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Results of the 2007 survey of the Albany marine area for introduced marine species

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Executive summary

A survey of the Albany marine area (King George Sound, Princess Royal Harbour and Oyster Harbour) for introduced marine pest species was conducted in 2007. This survey was trialling the new system of monitoring for introduced marine pests developed by the National Introduced Marine Pests Coordination Group (NIMPCG). This study represents one of the first trials of this system (the first trial commenced in South Australia is still ongoing). In this survey fifty-two of the fifty-five potential pest species were targeted. Three species were excluded on the basis of salinity and/or temperature tolerances being exceeded. A wide variety of sampling methods were all used in two seasons (winter and spring): surface scrapes, grabs, visual census, small cores, large cores, traps, and plankton nets. A total of 875 flora and fauna samples were collected from 39 locations within the Albany marine area. Samples were sorted to major taxonomic groups and scanned for individuals that could possibly be one of the 52 target species; only possible target pest species were identified to species. In addition, 108 settlement plates were installed in the Albany marine area in October 2007 and collected in February 2008.

The only species recorded from Albany that were on the target list was the polychaete *Sabella spallanzanii* and the marine alga *Codium fragile* ssp. *tomentosoides* (now *C. fragile* ssp. *fragile*). *Sabella spallanzanii* was previously known from the area, but the single specimen of *C. fragile* ssp. *fragile* was a new record. Following the finding of *C. fragile* ssp. *fragile* in Princess Royal Harbour, an extensive survey specifically targeting this species was conducted in June 2008. No further specimens were found during the survey. The Port of Albany later collected thirteen additional individuals outside the initial survey area and their identity was confirmed as *C. fragile* ssp. *fragile*.

Six introduced species not on the NIMPCG target list were also recorded during the present study. Two (the marine algae *Grateloupia imbricata* and *Ulva fasciata*) are new records for the Albany marine area, bringing the total number of introduced species known from this region to 27. It emphasises the fact that additional surveys in any given area of Western Australia have a high probability of detecting more species

1.0 Introduction

Introduced marine species are organisms that have moved from their native environment to another area of the world's oceans. In their new region, introduced marine species can potentially threaten human health, economic values, or the environment, thereby becoming introduced marine pests. This is a global problem, second only to habitat change and loss in reducing global biodiversity (Millennium Ecosystem Assessment 2005). Many introduced marine species remain inconspicuous, but one in six to ten becomes a pest (Anonymous 2002). Most introductions are accidental due to vessels moving from country to country, with the pests being transported in ballast water, on hulls, or in internal seawater pipes. There have been no successful deliberate introductions for aquaculture, aquaria or recreational fishing to the WA marine environment (Huisman *et al.* 2008). Introduced marine species may also arrive naturally via marine debris and ocean currents (Wells and Kilburn 1986).

Over 250 introduced marine species are known in Australia (NIMPIS 2002); Port Phillip Bay, Victoria has the greatest known number of introductions, at 99 species (Hewitt *et al.* 2004). Sixty marine species have been introduced to Western Australia and are currently established here (Huisman *et al.* 2008). Most (37) are temperate species that occur from Geraldton south; only 6 are tropical species that occur from Shark Bay north; 17 occur in both the southern and northern halves of Western Australia. Because of the prevalence of temperate species, southern marine areas have more introduced marine species than northern areas: the Fremantle marine area (including Cockburn Sound and the lower Swan River) has 46 introduced species. Fremantle is the largest port in temperate WA by vessel movements. Albany (25 introduced species), Bunbury (24 introduced species) and Esperance (15 introduced species) are all smaller ports than Fremantle and consequently have fewer numbers of introduced marine species (Huisman *et al.* 2008).

Once a species becomes established in the marine environment, it is almost impossible to eradicate. Introduced marine pests in Australia and overseas have caused many millions of dollars of damage to local economies and can require the expenditure of many more millions of dollars annually in control and remediation efforts. There has only been one successful eradication of an introduced marine species in Australia, the black striped mussel that was found in Darwin Harbour in 1999 (Willan *et al.* 2000).

During the 1990s and earlier in this decade, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Centre for Research into Introduced Marine Pests (CRIMP) undertook extensive baseline surveys of most major Australian ports for introduced marine species. The goal was to establish a national database of the distribution of introduced species present as a first step in addressing the problem. The underlying objective was that to understand if a species is introduced, there must first be a thorough understanding of what species occur naturally in an area. Hayes and Sliwa (2003) and Hayes *et al.* (2005) analysed the CSIRO results and conducted an extensive search of the international literature on introduced marine species and their effects. Information was developed on 1582 species reported worldwide as having being introduced. A comprehensive risk assessment then developed a list of 55 species that have been shown to be invasive and to cause problems in Australia or overseas. The National Introduced Marine Pests Coordination Group (NIMPCG) used this information to develop a new national introduced marine pest monitoring strategy (NIMPCG 2006a; 2006b) to target these 55 species. The strategy has at its core a set of minimum requirements for marine pest monitoring and the collection of monitoring data from marine environments. The primary monitoring objectives of the strategy are:

- "To detect new incursions of established target species in various habitats in a given

location, *i.e*. those species already established in Australia or New Zealand but have not been previously recorded at that location.

- To detect target species not previously recorded in Australia or New Zealand that are known to be pests elsewhere.

The secondary monitoring objective is:

- To detect species that appear to have clear impacts or invasive characteristics."

The second monitoring objective recognises that there may be species that invade an area but are not on the target list.

It should be noted that the NIMPCG methodology is based on presence or absence; it is not quantitative. If even a single individual of a target species is located, other mechanisms will then be used to determine the required response.

The present survey was undertaken to trial the NIMPCG manual in a Western Australian marine area. A separate report (Wells *et al*. 2008) has been submitted to NIMPCG detailing any problems associated with the NIMPCG methodology when put into practice. This report presents the survey results. The statistical methodology used in Albany was based on a 95% probability of detecting the presence of a species on the target list; to reduce costs and sampling efforts NIMPCG has since reduced the level to 80%.

The National Monitoring System includes 18 marine areas around Australia, the areas were chosen as representing 80% of the risk of introducing marine pests in to Australia and to ensure a broad geographic coverage (NIMPCG 2006a; 2006b). Three marine areas in Western Australia are on the national system: Dampier, Port Hedland and Fremantle. Albany was chosen for the WA trial for a number of reasons. Albany has a long history of European interaction, including the original wooden sailing vessels that first explored Australia. Albany is not part of the 18 marine areas proposed in the National Monitoring System, as such a survey in Albany will provide additional information on introduced species in Western Australia. Furthermore Albany was the location of the first settlement in Western Australia in 1827, two years before Perth. The Albany marine area has the widest habitat diversity on the south coast (Wells 1990), but the area is still small enough to be sampled readily. In this region there are a wide variety of potential sources of introduced marine species, including aquaculture, fishing, a yacht club, and the commercial trading port. The whaling industry operated out of Albany until the late 1970s, and the town jetty has been used by a wide variety of vessels. Deliberately wrecked vessels (*Cheynes III* and *HMAS Perth*) also present opportunities for introduced species.

