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Mapping Seabed Vegetation with Sidescan Sonar

P.J. Mulhearn

DSTO-TN-0381

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Maritime Operations Division
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ABSTRACT

Beds of marine vegetation such as seagrass and the larger algae may, if dense enough, mask the presence of seabed mines. An investigation is underway in Sydney Harbour of the extent to which seabed vegetation is discernable on sidescan sonar images. To date it has been found that, in some cases, sidescan sonar images provide very similar coverage to air photographs of seagrass beds. When seagrass is seen this readily on sidescan it is likely to be a problem for mine hunting. In those cases where sonar images and air photographs disagree, it is probable that the seagrass is relatively sparse, but this requires further investigation. At most sites the presence of the larger marine algae could not be discerned on sidecsan imagery, suggesting in many cases, but one cannot say all, that algae will not present a problem for mine hunting.

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Executive Summary

Seabed vegetation, such as seagrass and seaweed, has the potential to mask the presence of bottom sea mines, primarily by interfering with the acoustic shadow normally cast by a proud mine. Such a mine is normally more easily detected by its shadow than by the direct reflection of its ensonified surface. Examples of common seaweeds are kelp and Sargassum. Around Australia's coastline and especially in the archipelagos to our north, seagrass beds are common in sheltered areas with sandy sea floors. That is they are common in areas suitable for amphibious operations and could well make hunting for the smaller anti-invasion mines quite difficult. Reasonably dense marine vegetation is limited to depths with light levels adequate for photosynthesis. It can be a factor in shallow ports and has been observed in DSTO sidescan sonar trials in Corio Bay, Victoria.

A study is underway in Sydney Harbour into how well marine vegetation can be mapped by sidescan sonar. In circumstances where the vegetation does not show up on sidescan it is unlikely to be a problem for mine hunting, and vice-versa. To date it has been found that in some cases sidescan sonar images and air photographs of seagrass beds agree well, but in other cases the seagrass does not show up at all well on the sonar. The reasons for this difference are not clear and require ongoing investigation. It may be that the sonar does not "see" less dense seagrass beds, and there were some indications that the seagrass was less dense at the sites where it did not show up on the sonar. It is certainly worth elucidating the conditions under which seagrass beds will and will not be a problem for mine hunting. In general seaweeds (also called macroalgae) are very hard to detect with sidescan sonar, so in many cases will not constitute a problem for mine hunting.

This research should aid in the planning of mine clearance operations in shallow ports and in the approaches to beaches.

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1. Introduction

Seabed vegetation, i.e. seagrasses and seaweeds (the scientific term for the latter is macroalgae), has the potential to mask the presence of bottom sea mines primarily by interfering with the acoustic shadow normally cast by a proud mine. Such a mine is normally more easily detected by its shadow than by the direct reflection of its ensonified surface. Figure 1 illustrates the situation. Examples of common macroalgae are kelp and Sargassum. There is very poor information on the distribution of areas of seabed vegetation around Australia so there exists a need to examine better ways to map beds of seagrass and macroalgae. A series of surveys has been undertaken in Sydney Harbour to determine which types of vegetation can be mapped with sidescan sonar. If a vegetation type can be mapped with sidescan and it is sufficiently dense and tall, it will interfere with mine detection. If it cannot be detected by sidescan then its presence should not matter as far as detection is concerned, although it would inhibit mine burial.

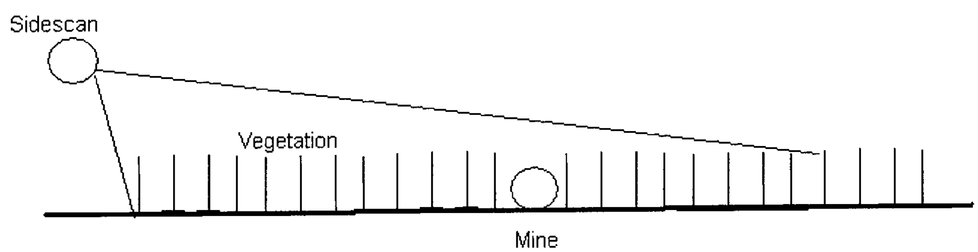


Figure 1. Illustration of a bottom mine in an area of seabed vegetation. Tops of some vegetation will backscatter sound to the sidescan sonar, masking the mine's acoustic shadow. The return from the front of the mine may also be less apparent.

Marine vegetation can be broken in to two main categories: seagrasses which are underwater flowering plants with roots, and algae, much simpler plants which do not have flowers or roots. Most larger varieties of macroalgae have a hold-fast by which they attach to the bottom. Seagrasses prefer sheltered areas with a sandy or muddy sand seabed and do not grow well in areas affected by wave action. They require reasonably clear water to grow well and although some species grow down to depths of 10 m or more, those in Sydney Harbour are restricted to depths of 5 m or less. Macroalgae also prefer relatively clear water but will grow to larger depths than seagrasses. They require either a rocky or shelly bottom for attachment of their hold-fasts and they can withstand considerable wave action.

Because marine vegetation grows best in shallow waters with plenty of light, it would normally only be a problem in water depths less than 10 m. It will therefore impact mainly on MCM operations in shallow ports and amphibious operations. In waters around Australia's northern coastline and in the archipelagos to our north seagrass beds are very common in sheltered areas with sandy seabeds. Figures 2 and 3 show distributions around Australia and Indonesia. An apparently unusual situation occurs in Torres Strait where there are some "very lush" seagrass beds deeper than 30 m (Poiner and Peterken, 1995).

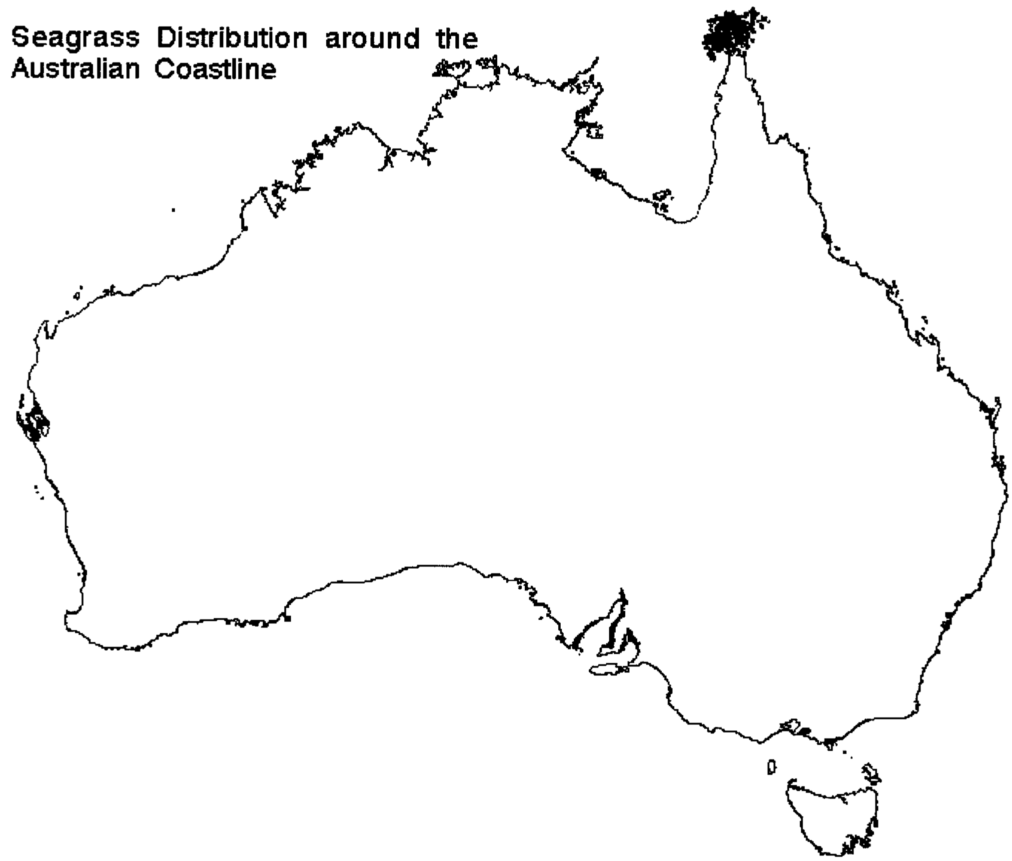


Figure 2. Distribution of seagrass around Australia. (A map produced by CSIRO taken off: http://www.environment.gov.au/marine/information/reports/vegetation/index.html)

