DECLINE OF SEAGRASS BEDS IN PRINCESS ROYAL HARBOUR AND OYSTER HARBOUR, ALBANY

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Decline of Seagrass Beds in Princess Royal Harbour and Oyster Harbour, Albany, Western Australia

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CONTENTS

FIGURES

ii SUMMARY

Since 1962, seagrass cover and density have declined markedly in Oyster Harbour and Princess Royal Harbour (PRH), Albany. Underwater photographs, taken in 1986, have shown evidence of old, dead rhizomes in the substrate and unhealthy, algae-covered *Posidonia* throughout PRH. Oyster Harbour, although not so intensively examined, appears to have similar problems.

In terms of biomass and area covered in both harbours, *Posidonia australis* and *P sinuosa* were the two most important seagrasses. By 1984, 46% and 66% of seagrass cover in Oyster Harbour and PRH respectively had been lost, and there is no evidence to suggest revegetation. Bastyan (1986) reported on this loss of seagrass cover to 1984, and claimed that seagrasses were being smothered by epiphytic algae. The seagrass cover has continued to decline since then.

From the evidence and experience in other Western Australian bays and estuaries, particularly Cockburn Sound and Peel-Harvey Estuary, the decline of seagrass and proliferation of fast growing, highly productive macroalgae is caused by high nutrient levels in the water. These nutrients (nitrogen and phosphorus) are entering the embayments through drainage water from agricultural lands, from a fertiliser factory near PRH and from other anthropogenic sources. At this stage there is probably a considerable nutrient store in both harbours. This store is mainly organic nitrogen and phosphorus compounds associated with sediments and organic detritus on the bottom. It would be difficult and very expensive to remove this organic material from either harbour.

If the input nutrient loads were reduced immediately, there would probably be no return to the original pristine conditions, which were probably similar to those of nearby King George Sound. Existing seagrass beds in reasonable condition may recover, but revegetation by *Posidonia* would be negligible. Plant colonisers would appear, and at least stabilise sediments and afford shelter to some juvenile fish and crustacea. The main colonisers in bare areas in seagrass beds are the small seagrass species, *Halophila ovalis*, *Heterozostera tasmanica* and occasionally *Amphibolis* species. Information on the relative habitat value of *Posidonia* beds in south-Western Australia compared with the seagrass beds comprising the smaller coloniser *Ruppia* is available in Lenanton (1977, 1982), Scott (1981), and Scott *et al* (1986); while comparisons between *Posidonia* and *Zostera* were made by Middleton *et al* (1984).

If the nutrients loads are not reduced, the *Posidonia* beds will die out completely, eutrophication will occur, and blooms of nuisance algae such as *Enteromorpha*, *Cladophora* and *Ulva* will develop more frequently. Water clarity will be reduced and there may be considerable sediment movement.

Artificially revegetating denuded areas with *Posidonia* has not been attempted in Australia. Vegetative and reproductive propagules can be obtained easily, but to anchor them and successfully rehabilitate seagrasses in these harbours could prove very costly.

1. TERMS OF REFERENCE

In response to a request by the former Department of Conservation and Environment (now integrated into the Environmental Protection Authority), this report has been prepared to cover the following terms of reference:

- Examine existing data and information regarding distribution of seagrass meadows in Princess Royal Harbour and Oyster Harbour and comment on the reliability.
- Evaluate the nature and magnitude of the changes reported by Bastyan (1986).
- Consider and describe the likely situations in these harbours in the future (perhaps 2, 5, 10 and 20 year scenarios), if present apparent trends continue.
- Describe and comment on the implications of the worst possible scenario developing (for example, effective loss of all seagrass meadows from either or both harbours).
- Comment on possible management options to halt or reverse present trends.
- Consider and predict the likely situations in these harbours (perhaps 2, 5, 10 and 20 year scenarios), if immediate actions are implemented to significantly reduce anthropogenic influences (including nutrient inputs) on marine communities in the harbours.

2. DESCRIPTION OF THE AREA

Bastyan (1986) has described the general and biological characteristics of Princess Royal Harbour (PRH) and Oyster Harbour. Mills and Brady (1985) described the physical features, particularly relating to water circulation in PRH, and Atkins et al (1980) described chemical aspects of water in PRH. Each harbour is connected to King George Sound by a narrow channel. There are small beds containing at least five species of *Posidonia* just outside the mouth of Oyster Harbour and at Gull Rock (Figure 1), and extensive seagrass meadows growing to at least 17 m depth in Frenchman Bay and Barker Bay. King George Sound has a maximum depth of about 20 m, contains a few small islands and many reef areas, and is open to the Southern Ocean to the east and southeast.