There is already considerable information on introduced species in the Albany marine area. Wells and Bryce (1993) recorded the introduced nudibranch species *Polycera hedgepethi* in Princess Royal Harbour. CRIMP (1997) recorded eight introductions: the polychaete *Sabella spallanzanii,* the dinoflagellate *Gymnodium catenatum,* the oyster *Crassostrea gigas,* and the ascidians *Ascidiella aspersa, Ciona intestinalis, Botrylloides leachi, Styela clava* and *S. plicata.* In addition three cryptogenic species were detected: the ascidian and the bryozoans *Cryptosula pallasiana, Bugula neritina,* and *Bugula flabellata.* The blue mussel (*Mytilus edulis*), a major aquaculture species, is believed to be introduced (Huisman *et al*. 2008), and the European oyster (*Ostrea edulis*) was recently found at Albany (Morton *et al.* 2003). The Pacific oyster (*Crassostrea gigas*) was transported to Albany for aquaculture, but the shipment was in poor condition and failed to survive (Thomson 1959). Overall, 25 introduced marine species are known from the Albany marine area (Huisman *et al.* 2008).

2.0 Methods

The sampling methods used in this survey were those outlined in the Australian Marine Pest Monitoring Guidelines: Version 1 (NIMPCG 2006). The sampling strategy for the trial of the Albany marine area was submitted by Travers (2007) to NIMPCG and approved prior to the survey commencing.

The NIMPCG (2006a; 2006b) methodology provides an Excel spreadsheet to use in determining sample sizes. Published information on the temperature and salinity tolerances of 41 of the 55 target species (Table 1) is incorporated into the Excel spreadsheet (for 14 species there is no published information). Water temperatures in both Princess Royal and Oyster Harbour range from about 14º C in June to 21º C in February to April. Princess Royal Harbour generally remains at about full strength seawater (35‰) throughout the year, as there is no riverine input. Salinities in Oyster Harbour are similar during summer, but during winter there is considerable freshwater input from the King and Kalgan Rivers and salinity throughout the harbour can reach very low levels, e.g. 5‰ in 2005 (G. Bastyan, pers. comm.). Incorporation of these temperature and salinity data into the spreadsheet eliminated three species that could not survive in the Albany marine area: the bivalve mollusc *Limnoperna fortunei*, and the fishes *Tridentiger barbatus* and *T. bifasciatus*.

2.1 General sampling

Maps of the area were used to categorise marine habitats in each of the three harbours: Oyster Harbour, Princess Royal Harbour and King George Sound (Figure 1). The seafloor of King George Sound consists mainly of sand, seagrasses, rocky areas, and artificial hard structures, such as shipwrecks and navigational markers. Oyster Harbour has large areas of sand and seagrass, smaller areas of rocks, and numerous artificial hard structures within the boating marina and navigational markers. Princess Royal Harbour contains large areas of shallow sandflats, seagrass, several shipwrecks, rocks, jetties, mud, and artificial hard surfaces within the Princess Royal Sailing Club, navigational markers, and the Port of Albany. The area of each of the habitats in each harbour was calculated using the NIMPCG habitat classifications: hard substrate horizontal or vertical; soft substrate epifauna; soft substrate infauna; and plankton volume. The spreadsheet then determined for each species the number of samples required to obtain the 95% confidence level of detecting a species if it is present. As suggested in the monitoring manual, the adult stage of each species was targeted where possible.

Once this total number of samples was derived, sampling sites within each habitat type within each region were assigned using a systematic, rather than random method, as described in the manual. To define the location of sampling sites, for each habitat type within each region a grid of an appropriate scale was overlain on the habitat map. Where a grid point intersected with the habitat type to be sampled, the latitude and longitude of that position were recorded until the total number of samples for that habitat in that region was reached. Locations in which any marine pests were previously recorded were also incorporated into this design, e.g. channel markers on which *Sabella spallanzanii* was recorded.

Seasonality is an important consideration when designing species-specific sampling designs. The monitoring manual states that the monitoring should be targeted towards the time of year when target species are at their predicted maximum abundance or in a particular life stage that is relatively easy and cost-efficient to detect, or both. As the adult stage of many species is likely to be found throughout the year, it is the detection of the juvenile stage that is the most

important consideration when planning sampling times. From an analysis of the conservative estimates of the planktonic period for certain target species, the monitoring was planned for May/June and October/ November.

Several problems during the actual sampling caused modifications to the field program. Grab samples proved ineffective during the June field trip and were abandoned. The sediment was either too hard or the large corer could only be used in areas where grabs were originally intended. In other areas the sediment contained a deep layer of dead macroalgae that prevented a grab sample being taken. Beam trawls were initially used in Princess Royal Harbour but the cod-end quickly filled with dead macroalgae, making it impossible and dangerous to bring the beam trawl back to the surface. As the algal layer over trawl bottom in Oyster Harbour was similar to that in Princess Royal Harbour, beam trawls were abandoned there also. Fish were sampled from crab traps and seine nets. As the two target species were gobies, these were sampled with hand nets when conducting an underwater visual census. The plankton nets were built specifically for the sampling programme. Delays in their construction prevented their use in June. However, they were used during the October/ November sampling.

Despite these problems, extensive sampling was undertaken. Tables 2-4 show the details of the sampling program and Figures 2-4 show the sample locations. After collection samples were preserved in 70% ethanol. They were initially sorted into broad taxonomic groups (e.g. ascidians, barnacles, sponges etc.) prior to more detailed taxonomic examination for species on the NIMPCG (2006a; 2006b) list. Only specimens that could be target species were fully identified.

2.2 Settlement plates

Settlement plates were installed at 11 locations (Figures 5 and 6). Locations were selected to monitor a broad spatial range and also areas where vectors such as shipping, commercial fishing operations and open water sailing vessels are present, *i.e.* port operations, commercial harbours and sailing clubs. Twenty-seven settlement plate systems were deployed, with a total of 108 individual plates. They were similar to those used in CRIMP surveys and also by the Northern Territory Department of Primary Industry, Fisheries and Mines as part of long term monitoring for introduced marine species in Darwin Harbour. The system consists of 20 mm sections of PVC pipe on which two 10 x 10 cm plates are fixed in a horizontal position and two are fixed in a vertical position (Figure 7); thus each array contains four plates. Arrays also have rope collectors which act as a different type of habitat for settlement. Settlement plates were deployed in the middle of August 2007 and were collected in early February 2008. Twelve of the 108 plate arrays were missing due to storm activity in the area; four each from sites along the Albany wharf, Albany town jetty and Emu Point.

