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MANGROVE PRODUCTIVITY MONITORING STUDY

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REPORT DETAILS

Title:	MANGROVE PRODUCTIVITY MONITORING STUDY
Client:	PORT OF BRISBANE AUTHORITY
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Synopsis:

This report relates to the monitoring of mangrove productivity in the Fisherman Islands mangroves for the years 1992/93. Mangrove productivity attributes monitored included litterfall and stem girth increment.

REVISION/CHECKING HISTORY

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Fisherman and Whyte Islands have been developed as a major port facility at the Brisbane River mouth by the Port of Brisbane Authority (PBA). The PBA foresees the need to expand port capacity which will involve disturbance of intertidal and subtidal lands of the Fisherman Islands, some of which are vegetated by mangroves.

Mangrove areas cover approximately 220 ha. Mangrove communities of Moreton Bay are highly productive and structurally complex. They provide large amounts of plant litter, an important primary food source for aquatic organisms of mangrove-dominated estuaries. Mangroves are also important nursery and feeding grounds for many fishes and crustaceans, most of which are of direct importance to commercial and recreational fisheries.

In a regional context, the mangroves of the study area on Fisherman Islands represent 1.7% of the 13900 ha of mangroves in Moreton Bay.

This document provides the 1992/93 results of a mangrove productivity monitoring study in the Fishermen Islands region, commissioned by the PBA and it is the second report of a three year survey. It expands on the results of earlier mangrove monitoring initiated in September 1991. The earlier study (WBM Oceanics Australia 1992) described the structure of the mangrove communities at which monitoring studies were conducted, and the results of initial monitoring (up to February 1992).

The study has gathered data on the productivity of mangrove communities at four sites in the study area from September 1991 to May 1993. Litterfall and stem girth increment were the two aspects of mangrove productivity monitored. The data from this study will enable detailed comparisons to be drawn between mangrove communities prior, during and following reclamation works. Key findings of the studies are:

- The mangroves at the monitoring sites are typical in structure and composition to mangrove communities elsewhere in Moreton Bay

- The mangroves are healthy and not subject to on-going adverse impacts

- Annual total litterfall ranged from 4.86 to 6.96 t/ha/yr, agreeing closely with other litterfall studies conducted in Moreton Bay and indicating that port-related activities have not adversely affected productivity of adjacent mangroves

- Stem growth over the duration of the study was very small and highly variable

- No major structural changes in the mangrove communities at the sites were observed over the monitoring period (September 1991 to May 1993) although changes may occur over a longer term

Seasonal patterns in litterfall are emerging from the study results. The first major fruit litterfall has been recorded since the study was initiated (September 1991), indicating that fruit production is not always annual. Continued monitoring will allow verification of the periodicity of fruit production in the *Avicennia marina* - dominated mangrove communities adjacent to the Port of Brisbane. This information will be vital to the Port Authority if it plans seed collections for mangrove regeneration projects.

Litterfall monitoring is proceeding without major technical problems and is probably the longest of such studies to be conducted in Moreton Bay. Results to date have been very reliable.

Litterfall monitoring extended over the next 1-2 years would provide data encompassing a broad range of seasonal and annual variation in productivity. Litterfall should continue to be collected at intervals of no more than two months; longer intervals allow trapped litter to decompose and result in underestimation of litterfall production.

Stem girth increments were very small, in many cases negative (decrements) and highly variable, despite the relatively uniform size of the tree stems measured. The initial expectations of the stem girth increment data have not been realised. However, with the monitoring equipment already installed, it is relatively inexpensive to take further readings. Over a longer measurement period (up to five years) changes in stem girth increment may be larger and more readily interpreted.

Monitoring to date has provided a full year baseline data set and should be continued in order to elucidate seasonal and annual trends in mangrove productivity during and following reclamation activities.

The on-going mangrove monitoring program provides a means by which any adverse effects to mangrove communities neighbouring the port development area can be assessed.

1.0 INTRODUCTION

The Port of Brisbane Authority (PBA) has developed Fisherman and Whyte Islands as a major port facility at the mouth of the Brisbane River. Tidal wetlands (saltmarsh, mangroves and seagrass) occur on and adjacent to the islands.

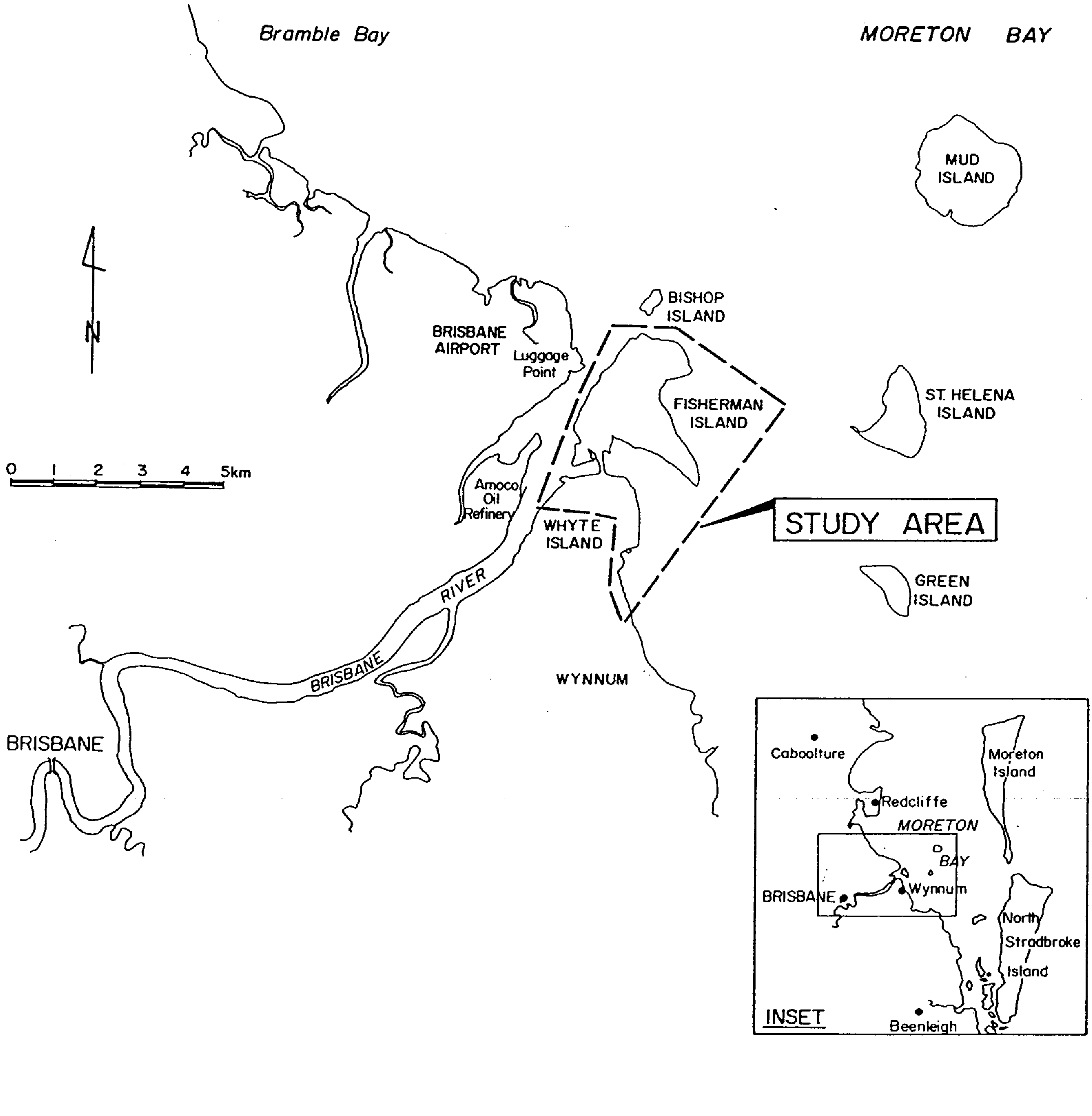
The PBA has identified a long term need to expand the capacity of the port to accommodate a future expansion in port usage (PBA 1992). The Moreton Bay Strategic Plan (DEH 1992), designed to ensure appropriate land use within Moreton Bay, accommodates lands at the Fisherman Islands for port-related activities.

