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THE PRESENT STATUS OF HYDROGRAPHY IN PAPUA NEW GUINEA

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ABSTRACT

The importance to Papua New Guinea of water-borne transport is emphasized and the current status of hydrography in its waters is assessed. Current requirements are reviewed and recommendations as to future policy made.

INTRODUCTION : A NATIONAL PERSPECTIVE

Papua New Guinea (PNG) (fig. 1) became an independent nation in 1975. The modern basis of the country in terms of infrastructure and rationale is, and is likely to remain for some time to come, essentially Australian in character : cultural and economic links with Australia, which formerly administered both Papua and New Guinea, have remained strong. The State, which has a population of some 3 million (predominantly rural, and divided into at least 700, often isolated, language groups) is relatively under-populated and an optimum population of about 9 million has been envisaged. The growth rate is estimated at just over 2 % at present. The land area by comparison is large, at some 46 thousand square km, and the coastline exceeds 7,000 km in length.

In global terms, PNG is a late developer as a provider of raw materials, which it possesses in variety and abundance. Geo-politically, it occupies a strategic position in relation to the Torres Passage between the Indian and S. Pacific Oceans, which is of obvious interest to Australia – and which could take on added significance should major powers extend their rivalry from S.E. Asian and Indian Ocean areas to the Pacific. In this respect, the considerable potential for naval bases could be

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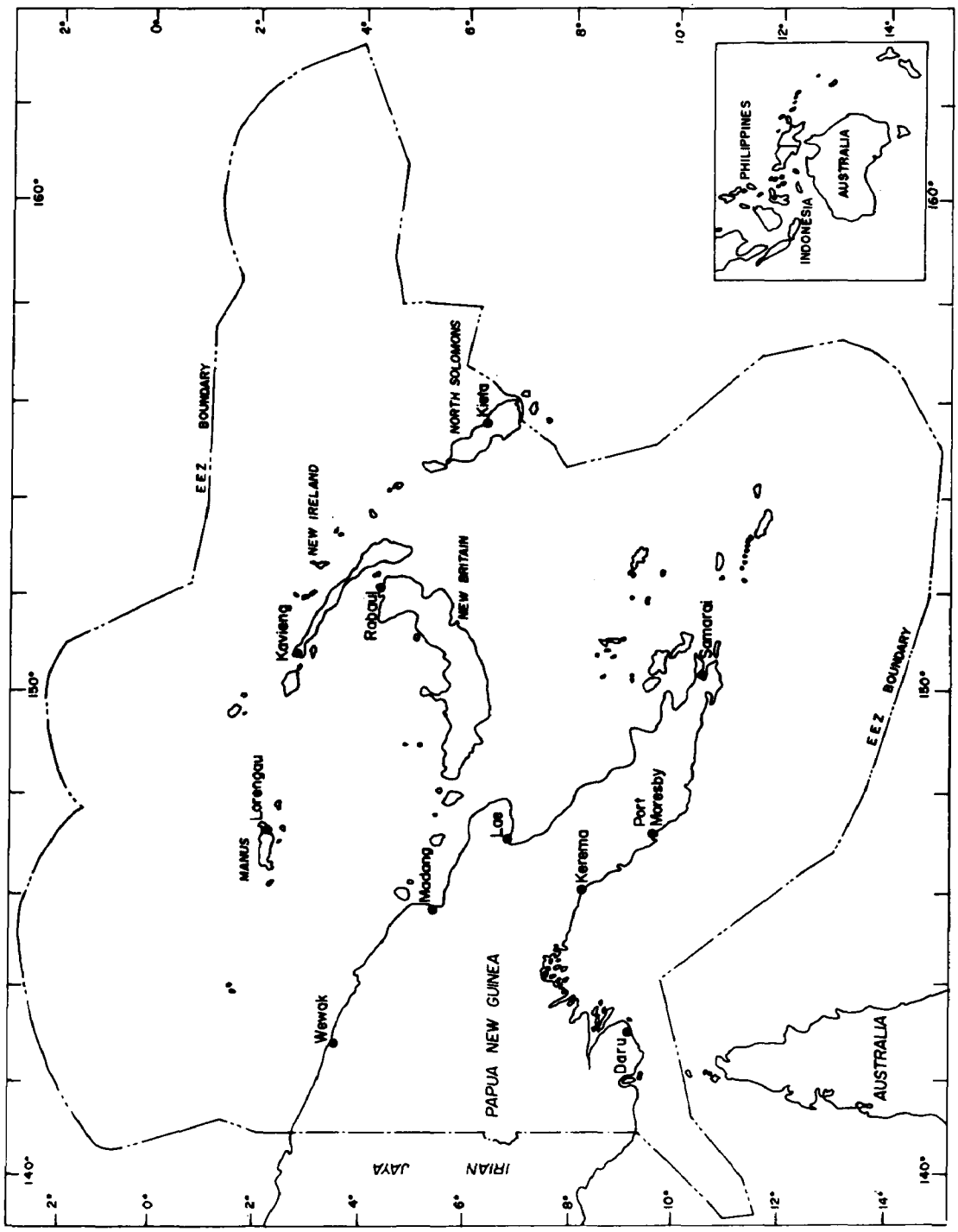

