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# EFFECT OF BOAT MOORINGS ON SEAGRASS BEDS IN THE PERTH METROPOLITAN REGION



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# Effect Of Boat Moorings On Seagrass Beds

# in the Perth Metropolitan Region

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**SUMMARY**

Boat impacts on seagrass meadows in the Perth metropolitan region were assessed.

The areas of seagrass meadow lost to moorings totals some 5.4 hectares in the Rottnest, Warnbro Sound and Cockburn Sound regions, with most loss (3.14 hectares) in the Rottnest area. This area lost represents 0.2% of the total area of seagrass in these regions.

While only relatively small areas of seagrass are involved in mooring damage, the effect is much greater than if the equivalent area was lost from the edge of a meadow. These 'holes' result in an increase in the 'edge' length which is vulnerable to erosion. Mooring damage has resulted in an increase in the length of eroding edge of seagrass of about 8.5 km in Cockburn and Warnbro Sounds and 13.5 km around Rottnest Island.

'Cyclone' moorings were found to be much less damaging to seagrass meadows than 'swing' moorings. 'Cyclone' moorings generally result in a permanent scour area of about 3 $m^2$. 'Swing' moorings scour an area dependent on the length of chain used. The average scoured area of 'swing' moorings in Cockburn and Warnbro Sounds was found to be 39 $m^2$.

Ferry traffic to Rottnest Island causes considerable sediment resuspension in Thomson Bay, and this is thought to be responsible for the loss of 6 hectares of seagrass meadow in the vicinity of the ferry landing jetty over the last 20 years.

## 1. OBJECTIVE

This report is concerned with damage to seagrass meadows caused by boat moorings, recovery after disturbance, and more generally with other boat impacts on seagrasses. It addresses:

(i) Areas of meadows lost in the metropolitan region because of

- (a) boat moorings,
- (b) boat harbour construction,
- (c) anchor damage.

The areas of disturbance are addressed in relation to the total area of seagrass meadow in the regions concerned.

(ii) Effects of different mooring types on seagrass beds.

(iii) Effects of boats on light reaching seagrasses.

(iv) Impact of boat discharges.

## 2. METHODS

Seagrass meadows along the coast from Ocean Reef to Becher Point and offshore to Rottnest Island (Figure 1a - e) were surveyed in this study.

In each of the mooring regions the scoured area due to boat moorings was estimated by multiplying the average scour area for that region by the number of moorings. For Rottnest Island the number and location of moorings was supplied by Mr A Kirk of the Rottnest Island Board. The number of moorings in Cockburn and Warnbro Sounds was unknown and numbers were estimated from field surveys. The estimate of mooring damage to seagrass meadows in Cockburn and Warnbro Sounds is most likely underestimated: some scoured areas, which may have been caused by moorings which had been temporarily or permanently removed, were not included in the estimates due to the uncertainty of their origin. The average scour area in each mooring region was calculated from measurements of scour diameter, made using a tape measure or passing a boat of known length over the scour. Some 153 scours were measured at Rottnest Island, 120 in Cockburn Sound and 66 in Warnbro Sound.

The following aerial photographs were also used to estimate areas of seagrass loss.

Lands and Surveys Department : aerial photographs.

| | | | | | |
|---|---|---|---|---|---|
| W.A. | | Dec 1976 | Cockburn and Warnbro | Runs 1-11 | 1:10,000 |
| W.A. | 2235 | June 1984 | Cockburn Sound | Runs 1-7 | 1:10,000 |
| W.A. | 2346 | Sept 1985 | Mullaloo | (5123 - 5130) | 1:8,000 |
| W.A. | 1859 | Feb 1986 | Rottest | Run 2 (5238) | 1:10,000 |
| W.A. | 2490 | Feb 1987 | Mullaloo-Mandurah | (5239) | 1:15,000 |
| W.A. | 2487 | Feb 1987 | Mullaloo | (5171 - 5179) | 1:8,000 |

## 3. CAUSES OF SEAGRASS MEADOW DAMAGE

### 3.1 BOAT MOORINGS

#### 3.1.1 AREAS LOST

Areas of seagrass meadow lost in the metropolitan region, as a direct result of damage caused by boat moorings, are shown in Table 1. The areas of seagrass meadow lost due to a single mooring ranged from about 3 $m^2$ to 300 $m^2$ depending on the type of mooring and length of chain used. Most damage has occurred around Rottnest Island, which has large numbers of moorings. Around Rottnest Island (Figure 1a), the area lost due to boat moorings represents only 1.4% of the area of seagrass in the mooring regions. In Thomson Bay, which has the largest number of moorings, about 2.45 hectares of seagrass meadow has been lost as a direct result of boat moorings (Figure 2).

Table 1. Area of seagrass meadows lost in the metropolitan region due to boat moorings.

| Location | Number of Moorings | Scoured Area ($m^2$) | Area of Seagrass within Mooring region * ($m^2$) | Percentage of Seagrass Meadow Lost due to Moorings |
|---|---|---|---|---|
| **Rottnest Island** | | | | |
| Catherine Bay | 31 | 250 | 81,000 | 0.3 |
| Stark Bay | 105 | 1,830 | 160,000 | 1.1 |
| Rocky Bay | 191 | 2,390 | 319,000 | 0.8 |
| Geordie Bay | 92 | 720 | 105,000 | 0.7 |
| Longreach Bay | 73 | 590 | 102,000 | 0.6 |
| Porpoise Bay | 33 | 130 | 286,000 | 0.1 |
| Marjorie Bay | 64 | 1060 | 245,000 | 0.4 |
| Thomson Bay | 344 | 24,380 | 934,400 | 2.6 |
| Total | 933 | 31,350 | 2,232,400 | 1.4 |
| **Warnbro Sound** | 105 | 4,460 | 208,000 | 2.1 |
| **Cockburn Sound** | 253 | 18,360 | 955,000 | 1.9 |

* Mooring regions are shown in Figure 1 (a-e).

