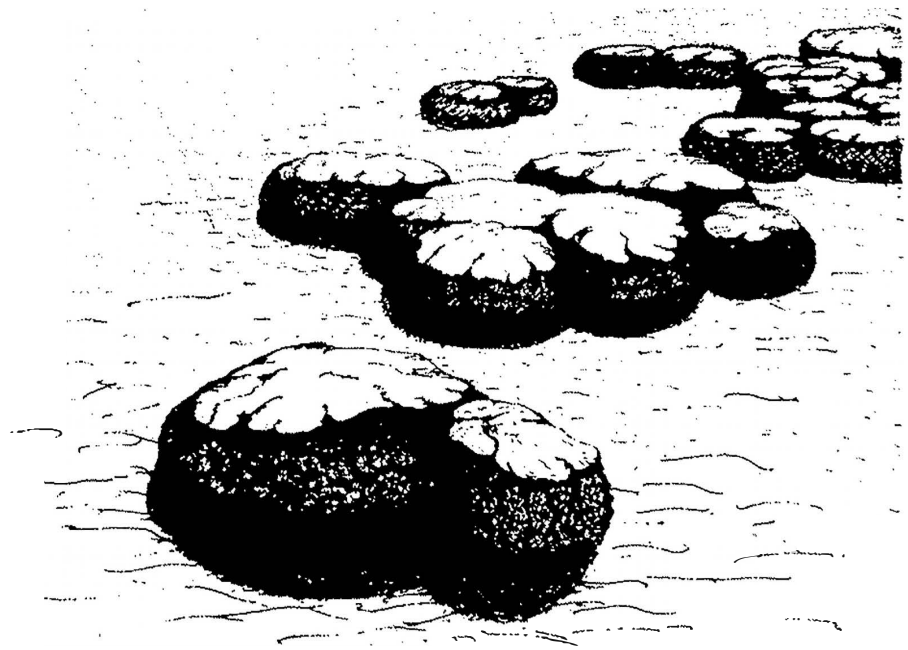
Conservation of Hamelin Pool

Western Australia



Department of
Environmental Protection
BULLETIN

CONSERVATION OF HAMELIN POOL, WESTERN AUSTRALIA

Department of Environmental Protection

Western Australia

March, 1975

CONSERVATION OF HAMELIN POOL, WESTERN AUSTRALIA

SUMMARY

A meeting of geologists convened by the Environmental Protection Authority of Western Australia has recommended that further action be taken to preserve Hamelin Pool in its natural state because of its great scientific importance. The most outstanding feature of the natural history of the area is the occurrence of columnar algal stromatolites in the intertidal zone and the adjoining shallow subtidal zone of Hamelin Pool. These stromatolites are unique in modern seas, and it is of great importance that they be preserved for posterity.

The committee recommends that the present Class A reserve for the preservation of sedimentary deposits covering the intertidal zone of Hamelin Pool be extended for 2 chains (40.23m) inland to cover the coquina beach ridges. The reserve should be vested in the Wildlife Authority, and its purpose should be expanded to cover conservation of fauna and flora, use in geological and biological education, and use in scientific research.

Once appropriate legislation to allow submarine reserves is enacted the reserve should be further extended to cover the waters and sea floor of Hamelin Pool, and the adjacent Faure Flats area to the north. In the interim, the Fisheries and Fauna Department should be requested to prohibit interference with the fauna and flora on the sea floor of this area as far as practicable.

Public access to the coastal area of stromatolites and beach ridges should be provided at one or more localities to be selected by the Wildlife Authority on the basis of appropriate expert advice. Access to other areas of the reserve should be prohibited without permission from the Authority, as many of the stromatolites can be readily destroyed by human interference.

INTRODUCTION

A meeting of a committee of geologists with expertise in the study of stromatolites and the marine environment was arranged on 24 and 25 August, 1973 by the Environmental Protection Authority of Western Australia. The purpose of this meeting was to consider the advisability of taking further action to preserve the Hamelin Pool area in its natural state because of its scientific importance.

The meeting was chaired by Professor R. Rezak (Texas A. & M. University), the other members of the committee being Dr S.M. Awramik (Harvard University), Dr B.W. Logan (University of Western Australia), Dr A.R. MacGregor, (University of St Andrews), Dr P.E. Playford (Geological Survey of Western Australia), Professor C.C. von der Borch (Flinders University) and Dr M.R. Walter (Bureau of Mineral Resources, Geology and Geophysics).

It was decided to draw up the present document for publication by the Environmental Protection Authority, setting out the case for preservation of the area and making a number of recommendations on the means of achieving this objective.

DESCRIPTION OF THE AREA AND UNIQUE NATURAL FEATURES

Hamelin Pool is a landlocked marine basin partially separated from the rest of Shark Bay by a shallow barrier bank, the Faure Sill (Figures 2, 3). This morphology, combined with the low precipitation (about 225 mm per annum), high evaporation (about 2,250 mm per annum), and the prevailing

