METHODS

Site Description

Oyster Point is on the mainland coast at the northern end of the Hinchinbrook Channel (Figure 1). Two mainland catchments flow into this region. At the northern end, waters flow off the Cardwell Range that includes rainforests, plantation pine forests and agricultural land. At the southern end lies the Herbert River catchment that comprises mostly agricultural land (sugar cane and pasture).

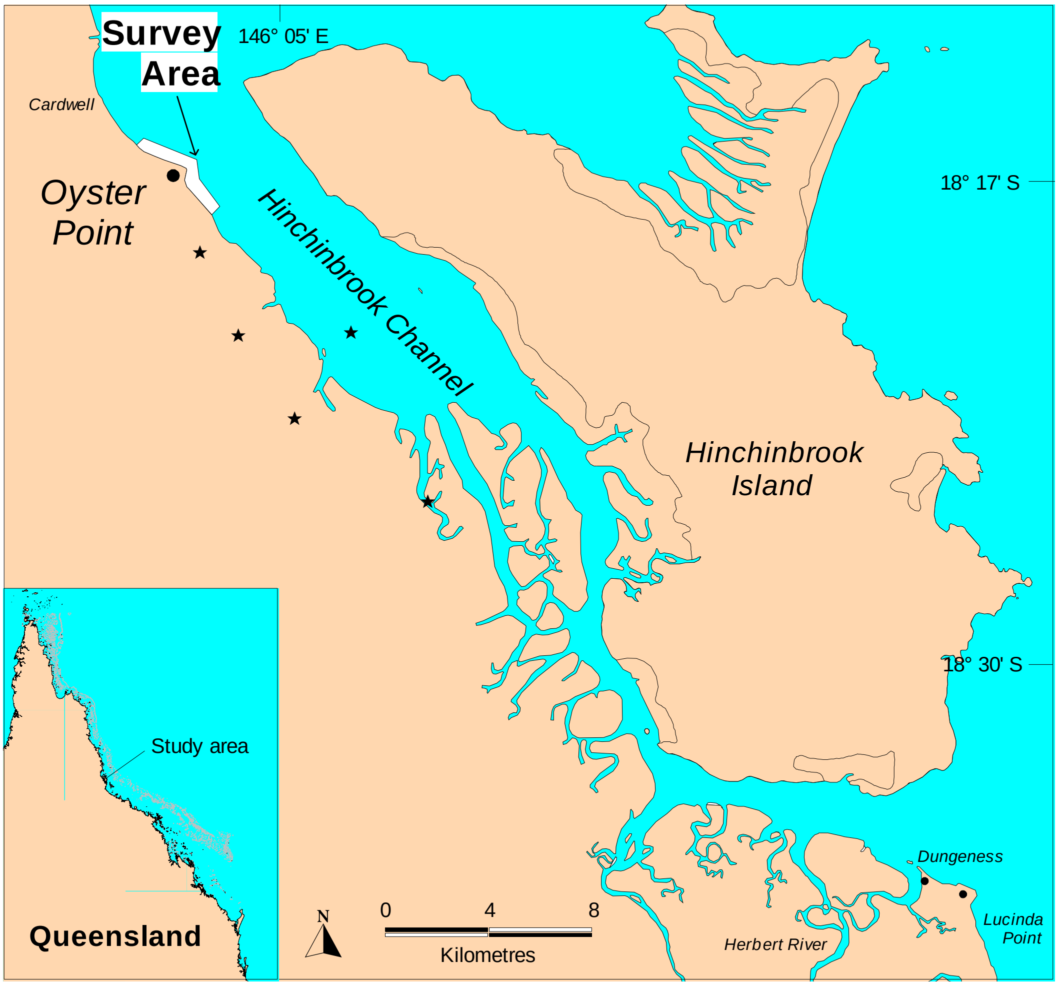

Figure 1. Location of Oyster Point survey area.
(★ denotes existing aquaculture facilities.)

Hinchinbrook Channel is approximately 4 km wide and up to 20 m deep near Oyster Point. Mangrove and *Melaleuca* wetlands and dry sclerophyll woodlands form a major part of the vegetation of the landward (western) margin of the channel. Average annual rainfall for the Cardwell area is 2129 mm, of which 1450 mm falls from January to March (Director of Survey, Department of Defence, Canberra). The only urban coastal developments adjacent to the channel are Cardwell immediately north and the small township of Dungeness in the south. There are two prawn farms and two barramundi farms operating south of Oyster Point, and a small pearl-raft aquaculture operation in the Hinchinbrook Channel. The Port Hinchinbrook development at Oyster Point is a residential and tourist complex including a marina and access channel.

Sampling Design

Seagrass survey methodology was based on standard techniques developed for monitoring seagrasses in tropical Queensland ports (see Coles et al. 1996b; Lee Long et al. 1996). Transects, fixed point sample sites and randomly located sites were used to map the seagrass meadow boundaries and estimate biomass (by species) in the monitoring region which extended 2 km north and 2 km south of Oyster Point (Map 1). Impacts were assumed to be most likely in the north survey region because of the net northward current flow and possible entrainment of sediments (Wolanski 1994; Sinclair Knight Merz (SKM) 1998).

