Technical reports of the Queensland Museum

No. 001

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Report written for: Environmental Protection Agency (EPA) (December, 2006)

BIOLOGICAL BASELINE SURVEY OF THE EX-HMAS BRISBANE ARTIFICIAL REEF

Schlacher-Hoenlinger, M.A., Walker, S., Johnson, J., Schlacher, T. & Hooper, J.N.A. 2006 (published online 2009). Biological baseline survey of the ex-HMAS Brisbane Artificial Reef. Technical reports of the Queensland Museum No 001. www.qm.qld.gov.au (ISBN978-0-9805692-6-1)

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Executive Summary

The ex-Navy ship HMAS Brisbane was scuttled off the Sunshine Coast on 31 July 2005, to create an artificial reef and to provide world-class diving opportunities on a significantly large warship in South-East Queensland. The wreck has since underpinned a significant expansion of the local diving and associated tourism industry, and has become a significant natural and economic asset of the region. The wreck also forms a significant addition to hard-substrate habitats of the local nearshore marine zone.

This report summarizes the findings of a biological baseline survey of the wreck conducted by the University of the Sunshine Coast and the Queensland Museum. It presents an inventory of the diversity of larger, sessile invertebrates and fish that inhabit the wreck 12-18 months after the scuttling.

102 species of larger invertebrates were recorded on the wreck. Crustaceans (25 species) and sponges (Porifera, 24 species) are the most diverse faunal component, followed by molluscs (bivalves and snails, 17 species) sea squirts (Ascidiacea, 13 species), and lace corals (Bryozoa, 9 species). Other groups found on the wreck include Echinoderms (e.g. black feather stars, sea urchins) and tube worms (Polychaeta).

For some faunal groups (e.g. sponges) the wreck fauna may be broadly representative of the species composition found on natural reefs in the area, although comprehensive surveys of many components of natural reefs in the region have never been undertaken. Conversely, most of the dominant fauna that has currently colonised the wreck differs from that of surrounding natural habitats. For example, no hard corals or soft corals, and coralline algae were recorded on the wreck, although these are common members of the seafloor communities in the region. Further colonisation of the wreck over time may, however, result in more species typical of natural reefs to occur on the wreck, but this requires ongoing biological surveys to verify.

150 species of fish were recorded on the wreck. The most speciose families were damselfishes (Pomacentridae, 15 spp.), wrasses (Labridae, 13 spp.), trevallies (Carangidae, 13 spp.), butterflyfishes (Chaetodontidae, 9 spp.), surgeonfishes (Acanthuridae, 8 spp.) and tropical snappers (Lutjanidae, 8 spp.).

Fish abundance was high for some species, especially bigeyes (Priacanthus spp.), Capricorn Cardinalfish (Apogon capricornis), Longnose Trevally (Carangoides chrysophrys), fusiliers (Pterocaesio spp.), Blacksaddle Goatfish (Parupeneus spilurus), Longfin Bannerfish (Heniochus acuminatus), Black Rabbitfish (Siganus fuscescens) and two damselfish species (Chromis nitida and Neopomacentrus bankieri). The minimum number of each of these species was estimated to be between 150 and 3200 individuals when counts were made.

Fish biomass on the wreck was substantially greater than what would normally be expected for similar-sized natural reefs in the area, with unusually large concentrations of herbivores (eg rabbitfish) planktivores (eg fusiliers and Yellowback Pullers) and higher order predators (eg trevallies and tropical snappers).

In species richness terms, carangid and caesionid fish species were generally over-represented on the wreck, whilst pomacentrids and labrids were significantly under-represented. Additional research is required to more fully document fish diversity on both the wreck and local natural reefs and to contrast this with evolving changes to the fauna on the wreck.

The diversity and abundance of fish species differs markedly between different sectors of the wreck. Species richness and trophic complexity was greatest around exposed horizontal deck surfaces (106 spp. recorded) and lowest in the heavily shaded internal areas (46 spp.). Overall fish numbers in the internal areas were mainly comprised of large monospecific aggregations of Capricorn Cardinalfish and Yellowback Pullers. The area around the superstructure (82 spp.) supported smaller numbers of many of the species that were also found around the decks, but diversity appeared to be enhanced by stronger exposure to currents and surge from surface wave action. The vertical hull and adjacent sandy bottom sector (89 spp.) was dominated by loosely associated groups of

pelagic and predatory species, particularly trevallies (Carangidae), tropical snappers (Lutjanidae) and emperors (Lethrinidae). Some fishes recorded in this sector (eg flatheads) were primarily sand-dwellers that would not be strongly associated with habitats provided by the wreck.

Fish communities appear to change over time: in late spring (Nov.) diversity was lower (110 species) compared with the mid-winter (July) surveys (131 species). A similar but more striking trend was also noted for the abundance of most of the dominant fish species between these periods. This may indicate that some emigration from the wreck has occurred since winter to balance population levels that may have been unsustainable during the early phases of the wreck. Again, whether fish communities and biomass changes significantly over time requires ongoing monitoring programs.

Physical habitat features (e.g. depth, aspect) are important in determining the rate of colonization by encrusting assemblages ('fouling communities'). The vertical sides of the ship have been settled by more species at significantly higher densities than the horizontal surfaces; smothering by sediment which settles on horizontal areas may explain this pattern. Also, the encrusting fauna on the vertical surfaces is more diverse and abundant on the outside than on the inside of the ship, which is likely due to the random settlement and survival of larvae on accessible surfaces, and which may also change over time through succession.

The benthic assemblages are currently in a state of flux with colonization still progressing. As space for settlement and growth will become more limiting biotic succession will occur through competition and overgrowth. Pilot studies on temporal trajectories indicate that faunal composition and abundance changed in the relatively short period between July and November 2006. Amongst the sessile invertebrates that form three-dimensional biological structures on the ship, colonies of Bryozoa (lace corals) decreased whereas Porifera (sponges) became more structurally complex. Small mobile animals (eg. Crustacea) were also more numerous in November, possibly indicating seasonal recruitment pulses. The presence of larger cryptic animals (e.g. octopus) on the wreck suggests that immigration of mature individuals from adjacent habitats complements colonization via larval recruitment to the wreck.

This baseline survey represents a reference point against which future colonization of the wreck can be benchmarked. Arguably, the assemblages on the wreck are in a relatively early stage of succession, but the rate at which faunal diversity will increase and assemblages change is currently not known. Therefore, a key recommendation of this study is to implement a medium-term (e.g. 3 years) scientific monitoring program that documents the nature and dynamics of biological colonization.

The ecological value of significant artificial reefs such as scuttled ships is frequently argued in terms of creating essential habitats of high ecological value. Although the wreck of the ex-HMAS Brisbane currently supports a diversity of species, it may be still be lower than that of surrounding natural reefs. Continued colonization of the wreck is predicted to enhance the habitat value of the wreck, but the trajectories of this change cannot be extrapolated from existing data. Thus, a further key recommendation of this report is to determine the current and future habitat value of the ship in relation to the mosaic of existing ecosystems surrounding the wreck in the nearshore zone.

The wreck is visited by a large number of divers, but awareness about the ecological features of this important asset appears limited outside the diving community. Therefore, it is recommended that an interactive communication and education strategy is developed that provides comprehensive information to a variety of audiences and delivers hands-on outreach and education products on the biological assets of the wreck.

1. INTRODUCTION

The HMAS Brisbane is a 133 metre, Charles F Adams Class DDG, Guided Missile Destroyer, with a long history of distinguished service in the Australian Navy. After decommissioning, the Queensland Government obtained her from the Commonwealth to create an artificial reef off the Sunshine Coast, and the ship was scuttled there in August 2005.

Artificial reefs, including those of purposefully sunken vessels, can be important assets in terms of their recreational (e.g. diving, fishing, surfing, etc.) and ecological values (e.g. new habitats, refugia for benthic invertebrates and fish; Bortone & Kimmel, 1991; Malcolm et al., 1999; Svane & Petersen, 2001).

Artificial reefs provide opportunities to quantify colonization of newly created, artificial substrates by marine organisms (Cummings, 1994; Svane & Petersen, 2001). This is becoming an increasingly important issue to national biosecurity agencies charged with the detection, monitoring and control of invasive species in Australia (e.g. Hewitt & Martin, 2002).

Epibiota, the attached plants and animals that settle and grow on hard substrata, are a major component of biogenic structure in subtidal habitats, particularly on artificial reef structures. Epibiota provide fish with important resources, such as food and shelter and therefore have large effects on the distribution and abundance of fish. The composition and amount of sessile marine flora and fauna, which itself may vary considerably between different parts within the artificial habitat and considerably between natural and artificial structures, may influence the number and types of fish associated with these artificial habitats.

On wrecks the abundance and diversity of fish is positively correlated with the amount of foliose algae, mussels, sponges and solitary ascidians (Clynic, 2005; Santos et al., 2005). These epifaunal assemblages may undergo marked changes in biomass and species composition during the initial stages of colonization of the wreck. Variability reduces with increasing length of exposure until a diverse artificial reef community is established (Brown, 2005). Most artificial reef studies have examined only the early colonization stages. Thus, the time required for the development of stable and diverse assemblages is generally unknown or poorly understood, but may be a decade or longer (Perkol-Finkel & Benayahu, 2005). Equally, comparative studies between artificial and natural reefs (NR) are scarce, but wrecks may be distinct in terms of diversity and living cover compared with neighbouring natural reefs (Perkol-Finkel & Benayahu, 2005).

Several artificial reefs have been created adjacent to major Australian centres (e.g. ex- HMAS 'Swan' off Perth - Anon., 2004, the ex-MV 'Marchart' off Darwin - Hooper & Ramm, 1989), but the rates and trajectories of biological colonization of the shipwrecks have not been determined and thus remain poorly understood. Yet, monitoring programs are essential to assess whether artificial reefs simply become fish attracting devices (FADs), or become established as benthic ecosystems that can enhance the habitat and biological diversity of an area (Carney, 2005).

The sinking of the ex-HMAS 'Brisbane' in July 2005 provided a unique opportunity to undertake such a biological monitoring program. The monitoring program was primarily designed to document invertebrate and fish diversity on the wreck. It also determined which factors (e.g. exposure, depth) influence the species composition of fouling communities on the wreck. Thirdly, broad comparison of the wreck-associated fauna are made with that of natural reefs in the area.

The University of the Sunshine Coast and the Queensland Museum were commissioned by the EPA in June 2006 to undertake the initial biological baseline surveys of the ex-HMAS 'Brisbane'.

This report summarizes the findings from a comprehensive field survey undertaken on the wreck in July 2006, complemented by a smaller follow-up sampling event in November 2006

2. MATERIALS & METHODS

The field surveys comprised three monitoring modules:

a biodiversity survey of macrobenthic invertebrates that had colonized the wreck over the 12 months period since the scuttling of the ship,

b biodiversity survey of the fish fauna on the wreck and in its vicinity, and

c survey of the encrusting micro-invertebrates and algae ('fouling communities') on the wreck's vertical and horizontal surfaces.

2.1. BIODIVERSITY ASSESSMENTS

2.1.1. Sessile Invertebrates and Small Mobile Fauna

The assessment of sessile biota and small mobile fauna on the ex-HMAS Brisbane was primarily designed to document the biodiversity and community composition of macro-invertebrates on the wreck.

The baseline surveys of macro-invertebrates, algae, as well as encrusting fauna and flora involved swimming transects along the length and breadth of the wreck using scuba, examining representative horizontal and vertical surfaces, and also surveying the seabed surrounding the wreck out to a specified distance (3 m).

A comprehensive survey was conducted in July 2006 and this forms the bulk of the data presented in this report. A smaller, follow-up collection was done in November 2006 to obtain preliminary data on possible seasonal changes in community structure.

The techniques used included underwater photography as well as extractive sampling of representative taxa (Algae, Worms, Porifera, Cnidaria, Mollusca, Crustacea, Bryozoa, Echinodermata and Ascidiacea).

The underwater field surveys involved 42 dives with over 50 hours logged dive time. All biota were photographed in situ and a high-quality collection of voucher specimens was made and housed at the Queensland Museum. This collection of sessile and small mobile fauna on the wreck was used for taxonomic Quality Assurance and as a reference collection for future monitoring events. Hundreds of samples were obtained from the wreck and several hundred photos in situ and in the laboratory were taken. For more accurate species identification of Bryozoan specimens, SEM (Scanning Electron Microscope) images were taken (Fig. 24 & 15).

A species lists of algae and macro-invertebrates from the two field surveys was completed (Table. 1). Estimates of species richness are highly dependent on sampling effort. Therefore, the species lists presented in this report reflects accurately all species collected, observed, and identified during the field surveys in July and November 2006, but it should not be taken as a “complete” inventory of species inhabiting the wreck. It does – with high probability - contain the majority of species occurring on the wreck at the time of the surveys (July and November 2006), but more species are likely to be encountered with greater sampling and collection efforts.

2.1.2. Fish

Fish communities were surveyed using rapid visual census techniques modified from Hutchins (2001). Sheets of waterproof paper were mounted on a clipboard and printed with pre-prepared lists of the most common fish species known from the Sunshine Coast area. Swimming transects of approximately 45 minutes were conducted throughout pre-determined parts of the wreck and all species were recorded and their abundance noted. Numbers were continuously updated during the dive as additional fishes were observed. This technique necessarily concentrates on the more conspicuous species that can be observed and identified accurately underwater, but small and cryptic species were also sought and recorded to the greatest extent allowable by available dive time.

The wreck was roughly divided into a number of sectors, and separate counts were made for each of these areas to determine if there were corresponding differences in fish diversity and abundance (Table 2). The sectors were delineated as follows: a) Superstructure (mostly vertical surfaces, depth ~3-10 m), b) Decks (mostly horizontal surfaces, depth ~10-18 m), c) Internal (shaded areas with vertical and horizontal surfaces, depth ~12-22 m, d) Lower Hull (vertical surfaces of the wreck and adjacent sandy substrate, depth ~18-27 m). For the two areas with external vertical aspects (superstructure and lower hull) fishes within a horizontal radius of at least 5 m were included in the counts. Each dive concentrated solely on a particular sector. Fish noticed to have moved between sectors of the wreck during recording events were counted in the sector that they appeared most closely associated with. Counts were converted from actual and estimated numbers to a log 5 scale of abundance (Hutchins, 2001). Initial surveys were undertaken in July 2006, and repeated using the same methods in November 2006 to allow assessments of temporal variability.

2.2. Encrusting biota ('fouling communities')

2.2.1 Field Surveys

The quantitative assessment of encrusting macro-invertebrates on the ex-HMAS Brisbane was designed to quantify the coverage and community composition of encrusting biota on the wreck. Three key-objectives were addressed: 1) Determine spatial differences between vertical surfaces on the sheltered port and exposed starboard sides of the wreck at three different depths (12, 18, 23 m). 2) Examine the spatial variation across different surface orientations (vertical vs. horizontal) on the wreck, at two depths (12 and 18 m), and 3) Examine patterns of community composition of encrusting faunal assemblages inside and outside the wreck (Figs. 1-3).

The composition of the bio-fouling community was determined at several replicate transects with different orientations (vertical vs. horizontal) and exposures (i.e. sheltered port vs. exposed starboard sides of the wreck). Each transect was sampled at 3 depths (12 m, 18 m, 23 m). We also sampled the inside of the wreck at a depth of 18 m. The locations of sampling sites are shown in Figures 1-4.

Briefly, three transects were sampled along the length of the vertical hull from bow to stern, at 18 m and 23 m depth. Three transects were sampled along the main deck (horizontal surface) at approximately 18 m. Vertical surfaces inside the wreck were sampled at three transects, corresponding to the position of the vertical sites outside the wreck at 18 m depth. At 12 m depth, only 2 transects on the exposed and sheltered vertical sides of the wreck and two horizontal transects were sampled, due to a lack of available surfaces to sample around the superstructures.

At each site the encrusting community was documented using a photo-transect method. Digital photos were taken with an Olympus 4MP UZ digital camera, at each of 15 replicate plots (photo quadrat frames) separated by 1 m, along the 20 m transect line. Each photo quadrat covered an area of 625 cm2. Representative voucher samples were photographed and collected for identification to the lowest possible taxonomic level.

In the laboratory, each photo-quadrat was analysed using the image analysis software 'Coral Point Count' (Kohler & Gill, 2006). The area inside the photo-quadrat was selected, then 100 randomly distributed points were superimposed over each image, and under each point the identity of each taxon was recorded.

2.2.2 Data Analysis

The spatial variation of assemblages between different exposures (exposed-starboard versus sheltered-port), depths, and orientations was analysed using non-metric multidimensional scaling (nMDS) on a Bray-Curtis similarity matrix of the mean value of the 15 quadrats for each transect, with no transformation of the data and analysis of similarity (ANOSIM; Clarke, 1993). Principal species contributing to any separation between groups were determined using the SIMPER routine (Clarke, 1993).

Spatial variation in total coverage, species density (number of species per 625 cm2) and the coverage of principal taxonomic groups was analysed using the following univariate statistical methods: (1) the difference between exposure and depth was examined using a crossed ANOVA with exposure (port or starboard) and depth (12 m, 18 m or 23 m) as factors, (2) the difference between orientations at two depths was examined with a crossed ANOVA with orientation (vertical and horizontal) and depth (12 m & 18 m) as factors, and (3) the difference between inside and outside at 18 m was examined, using a one-way ANOVA with location as the single factor. Homogeneity of variance was checked with Cochran's test; when variances were heterogeneous ($p<0.05$), the percent coverage data were arcsine transformed and species density data were log transformed (Underwood, 1981).

RESULTS

3.1. Invertebrates

3.1.1. Invertebrate Diversity & Species Composition

Colonization of the wreck has progressed considerably one year after the sinking of the ex-HMAS Brisbane. The entire superstructure and deck areas of the wreck are covered with an abundance of marine life (Figs. 5 & 6). Oysters and barnacles provide important microhabitats for a diverse assemblage of invertebrates, including juvenile rock lobsters, banded coral shrimps, crabs, sea urchins, feather stars, starfish, and also numerous small fish (Figs. 7-16, 18 & 19). The vertical sides of the hull and the superstructure are colourful due to a covering of bright red and yellow encrusting sponges, as well as striking orange and white lace corals. Inspections inside the ship revealed numerous small barnacles, sea squirts, fan worms and several species of sea fir.

The comprehensive surveys in July and November 2006 yielded 102 species of macro-invertebrates: 24 species of sponges (Porifera), 5 species of sea fir (Hydroidea), 25 species of crustaceans including several species of barnacles, 13 species of sea squirts (Ascidiacea), 9 species of lace corals (Bryozoa), and several other animals, such as black feather stars and sea urchins (Echinodermata), tube worms (Polychaeta) and 17 species of molluscs (Table 1).

The assemblages were dominated by oysters and, to a lesser degree, by barnacles. Overall, the diversity of sessile invertebrates at this stage of colonization appeared lower compared with adjacent natural reefs.

3.1.2. Comparison with Adjacent 'Natural' Habitats

Data for sponges and soft corals/ gorgonians exist for seafloor habitats off the Sunshine Coast, particularly from reefs extending from the Inner and Outer Gneerings out to Murphy's Reef. These data originate from previous collections by the study team which undertook this survey. Between 1991 and 2000 we sampled reefs off the Sunshine Coast and found a rich fauna of 247 species of marine sponges (Porifera), which represent a unique fauna in this biogeographic transition zone (Hooper & Kennedy, 2002).

For most sponge groups the fauna colonizing the wreck is broadly representative of natural reefs in the Mooloolaba area (although comprehensive surveys of many components of the natural biota e.g. encrusting components, have never been undertaken). Conversely, the dominant colonising fauna is not proportionally representative of the surrounding natural biota – for example no hard corals or soft corals, coralline algae etc were recorded on the wreck although these are common members of the surrounding benthic community. It is expected that a succession of other biota will occur over time through recruitment, competition for space, light etc. Given the lack of time for recruitment to the wreck, it is predicted that species diversity will increase over time, but the exact trajectories, interactions and responses to environmental factors cannot be extrapolated and require ongoing monitoring of the wreck.

Interestingly, two species of molluscs - Mediolus trailii (Purple mussel) and Pteria falcata (Sickle-sword wing oyster), as well as one species of crustacea - Synalpheus iocostata (Small snapping shrimp), were found which were previously only recorded from North to North-West and/or Western-Australia (Lamprell & Healy, 1988).

3.1.3. Preliminary Observations on Temporal Changes

A follow-up collection was undertaken in November 2006 to obtain pilot data on temporal changes in the faunal assemblages. The diversity and structure of the wreck-associated fauna showed considerable variation over a short time period from July to November 2006.

Temporal comparisons showed a lower abundance of three-dimensional bryozoan colonies and larger barnacles. By contrast, Porifera showed higher abundance and an increase in three-dimensional growth. Hard, rigid structures of lace corals could have been ripped out or broken of by high wave actions and winter storms, whereas the more flexible structures of sponges are more likely to resist physical disturbance.

Small mobile species were more numerous in November than in the July baseline

survey, indicating more recruitment with time or/and seasonal recruitment pulse. Larger cryptic animals (e.g. octopus) were also observed, indicating immigration of mature individuals from adjacent areas.

Because the assemblages on the wreck are currently in a relatively early stage of succession, its reasonable to assume that biodiversity of the assemblages will increase over time. It can, however, not be predicted at which rates the faunal diversity will increase and assemblages change. What our data show is that community composition, abundance, biomass, structural complexity and diversity of the wreck appear to change relatively rapidly. It is, however, impossible to predict the future trajectories of these changes, which will require an ongoing, biological monitoring program.

3.2. Fish

The wreck has become an important habitat for fish.

Huge numbers of fish congregate over, around and inside the ship. 150 species have been recorded, and many thousands of individuals counted (Tables 2 & 3).

Largest of these include Whitespotted Eagle Rays (Fig. 23e) that patrol in midwater around the wreck, and Blotched Fantail Rays that usually occupy deep holes created by currents swilling around the bow and stern.

Species diversity was markedly different between some sectors of the wreck, especially between the upper and lowermost parts, and the internal areas. Above and around the periphery of the wreck, assemblages consisted of very large aggregations of trevallies, fusiliers and surgeonfishes (Fig.19, 21). Near the exposed surfaces, there were large numbers of bigeyes, goatfish, damselfishes, wrasses, surgeonfishes and rabbitfish (Figs. 21-24). Internal areas were dominated by a single species of cardinalfish (Fig. 23b). Around the lower sides and near the base of the wreck trevallies, tropical snappers (Fig. 21c, 26c) and emperors were in abundance. Common commercially and recreationally important fishes included subadult Red Emperor, Grass Emperor and Redthroat Emperor, and juvenile Snapper and Maori Cod. The protected status of the wreck may lead to it supporting an increasing number of more mature individuals of these species over time. Despite an obviously large biomass on the site, species diversity is lower and assemblages differ considerably from reef habitats of the local area.

3.2.1. Species Richness and Abundance

150 fish species belonging to 43 families were recorded on the wreck (Tables 2 & 3, Appendix 1). The most speciose families

Fish recorded on the wreck in November 2006 (Photo: Ian Banks)

were damselfishes (Pomacentridae, 15 spp.), wrasses (Labridae, 13 spp.), trevallies (Carangidae, 13 spp.), butterflyfishes (Chaetodontidae, 9 spp.), surgeonfishes (Acanthuridae, 8 spp.) and tropical snappers (Lutjanidae, 8 spp.), which in combination comprised 44% of the total species pool.

Abundance was high for some species, especially bigeyes (Priacanthus spp.), Capricorn Cardinalfish (Apogon capricornis), Longnose Trevally (Carangoides

chrysophrys), fusiliers (Pterocaesio spp.), Blacksaddle Goatfish (Parupeneus spilurus), Longfin Bannerfish (Heniochus acuminatus), Black Rabbitfish (Siganus fuscescens) and two damselfish species (Chromis nitida and Neopomacentrus bankieri). Numbers of these species were estimated to be within the log5 abundance bands of 126-625 and 3126+ individuals, when recordings were taken in July (Table 2). Counts of the same species were significantly lower in November, but remained high in absolute terms.

Fishes of the families Orectolobidae (wobbegongs), Holocentridae (squirrelfishes) and Plesiopidae (prettyfins) were conspicuously absent during the surveys, but would gradually be expected to become established on the wreck through localized migration of adults, or recruitment of larvae and juveniles.

Muraenids (moray eels), scorpaenids (scorpionfishes), tripterygiids (triplefins) and gobiids (gobies) are diverse groups known to be common on reef habitats throughout the region (Appendix 1; Johnson, 1999), but were either not recorded, or represented by very few individuals. Visual recording techniques are not suitable for assessing populations of these families, as many are small and/or highly cryptic. It is therefore likely that species of these families and their abundance are significantly understated in the results.

3.2.2. Trophic Structure

Higher order predatory fish were particularly abundant (eg. Carangoides spp., Caranx spp., Seriola spp. and Lutjanus spp.), as well as plankivores (eg. Pterocaesio spp., Chromis nitida and Neopomacentrus bankieri) and herbivores (eg. Siganus fuscescens and Acanthurus spp.) around the wreck.

By contrast, the numbers of many species specialising on benthic invertebrates (eg. many labrids, such as Choerodon, Coris and Halichoeres spp., Scarus spp., Pomacanthid spp., and some Chaetodon and Pomacentrid spp.) were low, probably due to the lack of hard coral growth, and absence of complex rubbly structure in the surrounding (mostly clean sandy) substrate. Some species that are able to utilise a wider variety of invertebrate prey items, such as the labrids, Pseudolabrus guentheri and Thalassoma spp. and the pomacentrids, Pomacentrus australis and Pristotis obtusirostris were numerous. The population of Labroides dimidiatus, a specialist feeder on ectoparasites and mucus of large fishes, has benefited from the abundance of large host fishes.

Some parallels can be drawn between the trophic structure of the HMAS Brisbane fish community and that of two other large wreck sites in Queensland. The Curtin Artificial Reef, off Cowan Cowan in Moreton Bay, consists of numerous wrecks of small ships and other items sunk from 1968 in 11-30 m, on current swept sandy substrate (Wright, 1990). The ship Yongala sank in the Great Barrier Reef lagoon, off Cape Bowling Green in 1911 on sandy bottom in 16-30 m (Malcolm et al., 1999). Large numbers of similar planktivores and predatory fishes are also a feature of these wrecks, however numbers of herbivorous species (eg acanthurids and siganids) are considerably lower (Malcolm et al., 1999; Johnson, unpublished data). As may be expected on the two older wrecks, there is also a much greater proportion of mature and very large predatory fishes. As well as the suite of carangids found on the HMAS Brisbane, there are large resident serranids (especially Epinephelus lanceolatus and E. coioides) and seasonally variable aggregations of scombrids (mackerels and tunas), and Rachycentron canadus (Black Kingfish). The Yongala is unique within Australia in its assemblages of large Lutjanus species and is well known for large Caranx ignobilis (Giant Trevally) and Plectropoma spp. (coral trouts) (Malcolm et al., 1999).

3.2.3. Spatial Variation in Fish Communities

Marked spatial differences in fish species diversity and abundance were noted between some sectors of the wreck (Tables 2-3). Species richness and trophic complexity was greatest around the exposed horizontal deck surfaces (106 spp. recorded) and lowest in the heavily shaded internal areas (46 spp.). Overall fish numbers in the internal areas were dominated by large monospecific aggregations of Apogon capricornis (Capricorn Cardinalfish), and to a lesser extent, Chromis nitida (Yellowback Pullers). The area around the superstructure (82 spp.) supported smaller numbers of many of the species that were also found around the decks, and diversity appeared to be enhanced by stronger exposure to currents, and surge from surface wave

action. The presence of some horizontal (as well the predominant vertical) surfaces also added to the complexity of this habitat, complicating clear comparisons between it and other sectors of the wreck.

The vertical hull and adjacent sandy bottom sector (89 spp.) was dominated by loosely associated groups of pelagic and predatory species, particularly trevallies (Carangidae), tropical snappers (Lutjanidae) and emperors (Lethrinidae). Some fishes recorded in this sector (eg Dasyatis kuhlii, Inimicus caledonicus, platycephid spp., Pentapodus paradiseus, Choerodon cephalotes, Parapercis nebulosa and Feroxodon multistriatus) are primarily sand or low relief rubble bottom dwellers that would not be strongly associated with habitats provided by the wreck.

3.2.4. Temporal Variation

Significant temporal differences in the fish communities were observed between the two surveys. Species richness was lower in late spring (November) than in mid winter (July), with 110 versus 131 species recorded (Tables 2-3). Forty species that were recorded in July were not observed in November, but this is counterbalanced by an additional 19 new species records in November. Excluding chance encounters, where only a single individual was observed, the November species counts was still lower by 29 species while only 9 new fishes were observed.

A similar but more striking trend was noted for the abundance of most of the dominant fish species between these periods. Counts for most other species either declined or remained relatively static in November. This may indicate some emigration from the wreck since winter, and depletion of small schooling fishes through predation, thereby balancing the large July population levels that were apparently not unsustainable.

Attacks by predators Carangoides and Seriola spp. on Pterocaesio spp. and Apogon capricornis throughout all major parts of the wreck were frequently observed during the study. The relatively open nature of the wreck, where large entrances have been cut into most internal areas to improve diver safety, appears to have facilitated predatory forays by these species into the internal part of the wreck.

Some observed changes in diversity and abundance were almost certainly attributable to regular seasonal migratory patterns, rather than predator-prey relationships or other factors. In November an aggregation of large Platycephalus fuscus (Dusky Flathead) were noted, whereas the species had been entirely absent from the site in July. This species is known to migrate from estuaries and aggregate for spawning purposes in late spring, probably explaining the occurrence of large individuals at the wreck during this time. Conversely, Pagrus auratus (Snapper), a species known to aggregate in winter months, was slightly more numerous in July than in November.

Fish species diversity is expected to increase over time, especially as various sessile invertebrate communities grow, establish and become more diverse, thereby providing 'biotic structure' and potential prey items for the fishes. In the medium term, numbers of some species (eg. Capricorn Cardinalfish) may fall correspondingly, due to increasing competition and predation pressures from more diverse assemblages. Notably, few if any large resident serranids and orectolobids (gropers, rockcods, wobbegongs), that are typical of large established wrecks, are currently present. These will almost certainly move in over time, either as migrating adults or recruiting juveniles. Juveniles of several species of Epinephelus were recorded, indicating that the level of recruitment is strong.

3.2.5. Comparisons with Nearby Natural Reefs

Visual techniques present limitations in recording fish biodiversity, as numerous small cryptic species are usually overlooked, and accurate identification is difficult for some species, even by the most skilled observers. Nonetheless, these techniques provide rapid results through non-destructive means, are accurate for the more conspicuous species that they are primarily intended to assess, and may readily be duplicated in the future by suitably qualified observers.

