MARINE SYSTEMS OF DAMPIER ARCHIPELAGO

Papers presented to a workshop convened by the

Department of Conservation and Environment at the Department of Botany, University of W.A. 3 Sept. 1981

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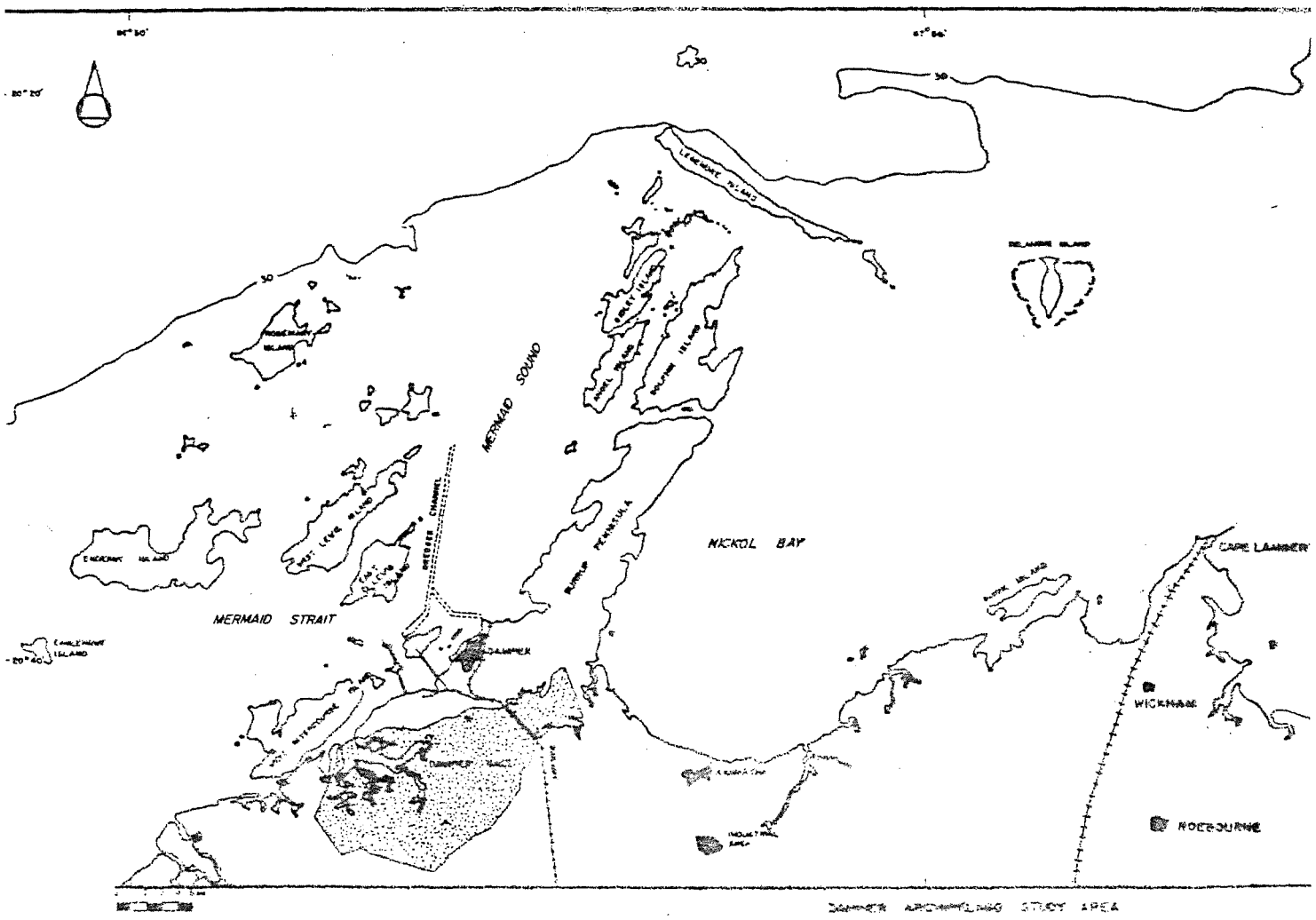

MARINE SYSTEMS OF DAMPIER ARCHIPELAGO

The development of major industries (iron ore export ports, salt production and LNG-LPG production) on this section of the Pilbara coast is promoting rapid growth of population with its own social and recreational needs. With other industries expected to be attracted into this region, it has been predicted that this will be a major growth centre through the next 20 years. Thus it is important to plan for multipurpose use of this coast, aiming to avoid repeating mistakes made in the past where remedial action after extensive development has proved highly expensive owing to the limited range of options remaining.

To ensure that the developments on this coast are introduced with the least conflict between users, to make the best use of the little developed marine resources, and to maintain an attractive and satisfying environment, it is necessary to understand the key features of the marine ecosystems in the area and the driving forces maintaining them.

One early step is to review what is known and what studies are currently being carried out in the area. With this aim, a workshop was held on 3 September, 1981, at the Botany Department, University of Western Australia, bringing together 47 persons having widely ranging interests in this area.

The objectives of this workshop were to:

1. Obtain outlines of the studies which have been completed or are underway in the area.

2. Generate discussion on the natural systems of the area (both physical and biological) and how they operate and interact.

3. Examine user pressures as they exist now and as anticipated in the future.

4. Highlight key areas for future research.

5. Promote closer interaction and possible collaboration by people interested in or working in the area.

Although the wide ranging and useful discussions have not been recorded in full, speakers were invited to prepare brief summaries of their activities and interests in this area. These contributions together with a summing up, have been assembled for circulation to participants as a record of the workshop.

Our thanks go to Professor Arthur McComb for the use of the seminar room and facilities at the Botany Department.

GRAHAM CHITTLEBOROUGH
MARINE STUDIES BRANCH
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CONTRIBUTIONS

WATER MOVEMENTS AND PROPERTIES: DAMPIER ARCHIPELAGO

D.A. Mills

Marine Studies Branch
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Physical oceanography is central to most of the important marine processes occurring in the area, from the transportation of nutrients past the sessile plants and animals and the flushing, dispersion and dilution of wastes, to the migration of sand on the beaches and the movement of bottom sediments.

