TROPICAL AND TEMPERATE CARBONATE ENVIRONMENTS - THE EFFECTS OF SEA LEVEL, CLIMATE AND TECTONICS ON FACIES DEVELOPMENT

Joint BMR/TRC-JNOC Program

Phase 2

1992/93 - Southern Great Barrier Reef

Pre-Cruise Proposal

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EXECUTIVE SUMMARY

A joint BMR/JNOC cruise on R/V *Rig Seismic* will be conducted between 30 October and 2 December, 1992 to study the effects of sea level and climate on the facies development of the marginally tropical carbonates in the Capricorn Channel region of the southern Great Barrier Reef. The aim of the study is to develop models of carbonate deposition and facies development that can be applied to the interpretation of carbonate rocks in general. This is the second phase of a comprehensive study of both temperate and tropical carbonates, designed to compare and contrast these two systems whose basic, but profound, differences are largely related to climate and sea level. The first phase of the program was carried out on the continental margin of southern Queensland last year (Davies and Tsuji, 1992).

The second joint cruise will involve the collection of 1400 km of high-resolution multichannel seismic reflection data, 550 km of single-channel seismic reflection data, 360km of sidescan data, some 45 vibrocores and gravity cores on the shelf and upper slope, 22 camera stations, 5 dredge stations and 80 grab sample stations. A detailed seismic and sampling grid will be concentrated within the area of the reefs of the Capricorn and Bunker Groups and the outer shelf and upper slope to the east of the reefs.

The principal objectives of the cruise will be:

- to define the facies distribution of surface and subsurface sediments on the shelf and slope in the vicinity of the Capricorn-Bunker Group of reefs and the western part of the Capricorn Channel, including composition and fabric;

- to define the three dimensional facies geometry;

- to define the principal factors affecting facies distribution, particularly tectonics, hydroisostasy, subsidence, climate and sea level;
- to relate climate, sea level and facies to oceanographic variables along the margin;
- to model the climatic and sea level changes in relation to sediment composition and geometry;
- to relate sediment characters and causes to the understanding of ancient limestones.

INTRODUCTION

Carbonate sediments, through their dominantly biological composition are extremely sensitive indicators of the environment in which they have lived: sea level and climatic changes are faithfully recorded in the coral and algal skeletons which dominate the composition of the sediments deposited in such environments. In addition, such thick and widespread carbonate accumulations in many parts of the world have been shown to contain almost 50% of global oil and gas reserves. The continental margin of northeastern Australia, mantled by tropical and temperate carbonates, represents a modern analogue for many of these ancient carbonates, and can be seen as an essential exploration model, applicable to sedimentary basins both in Australia and many parts of the world. In addition, it is a prime focus for understanding the history and mechanisms of climate change in Australia over the past half million years.

The passive continental margin of northeast Australia extends for 2500 km from the tropics to temperate latitudes. It comprises the largest area of carbonate sediments deposited on a passive margin anywhere in the world, and includes both the Great Barrier Reef and the lesser known temperate carbonate buildups of southern Queensland and northern New South Wales. Its architecture has been primarily defined by Late Cretaceous rifting and it's sedimentary evolution owes much to the northward plate motion of Australia in the Cainozoic from temperate to tropical latitudes (Davies and others, 1987, 1989). The Great Barrier Reef represents the major feature on the margin, extending for 2000 km and comprised of 2500 individual reefs. It is widest in the central-south area around latitude 21_S where coral reefs and *Halimeda*-rich sediments dominate the outer shelf. Beyond 24_S the reefs and *Halimeda* packstones diminish, and the sediments on the shelf comprise red algal boundstones, bryozoan/foraminiferal grainstones and packstones, and rhodolith dominated buildups, bioclastic in nature and dominated by calcite rather than unstable aragonite. The facies and porosity/permeability attributes clearly reflect the change from tropical warm water to temperate cold water (Marshall and Davies, 1978; Davies and others, 1989). The reefs of the Capricorn-Bunker Group represent the southernmost limit of reef growth in the Great Barrier Reef, and are considered to be sensitive to climatic variations. Facies within these reefs, as well the surrounding sediments and the deeper water carbonates of the Capricorn Channel, should demonstrate a sensitive record of sea level and climatic change, that can be used to model these environmental changes and their effects on carbonate deposition.

PREVIOUS WORK

The main geological features of the notheast Australian region have been deduced from geological (Davies, 1977, 1983; Davies and Hopley, 1983; Day and others, 1974; Ellis, 1966; Marshall and Davies, 1978; Marshall, 1977, 1980) and geophysical studies (Davies and others, 1987, 1988, 1989; Symonds and others, 1983; Marshall, 1979; Nunn, 1982; and Searle, 1983) as shown in Figures 1 and 2. Plate tectonics, climate, subsidence, oceanography and sea level have all contributed significantly to the distribution of facies. With the exception of ODP Leg 133 further north, little attempt has been made previously to thoroughly understand the factors affecting the evolution of the northeast Australian margin or to use the record in the sediments as a library of past environmental change. Only Harris and others (1990) have attempted to relate sediment composition and distribution to causal mechanisms, although much of the ODP related research further north has provided the most important leap in understanding the relevance of the region to studies of climate change and passive margin evolution. The accumulating evidence (Marshall, 1983a; Davies and others, 1991) that parts of the Great Barrier Reef are less than one million years old and possibly as young as 500,000 years suggests that the environmental record it encapsulates is one with the highest known resolution anywhere in the world. This record has the potential to produce a definitive statement of natural global climate change and the mechanisms driving modern climate change. Further, the extreme youth of the system raises crucial scientific questions about its biological evolution and the dogmas assumed in this evolution, and provides a useful model for energy exploration elsewhere.

This proposal sets out a work program for the southern Great Barrier Reef, focussed on the Capricorn Channel and Capricorn-Bunker Group. It follows phase 1 of the joint BMR/TRC-JNOC study of tropical and temperate carbonates, which was conducted off Southern Queensland, between Fraser Island and Noosa Heads, during October/November last year.

Previous geological studies of the Capricorn Channel and Capricorn-Bunker Group have concentrated on the morphology (Maiklem, 1968; Marshall, 1972; Maxwell, 1968a); surficial sediment distribution (Conaghan, 1968; Belperio and Searle, 1988; Maiklem, 1966, 1967, 1970; Marshall, 1977; Marshall and Davies, 1975; Maxwell, 1968 a, b, 1969b, 1976; Maxwell and Maiklem, 1964; Maxwell and Swinchatt, 1970;

Palmieri, 1976); sea levels (Carter and Johnson, 1986; Maxwell, 1968a; Veeh and Veevers, 1970); reef top morphology and sediment distribution (Davies and West, 1981; Davies, Radke and Robison, 1976; Flood, 1976a, b, 1977 a, b; Flood and Orme, 1977; Hopley, 1982; Jell and Flood, 1978; Jell and others, 1965; Maiklem, 1968; Maxwell and others, 1961, 1963, 1964); Holocene reef facies, cementation, and evolution and growth (Davies, 1977, 1983; Davies and Hopley, 1983; Davies and Kinsey, 1977; Davies and Marshall, 1979, 1980; Davies and others, 1977a, b; Marshall, 1983 a, b; Marshall and Davies, 1981, 1982, 1984 a, b; Maxwell, 1962); shallow geological structure (Davies, 1974b, 1983; Davies and others, 1981; Ericson, 1976; Harvey and others, 1979; Marshall, 1977; Maxwell, 1969a; Richards and Hill, 1942; Searle and others 1977; Traves, 1960); and biostratigraphy (Hekel, 1973; Lloyd, 1967, 1977; Palmieri, 1971, 1974).

In addition, there has been regional aeromagnetic, gravity and seismic surveys carried out by government and exploration companies in the region (Affleck and Landau, 1965; Baxmann, 1971; Benbow, 1980; Bruce, 1964; Dooley, 1959; Gulf AOG, 1974; Hill and Pigram, 1990; Tiger, 1969; Wilson, 1967). Four wells have been drilled in the area. The Heron Island borehole was drilled in 1926 to a depth of 223 m (Richards and Hill, 1942), and penetrated 154 m of Quaternary reef material overlying Pliocene? shelf sediments. Wreck Island 1 well (Humber Barrier Reef Oils Ltd, 1960) was drilled to 575 m and confirmed the presence of Tertiary marine sediments above Mesozoic basement beneath the shelf. Capricorn 1A and Aquarius 1 were drilled in the Capricorn Channel and penetrated Tertiary marine sediments, mainly marls, overlying Mesozoic and Palaeozoic? basement respectively (Carlsen and Wilson, 1968 a, b; Ericson, 1976).

1992 STUDY AREA

The part of the northeast Australian continental margin that has been selected for the second phase of the joint BMR/TRC-JNOC program is shown in Figure 3. It includes the Capricorn-Bunker Group and Capricorn Channel. The reasons for the selection of this area are documented below.

Climate

The regional climate is subtropical, with distinct winter and summer seasons and wind patterns. Average annual temperatures and rainfall at Bundaberg and Rockhampton, southwest and west of Capricorn-Bunker Group are shown in Table 1.

Winds are predominantly from the southeast throughout the year (Fig. 4). The period August to December is consistently calmer than during the winter. The summer tendency is for infrequent very strong winds, whereas the winter winds are consistently strong. Cyclones superimpose their effects on the trade winds. They are clearly the cause of the strongest winds that affect the region.

Oceanography

The oceanic circulation system off eastern Australia is dominated by the East Australian Current (Church, 1987; Wyrtki, 1960, 1966), which is a strong narrow southerly flow that forms the western boundary current. The current sweeps over the continental shelf between 20_S and 25_S and then moves southwards (Fig. 5). Circulation is somewhat affected between the Swain Reefs and Fraser Island because of the large embayment of the Capricorn Channel, but the major part of the current flows southwards.