FIG. 1. – (After YOUNG and LYONS, 1981). No legal or political significance should be ascribed to the position of the EEZ as delineated. Its current position is understood to be under review.

very relevant. A complex central mountain range dominates the country; about 100 km wide near W. Irian, it broadens in the Highlands provinces to some 300 km, but then narrows towards its south eastern extremity. Steep topography, allied with heavy rainfall, account for complicated drainage patterns associated with a number of major rivers, which occupy the lowland areas north and south of the main divide. These convey much sediment seawards; coastal siltation and sandbank formation result. The river flood plains contain freshwater swamp areas, and mangroves are a common feature of tidal flats. The islands are predominantly mountainous and there are extensive offshore coral reefs.

Non-electronic internal communications have always been poor, as a result of difficulties of terrain, ecology and climate. Inter-regional road transport is extremely limited: only the Highlands Highway and the Ramu Highway (Lae to Mendi and Madang respectively) constitute such links. The capital, Port Moresby, is not linked by road to other than its own hinterland. Further developments are obviously of high priority but the costs of both construction and maintenance are extremely high by any international standard. Specific development projects will pose their own demands. Air transport, by contrast, plays a vital national role, but again costs of operations are very high for a variety of reasons. As a result, both passenger and freight tariffs are also high, and, given fuel price increases and declining commodity prices, it seems that growth in this sector will be limited at least in the short term. Water-borne transport is essential for both onshore and offshore development projects.

Resources are still largely untapped. Minerals are of major significance – major copper and gold deposits are in the North Solomons (Bougainville) and the Western Province (Ok Tedi) with other metalliferous deposits elsewhere, often in remote areas with access problems. In addition, oil and gas deposits are known to exist both inland and offshore.

Fig. 2 shows the three major basins in PNG – the Papuan Basin, the North New Guinea Basin and the Cape Vogel Basin. The Papuan Basin extends well offshore and is the largest, at some 250,000 sq km in area; gas discoveries there are not yet large enough to consider export potential at present but should be adequate for meeting domestic needs for power generation for a very long time. Currently, both the North New Guinea and Cape Vogel Basins are substantially under-explored, but an exploration promotion project now being carried out by the Minerals and Energy Department is being financed by the World Bank and is likely to lead to an upsurge in overall activity in this survey-intensive sector.

The previous dominance of cash crops such as coffee, cocoa, coconuts and oil palm has latterly been adversely affected by the advent of copper mining. Timber, livestock and fish are the other major products; the latter two can contribute significantly to national protein consumption which has traditionally been low. Tourism remains under-exploited as compared to other countries in Oceania, although the potential seems very high. On the mainland this would appear to centre on the unique culture and society, whilst the warm climate, offshore coral reefs and islands could in combination prove an aquatic attraction of much value.

A fact of obvious importance to all surveying operations, whether ashore or at sea, is that PNG lies in the collision zone between two thick lithospheric "plates" (the Pacific and the Australian) (fig. 3). This results in a complex tectonic regime in