The water circulation regime must not only be adequately described and its time scales identified, but also understood in terms of the action and relative importance of the driving forces. These forces, exerted by tide, wind, density gradients and continental shelf processes must be considered along with the role played by the bathymetry and form of the area.

The Marine Studies Branch is conducting a series of drogue studies throughout the Archipelago. These data, together with water level and wind readings are leading to a delineation of tidal and wind-driven flows. In relatively open water of 6 m depth or more, the results suggest the frequent occurrence of a vertical current shear induced by local wind stress, which may operate either parallel or transverse to coastlines. Wind induced gradients of water level may control the flow of water through more restricted waters. These wind-induced phenomena become more evident at mid to low tidal ranges. Horizontal shear of tidal currents away from the coast are noted.

Temperature and salinity data are being collected at stations throughout the Archipelago. In particular, temperature differences of several degrees have been measured in these waters.

The Branch now plans to commence continuous current metering in the Archipelago in order to encompass a wider range of conditions and to identify more systematically the tidal, wind driven and other residual responses of these waters.

Due to its geographical complexity this region presents difficulties to a synoptic understanding of its dynamics. The Branch is examining the feasibility of using remote sensed SST as a tracer of water movement to help overcome this difficulty. To this end a program which would also involve co-ordinated ground truth measurement is being prepared.

Due to the scale of the region the Branch sees value not only in the exchange of data with others working in the field, but also in the co-ordination of instrument deployment, where possible to build up a more meaningful data base.

The provision of a continuously recording anemometer in a suitably representative location is also seen as a pressing need.

BASE-LINE LEVELS OF METALS, PETROLEUM HYDROCARBONS AND CHLORINATED HYDROCARBONS

V. Talbot

Marine Studies Branch
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1. Work commenced

1.1 Metals

Oysters (two species) have been sampled from ten locations around Mermaid Sound, on three occasions. Surface sediments have been collected from ten stations, on two occasions. All samples have been analysed for seven metals.

Water sampling quarterly at a shelf station north of Legendre Island. This offshore station is part of a national project to establish base-line levels of metals in ocean waters around Australia.

1.2 Hydrocarbons

Water sampling quarterly at a shelf station north of Legendre Island. As for the metals, this is part of a national project to establish base-line levels of petroleum hydrocarbons and chlorinated hydrocarbons in ocean waters around Australia.

2. Forthcoming work

2.1 Metals

Quarterly monitoring for heavy metals in sediments and oysters at five stations between Dampier marina and Conzinc Bay.

2.2 Hydrocarbons

A broad regional survey for petroleum hydrocarbons and chlorinated hydrocarbons in water, oysters and sediments. Subsequent monitoring at five stations, as for heavy metals.

PRIMARY PRODUCTION AND ECOLOGY IN DAMPIER ARCHIPELAGO WATERS

A.W. Chiffings

Marine Studies Branch
Department of Conservation and Environment

SYNOPSIS OF PROGRAMME

AIM

1. To understand and quantify primary production in the region so that the impact of previous and future environmental changes may be assessed.

OBJECTIVES

1. To assess the relative importance of the individual primary producers in the Archipelago. These producers include -

   (i) phytoplankton
   (ii) periphyton
   (iii) macroalgae
   (iv) seagrass
   (v) mangroves
   (vi) blue-green algal mats
   (vii) corals

2. To determine the factors critical in controlling production rates and the standing stock. Factors critical to production probably include availability of light and nutrients and factors critical to changes in standing stock will include production rates, grazing, seasonal die-off and physical changes.

3. Obtain a descriptive account of species diversity and changes in same on a seasonal basis for each group of the primary producers.

APPROACHES

Considering the large area the intended approach is to break the area down into a number of discrete systems and select representative sites within these systems. Gradients and boundaries will be investigated throughout the region with respect to physical, chemical and biological parameters. Once this has been done an attempt will be made to quantify changes in standing stock and production rates and then subsequently to look at flux rates for nutrients and carbon throughout the entire system.

WORK TO DATE

Over the last 12 month period four trips have been made at approximately three monthly intervals. During these trips an idea has been obtained in a descriptive sense of the distribution of the primary producers throughout the region. Quantitative measurements have been made on physical and chemical parameters throughout the waters of the region as well as some effort being made to quantify nutrient flux from the mangrove areas. Data collected to date are being assessed. Subsequently, new programmes will be designed to initiate work which is to be undertaken over the next three year period.

THE NORTH WEST SHELF GAS DEVELOPMENT

R.H. Jenkins — Environmental Coordinator
Woodside Offshore Petroleum Pty. Ltd.

The range of activities and the predicted time schedules associated with the Project were presented and, in particular, the Woodside operations offshore and in Mermaid Sound were briefly summarised.

The aim of the presentation was to provide background information about those activities, for which environmental studies had been undertaken and which would be described by I. LeProvost and T.D. Meagher.

The discharge of cooling water had been identified in the EIS/ERMP as a potential significant environmental aspect of the project.

The current Woodside proposals to build a weir across the mouth of No Name Creek to create a ponding effect was described. The environmental benefits of this proposal were expected to be:

(i) some loss of heat to the atmosphere before the waters are discharged into Mermaid Sound;

(ii) loss of free chlorine, added to the inlet of the cooling water tunnel to reduce fouling; and

(iii) reduced erosion effects and retention of sediments behind the bund.

The installation of the submarine pipeline posed engineering problems in the relatively shallow waters of Mermaid Sound associated with its protection from ships and anchors and its stability under cyclonic conditions. The current proposal to pretrench some of the route and to plough the remainder was described.

The new shipping channel would generate significant quantities of spoil (approximately 11 x $10^6 m^3$), the majority of which needed to be dumped at suitable locations offshore.

Most of the material generated from the dredging in the Supply Base was utilised on land for reclamation within the Supply Base. Some was dumped on land behind a retaining bund.

INVOLVEMENT OF MAUNSELL IN THE DAMPIER ARCHIPELAGO

G. Ryan Maunsell-Nedeco

Maunsell and Partners Pty. Ltd. were originally involved in the Dampier Archipelago area when they managed the Environmental Impact Statement and Environmental Review and Management Programme for Woodside Offshore Petroleum.

