The Canberra

Marine Ecosystem Monitoring Program

6-Months Post Scuttling

Draft Interim Report

CEE Consultants

Draft

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Cover Photo: Divers above the HMAS Canberra surrounded by a school of White Trevally (*Pseudocaranx dentex*), March 2010.

The Canberra Dive Site
Marine Ecosystem Monitoring Program

1 BACKGROUND

The Canberra (decommissioned FFG-02, 'the Canberra') is a former guided-missile frigate of the Royal Australian Navy. The ship was scuttled on 4 October 2009 off Collendina on the Bellarine Peninsula of Victoria as an artificial reef and dive site for recreational divers (**Error! Reference source not found.**). The scuttling followed a period of extensive consultation with stakeholders and regulators to determine the scuttling site, environmental requirements for vessel preparation, scuttling procedure and monitoring program. Various internal and external fittings and machinery were removed, including the top sections of the main and radio masts. Parks Victoria now manages the dive site and coordinates monitoring of the wreck of the Canberra.

Parks Victoria initiated an ongoing ecological monitoring program to identify and manage potential marine pest colonisation of the wreck and inform stakeholders of the progressive colonisation of the wreck and any changes to local ecosystem values. As creation of ecosystem values were listed as an objective of the project (through creation of an artificial reef), an ecological monitoring program was required by the Commonwealth Department of Environment, Heritage and the Arts who issued the Sea Dumping Permit. Parks Victoria commissioned CEE to undertake 6-monthly ecological monitoring of the wreck for 2 years post-scuttling.

This report describes the aims, scope and methods of the marine ecosystem monitoring program. It is an interim report for the 2, 4 and 6 month post scuttling pest inspections and the 6 month post scuttling ecosystem assessment.

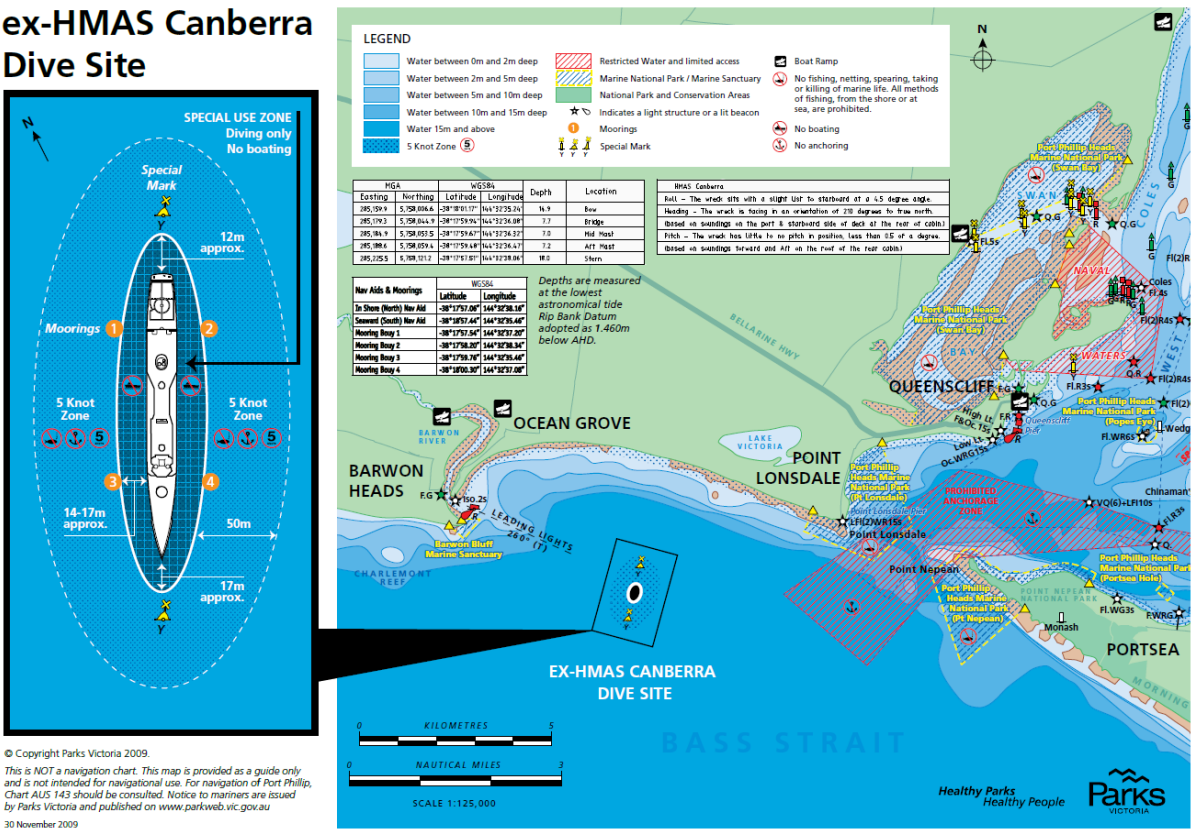


Figure 1. Plan of the Canberra dive site

1.1 Aims

The aims of the ecological monitoring program are:

1. To monitor the characteristics and rate of colonisation of the vessel by marine organisms to inform stakeholders and provide scientific documentation that can be used to inform the assessment of similar proposals in the future;
2. Fulfill the requirements of the Sea Dumping Permit by identifying any changes to local ecosystem values relating to the installation of the Canberra as an artificial reef
3. To identify marine pests on the vessel and inform Parks Victoria of their presence and likelihood of persistence and/or local ecological impacts;

1.2 Scope

The scope for the marine ecosystem monitoring program includes the following tasks:

1. Inspections for marine pests at 2, 4 and 6 months post scuttling and then at six monthly intervals;
    a. In the 2 and 4 month inspections, scientific divers to inspect the open areas of the ship for a range of marine pests, complete fish checklists and compile general observations and photographic or video records of marine organisms on the wreck;
    b. The subsequent 6 monthly pest inspections to be conducted in conjunction with ecosystem monitoring tasks (described below);
    c. Where any marine pests are identified, conduct further detailed inspections with a view to determining the appropriate management and removal response in consultation with Parks Victoria;
2. Ecosystem monitoring 6 months post scuttling and then at six monthly intervals for 24 months:
    a. Document the sessile marine organisms on vertical surfaces at 12 positions distributed over 3 depths and 2 locations on both the port and starboard sides of the ship using quantitative photoquadrat methods;
    b. Document the sessile marine organisms on edges and horizontal surfaces along 6 video transects at two depths and 3 locations on both the port and starboard sides of the ship using qualitative video transect methods;
    c. Document the mobile fauna present on and around the ship using fish census methods

2 ECOLOGICAL CONTEXT

The surrounding environment plays a fundamental role in the development of the marine ecological characteristics of the Canberra. This section describes the features of the environment including the area's bathymetry, seabed, oceanography and meteorology, biology and ecology.

2.1 Bathymetry

The wreck of the Canberra is located in between 28 m and 27 m water depth. The wreck is located in a shallow canyon feature on the seabed that represents an ancient course of the Barwon River. The sides of the canyon are variable in height, with substantial reef outcrops to the northeast, northwest and southwest of the position of the Canberra. The canyon slopes gently to the south. The bathymetry offshore from the Bellarine Peninsula includes a variety of rocky outcrops, sand patches, and rubble and rhodolith beds and typically reaches 30 m depth between 2 and 4 km offshore.

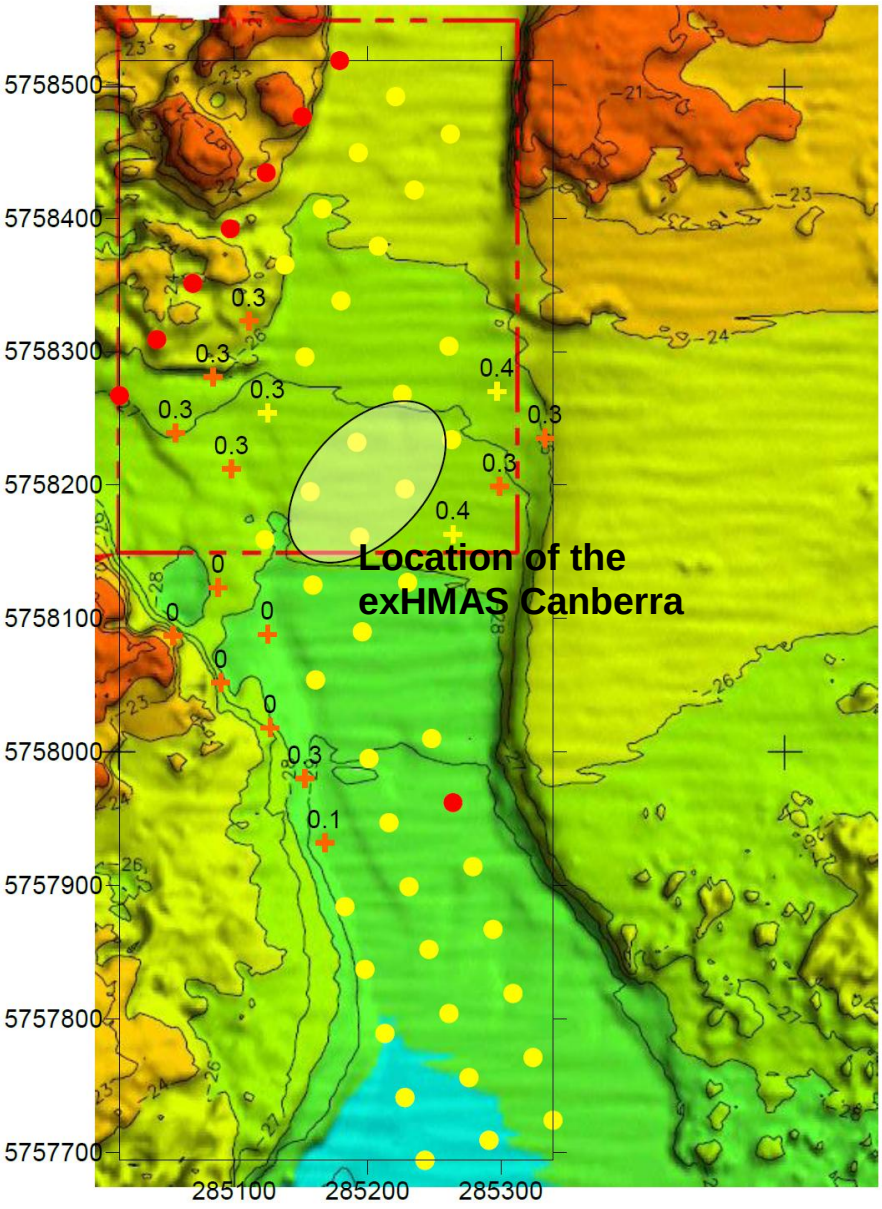


Figure 2 Bathymetry and seabed features near the Canberra Dive Site

Basemap – PoMC, Datum WGS 84, zone 55H

2.2 Seabed

The seabed in the area includes soft sandy sediments, gravel, cobbles and rhodoliths (calcium carbonate cobbles built by encrusting coralline algae) boulders and solid reef. Reefs in the area are composed of calcarenite and loose material is derived from this rock type also.

The seabed surrounding the wreck comprises sand material between 1 and 1.5 m thickness underlain by rhodoliths (Figure 2). The base of the canyon is mostly sandy seabed, generally less than 1 m thick underlain by cobble and rhodolith material. In many parts of the canyon, particularly towards the sides, the seabed is exposed cobble. The sides of the canyon include reef, sand and cobble slopes. The highest relief reef nearby can be found to the southwest, north-northwest and north-north east of the wreck.

The seabed within the wider area (between Barwon Heads and Pt Lonsdale has generally similar features. The seabed is a mosaic of sand, cobble, boulders and reefs. The reefs in the area have generally low relief (between 1 and 2 m above the surrounding seabed). Due to the soft and easily eroded calcarenite rock the reefs have many undercut ledges and small pinnacles and therefore have complex structure (high rugosity). The main exception in the area is Castle Rock, a large outcrop of rock which ranges from around 20 m depth at its base to 13 m depth on its top. The base of the rock is undercut forming deep overhangs and the top of the rock has numerous small pinnacles (looking like the battlements of a castle).