Hence, the inventory of 150 fish species recorded in this study by visual census is considerable, compared to the 309 marine subtidal fish species recorded between Noosa Heads and Caloundra from a combination of collections and incidental visual observations in 1-35 m depth from 1970-1999 (Queensland Museum

specimen records; Johnson unpublished data: Appendix 1).

No adequate studies of Sunshine Coast reef fishes have been completed using visual census techniques alone, so detailed comparisons between fish communities recorded on the wreck of the HMAS Brisbane and local reefs are problematic, and the following comments are of a general nature only. Some groups and numerous species commonly found on local reefs are at this time largely absent from the wreck (eg holocentrids, pempherids and scorpaenids and some pomacentrids, chaetodontids and labrids). Fish biomass on the wreck was markedly greater than what would normally be expected for similar-sized natural reefs in the area, with unusually large concentrations of herbivores (especially Si ganus fuscescens), planktivores (Pterocaesio spp. and Chromis nitida) and higher order predators (eg Carangoides spp., Caranx spp. and Lutjanus spp.). Nearby reef systems are generally populated by far fewer numbers of individuals, but are characterised by higher species diversity overall. Carangid and caesionid species were generally over-represented on the wreck, whilst pomacentrids and labrids were significantly under-represented. No unusual species were recorded, however the record of Epinephelus areolatus (Yellowspotted Rockcod; Fig. 19f) represents a southern extension to its known range. Additional research is required to more fully elucidate fish diversity on local natural reefs and to contrast this with evolving changes to the fauna on the wreck over time.

3.3. Encrusting Biota ('Fouling Assemblages')

A diverse assemblage of sessile, encrusting invertebrates occupied a large proportion of the surface of the Ex-HMAS Brisbane. The fouling communities were dominated by barnacles (Balanus spp.) and bivalves, with less abundant taxa including bryozoans, sponges, polychaetes and ascidians. The diversity and abundance of species varied significantly with depth, surface orientation and whether the assemblage was inside or outside the wreck (Figs. 27 & 28).

3.3.1. Variation with Exposure and Depth

Due the predominant southeast direction of currents, swell and wave action, we expected that there would be variation in the assemblages between the port and starboard sides of the wreck, due to variation in larval supply and physical disturbance (Cummings, 1994; Svane & Petersen, 2001). The assemblages on the starboard (exposed) and port (sheltered) sides of the wreck had similar total coverage of sessile fauna (Fig. 29).

However, there were substantial differences in the types of species present and the proportion of space occupied by each species on different sides of the wreck. The species density (number of species per 625 cm2) was significantly reduced on the port side of the wreck compared with the starboard side (Table 3; Fig. 30a), and both the coverage and species density decreased sharply between 18 m and 23 m on both sides of the wreck (Fig. 29a).

Multivariate analysis of the mean composition and coverage of the assemblages per transect, showed that there was a highly significant variation between the different depths (ANOSIM, R=0.497, p=0.001), with no overall difference between the port and starboard sides of the wreck (ANOSIM R=0.065, p=0.37). Three species (Balanus sp.1, Schizoporella sp.1, Pictata maculata) accounted for approximately 75% of the biotic differences between the three depth bands on the port and starboard sides of the wreck (SIMPER; Fig. 31a)

The significant decrease of species richness, density and coverage at 23 m can be attributed primarily to residual 'antifouling' paint on the hull of the wreck, which can retard the settlement of sessile species (Svane et al., 2006).

The vertical surfaces at 23 m may also be subjected to increased sand scour compared with shallower transects at 12 m and 18 m, due to their proximity to the sandy bottom. Sand scouring has been shown to reduce the survival of sessile species, both through direct abrasion and smothering (Sousa, 1979). Given the substantial coverage of sessile invertebrates at the shallower depths, it is unlikely that the reduced coverage of species at 23 m is due to a lack of larval supply, though this aspect would require further study to ascertain rates of settlement and recruitment at this depth.

Barnacles (primarily Balanus sp. 1) dominated the sessile assemblages on the vertical sides of the wreck at all depths.

The coverage of barnacles on the wreck was significantly influenced by both depth and exposure, with a large increase in coverage on the port side of the wreck at 18 m (Table 4; Fig. 32a). The coverage of barnacles was significantly reduced at 23 m and was quite variable, primarily restricted to small patches surrounded by bare metal, but coverage of barnacles remained higher than that of any other taxonomic group.

Bryozoans also contributed significantly to the total coverage of sessile species and, like the barnacles, there was a significant interaction between depth and exposure (Table 4). Bryozoans occurred primarily at 18 m, and they covered twice the amount of space on the starboard side of the wreck compared with the port side. A similar pattern was also seen for sponges (Porifera), with a significant increase in coverage on the starboard side of the wreck, particularly at 18 m depth (Table 4; Fig. 33a).

The large increase in coverage of these species indicates that they may have settled earlier than those on the port side of the wreck, which increased the length of time for growth, or that larval supply primarily occurs on the starboard side of the wreck, as we predicted (Cummings, 1994; Svane & Petersen, 2001). Survivorship may also differ between the two sides of the wreck because of hydrological factors such as the direction of storms and prevailing currents (Cummings, 1994; Svane & Petersen, 2001). Unlike barnacles, which have a long planktotrophic larval stage (Pechenik, 1999), many colonial invertebrates such as bryozoans, sponges and ascidians brood their larvae, which results in a short dispersal distance (e.g. sponges do not have a pelagic larva), and a non-feeding larval phase (Uriz, et al., 1998; Maldonado & Bergquist, 2002; Maldonado, 2006). When spawned, some larvae have a limited amount of time and resources in which to respond to settlement queues (Marshall et al., 2003). Larvae, carried in the predominant southeast water currents, may settle when they reach the first appropriate settlement surface (the starboard side of the wreck), potentially decreasing the larval supply to the port side of the wreck. Likewise the different sides of the wreck may have different source populations, with larval supply and recruitment depending on the direction of prevailing currents. More work is necessary to understand the importance of larval supply, settlement and recruitment for sessile encrusting organisms like bryozoans and poriferans on this wreck, and for connectivity between the artificial reefs and surrounding natural populations in general.

Bivalve molluscs were mainly present on vertical surfaces at 12 m, covering between 10 – 18% of the available surface area (Fig. 34a). There was a significant effect of depth on the distribution and coverage of bivalves, with a large decline in coverage at 18 m and bivalves were absent at 23 m (Table 4). Unlike the bryozoans and poriferans, bivalves covered more space on the port side of the wreck at 12 m, although this was not a significant difference (Table 4). Bivalve molluscs such as P. maculata have a hard outer shell and attach strongly to the substrate (Dame, 1996), which could increase their resistance to physical disturbance from wave action. At 12 m, the predominant southeast swell and wave direction may increase the level of physical disturbance on the starboard side of the wreck, which could alter survival rates of other less robust species, decreasing competition and allowing the bivalves to occupy more space.

We also examined the amount of space occupied by algae and found that there was a significant effect of depth, with higher coverage at 12 m, decreasing with depth (Table 4; Fig 35a). This result is most likely to be due to the decreasing levels of light at the deeper sites. At 18 m there was a decrease in coverage of algae and an increase in the coverage of sessile fauna. This could indicate that competition for space is occurring between algae and sessile fauna at shallower depths (Underwood & Anderson, 1994). More work is necessary to determine whether the patterns of sessile species shown are due to variation in larval supply and recruitment, physical disturbance or competition from photophilic organisms, such as algae.

3.3.2. Vertical versus Horizontal Surfaces

The main comparison between vertical and horizontal surfaces was done at 18 m and 12 m depth, due to constraints on the availability of suitable horizontal habitat at other depths. We compared vertical surfaces on the port and starboard sides of the wreck with horizontal surfaces on the main and upper decks of the wreck. Overall, there was a large decrease in the coverage of sessile fauna from vertical to horizontal surfaces at both depths, with a reduction in total sessile coverage of 50% at 12 m, and 70% at 18 m (Table 5; Fig. 29b).

Species density was also significantly reduced on the horizontal surfaces (Table 5; Fig. 30b). Balanus sp. 1 and Pinctada maculata dominated the horizontal sites, the only other species found on the horizontal surfaces were a bryozoan and a sponge. By contrast, total species richness was markedly higher on vertical surfaces with an average of 11 taxa on the port side and 14 taxa on the starboard side of the wreck at both depths.

Multivariate analysis of the mean composition and coverage of the assemblages per transect, showed that there was a highly significant variation between vertical and horizontal orientations (ANOSIM, R=0.918, p=0.002), and between 12 m and 18 m depth (ANOSIM R=0.413, p=0.012). Three species (Balanus sp.1, Schizoporella sp.1, Pictata maculata) accounted for more than 80% of the biotic differences between the horizontal and vertical surfaces and different depths (SIMPER; Fig. 31b)

The coverage of Balanus sp. 1, which contributed over 48% of the total coverage on vertical surfaces, was dramatically reduced on the horizontal surfaces compared with the vertical surfaces (Table 6; Fig. 32b). This could have been due to competitive exclusion from bivalve molluscs, which showed a dramatic increase in coverage between vertical and horizontal surfaces of 96% at 12 m, and a 724% increase at 18 m (Fig. 34b). Other taxonomic groups (Porifera, Bryozoa, Polychaeta and Ascidiacea) were either extremely low in coverage or absent from the horizontal surfaces (Figs. 33b, 36b-38b).

Algal coverage declined irrespective of surface orientations with depth. This was particularly pronounced on the horizontal surfaces at 18 m where coverage was reduced to approximately 2% (Fig. 35b). The strong depth effect is likely to be due to light attenuation with increasing depth.

We found that sediment did not accumulate on the vertical surfaces of the wreck but contributed to over 60% of the coverage of quadrats on the horizontal surfaces. It is thus likely that the difference in sessile invertebrate and algal coverage between horizontal and vertical surfaces was due to smothering by sediment on the horizontal surfaces (Sousa 1979).

3.3.3. Inside versus Outside Areas of the Wreck

To determine how the composition of the sessile fauna differed between vertical surfaces on the inside and outside of the wreck, we compared vertical surfaces outside (port and starboard) with corresponding vertical surfaces inside the wreck at 18 m depth. We expected that sites inside the wreck would have decreased coverage, compared with sites on the outside of the wreck, due to decreased water flow and larval supply. In fact, there was a 49% decrease in the coverage, and 30% decrease in the species density of sessile invertebrates on the vertical surfaces inside the wreck compared with areas on the outside (Table. 7; Fig. 29c & 30c).

Multivariate analysis of the mean composition and coverage of the assemblages per transect, showed that there was a highly significant variation between the assemblages on vertical surfaces inside and outside the wreck (ANOSIM, R=0.852, p=0.012. Three species (Balanus sp.1, Schizoporella sp.1, Filograna implexa) accounted for 79% of the biotic differences between the inside and outside (SIMPER; Fig. 31c).

The majority of taxonomic groups sampled (Barnacles, Bryozoa, Bivalvia, and Porifera) had significantly higher coverage on the outside of the wreck compared with the inside (Table 8; Figs. 32c-34c & 37c). Polychaetes were the exception, with coverage increasing from 1% on the outside to 15% on the inside of the wreck (Fig. 36c). The dominant species in this group was Filograna implexa. This tube dwelling serpulid polychaete can form large, dense colonies through asexual reproduction (Rouse & Pleijel, 2001). Sites that were inside the wreck were largely covered by F. implexa and another sabellid polychaete species. A decrease in the level of physical disturbance inside the wreck may have resulted in decreased physical damage of these colonial polychaetes, allowing the delicate colonies to grow and occupy greater than 30 % of the available space in some quadrats.

4. Recommendations

A number of factors contribute towards making the ex-HMAS Brisbane an important asset of South-East Queensland:

(1) considerable investment by the State Government in creating the artificial reef

the of the ex-HMAS Brisbane,

(2) ongoing commitment of resources by EPA/QPWS in maintaining and enforcing the conservation area around the wreck,

(3) measurable benefits for the local/ regional tourism industry from the wreck, particularly through dive tourism, and

(4) high-profile public interest in the ship and cultural heritage values associated with an ex Australian navy ship.

Given the importance of the wreck for the above reasons, the ecological features of the site need to be more comprehensively assessed to complement the range of socio-economic values that are already associated with the wreck.

This report shows conclusively that the wreck is currently in the process of becoming an artificial reef that can support a range of biodiversity that may have the potential to contribute significantly towards the overall diversity of the nearshore zone in the region.

The scope of this study was, however, limited to a baseline survey only, and thus a series of future, scientific investigations on the biological processes on the wreck are required. Furthermore, the ecological features of the wreck are currently not adequately communicated, requiring a comprehensive education and outreach programme.

Therefore, the following three key-recommendation are made:

Recommendation 1:

Establish and resource a scientific monitoring programme that quantifies the rate of change of the biological assemblages on the ship wreck over a minimum time frame of 3 years.

Colonization of the wreck

In addition to its socio-economic value as a highly attractive dive destination, the wreck is predicted to play a significant role as a valuable habitat addition to the nearshore marine zone in supporting a diverse assemblage of invertebrates and fish. Indeed, the this first baseline survey undertaken by the University of the Sunshine Coast and the Queensland Museum in 2006 has documented 103 species of invertebrates and 150 species of fish associated with the wreck.

This baseline survey represents a basic reference point against which future colonization of the wreck by marine life can be benchmarked. It can be argued that the current state of colonization of the wreck represents a relatively early stage in the ecological succession of the wreck-associated assemblages, and that biodiversity of the wreck fauna will increase over time. These are merely simple predictions based on experience from artificial reefs and wreck in other locations, but the actual trajectories and dynamics of any further colonization on the ex-HMAS Brisbane can only be determined through continued ecological monitoring of the wreck-fauna. Thus, a continued monitoring programme need to be funded to quantity the nature and dynamics of biological colonization processes on the wreck over the next three years.

Diversity of encrusting marine invertebrates colonizing the wreck by July 2006 (Photo: MA Schlacher, USC/ QM)

Stenopus hispidus (banded coral shrimp) recorded on the ex-HMAS Brisbane (Photo: MA Schlacher, USC/QM)

Recommendation 2

Establish and finance studies that document that ecological value of the wreck in terms of creating essential habitats that enhance the biodiversity of the marine ecosystem complex in the vicinity of the wreck site.

Wrecks as essential habitats

A prime argument for the scuttling of ships to create artificial reefs is that these structures provide essential habitat for fish and invertebrates. Thus, 'habitat value' is frequently cited as a crucial benefit of artificial reefs.

The initial results from the baseline survey indicate that although the wreck of the ex-HMAS Brisbane does currently support a diversity of biota, the diversity of the wreck-associated fauna remains lower compared to natural reefs in the area.

Therefore, the ecological value of the wreck in terms of the provision of a structurally complex habitat in the nearshore marine zone is probably not yet fully realised. Thus, the second key recommendation is to determine the ecological habitat value of the wreck as part of the larger complex of benthic habitat mosaics in the area.

Bluestriped Fang-blenny (*Plagiotremus rhinorhynchus*) recorded on the wreck in July 2006 (Photo: MA Schlacher, USC/ QM)

Recommendation 3

Undertake the development and implementation of a public outreach programme that delivers high-quality and comprehensive information and education content about the ecological features of the wreck to a wide range of audiences.

Public education and outreach

While the wreck is visited by a large number of divers, there is very little information available on the ecological features of the site. Furthermore, the general public can currently not readily access information about this artificial reef, and many visitors to the Sunshine Coast are unaware about this important marine asset.

Therefore, a central component of future project is an interactive communication strategy that will:

a) centralise information about the wreck in a single hub,

b) link this project closely with stakeholder groups and the general public by providing regular and scientifically robust information about the fauna associated with the wreck,

c) educate divers about the diversity of the wreck-associated fauna and its value as a habitat, and

d) provide easy web-based access to all information about the site.

Key products developed and produced by us will include:

An "ex-HMAS Brisbane website" (inclusive of hosting for the duration of the project),

i) regular newsletters (2 issues per year) containing updates about ecological processes on the wreck aimed at the diving community (input will also be sought from other stakeholders),

ii) education of site visitors through information sheets, posters and hands-on training workshops on marine life, and

iii) regular press releases informing the general public about progress on the wreck.

6. Acknowledgments

We greatly appreciate the input of Ian Banks (Diving the Gold Coast) for assisting us in our fish survey by taking high quality fish images in situ and providing us with his excellent photo material.

Ian McKinnon and his team (Scuba World) are thanked for the professional dive logistics that made field sampling very efficient in this short period of time.

We appreciated the participation in field work and help with collection logistics of the Museum Collection manager, Merrick Ekins.

Peter Davie and Darryl Potter are warmly thanked for helping with Crustacean and Mollusc taxonomy.

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the wreck at 18 metres.

Fig. 31. nMDS plots of the sessile invertebrate assemblages on the ex-HMAS Brisbane, showing the mean value for each transect (n = 15 quadrats). a) on the Port and Starboard sides of the wreck at different depths (12, 18 & 23 metres) (stress = 0.05). b) on vertical and horizontal surfaces at 12 and 18 metres depth (stress = 0.04). c) on vertical surfaces inside and outside the wreck at 18 metres (stress = 0.01).

Fig. 32. Mean percent coverage of Barnacles (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 23 m = Starboard 23 m < Port 12 m = Starboard 12 m = Starboard 18 m < Port 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 33. Mean percent coverage of Bryozoans (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 12 m = Port 23 m = Starboard 12 m = Starboard 23 m < Port 18 m < Starboard 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 12m = Horizontal 18 m = Vertical 12 m < Vertical 18 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 34. Mean percent coverage of Bivalves (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 35. Mean percent coverage of algae (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 18 m < Vertical 18 m < Vertical 12 m < Horizontal 12 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 36. Mean percent coverage of Polychaetes (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 37. Mean percent coverage of Poriferans (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 12 m = Port 18 m = Port 23 m = Starboard 23 m < Starboard 12 m < Starboard 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Fig. 38. Mean percent coverage of Ascidians (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres. 99

Table 1. Ex-HMAS BRISBANE: SPECIES LIST- Algae and Invertebrates

ALGAE:

Peyssonnelia capensis (Encrusting redalgae, orange; Fig. 7.a)

Coraline redalgae (Encrusting, pink; Fig. 7 b)

WORMS:

Filograna implexa (Fan worm; Fig. 7.c)

Sabellastarte indica (Fan worm)

Nereididae sp. (Polychaete worm)

Stylochidae sp. (Polyclad flatworm)

PORIFERA:

Mycale (Mycale) sp. 1566 (Thickly encrusting, soft, pink in situ, bright red on deck; Fig. 7.d)

Dactylia sp. 1823 (Massive, pink in situ, bright red on deck; Fig. 7.e)

Batzella sp.4215 (Yellow, massive with oscules; Fig. 7.f)

Callyspongia sp. 456 (Grey, thickly encrusting with raised oscules and short tubes; Fig. 8.a)

Clathrina sp. 519 (Calcarea, cushion – mass of anastomozing tubes; Fig. 8.b)

Grantiopsis sp. 1582 (Calcarea, white tubes; Fig. 8.c)

Siphonochalina deficiens ('Beautiful' sponge, tubular; Fig. 8.d)

Aplysilla sulfurea (Thickly encrusting, green-yellow; Fig. 8.e)

Cliona sp. 4216 (Thinly encrusting, yellow, from 25m; Fig. 8.f)

Batzella sp. 4217 (Thickly encrusting, soft, red in situ and on deck, with oscules; Fig. 9.a)

Batzella sp. 2175 (Red, encrusting, slimy; Fig. 9.b)

Haliclona (Haliclona) sp. 3573 (Encrusting, red-orange-pink-purple, very slimy; Fig. 9.c)

Chondropsis sp. 4218 (Light pink, fluffy, encrusting on shells; Fig. 9.d)

Crella sp. (Orange, massive with round oscules; Fig. 9.e)

Dysidea sp. (Grey, thinly encrusting; Fig. 9.f)

Cribrochalina sp. 2666 (Grey, short tubes to cushions with big oscules)

Hymedesma sp. 4326 (Yellow, thickly encrusting)

Chondropsis sp. 4332 (Beige-yellow-pinkish, encrusting)

Callyspongia (C) sp. 3491 (Orange, basal mass with smooth and conulose tubes)

Dysidea sp. 4327 (Beige cushion)

Callyspongia (C) sp.4328 (Blue-grey, massive with big oscules)

Batzella sp. 4329 (Purple, encrusting)

Callyspongia (C) sp.4330 (Beige, massive)

Chondropsis sp. 4331 (Bluish-grey, conulose with big oscules)

CNIDARIA:

Hydroidea sp. 1 (Fluffy bushes at 27m; Fig. 10.a)

Macrorhynchia philippina (White stinging sea fir; Fig. 10.b)

Plumularia sp. 1 (Delicate sea plumes; Fig. 10.c,d)

Macrorhynchia phoenicea (Brown sea fir; Fig. 10.e)

Anemones sp. (Fig. 10.f)

MOLLUSCA:

Dendostrea folium (Leaf oyster; Fig. 11.a)

Pictada maculata (Spotted pearl oyster; Fig. 11.b,c)

Pteria penguin (Pinguin wing oyster; Fig. 11.d)

Pteria coturnix (Quail wing oyster)

Pteria lata (Red wing oyster)

Pteria falcata (Sickle-sword wing oyster)

Pteria brevialata (Short-winged wing oyster)

Chama fibula (Brooch jewel-box clam Fig. 11.f)

Hiatella australis (Australian rock-borer clam)

Cymatium parthenopium (Broad-ribbed triton Fig. 11.e)

Scaeochlamys livida (Scaly scallop)

Tugali parmophoidea (Flat slit-limpet)

Cronia aurantiaca (Almond rock-whelk)

Mediolus trailii (Purple mussel)

Hexabranchus sanguineus (Spanish dancer)

Octopus cf. cyanea (Day octopus)

Octopus sp.

CRUSTACEA:

Megabalanus tintinnabulum (Bell barnacle; Fig. 12.a,b)

Balanus sp. 1 (Fig. 12.c)

Balanus amphitrite (Purple acorn barnacle)

Megabalanus trigonus (Triangular acorn barnacle)

Lepas anserifera (Goose barnacle)

Panulirus versicolor (Painted spiny lobster; Fig. 12.d,e)

Stenopus hispidus (Banded coral shrimp; Fig. 12.f)

Leptograpsus variegates (Purple footed shore crab; Fig. 12.f)

Pachycheles sp. orange (Porcelaine crab)

Petrolisthes sp. spiny (Porcelaine crab)

Pilumnus sp. spiny (Xanthid crab)

Caprellid sp. (Skeleton shrimp)

Heteropanope sp. (Hairy crab)

Thacanophrys sp. (Pink spider crab)

Pilumnus sp. (Red hairy crab)

Ancylocheles gravelei (Brown-spotted porcelain crab)

Percnon planissimum (Sally lightfood crab)

Alpheid sp. (Lace coral snapping shrimp)

Alpheus sp. (Orange-tailed snapping shrimp)

Periclimenes sp. (Lace coral shrimp)

Palaemon sp. (Shrimp)

Synalpheus iocostata (Small snapping shrimp)

Galathea sp. (Spiny squat lobster)

Gammaridea sp. (Amphipod)

Amphipod sp.

BRYOZOA:

Biflustra sp. 1 (Pink-green, encrusting; Fig. 13.a)

Celleporaria sp. 1 (Blue, encrusting; Fig. 13.b)

Biflustra sp. 2 (Grey-pinkish, massive; Fig. 13.c)

Membranipora savertii (White-grey, looks like a branched, flat coral; Fig. 13.d)

Reteporella graeffei (Phidoloporidae, orange, mesh-like; Fig. 13.e)

Triphillozoon sp. 1 (Phidoloporidae, white, mesh-like; Fig. 13.f)

Schizoporella sp. 1 (Encrusting, black-brown-purple; Fig. 14.a)

Bryozoa 1 (White, branched, globular, mesh-like; Fig. 14. b)

Bryozoa 2 (Flat, Halimeda-like; Fig. 14.c)

ECHINODERMATA:

Temnopleurus sp. (White seaurchin with purple spines; Fig. 14.d)

Cenolia sp. (Black feather star Fig. 14.e)

Diadema setosum (Black sea urchin; Fig. 14.f)

Ophiuroidea sp. (Small brittle star)

ASCIDIACEA:

Phallusia obesa (White with black- blue spots, solitary Fig. 15.a)

Phallusia julinea (Little, bright yellow transparent Fig. 15.b)

Cnemidocarpa stolonifera (White-red mottled, solitary Fig. 15.c)

Phallusia millari (White, big, shiny, solitary Fig. 15.d)

Phallusia millari (White, big, warty, solitary Fig. 15.e)

Polycarpa ovata (Orange Fig. 15.f)

Microcosmus exasperatus (Orange or white with orange parts in situ Fig. 16.a)

Rhopalaea crassa (Transparent, solitary Fig. 16.b)

Pyura stolinifera (Brown to blue, orange inside, solitary; Fig. 15.g, Fig. 16.c)

Symplegma brakenhielmi (Grey-pinkish, colonial; Fig. 16.d)

Eusynstyela latericius (Bright purple, colonial; Fig. 16.e)

Ascidia archaia (Transparent, small, in clumps, solitary; Fig. 16.f)

Polyclinum vasculosum (Black, massive, colonial)

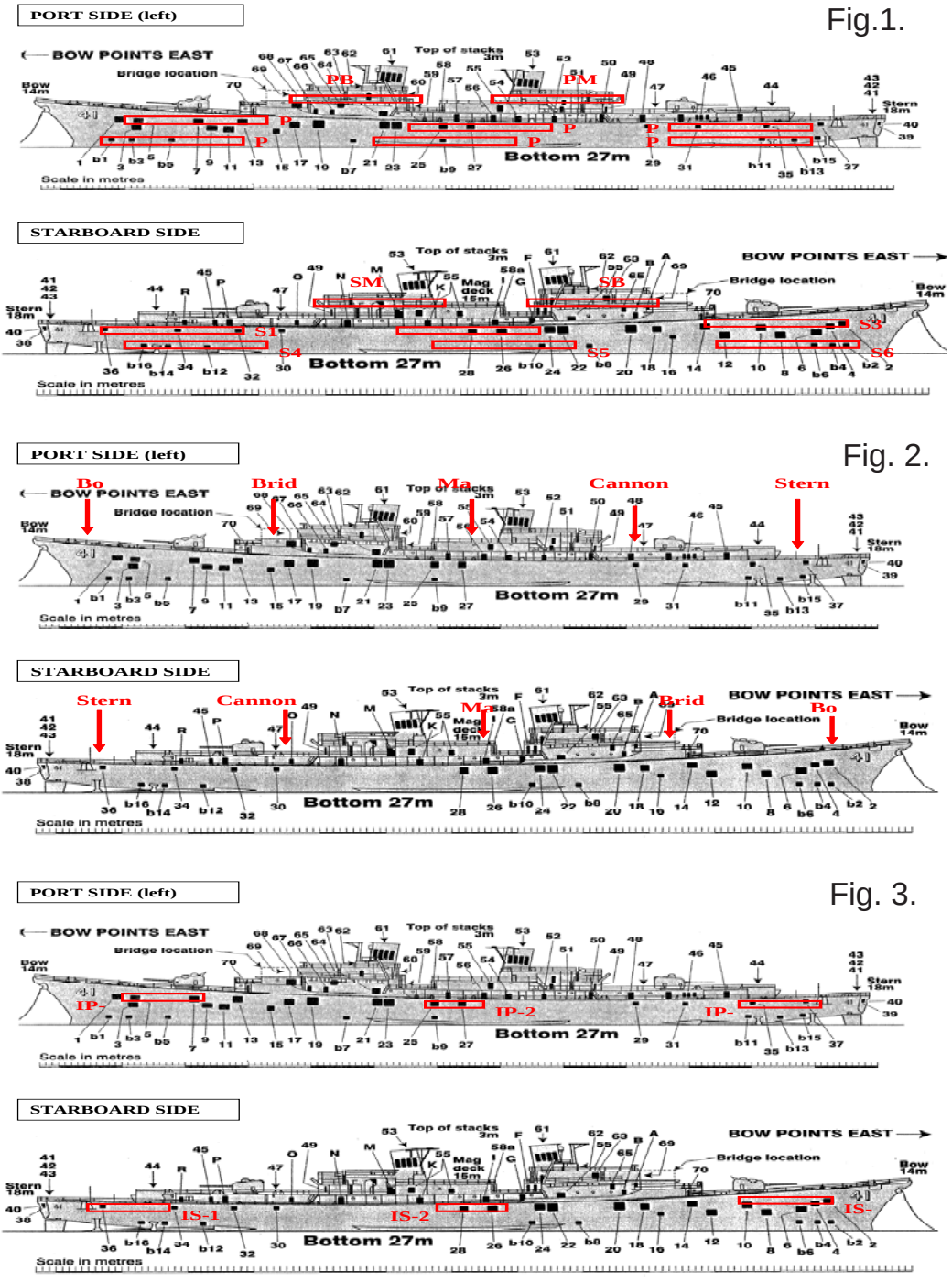


Fig.1.

Fig. 2.

Fig. 3.

Fig. 1 Position of sampling on the vertical sides of the ship at three depth bands.

