Biological Monitoring of the HMAS Swan

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ABSTRACT

Biological monitoring of the fish community that established on the HMAS Swan over a two year period has shown an increase in average richness from 2 to 32 species and an increase in abundance from 10 to nearly 1,300 individuals when compared to a nearby control site. The fish community on the vessel has rapidly shifted from omnivorous weed/sand fishes to one dominated by planktivorous and carnivorous reef fishes. The species richness and abundance on the HMAS Swan is beginning to approximate that of other natural reefs in the region; however, the species composition on the vessel is still distinctly different.

Monitoring of encrusting marine life over the same period has shown that the first biota to colonise the vessel were hydroids which rapidly covered exterior surfaces such that after 4 months they had covered approximately 70–90% of the area surveyed. Substantial algal growth was present during the summers of 1998 and 1999 and dominated the encrusting marine life on the starboard and upper surfaces. Other fauna groups such as sponges, ascidians, anemones and soft corals are showing marked signs of proliferation on the shaded portions of the vessel; however, the areas receiving full sunlight are less well colonised.

INTRODUCTION

Commissioned in 1970 as a class destroyer escort, the HMAS Swan is approximately 112 m in length, 24 m tall from keel to the tower, and 12 m wide amid ships. The hull is composed of steel plate while the upper decking and superstructure is aluminium.

The Geographe Bay Artificial Reef Society Inc. sank the HMAS SWAN 2.4 km off Point Piquet, Dunsborough Western Australia in 30 m of water as a dive wreck, artificial reef and tourist attraction on December 14th 1997. At the time of scuttling the HMAS Swan was regarded as the largest ship in the southern hemisphere to be deliberately scuttled for dive purposes.

Australia’s Commonwealth Environment Protection (Sea Dumping) Act 1981, aims to regulate the dumping of wastes and other materials into the sea by issuing Sea Dumping Permits and is administered by Environment Australia. In addition to the standard sea dumping conditions, Environment Australia requested that a rigorous biological monitoring program be undertaken to document the colonisation of the vessel by fishes and encrusting marine life. These data were not previously available for artificial reefs in Australia and were required to assess the ecological value of placing such a vessel on the sea bed. Due to the perceived potential for environmental impact resulting from residual hydrocarbons and electrolysis of metals aboard the HMAS Swan, it was decided to monitor sediment concentrations of key contaminants over the first 12 months after scuttling.

METHODOLOGY

Study Area

The location of the HMAS Swan and control sites is shown in **Figure 1**. The two sites are separated by approximately 3 km with the control site being up current.

Figure 1: Location of the HMAS Swan and Control sites

Fish Community

The assessment of colonisation rate of the HMAS Swan, once on the sea bed, required a series of surveys and as such had to be as non-destructive and non-disruptive as possible. Fish surveys were comprised of visual transects 100 m long by 5 m wide spatially separated by 10 m and they were adapted from methodologies described by Halford and Thompson (1994), GBRMPA (1978), and AIMS (1997) while taking into account the confounding effects of width of transect and observations time described by Bortone and Kimmel (1991).

To avoid the diurnal-nocturnal changeover periods of fishes, all surveys were undertaken between 0900 and 1600 hours (Carpenter *et al*. 1981). The effect of observer swimming speed on visual fish survey counts has been well documented (Lincoln Smith 1988). While conducting fish surveys, observers maintained a relatively slow speed sufficient to prevent being overtaken by previously tallied fishes yet slow enough to allow detection of cryptic species.

All observers used in the survey were fish biologists experienced at performing fish surveys. Consistency was maintained by having the same observers throughout the study. The identification manual used in the study was “Sea Fishes of Southern Australia” by Hutchins and Swainston (1986) supplemented by “The Fishes of Australia’s South Coast” by Gomon *et al*. (1994).

Encrusting Marine Life

The use of video cameras to survey and monitor benthic communities, together with scientific assessment of the validity of such methods, was developed by the Australian Institute of Marine Science (AIMS) in 1987 (Berkelmans 1992, Carleton and Done 1995). Sinclair Knight Merz has refined this initial work for specific survey purposes such as the HMAS Swan.

Video footage of the site was recorded with a High 8 video camera in a housing along 4 permanent 25 m transects (**Figure 2**). Each transect was marked by laying a 25 m measuring tape between the start and finish markers. On the vertical surface of the side of the vessel the measuring tape was held in place using doughnut magnets while on the horizontal upper decks it was simply weighted down.

A diver maintained a constant speed of 0.2 m/s and the video was kept approximately 0.3 m above the surface of the vessel or biota. This captured a band width of around 0.6 m and a total area of 15 m^2 per transect.

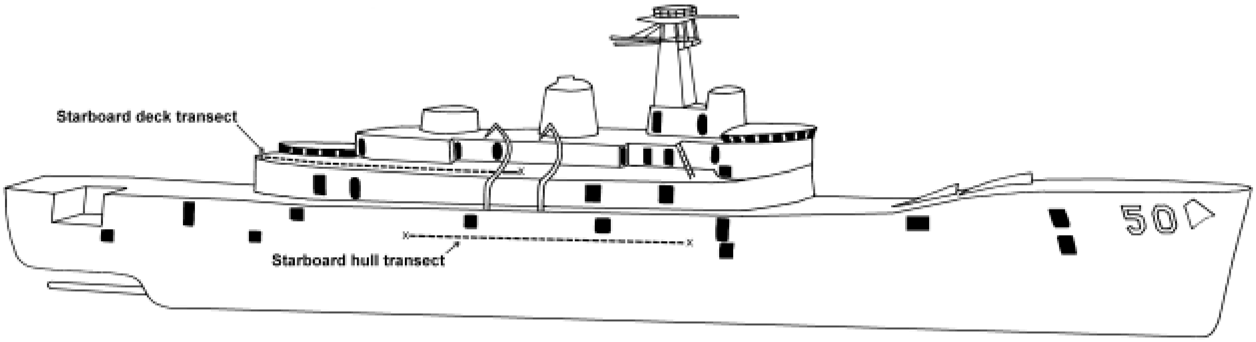


Figure 2: Video transect positions on the HMAS Swan

The recorded video tape of each transect was converted into a computer avi file using a video capture system at a rate of 25 frames per second. The resulting file contained approximately 3,125 frames and was stored on CD prior to analysis.

The Sinclair Knight Merz Video Transect Analysis System was used to analyse the recorded video transects. The start and finish points of each transect were marked and the program then proceeded to randomly select 300 frames along the transect and randomly position a spot on each frame for identification. While viewing the recording, the program paused at each of the randomly selected frames for the operator to identify the organism or substrate under the spot on the screen. Given that the transects were 125 seconds long (25 m recorded at 0.2 ms-1), the average distance between each selected frame was 8.3 cm or 0.4 seconds. The sampling rate meant that approximately 10% of the video recording was sampled.

