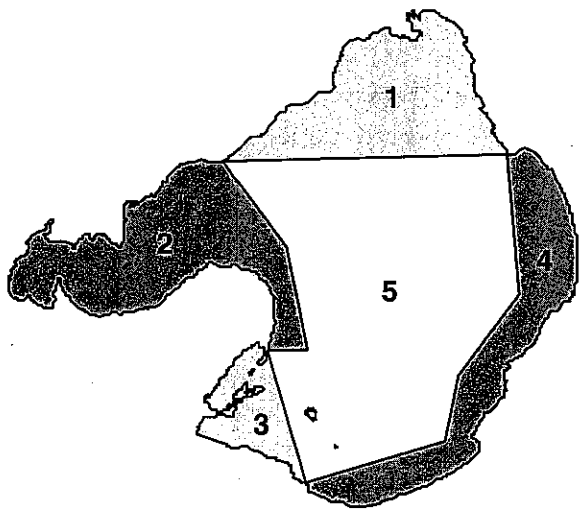

Figure 15.1. Port Phillip Bay regions: 1) Port Melbourne; 2) Geelong Arm; 3) the Heads; 4) the Eastern Shore and; 5) the Middle Bay.

Table 15.3. Total number of native species per phylum (n) and per region (1–5) that were collected on hard (H) and soft (S) substrates. Region 1) Port Melbourne; 2) Geelong Arm; 3) the Heads; 4) the Eastern Shore; and 5) the Middle Bay.

Phylum (n)	Substrate	Number of endemic species per region				
		1	2	3	4	5
Bryozoa (19)	H	7	6	9	7	4
Chordata (11)	H/S	4	8	2	0	0
Cnidaria (23)	H	9	8	5	15	10
Crustacea (140)	H/S	125	40	5	6	0
Echinodermata (10)	S	8	4	5	1	1
Mollusca (64)	H/S	24	12	1	6	2
Nemertea (7)	S	4	1	0	2	0
Polychaeta (132)	H/S	97	49	10	17	4
Porifera (27)	H	10	13	14	5	0
Urochordata (23)	H	16	6	8	3	3
Total number of species per region		304	147	59	62	24

15.4.1 Native species

The present survey collected and identified a total of 456 native species from 10 phyla. The numbers of native species per phylum collected by region is summarised in Table 15.3. Polychaetes were evenly distributed between the five regions, with other phyla being concentrated around the port regions of Melbourne and Geelong (region 1 and 2). Sixty percent of phyla appeared in all regions. The remaining 40% of phyla (chordates, nemerteans, crustaceans and sponges) were not collected at all sites due to the sampling effort for these organisms.

To summarise, the majority of native species were concentrated around the shipping regions of Port Melbourne (51.5%) and Geelong (25%), followed by fishing regions of the Eastern Shore (10.5%), the Heads (9%) and finally the shipping movement area in the Middle Bay (4%). This trend may be an artifact of sampling effort, which was concentrated around the Port of Melbourne and Geelong regions.

15.4.2 Introduced species

Fourty-nine introduced species were collected over the five sampling regions. Table 15.4 summarises the introduced species collected in this survey and their current distribution in Port Phillip Bay. The majority (76%) of introduced species were associated with hard substrates. Taxa with most introduced species were the Bryozoa (n = 12), Crustacea (n = 10), Cnidaria (n = 8), and Ascidiacea (n = 6). Three of these taxa (Ascidiacea, Bryozoa and Cnidaria) are common, dominant, hard substrate foulers (see Chapters 7 and 13).

Introduced species were concentrated around the shipping areas within the Port Melbourne (76%) and Geelong (64%) regions. The aquaculture area at Portarlington also had many introduced species, with the introduced hydroid *Ectopleura crocea* and the introduced fanworm *Sabella spallanzanii* commonly fouling aquaculture lines. In addition, a number of vessels moored at the nearby Portarlington marina were heavily fouled by *S. spallanzanii*. The fishing regions at the Eastern Shore (28%) and the Middle Bay (24%) had the next highest concentration of introduced species, followed by the Heads (14%).