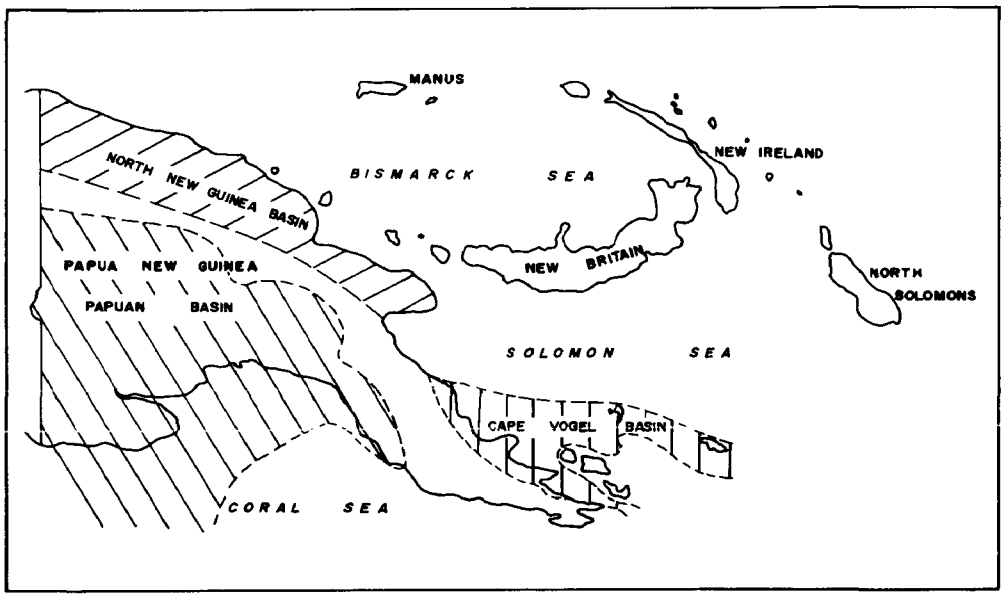

FIG. 2

the PNG area which covers over a million square km. A special feature of this interaction in the presence of two minor plates, the South Bismarck and Solomon Sea plates, and of two further small plates, North Bismarck and Caroline to the North. Thus the PNG area presents an unusually complex geodynamic picture, with some 11 boundaries between the 6 plates. Lateral and vertical movement rates can be high – as much as 10 cm per year in the former case; in addition, periodic earthquake activity and volcanic eruptions are a further result. Actual and potential effects on the stability of control networks may be very serious, as also is the aspect of any sudden alterations in submarine topography which are unpredictable both in location and extent. Over 100 major earthquakes have occurred in PNG since 1900 but associated effects such as landslips, submarine slides and coastal flooding due to tsunamis often cause greater destruction than the earthquakes themselves.

GENERAL HYDROGRAPHIC CONSIDERATIONS

The national hydrographic requirements of any developing nation are of great importance; economic expansion results in increased trade, and the necessary entry into its coastal waters and harbours of modern specialised vessels which are often very large. These require up-to-date and accurate charts, so that safe and economic passages can be made regularly and with total confidence. Almost invariably such a developing country has no hydrographic capability and possesses a limited chart coverage, probably based on work carried out in a previous century by a major Naval charting service. Traditional inshore position-fixing methods then normally