Fig. 2 Position of horizontal surface sectors sampled for fouling communities

Fig. 3 Position of sampling sites for fouling communities on the inside of the ship

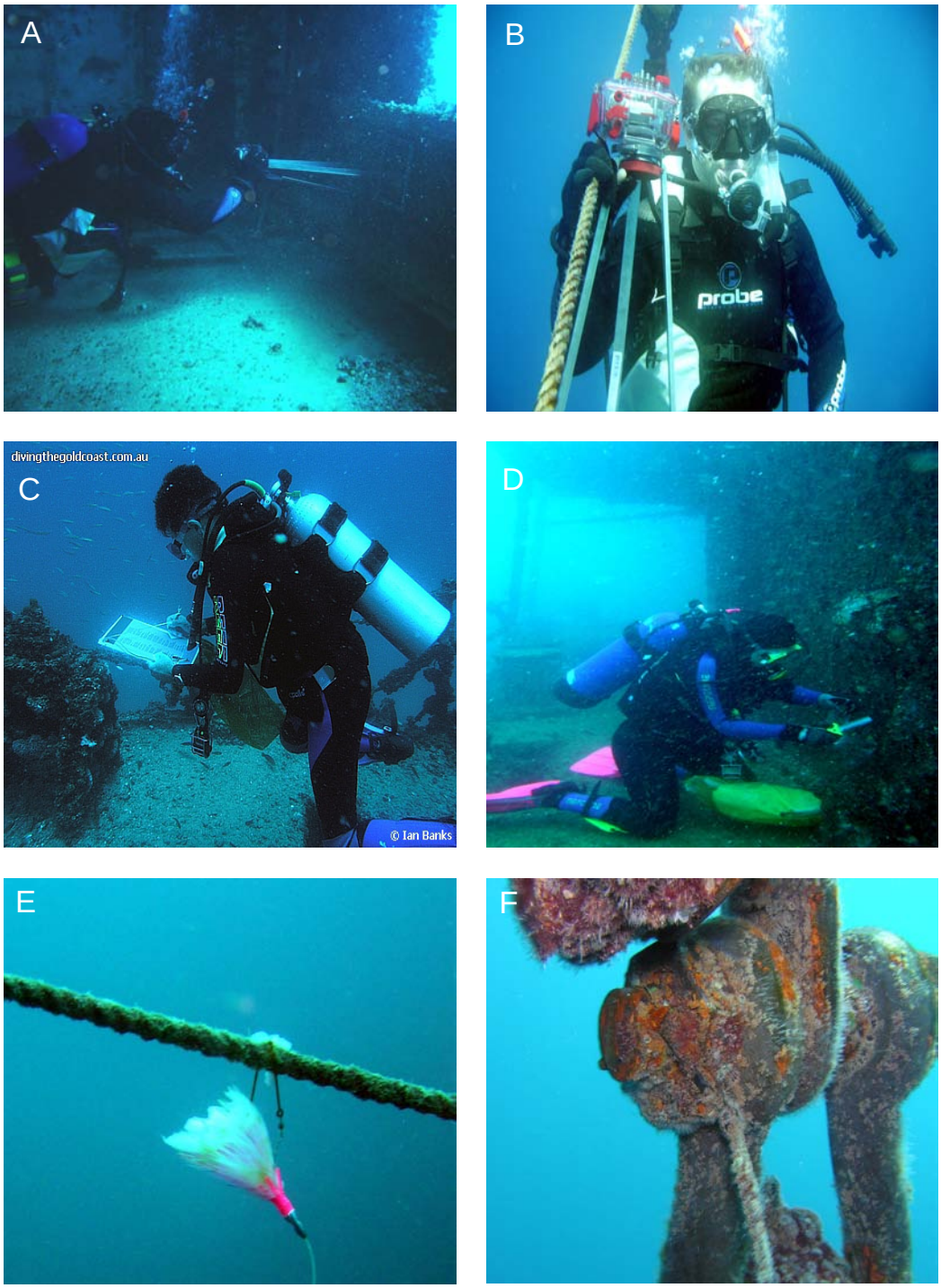


Fig. 4. a) photo transects sampling b) transect camera c) visual recording d) physical sampling e) illegal fishing f) mooring line

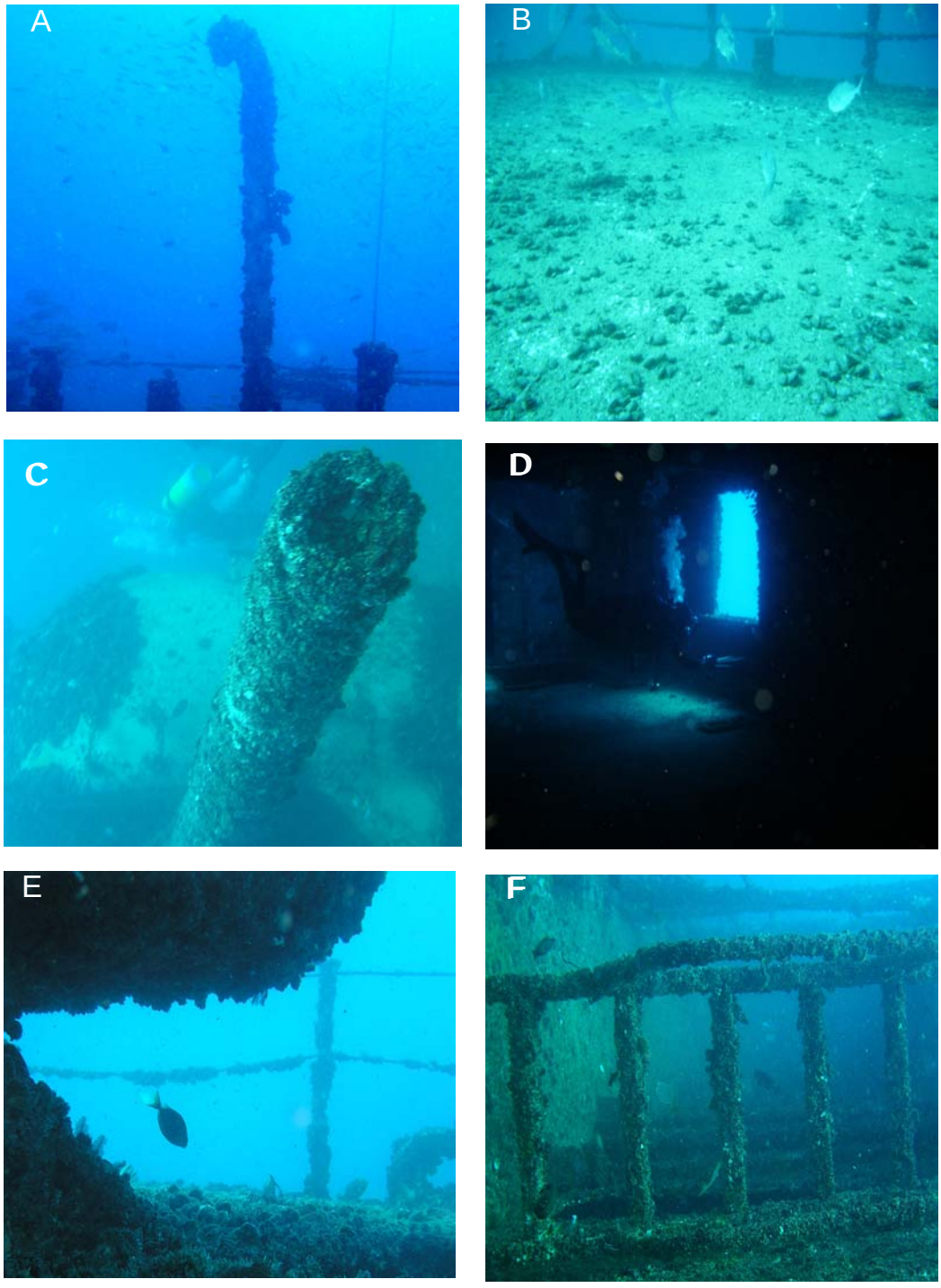


Fig. 5. a) bow b) deck c) cannon d) inside the wreck e) superstructure f) additional structures.

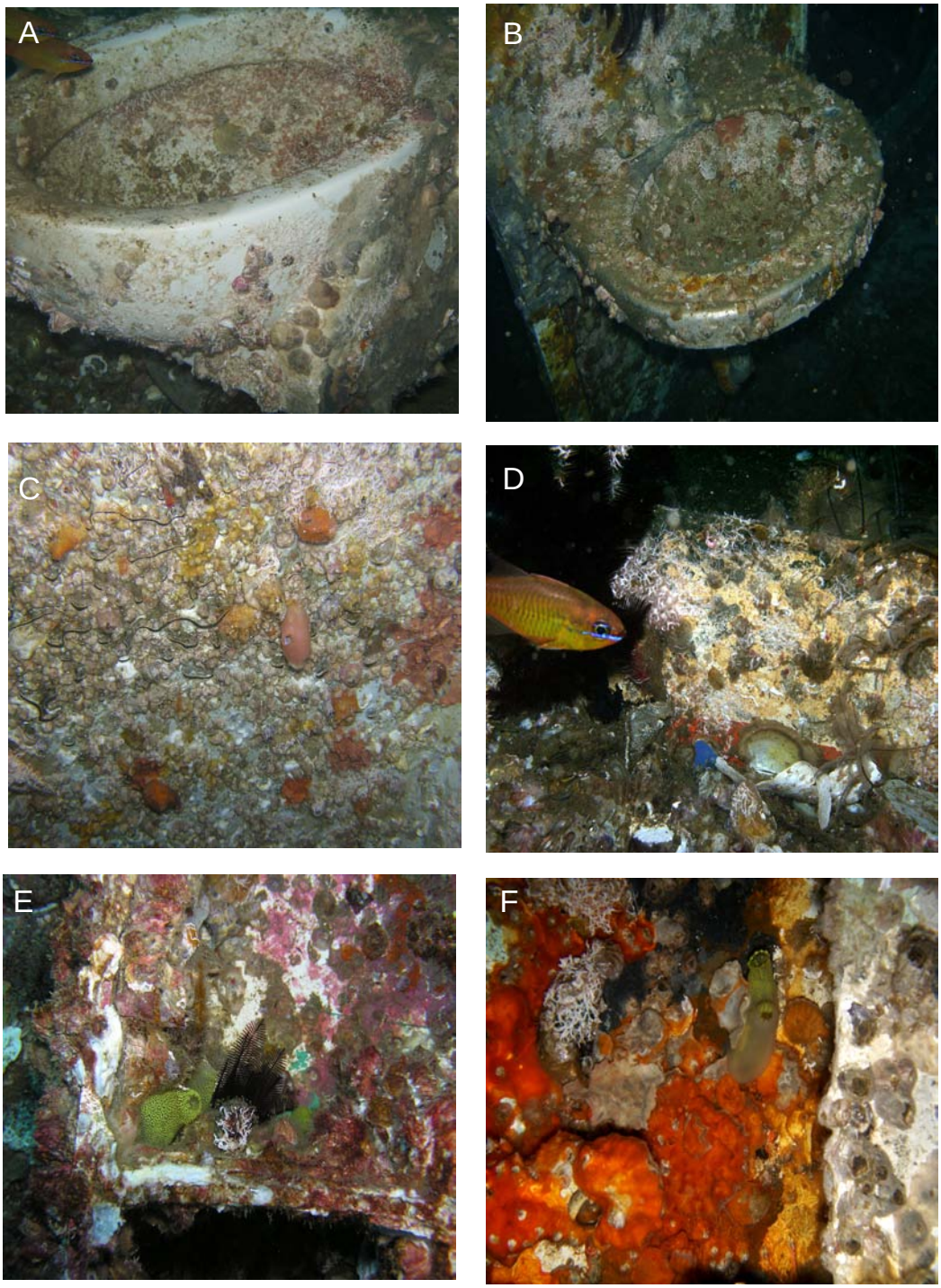


Fig. 6. a) encrusted toilet b) encrusted basin c) walls under the superstructures d) inside the wreck e) biodiversity in a funnel f) biodiversity in another funnel.

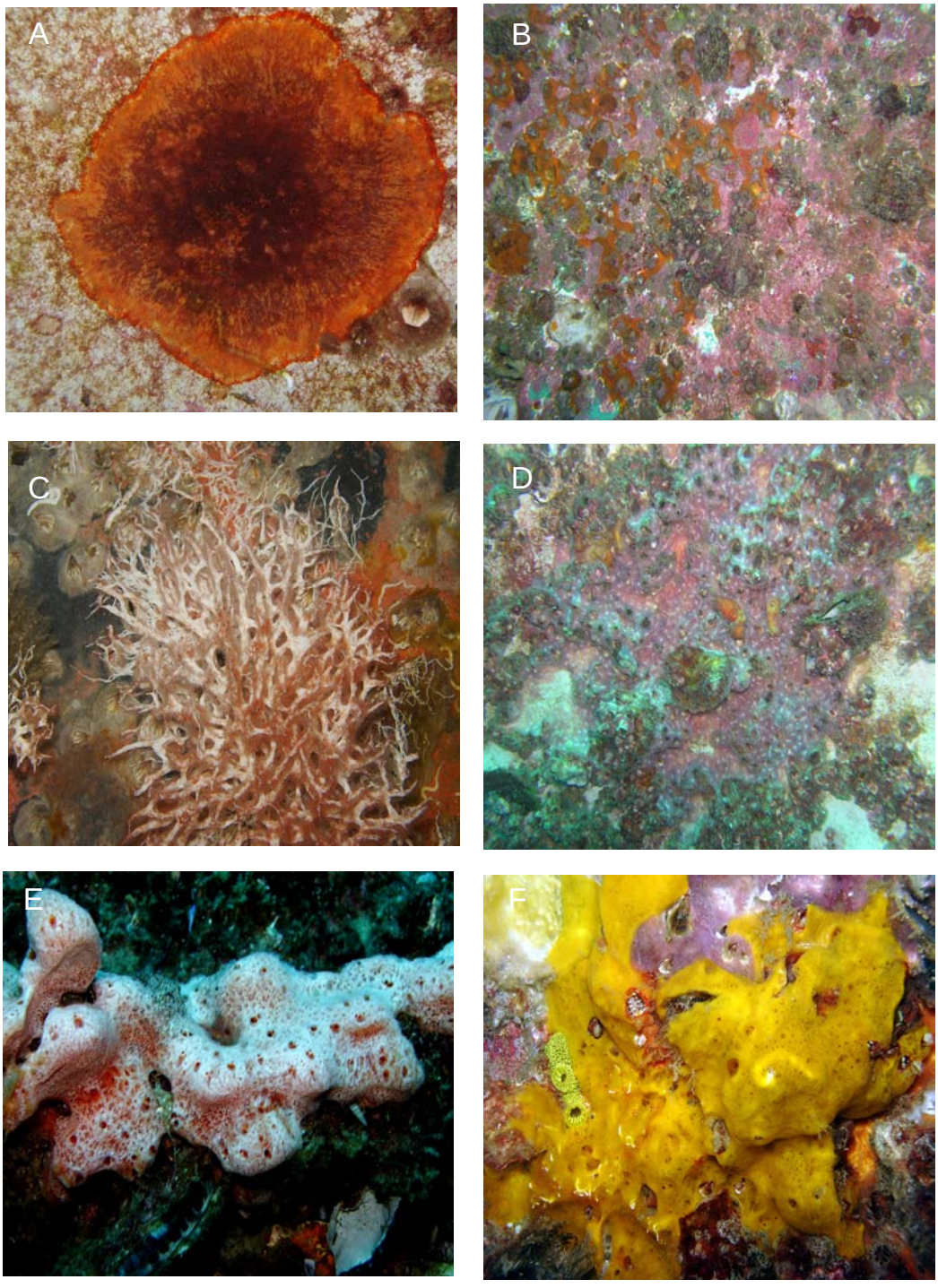


Fig. 7. a) Peyssonnelia capensis b) Coraline redalgae c) Filograna implexa d) Mycale (Mycale) sp. 1566 e) Dactylia sp. 1823 f) Batzella sp. 4215

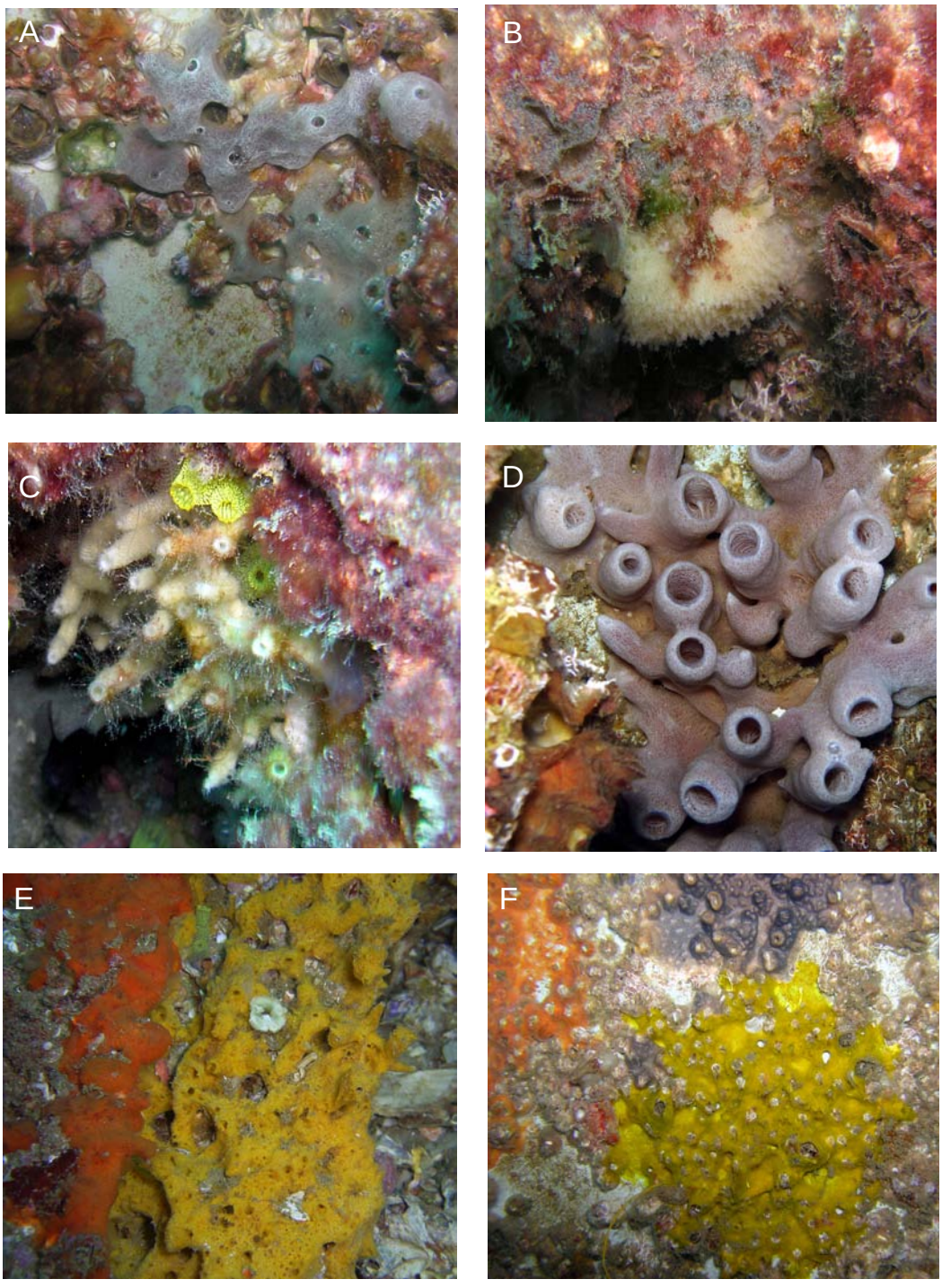


Fig. 8. a) Callyspongia sp. 456 b) Clathrina sp. 519 1c) Grantiopsis sp. 1582 d) Siphonochalina deficiens e) Aplysilla sulfurea f) Cliona sp. 4216

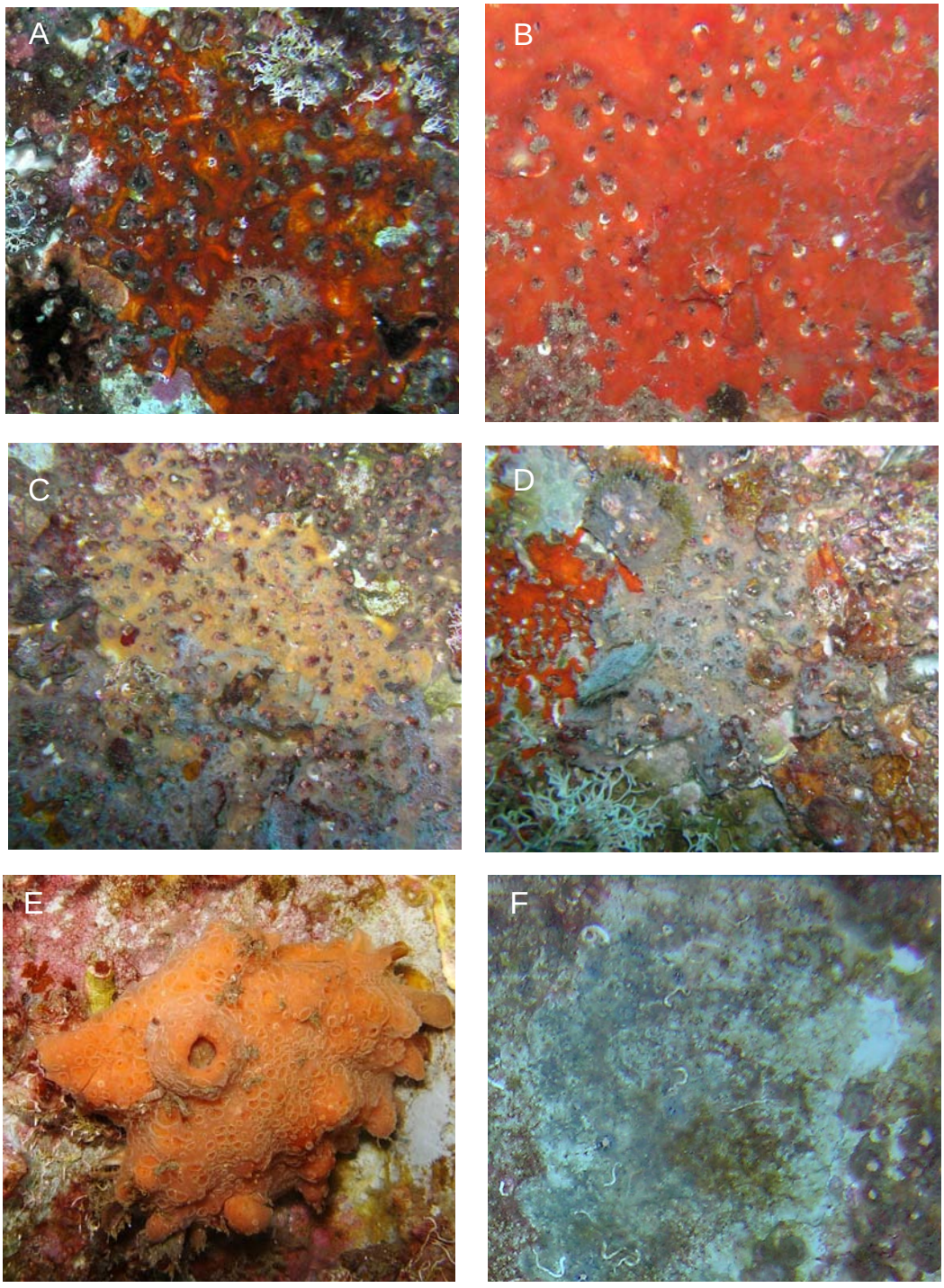


Fig. 9. a) Cliona sp. 4217 b) Batzella sp. 2175 c) Chondropsis sp. 4218 d) Haliclona (Haliclona) sp. 3573 e) Crella sp. f) Dysidea sp.

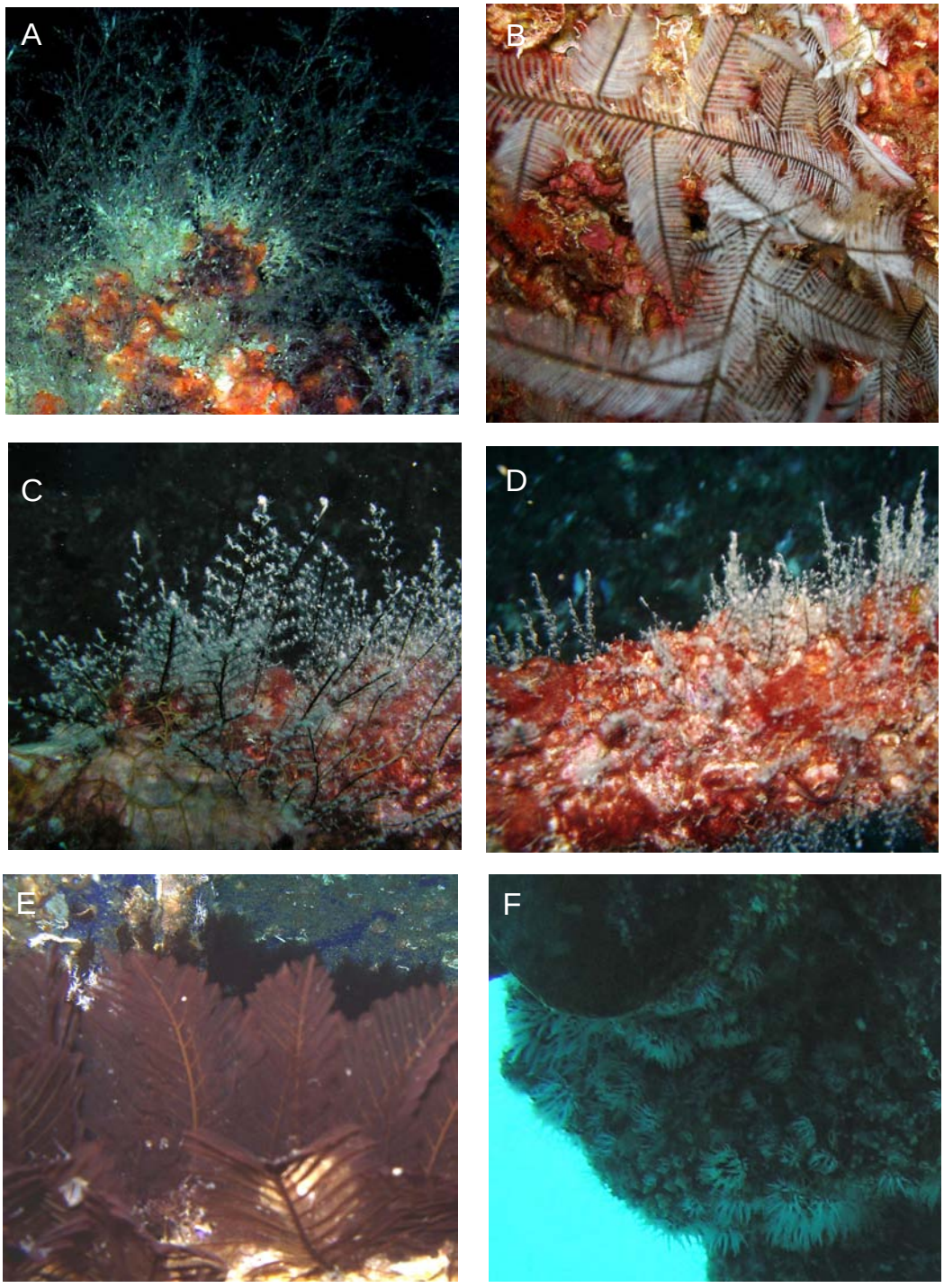


Fig. 10. a) Hydroidea sp. 1 b) Macrorhynchia philippina c, d) Plumularia sp. 1 e) Macrorhynchia phoenicea f) Anemones sp.

