DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BMR MARINE PROGRAM

Report by a BMR Committee on Forward Marine Program

Committee Members

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K.M. Kennedy
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CONCLUSIONS AND RECOMMENDATIONS

Recognition of the fact that the submerged Australian continental margin holds out the best prospects for future discoveries of petroleum and that the area urgently requires further investigation, together with other considerations detailed in this report, lead the Committee to conclude that there is a pressing need to accelerate the BMR's marine geological and geophysical program and to recommend that all necessary action be taken to achieve this end.

The Committee recommends that the regional geophysical coverage of the continental margin of Australia and its territories, excepting Antarctica, should be completed by 1980, and regional geological mapping of the Australian continental shelf by 1985. Surveys aimed particularly at the appraisal of the petroleum potential of untested areas, at assessment of specific mineral resources other than petroleum, and at other economic and scientific objectives, also need to be carried out concurrently.

In order to attain the scientific and economic objectives of the marine program, areal coverage will need to extend beyond the margins of the Australian continent and Australian island territories into adjacent areas of the western Pacific, eastern Indian Ocean, and the Australian sector of the Southern Ocean. Independent ocean-wide and global investigations by BMR cannot be foreseen at the present time.

Existing geological sampling is restricted to surface and very near-surface material, and positioning has relied on conventional techniques. In future surveys, subsurface samples are needed and navigational accuracy must be upgraded. Surface and near-surface sampling of the sea-bed on the continental slope in order to assist interpretation of seismic data is given high priority in the program proposed.

Regional geophysical survey field operations are currently carried out by contractors; it will be necessary to continue this mode of operation in the immediate future, but long-period contracts should be arranged in preference to short-period contracts when possible. In the longer term the Committee considers it desirable that BMR takes steps to build up its own field operating staff and equipment and to decrease reliance on geophysical contractors. Research and development should be continued to ensure that the geophysical techniques used keep abreast of modern technology. Seismic techniques used on previous surveys need to be upgraded.

A 5-year program for the years 1976-1980 is put forward in this report, with an explanatory statement accompanying each individual project. The resources required to carry out the program within the time span considered desirable are estimated to be $5 million per annum and 120 staff.

Further more detailed and special projects can be foreseen which will require this level of effort to continue for at least 20 years beyond 1980; the proposed regional surveys are likely to lead to increasing requirements for work of this nature.

The forward program should be under continuing review and amended as necessary in the light of contemporary priorities and advances in knowledge. This review must be based on a comprehensive appraisal of all relevant data as they become available, and the Committee recommends that BMR's effort in studies of this sort is expanded.

The proposed program will entail about 9 months sea time a year on mainly geological operations and about 6 months sea time a year for regional geophysical surveys. The Committee believes that the work could be carried out best by the full-time use of one properly designed and equipped oceanographic vessel with support from chartered vessels when necessary, but is not in a position to make firm recommendations on the desirability or otherwise of acquiring a ship and the means by which it might be acquired. It is recommended that an investigation in depth into all relevant aspects of this matter be started as soon as possible.

PREFACE

The mineral resources of the Earth are limited and known reserves of many will be exhausted in the foreseeable future. The position is particularly urgent in relation to petroleum. It is therefore important for Australia to know the resources it possesses so that appropriate policies and actions can be evolved for their management. The continental margins of Australia and its island territories will provide an increasing proportion of our total reserves in future years.

A knowledge of the likely resources adjacent to Australia and its island territories is also important background information for consideration of policies to be adopted towards the proposed International Law of the Sea. In this regard, the possibility that countries may be allowed to claim jurisdiction over areas beyond the 200-mile limit makes it imperative that we obtain the bathymetric, geological, and geophysical information of the continental margins, within the next few years.

At present petroleum is by far the most important potential mineral resource of the continental margin, although there may be significant deposits of other minerals such as heavy mineral sands, construction materials, coal, and phosphorite. Whilst petroleum exploration is at a high level throughout the rest of the world, in Australia it has fallen to a very low level. At present only two offshore drilling rigs are operating in Australian waters and no marine seismic exploration is being done. There is an urgent need to stimulate offshore exploration.

In the past, BMR has endeavoured to encourage exploration by carrying out regional investigations necessary to provide the framework of knowledge which guides the more detailed search for minerals. BMR has also undertaken more specific investigations in areas which have been neglected because of apparently poor prospects, in the hope that the new information obtained will upgrade the prospects of the area. There is a requirement now for this approach to be continued in the marine areas around Australia. Regional studies are also carried out by BMR so that the geology of Australia may be better known, and the extension of this work to the marine areas is natural, as the geology of the continent cannot be fully understood without a knowledge of these areas also.

If BMR's marine activity is continued at its present rate, it will take 10 to 20 years to complete the initial reconnaissance coverage of the continental margin and the offshore areas adjacent to Australian territories, even without the addition of any more specific investigations.

For the reasons outlined above it is important that the information required to make a preliminary broad assessment of the potential resources of these offshore areas be obtained within a much shorter period and an increased rate of coverage should therefore be adopted.

The most likely short-term economic return would be from petroleum discoveries, although other minerals could contribute significantly also. The knowledge gained of the geology of the Australian region would be invaluable scientifically and a sound basis for further exploration for minerals.

INTRODUCTION

At a Heads of Branches' meeting of the Bureau of Mineral Resources on 10 October 1971, a decision was made to set up a committee to review and report on a forward marine program for BMR.

The terms of reference for the Committee were laid down as:

- to define objectives for a forward program of activities in offshore areas, including consideration of whether the program should cover the shelf and slope only, the Australian plate, or also include International waters.
- to review, co-ordinate and formulate proposals for a forward program of activities for BMR to meet these objectives.
- to include in the review the equipment and personnel necessary to carry out the various stages of the program.
- to estimate roughly the cost of all phases of the proposed program.
- to consider the desirability and, if required, feasibility of acquiring a ship, or ships, for BMR and the alternatives of contracting ship time or full or partial contract surveys.

The composition of the Committee was:

H.A. Jones	-	Geological Branch
K.M. Kennedy	-	Operations Branch
E.R. Smith	-	Petroleum Exploration Branch
A. Turpie	-	Geophysical Branch

The Committee took the view that every type of marine activity in which BMR has been or might be involved came within the scope of the review. That is, the review was to cover crustal studies and engineering and coastal erosion surveys as well as the activities of the present marine geological and geophysical groups. It also considered that 'forward program' should be interpreted to cover at least the next 20 years.

The Committee interviewed other BMR Officers who are closely associated with BMR's marine program, to seek their advice and to allow them to present their views.

A meeting was arranged with officers of the Offshore and International Division of the Department to discuss requirements and priorities as seen by the Division, for further marine surveys to investigate resources and delimit marine marginal areas around Australia and its territories. They gave high priority to surveys over the Lord Howe Rise, the Norfolk Ridge, and the Heard-Kerguelen Plateau, and to completion of the survey and delimitation of the Australian continental rise in areas where insufficient information had been obtained.

SUMMARY OF BMR'S PREVIOUS MARINE ACTIVITIES

Geology

A marine geological survey of the Timor Sea was undertaken in 1960-61, in co-operation with Scripps Institution of Oceanography, but it was not until 1967 that a program of systematic mapping of the continental shelf was instigated by BMR. Since 1967, seven cruises covering 720 000 km^2 and totalling 22 months sea time have been completed. The region surveyed constitutes about one third of the area of Australia's shelf and uppermost slope (Plate 2), and at the present rate of progress, the regional mapping around the continent will be completed by 1986.

The field operations have entailed collection of sea-bed samples (generally dredge samples; occasionally short gravity cores) and bathymetric and shallow seismic profiling between the 20 m and 500 m isobaths. These data are interpreted in terms of sediment distribution and provenance, continental shelf morphology, and shallow structure, to elucidate the Late Cainozoic history of the continental margin. The results are used in the interpretation of past geological processes and as a basis for assessment of mineral resources other than petroleum.

Excluding salaries of staff, the total cost of the field operations since 1967 is of the order of $800,000.

Geophysics

Although minor geophysical surveys had been conducted offshore earlier, it was in 1965 that the first systematic survey of the Australian continental shelf was undertaken. A main objective of this survey was to extend the regional gravity survey of Australia over the shelf. A small reflection seismic equipment was also operated. Further surveys were done in 1967 and 1968 when magnetic measurements were added. At the end of this period the continental shelf and upper continental slope to a water depth of 2000 m along the western half of the Australian coast from Arnhem Land to the Northwest Cape had been surveyed at a line spacing of 10 n miles. Lines every 100 n miles had been run out into deeper waters. Some 32 000 line n miles were surveyed by contract at a cost of $1 300 000, with additional relatively small capital expenditure on BMR geophysical equipment.