Since that time, in conjunction with the Netherlands Engineering Consultants, Nedeco, they have been involved in all of the dredged aspects of the North West Shelf Project. In particular the dredging tasks are for:

The Supply Base
The Pipetrench
The Materials Offloading Facility
The Shipping Channel

For the Shipping Channel alone, approximately 11 x $10^6 m^3$ of dredged material is to be disposed of, 90 percent offshore. Amongst other aspects of the project the choice of suitable disposal areas has received extensive attention. Engineering and financial considerations in the choice of spoil areas have included:

- The volumes, types and grades of materials
- Likely disposal methods
- Transport costs
- Navigation requirements
- The mobility of dumped spoil

The possible disposal areas remaining after the above considerations have been subjected to extensive ecological surveys and studies.

As part of these ecological studies, and to ensure future navigational safety, the movement of dumped spoil has been studied. The investigations have been theoretical, and based on oceanographic and sedimentological information gathered during 1978 and 1981.

Sediment movement studies have considered bed and suspended loads, and as well as investigations of proposed spoil areas have encompassed probability studies of the rates of sedimentation in dredged areas.

DAMPIER ARCHIPELAGO PROJECTS

I. LeProvost LeProvost, Semeniuk & Chalmer

1978-79 (with Tim Meagher, Shirley Slack-Smith, Loisette Marsh and Barry Hutchins)

Described marine environment of Dampier Archipelago for the ERMP of Woodside's North West Shelf Development Project on behalf of Maunsell & Partners. A twelve month study including field sampling, mapping distribution of habitats and biotic assemblages, literature survey and impact assessment.

1980 Described mangrove environment of Maitland River Delta on behalf of Dampier Salt (Operations) Pty. Ltd. A three month study involving field sampling, mapping distribution of mangrove associations and habitats, comment on condition of area.

1980-81 Research towards developing a biological monitoring programme aimed at determining the effects of the Woodside LNG development on the marine biota of the west coast and nearshore waters of Burrup Peninsula. The principal effects of this development have been identified as the discharge of 50 cusecs of water heated 11^{o}C above ambient, and dredging operations. A twelve month study aimed at selecting suitable monitoring organisms from a range of habitats. These habitats are:

- high tidal salt flats
- mangal
- low tidal sand flats
- beaches
- nearshore (0 - 2 km) subtidal sediments
- intertidal rocky shore
- intertidal limestone pavement
- subtidal rocky shore

The study involved four seasonal field surveys to determine the population dynamics of potentially suitable organisms. Study has just been completed. Detail on the objectives of the monitoring programme and the rationale and scope of the research study are presented in:

LEPROVOST, M.I. Marine Biological Monitoring Programme for the North West Shelf Gas Development. Conference on Environmental Engineering, Townsville, 8-10 July 1981. The Institution of Engineers, Australia. National Conference Publication No. 81/6, pp 73-77.

Details on the range of marine habitats, factors controlling their distribution and the range of biotic assemblages occurring within the Archipelago are presented in:

SEMENIUK, V., CHALMER, P.N., and LEPROVOST, M.I. The Marine Environments of Dampier Archipelago. Royal Society of W.A. (in press).

INVESTIGATIONS IN THE DAMPIER ARCHIPELAGO

T.D. Meagher T.D. Meagher and Associates

The firm has undertaken a range of biological investigations requested by Woodside in relation to:

(a) The control of fouling organisms in the proposed LNG cooling water system.

(b) The management of spoil that will be generated by the installation of the gas pipeline through Mermaid Sound and dredging the shipping channel.

The principal of the firm was also directly involved in earlier marine biological investigations for the ERMP and an investigation to determine the rate of fouling growth on offshore platforms. These have provided some longer term familiarity with the marine ecosystem of the Sound.

Specific work elements which have been undertaken in the course of the more recent investigations are outlined below.

1. Measurement of physical water quality criteria

Profiles of water turbidity, light attenuation, salinity and temperature, have been taken over a broad area of Mermaid Sound, during the period from March to August, 1981. Measurements have not been routinely taken at fixed stations. They have been taken where appropriate whilst conducting other study tasks.

Although the data are as yet by no means complete, they do clearly show that turbidity is a major factor in habitat distribution. Turbidity varies locally throughout the Sound. It also shows marked overall seasonal variation. It is concluded that continued acquisition of this data is fundamental to understanding the Mermaid Sound ecosystem. The major physical variables are temperature, turbidity and turbulence.

2. Sediment Traps

A series of sediment traps have been placed at a range of locations throughout the Sound. At each station there are two traps, one 50 cm above the seafloor, the other 5 cm above seafloor. Trap diameter is 100 mm. Data has been collected monthly since March 1981, and is continuing. Results are complementary to the turbidity studies. They give a longer term indication of re-suspension than do the short-term field surveys with turbidity meter. Samples are analysed for dry weight, size distribution and total nitrogen content.

3. Seafloor Photographic Reconnaissance

Conventional underwater photographic techniques have been refined to obtain high clarity, vertically-controlled photographs of the seafloor at a fixed distance under clear to quite turbid conditions. As a result, comparable samples of equal area are recorded. These enable rapid mapping of broad areas on a statistical basis. Data can be re-assessed in the office and subsequently compared to later surveys. Detailed underwater proformas have been completed during photographic sampling.

4. Sampling of Sediment Infauna

Much of the seafloor of the Dampier area is comprised of soft sediment seafloor. Samples of the biota within the soft sediments have been obtained using venturi airlift in association with an underwater seive.

Animals are preserved and identified to lowest practicable taxa. From the mouth part morphology, a feeding strategy is assigned to each taxa. Species saturation curves have been obtained to determine adequacy of sampling. Based on this, an appropriate number of replicate samples have been taken from selected areas for statistical comparison. A broad range of statistical analyses have been applied to the data.

As a result it has been relatively easy to assign habitat characteristics to the areas surveyed based on trophic levels, species richness, etc. The parameters obtained are to alter markedly in response to environmental change. It is considered by us that the technique is a fundatmental monitoring tool very suitable to proposed developments in Mermaid Sound.

5. Settlement Frames

A large-sized settlement mooring frame has been established in Flying Foam Passage. This complements data from earlier studies of similar frames located off Kendrew Island, the Monte Bellos and at North Rankin. Some component surfaces of the frame are changed at approximately monthly intervals to obtain an indication of settling periods for different groups of fouling organisms.