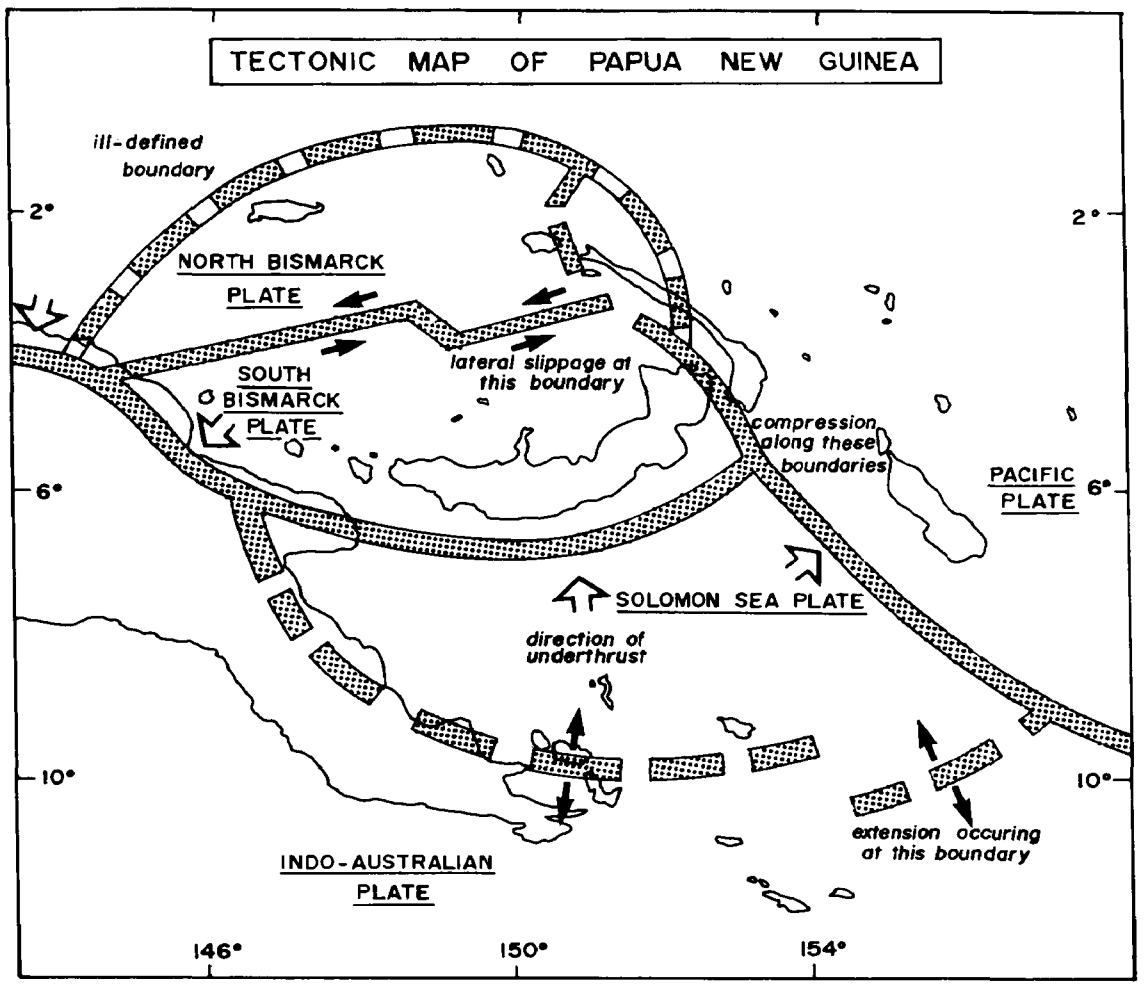

FIG. 3

involved close visual fixing by horizontal sextant angles during daylight hours, and the quality of the surveys was often high; however, the lead-line was not superseded until the 1930's. Offshore work was obviously of much lower reliability and remained so until electronic position-fixing was introduced during the 1950's. Many charts of the waters of even the more developed countries still depend to a large extent on arbitrary or indiscriminate 19th-century lines of soundings of questionable accuracy both in depth and position. The lines naturally tend to follow transportation corridors between ports, but reliance thereon is unwise; the initial work may have failed either to detect or to correctly position potential hazards, while interim changes, for example due to siltation, coral head growth, or submarine volcanic activity, may often have occurred. In theory, the continual updating, via user notification and "Notices to Mariners", should be such as to monitor these, but in practice this process is likely to have been fallible. In all cases, the increased draught of current shipping emphasizes the potential dangers involved.

In the case of PNG waters, modern charting operations were initiated extra-nationally as a result of military and naval requirements during World War II, when urgency was connected with offensive operations including the landing of forces from the sea. The work was done by the hydrographers of the Royal Navy (RN) and the Royal Australian Navy (RAN), and the latter continued to work in the area until Independence in 1975, when provision of charts and maps of PNG waters became the responsibility of the nation.

As a result of the pre-Independence work, a series of 1:300 000 charts exists for general navigation, although there are large gaps, and many areas have never been surveyed. Much coastal navigation is correctly regarded as hazardous as a result.

A Memorandum of Understanding was signed in 1978 which allowed for Australia to give help in the hydrographic field if requested, and able, to do so; aspects specified therein include charting, tidal predictions, training facilities and exchange of information. However, since 1975, due to its own urgent requirements for charting in Australian waters as a result of the increased draught of ocean-going vessels, the RAN has had little time to spare for PNG, and its outlined five-year plan (Hydroscheme 80) in fact includes no work in PNG sea areas. Any requests by PNG authorities would have to be considered together with other priority requirements, and take an appropriate place in the next 5-year programme, which is due to commence in 1985. The Hydrographer (RAN) considers, in any case, that establishment of a viable hydrographic surveying organization in PNG would greatly increase the ability to publish modern charts of the area. The reasons why PNG, as a country with great development potential, a long coastline and a large Exclusive Economic Zone (EEZ), should develop its own national and self-sufficient hydrographic unit have been well rehearsed. For example, all publications must have official authority and should be available to all potential users; the service must have formal, official links with other relevant Government departments, such as those of transport, port authorities and land surveyors, and should have representation at a suitably high administrative level. Although the establishment of such a service is very expensive, the problem must be addressed. If the work were merely performed on a piecemeal *ad hoc* basis by external contractors, the final cost would probably be higher, no effectively planned national 'bank' of data would be achieved, and, equally important, no national expertise would be generated.

