

Distribution of deep-water seagrass habitats between Cape Weymouth and Cape Tribulation, northeastern Queensland.

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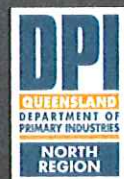
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Great Barrier Reef
Marine Park
Authority



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The Department of Primary Industries, Queensland has taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Seagrass distribution and abundance can change seasonally and between years, and readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

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SUMMARY

1. Vast areas of seagrass habitat were located in a survey of inter-reef bottoms in Great Barrier Reef region, northeastern Australia, at depths between 15 and 58m, composed primarily of *Halophila* species.
2. Inter-reef meadows included *Halophila ovalis*, *H. spinulosa*, *H. tricostata*, *H. decipiens* and related plants of this genus which may be undescribed species. High fecundity, fast growth and adaptability to low-light conditions possibly favour *Halophila* species over others in deep water.
3. Observed distribution patterns (restricted to south of 14°S) for the annual species *H. tricostata* and *H. decipiens* cannot be explained without further analysis.
4. There is only a superficial knowledge of the ecological role of these deep-water communities, and little information on spatial distribution and patterns of temporal change. Preliminary findings indicate that as nursery habitat for juveniles of commercially valued prawns and fish, deep-water seagrasses support far less animals on a unit area basis, than do nearby shallow-water seagrasses. There is an established close association between area of seagrass and dugong population size.
5. Information on deep-water seagrass biology, physiology and prevailing environmental conditions is required to analyse the health and stability of these resources. There is a possibility of widespread losses of deep-water seagrass caused by high sediment loads and flood runoff from coastal catchments. Prudent land-use management will help to minimise these impacts.
6. The Cooperative Research Centre for Sustainable Use of the Great Barrier Reef supports efforts to map remaining areas of deep-water seagrass habitats. Research programs will establish the patterns and mechanisms involved in loss and recovery of these meadows, and provide information which will help minimise anthropogenic impacts on this component of the Great Barrier Reef ecosystem.

PLANNING & ZONING IMPLICATIONS

The region surveyed supports at least 2000 km² of deep-water seagrass habitat, a larger areal extent than was thought to exist, and results indicate a possible further resource in remaining unsurveyed areas of the Great Barrier Reef.

The ecological importance of these inter-reef habitats is only partly understood. Vast deep-water meadows of *Halophila ovalis* and *H. spinulosa* are important dugong feeding habitat in the Lookout Point to Barrow Point region, and similar habitats in other localities are likely to be important to local dugong populations. Areas of deep-water seagrass habitat close to Corbett Reef and at various sites on the outer-shelf should be considered for special protection as dugong and turtle habitat. Near Corbett Reef for example, seagrasses were found to lie outside zones designed to protect them. In light of this survey zoning changes to protect such areas may need to be considered.

Apparent northern limits to the distribution of *H. tricostata* and the *Halophila* sp. at about Princess Charlotte Bay require further investigation. Surveys further north of Cape Weymouth would help to answer these questions.

Large areas of the outer-shelf were covered by algae gardens dominated by *Caulerpa* and *Halimeda* species, which apparently contribute enormously to the thick, undulating deposits of *Halimeda* sand substrates in those parts of the Great Barrier Reef.

The ecological role of these dense algae gardens is not fully understood, although they may include nursery habitat values, as numerous small fish and macro-invertebrates were visible from video records. Faunal samples and studies of the growth and productivity of these algae are necessary. These appear to be habitats which require good water quality for survival. They may also require special protection from physical damage. Very little is known about these habitats and further studies are strongly recommended.

Unvegetated bottom was common on the inner- and mid-shelf. Bare substrate areas are regularly trawled in the north-east coast penaeid prawn fishery (April to December), and various degrees of the physical impact of trawl gear on the bottom was evident in video images. It is difficult to estimate the historical impacts of trawling on deep-water seagrass habitats without previous information on seagrass distribution and abundance.

Halophila tricostata and *H. decipiens* are abundant on trawled areas south of Princess Charlotte Bay despite trawling activity in this region, which indicates that trawling may not be the reason for the apparent absence of these species further north.

The overall pattern of seagrass distribution and abundance in this region will be examined further when all data has been collated. Growth and survival of seagrasses in deep-water of the Great Barrier Reef are most likely affected by shelter from wave and swell energy, bathymetry, and the availability of nutrients and photosynthetically active radiation (light). Biological factors such as competition (from algae) and grazing are more difficult to identify. Physical environment data from this and further surveys will be used to help estimate the probability of seagrass occurrence for areas not sampled between transects.

3.1 Introduction

Knowledge of seagrass resources to date is biased to shallow water communities. These are relatively accessible, very productive, diverse, and have a recognised set of values to coastal marine ecosystems. Seagrasses in deep-water (>15 m depth) have only recently been discovered to be a substantial resource, covering areas as large as 1200 km² in the northern Great Barrier Reef (Lee Long *et al.*, 1989) and 1000 km² in Hervey Bay, southern Queensland (Lee Long *et al.*, 1993).

Anomalies between the recorded size of some dugong populations and the known extent of their seagrass food resource led to further surveys in the Great Barrier Reef region, where there are vast areas of sheltered continental shelf as yet unsurveyed for deep-water seagrasses. These soft-bottom, inter-reef areas make up approximately 90% of the 250,000 km² of the Great Barrier Reef region. Much of this area also supports a trawl fishery for penaeid prawns.

Patterns of distribution and abundance inshore are influenced by coastal topography and bathymetry and freshwater runoff (Coles *et al.*, 1987; Lee Long *et al.*, 1993). Along the Great Barrier Reef, the abundance and distribution of deep-water seagrasses are expected to be partly influenced by patterns of bathymetry, coastal and shelf characteristics. On this premise, it was agreed to examine separate regions, and a single northern region (characterised by narrow shelf, ribbon reefs and relatively low human impact) was chosen for the first year of sampling.

This report presents the preliminary findings of our study of the presence of seagrasses at depths greater than 15 m in the northern Great Barrier Reef, and of the species and communities present.

In designing the study we expected that the abundance of seagrass in deep water across the shelf would be strongly influenced by:

- a) depth (and light) and position relative to the long-shore coastal boundary layer;
- b) proximity to, and shelter provided by, reefs and islands; and
- c) trawling activity.

The objectives of the study were;

- ❶ *To determine the distribution of seagrass habitat in deep water (>15m) in the northern GBR.*
- ❷ *To recommend planning and zoning, if any, for deep-water seagrass habitats.*

3.2 Methods

Sites

To enable most effective sampling of the GBR it was decided to examine separate regions which appear similar according to patterns of bathymetry, coast and shelf characteristics, and reef topography - factors which may affect seagrass distribution and abundance. A single northern GBR region, extending from Cape Weymouth (approx. 12°S) to Cape Tribulation (approx. 16°S) (an area of approximately 27 000 km²), was chosen and sampling was conducted in November 1994. This section is characterised by a narrow continental shelf, a series of ribbon reefs along the outer-shelf and a relatively low level of human impacts (Figure 1). The shelf width here varies from 25 to 60 km but it narrows to a minimum of 24 km at Cape Melville (Maxwell, 1968). Depth is usually less than 36 m, but reaches 60 m and is unsurveyed in places.

Tides in this area are semidiurnal and tidal range varies from 1.6 m at Howick Island to 1.98 m at Morris Island (Queensland Dept. of Transport, 1994).

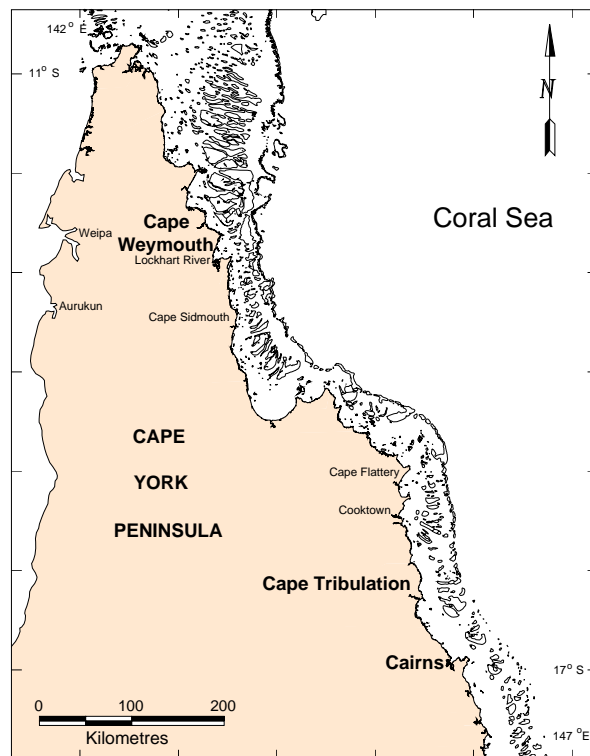


Figure 1. Location of survey area between Cape Weymouth and Cape Tribulation, November 1994.