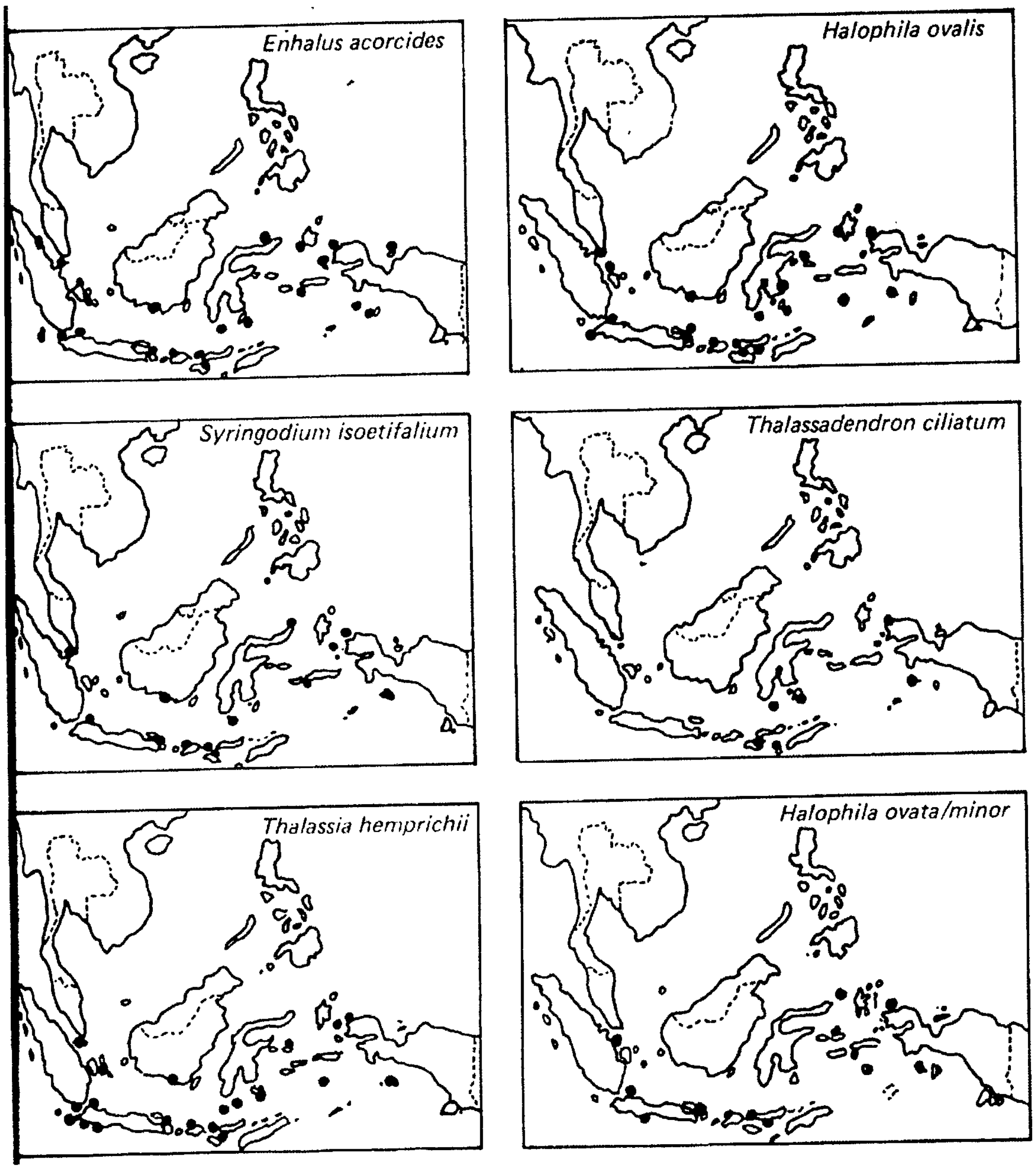


Figure 3. Distributions of various seagrass species in Indonesia (from Kiswara & Hutomo, 1985, as shown in Nontji, 1987).

A small amount has been published on the imaging of marine vegetation with sidescan sonar, much of it related to mapping seagrass beds. Newtown and Stefanon (1975) mapped *Posidonia* seagrass beds using an EG&G sidescan with a frequency of 105 kHz. Blondel and Murton (1997) show an image of *Zostera* seagrass beds obtained with a 100 kHz sidescan. Carter et al (1993) also imaged seagrass beds near Townsville but specified neither the type of seagrass nor the sidescan frequency. Lyons and Pouliquen (1998) investigated the imaging of *Posidonia* seagrass beds in various parts of the

Mediterranean using sidescan frequencies from 29 to 385 kHz. They found there was little dependence of backscatter intensity on either frequency or grazing angle. McCarthy (1997) carried out more controlled experiments on *Zostera* in the laboratory and in a small tank facility and also found little dependence of backscatter on either frequency or grazing angle. In part of her study she also examined the dependence of backscatter on the orientation of a single *Zostera* leaf. She concluded that the backscatter was primarily due to gas filled lacunae, which run inside seagrass leaves. (Drawings of local species of *Posidonia* and *Zostera* can be found below in Figure 7). During a survey of Sydney Harbour in November 1997 with a STN Atlas Fansweep 20 Multibeam Sonar, (Jenkins, private communication) the sidescan mode of the instrument showed up strong returns from patches of sea grass on the eastern side of The Bar at the entrance of Middle Harbour (Site 5 in Figure 4). Similarly Klein 2000 sidescan surveys in Sydney Harbour in 1999, using frequencies of 100 and 500 kHz, obtained images of seagrass and floating algae (Jenkins and Zajac, 1999).

Little has been published on sidescan sonar imaging of macroalgae, other than the coralline algae *Halimeda* whose skeletons form reefs in tropical waters (Blondel and Murton, 1997; Roberts et al., 1987; Rao et al., 1994). During surveys near Geelong in July 1995 patches, which were assumed to be marine growth, showed up well on the Klein 595 sidescan records (Mulhearn, 1997). Patches of marine algae and of large tubeworms (*Sabella spallanzanii)* were present. However the types of algae were not determined nor the positions of the different weed and tube worm patches analysed, to see how well they correspond to the positions of features on the sidescan images. Water depths surveyed in Corio Bay were from 7 m to 9 m. Healey (2001) reported that the sidescan sonar on the REMUS AUV was able to obtain good images of kelp beds off California. These are very large plants extending into the water column well above the seabed.

2. Methods

During 1999 a major survey, using precise navigation, was undertaken to map much of the western part of Sydney Harbour (Smith, 1999). This involved multibeam echosounders, Klein 5500 sidescan sonar and normal incidence echosounder seabed classification devices. The sidescan sonar data from this survey was examined for evidence of marine growth and a number of sites were subsequently surveyed with an underwater video camera. Further sidescan surveys were undertaken in April 2000 at sites not covered in 1999, where seabed vegetation was known or suspected to be present. Sites surveyed for vegetation are listed in Table 1 and shown in Figure 4. Sites described as "Not weed" in Table 1 are ones for which sidescan sonar images showed vegetation-like features which turned out to be something else.

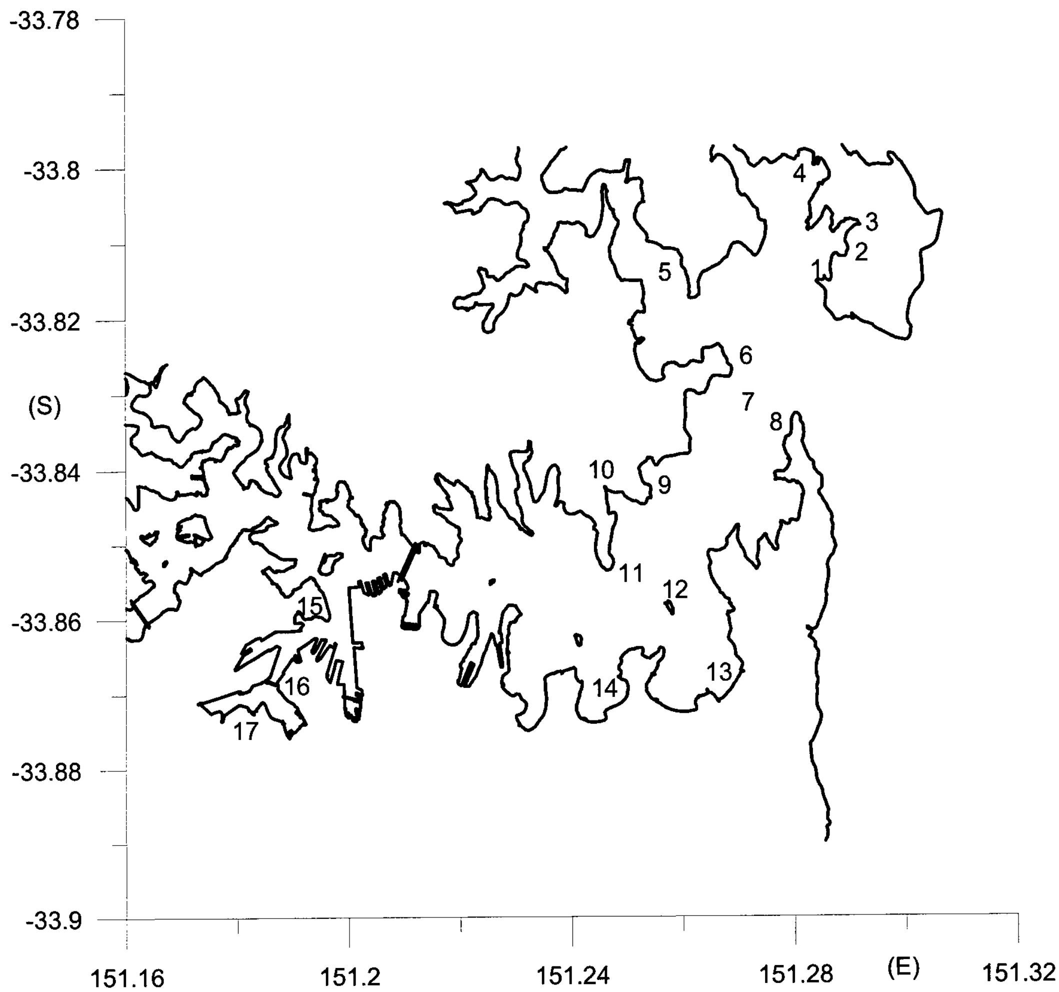


Figure 4. Map of Sydney Harbour showing sites investigated. (For sites numbered see Table 1).

Table 1. Sites surveyed

Site Numbers	Site	Type of vegetation
1	Quarantine Beach	Seagrass
1	SW approach to Quarantine Beach	Macroalgae
2	Store Beach	Seagrass
3	Collins Beach	Seagrass
3	Near Collins Beach	Kelp on rocks
4	Manly Cove	Macroalgae and seagrass
5	Castle Rock, Clontarf	Seagrass
6	Middle Head	Kelp on rocks
7	Sow & Pigs Reef	Low brown weed on shelly sand
8	Lady Bay, South Head	Rocks & kelp on rocks
9	Chowder Bay	Kelp and other macroalgae
10	Head of Taylors Bay, Mosman	Seagrass
11	East side of Bradleys Head	Kelp
12	Shark Is.	Kelp on rocks
13	East side of Rose Bay	Macroalgae
14	Double Bay	Macroalgae and some seagrass
15	Off Peacock Pt	Not weed
16	Mouth of Blackwattle Bay	Not weed
17	Off Glebe Pt., Rozelle Bay	Not weed

Sidecsan sonar and seabed videoing work was carried out from a 12.2 m (40ft) workboat, AWB 440. The sidescan sonar system used was a Klein 5500 multibeam sidescan, operating at a single frequency of 455 kHz. Data were recorded to magneto-optical disc. The sidescan tow-fish was rigidly mounted on a frame on the boat's bow (Figure 5). Differential GPS navigation was used. The DGPS reference station was a MX9250 Leica.