Surface circulation in the Capricorn Channel/Hervey Bay area has been studied by sea-surface drifters (Woodhead, 1970; Fig. 6). As the East Australian current moves southwards past the Swain Reefs it is partly deflected, and water moves into the Capricorn Channel where it forms a clockwise gyre immediately south of the Swain Reefs; another clockwise gyre is believed to form in Hervey Bay as a result of the deflection by Fraser Island.

The tides along the Queensland coast are predominantly semidiurnal (Fig. 7). There is a progressive increase in the tidal range towards Broad sound (Fig. 8), where the maximum is more than 10m. Because of the large tidal range, extensive areas of the reefs oscillate between subaerial and submarine, and tidal currents are strong over most of the region. In the inter-reefal channels, tidal current velocities of 100 cm/sec are common (Davies and Marshall, 1986).

As a result of the dominant southeasterly waves and swell, the overall direction of longshore drift along the coast is northwards.

Regional Geology

Geophysical Surveys (Dooley, 1959, 1965: Gulf AOG, 1965; Wilson, 1967; Ericson, 1976) have delineated areas of shallow basement along the axis of the Capricorn-Bunker Group and the Swain Reefs, and regions of deep basement beneath the Capricorn Channel and Hervey Bay. The areas of shallow basement relate to the

Bunker High and Swains High respectively, whereas the areas of deep basement relate to the Capricorn Basin and Maryborough Basin.

The Bunker High is a basement ridge that extends from the Capricorn Group to the northern tip of Fraser Island. It is considered to be a horst-like feature, some 300-600 m below sea level. Wreck Island 1 well (Humber Barrier Reef Oils Ltd, 1960) bottomed in what is considered to be Grahams Creek Formation (Lower Cretaceous) at a depth of 543 m. Aeromagnetic data (Gulf AOG, 1965) over the Swains High suggests that a magnetic basement occurs at about 1.5 km or less. Subsequent seismic refraction data indicates that basement may be as shallow as 600 m.

In the Capricorn Channel, both seismic and magnetic data have defined a basinal structure that is open to the southeast, confined by structural highs on either side, and which shallow to the northwest. Results from drilling in the basin have indicated a relatively thick Cenozoic sequence, overlying a Mesozoic-Palaeozoic basement (Fig. 9). Within the wells, the Palaeogene succession is predominantly non-marine, whereas the Neogene and Quaternary sequence was deposited in a shallow marine environment. Miocene carbonate rocks, which contain the large benthonic foraminifera *Lepidocyclina,* have been reported from wells, Aquarius 1, Capricorn 1A and Wreck Island 1. (Fig. 10). This particular foraminifera has been identified from dredge samples off Fraser Island during the previous cruise (Davies and Tsuji, 1992).

Morphology

The regional morphology of the area has been described previously by Maxwell (1968a) and Marshall (1972, 1977). The Capricorn Channel forms a broad embayment of the continental margin (Fig. 3), that is bounded to the northeast by the Swain Reefs and to the southwest by the Capricorn-Bunker Group. There is no definite shelf break in the Capricorn Channel, and the seafloor forms a broad plain that slopes gently to the southeast. This embayment of the continental margin is a surface manifestation of the underlying Capricorn Basin. Within the channel there is a small trough-like feature, extending along the 200 m isobath, and which is considered to be a eustatic feature (Marshall, 1977).

Seawards of the Capricorn-Bunker reefs, the shelf extends as a relatively shallow 55-65 m) platform before sloping down relatively steeply to the floor of the Capricorn Channel at 300 m (Fig. 3). This relatively steep slope marks the eastern edge of the

Bunker High, and is considered to be the expression of the western bounding fault of the Capricorn Basin (Fairbridge, 1950). However, shallow seismic data does not indicate a fault near the surface (Marshall, 1977).

The morphology of the reefs and cays of the Capricorn-Bunker Group has been described in detail by several workers (Davies and others, 1976; Domm, 1971 Flood, 1976a, b, 1977a, b; Fosberg and others, 1961; Jell and Flood, 1978; Maiklem, 1968; Maxwell 1968a). These reefs are not barrier reefs, such as occur to the north, but occur some 10-20 km from the edge of the shelf, and are more like the mid-shelf platform reefs to the north. The reefs themselves have fairly well defined zones, extending from a generally steep windward slope, algal rim, reef flat and sand flat; a lagoon (if present); a leeward reef flat, often with a cay, and a relatively gentle reef slope.

To the north of the Capricorn reefs there are a series of reefal shoals whose tops are fairly shallow, but which progressively deepen to the north. These features appear to be either drowned reefs or reefs that are only now catching up to sea level. East of the reefs there are several reefal banks, but near the shelf edge there appears to be the remnants of a previous carbonate platform. The upper part of the slope is indented with small terraces and nick points, the most prominent of which occurs at about 160 m. A sample of shallow water coral from 175 m was dated from between 13 600 to 17 000 years B.P. (Veeh and Veevers, 1970).

Facies Distribution

The distribution of samples previously collected in the area is shown in Figure 11, and the grainsize and calcium carbonate content are shown on the large format maps and the sediment distribution map in Marshall (1977). The sediments are very diverse, and up to nine lithofacies have been identified by Marshall (1977). Texturally, the sediments range from gravels to silty clay. Sand- and gravel-size components dominate the shelf, whereas fine-grained sediments occupy the Capricorn Channel. The relatively coarse sediments on the shelf consist of both modern and relict types, some of which have been redistributed, either by modern processes, such as currents, or by the post glacial transgression (e.g. Maxwell, 1968b). Most of the gravel is concentrated around the reefs and reefal banks, where it consists mainly of coral, coralline algae and molluscan detritus. In the Capricorn Channel, sediments range from silty sands to silty clays. A narrow zone of relict clayey silt to silty clay stretches across the channel in the vicinity of the 200-m trough (Marshall, 1977). Along the axis of the channel a zone of clayey silt is bounded by the 80 m isobath, whereas beyond 200 m a sand-silt-clay sedimentary regime is apparent.

The carbonate content of the sediments is highly variable, ranging from 2-100 percent. Highest values naturally occur around the reefs and banks. However, in the southern part of the reefs, there is a steep gradient in carbonate values to the west of the reefs, with values diminishing from 95 to 27 percent in less than 20 km (Marshall, 1977). Areas of moderately high carbonate (60-90%) cover a large part of the outer shelf and the Capricorn Channel, whereas there are only intermediate to moderately low values in areas of relict sediments such as the 200-m trough.

An interesting feature of the shelf sediments is that the majority of larger foraminifera, in particular *Marginopora vertebralis* and *Alveolinella quoyi*, are stained black or brown (Maiklem, 1967). In places these stained foraminifera constitute up to 20 percent of the sediment, giving it a speckled appearance. The staining is considered to be a result of the precipitation of iron monosulphides under the influence of sulphate-reducing bacteria (Marshall, 1977). Other features include relict Mg-calcite ooids (Marshall and Davies, 1975) in depths of 100-120 m, and an area of relatively high glauconite formation in an environment that is predominantly pelagic carbonate .

Seismic Interpretation

The following seismic data has previously been collected in the proposed study area:

BMR continental margin data collected in the early 1970s.

BMR shelf mapping sparker data also collected in the early 1970s.

Gulf and Shell seismic reflection and refraction lines collected in the mid 1960s.

A close grid of seismic reflection lines shot by Gulf in the Capricorn Channel in the mid to late 1960s.

BMR multichannel airgun array reflection data (Cruise 91) shot in 1990.

The position of previously collected seismic data is shown in Figure 12. Although the early data is of poor quality and emphasis on penetration over resolution makes most of the data of minimal use to the present study, the BMR continental margin survey lines from this area commonly show what appear to be topographic highs in the subsurface (Fig. 13). To the north of Fraser Island these highs are interpreted by us as being either Tertiary volcanics, basement highs or Tertiary carbonate platforms (Fig. 14). Further north, but to the south of the Swain Reefs, other highs have been interpreted by us as being either basement highs or Tertiary carbonate platforms (Fig. 15). In the latter case, it is possible that they represent an extension of the Miocene platforms that have been discovered beneath the Marion Plateau (Davies and others, 1989). However, at this stage it is impossible to definitely ascribe a particular origin to any of these highs.

Within the Capricorn Basin, at least four prominent unconformities, designated as S_1 to S_4 (Marshall, 1977) have been identified within the Tertiary and Quaternary section. The lowermost unconformity, S_4, represents the transition from non-marine to marine sediments at the base of the Miocene. S_3 occurs on the slope of the Bunker High as an erosional unconformity, usually above 550 msecs, whereas towards the centre of the basin it becomes more conformable with the over- and under-lying sedimentary strata. The tentative age of S_3 is early Middle Miocene. Two, fairly planar horizons, S_1 and S_2, occur higher in the section, but their age and origin is relatively unknown.

Both seismic and well data indicate that the Capricorn Basin began to subside during the Late Cretaceous, possibly in response to the opening of the Tasman Basin. Folding of Mesozoic rocks in the adjacent Maryborough Basin took place around about the middle of the Late Cretaceous, as a result of reactivation of earlier structures. The Capricorn Basin, Bunker High and Swains High all appear to have been established by the end of the Cretaceous. Geohistory analysis of the Capricorn 1A and Aquarius 1 wells, both of which show a similar subsidence pattern, indicates a slow subsidence phase up to mid Oligocene time (30 Myr), followed by an increased subsidence phase until the mid Miocene (11 Myr). Decreased subsidence, followed by a presumed, but little understood uplift during the Late Miocene and Early Pliocene, was succeeded by an unusually high rate of subsidence from the Middle Pliocene to the present (Davies and others, 1989). On this basis, the S4 unconformity could be indicative of the increased subsidence phase, when marine conditions were initiated.