Sampling & Experimental design

Bottom vegetation and sediment characteristics were recorded at sites along cross-shelf transects which began nearshore at the 15 m depth contour and ended near the edge of the continental shelf, 1 nautical mile (nm) short of the outermost reefs of the Great Barrier Reef. Twelve cross-shelf transects were chosen at random within the region, with the constraint that the minimum distance between transects be 10 nm. A single site was chosen at random within every nautical mile distance along each transect. Additional sites were haphazardly chosen in open water between transects and in the areas within 1 nm of around reefs or islands, to check for continuity of seagrass presence.

At each site several parameters were examined (in order of importance):

- i. presence/absence of seagrass
- ii. seagrass species composition (seagrass identification according to Kuo and McComb (1989))
- iii. % cover of algae and algal type
- iv. sediment characteristics (differentiated by visual estimate of grain size: shell grit, rock, gravel (>2000µm), coarse sand (>500µm), sand (>250µm), fine sand (>63µm) and mud (<63µm))
- v. presence/absence of benthic fauna

A global positioning system (GPS) was used to locate each survey point (latitude and longitude). A depth sounder was used to measure water depth. At deep water sites an underwater video was used to record bottom habitat characteristics and to determine presence/absence of seagrass. The visual record of the strip transect was made over a minimum 100 m distance to obtain a measure of the patchiness of bottom vegetation, and for a permanent record. If seagrass was present at a site, we stopped at the end of a strip and either a diver, grab/sled-net, or both was used to sample seagrass plants for identification. Divers made visual estimates of seagrass biomass for future analysis. A

major consideration for safety and planning was that dives were restricted to bottom times of approximately 4 minutes and a maximum 4 dives per diver per day.

↙ 3.3 Results

Occurrence of seagrasses

In the study area between Cape Weymouth (approx. 12°S) and Cape Tribulation (approx. 16°S) seagrasses occurred at 145 (44 %) of a total 331 sites (Figure 2). Seagrass occurred most frequently (64 % of sites) in the region from Princess Charlotte Bay (14°S) south to Cape Tribulation (16°S). North of Princess Charlotte Bay seagrass was found at only 18 % of sites. In this section of the study area, they were found most frequently at sites on the outer-shelf, seaward of the mid-shelf reefs (Figure 2).

Species Distribution

Only species of the genus *Halophila* were found in the study, including plants which may be undescribed species.

Family Hydrocharitaceae

Halophila decipiens Ostenfeld

Halophila ovalis (R. Br.) Hook.f.

Halophila spinulosa (R. Br.) Aschers.

Halophila tricostata Greenway

Halophila sp

Halophila sp resembles the recently described *Halophila capricorni* (Larkum, 1995), but may be an undescribed species.

Halophila spinulosa often occurred as the dominant species mixed with *H. ovalis* (Figures 3a,b). In the area between 14°20'S and 14°50'S they occurred in almost continuous meadows from the inner-shelf to the outer-shelf (Plate 1). North and south of this area, these two species were found mostly on the outer-shelf (seaward of the mid-shelf reefs). *Halophila tricostata* was most abundant in the inner-shelf, and was only found south of Princess Charlotte Bay (Figure 3c), commonly on mud dominant substrates. *Halophila decipiens* occurred at the widest range of sites and was often found with *H. tricostata* or *H. ovalis* (Figure 3d) (Plate 2). The plants we recorded as *Halophila* sp. were uncommon, and were only at sites on the mid- to outer-continental shelf, south of Princess Charlotte Bay (Figure 3e).

At sites on the outer shelf, *Halophila spinulosa*, *H. ovalis* and the undescribed seagrass *Halophila* sp. were sometimes found within vast meadows of green macro-algae - comprised primarily of *Caulerpa* spp, *Halimeda* spp, and *Dictyosphaeria* spp.



Plate 2. *Halophila spinulosa*/*Halophila ovalis* meadow at 30 m.



Plate 1. *Halophila ovalis*/*Halophila decipiens* meadow at 27m.

Depth distribution of seagrasses

All 5 species occurred at depths to more than 40 m (Figure 4). *Halophila decipiens* occurred mainly in depths greater than 25 m but less than 35 m (Table 1), although it was found to 58 m - the deepest that seagrasses were recorded in the present study. *Halophila tricostata* was found at all depths to 54 m, although concentrated in the 25-35 m depth zone (Table 1). The *Halophila* sp. occupied the narrowest depth range, and the deepest mean depth. The mean depths of occurrence, from a sampling range of 15 - 62 m, were between 23 m and 33 m; and were shallowest for *H spinulosa* and *H. ovalis* (Figure 4).

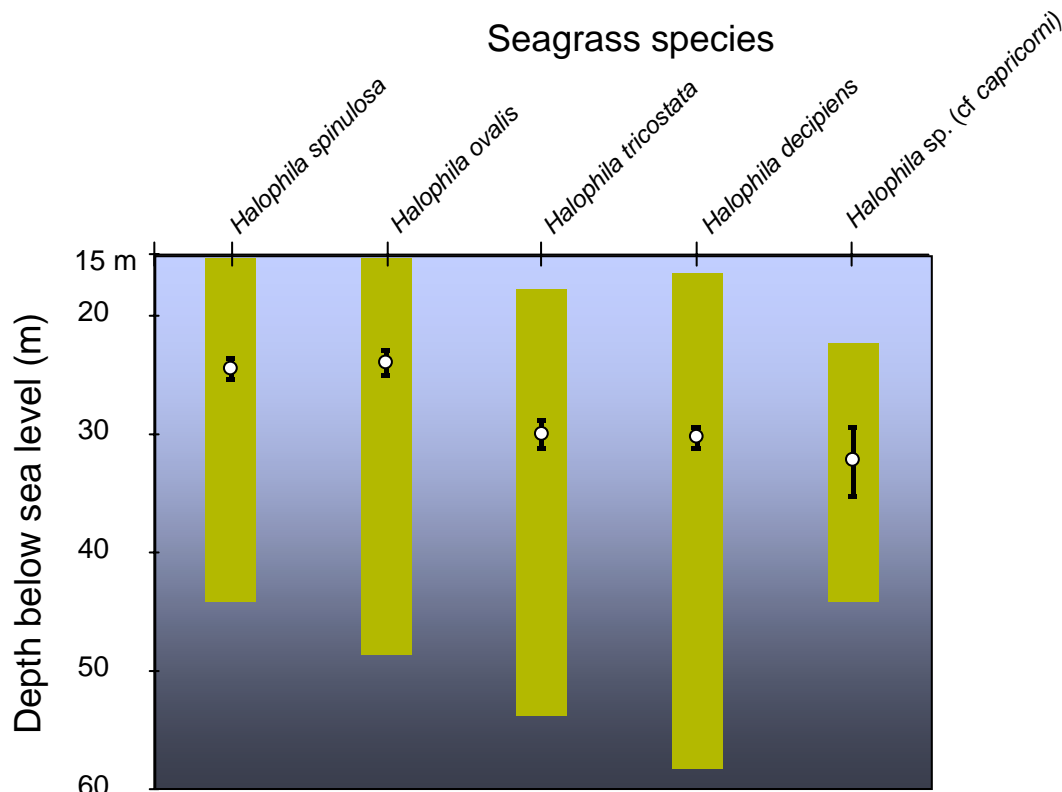


Figure 2. Means, standard errors and ranges of recorded depth (below sea level) of occurrence of seagrasses in waters greater than 15m deep in the northern Great Barrier Reef survey area.

Table 1. Percent frequency of occurrence of each seagrass species at depth.

