INFORMATION SERIES QI03016

Seagrass resources of the Booral Wetlands and the Great Sandy Strait:

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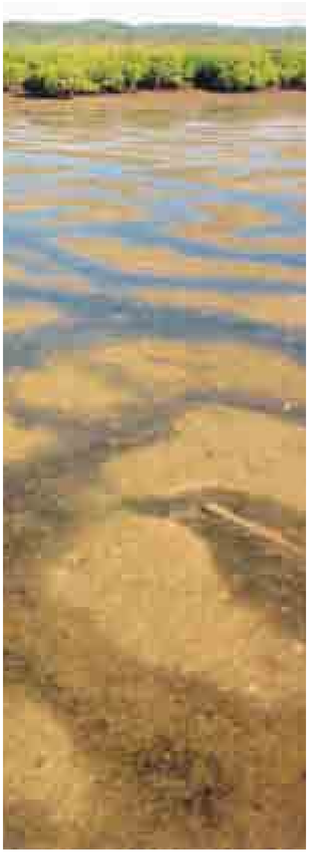

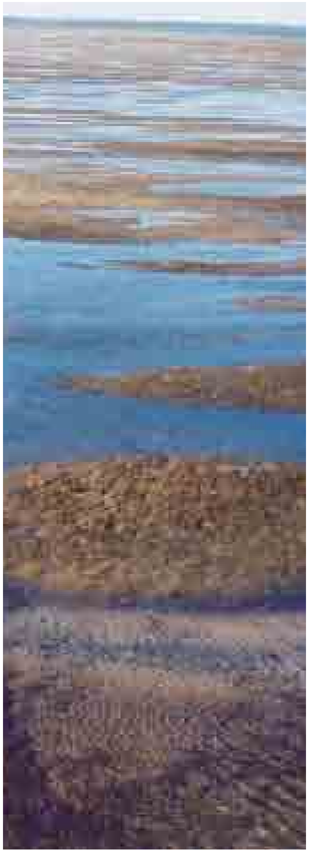

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S J Campbell

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Seagrass resources of the Booral Wetlands and the Great Sandy Strait:

February/March 2002

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Disclaimer
Information contained in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought. Seagrass maps in this report are magnified so that small meadows can be illustrated. Estimates of mapping error (necessary for measuring changes in distribution) are not to be inferred from the scale of these hard-copy presentation maps. These can be obtained from the original GIS database maintained at the Northern Fisheries Centre, Cairns.

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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EXECUTIVE SUMMARY

An aerial survey of intertidal seagrasses in the Booral Wetlands and the Great Sandy Strait was conducted on the 27th and 28th February 2002 to assess the recovery of the resource since the major losses a consequence of the Mary River flood in February 1999.

The Booral Wetlands support 62.77 ±87.97 hectares of intertidal seagrass, dominated by isolated patches of *Zostera capricorni* (Aschers.), a common species in southern Queensland. The plants were generally of a small morphology with a canopy height <5cm. The other seagrass species present was *Halophila ovalis* ((BR.) D.J. Hook) a colonising species common in Queensland, however its distribution within the survey area was patchy.

Immediately north of the Booral Wetlands, the light/moderate *Zostera capricorni* with *Halophila ovalis* patches were more aggregated and eventually became continuous is nature, particularly in the vicinity of the marina. South of the wetlands, on the more exposed sections of the intertidal flats, the meadows were patchy and isolated to erosion channels created by tidal currents. Further south towards Mary River heads and continuing east along the northern bank, the light *Zostera capricorni* meadows were more continuous and quite extensive.

Community seagrass monitoring in the Booral region began in August 1999 and reported initial re-colonisation in November 2000 of seagrasses and significant increases in cover of seagrasses from November 2001 to November 2002.

7007 ±1945 hectares of intertidal seagrass meadows were mapped on the mud/sand banks within the Great Sandy Strait in February 2002. This represents approximately over 100% recovery in distribution since the total loss of seagrass meadows in some regions of the Great Sandy Strait in early 1999. In most areas the seagrass abundance has recovered to pre-flood levels. At a few localities abundances were marginally lower, however this may be a consequence of inter-annual differences. Only six seagrass species were observed in February 2002, this is one less than December 1998. No plants of the species *Cymodocea serrulata* which was present on the large subtidal bank between Kauri Creek and Tin Can Inlet, were observed during the survey.

Approximately 90% of the seagrass meadows in the Great Sandy Strait were *Zostera capricorni* dominated communities (plants generally of a small morphology with a canopy height <5cm). The remainder were a mixture of Halodule and Halophila dominated.

Seagrass abundance in the Great Sandy Strait also appears to have recovered to near pre-flood levels. All intertidal seagrass meadows in the Great Sandy Strait were mostly light to moderate abundance (<50% cover) and 75% of the seagrass communities were classified as light abundance (ie. <10% cover). This is similar to December 1998 abundances, however 2% of meadows were lower in February 2002.

Long term monitoring at Seagrass-Watch sites within Booral wetlands by local community volunteers, shows that initial re-colonisation of seagrass occurred in November 2000, 21 months post-flood. Full recovery of meadows to pre-flood cover values (~20-40%) occurred August 2002, 30 months post-flood. Monitoring sites also exhibited seasonal tends in abundances with highest cover in November and lowest seagrass cover post-summer from April to June. This typical seasonal response coupled with a trend of increasing seagrass cover indicates a post-flood recovery.

Recovery is also apparent in the deeper water seagrass communities of Hervey Bay. Deepwater (>10m) seagrass in the path of the main flood plume declined significantly in abundance within 6 months of the impact, and remained significantly lower than outside the impact area after 9 months. In February 2002 however, deepwater seagrass abundances at monitoring sites within the impacted area had recovered to near pre-flood levels.

The areas of seagrass that showed little recovery were the shallow sub-tidal seagrasses (2-4 m) along Dayman Bank, immediately adjacent to the city of Hervey Bay. After the flood in February 1999, these meadows declined dramatically in abundance and distribution, with most plants dead by November 1999. Only a few isolated patches of seagrass had recovered off the northern tip of the bank in February 2002.

A GIS of the intertidal seagrass meadows was created in MapInfo® using the survey information. A CD Rom copy of the GIS with metadata was archived at QT Brisbane and the original archived with the custodians (DPI) at Northern Fisheries Centre.

INTRODUCTION

The importance of seagrass meadows as structural components of coastal ecosystems is well recognised. Seagrasses stabilise coastal sediments; are important primary producers; are an important part of the nutrient cycle in the marine system; provide habitat for fish and invertebrates; and are a nursery ground for many prawn species. Seagrass meadows are also essential food for dugong, *Dugong dugon* (Miller) and green sea turtles, *Chelonia mydas* (Linnaeus). Intertidal seagrasses also provide important habitat for wading birds. Coastal seagrass meadows are therefore an important resource economically and ecologically.

Destruction or loss of seagrasses has been reported from most parts of the world, often from natural causes, eg "wasting disease", or high energy storms. More commonly destruction has resulted from human activities, eg. as a consequence of eutrophication, or land reclamation and changes in land use. Anthropogenic impacts on seagrass meadows are continuing to destroy or degrade coastal ecosystems and decrease their yield of natural resources.

Seagrass meadows provide a major marine habitat in the Great Sandy Strait. The meadows form part of significant Ramsar wetlands sites, are within the proposed Great Sandy Marine Park (Northern Section), and provide critical nursery habitat for regional prawn and finfish fisheries.

A Dugong Protection Area of 1703 km^2 in which gill- and mesh-netting practices were modified rather than banned, was established in the Great Sandy Strait and the southern part of Hervey Bay in January 1998 to help halt the decline of dugong numbers. The number of dugong which are dependent of the seagrass in the Hervey Bay/Sandy Strait region were estimated to be 1708±392 in 2001 (I. Lawler, JCU, Pers. Com.), which comprises about 30% of the total population south of Innisfail (Marsh and Lawler 2001). Green sea turtles are even more abundant than dugong and are also dependent on seagrass meadows for food. The area and abundance of seagrass meadows in the region are affected by seasonal factors (eg. sedimentation, temperature, light) and by climatic events (Conacher *et al*. 1999).

The Hervey Bay and Great Sandy Strait region is one of the most productive fishing regions of Queensland. The fisheries resources of the region support an important trawl fishery for prawns and scallops and there is a large recreational fishery for whiting and other estuarine as well as various pelagics and some reef fish (Hyland 1993). The Hervey Bay and Great Sandy Strait region is second only to Moreton Bay as a destination for recreational fishers (Moore 1986).

The Great Sandy Strait provides an important habitat for a wide variety of estuarine finfish. Both recreational and commercial fishers target these. The commercial catch of estuarine fish is predominantly mullet, taken in rivers by general purpose net and along foreshore by beach seines. These fishing methods also take whiting, yellowfin bream, gar and dusky flathead. Commercial fishers may also use gill- or mesh-nets, baits nets or tunnel nets. Tunnel netting however, is limited and more common in Tin Can Inlet. Juvenile yellowfin bream occur in areas associated with seagrass and mangroves in estuaries. Dusky flathead are also dependent on estuarine and inshore coastal habitat throughout their lifecycle.

There are 4 Fish Habitat Areas in the Great Sandy Strait, totalling 35,510 ha (Beumer *et al.* 1997). Fish Habitat Areas have been declared to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend (Zeller 1998). Declared Fish Habitat Areas protect critical wetland habitats sustaining the fish and invertebrate stocks upon which recreational, commercial and indigenous fishing practices depend. It is of vital importance that the character and structure of the physical environment and the chemical environment remain unaltered by human impacts for continued fisheries productivity.

Seagrass distribution was first mapped in the Great Sandy Strait in July/December 1973 (Dredge *et al.* 1977). Seagrass was found south of the co-tidal line, which occurs at Moonboom Islands (25°20’ S). No seagrass was found north of Moonboom Islands, including Urangan. In October-November 1992 an aerial photographic survey of the Strait was conducted and significant increases in seagrass distribution, relative to 1973 surveys, were reported in the northern section of the Strait, between River Heads and Urangan (Fisheries Research Consultants 1993).

