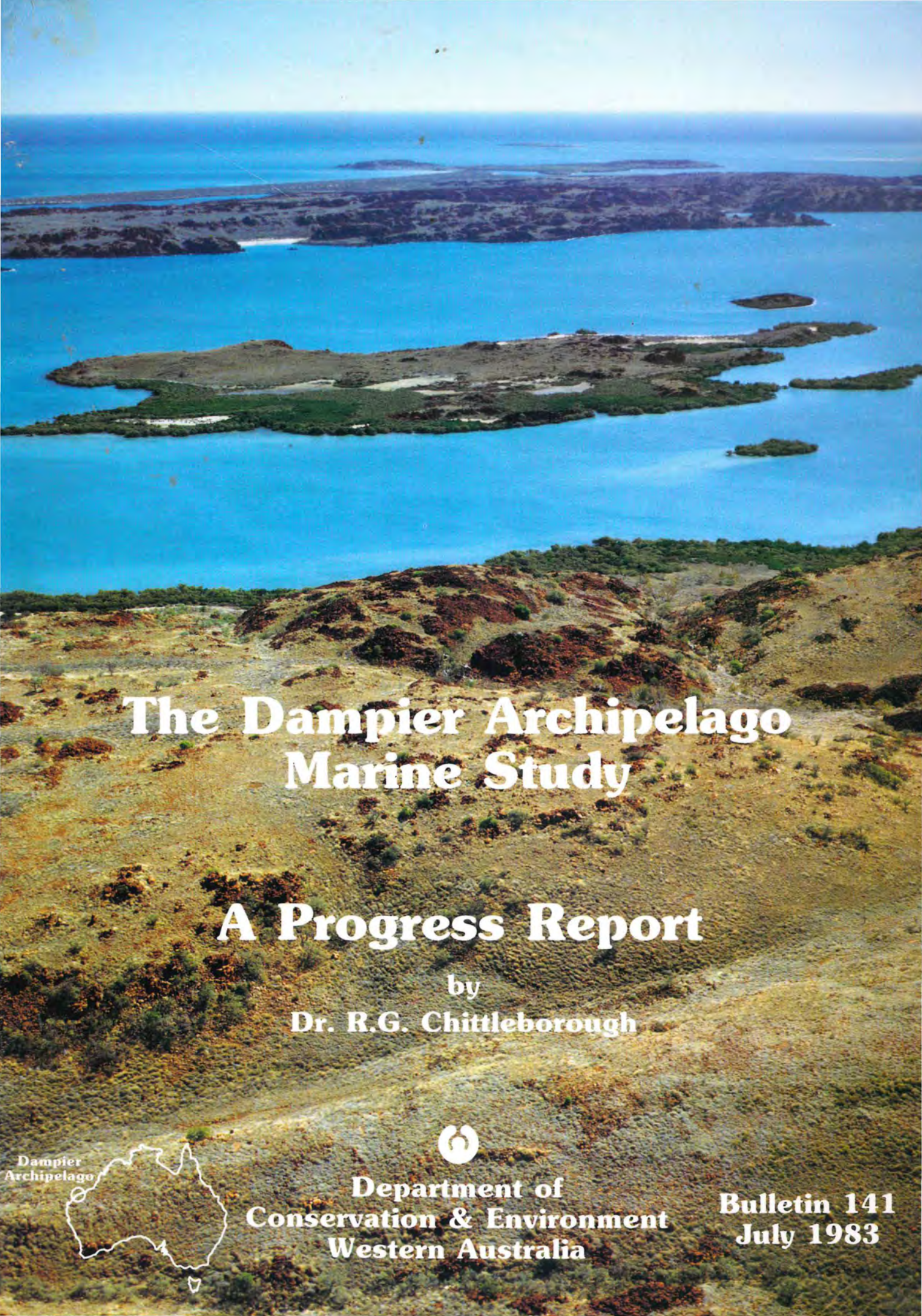

# The Dampier Archipelago Marine Study

## A Progress Report

by

Dr. R.G. Chittleborough




Department of
Conservation & Environment
Western Australia

Bulletin 141
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*Front Cover:* S. Chape
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# INTRODUCTION

The Dampier Archipelago lies in an area which has already attracted a number of industries and has considerable potential for further development and for population growth. With the development of iron ore export ports, a solar salt works and the construction of an LPG-LNG plant and terminal for off-shore gas, this sector of the Pilbara coast will continue to be a major growth centre.

Because of the increasing environmental pressures that growth will bring, the Marine Branch of the Department of Conservation and Environment is carrying out a major study of the coastal water environments and their resources so that these can be safeguarded and utilised on a sustainable basis as industrial and urban growth continues. This is consistent with the World Conservation Strategy which defines conservation as the management of human use of the biosphere (the thin covering of the earth that contains and sustains life) so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.

The climate is very severe — temperatures can be high, rainfall is low and erratic (annual average 277 mm) and evaporation (over 3200 mm per year) exceeds rainfall throughout the year (Figure 1) — but the tropical waters of the Archipelago afford a wide variety of habitats supporting a rich diversity of fauna and flora. For people, the range of resources and recreational activities is great.

