⇘DISCUSSION

Seagrasses

In the present surveys 13,076 ±800 ha of seagrass habitat was mapped in September 1995 and 13,001 ±890 ha in April 1996. Distribution patterns in these surveys were similar to those from the original post-wet broad-scale survey in March 1987 where an estimated 7,000 ha of seagrasses was mapped (Coles *et al.* 1987; Lee Long *et al.* 1993, corrigendum 1994). A number of intertidal meadows and most of the 1,300 ha of subtidal meadows were not mapped in the 1987 broad-scale survey, because of the sea conditions at that time.

The area of subtidal seagrass habitat found is only small, contributing approximately 10 % of the total seagrass resource. Strong tidal currents and associated high water turbidity in Shoalwater Bay proper limit light penetration and therefore the depth to which seagrasses can grow. The deepest seagrasses occurred in Shoalwater Bay was 8.2 m below MSL, although seagrasses have been recorded to 58 m below MSL at other localities (Lee Long *et al.* 1996). Runoff in Shoalwater Bay is from either Defence Reserve or grazing land; no urban runoff is likely. Soils are loose and probably easily eroded, and high water turbidities can occur during monsoonal runoff.

Most seagrass meadows in Shoalwater Bay were on intertidal banks often fringing the mangrove tree line (up to 0.7 m above MSL). Seagrass meadows in the southern section of the Bay were often in narrow strips which could only be mapped with extensive dive surveying and ground truthing. In contrast, northern parts of the Bay supported extensive meadows which were easily seen during aerial surveys. Seagrass distribution was greatly influenced by the topography of the tidal banks with small changes in level effecting drainage, exposure and consequently seagrass growth. In mid-western and eastern sections of the Bay, meadows occurred in a mosaic of patches where pools and channels allowed the growth of plants on otherwise exposed banks.

With large tidal ranges seagrasses are exposed for long periods during low tide, and appeared to have a large influence on where the upper limit of seagrass growth occurred. In places, water is retained on the flats at low tide and seagrasses are better protected against desiccation, extending the upper limit to around 0.7 m above MSL. Differences in the upper depth distributions between surveys could not be attributed to seasonality however, as they were probably an artefact of slight changes in sampling of the upper limits of distribution between surveys. During the September 1995 survey the upper limits of seagrass distribution were mapped mainly by aerial surveys, where very few depth measures could be taken. In April 1996, tidal conditions allowed divers to access the upper limits and obtain more depth measures, and this improved the information on upper depth distribution for each species.

The lower depth limits of seagrass growth were significantly lower in the April survey, particularly for species such as *H. pinifolia, H. decipiens, H. ovalis* and *H. uninervis*. *Halophila spinulosa* varied little in maximum depth between surveys. This seagrass species appears to be one of the most well adapted to low light environments in the Great Barrier Reef region (Lee Long *et al.* 1993; Coles *et al.* 1996).

Seagrass species biomasses were variable between habitat types within the study area (demonstrated by the large ranges in Figure 3). When all sites (from all habitat types) were pooled however, the variation in above-ground biomass was low (see Standard Errors for each species in Figure 3). This appears a consequence of the high number of sites surveyed on the large intertidal banks, of which the seagrass biomasses for most species were not highly variable.

Differences in the general morphology of *Zostera capricorni* and *Halophila ovalis* were also noted during both surveys. *Zostera capricorni* shoots on the large intertidal banks on the western side of the bay were much shorter and more densely clumped together than have been observed at other locations along Queensland's eastern coast. *Halophila ovalis* plants in the north-western section of the bay, from Sabina Point north to Stannage Bay, were more elongate

than the typical round-to-oval shape of this species. Plants from Stannage Bay may be described as a new species (John Kuo pers. comm.). The causes of such morphological variation are unknown and requires further investigation.

The amount of algae present at sites was variable throughout the survey area. The amount of epiphytic green filamentous algae however, was very high at Triangular Island, particularly in Little Bang Bay on the northern side. Approximately half of the sites examined in Little Bang Bay had algal cover between 80 and 95 %. This bay is often used for undersea detonations, and it is possible that the high phosphate content of explosives may have elevated the available P in this area and allowed high growth-rates of filamentous green algae.