Further expansion of port-related facilities on the southern side of the mouth of the Brisbane River, as described in the PBA strategic plan, will require disturbance of intertidal and subtidal lands at the Fisherman Islands, some areas of which support mangroves.

WBM Oceanics Australia was commissioned by the PBA to undertake studies of tidal wetlands occurring on and adjacent to Whyte and Fisherman Islands and the Wynnum foreshores. The study area is shown diagrammatically in Figure 1.1, and in aerial photography (1991) in Figure 1.2.

The present studies are the continuation of mangrove productivity monitoring, initiated in September 1991 and reported earlier (WBM Oceanics Australia 1992).

The results of the present study will provide the PBA with background information for port environmental management and possible opportunities to accommodate development strategies which enhance, rehabilitate, restore and even create mangrove habitat areas. Section 8.0 provides a glossary of terms used in this report.



STUDY AREA

FIGURE 1.1

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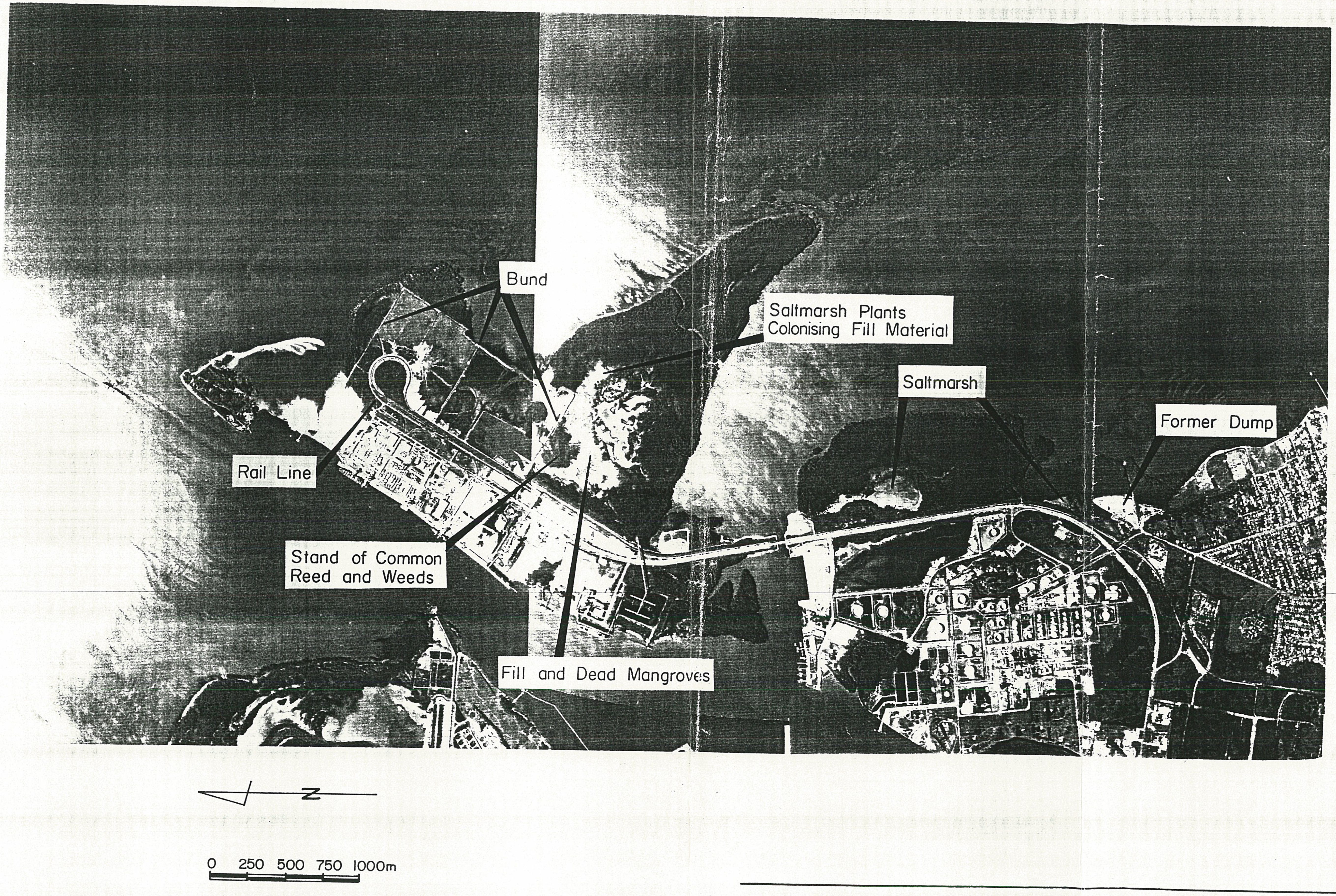

FIGURE
1991 AERIAL PHOTOGRAPHY OF STUDY AREA 1.2

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2.0 MANGROVE VEGETATION IN THE STUDY AREA

A detailed description of the extent of various wetland types (mangroves, saltmarsh, seagrass) that occur in the study area is provided in the preceding report (WBM Oceanics Australia 1992).

2.1 SPECIES COMPOSITION

Mangroves are the most conspicuous component of tidal wetlands in the Fisherman Islands region and occur from the mean tide level to extreme high water spring level. Seven mangrove species (Table 2.1) occur in Moreton Bay (Hyland and Butler, 1988), five of which were observed during the present field surveys on Fisherman and Whyte Islands and the adjacent Wynnum foreshores.

Hutchings and Saenger (1987) noted that in terms of the number of species and structural complexity of forests, the Moreton Region has one of the most highly developed mangrove areas along the east coast of Australia.

2.2 REGIONAL SIGNIFICANCE

WBM Oceanics Australia (1992) provided an accurate assessment of mangrove areas near the Fisherman and Whyte Islands. In contrast to previous studies, the assessment was undertaken using a combination of aerial photography and detailed ground surveys (truthing).

Other studies on mangrove communities near the Fisherman Islands is provided in WBM Oceanics Australia (1992) and any inaccuracies in these studies is discussed.

The area of mangroves in the Fisherman Islands study area (351 ha) (WBM Oceanics Australia, 1992) represents 2.7% of the 13900 ha mangrove resource of Moreton Bay, from the southern tip of south Stradbroke Island to Caloundra (Hyland and Butler 1988).

The structure of the mangrove forests in the study area varies from low shrubland to forest and is typical of mangrove communities occurring at the mouths of rivers along western Moreton Bay.

The changes in areas of mangroves at Fisherman Islands will be calculated from aerial photographs at the completion of bund wall extensions currently under construction. Bund walls will be completed in June/July 1993, and therefore areas of disturbance will be calculated in the 1993/1994 report.