Species	15 to 25 m	>25 to 35 m	>35 m
<i>Halophila decipiens</i>	27	49	23
<i>Halophila ovalis</i>	66	28	6
<i>Halophila spinulosa</i>	58	39	3
<i>Halophila tricostata</i>	31	49	20
<i>Halophila</i> sp.	14	57	29

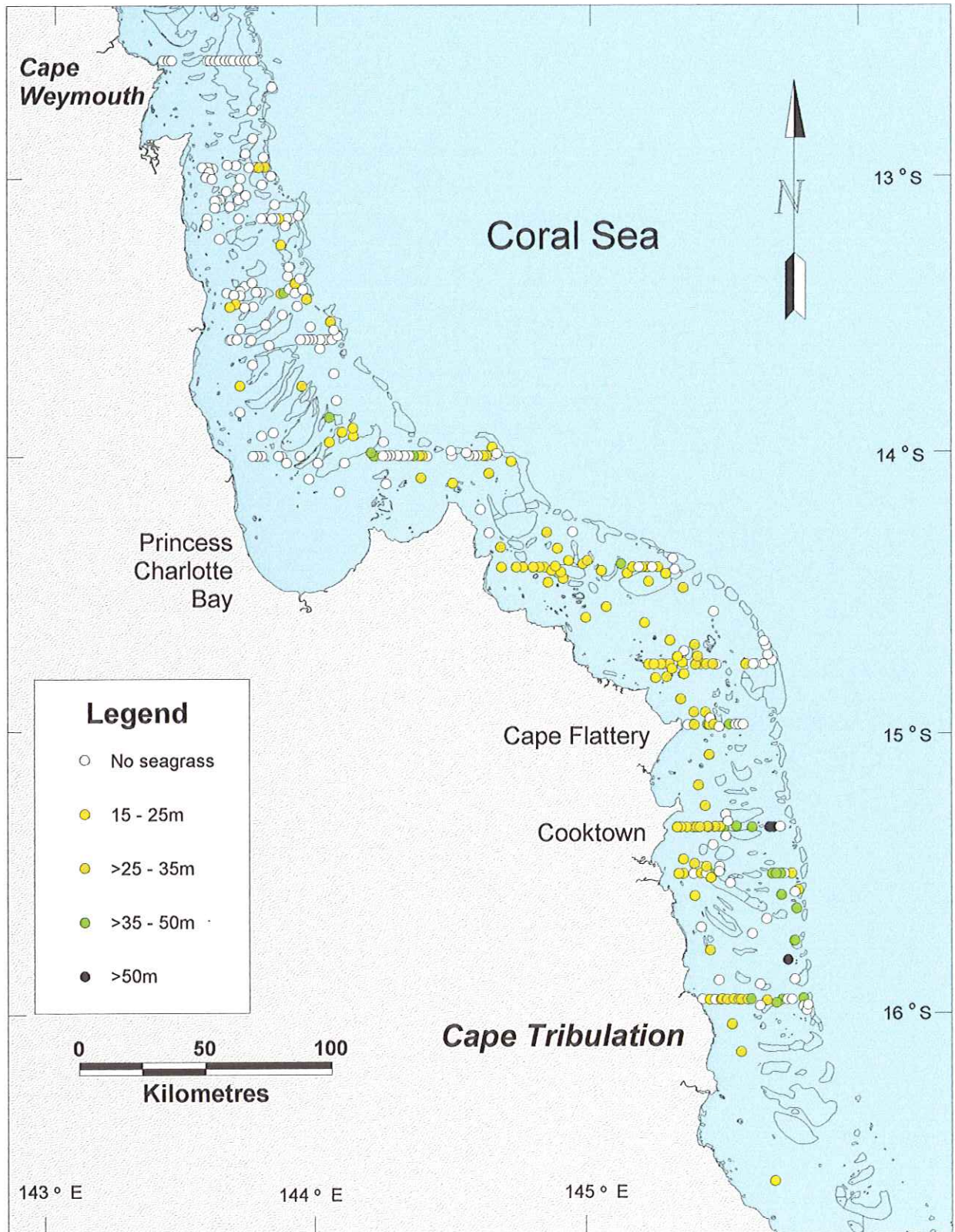


Figure 2. Presence and depth distribution of deep water seagrass sites between Cape Weymouth and Cape Tribulation, November 1994.

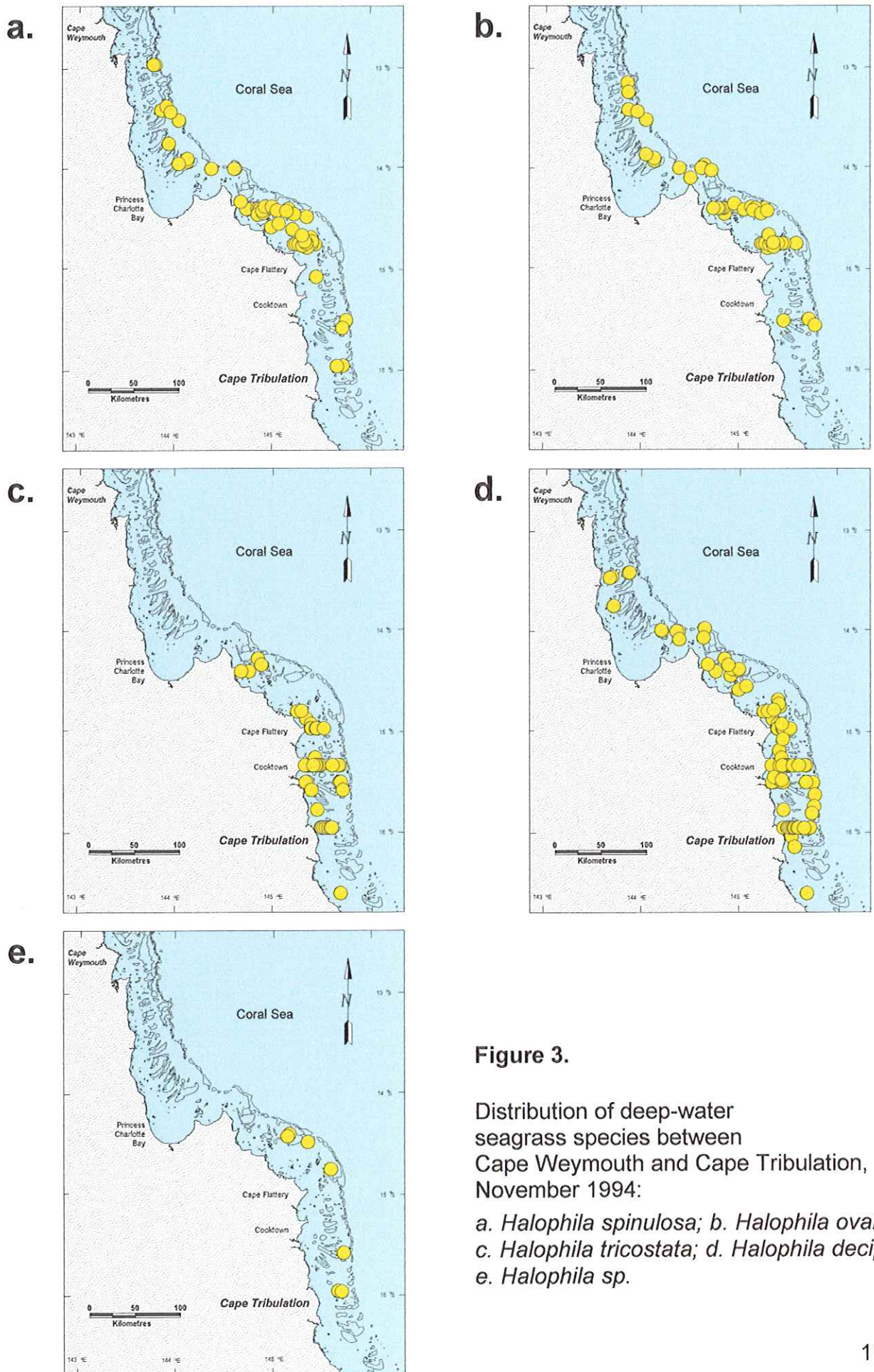


Figure 3.

Distribution of deep-water seagrass species between Cape Weymouth and Cape Tribulation, November 1994:

- a. *Halophila spinulosa*;
- b. *Halophila ovalis*;
- c. *Halophila tricostata*;
- d. *Halophila decipiens*;
- e. *Halophila* sp.

Other benthos

7 groups of benthic fauna were recorded opportunistically in the survey. Data collected for each group was qualitative and provides checklists for species where possible.