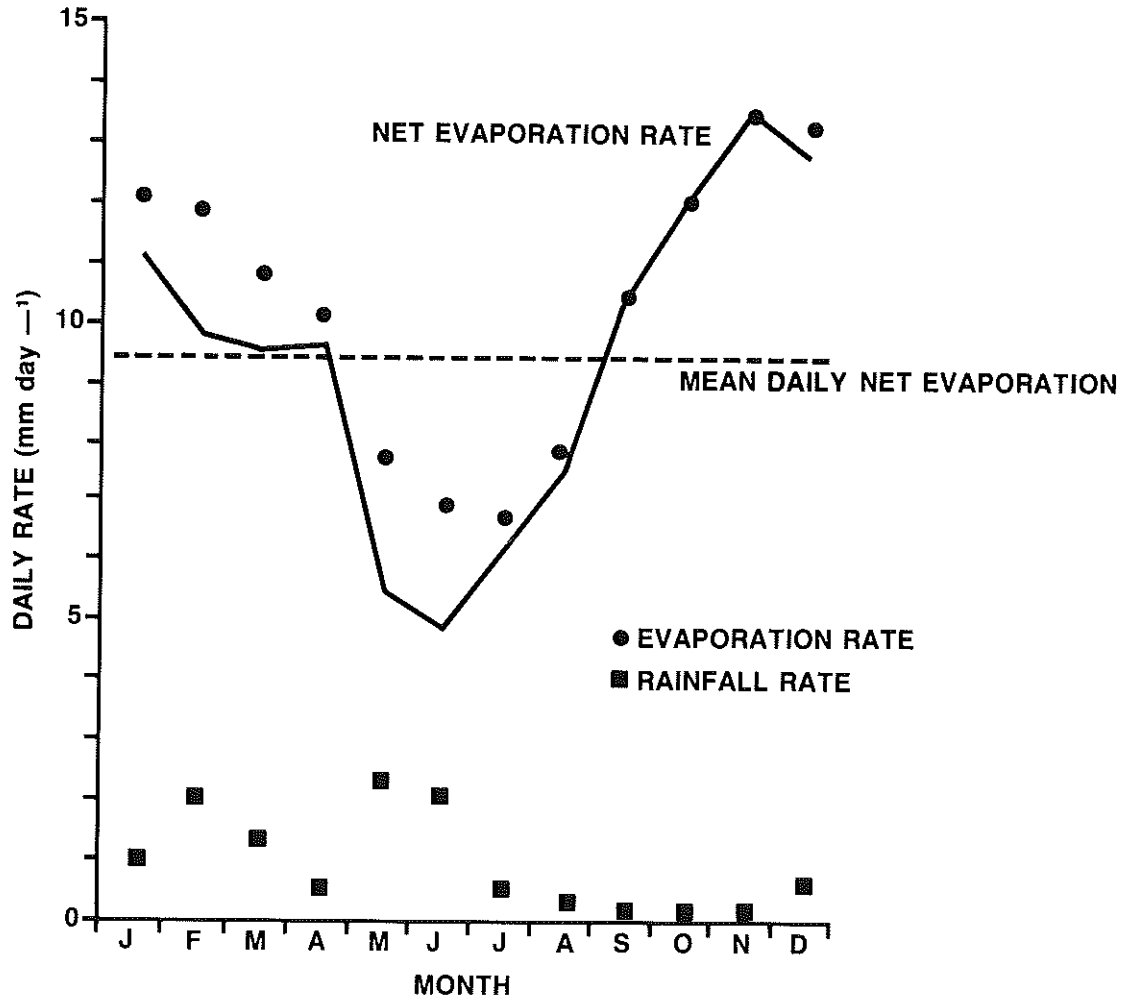



Figure 1. Rainfall and evaporation rates recorded throughout the year by Dampier Salt.

## NEED FOR AN EARLY STUDY

It is important that the study is undertaken before this environment is severely altered by man-made pressures. Because the Cockburn Sound Study and the Peel-Harvey Inlet Study were initiated in response to problems already developed, they suffered from inadequate background information about the systems before the impact of major man-made changes. The need for early studies is obvious.

In the case of Dampier Archipelago an early start is even more important as so little is known of how coastal ecosystems function on this arid tropical north-west shelf. In the past, most research has concentrated on ecosystems in temperate waters of the south-west coast.

The Dampier Archipelago marine ecosystem is not entirely untouched by man. Dredging of shipping channels and harbour berths has already removed and dumped over 18,000,000 $m^3$ of dredge spoil, and a further 10,000,000 $m^3$ will be moved in the near future. At least 1200 ha of mangrove woodlands have been killed and other areas are showing signs of stress. Roads, causeways, groynes, land-fill, boat harbours, sewage discharge etc., each have localised effects. Recent analysis of oysters from throughout the Archipelago showed elevated levels of copper and zinc in those taken close to Dampier townsite. In addition, spear, line and net fishing, as well as shell collecting, may also have had some impact on resources available.

The study will provide the information essential for better management of these coastal waters.

## REGIONAL STUDY REQUIRED

Some studies of particular facets of the coastal environment in this region have already been done by major industries and others:

- oceanographic and sediment studies aimed at resolving problems associated with shipping access, platform stability, laying of submarine pipelines and discharges of waste heat;
- ecological studies to monitor possible effects of discharges of waste heat and to select spoil disposal sites.
- A study by the W.A. Museum in 1974 on reef ecology at Kendrew Island on the outer shelf of the Archipelago.

Useful as these studies may be, they do not give an adequate picture of the system as a whole. Specific environmental problems have been studied in isolation; for a full assessment of the impact on the system as a whole, the present Study must consider the combined effect of natural and man-made pressures from all sources, and the relationships between species and habitats in the whole ecosystem. Such a regional study can hardly be expected of individual developers; it is the responsibility of those who manage the orderly development of the area as a whole, i.e. the Government of Western Australia.

The Study commenced with some broad scale surveys during the summer of 1980-1981. The first phase centred on static observations such as:

- mapping of habitats
- measurement of standing crops of primary producers
- water parameters.

As these facets are understood and require only monitoring, research is now concentrating on dynamic processes such as:

- synoptic studies of water circulation and exchange
- community metabolism
- energy flow, etc.