In 1970 a survey of the Bismarck Sea, the margin of southeast Papua New Guinea, and the Gulf of Papua was undertaken with line spacings of 10 n miles on the continental shelf and 20 n miles in deeper waters; about 15 000 line n miles were surveyed at a contract cost of $800 000.

The Australian Government during 1970 required a quick bathymetric and geophysical reconnaissance of the Australian continental slope to investigate its extent and economic potential. The line spacing chosen was 20 miles, increased to 30 n miles in some areas, and the survey was to be completed in two years. To aid interpretation survey lines were continued over the continental shelf and some lines were extended beyond the foot of the slope across the continental rise and into the abyssal plain. About 100 000 line n miles were surveyed at a contract cost of $2 818 000; the survey ended in January 1973.

In all some 150 000 line n miles have been surveyed (Plate 1) at a total contract cost of $5 000 000. A major additional cost is that of computer processing of marine data, which has amounted to roughly $500 000 to date.

The results of these surveys have been made available to industry and others for inspection, by sale of maps and seismic sections, and by loan of seismic magnetic tapes, and much interest has been shown. Advice to Government has been based on these surveys. Data at this scale have proved sufficient to give a good preliminary evaluation of the economic potential of the continental margin, but more detailed work will be required to give an adequate assessment.

BMR has participated in several combined land/marine surveys to investigate the crustal structure at the continental margin. The more important of these surveys were the Bass Strait Upper Mantle Project in 1966, the Carpentaria Region Upper Mantle Project in 1966, and investigations from 1967 through 1973 in the Papua New Guinea region. Each survey followed a pattern of exploding shots at sea which were detected on land at several recording stations. The largest was the 1973 East Papua Crustal Survey, which was organized by BMR and involved several geophysical institutions both from Australia and overseas. Costs borne by BMR for the 1973 survey were about $300 000.

BMR OBJECTIVES RELATED TO MARINE PROGRAM

The primary function of BMR is to obtain, study, publish, and provide basic geological and geophysical information necessary for the exploration and development of the nation's mineral resources; associated with this function, and of increasing importance, is the broad assessment of the nation's mineral resources. In order to support the primary function of obtaining basic information, experimental studies and research in the earth sciences may be undertaken. Other functions which have relevance to a marine program are the provision of geoscience services to other Australian Government departments and organizations and basic investigations of the earth's magnetic and gravitational field.

These broad functions need to be translated into more specific objectives in order to plan a marine program for BMR. The Committee considered the various types of information which are required to achieve the overall aims of BMR and concluded that there are five principal objectives which should be pursued. These are:

Outline the main morphological features of the sea-bed, in so far as these are relevant to geology and mineral resources.

Determine the processes controlling the erosion, transport, deposition, and diagenesis of sediments.

Establish the stratigraphic sequence from the sea-bed to basement and the nature of the basement.

Locate the major structures within the sedimentary basins and determine the type of structural deformation.

Outline the tectonic history and crustal structure of the continental margin and adjacent areas.

ASSIGNMENT OF PRIORITIES

Unconditional priorities for the future marine program cannot be laid down in advance because unforeseen influences demanding significant reorientation of effort may arise. However, despite factors which cannot be predicted at the present time, it is necessary to define a fairly firm program for the next five years so that planning may proceed. Priorities should be under continuing review and the program amended as necessary in the light of advances of knowledge and current requirements; to this end the Committee recommends the expansion of existing effort directed at the compilation, assessment, and interpretation of all geological and geophysical data relevant to the marine area, on a continuing basis.

The following general principles have been followed by the Committee in the allocation of priorities in the short term:

The collection of basic data on a regional basis should be completed as a first step, as this guides further exploration and leads to many of the detailed investigations of specific areas. This should not be construed, however, as meaning that regional surveys should always take priority over detailed or specific investigations which may call for urgent attention.

The emphasis in BMR program should be to foster the exploration and assessment of Australia's mineral resources and hence projects with a more direct economic significance should generally receive priority over those of a more scientific nature.

From time to time various minerals may be of greater relative importance and consequently priorities will be affected. At the present time petroleum is of the greatest significance in offshore areas and has the highest priority.

Knowledge of the continental margin of Australia should receive attention ahead of the more remote territories, such as Norfolk Island, and Antarctica. This general principle may be overridden by economic considerations or by political requirements, such as those relating to sovereignty, Law of the Sea matters, and the control of exploitation and pollution.

The operations of other organizations in offshore areas will affect BMR's priorities. BMR should not undertake detailed investigations in an area which is likely to be explored by others in the near future.

If the foregoing principles were strictly adhered to, projects such as crustal seismic surveys, heat flow, and geochemical and biochemical studies would probably not get off the ground for 10 or more years. It is desirable that such projects are undertaken concurrently with other work and on a regular basis; the Committee considers that the effort for these surveys should be about 10 percent of BMR's total marine program.

Projects which arise on an occasional basis, such as requests for engineering-type surveys and co-operative international projects, cannot be assigned priorities in advance, but must be judged on their merits. Allowance has been made for such projects in the forward program.

FORWARD PROGRAM

In this section consideration is given to the type and scope of operations necessary to achieve the principal objectives defined above, and to the time scale to be aimed at. In particular, activities recommended which depart significantly from current BMR practice are discussed.

The various types of marine operations which need to be carried out can be broadly grouped into: regional surveys, which include the systematic geological and geophysical surveys and geological sampling to provide stratigraphic control; special investigations, which include detailed surveys of mineral provinces and specific geological problems, crustal studies, heat flow work, and stratigraphic drilling; and other miscellaneous surveys, which include engineering and environmental surveys, co-operative international projects and foreign aid. A list of 88 projects grouped in these three categories is given in Table 6.

The proposed program 1976-1980 is given in Table 1.

Areal extent of operations

Most of BMR's offshore work will be concentrated on the shelf, slope, and rise of the Australian continent and on the areas surrounding Australian territories. However, attainment of the objectives of the forward marine program will certainly require that some surveys will extend into adjacent areas of the western Pacific, eastern Indian Ocean, and the Australian sector of the Southern Ocean. The Committee considers it neither practicable nor desirable to define the boundaries of BMR's area of responsibility offshore with greater precision.

Ocean-wide or global investigations of the sort undertaken by large foreign oceanographic institutions are not envisaged as being within BMR's role in the foreseeable future. However, the Committee believes that under some circumstances participation by BMR scientists in such expeditions will benefit Australia and therefore should be encouraged when appropriate.

Description of operations and recommended time scale

If BMR continues its marine operations at the same level of activity as in recent years, it will take 10 years to

complete a first regional geophysical coverage of the margin of Australia and its territories, excluding Antarctica, and 10 years to complete a regional geological survey of the Australian continental shelf.

This is without the addition of detailed and special surveys needed to complement the regional reconnaissance work. Having regard to the pressing national needs argued in the preface to this report it is the Committee's view that the BMR's marine program should be accelerated. Consideration has been given to the time scale within which the various objectives should be achieved and it is recommended that the aforementioned regional geophysical surveys should be completed by 1980, and regional geological surveys by 1985 (excluding Antarctica in both cases). Selected detailed investigations and special purpose surveys should be undertaken concurrently with the regional surveys. To achieve these ends a level of activity between two and three times higher than that averaged over the past five years will need to be maintained.

In the following paragraphs the objectives of the various types of operation included in the forward program are summarized and recommendations on time scale are made.

Regional geophysical surveys. Previous regional geophysical surveys by the BMR have delineated the main geological structural units of the continental margin, outlined areas of high petroleum potential, and enabled succeeding exploration surveys to be planned more efficiently. Advice to Government on the extent of the continental margin and its mineral potential has been based on the information obtained.

Throughout the course of the regional geophysical surveys, new and improved techniques have been introduced from time to time for navigation and geophysical measurement, recording, and display. Research and development should be continued with the aim of keeping these surveys abreast of modern technology. From BMR's experience on previous surveys it is seen that a greater depth of penetration by the seismic method would be of great value to the geological interpretation of the survey data and would be worth the additional expenditure of obtaining it. The Committee proposes that for future surveys the Seismic System is upgraded with a more powerful source, increased number of channels, and digital recording.

Completion of the regional geophysical coverage of the Australian continental margin and of the submarine

continental areas surrounding Australian territories, with the exception of Antarctica, should be given high priority and achieved by 1980. This will require six months sea-time a year, on average, from 1976.

Regional geological surveys. These surveys are undertaken to map and describe the superficial sediments, interpret existing sediment distribution patterns, and determine the form and structure of the upper sedimentary sequence. The results assist in establishing the Late Cainozoic geological history of the continental margin and in understanding past and present geological processes; they are also a necessary background for exploration for resources, such as heavy mineral sands and construction materials, and are required for an adequate understanding of marine processes controlling erosion, waste disposal, and other factors of concern to man.