Figure 3 Rhodoliths underlying the sand surrounding the dive site

2.3 Oceanography and Meteorology

The Bellarine Peninsula is located in central northern Bass Strait. The coastline faces south-southwest. It is therefore an exposed and high energy coastline affected by Southern Ocean swells which arrive through western Bass Strait and waves and swells produced by winds within Bass Strait. Median wave heights along the Bellarine Peninsula are around 1.5 m – the median wave period is 10-11 seconds indicating the area receives quite high wave energy (SEA, 2004). Storm waves in the area may be up to 9 m.

Prevailing winds in the area are from the southwest, producing waves and currents which flow from west to east. The tidal circulation in Bass Strait also moves water from west to east along the central Victorian coast.

The area is also likely to be influenced by periodic freshwater discharges from the Barwon River Estuary after heavy rainfall. Water temperatures in northern Bass Strait range between a minimum of around 11^{o}C in spring and a maximum of around 20 ^{o}C in autumn.

2.4 Light

Light availability has a profound effect on the composition of fouling communities on natural and artificial reefs. The Canberra has a wide range of light availabilities depending on depth and orientation of the surface in question. The ship is oriented south-southwest to north-northeast, with the bow facing the general direction of prevailing seas from the south southwest. The port side of the ship therefore faces east-south east and the starboard side of the ship west-north west. The ship also has developed a list to starboard of around 17 degrees. Both these factors as well as depth are primary determinants of light availability on the vertical sides of the ship, while depth is the primary determinant for horizontal surfaces (recognising that the superstructure shades some parts of the deck).

The differences in light availability on the wreck can be summarised as follows:

- The upwards orientation of the port side of the ship means it receives more light than the starboard side due to the shadow cast by the listing ship, negating any light advantage of the starboard side's more northerly aspect;
- The hull at the middle of the ship (midships) is vertical all the way to the waterline while the aft and forward sections of the ship are overhung by the main deck from around 5 m above the water line to the keel, so towards the waterline the middle of the hull receives more light than the fore and aft sections of the hull;

Simply, parts of the hull and superstructure on the port side of the ship receive more light than their counterparts on the starboard side of the ship; and, deeper and overhung sections on each side of the ship receive less light than shallower sections.

2.5 Marine ecosystem

The Bellarine Peninsula is situated within the Bass Strait provincial bioregion and the Central Victorian meso-scale bioregion (IMCRA v4, 2006). This bioregion is classified as warm temperate and has a mixture of species typical of western Bass Strait, eastern Bass Strait, the south coast of NSW and southern Bass Strait (Ferns and Hough, 2000).

The characteristics of the marine community of a location are determined by the physical environment and the nature of adjacent marine communities. Sunlight, water temperature, water movement and seabed composition are key determinants of the biological characteristics of a location.

The marine environment offshore from Collendina area has large variations in solar irradiance (sunlight), water temperature and waves, with moderate tidal currents. The summer and autumn months (December to April) experience long days with warm water temperatures and generally small waves. The winter and spring months (May to November) have short days with cool water and frequent large waves associated with storms, with corresponding relatively low biological productivity and rough conditions in winter and higher productivity during the warming waters and longer day lengths into summer. The overall result is strong seasonality in the presence or abundance of many benthic, pelagic and planktonic species, with consequent changes in community characteristics over the year and between years.

The marine ecosystem offshore from Collandina can be broadly divided into:

- benthic species, which live or in the seabed;
- demersal species, which swim freely over the seabed;
- pelagic species, which swim freely in the water column; and
- planktonic species, which have limited ability to swim and generally drift with the water currents

The characteristics of benthic communities are strongly dependent on seabed habitat and water depth. Benthic communities include:

- reef (or hard) seabed communities;
- soft seabed comprising silts, sands and gravel; and
- rubble communities comprising small rocks that are episodically mobilised by wave currents.

2.5.1 Benthic community

Reef communities at depths less than 30 m are dominated by algae, with sessile and mobile invertebrates a major component of the benthic assemblage. The algal assemblage on reefs near the Canberra is dominated by large brown algae such as the kelp *Ecklonia radiata*, bristled crayweed *Seirococcus axillaris*, *Acrocarpia paniculata* and *Cystophora platylobium.* These large brown algae form a canopy beneath which smaller mid-storey and under-storey algae grow. Foliose red algae species are abundant in the mid-storey, particularly *Phacelocarpus peperocarpus* and *Plocamium sp*. The green algae *Caulerpa brownii* is also abundant and can cover areas of seabed of around 1 m^2. Brown algae including *Zonaria spp.* and Dictyotales spp. are also common in the mid-storey. The under-storey comprises mostly red algae species including encrusting and erect coralline algae and *Peyssonnellia novaehollandiae* and *Sonderopelta sp*.

Sessile benthic invertebrates on reefs include a range of sponge, cnidarian (soft corals, gorgonians, anemones, hydroids), bryozoans (lace corals) and ascidian (seasquirts) species. Sponges, bryozoans and ascidians can be found in both exposed locations and beneath undercuts or shaded areas where algae are less abundant. Cnidarians are also most commonly found beneath undercuts or shaded areas where algae are less abundant.

Mobile benthic invertebrates on reefs include a range of gastropod molluscs (abalone, sea-snails), echinoderms (sea stars, sea urchins, feather stars) and crustaceans (crabs, shrimp,crays). The giant cuttlefish and southern calamari squid are also common in the area.

Reef fish common to the area include some sharks (Port Jackson, collared catshark and draughtboard shark), perch, hulafish, the iconic blue devil, the southern goatfish, bullseyes, boarfish, old-wives, magpie morwong, southern sea carp, the Victorian scalyfin, blue throat and senator wrasses, weed whiting, blennies, numerous leatherjacket species and the globe (or Puffer) fish.

2.5.2 Soft seabed habitat

The seabed around the Canberra comprises fine to coarse sand, with few biota visible on the seabed. Rhodoliths are present in the sand (see Section 2.2), but there were no significant living rhodoliths in close proximity to the wreck. Animals living within the seabed are likely to comprise a diversity of very small invertebrates including a variety of crustaceans, various clams and polychaete worms.

2.5.3 Demersal, pelagic and planktonic communities

A variety of pelagic and demersal fish occur in the waters offshore from Collandina. Some are present all year round, while others occur seasonally. Demersal fish occurring often near reefs include longfin pike and sea sweep, while mackerel, trevally, barracouta, kingfish, Australian salmon and a range of other species may move through the area from time to time.

The waters around the Canberra are often blue in colour which indicates a low standing crop of microscopic phytoplankton. However, the zooplankton community may be visible from time to time as large zooplankton such as salps and sea jellies can be common in the area, especially in the warmer months.

2.6 Local environmental implications for colonisation of the Canberra

The physical environmental, biological and ecological factors discussed above are the primary determinants of the rate and characteristics of colonisation of the wreck. The characteristics of the wreck are also strong determinants of colonisation. The wreck provides a new artificial hard substrate habitat to the area. The wreck has large areas of vertical and horizontal smooth surfaces both inside and outside the ship, as well as complex physical features such as edges, railings, fittings and masts. It also has large areas of covered and enclosed space.

Some general considerations determining the rate and characteristics of colonisation of the wreck include:

1. The colonisation by fouling organisms depends on the abundance of propagules and larvae available for settling initially at the time of scuttling as well as the availability of light and food for the growth of newly settled organisms;
2. As a new artificial habitat, the wreck will initially favour organisms which can settle and survive on bare, artificial substrates;
3. Many reef-associated species disperse over short distances so available propagules and larvae are likely to be from nearby areas – early stages of colonisation of the wreck will be mostly by locally abundant species;
4. The characteristics of the organisms ultimately colonising the wreck is determined by the propagules and larvae available over long time scales (years) and interactions between colonising organisms;
5. The rate at which the wreck achieves a stable colonisation state (if ever) depends on:
    - the stability of the substrate (for example, ablation of paint, flaking and corrosion of surface metals),
    - removal of established organisms by storms, grazing, predation, ecological competition and other environmental factors;
6. Adult and larval planktivorous pelagic fish are likely to rapidly adopt the wreck as are attracted to large and complex structures even in the absence of established fouling communities;
7. Adult benthic fish depend on availability of suitable physical and biological habitat and will colonise wrecks once a fouling community begins to develop;
8. As an artificial habitat, the wreck will favour and disadvantage particular species and ultimately result in an assemblage with characteristics which may be quite different from those of nearby reefs.

Much of the hull below the waterline had been cleaned by divers prior to scuttling. Hence, the time the Canberra was essentially bare of marine biofouling above and below the waterline at the time of scuttling. Below the waterline some biological films were likely to have developed after the hull was cleaned, some mussels remained in inaccessible places.

The scuttling of the ship in late spring coincided with a period of high biological activity, in particular high availability of algal propagules and invertebrate and fish larvae. Daylength and light intensity

was optimal for rapid algal growth. The growth of newly settled suspension feeding invertebrates was advantaged by the abundance of propagules and larvae as food.

The rapid development of a primary fouling community on the ship meant that it also rapidly became attractive to the larvae of benthic fish and adult benthic fish. The large and complex structures of ship wrecks are known to be attractive to pelagic fish (especially small pelagic sepcies such as mackerel) even in the absence of mature fouling communities.

The wreck of the Canberra is in the early stages of development as an artificial reef. Establishment of a stable benthic assemblage is likely to take many years.

Experience in monitoring other ships scuttled to create artificial reefs and dive sites shows that common species have clear preferences for different habitats on wrecks. Vertical surfaces are typically colonised by a range of invertebrates with a smaller proportion of cover by turfing and encrusting algae. Horizontal surfaces tend to accumulate sediment and are often disturbed by divers and consequently have low cover of marine organisms. Edges, railings, hull and superstructure openings typically have the heaviest fouling – presumably due to the higher water movement associated with them, allowing algae and invertebrates access to high water flow and volumes.

3 METHODS

This section describes the methods used in the ecosystem monitoring tasks described above. These methods take account of the ecological context of the site and site specific environmental factors.

3.1 Sessile Biota (Algae and Invertebrates)

Macroalgae and sessile invertebrates will form the basis of the permanent benthic community on the Canberra. Two methods were used to document the sessile biota associated with (1) the vertical surfaces of the ship and (2) the horizontal surfaces and exposed edges and railings of the ship.

3.1.1 Vertical Surfaces

The fouling community associated with the vertical surfaces of the ship (outsides of the hull and superstructure) was documented using photoquadrats. The method photographically records the fouling community associated with a range of light and wave environments on the ship by monitoring different depths, sides and sections of the wreck.

High quality digital images were taken of numerous 30 cm by 40 cm areas (photoquadrats) of the hull using underwater cameras and strobes. Photoquadrats were collected at positions shown in Figure 4 as follows:

- Ten photoquadrats were collected along 10 m transects (~1 per metre);
- Transects were positioned at 3 depths:
    - 25 m depth - just above the ship's waterline (positioned above the antifouling paint)
    - 20 m depth – just below the main deck
    - 15 m depth – on the upper section of the superstructure (between 01 and 02 decks)
- Transects were positioned on both the aft and mid section of the ship
    - below and on the side of the hanger aft, and;
    - above the conspicuous bilge keels midships;
- Transect locations were positioned on both the port and starboard sides of the ship
- Photoquadrats were collected around a hull openings 26 and 67 on either side of the ship below the main deck (Figure 4),
    - 6 photoquadrats were positioned around each opening.

Photoquadrats were subsequently analysed to identify and quantify the species growing on the vertical surfaces. Relative abundance was determined using point intercept techniques:

- 10 points randomly positioned within a 5 cm by 2 cm grid (one point per grid sector) was superimposed on each photoquadrat;
- The biological or other category occurring under each point was recorded and used to calculate the percent cover of that category within each photoquadrat and each transect.

The species present in each of the photoquadrats was recorded in a database allowing differences in species composition between photoquadrats and transects to be determined.

3.1.2 Horizontal Surfaces

The fouling community associated with the horizontal surfaces and edges of the ship (decks, railings and fittings) was documented using video transects. This method documents the fouling community and fish associated with the two major areas of horizontal substrate as well as complex structures (railings, fittings) on the main deck and the top of the superstructure. The camera was held oblique to the deck along the transect so that both sessile and mobile biota (such as fish) were recorded.

