CHAPTER 2

Coastal and Nearshore Zone Changes in the Cleveland Bay Area

Dredging, by removing sediment from one locality and dumping it in another, not only influences these two localities, but may also affect other areas of the seabed and neighbouring coasts to which the dumped sediment may be carried subsequently by wind, wave and tidal processes. A series of aerial photographs can provide a valuable record of coastal change and, under clear water conditions, of changes in the nearshore zone. These changes may be entirely natural or may be influenced by man to some degree where engineering structures are built and dredging takes place. Vertical aerial photographs of the Cleveland Bay area spanning the last 47 years, from 1941 to 1988 (Table 5) have been analysed to determine the type and amount of coastal and nearshore changes. These will be considered in detail in this chapter, plus an assessment of changes shown by a limited number of ground surveys. Subsequently the natural processes and man induced effects will be assessed in an attempt to determine the causes of the changes.

The aerial surveys listed in Table 5 were selected to span as long a period, and to give as regular a time interval between surveys, as possible. Because of the small number of aerial surveys undertaken in the 1940's, 1950's and 1960's the time interval was at its longest 17 years. Many more aerial surveys have been flown in the 1970's and 1980's, therefore the time interval has been reduced to 3-4 years generally for this period. The surveys selected were also those which gave an extensive cover of the Cleveland Bay area, at a small enough scale to show detailed coastal and nearshore features. Photographs at a scale of about 1:12,000 are particularly valuable and as six of the surveys were at this scale they could be compared directly. All the aerial

surveys chosen from 1974 onwards used colour film and this provides a considerable advantage over black and white when detailed variations in sediment and vegetation are being studied. However after analysing colour aerial photographs it is relatively easy to analyse black and white photographs of the same area and similar range of phenomena.

The coasts of Cleveland Bay and the adjacent nearshore areas will be examined in an anticlockwise sequence from Shelly Beach - Cape Pallarenda to Cape Cleveland. A similar anticlockwise sequence around Magnetic Island will begin at West Point (Figure 1).

Shelly Beach - Cape Pallarenda

The best exposure of the intertidal and subtidal zones as well as the coastline itself is shown on the aerial surveys of 1-7 June 1959, 30 May 1974, 14 July 1981 and 15 June 1985 (Figure 6). The rock coast of Cape Pallarenda is cut in granite and volcanic agglomerates and two sand beaches have formed within an embayment and west of the rock outcrops. Shelly Beach is backed by a 3km long vegetated sand bar/spit which formed from east to west as indicated by the alignment of its lateral ridges. It may have originated as a nearshore bar which was driven landward by wave washover processes as it extended westwards, in a similar manner to the east Burdekin delta spits and bars (Pringle, 1983 and 1984). Streams from the higher ground inland flow into Shelly Creek which lies along the landward side of the bar/spit and has mouths at both its east and west ends. Throughout its length Shelly Creek is flanked by mangroves which reach the coast near its mouths. An extensive intertidal and subtidal foreland has developed northwards from the Shelly Beach - Cape Pallarenda coast and has been shaped by sediment supply and wave and tidal processes acting from both east and west.

The major change along the coast, revealed by these aerial photographs, is to the sand beach east of the east mouth of Shelly Creek. During the period 1959-1985 this beach was driven shorewards into the mangroves on its landward side. Some of these, now on the seaward side, have died as their roots are exposed by wave erosion.

Comparing the intertidal and subtidal foreland on the different surveys is complicated, firstly by the varying photographic cover of this area (this locality lies at the end of the Beach Protection Authority's St. Lawrence - Townsville coastal segment for aerial surveys) and secondly by the different tidal heights. Overall, the position and form of the major sand banks were similar on the four surveys. The main sediment source appears to lie in the west mouth of Shelly Creek and the mouths of the Bohle and possibly Black Rivers further west. This sediment is transported north-eastwards by wave and possibly tidal current action and is formed into major sand bars aligned south-west to north-east. A much smaller amount of sediment appears to be carried westwards around Cape Pallarenda to form curved sand banks close to the coast in the north-facing embayment and possibly feeding sand bars lying parallel to the coast further west. The eastward side of the foreland is not continuous as a deeper water area lies north of these smaller sandbanks. North of this, towards the apex of the foreland, the major sand bars swing round northward from their south-west to north-east alignment. This effect and the deeper water area are probably produced by strong tidal and wind-induced currents and possibly wave action within the narrow confines of West Channel between the mainland and the south-west coast of Magnetic Island.