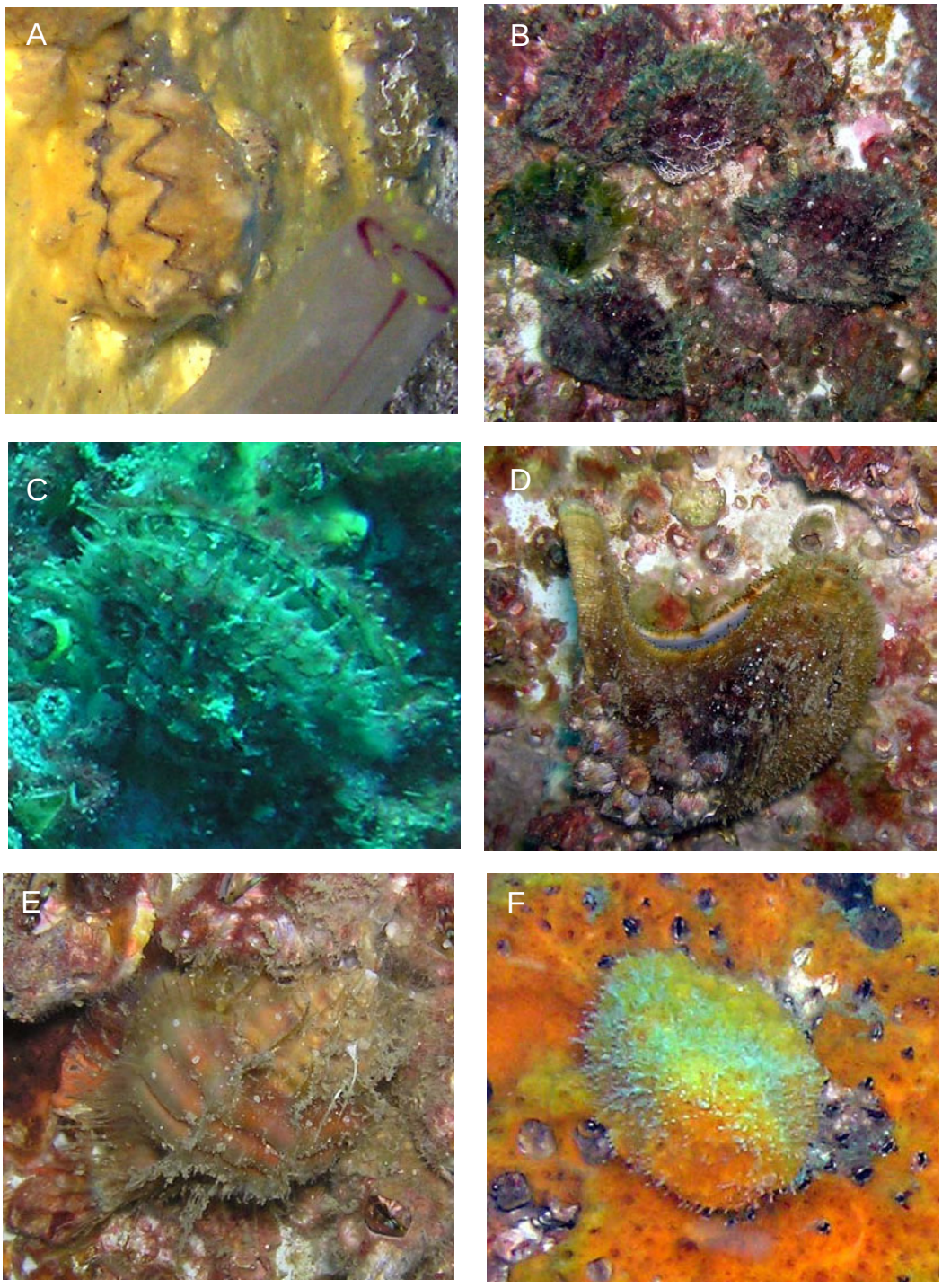


Fig. 11. a) *Lopha cristagalli b, c) Spotted p*earl oyster (Pictada maculate) d) Pinguin wing oyster (Pteria penguin) e) Broad-ribbed Triton (Cymatium parthenopium) f) Brooch Jewel-box clam (Chama fibula)

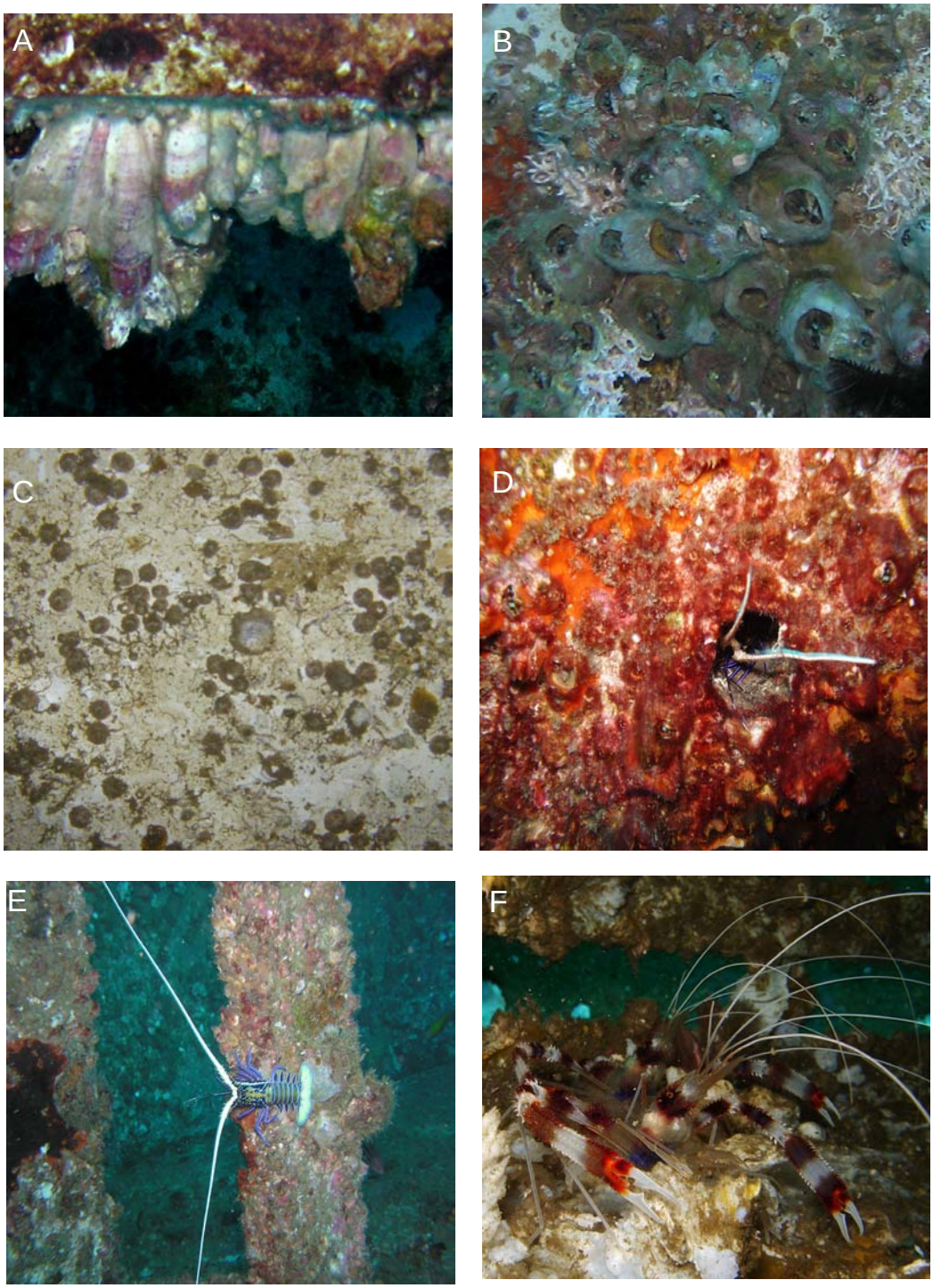


Fig. 12. a, b) Megabalanus tintinnabulum c) Balanus sp. 1 d, e) Panulirus versicolor f) Stenopus hispidus

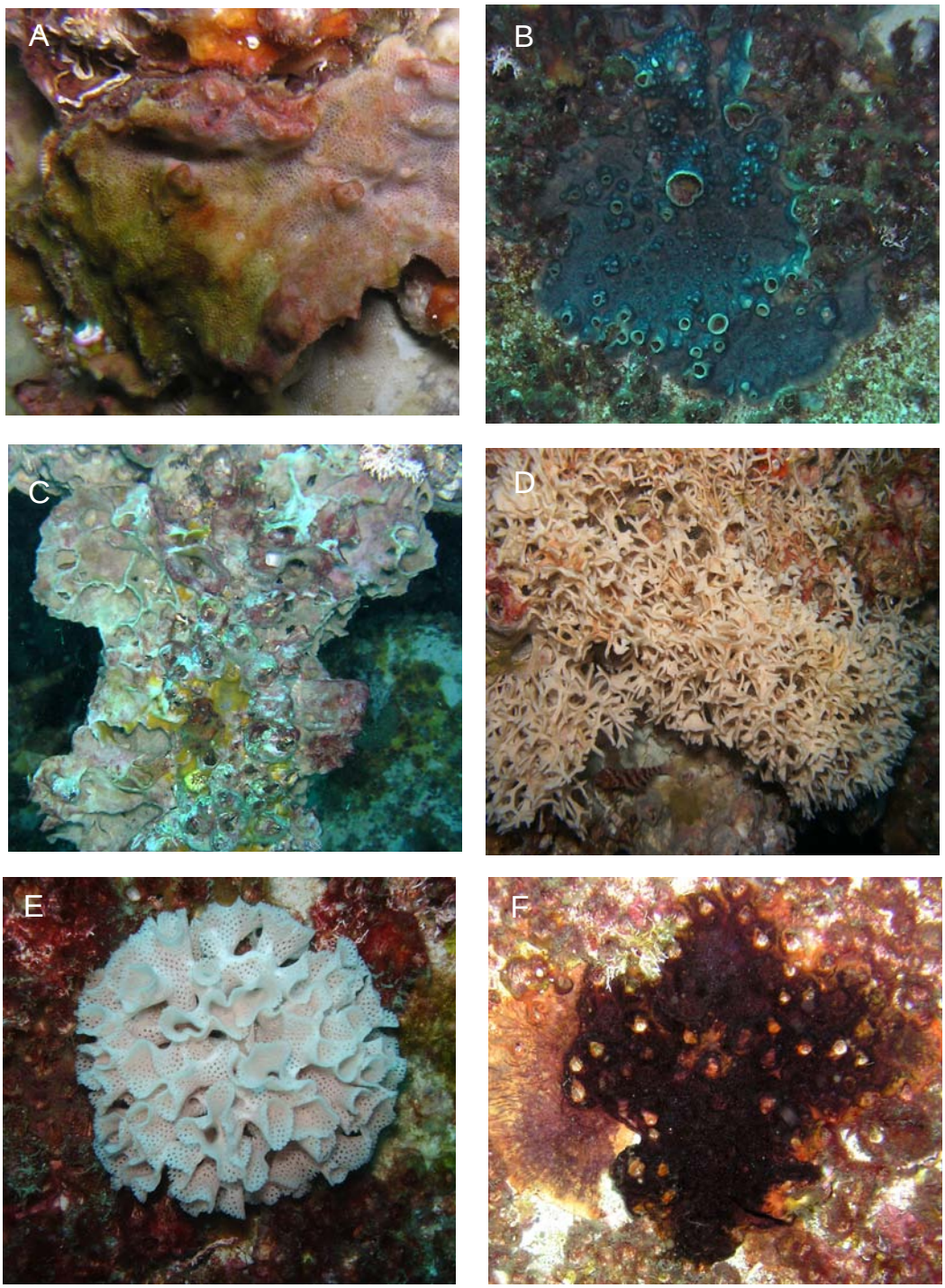


Fig. 13. a) Biflustra sp. 1 b) Celleporaria sp. 1 c) Biflustra sp. 2 d) Membranipora savertii e) Triphyllozoon sp. 1 f) Schizoporella sp. 1

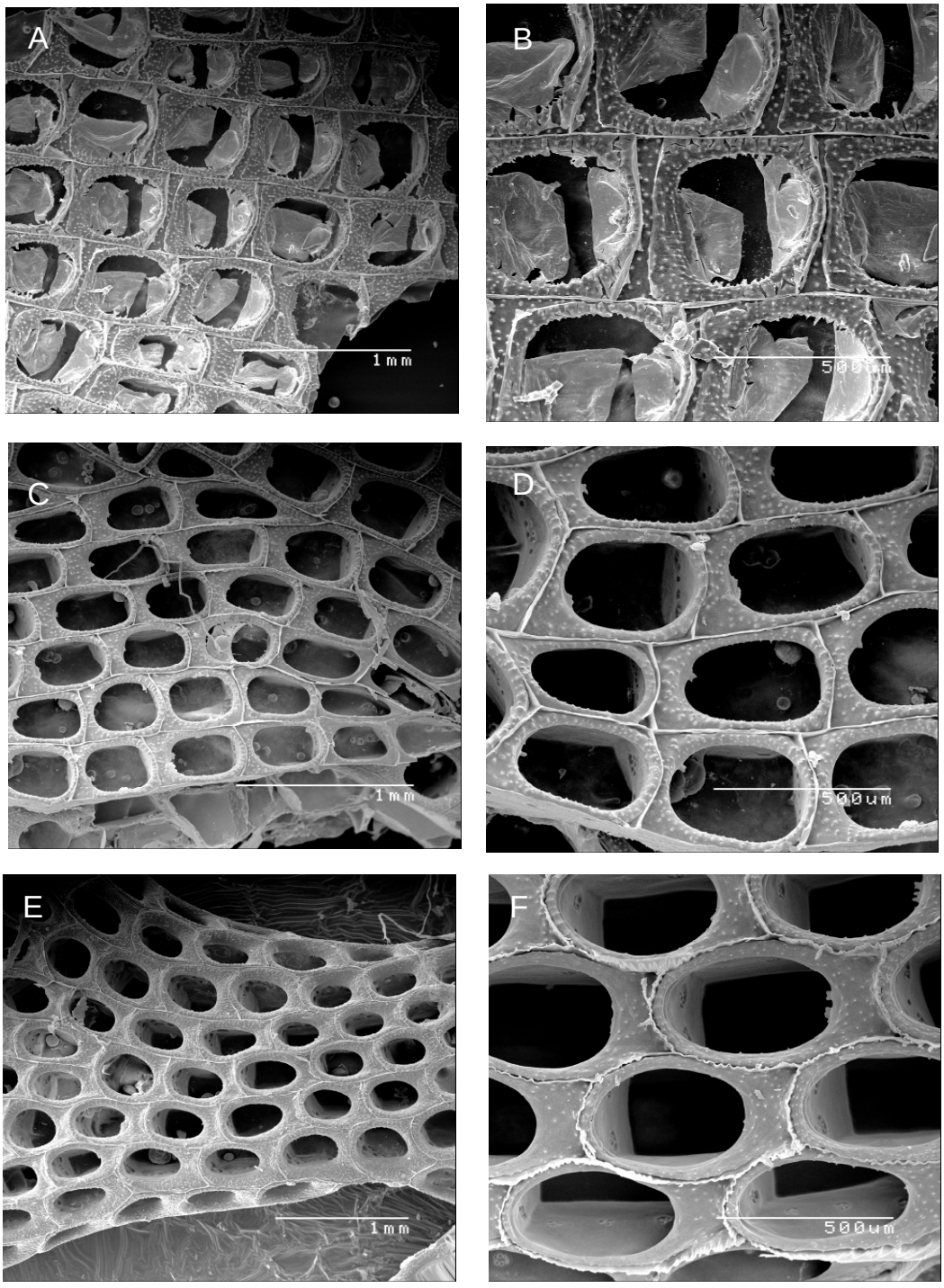


Fig 14. SEM photographs of Bryozoan: a, b) Biflustra sp. 1 c, d) Biflustra sp. 2 e, f) Membranipora savertii

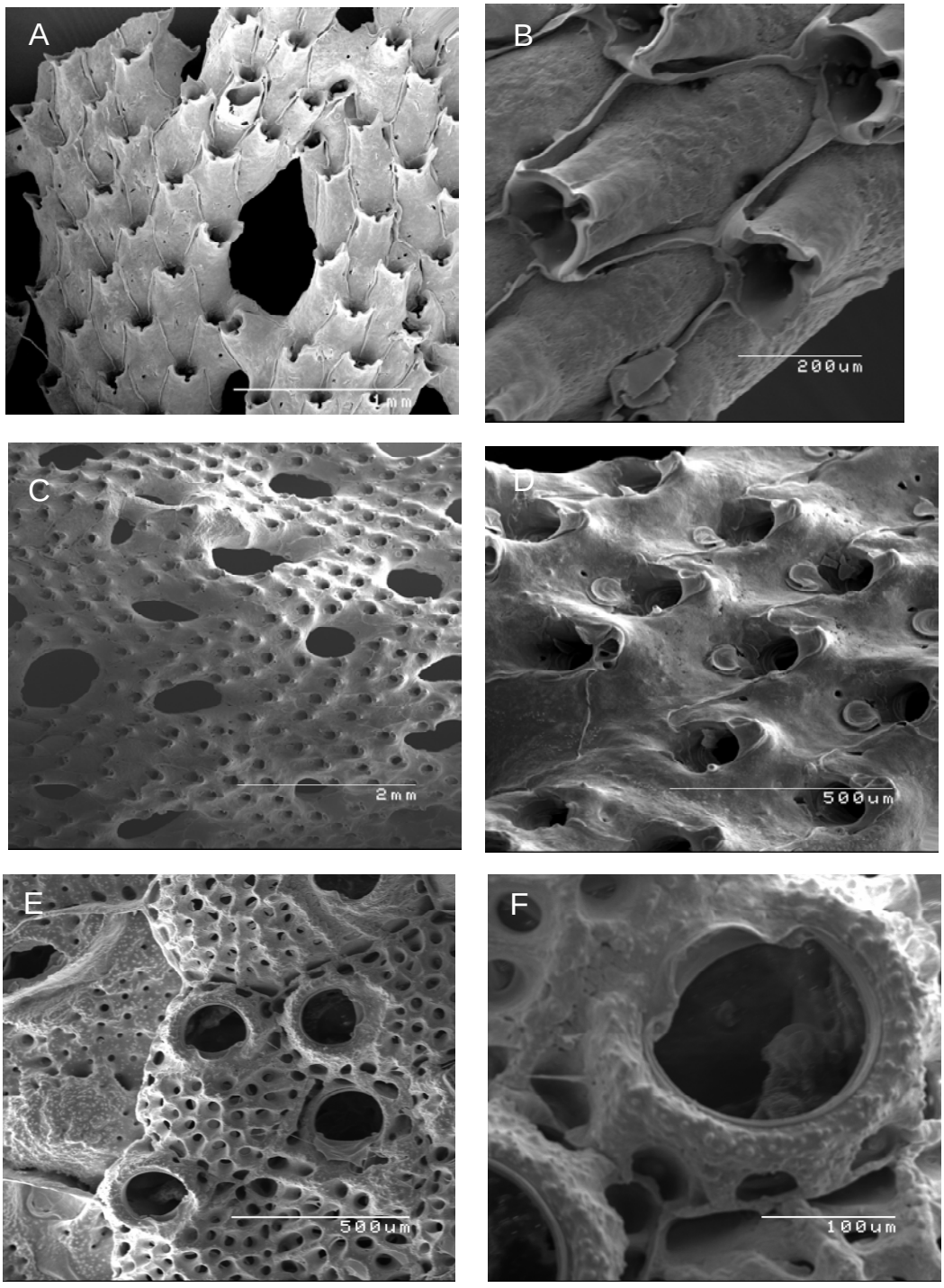


Fig 15. SEM photographs of Bryozoan: a, b) Reteporella graeffei c, d). Triphillozoon sp. 1 e, f) Schizoporella sp. 1

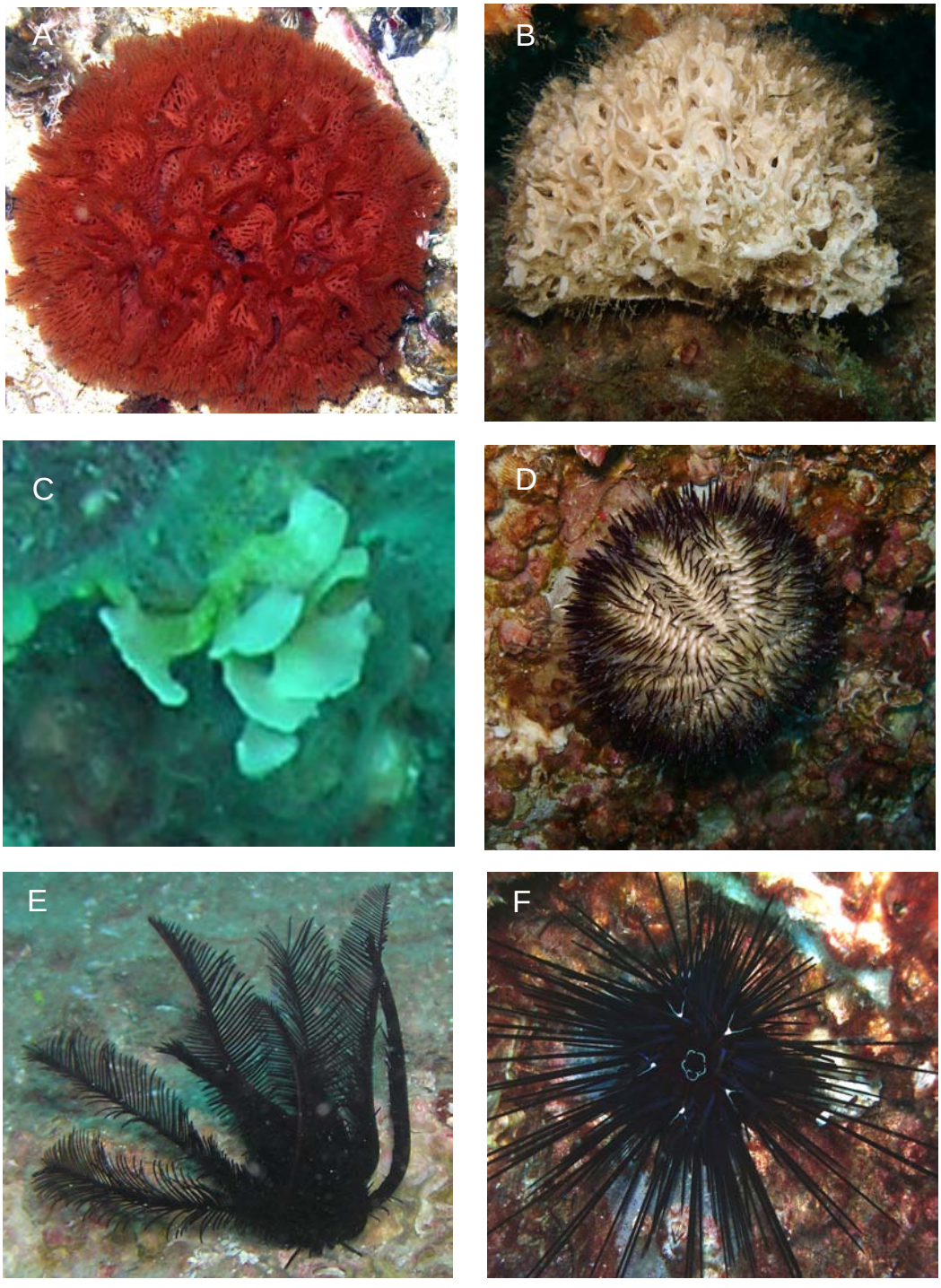


Fig. 16. a) Reteporella graeffei b) Bryozoa 1 c) Bryozoa 2 d) Temnopleurus sp. e) Cenolia sp. f) Diadema setosum

Fig. 17. a) Phallusia obesa b) Phallusia julinea c) Cnemidocarpa stolonifera d) Phallusia millari. e) Phallusia millari f) Polycarpa ovata g) Pyura stolinifera

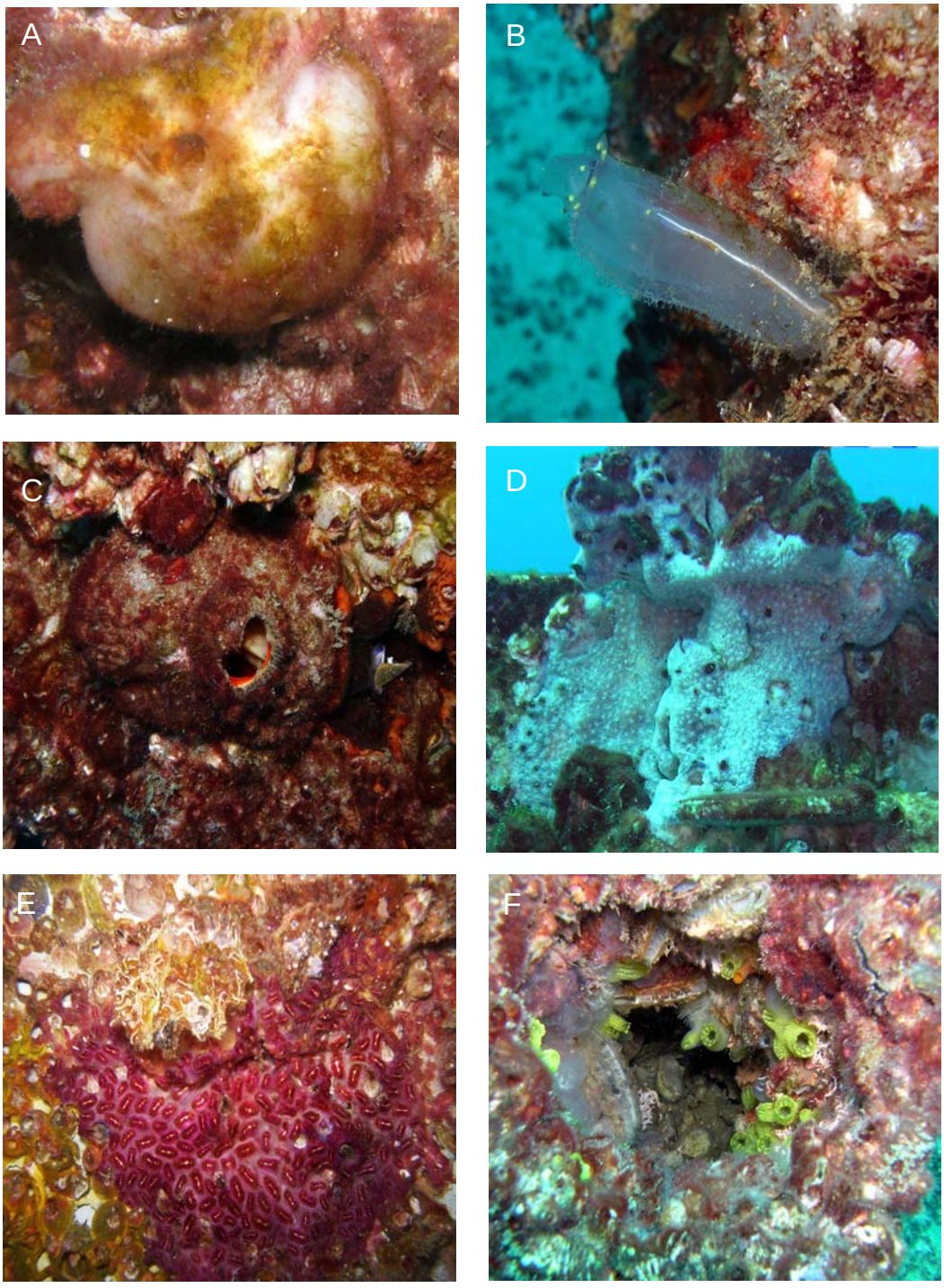


Fig. 18. a) Microcosmus exasperatus b) Rhopalaea crassa c) Pyura stolinifera d) Symplegma brakenhielmi e) Eusynstyela latericius f) Ascidia archaia and Phallusia julinea

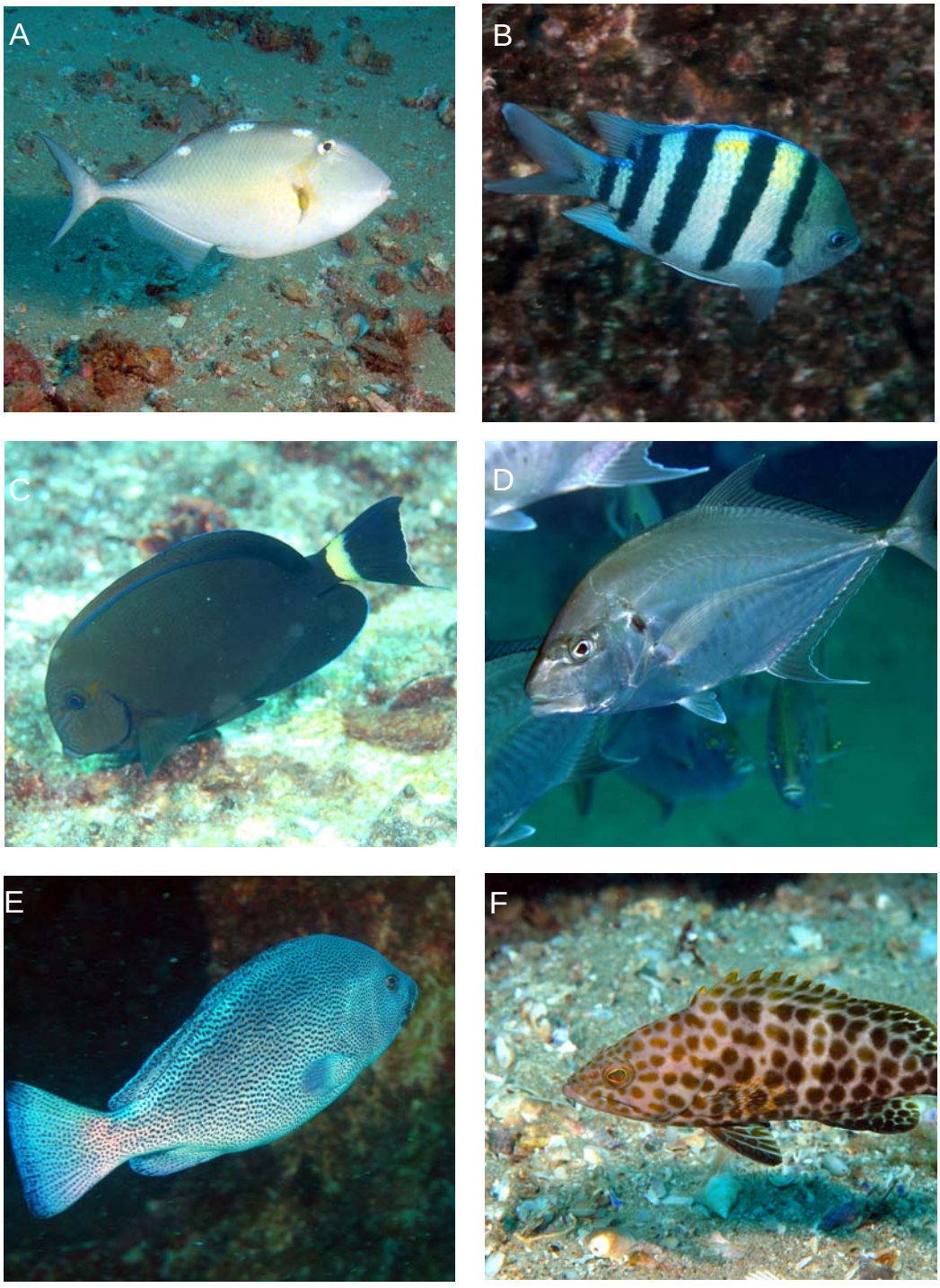


Fig. 19. a) Abalistes stellatus b) Abudefduf vaigiensis c) Acanthurus grammoptilus d) Carangoides chrysophrys e) Epinephelus cyanopodus f) Epinephelus areolatus

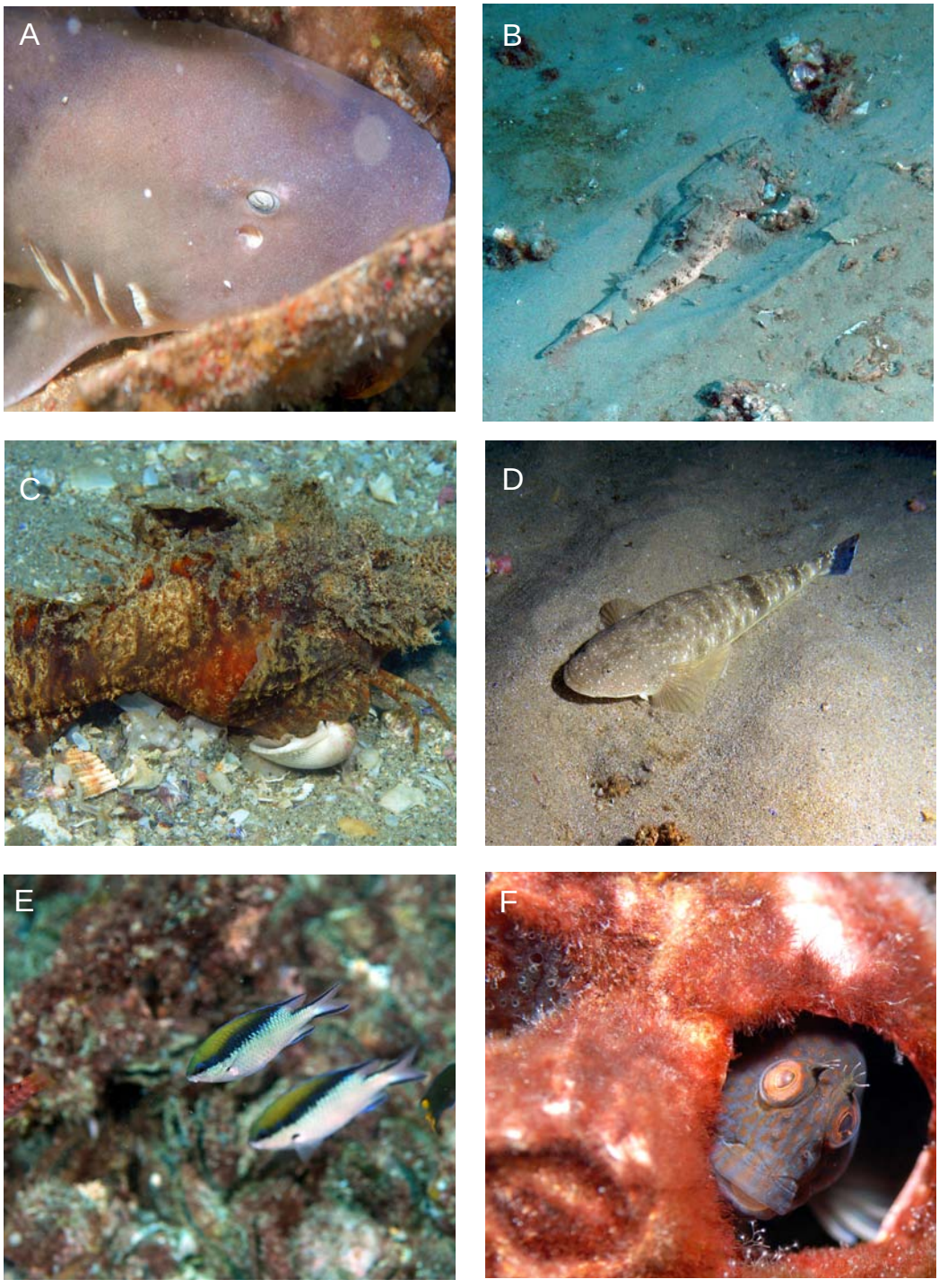


Fig. 20. a) Chiloscyllium punctatum b) Cymbacephalus nematophthalmus c) Inimicus caledonicus d) Platycephalus fuscus e) Chromis nitida f) Parablennius intermedius