## THE STUDY PROGRAMME

To ensure an adequate understanding of the dynamics of such a complex and little known tropical system, priority was given to those aspects which are basic to the functioning of the ecosystem as a whole.

Because the system is responding continuously to changing environmental pressures (e.g. seasonal cycles, random events such as cyclones, or long-term trends in climatic conditions), it must be studied over sufficient time to measure at least some of the responses to changing pressures.

### Habitats

First priority was given to mapping major marine habitats in the area to determine their distribution and extent. Using vertical colour aerial photography in calm weather at low tide, major habitats (e.g. rocky shore, mangroves, sand, mud, algal beds, coral platforms) were mapped along the shores and in shallow waters; the information was checked directly by diving.

In waters over 5m deep, bottom sampling and underwater photography were used to reveal details of the sea floor. Additional information was obtained from high quality underwater photography commissioned by industry to assess sites for dredge spoil disposal and from a detailed bathymetric survey by the Australian Survey office of areas which have been poorly charted.

### Water movements

Information on the passage of water through the islands of the Archipelago under different meteoroligical and oceanographic conditions is crucial as the waters transport the nutrients essential for plant growth, the food supply of much of the fauna, and the eggs, larvae or juveniles of many species dependent on currents for dispersion and recolonisation. The currents may also be called upon to carry away industrial and urban wastes, oil spills etc.

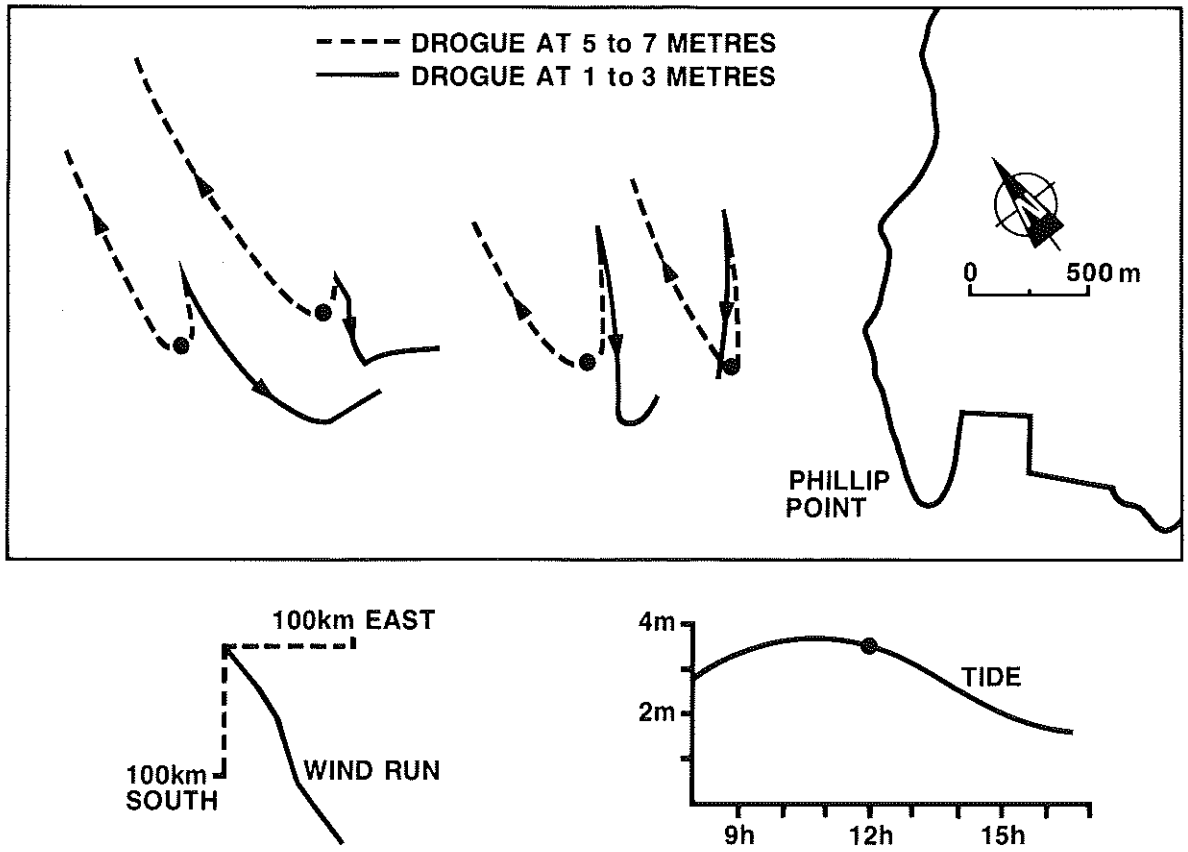



Figure 2. Paths of pairs of drogues released at different depths in Mermaid Sound on 5 March 1981.

Several methods are being used to investigate water movements. Short-term measurements (through a tidal cycle) have been made by tracking sets of drogues suspended at different depths. This has shown the relative effects of surface wind stress and tide on movement at various depths (Figure 2). It has also enabled flow patterns to be charted in areas of complex bathymetry, e.g. shoals, channel mouths.

For longer term movements of water (through successive lunar cycles), continuously recording current meters are moored at selected depths at different locations through the Archipelago. These instruments also record water temperature. Simultaneous weather information is obtained from established meteorological stations on the mainland, supplemented by an anemometer set up by the study group on Conzinc Island. Thus data are being obtained under a wide range of tidal and meteorological conditions, yielding information about coastal water movements ranging from short-term episodes such as a passing cyclone (Figure 3), to low level, persistent events which may be at least as important in terms of their ability to flush water through the Archipelago.