2.3 *Codium* survey

A single algal specimen collected at the Town Jetty, Princess Royal Harbour, was identified as the target species *Codium fragile tomentosoides* (now considered to be *C. fragile fragile* [Trowbridge 1996]). Following discussions with the Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE), a detailed survey was conducted in June 2008 to determine whether there were additional individuals in the area.

Divers visual inspections on SCUBA were conducted at the Town Jetty, the Main Wharf area, Camp Quaranup Jetty, the Quarantine Jetty, and Princess Royal Harbour Sailing Club (Table

6, Figure 8). Inspections included examination of artificial structures such as pylons, mooring buoys, debris, and adjacent substratum. Intertidal surveys immediately surrounding these key sites were also conducted where practical. Table 6 provides details of all sites examined, the method(s) used and any extra information regarding the sampling undertaken at each site. Subtidal inspections always involved at least three divers or snorkellers. Divers entered the water together and descended to the seafloor where they would space themselves approximately 1-2 m apart, depending upon visibility, and available space. Divers would proceed along the seafloor until pylons or other structures were encountered. They would then inspect the entire structure for the presence of *C. fragile fragile.* This method ensured that all structures and benthic substratum were inspected in a methodical and thorough manner.

Intertidal and beach surveys were also undertaken by three people. In such cases, individuals traversed an area examining rocks, structures, beach, and shallows for the presence of the target species. Wrack, debris and rock walls were examined in detail to determine if any detached individuals were present, which would provide an indicator that it is or was present in the vicinity.

3.0 Results

The purpose of this survey was to identify if there were any NIMPCG listed introduced species present in the Albany marine area. As such only those specimens displaying characteristics similar to listed species were identified to lowest taxonomic unit. Identification of this material did not progress to species level if the material was found to differ from the characteristics of the listed species. The majority of the collected material were classed as indigenous and not identified beyond morpho-species (*e.g*. solitary ascidian 1).

3.1 General survey

A total of 875 flora and fauna samples were collected from 39 locations within the Albany marine area. In summary, 93% of the samples were animal material and 7% plant material. Of all samples collected 96% were identified as native species.

Algal samples were dominated by members of the Rhodophyta (Table 7). Eight phyla of animals from 22 classes were represented in the Albany samples. Crustaceans, molluscs and annelids made up the vast majority of the samples collected (37%, 25% and 21% respectively) (Figure 10). Within the crustaceans the malacostraca (amphipods) dominated the samples (Table 7).

The dominant dinoflagellate cysts encountered were *Gymnodinium microreticulatum* and protoperidinioids, including *Diplopelta parva* and *Protoperidinium avellana*.

Eight introduced marine species were identified in this study:

- polychaete: *Sabella spallanzanii*
- bryozoans: *Bugula flabellata*
  Bugula neritina
- solitary ascidians: *Ciona intestinalis*
  Styela plicata
- algae: *Grateloupia imbricata*
  Ulva fasciata
  Codium fragile fragile

The Centre for Research into Introduced Marine Pests (CRIMP) also recorded the four animal species listed above in their 1996 survey of the Albany region (CRIMP 1997). Neither of the two algal species was recorded. Both algal species are listed by Huisman *et al.* (2008) in their review of non-indigenous species in Western Australia.

The red alga *Grateloupia imbricata* is native to Japan and the Mediterranean. Within Western Australia it has only previously been recorded from a rocky groyne in Cottesloe (Huisman *et al.* 2008). The green alga *Ulva fasciata* is regarded as widespread in tropical to temperate regions and has been recorded in the Swan River Estuary. It is, however, regarded as cryptogenic on the lower west coast of WA (NIMPIS 2002) and has not been recorded in Albany.

3.2 Settlement plates

Five introduced species were identified from the settlement plate arrays: the bryozoans *Bugula flabellata* and *Bugula neritina*; the ascidians *Ciona intestinalis* and *Styela plicata*; and the European fanworm *Sabella spallanzanii*. *Sabella spallanzanii* is the only NIMPCG listed pest species.

3.3 Codium survey

Codium fragile ssp. *fragile* has an undifferentiated juvenile vaucherioid (mat-forming) stage that can persist for months or even years. As this stage is extremely difficult, if not impossible, to detect in the field all information pertaining to the absence of *C. fragile* ssp. *fragile* relate to the adult erect thalli stage, but no thalli were found during the survey.

4.0 Discussion

At the commencement of this study there were three known introduced species listed on the NIMCPG (2006) target list present in Western Australia (Huisman *et al.* 2008):

- toxic dinoflagellate *Alexandrium minutum*;
- European fanworm *Sabella spallanzanii*; and
- Asian date mussel *Musculista senhousia*

This survey recorded two of the 52 listed pest species identified as having the potential to inhabit the Albany marine area. The first was the polychaete worm *Sabella spallanzanii. Sabella spallanzanii* was recorded in very high densities on piles, rocks and debris and on the substrate in 48% of sites surveyed and as a species represented 4% of all samples collected. It is highly probable that the European fanworm (*Sabella spallanzanii*) is translocated within Australia by domestic hull fouling. It is not possible to determine the origin of *Sabella spallanzanii* in the Port of Albany on the basis of existing information; genetic evaluation is required. *Sabella spallanzanii* was first introduced into Western Australia (Albany) in 1965. Since then this species has also been detected in Bunbury and Fremantle ports, as well as ports of the eastern seaboard (Clapin and Evans 1995; Huisman *et al.* 2008).

The second NIMPCG listed pest species recorded in this study is the invasive macro-algae *Codium fragile* ssp. *fragile.* This is the first record of this pest species in Western Australia. A single individual of the alga *Codium fragile* ssp. *fragile* was collected from the Albany Town Jetty. *Codium fragile* ssp. *fragile* is identified by Hayes *et al.* (2005) as one of the ten most damaging potential domestic target species based on overall impact potential (economic and environmental). A hazard ranking of potential domestic target species, based on invasion potential from infected to uninfected bioregions, identifies *C. fragile* ssp. *fragile* as a 'medium priority species' - these species have a reasonably high impact/or invasion potential. This species is listed on the Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) Trigger List as a "Species Established in Australia, but not Widespread". The presence of *C. fragile* ssp. *fragile* initiated a CCIMPE response and a survey for the species was conducted in June 2008. No individuals were found in the June investigation. However, in July 2008 thirteen specimens were collected outside the initial June survey area by the Albany Port Authority and their identity confirmed by Dr John Huisman.