Approximately 62 % of the known seagrass resources in the Mackay/Capricorn section of the Great Barrier Reef Marine Park are located within the Shoalwater Bay survey area. The nearest other large seagrass meadows exist 150 km south at Gladstone, patchy meadows 50 km north at Clairview and extensive meadows 300 km north at the Whitsunday Island group (Coles *et al.* 1987b). This makes the Shoalwater Bay area regionally important as prawn and fish nursery habitat and as feeding area for dugongs and green sea turtles.

Prawns and Fish

Seagrass habitat in Shoalwater Bay is important regionally to commercial fisheries. Commercially important species of prawns dominated beam trawl samples at all sites. Juvenile penaeid prawns were more common at Port Clinton and Island Head Creek sites, where substrate types were mud and fine sand. Sites where western king prawns dominated beam trawl samples (in Shoalwater Bay) had mostly sandy substrates. This was also the pattern in beam trawl samples from the 1987 broad-scale survey (Coles *et al.* 1987b).

Large numbers of other invertebrates and juvenile fish from beam trawl samples indicate a rich food source for local marine food webs. The Shoalwater Bay seagrass meadows are likely valuable nursery habitats which provide food and shelter for juveniles of commercially and recreationally important species and the basis for very productive coastal marine communities.

Dugongs

The Shoalwater Bay area supports the most important dugong habitat in the Great Barrier Reef region south of Cape York (Marsh *et al.* 1995). In Shoalwater Bay, dugong numbers have declined from an estimated 765 ±161 animals in 1987 to 406 ±78 animals in 1994 (Marsh *et al.* 1995).

The pioneering seagrass species such as *Halophila* and *Halodule* which dominate much of the Shoalwater Bay seagrass communities are the preferred diet for dugong (Preen 1995). Although Preen has regularly sighted dugong at the upper limits of seagrass distribution, dugong feeding trails were most commonly seen along the seaward perimeter of meadows, and this may be because of the palatability, dietary value or accessibility of these seagrasses to dugong. Numerous feeding trails were also found in meadows dominated by *Zostera capricorni* in the present surveys. *Zostera capricorni* has since been confirmed as a major dietary component for dugong of the area (Tony Preen, pers. comm.). In the Shoalwater Bay area there is little subtidal seagrass, due to a combination of high tidal fluctuations and high turbidities, so much of the available seagrass resource is on large intertidal banks. Subtidal meadows may provide important feeding opportunities for dugongs during low tides, however biomass of these meadows was very low and productivity in these turbid, deep-water conditions may also be too low to support large food demands of dugong. Few, if any, dugong feeding trails were observed in these meadows.

Dugongs are known to feed throughout the day and night. Dugongs have been recorded to move throughout the bay and into the rivers in the lower section of Shoalwater Bay around the period of high tide (Tony Preen, pers. comm.). Narrow strips of seagrass found along creek banks had dugong feeding trails in September 1995, where the animals selected to graze on steep banks

close to deeper water to avoid stranding. Almost no seagrass was found on river/creek banks in April 1996, and thin strips of habitat that were present had no feeding trails.

Gill netting is recognised as the most important fishing method in the Shoalwater Bay area (Fitzsimmons 1996) and is believed to be a significant source of anthropogenic mortality of dugong (Marsh *et al.* 1995). Gill nets set out from mangrove edges can accidentally capture dugongs, and records of bycatch of dugong in Shoalwater Bay increased in 1995 (Marsh *et al.* 1995). With very little sub-tidal seagrass in Shoalwater Bay available for feeding, dugongs are forced to utilise the same areas as gill-netters, increasing the chances of accidental capture of dugongs in nets.