The positions of the six video transects are shown in Figure 4:

- Two transects were located at 18 m depth along the port and starboard sides of the flight deck;
- Two transects were located at 13 m depth along the top of the superstructure (02 deck) from the bridge aft to the hanger doors; and
- Two transects were located at 15 - 16m depth along the main deck between the front of the superstructure to the bow bulwark.

Video transects were initially qualitatively analysed for the presence and absence and relative abundance of algae, invertebrates and fish. The records may be quantitatively analysed if required in the future.

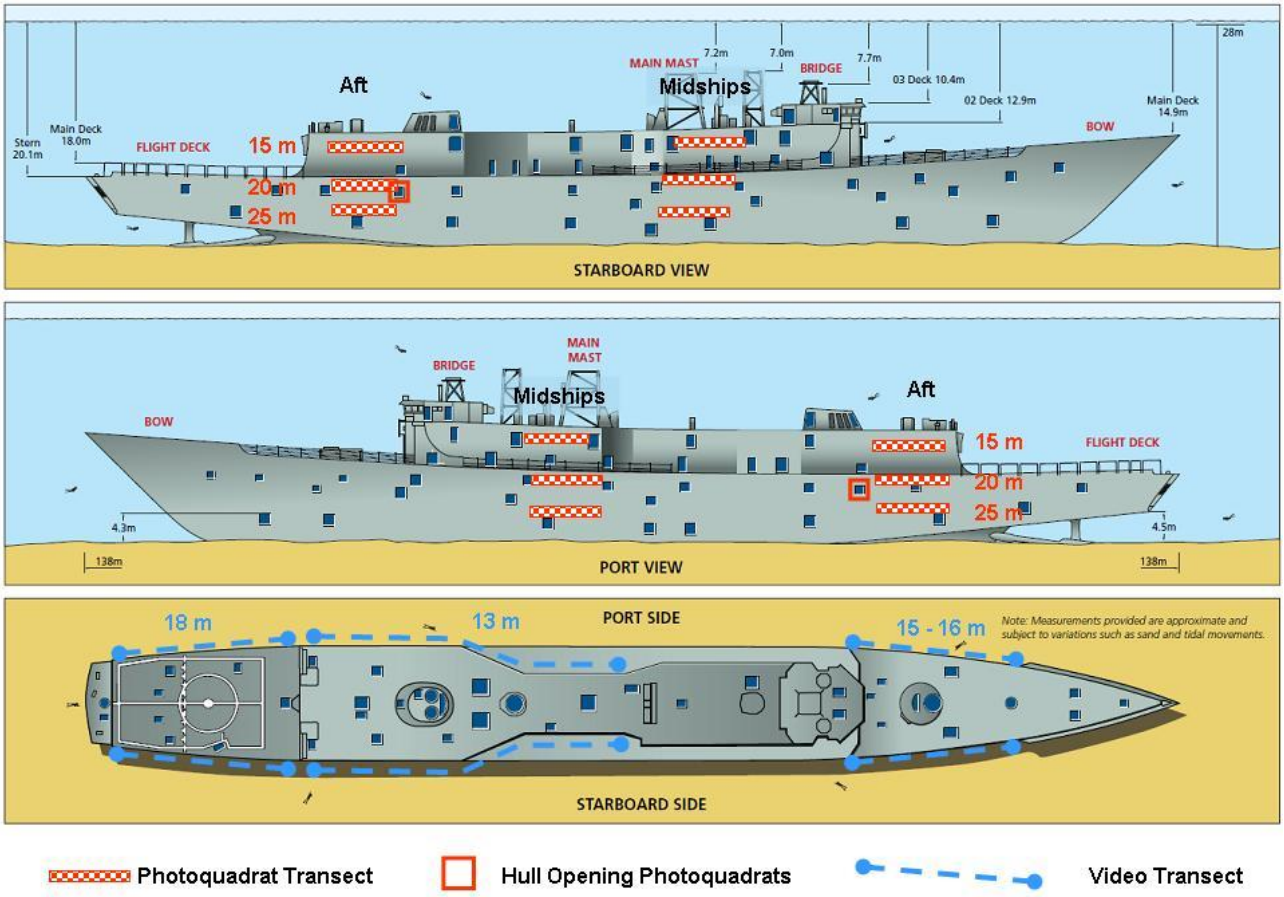


Figure 4 Photoquadrat and video transect positions

3.2 Mobile Biota (Invertebrates and Fish)

The presence of fish and other mobile biota were recorded at different locations around the wreck to provide information on the mobile biota associated with the various habitats on the ship including:

- deep water around the base of the wreck (Site 1 transom and Site 2 skeg),
- open areas with little complex structure (Site 3 flight deck and Site 4 bow),
- open areas with some complex structure (Site 5 hanger roof) and
- open areas with complex structure (Site 6 bridge and Site 7 masts).

In each area multiple structural features occur including simple horizontal and vertical surfaces, hull openings providing semi-enclosed habitat, complex structures such as railings, deck fittings and masts. Fish species and their approximate abundance was estimated over a five mintte period at each sites.

3.3 Reference Sites

Two reference sites were established at nearby reefs (Figure 5) to provide comparative data on the composition of natural reef assemblages and to document changes that occur in those assemblages in the future. Marine biota at each reference site were documented along a 100 m video transect. Table 1 lists the position of the Canberra and end points of the reference transects. The survey methods at the reference sits are described below

Table 1. Coordinates of ex HMAS Canberra and reference sites

Site	Transect Start	Transect End
The Canberra	285273E 5758191N (Bow)	285338E 5758305N (Stern)
East Reference Site	289751E 5758536N	289656E 5758562N
West Reference Site	284907E 5758151N	284814E 5758179N

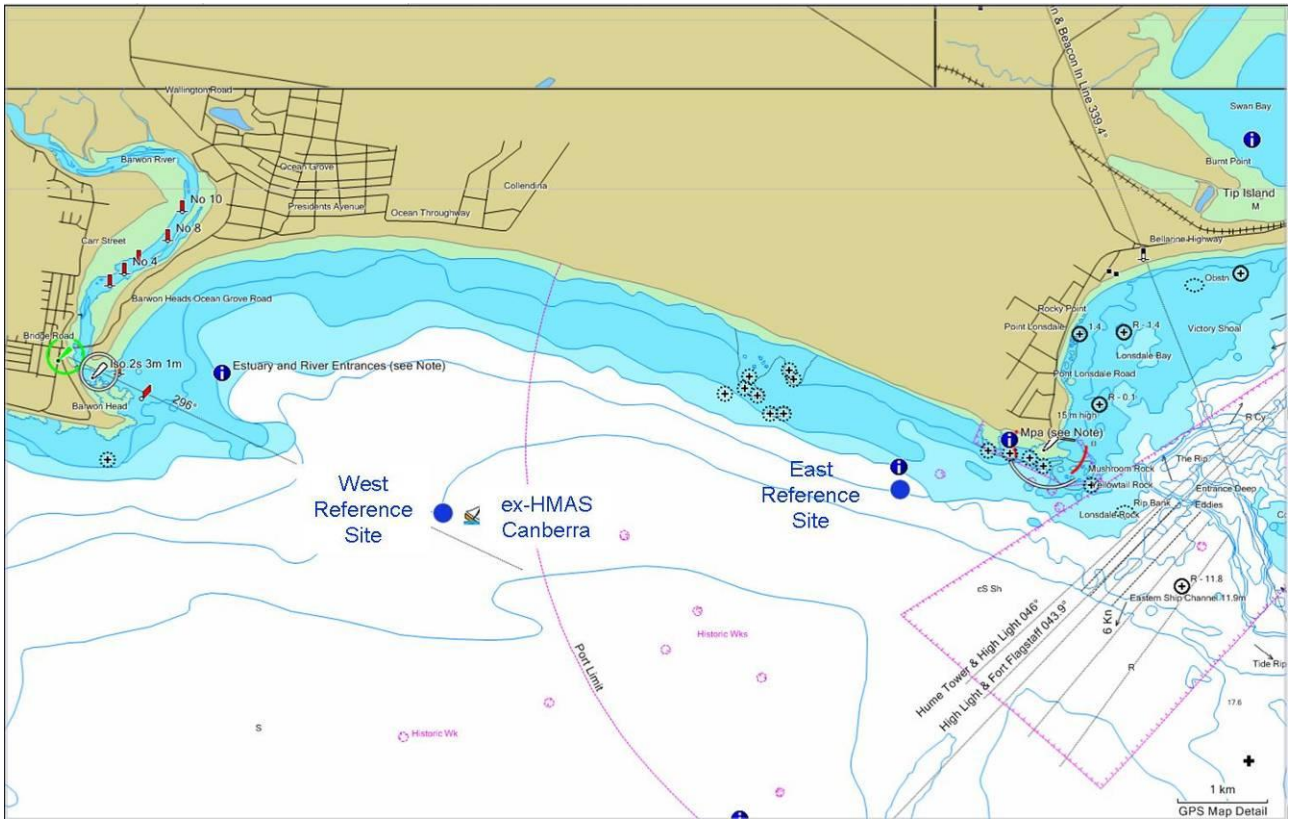


Figure 5 Position of reference sites relative to the Canberra wreck

3.3.1 Sessile algae and invertebrates at reference sites

Sessile organisms attached to the upwards facing surface of the reefs were recorded by video along the transect. The video camera was held perpendicular to and 0.5 m above the seabed, giving a 100 m long and around 1 m wide continuous record of the seabed. The video may analysed by extracting frame images and using the same point-intercept method as the Canberra. The presence/absence of identifiable species was recorded for each video transect. At this stage of the monitoring program, only presence/absence observations are reported for reference sites.

3.3.2 Mobile biota at reference sites

Mobile invertebrates are documented using video transects recorded with the camera held oblique to the seabed while swimming back along the 100 m transect at each site. The presence/absence

of key algae, invertebrate and fish species from these videos in conjunction with diver observations was assessed.

4 RESULTS

The data collected from the 6 month ecosystem survey are presented below. These results are discussed in terms of the rate and characteristics of colonisation of the wreck for the period October 2009 to May 2010.

4.1 Sessile Organisms - Vertical Surfaces

A total of 153 photoquadrats were collected and analysed from the 12 transects, including 12 extra photoquadrats collected around the edges of hull openings on either side of the ship.

A total of 28 species and organism categories were identified and quantified in the 6-month photoquadrat series (Table 2).

Table 2 Species and organism categories used in analysis of photoquadrats

Group	Species/Category	Group	Species/Category
Red Algae	Encrusting Coralline	Annelid	*Filograna* sp.
	Foliose Red		Tubeworm
	Fleshy Red		*Galeolaria* sp.
	Feathery Red	Mollusc	*Electroma georgiana*
	Filamentous Red	Bryozoan	Lace Bryozoan
Brown Algae	Encrusting		Flat encrusting
	Dictyotales		*Celleporaria* sp.
	Juvenile Laminarian	Ascidian	*Botrylloides magnicoecum*
Green Algae	Ulvales sp.		*Botryllodies* sp. (encrusting)
Poriferan (Sponge)	Sycon sp. 1		*Didemnum* sp.
	Sycon sp. 2.		*Herdmania fimbriae*
	White/Brown Amorphous		*Pyura gibbosa*
	White Osculated Encrusting	Other	Algae-Invertebrate Matrix
Cnidarian	Hydroid (general)		
	Pinauay crocea		

Some organisms were easily identifiable to genus or species level. Other organisms were identified based on morphological characteristics. The “Algae-Invertebrate matrix” listed under ‘other’ was among the most abundant categories (measured as percent cover). It was most common on parts of the wreck receiving sufficient light for macro-algal growth. Most of the matrix components are extremely small but appear to include filamentous red algae with attached sessile invertebrates including sponges and ascidians (filter feeders) and mobile crustaceans (including amphipods whose appendages suggest they are also filter feeders). A close-up photograph of the Algae-Invertebrate matrix category is shown below in Figure 6.