At the International Hydrographic Conference, held in Monaco in April 1982, it was agreed that regional Hydrographic Commissions should be established : the relevant Australian and New Zealand authorities supported the Fiji proposal to establish a S.W. Pacific Hydrographic Commission, and any further support would be welcomed. Needless to say, it would be much to the advantage of PNG if it were to actively participate in such a body.

In February 1980, at the request of the Department of Transport and Civil Aviation, Commodore A.H. COOPER, Professional Assistant (Hydrography) on the staff of the International Hydrographic Bureau, visited Port Moresby specifically to advise on departmental responsibility for hydrography and the acquisition of a suitable vessel. Virtually no effective action has yet been taken on his report and recommendations. The current establishment of the Hydrographic Section, as a sub-division of the Marine Division of the Department of Transport, is such that it

is at present impossible to embark on any work other than small projects. There are only four established positions under the Marine Officer (Hydrography), a post which is at present occupied by a national, trained by the RAN and in Japan, but all of these are vacant despite repeated attempts at recruitment both nationally and overseas. As a result, the one officer has no staff, and, at the time of writing, no survey vessel; his rôle is the frustrating one of advising on potential and actual needs, and the inspection and checking of contractors' work. Rather fortuitously, the 1982 Department of Transport budget allowed funding for the acquisition of a new 8 m "Sharkcat" twin diesel survey boat. When delivered, this should be fitted with the almost-unused equipment already held (a Decca Trisponder position-fixing unit, and a Raytheon echo sounder) together with a new ATLAS DESO echo sounder; an important side-scan sonar facility for the detection and location of wrecks and pinnacles is unfortunately unserviceable.

This nascent, but minimal, Hydrographic Unit will obviously only be capable, at best, of very local inshore surveys within ports, harbours and rivers in PNG. It is equally apparent that, in view of the unrealistic and absurd lack of proper office and drafting support, the amount of work that it could carry out will be extremely limited, and clearly could not arrest the continuing accumulation of surveying tasks required.

CURRENT REQUIREMENTS

The requirement for surveys is great. Several areas for operations may be identified and in all of these the situation is one of real urgency for the realisation of development potential. Before looking at these individually, a point of some relevance must be made regarding the rather complex nature of existing PNG land-based control. Much of this is based on the Australian Geodetic Datum (AGD) and the Australian National Spheroid (ANS), but no integrated control system exists nationally – later satellite work which has been extended to the outer islands is based on the World Geodetic System 1972 (WGS 72). The latter system is on a different spheroid, whose "fit" to PNG is far from ideal, with geoid/spheroid separations of + 60 to + 85 metres, as compared to + 18 and – 7 metres for the ANS, both spheroids having similar deflections of the vertical. Similarly, there is as yet no integrated levelling network in PNG.

It is at present envisaged that, since much future mapping and charting, offshore navigation, oil rig positioning and isolated terrestrial surveys will increasingly employ the Doppler or other space geodesy techniques, a fully integrated system of control based on WGS 72 will be aimed at, despite the large geoid/spheroid separations involved.

In the *charting* field there has been virtually no work done since Independence. The charts covering the EEZ number some 55, mostly of small scale and of pre-1965 vintage; although they incorporate corrections to 1980, they are based on a variety of horizontal datums (e.g. local, AGD or unknown), spheroids (e.g. CLARKE 1880, CLARKE 1885, ANS), projections (e.g. Gnomonic, Mercator, Transverse Mercator) and vertical datums, the vertical references to which soundings are

reduced and tidal predictions made. As a result, inconsistencies arise both in positioning and depths between successive, corresponding, or overlapping charts. In addition, ground distance discrepancies up to 3 nautical miles can occur between features positioned on the 1:100 000 land map series and on the appropriate 1:300 000 charts.

Much of the north coast has never been surveyed, and the coastal stretch between Wewak and Madang only at a scale of 1:750 000, which does not permit accurate navigation (1 cm of chart representing 7.5 km of ocean). As a consequence, shipping must stay offshore when on passage between these ports. There is also an urgent requirement for a more direct route between Port Moresby and Lae – at present, vessels of any size are routed north of the D'Entrecasteaux Islands, whereas a passage through the Goschen and Ward Hunt Straits would result in large savings in time, fuel and expense.