In 1994, a broad scale survey of the Great Sandy Strait seagrass meadows was conducted (mainly by air) which reported an increase in distribution of meadows south of Urangan to River Heads compared with 1992 (Fisheries Research Consultants 1994a). In June 1994, long-term monitoring transects were established throughout the Great Sandy Strait. Resurveys were conducted in March 1995, November 1996, February 1998, September 1998 and February 1999. Large decreases in seagrass distribution were recorded in 1996 and recovery to February 1999 remained low (Conacher *et al.* 1999).

In December 1998 a detailed dive and aerial survey of the Great Sandy Strait was conducted which reported dense *Zostera capricorni* with *Halophila ovalis* (mud/sandy) meadows present on mud/sand banks throughout the region (DPI Unpublished data). Seagrass meadows in the Great Sandy Strait region are susceptible to sedimentation damage caused by flooding, suffering from the both the lack of light caused by turbid water and from deposited mud (Robertson and Lee Long 1991).

Flooding of the Mary River and other tributaries in the Sandy Strait in February 1999 caused the complete loss of seagrass meadows in the northern Great Sandy Strait and loss of some other regions in the central and southern Sandy Strait region (McKenzie *et al*. 2000). Flood waters also supply loads of nutrients and toxicants (eg herbicides) to seagrass areas that promote algal blooms, reduce light availability, impede photosynthetic processes and inhibit germination of seagrass seedlings. The recovery of seagrass meadows after flooding is dependant on prevailing environmental conditions and may be impeded by pollutants from urban and coastal development.

A focus of the present study is on the Booral Wetlands adjacent to the mouth of the Mary River. Total loss of seagrass meadows (~50 ha) in the Booral Wetlands occurred in February 1999. Community seagrass monitoring initiated in the Booral region in August 1999 has aided our understanding of seagrass recovery after loss and results of the program are also presented.

This report presents the results of a survey conducted in February 2002. The objectives were:

- *To map the distribution and abundance of seagrass meadows in the Great Sandy Strait, specifically the Booral Wetlands region, in February 2002*
- *To assess changes in seagrass distribution and abundance since the December 1999 surveys,*
- *To assess recovery of deepwater seagrasses in Hervey Bay since February 1999, and*
- *Provide a CD-Rom containing the GIS of seagrass distribution.*

METHODOLOGY

Site Description

The Great Sandy Strait is a sand passage estuary between the mainland and Fraser Island and encompasses a area of approximately 93,160 hectares, making it the fifth largest enclosed embayment on Queensland's coastline. It comprises vast mangrove habitats and seagrass meadows.

The region is defined in this report as south of a line between Moon Point and Dayman Point, to a line between Hook point and Inskip Point, and includes Tin Can Inlet (Map 1). The hinterland to the south and west of the strait is made up of two major drainage basins; these are the Tin Can watershed and the Boonooroo watershed (Dredge *et al.* 1977). The Tin Can watershed includes the watercourses of Teebar Creek, Snapper Creek and Kauri Creek (Map 1). The watershed is bounded by the Cooloola National Park to the east, which includes a significant sand mass of coastal dunes, and open layered woodland, sclerophyll woodland and heath to the west. The Boonooroo watershed extends north-south between Tinnanbar and Shoulder Point (south head of Mary River) and is characterised by broad ridges and low, gently undulating country covered with layered woodland (Dredge *et al.* 1977). This section of the Strait also has extensive mangrove wetlands. The major watercourse in this section includes Poona and Tuan Creeks, which drain from extensive pine plantations and agricultural lands. The eastern side of the Great Sandy Strait is bounded by Fraser Island, from which several small watersheds drain from the high sand dunes. There are several unsewered villages scattered along the shores throughout the Great Sandy Strait and the fishing port of Tin Can Bay township within Tin Can Inlet. The Booral Wetlands are situated in the region adjacent to the mouth of the Mary River (Figure 2).

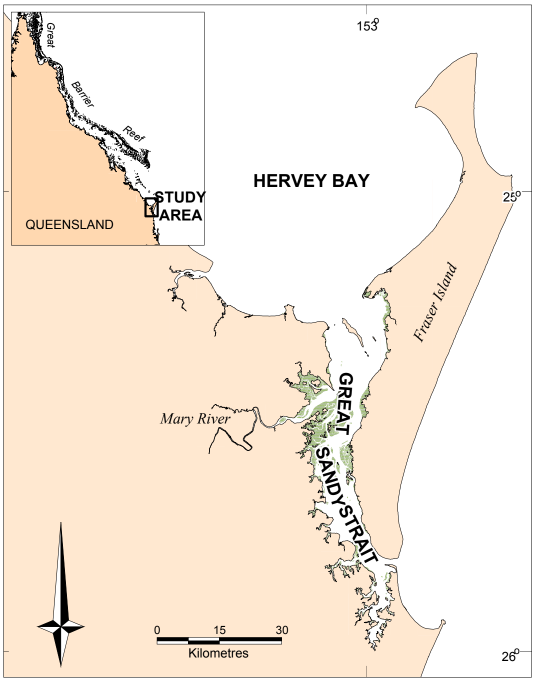


Figure 1. Location of Great Sandy Strait Region study area.

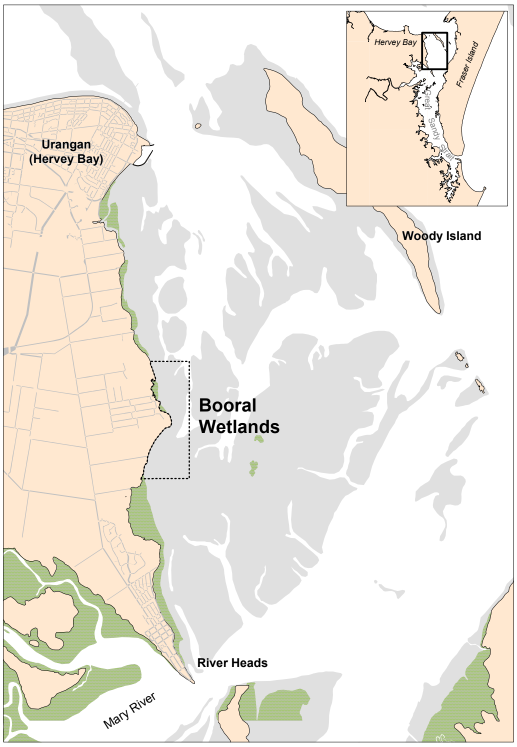


Figure 2. Location of the Booral Wetlands and Great Sandy Strait Region.

The Great Sandy Strait was listed as the 992nd Wetland of International Importance under the Ramsar agreement, in May 1999. The Strait includes the largest area of tidal swamps within the southeast Queensland bioregion, consisting of intertidal sand and mud flats, extended seagrass meadows, mangrove forests, salt flats/marshes, and often contiguous with freshwater *Melaleuca* wetlands and coastal wallum swamps. It is an exceptionally important feeding ground for migratory shorebirds and important for a wide range of other shorebirds, waterfowl and seabirds, marine fish, crustaceans, dugong, sea turtles and dolphin (Ramsar 1999).

The Mary River flows into the northern Great Sandy Strait before entering Hervey Bay from the south (Figure 2), and drains a catchment of 9600 km^2. Land use practices in this catchment have resulted in problems due to flooding, severe stream-bank erosion and land degradation (Anon 1993).

The Mary River catchment has been extensively cleared for agriculture and the lower reaches of the Mary River are under significant pressure from grazing and agriculture (Anon 1993). The main land use is dairying, beef grazing, with some area of sugarcane and agriculture in the lower catchment areas. Fertiliser use is relatively low (Anon 1993). The State of the Rivers Report rates most of the streams in the Mary catchment as being in a moderate to poor overall condition, emphasising the erosion problems as well as the poor status of the riparian vegetation (Johnson 1997). Herbicide and insecticide concentrations present in the Mary River and in Hervey Bay sediments were measured between 1993 and 1996 (Anon 1996). Sediment and river water pollutant concentrations were below detection limits for most compounds. The herbicides 2,4-D and Triclopyr were detected at trace concentrations (<0.2 μg l^{-1}).

The major urban development in the immediate region is the City of Hervey Bay, in the northern Great Sandy Strait. Pollutants (nutrients, toxicants) from the urbanisation and stormwater runoff would be expected, but have not been analysed in this report.

Climate in the region is subtropical and coastal. Seasonal influences are derived from the tropical zone to the north, the temperate zone to the south and the thunderstorm breeding area to the south west (Dredge *et al*. 1977). Mean annual rainfall (from 127 years data) is 1166 mm for the region (Bureau of Meteorology 2001). Rainfall is greatest between December and March. Mean daily temperatures ranged from 15.2 to 26.9°C (87 years average), with January being the hottest month and July the coolest (Bureau of Meteorology 2001).

Survey Methods

Intertidal seagrass distribution was assessed using aerial photographs and helicopter surveys in areas exposed at low tide. Helicopter based sampling is a time and cost effective method for surveying extensive intertidal areas at low tides. In submerged areas, sampling methods were boat based and used underwater video and Van Veen sediment grabs.

An aerial survey of intertidal seagrasses was conducted on the 27th and 28th February 2002. During the flight, observers interpreted the distribution of seagrass onto survey charts and a digital video camera was used to store a visual record for future reference and to aid interpretation when mapping on the GIS. Ground truthing sites were haphazardly selected across intertidal banks. Where seagrass was present, ground truthing of the habitat while hovering less than a metre above the ground enabled observers to visually estimate seagrass abundance, seagrass species composition, meadow landscape category (see following page) and sediment categories. Site positions were recorded using a dGPS. The boundary of some meadows was also mapped while hovering directly over the

meadow edge and the position fixed using a dGPS (± 5 metres).

Aerial photographs of intertidal areas adjacent to the Urangan marina were sourced from the Queensland Department of Main Roads photographic flight runs taken in October 2001. These photos were taken at low tide when intertidal areas were exposed and were easily interpreted for presence or absence of seagrasses.