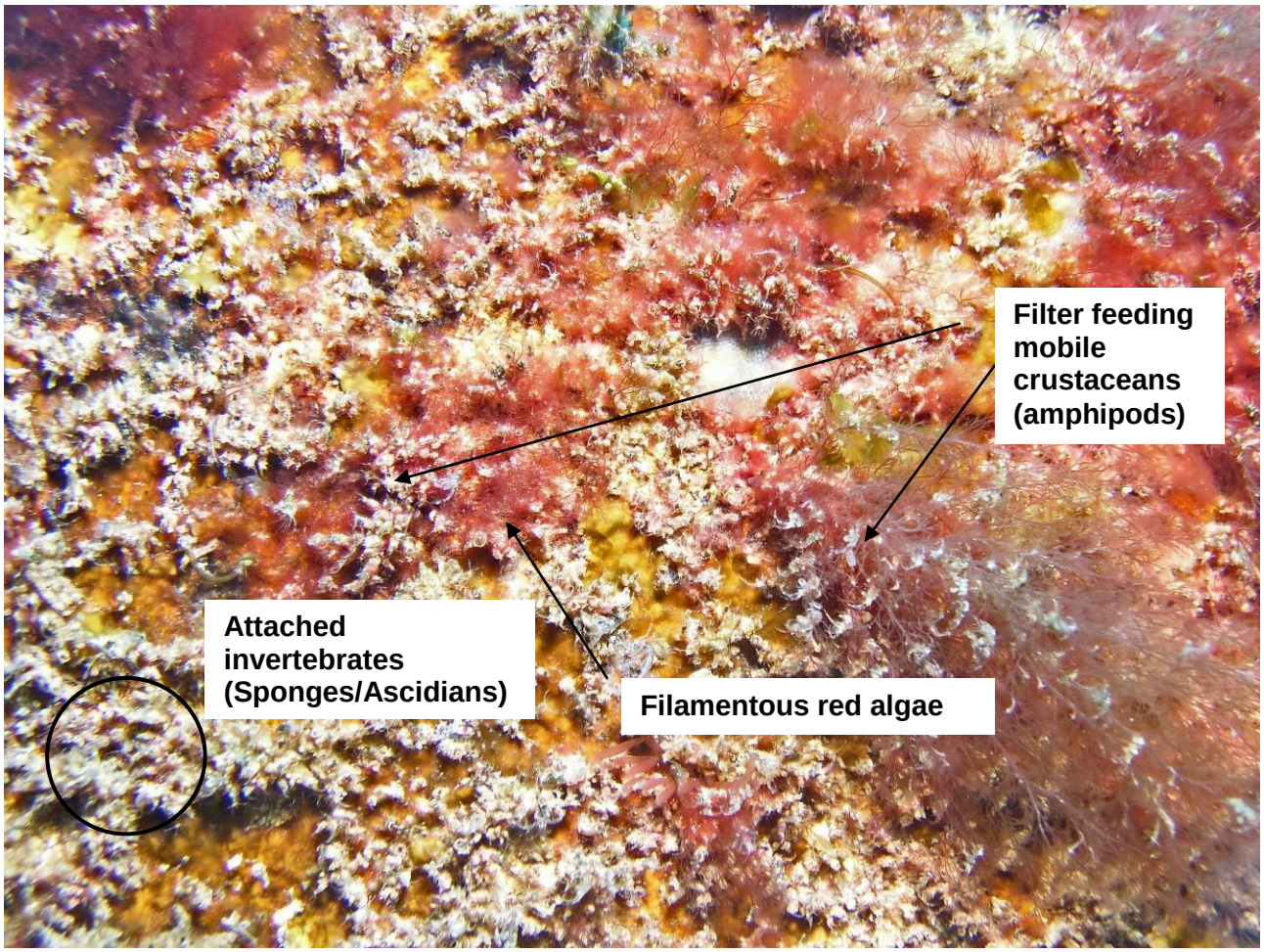


Figure 6 Algae-invertebrate matrix

A photoquadrat from each transect is shown below in Figure 7 (port) and Figure 8 (starboard). These images shown the appearance of the fouling community on the wreck at the different positions and depths surveyed. Key species are identified in the photos.

The photoquadrats show clear differences in the fouling community which has colonised the wreck between the two sides of the ship and at the different depths. These differences are primarily differences in the relative abundance of algae versus invertebrates. On both sides (port and starboard) photoquadrats from deeper parts of the wreck have higher abundance of invertebrates than those from shallower parts of the wreck. Algae is more abundant at shallower depths where light availability is greater.

As the ship has a 17 degree list to starboard, the port side of the ship receives more light than the starboard side. This is reflected in the higher relative abundance of algae and lower relative abundance of invertebrates on the port versus the starboard side. This is most evident at depth.

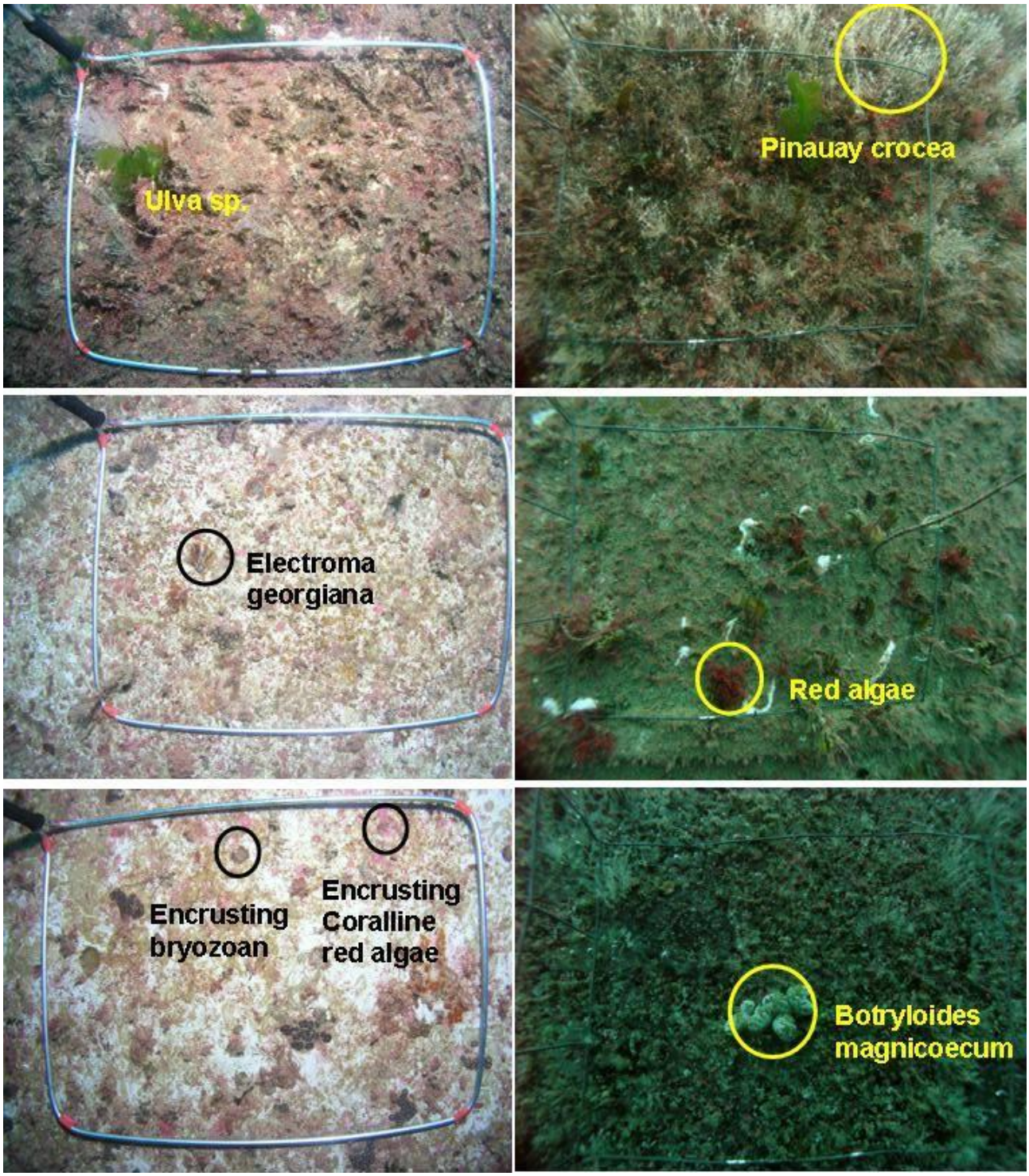


Figure 7 Photoqadrats from the port side of the Canberra

Top to Bottom: 15 m, 20 m and 25 m depth
Left to Right: Midships and Aft

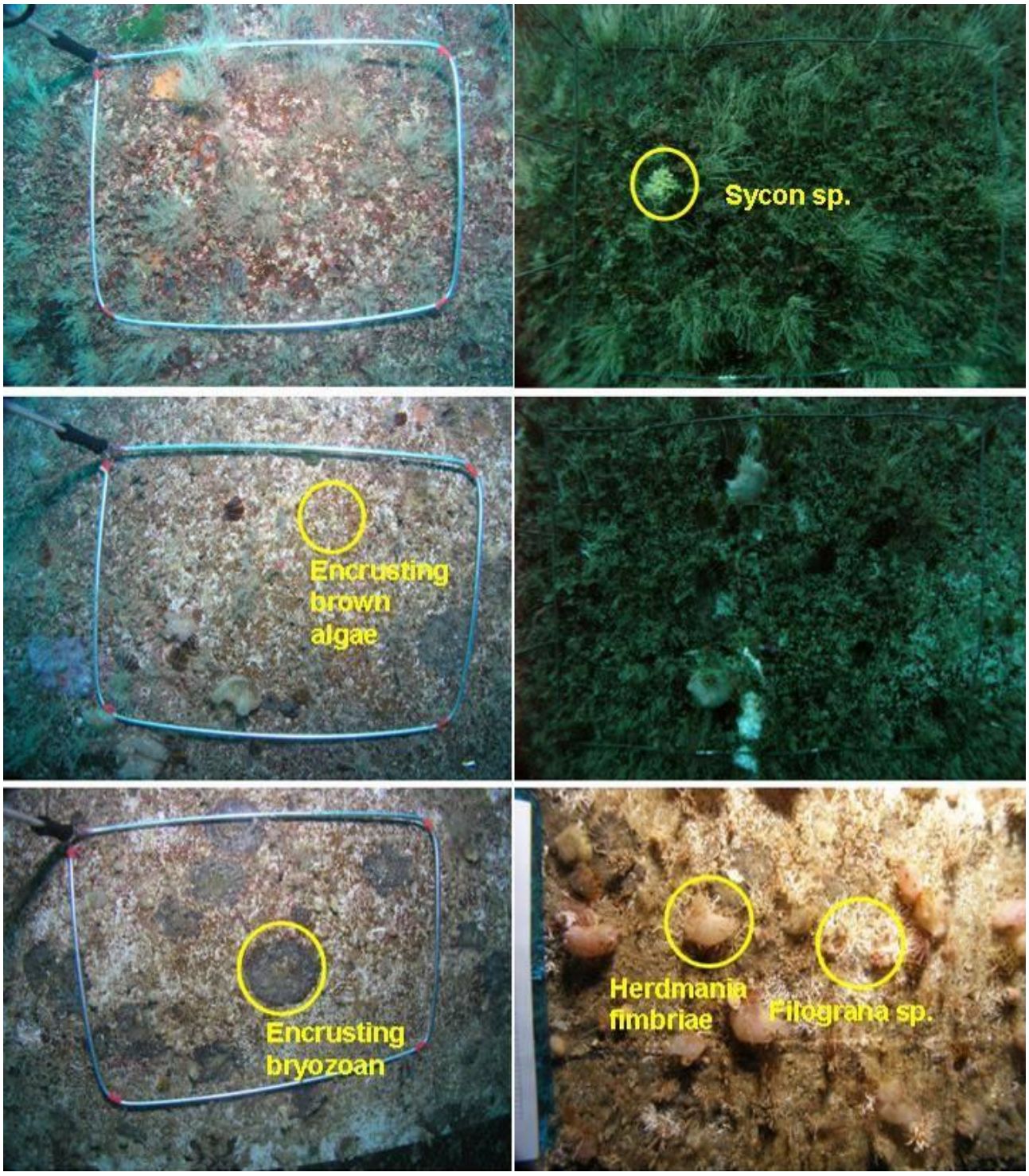


Figure 8 Photoqadrats from the port side of the Canberra

Top to Bottom: 15 m, 20 m and 25 m depth
Left to Right: Midships and Aft

4.1.1 Presence/Absence data

Table 3 shows the proportion of quadrats containing each species or organism category from the transects and hull openings. The data provide an indication the abundance of species and the species composition of the sessile assemblage on different parts of the ship.