Salinities over the *Posidonia* beds in the two harbours range from 31 parts per thousand to 35 parts per thousand (Bastyan, 1986). Oyster Harbour has two inflowing rivers whose catchment areas are farmed extensively.

The following seagrass species are found in King George Sound:

Posidonia australis		"australis" complex
P sinuosa		" "
P den Hartogii		"ostenfeldii" complex
P robertsoneae		" "
P kirkmanii		" "
P ostenfeldii	(drift only)	" "
Heterozostera tasmanica		
Halophila ovalis		
Amphibolis antarctica		
A griffithii		

Figure 2a. *Posidonia sinuosa* bed at 15 m depth in Frenchman Bay, January 1987. Note dense, healthy seagrass.

Figure 2b. *Posidonia australis* bed at 1.5 m depth in Frenchman Bay, January 1987. Note dense, healthy seagrass, relatively free of epiphytes.

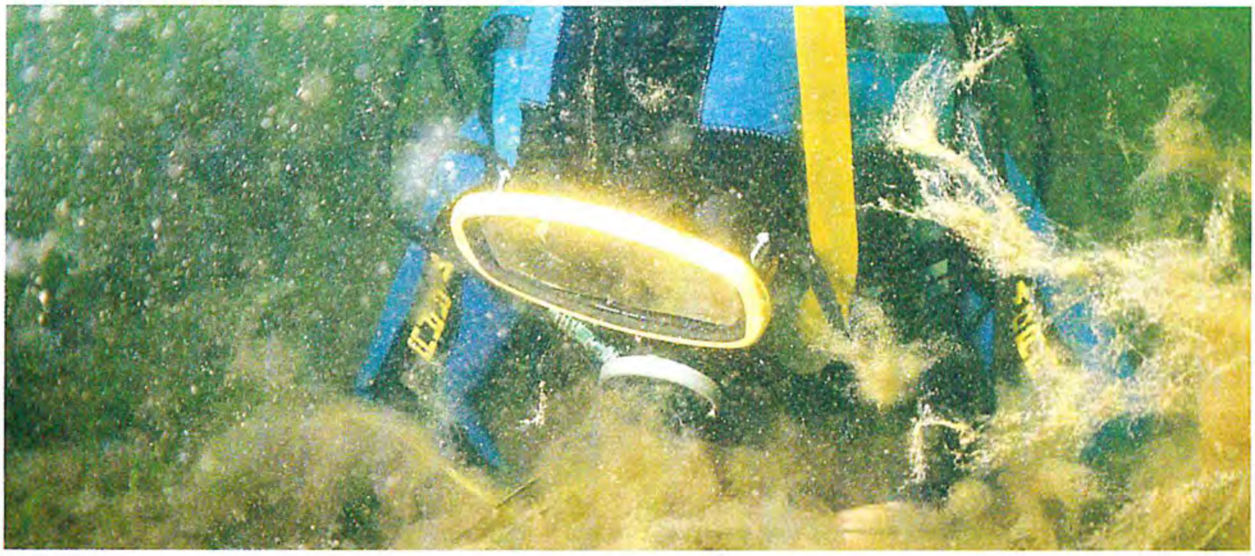

Figure 2c. Filamentous alga (epiphyte) covering *Posidonia sinuosa* in the eastern part of Princess Royal Harbour, 4.5 m depth, November 1986. Note seagrass is almost totally covered with alga.

Figure 3a. *Posidonia australis* and *P sinuosa* in the western end of Princess Royal Harbour, 1.5 m depth, November 1986. Note seagrass here is very sparse, probably due to the quantity of smothering benthic algae.