An interesting finding of the June 2008 survey was that many of the algal species collected during the initial June 2007 trial in Albany were not present. Since a mature, reproductively active specimen of this species was collected in June 2007 (southern hemisphere winter) it was expected that if *Codium fragile* ssp. *fragile* were in Princess Royal Harbour it would be present at this time of year. The absence of *Codium fragile* ssp. *fragile* and other algal species, collected during the previous monitoring suggests that there may be significant temporal variability in algal community structure in this region. Trowbridge (1996) reported that *Codium fragile* ssp. *fragile* dies back during winter months in the northern hemisphere. Information from New Zealand, support this and indicates that the thalli of *Codium fragile* ssp. *fragile* dieback in autumn, with the visible thalli growing in spring and summer. It is therefore proposed that the same sites targeted in this June 2008 field survey, be re-surveyed in the spring/summer period of 2008/2009.

CRIMP (1997) recorded two species on the NIMPCG (2006a; 2006b) list that were not collected in this current study: the dinoflagellate *Gymnodinium catenatum* and the oyster *Crassostrea gigas.*

The original identification to CRIMP was: "*Gymnodinium catenatum* – like cysts" (Prof Gustaaf Hallegraeff, 2007, pers. comm. to Dr John Huisman, including emphasis). This taxon was subsequently described as a new, non-toxic species *Gymnodinium microreticulatum* (Bolch *et al*., 1999). *Gymnodinium catenatum* has never been seen in WA waters (Hallegraeff, 2007, pers. comm. to Dr John Huisman).

Thomson (1952; 1959) reported that the Pacific oyster, *Crassostrea gigas* was introduced into Oyster Harbour, Albany and Tasmania after World War II for aquaculture. As the broodstock was shipped by sea and was in poor condition when it arrived in Australia, the species did not survive in either area. In 1949 a second shipment was sent by air to Tasmania and survived. Furlani's (1996) distribution maps (by biogeographical regions) showed *C. gigas* as occurring in Western Australia from the South Australian border to North West Cape. However these distributions are based on a single record from Albany and a single dead shell recorded from Cockburn Sound (west coast). The survey of Albany by CRIMP (1997) listed *C. gigas*. The NIMPIS (2002) website used these records. However, *C. gigas* was not recorded by a WA Museum survey of molluscs of the Albany area (Roberts and Wells 1980), nor was it collected by any of the mollusc experts at the 1988 Albany international marine biological workshop (Wells *et al.* 1990; 1991). Extant, properly labelled material from CRIMP surveys in WA has been accessed into the collections of the WA Museum, but there was no material of *C. gigas* from Albany. Following representations by one of the authors (F.W.), *C. gigas* was removed from the NIMPIS database. The species does not occur in WA (Huisman *et al.* 2008).

In addition, six introduced species not on the NIMPCG (2006a; 2006b) list were recorded during the present study: the bryozoans *Bugula flabellata* and *B. neritina*; the solitary ascidians *Ciona intestinalis* and *Styela plicata*; and the marine algae *Grateloupia imbricata* and *Ulva fasciata.* The four species of bryozoans have all been previously recorded from Albany (CRIMP 1997; Huisman *et al.* 2008). *Grateloupia imbricata* (Cottesloe) and *Ulva fasciata* (Swan River) have previously been recorded in WA only from the Perth metropolitan area (Huisman *et al.* 2008). The addition of these two species brings the total number of introduced species known from the Albany marine area to 27. It emphasises the fact that additional surveys in any given area of Western Australia have a high probability of detecting more introduced marine species.

5.0 Acknowledgements

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7.0 Tables and figures

7.1 Tables

Table 1. Target species of introduced and potentially introduced marine species on the national monitoring program (NIMCPG 2006).

Group	Species	Group	Species
Ballast Water			
Dinoflagellates	*Alexandrium catenella*	Diatoms	*Chaetoceros convolutus*
	Alexandrium minutum		*Chaetoceros concavicornis*
	Alexandrium monilatum		*Pseudo-nitzschia seriata*
	Alexandrium tamarense	Ctenophorans	*Beroe ovata*
	Dinophysis norvegica		*Mnemiopsis leidyi*
	Gymnodinium catenatum	Copepods	*Acartia tonsa*
	Pfiesteria piscicida		*Pseudodiaptomus marinus*
			Tortanus dextrilobatus
Hull Fouling			
Algae	*Bonnemaisonia hamifera*	Cnidarians	*Blackfordia virginica*
	Caulerpa racemosa	Polychaetes	*Sabella spallanzanii*
	Caulerpa taxifolia		*Hydroides dianthus*
	Codium fragile spp.		*Marenzelleria* spp.
	Grateloupia turuturu	Barnacles	*Balanus eburneus*
	Sargassum muticum		*Balanus improvisus*
	Undaria pinnatifida	Crabs	*Callinectes sapidus*
	Womersleyella setacea		*Carcinus maenus*
Bivalves	*Corbula amurensis*		*Charybdis japonica*
	Ensis directus		*Eriocheir* spp.
	Limnoperna fortunei		*Hemigrapsus sanguineus*
	Mya arenaria		*Hemigrapsus takanoi*
	Varicorbula gibba		*Rhithropanopeus harrisii*
	Musculista senhousia	Ascidians	*Didemnum* spp.
	Mytilopsis sallei	Seastar	*Asterias amurensis*
	Perna perna	Fish	*Neogobius melanostomus*
	Perna viridis		*Siganus luridus*
	Crassostrea gigas		*Siganus rivulatus*
Gastropods	*Crepidula fornicata*		*Tridentiger barbatus*
	Rapana venosa		*Tridentiger bifasciatus*

Table 2. Key to regions sampled, the map reference number and site name.

Region	Map reference #	Site
King George Sound	1	Anchorage B
	2	Channel Marker 4
	3	Channel Marker 5
	4	Channel Marker 6
	5	Cheynes 3
	6	Frenchmans Bay
	7	HMAS Perth
	8	Middleton Beach
	9	Mossie Marker
	10	Vancouver Beach (beach walk)
	11	West of Mossie Marker
Oyster harbour	1	Emu Point Marina jetty 1
	2	Emu Point Marina jetty 2
	3	Emu Point Marina jetty 3
	4	Emu Point Marina jetty 5
	5	Kalgan River Bridge
	6	King River Bridge
	7	Marker 4
	8	Mid harbour
	9	Starboard marker 5
	10	Starboard marker N/W Green Island
Princess Royal harbour	1	Camp Quaranup Rocks
	2	Cheynes II wreck
	3	Kingfisher wreck
	4	Marker 16
	5	Navigation marker ISO 8S4
	6	Princess Royal Harbour Yacht Club - pylon 1
	7	Princess Royal Harbour Yacht Club – pylon 2
	8	Princess Royal Harbour Yacht Club – pylon 3
	9	Princess Royal Harbour Yacht Club – pylon 4
	10	Princess Royal Harbour Yacht Club – pylon 5
	11	Camp Quaranup Jetty
	12	Sarah Burnett Wreck
	13	South east Pile
	14	South east of Princess Royal Harbour Yacht Club
	15	South spit
	16	Town Jetty 1
	17	Town Jetty 2
	18	Town Jetty 3
	19	Tug boat harbour
	20	West of Princess Royal Harbour Yacht Club
	21	Wharf 1 – pylon 1
	22	Wharf 1 – pylon 2
	23	Wharf 1 – pylon 3
	24	Wharf 3 – pylon 1
	25	Wharf 3 – pylon 2
	26	Wharf 3 – pylon 3
	27	Wharf 6 – pylon 1
	28	Wharf 6 – pylon 2
	29	Wharf 6 – pylon 3

Table 3. Sampling methods used in monitoring the Albany marine area for species on the NIMPCG (2006a; 2006b) list.