The table shows that only two categories were present on all parts of the ship surveyed: Encrusting Brown Algae and *Electroma georgiana*. Various other species were found on most parts of the ship including encrusting red coralline algae, red filamentous algae, the White/Brown amorphous sponge, *Pinauay crocea*, flat encrusting bryozoans and the algae-invertebrate matrix.

The distribution of most categories appeared to have clear relationships with light availability. For example:

- encrusting red coralline algae were found in over 90% of quadrats on all but the starboard aft section of the ship at 25 m depth (the position with the lowest light of all the photoquadrat sites);
- Ulvales and red feathery algae were only found on the two shallowest sites (15 m) on each side of the ship; and
- red filamentous algae were found on both sides of the ship but were absent from deeper sites on the starboard side.

Many invertebrates exhibited the inverse pattern to the algae: sponges, hydroids, molluscs and ascidians were all more common on the starboard, shady side of the ship.

The distribution of some categories appeared to have strong relationships with water movement. It was noticed in the initial stages of colonisation that the heaviest growth was concentrated on edges (railings etc) and hull openings. Such patterns have also been noted on the Troy-D in Tasmania, where the kelp *Ecklonia radiata* is generally confined to the deck edges and railings. On the Canberra similar patterns have been seen for algae and the filter-feeding invertebrates *Pinauay crocea* and *Electroma georgiana*. For this reason, areas around hull openings and railings and deck edges are being monitored. Photoquadrats were collected around two hull openings below main deck level towards the aft section of the ship (Figure 4).

Of particular interest is the proportion of quadrats (around openings) in which juvenile laminarian algae (kelps) and *Pinauay crocea* are present. Over the whole wreck, the highest proportion of quadrats containing juvenile laminarian algae was seen at the two hull opening positions, and they were present in 100% of quadrats on the port side. *Pinauay crocea* was also found in 100% of quadrats at these positions, and was generally more common in photoquadrats at shallower depths elsewhere.

The identity of the juvenile kelps on the Canberra is not yet know. However, they are likely to be *Ecklonia radiata*, which is the most abundant kelp on natural reef in the area. The plants were not the introduced *Undaria pinatifidda*

Table 3 Proportion of photoquadrats (vertical surfaces) containing each species/category for The Canberra

	Side	Port						Starboard						Total	Port	Starboard
	Depth	25 m		20 m		15 m		25 m		20 m		15 m			23 m Access Hole	23 m Access Hole
	Position	Mid	Aft	Mid	Aft	Mid	Aft	Mid	Aft	Mid	Aft	Mid	Aft			
Group	Category Quadrats	12	11	12	9	12	12	12	11	13	11	12	15	161	6	6
Red Algae	Encrusting Coralline	100	91	92	100	92	100	100	0	100	100	100	100	90	100	100
	Foliose Red	0	0	0	78	17	42	0	0	0	0	0	0	10	0	0
	Fleshy Red	8	0	8	0	33	0	0	0	0	0	0	0	4	0	0
	Feathery Red	8	0	8	67	75	100	0	0	0	0	0	0	20	17	83
	Filamentous Red	100	100	92	100	92	100	0	0	0	100	25	100	67	100	100
Brown Algae	Encrusting	25	82	75	100	92	100	100	100	100	100	100	100	89	67	100
	Dictyotales	0	0	0	11	8	8	0	0	0	0	0	0	2	0	0
	Juvenile Laminarian	0	0	0	0	17	17	0	0	0	0	8	0	4	100	33
Green Algae	Ulvales sp.	0	0	0	0	25	50	0	0	0	0	33	20	11	0	0
Poriferan	Sycon sp. 1	8	64	17	0	0	0	50	91	15	36	17	20	26	0	50
	Sycon sp. 2.	0	0	0	0	0	0	0	18	0	0	17	13	4	0	17
	White/Brown Amorphous	100	55	92	0	92	17	100	91	100	91	100	73	75	33	33
	White Osculated Encrusting	0	0	8	0	0	0	0	45	8	0	0	0	5	0	17
Cnidarian	Hydroid (general)	0	0	0	0	0	0	83	36	31	0	0	0	13	0	0
	Pinauay crocea	0	0	0	11	83	100	42	18	85	100	100	100	56	100	100
Annelid	Filograna sp.	0	100	0	0	0	0	42	100	54	45	8	7	29	0	0
	Tubeworm	0	18	0	0	0	0	0	0	0	0	0	0	1	17	17
	Galeolaria sp.	17	64	0	11	0	0	33	0	0	55	0	0	14	0	0
Mollusc	Electroma georgiana	67	55	50	89	50	67	100	100	100	91	25	53	70	67	83
Bryozoan	Lace Bryozoan	0	9	0	22	0	0	25	36	8	18	0	7	10	0	0
	Flat encrusting	83	73	83	33	33	0	75	18	46	27	92	13	48	50	17
	Celleporaria sp.	33	0	8	22	0	0	17	9	8	0	33	0	11	0	0
Ascidian	Botrylloides magnicoecum	0	0	0	0	0	0	8	36	0	9	0	13	6	0	0
	Botryllodies sp. (encrusting)	100	73	42	0	0	0	58	64	38	0	8	0	32	17	0
	Didemnum sp.	0	0	0	0	0	0	8	27	0	0	0	0	3	0	0
	Herdmania fimbriae	0	0	8	0	0	0	75	100	69	64	25	13	30	17	50
	Pyura gibbosa	0	0	0	0	0	0	0	9	0	0	0	0	1	0	0
Other	Algae-Invert Matrix	25	91	75	100	92	100	0	0	0	100	50	100	61	100	100

4.1.2 Relative abundance data (vertical surfaces)

The average relative abundance of the major groups of each fouling category over the entire ship is shown in Figure 9. The most abundant biota were sponges (Porifera), brown algae and red algae which represented approximately 50 percent of the biological cover of the vertical surfaces of the hull. The algae-invertebrate matrix was the most abundant category overall (22% cover) but only slightly more abundant than sponges and brown algae (each around 19% cover). Cnidarians (hydroids) were also common over the hull. The other groups of organisms accounted for less than 5% cover, while bare substrate (paint, metal) accounted for just under 10% cover. Over 90% of the vertical surface area of the ship was therefore covered by fouling organisms at the time of the 6 month survey.

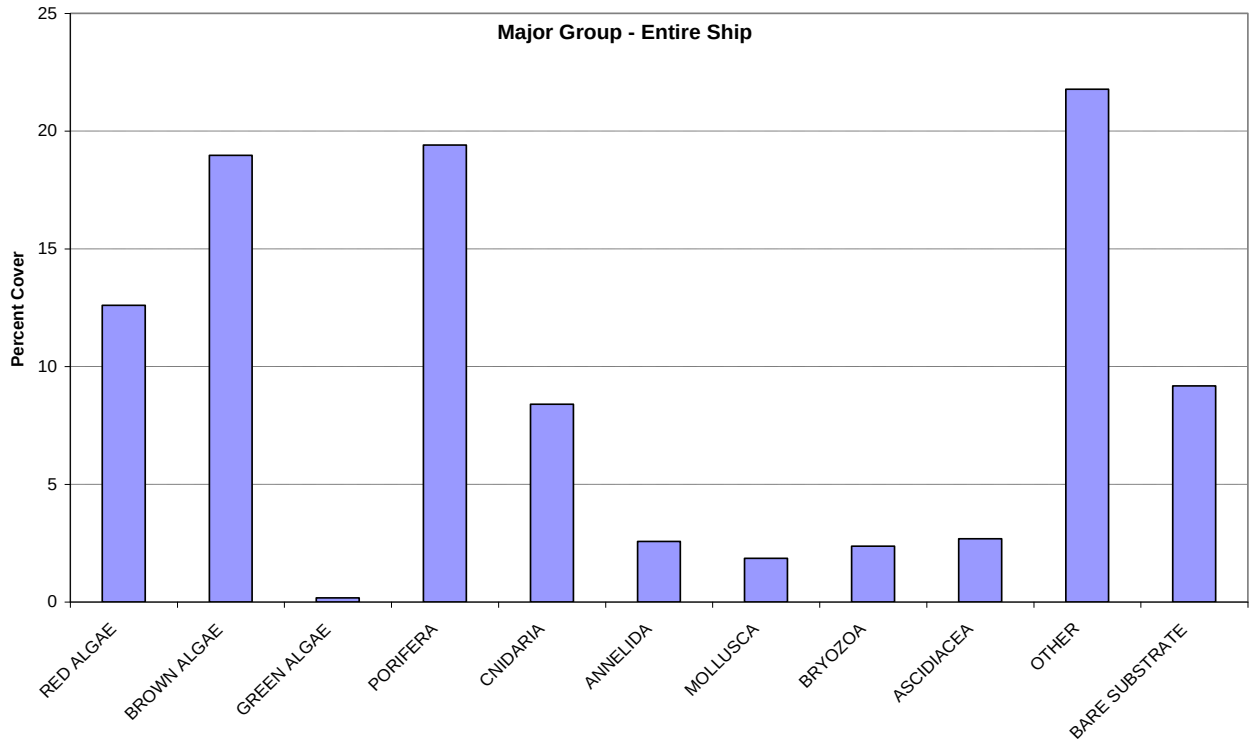


Figure 9 Relative abundance of major fouling groups – average

The difference between the relative abundance of the major fouling categories on the port and starboard sides of the ship are illustrated below in Figure 10. The major differences are seen in the red algae, brown algae, cnidaria (hydroids), and algae-invertebrate matrix (other) categories. A similar area of both sides of the ship was bare.

The differences in the abundance of the major fouling organism groups are generally explained by just one or two organism categories within those groups, as discussed in the next section.

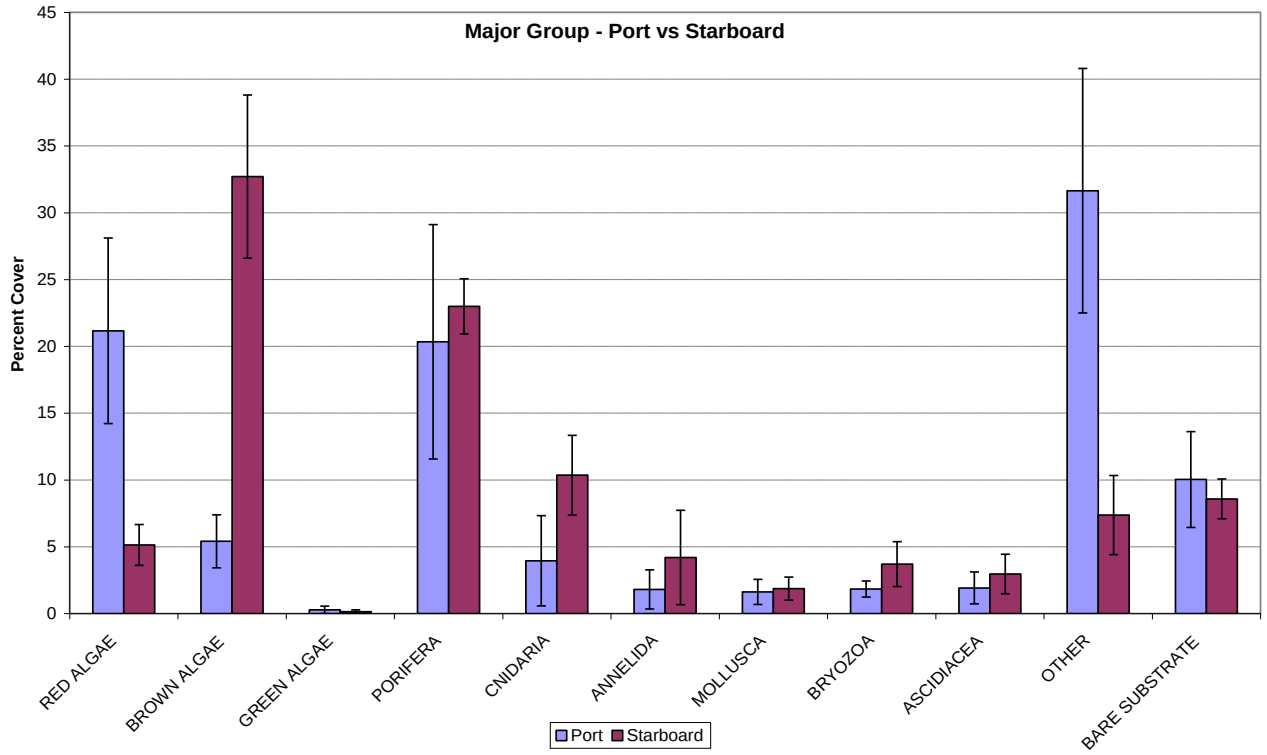


Figure 10 Relative abundance of major fouling groups – Port vs. Starboard

The relative abundance of the major categories of fouling organisms (those with >5% cover) at each photoquadrats site (transect) is shown below in Figure 11.