Current seabed-sampling techniques result in lithofacies maps which show surface sediment characteristics only. The gravity and piston coring equipment in use is ineffective in the dominantly coarse-grained shelf sediments. It is considered important that the methods of collecting subsurface samples be improved on future surveys to enable more effective detailing of Quaternary stratigraphy and, where possible, the mapping of bedrock geology, and control of seismic profiling data. A vibrocorer or similar device will be required for sampling unconsolidated sediments and a rotary coring device for sampling hard rock.

Seawater chemical data should be collected as a matter of routine during the regional surveys, in-so-far as they relate to mineral formation and diagenesis within the surface sediments, and complementary ecological and biochemical studies should be carried out in collaboration with the Baas Becking group.

Positioning during past surveys has been carried out by celestial navigation, radar, and conventional pilotage techniques. This has met the needs of the type of work undertaken to date, but greater accuracy in positioning will be required in future surveys to locate the vessel over previously identified coring targets, and to enable surface sampling and seismic data to be tied adequately to existing geophysical traverses. A radio positioning system and/or satellite navigation supplemented by a sonar doppler system will be needed.

It is recommended that mapping of the continental shelf with improved data gathering facilities should be continued at its present rate of 3 months per year and completed within 10 years. The Antarctic and insular shelves

will still remain, to be surveyed, as will re-mapping with improved facilities of areas completed before 1975.

Stratigraphic control of seismic data. The regional geophysical surveys completed by 1975 have produced a very large amount of seismic data over areas of the continental margin seaward of the continental shelf, some of which are considered to have high petroleum-bearing potential. Almost all of these regions are untested by drilling because of the comparatively great water depths, although the rate of advance in oil drilling technology makes it certain that many will be within reach of exploitation in 10 to 15 years time. Assessment and orderly development of Australia's petroleum resources urgently demand that these areas be quickly assessed as fully as possible in order to encourage and direct exploration.

Such an assessment would be greatly assisted by direct sampling of key stratigraphic horizons in areas where existing stratigraphic control by extrapolation from remote wells on the continental shelf is inadequate. This can be done by shallow drilling or dredging at sites where these horizons come close to or crop out at the sea floor. These techniques are untested in Australia and nowhere are they well developed. An initial survey is proposed over the Exmouth Plateau, and if it is successful a continuing program occupying three months per year will be necessary to cover the more important areas of the continental margin within five years.

Surveys of specific mineral provinces. Surveys to assist in the assessment of mineral resources other than petroleum will need to be undertaken from time to time and in particular instances will demand a significant proportion of the total marine effort; about 3 months a year sea-time should be programmed for this work from 1976.

Crustal Surveys. Much of the data already gathered by the regional geophysical surveys assists in interpreting the nature of the crust and upper mantle around the Australian continental margin, but deep seismic information is needed to establish the basis for such interpretations. The field surveys to be considered are mainly deep seismic refraction and possibly deep seismic reflection. Either purely marine traverses, which may involve one or two boats, or traverses across both land and sea may be required from time to time.

Needs are recognized for many of these surveys. Allowance has been made for one such survey in the first five years program.

Investigations of specific geological problems. A large number of projects aimed at resolving specific geological problems can be foreseen, but realistic appraisal of financial and manpower resources likely to be available in the next five years has precluded programming of any such special surveys in this period. If some of this work is of particular current importance it may be accommodated in the course of other projects in the program. Much of this work will be directed towards more detailed investigation of petroleum provinces.

Engineering surveys. BMR has been involved in coastal engineering projects in the past and demands for such work are likely to continue to arise. These surveys are largely concerned with investigations of foundations and erosion. Staff other than those wholly engaged on marine work are mainly used and ships are usually provided by other organizations. It is estimated that about four man-months a year on average will be needed for these projects.

Stratigraphic drilling. Instances may arise where information vital to the interpretation of the stratigraphy of an area can only be obtained by drilling a deep stratigraphic well. If there appears to be no prospect of this work being done by other organizations, and if the prospectivity of the area warrants the expenditure, drilling of the well by contract should be undertaken. A need for this cannot be foreseen at the present time.

Heat flow. Measurements of heat flow on the ocean floor provide important data on fundamental geological problems and do not require heavy expenditure on capital equipment. Heat flow measurements should be undertaken, at least as the opportunity offers, in conjunction with other work.

International projects. BMR has participated in international projects of one sort or another on a number of occasions and the Committee considers that work of this nature can be valuable under some circumstances. Such projects cannot be programmed in advance but may warrant priority when they arise. Only one or two staff and possibly some equipment are likely to be involved in any one project, major facilities being provided by other participants. About six man-months per year should be allowed for work of this sort.

Co-operative projects. There are a number of Australian university groups with active programs in marine geoscience with whom BMR has co-operated usefully in the past. It is considered desirable that such co-operation should continue in order to make best use of available facilities and specialist knowledge. Special provision on forward program

has not been made for this work because it can normally be accommodated within other projects.

Co-operation with other organizations with interests in marine science, for example the Australian Institute of Marine Science, CSIRO, and Museums, should also be encouraged when appropriate.

Proposed program

The above considerations and arguments have led to the fairly detailed recommended program for the next five years, 1976-1980, as set out in Table 1. A brief explanation of the purpose of each project is included in the table. To carry out the program proposed a rapid increase in marine activity will be necessary; by 1977 it will build up to a total of 12 months sea time a year on regional surveys and about 4 months a year on other projects.

In the longer term a continuing need to maintain a high level of effort can be foreseen. Table 6 lists the large number of projects which appear necessary in the light of existing knowledge; together these total about 20 years effort at the proposed level of activity. Advance of knowledge and changing circumstances will no doubt lead to substantial changes in this list of projects, but the overall requirement will not be less than that shown.

COST ESTIMATES AND STAFF REQUIREMENTS

BMR's average yearly expenditure on marine activities over the past five years has been $1 200 000. On present day costs this figure would be of the order of $2 000 000. The corresponding yearly cost of carrying out the increased program recommened in this report will be about $5 000 000. These figures include salaries and allowances as well as operational costs. In addition an initial capital expenditure of $1 000 000 will be required (Table 3), mainly for equipment to improve the geological methods of sample collection and navigation as recommended in the forward program. If the program is to start on time as proposed, the increased rate of expenditure will have to start in the financial year 1975/76. A financial statement for 1975/76 in Table 2 shows a commitment of $3 580 000 and cash of $1 172 000. Only salaries and allowances for existing staff and relatively minor items for publications and computing have been included in the present 1975/76 estimates. Additional financial statements in Table 2 are for the financial years 1976/77 and 1977/78. The financial statement for 1977/78 represents an on-going expenditure that will be repeated in later years. Commitments and cash are each about $5 000 000.

The BMR staff required for the proposed increased program is estimated to be 116 whereas 47 are employed on marine work now. Recruitment of additional staff will have to start in 1976 and be nearly complete in 1977 if the program is to be achieved on the projected time scale.

These estimated costs and staff numbers for the next several years assume that contract services will be used mainly as outlined in the next section of this report. If, as recommended by the Committee, a Government ship is obtained for BMR use, capital equipment estimated to cost a further $1 024 000 (Table 4) will be required to equip the ship for geophysical surveys. In such a case, while there will be a requirement for some increase in BMR professional and technical staff, the ship would probably be crewed by the Department of Transport and some temporary scientific and technical staff would be hired on contract and the average overall cost would not be expected to be greatly different.

Storage of the data, particularly the bottom samples which need to be kept in refrigeration, represents a cost which has not been determined but must be ultimately considered. Australian Archives would probably undertake this function.

Accommodation for the additional staff and laboratories will also represent an additional cost.

Staff Requirements

The first permanent marine staff positions in BMR were created 10 years ago and marine geological and geophysical surveys have been carried out since that time. Much of the data has been analysed, interpreted and the results published but much more remains to be done.

The number of people engaged continuously on marine geophysics has climbed from about 7 in 1970 to about 32 at present. Additional temporary positions were obtained for the specific purpose of carrying out the Continental Margin Survey, 1970-1973, and these were continued for the purposes of processing, analysing, and interpreting the data from that survey. Also, staff additional to establishment have been directed to this work because of the priority accorded it. The above figures include support staff, mainly draftsmen; they do not include people engaged occasionally on marine geophysics from Engineering Geophysics and Structural Surveys groups, nor do they include staff from the Petroleum Exploration Branch engaged in the study of marine sedimentary basins.

Marine geological investigations have occupied full time an average of three professional and five technical staff since 1967. Suitably qualified staff to fill the marine establishment of five professional positions have not been available for much of this period, although at present the total existing effort exceeds five.

The experience gained over the last 10 years allows realistic estimates to be made of the staff necessary for efficient operation, and in particular enables assessments of the appropriate ratio of sea-time to office-time for the various classifications, and the manpower requirements for planning and direction, contract arrangements and supervision, equipment development and maintenance, data accession, processing, storage and retrieval, interpretation and reporting and some research and development of techniques.

