3. THE PRESENT STATE OF KNOWLEDGE

(i) Bathymetry

Substantial bathymetric surveys have been undertaken in recent years by the Navy using both ship-borne depth sounders and airborne laser. These have enhanced knowledge of reef topography and of selected channels, but there remains some need for more detailed bathymetry in areas far from shipping routes and particularly on the continental slope. Landsat processing, involving work by David Jupp (CSIRO), ASO and DMS will give bathymetric data for the top 15 m in two years for the entire Great Barrier Reef Region.

(ii) Meteorology

Several offshore meteorological stations are maintained by the Bureau of Meteorology, but these are mainly in the southern region and most physical studies are obliged to set up their own automatic stations if wind and mean sea level pressure are required. The Bureau has available mean sea level pressure analyses on a 3^{o} x 3^{o} grid at 6 hourly intervals but it is not known whether the interpolated surface wind (calculated from the geostrophic approximation) or the interpolated mean sea level pressure would be sufficiently accurate for studies of, for example, wind driven circulation or wind wave generation and associated erosion or sedimentation. Such a calculation has proved adequate on the North American West Cost. Wolanski (1983) has made a study of the trade winds over the Coral Sea and the Great Barrier Reef.

(iii) General Hydrography and Large Scale Circulation

Since the review by Pickard et al (1977) there has been additional work in the Coral Sea by CSIRO in the region immediately adjacent to the Great Barrier Reef showing an East Australian Current starting at about $18^{\circ} \pm 2^{\circ}$, strengthening as it goes south. Andrews and Gentien (1982) found the East Australian Current off Townsville pulses four times a year. Church and Boland (1983) describe the existence, at $18^{\circ}S$, of a southward flow in the top 300 m of the Coral Sea immediately adjacent to the reef with a permanent northward flowing undercurrent between 400 m and 1000 m. Church and Golding (1983) describe the data collected in the western Coral Sea by CSIRO during 1980 and 1981. There exists sufficient data to give a reasonable seasonal climatology of temperature and salinity and Ridgway has determined mean and seasonal temperature-salinity relationships for the western Coral Sea, and shown that these relationships are sufficiently reliable that the dynamic height may be computed from the temperature field along.

Water properties are known to be different inside the Lagoon compared with those of the Coral Sea. In the Lagoon the water appears to be well mixed in the vertical direction, except for depths greater than 40 m during October through December when weak stratification may exist. Pickard et al give typical values of temperature and salinity as a function of season, but the only study of differences either side of the Reef has been made by Andrews et al (1982) in a rectangle (at $18^{\circ}S$ 100 km along the reefs, from the Lagoon to the Coral Sea. There are no studies of differences in hydrographic properties at any other latitudes. Andrews and Gentien (1982) found that meanders of the East

Australian Current occur with 90 day period and force upwelling on the slope to the shelf break. Nutrients are pumped inshore from the shelf break in a bottom Ekman layer forced by periodic (about 20 days) reversals in the longshore wind component. Upwelling intrusions penetrate the entire reef zone, but rarely enter the Lagoon. These two processes (East Australian Current and wind stress) produce an enrichment equivalent to about 175 g cm^{-2} yr^{-1} in a 50-60 km strip in from the shelf break.

Cross shelf baroclinic transport has been studied in a 200 km longshore strip, by correlating thermoclinic waves (created by onshore surges of shelf break water) with winds, atmospheric pressure and mean sea level (Andrews, 1982). Longshore winds produce thermal waves of periods near 4 days in summer and 8 days in winter which travel northwest at 50 km/day. Longer period (10 to 70 day) waves do not travel, but form a standing wave with an antinode east of Townsville.

On a smaller scale there have been studies related to the following:

1. Mixing of river plumes showing persistence of sharp fronts and large separate patches of order 30 km (Wolanski).

2. Flushing of small lagoons inside reefs, indicating flushing times of a few days (Wilson), to a few hours (Andrews et al, 1982).

3. Observations of cold water upwelling onto the shelf and mixing with shelf water (Andrews).

4. Mixing associated with low Richardson Number has been observed over the slope outside the reef (Wolanski).

5. Mixing within Reef structures (Andrews and Muller, 1982).

6. Mixing behind islands and reefs due to the wake (Wolanski, Jupp, Heron).

(iv) Tidal Currents and Heights

A sea level data bank is archived at F.I.A.M.S. Constants have been analysed for many stations and are archived by Lennon at the Tidal Laboratory at Flinders University. In addition, tidal height data is being collated by Hamon.