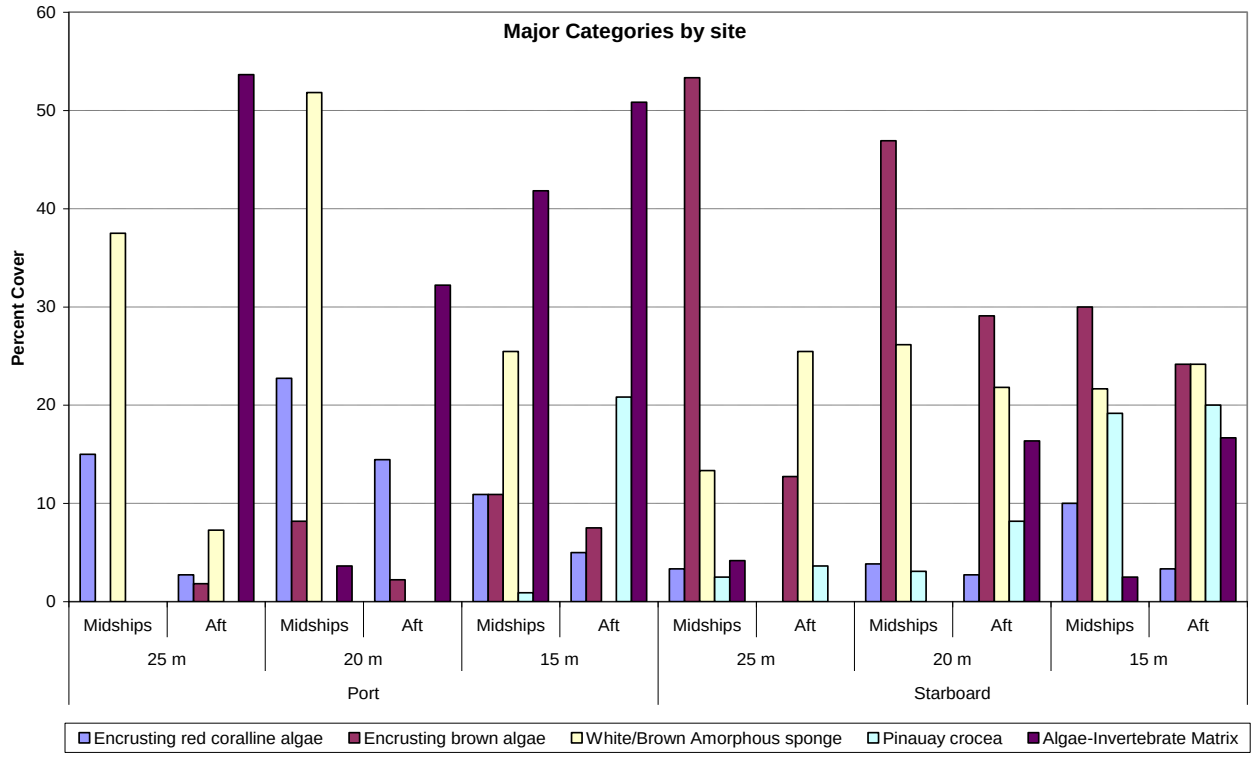


Figure 11 Relative abundance of major categories by site (>5% cover)

The difference in the abundance of red algae between the port and starboard side of the ship was mostly due to red encrusting coralline algae, as shown by Figure 11. Comparing sites in the same position on each side of the ship (port vs starboard), encrusting coralline algae were more abundant at all the sites on the port side. They were also more abundant at the shallower sites and the midships sites where light availability is higher.

Brown algae exhibited an inverse pattern to the red algae, which appears to contradict general algal preferences for light. The brown alga most common on the starboard (low light) side of the Canberra was encrusting brown algae. On the basis of the results, this category appears to be well adapted to colonising new surfaces under relatively low-light conditions.

The cryptogenic hydroid species *Pinauay crocea* was the most common cnidarian (Figure 11). The distribution of this species appears to be related more to water movement than to light availability. Hydroids are filter feeders and as such prefer areas of higher water movement – giving them access to larger volumes of water. *Pinauay crocea* was most abundant at shallower depths which experience stronger wave action, and on the starboard side which is less protected from prevailing seas. While the percent cover of this species is quite low on the vertical sides of the ship, it is one of the most conspicuous and abundant species on the ship. It is most abundant on the masts, railings, fittings and around openings, where water movements are high. It is also the most abundant fouling invertebrate growing on remaining antifouling paint, particularly under the stern of the ship (Figure 15).

The algae-invertebrate matrix was the most abundant category overall on the ship. Figure 11 shows its abundance on each part of the ship. It was most abundant on the port side of the ship and at shallower depths where light availability is highest. A large component of this category was filter feeding invertebrates. However, the invertebrates were living on and amongst filamentous red algae.

The White/Brown amorphous sponge was common throughout the ship and accounted for almost 19 % cover. It was found at all sites on the starboard side of the ship at abundances of between 13 and 26 %. On the port side it was found at four sites, at between 7 and 52 % cover.

4.2 Horizontal surfaces

Previous inspections of the vessel showed that the decks had been rapidly colonised by fast growing, 'ruderal' (first colonising plants) algae species and suspension feeding invertebrates after scuttling in late October 2010:

- Four months after scuttling (February 2010) the exposed decks had a dense cover of delicate algae species (mostly red algae);
- Five months after scuttling (March 2010) the algal assemblage on the exposed decks had become more diverse and increased in biomass in March 2010. The dominant algae were still delicate 'feathery' red algae species.

CEEs observations over 20 years at the Devonport Sewage Outfall and conversations with S. Shepherd (PIRSA-SARDI) indicated that these species are only seen in oceanic environments when substrate has been cleared of other biota. These ruderal or primary successional algae species were expected to be ephemeral and to die off with the onset of cool temperatures and low light in winter.

The 6 month ecology survey in May 2010 found the algal biomass (particularly red algal species) had substantially declined. A sparse cover of mainly red algae and some *Ulva* and brown algae remained on the main deck (1 deck). Red algae, Ulva and brown algae were more abundant on the top of the superstructure (02 deck). Algal abundance was greatest on top of the bridge and stack, where the highest abundance of brown algae occurred.

Few invertebrates were seen attached directly to horizontal surfaces. The most abundant invertebrates were the hydroid *Pinauay crocea* and the ubiquitous butterfly wingshell *Electroma georgiana*. *Pinauay crocea* is considered a cryptogenic species: it is likely to be introduced but is not listed as a pest. It was attached mainly to edges (of deck fittings, railings, safety lines) with some also attached to larger algae. The fairy mussel *Electroma georgiana* was found attached directly to horizontal surfaces in places, but was mostly attached to the thick stems of red algae and other algae or edges. These suspension feeding invertebrates require access to large volumes of water – hence their preference for elevated positions where water movement is greatest.

4.2.1 Main deck (01 Deck)

Qualitative assessment of the video record of the transects recorded along the periphery of the main deck around the flight deck (18 m depth) and bow (16 m depth) during the May 2010 survey found that:

- The algal and invertebrate assemblage was similar throughout the Main Deck areas
- Algal abundance was lowest on the deeper main deck than the shallower horizontal surfaces
- Algal abundance was greatest away from areas overshadowed by the superstructure where light availability is higher;
- The dominant algae were ruderal red algae species, encrusting red coralline algae, encrusting brown algae. *Ulva* and Dictyotales spp. were also present;
- Algae, particularly juvenile kelps were most abundant on edges (Deck fittings, cut-outs, rails, deck edge) where water movement is stronger;
- Algal cover was estimated to be between 30 and 50 % with the remaining horizontal surface area covered by a thin layer of silt;
- *Pinauay crocea* and *E. georgiana* were the most abundant invertebrates

4.2.2 Bridge, Masts and Stack area (02 Deck)

The top of the superstructure is at around 12 m depth and thus receives more light than the main deck.Qualitative inspection of the video transects recorded along the periphery of 02 deck, from the bridge to the aft end of the hanger found that:

- Algal abundance was higher than on deeper parts of the wreck;
- The algal and invertebrate assemblage was similar in all areas of the deck surface;

- The dominant algae were ruderal algae species, Ulva and Dictyotales spp. were more abundant than in deeper areas. Some brown algae from the order Fucales were present;
- Algae, particularly juvenile kelps were most abundant on edges (Deck fittings, cut-outs, rails, deck edge) where water movement is stronger;
- Algal cover was estimated to be between 50 and 70 % with the remaining horizontal surface area covered by a thin layer of silt; and
- *Pinauay crocea* and E. *georgiana* were the most abundant invertebrates, some scallops (including the Doughboy Scallop *Mimaclamys asperima*) were present.

4.2.3 Top of Bridge, Stack

The top of the Bridge (03 deck) and stack are the shallowest (10 m) horizontal surfaces on the wreck and receive more light than both the main deck and the top of the superstructure. Diver observations of these areas have found the following:

- *These areas have the highest cover of algae of any part of the ship;*
- *Ruderal red algae were the dominant group of algae, though brown algae from the groups Dictyotales and Fucales were more abundant here than anywhere else on the wreck.*
- *Pinauay crocea and E. georgiana were the most abundant invertebrates as with elsewhere on the wreck.*

Images taken around the superstructure are shown below in Figure 12.