Seabed videoing was carried out to check what the sidescan sonar was imaging. A National Colour CCTV System (Model WV-CM110A) was used. The video camera was contained in an underwater housing which was either bow-mounted, similarly to the sidescan tow-fish, or towed in the protective frame shown in Figure 6.

Air photos of the areas surveyed with sidescan were compared with sidescan mosaics, where possible. This was done to determine to what extent visual and acoustic mappings visualise the same features. One set of colour air photos was obtained from Manly Council for their council area. These were acquired by AAM Services on 12th May 1999. The originals were at approximately 1:5000 scale. A second set of colour ortho-photos, with 0.02 m resolution and positional accuracy, was obtained for the Sydney Harbour LandData Consortium by Sinclair Knight Merz Pty. Ltd on 6th January 2000. Other photos were obtained via the web site of the Office of the Sydney Harbour

Manager (http://bearings.nsw.gov.au/) from Land and Property Information New South Wales, a NSW government enterprise. These photos were obtained on 5 May 1999 and have a scale of 1:12,000, a pixel size of 0.3 m and a positional accuracy of 0.25 m.

Comparisons between photos of different dates showed that there was little change in any of the area coverage of seagrass beds, or in the areas of macroalgae at the one site (site 14) where comparisons could be made. However video surveys in Rose Bay over several years revealed significant changes at that particular location.

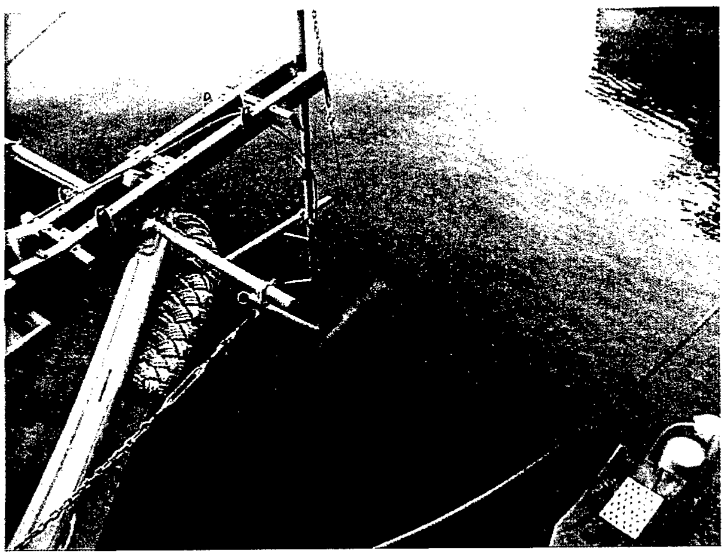


Figure 5. View from above of Klein 5500 tow-fish mounted on the bow of the workboat AWB 440.

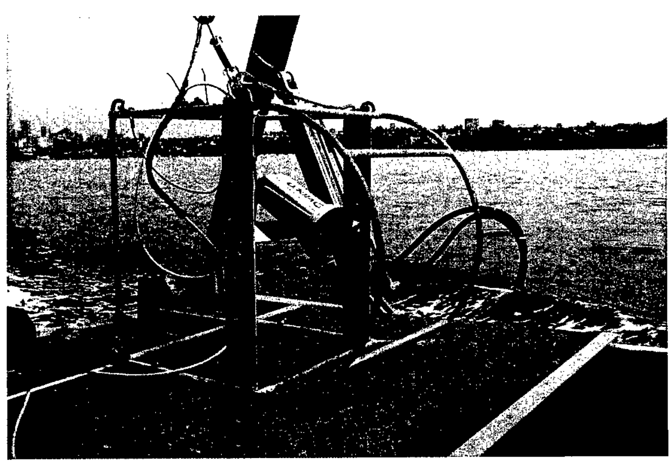


Figure 6. Underwater video camera mounted for towing in its protective frame.

3. Results

3.1 Seagrass areas

While the seagrass beds in Sydney Harbour are not as extensive as at many other locations (e.g. Botany Bay, Jervis bay) they are sufficient for the purposes of this study. The main species found in the Harbour are shown in Figure 7. The locations of the beds surveyed are at sites 1 to 5 and 10 on Figure 4 and in Table 1.

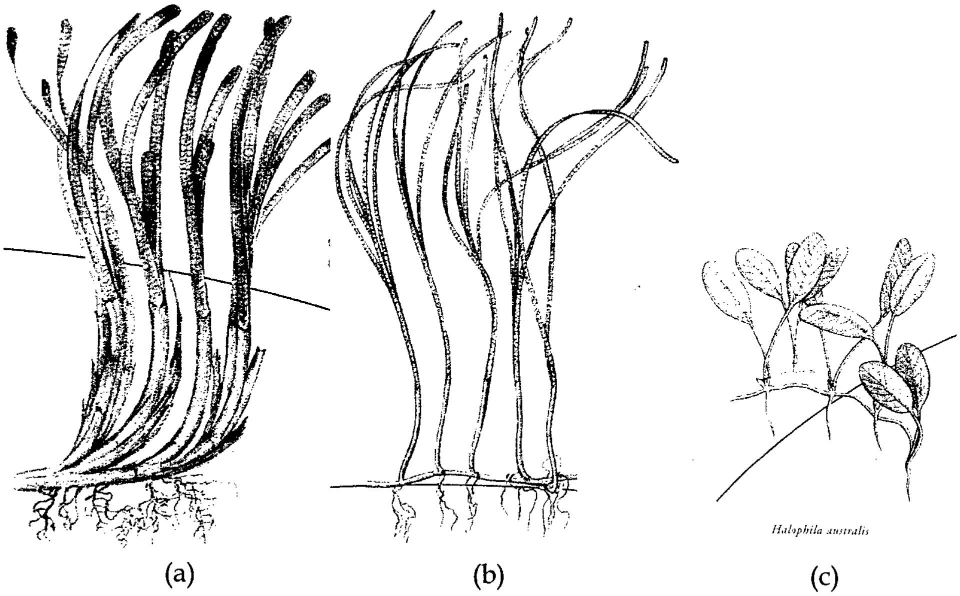
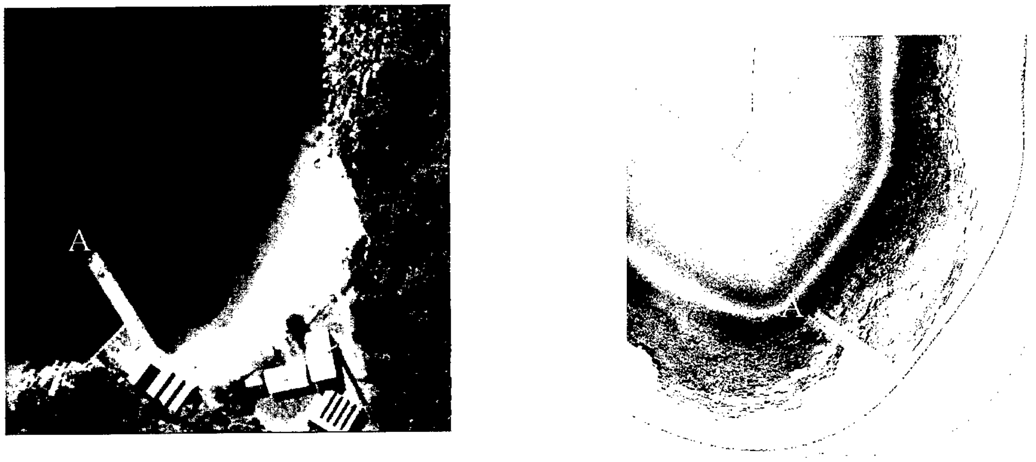


Figure 7. Main types of seagrass found in Sydney Harbour: (a) Posidonia australis, (b) Zostera capricorni, (c) Halophila australis. (Drawings are from CSIRO Division of Fisheries pamphlet "Seagrasses")

A sidescan mosaic and an air photo of the area off Quarantine Beach (Site 1) are compared in Figure 8. The wharf in each image is labelled A. In the sidescan image darker shades corresponds to higher acoustic return. The pattern of seagrass beds seen in the air photo is not reproduced in the sidescan image. This may be because the seagrass at this site appeared to be relatively sparse. Frame grabs from underwater videos at this site are shown in Fig 9. The seagrass in these pictures is either *Posidonia* or *Zostera*. In video images obtained from an underwater video camera, towed by a boat, it is often quite hard to distinguish between these two types.



(a) (b)

Figure 8. Quarantine Beach (Site 1): (a) Air photo of 12 May 1999; (b) Sidescan sonar mosaic of 18 April 2000.

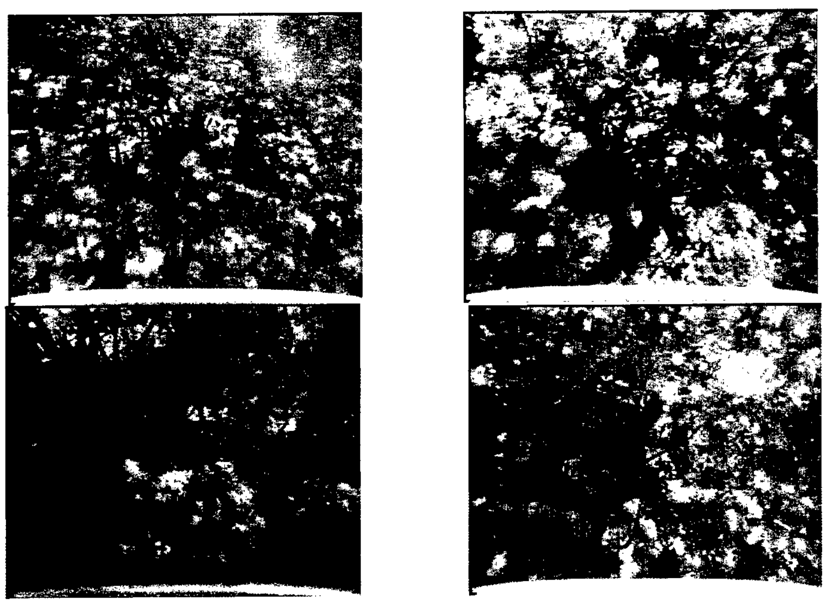


Figure 9. Frame-grabs from video of seagrass area off Quarantine Beach, taken on 8 July 1999.