Surveys of Round Cape (Central Province), the approaches to the Trobriand Islands and the East Cape Channels are also needed, to provide both considerable savings in cost to shipping generally and navigational safety for vessels of the PNG Defence Force, which cannot at present patrol such waters at night.

Ideally, a 1:100 000 coastal charting series should be produced to complement the land-based topographic mapping; 10 RAN charts at this scale exist, and probably some 70 - 80 more would be needed, bearing in mind that the limits of a chart series cannot really be set by geographical coordinate division and that large overlaps are very frequently required for navigational safety purposes. Such a work programme alone would fully occupy the lifetime of any survey vessel.

The Harbours Board urgently requires a series of regular surveys of the major and developing ports. Of these, only Lae has been surveyed since 1973, yet it is acknowledged that, due to movement of sandbanks, siltation, coral head growth or potential coastal instability, surveys of ports such as Wewak, Madang, Kimbe, Kieta, Kavieng, Rabaul and Port Moresby require updating every ten years whilst Daru and Lae should be re-surveyed at three-year intervals. Port Moresby alone poses two significant problems : surveys of the approaches to the new container-ship wharf and of the proposed deep-water port for the Ok Tedi scheme have not been carried out.

A contract survey of the Kupiano Harbour has been done but has yet to be checked and approved; Kerema Bar has yet to be surveyed.

Surveys of the major rivers, the Fly and the Sepik, are required, the former being of major topical interest in connection with the Ok Tedi Scheme. Contractors have charted the passage to Kiunga (fig. 4) but the positioning of appropriate marks and beacons is incomplete and in any case the shifting, unstable nature of this waterway demands continuous attention. The Sepik, too, is expected to develop in significance in the very near future, again in connection with mineral work and probably forestry development.

Forest development projects requiring logging outlets are also pressing. These are now to be funded through the Office of Forests, the Hydrographic Officer being required to issue specifications, coordinate the work and carry out supervision and checking as appropriate. Contracts are to be put out to tender. The principal areas involved in the near future are in Karu Bay, New Ireland, Tonolei Harbour, North