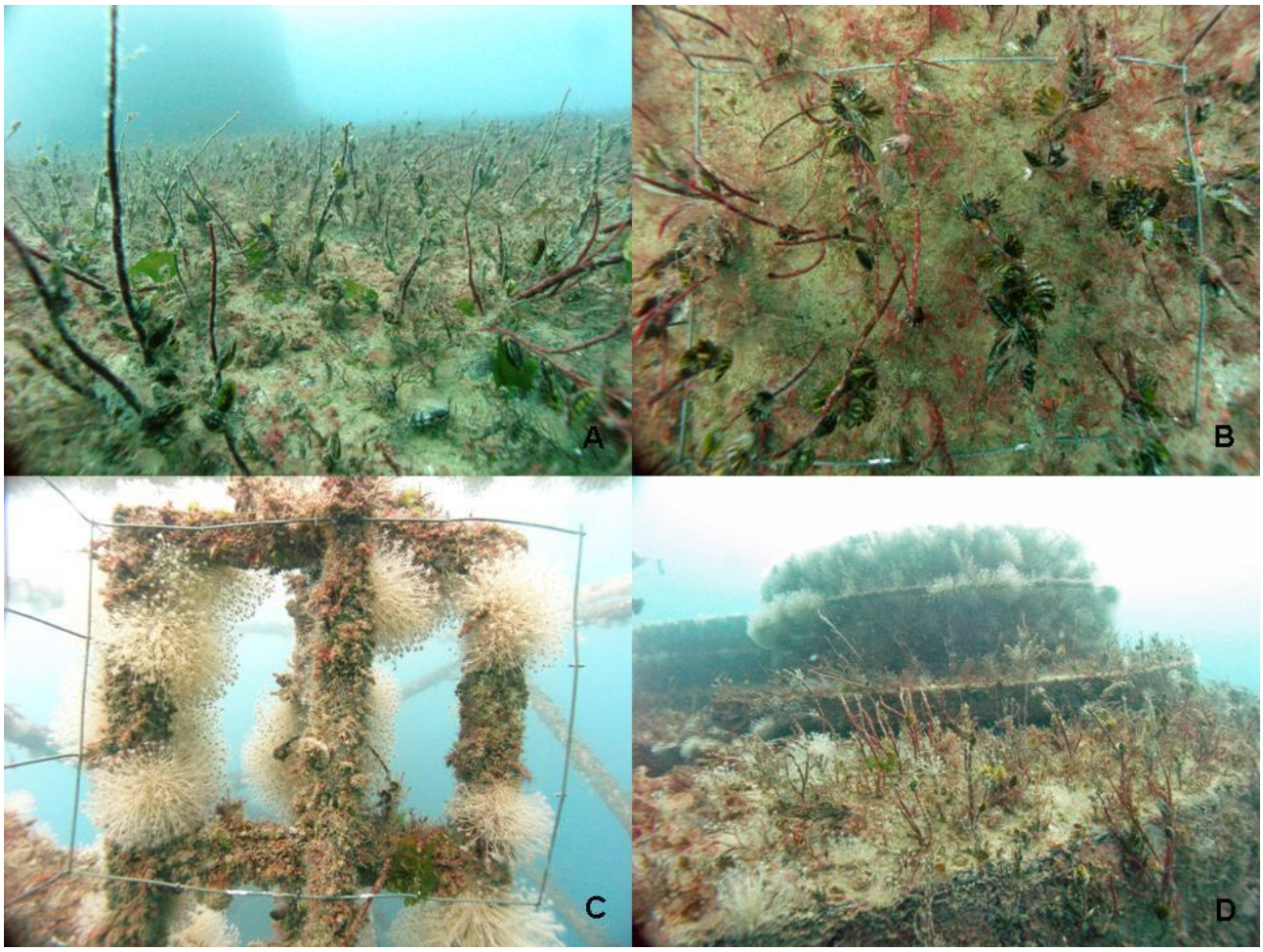


Figure 12 Images taken around the superstructure – May 2010

A) Fouling (mostly algae) on the top of the superstructure (02 deck), near the stack
B) Photoquadrat showing algae and *E. georgiana* on 02 deck
C) Fouling on the main mast
D) Fouling on the stack

4.3 Mobile Biota

Table 4 shows the fish and one invertebrate species present on the Canberra and at the reference sites at the time of the 6 month survey in May 2010. The table includes a column for species that have been seen previously. Table 5 shows details of family and species names.

Table 4 Fish and invertebrates identified on the Canberra and at Reference Sites

	The Canberra							Reference Sites	
Area	**Transom and Skeg**	**Flight Deck**	**Hanger Roof**	**Masts**	**Bow**	**Bridge**	**Previous Surveys**	**West (from video)**	**East**
Common Names									
Collared catshark									P
Seargent baker							P		
Perch					P	P	P	P	P
Southern hulafish		P			P	P	P		P
Southern blue devil									P
Longfin pike		P	P	P					
Mackerel		P	P	P					
Southern goatfish		P	P		P		P		
Bullseyes		P	P		P	P	P		P
Sea sweep		P	P	P			P		
Boarfish									P
Old-wives									P
Magpie morwong		P			P				P
Sea carp									
Victorian scalyfin									P
Blue throat wrasse				P	P		P	P	P
Senator wrasse									P
Weed whiting									P
Blenny						P			
General leatherjacket		P	P	P			P	P	P
Toothbrush leatherjacket									
Yellowstripe leatherjacket									P
Horseshoe leatherjacket									P
Globefish							P		P
Ringed toad fish							P		
Giant cuttlefish				P					
Subtotals	0	8	6	6	6	4	10	3	16
Totals	14 spp							16 spp	

Table 5 Fish family and species names

Family	Species	Common Name

Parascyllidae	*Parascyllium variolatum*	Collared Catshark
Aulopidae	*Aulopus purpurissatus*	Seargent Baker
Serranidae	*Caesioperca sp.*	Perch
Plesiopidae	*Trachinops caudimaculatus*	Hulafish
	Paraplesiops meleagris	Blue Devil
Dinolestidae	*Dinolestes lewini*	Longfin pike
Carangidae	*Trachurus declivis*	Mackerel
Mullidae	*Upeneichthys vlamingii*	Southern Goatfish
Pempheridae	*Pempheris multiradiata*	Bullseye
Scorpinidae	*Scorpis aequipinnis*	Sea Sweep
Pentacerotidae	*Pentaceropsis recurvirostris*	Boarfish
Enoplosidae	*Enoplosus armatus*	Old-Wives
Cheilodactylidae	*Cheilodactylus nigripes*	Magpie Morwong
Aplodactylidae	*Aplodactylus arctidens*	Sea Carp
Pomacentridae	*Parma victoriae*	Victorian Scalyfin
Labridae	*Notolabrus tetricus*	Blue Throat Wrasse
	Pictilabrus laticlavius	Senator
Odacidae	*Siphonognathus sp.*	Weed whiting
Blennidae	*Parablennius tasmanianus*	Tasmanian Blenny
Monacanthidae	*Meuschenia/Acanthaluteres spp.*	Leatherjackets
	Acanthaluteres vittiger	Toothbrush leatherjacket
	Meuschenia flavolineata	Yellowstripe leatherjacket
	Meuschenia hippocrepis	Horseshoe leatherjacket
Tetraodontidae	*Diodon nicthimerus*	Globefish
	Omegophora armilla	Ringed Toad Fish
Sepiidae	*Sepia apama*	Giant Cuttlefish

The most abundant fish species present on the Canberra wreck include:

- Mackerel
- Long-fin pike
- Leatherjacket species
- Blue-throat wrasse
- Southern hulafish
- Bullseyes
- Perch
- Southern goatfish

Most of these species are ubiquitous on Victorian rocky reefs and have clear associations with certain sections of the ship or physical habitats.

The small pelagic species mackerel (*Trachurus declivis*) and long fin pike (*Dinolestes lewinii*) were the most abundant fish on the ship during the 6 month survey. Large schools of both species were associated vessel sections with high vertical structure and clear access to open water: the masts and hanger of the wreck. Mackerel are not commonly associated on natural reefs along the Victorian coastline. Mackerel have been observed aggregating on the wreck of the Troy-D wreck near Maria Island in Tasmania, but are not common on natural reefs of high relief nearby (S. Ibbot, pers. comm.).

Leatherjackets (*Meuschenia* and *Acanthaluteres spp.*) were among the first fish to colonise the wreck. Most were juveniles making positive identification of their species difficult. They were associated with areas of high algae cover, such as the main deck and top of the superstructure, and were mostly seen around deck fittings which provide some shelter. Leatherjackets on natural reefs are most commonly associated with complex habitats and high algal abundance.

The blue-throat wrasse (*Notolabrus tetricus*) was another species which rapidly colonised the wreck. It is one of the most ubiquitous and abundant rocky-reef species on the Victorian Coastline. Young females and some juveniles were present on the wreck. No large males were sighted. Like the leatherjackets the blue-throat wrasse is most strongly associated with the algae covered decks and fittings.

The southern hulafish (*Trachinops caudimaculatus*) was present on the upper parts of the wreck with small schools sighted around many of the deck and hull openings. On natural reefs they are usually found near and under ledges. On the wreck they show a clear preference for partly enclosed spaces.

Like hulafish, schools of bullseyes (*Pempheris multiradiata*) are commonly seen under ledges on natural reefs. On wrecks they are generally found inside and near openings leading into wrecks. Bullseyes nn the Canberra can be seen on the lower parts of the hull, near hull openings and also within the inside the upper parts of the wreck. Both adult and juvenile bullseyes were sighted during the 6 month survey.

Several individual juvenile perch (*Caesioperca sp*) were seen during the 6 month survey and have been seen in previous surveys. On natural reefs they tend to form schools over high relief reefs but are also often seen swimming alone. They are generally found in water over 15 m deep along the Victorian coastline.

The southern goatfish was seen on all the decks of the Canberra, browsing amongst the algae and invertebrates. They were also seen on the sandy seabed beneath the Canberra. southern goatfish are common on natural reefs in the area and browses over algae covered reefs and soft sediments.

4.4 Reference Sites

The two reference sites (west and east) represent some of the diversity of natural reef habitats in the area.

- The west reference site comprises low profile reef with low topographic relief, low lying patches of the reef are covered by loose material such as cobble and rhodoliths. Some large boulders are also present. It has an average depth of around 20 m.
- The east reference site comprises low profile reef with moderate topographic relief. Gutters in the reef are filled with sand. The area has a large number of small pinnacles and ledges giving the area complex structure. It has an average depth of around 14 m.

4.4.1 West Reference Site

The sessile reef assemblage at the west reference site (20 m depth) was dominated by macroalgae. The algal community was dominated by a canopy comprising the brown algae *Ecklonia radiata*, *Seirococcus axilaris* and *Acrocarpia paniculata*, midstorey of foliose red algae including *Plocamium spp.* and *Phacelocarpus sp.* and an understorey of encrusting coralline red algae and *Peyssonnellia novaehollandiae*. Sessile invertebrates included sparsely distributed sponges and abundant solitary ascidians (*Herdmania grandis*).

Few fish were sighted, several individual blue throat wrasse (*Notolabrus tetricus*), Leatherjackets (*Acanthaluteres/Meuschenia sp*) and a single perch (*Caesioperca sp*) were seen (Table 4). Few mobile invertebrates were seen below the algal canopy.

4.4.2 East Reference Site

The sessile reef assemblage at the east reference site was also dominated by algae. Due to its shallower depth several species not seen at the west reference site were seen at the east reference site. The canopy was dominated by *Ecklonia radiata*, *Phyllospora comosa* (in shallower areas), *Seirococcus axillaris* and *Cystophora platylobium*. The mid storey comprised diverse red (*Phacelocarpus, Plocamium sp*), Brown (Zonaria spp.) and Green (Caulerpa spp., *Ulva* sp.) algae. The understorey included encrusting and erect coralline red algae and fleshy red algal species (*Peyssonnelia novaehollanidae, Sonderopelta sp*).

Invertebrates at the east reference site are diverse and abundant owing to the moderate relief and high rugosity reef. Undercuts are home to many species of sponges, hydroids, gorgonians, bryozoans, crinoids and ascidians. Soft corals including *Erythropodium hicksoni* and *?Capnella sp.*) were seen in places. Patches of reef (generally crests) are crowded with the solitary ascidian *Herdmania grandis* in areas lacking an algal canopy and sparsely distributed *Pyura spinifera* (also a solitary ascidian) are present.

Fish were abundant all along the transect, with 17 species identified during the two dives at this site (Table 4). Numerous sea stars were seen along the transect (*Tosia* spp., *Nectria* sp. *Echinaster* sp.).

