APPENDIX 1

The full range of environments where suitable biogenic carbonate deposits may occur include:

1 reef flat sediment accumulations
2 beaches and spits associated with fringing reefs
3 shell beaches, chenier ridges, and shell banks
4 fossil reefs
5 coral cays and associated beaches
6 sub-tidal leeward detrital reef slopes
7 *Halimeda* banks.

1 Reef flat sediment accumulations

Coral debris produced by high-energy wave action on the windward reef front and crest may be transported onto the reef flat. Subsequent movement of the sediment is episodic and it may be temporarily stored in a variety of accumulations including rubble zones, sanded reef flats, shingle ramparts and unvegetated cays. A wide range of sediment particle sizes occurs, although wave action can selectively sort the material into well sorted accumulations.

2 Beaches and spits associated with fringing reefs

Temporary storage of coral sediment can occur in beaches behind or downdrift of fringing reefs. Sediments are commonly fine grained (0.25–1 mm), although some coral shingle beaches occur, and may contain appreciable amounts of terrigenous (i.e. non-carbonate) materials. This is particularly true of beaches backed by large catchment areas, from which considerable quantities of terrigenous sediment can be delivered to the coastal zone. Thus, in mainland locations and on the larger high islands, beach sediments near fringing reefs are predominantly composed of non-carbonate materials.

Long term storage of carbonate sediment can occur in spits, beach ridges, and raised beaches. Such deposits are known from numerous islands between Cairns and the Whitsundays (Hopley 1971, 1975), and essentially represent fossil beach deposits that now occur above the level of high tide. Extraction of these deposits would amount to mining of a non-renewable resource. These sites have not been investigated in this report.

3 Shell banks, chenier ridges, and shell beaches

In some estuarine settings large populations of bivalves occur in the mud of the intertidal and shallow sub-tidal zones. Erosion of the mud by tidal currents exposes the shells to wave action which can then sweep them up into shell banks or beaches. If the shoreline advances the beach becomes abandoned in the supra tidal flats and is called a chenier ridge. Shell content in the cheniers is variable, and older ridges have considerable vegetation and soil development. They represent a potential on-land source of shell-grit but the material would require washing and crushing for use in marine aquaria. Shell-rich chenier ridges are known from numerous parts of the Queensland coastline (Short, 1990). However, only those in Broad Sound are easily accessible.

4 Fossil reefs

Fossil or dead reef complexes have not been investigated in the Great Barrier Reef Region. However, such structures are known from around islands in central and southern Moreton Bay (Orme and Day, 1978), and have been dredged for many years to provide raw materials for the cement industry in Brisbane (Willmott et al., 1978; O'Flynn et al., 1983). Ten of these have been mapped as significant sources of coral sediment, and 6 are currently leased for dredging operations

5 Coral cays and beaches

Coral cays and their beaches are composed almost entirely of carbonate sediments, swept up from the reef flat by wave action. Two types are recognised, those composed of coral shingle, and those composed of fine coral sands (0.25-1 mm). Generally the sediment sizes are unsuitable for marine aquaria. All these cays are vegetated, although to greatly varying extents and their environmental sensitivity renders them unsuitable as carbonate sediment sources. None occur in the coastal areas excluded from the GBRMP. However, a number are known to occur in the Flinders and Holmes Reefs, some 250 km and 325 km NE of Townsville. Cays in the Flinders Reef have already been used as a bulk source of coral sand.

6 Sub-tidal leeward detrital reef slopes

A prominent feature on the lee sides of large crescentic, lagoonal, planar and ribbon reefs is a detrital slope of fine to medium coral sands (0.125-0.5 mm), that may extend down into water 30 m deep. This material represents a loss of sediment from the reef flat, and as such would constitute an environmentally sound potential source of carbonate sediment. However, the sediment sizes are probably too fine for marine aquaria, and cost of extraction would be prohibitive. None occur in areas excluded from the GBRMP.

7 *Halimeda* Banks

Extensive banks of *Halimeda* derived carbonate sediments occur in some areas of the Great Barrier Reef Region (Drew and Abel, 1985). The sediments are up to 75% carbonate and consist of 20-30% *Halimeda* fragments 2-5 mm in diameter. The banks lie in 20-50 m water depths and occur near the outermost barrier reefs. While they do contain sediments suitable for use in the marine aquaria trade, costs of recovery would be prohibitive, and they only occur inside the GBRMP.