Table 5 gives a breakdown of the staff situation as at present and of the additional staff needed to achieve the proposed program. The total staff required to carry out the proposed increased program is 116, with the professional staff of 49 comprising geologists/geophysicists (40), palaeontologists (3), geochemists (3), engineers (3). The Committee realizes that a detailed investigation of the needs could vary the composition of the numbers, but not to a significant degree.

As noted above, in the event that a Government owned ship will be provided for BMR use, there will be a requirement for some increase in BMR staff.

SHIPS AND CONTRACT SERVICES

In the past, BMR's marine surveys have been carried out from chartered vessels; separate contracts are arranged for each project and only in one instance has the same vessel serviced two consecutive surveys. In the case of the multisensor geophysical surveys, contract services have also been used for shipboard scientific operations with differing degrees of involvement of BMR staff and equipment. Reasons for the adoption of the present system, its advantages and disadvantages, and possible alternatives are discussed below.

Regional geophysical surveys

At present the contractors for the geophysical surveys provide the ship and crew, and geophysical staff and equipment with necessary shore-based support. Supervision and quality control on board, and post-survey data processing and presentation were done by BMR. In the early surveys, part of the equipment was provided by BMR, but for a number of reasons this arrangement did not prove to be satisfactory. Since ships equipped to be capable of carrying out the multisensor type of survey required by BMR are now normal to the geophysical contracting industry, it is not proposed at this time to require contractors to use BMR equipment to any great extent. For the two major geophysical surveys carried out since 1968 the contractors have been obliged to import foreign vessels because no suitable Australian-flag ships were available; there is a considerable likelihood that future contract geophysical surveys will need to make use of imported ships also.

It should be noted that the only geophysical contractors with the necessary competence are overseas based. In order that BMR should not be entirely dependent on these overseas contractors and should be able to evaluate and control the work done, a high level of technical competence must be maintained, and this can only be gained by continuing to engage in research and development in field techniques.

While surveys are still being done under contract it will be desirable to enter into long-term agreements. This will be advantageous in several ways: savings will be made in incurring less frequent mobilization fees; efficiency will be increased by the contractor's staff becoming familiar with BMR requirements over a longer period; and fees will be reduced because the contractor is guaranteed work over a longer period.

Advantages of BMR-operated geophysical surveys

It would be preferable that BMR build up a skilled group of people to run its own marine geophysical surveys; a nucleus of such a group already exists. Before this could be done a suitable ship would have to be provided by the Government on a long-term basis, together with the necessary geophysical equipment.

Advantages seen by the Committee of BMR-run surveys are that BMR would have better control of the surveys with less dependence on overseas technology; that there would be a build up of Australian technology and employment of more Australian personnel; and that there would be savings in foreign exchange.

Should a ship become available, BMR would probably still engage temporary technical staff on contract from a major geophysical contractor to assist in running the shipboard equipment. This would have some advantages, among which would be the cross-fertilization of expertise and experience which would result, and the overcoming of difficulties associated with the lack of flexibility in recruitment of technical staff under Public Service regulations.

Regional geological surveys

Regional geological surveys are carried out by BMR with only ship and crew supplied by a contractor. Previous surveys have made use of vessels of about 40 m, some of which have been far from satisfactory owing to the small number of locally available ships of the right size from which to choose. There has been some deterioration in the ship charter situation, and there is now doubt whether the survey planned for late 1975 will be able to go ahead because not one suitable vessel has been offered in response to a recent call for public tenders.

The additional equipment necessary to upgrade sampling techniques on future surveys will require a larger vessel (50 m minimum) with station-keeping ability and special facilities for handling over-the-side equipment. Useful

work could be carried out from a refitted vessel which met the basic requirements of size and suitable general arrangement, but fully efficient operation will require a ship specifically designed for marine geological work.

Mineral resource surveys and miscellaneous investigations

It is envisaged that some projects of this nature will be done by contract, with the contractor supplying the vessel. Thus drilling for heavy mineral sands or for construction materials would probably be most effectively carried out by contractors experienced in the offshore mining industry. Other projects in this group will be of a co-operative nature, and will use vessels of other organizations. On the other hand, deep-sea manganese nodule investigations would be best carried out by the same type of vessel as that used for the regional geology and slope sampling in future surveys, while some near-shore special-purpose surveys should best employ locally-chartered small vessels.

Full time use of an oceanographic vessel

The proposed marine geophysical program comprises six months multisensor geophysical survey a year and occasional other surveys such as crustal refraction and co-operative projects with other organizations. The proposed marine geological program comprises three months regional survey, three months stratigraphic control, and four months special and miscellaneous surveys. In general, survey procedures do not allow for the different major types of survey being done concurrently from the same ship in an efficient manner. If one ship could efficiently carry out the different types of survey consecutively, then there would be more than enough work to keep her fully occupied.

Most vessels used for geology and geophysics overseas are designed for a variety of functions. This results in some inefficiencies in that the full capabilities of the ship are not used all the time and certain characteristics essential for some operations detract from her performance on other work. Although, some shortcomings are inevitable, these can be reduced by careful design and cruise planning and the Committee considers that most of BMR's major surveys could be carried out by the one ship.

The size of a suitable oceanographic vessel lies in the range 50 m to 70 m. Such a vessel could be designed specially for the purpose and built in an Australian shipyard. This would take some years, although it should be pointed out that some effort has already gone into the design exercise, and a general arrangement plan of a suitable vessel was drawn

up by the Australian Shipbuilding Board in 1969. The estimated cost of the vessel at that time was $1 600 000. Such a ship would presumably be manned and run by the Department of Transport; the estimated yearly cost in 1969 was $180 000. Today these costs would be about double the figures quoted. Alternatively a suitable ship might be purchased more quickly and cheaply overseas, or could be taken on long-term charter. No suitable Australian-flag vessel is known to exist, although no doubt there are Australian ships that meet the basic requirements of size and general arrangement and that could be modified for the purpose.

The Committee recognizes that factors other than short-term expediency will influence any decision on the means of acquiring a ship. Some factors such as the use of foreign-flag ships and the question of support for the local shipbuilding industry involve policy attitudes of other Government Departments which have not been explored. Others, such as the future availability of Australian vessels, cannot be predicted at the present time.

Advantages and disadvantages of a BMR ship

The BMR marine program is foreseen as continuing for over 20 years, which is a sufficient period to justify the Australian Government in providing a special ship by building, buying, or long-term charter, provided that the program is approved and provided that sufficient advantage is seen to be gained.

Advantages seen by the Committee are:

- availability of a suitable and properly designed ship for the marine surveys with consequent improvement in operational efficiency.
- substantial cost savings on mobilization fees, ($277 000 for the geophysical survey in 1970).
- building up of Australian technology and national prestige in marine science. Compare the facilities available at the Bedford Institution in Canada and at N.E.R.C. in U.K., etc
- employment of Australian personnel.
- savings in foreign exchange.
- support to the local ship building industry if a ship is built or modified in Australia.

- time and effort expended on fitting and removal of BMR equipment before and after each survey will be reduced, as some systems will be permanently installed on the ship.

Disadvantages in BMR's having a single ship provided by the Government are:

- less flexibility in time scheduling to take advantage of suitable weather, where the different types of survey are made consecutively with the same ship throughout the year, than if more than one ship were chartered and surveys run concurrently.

- the multipurpose design of the ship is not optimum for either geological or geophysical surveys separately.

However, these disadvantages would be small and such a ship would be a great improvement on anything normally available for either type of survey.

Conclusions on ship operations

On the evidence now before it, the Committee believes that the proposed future geological and geophysical program could best be carried out by the full-time use of one properly designed and equipped oceanographic vessel, with support from chartered vessels from time to time. It is recommended that a thorough investigation into the desirability of acquiring a ship and the best means by which it might be acquired be started as soon as possible. This investigation will need to take account of all relevant aspects of Government policy, as well as of questions of operational efficiency, timing, and comparative costs.

It is expected that regional geophysical surveys programmed for the period to 1980 will continue to be carried out by geophysical contractors. However, if a suitable ship were obtained on long-term charter, it might be possible for BMR to start carrying out its own geophysical surveys by 1978.

Geological-type surveys programmed for 1976-1980 will require rather larger and better-equipped vessels than those used to date. In the short term, BMR will have to continue to rely on chartered vessels and the Committee foresees difficulties in obtaining suitable vessels in Australia. The prospects of hiring a foreign ship need to be investigated; policy objections to this course of action may be partly satisfied if a charter was arranged on a bare-boat basis, with crew supplied by Department of Transport.