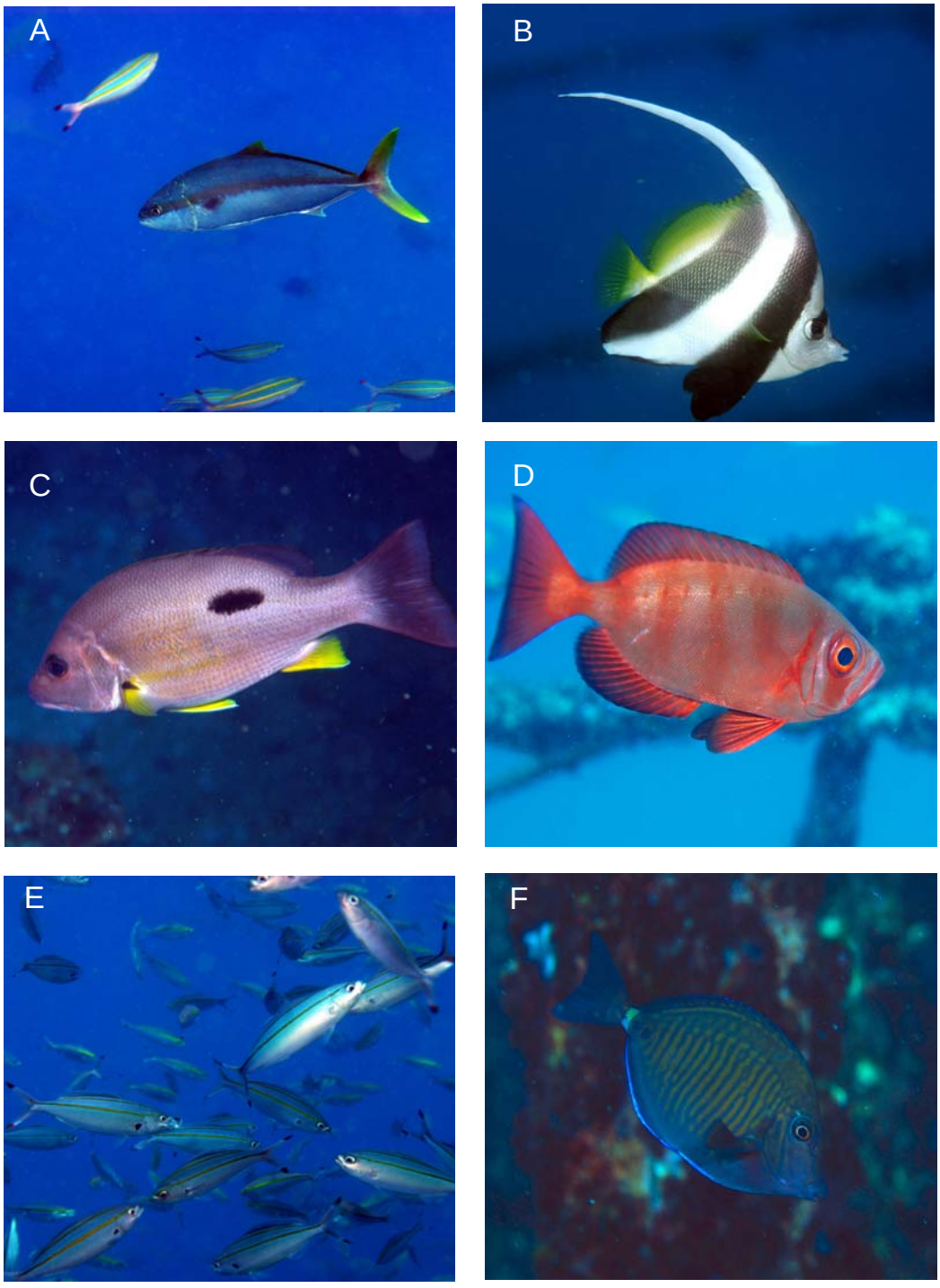


Fig. 21. a) Seriola lalandi b) Heniochus acuminatus c) Lutjanus russelli d) Priacanthus hamrur e) Pterocaesio digramma f) Prionurus maculatus

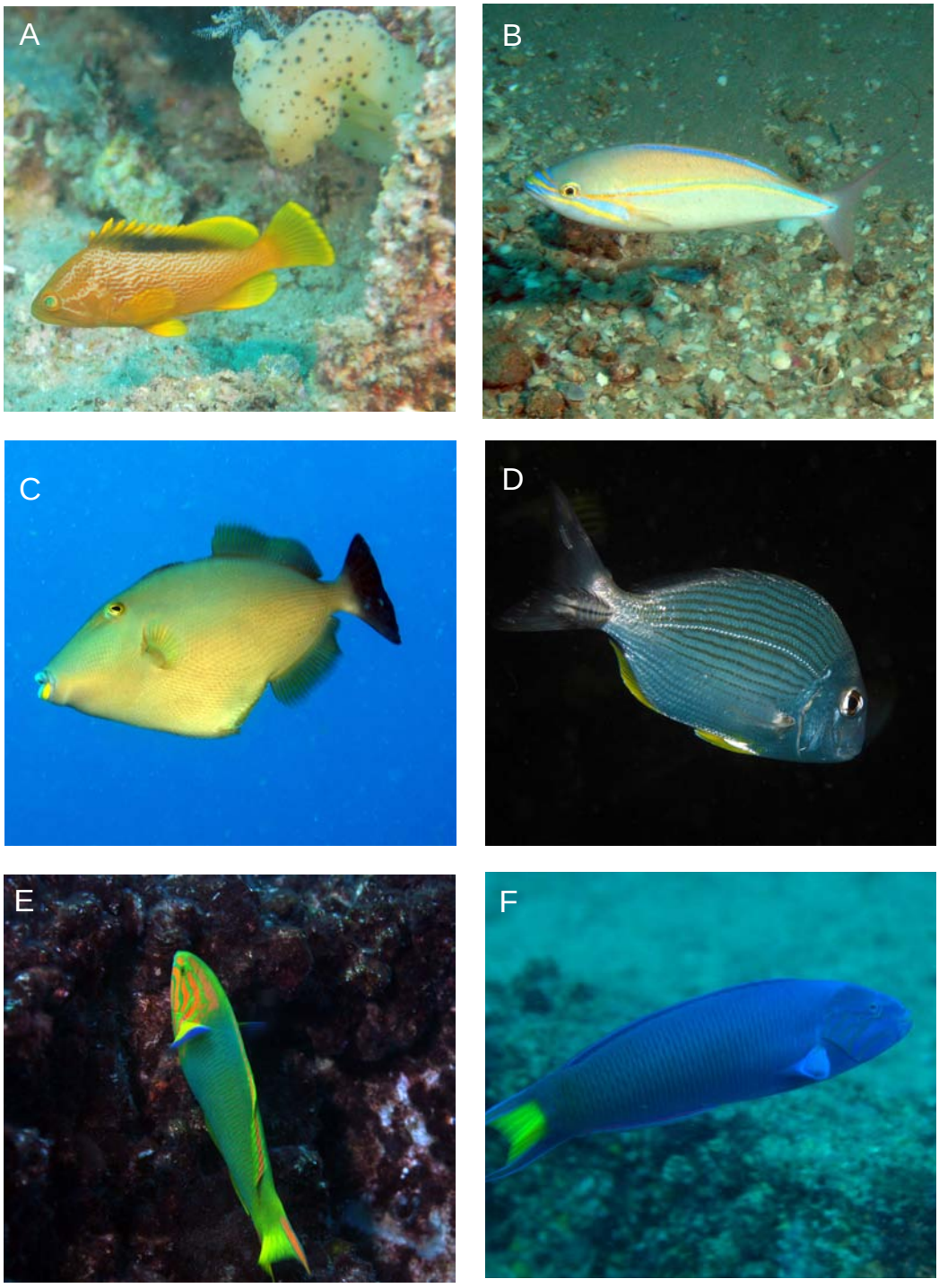


Fig. 22. a) Epinephelus undulostriatus b) Pentapodus paradiseus c) Sufflamen fraenatus d) Rhabdosargus sarba e) Thalassoma lutescens f) Thalassoma lunare

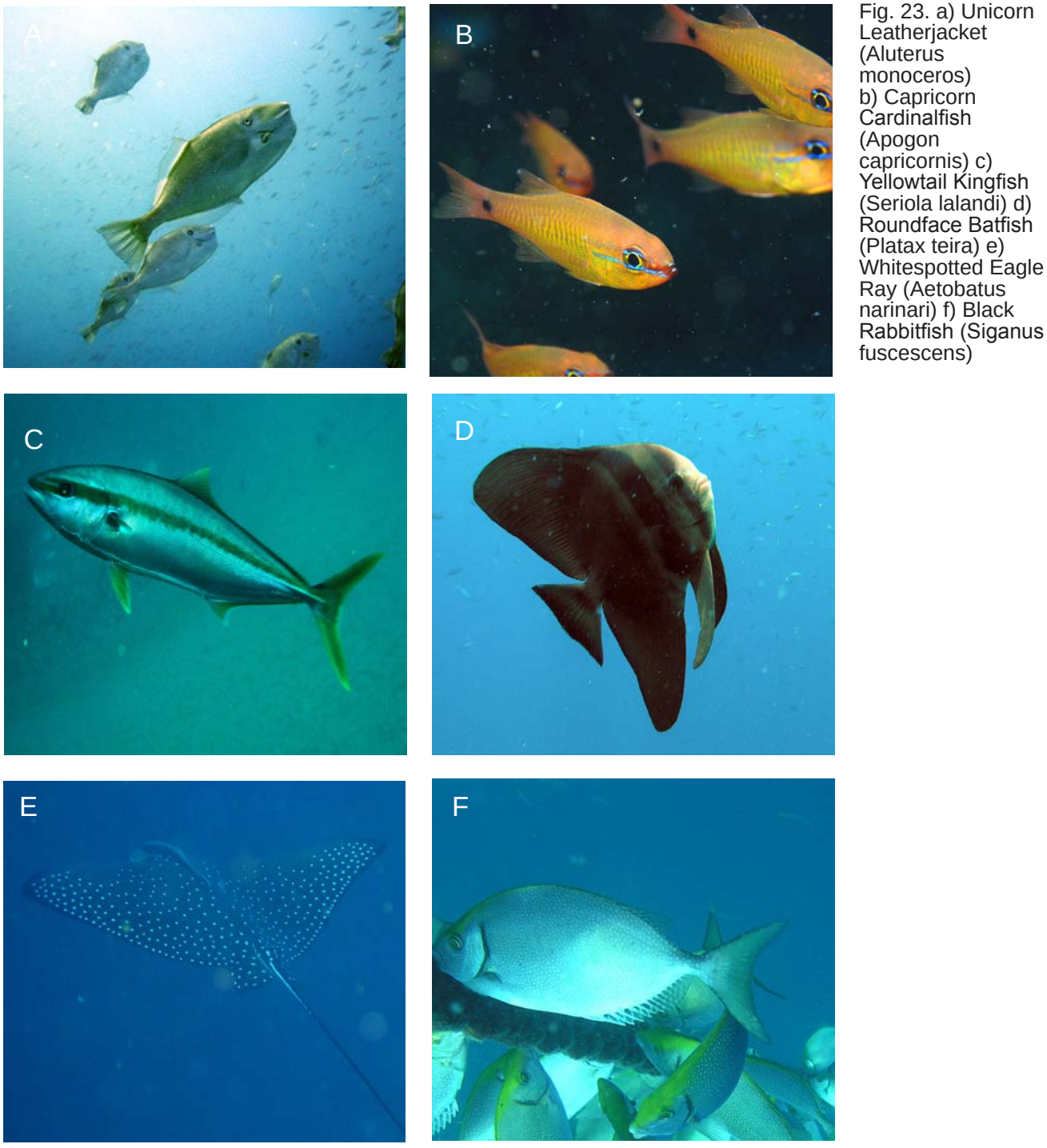


Fig. 23. a) Unicorn Leatherjacket (Aluterus monoceros) b) Capricorn Cardinalfish (Apogon capricornis) c) Yellowtail Kingfish (Seriola lalandi) d) Roundface Batfish (Platax teira) e) Whitespotted Eagle Ray (Aetobatus narinari) f) Black Rabbitfish (Siganus fuscescens)

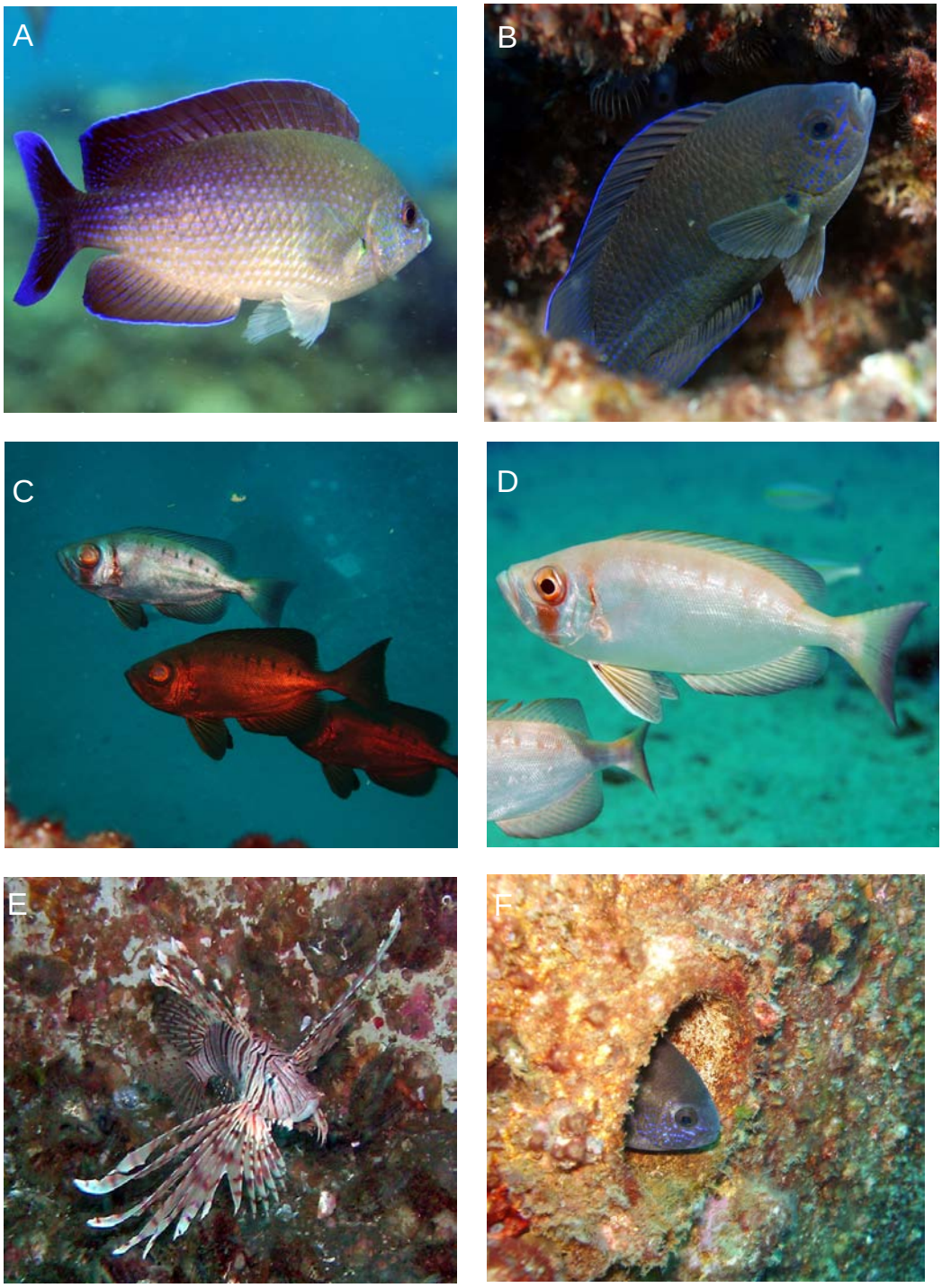


Fig. 24. a) b) Gulf Damsel (Pristotis obtusirostris c) Spotted Bigeye (Priacanthus macracanthus) d) Lunartail Bigeye (Priacanthus hamrur) e) Common Lionfish (Pterois volitans) f) Australian Damsel (Pomacentrus australis).

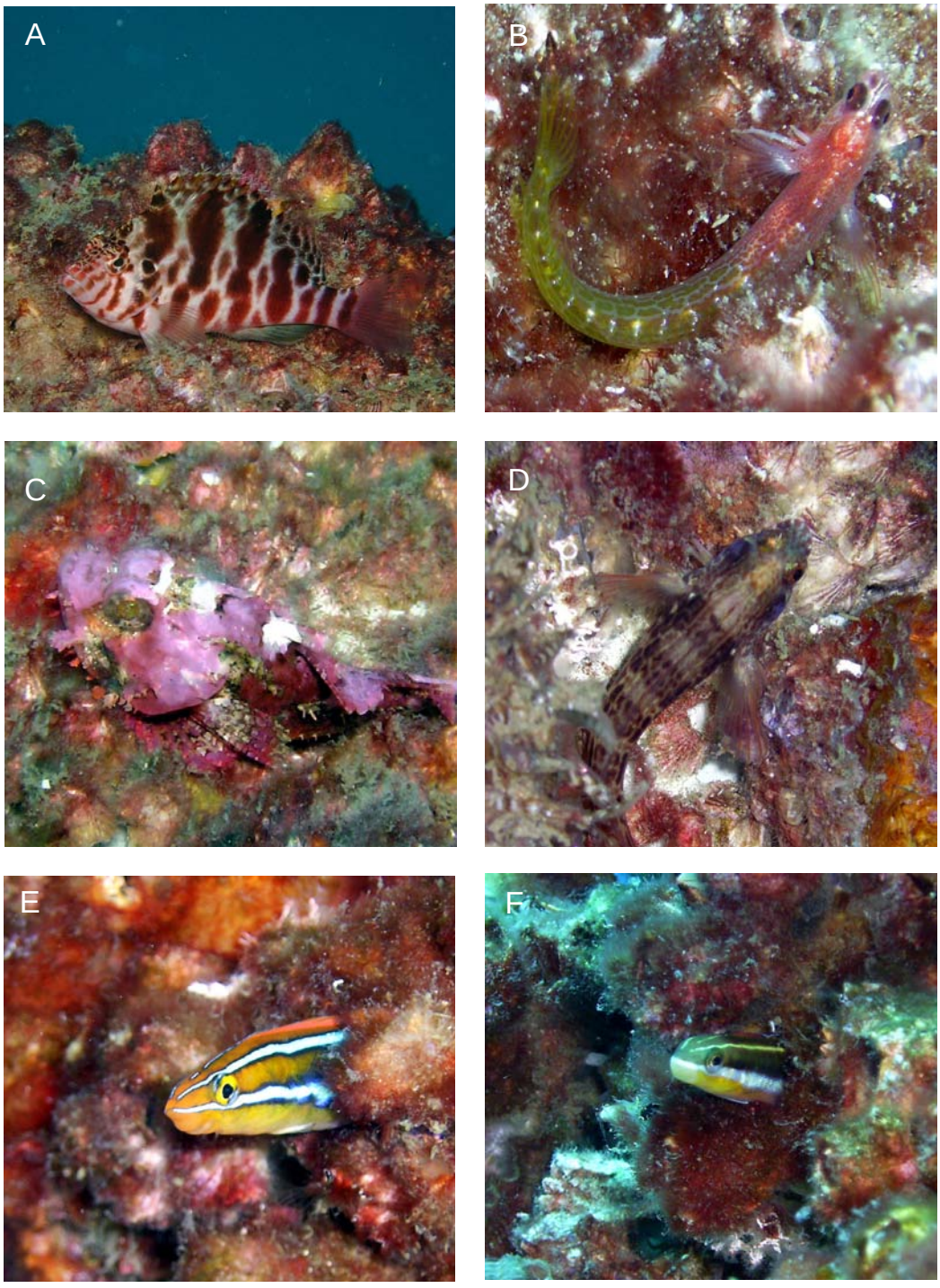
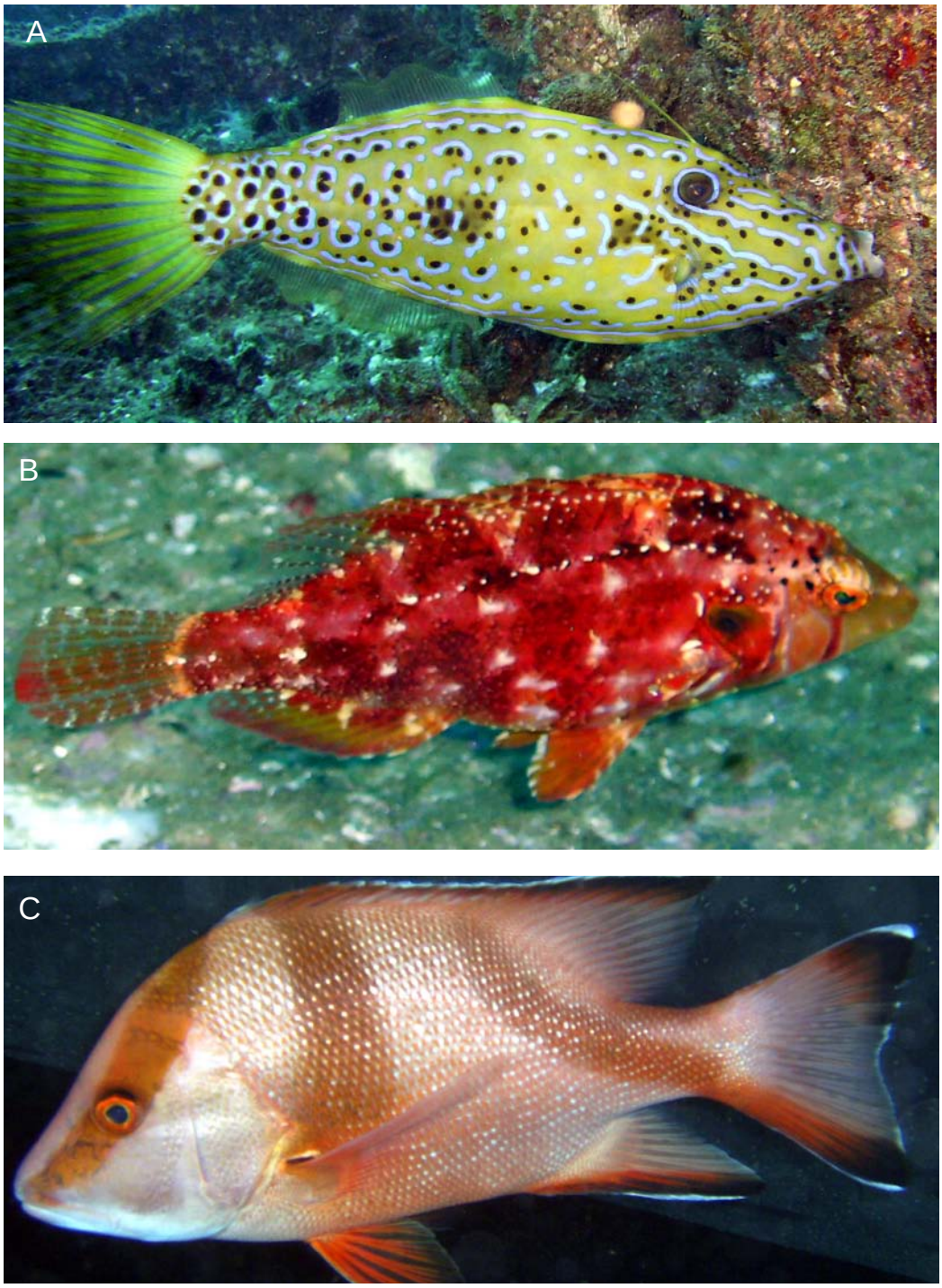


Fig. 25. a) Blotched Hawkfish (Cirrhitichthys aprinus) b) Manyspot Blenny (Laiphognathus multimaculatus) c) Eastern Red Scorpionfish (Scorpaena cardinalis) d) Horned Blenny (Parablennius intermedius) e, f) Bluestriped Fangblenny (Plagiotremus rhinorhynchus).

Fig. 26. a) Scrawled Leatherjacket (Aluterus scriptus) b) Cockerel Wrasse (Pterogogus enneacanthus) c) Red Emperor (Lujanus sebae)



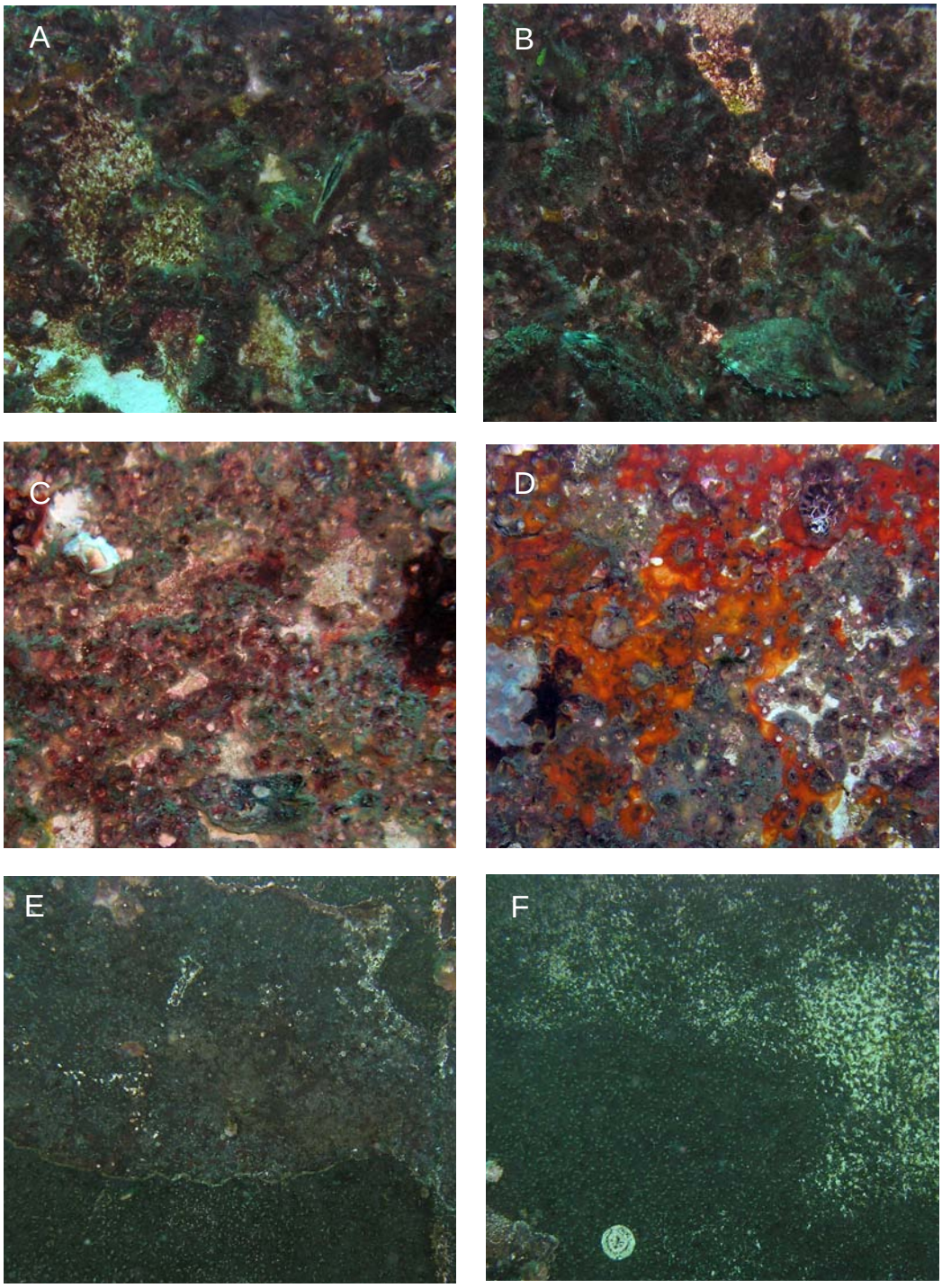


Fig. 27. Sessile invertebrate assemblage on the port and starboard sides of the wreck at each depth (12, 18 & 23 metres).