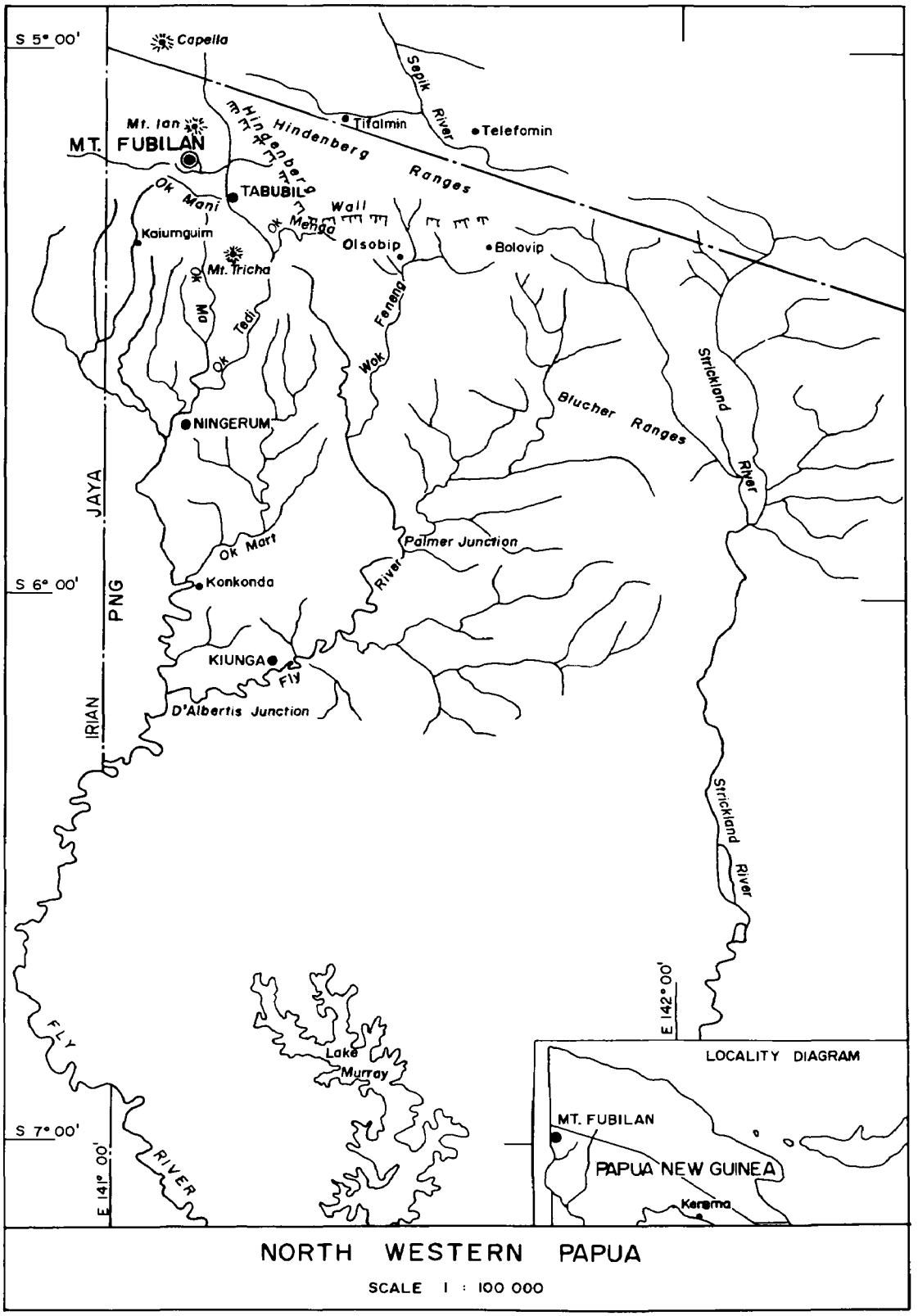
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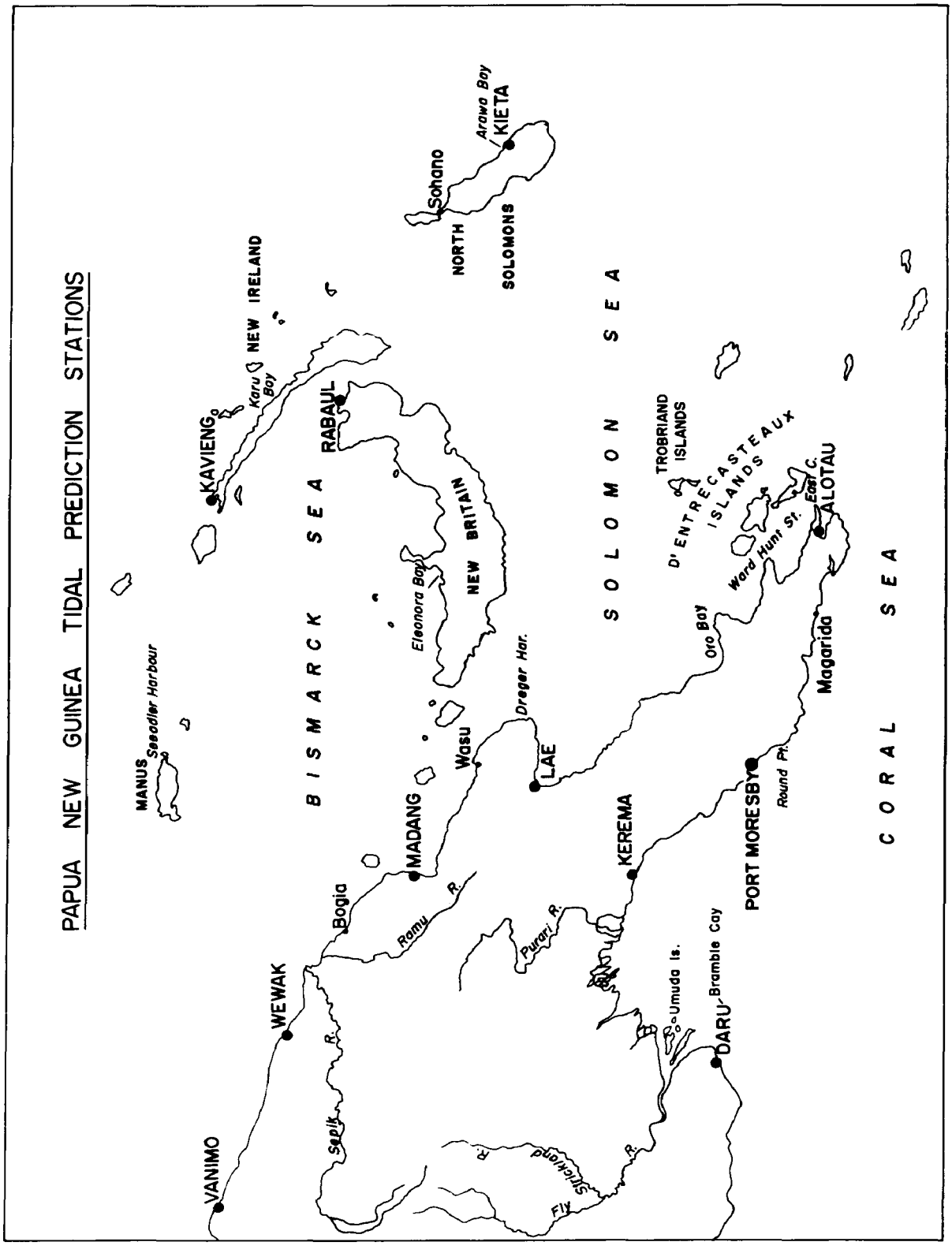
FIG. 4