Most moorings in Cockburn Sound are situated in Mangles Bay between the Garden Island causeway and the northern jetty of the Rockingham Yacht Club (Figure 1d). Of 253 boat moorings in this area, 102 are located outside the seagrass meadow and cause no damage. The remaining moorings (151) have resulted in the loss of 1.8 hectares of seagrass, which represents about 1.9% of the seagrass meadow in this mooring region. As a proportion of the total area of seagrass in Cockburn Sound (1,100 hectares), the scoured area is insignificant (0.17%). Most of the seagrass loss in Mangles Bay (Figure 3) has been caused by two large barges (about 1.4 hectares). These are moored in shallow water and probably sit on the bottom at low tide. There were large numbers of sand patches (blowouts) within the mooring region in Cockburn Sound that may be the result of mooring damage, but these areas (about 1.5 hectares) were not included due to the uncertainty of their origin.

Figure 2. Aerial photograph showing damage to the seagrass meadow in Thomson Bay.
Note the large sand patch around the ferry jetty.
(Photograph : Lands and Surveys Department)

Figure 3. Aerial photograph showing damage to the seagrass meadow in Mangles Bay.
Note the large scoured areas caused by the barges.
(Photograph : S. Chape, State Planning Commission)

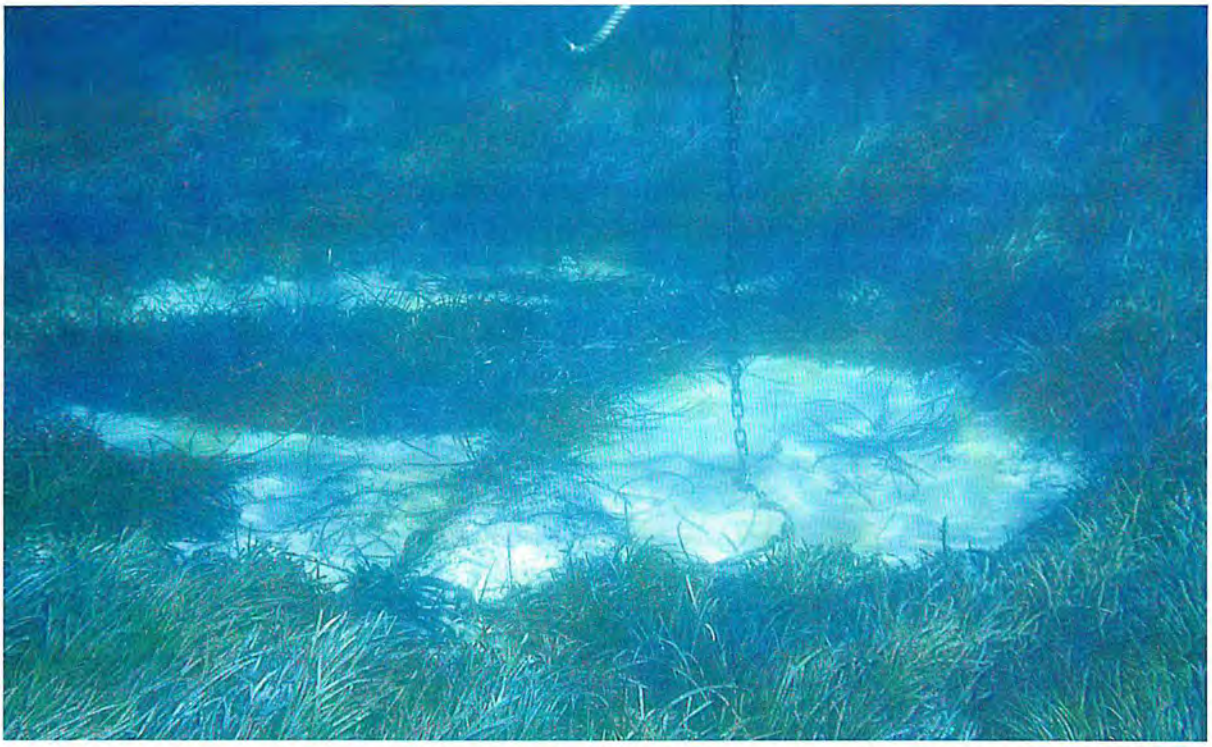

Figure 4. Photograph of a swing mooring showing typical damage caused by the mooring chain to the seagrass meadow. The seagrass in the centre of the scoured area is drift material. (Photograph: G. Bastyan)