In Figure 10 an air photo and a sidescan sonar image of the area off Store Beach (Site 2) are compared. There are a number of similarities in the two images, as can be seen by comparing features at A, C and D. The dark area at B in the sidescan mosaic is not reproduced in the air photo. Its darkness indicates that this is an area of high acoustic backscatter, but it is not clear what it is. Looking from the boat operating the sidescan sonar, the seagrass beds appeared to be relatively dense in water too shallow for the boat to penetrate. The boat's draft is approximately 2.5 m. The better correspondence between the air photo and the sidescan image at this site may be due to the seagrass being thicker. Frames from a video of the seagrass here are shown in Figure 11. Again this is either *Posidonia* or *Zostera.*

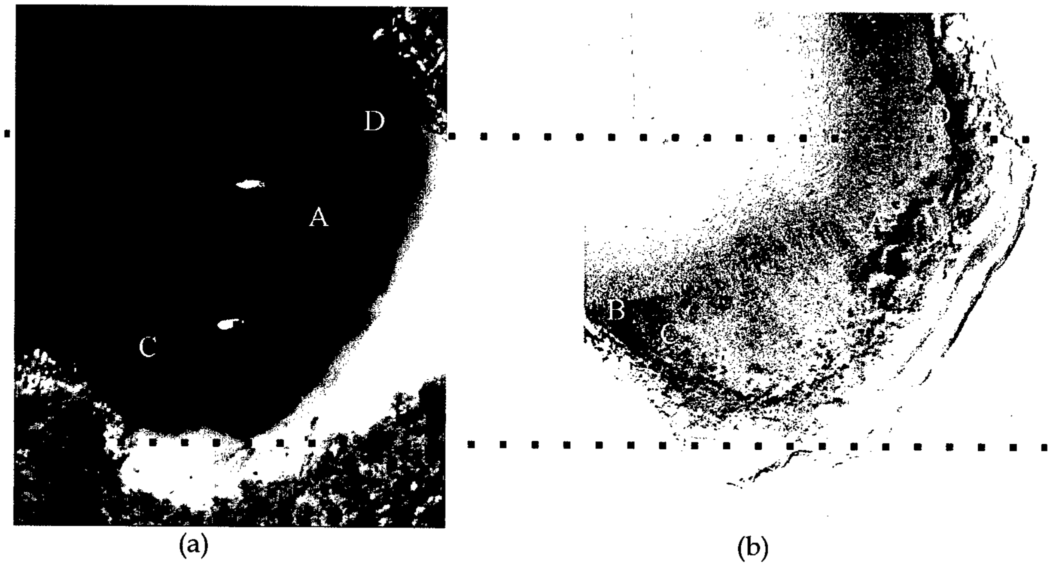


Figure 10. Store Beach (Site 2): (a) Air photo of 12 May 1999; (b) Sidescan sonar mosaic of 18 April 2000.

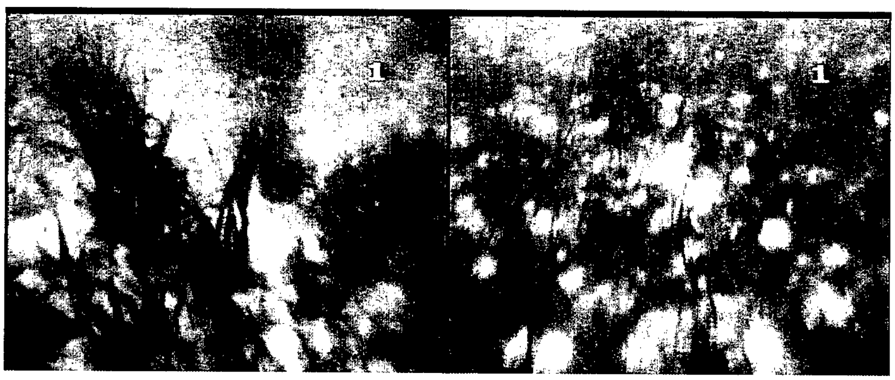


Figure 11. Frame-grabs from video of seagrass area off Store Beach, taken on 15 February 2001.

An air photo and a sidescan image of the area off Collins Beach (Site 3) are compared in Figure 12. Here the correspondence between the two images is again not very good. For reference the point at B is labelled in both images. Note that the features near A in the air photo, which were observed to be seagrass, are not visible in the sidescan image. It is not clear why this is so, but it may be that the seagrass here is relatively sparse. Frames from a video at this site are shown in Figure 13. Again the seagrass is either *Posidonia* or *Zostera.*

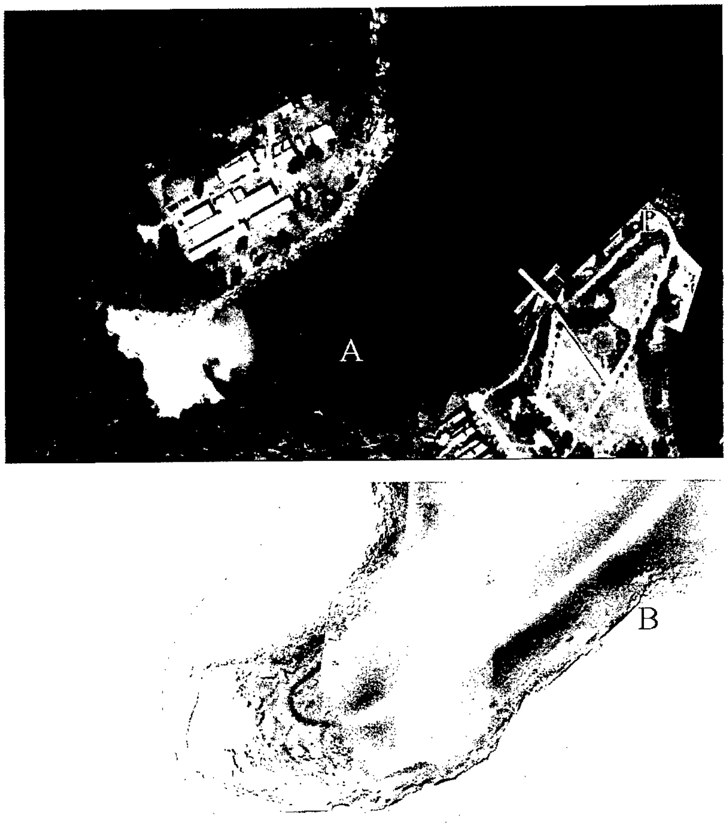


Figure 12. Collins Beach (Site 3): Upper: Air photo of 12 May 1999; Lower: Sidescan sonar mosaic of 18 April 2000.

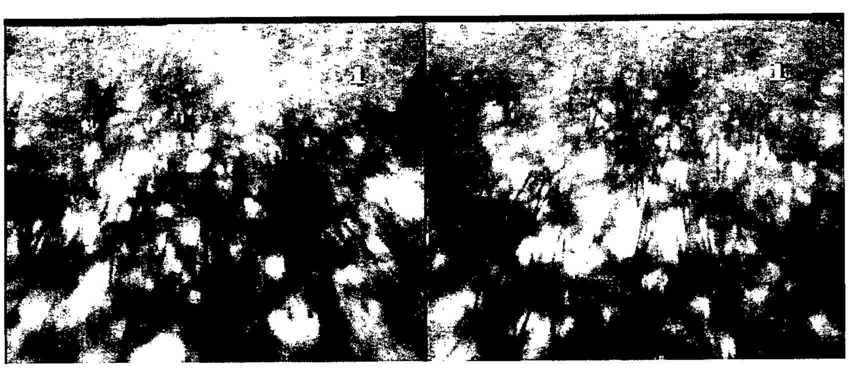
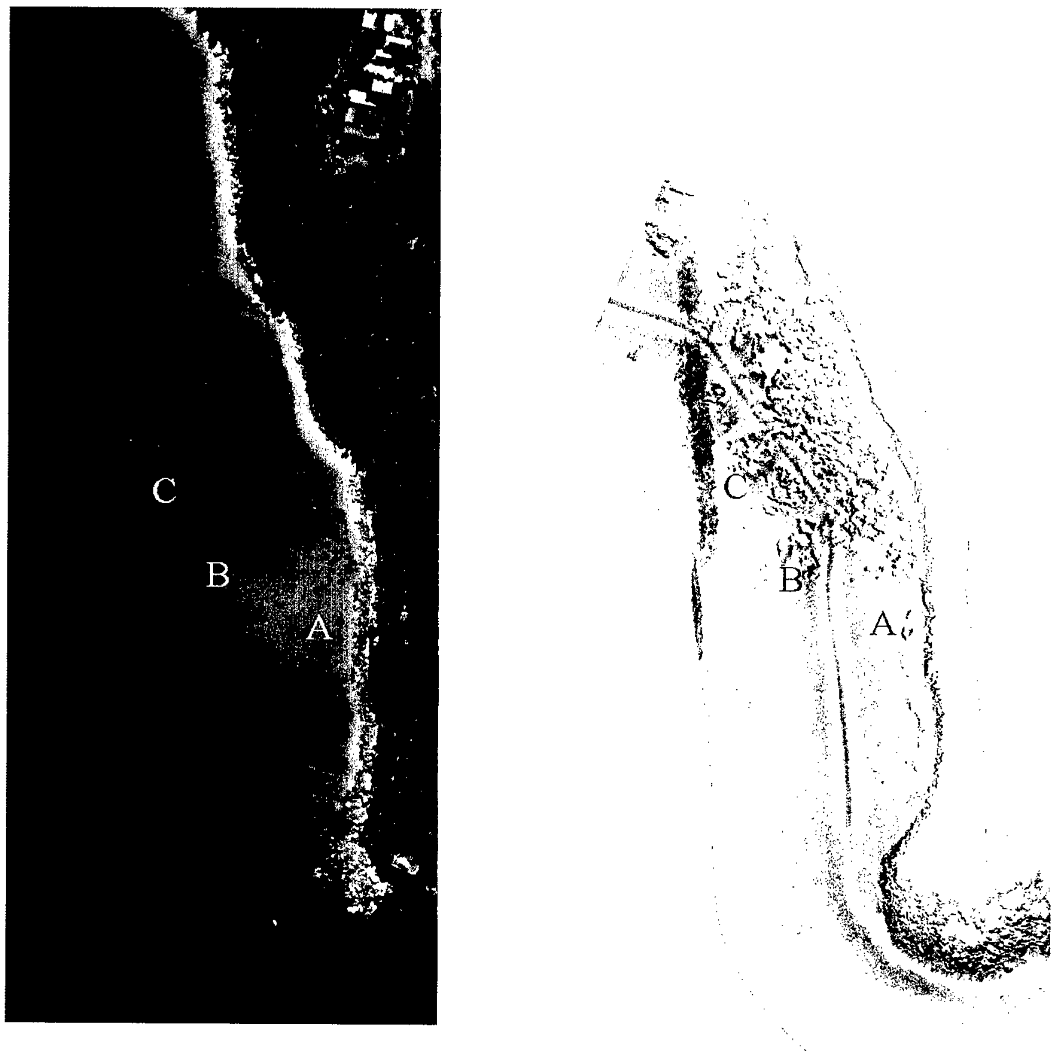


Figure 13. Frame-grabs from video of seagrass area off Collins Beach, taken on 15 February 2001.