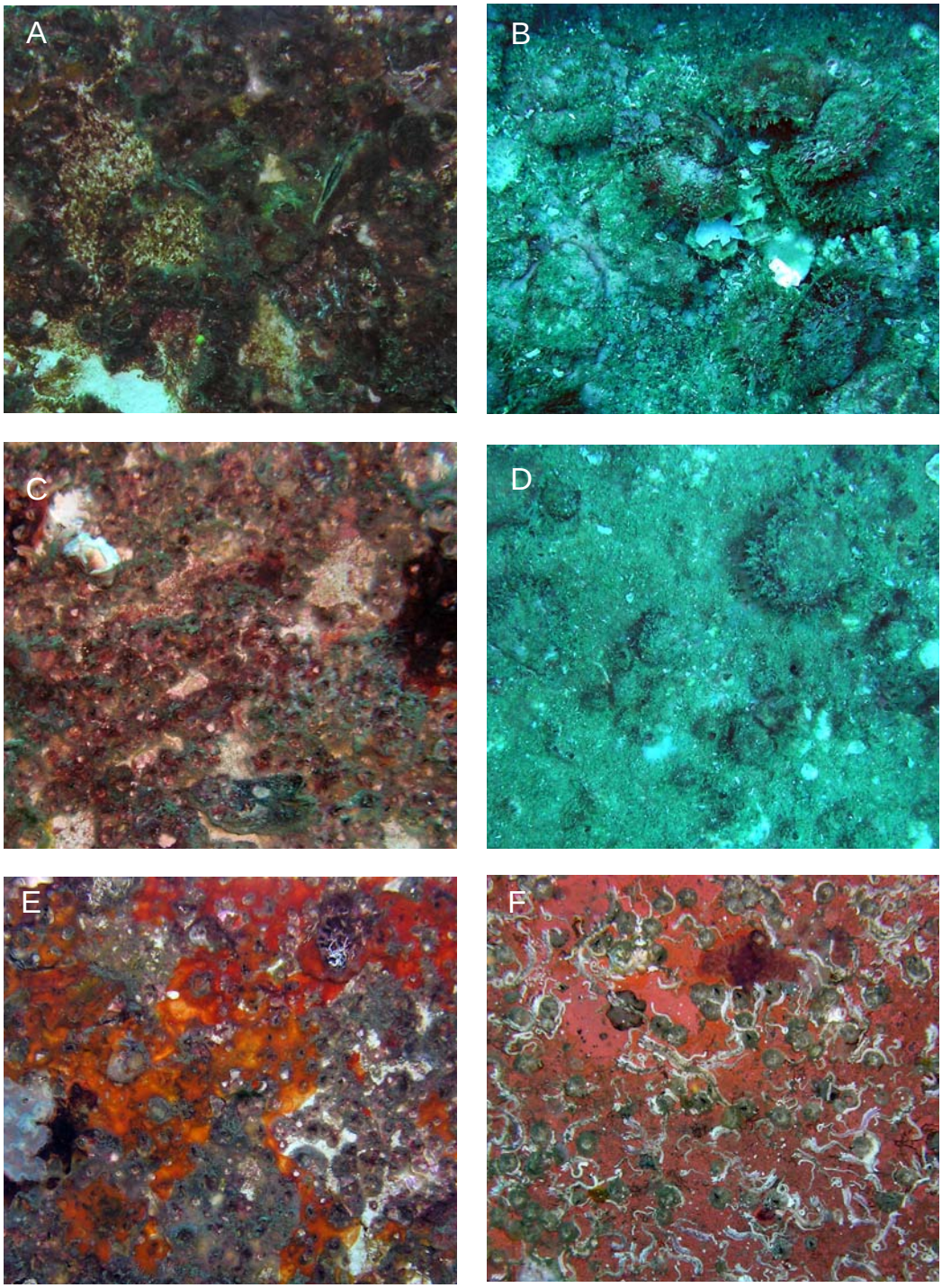


Fig. 28. Sessile invertebrate assemblages a) On vertical and horizontal surfaces of the wreck at 12 and 18 metres depth. b) Inside and outside the wreck at 18 metres depth.

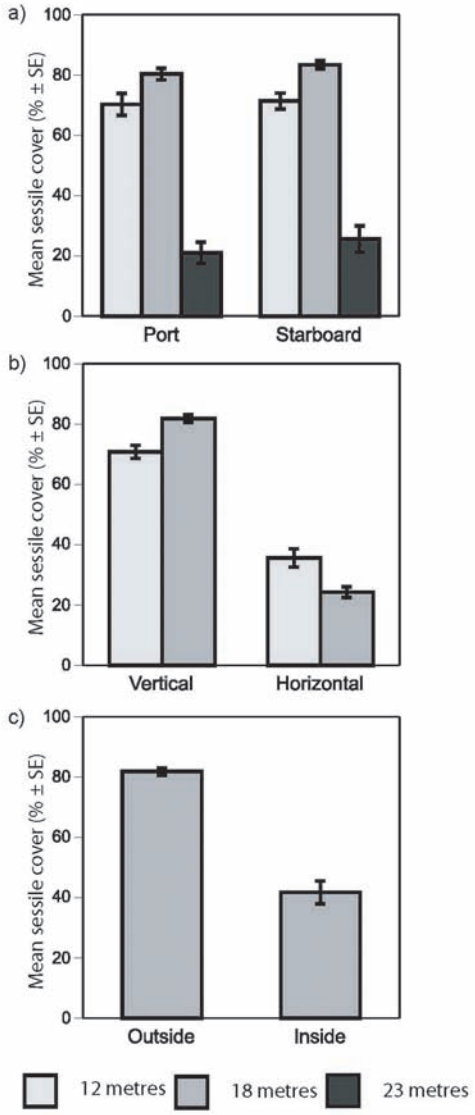


Fig. 29. Mean percent coverage of sessile fauna (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 18 m < Horizontal 12m < Vertical 12 m < Vertical 18 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

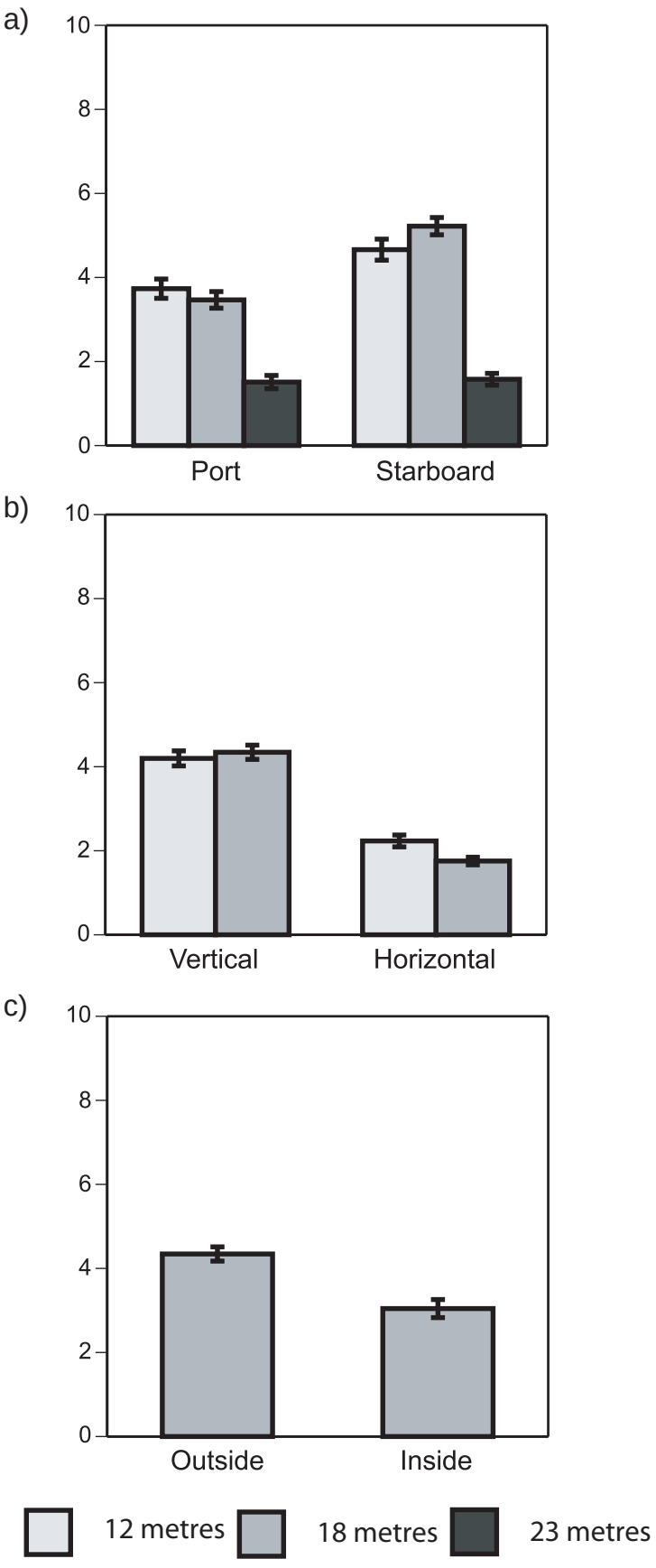


Fig. 30. Sessile species density expresses as the mean number of species per 625 cm2 (SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres)(SNK: Port 23 m = Starboard 23 m < Port 12 m = Port 18 m < Starboard 12 m < Starboard 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 18 m < Horizontal 12m < Vertical 12 m = Vertical 18 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

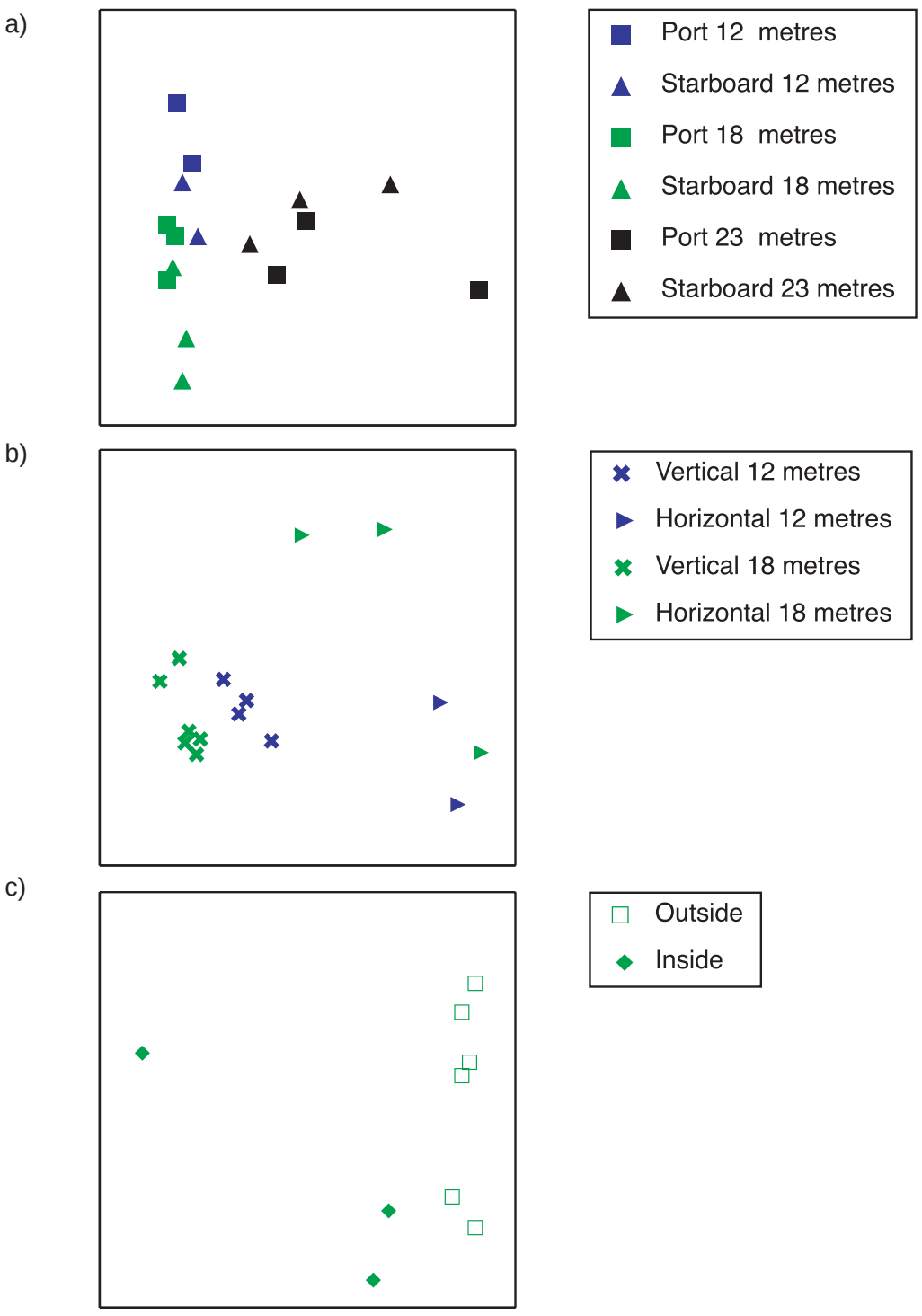


Fig. 31. nMDS plots of the sessile invertebrate assemblages on the ex-HMAS Brisbane, showing the mean value for each transect (n = 15 quadrats). a) on the Port and Starboard sides of the wreck at different depths (12, 18 & 23 metres) (stress = 0.05). b) on vertical and horizontal surfaces at 12 and 18 metres depth (stress = 0.04). c) on vertical surfaces inside and outside the wreck at 18 metres (stress = 0.01).

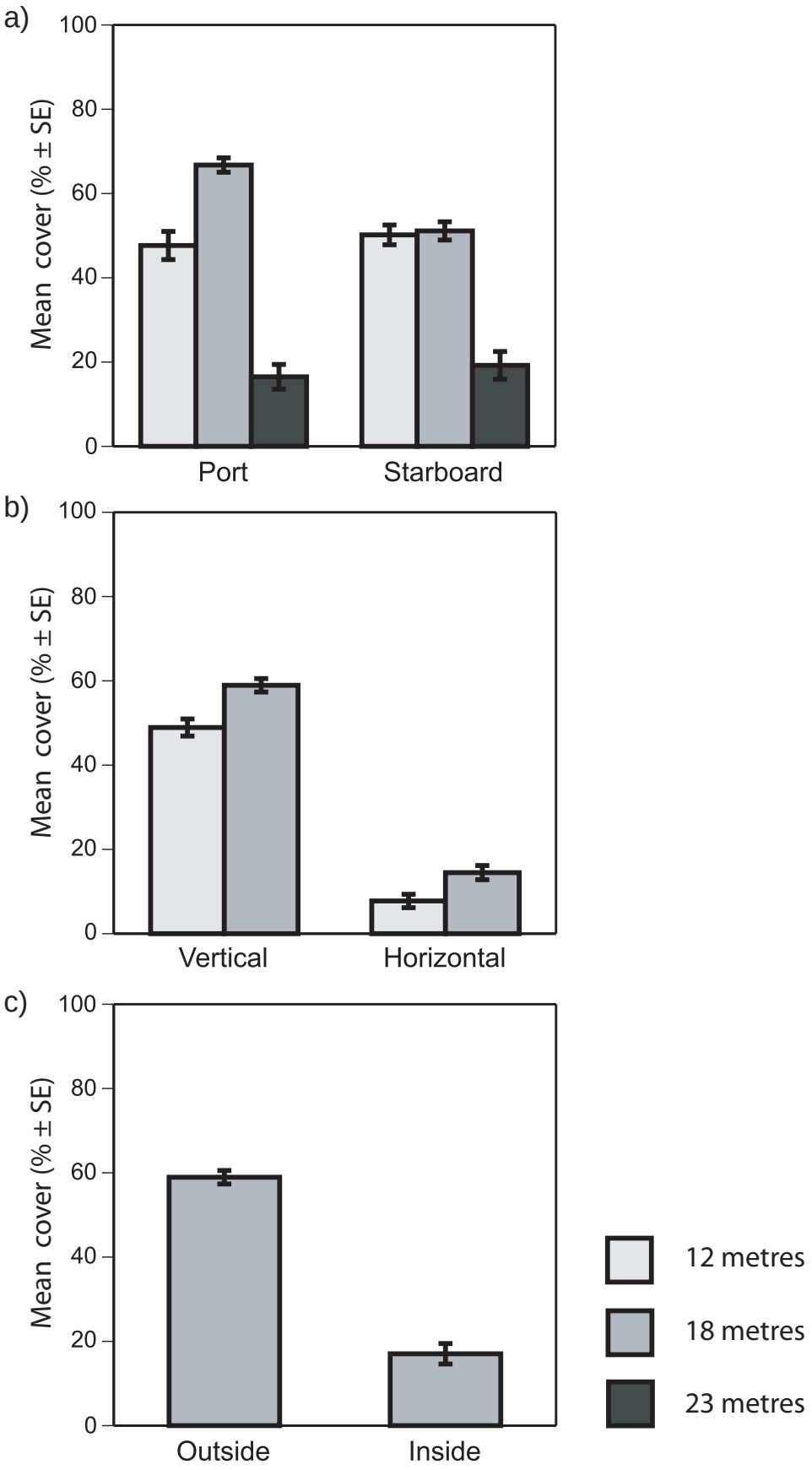


Fig. 32. Mean percent coverage of Barnacles (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 23 m = Starboard 23 m < Port 12 m = Starboard 12 m = Starboard 18 m < Port 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

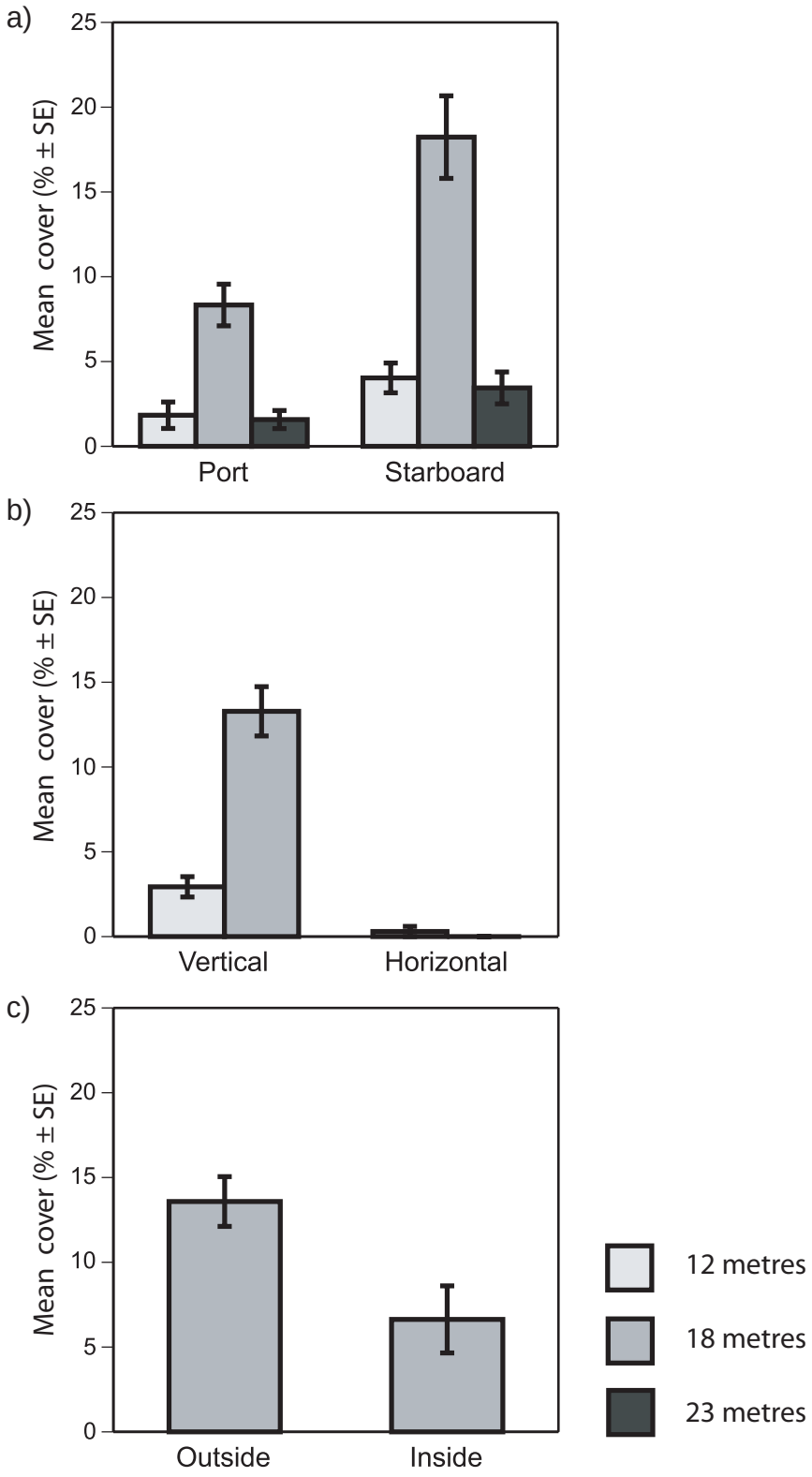


Fig. 33. Mean percent coverage of Bryozoans (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 12 m = Port 23 m = Starboard 12 m = Starboard 23 m < Port 18 m < Starboard 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 12m = Horizontal 18 m = Vertical 12 m < Vertical 18 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

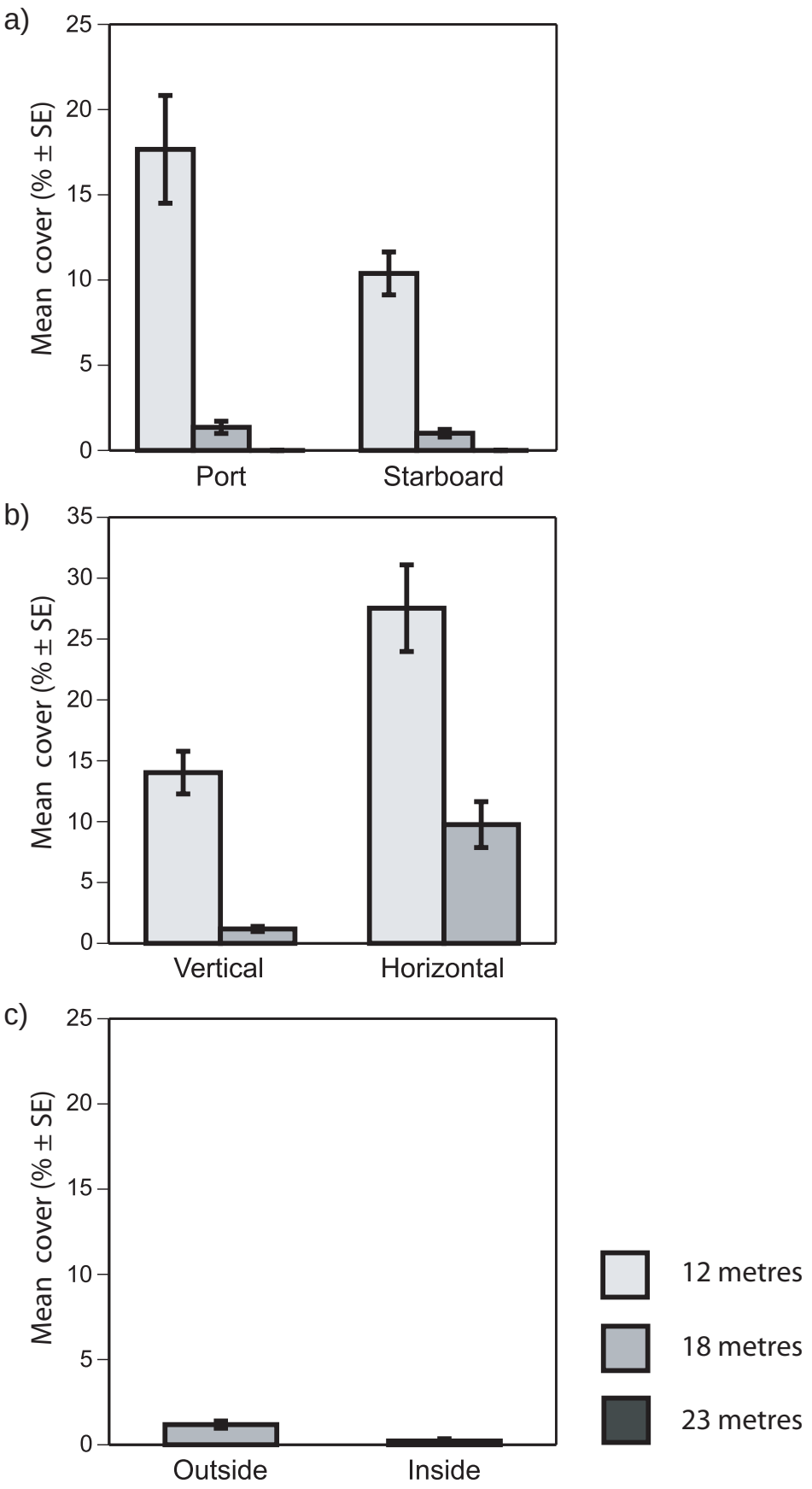


Fig. 34. Mean percent coverage of Bivalves (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

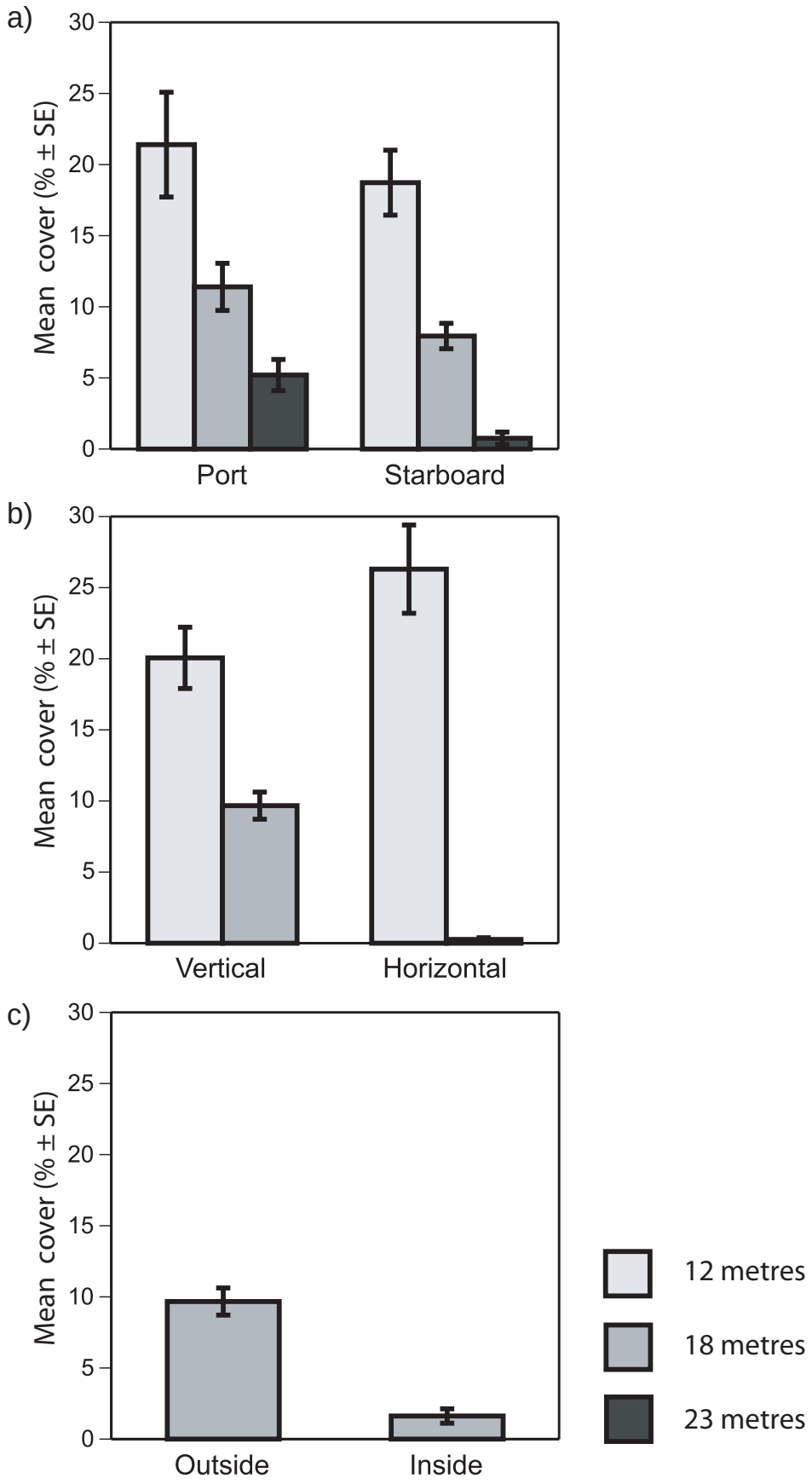


Fig. 35. Mean percent coverage of algae (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth (SNK: Horizontal 18 m < Vertical 18 m < Vertical 12 m < Horizontal 12 m). c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

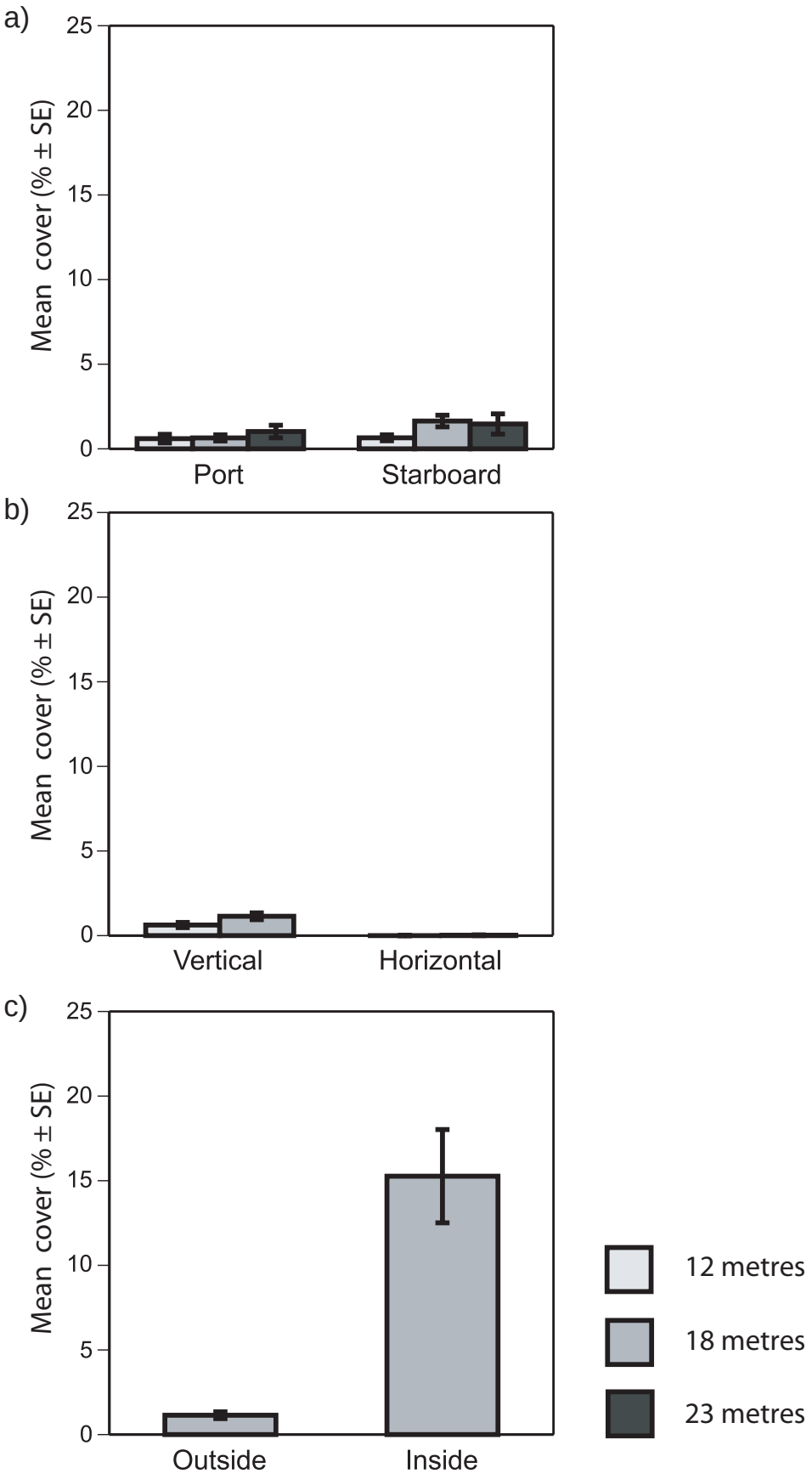


Fig. 36. Mean percent coverage of Polychaetes (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