6. Analysis of Bivalve Gonad

Samples of pearl shell and wing shell have been collected at approximately monthly intervals and dissected to evaluate gonad reproductive condition. This information has been combined with the settlement frame information to obtain an indication of spawning and recruitment behaviour in these bivalves.

7. Chlorine Demand

In order to determine the most efficient and environmentally appropriate chlorination routine for fouling control, tests have been made of the chlorine demand in the seawater on a seasonal and spatial basis. It is found that there is marked seasonal variation and considerable local variation. These effects are not simply due to temperature. As chlorine demand reflects organics in the water column it may be a parameter of some merit in defining water quality, not only in this study area, but elsewhere.

8. Toxicity Testing with Chlorine

Some broadly based toxicity tests have been made with chlorine on samples of plankton. These have been useful in ascertaining the lowest practical dose. They also indicate mechanisms by which chlorine acts. This aspect has not previously been adequately addressed in the literature.

OPERATIONS IN MERMAID SOUND

K.L. Piggott

Environmental Engineering
Hamersley Iron Pty. Ltd.

Within the context of the seminar, two developments of Hamersley's are of interest.

- Upgrade of off-loading facilities at Parker Point
- Port study for feasibility of upgrade to accept 250,000 tonne vessels.

Government approval for increasing the ship capacity of Parker Point has been obtained through the established procedures of the Company's State Agreement.

In both cases, investigations are directed to the physical environmental factors. For the Parker Point upgrade, minor quantities of material are being dredged at the turn of the channel into Parker Point to enable vessels of 140,000 tonnes to manoevre into the wharf. Consideration was given to depositing this spoil into a sea bed depression to the east of the channel but in fact it has been possible to place this material on existing spoil grounds already designated to the east of East Lewis Island. Soundings and sediment flow potential will be determined during and on completion of this work. From previous experience the placement of this limited quantity of dredge material on the existing spoil ground is not expected to give rise to difficulties.

The Port Study is essentially an investigation of the physical requirements for accepting larger vessels into the Port, specifically questions such as channel width, channel alignment and suitability of the existing tug fleet must be determined in providing acceptable manoevrability for these larger vessels. Such questions are conveniently investigated by mathematical modelling. For this purpose, available physical data for the area has been collected and supplementary data acquired by field measurements to validate the hydraulic model.

Other capabilities of the model such as storm surge simulation, sedimentation studies etc. would require validation for the study area.

MONITORING BY CLIFFS ROBE RIVER IRON ASSOCIATES

C.J. Morris

Environmental Officer
Cliffs Robe River Iron Ass.

Cliffs Robe River Iron Associates have been actively engaged in monitoring the coastline, in the vicinity of Cape Lambert, as part of its overall environmental management programme, since 1977.

Accordingly, paired sets of oblique photographs have been prepared, using colour and false colour infra-red film. An initial run was flown during 1977 along the vicinity of Cape Lambert coastline and repeated in 1979. Further runs are to be made in 1980/81.

A set of low tide colour and false colour infra-red mosaics of the Cape Lambert mangroves and coast have been prepared from runs flownin 1977.

Ground checks have been made based on anomalies recorded in photographs, and a continuous monitoring programme will be developed around biological data collected from the mangrove shoreline and creeks during January, 1979.

SOME ASPECTS OF THE PHYSICAL OCEANOGRAPHY OF THE NORTH WEST SHELF OFF DAMPIER

P.E. Holloway

Department of Civil Engineering
The University of Western Australia

A study of the physical oceanography of the North West Shelf is in progress and aims at identifying and explaining the features of the dynamics of the flow over the shelf and slope regions off Dampier. Extensive current meter and temperature-salinity data have been collected over the last three summers by Woodside Offshore Petroleum and is being analysed. The Dampier Archipelago forms the coastal boundary layer to the region being studied and in this talk some results most relevent to this region are discussed.

Temperature-salinity sections across the shelf show how, in summer, the coastal regions provide high salinity water to the rest of the shelf. The saline water moves across the shelf as a density current. Strong semi-diurnal tides dominate the flow over the shelf and harmonic analysis of current meter records shows that coastal bathymetry has a strong influence on the magnitude and direction of the tidal currents. Strong internal tides exist near the shelf break but are less evident near the coast. Measurements during two tropical cyclones indicate that the entire shelf region is strongly influenced. The two cyclones, with different characteristics, produced different responses in the currents across the shelf. In one case the maximum response was observed near the coast with current speeds reaching 100 cm/s. Considerable energy exists in the currents at the inertial and lower frequencies. This low frequency energy is a maximum near the shelf break but is still significant near the coast. The low frequency currents are well correlated to the component of the wind parallel to the coast.

CORALS AND ECHINODERMS OF THE DAMPIER ARCHIPELAGO

L.M. Marsh Western Australian Museum

I have been involved in two museum projects in the Dampier Archipelago. The first (1972-74) was primarily a monitoring survey of the Crown-of-thorns starfish (Acanthaster planci) at Kendrew Island, led by Dr. B.R. Wilson, and involving the museum departments of Ichthyology, Malacology and Carcinology.

The second was part of a survey of the reef fishes, marine plants, molluscs and corals of Burrup Peninsula and some islands of the Archipelago, made under contract as a contribution to the EIS for the N.W. Shelf natural gas onshore facility (1978).

Kendrew Island - The monitoring survey of Acanthaster (three times a year over three years) showed a widely dispersed, large population with seasonal aggregations in shallow water prior to the breeding season. The population level although high was not thought to be out of balance with the coral reef, however the study was terminated before the complete pattern was clear and a subsequent visit (1978) showed severe destruction of the reef (probably as a result of cyclone damage) with a persistent population of Acanthaster preventing substantial coral regeneration. The Kendrew Island surveys also produced the first intensive collections of coral from the Dampier Archipelago and augmented the knowledge of fish, echinoderms, molluscs, crustacea and other invertebrates from the area. Taxonomic problems in several groups have delayed publication of faunal lists but they are in preparation.

Two detailed transects were made across the Kendrew Island reefs from shore to a depth of ca 10 metres but again publication has been delayed by taxonomic problems.