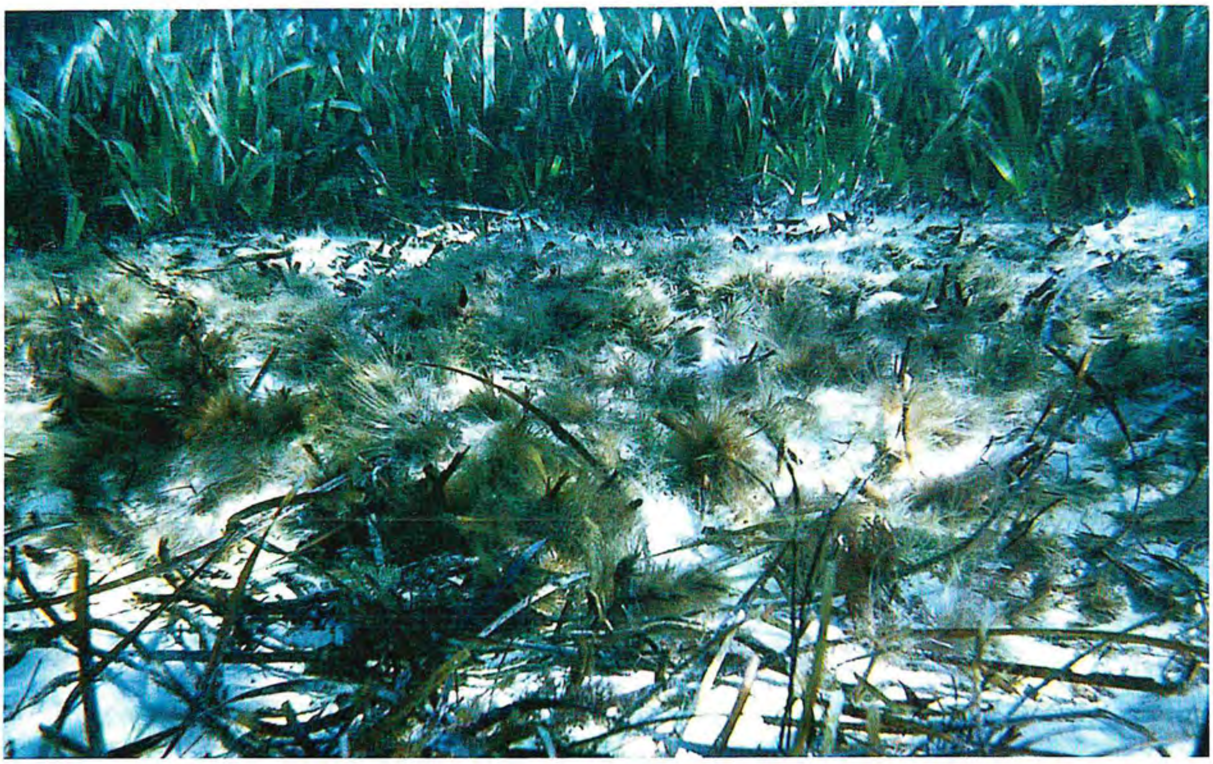

Figure 5. Photograph showing a depression in the seagrass meadow caused by a swing mooring. Note intact seagrass meadow at the edge of the scoured area. (Photograph: G. Bastyan)

In Warnbro Sound most boat moorings are located between the Safety Bay jetty and the last boat ramp to the east of Safety Bay Road (Figure 1e). The moorings are generally placed between the shore and the 2.0 m AHD contour, an area of extensive *Posidonia* meadow. The area of seagrass within which the moorings are situated is about 21 hectares, of which some 0.45 hectares (2.1%) has been lost as a result of boat moorings currently in place. There were also numerous sand patches (blowouts) in this region that may have been scoured by moorings which have been removed, and if this is so the area of seagrass lost in this region due to moorings may be of the order of 2.7 hectares. As a proportion of the total area of seagrass in Warnbro Sound (940 hectares) the damage caused by the boat moorings is insignificant (0.05%). However, because the moorings are all located within one small region, the visual impact of the damage is striking.

Seagrass meadows are significant to near-shore coastal ecosystems, having both physical and biological effects on the environment. These include reduction in water movement, and hence prevention of erosion; trapping and binding of sediments and organic detritus; provision of habitat for commercial fish and crustaceans; provision of a stable surface for colonisation by epiphytes; high rate of production; contributions to detrital foodchains; contribution of calcium carbonate by epiphyte deposition to sediments and essential roles in nutrient trapping and recycling.

All these functions rely on the existence of an intact, well-developed leaf-canopy. Where the meadow becomes sparse, or, more particularly in this case, if "holes" are created in the canopy by moorings (eg. Figures 4 and 5), the meadow ceases to have a physical integrity, which then influences its biological integrity. Thus, even though only relatively small areas of seagrass are involved in mooring damage, the effect is much greater than if the equivalent area was lost from the edge of a meadow. In particular, these 'holes' result in an increase in the 'edge' length which is vulnerable to erosion e.g. mooring damage has resulted in an increase in the length of eroding edge of seagrass of about 8.5 km in Cockburn and Warnbro Sounds and 13.5 km around Rottnest Island. 'Edge effects' may already have caused the loss of significant areas of seagrass. There were numerous 'blowouts' and thinning of the seagrass meadow within all the mooring regions.

Recolonisation by seagrass of previously damaged areas was observed in Porpoise Bay at Rottnest Island. About 10 moorings have been removed from Porpoise Bay and the scoured areas were found to be recolonised by pioneer seagrasses such as *Halophila* and *Heterozostera*; however, these species are extremely susceptible to storm erosion (Kirkman, 1985). The moorings were located in a *Posidonia* meadow and it is not known if *Posidonia* will re-establish in these scoured areas.

Mining for *Posidonia australis* fibre in Spencer Gulf, South Australia in 1917 left scars which are still visible (Kirkman and Parker, 1978). In Botany Bay, New South Wales, experimental clearings of *P. australis* remained base over a 35 month study period (Larkum, 1976).

Usually the depression in the meadow (Figure 5) caused by moorings is about 0.5 m, but scours as deep as 1 m below the natural level of the sediment surface were observed at Rottnest Island.

### 3.1.2 CONSEQUENCES OF MOORING DAMAGE

#### 3.1.2.1 Physical Effects

(a) Seagrasses slow the rate of water flow over the bottom (Fonseca *et al.* 1982) and this enhances the rate of sediment deposition within the meadow, as suspended particles fall from the water column when velocities decrease. These sediments are then bound by the network of growing rhizomes (Scoffin 1971), which stabilise an otherwise unstable environment. Seagrasses therefore allow the establishment and maintenance of sediment communities and also help prevent the erosion of these sediments.

Seagrass leaves have a high tensile strength and are also very flexible, having cell walls of pectin and cellulose (Kuo 1978), which, unlike the walls of many terrestrial plants, are not rendered inflexible by the deposition of lignin. This, in combination with a high leaf density, makes an intact meadow capable of baffling a current speed of 0.5 m $s^{-1}$ (Fonseca et al. 1982), and absorbing the wave energy of a 0.6 m wave (Davies 1970). This has an influence on the adjacent beach zone, as the kinetic energy of waves is diminished or dissipated before they reach the shore (Searle and Logan 1978).

**Consequence of mooring damage:** The "holes" are differentially eroded, and this can lead to undercutting of the surrounding area, with greater potential for erosion during subsequent storms. Seagrass detritus collects in these depressions and may restrict the chances of successful recolonisation.

(b) The trapping capability of seagrass meadows extends to organic detritus, which is therefore kept within the system, and not lost to the open ocean (Walker and McComb 1985). This detritus ensures the recycling of nutrients within the meadow and is of considerable biological significance.

**Consequence of mooring damage:** Loss of detritus and nutrients from the area damaged may extend further into the meadow as the edges are less effective at baffling the water movement.

(c) Seagrass beds are significant nursery areas for commercially-valuable species. The structure provided by a seagrass canopy acts as a refuge from predation for juvenile fish and crustaceans, many of which are recruited to commercial fish populations, after spending much of their growth phase in the relative protection of a seagrass meadow (Pollard 1984).