Deepwater seagrass (>10m water depth) in Hervey Bay was examined at 13 sites using boat-based methods (Map 1). A real time underwater video camera system was deployed from a vessel and used to assess seagrass habitats. To standardise images, a 0.25 m^2 quadrat which filled the field of view was fixed in front of the camera lens as part of the camera support frame. Five minutes of video footage was recorded for each site. A Van Veen grab was used to confirm the seagrass species identified on the camera monitor, to determine presence of seagrass rhizome, and to assess sediment type. Site locations were chosen from McKenzie *et al*. (2000) and represented locations inside and outside the February 1999 flood plume area. Sampling was conducted on the 1st March 2002. Images were archived on DVCAM and VHS video tapes and visually compared with previous video records.

Data Collection

Seagrass habitat characteristics including above-ground seagrass biomass, species composition, sediment type, and geographic location were recorded at each ground truth site.

Above-ground seagrass biomass was determined by a "visual estimates of biomass" technique modified from Mellors (1991). At each intertidal site, observers recorded an estimated rank of seagrass biomass and species composition in three replicates of a 0.25 m^{-2} quadrat per site. On completion of the survey, each observer ranked ten harvested quadrats and the above-ground dry biomass (g DW m^{-2}) was measured for each quadrat. The regression curve representing the calibration of each observer's ranks was used to calculate above-ground biomass from all their estimated ranks during the survey. All observers had significant linear regressions (r^2 >0.95) when calibrating above-ground biomass estimates against a set of harvested quadrats.

Field descriptions of sediment type were described using visual estimates of grain size: shell grit, rock gravel (>2000μm), coarse sand (>500 μm), sand (>250 μm), fine sand (>63 μm) and mud (<63 μm). Sediment categories were determined by the dominant sediment type (eg. sand/mud = more sand than mud).

The presence and types of meadows was based on above-ground seagrass evidence only. Below-ground rhizome presence was not assessed during helicopter sampling although sediment grab samples from the boat survey were checked for all evidence of seagrass.

Isolated seagrass patches - The majority of area within the meadows consisted of unvegetated sediment interspersed with isolated patches of seagrass.

Aggregated seagrass patches - Meadows comprised of numerous seagrass patches but still featured substantial gaps of unvegetated sediment within the meadow boundaries. In some instances seagrass was confined to tidal channels on mud-banks.

Continuous seagrass meadow - The majority of area within the meadows was comprised of continuous seagrass cover interspersed with a few gaps of unvegetated sediment.

Deepwater sites were checked for seagrass abundance by replaying and examining the video tapes. Seagrass biomass estimates were based on 10 random time frames, at a one-second accuracy, allocated within the 5 minutes of footage for each site (within site variance was reduced by at least 50% with 10 replicates). Above-ground seagrass biomass was determined by a "visual estimates of biomass" technique modified from Mellors (1991). Seagrass species composition was also noted. The video was paused at each of the 10 random time frames selected. If the sea-bed was not visible the tape was advanced to the nearest point on the tape where it was visible. From this frame an observer recorded an estimated rank of seagrass biomass and species composition. On completion of the videotape analysis, the video observer ranked ten additional quadrats that had been previously videoed for calibration. These quadrats were videoed in front of a stationary camera, and then harvested, dried and weighed. A regression curve was calculated for the relationship between the observer ranks and the actual harvested value. This curve was used to calculate above-ground biomass for all estimated ranks made from the survey sites. All observers had significant linear regressions (r^2 =0.95) when calibrating aboveground biomass estimates against the harvested quadrats.

Geographic Information Systems (GIS)

The GIS basemap of the study region including coastline, sandbanks, mangroves and islands was created by DPI (McKenzie In Prep), using rectified aerial photographs, the Digital

Cadastral Database (DCDB courtesy DNR) and AusLig© database (digitised at 1:250,000 scale).

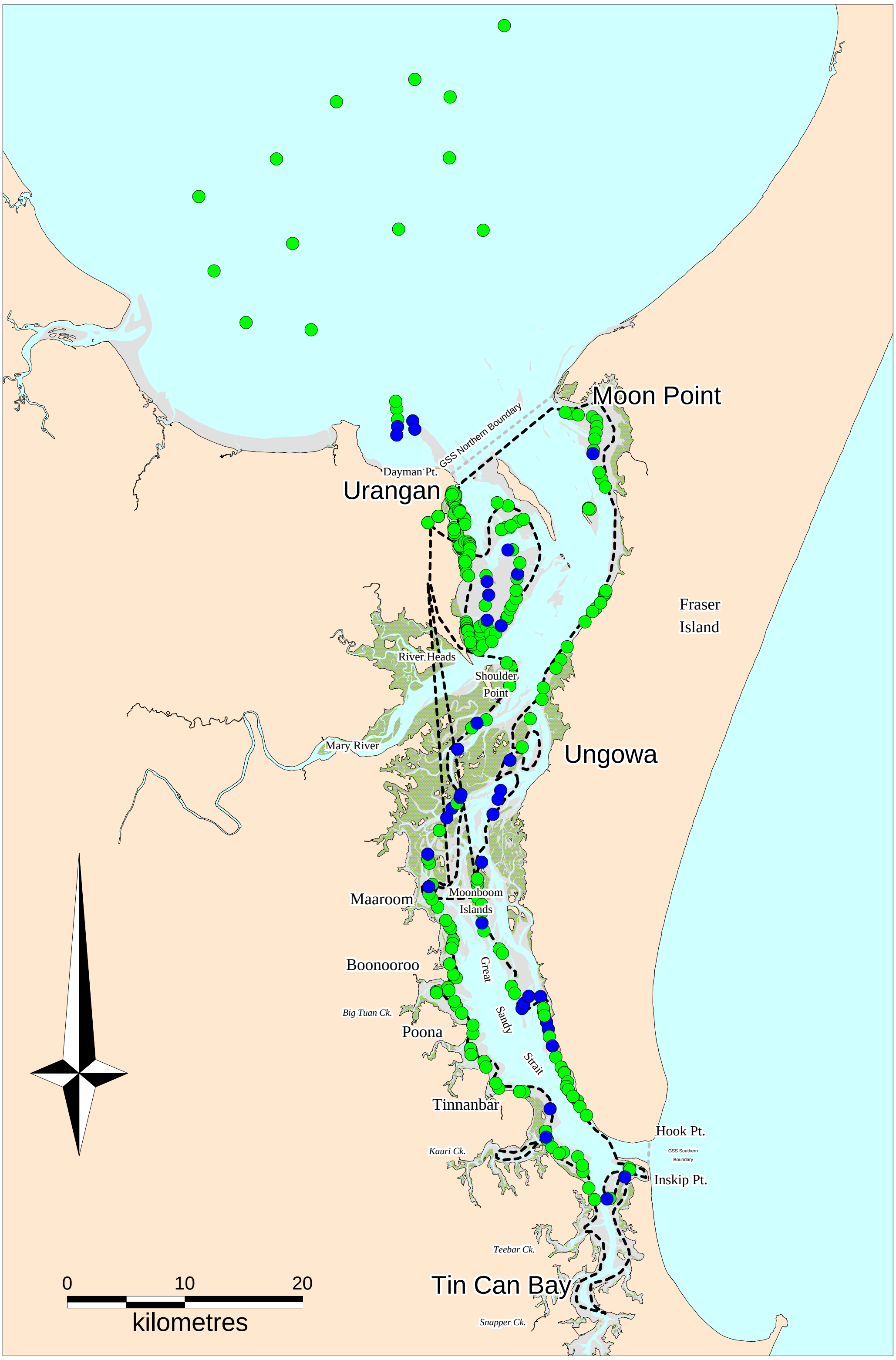
A GIS of the intertidal seagrass meadows was created in MapInfo® using the survey information. A CD Rom copy of the GIS with metadata was archived at QPWS Maryborough and the original archived with the custodians (DPI) at the Northern Fisheries Centre.

Errors in GIS maps include those associated with digitising and rectifying basemaps and with Global Positioning System (GPS) fixes for survey sites. Each seagrass meadow was assigned a qualitative mapping value, determined by the data sources and likely accuracy of mapping. Mapping quality was based on the range of mapping information available for each meadow and associated estimates of reliability (R) in mapping meadow boundaries. Estimates of mapping quality ranged from 7.5 to 100 m.

Table 1. Ranks of mapping quality for seagrass meadows mapped in the Great Sandy Strait.

Map Quality	Data sets	Comments
1	Helicopter reconnaissance, aerial photos & ground truth	Detailed checking of meadow boundary during surveys. Images and photos of high resolution. *Error = 7.5 to 15 m.*
2	Helicopter reconnaissance, aerial photos & ground truth	Some meadow boundaries checked. Images and photos of high resolution *Error = 10 to 75 m.*
3	Helicopter reconnaissance, aerial photos & ground truth	Occasional meadow boundary checked. Reasonable definition in images & photos. *Error = 15 to 100 m.*
4	Helicopter reconnaissance & boat survey	No image or photo available at required resolution. Some meadow boundaries checked. High reliance on video from low level helicopter flight. *Error = 20 m.*
5	Underwater video survey only	Subtidal meadows not visible in remote-sensing images. Data densities generally low and reliant solely on boat (video) survey. *Error = 30 m.*
6	Helicopter reconnaissance only	Photos of suitable resolution. Meadow boundaries checked during ground truth survey. No dive survey. *Error = 25 to 100 m.*

MAP 1. Location of ground truth (sampling) sites and helicopter flight path in the Great Sandy Strait & Hervey Bay, February & March 2002.



LEGEND

- Ground truth site (seagrass present)
- Ground truth site (seagrass absent)
- Helicopter flight path
- Mangroves
- Mudbank

Source: McKenzie, L.J. and Campbell, S.J. (2003). Seagrass habitats of the Booral Wetlands and the Great Sandy Strait, February/March 2002. DPI Information Series QI030XX (DPI, Cairns) 20 pp.

Sampling dates: 6-14th December 1998 (DPI unpublished data)
24-26th November 1999 (McKenzie et al. 2001)
27 - 28 February 2002.