Habitat	Functional Group	Sampling Method
Hard-surfaces	Motile	Trap, Scrape, Visual
Hard-surfaces	Sessile fouling	Scrape, Visual, Settlement plates
Sub-tidal Soft surfaces	Motile epifauna	Visual, Trap, Grab, Seine, Beam Trawl
Sub-tidal Soft surfaces	Sessile epifauna	Visual, Core, Grab, Settlement plates
Water Column	Holoplanktonic	Plankton net (20, 100 & 300 µm)
Water Column	Meroplanktonic	Plankton net (20, 100 & 300 µm)

Table 4. The sampling methods and numbers of samples collected at each of the three regions in the Albany marine area.

Method	Princess Royal Harbour				Oyster Harbour			King George Sound		
	APA Wharf	Princess Royal Sailing club	Vancouver Peninsula	Channel Markers	Emu Point Marina	Kalgan/King Bridge	Channel Markers	Anchorage	Cheynes III	Total
Scrape	27	6	6	9	9	6	10	–	4	77
Settlement plate	12	6	–	–	6	–	–	–	–	24
Grab	6	3	3	–	3	4	–	6	–	25
Visual census	6	3	5	3	3	4	5	4	2	35
Small core	6	3	–	–	6	4	–	6	–	25
Large core	6	3	–	–	6	4	–	6	–	25
Trap	9	–	3	–	6	6	–	–	–	24
Plankton net (20 µm)	3	2	2	–	3	4	–	6	3	23
Plankton net (100 µm)	3	2	2	–	3	4	–	6	3	23
Plankton net (300 µm)	3	2	2	–	3	4	–	6	3	23
Total	81	34	27	12	54	50	15	40	15	**328**

Table 5. Locations in Albany where settlement plates were installed. Details of water depth and numbers of plates at each location are shown.

Albany			
Location number	**Location**	**Depth (m)**	**# Plates**
1	Town Jetty North	1	4
	Town Jetty North	4	4
2	Town Jetty Middle	1	4
	Town Jetty Middle	4	4
3	Town Jetty South	1	4
	Town Jetty South	4	4
4	Wharf 1 west	1	4
	Wharf 1 west	4	4
	Wharf 1 west	10	4
5	Wharf 1 east	1	4
	Wharf 1 east	4	4
	Wharf 1 east	10	4
6	Wharf 3 west	1	4
	Wharf 3 west	4	4
	Wharf 3 west	10	4
7	Wharf 3 east	1	4
	Wharf 3 east	4	4
	Wharf 3 east	10	4
8	Wharf 6 west	1	4
	Wharf 6 west	4	4
	Wharf 6 west	10	4
9	Wharf 6 east	1	4
	Wharf 6 east	4	4
	Wharf 6 east	10	4
10	Princess Royal Harbour Yacht Club NW corner	1	4
	Princess Royal Harbour Yacht Club NW corner	1	4
11	Emu Point Marina north	2	4
	Emu Point Marina south (a)	2	4
	Emu Point Marina south (b)	2	4
Total for Albany	**11**		**108**

Table 6. Site numbers of sample locations for *Codium fragile fragile*, as shown in Figure 8.

Site	Location	Method(s) used	Additional information
1	Main wharf – berth 6 (max depth 14.6 m)	Sub-tidal survey Multiple depths	3 divers spaced 1 m apart. Approx length 180 m, three depths.
2	Main wharf – berth 1 (max depth 10 m)	Sub-tidal survey Multiple depths	3 divers spaced 1 m apart. Approx length 100 m, three depths.
3	Town Jetty (max depth 6 m)	Sub-tidal survey Multiple depths	3 divers spaced 1 m apart. Approx length 180 m, three depths.
4	Middleton Beach	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 1,500 m.
5	Camp Quaranup Jetty (max depth 2.6 m)	Sub-tidal survey Multiple depths	3 divers spaced 1m apart. Approx length 20 m, two depths. Surveyed 2 m either side, and end of Jetty.
6	Quarantine Jetty (max depth 2.2 m)	Sub-tidal survey Multiple depths	3 divers spaced 1 m apart. Approx length 50 m, two depths. Surveyed 2 m either side, and end of Jetty.
7	Princess Royal Sailing Club. Main Jetty facing into harbour (max depth 5 m)	Sub-tidal survey Multiple depths	3 divers spaced 1 m apart. Approx length 100 m, three depths. Surveyed 1 m either side of Jetty.
8	Oyster Harbour opening and Emu Point Marina	Inter-tidal survey	3 people, haphazard surveys of rock walls, marina structures, beach, wrack and shallow waters. Approx distance covered 1,500 m.
9	Enclosed area west of Town Jetty (less than 3 m deep)	Sub-tidal survey	4 people, back and forth snorkel surveys of shallow waters (< 3 m). Surveys 1.5 m apart, each person completed at least three 300 m long surveys. Examined substratum, rock walls.
10	Shallow areas of Town Jetty (less than 3 m deep)	Sub-tidal survey	4 people, back and forth snorkel surveys of shallow waters (< 3 m). Surveys 1.5 m apart, each person completed at least two 150 m long surveys. Examined substratum, rock walls, pylons and boat berths.
11	Shallow water area east of Town Jetty (less than 3 m deep)	Sub-tidal survey	4 people, back and forth snorkel surveys of shallow waters (< 3 m). Four people at 1.5 m apart, each person completed at least two 150 m long surveys. Examined substratum, rock walls and pylons.
12	Melville Point	Inter-tidal survey	3 people, haphazard surveys of rock walls, any structures, beach, wrack and shallow waters. Approx distance covered 100 m.
13	Frenchman Bay Road	Inter-tidal survey	3 people, haphazard surveys of rock walls, beach, wrack and shallow waters. Approx distance covered 100 m.

Site	Location	Method(s) used	Additional information
14	Rushy Point	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 100 m.
15	Quaranup Road	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 150 m.
16	Goode Beach	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 200 m.
17	Whalers Beach	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 100 m.
18	Whaling Station	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 100 m.
19	Salmon Pools	Inter-tidal survey	3 people, haphazard surveys of beach, wrack and shallow waters. Approx distance covered 50 m.