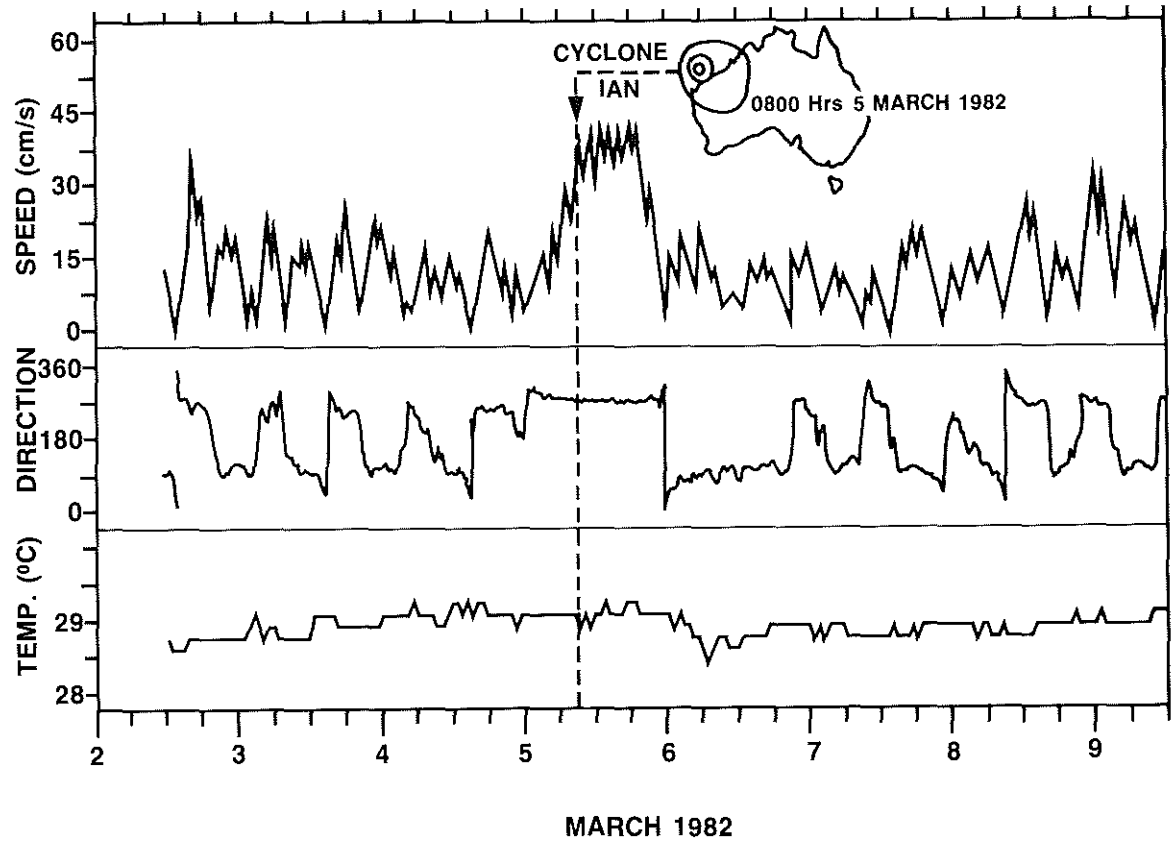
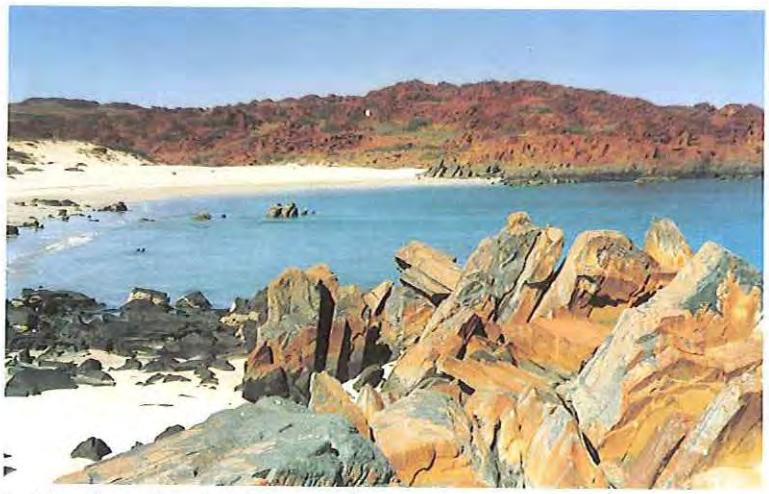



Figure 3. Data recorded on tape by a current meter moored in Dampier Archipelago waters.

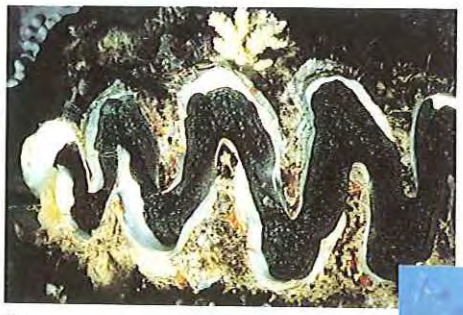
A less direct but useful approach to understanding water circulation is by regularly manning boat stations across the Archipelago and measuring profiles of temperature and salinity through the water column. These properties serve as tracers of water movement. Furthermore, the distribution of water density (which is determined by temperature and salinity) may act either to induce water movement (density current) or to inhibit the exchange of materials between the Archipelago and shelf waters. An example is shown in Figure 4.

# Resources



1. *Fine beaches between rocky headlands.*

2. *Plentiful oysters.*



3.

*3-6: Diverse coral community.*

4.