15.5 INTRODUCTIONS NOT ON THE TARGET LIST

Cancer novaezelandiae was identified from Mentone in the region (McNeil and Ward 1930) but was not collected in the bay-wide survey or noted on the target list. *Cancer novaezelandiae* may be an historical introduction that has become locally extinct. One introduced species (*Paracerceis sculpta*) was collected, but was not detailed in the target list. The collection of *P. sculpta* represents the first record of this species in temperate Australian waters, although, *P. sculpta* has been collected from tropical Australian waters (Harrison and Holdich 1982). A brief taxonomic description of each species is provided below. A flat worm species, *Euplana gracilis*, native to the Atlantic coast of North America was identified previously (Prudhoe 1982) and is not treated herein.

15.5.1 Crustacea

Family Cancridae

Cancer novaezelandiae (Jacquinot and Lucas 1853)

Synonymy and taxonomy

Platycarcinus novae-zealandiaea, Jacquinot and Lucas 1853; *Cancer novae-zealandiae*, Milne Edwards 1865. — Miers 1874, 1876. — Filhol 1886. — Lenz 1901. — Chilton 1909, 1911. — Thomson 1912. — Thomson and Anderson 1921. — Stephensen 1927. — Chilton and Bennett 1929. — Young 1929. — McNeil and Ward 1930. — Richardson 1949; *Cancer novaezelandiae* Dell 1963, 1968, 1969. — Vermeij 1977. — Marsden and Fenwick 1978. — Probert *et al.* 1979. — Marsden 1981. — Knox 1983. — Wear and Fielder 1985. — McLay 1988. — Furlani 1996.

Table15.4. Introduced species collected (n) from regions 1–5 on hard (H) and soft (S) substrate during the bay-wide survey, 1995–1996. Regions are as in Table 15.3.

Taxa	Species	Substrate	Port Phillip Bay regions				
			1	2	3	4	5
Porifera	*Aplysilla rosea*	H			+	+	
	Dysidea fragilis	H	+				
	Haliclona heterofibrosa	H		+			
	Halisarca dujardini	H	+				
Cnidaria	*Bougainvillia muscus*	H	+	+			
	Clytia hemisphaerica	H	+	+			
	Clytia paulensis	H	+	+			+
	Ectopleura crocea	H		+			
	Obelia australis	H	+			+	
	Plumularia setacea	H	+	+			+
	Sarsia eximia (radiata)	H		+			+
	Turritopsis nutricula	H		+			
Polychaeta	*Sabella spallanzanii*	H/S	+	+			+
Mollusca	*Corbula gibba*	S	+	+			+
	Musculista senhousia	S	+	+			
	Raeta pulchella	S	+				
	Theora lubrica	S	+	+			
Crustacea	*Balanus amphitrite*	H	+	+		+	
	Balanus variegatus	H	+	+		+	+
	Carcinus maenas	S	+	+	+	+	
	Cirolana harfordi	H		+			
	Corophium acherusicum	S	+	+	+	+	
	Corophium insidiosum	S	+				
	Corophium sextonae	S			+		
	Elminius modestus	S	+			+	
	Paracerceis sculpta	H/S	+			+	+
	Pyromaia tuberculata	S	+				
Bryozoa	*Aetea anguina*	H	+				+
	Amathia distans	H	+	+			
	Bugula flabellata	H	+	+			+
	Bugula neritina	H	+	+			
	Bugula stolonifera	H	+	+			
	Conopeum reticulum	H	+	+			
	Cryptosula pallisiana	H	+	+		+	
	Electra pilosa	H				+	
	Membranipora membranacea	H			+		
	Schizoporella unicornis	H			+		
	Tricellaria occidentalis	H	+	+	+	+	+
	Watersipora subtorquata	H	+	+	+	+	
Ascidiacea	*Ascidiella aspersa*	H	+				+
	Botrylloides leachi	H	+	+			
	Botryllus schlosseri	H	+			+	
	Ciona intestinalis	H	+				
	Styela clava	H	+		+		
	Styela plicata	H	+				
Pisces	*Acanthogobius flavimanus*	H		+			
	Acentrogobius pflaumi	H	+	+		+	+
	Forsterygion lapillum	H	+	+			
	Tridentiger trigonocephalus	H	+				
Total number of introductions per region			38	31	7	14	12

Native distribution
Native to New Zealand.

