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GEOSCIENTIFIC DATABASES AND RELATED COASTAL ZONE MANAGEMENT ISSUES: PROJECT SUMMARY REPORT

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Stilt village, southern shore of Labuan Island, Malaysia

Keyworth, Nottingham, British Geological Survey, 1996

This report is one of a series which summarises the findings of individual projects within the Overseas Development Administration (ODA)/ British Geological Survey (BGS) Technology Development and Research Programme. This programme forms part of the British Government's provision of technical assistance to the developing countries. The report is intended for advisers and those concerned with development policy; programme and project officers in the donor agencies and development banks; and planners in the developing countries. Its aim is to draw attention to, and promote the practical application and take-up of, R & D techniques in operational development projects.

INTRODUCTION

The root causes of environmental problems in the Asia region are poverty, the lack of development, and environmentally unsound development. Most of the major urban centres of the region are located in coastal environments and the understanding of these environments is becoming increasingly important in planning their development.

The need has been recognised for 1) geoscientific data to assess man-made urban and coastal ecosystems in east and southeast Asia, 2) that the geological conditions in these areas need to be understood prior to development, though this rarely happens, and 3) that geoscience is an important part of Coastal Zone Management (CZM).

In 1990, CCOP, a regional intergovernmental organization for the Co-ordination of Coastal and Offshore Geoscience Programmes in East Asia, initiated a programme called *COASTPLAN* to examine CZM issues in the region. The Netherlands Government, agreed to fund much of the programme, and in September 1992, CCOP drew up a planning document defining *COASTPLAN.*

COASTPLAN is divided into three parts: seminars in east Asia by experts in CZM from the CCOP Co-operating Countries to demonstrate how the subject is being approached in these countries; the placement of an expert in coastal zone geoscience in the CCOP Technical Secretariat; and a study of coastal areas from the region to demonstrate to CCOP Member Countries modern techniques in CZM.

Following the 1992 agreements, BGS approached the UK Overseas Development Administration (ODA) for funds from its Technology Development and Research Programme (TDR) to fund the design and development of geoscientific databases within the overall *COASTPLAN* programme. Geoscientific data from the coastal and offshore zone of the region was accumulating rapidly in the geological surveys of the CCOP member countries, but was not being collected into a coherent digital database. Without such a database information was in danger of being lost, or certainly not being easily available, and it would not be possible in future to move the information into a geographic information system (GIS). The programme was approved by ODA and commenced in April 1993, before *COASTPLAN* was underway.

BGS decided in late 1993, as the site of the *COASTPLAN* studies were undecided, to commence the studies centred on the island of Labuan, Malaysia. This location was chosen as data were available from the island following extensive coastal studies by the Jabatan Penyiasatan Kajibumi Malaysia (Geological Survey of Malaysia - GSM), and their expanding general interest in marine and coastal geology. The three year programme has been a co-operative venture between BGS and GSM. GSM have provided both logistical and financial assistance, and the data used to carry out the programme.

The joint BGS/GSM project was divided into three parts. Part 1 describes the development of a digital database for coastal and offshore geoscientific data using as an example the database set up for the GSM. Part 2 is a case study of the coastal geology of Labuan, using the type of data on the a database, and the results of a field visit. Part 3 is an assessment of the value of remote sensing data from Labuan and its surrounds, to general CZM matters

The British Geological Survey has extensive experience in onshore and offshore digital databases, and the development of such systems over the last 25 years has facilitated the move into digital cartography and geographic information systems. This project sets out a digital database concentrating on coastal and offshore data for use by geological surveys from east Asia which, when installed, will allow the move into other technologies. What has to be made clear is that setting up the database is merely the first step, and that the time consuming task of rigorous data entry must be carried out continuously if the database is to have a long term and nation-wide application.

DATABASE DESIGN AND IMPLEMENTATION

Presently most of the geological surveys in east Asia have no nation-wide digital system for storing existing and newly acquired geoscientific information. In most cases the volume of data is not excessive and could be integrated easily into a digital database. However, unless its implementation is embarked upon soon, it will become increasingly difficult to set up a comprehensive database.