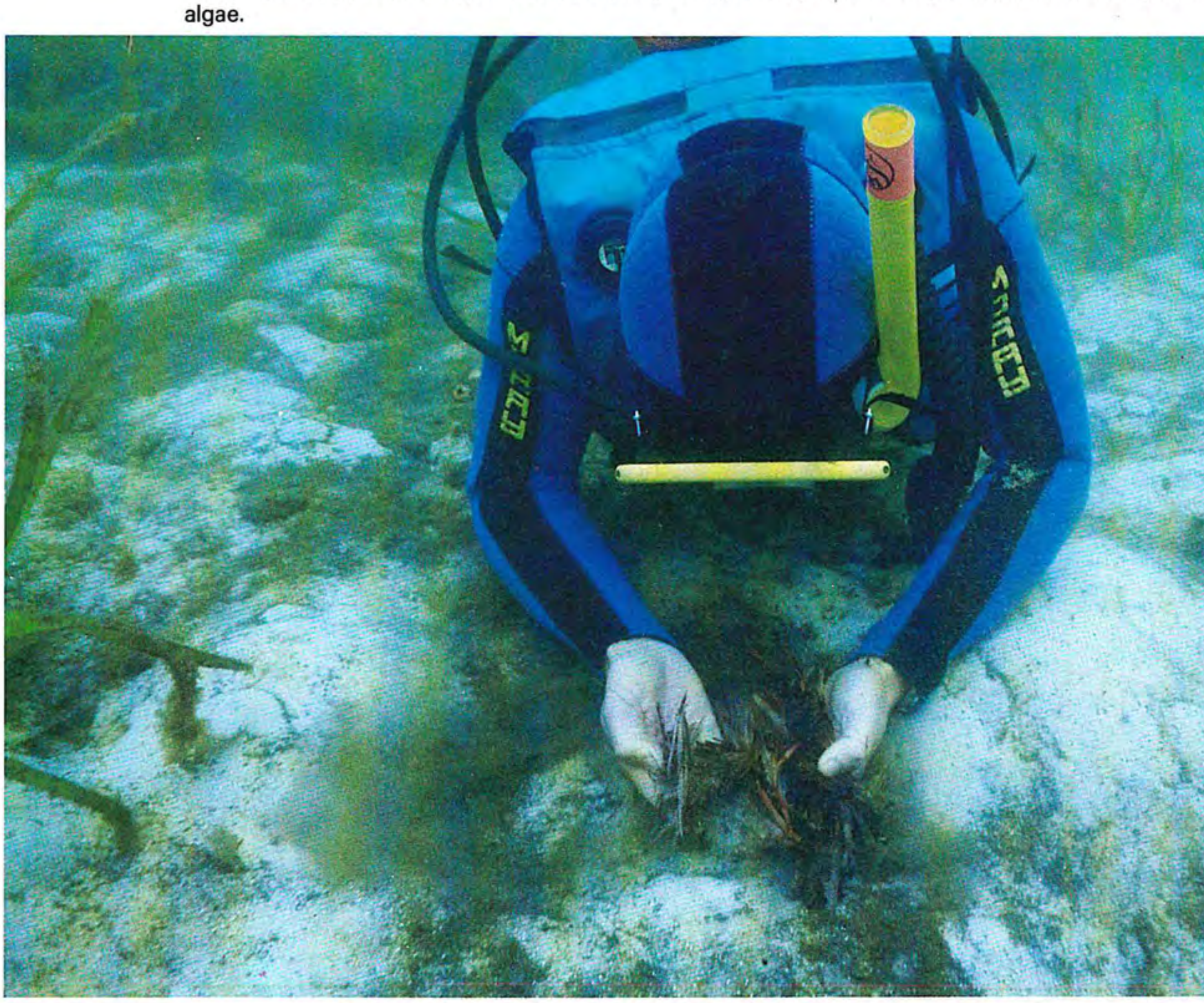

Figure 3b. Diver examining remains of seagrass leaf - bases and rhizomes dug out from under the sand. This indicated a seagrass bed once covered the site. Photograph taken in the eastern end of Princess Royal Harbour, 4.5 m depth, November 1986.