**Consequence of mooring damage:** Loss of habitat.

3.1.2.2 Biological Effects

(a) The area of seagrass leaf surfaces is up to 15 times larger than that of the bottom on which the seagrass grows (McComb *et al.*, 1981). This surface is stable, unlike the uncolonised sediments, and is available for settlement by a large number of plants and animals as epiphytes (Harlin 1980). These epiphytes are extensively grazed, both directly by fish, but also by smaller organisms, such as amphipods, which form an important part of the food chain (Lenanton *et al.* 1982).

**Consequence of mooring damage:** Loss of up to 15 $m^2$ of leaf surface for each square meter of seafloor scoured of seagrass, with consequent effects on epiphytic biota and associated food-chains. Edges of the "hole" have depauperate epiphytic assemblages due to scouring by sediment.

(b) Seagrass meadows have high rates of productivity (1-5 g dry wt $m^{-2}d^{-1}$) which are maintained by rapid production of new leaves, and the shedding of old leaves. This production is thus a "conveyor belt" of continously renewed substrate (Walker, 1985). This is particularly significant as a contribution to sediment production, as calcareous epiphytes are shed and retained within seagrass meadows, and new substrate is available for colonization (Walker and Woelkerling, in press).

**Consequence of mooring damage:** Loss of production, and potential for greater loss if storm damage leads to a larger area of seagrass removal.

(c) The majority of the seagrass production is not consumed directly, but is broken down, providing a massive input to the detrital food chains. The microbial populations associated with this decomposition also constitute an energy- and nutrient-rich food source. This particulate material is utilised by filter feeding animals which may be important components in food chains.

**Consequence of mooring damage:** Loss of detrital material supporting food webs.

(d) The high biomass of the meadows (1-2 kg dry weight $m^{-2}$, above-ground biomass) makes the seagrasses an important nutrient pool, as the plants absorb nitrogen and phosphorus both from the water column and from the sediments. These nutrients can enter the food chain via the mechanisms cited above, and efficient recycling both within the plants themselves, and within the meadows by decomposition, allow high rates of production to be maintained in nutrient-poor conditions (McComb *et al.* 1981).

**Consequence of mooring damage:** In the absence of an intact canopy, nutrients are lost, particularly through loss of detritus. Leaf litter then decomposes elsewhere (e.g. on beaches), and the nutrients are unavailable for seagrass growth.

## 3.2 BOAT HARBOUR CONSTRUCTION

The largest boat harbour development in the Perth metropolitan region has occurred at Fremantle, an area of sparse seagrass (Figure 1c). The new boat launching facility on the west side of the Garden Island causeway at Rockingham (Figure 1d) enclosed an area of healthy seagrass of about 2.2 hectares, which has since died. This represents about 0.2% of the total area of seagrass in Cockburn Sound.

The construction of breakwaters associated with boat harbour developments may also cause localized loss of seagrass due to the changes to sediment tranport patterns. Groynes protruding into the subtidal have been found to influence sediment distributions along the shoreline for a distance up to 6 times the length of the groyne (Riedel and Byrne, 1986).

Searle and Logan (1978) reported that localized losses of seagrass of up to 45% have occurred around breakwaters in Geographe Bay. About 2.8 hectares of seagrass have been lost since 1965 due to sand accretion at the southern end of the Garden Island causeway.

In large developments such as the Hillary's Boat Harbour (Figure 1b) the siting of the breakwaters themselves over seagrass meadow can result in significant loss of seagrass. Some 4.8 hectares of seagrass were covered by the rock groynes at Hillary's. About 13 hectares of seagrass meadow was enclosed within the Hillary's breakwaters. There would be value in initiating a programme to assess the damage, if any, to the meadow with time.

## 3.3 ANCHOR DAMAGE

Preliminary investigations have revealed that very little, if any, damage to seagrass meadows occurs as a result of boat anchors from small boats. If damage does occur, the areas involved must be small and the canopy may readjust to obscure the effects. This minimizes the potential for erosion, as the leaf canopy still baffles the substratum, and these small areas of loss are unlikely to be of ecological significance. On the other hand, anchor drag scars from larger vessels have been reported by Cambridge and McComb (1984) in Cockburn Sound.

## 4. EFFECTS OF DIFFERENT MOORING TYPES ON DAMAGE TO SEAGRASS MEADOWS

Two types of moorings are commonly used in the metropolitan region. 'Cyclone' moorings are installed by blasting three radially arranged holes, and inserting anchor weights into the holes. These anchors are connected by lengths of heavy chain to a central ring on a swivel, then via another chain to a surface buoy. 'Cyclone' moorings are generally installed by professional divers. 'Swing' moorings (Figure 4), the more common type, usually consist of a single heavy anchor (often an engine block) connected to a surface buoy by a very long length of heavy chain.

'Cyclone' moorings generally cause a permanent scour area of about 3 $m^2$. The damage could be reduced by shortening the length of chain connected to the surface float. 'Swing' moorings scour an area dependent on the length of chain used. The average size of the scoured area of swing moorings in Cockburn and Warnbro Sounds was found to be 39 $m^2$ . Swing moorings for boats > 8 m generally result in a scoured area of 176-314 $m^2$ .

## 5. EFFECTS OF BOATS ON LIGHT REACHING SEAGRASS MEADOWS

Preliminary experiments have shown that the shadow of a boat moored over a seagrass meadow may reduce the light reaching the meadow to 7-16% of that in full-sunlight depending on water depth (Table 2). The percentage reduction of full sunlight decreased with increasing depth due to back-scattering of light. The width of the shadow depends on water depth and boat size. The reduction of light due to a boat shadow also depends on variable factors such as the turbidity of the water and surface water turbulence. The data presented here can only serve as a guide to the likely significance of boat shadows on reducing the amount of light reaching a seagrass meadow.

The compensation light level for seagrasses varies between 20-100 $\mu$Ei $m^{-2}sec^{-1}$. The amount of light reaching a seagrass meadow at a depth of 5m within a boat shadow on a clear summer's day would be about 130 $\mu$Ei $m^{-2}sec^{-1}$, well above the compensation light level, falling in winter to about 30$\mu$Ei $m^{-2}sec^{-1}$ which would be below the compensation point for some seagrass species. Given that a boat rarely remains stationary when attached to a mooring, but generally swings in an arc, the effects of shading due to the boat shadow are probably minimal. If boats were permanently moored in such a way as to restrict their movement (eg. front and stern anchors) this could have a significant effect on light levels during winter.