TABLE 1

PROPOSED MARINE FIELD PROGRAM 1976-1980

1976

PROJECT	TIMETABLE (at sea)	EXPLANATION
Regional geophysical survey of Arafura Sea, Gulf of Carpentaria and Torres Strait. Continuous bathymetric, seismic, gravity and magnetic profiles mostly at about 20 n mile spacing.	August to December 1976. (4 months)	From what is known of the Arafura Sea, Gulf of Carpentaria, and Torres Strait region, it is fairly uniform and lacking in structure. Its petroleum potential would be regarded as poor to fair with the higher potential in the western Arafura Sea and in the northeast at the boundary of the Carpentaria Basin with the Morehead Basin. However, there is at present insufficient information to allow an adequate assessment to be made and to justify the present lack of interest and withdrawal of all exploration activity from the area. The results of the proposed survey could possibly lead to stimulation of further activity in the area.
Stratigraphic control of seismic data: Exmouth Plateau. Shallow coring and dredging on the margins of the Exmouth Plateau in water depths of about 2000 m to identify specific stratigraphic horizons.	September-November (3 months)	Remote sensing techniques suggest that the Exmouth Plateau has very promising potential for large hydrocarbon accumulations. Existing stratigraphic control from remote wells on the continental shelf is inadequate and direct sampling is necessary for a fuller appraisal of the area's potential to be made. Suitable deep-water sea-floor sampling equipment has yet to be obtained.
Regional geological survey of the continental shelf: Barrow Island to Geraldton Surface and subsurface sampling of the sea bed, bathymetric and shallow seismic profiling. (Alternative project)	September-November (3 months)	Continuation of the regional geological surveys which will complete the coverage over the shelf of the western margin of the continent. This survey will take place only if non-availability of deep water geological sampling equipment necessitates postponement of the Exmouth Plateau sampling program.

TABLE 1 (continued)

PROJECT	TIMETABLE (at sea)	EXPLANATION
Capricorn and Bunker Groups augering	May (1 month)	A co-operative project with ANU designed to establish a sea level curve for the east coast and to investigate the constructional history of the southern Great Barrier Reef. Shallow auger holes will be put down. The project has been postponed from 1974 and 1975, and is still subject to Governmental approval. It will involve some marine geology staff and low-cost charter of a landing barge only.
Heavy mineral sands, eastern shelf. Offshore drilling.	May-June (2 months)	To investigate offshore heavy mineral sand resources. Shallow drilling by contract. Tenders are now being examined. Work by a mining company in the late 1960s indicated that substantial low-grade deposits may be present, but further drilling is needed for an adequate assessment to be made. A seismic survey was carried out by the BMR in 1974 to outline areas to be drilled.
Woods Hole Indian Ocean cruise; Co-operative multidisciplinery project off northwest Australia	August-September (6 weeks)	Geophysical and geological work off northwest Australia. The proposal is still indefinite and some financial contribution from BMR may be called for. If it eventuates, this project will provide useful additional data at relatively low cost and will also supply valuable training and experience in oceanographic techniques for BMR officers working with one of the world's foremost oceanographic institutions.

TABLE 1 (continued)

1977

PROJECT	TIMETABLE (at sea)	EXPLANATION
Regional geophysical survey: Great Barrier Reef. (and further work outside the Reef over the Queensland Trough and Coral Sea Plateau). Continuous bathymetric, seismic, gravity and magnetic profiles, together with other measurements as required, at 10 n mile spacing or less.	6 months	The Great Barrier Reef covers an area that is recognized as having a fair petroleum potential. The recommendations of the Royal Commission enquiring into petroleum prospecting in the GBR will probably result in the banning of such activity to a large extent, at least for the present. In order to enable better assessment of the potentialities and possibilities of the GBR, it is recommended that BMR conduct a reconnaissance geophysical survey of the area. The results of such a survey will be useful not only in studying the geology and petroleum potential but in improving out understanding of the reef itself. Traverses within the GBR will be dictated to a large extent in direction and spacing by the reefs. A spacing of 10 n miles or less will probably be desirable to get sufficiently detailed information. Traverses in the Queensland Trough/Coral Sea Plateau area will supplement information obtained from the Continental Margin Survey and will look at the gaps in the information brought to light from a study of those results.
Stratigraphic control of seismic data: Northwest Australian margin. Shallow coring and dredging on marginal plateaus and the continental slope of northwest Australia.	September-November (3 months)	See 1976. Marginal plateaus and the continental slope in the region between the Timor Trough and Scott Reef apparently overlie thick sedimentary sequences prospective for petroleum. Stratigraphic control is needed for a fuller understanding of economic potential. This project is subject to the success of the similar project in 1976.
Regional geological survey of the continental shelf: Gulf of Carpentaria (or WA if not done in the previous year). Surface and sub-surface sampling of the sea-bed, bathymetric and shallow seismic profiling.	3 months	Continuation of regional shelf surveys (see 1976). Gulf of Carpentaria will have geophysical coverage in 1976. Assessment of these data will influence the geological program.

TABLE 1 (continued)

PROJECT	TIMETABLE (at sea)	EXPLANATION
Heavy mineral sands, drilling and/or geophysical investigation.	6 weeks	This will be either a continuation of the 1976 drilling of the eastern shelf, or a follow-up of indications of heavy minerals which may be recorded during the 1976 shelf reconnaissance. The project is dependent on results of previous surveys.
Manganese nodule investigation, Tasman & Coral Seas.	6 weeks	Manganese nodules have been recorded in the central Tasman and southern Coral Seas, but there are few data on the extent, concentration, and metal content of the nodules. Limited-scale reconnaissance is required to gain additional information on this potentially valuable mineral resource. The project is dependent on the availability of a suitable vessel and equipment.
Contingent survey	6 weeks	Survey in collaboration with other agencies, engineering surveys, systems development work.

TABLE 1 (continued)

1978

PROJECT	TIMETABLE (at sea)	EXPLANATION
Regional geophysical survey: Lord Howe Rise and Norfolk Ridge. Continuous bathymetric, seismic, gravity and magnetic profiles, possibly 50 n miles apart.	6 months	The Lord Howe Rise and Norfolk Ridge are massive submarine features to the east of Australia which are believed to be covered by substantial thicknesses of sedimentary rocks. These areas are of considerable geological interest as well as having some petroleum potential. The geological history of the Lord Howe Rise in particular is closely related to that of Eastern Australia. It is presumably of importance to Government policy-making to have an assessment of the petroleum potential of these areas. It would seem that initial surveys with lines spaced 50 miles apart would be sufficient for this purpose. However, some surveys have already been done over these areas by other groups and the question of the amount of work to be done must await the assessment of such existing results as may be available.
Regional geological survey of the continental shelf. Great Barrier Reef (or Gulf of Carpentaria if not done in 1977).	3 months	See 1976-7. Geophysical data from 1977 surveys will be used in planning this project.
Stratigraphic control of seismic data.	3 months	Area to be investigated will be decided on contemporary priorities. The project will be subject to success of previous surveys.
Investigation of mineral resources (placers, construction materials, manganese nodules etc.).	3 months	One or more surveys dependent on contemporary priorities.
Contingent survey	6 weeks	As for 1977

TABLE 1 (continued)

1979

PROJECT	TIMETABLE (at sea)	EXPLANATION
Regional geophysical surveys of the Tasmania Plateau and Bass Strait. plus further traverses in the Great Australian Bight. Continuous bathymetric, seismic, gravity and magnetic profiles at 20 to 100 n miles apart.	6 months	These surveys are required to cover areas that were omitted from the Continental Margin Survey. The Tasmania Plateau, much the largest of these areas, was omitted largely because of bad weather; while there is little to indicate much petroleum potential for the Tasmania Plateau, it is still to a large extent an unknown area.
Regional geological survey of the continental shelf; Great Barrier Reef.	3 months	Results from previous geophysical surveys will be utilized.
Stratigraphic control of seismic data.	3 months	Area dependent on contemporary priorities.
Investigation of mineral resources or Crustal survey	3 months	Dependent on contemporary priorities.
Contingent survey	6 weeks	As for 1977

TABLE 1 (continued)

1980

PROJECT	TIMETABLE (at sea)	EXPLANATION
Regional geophysical surveys of the Wallaby Plateaus and Heard/Kerguelen Plateau.	6 months	The survey of the Wallaby Plateaus is required to cover an area of the Australian continental margin not covered by the Continental Margin Survey. The plateaus although deep appear to have considerable sedimentary cover in parts. The reason for the survey of the Heard/Kerguelen Plateau is similar to that for the Lord Howe Rise and Norfolk Ridge. (See 1978).
Regional geological survey of the continental shelf: Great Barrier Reef or Great Australian Bight.	3 months	Results from previous geophysical surveys will be utilized.
Stratigraphic control of seismic data	3 months	Area dependent on contemporary priorities.
Investigation of mineral resources	3 months	Dependent on contemporary priorities.
or		
Crustal survey		
Contingent survey	6 weeks	As for 1977

TABLE 2/1

FINANCIAL STATEMENTS FOR PROPOSED MARINE PROGRAM

1975/76

Item	Commitment	Cash
Regional Geophysical Survey		
Arafura Sea, Gulf of Carpentaria, Torres Strait (4 months Aug-Dec 76) - Contract	$1 600 000	-
Data Acquisition System - refer Table 3.	150 000	150 000
Geological Surveys		
Reconnaissance Geraldton to Cape Leeuwin (Sept-Dec 75)	(committed 74/75)	160 000
Stratigraphic control - Exmouth Plateau (Sept-Nov 76)	400 000	-
Woods Hole Indian Ocean Cruise (Aug-Sept 76)	250 000	-
Heavy Mineral Sands - east coast offshore drilling (April-May 76)	350 000	350 000
Capricorn and Bunker Groups augering (May 76)	12 000	12 000
Capital items - refer Table 3	818 000	500 000
	$3 580 000	$1 172 000

N.B. Operating costs, data processing and computing, publications and salaries and allowances are not included in this statement for 75/76 because they relate mainly to on-going approved projects and would therefore be covered in the existing Estimates.