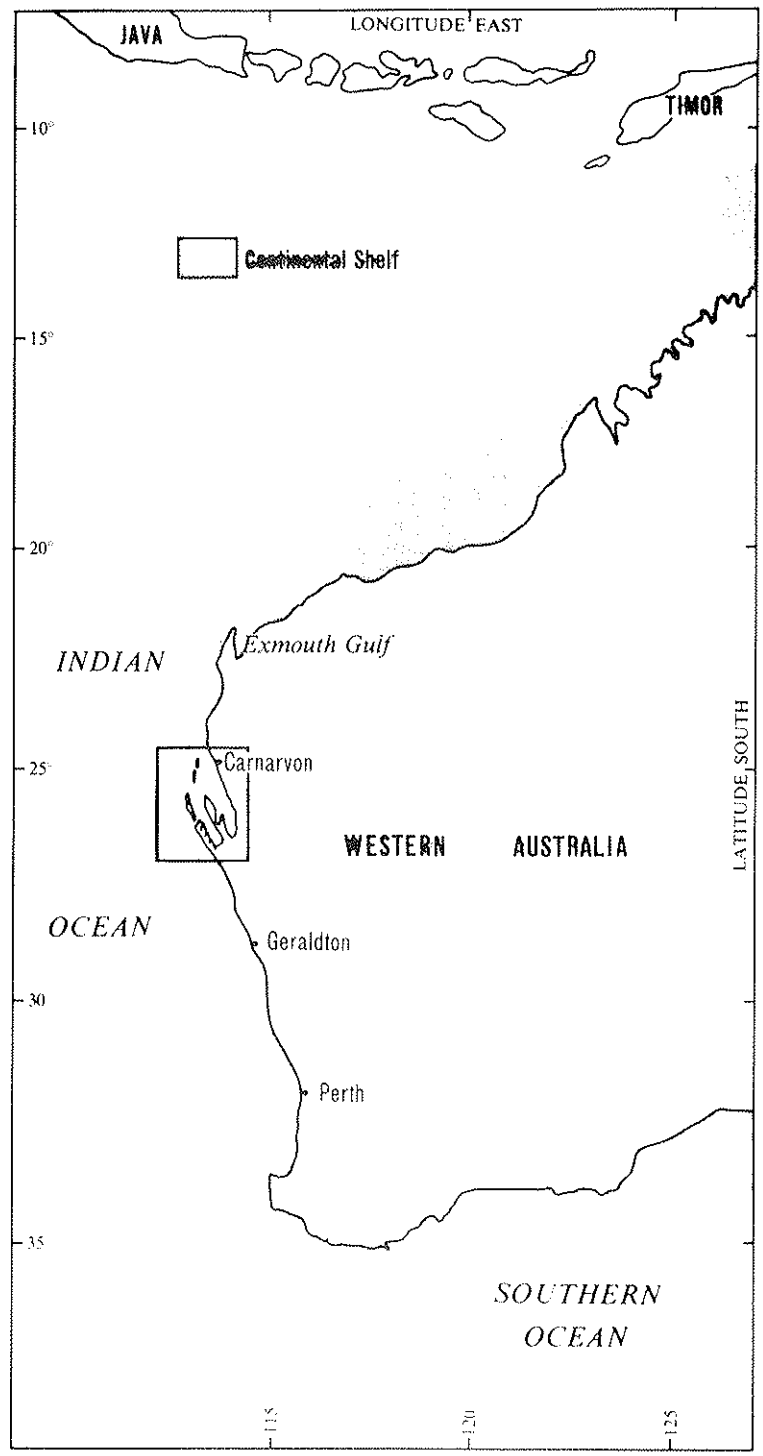


Figure 1. Locality map, Western Australia, showing location of Shark Bay inset.

southerly winds, make the Hamelin Basin one of few in the world where marine waters are hypersaline, the salinity ranging from 55 to 70°/$_{oo}$, almost twice that of normal sea water. The size, depth and other geomorphologic features of the basin combine with the high salinity to make this an environment unique in modern seas.

Hypersaline conditions in Hamelin Pool have led to the development of a number of unique geological and biological features. Outstanding among these are algal stromatolites (Figures 6 to 8) which are "living fossils" of comparable scientific importance and rarity to highly protected elements of the Australian fauna and flora. In addition, there are restricted communities of marine organisms tolerant of hypersalinity, vast deposits of shells (coquinas) (Figure 9), ooid shoals, and lithified sediments of Recent age, all rare or scientifically important.

GEOLOGICAL FEATURES

Algal Stromatolites: Stromatolitic sediments in Hamelin Pool are formed by blue-green algae (which trap and bind sediment particles) and a variety of physical and chemical processes. The algae form a cohesive mat that tends to cover supratidal, intertidal, and some shallow subtidal surfaces.

The mat-sediment complex is shaped by physical and biological factors into a variety of stromatolite structures:

(1) extensive flat-lying sheets (Figure 8A),

(2) ridge and rill structures,

(3) rings and crescents,

(4) linked ellipsoids and columns (Figure 7B)

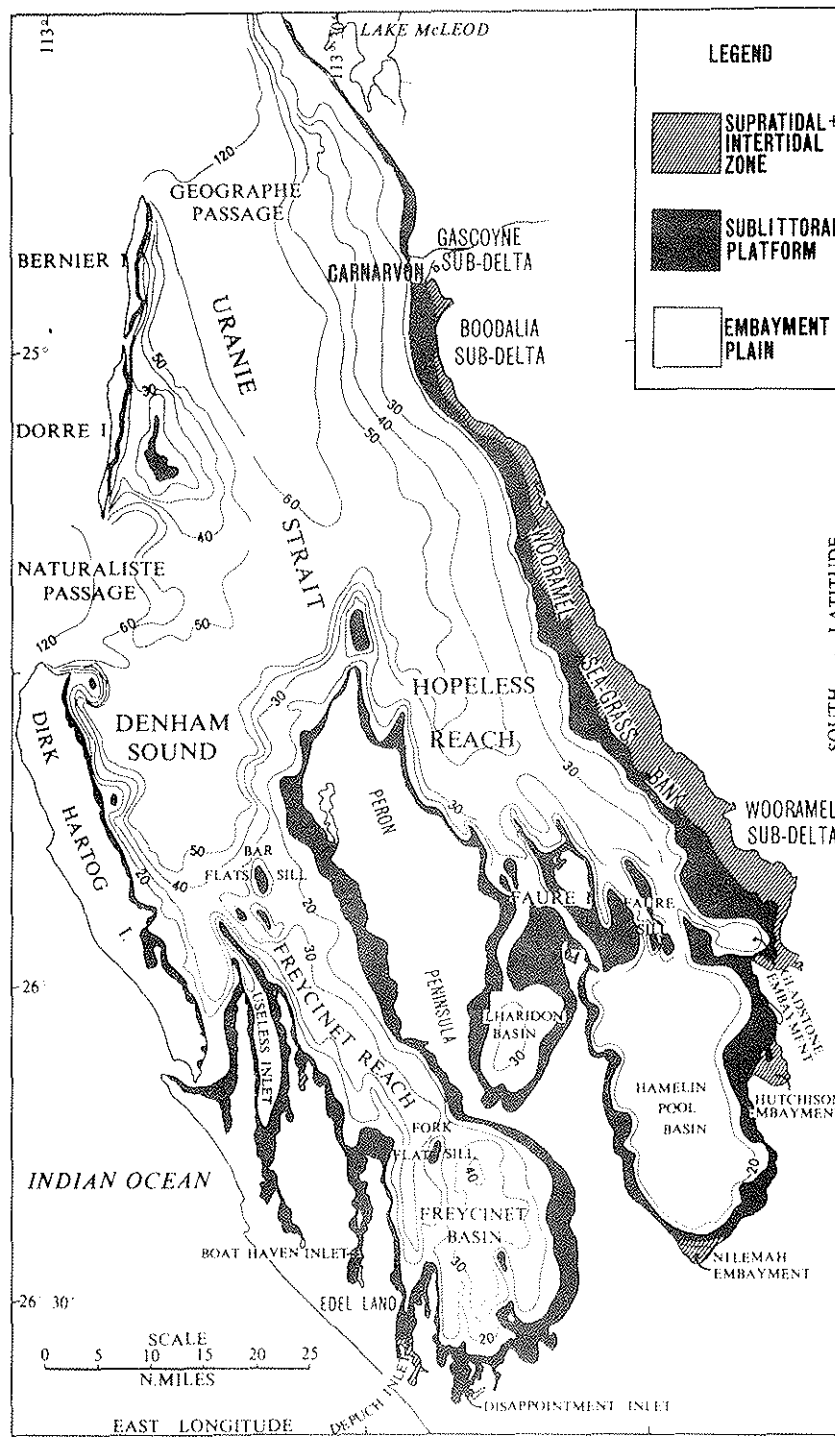


Figure 2. Bathymetric map, Shark Bay, showing location of major features; contour interval in feet (after Logan and Cebulski, 1970).