PAPUA NEW GUINEA TIDAL PREDICTION STATIONS
BISMARCK SEA
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CORAL SEA
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Sepik R.
VANIMO
MANUS
Seeadler Harbour
Oro Bay
KEREMA
Purari R.
Fly R.
Stickland R.
Umuda Is.
DARU
Bramble Cay
PORT MORESBY
Round Pt.
Ward Hunt St.
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Solomons, and in Manus Island. Although the details for the latter are not finalized, two outlets may be required there.

Traditionally, all tidal analyses and predictions are produced by the RAN, while PNG pays for them as stipulated in the Memorandum of Understanding. Five PNG ports [Port Moresby, Lae, Seeadler Harbour (Manus), Dreger Harbour and Arawa (Bougainville)] are listed as standard, and predictions for a further 22 locations (fig. 5) are available at considerable cost. In theory, there are, in all, five automatic tide gauges, at Port Moresby, Vanimo, Madang, Lae and Rabaul. However, in practice their continued operation poses problems, due to scarcity of local operators and lack of finance and adequate supervision from the undermanned hydrographic section, and gaps in the recordings result.

NON-TRADITIONAL ALTERNATIVE METHODS

Recent developments in remote-sensing techniques could be of great use to PNG in its present parlous hydrographic position; their advantages lie in reduction of the expensive ship-time factor and/or the lack of requirements for shore control and installation of electronic position-fixing facilities for offshore operations. Such relatively cheap, non-traditional methods have their own limitations and disadvantages and should be used with discretion; they should not be regarded, for example, as having replaced modern and rigorous hydrographic charting operations. Professionally, it is accepted that before a particular route is shown to be safe for surface navigation, the area must be surveyed by conventional means.

Photobathymetry is suitable for detailed mapping in clear shallow waters and, although it obviously requires ground control for aerotriangulation, it may be used to release ships for operations in deeper waters. A cost advantage over ship-borne methods of about 5:1 is claimed, together with accuracies of around 1 m and water penetrations of up to 30 m. However, PNG might not be able to support such high technology, which is anyway still undergoing evaluation in Australian waters.

LANDSAT imagery is again suitable for reconnaissance mapping and reef location (but not coral head detection) in shallow waters, at present with a positional accuracy adequate for 1:250 000 mapping. In Australian conditions, depth measurements up to 25 m with 10 % RMS accuracy have been achieved. It must be noted that depth derivation must be generally based on known depths in the area of the LANDSAT scene, and that features found by LANDSAT must be related in position to other navigational dangers or features which a vessel uses to determine its position, even if the absolute position of these features is not known. The greater turbidity which characterises many PNG coastal areas may reduce the effectiveness of the above techniques, but both methods are a means of rapid data gathering, at very least for reconnaissance purposes.

SUMMARY

It should be apparent from the foregoing that the hydrographic tasks required in PNG waters are such as to require immediate, positive, and effective action. A

line of approach which would appear to offer many advantages would be a decision to transfer responsibility to the PNG Defence Force. The present apparently insoluble problems of recruitment and funding might thus be overcome and training could presumably be arranged (to the requisite published and approved standards of competence required by the profession) through the RAN. As already indicated, participation by PNG in the cooperative pooling of resources with other interested countries in the S.W. Pacific would be highly beneficial and the establishment of a regional Hydrographic Commission should be actively encouraged.

Acknowledgements

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