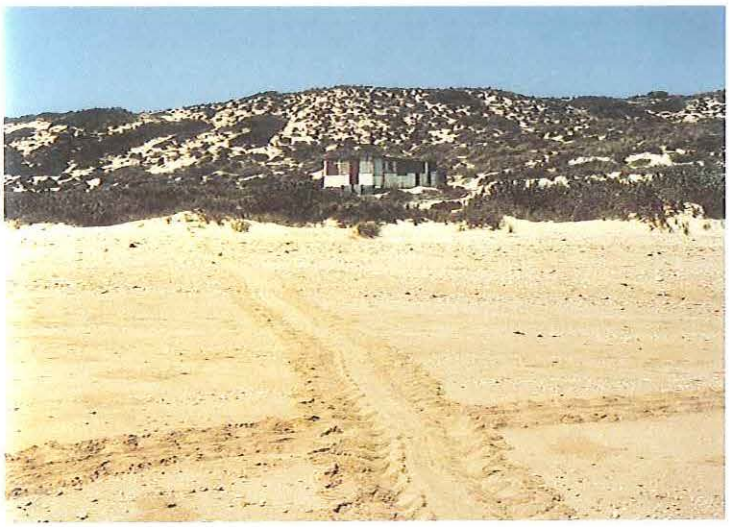
5.

6.

7. *Productive mangroves.*

8. *Fish.*

# Pressures



*9. Competing uses: fine beaches for turtle breeding, holiday shacks — and mining limesands.*

*10. Industry — LNG plant.*

*11. Shipping — iron ore.*

*12. Dredging.*

*13. Mangroves cut off.*

*14. Shell collecting takes its toll.*

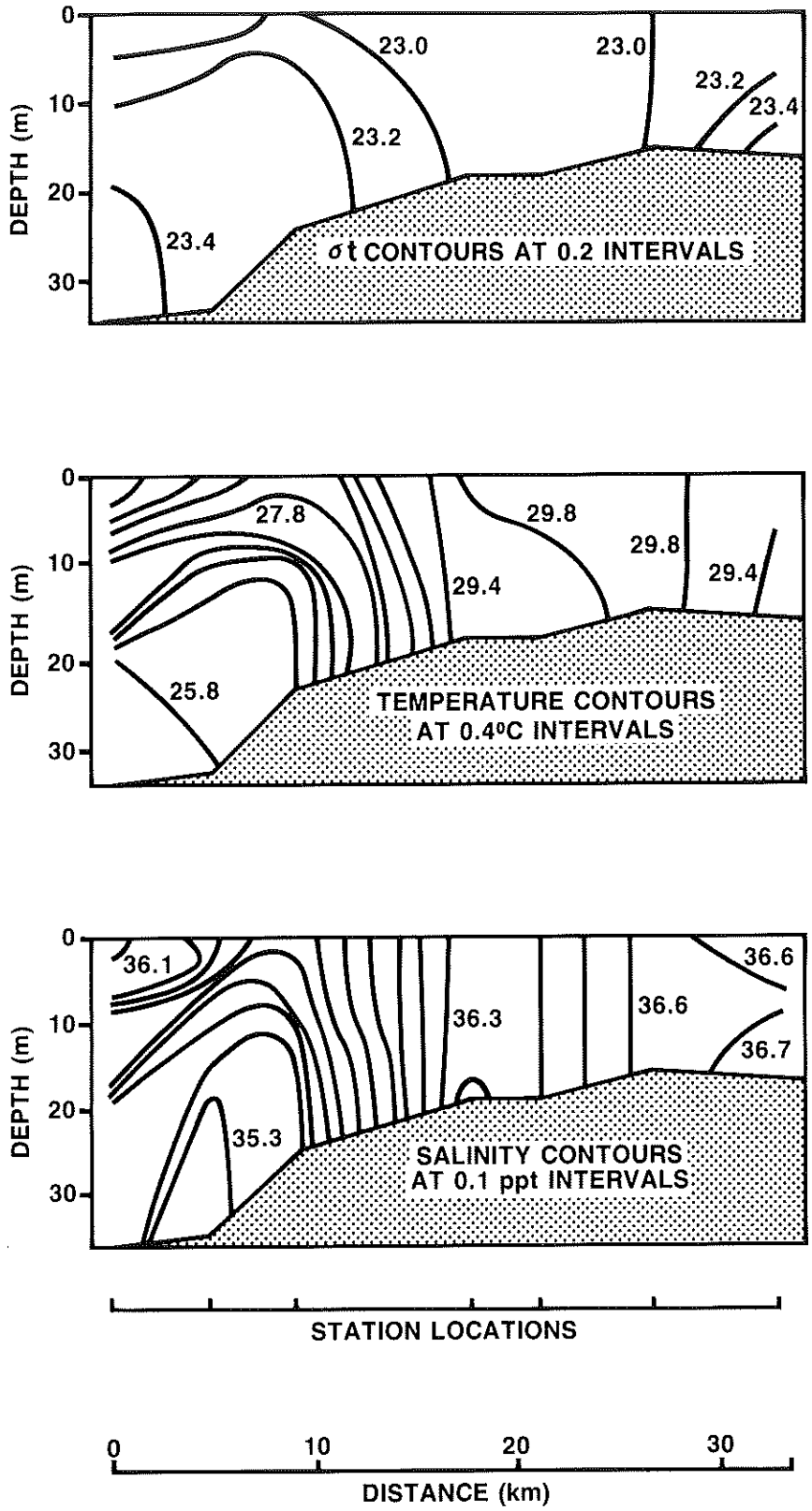



Figure 4. Salinity, temperature and density profiles through Mermaid Sound; 12 December 1982.