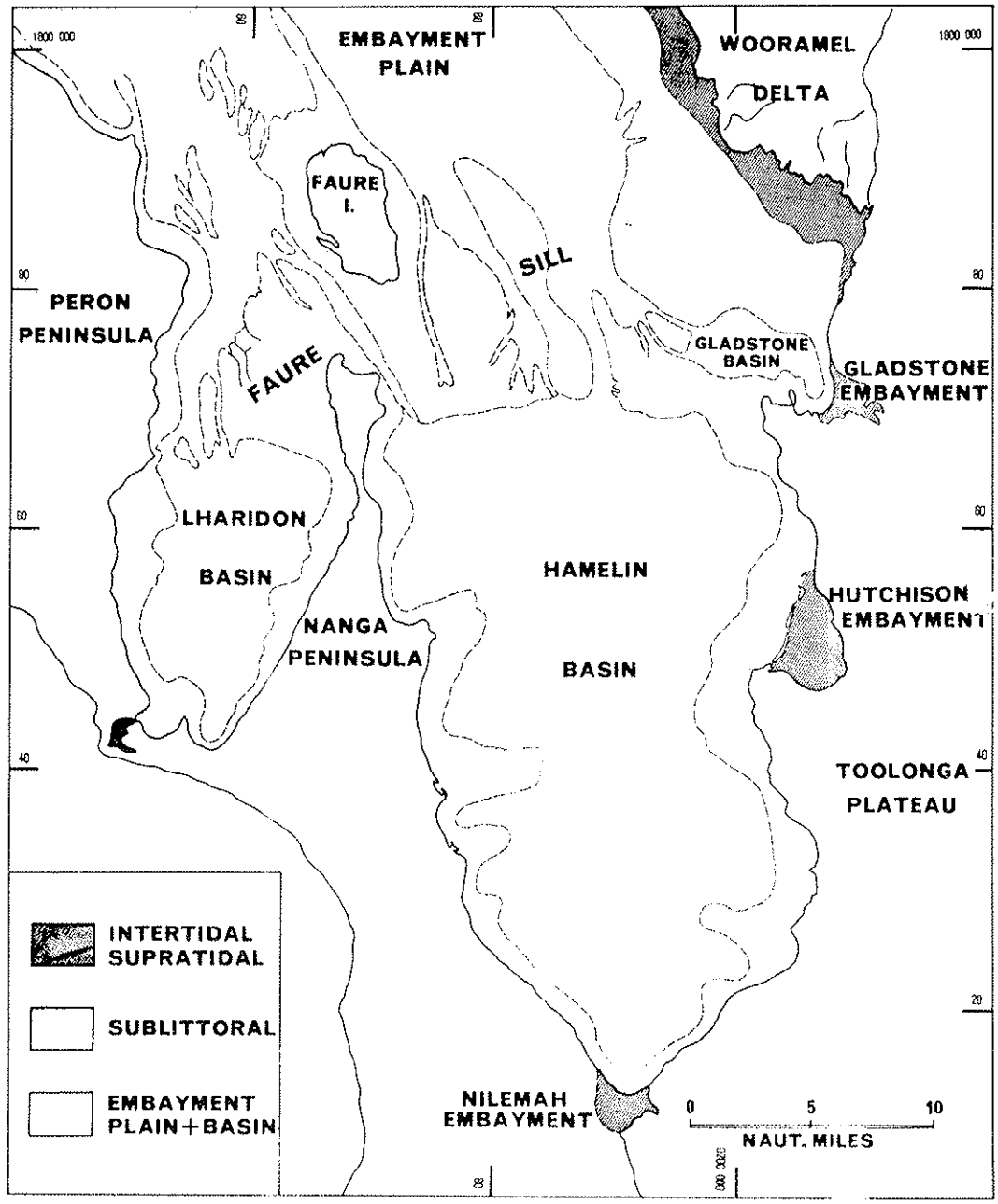


Figure 3. Bathyretric features Hamelin Pool basin and Faure Sill, showing distribution of embayment plain and basin areas; sublittoral platforms and intertidal-supratidal flats (After Hagan and Logan, 1974).

(5) discrete ellipsoidal and circular columns (Figures 6, 7, 8),

(6) calyx and tiered-calyx structures.

Coquinas: The coquinas are sedimentary rocks wholly composed of the shells of marine organisms. These sediments are particularly abundant in Hamelin Pool where they have accumulated from populations of a small bivalve, *Fragum hamelini*. There are 2 types of coquina deposit:

(1) beach-ridge and storm-ridge deposits that occur above sea level around the margin of Hamelin Pool (Figure 9), and

(2) submarine, thin, sheet-like deposits that cover shallow offshore areas.

Ooid Shoals: Ooids are spheroidal grains formed by precipitation of calcium carbonate from hypersaline waters. Shoals composed of ooid sand are forming in Hamelin Pool and there are also emergent shoals of Pleistocene age in coastal areas.

Cemented Sediments of Recent Age: The sediments in subtidal, intertidal and supratidal areas of Hamelin Pool are being lithified by the precipitation of calcium carbonate cements.

BIOLOGICAL FEATURES

Algal Mat Community: Algal mat communities are unusually widespread and diverse along the shores of Hamelin Pool. They form seven distinctive communities composed of blue-green algae, green algae, and bacteria in delicate ecological balance with the environment. The algal-mat communities interacting with the physical environment are responsible for the wide spectrum of stromatolite morphologies present in the Pool.