Australian distribution
Tasmania: Hobart; New South Wales: Eden; and Victoria: Western Port, the central Victorian coastline and Port Phillip Bay.

Port Phillip Bay distribution and first records of collection
It was recorded from Mentone in 1930 (McNeil and Ward 1930) however, has not been collected since. This may represent a local extinction/failed invasion.

Description
A decapod crab. The carapace is domed, elliptical 28–112 mm wide, expanded sideways over short, slender legs. Its colour is grey to rust red above and cream below, often speckled with pinkish-brown. It holds its legs inert when uncovered making no attempt to escape.

Known or inferred impacts
Not known for Australia waters.

Comments
Cancer novaezelandiae is a nocturnal feeder that migrates into the littoral zone at night. Ovigerous females have been collected during summer/autumn in New Zealand and observed in winter in Tasmania (K Gowlett-Holmes pers. comm.). It lives in the subtidal zone in harbours, estuaries and rocky coastlines.

Family Sphaeromatidae
Paracerceis sculpta (Holmes 1904)

Synonymy and taxonomy
Dynamene sculpta Holmes 1904;
Cilicaea sculpta Richardson 1905;
Paracerceis sculpta Richardson 1905. — Menzies 1962. — Millar 1968. — Pires 1981. — Harrison and Holdich 1982. — Shuster 1987. — Rodriguez *et al.* 1992. —Furlani 1996;
Sergiella angra Pires 1980, 1981.

Native distribution
North American Pacific coast, California to Mexico.

Australian distribution
Queensland: Townsville (Furlani 1996), Hay Point; New South Wales: Eden; and Western Australia: Swan River and Bunbury (CRIMP collection).

Port Phillip Bay distribution and first records of collection
Collected by CRIMP, at the Anne St. Pier, 19 September 1995. No other known records.

Description
See description in Chapter 10 of material provided to G Poore for verification.

Known or Inferred Impacts
Unknown for Australian waters.

Comments
Paracerceis sculpta breeds in intertidal sponges. It lives in the intertidal/infralittoral zone in macroalgae and under stones and is able to withstand strong wave action. Previously, it has only been recorded in North Queensland (Harrison and Holdich 1982). It is often associated with *Sphaeroma walkeri* and *Paradella dianae*.

15.6 DISCUSSION AND CONCLUSIONS

15.6.1 Sampling proficiency (target versus survey species)

Sampling proficiency for determining the presence of introduced species varied between regions and substrates (Table 15.5). Hard substrate sampling detected 47.5% of the total known target species (excluding the algae). Similarly, soft substrate sampling methods were 48% effective at detecting introductions (excluding algae and dinoflagellates). Detection of introduced species in the groups Chordata (100%), Ascidiacea (86%), Crustacea (80%), Porifera (66%), Cnidaria (60%), Mollusca (57%) and Bryozoa (52%) was high (Table 15.5). Conversely, few introductions were detected for the invertebrate groups Echinodermata (0%) and Polychaeta (12.5%; Table 15.5). Factors limiting detection include seasonality due to biphasic life histories (e.g. hydroids), recognised limited distribution (e.g. *Molgula manhattensis* and *Ectopleura crocea*) or habitat. Detection of cryptogenic and possibly introduced species (Bryozoa 0%, Crustacea 66%, Mollusca 0% and Porifera 0%) was also variable (Table 15.5).