STUDY TRANSECTS

That part of the margin shown in Figure 16 has been chosen for detailed study on the following basis:

1. The distribution of carbonate sediments.

2. The expected distribution of various types of carbonate sedimentary facies in relation to oceanographic conditions, water depth, bathymetry, sea level changes, etc.
3. Sedimentation rates, particularly in relation to the range of ages that can be sampled by coring on the outer shelf and upper slope.
4. The expected development of Tertiary carbonate platforms.

The study area has, in turn, been divided into three sub-areas based on their bathymetric, structural and sedimentological features. The distinctive characteristics of each of the three areas are defined below:

Bunker Group Area

- This is the southern limit of reef development off eastern Australia.
- This area incorporates the major elements of the margin in the Capricorn region; including a shelf with a series of north westerly trending reefs situated on the outer shelf, a short, steep slope at the edge of the shelf, and a basin-like upper slope.
- Terrigenous sediments are distributed on the inner shelf and carbonate sediments on the outer shelf and beyond, but there is an extremely steep gradient between the two.
- Grainsize distribution patterns show the reverse pattern to normal shelf equilibrium condition; i.e. a textural gradient from fine sediment on the inner shelf to coarse sediment on the outer shelf (mainly as a function of the carbonate component).
- In the mid-shelf area, black stained foraminiferal tests have been reported (e.g. Maiklem, 1967).
- The tropical biological association, dominated by corals, is developed on middle to outer shelf.
- Planktonic foraminifera dominate the fine sedimentary facies on the basinal slope, deeper than 200m.
- Development of a predicted Tertiary carbonate platform north of Fraser Island.
- The influence of inter-reefal currents on depositional patterns.

This area is important for understanding the following:
1. the development of marginally tropical carbonate platforms, and their sensitivity to climatic change
2. the variability of carbonate sedimentary facies in relation to depositional environment and latitudinal change
3. the development of a carbonate platforms with respect to their interaction between terrigenous and carbonate sediments
4. the hydrocarbon source potential of inner shelf fine sediments and basinal fine sediments

5. the development of Tertiary carbonate platforms and associated sedimentary units
6. climatic fluctuation and sea level change in the Quaternary

Capricorn Channel Area

- The area occupies the central part of the relatively low energy Capricorn Channel.
- The topography from shallow to deep changes gradually, and is an excellent example of a carbonate ramp.
- Sediments are dominated by fine-grained carbonates with a high proportion of planktonic foraminifera.
- Relict sediments, consisting of ooids and bryozoans, are distributed along the 100-120 and 140-160 m contours respectively.
- A distinctive trough-like feature is developed along the 200m contour, that could be related to a low sea level event of unknown age.
- Glauconite, indicative of low sedimentation rates, is distributed between the 100 to 200m contours.
- Mound-like reflections, suggesting the development of Tertiary carbonate platforms, are observed in the subsurface.

This area is important for understanding the following:
1. the reservoir potential of lowstand carbonate sediments
2. the development of Tertiary carbonate platforms and associated sedimentary units in relation to those of the Marion Plateau
3. climatic fluctuation and sea level change in the Quaternary
4. source rock potential of basinal fine carbonates

Moresby Bank Area

- This area is the northern extension of the Capricorn-Bunker Group.
- Banks, shallower than 20m deep, are developed.
- Corals are flourishing on the top of the banks.
- The banks encroach an area of relict quartzose sand waves.

This area is important for understanding the following:
1. processes of reef development; catch-up vs drowned reefs
2. the relationship between the bank carbonates and relict quartzose sand as a function of high and low sea level processes.

Survey Tracks and Sampling Locations

The proposed location of multichannel seismic, single-channel seismic and sidescan sonar lines are shown in Figures 16, 17, and 18 respectively. At present, the program is designed with minimal down time for weather or equipment failure. Because of the requirement to tow both source and streamer at very shallow depths (1-3 m) for multichannel seismic profiling, we might expect some down time due to bad weather conditions. However, both wind and swell at this time of year in the Capricorn Channel are relatively minimal. If there is loss of time, we intend to shorten the lines behind the reefs in the Bunker Group Area, and, if necessary, in the Moresby Bank area. With the boomer and sidescan, we intend to be flexible with respect to the schedule outlined, and try to cover those areas where we achieve best results.

We expect to encounter an extension of the Tertiary carbonate platforms, which from multichannel seismic data appear to extend north from Fraser Island and south of the Marion Plateau. The sidescan sonar survey is intended to provide us images of features, such as ripples, dunes, outcrops or troughs, which may have some relationship to the oceanographic environment, both present and past, and sea level changes. It is intended that the single channel, high resolution seismic will provide information on the three dimensional relationship between facies and sedimentary structures within the shallow sedimentary sequence.

The location of grab, dredge and coring sites is shown in Figure 19. The locations are indicative at this stage, and could be changed if more significant locations present themselves on board ship after studying the results of the seismic and sidescan surveys. ROV and camera stations will be proposed on board ship based on the sediment sampling and sidescan results.

WORK PROGRAM - 1992/93

1. Pre-Cruise Program
- Scientific data analysis:
- Compile and prepare bathymetric base maps.
- Collect and synthesise all geophysical data. Prepare maps showing distribution in each transect area, the development of the Quaternary section and specific seismic geometries as a basis for defining seismic acquisition strategies.

- Collect and synthesise all geological and geochemical data and prepare maps of grain size, carbonate and facies variations. Hypothesise on the principal factors affecting facies distribution. Define a sampling strategy.
- Conduct a literature survey of all previous work (a) in the study area and (b) related studies elsewhere.

-Preparations for Cruise
- Maintenance and testing of the following equipment items - seismic acquisition systems (waterguns and boomer), sidescan-sonar, underwater camera, vibrocorers, and piston corers.
- Purchase consumables.
- Organise the in-port readiness of RV Rig Seismic.
- Organise the transfer of resources from Canberra to Sydney.
- Prepare and maintain necessary onshore navigation facilities.
- Liaise with all relevant State and Federal organisations. In particular, obtain permission from the GBRMPA for conducting research in the Capricorn Section of the Marine Park.

2. Rig Seismic Cruise - 30 October and 2 December, 1992 (Figure 20; Table 2)
It is intended to collect the following data:
- 1400 km of high resolution multichannel watergun data
- 550 km of single channel seismic reflection data
- 360 km of sidescan data
- 45 vibrocores and gravity cores
- 80 grab samples
- 20 sea bottom photo stations
- 5 dredge stations
- 3 days ROV work

On board work will involve:
- preliminary interpretation of seismic and sidescan monitor sections
- preparation/photography of cores
- core/grab/dredge description
- maintenance and curation of cores
- processing of underwater photographs
- preparation of track charts.

The principal objectives of this cruise will be:

- to define the facies distribution of surface and subsurface sediments on the shelf and slope in the vicinity of the Capricorn-Bunker Group of reefs and the western part of the Capricorn Channel, in including composition and fabric;

- to define the three dimensional facies geometry;

- to define the principal factors affecting facies distribution, particularly tectonics, hydroisostasy, subsidence, climate and sea level;

- to relate climate, sea level and facies to oceanographic variables along the margin;

- to model the climatic and sea level changes in relation to sediment composition and geometry;

- to relate sediment characters and causes to the understanding of ancient limestones.

3. Post Cruise program

The major components of the work program are:

- seismic data processing and interpretation
- navigation data processing
- sediment data processing including sampling, description and analysis of cores
- preparation of post-cruise report
- preparation for oceanographic phase of current meter deployment
- preparation for third cruise scheduled for October/November 1993

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This list contains a broad spectrum of references that are relevant to the region to be covered by all three cruises and to the type of study. Specific references cited in the text are marked with an asterisk.

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EQUIPMENT LIST

Geophysical and Geological Equipment

Fjord Instruments seismic receiving array: for this survey configured as 6.25 m group lengths with 96 channels and 600 m active streamer length.

Syntron RCL-3 cable levellers; individual remote control and depth readout.

Seismic Systems S-15 and S-80 high resolution water guns.

Air compressor system: 6 x A-300 Price compressors, each providing 300 scfm at 2000 psi (62 litres/min at 14 MPa).

Digital seismic acquisition system designed and built by BMR: up to 320 data channels, special 16 bit floating point, SEG-Y output at 6250 bpi.

Raytheon echo sounders: 3.5 kHz (2 kW), 16 transducer sub-bottom profiler and 12 kHz (2 kW) bathymetric system.

Geometrics G801/803 magnetometer/gradiometer.

Bodenseewerk Geosystem KSS-31 marine gravity meter.

EG&G model 990 sidescan sonar with 1000 m coaxial cable.

EG&G Uniboom sub-tow single channel boomer.

Australian Winch and Haulage deepsea winch with 10 000 m of 18 mm wire rope, and hydrographic winch with 4000 m of 6 mm wire rope.

15 metre A-frame with 12.5 ton load capacity.

Submersible Services (Aust.) vibrocorer; 6 m x 75 mm.

Gravity/piston coring system; <15 m x 75 mm.

Chain bag rock dredges.

20 litre capacity van Veen grabs.

Navigation Equipment

Magnavox T-Set Global Positioning System navigator.

Racal Differential GPS system.

Magnavox MX 1107RS and MX 1142 transit satellite receivers.

Magnavox MX 610D dual axis sonar doppler.

Sperry and Arma Brown gyro-compasses, plus Ben paddle log.