## Primary producers

Although most people are more interested in the fish and shellfish in these waters, such resources are totally dependent (directly or indirectly) upon organic material produced by plants. A very considerable part of our research is focussed upon these primary producers. The total amount of each group present (i.e. the standing crop) must be determined and the rates of production measured to assess the contribution of each to the productivity of the system as a whole.

On the Pilbara coast, the larger algae appear to play a greater role than in some other tropical ecosystems. By measuring the biomass (weight per unit area) of macro-algae at selected stations, variations in the standing crop with time and place can be followed. Figure 5 shows that not only is there a seasonal cycle in algal biomass, but also that the summer crop of 1981-82 was very greatly in excess of that of 1982-83. This illustrates very clearly the hazard of using results from a single year's survey to typify an ecosystem. Because of such natural fluctuations, a time span of several years is desirable (though not always available) in order to cover the normal range of variability.

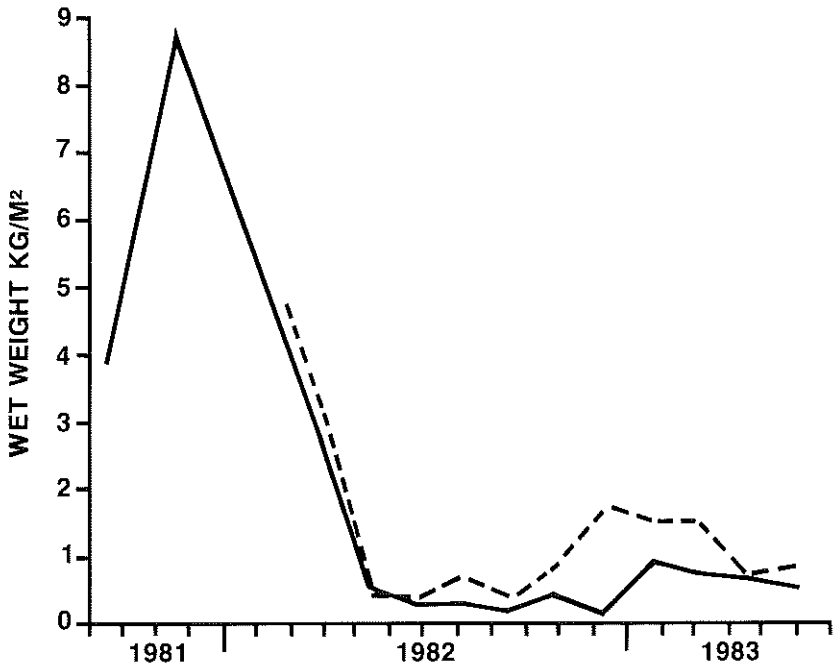



Figure 5. Macro-algal biomass at two stations within Dampier Archipelago.

A Marine Science and Technology grant has enabled scientists from Murdoch University to commence a joint study of algal taxonomy and the role of algal turf in Dampier Archipelago.

The Department of Conservation and Environment has funded a student from the Botany Department, Univerisity of W.A., in a brief study of the blue-green algal matts on inter-tidal flats near mangroves. A times of peak activity (i.e., after rain) these algal matts may fix atmospheric nitrogen at rates sufficient to represent a significant source of nitrogenous material.

Some initial observations have been made on mangroves but further work on this important part of the system has been delayed until staff and facilities became available.

As part of an Australia-wide series of stations established by the Australian Institute of Marine Science to use leaf production as a means of comparing productivity of different mangrove systems, this Department is maintaining a station within healthy mangroves near Dampier. Leaf litter collectors are cleared each month and the material sent to AIMS at Townsville for analysis.

Although one species of the phytoplankton (*Trichodesmium* sp.) blooms during summer months producing patches of cells floating on the surface of the water, evidence to date indicates that phytoplankton may rank rather low among the primary producers of this ecosystem. The role of phytoplankton in the system will be reviewed during the summer of 1983-84.

Plant production within Dampier Archipelago may be sufficiently high not only to support the fauna within these waters, but also, as organic material is carried offshore, to contribute to the system supporting the large fish stocks being fished on the mid-shelf. In order to test this hypothesis, links have been established with the CSIRO multi-disciplinary study of demersal fish stocks of the northwest shelf (using the research trawler "Soela"). A joint project has been established to assess the transport of nutrients and particulate matter along a transact extending offshore through Mermaid Sound to the outer edge of the continental shelf.

At stations on the coral reefs of the Archipelago selected species of corals are being studied. Rates of growth compare very favourably with better known tropical reefs elsewhere. There is generally a seasonal cycle in growth rates of the corals, but in certain instances there appears to be some inhibition of growth at the height of summer, though not to the same degree as in mid-winter (Figure 6). Current research is measuring community metabolism across coral reef flats.

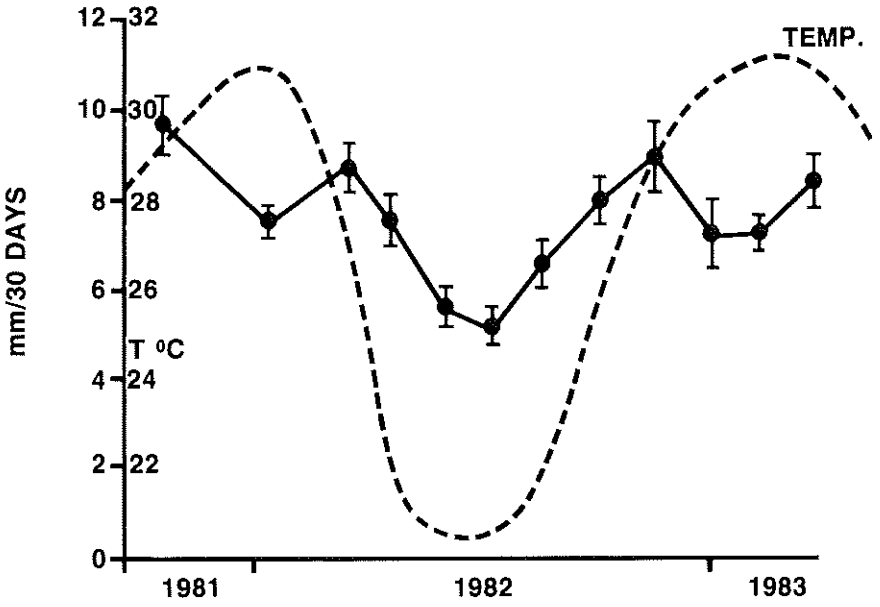



Figure 6. Growth rate of the coral, *Acropora formosa* at Conzinc Island, Dampier Archipelago.