The requirement is for a database which can store the existing range of geoscientific information, which has scope for expansion, which is globally supported, and from which maps may be generated. Another requirement is that the data are held in a format which can feed into a Geographical Information System (GIS)

The BGS use an ORACLE database which is linked to ARCInfo, Intergraph and MapInfo GIS'. As the Geological Survey of Malaysia (GSM) had ORACLE and ARCInfo it was decided to prepare the database for the project on PCORACLE, for compatibility with existing systems and expected future developments. The database described below is a simplified version of the BGS onshore and offshore ORACLE database. The database can be easily translated into a number of similar software packages in use in other organisations.

The database adopted for this project was PCORACLE Version 7. ORACLE 7 is usually mounted on a server (UNIX in the case of BGS) and accessed from a PC through DOS or Windows environments, via the SQL*Plus query language. Data entry forms are accessed through Windows and provide an input format to mirror the paper forms used to record data collection. ORACLE 7 is designed to work with multiple user access and network connections.

To access ORACLE effectively on a PC, the computer should have 8 mb or preferably 16 mb of RAM, and a 400 mb hard disk. To interrogate the database a user must have one or more of SQL*Plus, SQL*Forms or third-party software such as ACCESS.

Before database tables are designed the data classifications need to be standardised. This is especially important when establishing formats for unique identifiers. Offshore geophysical and sample data have been recorded in digital and analogue formats in Malaysian waters, and organised for specific projects rather than nation-wide. The format for renumbering site data was decided, after discussions with GSM staff, following the BGS system of numerical registration based on their geographical position.

The system uses degree rectangles, and each rectangle is defined by its southwestern coordinates. Thus all degree rectangles in Malaysian waters have a unique number, within which samples may be sequentially numbered. The database has been designed so that onshore data may also be labelled using the degree rectangle system, though a different system for the collation of onshore data already exists in Malaysia.

Paper forms which reflect the digital database table designs, and separate information into distinct sections, are provided for recording data in the field. Both index information, such as the location of onshore boreholes and offshore samples, or seismic data collection projects, and geological data, such as borehole lithology and particle size analysis, are recorded using these procedures.

BGS has dictionaries of logistical and geological terms which may be used within its digital databases, including lithostratigraphy, lithology, biostratigraphy, equipment type, etc.. These dictionaries are linked to database tables to prevent the input of misspelt or unapproved terms. Similar dictionaries were created as part of the design of the database for GSM, and these are to be filled and linked to relevant tables at an appropriate stage during the database's development.

Tables in a relational database such as ORACLE are structured to reflect databasing conventions and efficient working practices. For each table, a unique identifier or 'primary key' is established. This is an element, or group of elements (eg site number) unique for each set of data entered to that table, and tables are linked to one another through their primary keys. The tables reflect the contents of the input forms and the data may be selected on the basis of any one or more of the elements held in a table, or combination of tables.

A two-tier database was designed whereby two identical sets of tables were installed but input is only possible into the "first-stop" temporary tables. Once validated the data are transferred to the permanent tables by the data manager. The security of the database is ensured by allowing geologist to enter data only to the temporary tables. The permanent tables may be viewed and output from them generated by any staff member but only with read-write access. provision is also made to restrict access to the named users.

The database is made up of tables which contain specific boxes or fields. Thirteen tables have been prepared after discussions with GSM addressing the following information:

GSM locational and equipment data	Core Sample data
Grab Sample data	Non-GSM Site locational data
Particle size data	Gravity data
Onshore borehole locational data	Onshore borehole interval data
Seismic track line data	Seismic project limits
Geochemistry heavy mineral data	Geochem. heavy minerals-economic constituents
Geochemistry minor/major oxides	

Each form (Figure 1) relates to one or more tables in the database. Each may exist as a paper copy (sample information) or may be entered into the database directly (seismic track data), or may be entered by filling in an on-screen form (non-GSM sample data).

Specific required information from the database may be plotted onto a map using appropriate software. The map needs to be drawn to the appropriate projection, and needs to carry a coastline, held within, or which can be accessed by the software. Figure 2 shows a simple output from the database using ATLAS MAPMAKER, but GSM have more sophisticated packages which are now being used successfully.