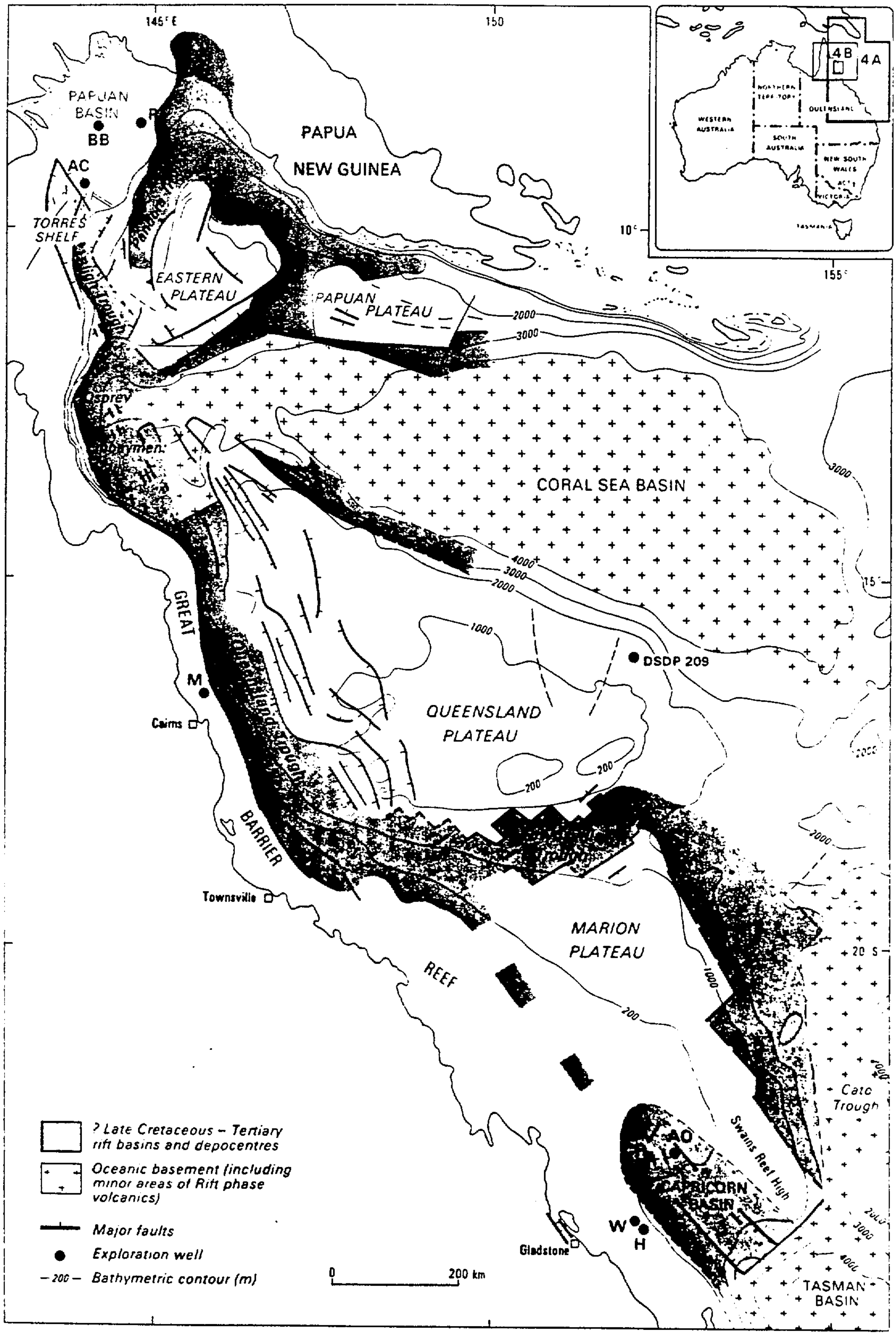

Figure 1. Map showing the major structural features of northeast Australia (after Davies and others, 1988).

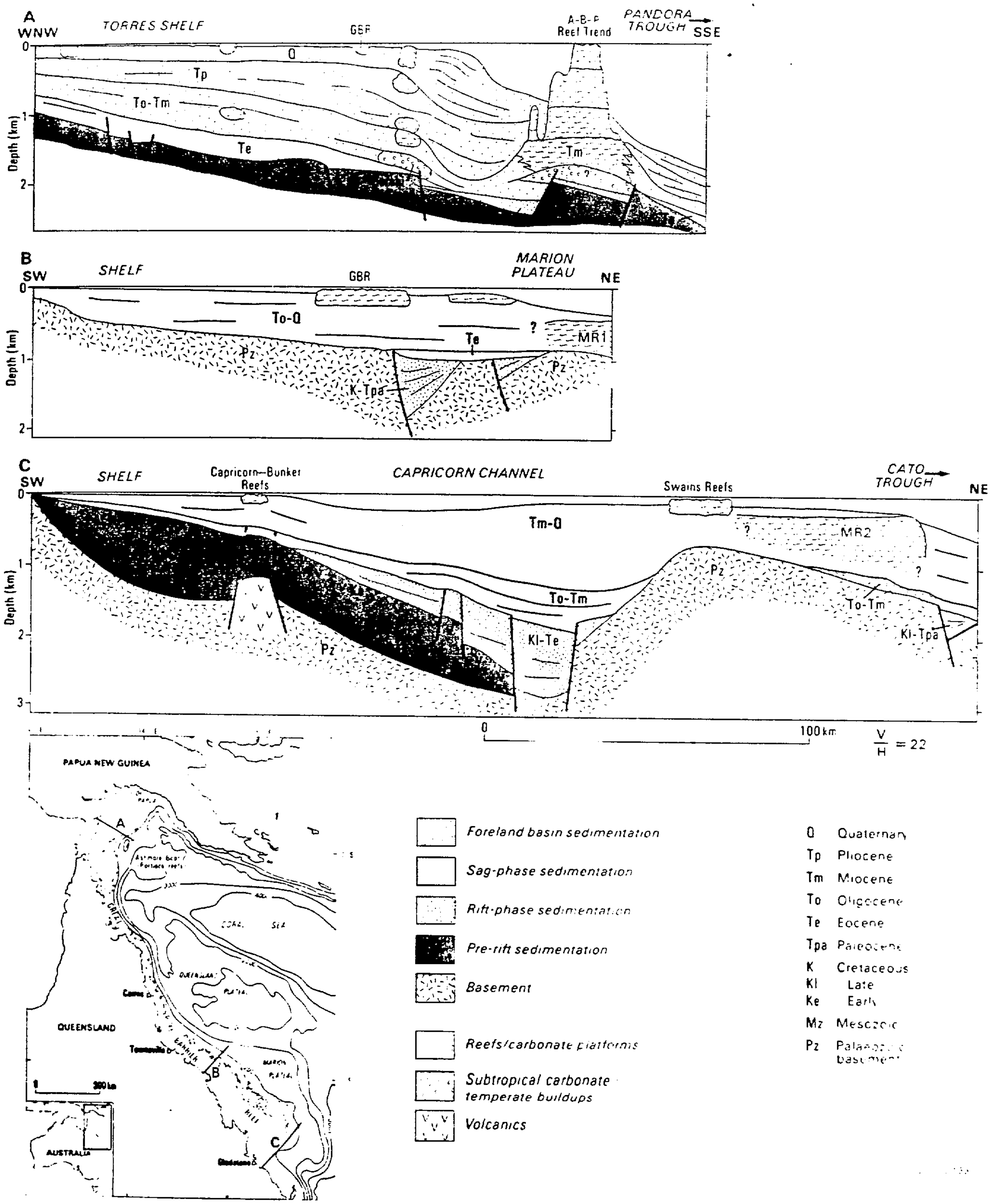

Figure 2. Schematic sections showing the structure and sedimentary geometry beneath the Great Barrier Reef Province (after Davies and others, 1989).

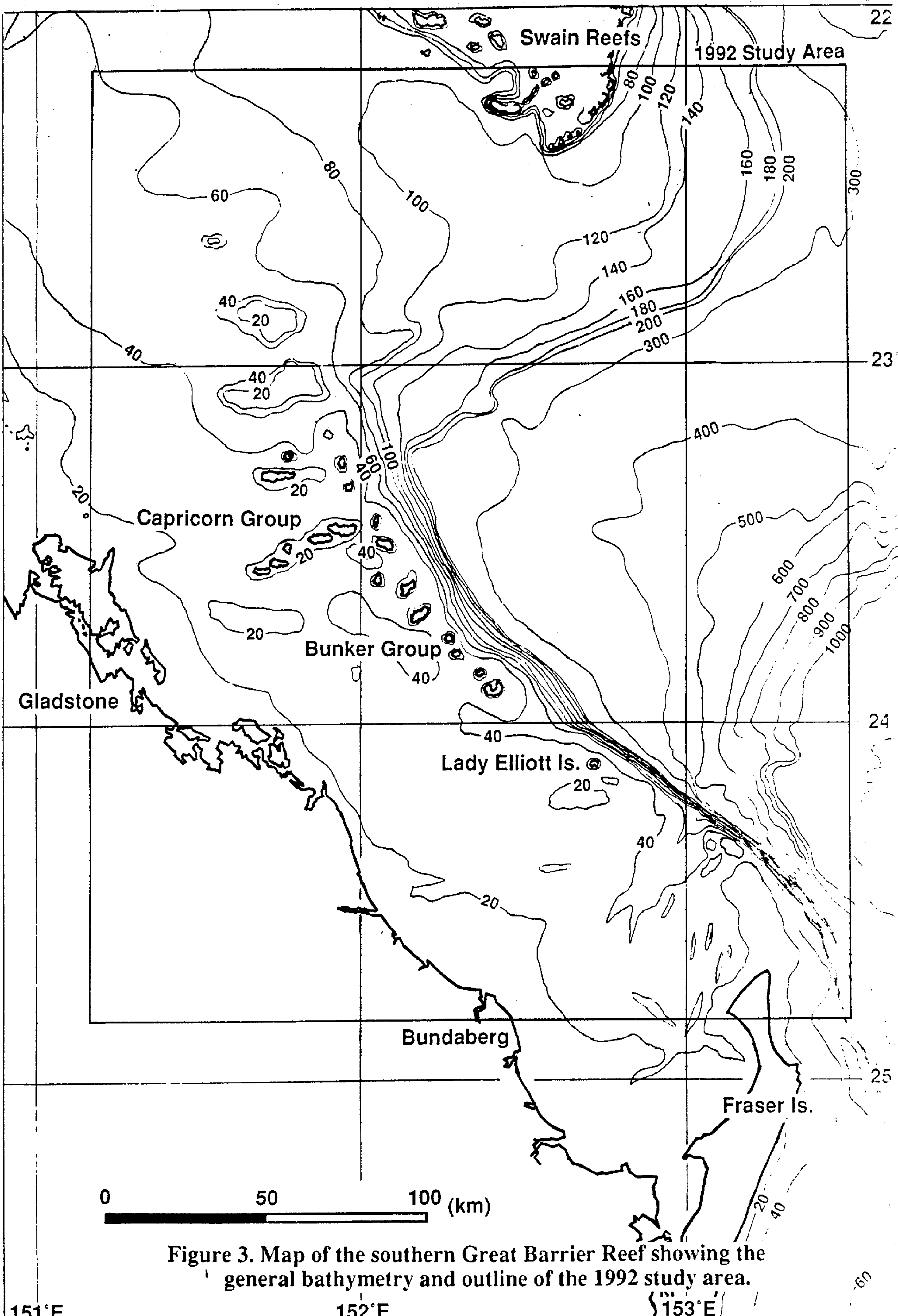

Figure 3. Map of the southern Great Barrier Reef showing the general bathymetry and outline of the 1992 study area.