Echinoderms

Echinoderms included 4 classes: Asteroidea, Crinoidea, Echinoidea and Holothurian. Crinoids were most common benthic fauna recorded from inner-, mid- and outer-shelf sites over the entire survey region (Table 2). Holothurians, Echinoids and Asteroids were less common, respectively.

Crinoids were more common on bare or algal bottoms with mud/sand substrates, and present to 45 m. Holothurians and echinoids were also widely distributed over the survey area, on mostly vegetated bottoms with sandy substrates (mixed with mud/shell and *Halimeda* sand on occasion) down to 48 m. Asteroids were more than often present of vegetated (seagrass and algae) mud/sand substrates to 45 m.

Table 2. Benthic fauna identified from survey of deep-water inter-reef soft bottom habitats

Faunal group	% survey sites	% seagrassed sites	If present, what is the chance of seagrass also being present (%)	Most commonly associated fauna (%)
Echinoderms				
Asteroids	2	3	83	Holothurians (67 %)
Crinoids	23	23	45	Scler. corals (31 %)
Echinoids	7	9	54	Crinoids (46 %)
Holothurians	12	13	48	Crinoids (48 %)
Alcyonarians	15	17	49	Crinoids (37 %)
Foraminifera	10	22	94	Crinoids (39 %)
Hydroids	7	10	64	Alcyonarians/Scler. Corals (41 %)
Sponges	11	10	40	Crinoids (31 %)
Soft corals	2	1	40	Alcyonarians/Hydroids (40 %)
Scleractinian corals	20	23	50	Crinoids (32 %)

Foraminifera

Foraminifera appear to have a distribution similar to the seagrasses which they are closely associated with (Figure 6b and Table 2). Forams were generally on mud/sand substrates, with variable amounts of algae to 48 m.

Hydroids

Hydroids were widely distributed over the survey area on mud/sand substrates with little algae to 46 m (Figure 6c). Hydroids were often associated with alcyonarians and scleractinian solitary corals (Table 2).

Alcyonarians

Alcyonarians were the third most common benthic faunal group encountered. They were widely distributed throughout the survey area (Figure 6a) on mud/sand substrates with generally low algal cover to 52 m. Alcyonarians were equally encountered on vegetated and unvegetated bottoms and often associated with crinoids (Table 2).

Sponges

Sponges were widely distributed (Figure 6d), usually on vegetated bottoms and mud or sandy substrates to 46 m. Sponges were often associated with crinoids (Table 2).

Soft corals

Soft corals were relatively rare in the deeper waters and often found close to reefs (Figure 7a). Soft corals were found on sparsely vegetated bottoms which were often inhabited by alcyonarians and hydroids. Soft corals were mainly found on mud/sand substrates to approximately 44 m.

Scleractinian solitary and colonial corals

15 species of solitary and 6 species of colonial scleractinian corals were identified from collections. They include:

<u>Solitary</u>	<u>Colonial</u>
<i>Catataphyllia jardinei</i>	<i>Caulastrea</i> spp.
<i>Cycloseris cyclolites</i>	<i>Echinopora</i>
<i>Cycloseris patelliformis</i>	<i>Galaxea</i>
<i>Cycloseris</i> spp.	<i>Goniopora columna</i>
<i>Cycloseris vaughani</i>	<i>Plerogyra sinuosa</i>
<i>Cycloseris lacrymalis</i>	<i>Seriaptora hystrix</i>
<i>Cynarina</i> spp.	
<i>Diaseris distorta</i>	
<i>Diaseris fragilis</i>	
<i>Duncanopsammia</i> spp.	
<i>Flabellum</i> spp.	
<i>Herpolitha limax</i>	
<i>Heterocyathus aequicostatus</i>	
<i>Heteropsammia cochlea</i>	
<i>Trachyphyllia geoffroyi</i>	

Solitary corals were distributed over the entire survey area (Figure 7b), mainly on mud/sand substrates and 47% of the sites had seagrass present (Table 2). The most common species of solitary coral was *Flabellum* spp. which was generally found in the mid shelf areas in 19-33 m depth. *Flabellum* spp. was present equally on vegetated and unvegetated bottoms. The deepest depth of any scleractinian coral recorded in the survey was *Plerogyra sinuosa*, a colonial, at approximately 45 m.

It appears that particular species have specific depth ranges or habitat preferences. Most species were not usually associated with a coral reef. *Cycloseris* was seldom found in any habitat other than on flat sandy substrates between reefs. *Cycloseris* sometimes occurred in large numbers in association with other free living corals - notably *Heteropsammia*, *Heterocyathus*, *Trachyphyllia* and *Diaseris*. *Cynarina* species were generally found on lower reef slopes (proximal sites) although they were also found living on soft substrates. Scleractinian corals were not generally associated with any other benthic fauna, although crinoids were present 32 % of the time (Table 2).

Dugongs

The only dugong sighted during the survey was a pair of animals near Corbett Reef, although evidence of feeding (feeding trails) was identified from other areas to the south. Feeding trails were recorded from only 5 sites which were concentrated in the area between Cape Flattery and Cape Melville (Figure 8). The deepest trails were observed was 33 m and the furthest trails were recorded was approximately 18 km from the coast. Feeding trails were generally observed in meadows of >80 % seagrass cover (*Halophila ovalis* and *H. spinulosa*) with <10 % algae present and mud/sand substrates.

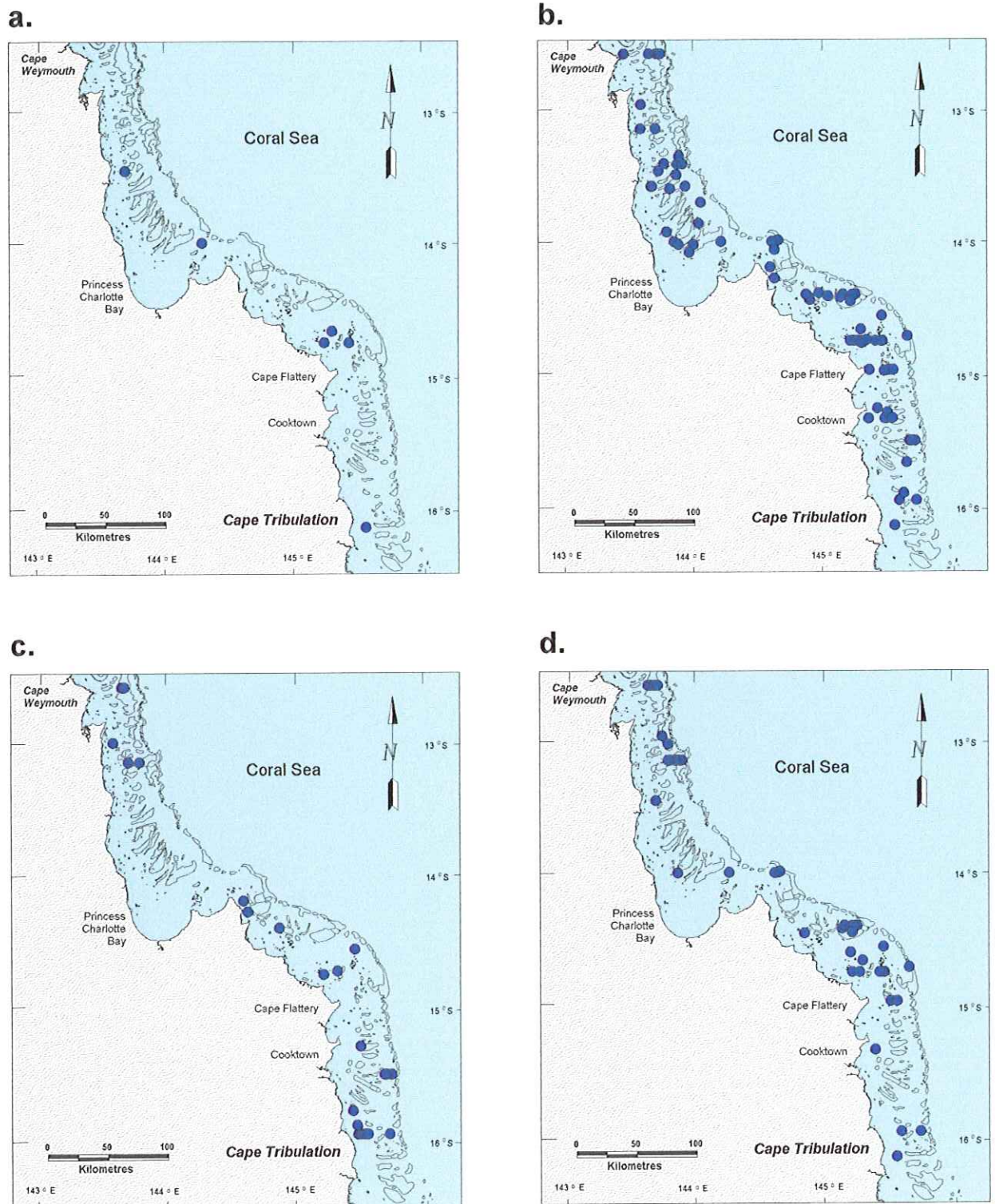


Figure 5. Distribution of echinoderms between Cape Weymouth and Cape Tribulation in depths >15m, November 1994:
a. Asteroids; b. Crinoids; c. Echinoids; d. Holothurians.