In Figure 14 an air photo is compared with a sidescan sonar mosaic of an area at the entrance to Middle Harbour near Castle Rock (Site 5). The correspondence between these two is quite good as can be seen by comparing features at places labelled A, B and C. (The dark linear feature in the sidescan image to the left of C is a boat wake). The seagrass beds at this site are relatively thick. Frames from the video at this site are shown in Figure 15.



(a) (b)

Figure 14. Near Castle Rock, Clontarf (Site 5): (a) Air photo of 12 May 1999; (b) Sidescan sonar mosaic of 18 April 2000.

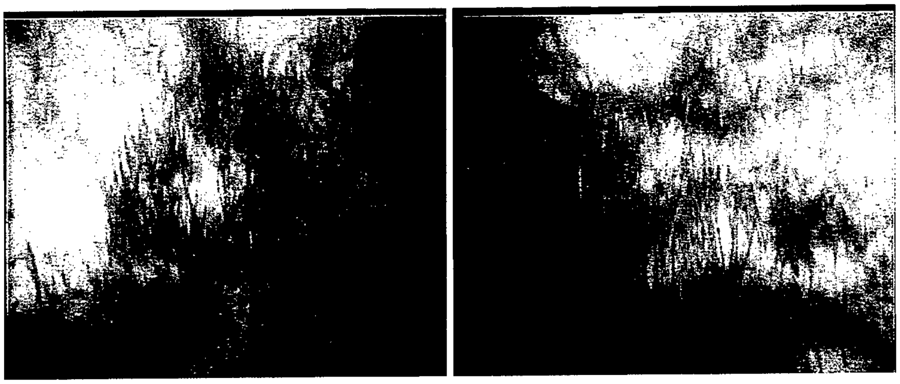
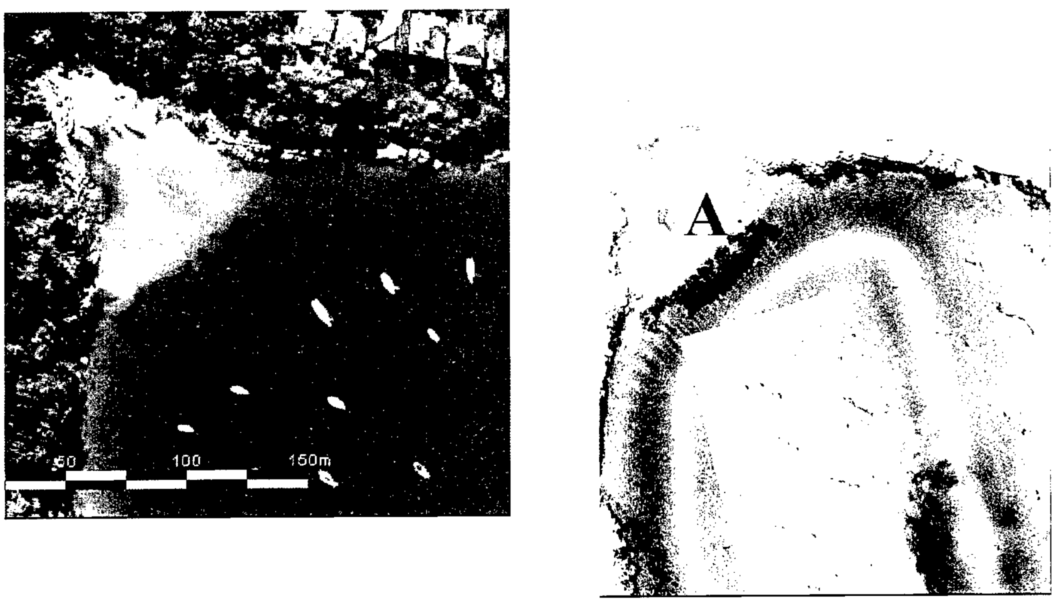


Figure 15. Frame-grabs from video of seagrass area near Castle Rock, taken on 15 February 2001.

An air photo and a sidescan image of the head of Taylors Bay (Site 10) are compared in Figure 16. A small but quite dense seagrass bed is at the position labelled A, and it shows up well in both images. A close up of the seagrass here is shown in Figure 17.



(a) (b)

Figure 16. Head of Taylors Bay (Site 10): (a) Air photo of 5 May 1999; (b) Sidescan sonar mosaic of 18 April 2000.

Figure 17. Frame-grabs from video of seagrass area at head of Taylors Bay, taken on 6 March 2000.

It seems that in some cases sidescan sonar can map seagrass bed distributions as well as air photos, but not always. The cases where the sidescan sonar cannot distinguish the seagrass may be those where the seagrass is not very dense, but this is still unclear. Seagrass leaves scatter sound well, because of the gas-filled lacunae which run inside them. If the amount of gas varies seasonally or diurnally or with plant health, there may be better times than others to hunt for bottom mines in seagrass areas. It may also be that seasonal cycle in these plants is not the same at all locations within a given harbour area, and this could be taken advantage of.

3.2 Areas with Macroalgae

A number of rocky areas in Sydney Harbour, with reasonable kelp cover (*Ecklonia radita)* were surveyed with sidescan sonar. These were a site near Collins Beach (Site 3), rocks around Middle Head (6), rocks near Lady Bay (Site 8), a rocky reef on the east side of Bradleys Head (Site 11), and a rocky reef on the north-west side of Shark Island (Site 12). At all these sites no sign of the kelp was discernable on the sidescan images, only the rocks. Examples of the kelp near Bradleys Head are shown in Figure 18.

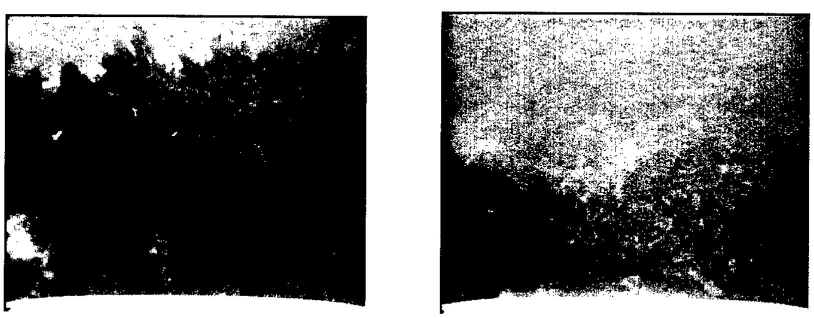


Figure 18. Frame-grabs from video of macroalgae on east side of Bradleys Head (Site 11), taken on 20 February 2001.

A number of locations were surveyed which contained macroalgae which was not kelp. These are sites 4, 9, 13 and 14 and a location near site 1. Sites are shown on Figure 4 and listed in Table 1. Because most macroalgae requires a rocky or shelly surface for their holdfasts, it may not always be clear if a sonar is imaging the algae or the substrate to which it is attached.

A section of the raw sidescan image (i.e. before any mosaicing), obtained on the approach to Quarantine Beach (Site 1) from the south-west is shown in Figure 19. The appearance of the features here is quite different to that of seagrass. Frames from the video taken at this site are shown in Figure 20. Patches of green algae can be observed. The seabed was too deep at this site for air photos to show any bottom features.

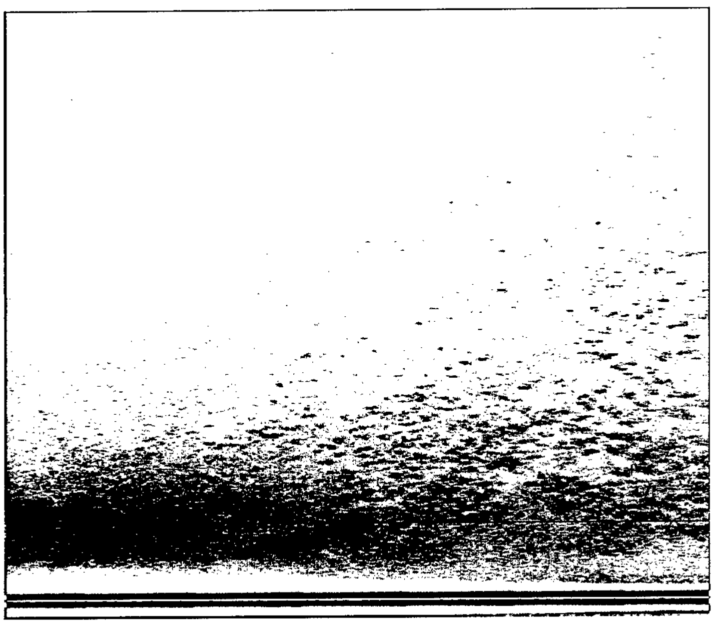
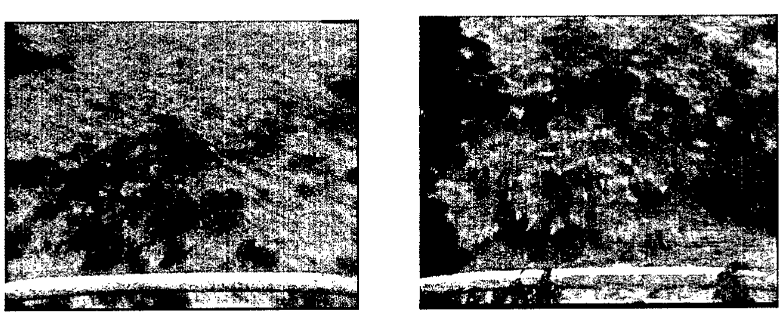


Figure 19. Raw sidescan image of seabed near Canae Point, approaching Quarantine Beach (Site 1) from the south-west. (Obtained on 18 April 2000).