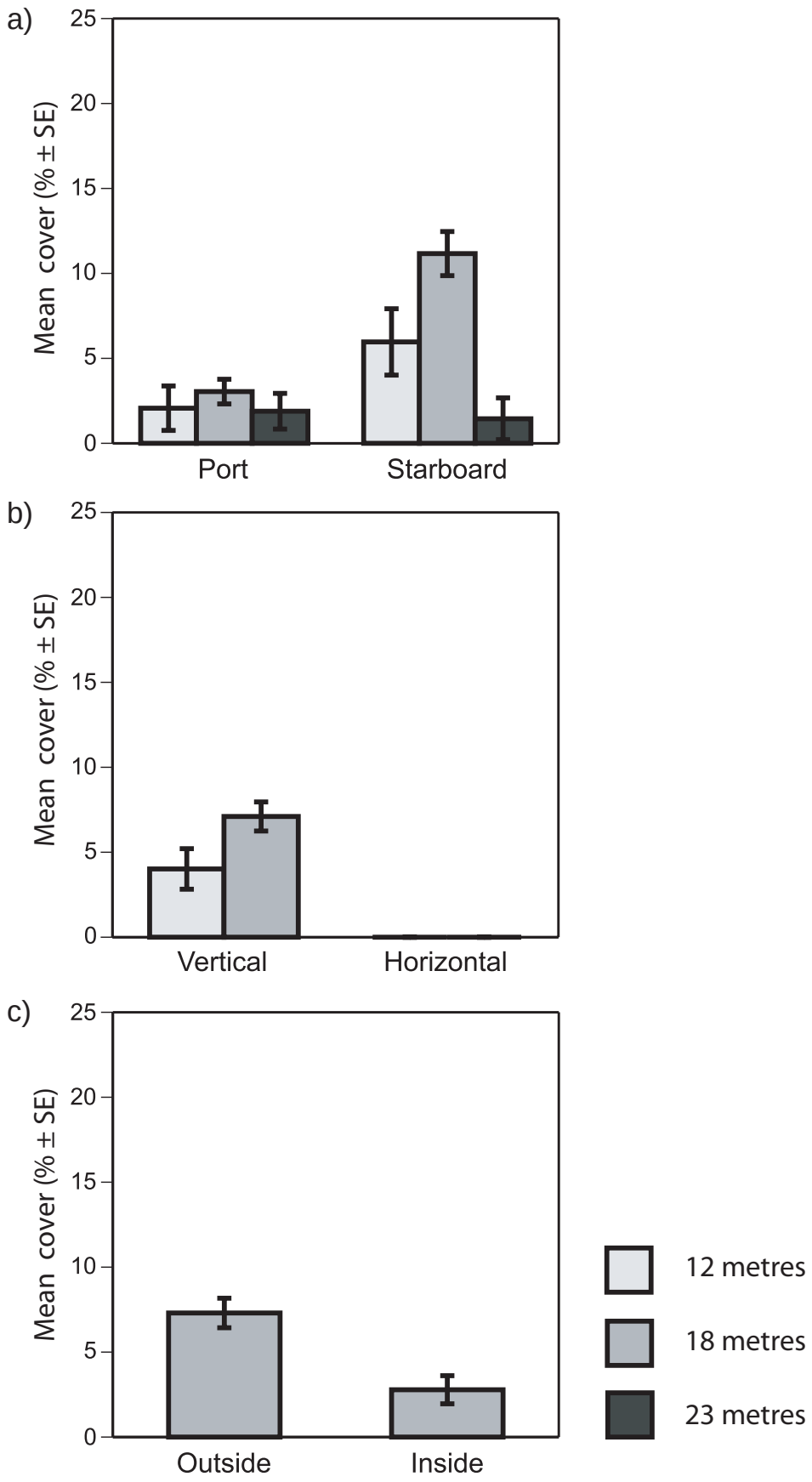


Fig. 37. Mean percent coverage of Poriferans (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres) (SNK: Port 12 m = Port 18 m = Port 23 m = Starboard 23 m < Starboard 12 m < Starboard 18 m). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

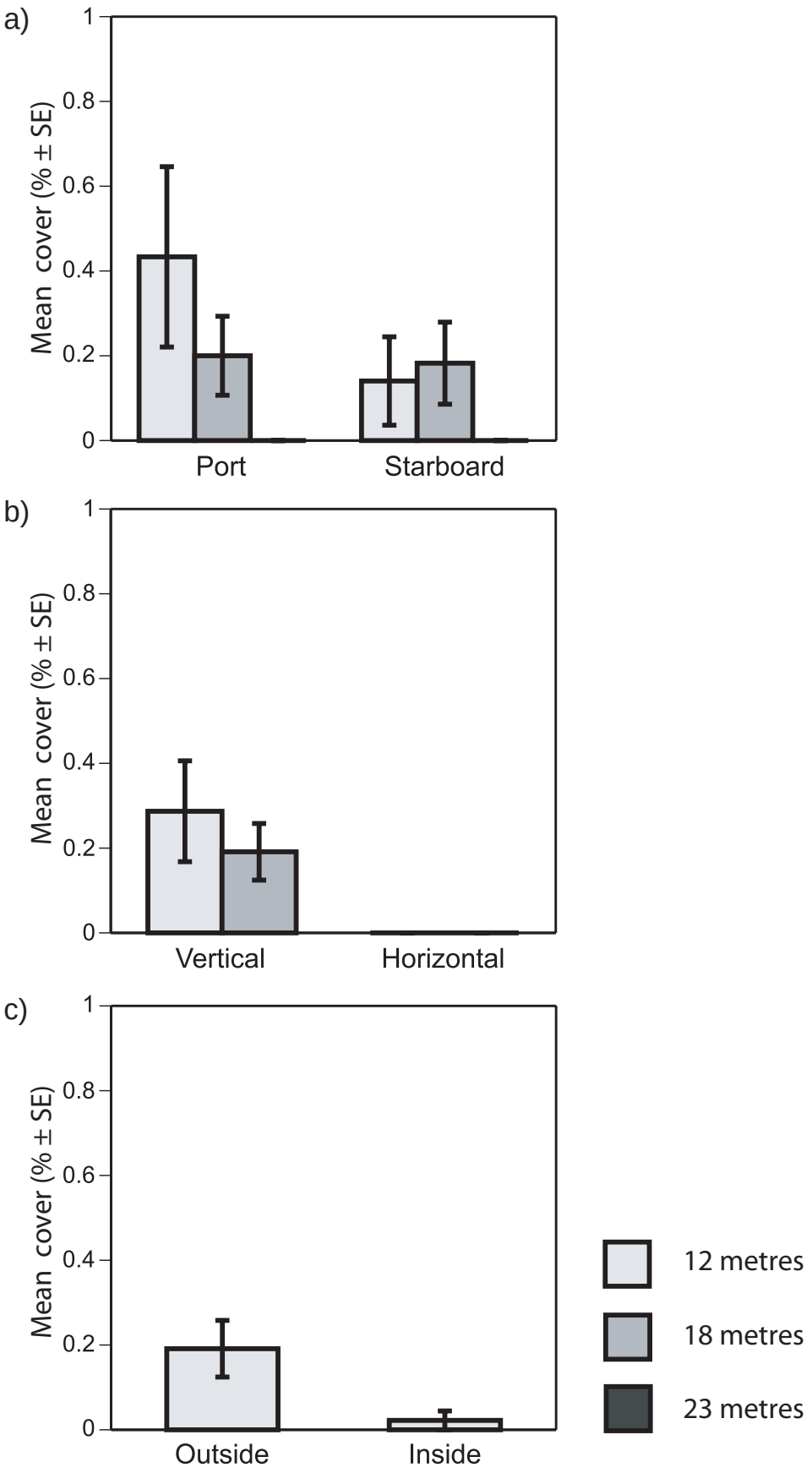


Fig. 38. Mean percent coverage of Ascidians (± SE). a) The difference between the two aspects of the wreck (Port and Starboard) at different depths (12, 18 & 23 metres). b) Difference between vertical and horizontal surfaces at 12 and 18 metres depth. c) Difference between vertical surfaces inside and outside the wreck at 18 metres.

Family Genus Species	Common Name	Abundance				
		Superstructure	Decks	Internal	Lower Hull	**Total**
Hemiscyllidae						
Chiloscyllium punctatum	Grey Carpetshark		-	*	-	*
Dasyatididae						
Dasyatis kuhlii	Bluespotted Maskray	-	-	-	1	**1**
Taeniura meyeni	Blotched Fantail Ray	*	-	-	1	**1**
Myliobatididae						
Aetobatus narinari	Whitespotted Eagle Ray	1	-	-	-	**1**
Synodontidae						
Synodus dermatogenys?	Banded Lizardfish	-	1	-	-	**1**
Fistulariidae						
Fistularia petimba	Rough Flutemouth	-	-	-	1	**1**
Scorpaenidae						
Inimicus caledonicus	Demon Stinger	-	-	-	*	*
Pterois volitans	Common Lionfish	*	2	-	*	**2**
Scorpaena cardinalis?	Eastern Red Scorpionfish	-	-	-	1	**1**
Platycephalidae						
Cymbacephalus nematophthalmus	Fringe-eye Flathead	-	-	-	1	**1**
Platycephalus fuscus	Dusky Flathead	-	-	-	*	*
Serranidae						
Epinephelus areolatus	Yellowspotted Rockcod	-	-	-	1	**1**
Epinephelus cyanopodus	Purple Rockcod	2	3	2	3	**3**
Epinephelus undulostriatus	Maori Rockcod	2	2	*	2	**3**
Plectropomus leopardus	Common Coral Trout	-	1	-	-	**1**
Pseudanthias squamipinnis	Orange Basslet	4	4	-	-	**4**
Triso dermopterus	Oval Rockcod	3	3	3	4	**4**
Grammistidae						
Diploprion bifasciatum	Barred Soapfish	*	-	-	-	*
Priacanthidae						
Priacanthus hamrur	Lunartail Bigeye	3	4	4	4	**5**
Priacanthus macracanthus	Spotted Bigeye	4	5	5	5	**6**
Apogonidae						
Apogon capricornis	Capricorn Cardinalfish	5	6	7	5	**7**
Apogon cavitiensis	Whiteline Cardinalfish	-	2	-	2	**2**
Apogon cookii	Cook's Cardinalfish	-	3	2	2	**3**
Apogon doederleini	Fourline Cardinalfish	-	-	-	4	**4**
Apogon limenus	Sydney Cardinalfish	*	4	3	4	**4**
Rhabdamia gracilis	Slender Cardinalfish	-	-	*	-	*
Echeneidae						
Echeneis naucrates	Sharksucker	1	-	-	-	**1**
Carangidae						
Carangoides chrysophrys	Longnose Trevally	3	4	*	5	**5**
Carangoides ferdau	Blue Trevally	-	3	-	-	**3**
Carangoides fulvoguttatus	Turrum	-	3	-	4	**4**
Carangoides gymnostethus	Bludger Trevally	*	-	-	3	**3**
Carangoides orthogrammus	Thicklip Trevally	-	3	-	2	**3**
Caranx melampygus	Bluefin Trevally	-	-	-	3	**3**
Caranx papuensis	Brassy Trevally	-	3	-	3	**4**
Caranx sexfasciatus	Bigeye Trevally	-	-	-	3	**3**
Decapterus russelli	Indian Scad	3	-	*	-	**3**
Gnathanodon speciosus	Golden Trevally	-	*	-	1	**1**

Table 2. Abundance of fishes visually recorded on wreck of HMAS Brisbane in July 2006, by sector of ship.

(abundance in log 5 scale: 1=1 fish, 2=2-5, 3=6-25, 4=26-125, 5=126-625, 6=626-3125, 7=3126+; * = not recorded here, but recorded on site during a later study period)

Seriola dumerili	Amberjack	2	3	3	3	**4**
Seriola lalandi	Yellowtail Kingfish	2	3	2	3	**4**
Trachurus novaezelandiae?	Yellowtail Scad	3	-	-	-	**3**
Lutjanidae						
Lutjanus adetii	Hussar	-	2	*	2	**3**
Lutjanus argentimaculatus	Mangrove Jack	-	2	3	3	**3**
Lutjanus carponotatus	Stripey Snapper	-	-	-	2	**2**
Lutjanus fulviflamma	Blackspot Snapper	*	2	-	2	**2**
Lutjanus quinquelineatus	Fiveline Snapper	-	2	*	2	**2**
Lutjanus russelli	Moses' Snapper	2	3	3	3	**3**
Lutjanus sebae	Red Emperor	-	-	*	4	**4**
Lutjanus vitta	Brownstripe Snapper	-	-	-	2	**2**
Caesionidae						
Caesio caerulaurea	Goldband Fusilier	3	3	*	-	**3**
Dipterygonotus balteatus	Mottled Fusilier	-	*	-	-	*****
Pterocaesio chrysozona	Yellowband Fusilier	4	5	*	3	**5**
Pterocaesio digramma	Doubleline Fusilier	6	6	5	5	**6**
Nemipteridae						
Pentapodus paradiseus	Paradise Threadfin Bream	-	-	-	3	**3**
Scolopsis monogramma	Rainbow Monocle Bream	-	-	-	2	**2**
Haemulidae						
Diagramma pictum labiosum	Painted Sweetlips	-	3	3	4	**4**
Plectorhinchus flavomaculatus	Goldspotted Sweetlips	-	2	-	2	**2**
Plectorhinchus gibbosus	Brown Sweetlips	-	-	-	2	**2**
Plectorhinchus lessoni	Striped Sweetlips	-	1	-	-	**1**
Lethrinidae						
Lethrinus genivittatus	Threadfin Emperor	-	-	-	2	**2**
Lethrinus laticaudis	Grass Emperor	-	2	*	3	**3**
Lethrinus miniatus	Redthroat Emperor	*	2	-	3	**3**
Lethrinus nebulosus	Spangled Emperor	-	-	-	2	**2**
Sparidae						
Acanthopagrus australis	Yellowfin Bream	-	-	*	-	*****
Pagrus auratus	Snapper	1	3	-	3	**3**
Rhabdosargus sarba	Tarwhine	2	3	*	3	**3**
Mullidae						
Parupeneus spilurus	Blacksaddle Goatfish	2	4	2	4	**5**
Monodactylidae						
Schuetta scalaripinnis	Eastern Pomfret	3	-	-	-	**3**
Pempheridae						
Pempheris affinis	Blacktip Bullseye	-	-	*	-	*****
Scorpididae						
Scorpis lineolata	Silver Sweep	3	3	-	*	**3**
Microcanthidae						
Atypichthys strigatus	Mado	3	3	-	-	**3**
Microcanthus strigatus	Stripey	-	-	3	2	**3**
Ephippidae						
Platax teira	Roundface Batfish	4	3	-	2	**4**
Chaetodontidae						
Chaetodon auriga	Threadfin Butterflyfish	-	2	-	-	**2**
Chaetodon citrinellus	Speckled Butterflyfish	2	3	-	-	**3**
Chaetodon guentheri	Guenther's Butterflyfish	-	2	-	2	**2**
Chaetodon kleini	Klein's Butterflyfish	-	3	-	-	**3**
Chaetodon vagabundus	Vagabond Butterflyfish	-	2	-	-	**2**
Chelmon rostratus	Beaked Coralfish	-	-	-	1	**1**
Chelmonops truncatus	Eastern Talma	-	2	2	2	**3**
Coradion altivelis	Highfin Coralfish	-	-	-	*	*****
Heniochus acuminatus	Longfin Bannerfish	3	4	2	4	**5**
Pomacanthidae						
Chaetodontoplus meredithi	Qld Yellowtail Angelfish	*	*	-	1	**1**
Pomacentridae						
Abudefduf bengalensis	Bengal Sergeant	1	-	-	-	**1**
Abudefduf sexfasciatus	Scissortail Sergeant	4	*	-	-	**4**

Abudefduf vaigiensis	Indo-Pacific Sergeant	*	*	-	-	*
Abudefduf whitleyi	Whitley's Sergeant	*	-	-	-	*
Chromis nitida	Yellowback Puller	5	5	5	4	**6**
Chrysiptera flavipinnis	Yellowfin Demoiselle	2	3	-	-	**3**
Dascyllus trimaculatus	Threespot Humbug	*	2	-	-	**2**
Neopomacentrus bankieri	Chinese Demoiselle	4	5	5	4	**6**
Neopomacentrus cyanomos	Regal Demoiselle	*	3	2	*	**3**
Parma oligolepis	Bigscale Scalyfin	3	4	2	2	**4**
Parma unifasciata	Girdled Scalyfin	*	3	-	*	**3**
Pomacentrus australis	Australian Damsel	3	4	3	3	**5**
Pomacentrus coelestis	Neon Damsel	2	3	-	-	**3**
Pomacentrus nagasakiensis	Blue-scribbled Damsel	*	3	-	-	**3**
Pristotis obtusirostris	Gulf Damsel	3	4	4	1	**4**
Cirrhitidae						
Cirrhitichthys aprinus	Blotched Hawkfish	2	3	-	2	**3**
Cyprinocirrhites polyactis	Lyretail Hawkfish	*	2	-	-	**2**
Cheilodactylidae						
Cheilodactylus vestitus	Crested Morwong	*	*	3	3	**4**
Sphyraenidae						
Sphyraena obtusata	Striped Barracuda	-	-	4	-	**4**
Labridae						
Austrolabrus maculatus	Blackspotted Wrasse	*	2	-	-	**2**
Bodianus axillaris	Coral Pigfish	-	*	-	-	*
Choerodon cephalotes	Purple Tuskfish	-	-	-	1	**1**
Choerodon venustus	Venus Tuskfish	-	1	-	2	**2**
Cirrhilabrus punctatus	Finespot Wrasse	2	3	-	-	**3**
Labroides dimidiatus	Common Cleanerfish	3	3	2	2	**4**
Pseudolabrus guentheri	Gunther's Wrasse	3	4	3	2	**4**
Pterogogus enneacanthus	Cockerel Wrasse	-	2	-	-	**2**
Stethojulis bandanensis	Redspot Wrasse	-	3	-	-	**3**
Thalassoma amblycephalum	Bluehead Wrasse	3	-	-	-	**3**
Thalassoma janseni	Jansen's Wrasse	-	1	-	-	**1**
Thalassoma lunare	Moon Wrasse	3	4	-	2	**4**
Thalassoma lutescens	Green Moon Wrasse	2	3	-	-	**3**
Scaridae						
Scarus ghobban	Bluebarred Parrotfish	-	2	-	3	**3**
Pinguipedidae						
Parapercis nebulosa	Pinkbanded Grubfish	-	-	-	*	*
Blennidae						
Aspidontus dussumieri	Lance Blenny	-	3	-	-	**3**
Ecsenius bicolor	Bicolor Combtooth Blenny	-	2	-	-	**2**
Laiphognathus multimaculatus	Manyspot Blenny	-	1	-	-	**1**
Meiacanthus lineatus	Lined Fangblenny	2	2	-	-	**2**
Parablennius intermedius	Horned Blenny	2	3	-	-	**3**
Plagiotremus rhinorhynchos	Bluestriped Fangblenny	2	3	-	-	**3**
Plagiotremus tapeinosoma	Piano Fangblenny	2	3	-	-	**3**
Acanthuridae						
Acanthurus dussumieri	Pencil Surgeonfish	*	3	-	2	**3**
Acanthurus grammoptilus	Inshore Surgeonfish	*	*	-	-	*
Acanthurus mata	Pale Surgeonfish	4	4	-	-	**4**
Acanthurus nigrofuscus	Dusky Surgeonfish	2	2	-	-	**2**
Acanthurus xanthopterus	Yellowmask Surgeonfish	-	3	-	3	**4**
Naso annulatus	Ringtail Unicornfish	2	2	-	-	**3**
Prionurus maculatus	Spotted Sawtail	*	*	-	-	*
Prionurus microlepidotus	Australian Sawtail	3	3	-	2	**4**
Zanclidae						
Zanclus cornutus	Moorish Idol	-	2	-	-	**2**
Siganidae						
Siganus fuscescens	Black Rabbitfish	6	6	3	3	**6**
Balistidae						
Abalistes stellatus	Starry Triggerfish	-	-	-	*	*
Rhinecanthus rectangulus	Wedgetail Triggerfish	*	2	-	-	**2**
Sufflamen chrysopterum	Eye-stripe Triggerfish	*	2	-	-	**2**
Sufflamen fraenatum	Bridled Triggerfish	*	3	-	-	**3**

Monacanthidae						
Aluterus monoceros	Unicorn Leatherjacket	4	3	-	2	**4**
Aluterus scriptus	Scrawled Leatherjacket	-	1	-	1	**2**
Cantheschenia grandisquama	Largescale Leatherjacket	-	*	-	-	*****
Meuschenia trachylepis	Yellowfin Leatherjacket	1	-	-	-	**1**
Monacanthus chinensis	Fanbelly Leatherjacket	-	2	-	-	**2**
Paramonacanthus otisensis	Dusky Leatherjacket	2	2	1	2	**3**
Ostraciidae						
Ostracion cubicus	Yellow Boxfish	*	-	-	-	*****
Tetraodontidae						
Arothron hispidus	Stars and Stripes Puffer	-	2	*	1	**2**
Arothron stellatus	Starry Puffer	-	-	*	2	**2**
Canthigaster valentini	Blacksaddle Toby	-	2	*	-	**2**
Feroxodon multistriatus	Ferocious Puffer	-	-	-	1	**1**
Diodontidae						
Dicotylichthys punctulatus	Threebar Porcupinefish	*	*	-	*	*****
Diodon hystrix	Spotted Porcupinefish	-	1	-	1	**2**
Total Species		55	95	29	79	**131**

Table 3. Abundance of fishes visually recorded on wreck of HMAS Brisbane in November 2006, by sector of ship

(abundance in log 5 scale: 1=1 fish, 2=2-5, 3=6-25, 4=26-125, 5=126-625, 6=626-3125, 7=3126+; * = not recorded here, but recorded on site during an earlier study period)

Family Genus Species	Common Name	Abundance				
		Superstructure	Decks	Internal	Lower Hull	**Total**
Hemiscyllidae						
Chiloscyllium punctatum	Grey Carpetshark	**-**	**-**	1	**-**	**1**
Dasyatididae						
Dasyatis kuhlii	Bluespotted Maskray	-	-	-	*	*****
Taeniura meyeni	Blotched Fantail Ray	1	-	-	1	**2**
Myliobatididae						
Aetobatus narinari	Whitespotted Eagle Ray	*	-	-	-	*****
Synodontidae						
Synodus dermatogenys?	Banded Lizardfish	-	*	-	-	*****
Fistulariidae						
Fistularia petimba	Rough Flutemouth	-	-	-	*	*****
Scorpaenidae						
Inimicus caledonicus	Demon Stingerfish	-	-	-	1	**1**
Pterois volitans	Common Lionfish	1	*	-	2	**2**
Scorpaena cardinalis?	Eastern Red Scorpionfish	-	-	-	*	*****
Platycephalidae						
Cymbacephalus nematophthalmus	Fringe-eye Flathead	-	-	-	2	**2**
Platycephalus fuscus	Dusky Flathead	-	-	-	3	**3**
Serranidae						
Epinephelus areolatus	Yellowspotted Rockcod	-	-	-	1	**1**
Epinephelus cyanopodus	Purple Rockcod	2	3	3	2	**3**
Epinephelus undulostriatus	Maori Rockcod	2	2	3	*	**3**
Plectropomus leopardus	Common Coral Trout	-	*	-	-	*****
Pseudanthias squamipinnis	Orange Basslet	2	3	-	-	**3**
Triso dermopterus	Oval Rockcod	2	2	*	*	**3**

Grammistidae						
Diploprion bifasciatum	Barred Soapfish	1	-	-	-	**1**
Priacanthidae						
Priacanthus hamrur	Lunartail Bigeye	3	3	3	3	**4**
Priacanthus macracanthus	Spotted Bigeye	2	4	2	3	**4**
Apogonidae						
Apogon capricornis	Capricorn Cardinalfish	3	4	6	4	**6**
Apogon cavitiensis	Whiteline Cardinalfish	-	*	-	*	*
Apogon cookii	Cook's Cardinalfish	-	*	*	*	*
Apogon doederleini	Fourline Cardinalfish	-	-	-	*	*
Apogon limenus	Sydney Cardinalfish	2	*	3	*	**3**
Rhabdamia gracilis	Slender Cardinalfish	-	-	4	-	**4**
Echeneidae						
Echeneis naucrates	Sharksucker	*	-	-	-	*
Carangidae						
Carangoides chrysophrys	Longnose Trevally	4	4	3	4	**5**
Carangoides ferdau	Blue Trevally	-	*	-	-	*
Carangoides fulvoguttatus	Turrum	-	*	-	*	*
Carangoides gymnostethus	Bludger Trevally	4	-	-	*	**4**
Caranx orthogrammus	Thicklip Trevally	-	*	-	*	*
Caranx melampygus	Bluefin Trevally	-	-	-	*	*
Caranx papuensis	Brassy Trevally	-	*	-	*	*
Caranx sexfasciatus	Bigeye Trevally	-	-	-	*	*
Decapterus russelli	Indian Scad	*	-	2	-	**2**
Gnathanodon speciosus	Golden Trevally	-	3	-	4	**4**
Seriola dumerili	Amberjack	3	3	2	3	**4**
Seriola lalandi	Yellowtail Kingfish	3	3	3	2	**3**
Trachurus novaezelandiae?	Yellowtail Scad	*	-	-	-	*
Lutjanidae						
Lutjanus adetii	Hussar	-	*	3	*	**3**
Lutjanus argentimaculatus	Mangrove Jack	-	*	*	2	**2**
Lutjanus carponotatus	Stripey Snapper	-	-	-	*	*
Lutjanus fulviflamma	Blackspot Snapper	1	*	-	*	**1**
Lutjanus quinquelineatus	Fiveline Snapper	-	*	2	3	**3**
Lutjanus russelli	Moses' Snapper	3	3	3	3	**4**
Lutjanus sebae	Red Emperor	-	-	2	4	**4**
Lutjanus vitta	Brownstripe Snapper	-	-	-	2	**2**
Caesionidae						
Caesio caerulaurea	Goldband Fusilier	3	4	3	-	**4**
Dipterygonotus balteatus	Mottled Fusilier	-	1	-	-	**1**
Pterocaesio chrysozona	Yellowband Fusilier	*	2	3	*	**3**
Pterocaesio digramma	Doubleline Fusilier	4	5	2	*	**6**
Nemipteridae						
Pentapodus paradiseus	Paradise Threadfin Bream	-	-	-	3	**3**
Scolopsis monogramma	Rainbow Monocle Bream	-	-	-	*	*
Haemulidae						
Diagramma pictum labiosum	Painted Sweetlips	-	2	*	3	**3**
Plectorhinchus flavomaculatus	Goldspotted Sweetlips	-	*	-	*	*
Plectorhinchus gibbosus	Brown Sweetlips	-	-	-	*	*
Plectorhinchus lessoni	Striped Sweetlips	-	*	-	-	*
Lethrinidae						
Lethrinus genivittatus	Threadfin Emperor	-	-	-	2	**2**
Lethrinus laticaudis	Grass Emperor	-	3	2	4	**4**
Lethrinus miniatus	Redthroat Emperor	1	*	-	*	**1**
Lethrinus nebulosus	Spangled Emperor	-	-	-	3	**3**
			-			
Sparidae						
Acanthopagrus australis	Yellowfin Bream	-	-	1	-	**1**
Pagrus auratus	Snapper	*	2	-	2	**3**
Rhabdosargus sarba	Tarwhine	2	2	1	3	**3**
Mullidae						
Parupeneus spilurus	Blacksaddle Goatfish	3	4	3	4	**5**
Monodactylidae						
Schuetta scalaripinnis	Eastern Pomfret	*	-	-	-	*