15.6.2 Community and survey comparisons

Comparisons with previous surveys are restricted by a number factors. Many previous studies have concentrated on benthic substrates (Poore 1992; Currie and Parry 1996). Few hard substrate surveys in Port Phillip Bay are available, and those that are available are mostly historical descriptive papers (see MacGillivray 1883a, 1883b, 1883c, 1884, 1885, 1886, 1887a, 1887b, 1887c, 1890; Dendy 1895, 1896 and 1897). Two exceptions are the 1957–1963 surveys conducted by the Victorian Fisheries and Wildlife Department and the National Museum of Victoria (PPES 1968–1971) and the 1968–1971 survey conducted by the Melbourne and Metropolitan Board of Works, the Victorian Fisheries and Wildlife and the Port Phillip Authority (Port of Melbourne Environmental Study 1979) Comparisons of the bay-wide 1968–1971, 1957–1963 and present 1995–1997 surveys were made to note community changes. This comparison is for zoobenthos only.

The present and 1957–1963 surveys combined sampled 1,075 species with 89 species (8.3%) occurring in both; 568 species were unique to the 1957–1963 survey and 418 were unique to the 1995–1997 survey resulting in a Jaccard's Index of Similarity of 9.9%. This implies that the community structure has changed dramatically in the past 32 years. Introduced species in the 1957–1963 survey were few (18 species), with 83% being collected in the 1995–1997 survey.

Comparison with the 1968–1971 survey also shows changes in community structure, however the changes are less extreme. The present and the 1968–1971 surveys combined sampled slightly fewer species (928) with 125 (13.5%) species occurring in both surveys. The 1968–1971 survey had 421 species that were only collected in that survey while the present survey had 382 unique species resulting in a Jaccard's Index of 18.4%. Changes in community structure such as these in Port Phillip Bay are expected and have been briefly discussed in Chapter 14 and by Currie and Parry (1996, 1998), and Wilson *et al.* (1966, 1988).

The number of introduced species in the 1968–1971 survey decreased to three species. The drop in recorded introduced species is ascribed to the incomplete identifications of many of the 1968–1971 specimens. Large proportions (74.5%) of these species were only identified to family or genus level. The present survey collected 49 introduced species, representing a 3-fold increase from the 1957–1963 survey. Thus, as time progressed, and if we ignore the 1968–1971 results, more introduced species became established in the bay. This trend is discussed in more detail in Chapter 18.

15.6.3 Impact of introduced pests

There have been few comprehensive studies on the impacts of introduced species in Australia (see Chapter 16). International research on impacts is more advanced, with studies on a number of introduced species including the zebra mussel, *Dreissena polymorpha* (see Claudi and Mackie 1993; Madenjian 1995; Mellina *et al.* 1995; Klerks *et al.* 1997); the introduced seagrass *Zostera japonica* (Baldwin and Lovvorn 1993, 1994; Thom *et al.* 1995); the ctenophore *Mnemiopsis leidyi* (GESAMP 1997); the green crab *Carcinus maenas* (Grosholz and Ruiz 1995, 1996; Kuris and Lafferty 1996); and the introduced seaweeds *Undaria pinnatifida* (M Stuart 1998; pers. comm.) and *Caulerpa taxifolia* (Verlaque 1994; Verlaque and Fritayre 1994; Francour *et al.* 1995; Villele and Verlaque 1995; Bellan-Santini *et al.* 1996; Ribera *et al.* 1996; Ferrer *et al.* 1997). Generally, impacts studies are conducted for introduced species that pose obvious threats to native biodiversity or have an obvious economic impact. Consequently, species that cause little economic impact are often disregarded (e.g. the bryozoan *Membranipora membranacea*).

Recognising impacts is difficult if a species has been present in an area for many years. For example, at least 50% of the introduced bryozoans in Port Phillip Bay were first identified in the late 1800's and could easily have arrived in the early 1800's on wooden ships as hull foulers (see Chapter 18). The time between arrival and detection is sufficient for community structure to be altered through competition and displacement of native species. Yet this would be undetected because studies of the marine fauna in Port Phillip Bay did not begin until the mid–1800's with few quantitative evaluations of community structure until the late 1960's.