CASE STUDY - LABUAN

Pulau Labuan is an island of approximately 92 km^2 lying off the coast of western Sabah, at the mouth of Brunei Bay. Extensive geological investigations were carried out on the island in the early 1990s as the federal government were considering reclaiming land along its coasts. Labuan has a tropical climate with an average annual precipitation of 3766 mm. Winds are generally light, and the island lies south of the main typhoon belt in the South China Sea. The NE monsoon blows from January to March and the SW monsoon dominates from June to October. Waves generated by these winds dictate littoral sediment transport directions along the coast. Tides around Lubuan have a maximum range of 1.3 m and generally flow at speeds of less than 1m/sec, with the maximum speeds in the narrow inter-island channels.

A few days were spent on the island in February 1994 in the company GSM geologists who had previously worked on the island. The morphology of the coast was examined during this visit and areas of erosion and accretion identified. The results were put into context on return to GSM offices in Ipoh, using air photographs and existing reports (Figure 3).

The western coast is parallel to the direction of the dominant winds. They intertidal zone is up to 150 m wide and is commonly backed to landward by a "raised beach" which lies about a metre above the modern high water mark. The coral reefs dominating the shallow sub-tidal zone are presently in poor health, possibly due to coral mining, though this largely ceased some 20 years ago. Areas of both erosion and accretion are found along the coast. Erosion leads to toppling of trees on the raised beach front, and is associated with a steep upper-beach profile. Locally man-made defences have been built where the coast road is close to the beach top. No major morphogenic features were recognised along this coast indicating the direction of nett sediment transport in the littoral zone. As the coast along the northernmost part of the coast is boulder strewn, and largely devoid of sand, most of the sand moving onto the beaches along this coast may come from the coral reefs immediately offshore. The present poor health of these reefs may have reduced the sand supply onshore and led to the local erosion along the coast.

The eastern coast of the island is sheltered from the SW monsoon but is open to the NE monsoon. A raised beach similar to that on the west coast is found along the parts of the middle section of the coast. The upper part of the modern beach is a medium-to coarse-grained coral and quartz-rich sand whilst the lower beach is finer grained and muddier. Beach rock is found both within the raised beach and on the lower beach. Variations in erosion and accretion are locally spectacular along this coast. The erosion has produced stretches of coast with truncated mangrove stumps, and accumulations of toppled coconut palms. A new house and an electricity sub-station built near the beach top have been protected by wirebasket (gabbion) walls, and erosion in the cemetery at the southern end of the embayment is removing graves dug in the clifftop during the 1930s. Much of the eroded sediment is deposited into the spits at Tanjong Aru, and at the mouth to the S. Ganggarak and the wide beaches in the southern part of the bay. The abrupt changes in erosion and accretion along this coast may be due to differences in exposure to waves brought about by the coral reefs lying about 1-2 km offshore. The coast is accretionary where the reefs afford protection from the waves, and the stretches of coast not afforded such protection are eroding. Other factors such as the amount of beach rock in the upper beach, which limits erosion, and starves down drift beaches, may also affect the state of the beach. The southern coast is largely sheltered from both dominant monsoons. Victoria Harbour is largely clear of sedimentation due to the strong currents in the channel at its mouth. The coast in Kine Benuwa Bay is largely in equilibrium as testified by the state of the 30 year old stilt village on its western shores.

The Hydrographic Office, UK, Ministry of Defence, supplied bathymetric maps of the coast of

Labuan collected in 1844, 1901 and 1966. These were contoured and digitised, and the changes in the positions of the coast compared to determine rates of erosion and accretion between the survey dates. The 1844 survey locally shows significant differences with later surveys, which could be the result of survey inaccuracy, but they may also be due to retreat or total loss, measured in hundreds of metres, of mangrove from the coast. The Tg. Aru spit extended southward by some 720 m between 1901 and 1966, and the spit at the mouth of the S Ganggarak extended some 200 m in the same time. Present day estimates of erosion, based on information from fishermen, and erosion around a jetty built in 1981, indicate erosion locally of about a metre a year. The position of low water mark has remained relatively constant between 1901 and 1966 (Figure 4). These bathymetric surveys are an essential tool for measuring historic rates of coastal change. Results collected over a period of a few years may not give the longer term perspective deduced from examination of these historic data, and the geomorphology of the coast.