Table 7. The phylum, class and common name (group), and the relative proportion of each group collected from the Albany marine area.

Phylum/division	Class	Common name	% of total species number
Chlorophyta		Green algae	17.2
Rhodophyta		Red algae	44.8
Phaeophyceae		Brown algae	38.0
			100.0
Dinoflagellates			None found
Diatoms			Not assessed
Copepoda			None found
Annelida	Polychaeta	Worm	19.2
Chordata	Ascidiacea	Ascidian	4.1
Chordata	Osteichthyes	Fish	0.2
Cnidaria	Anthozoa	Coral	0.6
Cnidaria	Gorgonacea	Sea pen	0.1
Cnidaria	Anthozoa	Anemone	1.9
Crustacea	Bivalvia	Bivalve	2.3
Crustacea	Brachiopoda	Prawn / Shrimp	0.1
Crustacea	Brachiopoda	Shrimp	0.6
Crustacea	Malacostraca	Crab	7.2
Crustacea	Malacostraca	Amphipod	13.9
Crustacea	Maxillopoda	Barnacle	9.4
Crustacea	Polyplacophora	Chiton	1.5
Echinodermata	Asteroidea	Sea star	0.8
Echinodermata	Echinoidea	Urchin	1.9
Echinodermata	Holothuroidea	Cucumber	2.3
Echinodermata	Ophiuroidea	Basket star	0.1
Mollusca	Bivalvia	Oyster	4.7
Mollusca	Bivalvia	Mussel	12.9
Mollusca	Gastropoda	Nudibranch	0.9
Mollusca	Gastropoda	Gastropod	5.3
Porifera	Demospongia	Sponge	2.7
			100.0

7.2 Figures

Figure 1. Map of the Albany marine area showing Princess Royal Harbour, Oyster Harbour and King George Sound.

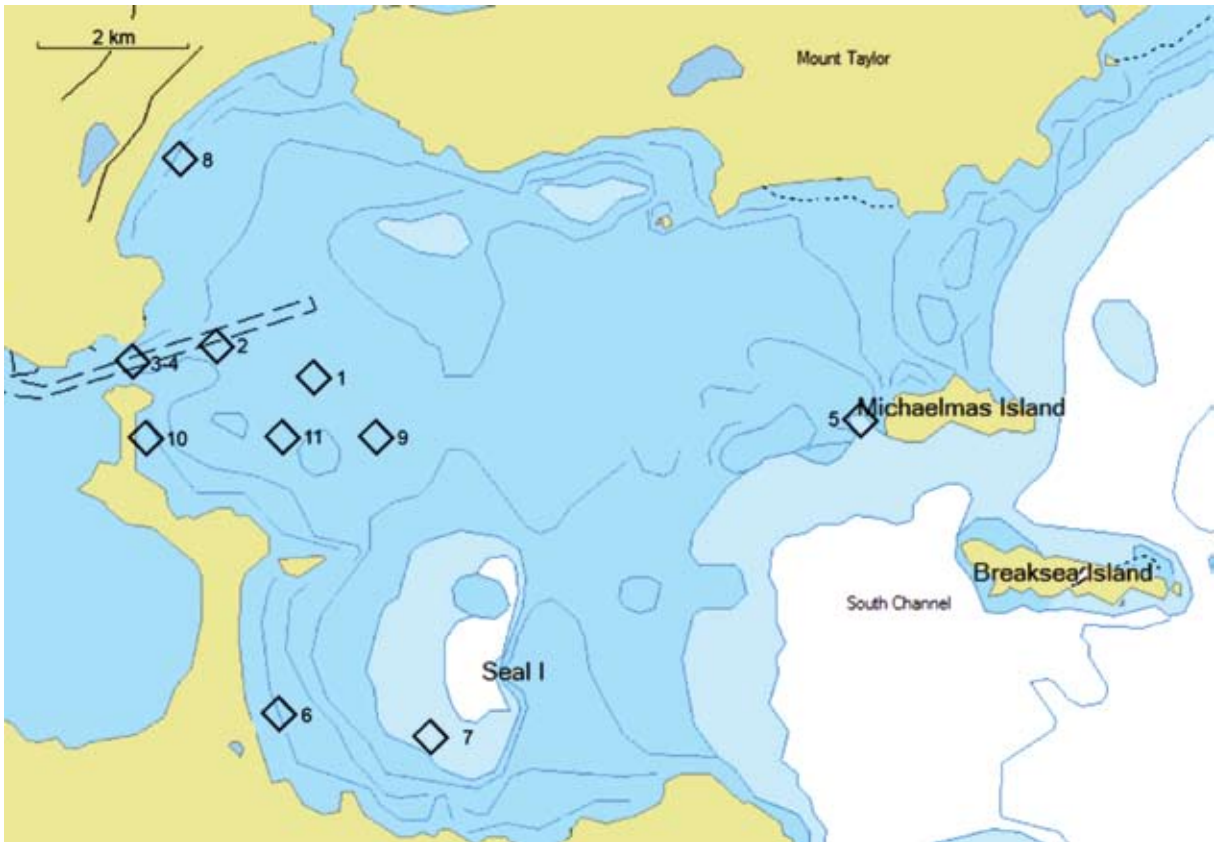

Figure 2. King George Sound sampling sites within the broader Albany marine area. Refer to Table 2 for site names.