Month	Bundaberg Average Daily Maximum (°C)	Bundaberg Average Daily Minimum (°C)	Bundaberg Average Rainfall (mm)	Rockhampton Average Daily Maximum (°C)	Rockhampton Average Daily Minimum (°C)	Rockhampton Average Rainfall (mm)
January	30.3	21.1	216	32.5	22.6	170
February	30.1	21.0	163	31.8	22.5	185
March	29.3	19.7	121	30.9	21.2	90
April	27.5	16.9	90	29.2	18.4	67
May	24.9	13.3	55	26.5	14.7	32
June	22.6	11.1	72	23.7	12.3	71
July	22.2	9.6	39	23.4	10.7	45
August	23.2	10.1	27	25.0	11.7	21
September	25.3	12.9	26	27.8	14.7	24
October	27.0	16.1	57	30.2	17.8	51
November	28.7	18.6	73	31.6	20.2	67
December	29.7	20.5	137	32.5	21.8	126

* Figures are based on readings taken over 30 years (Bureau of Meteorology, 1956).

Table 1. Average temperature and rainfall: Bunderburg and Rockhampton.

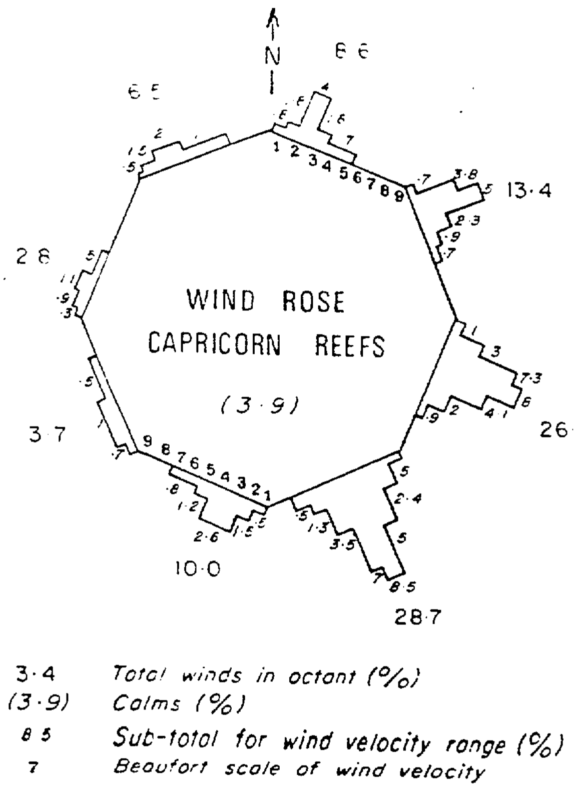

Figure 4. Wind rose diagram for the Capricorn-Bunker Group as shown by wind data collected for Heron Island (after Davies and Marshall, 1986).

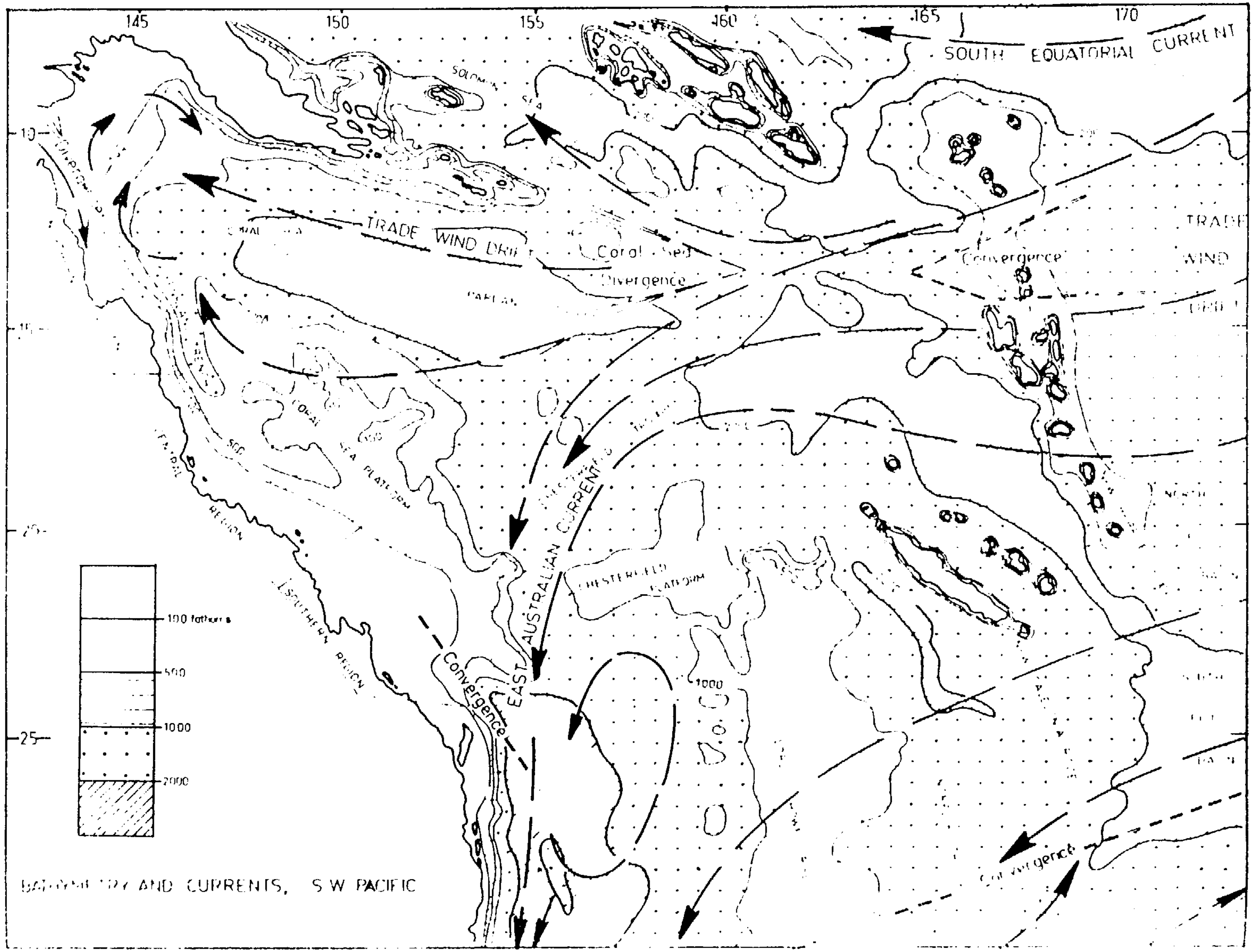

Figure 5. Bathymetry and oceanic circulation in the southwest Pacific Ocean (after Maxwell, 1969).

Figure 6. Surface water circulation pattern deduced from drifters (after Woodhead, 1970).

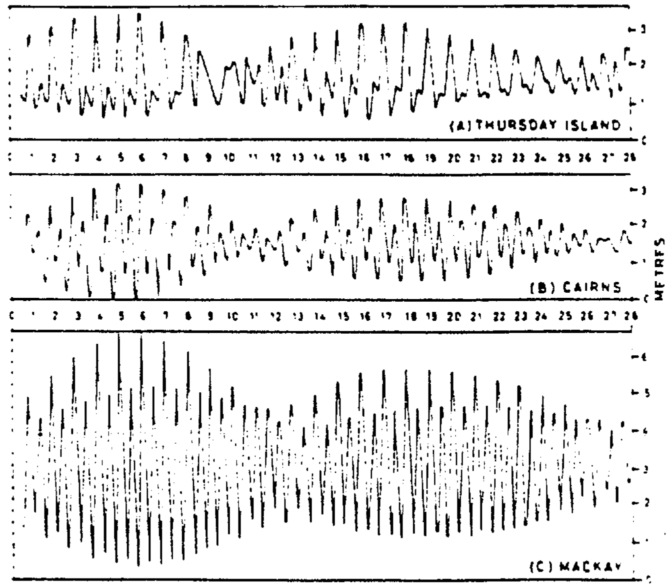

Figure 7. Tidal curves for Thursday Island, Cairns and Mackay (after Maxwell, 1968).