Table 2. Effect of boats on light reaching seagrass meadows.

A boat (7.0 m long) was anchored near Rottnest Island on a clear day (28.4.87) and light measured at different depths beneath the boat with a quantum sensor (Licor, Lamda Instrument Corp., USA).

| Depth (m) | Full Sunlight ($\mu$Ei $m^{-2}sec^{-1}$) | Boat Shadow ($\mu$Ei $m^{-2}sec^{-1}$) | Intensity in Shadow as a Percentage of Full Sunlight. |
|---|---|---|---|
| Air | 1,351 | | |
| 1.0 | 1,196 | 86.9 | 7.3 |
| 2.0 | 866 | 76.7 | 8.7 |
| 3.0 | 684 | 85.3 | 12.5 |
| 4.0 | 577 | 91.0 | 15.8 |
| 5.0 | 559 | 89.9 | 16.1 |

## 6. IMPACT OF BOAT DISCHARGES

Discharge of sewage and of rubbish, from moored boats into protected embayments around Rottnest Island, are a seasonal problem. During peak periods rubbish and sewage from moored boats often wash ashore and reduce the aesthetic and recreational value of beaches. Non-degradable items such as cans, bottles and plastic bags litter the seagrass meadows in heavily used bays. Other than reducing the aesthetic appeal of the meadows there is no evidence of damage to the seagrass meadows resulting from boat discharges.

## 7. OTHER BOATING IMPACTS ON SEAGRASS MEADOWS

Ferries to Rottnest Island cause considerable sediment resuspension as they manoeuvre to come alongside and leave the landing jetty in Thomson Bay. The sediment plumes are advected by water currents over the seagrass meadows in Thomson Bay, and may take up to 1 hour to settle out, leading to decreased light reaching the seagrass. One obvious effect has been the change in the size of the sand patch adjacent to the jetty (Figure 2), which has increased from 2.8 hectares in 1967 to 8.7 hectares in 1987. The number of ferries and frequency of arrivals and departures has increased, resulting in an almost constant plume of resuspended sediment drifting across the seagrass meadows. If this increase in ferry activity continues it may have a detrimental effect on the seagrasses in Thomson Bay.

If the arrival and departure of the ferries occurred within a few time periods instead of throughout the day the number of sediment resuspension events could be kept to a minimum so the period of light reduction would also be minimized. This would reduce the extent of further damage to the seagrass meadows in Thomson Bay.

## 8. CONCLUSIONS

1. Seagrass meadows are significant to nearshore coastal ecosystems, having both physical and biological effects on the environment. These functions rely on the existence of an intact, well developed leaf canopy. Holes created in the canopy by mooring interfere with the physical integrity of the meadow, and this influences its biological integrity. Even though only relatively small areas of seagrass are involved in mooring damage the effect is much greater than if the equivalent area was lost from the edge of a meadow.

2. The total area of seagrass meadow lost to anchor moorings totals some 5.4 hectares in the Rottnest, Warnboro Sound and Cockburn Sound regions, with most loss (3.14 hectares) in the Rottnest region.

3. The 5.4 hectares of seagrass meadow lost represents 0.2% of the total area of seagrass in the Rottnest, Warnbro Sound and Cockburn Sound regions. About 1.4% of the seagrass meadow in the Rottnest region has been lost due to mooring damage.

4. Thomson Bay, Rottnest, has the largest number of moorings, and 2.45 hectares have been lost there, representing 2.6% of the meadow.

5. While the total area of seagrass meadow lost is small, there is considerable visual impact in some areas.

6. 'Cyclone' moorings are much less damaging to seagrass meadows than 'swing' moorings.

7. Boat harbour construction , anchor damage ,and effects of boats in reducing light were found to have little significant effect on seagrass meadows in an ecosystem or regional context.

## 9. SUGGESTIONS

(i) The use of swing moorings in seagrass areas could be discouraged.

(ii) If moorings are to be placed within seagrass meadows, they could be placed in existing sand patches and the use of moorings of the 'cyclone mooring type' be encouraged.

(iii) The barge moorings in Mangles Bay at Rockingham could be shifted to deeper water outside the seagrass meadows.

(iv) Boat harbour developments could be located, where possible, in areas of coastline with little or no seagrass present.

(v) Disturbance of sediment by ferries could be minimised in the Thomson Bay area.