Numerous researchers (Smith and Carlton 1975; Simberloff 1986; Carlton *et al.* 1995; Shigesada and Kawasaki 1997) have discussed the potential impacts of introduced species. Potential impacts may include

- competition, displacement and extinction of native species;
- habitat alterations;
- introgression and hybridisation;
- ecosystem nutrient cycling modifications; and
- the vectoring of diseases.

Some of these impacts have occurred in Port Phillip Bay. For example, the introduced species *Sabella spallanzanii*, *Corbula gibba*, *Musculista senhousia*, *Theora lubrica*, *Euchone limnicola* and *Undaria pinnatifida*, have altered their habitats. These six species all occur in high densities and appear to have successfully out-competed native species. *S. spallanzanii* and *M. senhousia* can dominate both hard and soft substrates; the others dominate soft substrates. Other introduced species that have successfully competed for space include the introduced bryozoans, cnidarians and ascidians that are dominant on hard substrates.

The introduced alga *Codium fragile* ssp. *tomentosoides* is capable of interbreeding with the native *Codium fragile* subspecies (S Campbell pers. comm; also see Chapter 16). Furthermore, *Codium* can displace shellfish such as scallops, oysters and mussels, (Ramus 1971; Bleakney 1989) making it a potential pest. As discussed in Chapter 16, many introduced species can directly modify the substrate (e.g. *Corbula gibba*, *Corophium* sp., *Euchone limnicola* and *Musculista senhousia*) and alter nutrient cycling (e.g. *Corbula gibba*, *Codium fragile* ssp. *tomentosoides* and *Sabella spallanzanii*) (see Chapter 17; Harris *et al.* 1996).

As yet, the vectoring of diseases in introduced species has not been detected in Port Phillip Bay, but the potential for this to occur is significant due to the mariculture practices of importing spat and live adults. For example, in Tasmania, there have been concerns over the import of Atlantic salmon because of diseases they may bring into the Australian salmon mariculture industry.

In conclusion, few of the introduced species in Port Phillip Bay, or Australia have been extensively studied. Further research is required to fully comprehend the potential impacts that introduced species may have on our native species and habitats.

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Table 15.5. Introduced, cryptogenic and possibly introduced species on hard (H) and soft (S) substrates in the different regions of Port Phillip Bay. "Reported distribution" indicates known occurrence and distribution; "CRIMP survey" indicates occurrence and distribution as determined from the CRIMP bay-wide survey. Regions are as in Table 15.3; presence of species indicated by +; possible presence denoted by ?; [1] denotes species identified by taxonomic experts in this volume; [2] denotes species with a known limited distribution; [3] denotes species in a habitat unsampled by CRIMP survey; and [4] denotes species identified in Victoria but not in Port Phillip Bay.