TABLE 2.1: MANGROVE SPECIES WHICH OCCUR WITHIN THE MORETON REGION

SCIENTIFIC NAME	COMMON NAME
Avicennia marina (Forskal) Vierh. var. *australasica* (Walp.)*	grey mangrove
Aegiceras corniculatum (L.) Blanco*	river or black mangrove
Ceriops tagal var. *australis* C.T. White*	yellow-leaved spurred mangrove
Rhizophora stylosa Griff.*	spotted-leaved red mangrove
Bruguiera gymnorhiza (L.) Lam*	large-fruited orange mangrove
Exocoecaria agallocha L.	milky (blind-your-eye) mangrove
Lumnitzera racemosa Wild.	white-flowered black mangrove

* recorded in Fisherman Islands study area

2.3 ECOLOGICAL IMPORTANCE

Mangroves are highly productive ecosystems which contribute significantly to the coastal ecosystem through export of organic matter. The primary food source for aquatic organisms in most mangrove dominated estuaries, such as Moreton Bay, is particulate organic material (detritus) derived from the decomposition of mangrove forest litter (leaves, twigs, and reproductive or fruit material; Odum and Heald 1972). Mangrove plant litterfall (the most commonly measured component of net primary production) from Fisherman Islands and the Wynnum foreshores is 4.86 to 6.96 dry t/ha/yr (see Section 4.1.1).

During decomposition, mangrove litter becomes a food source for a wide variety of filter, particulate, and deposit feeders such as molluscs, crabs and polychaete worms. These primary consumers, which include representatives of most phyla, are food for secondary consumers, usually small forage fish species and juveniles of the larger predatory species that form the third consumer level (Odum and Heald, 1972). There are also important fisheries species which occupy both primary and secondary consumer levels. They feed directly on particulate organic detritus and also upon primary consumers.

Mangroves function as important fish nursery and feeding grounds. Numerous studies have noted that fishes (particularly juveniles) are more abundant in mangrove dominated areas than in other nearshore habitats (Robertson and Duke 1987, Morton 1990). Possible explanations for this increase in fish abundance near mangroves include high availability of foods (Beumer 1978, Blaber 1980, Morton 1990) and a high degree of structural heterogeneity of habitat in the form of prop roots, pneumatophores and tree stems (Robertson and Duke 1987). Many of the fishes present near mangrove areas of subtropical Queensland are of direct fisheries value (WBM Oceanics Australia 1991).

Morton (1990) examined fish communities using foreshore mangrove stands at Lota Creek (10 km south of the Fisherman Islands). He noted that:

- 46% of the species, 75% of the number of fishes and 94% of the biomass taken during the study were of direct importance to regional fisheries.

- Standing crop estimates for fish occurring within the mangroves were amongst the highest recorded for estuarine areas in Australia, whilst those for adjacent waters were comparable to those of other estuarine studies.

- A conservative estimate of the value of mangroves to fisheries was $8380/ha/yr. This was based upon the monetary value of fish caught during the study and does not take into account the numerous commercially important juveniles captured or non-commercial values (recreation, education).

Some prawn species, especially banana prawns, also rely heavily upon mangrove areas as nursery grounds (see Dall 1985 for review, Staples *et al.* 1985, Robertson and Duke 1987). Banana prawns (*Penaeus merguiensis*) are taken by beam trawlers operating near the mouth of the Brisbane River but are a relatively minor component of the Moreton Bay fisheries (WBM Oceanics Australia 1991). Staples *et al.* (1985) concluded that banana prawns are almost exclusively found along the mud banks immediately adjacent to the mangrove fringe. Prawns and similar macrobenthos within mangroves are also important food sources for many fish species (Blaber 1980, Morton 1990).

Few mammals, amphibians or reptiles inhabit subtropical mangroves exclusively. Mangroves generally provide an extension of their range or a bridging habitat between terrestrial habitats. Mangroves provide roosting (and to a lesser extent, feeding) sites for fruit bats and many species of estuarine birds.

Mangroves also stabilise foreshores, minimising erosion (Bird 1971, Bird and Barson 1977).

3.0 MONITORING PROGRAMME

The present monitoring program is a continuation of the mangrove productivity studies initiated in September 1991 (WBM Oceanics Australia 1992). This quantitative ecological data will assist in making objective assessments of any impacts to the mangroves resulting from proposed reclamation works.

Selection of monitoring sites, and monitoring parameters, was undertaken in consultation with PBA environmental personnel. Monitoring studies commenced in September 1991. The results of continued monitoring, up to May 1993, is documented in this report.

3.1 MONITORING SITES

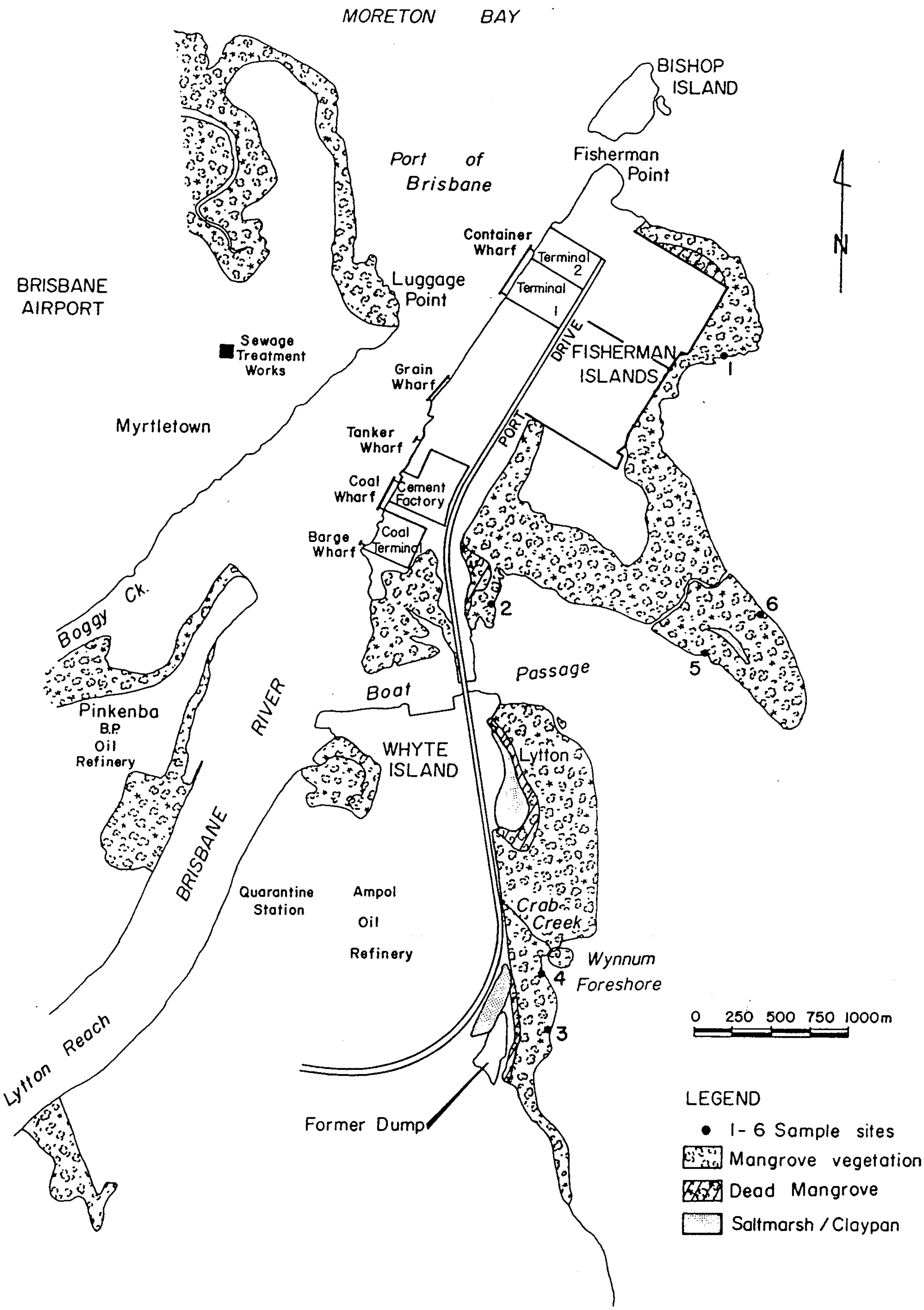
Six sites were identified by the PBA for the mangrove study; sites 1 and 6 in the eastern Fisherman Islands region, sites 2 and 5 fringing the Boat Passage and sites 3 and 4 on the Wynnum foreshores near Whyte Island (Figure 3.1).