Once the analysis of a transect had been completed, the program then calculated the abundance (percent cover) of benthic organisms and any non-colonised substrate.

Sediments

Marine sediment samples were collected from both the control site and the site where the HMAS Swan is now resting during the baseline survey (prior to the Swan being scuttled) and at intervals of 5 and 12 months after scuttling. Replicate samples were collected by divers at each site using a polycarbonate corer. Each replicate sample was comprised of a number of bulked samples collected from the top 2 cm of sediment randomly along a 100 m transect at each site.

Sediment samples were analysed for the metals aluminium (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), and zinc (Zn) and for total petroleum hydrocarbons. Statistical comparisons of mean contaminant concentrations between the control and HMAS Swan sites were calculated using t-tests with $\alpha = 0.05$. Comparisons between Baseline and subsequent sampling events were calculated using t-tests. Non-parametric comparisons were chosen because sediment metal concentrations are unlikely to be normally distributed, and the small number of samples prevents adequate testing for normality, which rules out using parametric tests such as ANOVA. Metals that were below detection limits were compared by substituting the detection limit as a representative value.

RESULTS AND DISCUSSION

Fish Community

The fish community on the HMAS Swan has shown a gradual increase in species richness or diversity over the 24 months of monitoring (**Figure 3**). A total of 77 species have been observed on the vessel during the monitoring program. Many species have been present during every survey, such as the ten most common species (**Figure 4**); however, a number of local species such as the Yellow-headed Hulafish, West Australian Jewfish and Pink Snapper and the tropical species Blue-lined Sabretooth Blenny and the deep water John Dory appear to be seasonal. The ten most common species accounted for 95.5% of the total fish abundance on the HMAS Swan during December 1999. Of this 44.4% were Rough Bullseyes which was one of the first species to colonise the HMAS Swan in significant numbers.

The average or mean number of species observed on each survey shows a rapid increase during the first 6 months since the vessel was scuttled followed by a gradual increase over the next 18 months (**Figure 5**). In comparison, that of the control site is relatively constant apart from a peak in May of 1999 when several tropical species were observed, presumably as a result of the influence of the tropical Leeuwin Current.

The abundance of fishes on the HMAS Swan showed a continual increase until the October 1999 survey when a sudden decrease was recorded (**Figure 6**). This reduction appears to be primarily due to reduced numbers of the most abundant species Rough Bullseyes, Black-headed Pullers and Yellow-headed Hulafish and to a lesser extent Tarwhine and Silver Trevally. This may be a seasonal effect or the natural development of a stable fish population.

The impact of recreational fishermen who have been heavily fishing the area even though it is an exclusion zone may have lead to reduced numbers of some target species such as the Tarwhine and Silver Trevally; however, this would not account for the decrease in the number of Rough Bullseyes, Black-headed Pullers and Yellow-headed Hulafish. The abundance in December 1999 showed a significant increase reaching a level similar to that of December 1998. The abundance of May 1999 may only be a seasonal effect, similar to observed algal growth, which was associated with large recruitment of Black-headed Pullers or an effect of the strong Leeuwin Current during that year; however, this can only be speculation.

The effect of fishing on the HMAS Swan is difficult to assess; however, the abundance of most fishes targeted by recreational fishers have either decreased (such as the Tarwhine, King George Whiting and Silver Trevally) or have disappeared altogether (such as the Long-snouted Boarfish and Baldchin Groper). The fact that significant numbers of fishers have been frequenting the HMAS Swan, particularly during winter, has undoubtably affected the fish population in the vicinity of the vessel.