REMOTE SENSING

GSM lent BGS a Landsat tape of a scene covering Labuan and western Sabah and surrounding waters (Path 118/Row 56) collected on 14 June 1991. A 1:100 000 scale image of the scene was produced using different processing for the onshore and offshore parts of the scene. TM Bands 3, 2 and 1 within the visible part of the spectrum were used offshore which appears close to its natural colour. Onshore TM Bands 4, 5 and 3 were used to produce a false colour image which highlighted differences in vegetation type and soil cover.

The aim of this part of the investigation was to assess how the remote sensed data aided the field observations of the coast zone. The information provided by the scene was of limited benefit to the well-studied coast of Labuan. Good bathymetry existed for the coast and the photogeological interpretations allowed an assessment of the morphological features of the coast. The scene was not processed to investigate specifically the bathymetry of the shallow sub-tidal zone, but it is doubtful whether the result would be better than the bathymetric survey (Figures 5 and 6).

Where the scene proved most useful was the broad assessment of the adjacent coast of western Sabah which was not visited during the study. The remote sensed image yielded significant data on the morphology and sedimentary processes affecting this coast which would be invaluable for any future study. Examples from the literature of more detailed studies of Landsat data from the region indicated that additional information could be obtained using processing leading to classification of vegetation types, and some data on the offshore bathymetry. However, the latter is very susceptible to error due to suspended sediment in the water, and is of limited value near delta and river mouths.

CONCLUSIONS

Many geological survey organisations from east Asia are collecting a range of geoscientific information from the coastal and offshore zone but few are integrating it into a digital database. Without such a database, an attempt to move coastal zone management into new technologies such as digital cartography and GIS will not succeed. The need is for a globally-supported digital database, that will include as much existing data as possible, and all future data, on a nation-wide basis.

Such a database has been set up successfully at the Marine Geology Group in the Geological Survey of Malaysia using PCORACLE though it can also be used on other similar relational database software. This database was demonstrated at a CCOP *COASTPLAN* workshop held in Manila in early 1996, and it is hoped that other geological surveys in the region will take it, or a similar system, aboard. The database holders must appreciate that setting up the system is but the first step, and if it is to be used then it must be constantly updated to be of use in succeeding years.