All sites are dominated by grey mangrove *(Avicennia marina* var. *australasica)* although red mangrove *(Rhizophora stylosa)* and yellow mangrove (*Ceriops tagal* var. *australis*) are numerically very minor components at some sites. No other mangrove species were observed at any of the sites although other species occur landward.

Each of the six sites is immediately landward of the fringing mangrove community. These communities were selected for study because:

- the stature of their component trees and their open structure allowed efficient measurement.
- their position slightly landward from the water's edge afforded some protection from human interference with measuring equipment.
- the mangrove communities at the six sites did not appear to be adversely affected by sediment runoff from landward reclamation works that have occurred for port development.

The structure of the mangrove community at each site is summarised in Section 4.0.



MANGROVE VEGETATION, FISHERMAN ISLAND 1991

FIGURE 3.1

WBM OCEANICS AUSTRALIA

3.2 MONITORING METHODS

3.2.1 Forest Structure

A detailed description of the techniques adopted for measurement of forest structure was provided in an earlier report (WBM Oceanics Australia 1992).

The variables measured in September 1991 to characterise forest structure at the six Fisherman Islands and Wynnum foreshore mangrove monitoring sites were:

(i) Projective foliage cover
(ii) Canopy height
(iii) Stand density
(iv) Stand basal area

3.2.2 Litterfall

Primary production, from wetland plant communities, is the basis of the estuarine ecosystem (Hutchings and Saenger 1987). Net primary production estimates (gross production less production lost in plant respiration) are not available for Australian mangroves (Hutchings and Saenger 1987). Instead, components of net primary production which are easier to measure are used to compare the relative productivity of different plant communities.

Litter production is a component of net primary production commonly measured in mangrove studies because it is more readily obtained than estimates from gas exchange systems or micro-climatology measurements (Boto 1983).

Plant litterfall monitoring was conducted at sites 1,4,5 and 6 (Figure 3.1). On the 13th September 1991, fourteen randomly located litter catchers were suspended from canopy branches at each site to keep them clear of high tides. Since then, litterfall collection has occurred as detailed below.

1st Collection	December 1991
2nd Collection	February 1992
3rd Collection	May 1992
4th Collection	July 1992
5th Collection	September 1992
6th Collection	November 1992
7th Collection	January 1993
8th Collection	March 1993
9th Collection	May 1993

Each litter catcher comprised a metal ring 50 cm in diameter ($0.2m^2$ catching area) around which an inverted cone of shade-cloth (50% shade) was constructed.

After collection, the plant litter was sorted into leaf, stem and fruit material (including all stages from bud to fully developed propagule), oven dried at 80°C for 48 hours, then weighed (± 0.01 g).

3.2.3 Stem Girth Increment

Stem girth increment studies were initiated at all six sites when dendrometers were installed on the 25th of October, 1991. A detailed description of the construction and installation of these dendrometers is provided in WBM Oceanics Australia (1992).

Ten trees at each site were permanently fitted with dendrometers. The dendrometers were read at relatively distant intervals (February 1992, September 1992 and March 1993) to avoid the considerable short term variations that occur in stem growth (Carron 1968) and focus on long term changes.

3.2.4 Photographic Record

In addition to these quantitative measures, a photographic record of the mangrove community at each site was made by taking a photo facing each major cardinal point - north, south, east and west - from a reference point marked with a 2.4 m star picket. These photographs will allow gross structural changes in the communities to be monitored.

Statistical Analysis

Mangrove litterfall was compared between sites for the first complete year (September 1991 to September 1992) and for each bimonthly collection using a one-way ANOVA in conjunction with a test of least significant difference ($p = 0.05$).

Statistical analysis was carried out using the computer software SPSSPC (SPSS 1988).

4.0 RESULTS

The structural features of the mangroves at each site are summarised in Table 4.1, and described in detail in an earlier report (WBM Oceanics Australia 1992).

4.1 LITTERFALL

Litterfall production is examined under the following categories:

- Annual Production
- Site Differences
- Seasonal Patterns

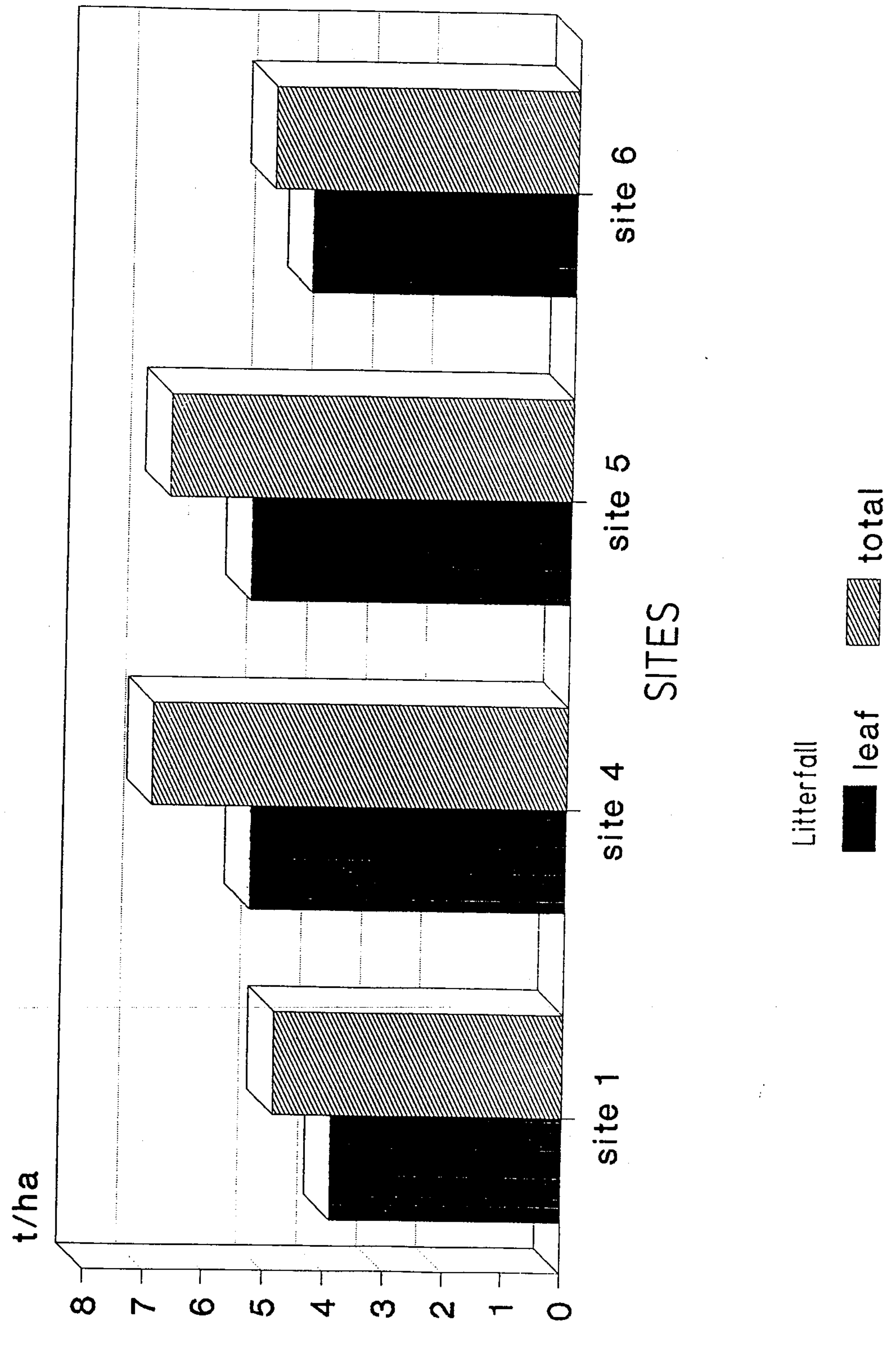
4.1.1 Annual Production

Total and leaf litterfall at each site in the first complete year of the litterfall study (from installation of litterfall catches in September 1991 to the fifth collection in September 1992) is set out in Table 4.2 and illustrated in Figure 4.1.

Preliminary analysis of litterfall since the end of the first year (September 1992) suggests that annual production in the following year (1992/93) will be greater, due to a fruit litterfall event that did not occur in the first year of monitoring (see 'Seasonal Patterns', below).

Total litterfall in the first year ranged from a low of 4.86 t/ha (site 1) to a high of 6.96 t/ha (site 4).

Leaf litterfall in the first year ranged from a low of 3.89 t/ha (site 1) to a high of 5.36 t/ha (site 5) and contributed from 76% (site 4) to 87% (site 6) of total litterfall (Table 4.2).



LITTERFALL,
SEPTEMBER 91 to SEPTEMBER 92

FIGURE
4.1

WBM OCEANICS AUSTRALIA

TABLE 4.1: STRUCTURAL FEATURES OF FISHERMAN ISLANDS AND WYNNUM FORESHORES MANGROVE MONITORING SITES

	SITE					
	1	2	3	4	5	6
Vegetation structural form	Open forest	Open forest	Low open forest	Low open forest	Low closed forest	Open forest
Dominant species	*Avicennia marina*	*Avicennia marina*	*Avicennia marina*	*Avicennia marina*	*Avicennia marina*	*Avicennia marina*
Projective foliage cover (%)	62	67	62	62	72	61
Canopy height (m)	10 - 13	10 - 13	8-10	8-10	8-10	10-13
Stand density (stems per ha)	334	462	830	876	893	380
Stand basal area (m^2/ha)	24.0	23.1	24.1	28.9	24.1	24.3
Stem Girth (cm)*	87.0 ± 4.4 (n=72)	73.5 ± 3.5 (n=68)	56.9 ± 2.5 (n=60)	59.7 ± 3.1 (n=60)	55.9 ± 2.2 (n=60)	86.1 ± 3.5 (n=60)
General description	Large tall trees, predominantly single-stemmed and widely spaced	Tall, medium diameter trees, single or double stemmed	Small crooked-stemmed trees, closely spaced	Small diameter, low spreading trees, crooked stems closely spaced.	Small trees, crooked stems, community of closely spaced trees.	Large tall trees, well spaced, predominantly single stemmed.

* mean ± standard error

TABLE 4.2: TOTAL AND LEAF LITTERFALL PRODUCTION
(t/ha; September 1991 - September 1992)

SITE	COMMUNITY STRUCTURAL TYPE	LITTERFALL COMPONENT		
		Total (t/ha) *	Leaf (t/ha) *	Leaf/Total (%)
1	*Avicennia marina* open forest	4.86 (0.36)	3.89 (0.25)	80
4	*A.marina* low open forest	6.96 (0.39)	5.29 (0.24)	76
5	*A. marina* low closed forest	6.75 (0.38)	5.36 (0.28)	79
6	*A. marina* open forest	5.08 (0.32)	4.44 (0.29)	87

* average (standard error)

4.1.2 Site Differences

The first year's total and leaf litterfall was significantly greater ($p=0.05$) in the low open and low closed *Avicennia marina* forests (sites 4 and 5 respectively), than in the taller *A.marina* open forests (sites 1 and 6, see Table 4.2 and Figure 4.1).

The trend of significantly higher litterfall production at sites 4 and 5 than at sites 1 and 6 was also apparent for many, but not all, of the bimonthly collections.

4.1.3 Seasonal Patterns

The seasonal pattern of average litterfall production, for the total and leaf litterfall components, is illustrated in Figures 4.2 and 4.3. The range in values for each collection, across all sites (1, 4, 5 and 6) is set out in Table 4.3. Site averages for leaf and total litterfall production had standard errors of less than 10% for most of the collections.

Total Litterfall

All sites displayed the same seasonal patterns in average total litterfall production (Figure 4.2) with maxima in May 1992 (autumn), November 1992 (spring) and March 1993 (autumn). Minima occurred in July and September 1992 (winter - spring).

TABLE 4.3: RANGE IN PRODUCTION (TOTAL AND LEAF LITTER) ACROSS ALL SITES (1, 4, 5 AND 6) OVER TOTAL MONITORING PERIOD.