Target species	Substrate	Port Phillip Bay regions									
		Reported distribution					CRIMP survey				
		1	2	3	4	5	1	2	3	4	5
Algae – introduced											
Antithamnionella spirographidis [1,2,3]	H	+									
Asperococcus compressus [1,2,3]	H	+									
Chondria arcuata [1,2,3]	H	+									
Cladophora prolifera [1,3]	S			+	+						
Codium fragile spp. *tomentosoides* [1,3]	S		+								
Deucalion levringii [1,3]	H	+		+							
Gymnogongrus crenulatus [1,3]	H	+	+								
Medeiothamnion lyalli [1,3]	H				+						
Polysiphonia brodiaei [1,3]	H	+		+							
Polysiphonia senticulosa (pungens) [1,3]	H	+	+		+						
Schottera nicaeensis [1,3]	H	+		+							
Solieria filiformis [1,2,3]	H	+									
Sorocarpus micromorus [1,2,3]	H				+						
Stictyosiphon soriferus [1,3]	H	+	+	+							
Ulva fasciata [1,2,3]	H	+									
Undaria pinnatifida [1,2]	H		+	+							
Algae – cryptogenic and possibly introduced											
Acinetospora crinita [1,3]	H		+	+	+	?					
Antithamnion cruciatum [1,4]	H	?	?	?	?	?					
Antithamnionella ternifolia [1,3]	H	+									
Arthrocladia villosa [1,4]	H	?	?	?	?	?					
Audouinella pacifica [1,2,3]	H	+									
Audouinella simplex [1,2,3]	H	+									
Bangia atropurpurea [1,3]	H	+	+	+							
Bryopsis plumosa [1,3]	H	+	+								
Caulerpa filiformis [1,4]	H	?	?	?	?	?					
Centroceras clavulatum [1,3]	H	+	+	+							
Ceramium flaccidum [1,2,3]	H	+									
Ceramium rubrum [1,2,3]	H	+									
Chaetomorpha aerea [1,3]	H	+	+	+	+	?					
Chaetomorpha capillaris [1,2,3]	H	+									
Chaetomorpha linum [1,2,3]	H	+									
Cladostephus spongiosus [1,3]	H	+	+	+							
Colpomenia peregrina [1,3]	H	+	+	+							
Colpomenia sinuosa [1,3]	H	+	+	+	+	?					
Cutleria multifida [1,3]	H	+	+		+						
Derbesia marina [1,2,3]	H	+									
Dictyota dichotoma [1,3]	H	+	+	+	+	?					
Discosporangium mesarthrocarpum [1,4]	H	?	?	?	?	?					
Ectocarpus fasciculatus [1,3]	H			+	+	?					
Ectocarpus siliculosus [1,3]	H	+		+	+	?					
Elachista orbicularis [1,4]	H	?	?	?	?	?					
Enteromorpha compressa [1,2,3]	H	+									
Enteromorpha intestinalis [1,2,3]	H	+									
Erythrotrichia carnea [1,2,3]	H		+	+							
Feldmannia globifera [1,3]	H	+		+	+						
Feldmannia irregularis [1,3]	H		+	+	+						
Feldmannia lebelii [1,2,3]	H			+							
Gelidium pusillum [1,3]	H	+	+	+	+						
Gymnothamnion elegans [1,3]	H			+							
Hildenbrandia occidentalis var. *yessoensis* [1,2,3]	H	+									

Table 15.5. continued.

Target species	Substrate	Port Phillip Bay regions									
		Target list					CRIMP survey				
		1	2	3	4	5	1	2	3	4	5
Hildenbrandia rubra [1,2,3]	H	+									
Hincksia granulosa [1,3]	H	+	+	+	+						
Hincksia mitchellae [1,3]	H	+		+	+						
Hincksia ovata [1,3]	H	+			+						
Hincksia sandriana [1,3]	H	+	+		+						
Kuckuckia spinosa [1,3]	H		+		+						
Leathesia difformis [1,2,3]	H			+							
Myrionema strangulans [1,3]	H		+	+							
Nemalion helminthoides [1,3]	H			+	+						
Petalonia fascia [1,3]	H	+	+		+						
Petrospongium rugosum [1,2,3]	H			+							
Peyssonnelia conchicola [1,2,3]	H	+									
Pilayella littoralis [1,3]	H		+		+						
Polysiphonia subtilissima [1,3]	H	+	+								
Pterocladia capillacea [1,3]	H	+		+							
Punctaria latifolia [1,3]	H	+	+		+						
Scytosiphon lomentaria [1,3]	H	+	+		+						
Sphacelaria fusca [1,2,3]	H	+									
Striaria attenuata [1,4]	H	?	?	?	?	?					
Stylonema alsidii [1,2,3]	H	+									
Ulva lactuca [1,2,3]	H	+									
Ulva rigida [1,2,3]	H	+									
Ulva stenophylla [1,3]	H	?	?	+	?	?					
Vaucheria piloboloides [1,4]	H	?	?	?	?	?					
Dinoflagellates - introduced											
Alexandrium catenella	S	?	?	?	?	?					
Dinoflagellates - cryptogenic and possibly introduced											
Alexandrium minutum	S	?	?	?	?	?					
Alexandrium tamarense	S	?	?	?	?	?					
Gymnodinium mikimotoi	S	?	?	?	?	?					
Gymnodinium pulchella	S	?	?	?	?	?					
Porifera – introduced											
Aplysilla rosea [1]	H			+					+	+	
Corticium candelabrum [1]	H			+							
Dysidea avara [1]	H			+							
Dysidea fragilis [1,2]	H	+					+				
Haliclona heterofibrosa [1,2]	H		+					+			
Halisarca dujardini [1,2]	H	+					+				
Porifera – cryptogenic and possibly introduced											
Callyspongia pergamentacea [1]	H			+							
Darwinella australianensis [1]	H			+							
Darwinella gardineri [1,4]	H	?	?	?	?	?					
Lissodendoryx isodictyalis [1]	H			+							
Phorbas cf. *tenacior* [1,4]	H	?	?	?	?	?					
Tedania anhelans [1]	H			+							
Cnidaria: Hydrozoa – introduced											
Amphisbetia operculata [1]	H			+							
Antennella secundaria [1]	H			+	+						
Bougainvillea muscus (ramosa) [1]	H	+	+				+	+			
Clytia hemisphaerica [1]	H	+	+	+	+	+	+	+			
Clytia paulensis [1]	H	+	+	+	+	+	+	+			+
Ectopleura crocea [1,2]	H		+				+	+		+	
Filellum serpens [1]	H			+	+						
Halecium delicatulum [1]	H			+	+	+					
Monotheca obliqua [1]	H			+	+	+					
Obelia dichotoma (australis) [1]	H	+	+	+	+	+	+	+		+	
Phialella quadrata [1]	H			+	+	+					