Funded by the Queensland Environmental Protection Authority, CRC Reef and the Department of Primary Industries.

Produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2003.

RESULTS

Intertidal seagrass resources

Six seagrass species, in three Families, of seagrass were found in the Great Sandy Strait in February 2002.

Family **CYMODOCEACEAE** Taylor
Halodule uninervis (wide- & narrow-leaf) (Forsk.) Aschers.
Syringodium isoetifolium (Aschers.) Dandy

Family **HYDROCHARITACEAE** Jussieu
Halophila decipiens Ostenfeld
Halophila ovalis (R. Br.) Hook f.
Halophila spinulosa (R. Br.) Aschers. in Neumayer

Family **ZOSTERACEAE** Dummortier
Zostera capricorni Aschers.

The Booral Wetlands support 62.77 ±87.97 hectares of intertidal seagrass, dominated by isolated patches of *Zostera capricorni* (Aschers.), a common species in southern Queensland. The seagrass abundance was generally <13 g DW m^{-2} (<20% cover). The plants were generally of a small morphology with a canopy height <5cm. The other seagrass species present was *Halophila ovalis* ((BR.) D.J. Hook) a colonising species common in Queensland, however its distribution within the survey area was patchy.

7007 ±1945 hectares of intertidal seagrass meadows were mapped on the mud/sand banks of the Great Sandy Strait (Map 1). Approximately 92% of the area of seagrass meadows in the Great Sandy Strait was dominated by *Zostera capricorni*. The remainder was dominated by other species including *Halophila spinulosa*, *Halophila ovalis*, *Halophila decipiens*, *Halodule uninervis* and *Syringodium isoetifolium* (Table 1). In February 2002, 14 seagrass meadow/community types were identified according to the order of species dominance, and meadow boundaries were mapped for each community type (Table 1).

Table 2. Above-ground seagrass biomass, percentage cover and the areal extent of seagrass for each seagrass community type identified in the Great Sandy Strait.

Seagrass community type	Biomass (g DW m^{-2})	% cover range	Area (ha ±R)
Halodule uninervis	21.7	1 - 25	10.36 ±7.55
Halodule uninervis with H. ovalis	<3 - 20	0.5 - 50	204.91 ±38.11
Halodule uninervis/S. isoetifolium with H. ovalis	< 25	10 - 50	18.61 ±3.87
Halophila decipiens	?	?	19.30 ±15.59
Halophila decipiens with H. spinulosa	?	?	1.98 ±1.96
Halophila ovalis	<0.3 - 1	0.1 - 10	50.25 ±19.24
Halophila ovalis with Zostera	<0.5 - 10.5	0.1 - 40	145.87 ±107.9
Halophila spinulosa with Zostera and H. ovalis	?	?	8.06 ±8.04
Halophla spinulosa	<20	1 - 10	23.44 ±7.05
Zostera capricorni	<4 - 27.4	0.1 - 50	2417.3 ±907.83
Zostera capricorni with H. uninervis/H. ovalis	<1 - 27	1 - 70	521.53 ±134.55
Zostera capricorni with Halophila ovalis	0.1 - 27.4	0.1 - 50	2904.89 ±741.89
Zostera capricorni/H. uninervis with H. ovalis	<20	3 - 40	291.64 ±65.94
Zostera capricorni/Halophila spp.	<10 - 15	0.2 - 20	389.15 ±93.21

Most meadows in the Great Sandy Strait were light to moderate cover (greater than 1% and less than 50% percent cover) and had light to moderate above-ground biomass (range 1 to 27 g DW m^{-2}).

In the north at Urangan, light/moderate *Zostera capricorni* with *Halophila ovalis* meadows (<27 g DW. m^{-2}, 10-50% cover) were present on mud/sand banks. The meadows are continuous in the vicinity of the marina, however further south they become aggregated and isolated patches of *Halophila ovalis* with *Zostera capricorni*.

In the Booral Wetlands the meadows were generally isolated patches of light *Zostera capricorni* with *Halophila ovalis*.

Extensive continuous meadows of light *Zostera capricorni* were present on the mudbanks on the northern bank adjacent to the mouth of the Mary River. On the more exposed sections of the bank the meadows are predominately isolated/aggregated patches and in some places the seagrass was confined only to erosion channels created by tidal currents.

Large light abundance *Zostera capricorni* and *Halophila ovalis* meadows (22.5 g DW. m^{-2}) were present between Mangrove Point and Big Woody Island on the sand banks and in some gutters, respectively.

In the region from Moon Point to Blackfellow Point were large *Zostera capricorni* with *Halophila ovalis* meadows of light abundance on the extensive intertidal flats. Further south along the edges of Fraser Island, the banks became narrower and light to moderate *Halophila* meadows were present. A moderate *Halophila ovalis* meadow with isolated patches of *Zostera capricorni* was present on the intertidal flats adjacent to the Kingfisher Resort.

South of White Cliffs, the intertidal banks were covered by moderate *Zostera capricorni* meadows (~25 g DW. m^{-2} on average) to just south of Wanggoolba Ck. These meadows were protected behind sand ridges on the channel edges of the intertidal banks. On the nearby Turkey Island complex, light *Zostera capricorni* meadows (~20 g DW. m^{-2} on average) were scattered on the mud banks surrounding the mangrove islands.

In the central section of the Strait, meadows dominated by *Zostera capricorni* with *Halophila ovalis* (~15 g DW. m^{-2} on average, but ranging from 0.01 to 27 g DW. m^{-2}) cover much of the intertidal banks surrounding Moonboom and Reef islands. Substantial continuous meadows of light/moderate *Zostera capricorni/H. uninervis* with *H. ovalis* cover

tidal banks between Maaroom and Boonooroo. Similarly, *Zostera capricorni* and *Halodule uninervis* dominated meadows, but generally of lower biomass (<13 g DW. m^{-2} on average) are present on the large intertidal banks surrounding the villages of Tuan and Poona. On the large intertidal bank on the eastern side of Poona Creek, numerous dugong feeding trails were observed in the very light *Halodule uninervis* meadow.

Significant meadows of moderate *Zostera capricorni* with *Halodule uninervis*/*Halophila ovalis* (20 – 27 g DW. m^{-2}) were also present on the intertidal flats in front of the Tinnanbar village and around on Cowra Point.

On the western (Fraser Island) side of the central Great Sandy Strait, from Duck Creek to Elbow Point, the intertidal banks were also covered by *Zostera capricorni* dominated meadows, which ranged from 15-27 g DW. m^{-2} on average. The seagrass meadows in Brown's Gutter had also been heavily grazed by dugong, evident from the high density of feeding trails.

In the southern section of the Strait, large meadows were present on the intertidal and shallow subtidal banks, but did not extend into Tin Can Inlet past Eudlo Point. Most meadows were dominated by light *Zostera capricorni.* The Kauri Creek bank had a light/moderate *Zostera capricorni* meadow (<20 g DW. m^{-2}) in large patches intertidally.

In Tin Can Inlet, there were *Zostera capricorni/Halophila ovalis* dominated meadows (<10g g DW. m^{-2} on average) on the large intertidal mud banks adjacent to the mouth of Teebar Creek. The other major seagrass meadows in Tin Can Inlet were in Pelican Bay at Inskip Point. These meadows were aggregated patches, which covered much of the intertidal mud flats, and were dominated by *Zostera capricorni* (<20 g DW. m^{-2} on average).

Subtidal meadows contributed <5% of the total seagrass distribution of the Great Sandy Strait. Subtidal meadow boundaries however, were not accurately mapped. Distribution of subtidal meadows was based mostly on December 1998 baseline survey and aerial observations. The presence of seagrass was confirmed by anecdotal reporting from community volunteers. In the northern section, subtidal meadows were in a narrow band along the edge of intertidal banks, between Wanggoolba Creek and Blackfellow Point, or in channels on intertidal banks west of Big Woody Island. In the south, subtidal meadows extended across the large banks between Kauri Creek and Tin Can Inlet and also formed a narrow band adjacent to the Elbow Point mudbanks. Subtidal meadows were dominated by *Halophila* species (*H. spinulosa, H decipiens, H. ovalis*) or *Z. capricorni* and biomasses varied between 1 and 27 g DW. m^{-2}, but generally <20 g DW. m^{-2}.

Comparison with previous surveys

The area of intertidal seagrass in the Great Sandy Strait (mapped predominantly from a helicopter) in December 1998 decreased approximately 50% after the flood in February 1999 to November 1999 (McKenzie *et al.* 2000). These losses occurred mostly within the plume area in the northern section of the Great Sandy Strait (Urangan - Moon Point in the north to Ungowa in the south). No seagrass was found at Urangan, the Booral Wetlands, Moon Point or the mouth of Wanggoolba Creek. A 95% loss of seagrass in the northern Great Sandy Strait region and the Booral Wetland region occurred following the flooding in February 1999 (Map 3). The only other significant losses of seagrass detected within the Great Sandy Strait was from the large intertidal bank between Kauri Creek and Tin Can Inlet (Tin Can Bay).

In February 2002 the total area of seagrass throughout the Great Sandy Strait had increased to 7007 ±1945 hectares (Table 2, Map 2). This was greater than the pre-flood survey conducted in December 1998.