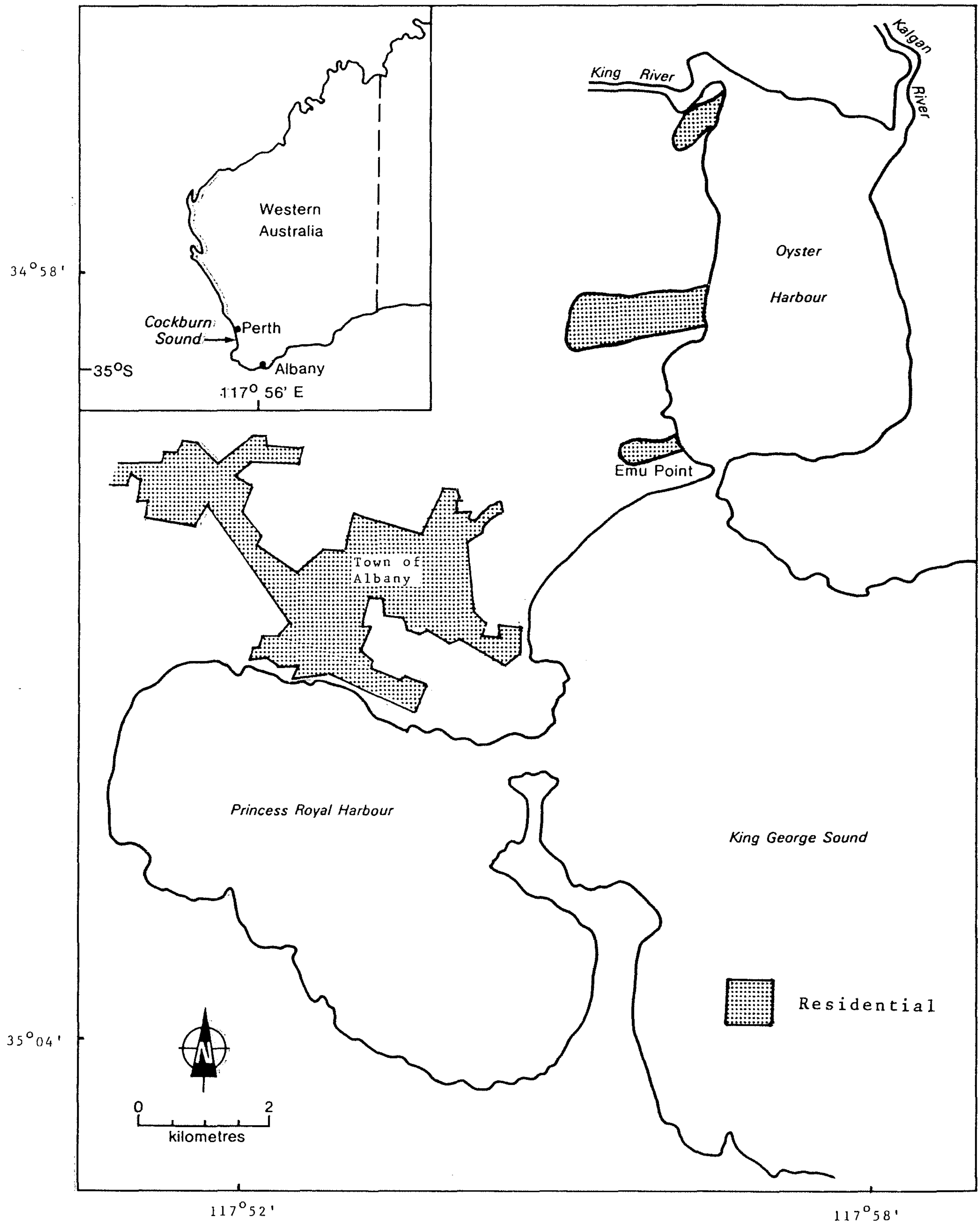

Figure 1. Map showing location of Princess Royal Harbour and Oyster Harbour at Albany.

P australis and *P sinuosa* are found in PRH and Oyster Harbour. The only other seagrass mentioned by Bastyan (1986) was *Amphibolis griffithii*.

3. SEAGRASS BIOLOGY

Altogether six species of *Posidonia* are found in King George Sound. These have been divided, by Kuo and Cambridge (1984), into two complexes - "australis" and "ostenfeldii". The members of the "ostenfeldii" complex (Kuo and Cambridge, 1984) are not likely to occur in sheltered bays as they are generally found in swell conditions. Other seagrasses, *H tasmanica*, *H ovalis* and *A antarctica*, are often associated with blowouts in *Posidonia* beds (Kirkman, 1985).

In most years the members of the "ostenfeldii" complex are prolific producers of seed in November, but these species of *Posidonia*, once established, do not rapidly produce horizontal rhizomes and spread. They do, however, send vertical roots deep into the sandy substrate so that they are well anchored and form multi-branched clumps. The growth form of these species is evident when a mature meadow is observed. The seeds have usually settled on the lee side of swell-formed ripples in the sand, and after three years or more, the meadow looks as though it has been planted in rows. Seedlings are quite robust and are reliant on the seed testa for at least a year after germination.