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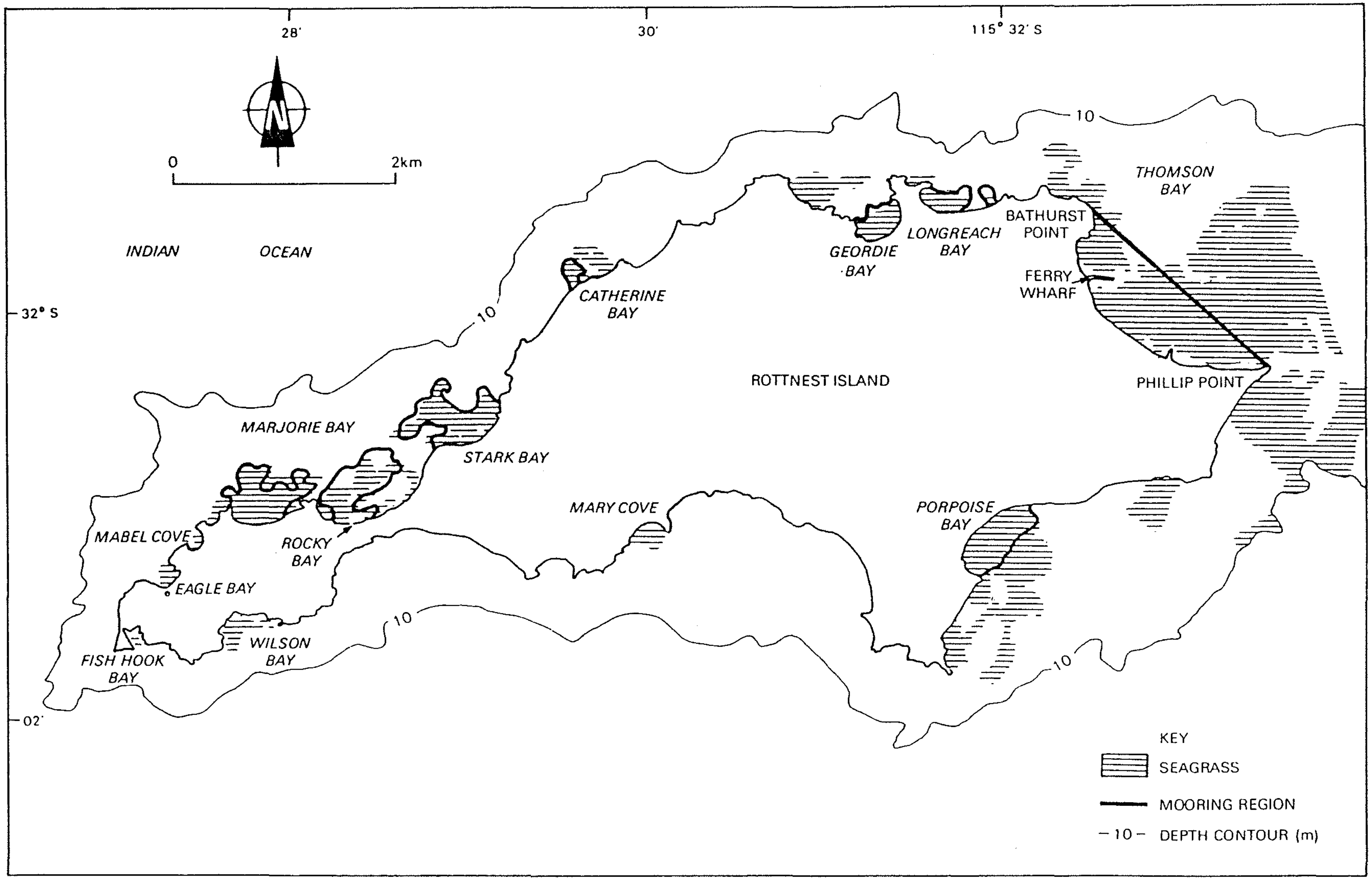


Figure 1a. Seagrass distribution around Rottnest Island. Location of the major mooring regions is shown. (reproduced courtesy of D. Walker)

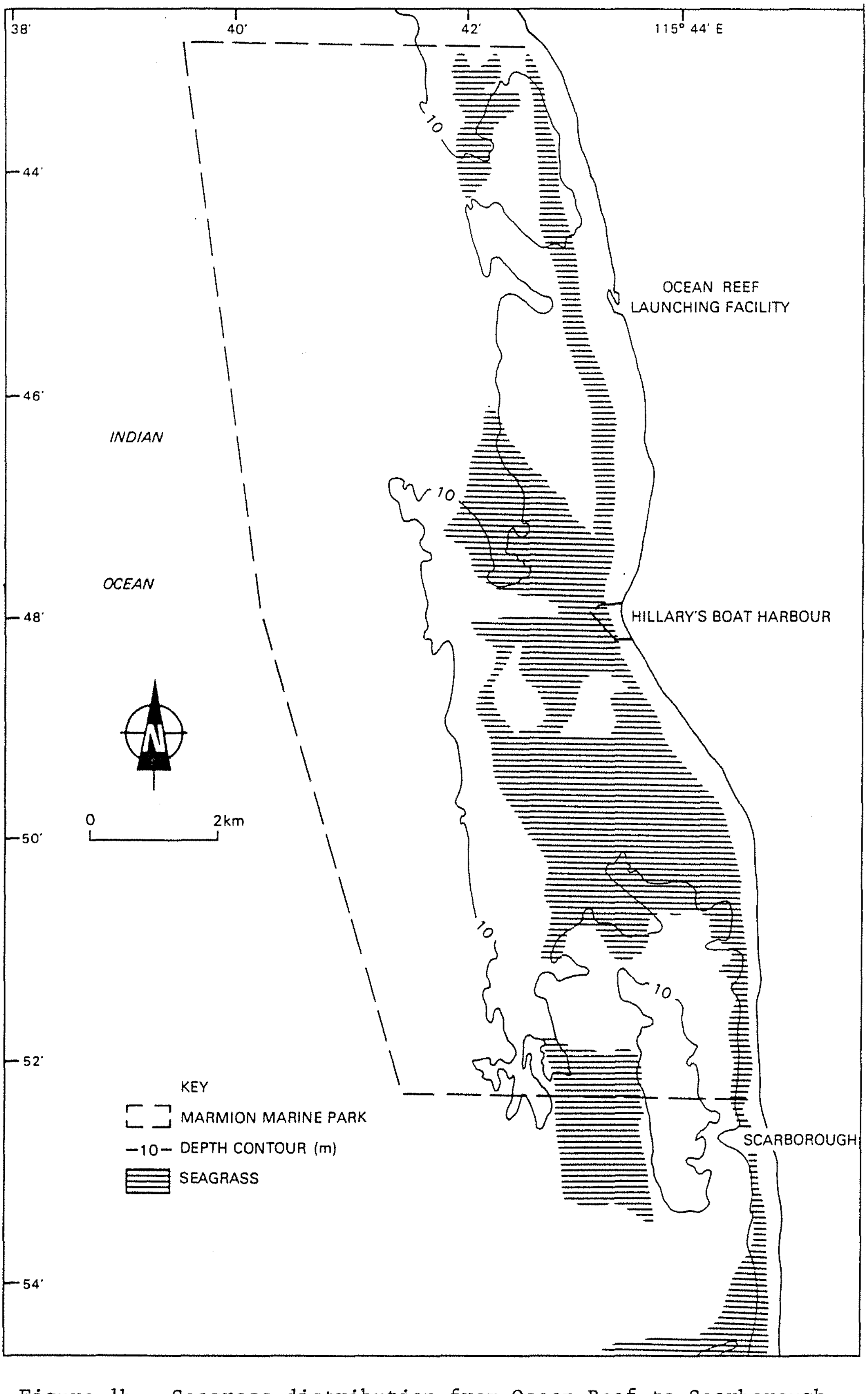


Figure 1b. Seagrass distribution from Ocean Reef to Scarborough (reproduced courtesy of E. Paling).