The second project was also carried out jointly with the museum departments of Ichthyology and Malacology and involved swimming rough transects from the intertidal to the bottom of the reef or rocky slope (ca 9 metres) at 24 sites: on the Burrup Peninsula from King Bay to Searipple passage, Conzinc Island, the southern end of Dolphin Island, the west side of Angel Island, Malus Island, Kendrew Island, Miller Rocks, between North Gidley and Legendre Islands and on the east side of Burrup Peninsula.

Observations of the coral species present (or genus where specific determinations were uncertain), their abundance (on a scale of 3) and depth range were recorded underwater and specimens collected where necessary. The presence of other invertebrates e.g. echinoderms, soft corals and ascidians was also recorded, identified to species level (echinoderms) on higher taxa.

Little vertical or horizontal zonation of the corals was discernible but it was evident that a small suite of species was

only found on silty bottoms in turbid water and a few species were confined to the seaward localities. Otherwise horizontal zonation was evident as a difference in the relative abundance of species from seaward to shoreward localities. A preliminary species list of corals and distribution tables within the archipelago have been prepared but more taxonomic work is needed before publication. Forty eight hermatypic coral genera are recorded (Wilson & Marsh, 1979), the highest number from any area so far studied in W.A., reflecting the faunal richness and great diversity of habitats in the Dampier Archipelago.

PUBLICATIONS

Wilson, B.R. and Marsh, L.M., 1974. Acanthaster studies on a Western Australian coral reef. Proceedings of the Second International Symposium on Coral Reefs, Queensland, 1973, 1: 621-630.

Wilson, B.R., Marsh, L.M. and Hutchins, J.B., 1974. A Puffer Fish Predator of Crown-of-Thorns in Australia. Search, 6 (11-12): 601-602.

Wilson, B.R. and Marsh, L.M., 1975. Seasonal behaviour of a "normal" population of Acanthaster in Western Australia. Crown-of-Thorns Starfish Seminar Proceedings, Brisbane, 6 September, 1974. Aust. Govt. Publishing Service, Canberra, 167-179.

Wilson, B.R. and Marsh, L.M., 1979. Coral reef communities at the Houtman Abrolhos, Western Australia, in a zone of biogeographic overlap. Proc. Int. Symp. on Marine Biogeography and Evolution in the Southern Hemisphere, Auckland, 1978. N.Z. DSIR Information Series 137, 1: 259-278. (Coral genera from the Dampier Archipelago are included in a table.)

UNPUBLISHED REPORT

Marsh, L.M., 1978. Pt IV, Report on the corals and some associated invertebrates of the Dampier Archipelago, (67 pp).

In: Hutchins, J.M., Slack-Smith, S.M. and Marsh, L.M., 1978. Report on the Marine Fauna and Flora of the Dampier Archipelago. Unpublished report submitted to Meagher and LeProvost, Consultant Biologists.

MOLLUSCS AND MARINE PLANTS OF THE DAMPIER ARCHIPELAGO

S.M. Slack-Smith Western Australian Museum

The latitudinal position of the Dampier Archipelago determines that its marine biota is typical of the tropical Indo-West Pacific region, but of a reduced diversity in consequence of its peripheral location. However the molluscan fauna at least is supplemented by a number of species endemic to the west coast of Western Australia. The terrestrial and freshwater molluscs are similarly typical of the faunal groups characteristic of the north-west of Australia, though again lacking in some forms restricted to more tropical habitats..

The geology and topography of the area ensure that a variety of habitats are amply represented at least in the marine environment where they differ in depth, turbidity, current and wave action, temperature and salinity ranges and in the nature of the substrate.

This habitat range is reflected in the diversity of the marine biota. Inshore waters are rich in forms found less abundantly further north and south along the mainland coast. These species are tolerant of the high turbidity and large temperature and salinity ranges which generally prevail. In contrast the offshore waters of the Archipelago are less turbid and more stable in terms of temperature and salinity. In these areas the biota is typical of that of tropical oceanic reefs. Such a habitat is found at the North West Cape reef tract and the Muiron Islands to the south and on the more westerly parts of Barrow and the Monte Bello Islands to the west. However it is not found to the north except on the small offshore reefs of the Rowley Shoals, Ashmore Reef etc.

Direct involvement by the W.A. Museum in research on the molluscan fauna of the Archipelago has been continuous since 1960. Material from various collecting and/or survey field trips forms a major part of the collections on which knowledge of the taxonomy and of the geographic and habitat ranges of Indo-Pacific marine molluscs and north-west Australian land molluscs is found. A variety of habitats have been sampled by various means. Very detailed data on the distribution of both molluscs and marine plants across an intertidal reef flat at Kendrew Island were obtained during the Crown-of-thorns Starfish Survey (1971-1974) and somewhat less detailed data from transects sampled from intertidal rocky shores to the channel bottom in the region of Mermaid Sound (1977). The study of the diversity and abundance of marine plants was correlated with studies on the sessile fauna during the latter survey.

Althogether more than 500 species of molluscs have been recorded from the Archipelago, though some are still not adequately identified. Some groups such as the oyster (Ostreidae and Gryphaeidae) the mussels (Mytilidae) and the heart cockles (Cardiidae) have received closer attention. Additions to this list of species with an increase in knowledge on their distribution and habitat requirements, will be made as opportunities occur to sample a wider range of localities in the Archipelago.

DAMPIER ARCHIPELAGO FISH STUDIES

J.B. Hutchins Western Australian Museum

During the Crown-of-Thorns Starfish investigation between 1972 and 1974, a survey of the fish fauna of Kendrew and Rosemary Islands was carried out. From individual studies by R.J. McKay, G.R. Allen and muself, a checklist for these two islands was prepared at the end of the programme. I subsequently authored a report on the reef fishes of the Archipelago for Meagher & LeProvost, marine consultants, based on a survey of selected sites throughout the area conducted in August 1978. From the above sources a checklist of the reef fishes of the Dampier Archipelago has now been prepared for publication. It is part of a larger study by me on the distribution of Western Australia's coastal reef fishes. The expected publication date is towards the end of 1982.

Surveys of areas not yet visited in the Dampier Archipelago are planned for the near future, if funds are available.