P australis and *P sinuosa* do not anchor as firmly as the species in the "ostenfeldii" complex, and *P sinuosa* does not flower as prolifically as the other *Posidonia* species. No one has yet attempted to recolonise seagrass beds with *Posidonia* seedlings, although a successful attempt at vegetative propagation in the Mediterranean with *P oceanica* has been made (Cooper, 1980). *P oceanica* has a different growth form from the Australian *Posidonia*, therefore, a method similar to Cooper's may not be successful. *Thalassia testudinum* seedlings have been used to revegetate areas of lost seagrass in the Carribbean, but this has proved very expensive (Thorharg, 1985, 1986).

Kirkman (1985) has shown that, within the eight years of his records, *P sinuosa* and *P australis* do not recover in blowouts or artificial clearings. There is ample evidence from other *Posidonia* beds that recovery is extremely slow, if it occurs at all. A clearing made for the extraction of fibre from *Posidonia* beds in Spencer Gulf in 1917 has not been recolonised (Clarke, pers comm), nor have the tracks made by an amphibious vehicle through a *Posidonia* bed during the Second World War in Botany Bay. Kirkman (1985) has shown that blowouts may be recolonized by *Halophila ovalis*, *Heterozostera tasmanica* or even the seedlings of *Amphibolis*. These colonizers may spread rapidly but may be short lived due to their being smaller and less well anchored and therefore more susceptible to removal by storms.

4. BENEFITS OF SEAGRASS BEDS

It is well known that seagrass beds located in Australian coastal environments provide important nursery areas for juvenile fish and crustaceans, many of which are commercially important (Pollard, 1984; Young 1978). Some of the more important commercial species that utilise seagrass beds are representatives of the flathead, trevally, bream, whiting, Australian salmon, mullet and leatherjacket families (Lenanton, 1977; Middleton *el al* 1984; Robertson, 1977, 1982, 1984).

Seagrass beds stabilise the sediments on which they grow (Thorhaug, 1986). The tough, deep rhizomes of *Posidonia sinuosa* and *P australis* prevent mass sand movement and erosion while the leaf blades act as baffles to water movement. Increased accretion may cover existing beds with sand more rapidly than they can grow out of it; the consequence of this is smothering and later death of these beds (Kirkman, 1978).

Seagrass leaf blades modify water currents causing suspended particles to sink to the bottom. These suspended particles may be organic in origin thus adding to the available food for animals living in the seagrass. Therefore as seagrass beds disappear it can be expected that water clarity will decrease, thus reducing the depth limits of the remaining beds.

5. CONSIDERATIONS

5.1 EXAMINE EXISTING DATA AND INFORMATION REGARDING DISTRIBUTION OF SEAGRASS MEADOWS IN PRINCESS ROYAL HARBOUR AND OYSTER HARBOUR AND COMMENT ON THEIR RELIABILITY

There is no doubt that the extent of seagrass beds in PRH and Oyster Harbour has declined since McKenzie (1962) reported on the area. Since then aerial photographs have not been very reliable without extensive field work to evaluate what is seagrass and what is macroalgae. It appears, from underwater photographs taken in PRH in November 1986, that large areas of seagrass have either been replaced by beds of *Cladophora* or have been covered by this macroalgae (Photograph 1). The deeper seagrass beds seem worst affected. Bastyan (1986) shows no seagrass in the centre of PRH and a reduction in seagrass bed area in the deeper parts of Oyster Harbour.

Aerial photographs taken in 1984 were used by Bastyan (1986). Both these, and those taken in 1985, do not allow accurate comparisons to be made between the earlier 1977 and 1982 photography because:

- The water clarity is poor compared with that of King George Sound where seagrass beds can easily be seen.

- There is no way to distinguish seagrass from accumulations of algae in the two harbours, nor can the area covered by dead rhizomes be distinguished from that covered by live seagrass. Underwater photography along three transects in PRH taken in November 1986 showed that most seagrass was covered, to some degree, with filamentous algae. These photographs also showed the *Posidonia* beds to be in very poor condition. The densest beds in PRH, in 1.5 m of water (Figure 3a), were less dense than beds in 15 m in nearby Frenchman Bay (Figure 2a).