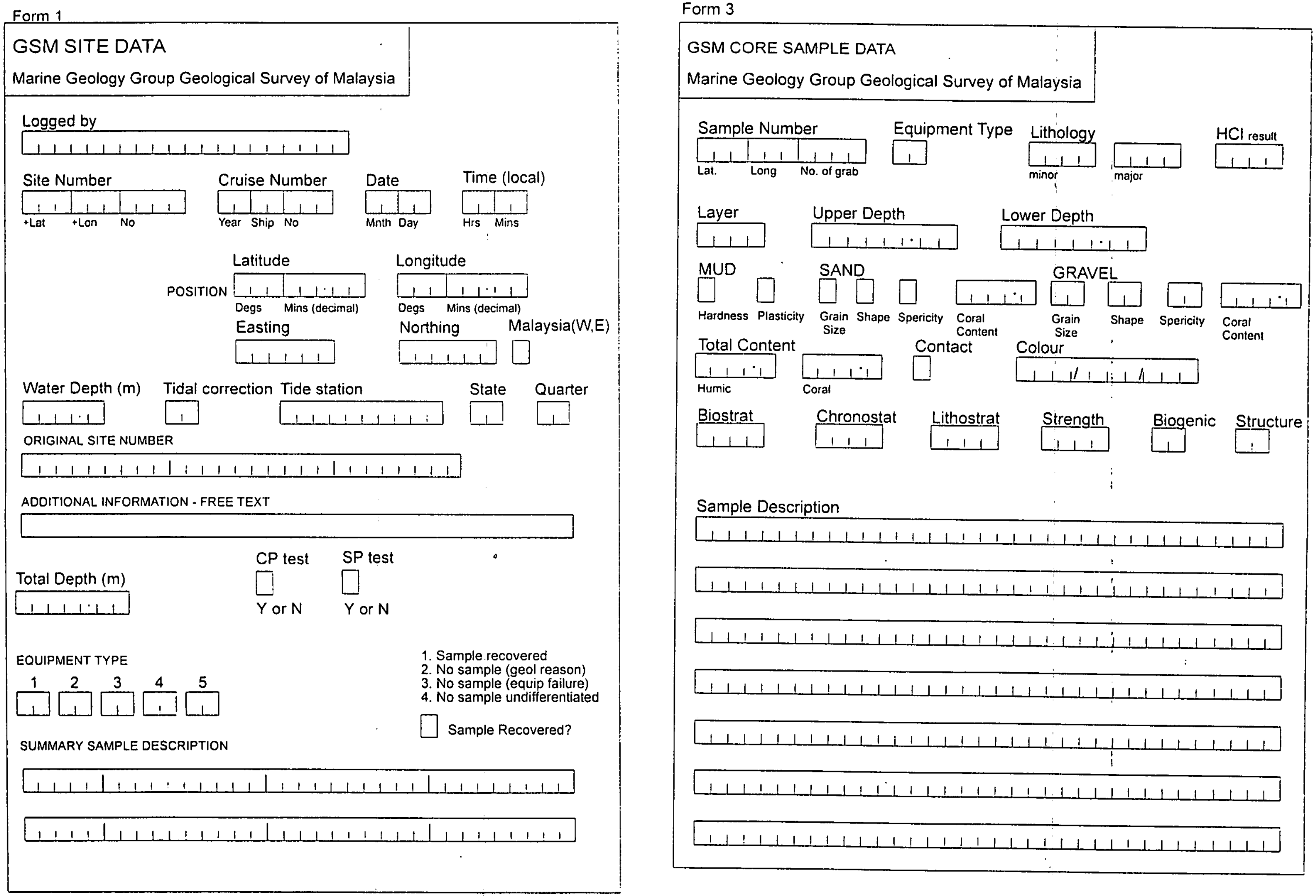
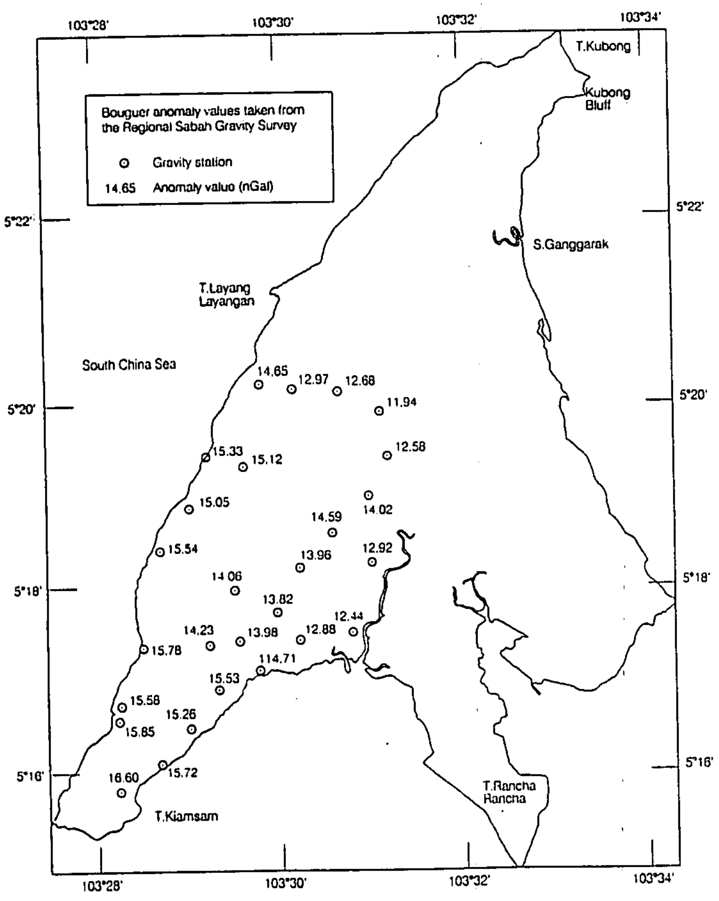


Figure 1 Examples of typical forms for putting information into the database



Selected Bouguer anomaly values for Labuan.