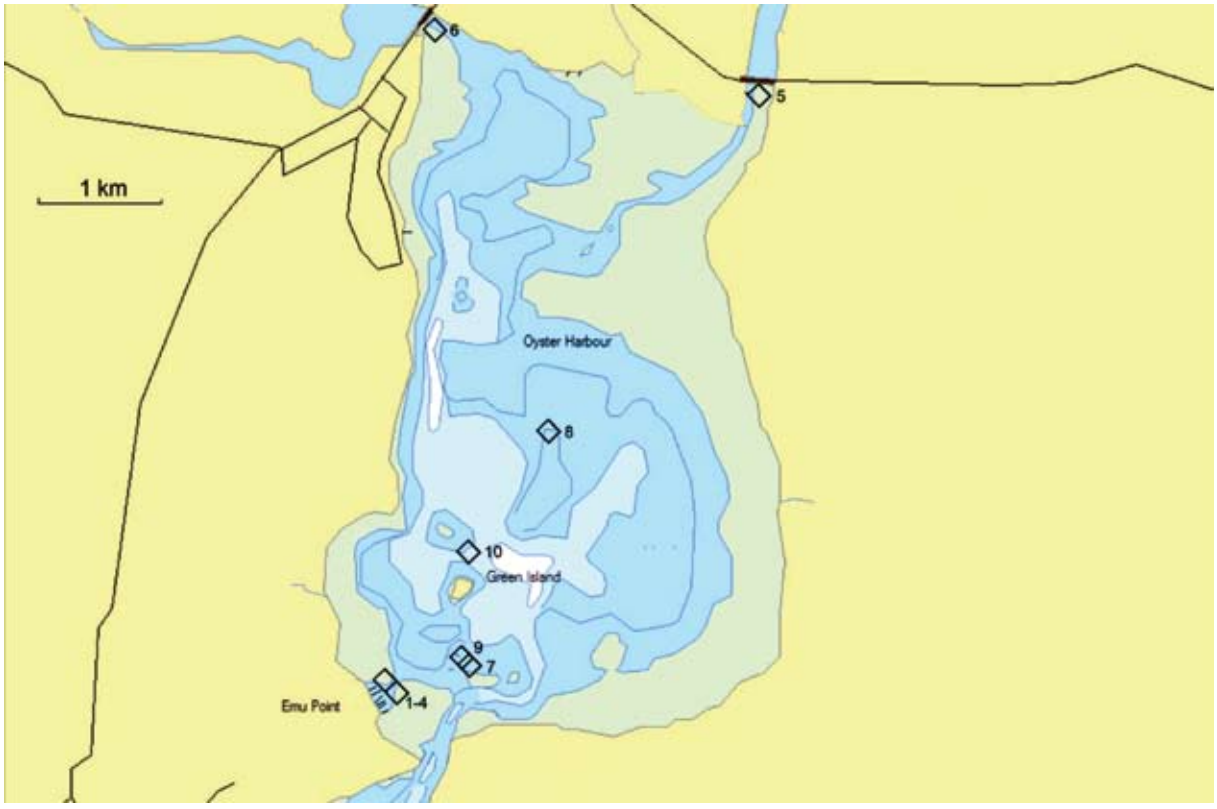

Figure 3. Oyster harbour sampling sites within the broader Albany marine area. Refer to table 2 for site names.

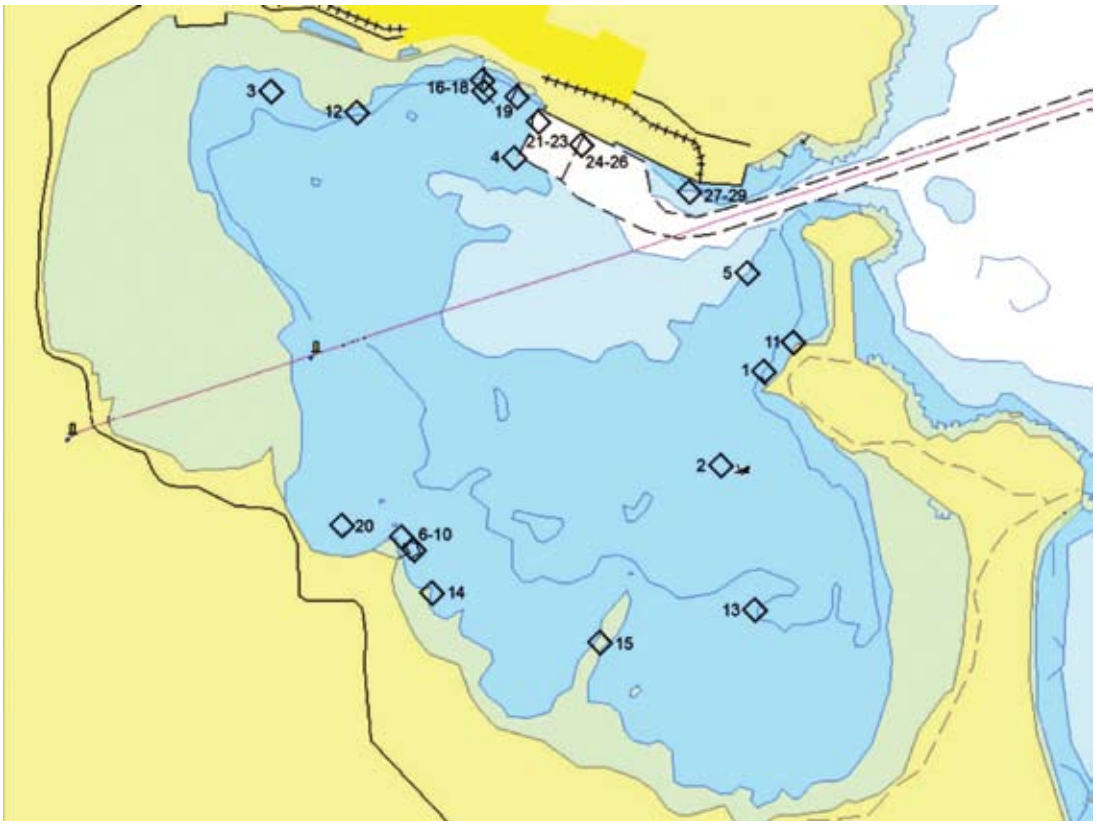

Figure 4. Princess Royal Harbour sampling sites within the broader Albany marine area. Refer to Table 2 for site names.