The loss of 0.8 km^2 of seagrass in PRH between 1981 and 1984 does not appear to be a great decline in seagrass cover. However if it is realised that nearly all the seagrass in PRH is covered by filamentous algae, and that this may have been included as seagrass bed in Tables 1 and 3 in Bastyan (1986), then it may be supposed that the expected life of these beds is limited. Without a complete field programme of underwater tows, and checks of aerial photography, it is not possible to define the rate of seagrass bed decline since 1984. Personal experience indicates that the future rate of decline will accelerate.

5.2 EVALUATE THE NATURE AND MAGNITUDE OF THE CHANGES REPORTED BY BASTYAN (1986)

The Bastyan report (1986) is a valuable document describing the seagrass beds and the reduction in seagrass cover in PRH and Oyster Harbour between 1962 and 1984, since it makes good use of aerial photographs and *in situ* observations along fixed transects. Aerial photography for 1985 is now available.

It is unfortunate that Bastyan's report (1986) did not compare the harbours with healthy seagrass beds from nearby. King George Sound has healthy beds with at least five *Posidonia* species, and four other species. Records of their depth limits, distribution and biomass would have been useful as comparisons with the two harbours where seagrasses are declining. Figure 2b shows *Posidonia australis* growing in 1.5 m of water in Frenchman Bay. A comparison of the species and biomass of epiphytes within the two harbours, with those in King George Sound, may have led to a statement as to whether epiphyte loads were unusually heavy or different in Bastyan's study area.

The cover by either seagrass or algae at the western end of PRH is not mentioned in Bastyan's (1986) report, yet there is a large vegetated area visible in each aerial photograph. In fact, this area is covered mainly by *P australis* with large patches of *Amphibolis antarctica* along the edges of the *P australis*. In the very shallow shoreward side of this bed, *Ruppia* sp is found in small quantities growing on the edges of the *A antarctica* clumps. *Heterozostera tasmanica* also grows with the other species. This area of seagrass is probably the healthiest in the harbour: it is not smothered by macroalgae, even though a drain from a potato-growing area flows into PRH close by. This may be because the macroalgae cannot tolerate the high ultraviolet light present in such shallow water. Another alternative for the lack of macroalgae in otherwise ideal conditions is that, being so shallow, wind blown waves can remove any epiphytic growth. It is notable, however, that where the Elleker Road Drain enters PRH there is bare sand.

Bastyan (1986) also states that there has been a considerable increase in algal growth in both harbours and suggests that high nutrient inputs are responsible for this. *Cladophora prolifera* accumulation is a symptom of eutrophication of the water in the Peel-Harvey Estuary (Gordon et al, 1981). Since *Cladophora* has accumulated in both Princess Royal Harbour and Oyster Harbour, Bastyan's suggestion seems well-founded.

5.3 CONSIDER AND DESCRIBE THE LIKELY SITUATIONS IN THESE HARBOURS IN THE FUTURE (PERHAPS 2, 5, 10 AND 20 YEAR SCENARIOS), IF PRESENT APPARENT TRENDS CONTINUE. DESCRIBE AND COMMENT ON THE IMPLICATIONS OF THE WORST POSSIBLE SCENARIO DEVELOPING (FOR EXAMPLE, EFFECTIVE LOSS OF ALL SEAGRASS MEADOWS FROM EITHER OR BOTH HARBOURS).

If the *Posidonia* beds of PRH and Oyster Harbour are lost and the nutrient input into these harbours continues, the water quality and substrate will change considerably. Although flushing rates in both these harbours are greater than for the Peel-Harvey Estuary, they may be slow compared with King George Sound. A further build up of macroalgae could also be expected at Albany. Blooms of algae such as *Cladophora*, *Enteromorpha* and *Ulva* may occur. Dead plant material could consequently accumulate on the bottom and act as a nutrient store. There would probably be very little export of these nutrients to King George Sound because of the slow flushing rates. The waters of these two enclosed harbours would have all the problems of eutrophic waters. If the apparent trends continue all seagrass beds will disappear in the order of about 5 years. There will be no recovery and blooms of algae will occur at least every summer. Sand movement within the harbours may fill in dredged channels within 20 years while erosion along the edges of both harbours will commence as soon as seagrasses disappear. It may even be possible for such large amounts of nutrients to be released that King George Sound seagrass beds are also affected. The above considerations cover the worst possible scenario.