Seismic track lines from the surveys around Labuan

Figure 2 Output of map data from the database

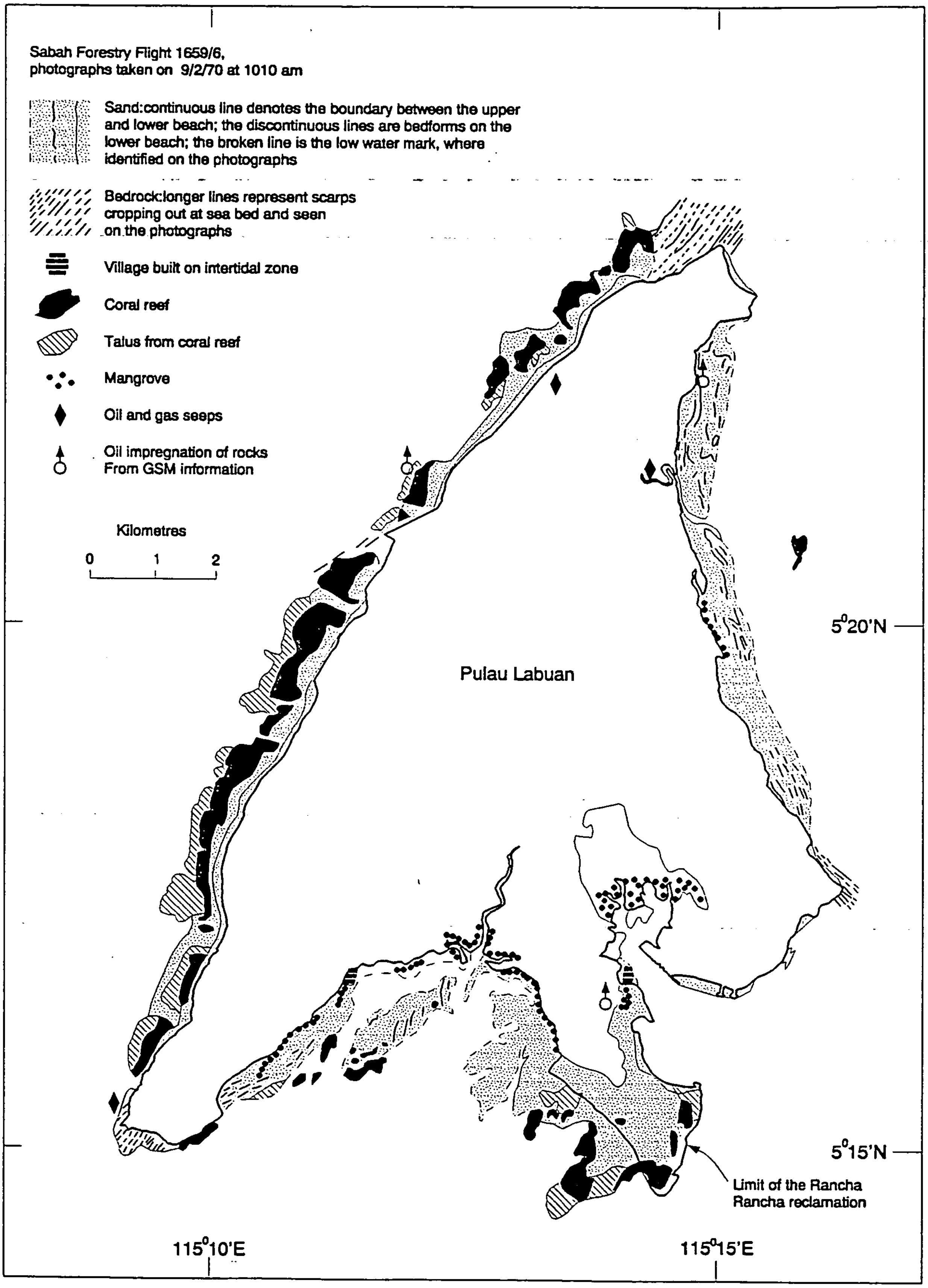


Figure 3 Airphoto interpretation of