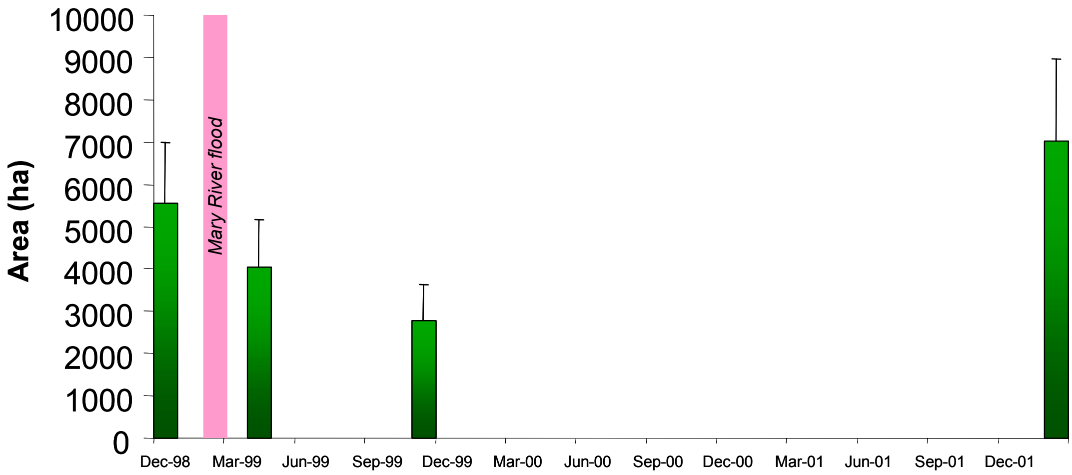


Figure 3. Mean area ±R (*estimate of reliability*) for seagrass mapped in the Great Sandy Strait pre- and post-flood.

Although no significant losses in seagrass distribution were recorded in the central Great Sandy Strait, the abundance of the seagrass meadows significantly declined in the 12 months post-flood.

Surveys in February 2002 have shown a near complete recovery of seagrass meadows throughout the whole region with higher total area of seagrass recorded in February 2002 compared with pre-flood December 1998 surveys (Table 3). Also, in February 2002 most meadows appeared to be of similar pre-flood abundances with biomasses approximately the same or marginally lower.

Table 3. Area (ha) estimates of seagrass meadows at 3 spatial scales in the Great Sandy Straits.

Regions	3 moths pre-flood **December 1998**	2 months post-flood **April 1999**	9 months post-flood **November 1999**	36 months post-flood **February 2002**
Booral Wetlands	46.4 ±13.9	0	0	62.8 ±25.2
Northern Great Sandy Strait	1,995 ±524	913.3 ±190.7	98.1 ±40.1	3,712 ±524
Total Great Sandy Strait	5,554 ±1,466	4,034±1115	2,779 ±862	7,007 ± 1,945

In the north at Urangan, the meadows have recovered to pre-flood abundances and approximate distribution. Many new extensive meadows have also appeared since the flood across the mudbanks immediately adjacent and to the north of the Mary River mouth. These predominately Zostera capricroni meadows had been previously mapped during aerial photographic surveys in October-November 1992 and 1994, but had been absent since 1996 (Fisheries Research Consultants 1993; Conacher et al. 1999; McKenzie et al. 2000).

The large *Zostera capricorni* with *Halophila ovalis* meadows on the extensive intertidal flats from Moon Point to Blackfellow Point have also fully recovered, although the abundances appeared marginally lower.

The *Zostera capricorni* meadows from White Cliffs to just south of Wanggoolba Ck (including the mud banks adjacent to Bennett's Creek) and on the nearby Turkey Island complex appeared to have also fully recovered.

No significant losses or changes in biomass were detected in February 2002, when compared to the December 1998 baseline, in the meadows on the intertidal banks surrounding Moonboom and Reef Islands, between Maaroom and Boonooroo, or adjacent to the villages of Poona and Big Tuan in the central section of the Strait.

In the very southern section of the strait, the large subtidal *Cymodocea serrulata* meadow between Kauri Creek and Tin Can Inlet, which the highest maximum biomass of any seagrass meadow in the Great Sandy Straits was recorded in December 1998, showed little sign of significant recovery. The intertidal *Zostera capricorni* meadow had recovered to some degree, although seagrass abundance was low. No plants of *Cymodocea serrulata* were observed in February 2002.

In Tin Can Inlet, the *Zostera capricorni/Halophila ovalis* dominated meadows on the large intertidal mud banks adjacent to the mouth of Teebar Creek were marginally lower in abundance when compared to the December 1998 baseline. Similarly, in Pelican Bay at Inskip Point, these *Zostera capricorni* meadows were marginally lower in abundance.

Long term monitoring at Seagrass-Watch sites (UG3 and UG4) (Map 1) within the Booral Wetlands shows that initial re-colonisation of seagrass occurred in November 2000, 21 months post-flood. Mean seagrass cover from November 2000 to February 2001 (21-24 months post-flood) was < 7% at UG3 and < 1% at UG4. During 2001 and 2002 mean cover values increased to 10-30% (Figure 4). Full recovery of meadows to pre-flood cover values (~20-40%) occurred at UG4 in August 2002, 30 months post-flood (Figure 4). At both sites a seasonal tend is apparent with highest cover in November and lowest seagrass cover post-summer from April to June. This typical seasonal response coupled with a trend of increasing seagrass cover indicates a post-flood recovery.

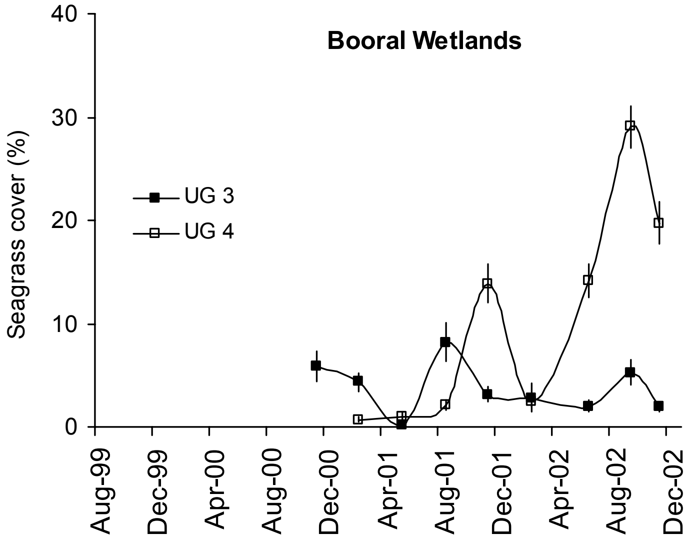


Figure 4. Seagrass abundance (% cover) at Seagrass-Watch long-term monitoring sites near the Booral Wetlands.

For the first 12 months after initial recolonisation (Novermber 2000-2001) the Booral Wetlands meadows were dominated by *Halophila ovalis* (20 to 85% of species composition) at both sites (Figure 5). In 2002 the percentage of *Halophila ovalis* present decreased to less than 10% at both sites (Fig. 3) and Zostera capricorni became the dominate species.

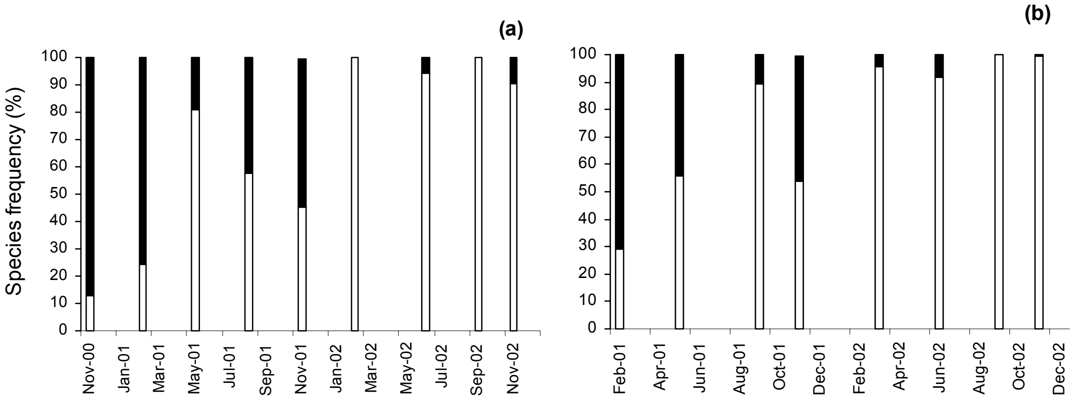


Figure 5. Species composition (%) of *Halophila ovalis* (■) and *Zostera capricorni* (□) at the Booral Wetlands.

Photographic records from the Seagrass-Watch long-term monitoring sites have also provided a record of recovery following the Mary River flood in February 1999. A photographic record of a typical quadrat following the recovery of the seagrass at Booral is shown (Plate 3). Seagrass recovery commenced after August 2001 with growth of *Halophila ovalis* and *Zostera capricorni* in November 2001 (30 months post-flood) and growth of predominantly *Zostera capricorni* in June 2002 (Plate 2).

Plate 1. *Zostera capricorni* and *Halophila ovalis* from Seagrass-Watch site UG4 at Booral Wetlands: (quadrat 0.25 m^{-2}) February 2001 (0% cover), August 2001 (0 % cover), November 2001 (30% cover) and June 2002, (20% cover).

February 2001 | August 2001 | November 2001 | June 2002

Deepwater seagrasses (>10m below MSL) of Hervey Bay

Video observations of deepwater seagrasses within the area most impacted by the February 1999 flood plume provided a visual record of seagrass plant physical responses to the effects of shading. As seagrass was measured at both flood-impacted and non-impacted sites, changes observed in seagrasses at non flood-impacted sites are possibly associated with normal seasonal fluctuations.

After the flood in February 1999, shallow sub-tidal (2-10m below MSL) seagrass declined dramatically in abundance and distribution, with most plants dead by November 1999. Deepwater (>10m) seagrasses in the path of the main flood plume declined significantly in abundance within 6 months of the impact, and remained significantly lower than outside the impact area after 9 months.

In February 2002, the deep water meadows at the sites examined in Hervey Bay were generally patchy light to moderate abundance of *H. spinulosa* with *H. ovalis/H. decipiens* on sand. The meadow mapped in December 1998 on the shallow subtidal Dayman Bank, extending from near Urangan out to near the fairway buoy, showed little recovery in the northern tip with light H. *spinulosa/ H. decipiens* (<5% cover) (Map 5).

Mean above-ground seagrass biomass at deepwater sites within the flood plume (Impacted sites) and for sites outside the flood plume (Reference sites) were pooled respectively for analysis. Impact and Reference sites did not appear to differ significantly in abundance in February 2002, and the all sites appear to have recovered to near or above pre-flood levels.