Areas of seagrass were clearly visible in the central and coastward sections of the foreland on the 1959, 1981 and

1985 aerial photographs. However none showed on the 1974 photographs despite their high quality and the water clarity which enabled the sand banks to be mapped easily.

Cape Pallarenda to Ross Creek

This section is clearly shown on most of the aerial surveys (Figure 7). A narrow upper beach of relatively coarse sand adjoins the sand dunes in Rowes Bay and below this, exposed at L.W., are a series of irregular sand bars and troughs, generally arranged parallel to the coast. There are only two exceptions to this pattern. At the mouth of Three Mile Creek an intertidal to subtidal delta has formed which is symmetrical in plan view, but which has the best developed sand bars directly seaward and to the north of the mouth. In the inner part of Rowes Bay adjacent to the granite headland of Kissing Point the intertidal zone widens. Only a very narrow sand beach exists flanked by fine sand and mud seaward, in which mangroves are colonizing. Towards LWM a series of oblique sand bars have formed. Between Kissing Point and Ross Creek mouth the coast flanking The Strand in Townsville is artificially protected with large boulders. Only a narrow sand beach is present here and its volume becomes less towards Ross Creek. Before the Harbour was constructed this beach would have received sediment from Ross Creek and Ross River, but the Harbour now blocks that, in acting like a giant groyne.

Changes along this coast have been slight between 1942 and 1988, as shown on the aerial photographs. The delta at Three Mile Creek mouth has remained similar in size and form; the features characterising the inner part of Rowes Bay show little change except for a slight extension of the mangroves; and between Kissing Point and Ross Creek the major change has been man-made with the formation of the marina and reclamation for the hotel and casino adjacent to the Eastern Breakwater of the Harbour.

Ross River to Sandfly Creek

The aerial surveys which best show not only this section of coastline but also the intertidal zone are those of 1-7 June 1959, 14 June 1974, 14 July 1981 and 15 July 1985 (Figure 8). Ross River, its tributary Stuart Creek and Stuart Creek's distributaries, Sandfly Creek and the smaller creek westwards, have provided the main source of terrigenous sediment input to Cleveland Bay until the building of Ross River Dam in 1973. The coastline is composed of sand ridges with areas of mangroves commonly both seaward and landward. The intertidal zone clearly shows that Ross River carried the largest sediment load which was initially deposited in an intertidal and subtidal delta with its apex eastwards of the river mouth, reflecting the eastward curve of the main channel. Smaller sediment loads were deposited by Sandfly Creek and the western distributary and this extended the delta eastwards, in a series of sandbanks.

Changes to this coastline between 1941 and 1973 were examined in detail by comparing aerial photographs taken in 1941, 1952, 1959, 1961, 1965, 1971/72 and 1973 (McIntyre and Associates, 1974). Erosion was most pronounced near the mouths of Ross River and Sandfly Creek (Figure 9), especially during the inter-survey periods 1952-1959 and 1965-1971/2 and is attributed to cyclones in 1956 and 1971. Progradation of sand ridges in the Ross River mouth area and mangroves and sand ridges near the mouth of Sandfly Creek partially counterbalanced the erosion. Changes were less marked along the central section of this coast, where progradation by mangroves was dominant overall.

Whilst knowledge of this type and scale of coastal change is important in understanding the evolution of a particular coastline, it was felt that in the current

project, where the possible effects of dredging are of major concern, a broader examination of both coastline and intertidal zone was more appropriate.