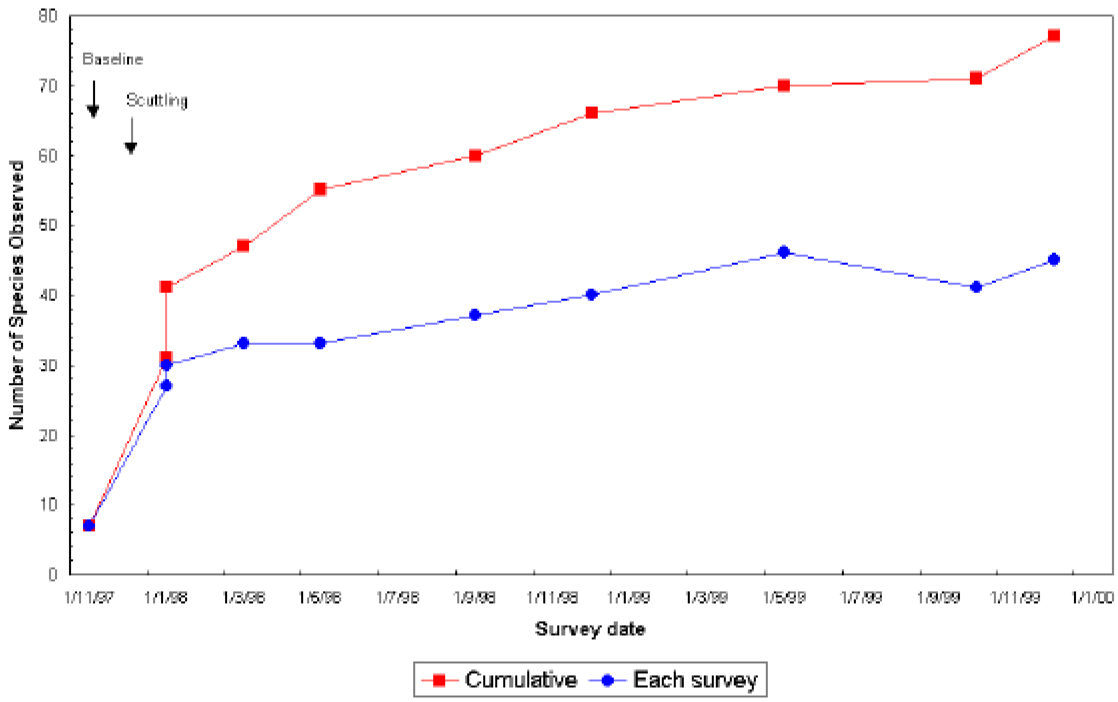


Figure 3: Cumulative number of species observed on HMAS Swan

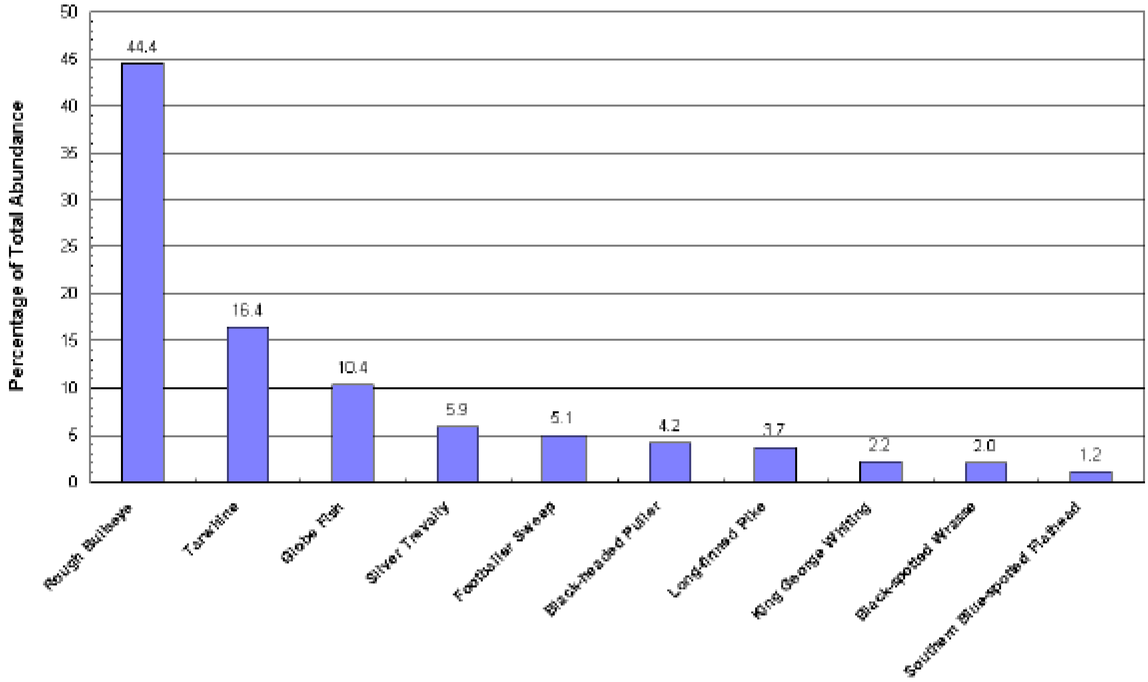


Figure 4: Ten most common fish species observed on the HMAS Swan

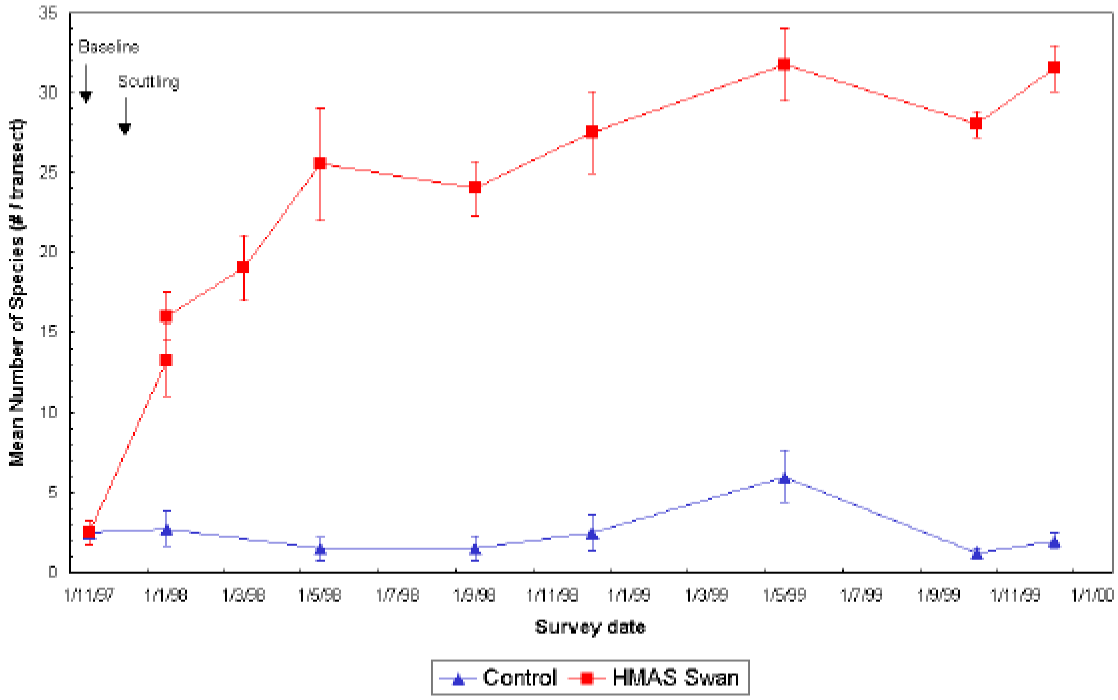


Figure 5: Mean fish species richness at HMAS Swan and Control sites

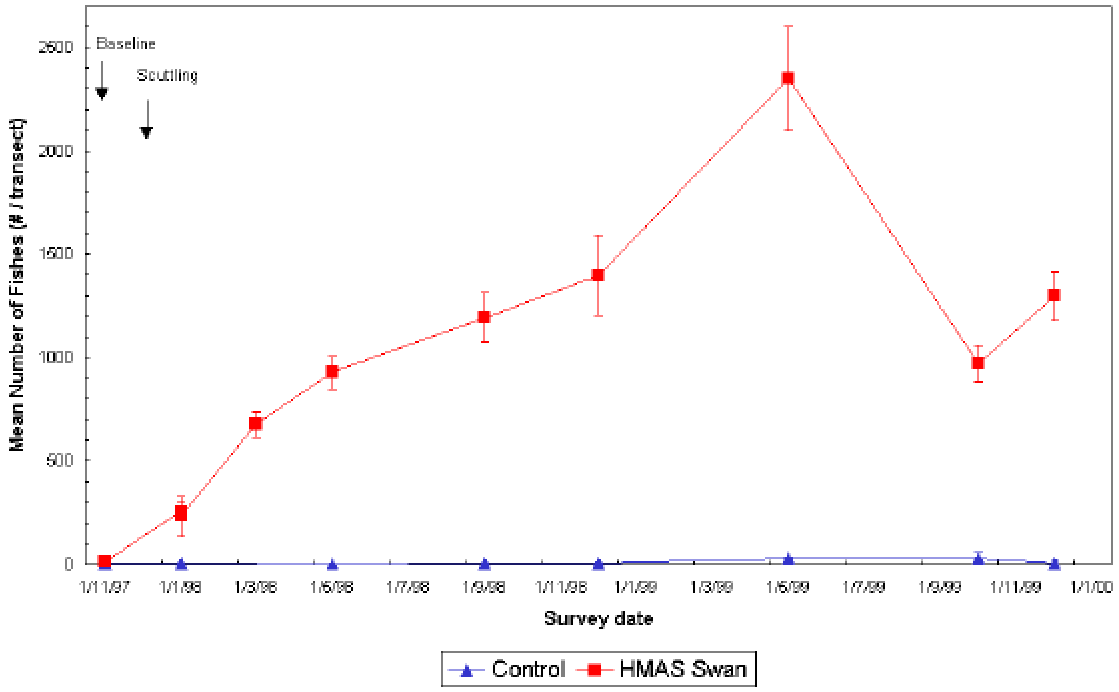


Figure 6: Mean fish abundance at HMAS Swan and Control sites

A limited number of surveys conducted on surrounding reefs and a jetty are presented for comparison with the data for the HMAS Swan during the December 1999 survey in **Table 1**. These data indicate that the species richness and abundance of fishes on the HMAS Swan are greater than that of Wright Bank and Geographe Ridge while still less than that of Busselton Jetty. While the number of surveys undertaken at these other sites is limited, the size and composition of the fish community on the HMAS Swan is remarkable for only a two year period.

Table 1: Mean fish species richness and abundance at other survey sites

Site	N	Richness †	Abundance †
HMAS Swan (December 1999)	4	31.5±1.5	1,299±117
Wright Bank	4	19.8±1.7	218±29
Geographe Ridge	2	23.0±0.0	724±277
Busselton Jetty	3	34.0±0.0	1,852±359

† Representative of a 100 m long by 5 m wide transect.

The ecology of the fish population on the HMAS Swan is described here by the habitat preference and feeding guild of the species present. The habitat preference, expressed as the percentage of fish abundance within the groups Pelagic, Weed/Sand and Reef, is graphically presented in **Figure 7**. Prior to scuttling the fish community in the area was comprised of species preferring Weed/Sand habitats. Since scuttling the species composition of the fish community has had a minor increase in pelagic species and a significant increase in species with a preference for reef habitat. It is also worth noting that the pelagic component of the fish community appears to be seasonal. These data indicate that the HMAS Swan is attracting reef fishes and is quickly approximating a reef fish community structure.