APPENDIX 2

Particle size and composition analyses

1.	Location:	Port Douglas, sand bar near Morey Reef (16-010)
	Grid reference[1] :	7965/347775
	Mean size:	0.18mm (fine sand)
	Sorting:	0.47 (well sorted)
	Composition:	non-carbonate
2.	Location:	Double Island, upper foreshore
	Grid reference:	8064/594501
	Mean size:	1.73mm (granule)
	Sorting:	0.52 (moderately well sorted)
	Carbonate%:	86%
3.	Location:	Double Island, sand spit, upper foreshore
	Grid reference:	8064/592498
	Mean Size:	0.89mm (very coarse sand)
	Sorting:	0.53 (moderately well sorted)
	Carbonate%:	93%
4.	Location:	Double Island, reef flat sand spit
	Grid reference:	8064/592497
	Mean size:	0.73mm (coarse sand)
	Sorting:	0.67 (moderately well sorted)
	Carbonate%:	92%
5.	Location:	Fitzroy Island, Nudey Beach, upper foreshore
	Grid reference:	8064/919275
	Mean size:	>4.00m (gravel)
	Sorting:	n.d.[2]
	Carbonate%:	95%
6.	Location:	Fitzroy Island, Nudey Beach, back shore
	Grid reference:	8064/919275
	Mean size:	0.62mm (coarse sand)
	Sorting:	1.18 (poorly sorted)
	Carbonate%:	82%

1 1:100 000 scale sheet number and Australian Map Grid Reference

2 n.d. = no data

7.	Location:	Fitzroy Island, Nudey Beach, inner back shore
	Grid reference:	8064/919275
	Mean size:	0.55mm (coarse sand)
	Sorting:	0.75 (moderately sorted)
	Carbonate%:	83%
8.	Location:	Fitzroy Island, Resort Beach, upper foreshore
	Grid reference:	8064/922278
	Mean size:	0.23mm (fine sand)
	Sorting:	0.45 (well sorted)
	Carbonate%:	85%
9.	Location:	Flying Fish Point, mid foreshore
	Grid reference:	8162/019649
	Mean size:	1.18mm (very coarse sand)
	Sorting:	0.49 (well sorted)
	Composition:	non-carbonate
10.	Location:	Johnstone River mouth, Coconut Point, mid foreshore
	Grid reference:	8162/005638
	Mean size:	0.80mm (very coarse sand)
	Sorting:	0.83 (moderately sorted)
	Composition:	non-carbonate
11.	Location:	Browns Beach, upper foreshore
	Grid reference:	8162/087497
	Mean size:	0.20mm (fine sand)
	Sorting:	0.42 (well sorted)
	Composition:	non-carbonate
12.	Location:	Browns Beach, mid foreshore
	Grid reference:	8162/088497
	Mean size:	0.71mm (coarse sand)
	Sorting:	1.20 (poorly sorted)
	Composition:	non-carbonate
13.	Location:	Lindquist Island
	Grid reference:	8162/105479
	Mean size:	n.d
	Sorting:	n.d
	Carbonate%:	92%

14. Location: North Cowley Beach, mid foreshore
Grid reference: 8162/092481

Mean size:
Sorting: 0.43 (well sorted)
Composition: non-carbonate

15. Location: Garners Beach, mid foreshore
Grid reference: 8162/045303

Mean size: 1.72mm (coarse sand)
Sorting: 1.60 (poorly sorted)
Carbonate%: 33%

16. Location: Garners Beach, upper foreshore cusps
Grid reference: 8162/045303

Mean size: 3.90mm (granule)
Sorting: 0.98 (moderately sorted)
Carbonate%: 19%

17. Location: Bingil Bay, mid foreshore
Grid reference: 8162/045282

Mean size: 0.42mm (medium sand)
Sorting: 0.58 (moderately sorted)
Carbonate%: 6%

18. Location: Lucinda Point, intertidal bar
Grid reference: 8160/309514

Mean size: 0.36mm (medium sand)
Sorting: 0.42 (well sorted)
Composition: non-carbonate

19. Location: Lucinda Point, intertidal zone
Grid reference: 8160/305511

Mean size: 0.35mm (medium sand)
Sorting: 0.67 (well sorted)
Composition: non-carbonate