TABLE 2/2

1976/77

Item	Commitment	Cash
Regional Geophysical Surveys		
Arafura Sea etc (Aug-Dec 76) - Contract	-	$1 600 000
Great Barrier Reef, Queensland Trough, Coral Sea Plateau (6 months 77) - Contract	$2 000 000	-
BMR operating costs	130 000	130 000
Equipment replacements	30 000	-
Data processing and computing	150 000	150 000
Geological Surveys		
Regional - Gulf of Carpentaria (3 months late 77)	400 000	-
Stratigraphic control - Exmouth Plateau (Sept-Nov 76)	-	400 000
Stratigraphic control - NW Shelf (3 months late 77)	400 000	-
Woods Hole Project (Aug-Sept 76)	-	250 000
Mineral resource investigation (3 months early 77)	350 000	100 000
BMR operating costs	17 000	17 000
Data processing and computing	20 000	20 000
Analytical services	50 000	50 000
Capital items - refer Table 3	-	318 000
Equipment replacements	135 000	-
Publications	50 000	20 000
Salaries and Allowances		
Existing staff (47)	600 000	600 000
Additional staff (69)	800 000	800 000
	$5 132 000	$4 455 000

TABLE 2/3

1977/78

Item	Commitment	Cash
Regional Geophysical Surveys		
Great Barrier Reef etc (6 months 77)	-	$2 000 000
Lord Howe and Norfolk Ridges (6 months 78)	$2 000 000	-
BMR operating costs	130 000	130 000
Equipment replacements	30 000	30 000
Data processing and computing	150 000	150 000
Geological Surveys		
Regional - Gulf of Carpentaria (3 months 77)	-	400 000
Regional - Great Barrier Reef (3 months late 78)	400 000	-
Stratigraphic control - N.W. Shelf (3 months 77)	-	400 000
Stratigraphic control - subject to requirements (3 months late 78)	400 000	-
Mineral resource investigation (3 months 77)	-	250 000
Mineral Resource Investigation (3 months early 78)	350 000	100 000
BMR operating costs	17 000	17 000
Data processing and computing	20 000	20 000
Analytical services	50 000	50 000
Equipment replacements	135 000	135 000
Publications	50 000	50 000
Salaries and Allowances		
Existing staff (47)	600 000	600 000
Additional staff (69)	800 000	800 000
	$5 132 000	$5 132 000

This pattern of expenditure remains fixed for the program proposed for the years beyond 1977/78. No allowance is made for inflation.

TABLE 3

CAPITAL ITEMS

Geophysical data acquisition system	$ 150 000
Winch - deep sea heavy duty, for dredging, coring etc. 8000 m tapered wire	180 000
Vibrocorer - shallow or deep water, for coring unconsolidated sediments to depth of 5-10 m.	63 000
Subsea drill - shallow or deep water for coring hard rock to depth of 1 m. minimum under 5 m. of sediment	85 000
Subsea television - shallow or deep water for drill site selection and monitoring drilling	40 000
Winch - shallow or deep water, large drum for conductor cable, hydraulic or air line	60 000
Satellite navigation receiver and computer	100 000
Sonar doppler - accurate positioning	40 000
Seismic profiling system - upgrading and replacement of existing system	35 000
P.D.R. - narrow beam echo sounder, 6000 m range	35 000
Current meters - automatic recording (4 required)	25 000
Laboratory onboard equipment - chemical analysis (including water auto-analyser) XRD, salinity and temperature probes	80 000
Instrument cabins - include self-contained cold storage unit (3 required)	30 000
Side-Scan sonar - shallow and intermediate depths for detailed morphology and drill site surveys	30 000
Free-fall samplers - grab sampling in abyssal depths (10 required)	10 000
Laboratory onshore equipment - chemical and grain-size analytical equipment, including automatic fine sediment particle size analyser, and atomic absorption equipment	60 000
Total cost of Capital Items	$ 968 000

TABLE 4

COST ESTIMATE FOR MARINE GEOPHYSICAL EQUIPMENT
(BMR-operated surveys)

	$	
NAVIGATION EQUIPMENT:		
Satellite Nav Receiver and computer	100 000	
Sonar Doppler system	50 000	
Gyrocompass	15 000	
Autopilot	10 000	
Electromagnetic Log	10 000	
	$185 000	$185 000
SEISMIC EQUIPMENT:		
Digital amplifiers/tape recorders (DFS IV)	127 000	
Cross section camera	20 000	
Streamer 24 channel, 2400 m	60 000	
High power sparker	100 000	
	$307 000	$307 000
Gravity meter		$250 000
Magnetometer (proton precession gradiometer)		$ 30 000
Data acquisition system (computers, amplifier/filters, A/D converters etc)		$189 000
ADDITIONAL SCIENTIFIC AND NAVIGATION EQUIPMENT:		
Water velocity meter	4 000	
Accelerometers	10 000	
Atmospheric temperature, pressure, humidity	2 000	
Inclinometers	5 000	
Anemometer	4 000	
Water salinity and temperature	8 000	
	$33 000	$ 33 000
Deck containers/instrument cabins		$30 000
		$1 024 000 Total

TABLE 5

MAN POWER

	Total existing effort	Total Establishment required for proposed program.
Geophysical Surveys		
Professional	17	29
Technical	7	19
Drafting	6	15
Clerical	3	7
CSO's	1	2
Geological Surveys		
Professional	6	20
Technical	5	16
Drafting	2	6
Clerical	-	2
Totals		
Professional	23	49
Technical	12	35
Drafting	8	21
Clerical	3	9
CSO's	1	2
	47	116

The professional staff of Total new Establishment requirement comprise geologists/geophysicists (40), palaeontologists (3), geochemists (3), engineers (3).

TABLE 6

LIST OF PROPOSED MARINE PROJECTS

REGIONAL SURVEYS

PROJECT	DURATION (cruise months)	REMARKS
Regional Geological Surveys		
W.A. Shelf, Geraldton to C. Leeuwin	3.0	Seismic line spacing 20 n.m. Shallow drilling and surface sampling variable spacing 2-10 n.m. Vessel of about 60 m required. Compatible with additional underway and station observations.
W.A. shelf, Barrow I. to Geraldton	3.0	"
Gulf of Carpentaria	3.0	"
S.A. and Victorian shelf, Ceduna to Bass Strait	6.0	"
Great Barrier Reef Torres Strait to Swains	9.0	"
W.A. Shelf, C. Leeuwin to Esperence	3.0	"
Great Australian Bight, Esperence to Ceduna	6.0	"
Lord Howe Island shelf	1.5	"
Norflolk Island shelf	1.5	"
Antarctica shelf	6.0	"
Heard Island shelf	1.5	"
Macquarie Island shelf	2.0	"
Christmas Island shelf	1.0	"
Regional Geophysical Surveys		
Gulf of Carpentaria	1.5	Line spacing 10-20 n.miles. Vessel of about 60 m required. 24-hour underway observation. Incompatible with any work requiring station time.
Arafura Sea	2.0	"
Torres Strait	0.5	"

TABLE 6 (continued)

PROJECT	DURATION (cruise months)	REMARKS
Great Barrier Reef	5.0	Line spacing 10-20 n.miles. Vessel of about 60 m required. 24-hour underway observation. Incompatible with any work requiring station time.
Bass Strait	2.0	"
Tasmania Ridge	3.0	"
Wallaby Plateaus	3.0	"
Cascade Plateau	1.0	"
Lord Howe Rise	9.0	Line spacing 20-50n.miles. Vessel of about 60 m required. 24-hour underway observations. Incompatible with any work requiring station time.
Norfolk Ridge	6.0	"
Heard-Kerguelen Plateau	3.0	"
Macquarie Ridge	1.5	"
Antarctic continental margin	4.0	"
Coastal Tie Surveys		
Inner shelf, Australia-wide multisensor geophysical survey	12.0	To tie together continental and marine data
Stratigraphic Control of Seismic Data		
Exmouth Plateau	3.0	Dredging and shallow coring to identify particular seismic horizons. Compatible with additional station observations and limited underway observations. 60 m vessel.
Scott Plateau & Ashmore Terrace	2.0	"
Timor Trough	1.0	"
Coral Sea Plateau	1.0	"
Ceduna Terrace	1.0	"
Carnarvon Terrace	1.0	"
Wallaby Plateaus	2.0	"
Naturaliste Plateau	2.0	"