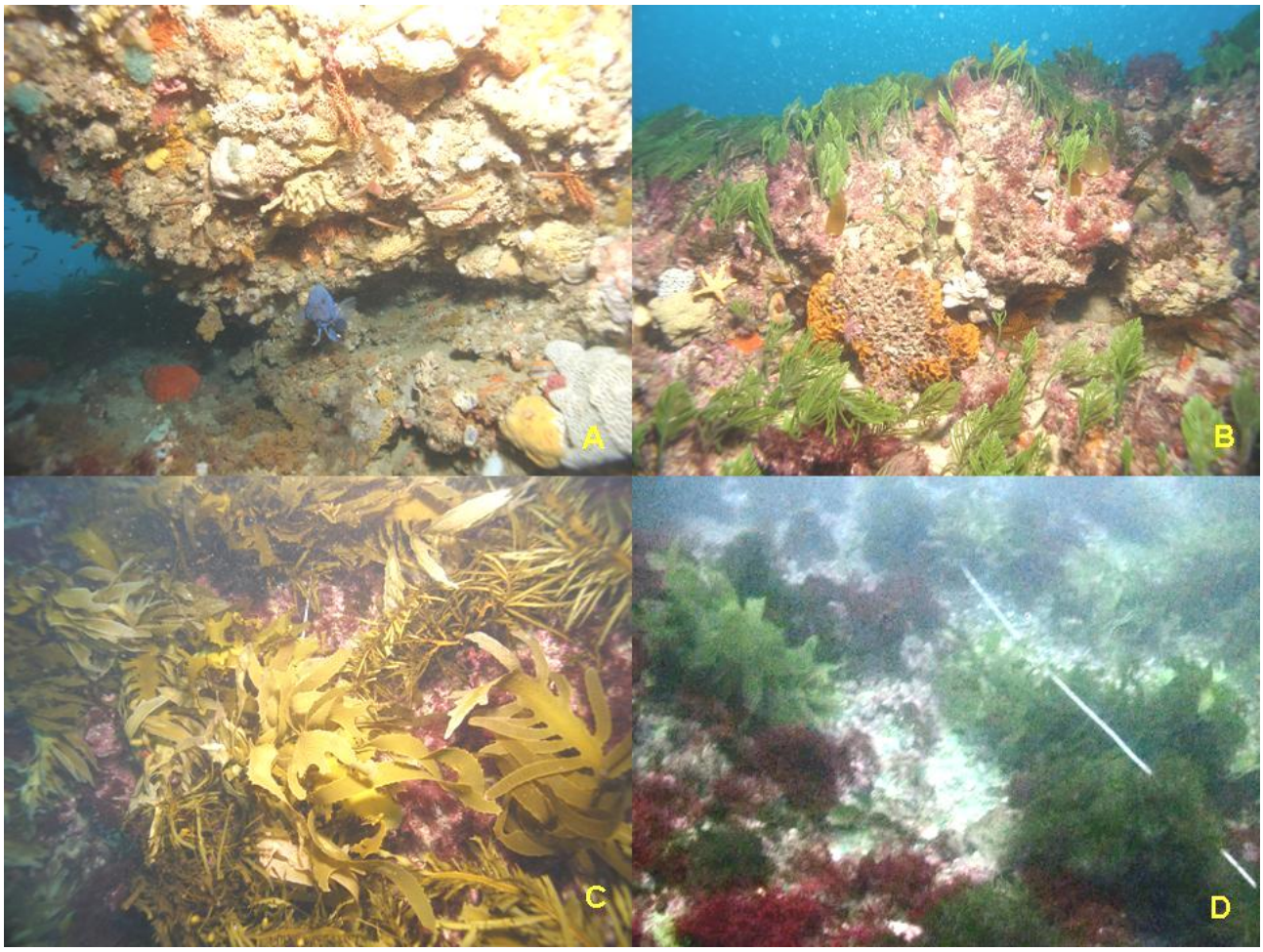


Figure 13 Images from reference sites

A) East reference: invertebrates and blue devil fish beneath ledge
B) East reference: *Caulerpa flexilis* and invertebrates on reef
C) East reference: *Eckonia radiata*, *Phyllospora comosa*, red encrusting and foliose algae
D) West reference: Rhodoliths, *E. radiata*, *Acrocarpia paniculata*, foliose red algae.

4.5 Introduced Species

The colonization of the wreck by invasive or pest species is a concern for Parks Victoria. No cryptogenic species with pest or invasive status[1] have been observed on the Canberra since scuttling . Only one cryptogenic (introduced) species has been identified in elevated abundance on the wreck – the hydroid *Pinauay crocea*. Blue mussels (Mytilus edulis galoprovincialis) have persisted in small numbers in tight corners since relocation of the vessel. Other cryptogenic species are likely to be present on the wreck, including *Botrylloides spp*, various invertebrates and algae.

4.5.1 Undaria pinnatifida

The Japanese Wakame kelp *Undaria pinnatifida* has not been observed on the Canberra. Parks Victoria has expressed particular concern for the potential colonization of the wreck by this species, which has invaded many shallow natural and artificial reef habitats within Port Phillip Bay, is widespread in south-east Tasmania. . It has recently become established in the artificially enclosed waters of Apollo Bay harbour. *Undaria pinnatifida* is native to northern Asia, around the coasts of Japan, Korea and China. It is now widespread in the north Atlantic and northern and southern Pacific oceans including southeast Australia and New Zealand.

[1] As listed on the NIMPIS database

Factors that influence the likelihood that the Canberra will be colonised by *Undaria pinnatifida* include

- the supply of propagules (spores);
- the suitability of the light environment;
- sufficient nutrients for growth; and
- the availability of suitable habitat (shallow reef).

Undaria pinnatifida, like all kelps, has a two phase life history, a macroscopic sporophyte (the kelp) and a microscopic gametophyte. The sporophyte has the primary role in dispersal of the species through release of zoospores which settle and develop into the microscopic gametophyte. The gametophyte produces either sperm or eggs; eggs are retained on the female gametophyte and generally do not survive if released (NIMPIS, 2010). Spores are released in spring/summer and develop as the gametophyte, fertilized eggs grow into sporophytes over winter. Sporophytes generally survive less than a year. The ship was scuttled in spring, at a time when *U. pinnatifida* sporophytes are releasing zoospores and gametophytes are developing.

The macroscopic sporophyte of this invasive species was not present on the vessel during preparations in Corio Bay nor after the hull was cleaned prior to scuttling. The microscopic gametophyte cannot be seen. However, inspections of the hull and nearby wharf during preparations did not find any adult sporophytes, so there was no nearby source for gametophyte spores prior to scuttling.

Potential sources of *U. pinnatifida* for colonization of the Canberra include:

- Dispersion of spores from adult plants within Port Phillip Bay;
- Spores released from drifting adult plants; and
- Sporores released from adult plants attached to passing boat and ship traffic.

Hence the risk of establishment of Undaria on the Canberra is the same as any new surface in proximity to Port Phillip (or Port Fairy) or potentially infected boating traffic along the Victorian coastline.

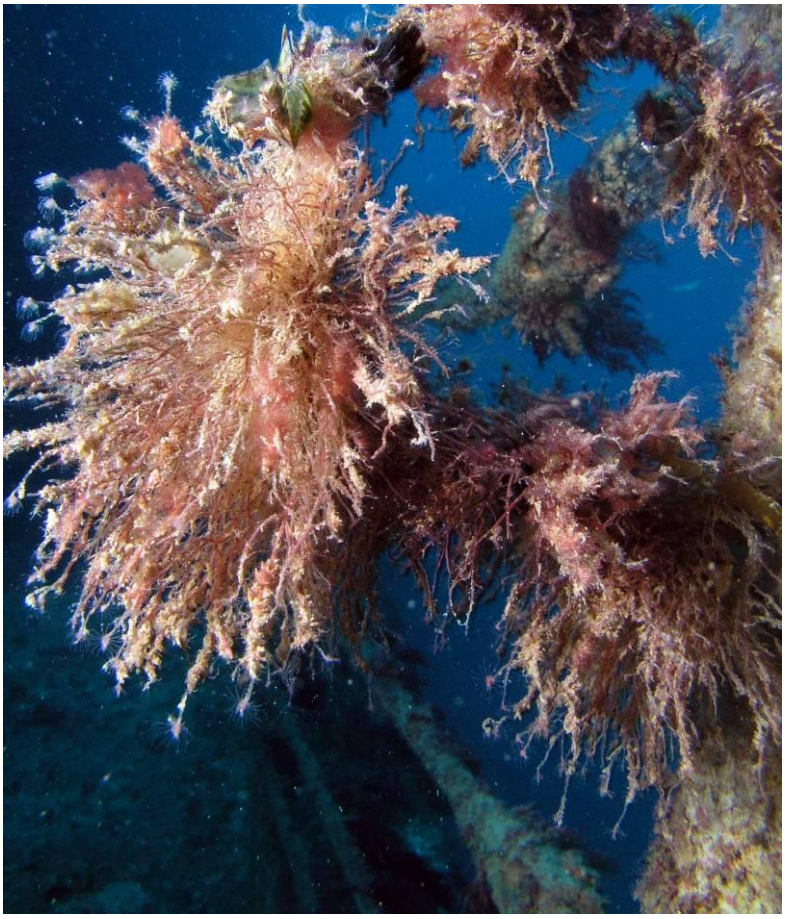
The six monthly monitoring surveys will continue to check for the presence of *Undaria* on the Canberra.

4.5.2 Pinauay crocea

The cryptogenic hydroid species *Pinauay crocea* (previously known as *Tubularia crocea* and *Ectopleura crocea*) is not considered invasive or a pest in Australian waters, though it is a known introduced species. It is native to the north Atlantic coast of America and is now found throughout temperate waters in the southern and northern hemispheres (Ruiz et al, 2006). Recent research into biofouling of mussel ropes within Port Phillip Bay found that this species was problematic due to its tendency to cause heavy fouling of the ropes and mussels and to possibly inhibit mussel recruitment (Fitridge, 2009).

Pinauay crocea is one of the most conspicuous components of the biological assemblage that has colonised the Canberra (Figure 14). It is present on all external surfaces of the ship, from the deepest to the shallowest sections of the ship. It is most abundant in areas of high water movement, such as hull openings, deck fittings, cables and railings, and generally at shallower depths.

Figure 14 *Pinauay crocea* growing on loose cable



Pinauay crocea is a colonial hydroid which grows in tufts of up to 12 cm high. Each colony consists of numerous unbranched stems each bearing a feeding polyp. It has a light pink colouration. The hydroid colony is asexual, the sexual stage (medusae called gonophores) grow on and remain attached to the parent colony. After fertilization of the eggs held by the female gonophores, larvae are released into the water column, settling after around 2 weeks. The asexual stage matures in around 2-3 weeks (NIMPIS, 2010b) and the species is reproductive year round (Fitridge, 2009). It is possible that several generations have reproduced and settled on the Canberra since it was scuttled and that the now very large *P. crocea* population started as a much smaller population.

The habitat of *P. crocea* includes both natural and artificial hard substrates and it can survive at a wide range of temperatures (9 to 21˚C), salinities (9 to 35 ppt) and depths (subtidal up to 40 m) (NIMPIS, 2010b). It is a relatively passive suspension feeder (it cannot move water like sponges or ascidians), capturing food particles on the tentacles borne by the polyp, and thus prefers areas of naturally high water movement.

The source of the initial recruits of *P. crocea* is uncertain. It is possible that this species traveled to the site with the ship (it being prepared in and traveling through Corio Bay, relatively close to mussel aquaculture operations where the species is abundant), but it may also have recruited from local populations on the open coast.

The newly scuttled The Canberra represented ideal substrate for the recruitment and success of this species. It was (and is) largely bare of other species and has extensive suitable habitat with high water movement.

The documented negative impact of this species in Victoria is the fouling of mussel ropes. No mussel aquaculture occurs along the open coast of Victoria and the Canberra is remote from all mussel aquaculture operations within Port Phillip Bay and Westernport Bay.

Figure 15 *Pinauay crocea* under the stern of the ship (skeg visible on left) – February 2010

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7 CONCLUSION

- In the 6 months after scuttling the wreck has been progressively colonised by an increasing number of species and an increasingly dense fouling assemblage.
- The rate of colonsiation by fouling species over the first 4-5 months was high. With the onset of cooler conditions in late autumn there was a rapid loss of algal biomass but invertebrate biomass continued to increase.
- The rate of colonization by fish species was also high, with the number of fish and fish species increasing as the density and diversity of the fouling assemblage increased.
- The fouling community is characterized by primary successional species – ruderal alagae and invertebrates such as hydroids, encrusting bryozoans, colonial and solitary ascidians.
- The characteristics of the fouling assemblage on the Canberra are quite different to benthic assemblages on nearby natural reefs.
- The fish on the wreck includes mostly reef species naturally abundant in the area. Pelagic species such as mackerel were attracted, and a range of demersal and pelagic species are expected to be seen episodically at the wreck as they pass through the region.
- The characteristics of the fouling assemblage will continue to change. It is noted that no substantial storms occurred in the 6 months since the Canberra was scuttled. Storms will remove fouling organisms from the wreck. It is expected the wreck will be affected by heavy storm waves at least once per year.

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