The map drawn from the 1959 aerial photographs (Figure 8) shows the Ross River mouth in a natural state except for the influence of the Harbour's Eastern Breakwater. The main channel curved eastwards from the mouth, but more minor channels were cut slightly to the west through sandbanks in which the river's load was initially deposited. The 1974 aerial photographs were taken at a higher state of the tide with the channels and banks therefore less exposed; a channel can be seen directly seaward of the mouth, but a major one eastwards is only hinted at. (The 1973 photographs show both channels more clearly). The major reclamation of land on the west shore of the mouth between 1968 and 1970 had involved the pumping ashore of 3,034,000 cu yards of sand from the adjacent intertidal sandbanks and this probably resulted in the development of a larger channel directly seaward of the mouth. By 1981 the main channel lay in this position, with the only evidence of the former eastward swinging one being in the position of the apex of the intertidal/subtidal delta. This change was strongly influenced by developmental dredging of the Ross River channel from 1977 into the early 1980's. Between 1981 and 1985 an angled harbour wall was constructed east of the Eastern Breakwater across part of the inter-tidal sandbanks on the west side of Ross River mouth. Changes will clearly result within the semi-enclosed area, but the main channel lying parallel to its eastern side has not changed position during this period. The minor channel leading westwards from it has diminished as sandbanks have grown west of the main channel. The apex of the delta in 1985 and in 1988 still shows the former dominance of the eastward curving main channel.

The intertidal zone beyond the mouth of Sandfly Creek and the western distributary has shown no major changes between 1959 and 1985. In each case the channel has curved westwards from the mouth and has contributed sand to the intertidal/subtidal delta and its eastward extension. The sandbanks between the two channels lie oblique to the coastline, being nearer to it at their western ends.

Along the coastline mangroves have become almost continuous, seaward of a vegetated sand ridge, during this period. Only immediately east of Ross River are they absent, with the sand ridge flanking the coast.

Sandfly Creek to Cocoa Creek

The aerial surveys of 11 August 1961, 9 October 1973, 30 May 1974, 28 November 1978, 14 July 1981 and 24 June/15 July 1985 provide the clearest views of this coast and the adjacent intertidal zone (Figure 10). This is a lower energy coast than that further west in Cleveland Bay, owing to the sheltering effect of Cape Cleveland. Three main creeks enter the bay along this coast, from west to east, Alligator, Crocodile and Cocoa Creeks. Elsewhere the coast is flanked almost continuously by mangroves and the adjacent intertidal zone is of mud or fine sand.

Changes along the coastline were examined by comparing aerial photographs taken in 1941, 1959 and 1973 (McIntyre and Associates, 1974)(Figure 11). The most pronounced erosion occurred between 1941 and 1959 along the mangrove coast between Sandfly and Alligator Creeks where a recession of 50m occurred, and along the west banks of the mouths of Alligator, Crocodile and Cocoa Creeks where about 30m was removed. Elsewhere between 1941 and 1973 mangrove colonization produced coastal progradation, of about 20m south of Sandfly Creek and east and west of Alligator Creek.

Examination of this coastline on the 1974, 1978, 1981 and 1985 aerial photographs revealed no change in the extent of the mangrove belt and little change in the channels and sandbanks in the intertidal zone seaward of the creek mouths. Elsewhere the intertidal zone of fine sediment was traversed by a network of very small drainage lines only. Between Sandfly Creek and the west side of Crocodile Creek no seagrass was visible on the 1974, 1978 and 1981 photographs. It was identified, however, on the 1985 survey near and seaward of LWM, between a point midway between Sandfly and Alligator Creeks and the west side of Crocodile Creek. Between Crocodile Creek and Cocoa Creek its extent varied on the different surveys:

1974 No seagrass was visible along this coast.

1978 Seagrass below LWM was visible immediately west of Crocodile Creek channel and north-eastwards from there parallel to the coast.

1981 Seagrass above and below LWM extended from immediately west of Crocodile Creek channel north-eastwards parallel to the coast.