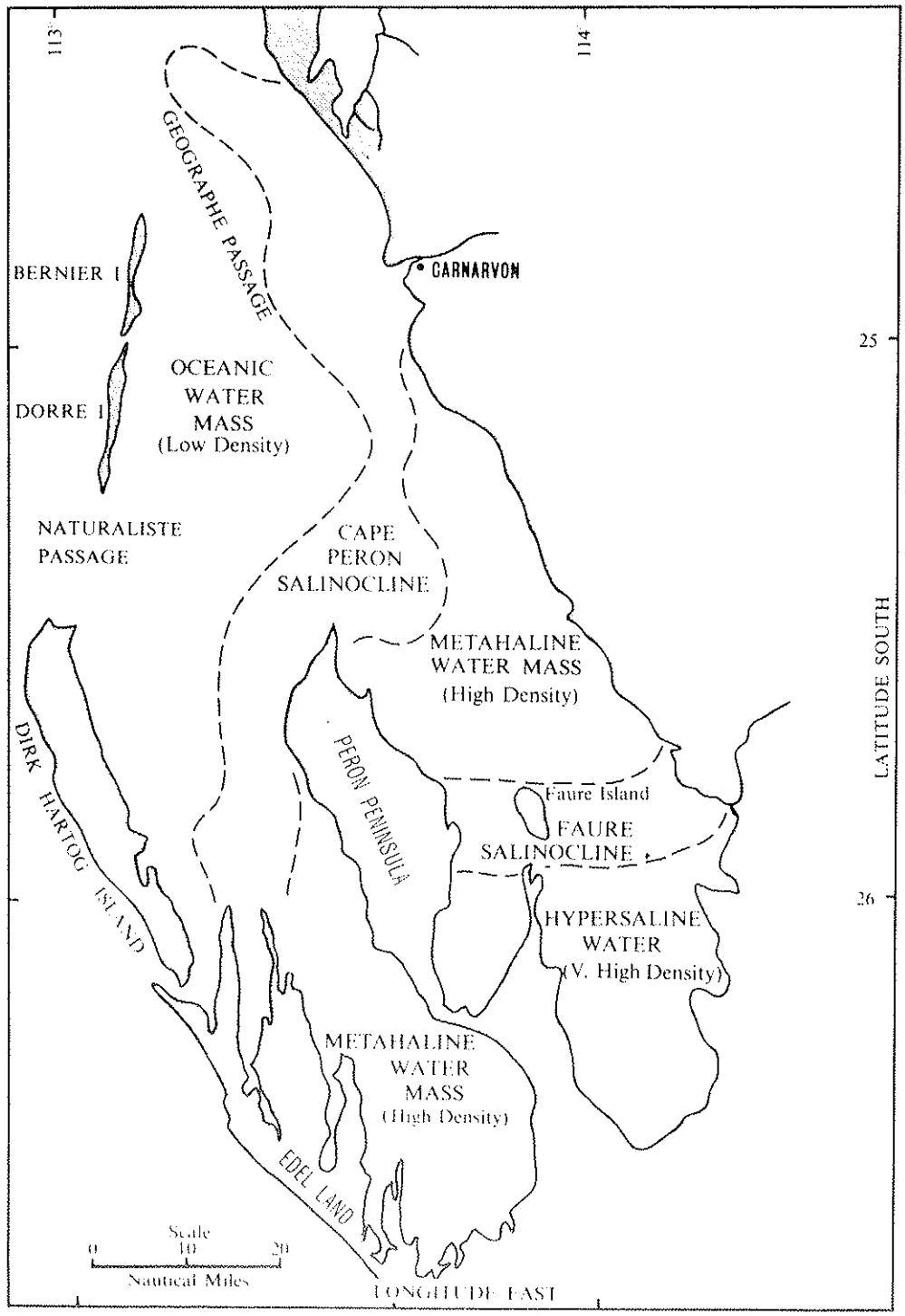


Figure 4. Distribution of water types, Shark Bay (after Logan and Cebulski, 1970).

Seagrass Community: Seagrass communities are composed primarily of marine plants with the grasses *Cymodocea* and *Posidonia* dominating the assemblage. The grasses support a prolific and varied community of shell-secreting organisms, including foraminifers, coralline algae and bryozoans. Gastropods, polychaete worms and crustaceans inhabit the sheltered areas between the plants. The grass communities extend across the salinity gradient on the Faure Sill, inhabiting depths between low-water level and about 15 m.

Carbonate sedimentation in grass meadows has been the major factor in the construction of the Faure Sill. The role of seagrass communities in sedimentation is well known as a result of research in Shark Bay, but little is known of the biology of these communities.

Fragum hamelini Community: The *Fragum hamelini* assemblage is very restricted in number of species present, and is characterized by the abundance of a single species, the small bivalve *Fragum hamelini*. The large bivalve *Hemicardium hemicardium* is also present in small numbers along with the foraminifers *Peneroplis planatus* and varieties of *Spirolina*.

There is evidence that *Fragum hamelini*, which lives in the hypersaline waters of Hamelin Pool and Lharidon Bight, is an ecological variant of *Fragum erugatum*, a species that inhabits waters of lower salinity elsewhere in Shark Bay and other parts of Western Australia. This is believed to be an outstanding example of the morphological adaptation of a species in response to changing salinity, and is of great interest to zoologists.