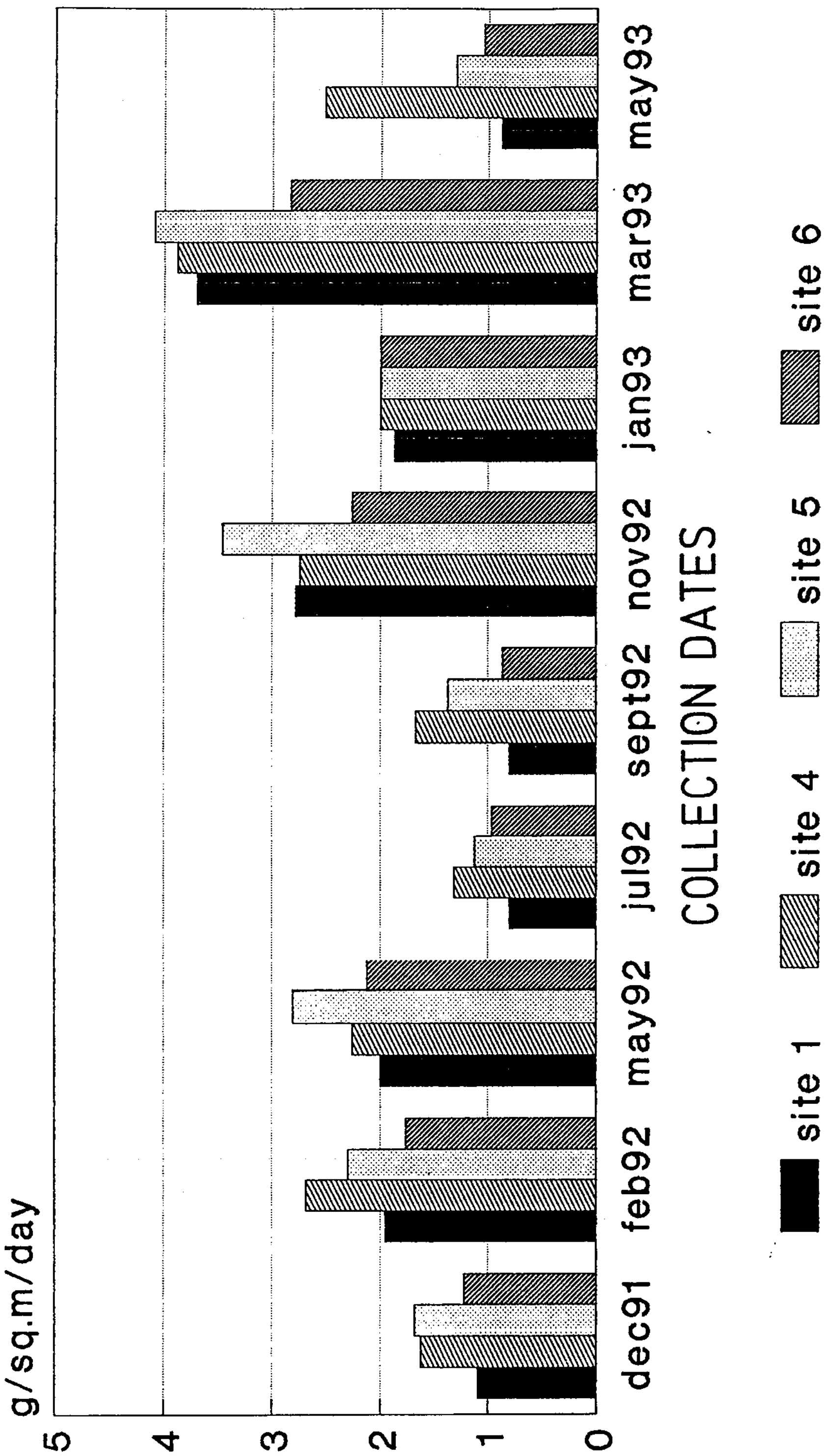
COLLECTION	RANGE ($g/m^2/day$)	
	TOTAL COMPONENT	LEAF COMPONENT
December 1991	1.09 - 1.68	0.99 - 1.47
February 1992	1.76 - 2.68	1.40 - 2.01
May 1992	2.00 - 2.80	1.73 - 2.29
July 1992	0.80 - 1.31	0.56 - 0.96
September 1992	0.80 - 1.67	0.64 - 1.23
November 1992	2.26 - 3.46	2.10 - 2.95
January 1993	1.87 - 2.00	1.40 - 1.57
March 1993	2.83 - 4.09	0.84 - 1.00
May 1993	0.87 - 2.51	0.52 - 0.93

Leaf Litterfall

Similar seasonal patterns occurred in leaf litterfall production as for total litterfall with maxima in May 1992 (autumn) and November 1992 (spring) and minima in July and September 1992 (winter to spring) and May 1993 (autumn). This was expected, since leaf litterfall accounted for 60% or more of total litterfall at most of the collections. However, the peak in total litterfall, in March 1993 did not correlate with a peak in leaf litterfall which comprised only 23% to 30% of total litterfall. This was due to a heavy fall of fruit material (discussed below), which accounted for 60 to 69% of total litterfall.

Fruit Litterfall

Fruit litterfall made only a minor contribution to total litterfall for most of the bimonthly collections (usually less than 5%) until March 1993 where it accounted for 60% to 69% of total litterfall.



AVERAGE TOTAL LITTERFALL

FIGURE

4.2

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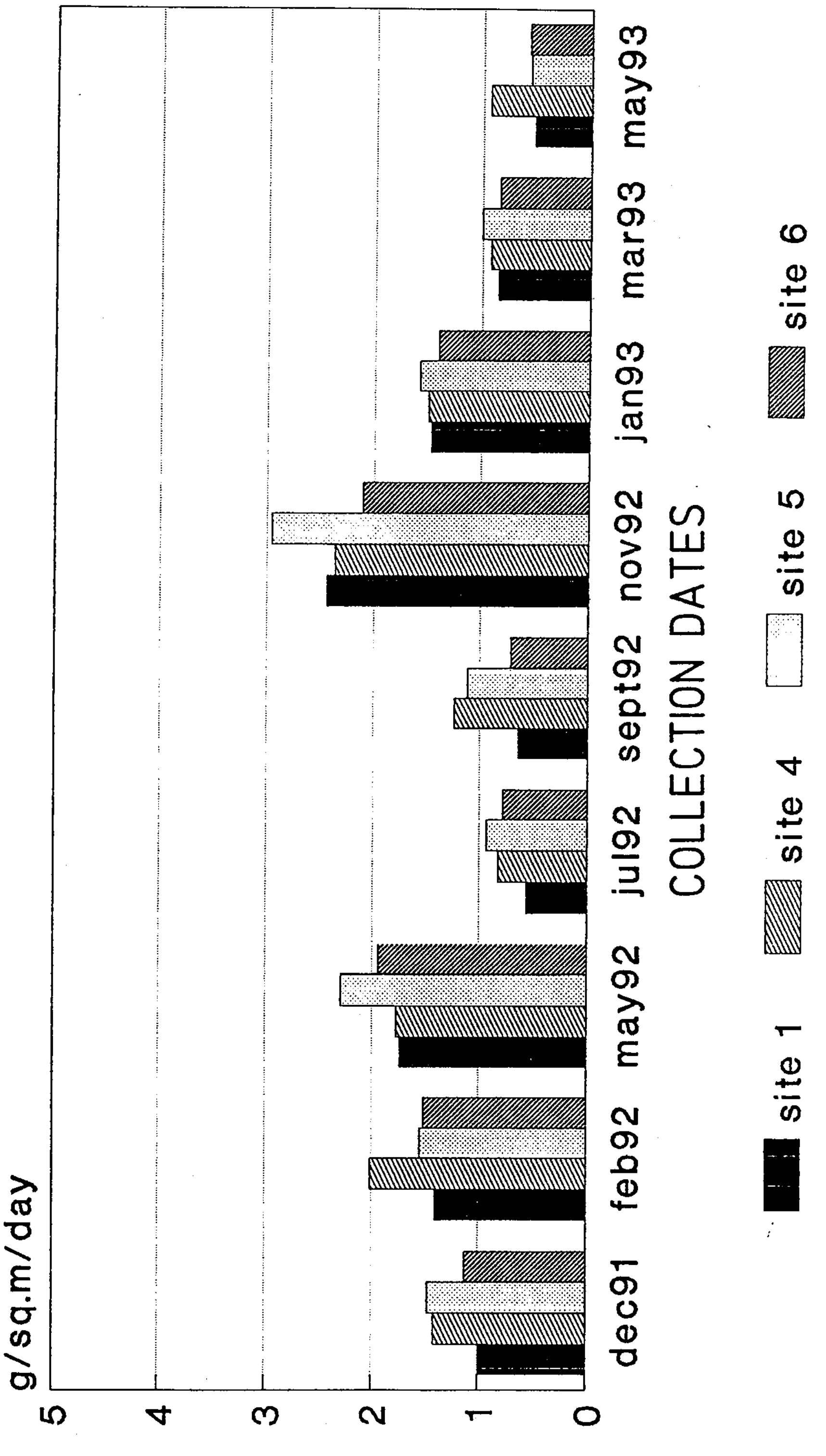

AVERAGE LEAF LITTERFALL

FIGURE 4.3

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The fruit material collected in March 1993 was the first major fall of any fruit material since the study was initiated 21 months previous in September 1991.