The feeding guild, expressed as a percentage of fish abundance within the groups Herbivores, Planktivores, Omnivores and Carnivores, is graphically presented in **Figure 8**. Prior to scuttling the fish community in the area was dominated by omnivorous fishes and to a lesser extent carnivorous fishes. Since scuttling the fish community has had a significant increase in the proportion of planktivorous and carnivorous fishes while the proportion of omnivorous fishes has markedly decreased. This would indicate that the vessel is either providing a food supply for the carnivores or simply a daytime residence for species that make nocturnal feeding forays. Planktivores have also increased since the vessel was scuttled and appears to be linked to the ever increasing zooplankton observed in the vicinity of the vessel.

Table 2 presents the number of fish species across the various habitat preferences and feeding guilds. Also presented in the number of species expected to be found in the area and the percentage represented on the HMAS Swan. The species that have been found on the HMAS Swan over the past two years accounts for only 24% of the total species expected to occur in the area; however, many of these species are either, uncommon species, pelagic species not often found close to shore or very deep water species. The number of species that would commonly be expected to be seen on offshore reefs over time would be approximately 150; therefore, the species observed on the HMAS Swan accounts for 51%.

Table 2: Fish species observed by ecological category

Ecological Categories	Location			Expected †
	HMAS Swan		Control Site	
Pelagic species	3	4%	0	68
Weed/Sand species	27	27%	17	102
Reef species	47	32%	7	146
Herbivores	0	0%	0	5
Planktivores	7	26%	1	27
Omnivores	38	33%	11	115
Carnivores	32	19%	12	169
Total species	**77**	**24%**	**24**	**316**

† Derived from Hutchins and Swainston (1986).