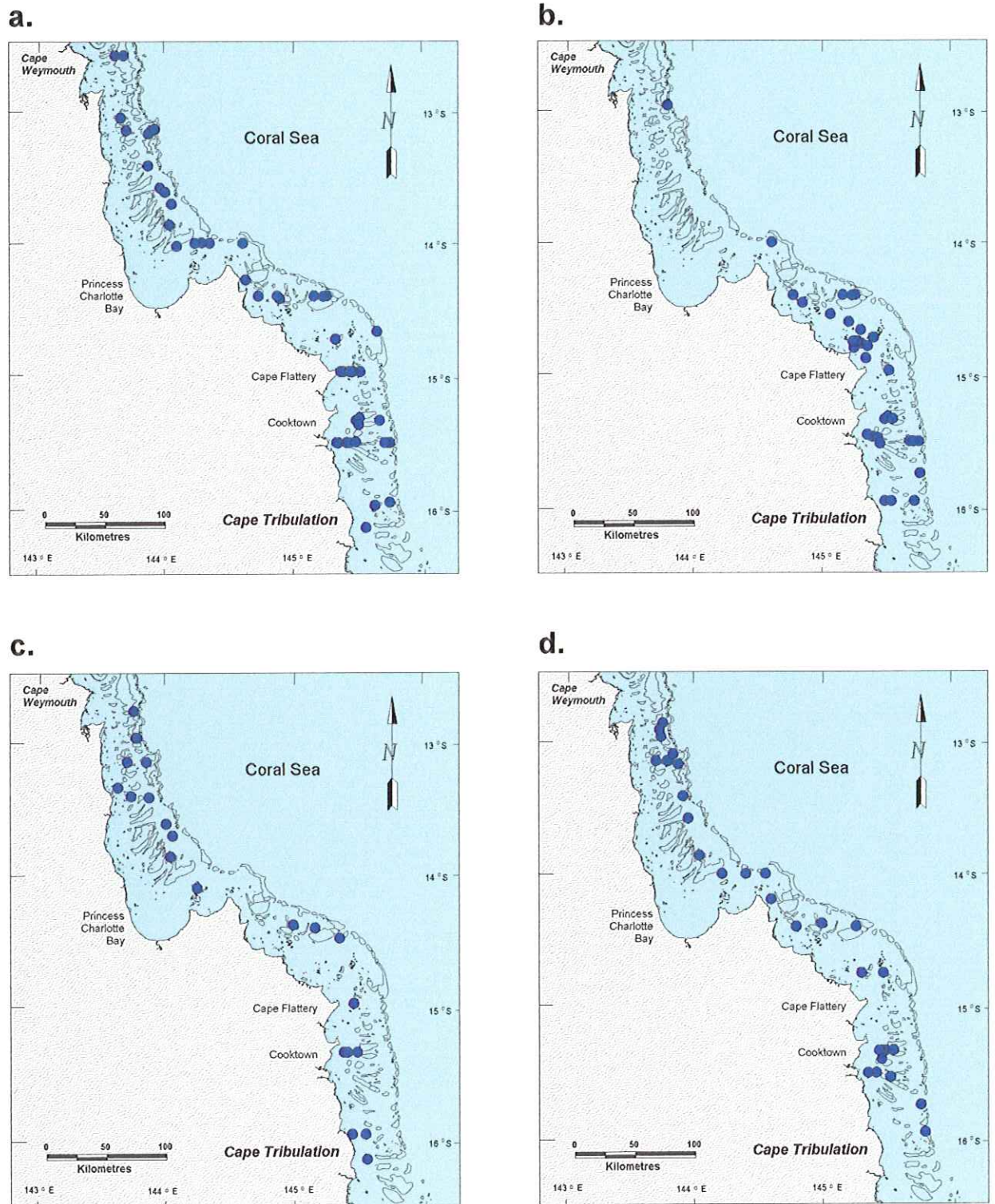


Figure 6. Distribution of a. alcyonarians, b. foraminifera, c. hydroids and d. sponges in depths >15m between Cape Weymouth and Cape Tribulation, November 1994.

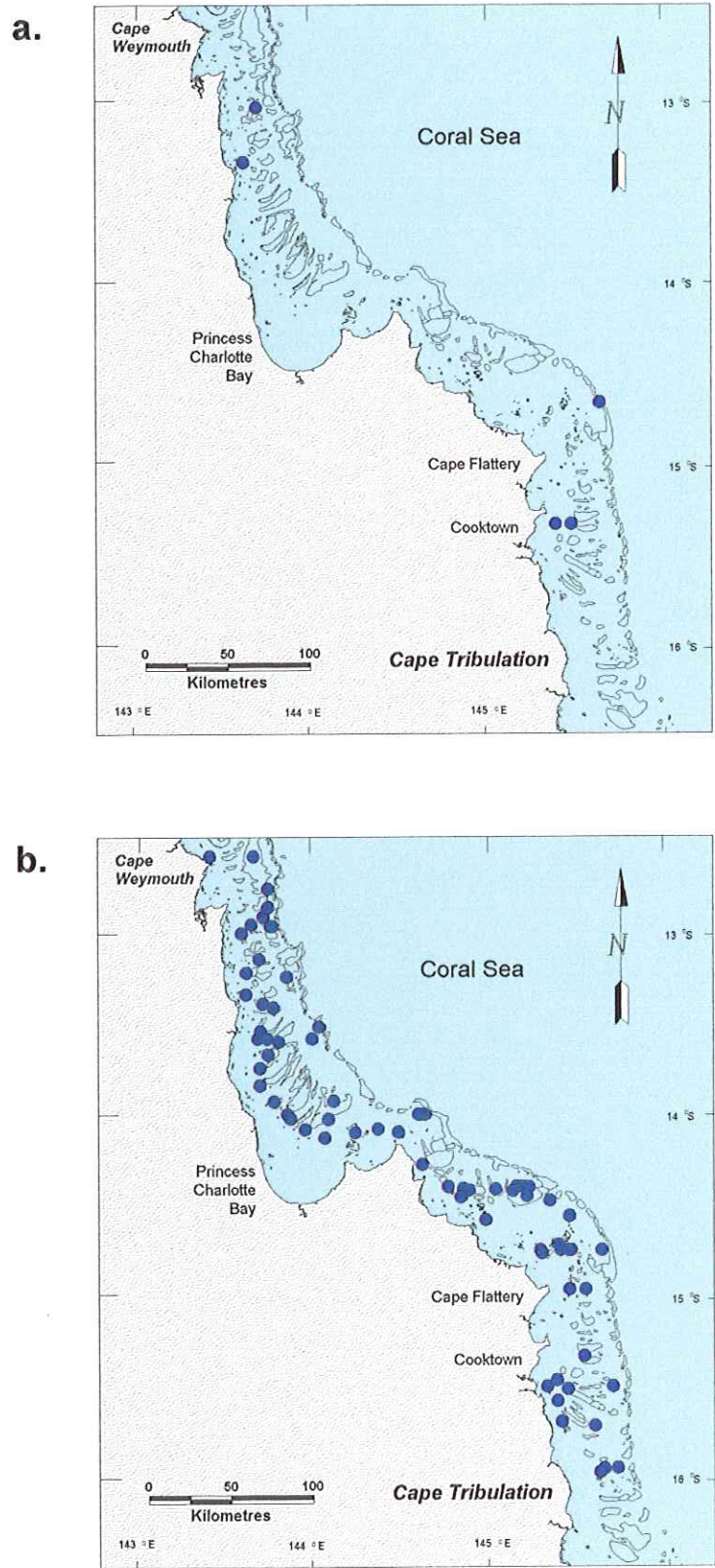


Figure 7. Distribution of a. soft corals and b. scleractinian solitary & colonial corals in depths >15m between Cape Weymouth and Cape Tribulation, November 1994.