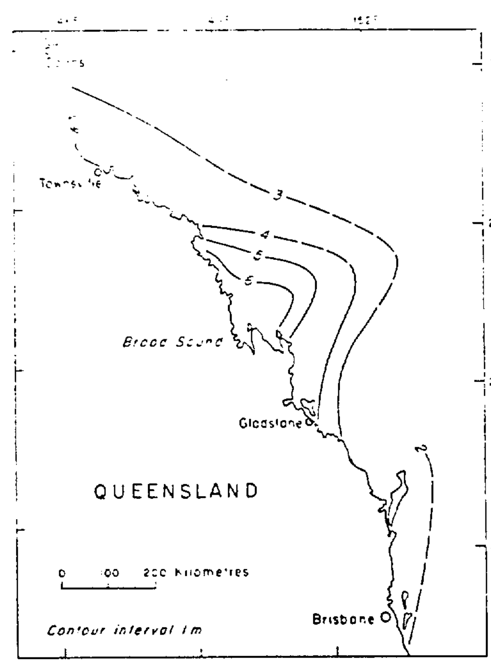

Figure 8. Variations in tidal range (m), central Queensland (after Maxwell, 1968).

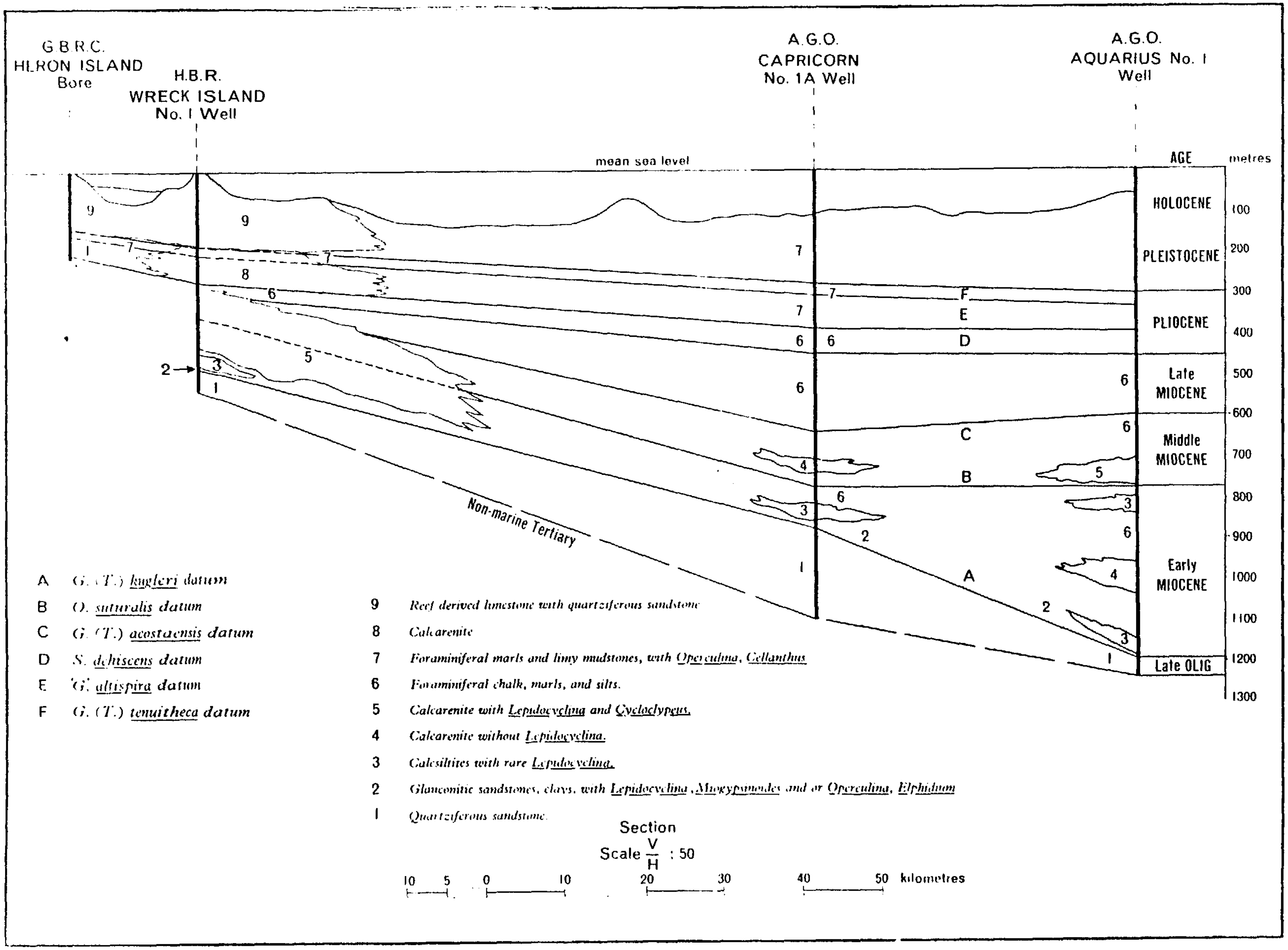

Figure 10. Biostratigraphic and sedimentary facies correlation of wells in the Capricorn Basin (after Palmieri, 1974).

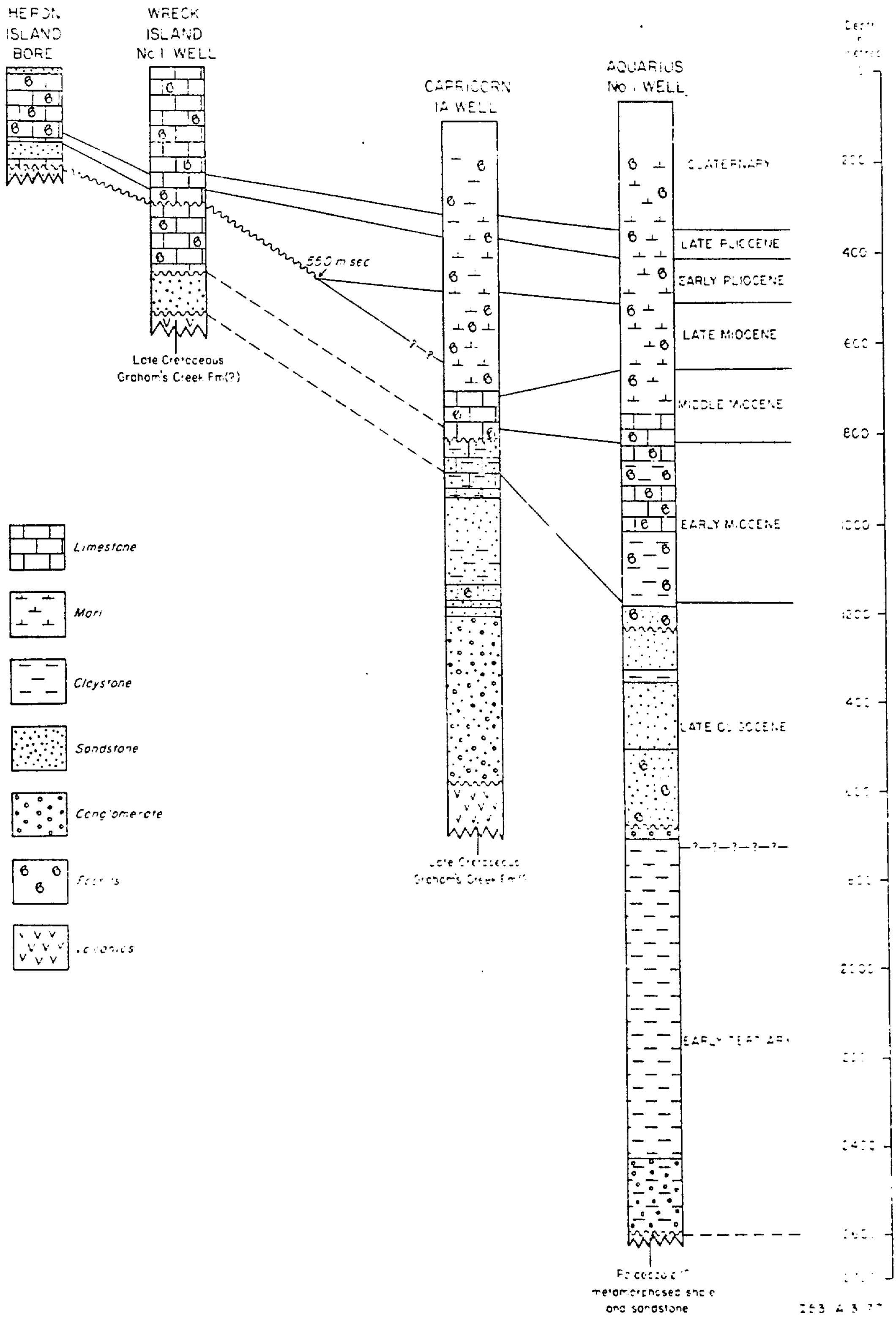

Figure 9. Stratigraphic correlation of wells in the Capricorn Basin
(after Marshall, 1977).