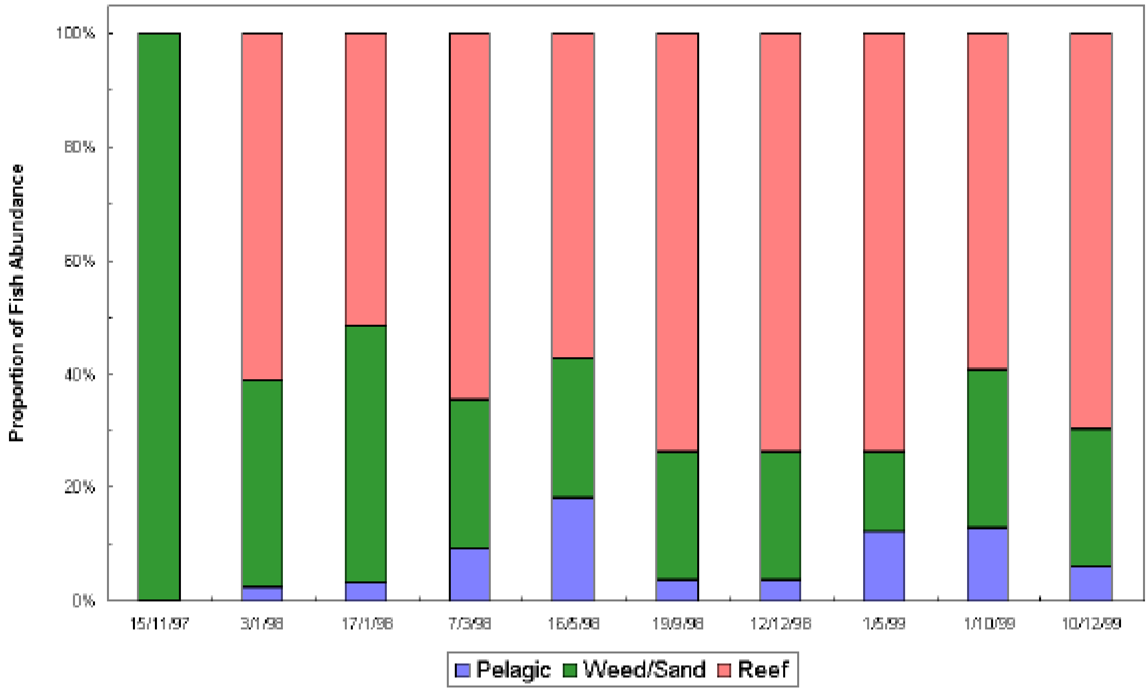


Figure 7: Fish habitat preference expressed as percentage of abundance

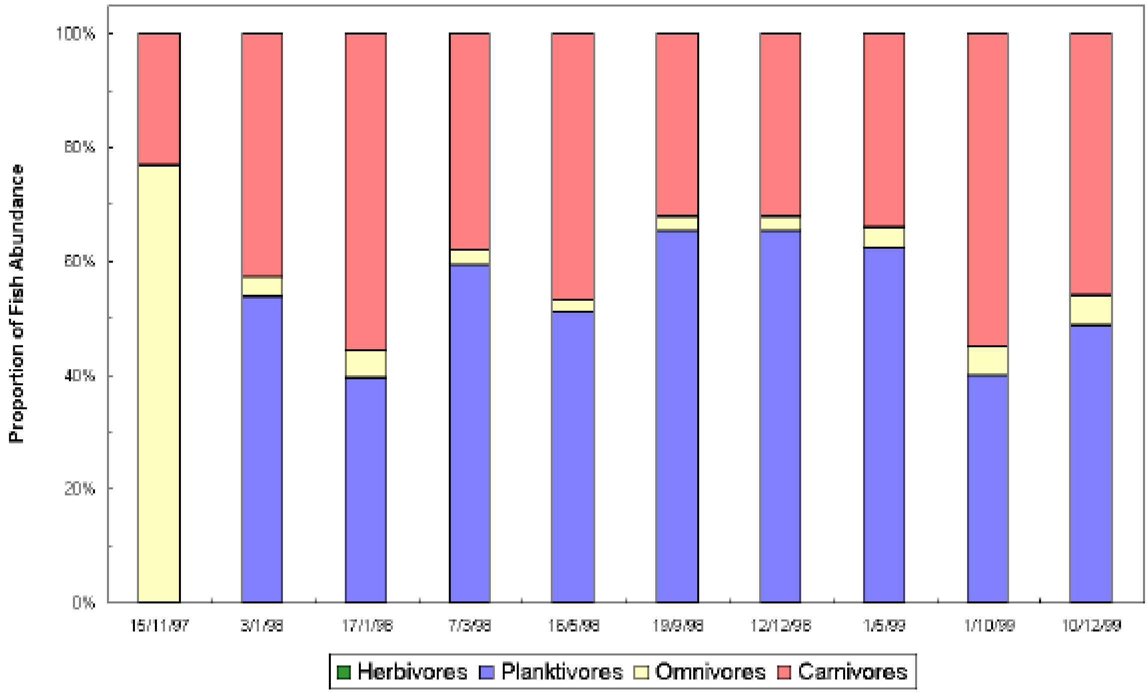


Figure 8: Feeding guild expressed as a percentage of abundance

A statistical comparison of the fish communities on the HMAS Swan and the control site during the surveys over the past two years, including the surveys of the adjacent reefs and Busselton Jetty is presented in the Multi-Dimensional Scaling (MDS) plot in **Figure 9**. This plot presents a comparison of the species richness and abundance at the time of each survey with similar communities being plotted closer together. The distance separating each point on the plot is a measure of similarity; therefore, the closer the two points are the more similar their fish communities were.

Dotted circles have been drawn around the groups which are similar. It can be seen that the fish communities of baseline control and baseline vessel surveys (A and I respectively) are equally similar to that observed during the other control site surveys (B through H). Similarly the fish communities associated with the HMAS Swan during the post-scuttling surveys (J through P) are very similar; however, the community present after 1 month is less similar than the rest. The other three sites surveyed (Wright Bank, Busselton Jetty and Geographe Ridge), while similar in the number of species and abundance, still have a different species composition and are thus represented as distinct fish communities.