20. Location: Lucinda Point, crest of sand spit
Grid reference: 8160/301513

Mean size: 0.35mm (medium sand)
Sorting: 0.50 (well sorted)
Composition: non-carbonate

21. Location: Alva, Lynchs Beach, intertidal bar
Grid reference: 8359/490504

Mean size: 0.23mm (fine sand)
Sorting: 0.48 (moderately well sorted)
Composition: non-carbonate

22. Location: Don River mouth, mid foreshore
Grid reference: 8558/280918

Mean size: 0.66mm (coarse sand)
Sorting: 1.07 (poorly sorted)
Composition: non-carbonate

23. Location: Don River mouth, upper foreshore
Grid reference: 8162/087497

Mean size: 0.37mm (medium sand)
Sorting: 1.07 (poorly sorted)
Composition: non-carbonate

24. Location: Stone Island, NW beach, mid foreshore
Grid reference: 8557/338847

Mean size: 0.85mm (very coarse sand)
Sorting: 0.53 (moderately well sorted)
Carbonate%: 88%

25. Location: Stone Island, SE beach, mid foreshore
Grid reference: 8557/350837

Mean size: 0.69mm (coarse sand)
Sorting: 0.52 (moderately well sorted)
Carbonate%: 90%

26. Location: Stone Island, Shoalwater Bay beach, mid foreshore

Grid reference: 8557/342842

Mean size: 0.56mm (coarse sand)
Sorting: 0.55 (moderately well sorted)
Carbonate%: 87%

27. Location: Stone Island, sand spit upper foreshore
Grid reference: 8557/335837

Mean size: 0.95mm (very coarse sand)
Sorting: 1.17 (poorly sorted)
Carbonate%: 75%

28. Location: Conway Beach, upper foreshore
Grid reference: 8657/813342

Mean size: 0.20mm (fine sand)
Sorting: 0.42 (well sorted)
Composition: non-carbonate

29. Location: Conway Beach, lower foreshore
Grid reference: 8657/813341

Mean size: 0.11mm (very fine sand)
Sorting: 0.54 (moderately well sorted)
Composition: non-carbonate

30. Location: Flinders Reef, 'tail' of AWS[1] cay, upper foreshore

Grid reference: 17°44'O"S/148°26'40"E

Mean size: 0.85mm (very coarse sand)
Sorting: 0.23 (very well sorted)
Carbonate%: 100%

31. Location: Holmes Reef, AWS Cay, east end, upper foreshore

Grid reference: 16°28'45"S/147°53'0"E

Mean size: 2.52mm (granule)
Sorting: 1.25 (poorly sorted)
Carbonate%: 100%

32. Location: Holmes Reef, top of AWS cay
Grid reference: 16°28'45"S/147°53'0"E

Mean size: 1.38mm (granule)
Sorting: 0.41 (well sorted)
Carbonate%: 100%

33. Location: Holmes Reef, AWS cay, westend upper foreshore

Grid reference: 16°28'45"S/147°53'0"E

Mean size: 2.00mm (granule)
Sorting: 0.76 (moderately sorted)
Carbonate%: 100%

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1 AWS = Automatic Weather Station

APPENDIX 3

Field Survey for Carbonate and Silica Sediment Deposits - Progress Report, November 1989.

INTRODUCTION

The Great Barrier Reef Marine Park Authority has commissioned the Department of Geography, James Cook University of North Queensland to conduct a field survey for carbonate and silica sediment deposits. The purpose of this study is to identify possible sources of:

1. high carbonate sediment deposits suitable for collection and use by the marine aquaria trade, and,

2. silica sediment deposits for beach replenishment purposes,

that are located within or adjacent to areas of the Great Barrier Reef Region, but not within the Great Barrier Reef Marine Park.

Collecting or taking of calcium carbonate and silica sediments from within the Great Barrier Reef Marine Park, in large quantities, or for commercial purposes is prohibited under Section 38 (2) of the *Great Barrier Reef Marine Park Act 1975*. However, such activities may be permitted in areas outside the Great Barrier Reef Marine Park where other statutory bodies are able to grant the necessary permission. The study aims to identify potential sources in such areas adjacent to the Great Barrier Reef Marine Park. The scope of the study does not extend to providing the full range of information that would be required in the event of any of these potential sites being used as carbonate or silica sediment sources.