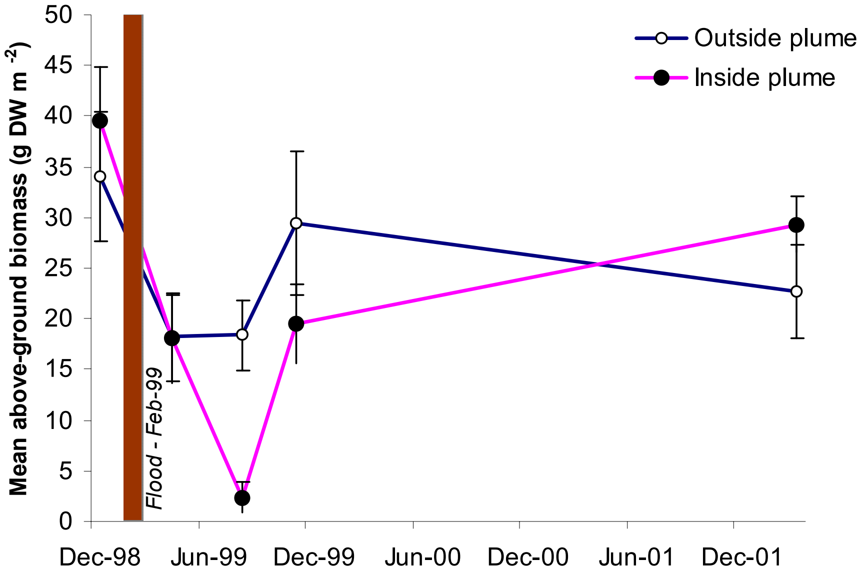
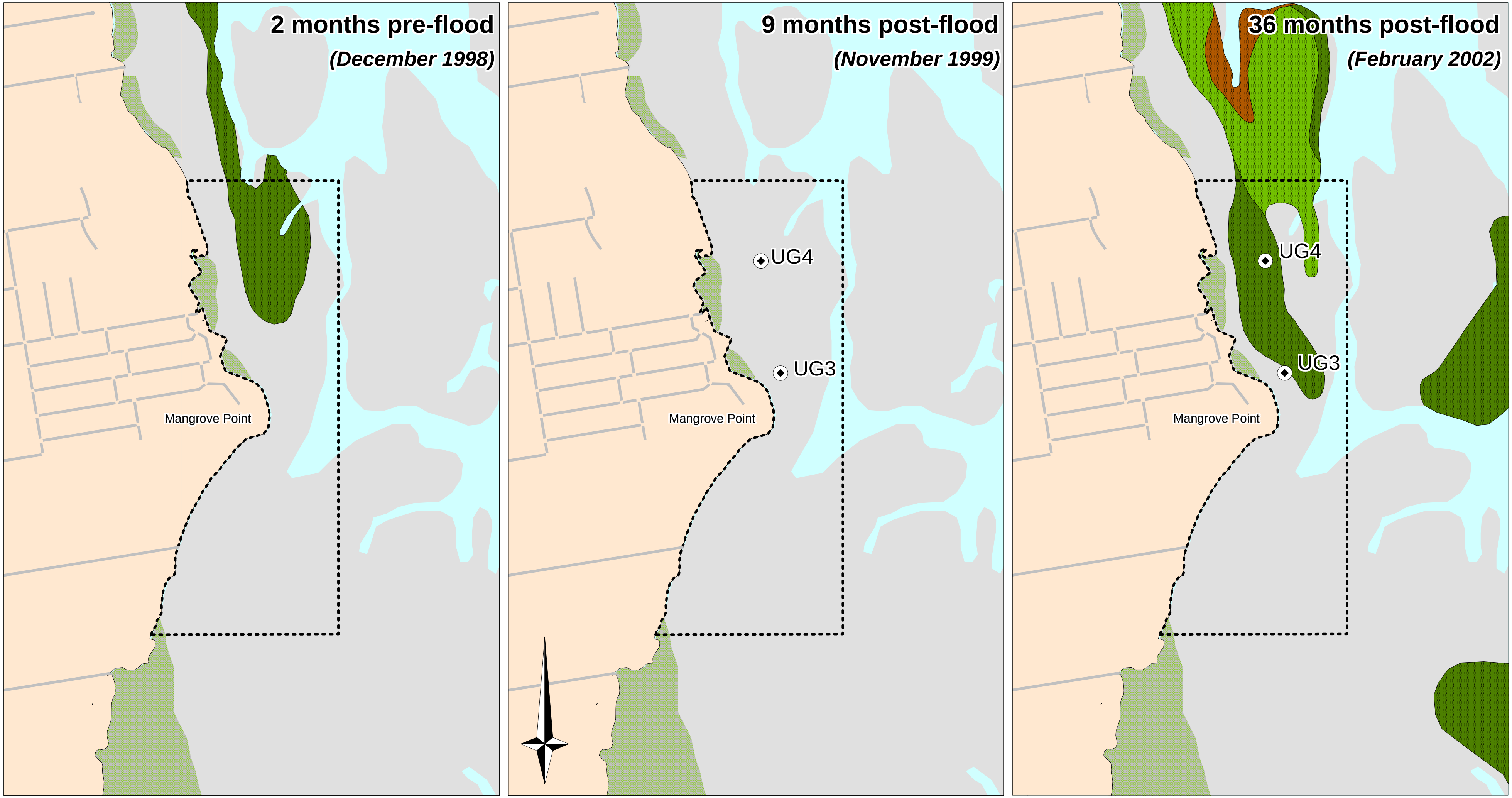


Figure 6. Plot of above-ground seagrass biomass (g DW m^{-2}, all species pooled) from survey sites inside (Impact) and outside (Reference) the area impacted by the Mary River flood plume following flooding in Hervey Bay and the Great Sandy Strait in February 1999. *Error bars represent 95% confidence limits.*

MAP 2. Distribution of seagrass meadows pre- and post-flood within and adjacent to the Booral Wetlands.



LEGEND

- *Light Halophila ovalis with Z. capricorni*
- *Light Zostera capricorni*
- *Light Zostera capricorni with Halophila ovalis*
- Seagrass-Watch long-term monitoring site
- Mangrove
- Mud/sand flats

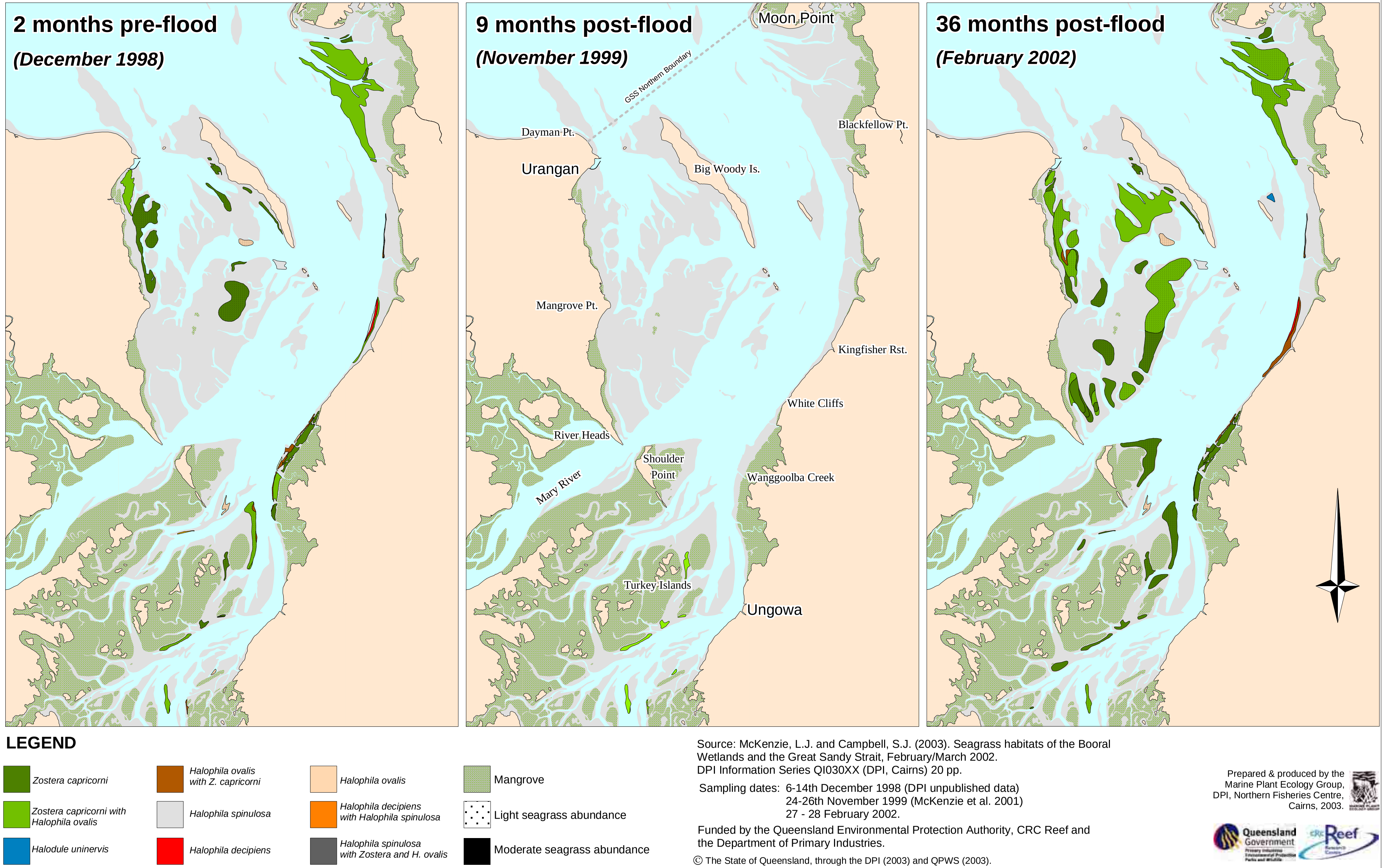
Source: McKenzie, L.J. and Campbell, S.J. (2003). Seagrass habitats of the Booral Wetlands and the Great Sandy Strait, February/March 2002. DPI Information Series QI030XX (DPI, Cairns) 20 pp.