UNPUBLISHED REPORT

Hutchins, J.B., 1978. I The Report of a reef fish survey conducted in the Dampier Archipelago during August, 1978. In: Hutchins, J.B., Slack Smith, S.M. and Marsh, L., 1978. Report on the marine fauna and flora of the Dampier Archipelago. Unpublished report submitted to Meagher and LeProvost, Consultant Biologists.

SOME ASPECTS OF COASTAL OCEANOGRAPHY IN THE DAMPIER REGION

R.K. Steedman

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Introduction

The waters of the North West Shelf remain relatively unexplored except for a narrow strip betwen Dampier and the North Rankin gas field, in Mermaid Sound and in Nickol Bay. The following ideas comment on some features which are felt to be important to the coastal ocean dynamics and the (natural) maintenance of the water quality.

Astronomical Tidal and Wind Driven Currents

It is well recognized from coastal tide height records[1] and more recently from current measurements[2], that the semi-diurnal astronomical tide dominates much of the water movement, i.e. time scale of 12 and 24 hours. One of the most striking features is the regularity of the water levels. The local wind driven circulation also contributes to the coastal water movement on time scales of 1 to 7 days. In the summer significant forcing occurs on a 24 hour time scale with the land and sea breeze cycle. In winter the sea breeze recedes and the monsoon stops, so that the synoptic weather influences dominate the winds on time scales of 3 to 5 days.

Both the mechanisms of tidal and wind forcing in coastal regions are well understood and there are numerous references in the literature [3-4-5-6-7]. This is reflected by the fact that local organizations often use numerical models of tide and wind driven circulations which are reliable and well proven. Ironically these studies are conducted in Holland or Denmark, as Australian expertise is not well established.

Other current and transport processes

As we progress with measurements and analysis in our waters it is clear that there are some subtle features which may greatly influence the coastal water quality. Let us single out two identifiable phenomena as examples, namely gravity current flow associated with the so called inverse estuary problem[8] and trapped coastal waves[9]. No doubt other interesting physical processes can be found such as Ekman adjustment in the coastal boundary layer[5] and frontal processes.

Gravity currents (The inverse estuary problem)

The annual evaporation and precipitation are about 1700 and 450 mm respectively, and there is no river run off in the Dampier area. Thus there is a large nett water loss in the shallow waters of the coastal zone. However some mechanism maintains the water quality, as the salinity, although higher near the shore at about 37 to 38^{o}/oo does not continue to increase. The problem is intriguing, as embayments of limited connection (exchange) with the open sea maintain a steady salt balance which is tolerated by the marine ecosystems. One explanation may be as follows. Measurements of the salinity distribution in the winter

suggest that a tongue of cold saline water moves within the first 1 to 3 m above the sea bed. The saline water near the shore cools more rapidly than waters 10 to 20 km offshore during the winter and this strip of more dense water moves out across the continental as a gravity flow following the lowest points in the bathymetry (figure 1). It appears that the process is accelerated in the winter and has a time scale of about 100 days. The under flow has a forward velocity of 0.01 m s^{-1}, based on the measured density gradients in Nickol Bay[10] and theoretical considerations (see Turner[11], pp.73-74).

Coastal Trapped Waves

Provis and Radok[12] showed that long coastally trapped waves propagate anticlockwise around the Australian coast, and have periods between 20 and 365 days with amplitudes of 20-50 cm (figure 2). Because of the long periods the embayments and nearshore regions are all penetrated by these waves. Preliminary calculations suggest velocities of the order of 0.001 m s^{-1}.

Both these subtle mechanisms have important implications for the transport processes of chemical and biological fluxes in the coastal zone.

Conclusions

Astronomical and wind driven water circulation processes with time scales of the order of 1 to 7 days are well understood and can be readily used for forecasting circulation and water quality. However more subtle, and not well understood mechanisms may play an important role in the coastal dynamics. Two identifiable processes are seasonal bottom gravity flows of saline waters and the influence of coastally trapped waves, both with time scales around 100 days. Other processes such as the barotropic and caroclinic Ekman adjustment in the coastal boundary layer[5] and frontal processes may prove important as more measurements and theoretical studies become available.

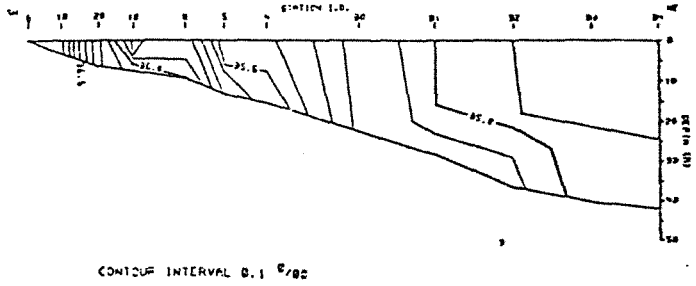

Fig 1 Longitudinal salinity cross-section, first regional survey, July 18 and 19, 1979.

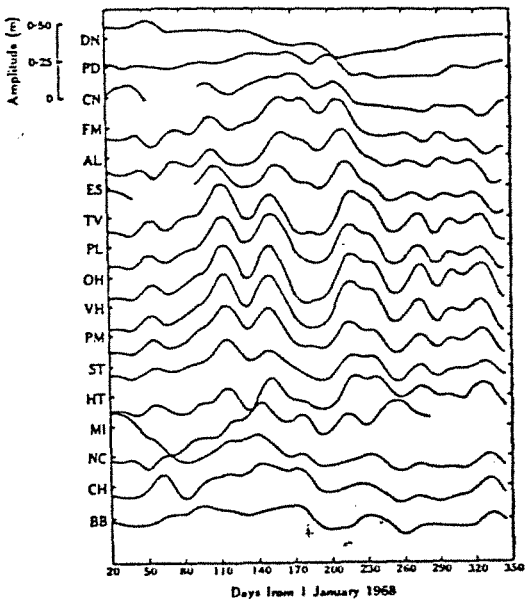

Fig. 2 Variations in sea level with periods between 20 and 365 days, obtained by filtering tide-gauge records from stations along the Australian coast. The data are plotted about their mean values and the names of the stations are

DN, Darwin; PD, Port Dampier; CN, Carnarvon; FM, Fremantle; AL, Albany; ES, Esperance; TV, Thevenard; PL, Port Lincoln; OH, Outer Harbor; VH, Victor Harbor; PM, Port Macdonnell; ST, Stanley; HT, Hobart; MI, Macquarie Island; NC, Newcastle; CH, Coffs Harbour; BB, Brisbane.

