

# FRANKLIN

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RESEARCH SUMMARY

CRUISE FR 01/96

HOLOCENE BIOGENIC SEDIMENTATION, NORTHERN  
ROTTNEST SHELF, WESTERN AUSTRALIA

## Itinerary

Sailed Fremantle 1700 ;11 January, 1996  
Arrived Fremantle 0800; 29 January, 1996.

## Principal Investigators

A/Prof Lindsay Collins  
Curtin University, Perth

Dr Yvonne Bone  
University of Adelaide

Prof Noel James  
Queens University

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R.V. FRANKLIN  
NATIONAL FACILITY  
OCEANOGRAPHIC RESEARCH VESSEL

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### Objectives

The continental margin of Western Australia, between latitudes 23 to 32°S, lies at the critical juncture between realms of cool- and warm-water carbonate sedimentation. This project will utilize bottom sampling, photography and high resolution seismic to document sediments and shallow stratigraphy in the transition zone. Specific objectives are:

1. To document the nature, distribution and density of modern, carbonate-producing organisms on the continental shelf and upper slope and to determine their relationship to the modern oceanographic regimen.
2. To produce a facies map of Holocene sediments, based on composition and age of bottom samples.
3. To determine the relative diagenesis of sediments recovered, and the extent of early sea floor cementation.
4. To document the Holocene-Pleistocene seismic stratigraphy of the shelf segment and relate this record to known fluctuations in sea level.
5. To determine how much of the shelf sediments are relict in nature and how much has been produced during the last sea level rise.

### Voyage Narrative

We departed Fremantle at 1700 hours on Thursday 11 January after a delay of several hours due to an industrial dispute. The sampling program commenced in Gage Roads off Fremantle with a 10 km long seismic profile.

The work program adopted consisted of taking PDR profiles of the continental slope and shelf in the shoreward direction, followed by sampling along the return traverse at selected sites. Seismic (Boomer and Sparker) profiles were also obtained along selected traverses. Sediment sampling was by epibenthic sled, pipe dredge and Smith-MacIntyre grab,

and biotic sampling was by the sled supported by a beam trawl. Cores were taken at the seaward extremities of some profiles, in depths of 400-600 metres, and camera stations were selected to characterise sediments, communities and substrates. Almost all sediment stations were supported by CTD's, and bottom water samples were collected for isotopic analysis. A total of 15 sampling and PDR profiles were obtained between latitudes 23-32°S, and 138 stations were occupied in the stretch from Fremantle to the southern Ningaloo Reef.

Weather conditions were as expected for the W.A coast in January; southerlies were usually up to 30 knots in the afternoons, and somewhat lighter in the mornings. When swell and sea conditions combined to halt the sampling, travel between profiles was opportunistically utilized to minimise weather downtime.

**Summary of work completed and preliminary observations**  
An excellent suite of shelf sediment samples and associated data have been acquired during what has been a successful voyage. The following paragraphs provide a summary of shipboard observations made by members of the scientific party.

## **Sediments**

Sediments are carbonate throughout, with terrigenous clastics locally abundant nearshore. The deposits are a mixture of relict and modern grains. Modern sediments are dominated by a cool-water skeletal biota, but modified by warm-water influence. Facies are largely determined by shelf bathymetry and latitude and can be separated into southern and northern sectors.

### Southern Sector

In the southern half the shelf is tripartite; inner shallow shelf, mid-shelf ridge complex and outer shelf ramp. The inner shelf, generally less than 50m, is variably veneered with siliclastic sediments along the shoreface, and a mixture of relict and modern sediment, is characterized by meadows of macroalgae (cf. *Eklonia*), coralline algal nodules (*Rhodolites*) and seagrasses (*Thalassodendron*). *Rhodolites* are substrates for bryozoans and encrusting foraminifers (cf. *Homotrema*). The mid-shelf ridge complex is a zone of variable bathymetry extending from 30-50m and with up to 30m of relief. The hard substrate is a site of prolific coralline nodules, kelp, sponge and bryozoan growth. There is minor growth of *Halimeda* (?tuna). Sediments are an admixture of these rhodolites and bryozoan-foraminiferal-mollusc sands. The Abrolhos are a coral reef complex located on a promontory, into the Leeuwin Current. Sediments near the reefs are generally clean, well-sorted sands with a significant coral component. In the lee of the reefs seagrass banks result in poorly-sorted mollusc and foraminifer-rich sands that are typically reducing. Everywhere the deep-shelf is a seaward-dipping ramp from ca. 50m to 250m. The seafloor is smooth and sediment-covered, with local prolific growth of sponges and bryozoans. The sediments are bryozoan-dominated with abundant benthic foraminifers. They become progressively muddier, finer-grained and more spiculitic with depth. Below a depth of 400m the deposits are carbonate muds with few large skeletal elements.