Site 20. Frame-grabs from video of macroalgae approaching Quarantine Beach from the south-west, taken on 27 February 2001.

Video film carried out at Sow & Pigs Reef (Site7) revealed a low, woolly looking brown algae on a shelly seabed. However on sidescan there was no indication of seabed vegetation. Most likely backscatter returns from the shelly sediments dominated the picture.

Another site with patches of macroalgae was Manly Cove (Site 4). A sidescan sonar and an air photo of this location are presented in Figure 21. For this sidescan image the sidescan was towed not bow-mounted, so that the image navigation in this case is not as good as it is for the other sidescan images. Common features in both the sidecan image and air photo are labelled A, B, C and D. There is not much correspondence between seabed features in the two images, except just above and to the right of the letter A, and around the south-west corner of the baths. It appears that much of the algae visible in the photo is invisible to the sonar, and that the air photo and the sonar are "seeing" different things. Probably the sonar is imaging hard seabed features, while the photo is showing the weed. Frames from video runs at this site are shown in Figure 22. The low, brown algae was seen in a broad area, around the location marked A, while the seagrass was restricted to the right hand side nearer the Manly Ferry Wharf. The dark area closest to the wharf is a deeper area at which finer material has been winnowed out, leaving a bed of shell.

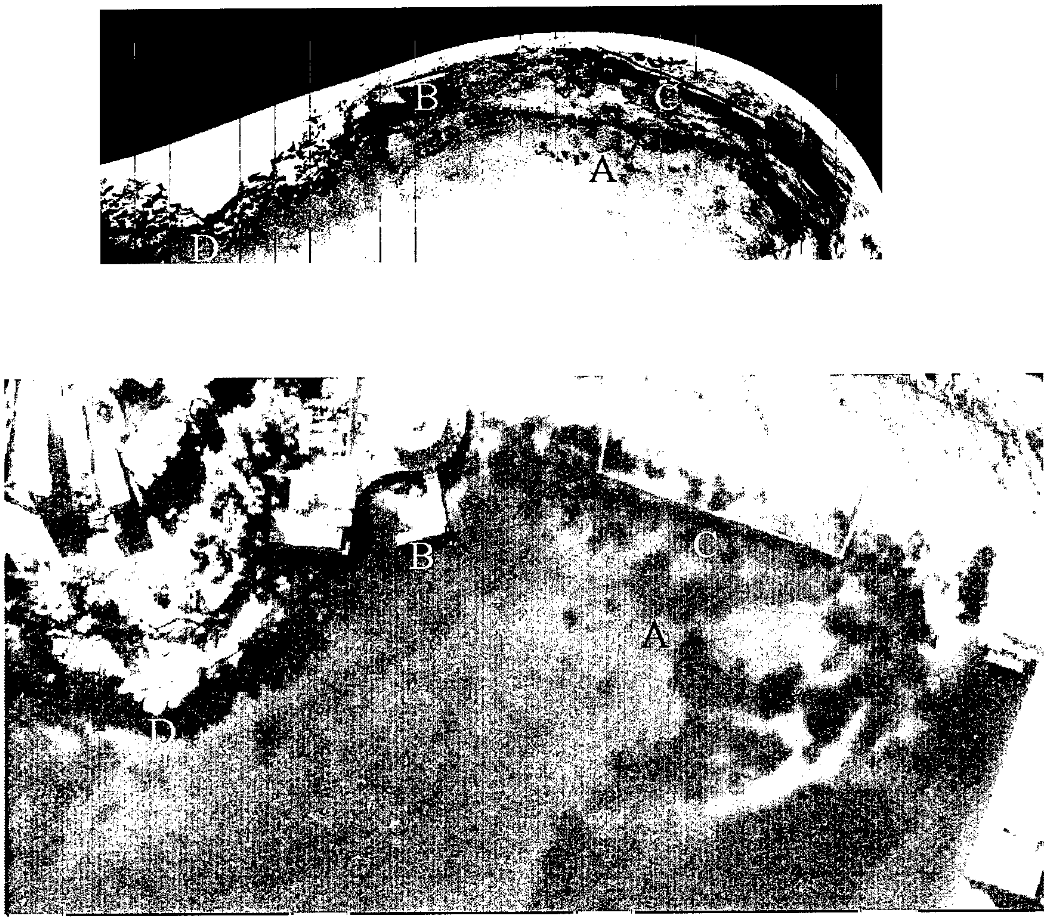


Figure 21. Manly Cove (Site 4): Upper: sidescan sonar mosaic of 13 March 2001; Lower: Air photo of 12 May 1999. A marks a seabed feature visible in both images; B marks the front of a small wharf; C is the fence on the long side of Manly Baths; D marks the headland to the west. Manly Ferry Wharf is on the right hand side of the air photo.

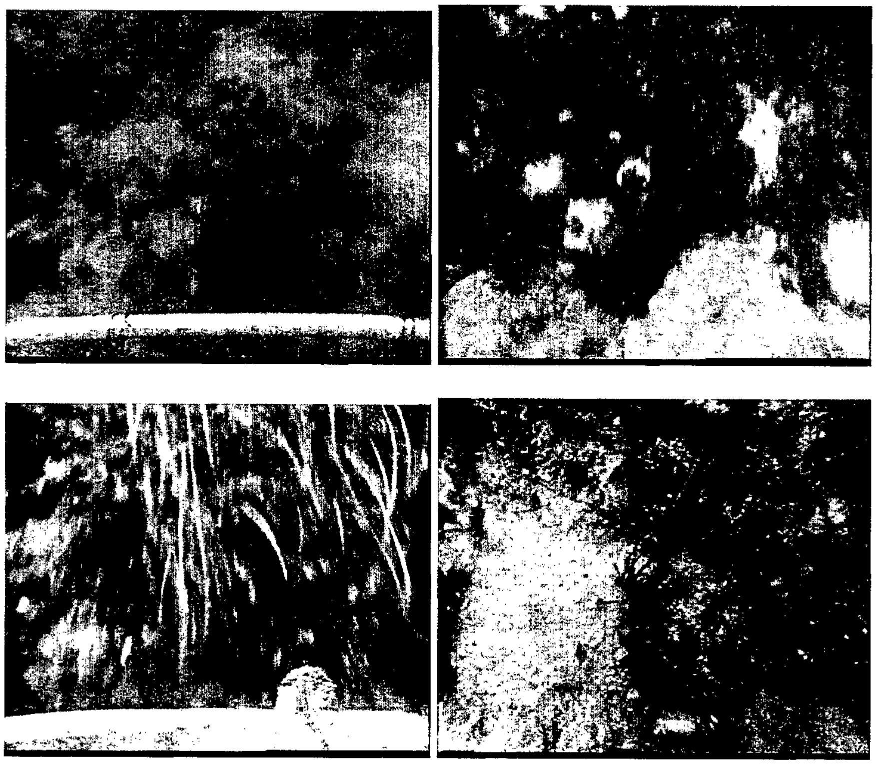


Figure 22. Frame-grabs from video of macroalgae and seagrass areas in Manly Cove, taken on 27 February 2001. Algae are in the top two frames, seagrass in the lower two.

A sidescan mosaic and an air photo of part of Chowder Bay (Site 9) are shown in Figure 23. In both a linear, curved feature can be seen near A. From the video film it appears that this is a man-made feature covered with algae. Frames from the video are in Figure 24. It is not clear if the sonar is imaging the structure or the algae on it. To the left of the curved structure, the features seen on both sidescan and air photo are due to a mixture of seabed growth.

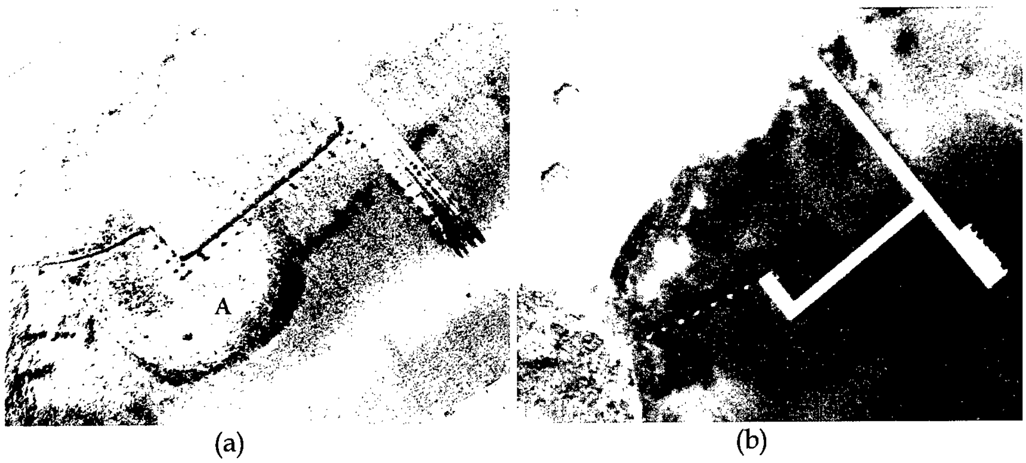


Figure 23. Head of Chowder Bay (Site 9): (a) Sidescan sonar mosaic of 18 April 2000; (b). Air photo of early 2001.

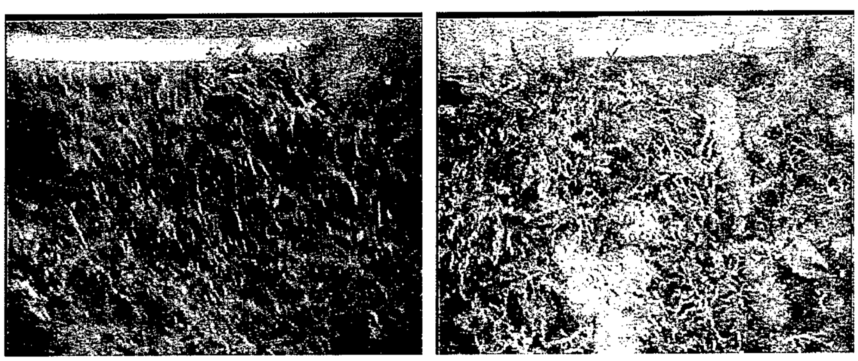


Figure 24. Frame-grabs from video of macroalgae on curved feature in Chowder Bay, taken on 20 February 2001.