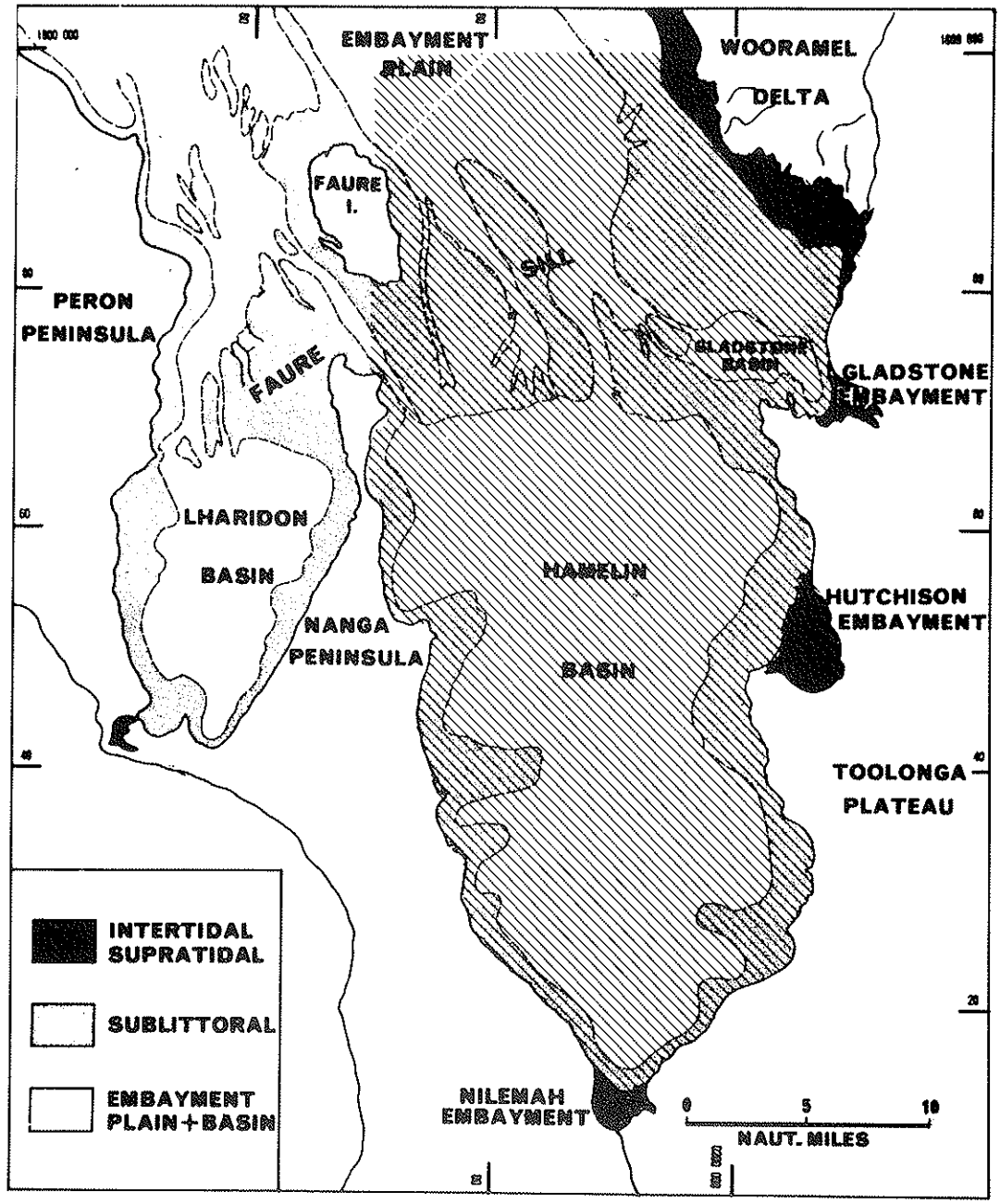


Figure 5. Map of Hamelin Pool basin and Faure Sill showing area of proposed reserve in line shading.

SCIENTIFIC INVESTIGATIONS

The scientific potential of the Shark Bay area was pointed out by C. Teichert (1946) after he had made a preliminary investigation of the area. The first known observations of algal reefs (stromatolites) in Hamelin Pool were made by R.L. Chase (in West Australian Petroleum Pty Ltd field records) during 1954-55.

Detailed studies of the Shark Bay area were initiated in 1956 by B.W. Logan of the University of Western Australia as a Ph.D. project (Logan, 1959). At that time he made a special study of the stromatolites (Logan, 1961; Logan, Rezak, and Ginsburg, 1964). Subsequently, Logan initiated a major research programme on various aspects of Shark Bay sedimentation and environments. This work has so far resulted in the production of 11 theses for higher degrees, and in the publication of two memoirs of the American Association of Petroleum Geologists (Logan and others, 1970, 1974; see reference list). Of particular importance to the case for the preservation of Hamelin Pool is the paper by Logan, Hoffman, and Gebelein (1974) on algal stromatolites. Aspects of the bivalve faunas of Shark Bay have been studied by the Western Australian Museum (Wilson and Stevenson, in press), and further work is planned.

CURRENT RESEARCH

Research projects active at the time of writing include:

(1) Carbonate bank and hypersaline basin development - G.M. Hagan and B.W. Logan

(2) Sedimentation in the Wooramel River delta - J.E. Glover

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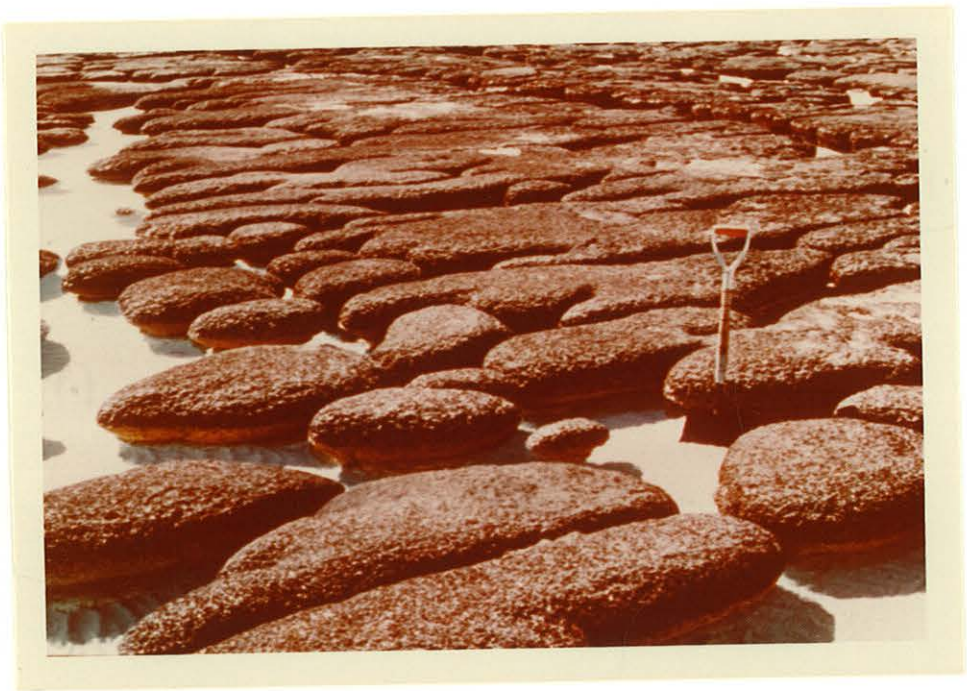

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Figure 6. Algal stromatolites, Hamelin Pool.
A. Columnar and confluent columnar structures;
B. Ellipsoidal columns