### Shark Bay

Sediments in the centre of Shark Bay are grey sands composed of benthic foraminifers and mollusc fragments. Large foraminifers (Marginopora), articulated coralline algae and worm tubes are locally abundant. The seafloor is largely covered with grass, mostly Posidonia and varieties of Zostera..

### Northern Sector

The majority of the shelf north of the Abrolhos to Ningaloo Reef has a ramp profile with no obvious shelf-slope break. The seafloor directly in front of the shoreline cliffs typically drops rapidly to 50m. Sediments shallower than 70 meters are fine to medium grained skeletal sands with a conspicuous relict component and little obvious modern sediment. Seaward of 70 m sediments are dominated by foraminiferal tests and increasing mud content with lithoclasts common between 100 and 150 meters. Sediments below 300 meters are dominantly pelagic in composition.

### **Bryozoans**

The higher latitudes of the cruise area show a similar distribution of bryozoans, in terms of growth forms, as Australia's southern margin. Inboard areas have few living forms, mid-shelf areas have abundant Adeona sp. and its associated assemblage i.e.. articulated zooidal (e.g. Orthoscuticella sp.) and articulated branching (e.g. Cellaria sp), with increasing abundance of flat, robust branching (e.g. Adeonellopsis sp.) and fenestrate (e.g. Iodictum sp.) forms towards the shelf edge. The shelf edge and slope are dominated by more delicate forms (e.g. Tubilopora sp.), including many cyclostomes (e.g. Hornera sp.). Hardground and outcrop cobbles and rhodoliths are substrate for encrusters (e.g. Celleporaria sp.) and a variety of articulated forms and lesser flat, robust branching forms. Bivalve-rich sands may have abundant vagrants (e.g. Selenaria sp.) or rooted foliose forms (e.g. Parmularia sp.).

From the Abrolhos northwards, the pattern gradually changes. Adjacent to Shark Bay, the articulated zooidal and articulated branching forms are rare, Adeona sp. has disappeared, along with most of the robust foliose forms. Those forms that are still present, mainly cyclostomes, have thinner walls and occur at more shallow depths (<100m) and higher bottom temperatures (up to 24°C) than their southern counterparts (>150m and <10°C). This pattern becomes even more pronounced northwards, except for the area adjacent to the reef, where there are abundant, large, bright red, colonies of erect Celleporaria sp.

Throughout the entire area, various species of vagrants are found wherever the substrate is sand only. Their depth ranges from the shallowest sites down to almost 200 m depth.

Overall, at least half of the sediment samples are bryozoan-rich, and many are almost entirely composed of bryozoans. Most samples consist of predominantly (1) living, (2) recently dead or (3) relict bryozoans, particularly on the northern ramp. Thus, it appears that bryozoans are an important contributor to tropical environment sediments as well as to temperate environment ones, and that a sharply defined transition zone between the two cannot be determined by the use of bryozoans on the Western Australian coast.

### **General Biology**

A selection of zoological specimens, with a particular emphasis on the echinoids, were sampled from the sediments captured in the sled. Amongst the crustaceans collected were shrimps, ostracodes, cirripedes (barnacles) and crabs. Hermit crabs inhabiting gastropods (snails) supplemented the mollusc collection. Other molluscs included bivalves, chitons and cephalopods (squid and octopus). Some worms, such as annelids and polychaetes, corals and pycnogonads (sea spiders) were taken. Small fish and the occasional sea snake were also entrapped. Echinoderms included crinoids (feather stars), asteriods (star fish), ophiuroids (brittle stars), holothurians (sea cucumbers) and echinoids (sea urchins). A thorough search for echinoids found many regular urchins, sand dollars and heart urchins; ranging in size from a grain of rice to a large handful. In all, a valuable acquisition (especially complemented by the sedimentary information) to be distributed to the various areas of taxonomic expertise within the Western Australian Museum for study, identification and curation into the State Collections.