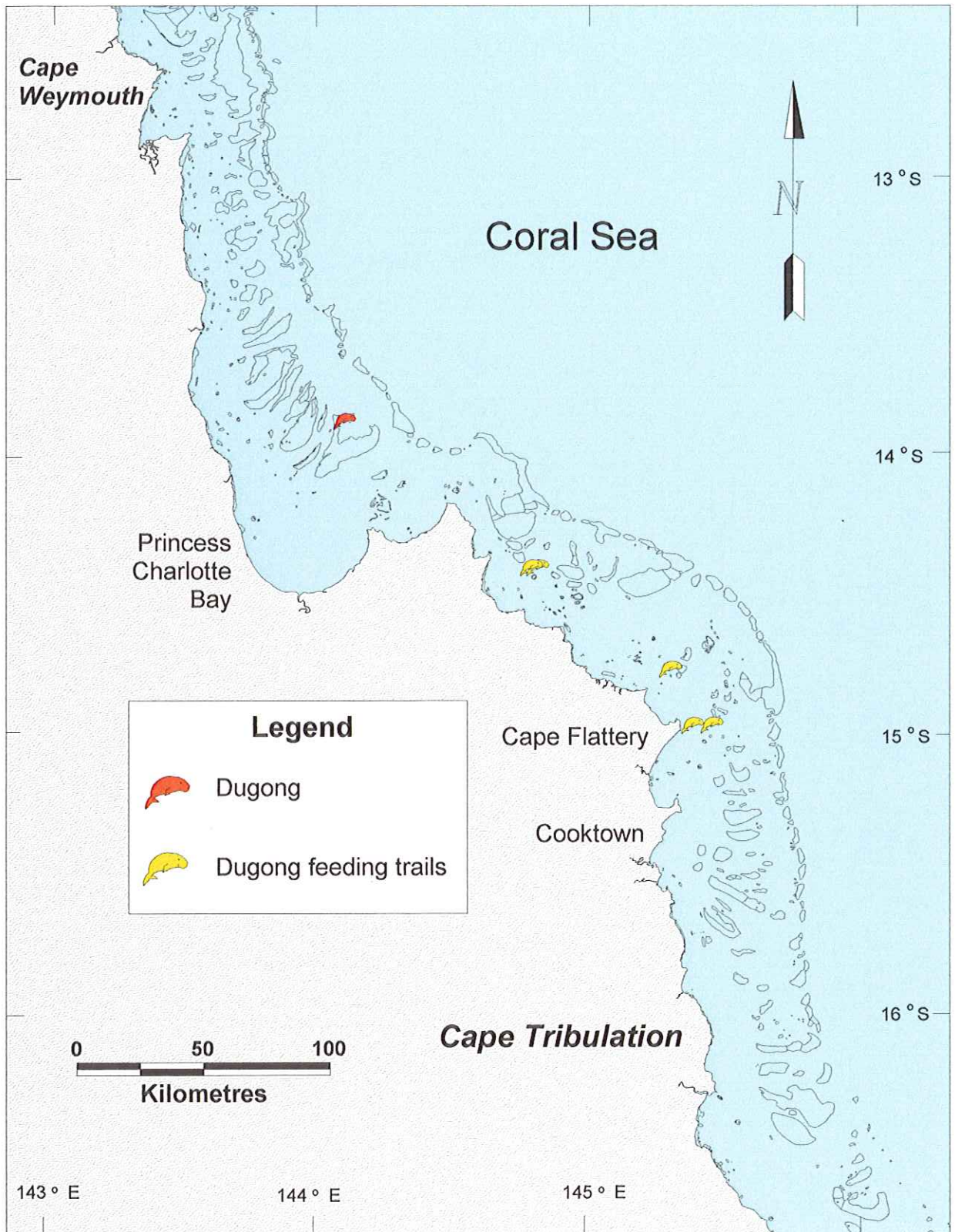


Figure 8. Distribution of sites at which either dugong or dugong feeding trails were recorded in depths >15m between Cape Weymouth and Cape Tribulation, November 1994.

3.4 Discussion

Results of early surveys indicated that seagrasses in depths less than 20 m were common only in sheltered areas of the coastal zone (Coles *et al.*, 1985, 1987, 1992). Previous estimates of seagrass areas deeper than 20 m came from limited surveys of meadows dominated by *Halophila spinulosa* and *Halophila ovalis* in the continental shelf area near latitude 14°30'S (Lee Long *et al.*, 1989) and in Hervey Bay, 25°S (Preen *et al.*, 1995). In the present study, seagrasses were found in previously mapped areas (Lee Long *et al.*, 1989) and at sites over vast areas previously unsurveyed.

One of the present authors (Vidler) conducted a preliminary reconnaissance survey of benthos on 2 cruises between 13.5°S to 14°S and 14.3°S to 14.5°S in August and September 1993 respectively (Figure 9). In the 1993 survey, 38 sites were examined at depths between 2 and 30 m and covered approximately 15 % of the area surveyed in the present (November 1994) study. The 1993 survey identified 4 species of seagrasses (*Halophila spinulosa*, *H. decipiens*, *H. ovalis* and *H. minor*) with up to 80 % cover.

The present study strongly suggests a widespread occurrence of seagrasses in the deep, inter-reef waters of the Great Barrier Reef. Information from this study will be used to estimate the total areal extent of these deep-water seagrass communities, using detailed data on bathymetry, sediment distribution, hydrology, human impacts and other environmental parameters which are likely to affect seagrass distribution in deep-water.

The present study has identified new deep-water seagrass habitats dominated by *Halophila spinulosa* and large meadows of the annual species *H. tricostata* and *H. decipiens*. Almost no other genus was found deeper than 15 m during previous surveys in the Great Barrier Reef region (eg., Coles *et al.*, 1987; Lee Long *et al.*, 1993). The information from this study has established the known depth penetration of these species. All of the *Halophila* species in this study occurred to depths greater than 40 m on the mid- and outer-shelf where good water clarity and light penetration permit seagrass growth in this region. Tissue analyses of these plants would provide valuable information on the physiological adaptations of these species for survival at depth.

The unidentified *Halophila* sp. may be a morphological variation of the species described as *Halophila capricorni* (Larkum, 1995). *Halophila capricorni* is described from a shallower, reef-associated habitat (sand/mud substrates in between coral heads) and other specimens from reef-associated habitats immediately south of this study area vary yet again in morphological characteristics (Kuo pers comm, 1995).

Halophila tricostata and *H. decipiens* are both annual species in northern Queensland (Kuo *et al.*, 1993). Both species were in flowering and fruiting condition and were common at sites which are regularly trawled during the northeastern Queensland penaeid prawn trawl season. These species might survive and reproduce in areas which are impacted by trawling primarily because of their high fecundity and ability to complete their life cycle in a period of a few months. Prawn-trawl fishers generally attempt to avoid trawling through this "blanket weed" when it appears late in the fishing season.

Unvegetated bottom was most common on the inner and mid-shelf. Bare substrate areas are regularly trawled in the north-east coast penaeid prawn fishery (April to December) and various degrees of the physical impact of trawl gear on the bottom were evident in video images

An explanation for the near-absence of seagrasses in deep-water (>15 m) on the inner-shelf north of Princess Charlotte Bay will require more information on environmental factors such as light, nutrients, hydrology and the biology of these seagrass species. *Halophila tricostata* was not found north of latitude 14°11'S in previous surveys of coastal seagrasses in Queensland (Coles *et al.*, 1987; Lee Long *et al.*, 1993; Kuo *et al.*, 1993) and in the present study it was not found north of 13°54'S. *Halophila* sp. was not found north of 14°24'S. Species in the genus *Halophila* produce many small seeds which could be readily transported north of Princess Charlotte Bay. It is unlikely that the

observed distribution pattern is a result of differential impacts of prawn trawling because both areas are trawled regularly for penaeid prawns and evidence of the impacts of trawl gear on the bottom was found at sites in both regions. Hydrological and environmental conditions north of here might obstruct transport of seeds, or may be unsuitable for growth of these species. Rivers north of Princess Charlotte Bay are small and seasonal and are unlikely to be major sources of sediment and nutrient to inter-reef waters compared with the rivers south of Princess Charlotte Bay. We speculate that nutrient loads from catchment runoff in the developed region could stimulate growth of deep-water seagrass on the adjacent shelf. Surveys further north of Cape Weymouth would help to answer these questions.