the coastal zone of Labuan

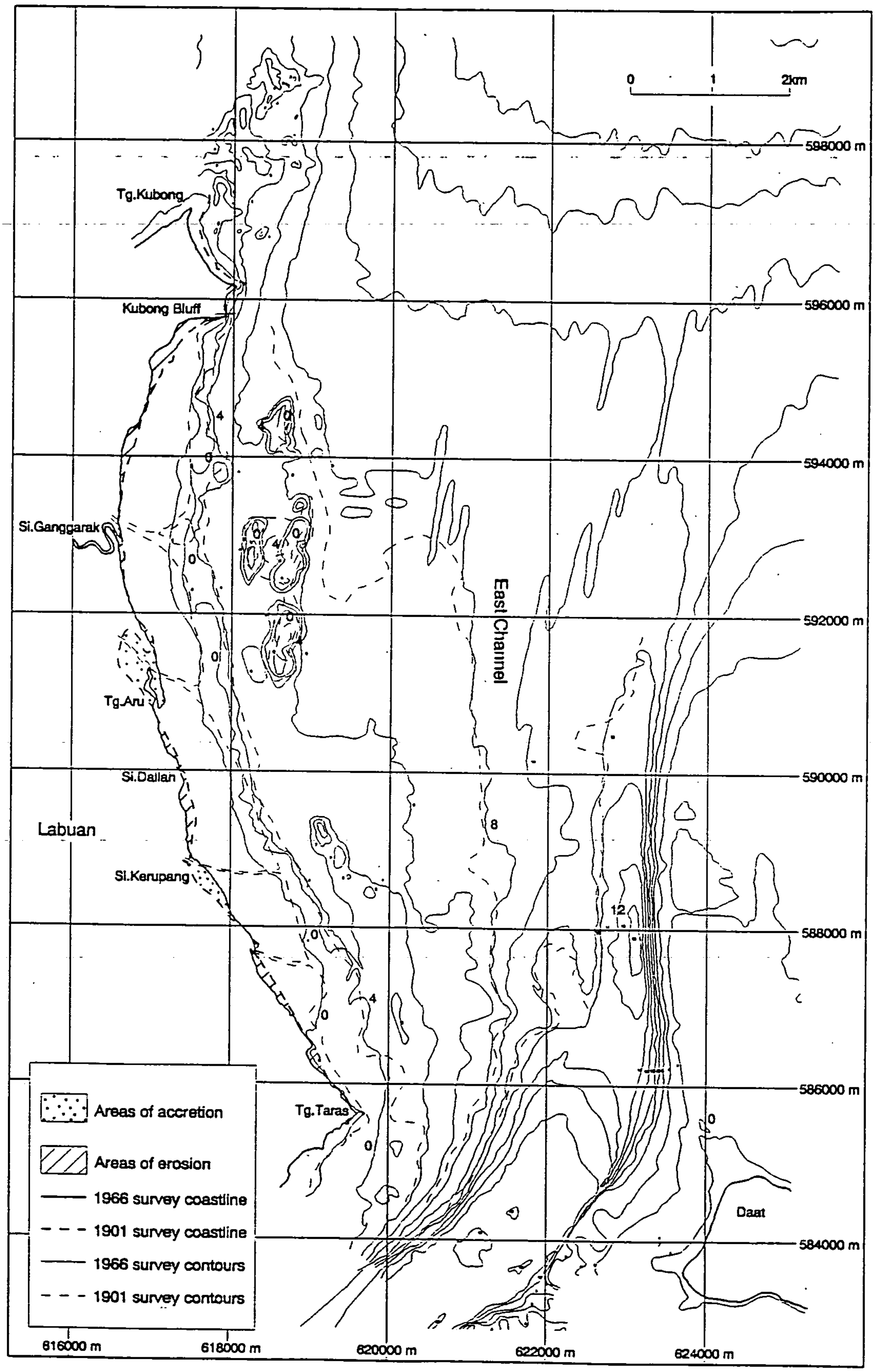


Figure 4 Comparison of the coastline of East Channel, Labuan between the 1901 survey and the 1966 survey