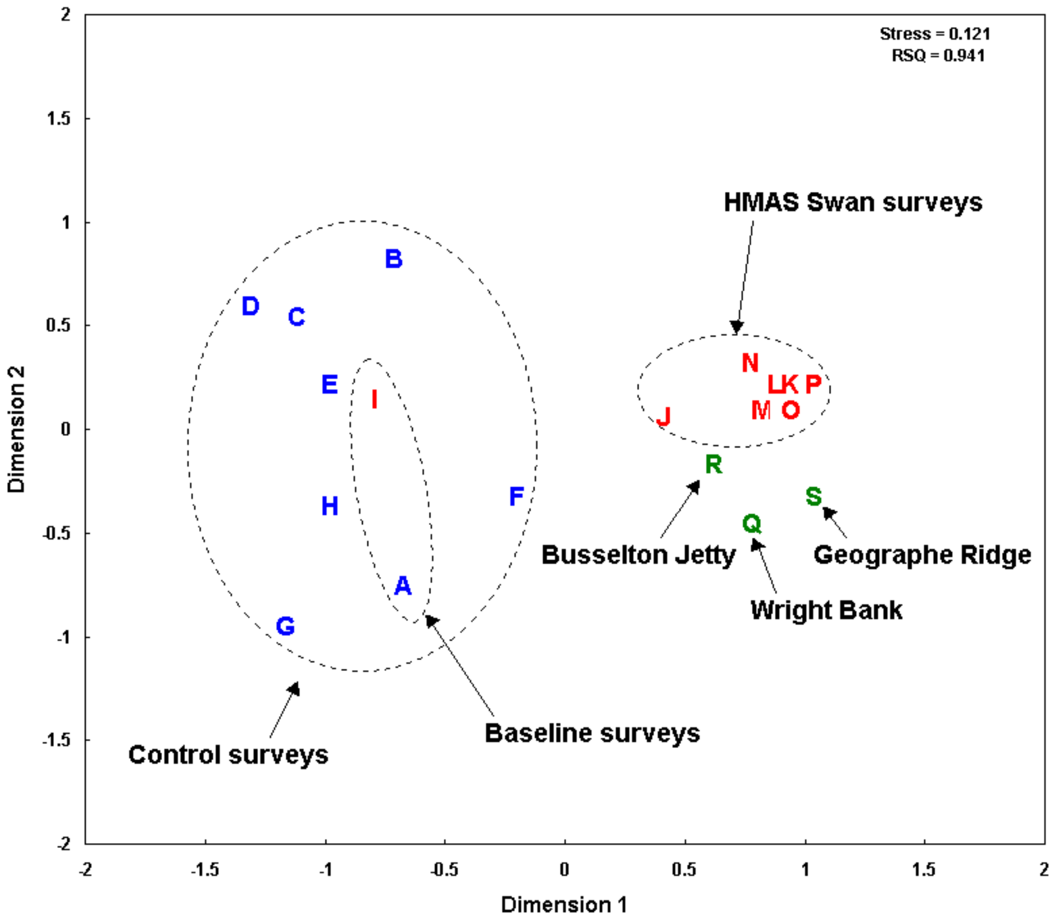


Figure 9: Statistical comparison of fish populations over time

Table 3: Fish Species Observed on the HMAS Swan

Taxonomic Name	Common Name	Taxonomic Name	Common Name
Heterodontus portusjacksoni	Port Jackson Shark	*Platax teira*	Round-faced Batfish
Trygonorhina fasciata	Fiddler Ray	*Chaetodon assarius*	Western Butterflyfish
Myliobatis australis	Eagle Ray	*Chelmonops curiosus*	Western Talma
Urolophus circularis	Circular Stingaree	*Enoplosus armatus*	Old Wife
Trygonoptera personata	Masked Stingaree	*Paristiopterus gallipavo*	Brown-spotted Boarfish
Trygonoptera ovalis	Striped Stingaree	*Pentaceropsis recurvirostris*	Long-snouted Boarfish
Aulopus purpurissatus	Sergeant Baker	*Chromis klunzingeri*	Black-headed Puller
Cnidoglanis macrocephalus	Estuary Catfish	*Parma mccullochi*	McCulloch's Scalyfin
Lotella rhacinus	Beardie	*Chromis westaustralis*	West Australian Puller
Trachichthys australis	Roughy	*Cheilodactylus gibbosus*	Crested Morwong
Centroberyx lineatus	Swallowtail	*Dactylophora nigricans*	Dusky Morwong
Zeus faber	John Dory	*Nemadactylus valenciennesi*	Queen Snapper
Neosebastes pandus	Gurnard Perch	*Cheilodactylus rubrolabiatus*	Red-lipped Morwong
Scorpaena sumptuosa	Western Red Scorpioncod	*Choerodon rubescens*	Baldchin Groper
Platycephalus longispinis	Long-spined Flathead	*Austrolabrus maculatus*	Black-spotted Wrasse
Platycephalus speculator	Southern Blue-spotted Flathead	*Pseudolabrus parilus*	Brown-spotted Wrasse
Hypoplectrodes nigrorubrum	Black-banded Seaperch	*Dotalabrus alleni*	Little Rainbow Wrasse
Epinephelides armatus	Breaksea Cod	*Pseudolabrus biserialis*	Red-banded Wrasse
Trachinops brauni	Blue-lined Hulafish	*Eupetrichthys angustipes*	Snakeskin Wrasse
Paraplesiops meleagris	Western Blue Devil	*Bodianus frenchii*	Western Foxfish
Trachinops noarlungae	Yellow-headed Hulafish	*Coris auricularis*	Western King Wrasse
Glaucosoma hebraicum	West Australian Jewfish	*Siphonognathus beddomei*	Pencil Weed Whiting
Dinolestes lewini	Long-finned Pike	*Parapercis ramsayi*	Spotted Grubfish
Sillaginodes punctata	King George Whiting	*Parapercis haackei*	Wavy Grubfish
Seriola hippos	Samson Fish	*Plagiotremus rhinorhynchos*	Blue-lined Sabretooth Blenny
Pseudocaranx dentex	Silver Trevally	*Parablennius intermedius*	False Tasmanian Blenny
Seriola lalandi	Yellowtail Kingfish	*Helcogramma decurrens*	Black-throated Threefin
Pagrus auratus	Pink Snapper	*Meuschenia galii*	Blue-lined Leatherjacket
Rhabdosargus sarba	Tarwhine	*Eubalichthys mosaicus*	Mosaic Leatherjacket
Parequula melbournensis	Southern Silverbelly	*Scobinichthys granulatus*	Rough Leatherjacket
Caesioscorpis theagenes	Fusilier Sweep	*Bigener brownii*	Spiny-tailed Leatherjacket
Pentapodus vitta	Western Butterfish	*Meuschenia flavolineata*	Yellow-striped Leatherjacket
Parupeneus spilurus	Blackspot Goatfish	*Aracana aurita*	Shaw's Cowfish
Upeneichthys vlamingii	Blue-spotted Goatfish	*Anoplocapros robustus*	Western Smooth Boxfish
Pempheris multiradiata	Common Bullseye	*Anoplocapros lenticularis*	White-barred Boxfish
Pempheris klunzingeri	Rough Bullseye	*Omegophora cyanopunctata*	Blue-spotted Pufferfish
Parapriacanthus elongatus	Slender Bullseye	*Omegophora armilla*	Ringed Toadfish
Neatypus obliquus	Footballer Sweep	*Diodon nicthemerus*	Globe Fish
Tilodon sexfasciatum	Moonlighter		

(a) School of Globefish *GP*

(b) School of Tarwhine *SM*

(c) School of King George Whiting *JO*

(d) Southern Blue-spotted Flathead *SM*

(e) Sergeant Baker *JO*

(f) School of Rough Bullseye *SM*

(g) False Tasmanian Blenny *SM*

Figure 10: Photographs of fishes observed on the HMAS Swan

Encrusting Marine Life

One month after the HMAS Swan was scuttled (Summer) the exterior metal surface already showed appreciable colonisation by hydroid colonies (*Tubularia ralphi*). The portions of the vessel that were analysed using video transect analysis indicate that between 10 and 15 % of the vessels outer structure was covered by hydroid growth (**Figure 11**). The hydroid colonises formed netlike structures radiating out from a central mass (**Figure 12a**). There were no signs of other invertebrate colonisation at this time.

After five months (Autumn) the HMAS Swan was nearly covered (70–90 %) by hydroid colonies (**Figure 11**). Also found along the video transects were tube worms and filamentous algae. Some areas of the vessel, in particular, inside the bridge and on some of the vertical surfaces towards the aft of the vessel, there was more dense colonisation by tube worms.

Twelve months after the scuttling of the HMAS Swan (Summer) much of the hydroid and algal growth had formed an organic mat which trapped fine silt particles and was being overgrown by other invertebrates. The port hull had a well established community of ascidians, anemones, sponges and bryozoans, whilst the superstructure and starboard areas of the vessel were heavily covered with algae (**Figure 11**). The brown algae species (*Sporochnus comosus*) formed dense branching fronds up to 60 cm long which moved with the prevailing currents (**Figure 12e**). Many fish species not previously observed on the vessel were found to inhabit the algae. Small clusters of soft coral (*Carijoa sp*.) were significantly larger and easily seen growing on the upper portions of the superstructure around the bridge and areas of similar depth to the stern.