The next record of occurrence of *H. tricostata* was recently from a shallow, coastal site in SW Gulf of Carpentaria (Kuo and Preen, pers comm.), which presents an anomaly in the geographical distribution of this species. *Halophila decipiens* was also uncommon north of Princess Charlotte Bay in this survey, but does occur in the northern Cape York Peninsular (Lee Long *et al.*, 1993), in the Torres Strait, the Gulf of Carpentaria (QDPI unpublished information) and in South East Asia (Fortes, 1989).

South of Princess Charlotte Bay, the decrease in occurrence of seagrass from nearshore to offshore may be a result of reduced nutrient availability (with distance from the mainland) and/or light availability (with depth). There is strong evidence of a relationship between increased light attenuation and reduced depth penetration in seagrasses (eg., Dennison, 1987; Dennison *et al.*, 1993). Adaptations to a low ambient light environment by *H. decipiens* might include a high ratio of leaf tissue to non-photosynthetic tissue, low leaf area index to reduce self-shading, high turnover of leaf material and the ability to rapidly colonise soft bottoms when light conditions are suitable (Josselyn *et al.* 1986). Information on seagrass tissue carbohydrate reserves and available light and nutrients may help to establish this relationship for seagrasses in the northern Great Barrier Reef. Planned surveys of additional areas may allow us to predict patterns of seagrass distribution and abundance in the unsurveyed areas between transects, using associated data on water depth, secchi depth, sediment composition, proximity to reefs and trawling activity.

Discoveries of large areas of seagrass in the Torres Strait (Pitcher *et al.* 1992), Queensland (Lee Long *et al.*, 1993) and Shark Bay, Western Australia (Anderson, 1994) supported early indications of a correlation between dugong population size and seagrass area in northern Australia (Marsh, 1989). Results from the present series of surveys provide additional evidence. Seagrasses discovered in areas distant from the coast may be important food sources to dugong. Dugong feeding trails in these seagrass meadows were recorded during dives to 23 m (Lee Long *et al.*, 1989) previously and to 33 m in this study. Many animals were recorded on the outer-shelf during aerial surveys of dugong (Marsh and Saalfeld, 1989) and are likely to require food resources in these areas.

Numerous sites on the outer-shelf had dense cover of macro-algae, predominantly green algae, including species of *Caulerpa* and *Halimeda*. Seagrass was found at some of these sites, but usually less abundant than the algae. These extensive algae “gardens” have been little studied and their ecological importance is poorly understood. In this part of the northern Great Barrier Reef the production of distinctive “*Halimeda*” sands from the green calcareous alga *Halimeda* has led to rapid accretion of CaCO₃-rich sediment over the back-reef area of the outer shelf (Orme *et al.*, 1978). Numerous small fish and macro-invertebrates were visible in video records from the present study and these habitats may be nursery areas for some species.

Year-round monitoring with small-mesh beam trawls has shown that as nursery habitat for juveniles of commercially valuable prawns and fish, deep-water seagrasses in the Turtle Group of islands in the northern Great Barrier Reef supported far fewer animals per unit area than adjacent shallow-water, coastal and estuarine seagrasses (Derbyshire *et al.*, 1995). Nevertheless, Derbyshire *et al.* (1995) did find in the deep-water meadows, large numbers of decapod and fish fauna of low commercial importance, but of value to extensive marine food chains. These meadows appear to occupy a large part of the available inter-reef area of the northern Great Barrier Reef and possibly serve other ecological roles, eg., as systems which enable “scrubbing” (assimilation) of nutrients and

stabilising of fine sediments in deep water. Deep-water seagrasses in other tropical regions may play similar roles and should be given consideration in marine environment management.

Recent widespread losses of deep-water seagrasses in southern Queensland were caused by light attenuation in the water column and/or burial by sediments, associated with large and prolonged flood events (Preen *et al.*, 1995). There is little data with which to measure the frequency and scale of such losses in the Great Barrier Reef region, but there is concern that chronic low level runoff impacts may reduce the vigour of these communities and /or their ability to recover from natural catastrophic impacts. Prudent land-use management will help to minimise impacts on these little-known but valuable habitats.

The health and stability of coastal seagrasses is important to regional fisheries (Thorogood *et al.*, 1990; Poiner *et al.*, 1989; Watson *et al.*, 1993), and the stability of large areas of deep-water seagrass is similarly important to dugong and turtle populations (Preen and Marsh, 1995). Long-term support for research from the CRC Reef Research Centre will provide information on the levels of natural and acceptable variability in these systems, so that impacts on the Great Barrier Reef can be assessed and managed. Research to provide information on patterns and mechanisms involved in loss and recovery of these meadows may help in management to minimise anthropogenic impacts on this important component of the Great Barrier Reef ecosystem.

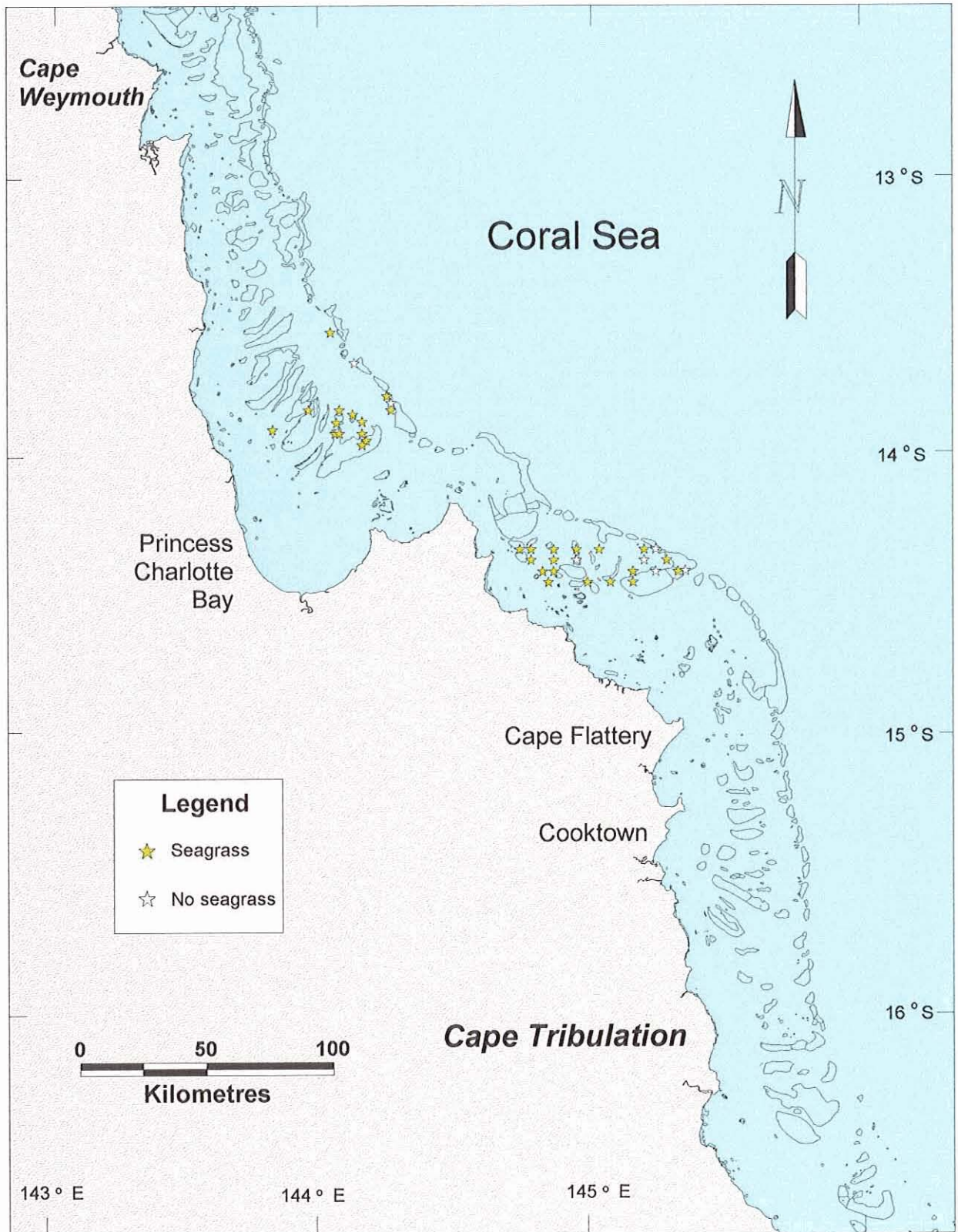


Figure 9. Distribution of sites examined by K. Vidler in July and August 1993, between Cape Weymouth and Cape Tribulation.