QDPI were asked to include control sites in the Oyster Point sample design from 1997 in a BACI-type design to test for further impacts on above ground biomass from dredging. Given the high spatial variability of the seagrass meadows, sediment types and water quality around Oyster Point, the establishment of 'true' control sites was not feasible. Instead, 'reference' regions were included to provide data on seagrass from areas close to the survey area. These were located 1 km north and 0.5 km south of the core monitoring area. Subsequent sampling of the reference regions from 1997 to 1999 indicated they were too different in seagrass biomass and water quality to be considered suitable for use in a comparative experimental design. The data from these regions were used to provide information as extensions of the north-south distance-from-Oyster Point and are treated this way in the final analysis.

Seagrass

Sampling was conducted in late spring (November/December) each year to allow comparison between years without a seasonal component:

13 – 15th November, 1995 (baseline)

18 – 20th December, 1997 (monitoring)

24 –27th November, 1998 (monitoring)

13 –15th December, 1999 (monitoring)

To measure changes in impact away from the source, 24 sampling transects in total were set perpendicular to the shoreline at measured intervals away from the dredged access channel,. Intervals between transects were approximately 100m in the first 1 km, then every 500m until the 2 km limit of the survey area.

Transects originated from permanent markers established in baseline surveys. Sampling sites on transects were a minimum 20 m apart and continued to at least the seaward edges of seagrass meadows. Additional random sites were sampled to measure continuity of bottom habitat between transects. Seabed habitat parameters were recorded at each site by a diver, within a 10 m radius of a point located by differential GPS.

At each site, the diver recorded estimates of aboveground seagrass biomass, percent seagrass species composition of biomass, percent cover of algae, sediment characteristics and other special notes. A differential global positioning system was used to accurately locate each survey site (±1.5m) and record time. Depths of survey sites were recorded with a depth sounder (nearest decimetre) and standardised to depth below mean sea level (MSL), corrected to tidal datum from recorded water levels for the Cardwell Storm Tide gauge (courtesy Queensland Transport, Maritime Division, 2001).

Above-ground seagrass biomass was determined in 3 replicate quadrats (each $0.25m^2$) at each site, using a “visual estimates of biomass” technique described by Mellors (1991). This technique involved each observer ranking seagrass biomass in the field. Ranks were calibrated for each observer against quadrats that were harvested and measured. The regression equation that best explained the diver's rank estimate of biomass was used to convert that diver's field estimates to aboveground biomass (g DW m^{-2}).

Seagrasses were identified according to Kuo and McComb (1989). Sediment characteristics were described using visual estimates of grain size: shell grit, rock gravel, coarse sand, sand, fine sand and mud.

Geographic Information System

All survey data were entered onto a Geographic Information System (GIS) (MapInfo®), for presentation of seagrass species distribution and abundance. A GIS basemap using aerial photographic images (courtesy Beach Protection Authority, 01/08/1991, altitude 1830m) was rectified to AMG Zone 55 coordinates.

Boundaries of seagrass meadows were determined based on the GPS fix at each survey site. Meadow boundaries drawn on GIS maps are our estimates based on above-ground seagrass presence/absence information and location of sample sites.

Location and size of meadows mapped are affected by errors associated with digitising and rectifying aerial photographs onto basemaps and GPS fixes for survey sites. The error in determining the area of seagrass was estimated to be ±10 m either side of the meadow edge based on the distance between survey sites. Other errors associated with mapping, such as differences between the GPS and the diver’s sampling position, were assumed to be embedded within this range. Estimates of error (in hectares) were calculated using the polygon buffer function in MapInfo®.

Analysis

Overall changes in seagrass biomass (all species and meadows pooled) between years were analysed using ANOVA. Biomass data were $\ln(x+1)$ transformed when data were non-normal.

“Reference” regions were different (seagrass biomass and water quality conditions) from the survey regions near Oyster Point. Because of this they could not be considered as “controls” for analysis of impacts in the survey regions. Instead, changes in seagrass biomass were assessed at each 100m interval away from Oyster Point and the access channel. The ‘reference’ regions only provide information as extensions of the north-south sample design.

The north and south survey regions at Oyster Point appeared to be affected differently by wind-driven waves and turbidity, and were treated separately. Subtidal seagrasses were analysed separately from intertidal seagrasses. Intertidal seagrasses receive a different light regime than sub-tidal plants because they are exposed at low tide. Mean lowest tide (0.45m above Lowest Astronomical Tide (LAT)) for the 2 month period (the period of shoot turnover for these species) prior to sampling was chosen as the level to separate intertidal sites from sub-tidal sites.

Year-to-year changes in aboveground seagrass biomass were analysed for all species pooled. Intertidal and sub-tidal zones were analysed separately in the northern and southern regions. Year-to-year changes in seagrass biomass were examined at each 100m increment away from Oyster Point using transect data only (Appendix - Table 2). Changes in the mean biomass value between 1995 to 1998 and 1998 to 1999 for each 100m increment within each depth zone (± the standard error of the difference between the two means) were plotted to assess trends (Figure 4).

Standard parametric tests were used for analysis of data (Sokal and Rohlf 1987). Non-parametric tests (Kruskal-Wallis) were used when data were unbalanced or non-normal. All divers had significant linear regressions when calibrating aboveground biomass estimates against a set of harvested quadrats (Appendix – Table 3). Depth analyses were performed on transect data only.