TABLE 6 (continued)

PROJECT	DURATION (cruise months)	REMARKS
DETAILED INVESTIGATIONS		
Detailed Follow-up Geophysical Surveys		
Exmouth Plateau	6.0	Line spacing 5 n.miles. 60 m vessel. 24-hour underway observations. Incompatible with work requiring station time.
Coral Sea Plateau	1.5	"
Ceduna Terrace	2.0	"
Scott Plateau and Ashmore Terrace	1.5	"
Timor Trough	2.5	"
Carnarvon Terrace	1.0	"
Wallaby Plateaus	4.0	"
Naturaliste Plateau	4.0	"
Stratigraphic Drilling		
Stratigraphic drilling on the continental margin	-	As required to obtain information essential to the broad evaluation of the prospectivity of a region. Contract drilling
Survey of Mineral Deposits in Superficial Continental Shelf Sediments		
Heavy mineral sands, eastern shelf	3.5	Detailed high resolution seismic surveys possibly supplemented by magnetic and radiometric observations, and surface and subsurface sampling. 25 m seismic vessel and larger drill vessel. Incompatible with other observations.
Heavy mineral sands, W.A. shelf	6.0	"
Tasmanian shelf submarine placers	3.0	"
Eastern shelf construction materials	4.0	"

TABLE 6 (continued)

PROJECT	DURATION (cruise months)	REMARKS
Manganese Nodule Reconnaissance:		
Tasman and Coral Seas	1.5	Deep sea floor television and photographic reconnaissance supplemented by dredging and free-fall sampling. 60 m vessel. Compatible with some underway and station operations.
Great Australian Bight and adjacent waters of Southern Ocean	2.5	"
Eastern Indian Ocean	4.0	"
Inner Shelf Surveys		
Southeast S.A.	1.5	Shallow seismic, bathymetric and shallow coring to complement onshore data. 25 m vessel.
Regional Geophysical Study of Tectonic Framework		
Roo Rise	1.2	Line Spacing 20 n.m. 60 m vessel. 24-hour underway observation. Incompatible with work requiring station time
Broken Ridge	2.0	"
Ninety East Ridge	6.0	"
Mellish and Rennell Rises	2.5	"
Argo, Gascoyne and Cuvier Abyssal Plains	1.5	Line spacing 50 n.m. 60 m vessel. 24-hour underway observations incompatible with work requiring station time.
Perth Abyssal Plain	0.5	"
Diamantine Fracture Zone	1.0	"
Great Australian Bight	2.0	"
South Tasman Basin	3.0	"
Coral Sea Basin	1.0	"
Solomon Sea	1.0	"
Southern Ocean	10.0	"

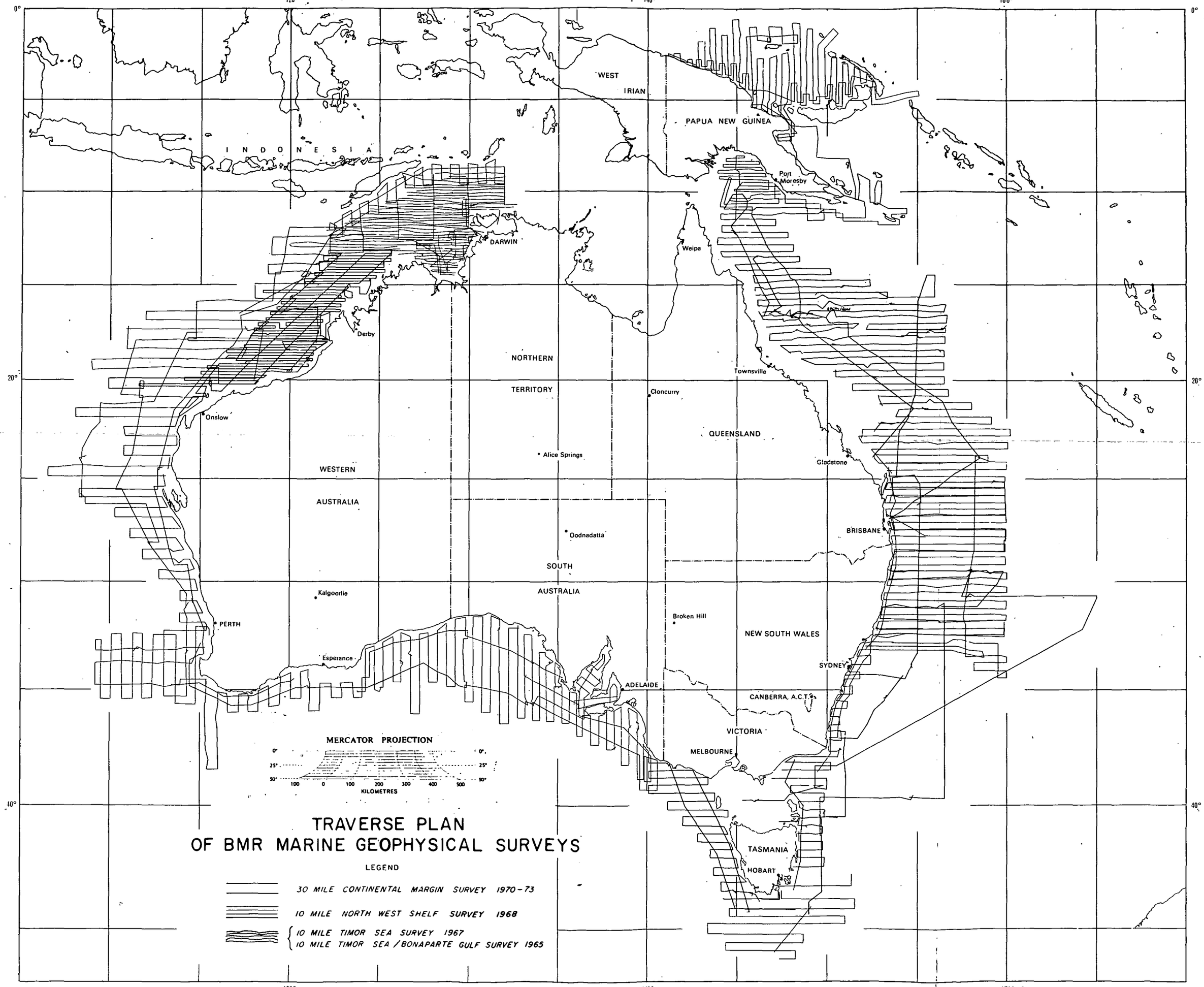
TABLE 6 (continued)

PROJECT	DURATION (cruise months)	REMARKS
Semi-Detailed Geophysical Study and Specific Geological Problems		
Offshore Pine Creek Mobile Belt	1.5	Mainly close-spaced seismic traverses possibly supplemented by other geophysical measurements and shallow drilling
Bonaparte Gulf	1.0	"
Offshore King Leopold Mobile Belt	1.5	"
Offshore Ankatell Gravity ridge	1.5	"
Exmouth Plateau deep structures	2.0	"
Bremer Basin	1.0	"
Ceduna Terrace deep structures	1.5	"
Offshore Sydney Basin area	2.0	"
Tasman Sea Guyots	1.5	"
Capricorn Basin area	2.5	"
Capricorn and Bunker Islands area	3.0	"
Great Barrier Reef	10.0	"
Coral Sea reefs	1.5	"
Surveys of Relevance to Fundamental Geological Problem		
Capricorn and Bunker Groups shallow drilling	1.5	Postponed from 1974 and 1975 programs
Timor Trough, geochemistry of bottom water, sediments and interstitial fluids	-	Sediment and water sampling, piston coring, carried out in conjunction with other work
Continental shelf, Australia-wide geochemistry of superficial sediments and sea water	-	"
Deep sea floor, Australian region heat-flow measurements	-	"
MISCELLANEOUS SURVEYS		
Participate in WHOI Indian Ocean Cruise	1.5 (1976)	Some BMR geophysical equipment may be used

TABLE 6 (continued)