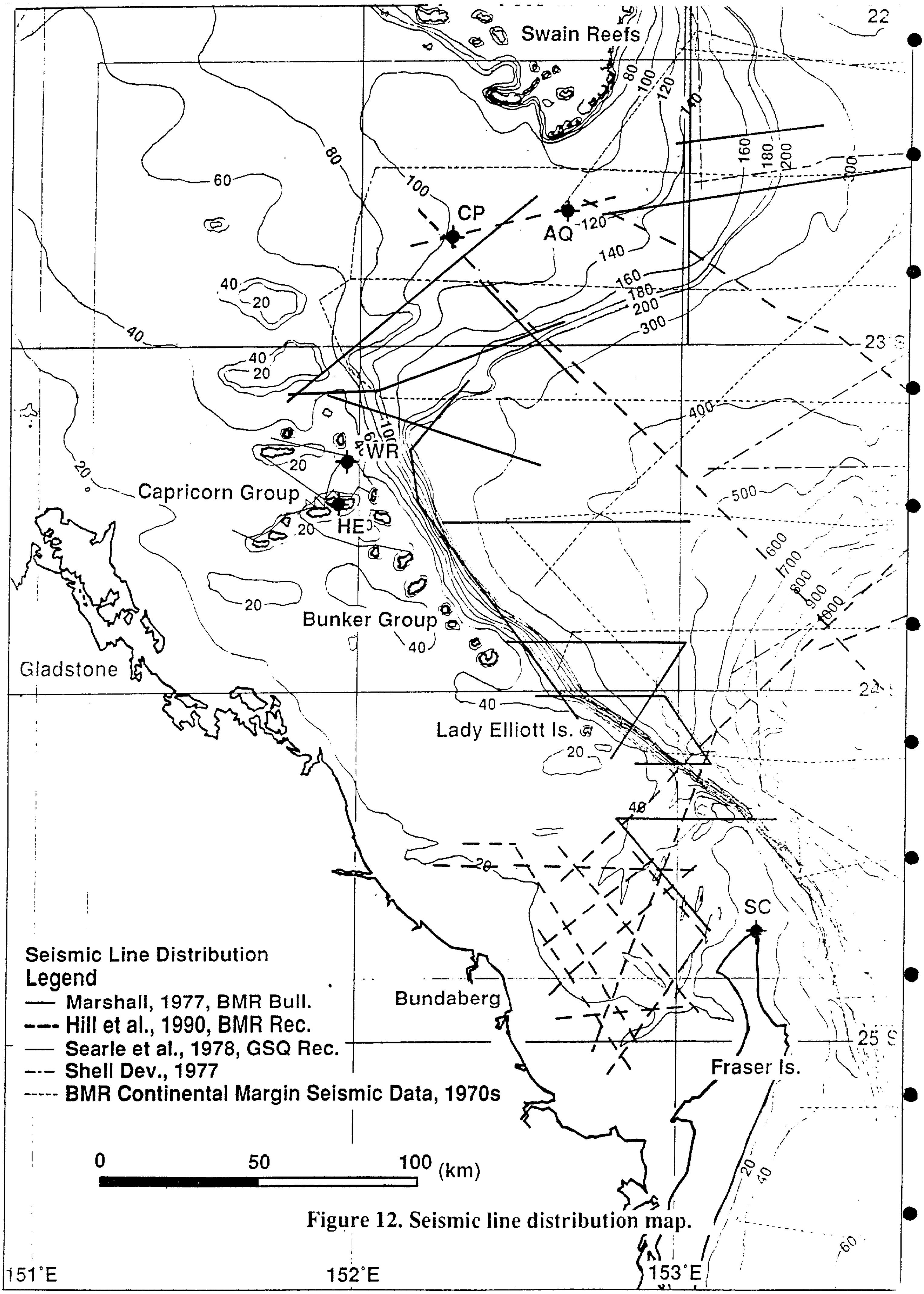

Figure 12. Seismic line distribution map.

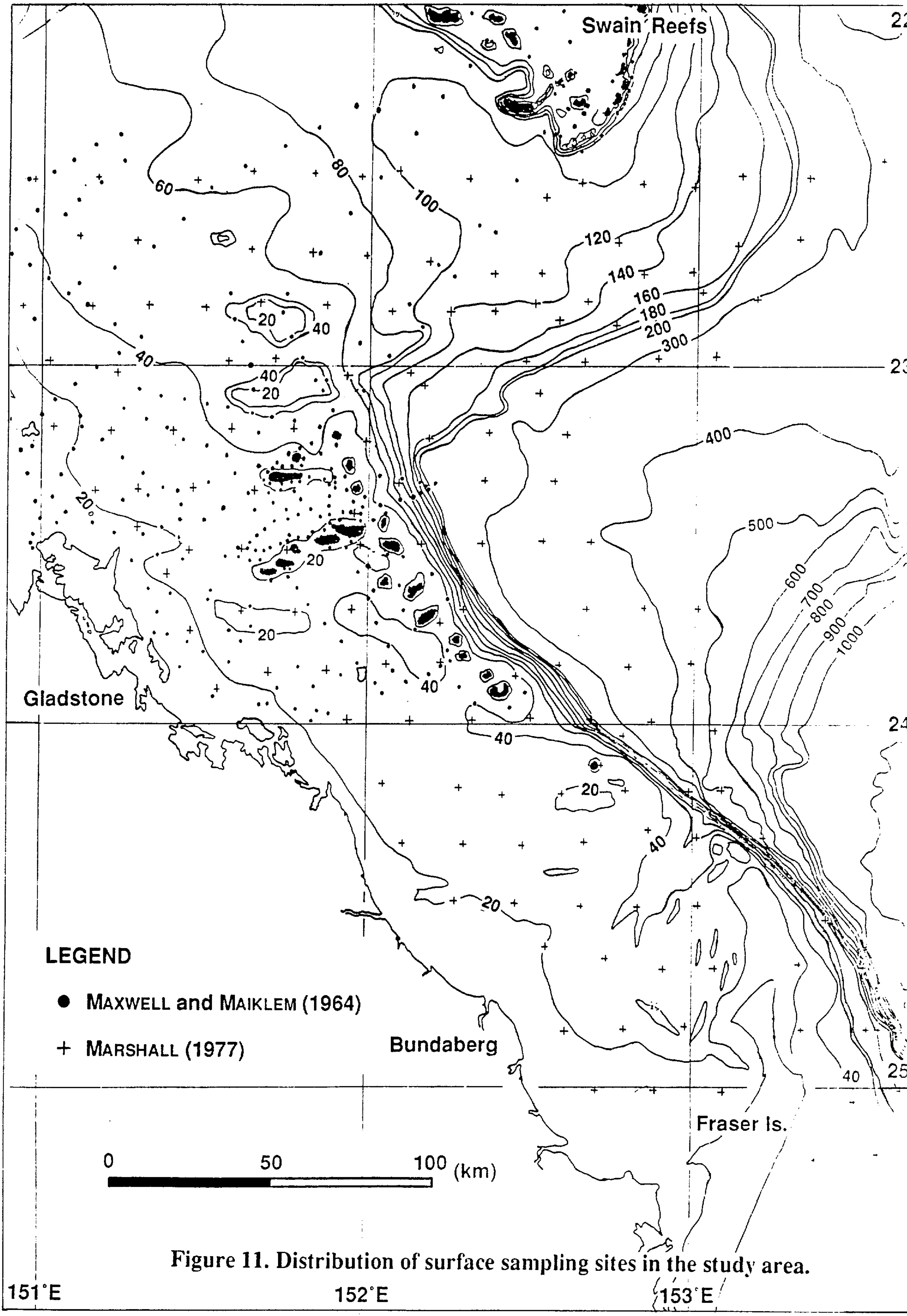

Figure 11. Distribution of surface sampling sites in the study area.

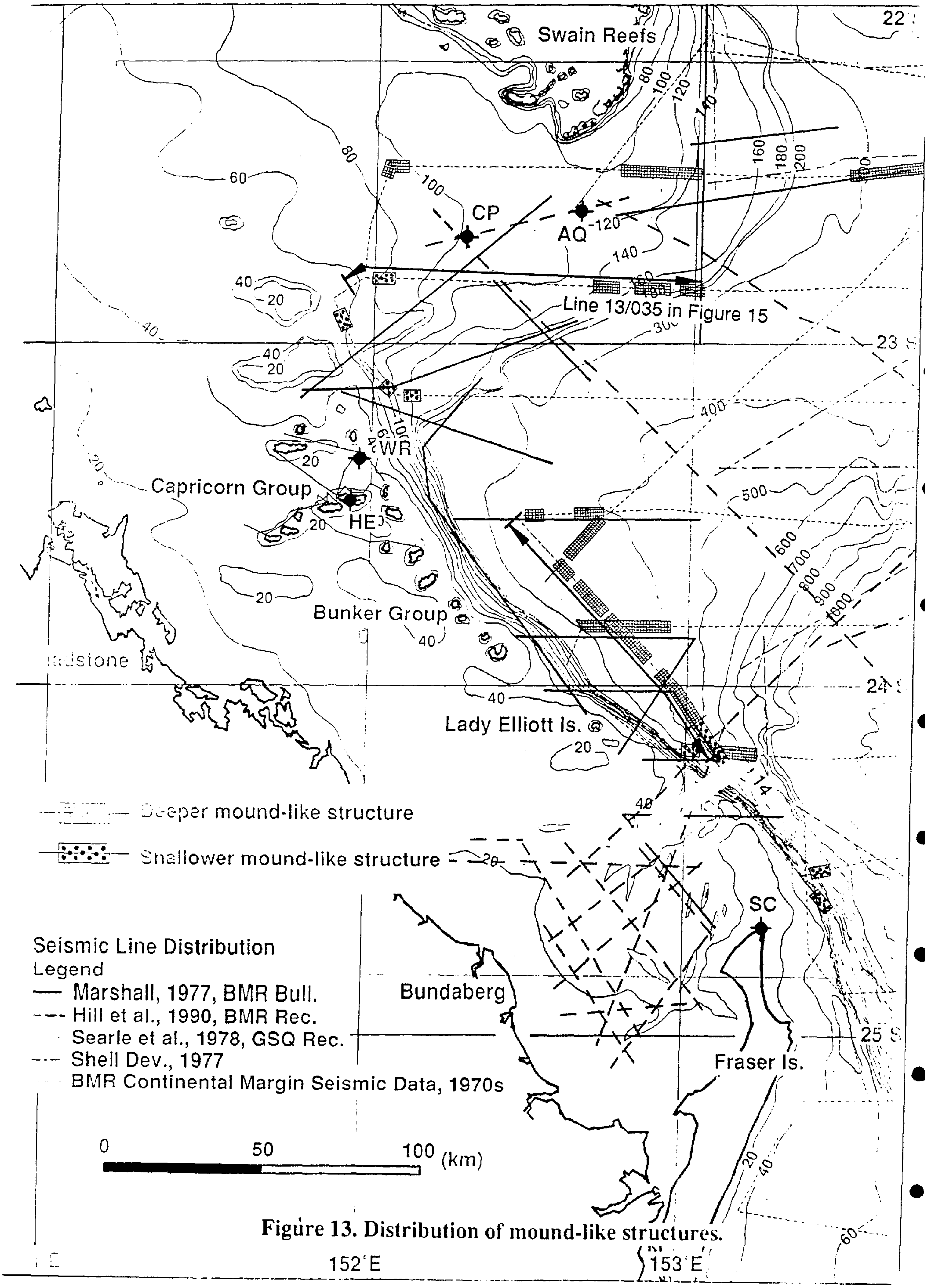

Figure 13. Distribution of mound-like structures.