Current data has been collected by several institutions: AIMS (Andrews, Wolanski), BMR (Davies), CSIRO (Church), DOT (Crossing), LIRS (Goldman), QU (Orme), UNSW (Middleton) and some of these data analysed for tidal currents. There appear to be no present plans for collation of current tidal data as is being done for heights. There is evidence that tidal currents are not as regular or predictable as tidal heights but an explanation is lacking. For some locations it may not be meaningful to list amplitude and phase "constants" for tidal currents.

Numerical models of tides (Apelt, Bode, Easton) are in various stages of development but are all depth integrated (barotropic). Numerical models are generally recognised to provide tidal heights and currents to a reasonable predictive level provided reasonable data is available as boundary forcing, and an appropriate parameterization of the reef on the flow is made.

Aspects of flow across and around reefs are being investigated theoretically (Middleton, Buchwald, and Huthnance (1983), Church and Wilson).

Baroclinic tides have been observed by Boland and Church in the continental slope region at 18°S.

(v) Longer Period Currents and Heights

A drift card study centred at Townsville shows most strong southeast winds generate a northwestward surface flow, but that flow is to the southeast during other wind conditions (Walker and Collins, 1980, 1983). Observations during 1982 show that northwestward flow during southeast winds occurs along the whole GBR (Walker and Collins, 1983). Surface drift-cards (Walker and Collins) and surface drogues (Woodhead, 1970) suggest that during periods of non-southeast winds a complex surface circulation may occur in the region of the Capricorn Channel. Belperio (1978) released four series of bottom drogues within 15 m near Townsville. Three of these were during southeast winds and the drogues moved to the northwest. The fourth was during light northwest winds and

moved to the southeast. Finally, MacFarlane (1980) released surface drogues in the Gulf of Papua and a number of these landed on the northeast Queensland coast as far south as 25°C.

Locations of meteorological, pressure gauge and current meter stations within the shelf and offshore regions of the northeast Australian coast up to mid 1981 are presented in various publications including Cresswell and Greig (1978), Church (1982), Wolanski and Ruddick (1981), Wolanski and Jones (1982), Wolanski and Bennett (1982) and Middleton (1983). More recent wind, current and pressure gauge moorings covering November 1981 to October 1982 are now in place from Cape Upstart to Cape York under a joint experiment by AIMS, UNSW and IOS.

On seasonal time scale, flow within the Lagoon tends to be northward north of about 18°S and southward at higher latitudes. During the summer season the flow may be variable in the north. These features are probably the result of differing balances between wind stress and imposed pressure gradient (due to variation in dynamic heights in the Coral Sea).

On subseasonal time scales, wind forcing is known to produce fluctuations of the order of days to months in the central reef section (Cape Upstart to Carter Reef). Wolanski and Bennett (1982) argue that fluctuations are predominantly first mode wind driven barotropic shelf waves, while Middleton and Cunningham (1983) identify first mode wind driven shelf waves in the region from the Capricorn Channel to the Whitsundays, although the evidence indicates that the presence of the extensive Swain Reefs substantially modifies the flow (Middleton, 1983).

Wind stress and friction appear to be important everywhere on the shelf in regions already studied. Wolanski and Ruddick (1981) have discussed the evidence for shelf waves in the far north, while Wolanski and Hughes (1982) have argued the case for wind-driven kinematic waves at about 10-12°S.

Numerical models of wind driven circulation (Bode) have been initiated for the southern section but these are in the preliminary stage. These need time dependent wind forcing as an input and, as for tides, good bathymetric parameterization of the reef.

The radar scanning system of Heron (COSRAD) is able to provide data on surface currents and directional wave spectra over a swath of 60° and to distances of 100 km from the location of the mobile transceiver. While this system is still in the testing phase, the potential for detailed studies of circulation is large.

(vi) Wind Waves and Swell

Wave measurement buoys have been deployed by the Beach Protection Authority at sites off Cairns, Townsville, Bowen, Mackay, Gladstone and Bundaberg (Cook, 1981). Details are becoming progressively available from that Authority. These buoys are located reasonably close to shore and no information is available on the outer edges of the continental shelf or in the Coral Sea. Substantial theoretical and numerical work is outlined in the many references by Sobey, Stark, Harper and Young.

(vii) Tropical Cyclones

Predictability of tropical cyclones as events is not yet satisfactory. The effects of tropical cyclones on flow in general within and outside the reef has been studied extensively by Sobey, Harper and Stark (1977) with numerical and theoretical methods. Field studies of cyclones (as being undertaken off the North West shelf by Imberger and Steedman) would provide much needed information.