Stem Litterfall

Stem litterfall values showed too much within-site variation for meaningful analysis. Standard errors of site mean stem litterfall were well above 10% at most of the collections. The reason for the high variability of stem litterfall values, compared to leaf litterfall values, is probably related to the greater variability in stem sizes (from small twigs to sections of large (dead) branches) and the more erratic nature of stem fall, compared to leaf fall.

4.2 STEM GIRTH INCREMENT

Results of the stem girth increment study are summarised in Table 4.4. Although tree girths within-site were relatively uniform, (standard error of average tree girth < 10%), stem girth increment was highly variable (standard error of average increment > 30%). Detailed analysis has thus not been made of average stem increment for each site. Instead, the range in girth increment is considered.

Girth increment across all six sites ranged from -4.1 mm to 1.8 mm at the first measurement period; -3.6 mm to 8.6 mm at the second and -3.8 mm to 12.5 mm at the third. The largest girth increments had occurred at sites 3 and 4 (12.5 mm, both sites) by the third measurement period, and to a lesser extent at site 5 (7.1 mm). The largest negative increments (decrements) by the third measurement period had occurred at sites 1 and 6 (-3.8 mm at both sites).

Stem girth decrement or girth shrinkage, was recorded at all three measurement periods, at all six sites (Table 4.4). Site 6 differs from the other sites because of the large number of stems exhibiting a decrement in girth - seven out of the ten trees at the first measurement period, six out of the ten at the second and five out of the ten at the third measurement period.

By contrast, the number of trees exhibiting a decrement in girth diameter at any of the five other sites, for all three measurement periods, was never more than five of the ten trees and usually less than four.

TABLE 4.4: SUMMARY OF STEM GIRTH INCREMENT (mm) FOR THE PERIOD 25/10/91 TO 12/3/92

Ten trees were monitored for stem girth increment at each site.

SITE	1	2	3	4	5	6
average girth*	753 ± 54.6	754 ± 48.2	636 ± 32.6	600 ± 26.8	773 ± 55.7	952 ± 62.7
range in increment:						
1st measurement period (25/10/92 - 7/12/92)	-0.8 to 1.8	-2.5 to 0.5	-2.5 to 0.5	-1.0 to 1.3	-2.3 to 1.8	-4.1 to 0.0
No. of trees with decrement	4	1	3	3	3	7
2nd measurement period (7/12/92 - 18/9/92)	-1.0 to 2.3	-2.5 to 3.1	-1.0 to 8.6	-0.1 to 5.6	-2.5 to 4.8	-3.6 to 1.3
No. of trees with decrement	3	2	1	3	4	6
3rd measurement period (18/9/92 - 12/3/93)	-3.8 to 3.3	-2.5 to 4.3	-0.3 to 12.5	-0.5 to 12.5	-2.5 to 7.1	-3.8 to 3.3
No. of trees with decrement	5	2	1	1	3	5

* average ± standard error

Photographic Record

The photographic record did not reveal any gross changes in the structure of the mangrove communities at the monitoring sites. Large changes were not expected, given the relatively short duration of the study (September 1991 to May 1993).

However, as noted in an earlier report (WBM Oceanics Australia 1992) a marked changed was noted on the mudflats immediately seaward of site 4, where a very large seedling population present in September 1991 (developed to about the second leaf-pair stage) experienced a mortality rate of greater than 90% by February 1992. By March 1993, these seedlings had not been replaced, probably as there had not been any significant falls of mature fruit (propagules) from adjacent mangrove communities since the demise of the previous crop of seedlings.

5.0 DISCUSSION

The importance of mangroves in the estuarine food chain and their role in shore stabilisation and protection are both connected with mangrove community structure (Rodriguez 1987) and have been the focus of much mangrove research.

The response of mangrove forests to stress (climatic and man-induced) can be identified with quantitative data (Odum et. al. 1982) hence the importance of continued collection of quantitative data by the Port of Brisbane Authority on the mangroves of the Fisherman Islands and Wynnum foreshores.

5.1 LITTERFALL

Estimates of average litterfall production (total and leaf components) were very reliable, with standard errors of within-site averages less than 10% for most of the collections made. This indicates that community structure, and particularly canopy cover was relatively homogeneous within each site and was effectively sampled by the number and spatial arrangement of litterfall catchers.

Averaged over all sites and all collections (December 1991 to May 1993), leaf fall accounted for 66% of total litterfall, while the fruit and stem components comprised only 16% and 18% respectively.

However, the March 1993 collection recorded the first major fruit litterfall event since the commencement of monitoring in September 1991 and fruit comprised 60% of total litterfall.

5.1.1 Annual Production

A review of studies of mangrove communities from around the world (Hutchings and Saenger 1987) reveals a wide range in litterfall production from 0.8 t/ha/yr in a temperate/subtropical *Rhizophora mangle/Laguncularia racemosa/Avicennia nitida* forest in Southern Florida (25°N) to 28.1 dry t/ha/yr in a mixed species tropical mangrove forest in North Queensland, Hinchinbrook Island (18°S, Table 5.1). Litter production is typically higher in tropical than in temperate mangroves, although there is considerable variation within a given mangrove community (Hutchings and Saenger 1987).

The range in annual total litterfall production for this study (4.86 t/ha to 6.96 t/ha) is comparable to the estimate of 6.42 t/ha for a low closed *Avicennia marina* forest on Mud Island, Moreton Bay (Davie 1984). The similarity between the two estimates suggests that the productivity of the Fisherman Islands mangroves, has not been adversely affected by port-related activities.

This study and that of Davie (1984) are among the few long-term (>12 month) studies of mangrove productivity in Moreton Bay. Continued monitoring of litterfall production will provide the Port Authority with data which it can use to assess the effects of port-related activities on mangroves.

5.1.2 Site Differences

The first year of monitoring (September 1991 to September 1992) revealed greater total and leaf litterfall production at sites 4 and 5 than at sites 1 and 6. This difference was also apparent in many of the bimonthly collections.

The significantly greater litterfall production (leaf and total components) at sites 4 and 5 may be due to their forests being in an immature development stage and growing more rapidly than the forests at sites 1 and 6. The structural features of the forests at sites 4 and 5 - lower canopy height, smaller average stem girths and higher stem densities - may also indicate their relative immaturity compared to sites 1 and 6. Stem girth increments at the last (third) measurement period were also greater at sites 4 and 5 than at 1 and 6, indicating the former sites are probably more actively growing than the latter pair.