## Sediments

The initial work focussed upon suspended sediments as these have the potential for reducing the penetration of light necessary for plant growth. Sediment traps were set at an array of stations at which light penetration through the water was measured regularly. A large proportion of the suspended sediment consisted of calcium carbonate fragments, but significant fractions of organic material (detritus) were also present. Cores taken through the sediment on the seabed by diving at a series of stations are now being analysed.

If funds permit, the Geology Department of the University of W.A. will undertake a thorough investigation of sedimentology within the Archipelago.

## Potential pollutants

Ideally background levels of pollution measured before development occurred, would provide baseline data against which subsequent levels could be compared. Oysters have been

sampled throughout the Archipelago and analysed for a broad spectrum of heavy metals. The results indicate that in the vicinity of Dampier township, some oysters have already accumulated copper and zinc in their tissues. At a station adjacent to the town, the concentration of copper in 10 oysters ranged from 22 to 200 mg/kg (mean 87 mg/kg), while the concentration of zinc ranged from 370 to 1800 mg/kg (mean 1004 mg/kg). Some of these oysters carry higher concentrations of copper and zinc than allowable under the Health Act for edible shellfish (70 mg/kg and 1000 mg/kg respectively).

As a follow-up to this, levels of copper and zinc in seawater and oysters are being measured on a line of stations away from Dampier. The relationship between concentrations in seawater and oysters must be established to determine the levels of these metals which can be allowed in seawater before oysters become unfit for human consumption by present standards.

Some baseline measurements have also been made of hydrocarbons and pesticide residues in seawater off the Archipelago.

### Consumers

Although industry consultants have compiled lists of species, little is known of relationships between consumers at different levels within the system. At present only two projects focus on consumer groups.

The Marine Branch is giving field support to the CSIRO Division of Fisheries Research in examining the role of sheltered habitats within the Dampier Archipelago as possible nursery ground for young fish of species important in the offshore trawl fishery. Our north-west shelf supports large stocks of demersal (bottom living) fish; from 1972 to 1978 the average annual catch of foreign trawlers on this shelf was over 53,000 tonnes per year. There are increasing indications that certain fish species important in this fishery may rely on sheltered inshore waters as nursery areas. For example, of 72 species of fish identified by an industry consultant group sampling within mangrove channels near Dampier, at least 20 were juveniles of species fished as adults on the mid-shelf. If present investigations verify the early indications, careful management of the inshore habitats will be essential to safeguard the large offshore fishery.

At least three species of turtle are known to breed in the Dampier Archipelago. One of these, the green turtle (*Chelonia mydas*), grazes directly on aquatic plants, younger specimens being abundant at times within shallow embayments. Mr Keith Morris of the Department of Fisheries and Wildlife, now based at Karratha, is including turtles in a survey of wildlife of the Archipelago. By an integration of effort it may be possible to quantify the role of these turtles as consumers within the system.

Records are being kept of all sightings of dugongs and humpback whales, the two marine mammals known to use these waters. Although humpback whales do not feed here, many used to come into the sheltered waters of the Archipelago each winter to breed (the try-pots from last century are still to be seen on Malus Island). With total protection of humpback whales over the past 20 years, numbers are increasing again.

## MAN'S USE OF THE RESOURCES

Apart from port and industrial pressures, human uses of resources within this ecosystem are increasing.

Commercial fishing within the Archipelago is not significant at present; the more important role of these sheltered waters may be as nursery grounds for large stocks fished offshore, as discussed previously. A modest scale prawn fishery in the vicinity of Nickol Bay has taken up to 476 tonnes/yr. From a recent survey of livebait schools, the Department of Fisheries and Wildlife concluded that the most effective area for the catching of livebait and for mooring holding caufs was within Dampier Archipelago. Two species of rock oysters (*Saccostraea commercialis* and *S. cucullata*) are abundant, having potential for culture,

perhaps making Perth independent of relatively expensive (and sometimes polluted) rock oysters from New South Wales.

Amateur fishing by line, net, or speargun is widespread and growing in popularity, although few statistics are available on either boat numbers or catches. At a fishing tournament held by the King Bay Game Fishing Club in mid-1982, the local fisheries officer weighed in a total catch of 1232 kg. This included 57 narrow barred spanish mackerel (538.75 kg), 11 sailfish (257.25 kg), 4 bronze whaler shark (167.75 kg), 6 great trevally (33.75 kg), 4 cobia (27.25 kg), and 4 mackerel tuna (23.0 kg).

Tropical fish are being taken alive for the saltwater aquarium trade, and shell collecting is popular with professionals as well as amateurs.

Fine beaches between rocky headlands in the Archipelago are highly valued for recreation as much of the Pilbara coast has less attractive silty sands and mangroves. However, there are potential conflicts here as many of the best beaches and dunes are also used by turtles for nesting and in addition have been pegged by industry for high quality limesands resources.