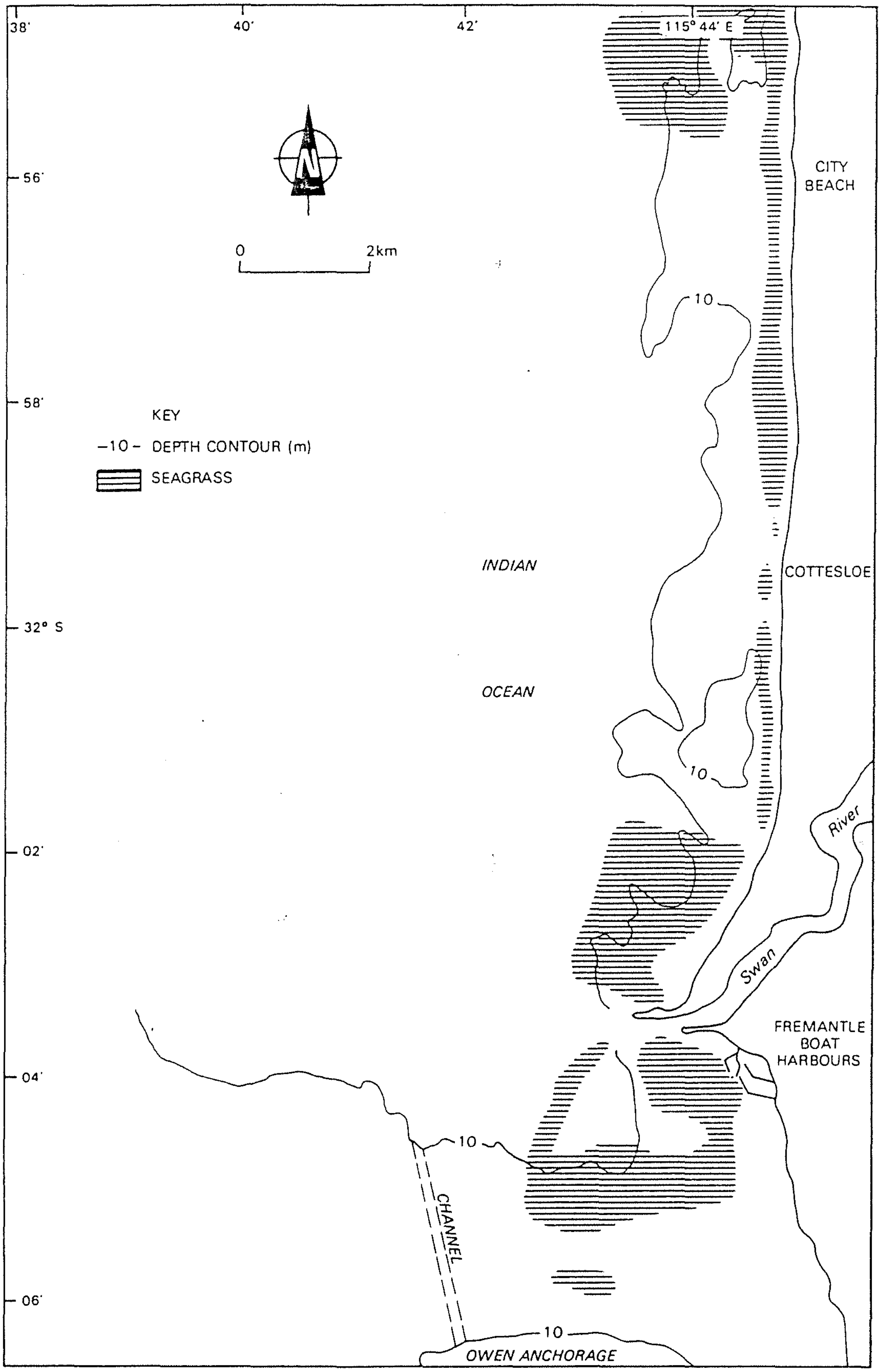


Figure 1c. Seagrass distribution from City Beach to Fremantle (reproduced courtesy of E. Paling).