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EXPERTISE IN LRM

E. Bettenay

Division of Land Resources Management
CSIRO

1. The physical and biological processes (marine) interact, and are in part controlled by, the land processes.

2. CSIRO, Division of Land Resources Management, have people actively involved in the land processes, and in the land-water interface.

   McArthur - coastal soil -, landform features
   Allison - coastal physical processes, marine-land interface, waves and currents

3. In the Dampier area our knowledge is minimal.

   Atlas of Australian Soils at $1:2 \times 10^6$

   1 unit i.e. BZ_{15}

4. Division of Land Use Research - Coastal lands of Australia.

   Visual photo interpretation to produce data (with existing geological maps etc.) of selected coastal features.

   Mid tide to 3 km inland.

   Format - Computer generated maps showing the coastline by asterisks where the feature of interest is absent and by a figure in km^2 in each section where it occurs, at 1:1 000 000 and $1:2.5 \times 10^6$.

   - knowledge also minimal.

5. We also have expertise in hydrology (of the land) and remote sensing.

   These are being combined - together with soils landform expertise - to look at the occurrence of mangrove species in relation to the sea-land interface between Exmouth and Broome.

REMOTE SENSING

Dr. Frank Honey, and Peter Hick would tell you much more but have prior engagements. Apart from air photography they are working with satellite imagery from Landsat and NOAA 6 and 7

LANDSAT MSS	.5 - .6 μ	Band 4	Blue Green
	.6 - .7 μ	5	Red
	.7 - .8 μ	6	Red + IR
	.8 - 1.1 μ	7	near IR

Combined to make enhanced maps; every 18 days. Can be enhanced for sea area; bathymetry.

NOAA tracking facility jointly between Bill Carrol at the Electrical Engineering Department at WAIT and Frank Honey in CSIRO Remote Sensing Group. In addition to visible and IR, has Thermal IR in 8-14 μ range. Can give temperature to ± 1°C; data received at 7.30 can be on screen by 9 am.

USERS OF RESOURCES IN THE DAMPIER ARCHIPELAGO

C. Nicholson

Department of Conservation and Environment
Karratha

The Archipelago is a rich and fascinating area with a long and interesting history of human use culminating in several important present day resource values.

Aboriginal occupation dates back to at least 6000 BC. Evidence is in
- rock engraving (many depicting marine animals)
- middens containing shells esp. Anadara cockles
- stone implement quarries
- habitation and burial sites.

All these are covered by the Aboriginal Heritage Act. The Searipple Passage end of Burrup Peninsula is listed by the Australian Heritage Commission. The Archipelago was rich in marine and land food resources and apparently able to sustain a sizeable population over a long period. The last inhabitants may have been eliminated about the time of whaling and pearling in the 1860s and 70s.

White exploration

William Dampier 1699	- two day visit, named an island Rosemary, may have collected a few plants.
Baudin 1802	- left behind some French names.
Phillip Parker King 1818	- two weeks' charting the Archipelago.
	- botanist Allan Cunningham took a poor collection of land plants because of drought.
Frank T. Gregory 1861	- exploring inland for cotton prospects, found pastures leading to Pilbara pastoral settlement 1864.
	- base camp at Hearson Cove.

Whaling — 1860s - 70s Bay or Right Whale. Remains of tryworks on Malus Island.

Pearling — 1860s, 70s. Based at Cossack, first pearling industry in W.A. Graves on Dolphin Island, remains of camp on Gidley Island. One licence current for Mermaid Sound.

Pastoral	Remains of pastoral activity on West Lewis - dry stone yards, shelters, well. History unknown.
Historic Sites	These sites on Hearson Cove and Malus, Dolphin, West Lewis and Gidley Islands have been recorded by the W.A. Museum and reported to the Australian Heritage Commission. Attempts are being made to give them appropriate status and management.
Port/ Industrial sites	Solar salt, iron ore and pellets, natural gas, power generation are the major present users of Mermaid Sound.
Mining	Extensive limesand and limestone deposits on the islands or close inshore are the subject of mineral claims. Only Hearson Cove has been mined to date. The limesand deposits are of marine origin, accumulating in bays. It is estimated that large scale iron or steel production could account for all limesand and limestone in the Archipelago.
Commercial Fishing	Limited mackerel, prawns, pearlshell.
Recreational Fishing	A major use of Archipelago waters; - netting in bays, line fishing, light game (especially over outer reefs) - Perth based North West Game Fishing Club lease and shack on Rosemary Island for many years.
Diving	Small but enthusiastic boating population; spearfishing, crayfish, coral-watchers.
Shelling	A popular activity along the coast, by amateurs. Possibility of intensive shelling by professionals.
Sailing	Smaller craft centred on Hampton Harbour. Dampier a port for ocean-goers.
Power-boats	Skiing in Hampton Harbour Pleasure-boating throughout Archipelago, basically eastwards from Dampier to Flying Foam Passage area in winter easterly conditions, westerly to Lewis, Malus, Rosemary in summer westerly conditions.
Island Recreation	Sandy, sheltered beaches popular for three categories of boating public. (1) Day trippers - swim, sunbathe, picnic on beach.

(2) Campers - weekends, on beach.

(3) Shacks - basic galvanised iron sheds for short holiday use, put up by small groups of friends. About 20, mainly on Malus, West Lewis. Six beach Reserves for Recreation vested in Minister for Conservation and Environment, on Rosemary Island (Norbill Bay), Malus Island (Whalers Bay), West Lewis Island, East Lewis Island, Angel Island, Delambre Island.

A local committee is preparing a report to the Minister on management proposals for these reserves. Most users appreciate the 'wilderness value' of the islands. Few venture inland into the spinifex and rocks.

Conservation: Most islands are now Conservation Reserves vested in WAWA following a series of reports:

- 1962 Academy of Science recommended a National Park, A Class with marine reserve to protect Delambre Island corals

- 1974 Conservation Through Reserves Committee 'green book' System 8.5

- 1975 EPA 'red book' recommendations 8.5 accepted by Cabinet with amendments.