PROJECT TIMETABLE

The project is being carried out in four phases:

1 October-November 1989; literature survey, map and aerial photograph analysis, site selection,
2 December 1989-January 1990; field work,
3 February-March 1990; laboratory analysis,
4 April 1990; Report preparation for submission by 30th April 1990.

Results of phase 1 are summarised in this report.

LITERATURE SURVEY

Literature consulted has included works on:

- marine aquaria,
- beach replenishment,
- Queensland coastal environments,
- descriptions of local coastal environments.

Relevant information has been published by, or is available from numerous bodies, including the Queensland Beach Protection Authority, Geological Survey of Queensland, CSIRO, Bureau of Mineral Resources, Great Barrier Reef Marine Park Authority, Queensland Department of Environment and Conservation (QNPWS), University of Queensland, James Cook University, and a wide range of academic journals and texts. There is little detailed information on

potential carbonate sediment sources along the Queensland coastline. However, there is a considerable body of relevant literature on silica sediment sources. This published information will be reviewed in the final report.

MAP ANALYSIS

Maps consulted include:

- topographical sheets (1:100 000 and 1:50 000)
- cadastral maps
- hydrographic charts
- Great Barrier Reef Marine Park zoning maps
- Department of Environment and Conservation/Queensland National Parks and Wildlife Service zoning plans
- Great Barrier Reef Index Series sheets and Gazetteer.

AERIAL PHOTOGRAPH ANALYSIS

Aerial photographs in the collections of the Great Barrier Reef Marine Park Authority and James Cook University Department of Geography have been examined. Most useful have been those flown at low levels for the Beach Protection Authority at a scale of 1:12,000. Higher altitude photographs obtained for the State and Commonwealth governments has also been used. This work has allowed identification of potential sediment sources in both onshore, and shallow nearshore environments. The usefulness of Landsat satellite images is also being assessed.

STUDY AREAS

The project objective is to identify sources of carbonate and silica sediment that are located within or adjacent to areas of the Great Barrier Reef Region, but not within the Great Barrier Reef Marine Park. The first step in the site selection procedure was to determine those areas of the Queensland coastline that have been excluded from the Great Barrier Reef Marine Park.

A total of 26 areas along the coastline have been excluded from the Park. They cover approximately 1400 km, which is 40% of the Great Barrier Reef Marine Park coastline. These areas may be subdivided as follows:

GBRMP Section	Number of areas excluded from GBRMP	Length of coastline	% of Section coastline excluded
Far Northern	11	197 km	23%
Cairns	4	367 km	70%
Central	6	289 km	31%
Mackay/Capricorn	5	533 km	46%
TOTAL	26	1386 km	39.8 %) of GBRMPA
TOTAL (excl. Far Northern)	15	1189 km	45%) coastline

The Far Northern Section areas are largely inaccessible and will not be investigated in the field. The study will concentrate on the 15 areas excluded from the Cairns, Central, and Mackay-Capricorn sections of the Park. While outside the jurisdiction of the GBRMPA, other organisations are concerned with coastal zone management in these areas. The Queensland Beach Protection Authority has prepared Erosion Prone Area Plans for many coastal Local Authorities, as well as having declared a number of Coastal Management Control Districts. Also, the Queensland Department of Environment and Conservation has established a number of Marine Parks that extend into these areas. Removal of carbonate or silica sediments from these areas may be unacceptable.

SITE SELECTION

Identification of potential sediment sources was based on the type of sediment sought, considerations of where these sediments generally occur, and the identification of such sites in the study areas.

1 Carbonate Sediment Sources

Carbonate sediments are required by the marine aquarium trade as a substrate and as a filter material. The requirements are:

i) high calcium carbonate content
ii) grains 2-5 mm in diameter
iii) uniform sized grains (well sorted)
iv) grains of a rough and angular shape.

Coral debris is particularly suitable, although shell grit, limestone and dolomite can be used.

The range of environments were suitable biogenic carbonate deposits may occur include:

- beaches composed of sediment derived from nearby fringing reefs
- coral cays
- sub-tidal detrital slopes of crescentic, lagoonal or planar reefs
- *Halimeda* banks
- shell banks, shell beaches, chenier ridges.

While these areas may be expected to contain a high percentage of carbonate sediments, the size, sorting and shape characteristics may not be suitable. For example, the 2-5 mm size range is quite rare in natural sediments, and most material would need crushing and grading for it to fit the above criteria. Most of the environments listed above occur within the Great Barrier Reef Marine Park and thus cannot be investigated. However, some reefs occur along the mainland coast in areas excluded from the Park.