After twenty four months the invertebrate growth on the port hull was the dominant encrusting marine community on the vessel with a high percentage of sponge and ascidian growth (**Figure 11**). The most conspicuous invertebrate was the solitary ascidian is *Herdmania momus* (**Figure 12d**), while most of the percentage cover was dominated by the sponge-like compound ascidian *Didemnum spongioides* (**Figure 12c**). Small clumps of hard coral (*Culicia tenella*) were present on the tower (**Figure 12b**). Brown algae once again covered the starboard hull and the upper decks; however, *Austronereia australis* was present in equal quantities with *Sporochnus comosus*. The top of the tower had a significant number of jingle shells (*Anomia trigonopsis*) firmly stuck to the upper surface and barnacles on the railings.

The differences noted in colonisation of the port and starboard hulls are likely to be related to the availability of sunlight. The orientation of the vessel with the bow to the north-west and the stern to the south-east causes the starboard side to receive a greater proportion of sunlight. The considerable algal growth on the starboard side of the vessel during the summers of 1998 and 1999 confirm this. Also, the sessile growth found on the port hull are indicative of more dimly lighted environments such as overhangs and under jetties such as the local Busselton

Jetty. This differential growth is clearly evident in **Figure 12f** which shows the bow of the vessel with port to the right and starboard to the left.

It is uncertain whether the port and starboard decks will ever become colonised to the same extent as the hull surfaces. It is unlikely that the difference is due to the decks being composed of aluminium compared to the steel of the hull. Many areas of the superstructure also comprised of aluminium such as the tower and railings are being well colonised. However, continued monitoring of these surfaces will attempt to confirm this.

The areas monitored by video transect analysis appear to be little affected by diver activity as they are either vertical or are too cramped for most divers to frequent. Conversely, the areas on the forward deck, the top deck, railings and the tower are prone to the accidental abrasive actions of divers. Nonetheless, these more diver prone areas are establishing a community of sessile invertebrates primarily during the winter months when less diving activity takes place.

Table 4: Invertebrate Species Observed on the HMAS Swan

Phylum	Taxonomic Name	Common Name
Protista	*Sporochnus comosus*	Brown algae
	Padina elegans	Brown algae
	Austronereia australis	Brown algae
Porifera	Many species to be identified	Sponges
Cnidaria	*Tubularia ralphi*	Hydroid
	Anthothoe albocincta	Anemone
	Corynactis australis	Jewel anemone
	Carijoa species	Telesto soft coral
Annelida	*Galeolaria caespitosa*	Tube worm
Arthropoda	*Lepas australis*	Goose barnacle
Mollusca	*Anomia trigonopsis*	Jingle shells
	Sepia apama	Giant cuttlefish
Echinodermata	*Centrostephanus tenuispinus*	Long-spined urchin
	Stichopus mollis	Soft sea cucumber
Chordata	*Clavelina molluccensis*	Blue-throated ascidian
	Herdmania momus	Solitary ascidian
	Botrylloides leachi	Leach’s ascidian
	Didemnum spongiodes	Sponge-like ascidian
	Pyura australis	Sea tulip

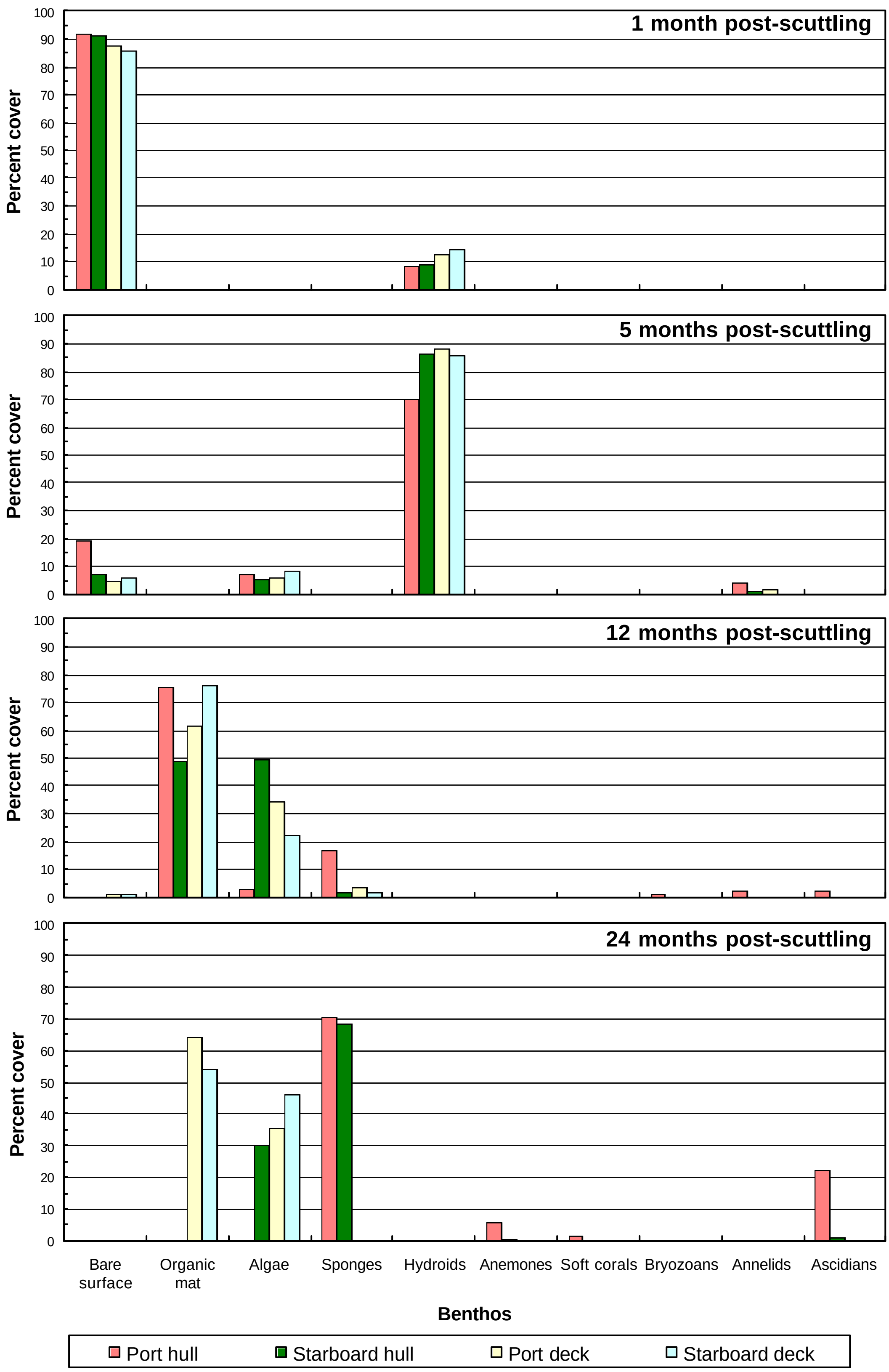
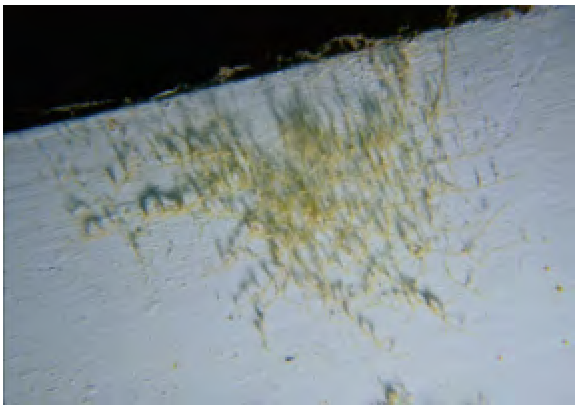
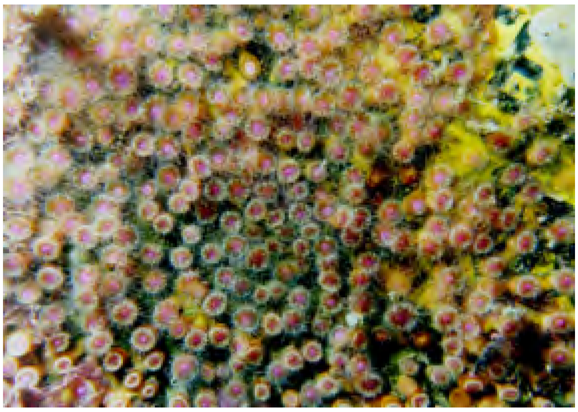