1985 Seagrass below LWM extended parallel to the whole section of coast and appeared relatively dense east and west of the Cocoa Creek channel.

Cocoa Creek to Cape Cleveland

The aerial surveys of 11 August 1961, 9 October 1973, 30 May 1974, 28 November 1978, 15 July 1981 and 24 June 1985 provide the best cover of this coast for the present study. Along the west side of the granite promontory of Cape Cleveland, with volcanic rocks forming its tip, rocky coasts and small headlands are interspersed with small bayhead sand beaches with mangroves in places (Figure 10).

Comparison between 1959 and 1973 aerial surveys (McIntyre and Associates, 1974) showed these beaches to be relatively stable in comparison with other Cleveland Bay beaches. The changes which were noted had no clear pattern. The beach near the lighthouse receded about 4m whereas the next bay south, Red Rock Bay advanced by a similar amount. Long Beach was relatively stable except near the creek mouth where the shore prograded by 3m as also did the beach in White Rock Bay. The sandy part of Laun's Beach remained stable. The mangroves occurring at intervals along this section of coast, were also stable generally but with a small advance taking place where silt had accummulated at the southern end of each patch. A mangrove advance of 20m occurred on Long Beach, 25m on Laun's Beach and about 10m north of Cocoa Creek, south of the most southerly rock outcrop of Cape Cleveland.

In the present study, examination of the 1974, 1978, 1981 and 1985 aerial photographs showed no clear change to the sand beaches along this section of coast and only small changes along two parts of the mangrove fringed coast. At the north-east end of Laun's Beach, the mangroves extended a short distance along the coast towards the rock outcrop between 1974 and 1985; and mangrove colonisation began on the north-east side of White Rock Bay. The extent of the seagrass varied on the different surveys, as was the case further west between Sandfly and Cocoa Creeks:

1961 Seagrass was visible below LWM seaward of the north-east end of Laun's Beach and Long Beach.

1973 No seagrass was visible above or below LWM.

1974 Seagrass was visible only below LWM immediately east of Cocoa Creek channel. From Cape Cleveland south to Long Beach the water was very turbid with large southward pointing plumes of sediment in suspension.

1978 Seagrass was visible below LWM north-east of Cocoa Creek in two bands parallel to the coast, with a strip of sediment between. Along the rocky coast, seagrass was visible below LWM only intermittently due to highlights on the photographs where the sun was reflected from the sea surface.

1981 North-east of Cocoa Creek seagrass was visible above and below LWM in the troughs between oblique bars of sediment (the south end of the bars, lying closest to the coast). There was thicker, more continuous seagrass seaward. Along the rocky coast, a large area of seagrass was visible above and below LWM extending from the first rock headland south of Cape Cleveland to Long Beach.

1985 North-east of Cocoa Creek seagrass was visible again in troughs between oblique sediment ridges, and opposite the first rock headland north of Laun's Beach, in troughs between sediment ridges parallel to the coast. Northwards to the first rock headland south of Cape Cleveland seagrass was visible below LWM, in patches interspersed with sediment nearer the coast, but with denser growth seawards.

Magnetic Island, South-West Coast

The aerial surveys of 1-7 June 1959, 11 August 1961, 30 May 1974, 28 November 1978, 14 July 1981 and 15 June 1985 give a good overall view of this coast and the intertidal zone. The coasts of Magnetic Island have a distinct feature not found on the mainland coast of Cleveland Bay, namely fringing coral reefs. Because the south-west coast is the most sheltered, coral reef growth has been most extensive here, probably since Holocene time, and an extensive reef flat with overlying sediment extends seaward into West Channel from near Nobby Head to the south side of Bolger Bay, (Figures 12 and 13). Apart from rocky shores near Nobby Head and West Point, the remainder of this coast is depositional, with sand beaches south of West Point, between Young and Bolger Bays and in Cockle Bay, and with mangroves fringing the remainder.