Sampling dates: 6-14th December 1998 (DPI unpublished data)
24-26th November 1999 (McKenzie et al. 2001)
27 - 28 February 2002.

Funded by the Queensland Environmental Protection Authority, CRC Reef and the Department of Primary Industries.

Prepared & produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2003.

MAP 3. Distribution of seagrass meadows pre- and post-flood in the northern Great Sandy Strait.



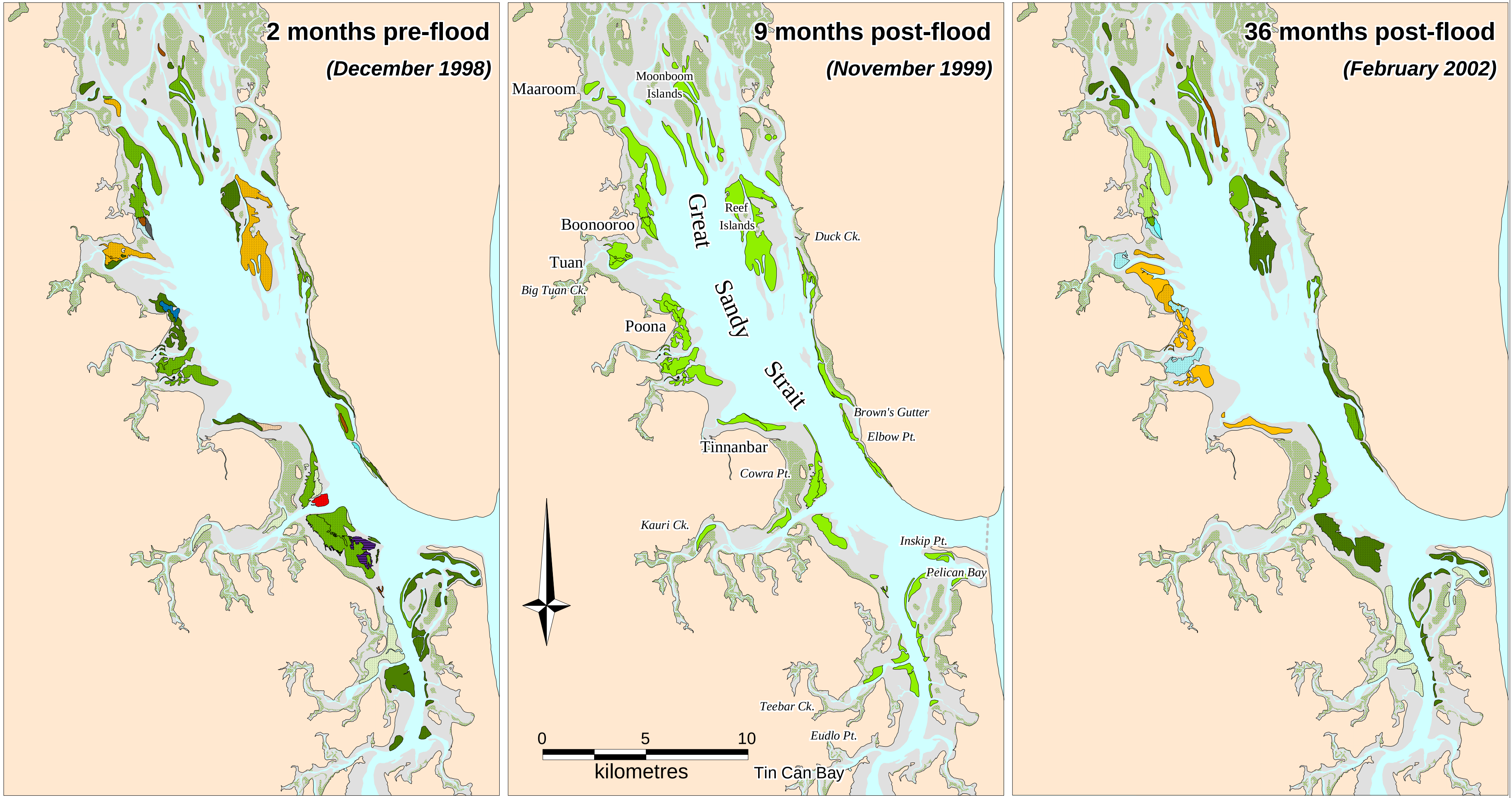
Source: McKenzie, L.J. and Campbell, S.J. (2003). Seagrass habitats of the Booral Wetlands and the Great Sandy Strait, February/March 2002. DPI Information Series QI030XX (DPI, Cairns) 20 pp.

Sampling dates: 6-14th December 1998 (DPI unpublished data)
24-26th November 1999 (McKenzie et al. 2001)
27 - 28 February 2002.

Funded by the Queensland Environmental Protection Authority, CRC Reef and the Department of Primary Industries.

Prepared & produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2003.

MAP 4. Distribution of seagrass meadows pre- and post-flood in the southern Great Sandy Strait.



LEGEND

Halodule uninervis with Halophila ovalis	*Halophila ovalis with Z. capricorni*	*Zostera with H. uninervis and H. ovalis*	*Cymodocea with mixed spp.*	Light seagrass abundance
H. uninervis/S. iseotifolium with H. ovalis	*Zostera/Halophila sp.*	*Zostera capricorni*	Intertidal mud/sand banks	Moderate seagrass abundance
Halophila ovalis	*Zostera/H. uninervis with Halophila spp.*	*Zostera capricorni with Halophila ovalis*	Mangrove	Dense seagrass abundance

Source: McKenzie, L.J. and Campbell, S.J. (2003). Seagrass habitats of the Booral Wetlands and the Great Sandy Strait, February/March 2002. DPI Information Series QI030XX (DPI, Cairns) 20 pp.

Sampling dates: 6-14th December 1998 (DPI unpublished data)
24-26th November 1999 (McKenzie et al. 2001)
27 - 28 February 2002.

Funded by the Queensland Environmental Protection Authority, CRC Reef and the Department of Primary Industries.

Prepared & produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2003.

MAP 5.

Above-ground seagrass biomass at each post-flood deepwater monitoring site in Hervey Bay - December 1998, April 1999, August 1999, November 1999 & March 2003.

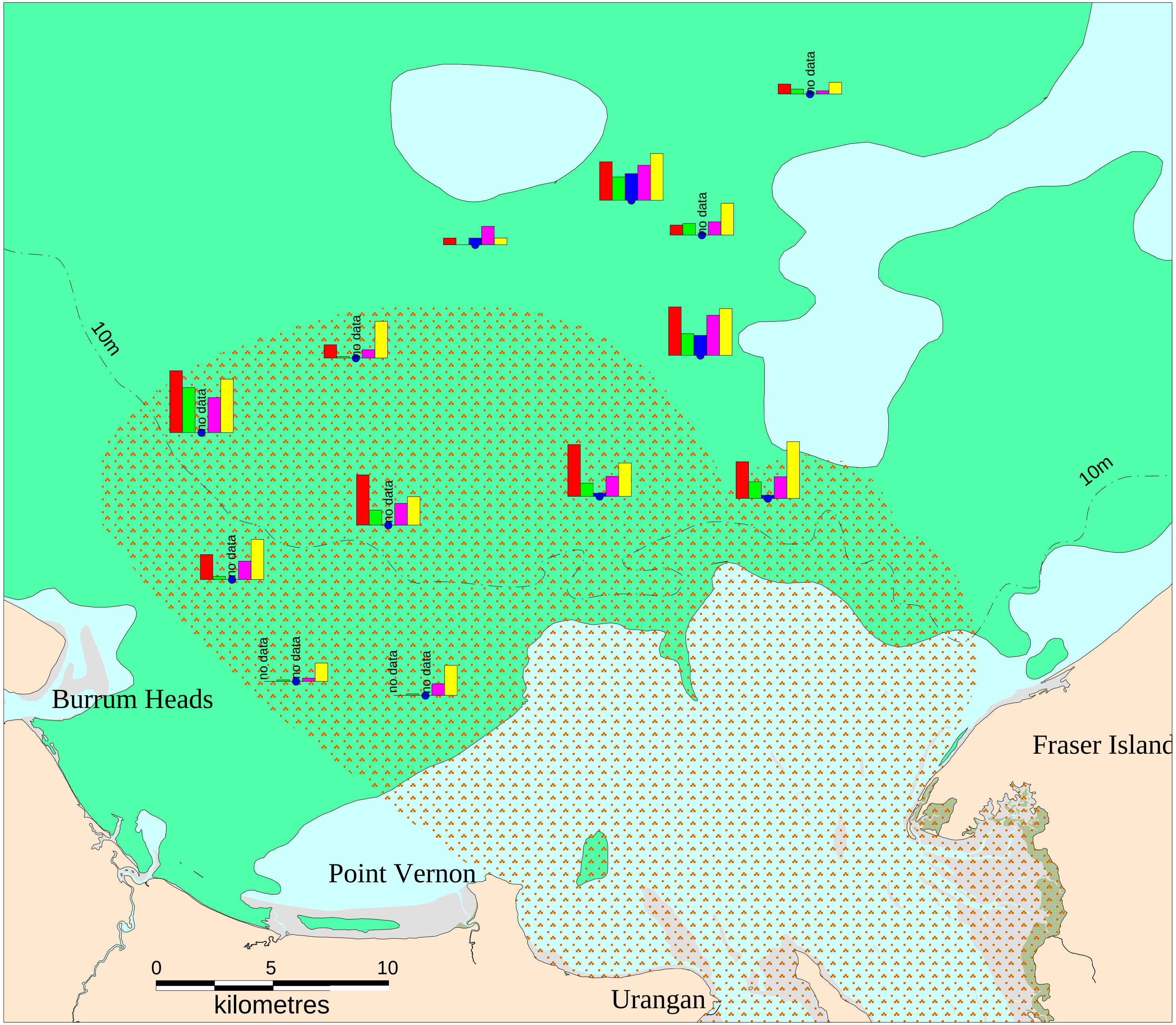
Deepwater seagrass distribution (based on QDPI survey, December 1998).