Another macoalgal site surveyed was on the eastern side of Rose Bay (Site 13) in 1998. This was an area with many patches of filamentous algae (See Figure 25). Sidescan images in this area showed features (Figure 26) which were much sparser than the seaweed patches and so were unlikely to have any correspondence with them. This seaweed would have little masking effect on seabed mines. No air photos able to show seabed features (except in the intertidal zone) have been obtained for this site.

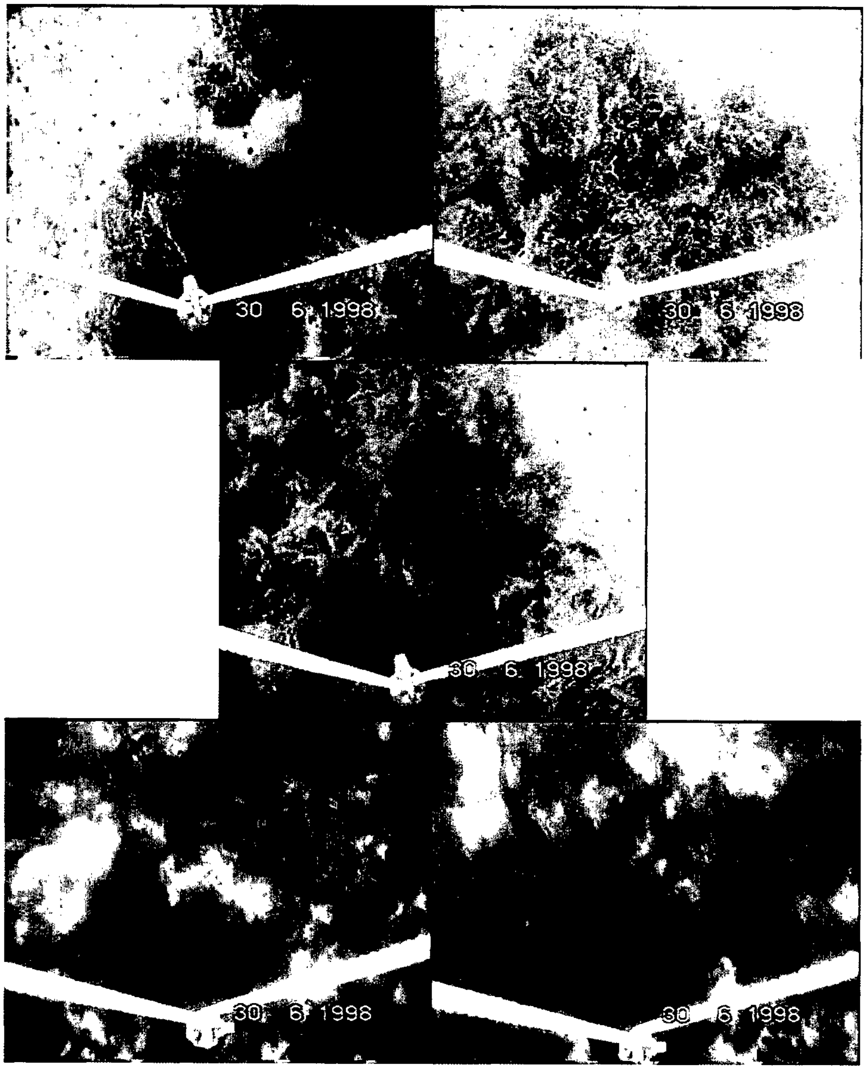


Figure 25. Frame-grabs from video of macroalgae in Rose Bay (Site 13), taken on 30 June 1998.

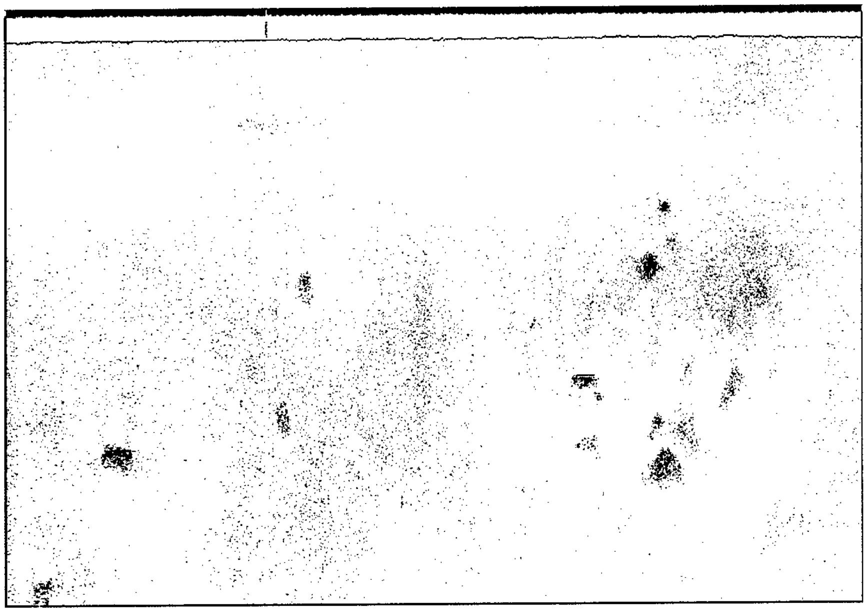
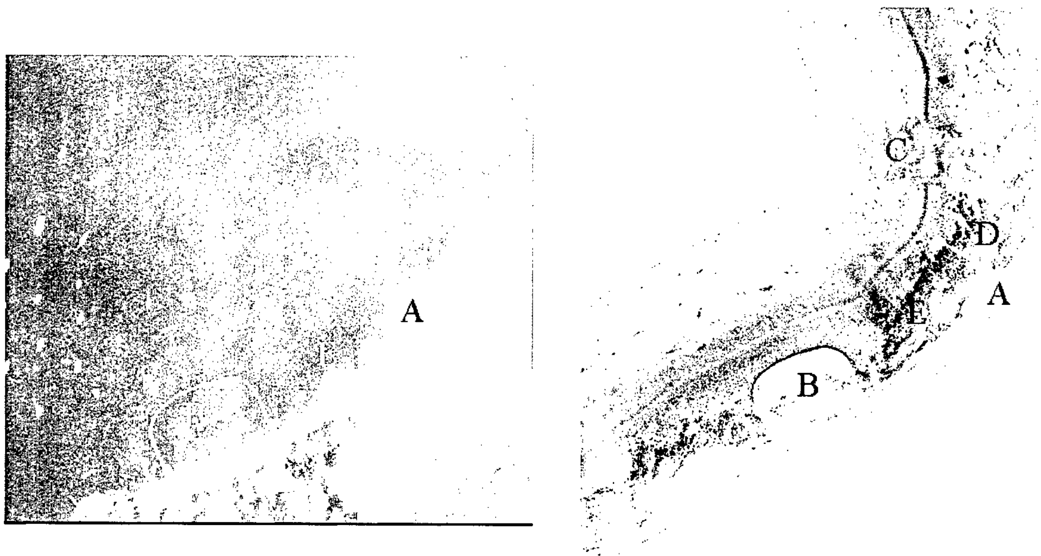


Figure 26. Raw sidescan image of area in Rose Bay with dense macroalgae, obtained on 2 July 1998. The features observable are far sparser than the algae.

The final algal site surveyed was off Seven Shilling Beach in Double Bay (Site 14). An air photo and a sidescan mosaic of the area are shown in Figure 27. The two have a number of seabed features in common, namely those labelled C, D and E. The label A indicates a small point on the beach, while B marks Redleaf Swimming Pool. Frames from seabed videos off Seven Shilling Beach are shown in Figure 28. Further investigation needs to be carried out at this site to understand some of the seabed features. It is a very awkward place to investigate because of the large number of boats moored there. The nature of the feature labelled C is unclear. E and D have the same appearance as each other on both the air photo and the sidescan image, but on the beach the material washed up shoreward of E is algal, while that shoreward of D is seagrass. Live seagrass was observed in the shallows near D (Figure 29 (b)). The shallow areas at Seven Shilling Beach are composed of sand, not shell or rock, so that at this site the sidescan sonar is imaging algae and/or seagrass. Video filming in deeper areas of Double Bay revealed some dense macroalgae, which did not appear at all on sidescan.



(a) (b)

Figure 27. Seven Shilling Beach, Double Bay (Site 14): (a) Air photo of January 2000; (b) Sidescan sonar mosaic of 18 April 2000.

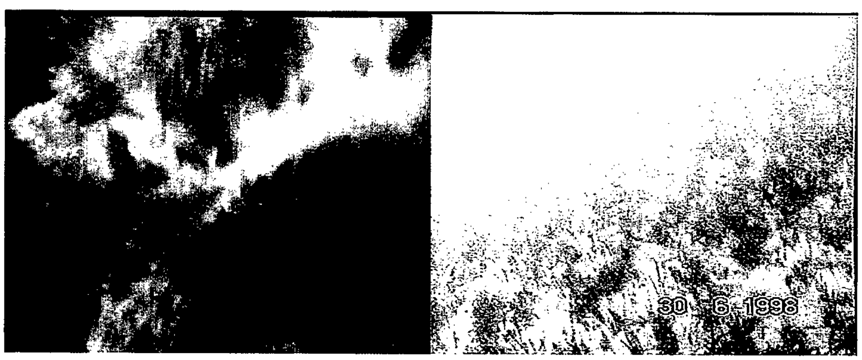


Figure 28. Frame-grabs from video of macroalgae and seagrass off Seven Shilling Beach, taken on 29 and 30 June 1998.

(a) (b)

Figure 29. Photographs of shoreline on Seven Shilling Beach, 9 March 2001, taken close to low tide. (a) Algae washed up shoreward of area E; (b) dead seagrass washed up shoreward of area D, with live seagrass in the shallows, in the distance.