The rocky shores and sand beaches show little change on this sequence of aerial surveys from 1959 to 1985, and the seaward margin of the mangroves is similar throughout. However whereas a dense continuous strip of mangroves is shown on the 1959 and 1961 photographs, extending landwards to salt flats or higher ground, marked destruction had

occurred by 1974 in a broad strip landward of the seaward fringe. This destruction was most marked in the mangroves between Bolger and Cockle Bays, although it had occurred to a lesser extent in the Young Bay mangroves. The zone of dead mangroves continued to be a prominent feature in 1978, but by 1981 regrowth was turning the strip into patches and those patches had diminished further by the 1985 survey.

The coral reef flat is the most dominant feature of the intertidal zone along the southern half of this coast, with fine-sand and mud in this zone northwards off Bolger and Young Bays. In 1959 patches of seagrass and sediment were visible under water extending between these two bays. Further south areas of seagrass were growing in the channels near the landward side of the coral reef flat north-west of Cockle Bay and seaward, interspersed with sediment, on the reef flat off Bolger Bay. Patches of seagrass and sediment were visible also in a belt off Cockle Bay and extending along the shore to near Nobby Head. This seagrass distribution pattern was broadly similar in 1961, but in 1974 no seagrass appeared, despite clear under-water visibility on the aerial photographs. In 1978 a small area was visible in the channel landward of the reef flat south of Bolger Bay, more extensive areas were seen under-water off Young Bay and there were possibly small patches interspersed with sediment south-east of Cockle Bay. The 1981 aerial survey showed dense seagrass growing in the channel landward of the reef flat south of Bolger Bay and seagrass patches growing extensively in the sediment on the reef flat seawards. Dense seagrass was also seen growing under-water off the north end of the reef, seaward of Bolger Bay. The 1985 aerial photographs show dense seagrass patches in the channel landward of the reef, north-west of Cockle Bay and on the northern end of the reef flat. Seagrass interspersed with sediment is also extensive on the reef flat north-west of the water pipeline which was installed between 1981-1985 (a

marked contrast existed between the two sides of the pipeline, with no seagrass identifiable to the south-east). Some seagrass was growing above LWM in the fine sediment seaward of Young and Bolger Bays.

Whilst much of the coral reef flat is dead with sediment on it, and seagrass in places, bare coral was visible in all the aerial surveys, off Cockle Bay, in the channel which separates the landward area of reef flat from the oval area seaward.

Magnetic Island, South-East Coast

The aerial surveys of 1-7 June 1959, 11 August 1961, 30 May 1974, 28 November 1978, 14 July 1981, 28 June 1985 and 30 June 1988 give good coverage of this coast and intertidal zone. The coast consists of a series of granite promontories separated by bays, which are only small along the northern half, but are much broader further south (Figure 12). In the major Picnic, Nelly and Geoffrey Bays large coral reefs have formed in the shelter of rock headlands to the north-east, with smaller reefs forming in similar positions in Alma, Arthur, Florence and Gowrie bays further north. In all except the last of these bays and in Rocky Bay sand bayhead beaches have formed.

From these aerial photographs at a scale of about 1:12,000 or more the sand beaches in the small bays show little change in width or bayhead position throughout the period 1959 to 1988. Similarly the coral reefs in the small Alma, Arther, Florence and Gowrie Bays, which are seen beneath the water on most of these surveys, show little detectable change in extent.

The three major bays have several characteristics in common and show a little variation between surveys. Picnic

Bay has a continuous upper beach of relatively coarse sand and is flanked by a lower beach of finer sand which reaches its broadest at the north-east corner of the bay. The fine sand covers the upper part of the coral reef flat. Seaward the reef flat with living coral is extensively exposed at LWST. The extent to which the reef flat was bare of sediment varied on different surveys. The lower beach was less extensive in 1974 than in 1959; it was more extensive west of the jetty in 1978 than in 1974; it was less extensive east of the jetty in 1981 than in 1978; but subsequently in 1985 and 1988 it showed little variation with 1981. A separate coral reef lies seaward and curves round Nobby Head.