Extent of flood plume (12th February 1999)

Seagrass biomass (g DW m-2)

50

Dec_1998
April_1999
Aug_1999
Nov_1999
Mar_2002



Source: McKenzie, L.J. and Campbell, S.J. (2003). Seagrass habitats of the Booral Wetlands and the Great Sandy Strait, February/March 2002.
DPI Information Series QI030XX (DPI, Cairns) 20 pp.

Sampling dates:
6-14th December 1998 (McKenzie et al. 2001)
14-17th April 1999, 14-17th August 1999 and
24-26th November 1999 (McKenzie et al. 2001)
1 March 2002.

Funded by the Queensland Environmental Protection Agency, CRC Reef and the Department of Primary Industries.

Produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2003.

DISCUSSION

Seagrass

This is the first study to document the recovery of tropical seagrass intertidal meadows in Queensland following widespread loss over thousands of hectares. The study has shown that despite a 100% loss of seagrass at Booral Wetlands and 50% loss of seagrasses throughout the Great Sandy Strait, following the flooding of the Mary River in 1999, most areas have recovered to pre-flood levels. Most of the seagrass in the intertidal regions of the northern Great Sandy Strait disappeared immediately or in the first few months after flooding. Light reduction and disturbance resulting from increased sedimentation during flood events was the most likely cause of seagrass loss at localities such as Booral (McKenzie *et al*. 2000). Despite the substantial loss of intertidal seagrass habitat all of these meadows have recovered within 3 years post-flood. This is consistent with previous studies in Hervey Bay where recovery of subtidal seagrasses began 1-2 years after the 1992 flooding event (Preen *et al.* 1995). In other areas where losses have occurred due to acute impacts (eg Townsville), seagrass meadows have recovered within 3 to 5 years (L. McKenzie pers.obs).

For the first 12 months of seagrass recovery from November 2000 to November 2001 *Halophila ovalis* comprised 20-85% of the species present at Booral. *Halophila ovalis* is considered a pioneer species and its abundance during 2001 suggests a period of re-colonisation following disturbance. From 2001 to 2002 *Zostera capricorni* increased its relative abundance indicating that the meadow was recovering to the ‘climax’ seagrass community established prior to flooding in February 1999.

Re-colonisation of seagrass at Booral Wetlands, 21 months post-flood suggests an improvement in water and/or sediment quality at that time. Information on water quality from sites in northern Sandy Strait suggests that post-flood recovery of seagrass species is dependent on the time it takes for concentrations of suspended sediments in the water column to decline and for improvements in post-flood light availability to occur (QDPI Unpublished data). At sites on Fraser Island initial re-colonisation of seagrasses in northern Sandy Strait occurred 21 months post-flood, coinciding with improved water quality (ie low turbidity). By comparison re-colonisation at Urangan was delayed (28 months post-flood) at sites with relatively poor water quality (QDPI Unpublished data).

The physical and chemical make-up of sediments can also influence seagrass germination and growth (Brenchley and Probert 1996). Seagrass recovery in the vicinity of Booral Wetlands was from seed germination suggesting that seeds buried in sediments during and after the flood remained viable. The prolonged dormancy of *Zostera capricorni* and *Halophila ovalis* seeds at Booral (21 months) was possibly due to flood related sediment deposition and burial. Favourable conditions for *Zostera capricorni* seed germination include the presence of nutrient rich anaerobic sediments and temperatures of 16-20^{o}C (Brenchley and Probert 1996). At Booral the presence of anaerobic muds, buried roots and rhizomes may have provided a possible nutrient source for resident seed banks. Water temperatures of 16-20^{o}C from May to October are also likely to have supported seed germination. The germination of many thousands of *Zostera capricorni* and *Halophila ovalis* seeds from 2000 onwards and the observed differences in the timing of germination onset between sites suggests that environmental conditions that promote germination differ markedly between sites.

The potential for seeds to disperse from sites in the southern Sandy Strait, where seagrass meadows remained intact, to the northern Sandy Strait cannot be discounted although seeds would have had to floated for more than 10 kilometres from southern areas. This is possible for species of *Halophila* whose seeds are microscopic, but unlikely for *Zostera* whose seeds can only disperse metres (M Waycott, JCU, Pers. Comm.). Transportation of seeds by dugong may also be a possibility, as seeds of *Zostera, Halodule* and *Halophila* have been found in droppings. The viability of seeds after passing through the dugong digestive tract however is unknown (M Waycott, JCU, Pers. Comm.).

Asexual regrowth from vegetative material may have also occurred but few cases of vegetative growth as the primary mechanism for re-colonisation were observed. Little information is available on the environmental cues that trigger asexual growth following dormancy. Recovery of intertidal meadows primarily through seed germination is consistent with previous reports of subtidal meadow recovery in Hervey Bay following flooding in 1992 (Preen *et al.* 1995).

It has been speculated that immediate losses in marine angiosperms may also be the result of herbicides attached to sediment particles washed down in the flood waters. Herbicides such as diuron are known to inhibit photosynthetic processes in seagrasses but no herbicide residues were detected in sediments and seagrass from Hervey Bay in 1997 (Haynes *et al*. 2000) or in sediments collected on Dayman Bank in 2000 (McKenzie *et al*. 2000). A recent survey (2002) however, found that the water and sediments in Hervey Bay and the Great Sandy Strait were contaminated with diuron and 3 other herbicides at relatively low concentrations (McMahan *et al.* 2003). The concentration of herbicides detected did not appear to affect seagrasses photosynthesis, however, there may be an affect on seagrasses of long-term exposure to low concentrations of herbicides (McMahan *et al.* 2003). This study was also outside the sugarcane growing-season and in the absence of a wet season when lower concentrations of herbicides, if any would be expected.

Preen *et al.* (1995) suggested that the intertidal and shallow subtidal seagrass habitat probably would have survived the turbid waters of the flood plumes of the flood – cyclone – flood event in 1992 had it not been for the substrate disturbance associated with cyclonic seas. In 1999 no such cyclone occurred and the present study clearly shows that disturbance from flood waters alone are capable of destroying large expanses of seagrass habitat.

Dugong and turtle

The intertidal seagrasses in the Great Sandy Strait were frequented by dugongs, evident by the high number of dugong feeding trails observed during the survey. The seagrasses also displayed signs of turtle cropping.

Dugong Protection Areas essentially protect dugongs only from netting and other pressures that are related to fishing practices. To manage DPA's effectively, water quality-related problems which effect dugong health, the sources of which lie outside the DPA borders, need to be addressed. Significant reductions in nutrient, sediments and pollutant inputs could be achieved by the adoption of industry codes of best practice by all farmers and by the implementation of the Integrated Catchment Management program (ICM). ICM programs incorporate better land management methods, retention and rehabilitation of riparian zones and wetlands, vegetation management on grazing lands, better fertiliser application technology, and urban stormwater management.

There is no information regarding the affect of the February 1999 Mary River flood on the local turtle population. Green turtle population fluctuations are known to vary from year to year, and recent evidence suggests this may be linked to their food resources.

The loss of expansive areas of intertidal and shallow subtidal habitat, and the degeneration of deepwater seagrasses, in the Great Sandy Strait and Hervey Bay as a result of the February 1999 Mary River flood, is likely to have affected the feeding behaviour and ultimately the breeding cycle of local turtle populations. This may not be evident however, until the 2001 or 2002 nesting season (*results not released by EPA as yet*). Without adequate knowledge of the distribution or abundance of green turtles in the region before or after the flood, it is unclear to what extent this climatic event may have affected the regional population.

⇘ *Long-term monitoring*

To identify and help manage destructive human activities in order to protect crucial fisheries, dugong and turtle habitats, a long term monitoring program for seagrasses has been established in the region - *Seagrass-Watch.* Community volunteers monitor seagrass abundance and composition at selected sites throughout Hervey Bay and the Great Sandy Strait. This is the most intensive seagrass monitoring program in the region and is currently supported by CRC Reef, Department of Primary Industries (Queensland) and Queensland Parks & Wildlife (EPA). Information from this program will be invaluable in monitoring the rate and extent of recovery of seagrass resources in the region.

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Appendix 1. Examples of seagrass above-ground biomass, from reference photos of a 0.25 m^2 quadrat.

Halophila ovalis **3.12 g DW m^{-2}**

Halodule uninervis **(wide) 6.44 g DW m^{-2}**

Zostera capricorni **7.4 g DW m^{-2}**

Zostera capricorni **11.6 g DW m^{-2}**

Zostera capricorni **13.4 g DW m^{-2}**

Zostera capricorni **16.8 g DW m^{-2}**

Zostera capricorni **18.84 g DW m^{-2}**

Zostera capricorni **26.4 g DW m^{-2}**

Appendix 2. Nomenclature developed for determining seagrass community meadow types of Queensland

Quantitative nomenclature of abundance of seagrass species dominated communities

Abundance category	Above-ground g DW m^{-2}			
	Halophila ovalis, H. decipiens, H. tricostata,	*Cymodocea serrulata, ,Halodule uninervis Syringodium isoetifolium*	*Halophila spinulosa*	*Zostera capricorni*
Light	<0.5 g	<5	<15	<20 g
Moderate	0.6 – 3.9 g	5.1 – 24.9 g	15.1-34.9 g	20.1- 59.9 g
Dense	>4g	>25	>35 g	>60 g

Composition nomenclature - composition defined by seagrass species dominance

Community/ Meadow type	Seagrass species composition
Species A	Species A is 90-100% of composition
Species A with species B	Species A is 61-89% of composition
Species A with Species B/ Species C *Alternatives:* *Species A with Genus spp.* *Species A with mixed spp.*	Species A is at least 50% of composition. Species B/ C make up other 50% composition
Species A/ Species B	Species A is 50-60% of composition, while Species B comprises 40-50% of composition

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