Figure 5 Landsat scene covering Labuan and surrounding waters

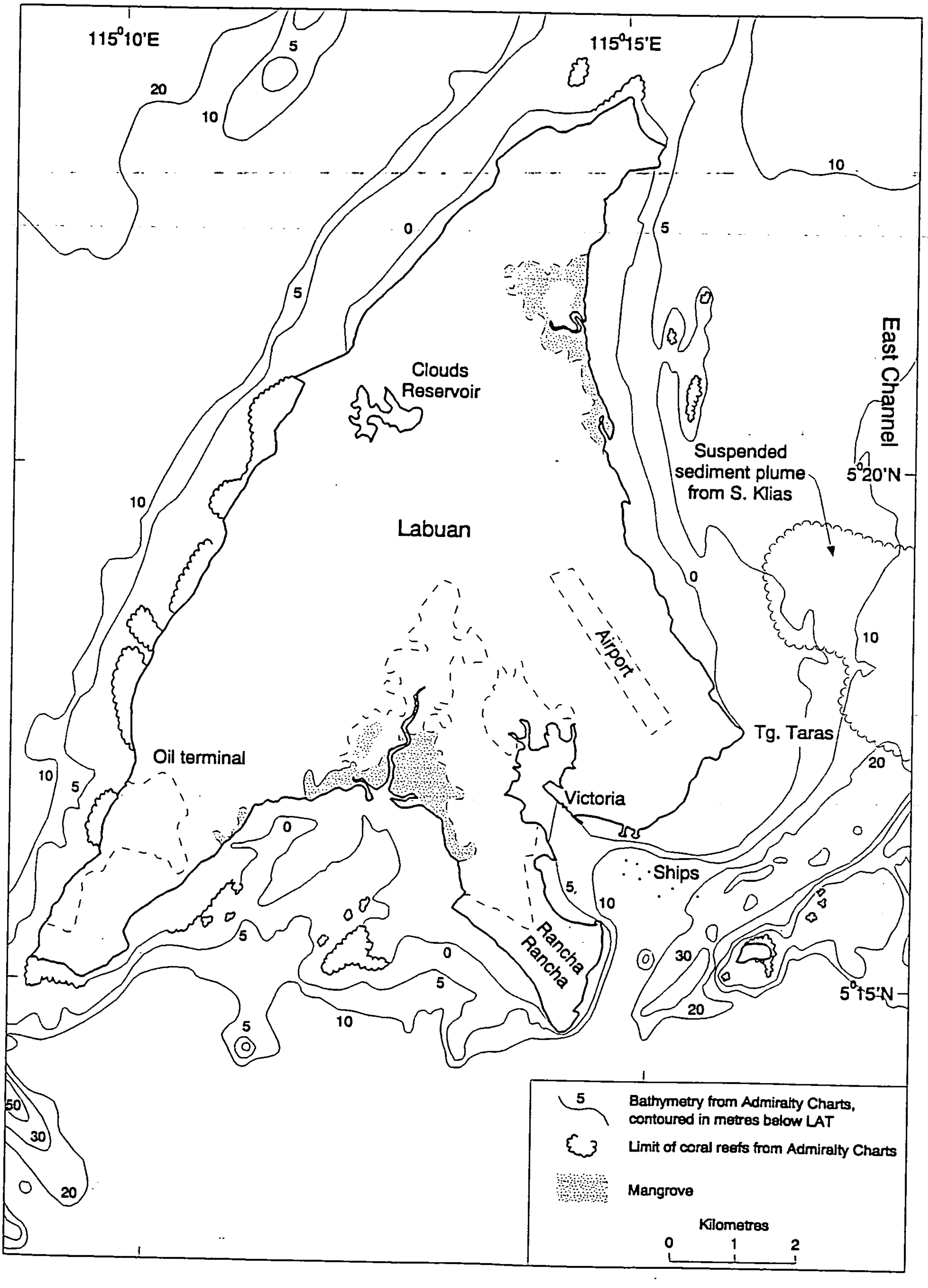


Figure 6 Interpretation of the Landsat scene covering Labuan and surrounding waters