Photos: P. Hoffman

A

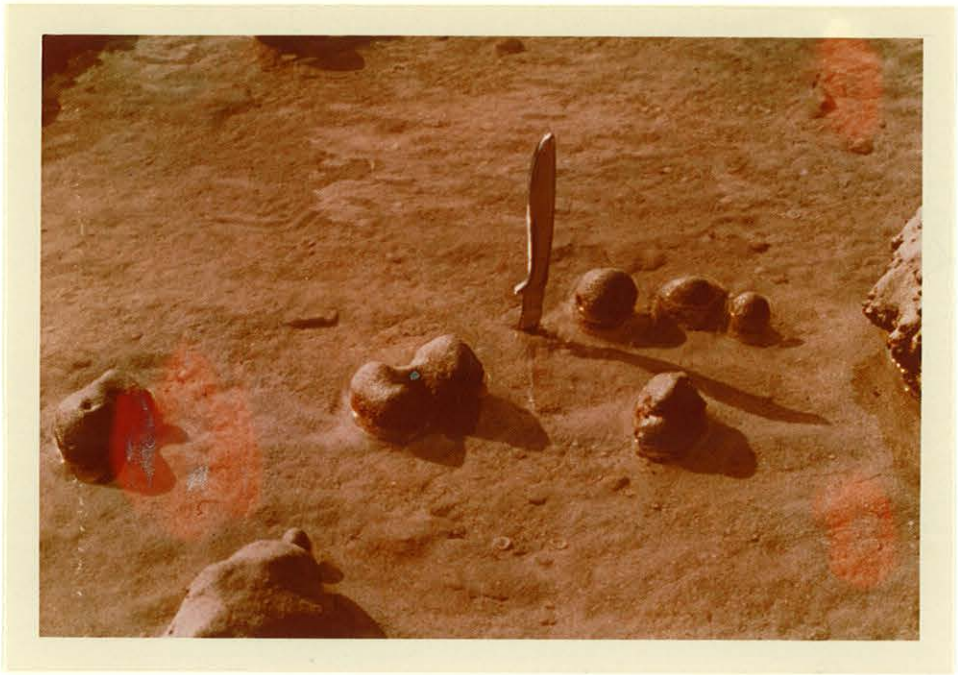

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Figure 7. Algal stromatolites, Hamelin Pool.
A. Small branched columns;
B. Confluent ellipsoidal columns.

Photo: B.W. Logan

A

B

Figure 8. Algal stromatolites, Hamelin Pool.
A. Stromatolitic sheet under continuous mat.
B. Growth series in columnar stromatolites.

Photos: B.W. Logan
P. Hoffman

A

B

Figure 9. Coquina deposits, Hamelin Pool. Shells of the bivalve *Fragum hamelini* are deposited in beach ridges during storms.

Photos: B.W. Logan

(3) Carbonate cements in Holocene carbonate sediments - B.W. Logan.

(4) Comparative studies of algal mat communities - S.M. Awramik and S. Golubic.

(5) Study of Hamelin Pool stromatolites - P.E. Playford and A.E. Cockbain.

FUTURE RESEARCH

The Hamelin Pool area will attract research scientists for many years to come and will also serve as a continuing educational area for both professional and undergraduate scientists from all parts of the world. Future research in the area will involve not only geologists, but also soil scientists, biologists, geochemists and physical oceanographers. Many of these research programmes can be inter-disciplinary. An example of this kind of research would be a team consisting of a geologist, a biologist, and a geochemist working together on the relationships between the algal mats, their substrates, and the surrounding waters.

IMPORTANCE OF THE ENVIRONMENT AND NATURAL FEATURES

The geological history of Hamelin Pool, along with the spectrum of natural features, makes this basin an outstanding natural laboratory for studies of carbonate sedimentation and marine biology. With publication of the results of a continuing research programme from the Department of Geology, University of Western Australia, this area has come to be regarded internationally as one

in which some important concepts of earth science can be developed and tested. International scientific interest in Hamelin Pool and adjacent area is expressed in:

1. Research expenditure in excess of $250,000 during the past few years with funding from the American Petroleum Institute, the Australian Research Grants Committee and the University of Western Australia.
2. Publication of research in international journals (see Bibliography), and
3. The number of international scientists who have visited Hamelin Pool to study stromatolites and other features at first hand. More than 50 geologists, from 7 countries, have recently visited the area. Further visits are anticipated in the future, especially in connection with the International Geological Congress in 1976.

Algal stromatolites: These are the major interest since Hamelin Pool is the most significant locality in the world where these structures are forming. This unique occurrence is more than a scientific curiosity, for it provides the earth scientist with the opportunity for detailed understanding of conditions in which ancient stromatolite-bearing limestones were deposited. Fossil stromatolites are widely distributed in rocks of all ages from as old as 3.0 billion years, and are some of the only undoubted traces of early life in very ancient strata of Precambrian age. Hamelin Pool is the only area in the world with a range of stromatolite forms comparable to those found in the geological column. The

importance of the structures is further highlighted by the fact that they can be associated with petroleum and base-metal deposits, and an understanding of their formation and occurrence aids exploration for these mineral commodities.

Coquinas: The coquinas of Hamelin Pool are unique deposits of great scientific interest and aesthetic appeal.

Ooid Sediments: Ooid sediments are rare in modern seas, being otherwise limited to parts of the Bahamas, Florida and the Persian Gulf. Ooid limestones are common in ancient sequences, and some are associated with petroleum reservoirs. Studies of modern ooid sediments yield valuable information which can be used in petroleum exploration; the Hamelin Pool ooid shoals offer exceptional opportunities for such observations.

Cemented Sediments: Submarine cementation is not widespread in modern seas. The Hamelin Pool occurrences are among the largest developments known. An understanding of the mechanisms involved and the environments in which sediments are lithified is important in exploration for petroleum and base metals.

POTENTIAL THREATS TO THE NATURAL ENVIRONMENT

TOURISM

The main tourist influx into the Shark Bay area is to the town of Denham on the Peron Peninsula from May to September when climatic conditions are most suitable for recreational activities. Hamelin Pool is barely touched by this influx but recreational use is commencing and will probably expand in the future as population growth in Western

Australia continues and the area becomes better known. Flagpole Landing and the Gladstone Embayment are two areas of Hamelin Pool that are regularly visited by small numbers of tourists. Many stromatolite structures are soft and friable and are readily destroyed by people walking through them. Continued uncontrolled tourist activities would certainly lead to the destruction of many stromatolites. There is also a growing litter problem, and in addition, there is a possibility of growing mobilization of coastal dunes, due to vehicular and pedestrian traffic. Local pollution of basin waters with sewerage and other effluents would also result if resorts were established. Such pollution, however minimal, would have drastic effects on the flora of the algal mats and should be avoided. It is therefore undesirable that any resort development be permitted in the area immediately adjacent to the Reserve.