Other areas within the Great Barrier Reef region which have high dugong populations (Marsh *et al.* 1995), also have substantial subtidal (deepwater) seagrass meadows. Extensive subtidal seagrass meadows have been found in the Starke River area (Lookout Point to Murdoch Point to the outer Great Barrier Reef) (Lee Long *et al.* 1989; Coles *et al.* 1995). Seagrasses were found to a depth of approximately 58 m and dugong feeding trails to a depth of 33 m (approx 18 km from the coast). In Hervey Bay the resident dugong population is dependent on extensive subtidal seagrass meadows within the bay, evidenced from a dramatic decline in dugong numbers following loss of approximately 1000 km^2 of the subtidal meadows (Preen *et al.* 1995).

In response to the decline of dugong and the high accidental catch of dugong in gill nets in the Shoalwater Bay area, a management plan has been developed which prohibits gill nets in the area (GBRMPA 1997).

Seagrass Monitoring

Monitoring programs should ideally be designed to quantify the causes of change; examine and assess acceptable ranges of change for the particular site; and to measure critical levels of impacting agents. Intensive monitoring of large areas or large suites of parameters is often prohibitively expensive and requires considerable expertise in the systems being studied. To measure regional changes, it is our view that mapping using qualitative information on spatial distribution and repeated biannually or at a suitable pre-determined time interval may provide a broad but sufficient indication of change. If changes in, for example, the area of seagrass measured this way continued in one direction for three or more sampling intervals, resources could be diverted to investigate the cause of change and, if possible, to take responsive action.

The present baseline surveys were designed to establish data sets on which monitoring programs could be based to investigate changes in seagrass biomass and distribution. These programs will enable measures of change in area of seagrass habitat and seagrass biomass within meadows.

Seagrass meadows can change in several ways. There can be a change in biomass without a change in area; a change in area, or shape, depth or location of a meadow; a change in species composition, plant growth and productivity, the fauna and flora associated with the meadow, or a combination of some or all of these. These changes will also occur naturally and on a regular seasonal basis. Environment monitoring programs require knowledge of these patterns of natural change. They also require cost-effective data collection, selection of appropriate parameters and scales, and measures of change which are statistically appropriate for determining if management action is required.

The present surveys provide a baseline suitable for developing a monitoring program, and where statistically valid measures of change can be gained. Sampling designs for monitoring, can now be developed to ensure that various levels of change can be detected.

It is difficult and expensive to accurately map and monitor large-scale and remote meadows. Satellite imagery and aerial photography are useful for mapping where dense seagrasses can be seen on very large scales (Kirkman, 1990; Hyland *et al.* 1989; Long, Skewes and Poiner, 1994), but cannot always be used successfully to map or monitor seagrass biomass (Walker, 1989) or identify seagrasses of low density, or in water too deep or too turbid for remote sensing (Hyland *et al.* 1989). In these instances ground surveys (walking, diving or grabs) are essential.

When the total seagrass resources of a locality are mapped, it is not necessary to monitor all of them in order to assess environmental impact. It is more cost effective to focus monitoring effort on priority areas or meadows. Selecting "monitoring meadows" requires some knowledge of the biology of species present and habitat/ ecological or economic value of the different meadows. From the present surveys the relative importance of different seagrass areas can be determined. Effort within long-term monitoring programs can then be focussed on the meadows which are important from ecological or economic points of view.

A "whole meadow" approach would be adopted as the monitoring unit and to enable detection of any change, a sampling design will require sites randomly (or haphazardly) spread across the whole meadow. If an adequate measure of spatial variability within the seagrass meadow is calculated from the baseline survey, it is possible to mathematically determine the required minimum number of randomly located sites, and sample units at each site, sufficient to detect any desired amount of temporal change for the meadow.

To resurvey the extent of seagrasses in the Shoalwater Bay area frequently would be logistically difficult and expensive. Although the information gained would be useful, we recommend that the most efficient method for monitoring would be to select "monitoring meadows" for monitoring at 1-2 year intervals and to resurvey the total area only every 3-5 years, preferably in Spring. Priority meadows for monitoring were determined from the seven meadows examined in the present surveys based on relevance to dugong management. We recommend monitoring intertidal meadows at Akens Island, Hideaway Bay (Triangular Island), Townshend Island and Port Clinton. Subtidal meadows at Strongtide Passage (meadows # 85 & 86 combined) or Canoe Pass would also be useful for monitoring.

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