Existing status: Rosemary, Enderby, A class Conservation; Dolphin B class.

Angel, Gidley, Hauy, Delambre, Malus, East and West Lewis C class.

Mistaken Island, East Intercourse - industrial leases.

Legendre - Ministerial Reserve for industry.

Intercourse Group, Eaglehawk vacant crown land.

Conservation values on Rosemary Island and Enderby Island based on presence of Rothschild's Rock Wallaby (which appears to graze mainly on the limesand vegetation). Other islands have small mammals, sea-bird colonies etc, relatively untouched with no introduced predators (except fox on Dolphin Island).

Apart from Delambre Island, no marine or aquatic reserves have been proposed as yet in the Archipelago.

Management by the various authorities in whom lands or waters are now or may be vested will need to be well co-ordinated, to balance the conflicting 'resource values' of the Archipelago and maintain its many and highly productive users.

ASPECTS OF COASTAL MANAGEMENT

G. Sansom

Coastal Planning & Management Adviser
Department of Conservation and Environment

A recent review of coastal management in Western Australia has identified the Dampier Archipelago - Nickol Bay sub-region as warranting a high priority for preparation of a coastal management plan. Such a plan would provide a basis for initiation and co-ordination of management programmes to be carried out by a range of State and Local authorities, operating under a variety of statutes. It could also address 'strategic' planning issues, such as whether further deepening of the Mermaid Sound shipping channels could provide a viable alternative to the proposed development of a deepwater port on Legendre Island, and if so, which of the two alternatives would be less damaging to the environment.

Effective management depends upon clearly articulated and widely-supported objectives, and on adequate information. Conversely, from a management viewpoint, the utility of information about an area such as the Dampier Archipelago is constrained by the availability of resources and administrative mechanisms required to implement management programmes. In Western Australia, management resources and mechanisms are frequently very limited. It is possible that we already have as much information about the Dampier Archipelago as can be effectively used (assuming that 'raw' data were collated and translated into a suitable form). Certainly, we should try to relate future research to feasible and/or probable management objectives.

Apart from controlling the environmental impact of specific industrial projects, chiefly through the ERMP and Agreement Act processes, management objectives for the Dampier Archipelago - Nickol Bay sub-region could feasibly be framed in the following areas, for which management mechanisms and resources are currently available (albeit to a very limited extent) -

(i) beach and island recreation;

(ii) coastal/island soil conservation;

(iii) recreational boating;

(iv) recreational fishing;

(v) wildlife conservation in general (chiefly terrestrial);

(vi) declaration of aquatic and terrestrial reserves;

(vii) oil spills.

In addition, consideration is now being given to possible future arrangements for determination and application of ambient water quality criteria.

Assessment of information availability and research needs in relation to these management areas would be very useful.

SUMMING UP BY CHAIRMAN

Today's review has shown that there is quite a wide range of data and a continuing interest in the waters and ecosystems of the Dampier Archipelago. However, the data are somewhat dispersed in time, space and scientific disciplines. While useful research has been made or is being carried out in certain localities or upon specific problems, it is difficult to relate these to the system as a whole. As well as detailed studies upon selected key facets, there is a need for broader surveys of key aspects (e.g., water circulation, habitats, user needs, etc.) so that the more specific studies can be put into wider perspective.

There is room for closer integration of the various investigations being carried out so that without affecting the independence of individual groups, exchange of data is further encouraged and overlap of effort avoided. As the distance and accessibility from major research centres is a continuing problem, it would be mutually beneficial if groups working in the Dampier Archipelago sought to interest workers from other institutions in joining field operations, thus minimising costs.

In some instances there is a scope for either uniformity of methodology or intercalibration of techniques. This is particularly important where data are to be applied to a wider understanding of the area.

Various speakers pointed to the need to sharpen research objectives so that the limited funds and field opportunities can be best applied towards clearly defined priorities rather than just an accumulation of knowledge. Studies of specific localised problems were leading to an understanding of processes on a local scale, but there was a need for these to be fitted into a picture on a regional scale. This was logically a government responsibility, though developers would benefit from such information.

Further consideration could be given to the needs of the various users of these waters, with attention to the expectations of the rapidly growing population requiring access to the coast and islands for a range of recreational activities. Planning for coastal management should include an assessment of needs for marine reserves, preferably in relation to land reserves. Sites for marine reserves would have to be selected not only on a basis of habitats and ecosystems requiring protection or management, but also on the potential impact of other users (e.g. dredge spoil disposal).

A regional map of marine habitats is needed as a matter of priority. This would enable the localities already studied and habitats identified, to be placed in wider perspective. A broad-brush of major habitats in the shallower waters is being prepared by Marine Studies Branch of DCE.

It was pointed out that in the vicinity of intense industrial activity, possible (but unknown) fish resources might have to be given up without assessment, given the limitations of research funds and the length of our coastline. While this might be acceptable where there are no commercial fishermen pressing their needs, the situation is quite different for recreational activities. A population expanding as a result of industrial growth becomes increasingly demanding for beach and water resources, especially on such an arid and hot coastline.

Some attention was focussed upon the possible use of screens over cooling water intakes as a valuable sampling mechanism for research upon larval and post-larval fish. There was some confusion here as the discussion turned to whether this entrainment could itself be the cause of significant mortality of fish. Quite apart from that question, such screens could certainly provide a useful and cheap sampling mechanism for research and long-term monitoring purposes. This could be important if it could be utilised to monitor pre-recruits to the extensive demersal fish stocks on the outer shelf.

Some of the logistics problems in studying such distant waters would be overcome if a field station having accommodation as well as working space could be established. On the northeast coast of Australia there are a number of field stations available to research workers, but none on the northwest coast. The Marine Studies Branch of DCE is negotiating for a site in the vicinity of Dampier.

Further consideration might be given to the possibility of establishing a common data base (or separate biological and physical data bases) for observations being gathered in these waters.

In conclusion, there appears to be a willingness to seek more opportunities for open and joint communciation and cooperation in studies upon the coasts and waters of Dampier Archipelago. Though brief, this workshop has been a valuable first step upon which we can build.

R.G. Chittleborough