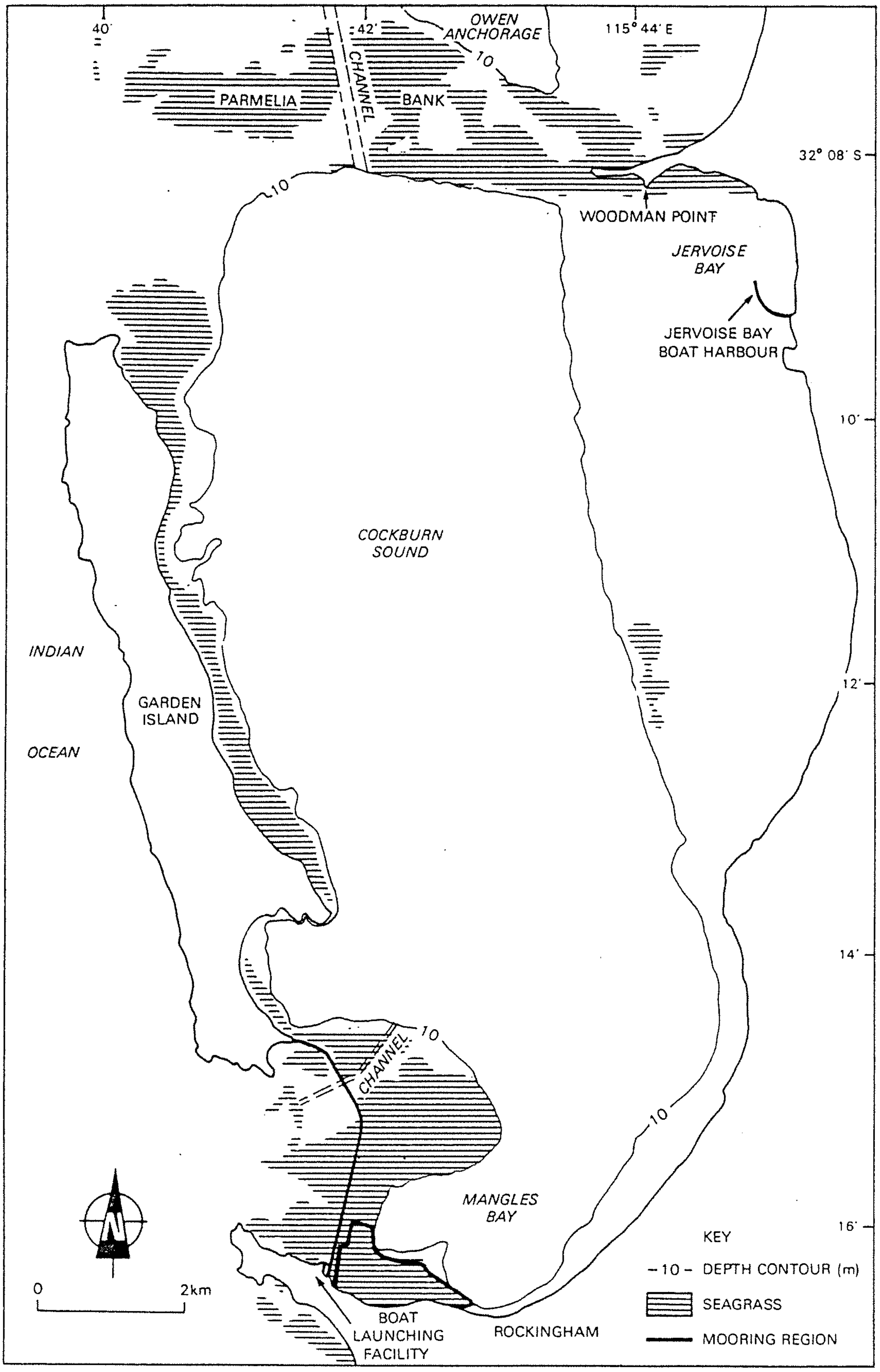


Figure 1d. Seagrass distribution in Cockburn Sound (reproduced courtesy of K. Hillman). Location of the mooring region in Mangles Bay is shown.

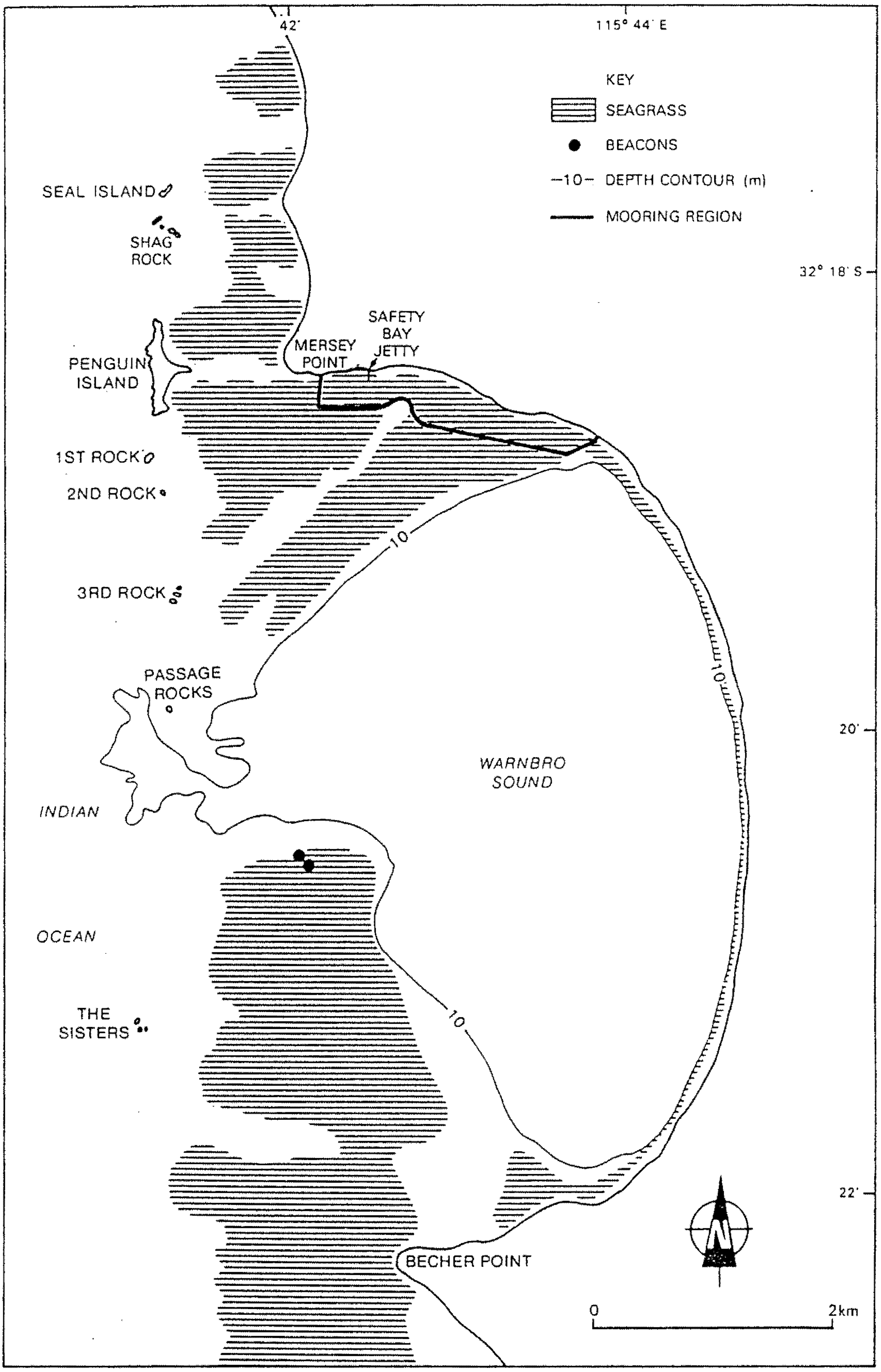


Figure 1e. Seagrass distribution from Shoalwater Bay to Becher Point (reproduced courtesy of Delta Holdings Pty. Ltd.) Location of the mooring region in Warnbro Sound is shown.