5.4 COMMENT ON POSSIBLE MANAGEMENT OPTIONS TO HALT OR REVERSE PRESENT TRENDS

In considering the results and conclusions from the study of seagrass decline in Cockburn Sound, near Perth (Cambridge and McComb, 1984; Cambridge et al, 1986; Silberstein et al, 1986), and the results of Bastyan's (1986) report, it appears reasonable to assume that excess nutrients in PRH and Oyster Harbour has indirectly caused the decline in seagrass density and cover. Silberstein et al (1986) suggest that seagrass loss in Cockburn Sound may be attributed to enhanced epiphyte loads following nutrient enrichment.

The amount of phosphate phosphorus, in the water of PRH determined by Atkins et al (1980), is higher than that at Marmion lagoon near Perth where seagrasses are healthy and abundant (Pearce et al, 1985). There is also a peak in winter that does not occur near Perth. Ammonia concentrations reported by Atkins et al (1980) are also higher than for waters near Perth. The nitrate concentrations in PRH are similar to those of coastal waters near Perth.

It is apparent that, to prevent further loss of seagrass, the nutrient load entering the harbours must be reduced to levels below some critical amount yet to be determined. The concentration of phosphorus and nitrogen must be such that the algal blooms are not sustained. Reduction of run-off nutrient load in the Peel-Harvey Estuary has been facilitated by farmers in the catchment area using slow release fertiliser, and in Cockburn Sound by the exclusion of industrial and urban wastes. If nutrient inputs are reduced, into the Albany harbours, it would be appropriate to instigate a monitoring programme to determine the response of the marine plant communities.

Once nutrient levels in the water column have been reduced sufficiently to prevent blooms of epiphytic algae growing on the seagrass, a possible management option would be some form of artificial revegetation of the seagrass areas. Natural colonisation of seagrass may take up to two orders of magnitude longer than artificial recolonisation (Thorhaug, 1986). Seagrasses could be replaced either as vegetative turfs or as seedlings, replanted throughout the damaged areas. As the most likely method to succeed is the transplanting of seedlings, which are readily available in summer, the first restoration attempt should be to investigate the possibility of growing *Posidonia* seedlings in the damaged seagrass areas. A detailed procedure and methodology for revegetation would have to be the subject of a separate study.

5.5 CONSIDER AND PREDICT THE LIKELY SITUATIONS IN THESE HARBOURS (PERHAPS 2, 5, 10 AND 20 YEAR SCENARIOS), IF IMMEDIATE ACTIONS ARE IMPLEMENTED TO SIGNIFICANTLY REDUCE ANTHROPOGENIC INFLUENCES (INCLUDING NUTRIENT INPUTS) ON MARINE COMMUNITIES IN THE HARBOURS

The vital question is - will the seagrasses return if nutrient input is reduced to levels at which algal blooms do not occur?

As stated earlier, *Posidonia australis* and *P sinuosa* are extremely slow to revegetate areas denuded of seagrass. Possibly the colonisers *Halophila ovalis* or *Heterozostera tasmanica* can successfully establish to a level where full cover is achieved, because both Oyster Harbour and PRH are relatively well protected from large storms. Nevertheless, these plants will never provide the biomass of a *Posidonia* meadow.

6. CONCLUSIONS

The fact that Bastyan (1986) did not mention *Halophila ovalis*, *Heterozostera tasmanica* and *Amphibolis antarctica* may be significant. These species usually colonise areas where *Posidonia* has been lost naturally. Their absence may be indicative of unsuitable areas for seagrass, thus adding further evidence to the suggestion that PRH and Oyster Harbour are now unhealthy habitats for seagrasses.

Experience from the Peel-Harvey Estuary should be used in solving the problems in PRH, and particularly in Oyster Harbour where farming practices in the catchment area may be adding to the nutrient load of the two rivers which discharge into the harbour.

One other consideration not mentioned by Bastyan (1986) is that a decrease in salinity may kill *Posidonia*. This is particularly applicable in Oyster Harbour into which two rivers, with extensively cleared catchments, empty, thus causing a greater freshwater input than previously. In Cockburn Sound, where large areas of seagrass have also died out, the possibility that increased freshwater input was responsible was not investigated, since there is no appreciable freshwater input into that Sound.

If present trends continue, both PRH and Oyster Harbour will become increasingly eutrophic, blooms of macroalgae will occur more commonly, and all the significant seagrass beds will be lost. As a direct result of seagrass loss, erosion and accretion will occur and valuable nursery areas for juvenile fish and crustacea will be lost. Water turbidity will increase and the blooms of macroalgae will cause problems in the harbours and on their beaches.

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