A total of 39 fully developed fringing reefs covering an area of approximately 51 km^2 occur in coastal areas excluded from the park.

Section	Number of fringing reefs out-side GBRMP	Total area covered	Average reef size	Numbers of reefs larger than 0.5 km^2
Cairns	23	40.05 km^2	1.74 km^2	15
Central	4	6.60 km^2	1.65 km^2	2
Mackay/Capricorn	12	4.13 km2	0.34 km^2	2
TOTAL	39	50.78 km2	1.30 km^2	19

It is likely that only the larger of these fringing reefs, greater than 0.5 km^2, would produce suitable quantities of carbonate sediment. Accessible coastline associated with reefs in the following areas will be investigated:

- Mossman - Port Douglas - Trinity Bay (7 reefs: 16-007, 16-008, 16-009, 16-010, 16-045, 16-047)
- Fitzroy Island (2 reefs: 16-054, 16-055)
- Double Point (near Innisfail) (1 reef: 17-039)
- Garners Beach - Bingil Bay - Clump Point (near Tully) (3 reefs: 17-049, 17-050, 17-052)
- Stone Island - Adelaide Point (near Bowen (2 reefs: 20-004, 20-005)
- Flat Top Island, Victor Island, Hay Point (near Mackay) (3 reefs: 21-007, 20-013, 20-015)

Suitable quantities of carbonate sediment in the form of shell material may be associated with shell banks, shell beaches and chenier ridges. These environments are known to occur in the Broad Sound area and they will also be assessed. Potential sources of carbonate sediment may also occur in reef areas to the east in the Coral Sea, and to the north in Torres Strait. Flinders Reefs and Holmes Reefs, the two most accessible of these areas, will be surveyed in this study.

2 Silica Sediment Sources

Silica sand is being sought by local authorities and tourist resort operators for beach replenishment purposes to:

i) increase the volume of the buffer zone between the sea and land developments for safety and erosion protection purposes, and,
ii) improve the visual quality and beach amenity.

The characteristics of the sand required will depend in each case on the nature of the beach that is to be replenished. Ideally the borrow sand should have the same composition, size and sorting characteristics as the areas that needs renourishment.

Environments where silica sediments may occur include:

- river channels
- dune systems
- beaches
- intertidal shoals and bars
- subtidal shoals in water shallower than 10 m depth
- shoals in water deeper than 10 m.

Sediments in these environments have been deposited by a variety of processes regimes and the resulting deposits are usually of quite different characteristics. River sediments are commonly coarser and more poorly sorted than beach sands, while dune sands, intertidal shoals and sub-tidal shoals are generally finer than beach materials. Thus, acceptable matching of supply and demand sediments may be difficult to achieve.

Source areas also need to be carefully chosen, as along the coastline these environments form closely interrelated sediment transfer and depositional systems. Removal of sand from an environment may cause erosion in other parts of the system. This is particularly true of beaches, which are the most active components of those systems. Deeper water shoals and inland sand dunes are the most acceptable potential sources as thy contribute little sediment to other parts of coastal systems.

Potential sites have been identified in areas where:

i) rivers deliver large volumes of sediment to the coastal zone
ii) large volumes of sediment are available
iii) the site is not actively supplying sediment to other parts of the coastal system, and
iv) there is no existing erosion problem.

Sites to be investigated are:

Cape Flattery dune field
Mossman-Port Douglas intertidal shoals
Johnstone River-Flying Fish Point
Cowley Beach
Lucinda shoals
Burdekin delta
Clark shoals
Don R. delta
Proserpine River
Sandringham Bay
Yeppoon intertidal shoals
Gladstone Harbour entrance.

SUMMARY

1 Areas of the Queensland coastline adjacent to, but outside the Great Barrier Reef Marine park are being investigated for potential sources of carbonate and silica sediments.

2 Due to the lack of reefs in these areas, deposits of carbonate sediments, suitable for use in the marine aquaria trade, are likely to be of limited extent.

3 Possible alternative sources may occur offshore on Flinders and Holmes reefs in the Coral Sea.

4 Sources of silica sediments are likely to occur in association with a number of the larger river sediment inputs to the coastal zone.

5 However, suitable matching of these source sediments with the beaches needing replenishment may be difficult to achieve.