Nelly Bay shows a similar distribution of upper and lower sand beaches to Picnic Bay, but towards the seaward side of the lower beach, sand bars are usually well developed, extending from the granite headland to the north-east towards the centre of the long upper beach. However the extent of sand bar formation showed some variation between surveys. There were less sand bars in 1974 than in 1959; they were better developed in 1978 than in 1974; they were less developed and smaller in 1981 than in 1978; there was little change in 1985, but in 1988 a very well developed large sand bar extended almost completely across the north-eastern end of the bay from close to the rock headland. Nelly Bay has an extensive coral reef seaward and south-west of the lower sand beach.

Geoffrey Bay has upper and lower beaches and a coral reef similarly distributed to those in Picnic and Nelly Bays. As in Nelly Bay sand bars develop along the seaward edge of the fine sand lower beach, from midway along the rock headland at the north-east end of the bay to about two-thirds of the distance south-westwards along the narrow upper beach. There were less variations on the lower beach in Geoffrey Bay than in Nelly Bay during the period of aerial surveys.

Little change occurred between the 1959 and 1981 surveys, then in 1985 the lower beach had extended towards the quay on the headland, but had moved away from it again by 1988.

Magnetic Island, North Coast

The aerial surveys of 1-7 June 1959, 11 August 1961, 30 May 1974, 28 November 1978, 14 July 1981 and 15 June 1985 provide the most complete cover of this coast. For most of its length this is a rocky coast mainly formed in granite, but with volcanic rocks outcropping near West Point (Figure 12). Bayhead beaches of relatively coarse sand have formed in the small bays: Radical, Balding, Maud, Norris, Wilson and Huntingfield Bays. Small coral reefs have developed seaward of the sand beaches in Maud and Wilson Bays which are well sheltered by rock headlands on their western sides. Horseshoe Bay is the only major bay along this coast. It has a long sand bayhead beach and coral reefs have formed in two sheltered embayments along the rock headland bounding its eastern side. A sand beach flanks the landward side of the northerly reef.

No pronounced changes could be detected in the small bays, either to the sand beaches or coral reefs, from the aerial surveys. In Horseshoe Bay, the sand beach varied little in width or length between 1959 and 1985. George Creek, which was diverted towards the eastern end of the beach in 1959 and 1961, had cut a more direct route seaward nearer the western end by 1974; then between 1981 and 1985 it became increasingly direct. The coral reefs and beach landward of the northern one changed little during the whole period, but there was a slight variation in the extent to which sand delivered by a small creek, covered the south end of the southern reef.

Ground Surveys

From the aerial surveys, changes in plan view have been mapped, described and discussed for the period 1941 to 1988. In comparison with the aerial surveys, coastal ground surveys have been much more limited in scope and frequency.

The most extensive ground surveys were carried out by the Beach Protection Authority in 1982 and 1983 along the west Cleveland Bay coast between Townsville Harbour and Cape Pallarenda, and on Magnetic Island between Picnic and Alma Bays on the south-east coast and between Radical and Horseshoe Bays on the north coast (Figure 14). 1/6 of the approximately 2,000m long cross profiles were surveyed only once, but the remaining 45 were surveyed in both years. Overall the vertical changes along these were slight and are summarized in Table 6. (As these survey results were obtained as plotted profiles amounts of change cannot be ascertained precisely).

Other coastal ground surveys were carried out by the Townsville Port Authority along 5 cross profile lines between Townsville Harbour and Cape Pallarenda (Figure 15). Replicate surveys were undertaken on 6 dates between 26 January 1978 and 28 March 1983 and a summary of the changes between successive surveys is given in Table 7. As with the Beach Protection Authority surveys, overall the vertical changes along the profiles were only slight (ie 0.1 - 0.2m accretion or erosion). The most consistent changes were in the sand bars and troughs along the landward 850m of the Run 4 profile in Rowes Bay. (Since this data was collected and analyzed a further survey was undertaken along 4 of the above cross profile lines on 7 December 1988).