### Foraminifera

Foraminifera found in the sediments of the Northern Rottneest Shelf were examined to meet four general goals:

- a) to document the appearance with latitude of species which harbour algal symbionts and are considered indicative of subtropical/tropical shelf environments;
- b) to utilise these symbiont-bearing species to indicate paleodepths of deposition of relict sediments;
- c) to characterise foraminiferal assemblages overall with latitude and depth along the shelf; and
- d) to determine the relative importance of foraminifera as sediment constituents in shelf and upper slope sediments.

Moreover, living specimens of several algal symbiont-bearing foraminiferal species were collected in sediment samples. These collections are providing additional research opportunities. For example, we discovered the occurrence of anomalous symbiont loss in Rottneest Shelf populations of *Amphistegina* spp. (This anomaly was recently described in Florida Keys populations of *Amphistegina*). In addition, we were fortunate to collect specimens of three species of living larger foraminifera whose algal symbionts have not yet been described. We intend to send living specimens to a specialist who will attempt to isolate and describe these unknown microalgae.

### Seismic Profiles

Eight high resolution seismic lines were attempted on this survey. This included a preliminary line located directly out of Fremantle harbour to the north of Rottneest Island which was used primarily to test and fine tune the equipment. The remaining lines, were all run from west to east to minimise the impact of the swell on the quality of the records and were designed to produce cross-sections through the continental slope and shelf at each location.

Generally good sub-bottom penetration was achieved on the slightly inclined slope encountered seaward of the reef and continental shelf area. Over reefs and carbonate hard ground the subsurface was masked by the strong seafloor reflection. Inclined reflectors (possible Tertiary prograding beds) were sometimes seen further east in the sub-surface on both sparker and boomer profiles.

## Physical Data

### Temperature and Salinity

Temperature and salinity data were recorded by CTD at 94 of the 131 stations sampled. The surface temperature ranged from 21.77C to 26.11C and the surface salinity from 34.97 ppt to 36.44 ppt.

From the CTD data it is evident that stratification of the water column occurs at the shelf edge and down the continental slope to at least 500m and can usually be divided into three layers. The uppermost layer has a depth range of 0 to 50m while the middle layer varies between 50 to 300m (eg at latitude 23S) and 50 to 200m (eg at latitude 31S). The bottom layer extends to the deepest measured depth of ~500m.

The salinity of the first layer varies between 35.0 ppt (latitude 23S) to 35.6 ppt (latitude 32S) with a general temperature range of 22C to 24C. Salinity in the middle layer increases with depth from 35.6 ppt to a maximum of 35.8 ppt while the temperature decreases to ~18C. Within the third layer salinity and temperature decrease rapidly with depth down to 34.4 ppt and 9C respectively at 300-500m.

Surface winds and tides, and the presence of different water masses (ie Leeuwin Current and South Indian Central Waters) are the most likely causes for the stratification.

### Currents

Current information was analysed at 20 minute averaged intervals from ADCP data taken along the ships track over the course of the voyage. These data were plotted at 15, 50, 100, 200, 250 and 300 metres below sea level. At 15 metres it is evident that along the inner and middle shelf the current trend is generally in a northerly direction from latitude 32S to 24S where there is a southerly swing. Along the outer shelf at the same latitudes the trend is to the south. Current velocities range to the south from less than 0.5 m/s to as high as 1 m/s around the Abrolhos Islands. These trends are consistent to depths of 200 metres where there is evidence of a current shift to the west between 24S and 23S, grading to a northerly flow at depths of 250 and 300 metres. Velocities of these bottom currents are consistently below 0.1 m/s.

The interaction of tides and winds in surface flows (wind was generally from the south between 15-30 knots), and the development of eddies in current bodies (ie Leeuwin Current and South Indian Central Waters) are the factors most likely responsible for the variations of current direction in the water column.

## Biotic Assemblages

The Rottneest Shelf supports a range of interesting biota which can be classed into five main assemblages depending on depth, latitude and geomorphology of the shelf. These assemblages are :

1. A coralline algal, bryozoan, sponge and seagrass assemblage occurring on the inner shelf between latitudes 29 and 32.,(southern margin).

2. A bryozoal/sponge assemblage on the outer shelf of the southern margin.
3. A coral platform/reef assemblage making up the Houtman -Abrolhos Islands and, further northward, the Ningaloo reef complex.
4. A seagrass assemblage which dominates Shark Bay.
5. An outer ramp foraminiferal assemblage occurring just off Shark Bay consisting of benthic forams in the shallower regions of the ramp and planktonic forams in the deeper regions.

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