Pempherididae						
Pempheris affinis	Blacktip Bullseye	-	-	3	-	**3**
Scorpididae						
Scorpis lineolata	Silver Sweep	3	*	-	2	**3**
Microcanthidae						
Atypichthys strigatus	Mado	*	*	-	-	*****
Microcanthus strigatus	Stripey	-	-	3	3	**3**
Ephippidae						
Platax teira	Roundface Batfish	3	2	-	*	**3**
Chaetodontidae						
Chaetodon auriga	Threadfin Butterflyfish	1	1	-	-	**2**
Chaetodon citrinellus	Speckled Butterflyfish	*	2	-	-	**2**
Chaetodon guentheri	Guenther's Butterflyfish	2	2	-	2	**3**
Chaetodon kleini	Klein's Butterflyfish	-	3	-	-	**3**
Chaetodon vagabundus	Vagabond Butterflyfish	-	*	-	-	*****
Chelmon rostratus	Beaked Coralfish	-	-	-	*	*****
Chelmonops truncatus	Eastern Talma	-	*	1	1	**2**
Coradion altivelis	Highfin Coralfish	-	-	-	1	**1**
Heniochus acuminatus	Longfin Bannerfish	3	3	*	3	**4**
Pomacanthidae						
Chaetodontoplus meredithi	Qld Yellowtail Angelfish	2	2	-	*	**2**
Pomacentridae						
Abudefduf bengalensis	Bengal Sergeant	1	-	-	-	**1**
Abudefduf sexfasciatus	Scissortail Sergeant	3	3	-	-	**3**
Abudefduf vaigiensis	Indo-Pacific Sergeant	3	4	-	-	**4**
Abudefduf whitleyi	Whitley's Sergeant	2	-	-	-	**2**
Chromis nitida	Yellowback Puller	4	5	4	3	**5**
Chrysiptera flavipinnis	Yellowfin Demoiselle	*	2	-	-	**2**
Dascyllus trimaculatus	Threespot Humbug	2	2	-	-	**3**
Neopomacentrus bankieri	Chinese Demoiselle	3	4	3	*	**5**
Neopomacentrus cyanomos	Regal Demoiselle	2	3	*	2	**3**
Parma oligolepis	Bigscale Scalyfin	1	3	*	*	**3**
Parma unifasciata	Girdled Scalyfin	2	3	-	1	**3**
Pomacentrus australis	Australian Damsel	3	3	3	*	**4**
Pomacentrus coelestis	Neon Damsel	4	3	-	-	**4**
Pomacentrus nagasakiensis	Blue-scribbled Damsel	1	2	-	-	**2**
Pristotis obtusirostris	Gulf Damsel	3	3	*	*	**4**
Cirrhitidae						
Cirrhitichthys aprinus	Blotched Hawkfish	3	3	-	*	**3**
Cyprinocirrhites polyactis	Lyretail Hawkfish	2	*	-	-	**2**
Cheilodactylidae						
Cheilodactylus vestitus	Crested Morwong	1	3	3	3	**3**
Sphyraenidae						
Sphyraena obtusata	Striped Barracuda	-	-	*	-	*****
Labridae						
Austrolabrus maculatus	Blackspotted Wrasse	1	*	-	-	**1**
Bodianus axillaris	Coral Pigfish	-	1	-	-	**1**
Choerodon cephalotes	Purple Tuskfish	-	-	-	1	**1**
Choerodon venustus	Venus Tuskfish	-	*	-	*	*****
Cirrhilabrus punctatus	Finespot Wrasse	3	2	-	-	**3**
Labroides dimidiatus	Common Cleanerfish	3	3	*	3	**4**
Pseudolabrus guentheri	Gunther's Wrasse	3	3	3	2	**4**
Pterogogus enneacanthus	Cockerel Wrasse	-	1	-	-	**1**
Stethojulis bandanensis	Redspot Wrasse	-	1	-	-	**1**
Thalassoma amblycephalum	Bluehead Wrasse	3	-	-	-	**3**
Thalassoma janseni	Jansen's Wrasse	-	1	-	-	**1**
Thalassoma lunare	Moon Wrasse	2	3	-	*	**3**
Thalassoma lutescens	Green Moon Wrasse	1	2	-	-	**2**
Scaridae						
Scarus ghobban	Bluebarred Parrotfish	-	*	-	*	*****
Pinguipedidae						
Parapercis nebulosa	Pinkbanded Grubfish	-	-	-	1	**1**
Blennidae						
Aspidontus dussumieri	Lance Blenny	-	3	-	-	**3**

Ecsenius bicolor	Bicolor Combtooth Blenny	-	*	-	-	*
Laiphognathus multimaculatus	Manyspot Blenny	-	*	-	-	*
Meiacanthus lineatus	Lined Fangblenny	*	*	-	-	*
Parablennius intermedius	Horned Blenny	2	*	-	-	**2**
Plagiotremus rhinorhynchos	Bluestriped Fangblenny	*	*	-	-	*
Plagiotremus tapeinosoma	Piano Fangblenny	2	2	-	-	**3**
Acanthuridae						
Acanthurus dussumieri	Pencil Surgeonfish	2	3	-	3	**3**
Acanthurus grammoptilus	Inshore Surgeonfish	3	2	-	-	**3**
Acanthurus mata	Pale Surgeonfish	2	3	-	-	**3**
Acanthurus nigrofuscus	Dusky Surgeonfish	1	*	-	-	**1**
Acanthurus xanthopterus	Yellowmask Surgeonfish	-	*	-	*	*
Naso annulatus	Ringtail Unicornfish	*	2	-	-	**2**
Prionurus maculatus	Spotted Sawtail	2	2	-	-	**3**
Prionurus microlepidotus	Australian Sawtail	3	3	-	*	**4**
Zanclidae						
Zanclus cornutus	Moorish Idol	-	*	-	-	*
Siganidae						
Siganus fuscescens	Black Rabbitfish	5	4	*	3	**5**
Balistidae						
Abalistes stellatus	Starry Triggerfish	-	-	-	1	**1**
Rhinecanthus rectangulus	Wedgetail Triggerfish	1	*	-	-	**1**
Sufflamen chrysopterum	Eye-stripe Triggerfish	2	2	-	-	**3**
Sufflamen fraenatum	Bridled Triggerfish	2	3	-	-	**3**
Monacanthidae						
Aluterus monoceros	Unicorn Leatherjacket	1	2	-	2	**3**
Aluterus scriptus	Scrawled Leatherjacket	-	*	-	*	*
Cantheschenia grandisquama	Largescale Leatherjacket	-	2	-	-	**2**
Meuschenia trachylepis	Yellowfin Leatherjacket	1	-	-	-	**1**
Monacanthus chinensis	Fanbelly Leatherjacket	-	*	-	-	*
Paramonacanthus otisensis	Dusky Leatherjacket	*	*	*	*	*
Ostraciidae						
Ostracion cubicus	Yellow Boxfish	1	-	-	-	**1**
Tetraodontidae						
Arothron hispidus	Stars and Stripes Puffer	-	*	1	*	**1**
Arothron stellatus	Starry Puffer	-	-	1	*	**1**
Canthigaster valentini	Blacksaddle Toby	-	*	1	-	**1**
Feroxodon multistriatus	Ferocious Puffer	-	-	-	*	*
Diodontidae						
Dicotylichthys punctulatus	Threebar Porcupinefish	2	1	-	1	**2**
Diodon hystrix	Spotted Porcupinefish	-	*	-	*	*
Total Species		68	66	33	46	**110**
Cumulative Total (July + Nov.)		82	106	46	89	**150**

Table 3: ANOVA of the variation in coverage of total sessile fauna, sessile species density and total algal coverage, between port and starboard sides of the wreck (Aspect) and at different depths (12, 18 & 23 metres).

Tab. 3 Source of Variation	df	Sessile coverage ^		Sessile species density		Algal coverage ^	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Aspect	1	0.11	1.59	48.59	32.51***	0.29	11.04***
Depth	2	12.6	183.58***	211.66	141.63***	2.24	86.62***
Aspect x Depth	2	0.02	0.34	16.02	10.72***	0.07	2.59
Error	234	0.07		1.49		0.03	

^ data were arcsine transformed to correct for heterogeneous variances after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Table 4: ANOVA of the variation in coverage of major taxonomic groups between port and starboard sides of the wreck (aspect) and at different depths (12, 18 & 23 metres).

Tab. 4 Source of Variation	df	Ascidiacea		Porifera ^		Bryozoa ^		Bivalvia ^		Polychaete ^		Barnacle ^	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Aspect	1	0.62	1.71	0.54	24.84***	0.53	20.95***	0.04	3.71	0.03	3.33	0.05	1.06
Depth	2	1.65	**4.56***	0.73	33.86***	1.52	59.95***	2.32	**194.30*****	0.01	1.25	6.65	137.10***
Aspect x Depth	2	0.46	1.26	0.26	**12.11*****	0.08	**3.27***	0.03	2.84	0.01	1.36	0.30	**6.10****
Error	234	0.36		0.02		0.03		0.01		0.01		0.05	

^ data were arcsine transformed to correct for heterogeneous variances after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Table 5: ANOVA of the variation in coverage of total sessile fauna, sessile species density and total algal coverage on horizontal and vertical surfaces (Orientation) across depth (12, 18 & 23 metres).

Tab. 5 Source of Variation	df	Sessile coverage^		Sessile species density[#]		Algal coverage ^	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Orientation	1	12.58	456.12***	14.61	179.7***	0.44	16.86***
Depth	1	0.00	0.05	0.23	2.86	5.25	201.31***
Orientation x Depth	1	0.84	**30.62*****	0.36	**4.48***	1.44	**55.22*****
Error	221	0.03		0.08		0.03	

^ data were arcsine transformed; [#] data were Log (x+1) transformed, to correct for heterogeneous variance after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Table 6: ANOVA of the variation in coverage sessile faunal groups on horizontal and vertical surfaces (Orientation) across depth (12, 18 & 23 metres).

Tab. 6 Source of Variation	df	Ascidiacea		Porifera		Bryozoa ^		Bivalvia ^		Polychaete ^		Barnacle ^	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Orientation	1	2.74	**7.06****	1484.20	**30.10*****	2.18	95.48***	0.04	**48.21*****	0.14	**33.99*****	0.01	**39.88*****
Depth	1	0.11	0.28	114.44	2.32	0.52	22.67***	2.32	**122.95*****	0.01	1.65	0.00	1.26
Orientation x Depth	1	0.11	0.28	114.44	2.32	0.62	**27.31*****	0.00	0.00	0.01	1.09	0.00	0.65
Error	221	0.39		49.32		0.02		0.03		0.004		0.00	

^ data were arcsine transformed to correct for heterogeneous variances after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Table 7: ANOVA of the variation in coverage of total sessile fauna, sessile species density and total algal coverage, inside and outside the wreck at 18 metres depth.

Tab. 7 Source of Variation	df	Sessile coverage ^		Sessile species density		Algal coverage ^	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Location	1	6.20	**148.14*****	50.64	**20.91*****	1.44	**75.72*****
Error	133	0.04		2.42		0.02	

^ data were arcsine transformed to correct for heterogeneous variances after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Table 8: ANOVA of the variation in coverage sessile faunal groups inside and outside the wreck at 18 metres depth.

Tab. 8 Source of Variation	df	Ascidiacea ^		Porifera ^		Bryozoa		Bivalvia ^		Polychaete ^		Barnacle	
		MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.	MS	F/Sig.
Orientation	1	0.00	**3.67**	0.48	**18.07*****	1450.01	**7.72****	0.09	**15.97*****	2.07	**70.24*****	52664	**217.74*****
Error	133	0.00		0.03		187.92		0.01		0.03		241.90	

^ data were arcsine transformed to correct for heterogeneous variances after Cochran's test. Level of significance: *p < 0.05, **p < 0.01, ***p < 0.001

Family Genus Species	Preferred Habitat	HMAS Brisbane visual	Other Sunshine Coast Sites	
			visual	collections#
Lamnidae (Mackerel Sharks)				
Carcharodon carcharias	P	-	-	X
Brachaeluridae (Blind Sharks)				
Brachaelurus waddi	R	-	-	X
Orectolobidae (Wobbegongs)				
Orectolobus maculatus	R	-	X	-
Orectolobus ornatus	R	-	X	X
Hemiscyllidae (Longtail Carpetsharks)				
Chiloscyllium punctatum	R	X	-	-
Carcharhinidae (Whaler Sharks)				
Carcharhinus falciformis	P	-	-	X
Carcharhinus obscurus	P	-	-	X
Rhinidae (Wedgefishes)				
Rhina ancylostoma	S	-	-	X
Rhinobatidae (Guitarfishes)				
Aptychotrema rostrata	S	-	-	X
Hypnidae (Coffin Rays)				
Hypnos monopterygium	S	-	-	X
Dasyatididae (Stingrays)				
Dasyatis kuhlii	S	X	X	-
Taeniura meyeni	S	X	X	-
Urolophidae (Stingarees)				
Trygonoptera testacea	S	-	X	X
Myliobatididae (Eagle Rays)				
Aetobatus narinari	P	X	-	-
Mobulidae (Devilrays)				
Mobula eregoodootenkee	P	-	-	X
Albulidae (Bonefishes)				
Albula argentea	S	-	-	X
Muraenidae (Moray Eels)				
Echidna nebulosa	R	-	-	X
Gymnothorax cribroris	R	-	-	X
Gymnothorax favagineus	R	-	-	X
Gymnothorax pseudothyrsoideus	R	-	-	X
Gymnothorax thyrsoideus	R	-	X	X
Congridae (Conger Eels)				
Ariosoma anago	S	-	-	X

Appendix 1. Fishes recorded on HMAS Brisbane in 2006 versus Sunshine Coast sublittoral marine fishes collected and visually recorded at sites up to 35 m depth*

(P = pelagic, not strongly habitat specific; R = reef; S = sand, low rubble)

Queensland Museum specimens and incidental visual records taken between Noosa Heads and Caloundra (26°22 - 26°49'S) in depths of 1-35m (excludes estuarine and littoral species).

Collections include specimens taken by demersal trawl, ichthyocides and hand-lining.

Ophichthyidae (Snake Eels)				
Malvoliophis pinguis	S	-	-	X
Clupeidae (Herrings)				
Sardinops neopilchardus	P	-	-	X
Spratelloides robustus	S	-	-	X
Synodontidae (Lizardfishes)				
Saurida gracilis	R	-	-	X
Saurida tumbil	S	-	X	-
Saurida undosquamis	S	-	-	X
Synodus dermatogenys?	R	X	-	-
Synodus sp.	R	-	-	X
Trachinocephalus myops	S	-	-	X
Plotosidae (Eeltail Catfishes)				
Euristhmus lepturus	S	-	-	X
Plotosus lineatus	R	-	-	X
Batrachoididae (Frogfishes)				
Batrachomoeus dubius	R	-	-	X
Halophryne queenslandiae	R	-	-	X
Antennariidae (Anglerfishes)				
Antennarius striatus	S	-	-	X
Histiophryne bougainvilli	R	-	-	X
Histrio histrio	P	-	-	X
Bythitidae (Live-bearing Cusk Eels)				
Dinematichthys sp. C	R	-	-	X
Monocentridae (Pineapplefishes)				
Cleidopus gloriamaris	R	-	-	X
Holocentridae (Squirrelfishes)				
Myripristis berndti	R	-	X	X
Sargocentron rubrum	R	-	X	X
Fistulariidae (Flutemouths)				
Fistularia commersonii	S	-	-	X
Fistularia petimba	S	X	-	X
Centriscidae (Razorfishes)				
Centriscus scutatus	S	-	-	X
Syngnathidae (Pipefishes)				
Filicampus tigris	S	-	-	X
Hippocampus tristis	S	-	-	X
Stigmatophora nigra	S	-	-	X
Syngnathoides biaculeatus	S	-	-	X
Scorpaenidae (Scorpionfishes)				
Apistops caloundra	S	-	-	X
Apistus carinatus	S	-	-	X
Centropogon australis	R	-	-	X

Dendrochirus zebra	R	-	-	X
Erosa erosa	S	-	-	X
Inimicus caledonicus	S	X	-	X
Liocranium praepositum	R	-	-	X
Minous versicolor	S	-	-	X
Parascorpaena picta	R	-	-	X
Pterois volitans	R	X	X	X
Scorpaena cardinalis	R	X	X	X
Scorpaena sp. nov.	R	-	-	X
Scorpaenopsis venosa	R	-	-	X
Synanceia horrida	S	-	-	X
Triglidae (Searobins)				
Chelidonichthys kumu	S	-	-	X
Lepidotrigla argus	S	-	-	X
Lepidotrigla umbrosa	S	-	-	X
Aploactinidae (Velvetfishes)				
Aploactis aspera	S	-	-	X
Pataecidae (Prowfishes)				
Pataecus fronto	S	-	-	X
Platycephalidae (Flatheads)				
Cymbacephalus nematophthalmus	S	X	-	-
Platycephalus arenarius	S	-	-	X
Platycephalus fuscus	S	X	X	-
Platycephalus longispinis	S	-	-	X
Platycephalus marmoratus	S	-	-	X
Dactylopteridae (Flying Gurnards)				
Dactyloptena orientalis	S	-	-	X
Dactyloptena papilio	S	-	-	X
Pegasidae (Seamoths)				
Pegasus volitans	S	-	-	X
Serranidae (Rockcods)				
Cephalopholis argus	R	-	-	X
Epinephelus areolatus	R	X	-	-
Epinephelus cyanopodus	R	X	-	-
Epinephelus fasciatus	R	-	X	X
Epinephelus maculatus	R	-	-	X
Epinephelus quoyanus	R	-	X	X
Epinephelus undulostriatus	R	X	-	X
Plectropomus leopardus	R	X	X	X
Pseudanthias squamipinnis	R	X	-	-
Rainfordia opercularis	R	-	-	X
Triso dermopterus	R	X	-	X
Grammistidae (Soapfishes)				
Diploprion bifasciatum	R	X	X	-
Grammistes sexlineatus	R	-	-	X
Pseudochromidae (Dottybacks)				
Ogilbyina novaehollandiae	R	-	X	X

Plesiopidae (Prettyfins)				
Paraplesiops poweri	R	-	X	X
Trachinops taeniatus	R	-	X	X
Acanthoclinidae (Spiny Basslets)				
Belonepterygium fasciolatum	R	-	-	X
Glaucosomidae (Pearl Perches)				
Glaucosoma scapulare	R	-	-	X
Priacanthidae (Bigeyes)				
Priacanthus hamrur	R	X	-	-
Priacanthus macracanthus	R	X	-	-
Apogonidae (Cardinalfishes)				
Apogon capricornis	R	X	X	X
Apogon cavitiensis	R	X	-	-
Apogon cookii	R	X	-	-
Apogon crassiceps	R	-	-	X
Apogon doederleini	R	X	X	X
Apogon fasciatus	S	-	-	X
Apogon limenus	R	X	X	X
Apogon nigripinnis	S	-	-	X
Apogon properuptus	R	-	-	X
Apogon semilineatus	S	-	-	X
Apogon semiornatus	R	-	-	X
Cheilodipterus macrodon	R	-	X	-
Rhabdamia gracilis	R	X	-	-
Sillaginidae (Whitings)				
Sillago ciliata	S	-	-	X
Sillago robusta	S	-	-	X
Rachycentridae (Black Kingfishes)				
Rachycentron canadus	P	-	-	X
Echeneididae (Remoras)				
Echeneis naucrates	P	X	X	X
Carangidae (Trevallies)				
Alectis ciliaris	S	-	-	X
Alepes apercna	S	-	X	X
Carangoides chrysophrys	P	X	-	-
Carangoides ferdau	P	X	-	X
Carangoides fulvoguttatus	P	X	-	X
Carangoides gymnostethus	P	X	-	-
Carangoides oblongus	P	-	-	X
Carangoides orthogrammus	P	X	-	-
Caranx melampygus	P	X	-	X
Caranx papuensis	P	X	-	-
Caranx sexfasciatus	P	X	-	-
Decapterus russelli	P	X	X	X
Gnathanodon speciosus	S	X	X	-
Scomberoides commersonianus	P	-	-	X
Seriola dumerili	R	X	X	X

Seriola lalandi	R	X	-	X
Seriolina nigrofasciata	P	-	-	X
Trachurus declivis	P	-	-	X
Trachurus novaezelandiae	P	X	-	X
Coryphaenidae (Dolphinfishes)				
Coryphaena hippurus	P	-	-	X
Lutjanidae (Tropical Snappers)				
Lutjanus adetii	R	X	-	X
Lutjanus argentimaculatus	R	X	X	-
Lutjanus carponotatus	R	X	X	-
Lutjanus fulviflamma	R	X	X	-
Lutjanus fulvus	R	-	-	X
Lutjanus kasmira	R	-	-	X
Lutjanus lemniscatus	R	-	-	X
Lutjanus malabaricus	R	-	-	X
Lutjanus monostigma	R	-	-	X
Lutjanus quinquelineatus	R	X	-	-
Lutjanus rivulatus	R	-	-	X
Lutjanus russelli	R	X	X	-
Lutjanus sebae	R	X	X	X
Lutjanus vitta	R	X	-	X
Caesionidae (Fusiliers)				
Caesio caerulaurea	R	X	-	-
Dipterygonotus balteatus	R	X	-	-
Pterocaesio chrysozona	R	X	-	-
Pterocaesio digramma	R	X	-	-
Nemipteridae (Threadfin Breams)				
Nemipterus theodorei	S	-	-	X
Pentapodus aureofasciatus	S	-	-	X
Pentapodus paradiseus	S	X	X	X
Scolopsis lineatus	R	-	-	X
Scolopsis monogramma	S	X	X	X
Lobotidae (Tripletails)				
Lobotes surinamensis	P	-	-	X
Gerreidae (Silverbiddies)				
Gerres subfasciatus	S	-	-	X
Haemulidae (Grunter Breams)				
Diagramma pictum labiosum	R	X	X	X
Plectorhinchus flavomaculatus	R	X	X	X
Plectorhinchus gibbosus	R	X	-	X
Plectorhinchus lessoni	R	X	X	-
Plectorhinchus picus	R	-	X	-
Plectorhinchus schotaf	R	-	X	X
Lethrinidae (Emperors)				
Gymnocranius audleyi	S	-	-	X
Lethrinus genivittatus	S	X	-	X
Lethrinus laticaudis	R	X	-	X
Lethrinus miniatus	R	X	-	X

Lethrinus nebulosus	R	X	-	X
Sparidae (Breams)				
Acanthopagrus australis	S	X	X	X
Pagrus auratus	R	X	X	X
Rhabdosargus sarba	R	X	X	-
Mullidae (Goatfishes)				
Parupeneus spilurus	R	X	X	X
Upeneichthys lineatus lineatus	S	-	-	X
Upeneus tragula	S	-	-	X
Monodactylidae (Silver Batfishes)				
Schuetta scalaripinnis	R	X	-	-
Pempheridídae (Bullseyes)				
Pempheris affinis	R	X	X	X
Pempheris ypsilychnus	R	-	X	X
Kyphosidae (Drummers)				
Girella tricuspidata	R	-	-	X
Kyphosus bigibbus	R	-	X	X
Scorpididae (Sweeps)				
Atypichthys strigatus	R	X	X	-
Microcanthus strigatus	R	X	X	X
Scorpis lineolatus	R	X	X	X
Ephippidae (Batfishes)				
Platax bataviensis	R	-	-	X
Platax teira	R	X	X	X
Zabidius novemaculeatus	S	-	-	X
Chaetodontidae (Butterflyfishes)				
Chaetodon auriga	R	X	-	-
Chaetodon citrinellus	R	X	-	-
Chaetodon guentheri	R	X	-	X
Chaetodon kleini	R	X	-	X
Chaetodon rainfordi	R	-	-	X
Chaetodon trifascialis	R	-	-	X
Chaetodon vagabundus	R	X	X	-
Chelmon rostratus	R	X	-	X
Chelmonops truncatus	R	X	-	X
Coradion altivelis	R	X	X	-
Heniochus acuminatus	R	X	-	X
Heniochus monoceros	R	-	-	X
Pomacanthidae (Angelfishes)				
Centropyge bispinosus	R	-	X	-
Centropyge tibicen	R	-	X	X
Chaetodontoplus meredithi	R	X	X	X
Pomacanthus semicirculatus	R	-	-	X
Pentacerotidae (Boarfishes)				
Paristiopterus labiosus	R	-	-	X

Pomacentridae (Damselfishes)				
Abudefduf bengalensis	R	X	-	X
Abudefduf sexfasciatus	R	X	-	X
Abudefduf vaigiensis	R	X	-	X
Abudefduf whitleyi	R	X	-	X
Amphiprion akindynos	R	-	-	X
Chromis nitida	R	X	X	X
Chrysiptera flavipinnis	R	X	-	-
Dascyllus reticulatus	R	-	-	X
Dascyllus trimaculatus	R	X	-	-
Mecaenichthys immaculatus	R	-	-	X
Neopomacentrus bankieri	R	X	-	-
Neopomacentrus cyanomos	R	X	-	-
Parma oligolepis	R	X	X	X
Parma unifasciata	R	X	-	X
Pomacentrus amboinensis	R	-	-	X
Pomacentrus australis	R	X	X	X
Pomacentrus bankanensis	R	-	-	X
Pomacentrus brachialis	R	-	-	X
Pomacentrus coelestis	R	X	-	X
Pomacentrus lepidogenys	R	-	-	X
Pomacentrus moluccensis	R	-	-	X
Pomacentrus nagasakiensis	R	X	X	X
Pomacentrus wardi	R	-	-	X
Pristotis obtusirostris	R	X	-	-
Stegastes apicalis	R	-	X	X
Stegastes gascoynei	R	-	X	X
Cirrhitidae (Hawkfishes)				
Cirrhitichthys aprinus	R	X	X	-
Cyprinocirrhites polyactis	R	X	-	-
Cheilodactylidae (Morwongs)				
Cheilodactylus vestitus	R	X	X	X
Dactylophora nigricans	R	-	-	X
Sphyraenidae (Barracudas)				
Sphyraena obtusata	R	X	-	-
Labridae (Wrasses)				
Achoerodus viridis	R	-	X	-
Anampses caeruleopunctatus	R	-	-	X
Austrolabrus maculatus	R	X	-	X
Bodianus axillaris	R	X	-	-
Choerodon cephalotes	S	X	X	X
Choerodon fasciatus	R	-	-	X
Choerodon graphicus	R	-	-	X
Choerodon venustus	R	X	-	X
Cirrhilabrus punctatus	R	X	-	X
Coris aurilineata	R	-	X	X
Coris aygula	R	-	-	X
Coris batuensis	R	-	X	-
Coris picta	R	-	-	X
Gomphosus varius	R	-	X	-
Halichoeres hortulanus	R	-	X	-
Halichoeres margaritaceus	R	-	-	X

Halichoeres marginatus	R	-	-	X
Halichoeres nebulosus	R	-	-	X
Halichoeres prosopeion	R	-	X	-
Labroides dimidiatus	R	X	X	X
Macropharyngodon choati	R	-	X	X
Macropharyngodon meleagris	R	-	-	X
Notolabrus gymnogenis	R	-	-	X
Ophthalmolepis lineolatus	R	-	-	X
Pseudolabrus guentheri	R	X	X	X
Pterogogus enneacanthus	R	X	-	-
Stethojulis bandanensis	R	X	-	-
Stethojulis interrupta	R	-	-	X
Suezichthys gracilis	S	-	-	X
Thalassoma amblycephalum	R	X	-	-
Thalassoma janseni	R	X	X	X
Thalassoma lunare	R	X	X	X
Thalassoma lutescens	R	X	X	X
Xyrichtys dea	S	-	-	X
Xyrichtys jacksonensis	S	-	-	X
Scaridae (Parrotfishes)				
Leptoscarus vaigiensis	S	-	-	X
Scarus ghobban	R	X	-	X
Opistognathidae (Jawfishes)				
Opistognathus eximius	S	-	-	X
Opistognathus jacksoniensis	S	-	-	X
Pinguipedidae (Grubfishes)				
Parapercis nebulosa	S	X	-	X
Parapercis stricticeps	S	-	-	X
Uranoscopidae (Stargazers)				
Ichthyscopus nigripinnis	S	-	-	X
Ichthyscopus sannio	S	-	-	X
Blennidae (Blennies)				
Aspidontus dussumieri	R	X	-	-
Aspidontus taeniatus	R	-	X	-
Cirripectes chelomatus	R	-	-	X
Crossosalarias macrospilus	R	-	-	X
Ecsenius bicolor	R	X	-	-
Laiphognathus multimaculatus	R	X	-	X
Meiacanthus lineatus	R	X	-	X
Parablennius intermedius	R	X	-	X
Parenchelyurus hepburni	R	-	-	X
Petroscirtes lupus	S	-	-	X
Plagiotremus rhinorhynchos	R	X	-	-
Plagiotremus tapeinosoma	R	X	X	X
Xiphasia setifer	S	-	-	X
Tripterygiidae (Triplefins)				
Enneapterygius atrogulare	R	-	-	X
Enneapterygius similis	R	-	-	X
Norfolkia squamiceps	R	-	-	X

Callionymidae (Dragonets)				
Calliurichthys ogilbyi	S	-	-	X
Eocallionymus papilio	R	-	-	X
Orbonymus rameus	S	-	-	X
Repomucenus calcaratus	S	-	-	X
Repomucenus limiceps	S	-	-	X
Gobiidae (Gobies)				
Bathygobius laddi	R	-	-	X
Callogobius sp.	R	-	-	X
Eviota sp.	R	-	-	X
Istigobius nigroocellatus	S	-	X	X
Priolepis cinctus	R	-	X	-
Priolepis nuchifasciatus	R	-	-	X
Acanthuridae (Surgeonfishes)				
Acanthurus dussumieri	R	X	-	-
Acanthurus grammoptilus	R	X	-	X
Acanthurus mata	R	X	-	X
Acanthurus nigrofuscus	R	X	-	-
Acanthurus xanthopterus	R	X	-	X
Naso annulatus	R	X	-	X
Naso maculatus	R	-	-	X
Naso tonganus	R	-	-	X
Prionurus maculatus	R	X	-	X
Prionurus microlepidotus	R	X	-	X
Zanclidae (Moorish Idols)				
Zanclus cornutus	R	X	X	-
Siganidae (Rabbitfishes)				
Siganus fuscescens	R	X	X	X
Bothidae (Lefteye Flounders)				
Arnoglossus fisoni	S	-	-	X
Engyprosopon grandisquama	S	-	-	X
Engyprosopon sp.	S	-	-	X
Soleidae (Soles)				
Aseraggodes melanostictus	S	-	-	X
Brachirus nigra	S	-	-	X
Pardachirus hedleyi	S	-	-	X
Soleichthys microcephalus	S	-	-	X
Synclidopus macleayanus	S	-	-	X
Zebrias scalaris	S	-	-	X
Triacanthidae (Tripodfishes)				
Tripodichthys angustifrons	S	-	-	X
Balistidae (Triggerfishes)				
Abalistes stellatus	S	X	X	X
Rhinecanthus rectangulus	R	X	-	-
Sufflamen chrysopterum	R	X	X	-
Sufflamen fraenatum	R	X	X	X
Monacanthidae (Leatherjackets)				
Aluterus monoceros	P	X	-	X
Aluterus scriptus	R	X	-	-

Brachaluteres taylori	S	-	-	X
Cantheschenia grandisquama	R	X	X	X
Meuschenia trachylepis	R	X	X	X
Monacanthus chinensis	R	X	-	-
Paramonacanthus filicauda	S	-	-	X
Paramonacanthus lowei	S	-	-	X
Paramonacanthus otisensis	S	X	-	X
Pervagor janthinosoma	R	-	-	X
Pseudomonacanthus peroni	S	-		X
Ostraciontidae (Boxfishes)				
Lactoria cornutus	S	-	-	X
Lactoria diaphana	S	-	-	X
Ostracion cubicus	R	X	X	X
Tetrosomus concatenatus	S	-	-	X
Tetraodontidae (Toadfishes)				
Arothron hispidus	R	X	-	-
Arothron manilensis	R	-	X	-
Arothron mappa	R	-	-	X
Arothron stellatus	R	X	X	X
Canthigaster valentini	R	X	-	-
Feroxodon multistriatus	S	X	-	X
Lagocephalus gloveri	S	-	-	X
Lagocephalus scleratus	S	-	X	-
Diodontidae (Porcupinefishes)				
Dicotylichthys punctulatus	R	X	-	X
Diodon holocanthus	S	-	X	-
Diodon hystrix	R	X	X	-
Tragulichthys jaculiferus	S	-	-	X
Total recorded	**357**	**150**	**94**	**278**
Total QM recorded				**309**