PROJECT	DURATION	REMARKS
Participate in IPOD and other international oceanographic projects		Staff and equipment only. 4 man-months per year from 1976?
Contribute to CCOP and other overseas aid projects		Involvement depends on availability of staff and equipment and on political pressures
Ad hoc coastal and marine geological and geophysical engineering surveys	3.0 p.a.	Small vessel seismic and sampling work
Crustal studies	1.5 p.a.	Individual very long seismic refraction lines, combined with continental work, usually jointly with other institutions (Australian and overseas)
Systems development and experimentation in field techniques.	1.5 p.a.	Some of this work can be accommodated during other surveys. 25 m vessel

PLATE 1



TRAVERSE PLAN OF BMR MARINE GEOPHYSICAL SURVEYS

LEGEND

30 MILE CONTINENTAL MARGIN SURVEY 1970-73

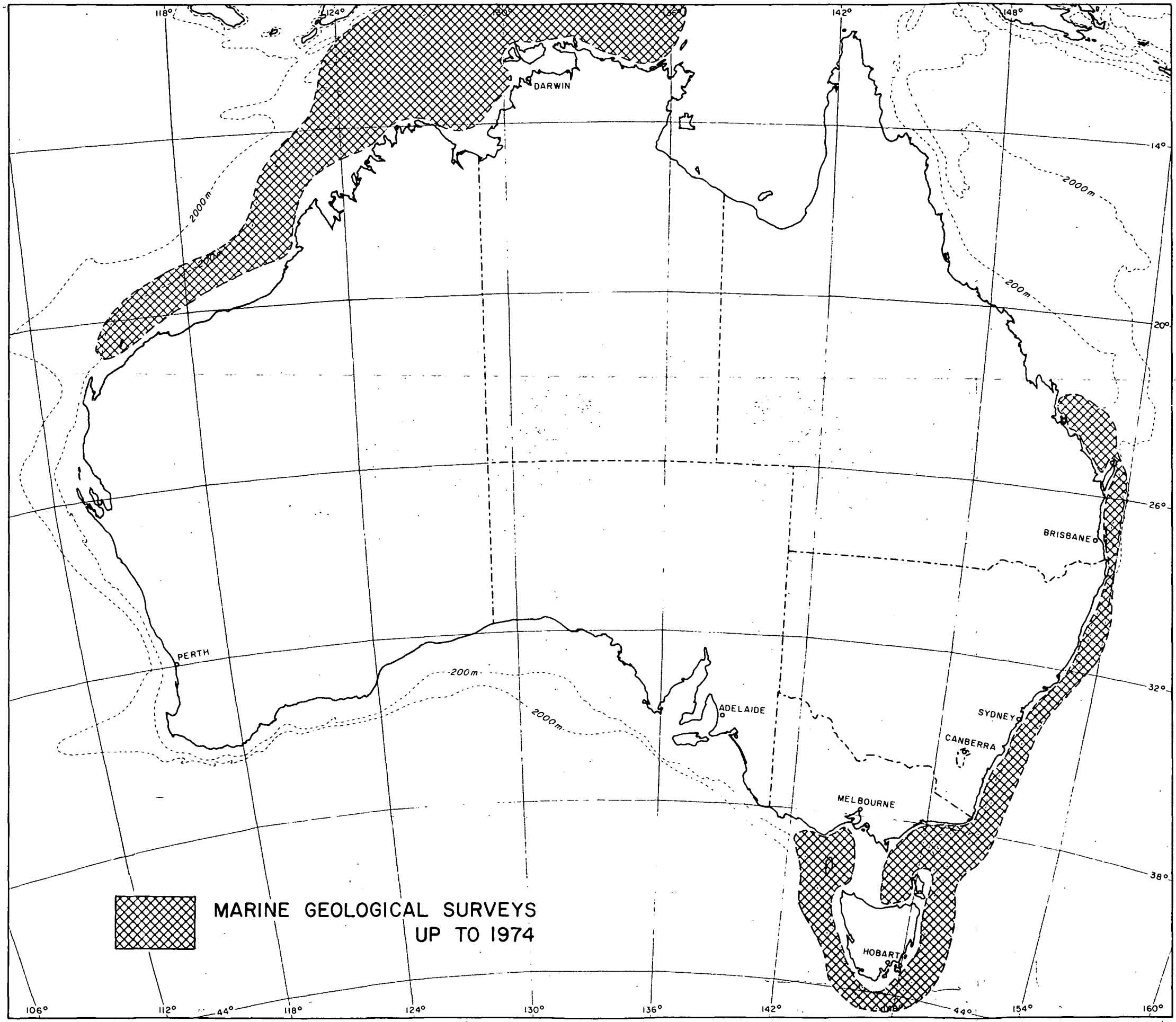
10 MILE NORTH WEST SHELF SURVEY 1968

10 MILE TIMOR SEA SURVEY 1967
10 MILE TIMOR SEA / BONAPARTE GULF SURVEY 1965

Record No. 1974/146

A/B8-123

PLATE 2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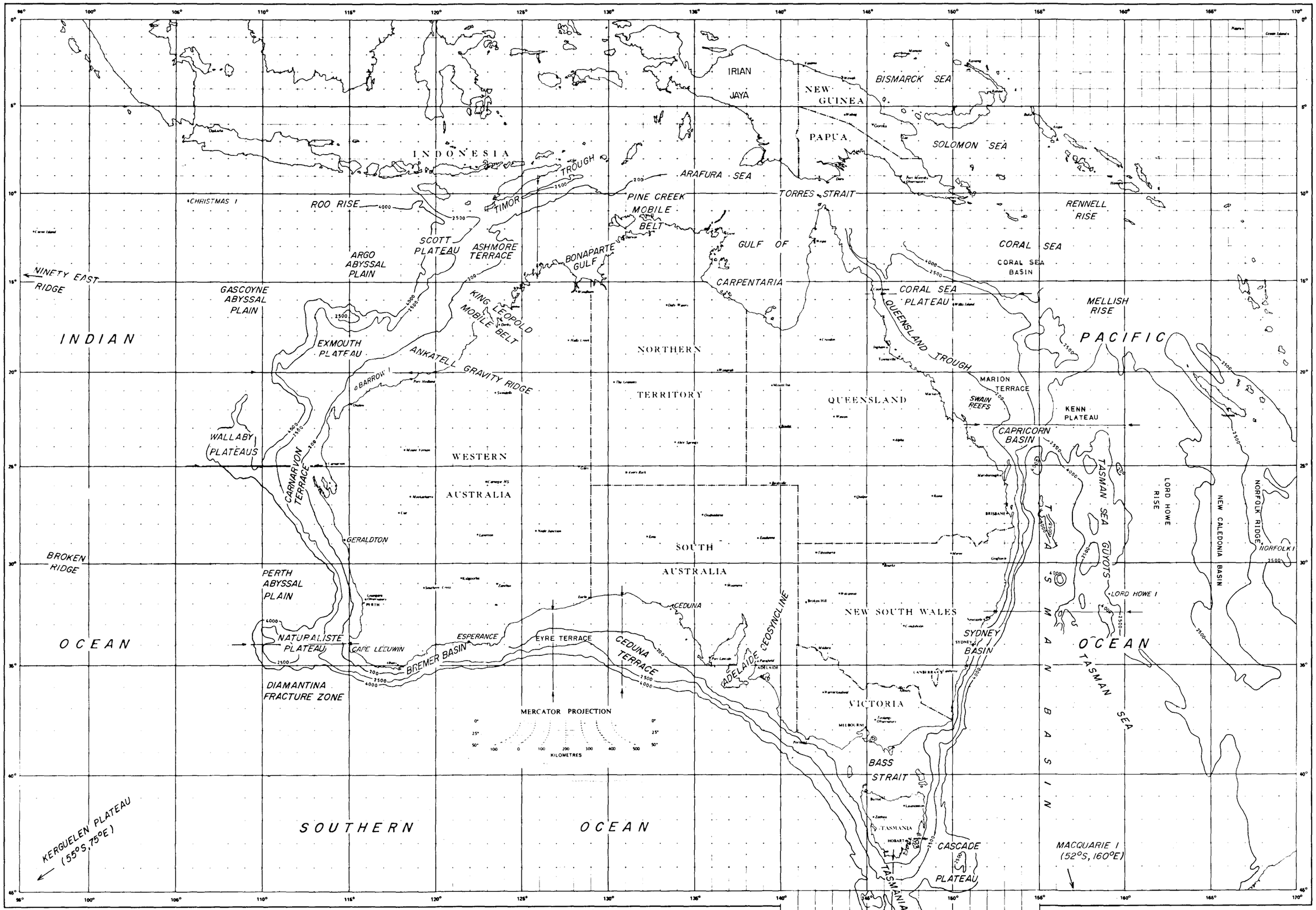
SYDNEY
CANBERRA
BRISBANE
HOBART
MARINE GEOLOGICAL SURVEYS
UP TO 1974



FORWARD MARINE PROGRAM
LOCATION MAP

A/B8-37-1