## RESEARCH FACILITIES

Interim accommodation was made available by Woodside and Hamersley Iron, but the lack of an adequate field station was a severe restriction at the commencement of the Study. Now, with the help of Hamersley Iron, an independent field station with living quarters and laboratory space has been established in the old Dampier hospital. The improved research opportunities have attracted scientists from other institutions. At present this is the only marine field station on the coast between Geraldton and Darwin.

The Marine Branch operates two power boats (8.1 and 5.5 m in length) and a punt and dinghy are available for work in mangrove channels and shallow bays. The Hampton Harbour Boat and Sailing Club has kindly leased a berth in its marina for our use.

Although the Marine Branch has only a small group (3-4 scientists and 1 technical officer) engaged in the Dampier Archipelago Marine Study, it functions as a core group developing an integrated research programme for the system as a whole (so far as funds will allow). The following institutions and departments are involved to varying extents:

Department of Conservation and Environment

University of Western Australia

Murdoch University

Department of Fisheries and Wildlife

Department of Lands and Surveys

Western Australian Museum

CSIRO

Australian Survey Office

Australian Institute of Marine Science.

## APPLICATIONS TO MANAGEMENT

As in any ecosystem, each part is dependent upon, or contributes to, other segments of that system. In the case of the Dampier Archipelago coastal ecosystem, the various components are linked by nutrient flow as illustrated in Figure 7.

Documenting the resources available in this area, and understanding their interdependence and responses to environmental pressures, will lead to better management of these coastal resources for the greatest sustainable benefit of present and future users.

While the prime focus is upon the Dampier Archipelago, the results of this regional study will have direct application to the Pilbara coast as a whole, shortening the response time needed if pressures increase elsewhere on the north-west coast.

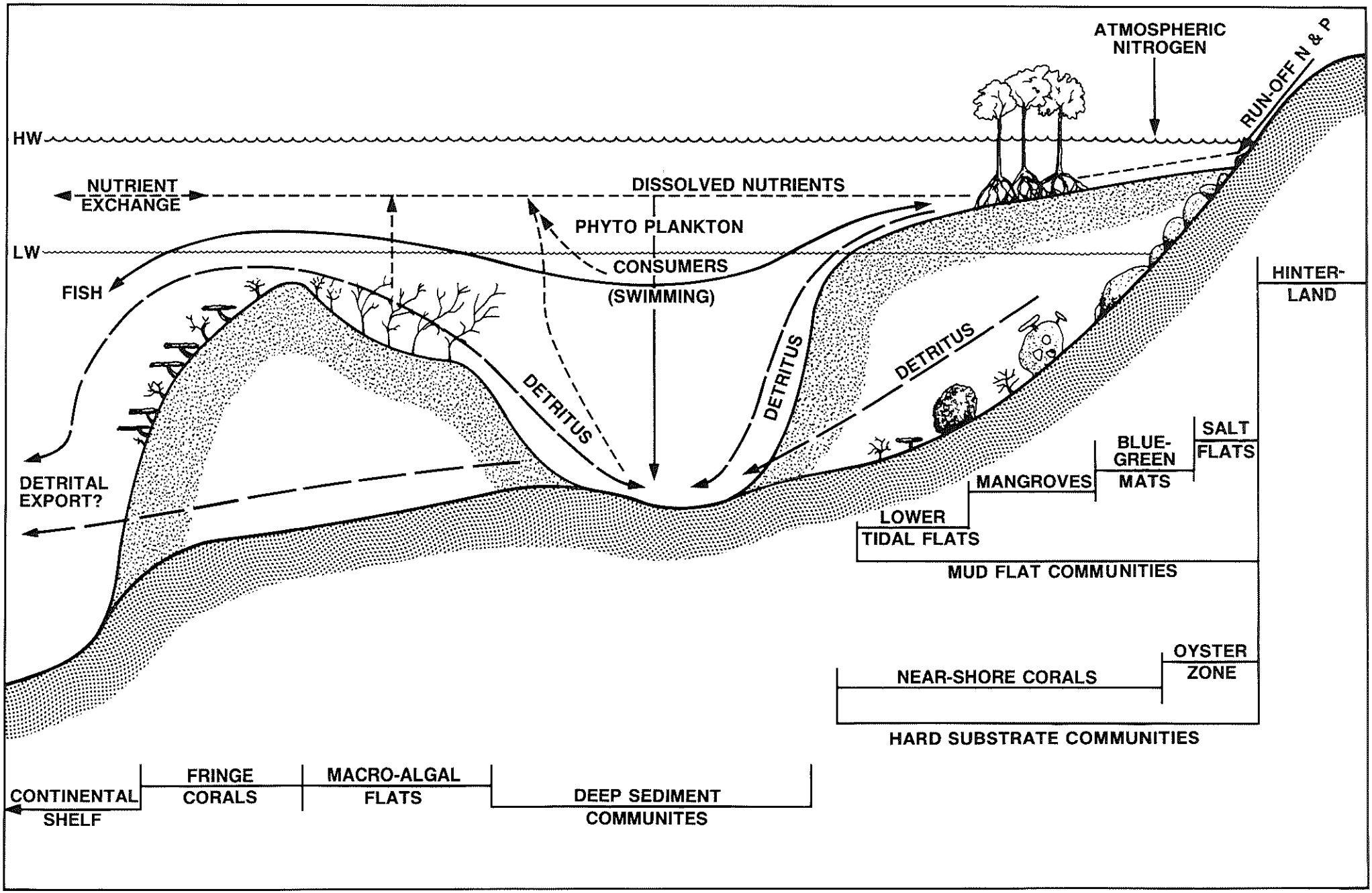



Figure 7. Nutrient flow confirms that no part of the system is independent of the whole.