MINING

The Hamelin Pool area is covered by permits to explore for petroleum, but there are no other current mining tenements. No plans for any large mining developments in the area have been proposed, and none are expected in the foreseeable future. The only mining that has occurred to date at Hamelin Pool has consisted of small-scale extraction of shell and coquinite as outlined below.

A number of small quarries have been developed in lithified *Fragum hamelini* coquinite at a few localities 100 to 300 m above high-water mark around the shores of Hamelin Pool. This coquinite has been used for building

purposes in the Shark Bay district. An application for a mining claim over a small quarry at Flagpole Landing was recently rejected by the Mines Department, but further quarrying may be authorized by the Department of Lands and Surveys.

Small quantities of unlithified *Fragum hamelini* coquina were excavated some years ago from several localities in the beach ridges flanking Hamelin Pool, but this is no longer allowed. The shell was sold for poultry consumption, and some was used in road making. In addition, an area of several hundred acres about 65 km east of Hamelin Pool was surfaced with the shell as a possible landmark for astronauts.

The closest current mining activity to Hamelin Pool is at Lharidon Bight, where a license to extract coquina has been granted to a company by the Department of Lands and Surveys. It covers a strip 2 chains (40.23 m) wide above high-water mark around the shores of the bight and was granted for 7 years as from January 1972. The terms under which this license was granted included special provisions (recommended by the Department of Geology at the University of Western Australia) to prevent or minimize damage to the sedimentary and hydrological regime in Lharidon Bight. Specific conditions relate to preservation of the algal mats, and there is total prohibition on any interference with the Faure Sill.

Total production of coquina from Lharidon Bight to date has amounted to 800 tonnes. Operations in the area were suspended in 1972, but may resume once the stockpile

of shell in Perth is exhausted. The shell has a small market for poultry consumption and for decorative use. The economics of extraction of this thin coquina deposit (averaging perhaps 3 m in thickness) in a strip 40 m wide along 65 km of coastline indicate that large-scale extraction for other purposes is unlikely.

The only other significant mining activity in the Shark Bay area is the harvesting of solar salt from artifical ponds on Useless Loop and the extraction of gypsum from nearby salt pans. There is no reason to believe that any part of the Hamelin Pool area can be economically developed for solar salt. There are some small deposits of gypsum in adjoining areas that have been pegged, but their development would not harm the environment of Hamelin Pool.

Petroleum exploration to date in the Shark Bay area has indicated no likelihood that oil or gas will be found in the vicinity of Hamelin Pool. However, subsurface evaporites (of Silurian age) have been found in the area as a result of petroleum exploration. It seemed possible that potash deposits could be found in these, but subsequent exploration with this objective proved negative. In summary, it is unlikely that any mining activity will occur in the foreseeable future in the Hamelin Pool area that would be deleterious to the environment. It is possible that further small-scale quarrying of coquinite for building purposes will be allowed, but provided this occurs outside the limits of the proposed reserve and is properly controlled, it need not

interfere with the sedimentary and hydrological regime in Hamelin Pool.

FISHING

Commercial fishing in the area is currently restricted to the vicinity of the Faure Sill, and it does not present any immediate threat to the environment. There is very little sport fishing in the Hamelin Pool area. Provided no fishing that involves any interference with the sea bed, the algal flora, or the shoreline of Hamelin Pool is allowed, there seems to be no reason for restricting the present level of fishing activity.

CONSERVATION REQUIREMENTS

The Hamelin Pool stromatolites between high and low-water marks are at present protected by a Class A Reserve, No. 30885. This Reserve was created in response to a request made in 1968 to the Department of Lands and Surveys by the Department of Geology of the University of Western Australia for a reserve covering Hamelin Pool, the Faure Sill, and the coast up to 5 chains (100.58 m) inland. This proposal was supported by the Geological Survey Branch of the Mines Department. A decision was made by the Department of Lands and Surveys to reserve only the intertidal area, because the State has no legislation authorizing the creation of marine reserves, and a 5-chain reserve above high-water mark would require resumption of a 3-chain strip of land from the adjoining pastoral properties. The boundary of these properties lies 2 chains above high-water mark, and

a 2-chain strip could therefore have been included in the reserve without resumption.

Preservation of the Hamelin Pool environment depends primarily on maintenance of hydrologic conditions in the area of the Faure Sill. Unnatural interference with the sill could lead to an increase in the exchange of waters across the sill and salinities in the Hamelin Pool basin would then fall to normal levels. This would lead to widespread changes in the biota and in sedimentation, resulting in the destruction of algal stromatolites, *Fragum* populations and a cessation of ooid formation and lithification. The inclusion of the sill in any reserve is therefore vital.

The preservation of algal stromatolites, coquinas, ooid shoals and cemented sediments also requires measures which will prevent destruction by activities of man, and only a minimum amount of development should therefore be permitted around the shores of Hamelin Pool.

RECOMMENDATIONS

The Committee unanimously recommends that Hamelin Pool and the Faure Sill be classified as a Class A Reserve vested in the Wildlife Authority in terms of the existing Act without power to lease. It is proposed that the following actions be taken.

1. The existing Class A Reserve No. 30885 be extended to 2 chains (40.23 m) above high water mark, and once appropriate legislation is enacted, the area of the balance of Hamelin Pool, as defined below, be included in this reserve (Figure 5). Details of the area required for reservation are as follows:-

(a) Hamelin Pool and its margins south of Australian National Grid, Zone 1 co-ordinate 1,770,000 yards N and including the coast to 2 chains (40.23 m) inland of high water level, and,

(b) The Faure Flats area north of Hamelin Pool, including the submerged banks and channels in the area bounded to the north by the 1,800,000 yards N co-ordinate; to the west by the coast of Nanga Peninsula and Faure Island or by co-ordinate 170,000 yards E; and to the east by the coast, extending to a distance of 2 chains (40.23 m) inland from high water mark.

2. The purpose of the reserve be expanded to include conservation of sedimentary deposits and fauna and flora, use in geological and biological education, and use in scientific research.

3. Until appropriate legislation is enacted to permit marine reserves, the Fisheries and Fauna Department be requested to prohibit interference with fauna and flora on the sea floor of this area as far as is practicable.

4. Public access to the coastal area of stromatolites and beach ridges should be provided from the road to Denham to one or more localities on the western side of Hamelin Pool near Nilemah. Sites should be selected by the Wildlife Authority in conjunction with expert advice. Access to other areas of the reserve should be prohibited other than with the permission of the Authority.