Figure 11: Encrusting community succession



(a) Early colonisation by hydroids SM

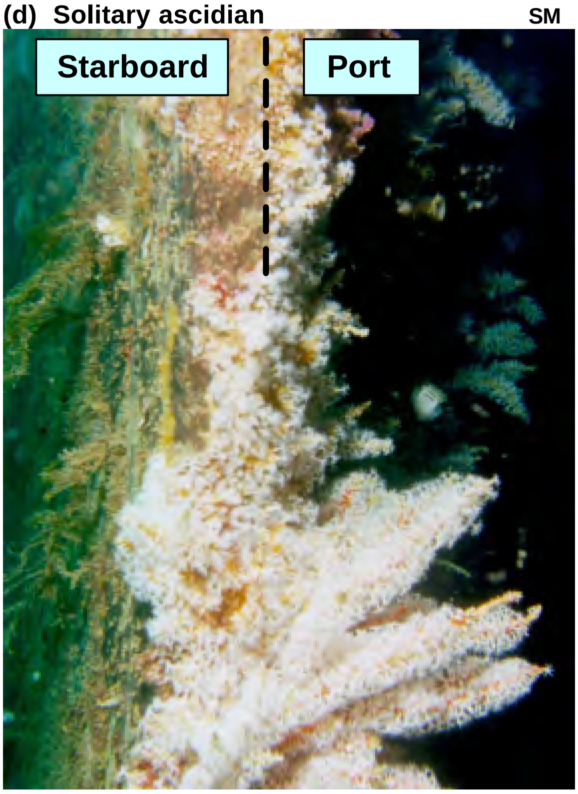


(b) Hard coral (*Culicia tenella*) PM

(c) Encrusting ascidian PM

(d) Solitary ascidian SM

(e) Algae (*Sporochnus comosus*) SM



(f) Bow view of HMAS Swan PM

Figure 12: Photographs of encrusting marine life

Sediments

Chromium and iron were found to be significantly elevated at the HMAS Swan site prior to scuttling indicating that the site had naturally elevated levels of these two metals compared with the control site. No statistically significant differences in sediment metal concentrations between the control and HMAS Swan site were noted after five months. By 12 months, however, there was a marked enrichment of aluminium, chromium, copper, iron, lead and zinc in the sediments adjacent to the vessel. Of these metals, only copper was found to exceed the Australian and New Zealand Environment and Conservation Council (ANZECC) sediment quality guidelines.

During a survey one month after scuttling, a tea coloured cloud could be seen leaving the interior of the vessel and staining the sediment within 5 m of the hull. This staining was likely ionised iron resulting from corrosion of the vessel (pers. comm. Vicki Richards of the Western Australian Museum).

None of the sediments from either site during the three sampling occasions contained measurable quantities of total petroleum hydrocarbons.

Table 5: Sediment analysis

Contaminants		Baseline		5 Months		12 Months	
		Control	Swan	Control	Swan	Control	Swan
Aluminium	(Al) mg/kg	1450±71	1650±71	1000±0	965±191	1650±636	14000±0†‡
Cadmium	(Cd) mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	(Cr) mg/kg	11±1	25±1†	14±1	17±1	14±7	47±1†‡
Copper	(Cu) mg/kg	2±0	3±0	2±0	7±2	<1	69±16†‡
Iron	(Fe) mg/kg	6400±141	6850±71†	3500±283	2250±778	2500±141	88500±2121†‡
Lead	(Pb) mg/kg	<1	<1	<1	7±7	<1	5±0†‡
Zinc	(Zn) mg/kg	5±0	5±0	3±0	19±18	8±3	80±3†‡
TPH	µg/kg	<100	<100	<100	<100	<100	<100

† Significantly greater than Control data (P<0.05).
‡ Significant increase from Baseline HMAS Swan data (P<0.05).

Enrichment of the sediments surrounding metal structures such as submerged ships and metal jetties is common. The area of enrichment expected for the HMAS Swan would be contained within a radius of 500 m from the vessel decreasing along a gradient until background levels would be reached. The most significant area of enrichment is likely to be to a distance of 200 m (pers. comm. Vicki Richards of the Western Australian Museum).

Enrichment of the sediments surrounding the HMAS Swan with aluminium and iron are most likely a result of corrosion of the super structure and hull respectively. The increase in copper may be due to the corrosion of brass material and electrical cable that was not removed from the vessel. The elevated levels of zinc and chromium may have resulted from the zinc chromate antifoulant paint used previously on the vessel (pers. comm. Vicki Richards of the Western Australian Museum). The reason for the increase in lead at the HMAS Swan site is uncertain since all lead ballast was removed from the vessel prior to scuttling. The lead may have originated from the vessel's paint; however, the chemical constituents of the various paints used on the HMAS Swan are not presently available.

It is unlikely that the metal enrichment of the sediments within the vicinity of the HMAS Swan will impact significantly on the marine life of the area.

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