TABLE 5.1: LITTERFALL VALUES FOR MANGROVE FORESTS IN AUSTRALIA AND USA (FLORIDA)

LOCATION	FOREST TYPE	LEAF LITTER (t/ha/yr)	TOTAL LITTER (t/ha/yr)	STUDY PERIOD	REFERENCE
Moreton Bay, Brisbane	*Avicennia marina* low closed forest to open forest	3.89 - 5.36	4.86 - 6.96	Sep 1991 - 1992	This study
Middle Harbour, Sydney	*A. marina* low closed forest	4.6	5.8	Mar 1977 - Apr 1978	Goulter and Allaway (1979)
Moreton Bay, Brisbane	*A. marina* low closed forest	-	6.42	Aug 1979 - Dec 1980	Davie (1984)
Moreton Bay, Brisbane	*A. marina* low open shrubland	-	1.94	Jan 1980 - Dec 1980	Davie (1984)
Missionary Bay, Hinchinbrook Island, North Queensland	mixed species	-	3.7 - 28.1	1975 - 1978	Bunt (1982)
Missionary Bay, Hinchinbrook Island, North Queensland	*Avicennia* sp. forest	6.6	9.5	1975 - 1976	Duke *et al* (1981)
Florida	*Avicennia germinans* forest	-	3.7 - 5.6	-	Lugo *et al.* (1980) cited by Odum *et al.* (1982)

5.1.3 Seasonal Patterns

(i) *Total Litterfall*

Maxima in total litterfall production occurred in May 1992 (autumn), November 1992 (spring) and March 1993 (autumn). A 17 month litterfall study in similarly structured mangroves (low closed *Avicennia marina* forest) on Mud Island, Moreton Bay, recorded peaks of litter production in the spring of 1979 and 1980 and minor peaks through autumn (Davie 1984). Periods of heavy litterfall were attributed to periods of shoot growth (Davie 1984).

The period of minimum litterfall production for both this study and that on Mud Island occurred during winter, when there is minimal shoot growth (Davie 1984).

There appears to be broad agreement in seasonal patterns of litterfall production between this study and the study on Mud Island (Davie 1984). Some variation might be expected, given the considerable temporal separation between these two studies.

(ii) *Leaf Litterfall*

Peaks and troughs in leaf litterfall generally mirrored that of total litterfall. This was expected, since leaf litterfall usually comprised 60% or more of total litterfall for most of the collections. The exception was the March 1993 collection, when there was a heavy fall of fruit material. In the weeks leading up to this event, it is likely that there was little shoot growth, with most of the plants' resources going towards production of reproductive material.

(iii) *Fruit Litterfall*

In the 21 months of the study to date, the March 1993 collection contained the first major fall of fruit material.

Other studies have also recorded fruit production in *Avicennia marina* during similar times of the year.

The occurrence of mature propagules on *Avicennia* on the central Queensland coastline has been recorded over the months of January, February and March, while on the eastern coast of South Africa, the fruiting period for *Avicennia marina* is March to April (Hutchings and Saenger 1987). Fruiting times for other mangrove species on the eastern

Australian coast are also reported to occur in the summer months (Hutchings and Saenger 1987).

The single fruit litterfall event recorded in the 21 months of this study indicates that *Avicennia marina* in the Fisherman Islands regions, do not fruit annually. A similar finding was made in a study of *Avicennia marina* in Westernport Bay, Victoria, where propagules are produced only every second or third year (Clough and Attiwill 1982).

In tropical areas, fruit production is an annual event (Hutchings and Saenger 1987), suggesting that the tropical environment is more favourable to mangrove fruit production than the sub-tropical environment of Moreton Bay or the temperate environment of Westernport Bay, Victoria.

A knowledge of when and how often the mangroves of the Fisherman Islands fruit will be vital to the Port of Brisbane Authority, if it plans to conduct any mangrove regeneration projects in the port's vicinity.

Mangrove fruit, or propagules, may not necessarily be washed into areas prepared for mangrove regeneration, thus it will be necessary to know when mature propagules can be collected from existing mangrove forests. Continuing the litterfall study into the coming years will aid the Port Authority in predicting when and how often mangrove propagules can be collected.

5.2 STEM GIRTH INCREMENTS

The small girth increments recorded during the study may be due to the relatively short length of the study (September 1991 to March 1993). As no other published studies of stem girth growth rates of mangroves were found, it has not been possible to assess how fast or slow the Fisherman Islands mangroves are growing.

The decrement in girth recorded on many of the stems at the first reading was first thought to be related to a settling-in of the dendrometers after their installation. However, decrements in girth recorded in the next two measurement periods at all six sites suggests that stem shrinkage is occurring.

Shrinkage is a common phenomenon in tree stems (Bormann and Kozlowski 1962) that have been attributed to low rainfalls preceding recordings. Rainfall for 1991 was 861.2mm, well below the long term average for Brisbane of 1150mm (140 year record to the end of 1991, source: Bureau of Meteorology). However, in 1992 Brisbane received above average rainfall of 1203.4mm (Bureau of Meteorology). Insufficient study has been conducted on the relationship between stem growth of mangroves and environmental factors (climatic, edaphic and biotic) to isolate the effects of particular factors such as rainfall and stem shrinkage may be due to a variety of factors.

The large number of stems exhibiting decrement in girth at site 6 compared to the other sites may be related to the apparent maturity of the mangrove community of site 6. The trees at site 6 may no longer be increasing in girth and the changes recorded may be responses to short-term environmental perturbations

Measurement of stem girth increment has not revealed any large changes in stem girth. However, continued recording of stem increment with the dendrometers is relatively inexpensive and if continued into the coming years may record stem growth data that can be more readily interpreted and related to productivity measured in the litterfall studies.

5.3 OVERVIEW

- mangroves at the monitoring sites are all healthy
- litterfall monitoring is proceeding without major technical problems and is probably the longest of such studies to be conducted in Moreton Bay
- within-site estimates of average litterfall are very reliable (low standard error)
- annual litterfall production is comparable to studies elsewhere in Moreton Bay
- seasonal and annual variation in litterfall production demonstrate the importance of long-term monitoring
- the first major fruit litterfall event for the 21-month study was recorded in March 1993, indicating that fruit production in the *Avicennia marina* mangroves of the Fisherman Islands is not always an annual event
- very little change in stem girth was recorded
- continued monitoring of stem girth will be relatively inexpensive and over the longer-term may provide more readily interpreted data
- the photographic record indicates that the monitoring sites have not changed perceptibly in structure

6.0 RECOMMENDATIONS

It is recommended that litterfall collections be continued to the end of the second year (September 1993) and into the following year to:

- establish whether the seasonal patterns observed in the first year are typical
- determine the extent of annual variation in litterfall production
- monitor the quantity and the periodicity of fruit production.

Information on when, and how often, fruit production occurs in the mangroves of the Fisherman Islands could be used by the Port Authority when planning fruit collection for mangrove regeneration projects.

Despite stem increment being less than was anticipated since installation of monitoring equipment in October 1991, it is recommended that:

- monitoring of stem girth increment be continued over a longer period to provide data showing larger movements that can be more readily interpreted.

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8.0 GLOSSARY OF TERMS

Saltpan/Claypan: unvegetated high tidal flats, generally landward of mangroves.

Edaphic: soil or substratum conditions.

Estuarine: of, or pertaining to an estuary.

Girth: measurement around a tree's circumference (Π.diameter).

Intertidal: land between high and low tides.

Mangroves: the term is used here interchangeably to refer to an individual species of plant or to a stand or forest of plants belonging to many species (after Hutchings and Saenger, 1987); a community (or a plant thereof) arising from an estuarine or tidal mudflat.

Saltmarsh: high tidal flats landward of mangroves vegetated by saltcouch grass and samphire bushes.

Seagrass: marine flowering plant growing on intertidal to subtidal flats.

Subtidal: below the level of lowest astronomical tides

Wetlands: plant habitats subject to tidal action including subtidal areas to an Australian Height Datum (AHD) depth of 6 m; encompassing saltmarsh/saltpan, mangroves and seagrass communities.