5. Honorary wardens resident in the district should be appointed to assist in policing the reserve.

6. No wheeled vehicles or power boats should be permitted on the reserve without permission. Launching of boats should not be allowed except where facilities for launching are provided.

7. No development, exploration or mining within the reserve, or within 5 miles of its boundaries, should be authorized without prior consultation with the Department of Environmental Protection.

8. The Committee recognises the future need for additional tourist development in the Shark Bay area, but considers that there are more attractive places than Hamelin Pool for tourist development, e.g. Lharidon Bight, Freycinet Estuary and Dirk Hartog Island. It is therefore recommended that resort development and unauthorised camping should be prohibited in the Hamelin Pool area.

BIBLIOGRAPHY

Publications

Brown, R.G. and Woods, P.J., 1974, Sedimentation and tidal flat development, Nilemah embayment, Shark Bay, Western Australia: *In* Logan *et al.*, Evolution and diagenesis of Quaternary Carbonate sequences, Shark Bay, Western Australia; American Association of Petroleum Geologists Memoir 22, p. 316-340.

Davies, G.R., 1970, A Recent seagrass bank, eastern Shark Bay, Western Australia: *in* Logan *et al.*, Carbonate Sedimentation and Environments, Shark Bay, Western Australia: American Association of Petroleum Geologists, Memoir 13, p. 85-168.

Davies, G.R., 1970, Algal-laminated sediments, Gladstone Embayment, Shark Bay, Western Australia: *in* Logan *et al.*, Carbonate Sedimentation and Environments, Shark Bay, Western Australia: American Association of Petroleum Geologists Memoir 13, p. 169-205.

Hagan, G.M. and Logan, B.W., 1974, History of the Hutchison embayment, tidal flat, Shark Bay, Western Australia: *In* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association of Petroleum Geologists Memoir 22, p. 283-315.

Hagan, G.M., and Logan, B.W., 1974, Development of carbonate banks and hypersaline basins, Shark Bay, Western Australia: *in* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association of Petroleum Geologists Memoir 22, p. 61-139.

Logan, B.W., 1961, *Cryptozoon* and associate stromatolites from the Recent, Shark Bay, Western Australia: Journal of Geology, v. 69, n. 5, p. 517-533.

Logan, B.W., Rezak, R., and Ginsburg, R.N., 1964, Classification and environmental significance of algal stromatolites: Journal of Geology, v. 72, n. 1, p. 68-83.

Logan, B.W., and Cebulski, D.E., 1970, Sedimentary environments of Shark Bay, Western Australia: *in* Logan *et al.*, Carbonate Sedimentation and Environments, Shark Bay, Western Australia: American Association of Petroleum Geologists, Memoir 13, p. 1-37.

Logan, B.W., Read, J.F., and Davies, G.R., 1970, History of carbonate sedimentation, Quaternary Epoch, Shark Bay, Western Australia: *in* Logan *et al.*, Carbonate Sedimentation and Environments, Shark Bay, Western Australia: American Association of Petroleum Geologists, Memoir 13, p. 38-84.

Logan, B.W., 1972, Carbonate Soils interbedded with Quaternary marine strata, Shark Bay, Western Australia: features and significance (abstract), XXth International Geological Congress, Montreal, 1972.

Logan, B.W., Hoffman, P., and Gebelein, C.D., 1974, Algal mats, cryptalgal fabrics and structures, Hamelin Pool, Western Australia: *in* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association of Petroleum Geologists Memoir 22, p. 140-194.

Logan, B.W., 1974, Inventory of diagenesis in Holocene-Recent carbonate sediments, Shark Bay, Western Australia: *in* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association Petroleum Geologists Memoir 22, p. 195-249.

Read, J.F., 1974, Carbonate bank and wave-built platform sedimentation, Edel Province, Shark Bay, Western Australia; *In* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association Petroleum Geologists Memoir 22, p. 1-60.

Read, J.F., 1974, Calcrete deposits and Quaternary sediments, Edel Province, Shark Bay, Western Australia: *in* Logan *et al.*, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia; American Association Petroleum Geologists Memoir 22, p. 250-282.

Teichert, C., 1946, Palaeoecology in Western Australia: 6th Rept Comm. on Paleoecology, National Research Council, Washington, p. 72-78.

Wilson, B.R., and Stevenson S. (in press), *Cardiidae* of Western Australia: Western Australian Museum Special Publication (in press).

Dissertations and Theses (chronologic order)

Logan, B.W., 1959, Environments, Foraminiferal Facies and sediments of Shark Bay, Western Australia. Ph.D. Dissertation, Univ. of W.A., 287 p.

Davies, Graham, R., 1967a, A Recent Seagrass Bank, Shark Bay, Western Australia: Ph.D. dissertation, Univ. of W.A., 141 p.

Davies, Graham R., 1967b, Algal-laminated Sediments, Gladstone Embayment, Shark Bay, Western Australia: Ph.D. Dissertation, Univ. of W.A., 53 p.

Davies, Graham R., 1967b, Algal-laminated Sediments, Gladstone Embayment, Shark Bay, Western Australia: Ph.D. Dissertation, Univ. of W.A., 53 p.

Collins, L.B., 1968, Sedimentation in a Hypersaline Basin, Lharidon Bight, Shark Bay, Western Australia. Hons thesis, Univ. of W.A., 74 p.

Tuppin, N.K., 1969, Carbonate Sediments and Sedimentation, Hopeless Reach, Shark Bay, Western Australia: Hons thesis, Univ. of W.A., 89 p.

Hagan, G.M., 1970, Tidal-flat history and sedimentation, Hutchison embayment, Shark Bay, Western Australia: Hons thesis, Univ. of W.A., 103 p.

Read, J.F., 1971a, Carbonate bank and wave-built platform sedimentation, Edel Province, Shark Bay, Western Australia: Ph.D. Dissertation, Univ. of W.A., 100 p.

Read, J.F., 1971b, Calcrete deposits and Quaternary sediments, Edel Province, Shark Bay, Western Australia: Ph.D. Dissertation, Univ. of W.A., 53 p.

Woods, P.J., 1971, Sedimentation and tidal-flat development, Nilemah embayment, Shark Bay, Western Australia: Hons thesis, Univ. of W.A., 176 p.

Hagan, G.M., 1973, Carbonate banks and hypersaline basin development, Shark Bay, Western Australia: Ph.D. Dissertation, Univ. of W.A., 116 p.

Johnson, D., 1974, Sedimentation in the Gascoyne river delta: Ph.D. Dissertation, Univ. of W.A., 141 p.