Table 15.5. continued.

Target species	Substrate	Port Phillip Bay regions									
		Target list					CRIMP survey				
		1	2	3	4	5	1	2	3	4	5
Plumularia setacea [1]	H			+	+	+	+				+
Sarsia eximia (radiata) [1]	H	+	+	+	+	+		+			+
Turritopsis nutricula [1,2]	H	+	+	+	+			+			
Platyhelminthes - introduced											
Euplana gracilis [4]	H/S	?	?	?	?	?					
Annelida: Polychaeta – introduced											
Boccardia proboscidea [1,2]	S	+									
Euchone limnicola [1]	S	+	+	+	+	+					
Hydroides norvegica [1,2]	S		+								
Mercierella enigmaticus [1,2]	H/S	+									
Myxicola infundibulum [4]	S		+								
Neanthes succinea [1]	S	+	+	+	+	+					
Pseudopolydora paucibranchiata [1]	S	+	+	+		+					
Sabella spallanzanii [1]	H/S	+	+		+	+	+	+			+
Mollusca – introduced											
Aplysiopsis formosa [1,2]	S			+							
Corbula gibba [1]	S		+			+	+	+			+
Janolus hyalinus [1]	S		+	+							
Musculista senhousia [1]	S		+				+	+			
Raeta pulchella [1]	S	+	+				+				
Theora lubrica (fragilis) [1]	S	+	+	+	+	+	+	+			
Mollusca – cryptogenic or possibly introduced											
Crassostrea gigas [1]	H/S		+								
Kaloplocamus ramosus [1,4]	H	?	?	?	?	?					
Okenia plana [1,4]	H	?	?	?	?	?					
Polycera hedgpethi [1,4]	H	?	?	?	?	?					
Arthropoda: Crustacea – introduced											
Balanus amphitrite [1]	H	+	+	+	+	+	+	+		+	
Cancer novaezelandiae [4]	S	+									
Carcinus maenus [1]	S	+	+	+	+		+	+	+	+	
Cirolana harfordi [1]	H/S		+					+			
Corophium acherusicum [1]	S	+	+	+	+		+	+	+	+	
Corophium insidiosum [1,2]	S	+					+				
Corophium sextonae [1]	S		+	+				+			
Jassa marmorata [1]	S	+				+					
Paracerceis sculpta [1,2]	S						+				
Pyromaia tuberculata [1]	S					+	+			+	
Arthropoda: Crustacea – cryptogenic and possibly introduced											
Balanus variegatus [1]	H	+	+	+	+	+	+	+		+	
Caprella acanthogaster [1,4]	S	?	?	?	?	?					
Caprella equilibra [1]	S	+	+				+	+			
Caprella penantis [1,4]	S	?	?	?	?	?					
Caprella scaura [1]	S	+	+	+			+	+	+		
Elminius modestus [1]	H	+	+		+		+			+	
Bryozoa – introduced											
Aetea anguina [1]	H			+			+				+
Amathia distans [1]	H	?	+	?	?	?	+	+			
Bowerbankia spp. [1,2]	H	+									
Bugula calathus [1,2]	H	+									
Bugula flabellata [1]	H	+					+	+			+
Bugula neritina [1]	H	+		+			+	+			
Bugula simplex [1,2]	H	+									
Bugula stolonifera [1]	H	+		+			+	+			
Celleporella hyalina [1]	H	+		+	+	+					
Conopeum reticulum [1]	H	+		+	+		+	+			