3.3 Areas which appeared like weed on sidescan, but were not

At a number of locations sidescan images were obtained in which there were features which had a weedy appearance, and so were investigated further. One of these was offshore in Lady Bay (Site 8). A raw sidescan image from there is shown in Figure 30. Video filming of this site revealed that the features were in fact scattered rocks (See Figure 31). Other sites with weed-like features on sidescan images were off Peacock Point (Site 15), at the entrance of Blackwattle Bay (Site 16) and off Glebe Point, in Rozelle Bay (Site 17). A raw sidescan image of the first of these is shown in Figure 32, while sidescan mosaics of the last two sites are shown in Figure 33. The features investigated at sites 16 and 17 are the darker areas labelled A, B and C. At sites 15 to 17 the water was quite turbid and visibility near the seabed was extremely poor. However the videos at sites 15 and 16 revealed that the seafloor was quite rough at these locations with numerous large stones and no sign of weeds. At site 17 the seabed was very muddy and visibility was very small. The nature of the dark features A and B in the sidescan mosaic remains unclear, but there is no weed there. It may be that in this soft mud the sonar is seeing sub-bottom features. The light levels would be just too low for vegetation. Similarly at sites 15 and 16, light levels are too low for any vegetation to grow well.

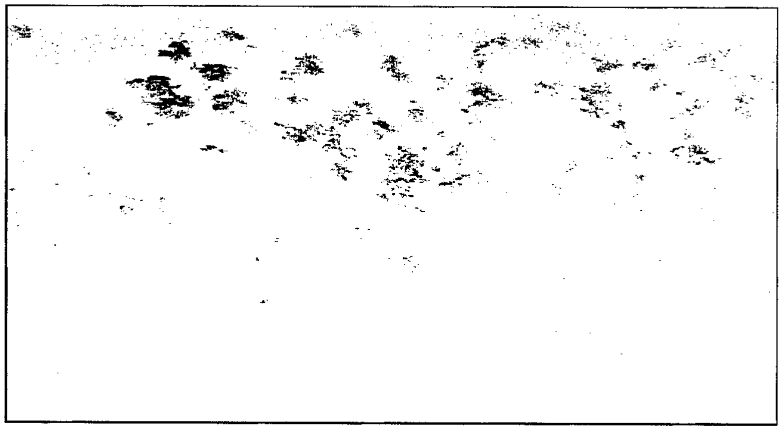


Figure 30. Raw (unmosaiced) sidescan image off Lady Bay (Site 8), taken on 18 April 2000.

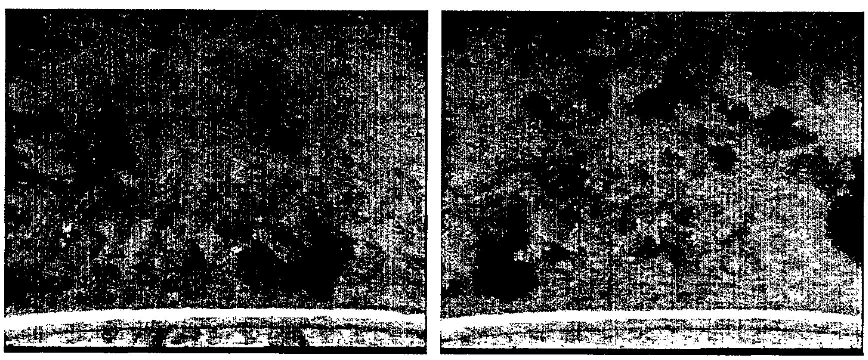


Figure 31. Frame-grabs from video of rocky area off Lady Bay, taken on27 February 2001.

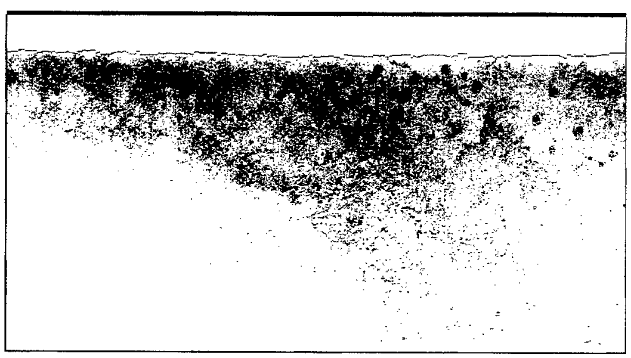
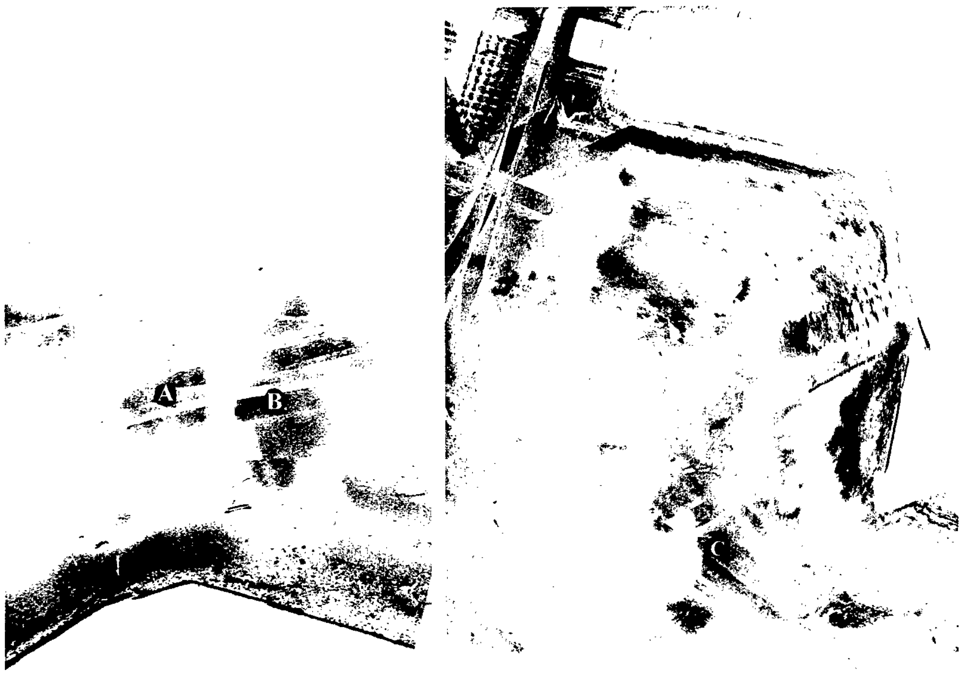


Figure 32. Raw sidescan sonar image, obtained 21 April 1999, of weed-like features off Peacock Point (Site15).



(a) (b)

Figure 33. Sidescan images of April 1999: (a) Dark patches off Glebe Point, Rozelle Bay (Site 17); (b) Dark patches in northern end of Blackwattle Bay (Site 16).

4. Discussion

At all the seagrass sites surveyed and at some of those with macroalgae it was possible to compare vegetation coverages as obtained by sidescan mosaics and air photographs. The sites at which there was either substantial agreement or disagreement are summarised in Table 2. For seagrass areas there was substantial agreement at three out of five sites. At the two for which agreement was poor there is some evidence that the seagrass coverage was relatively sparse compared to the other three, however further investigations are required to confirm this.

Because the backscatter from seagrass is primarily due to their gas filled lacunae, it is possible (as pointed out by Rob Williams of NSW Fisheries, private communication) that backscatter levels will vary with time of day and with season. It is also possible that the seasonal cycles of seagrass plants at different locations and of different species are not all in phase with each other. There have been no real investigations of temporal variations of backscatter from seagrass beds. If there are significant variations, then there may well be optimal times for using sonar to search for seabed mines within seagrass areas.

Table 2. Comparisons between sidescan sonar images and air photos

Site	Air photo & sidescan agree?
Seagrass sites	
Quarantine Beach (Site 1)	No
Store Beach (Site 2)	Yes
Collins Beach (Site 3)	No
Castle Rock (Site 5)	Yes
Taylors Bay (Site 10)	Yes
Macroalgal Sites	
Manly Cove	No
Chowder Bay	Yes
Double Bay	Yes, only close inshore

For macroalgal areas, where comparisons between sidescan images and air photos were possible, there was agreement at two sites: in Chowder Bay and close inshore at Double Bay. However at Chowder Bay it is very likely that the sidescan was imaging the structure on which the algae was growing and at Double Bay only algae close to shore could be seen with sidescan. The only other site at which macroalgae showed up on sidescan was on the south-western approach to Quarantine Beach (Site 1), but this site was too deep for air photos to show anything. Kelp beds on rocky surfaces could not be seen on sidescan images at the five sites surveyed, and other macroalgae, observed to be present at three more sites, could not be seen with sidescan either. Generally macroalgae did not show up on sidescan sonar at the sites surveyed. The major exception was at Double Bay, which is a site which deserves further investigation. This does not mean that no macroalgae can be detected with sidescan. It has been observed with sidescan in Corio Bay, Victoria (Mulhearn, 1997) and off California (Healey, 2001). It just means that the examples in Sydney Harbour cannot be detected. It is known that there is more substantial macroalgal growth in Jervis Bay, which may be a better location for further study of the effects of macroalgae on sidescan sonar and mine hunting

5. Conclusions

From this study so far it is clear that sidescan sonar can map seagrass beds very effectively, in some cases. The study is worth continuing in order to elucidate why marine vegetation is discernable in some cases and not others, and to determine if there are any diurnal or seasonal variations in backscatter levels from vegetated areas.

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19. ABSTRACT

Beds of marine vegetation such as seagrass and the larger algae may, if dense enough, mask the presence of seabed mines. An investigation is underway in Sydney Harbour of the extent to which seabed vegetation is discernable on sidescan sonar images. To date it has been found that, in some cases, sidescan sonar images provide very similar coverage to air photographs of seagrass beds. When seagrass is seen this readily on sidescan it is likely to be a problem for mine hunting. In those cases where sonar images and air photographs disagree, it is probable that the seagrass is relatively sparse, but this requires further investigation. At most sites the presence of the larger marine algae could not be discerned on sidecsan imagery, suggesting in many cases, but one cannot say all, that algae will not present a problem for mine hunting.