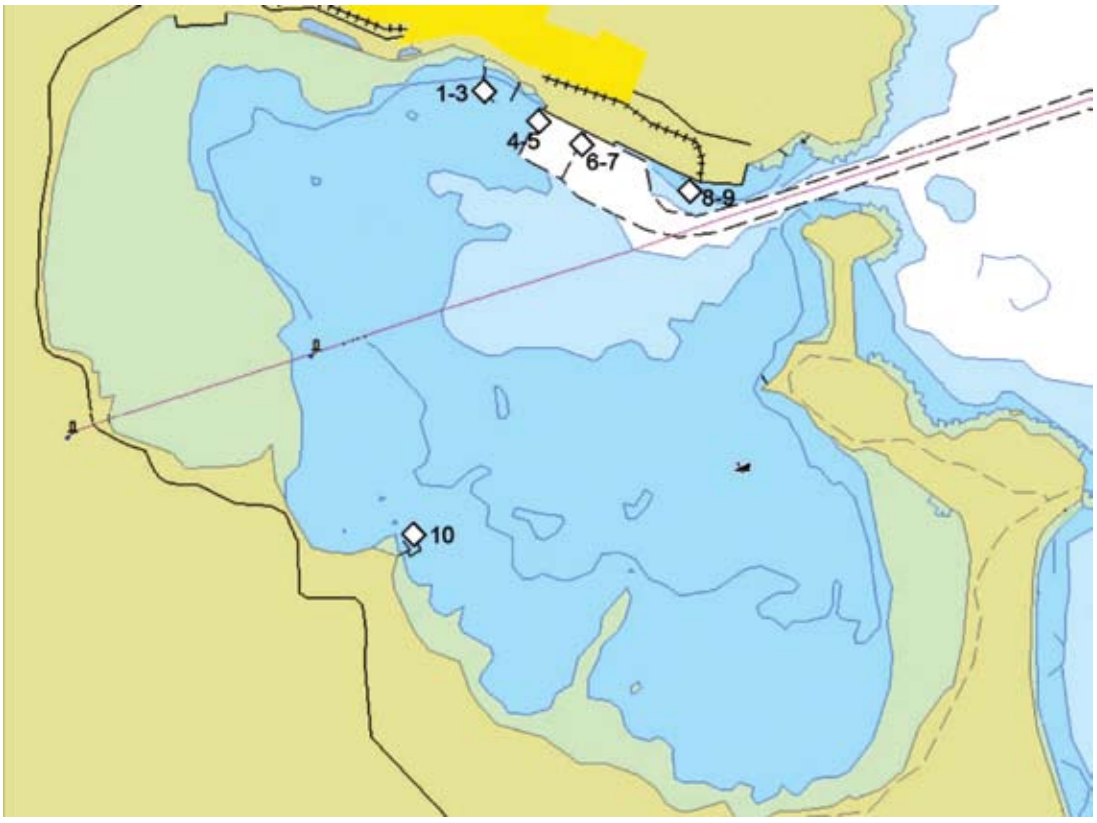

Figure 5. Locations (1-10) of settlement plates within Princess Royal Harbour, Albany. See Table 5 for location key.

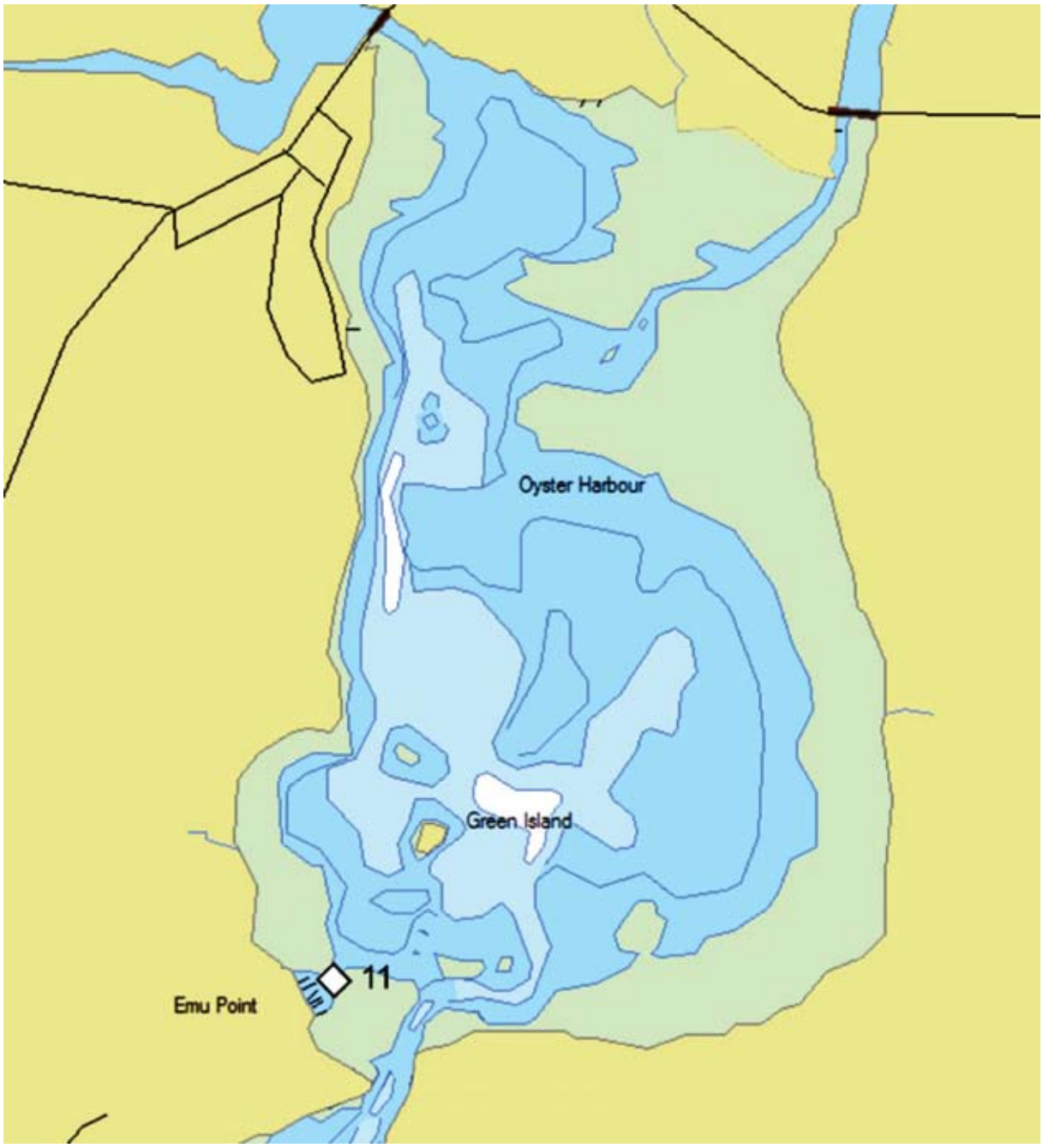

Figure 6. Location (11) of settlement plates within Oyster Harbour, Albany. See Table 1 for location key.

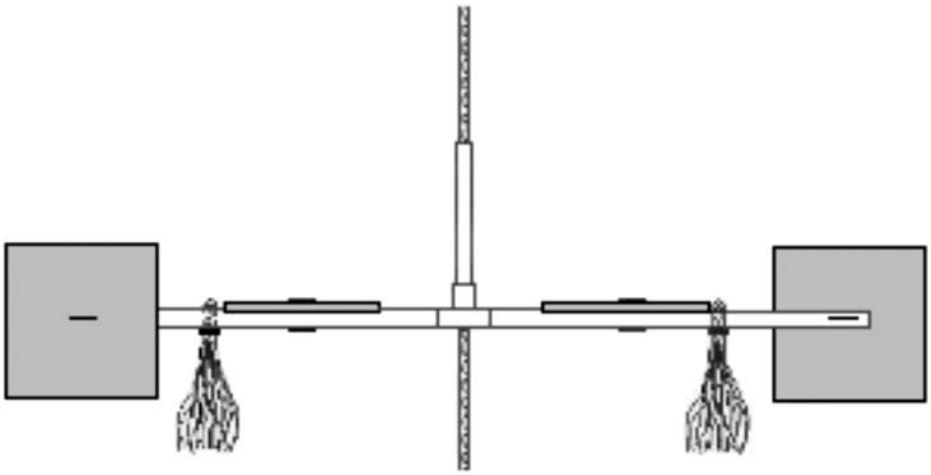

Figure 7. Illustration of the settlement plate system showing one vertical and one horizontal plate attached to each of the two arms of the system.

Figure 8. Sites surveyed to detect the invasive alga *Codium fragile fragile*. See Table 7 for site names and survey details.