Table 15.5. continued.

Target species	Substrate	Port Phillip Bay regions									
		Target list					CRIMP survey				
		1	2	3	4	5	1	2	3	4	5
Cryptosula pallasiana [1]	H	+		+			+	+		+	
Electra pilosa [1]	H	+	+	+	+	+				+	
Fenestrulina malusii [1]	H	+		+							
Membranipora membranacea [1]	H	+	+	+	+	+		+			
Microporella ciliata [1]	H	+		+	+						
Schizoporella unicornis [1,2]	H	?	?	?	?	?		+			
Scruparia ambigua [1]	H	+		+							
Scrupocellaria bertholetti [1,2]	H				+						
Scrupocellaria scrupea [1]	H	+	+	+	+	+					
Scrupocellaria scruposa [1]	H	+	+	+	+	+					
Tricellaria occidentalis [1]	H	+		+			+	+	+	+	+
Watersipora arcuata [1,2]	H	+		+							
Watersipora subtorquata (*subovoidea*) [1]	H	+	+	+	+		+	+	+	+	
Bryozoa – cryptogenic and possibly introduced											
Aeverrillia armata [1,4]	H	?	?	?	?	?					
Anguinella palmata [1,4]	H	?	?	?	?	?					
Bugula avicularia [1,4]	H	?	?	?	?	?					
Celleporaria albirostris [1,4]	H	?	?	?	?	?					
Conopeum seurati [1,4]	H	?	?	?	?	?					
Electra tenella [1,4]	H	?	?	?	?	?					
Hippothoa aporosa [1,4]	H	?	?	?	?	?					
Hippothoa distans [1,4]	H	?	?	?	?	?					
Hippothoa divaricata [1,4]	H	?	?	?	?	?					
Membranipora savartii [1,4]	H	?	?	?	?	?					
Membranipora tuberculata [1,4]	H	?	?	?	?	?					
Parasmittina trispinosa [1,4]	H	?	?	?	?	?					
Zoobotryon verticellatum [1,4]	H	?	?	?	?	?					
Echinodermata – introduced											
Asterias amurensis [1,2]	H/S	+	+		+						
Echinodermata – cryptogenic and possibly introduced											
Amphipholis squamata [1,4]	H	?	?	?	?	?					
Amphiura parviscutata [1,4]	H		+	?	+						
Taeniogyrus sp. [1,4]	H	?	+	?	?	?					
Chordata: Pisces – introduced											
Acanthogobius flavimanus [1,2]	H	+	+				+	+			
Acentrogobius pflaumi [1]	H	+	+				+	+			
Forsterygion lapillum [1]	H	+	+				+	+			
Tridentiger trigonocephalus [1,2]	H	+					+				
Chordata: Ascidiacea – introduced											
Ascidiella aspersa [1]	H	+	+		+	+	+				+
Botrylloides leachi [1]	H	+	+	+	+		+	+			
Botryllus schlosseri [1]	H	+					+			+	
Ciona intestinalis [1]	H	+	+				+				
Molgula manhattensis [1,2,3]	H	+									
Styela clava [1]	H	+					+		+		
Styela plicata [1,2]	H	+	+			+	+				