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3.6 Transfer of results

Television

- WIN TV (9) News (local) Tuesday 29th August
- TEN TV (10) News (local) Tuesday 29th August
- SUNSHINE TV (7) News (local) Tuesday 29th August
- ABC TV (2) News (statewide) Tuesday 29th August

Newspaper

- Cairns Post Friday 8th September (p 8) - *Seagrass find to aid research*
- Townsville Bulletin 5th September - *Seagrass a sign of healthy reef life*
- Townsville Bulletin 17th November - *Seagrass meadows found near Cairns*
- Courier Mail 5th September (p7)
- Capricorn Coast Mirror 12 September - *Seagrass meadows show no pollution*
- Torres News
- Cooktown Local paper
- Port Douglas Gazette
- Australian Associated Press

Other print media

- SCUBA diver magazine
- Australian Fisheries
- Cruising Helmsman
- Club Marine
- Qld Commercial Fisherman
- Fish & Boating - October edition, p5

Radio

- 4CA

Workshop/Seminar

- Coles, R.G., Lee Long, W.J. and McKenzie, L.J. (1995) Deep-water seagrasses in northeastern Australia. GBRMPA/CRC Researcher Days - 7th & 8th September 1995, Sheraton Breakwater Casino-Hotel, Townsville
- Lee Long, W.J., Coles, R.G. and McKenzie, L.J. (1996) Deep-water seagrasses in northeastern Australia - how deep, how meaningful? Proceedings of the International Seagrass Biology Workshop, Rottnest Island, Western Australia 25-29 January, 1996. (In press)

3.7 Literature cited

- Anderson, P.K. (1994). Dugong distribution, the seagrass *Halophila spinulosa*, and thermal environment in winter in deeper waters of eastern Shark Bay, Western Australia. *Wildlife Research* **21**, 381-8.
- Coles, R.G., Lee Long, W.J. and Squire, L.C. (1985). Seagrass beds and prawn nursery grounds between Cape York and Cairns, QDPI Information Series QI185017 Queensland Department of Primary Industries. 31pp.
- Coles, R.G., Lee Long, W.J., Squire, B.A., Squire, L.C. and Bibby, J.M. (1987). Distribution of seagrasses and associated juvenile commercial penaeid prawns in north-eastern Queensland waters. *Australian Journal Marine and Freshwater Research*, **38**, 103-119.
- Coles, R.G., Lee Long, W.J., Helmke, S.A., Bennett, R.E., Miller, K.J. and Derbyshire, K.J. (1992). Seagrass beds and juvenile prawn nursery grounds Cairns to Bowen. Queensland Department of Primary Industries Information Series QI 92012. 64 pp.
- Dennison, W.C. (1987). Effects of light on seagrass photosynthesis, growth and depth distribution. *Aquatic Botany* **27**, 15 -26.
- Dennison, W.C., Orth, R.J., Moore, K.A., Court Stevenson, J., Carter, V., Koller, S., Bergstrom, P.W. and Batuik, R.A. (1993). Assessing water quality with submersed aquatic vegetation, Habitat requirements as barometers of Chesapeake Bay health. *Bioscience* **43** (2), 86-94.
- Derbyshire, K.J., Willoughby, S.R., McColl, A.L. and Hocroft, D.M. (1995). Small prawn habitat and recruitment study - final report to the Fisheries Research and Development Corporation and the Queensland Fisheries management Authority. Queensland Department of Primary Industries, 43 pp.
- Fortes, M.D. (1989) Seagrasses: a resource unknown in the ASEAN region. ICLARM Education Series 5, 46 pp. (International Centre for Living Aquatic Resources Management, Manila, Philippines)
- Josselyn, M., Fonseca, M., Niesen, T. and Larson, R. (1986). Biomass production and decomposition of a deep water seagrass, *Halophila decipiens* Ostenf. *Aquatic Botany* **25**(1), 47-61.
- Kuo, J., Lee Long, W.J. and Coles, R.G. (1993). Fruits and seeds of *Halophila tricostata* Greenway (Hydrocharitaceae), with special notes on its occurrence and biology. *Australian Journal of Marine and Freshwater Research*. **44**(1), 43-57.
- Kuo, J. and McComb, A.J. (1989). Seagrass taxonomy, structure and development. In 'Biology of seagrasses: A treatise on the biology of seagrasses with special reference to the Australian region.' (Eds A.W.D. Larkum, A.J. McComb and S.A. Shepherd) Chpt.2. pp.6-73. (Elsevier, New York)
- Kuo, J., Lee Long, W.J. and Coles, R.G. (1993). Fruits and seeds of *Halophila tricostata* Greenway (Hydrocharitaceae), with special notes on its occurrence and biology. *Australian Journal of Marine and Freshwater Research*. **44**(1), 43-57.
- Larkum, A.W.D. (1995). *Halophila capricorni* (Hydrocharitaceae): a new species of seagrass from the coral sea. *Aquatic Botany* (In press).
- Lee Long, W.J., Coles, R.G., Helmke, S.A. and Bennett, R.E. (1989). Seagrass habitats in coastal, mid shelf and reef waters from Lookout Point to Barrow Point in north-eastern Queensland,

- a report to the Great Barrier Reef Marine Park Authority. Queensland Department of Primary Industries. 24pp.
- Lee Long, W.J., Mellors, J.E. and Coles, R.G. (1993). Seagrasses between Cape York and Hervey Bay, Queensland, Australia. *Australian Journal of Marine and Freshwater Research*. **44(1)**, 19-31.
- Marsh, H. (1989). Biological basis for managing dugong and other large vertebrates in the Great Barrier Reef Marine Park. Vol.1. Synthesis. Great Barrier Reef Marine Park Authority Publication #21.
- Marsh, H. and Saalfeld, W.K. (1989). Distribution and abundance of dugongs in the northern Great Barrier Reef Marine Park. *Australian Wildlife Research* **16**, 429-40.
- Maxwell, W.G.H. (1968). Atlas of the Great Barrier Reef. 258 pp. (Elsevier Publ. Co. Amsterdam)
- Orme, G.R., Flood, P.G. and Sargent, G.E.G. (1978). Sedimentation trends in the lee of outer (ribbon) reefs, Northern Great Barrier Reef Province. *Philosophical Transactions of the Royal Society of London -A*. **291**, 85-99.
- Pitcher, C.R., Skewes, T.D., Dennis, D.M. and Prescott, J.H. (1992). Distribution of seagrasses, substratum types and epibenthic biota in Torres Strait, with notes on pearl oyster abundance. *Australian Journal of Marine and Freshwater Research* **43**, 409-19.
- Poiner, I.R., Walker, D.I. and Coles, R.G. (1989). Regional studies - seagrasses of tropical Australia. In 'Biology of Seagrasses, A treatise on the biology of seagrasses with special reference to the Australian region'. (Eds. A.W.D. Larkum, A.J. McComb and S.A. Shepherd). pp.279-303. (Elsevier: Amsterdam, New York).
- Preen, A. and Marsh, H. (1995). Response of dugongs to large-scale loss of seagrass from Hervey Bay, Queensland, Australia. *Wildlife Research* **22**, 507-519.
- Preen, A.R., Lee Long, W.J. and Coles, R.G. (1995). Flood and cyclone related loss, and partial recovery, of more than 1,000 km² of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany* (in Press).
- Queensland Department of Transport (1994). Tide and Boating Guide, Including Official Tide Tables. 188 pp.
- Thorogood, C.A., Poiner, I.R., Somers, I.F. and Staples, D.J. (1990). Seagrass and cyclones in the western Gulf of Carpentaria. CSIRO Information Sheet No7. CSIRO Marine Laboratories, Cleveland, Australia. 4 pp.
- Watson, R.A., Coles, R.G. and Lee Long, W.J. (1993). Simulation estimates of annual yield, and landed value for commercial penaeid prawns from a tropical estuary, northern Queensland, Australia. *Australian Journal of Marine and Freshwater Research*. **44(1)**, 211-219.