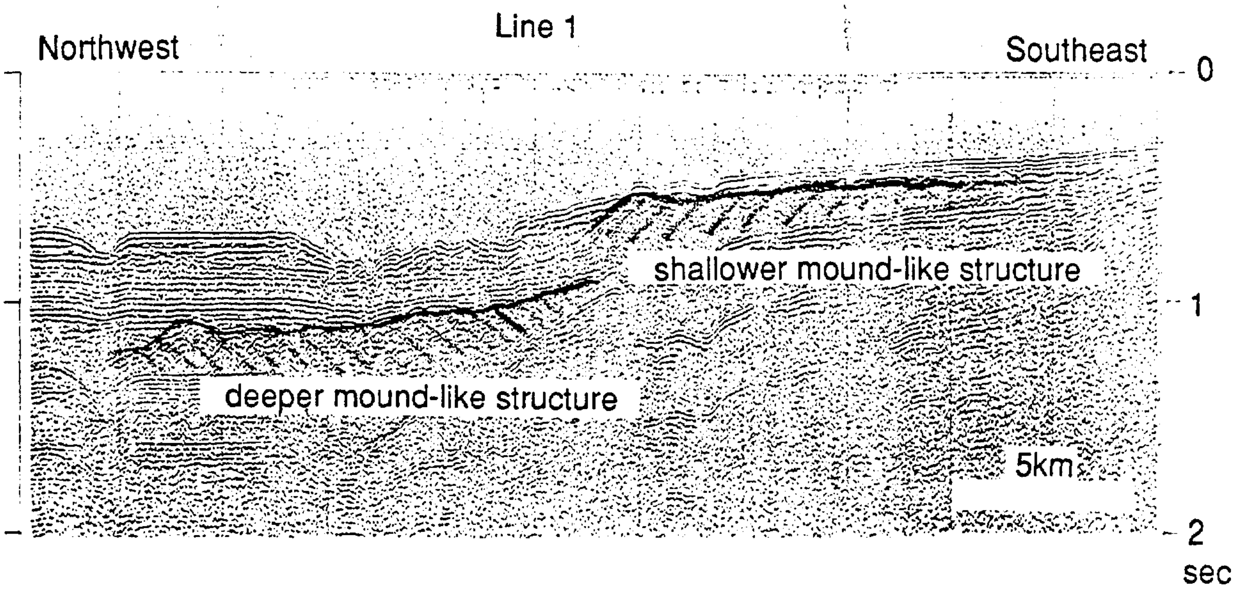

Figure 14. Seismic section showing deeper mounded structures in the subsurface north of Fraser Island.

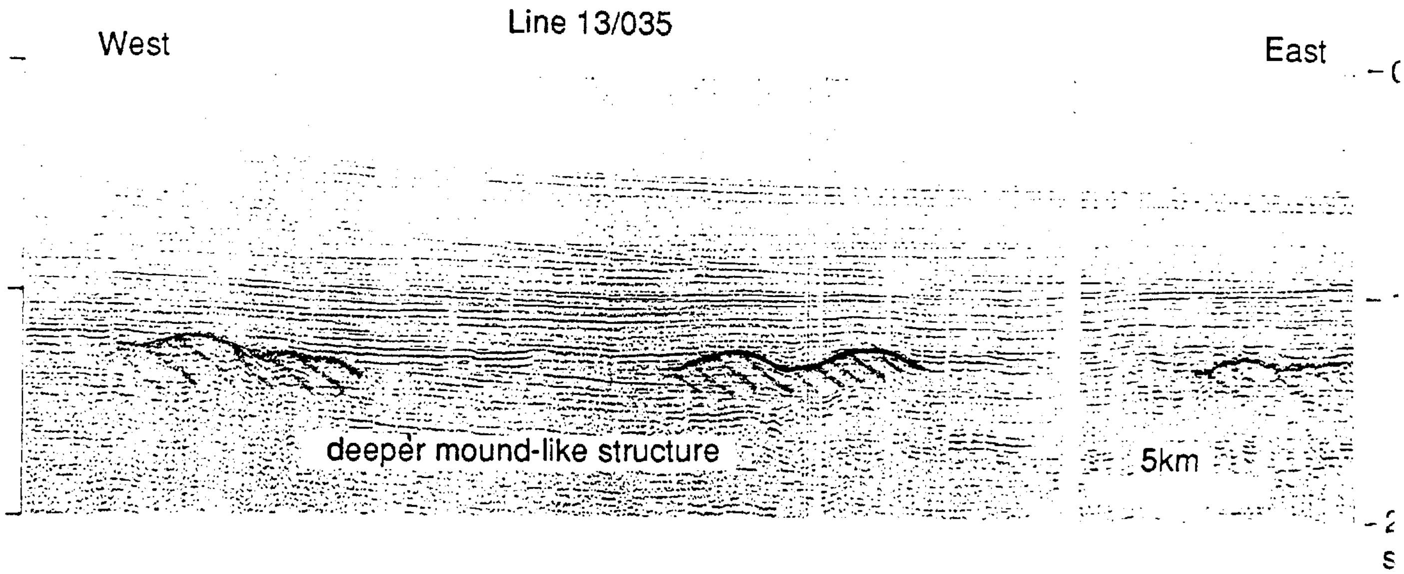

Figure 15. Seismic section showing mounded structures south of the Swain Reefs.

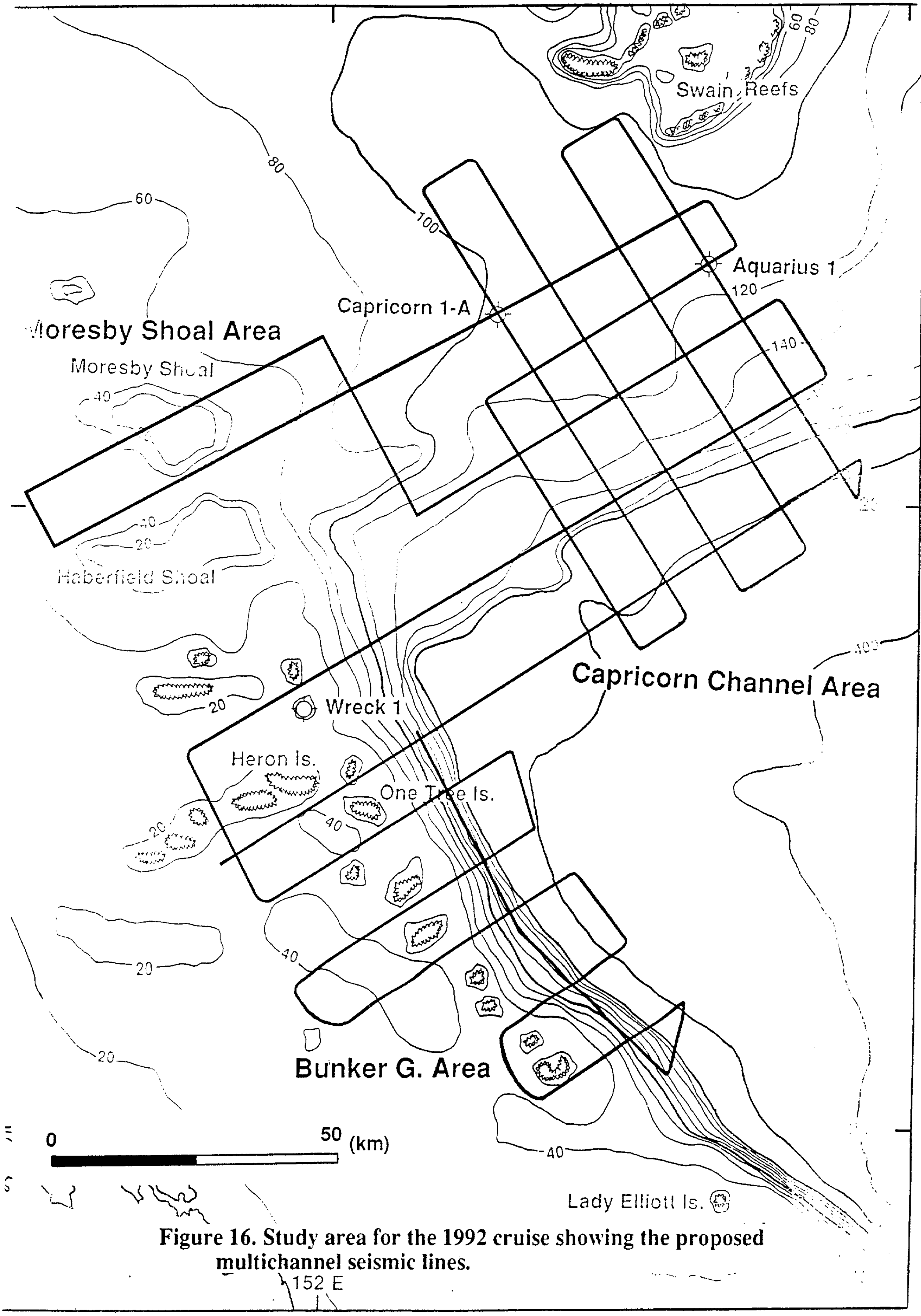

Figure 16. Study area for the 1992 cruise showing the proposed multichannel seismic lines.

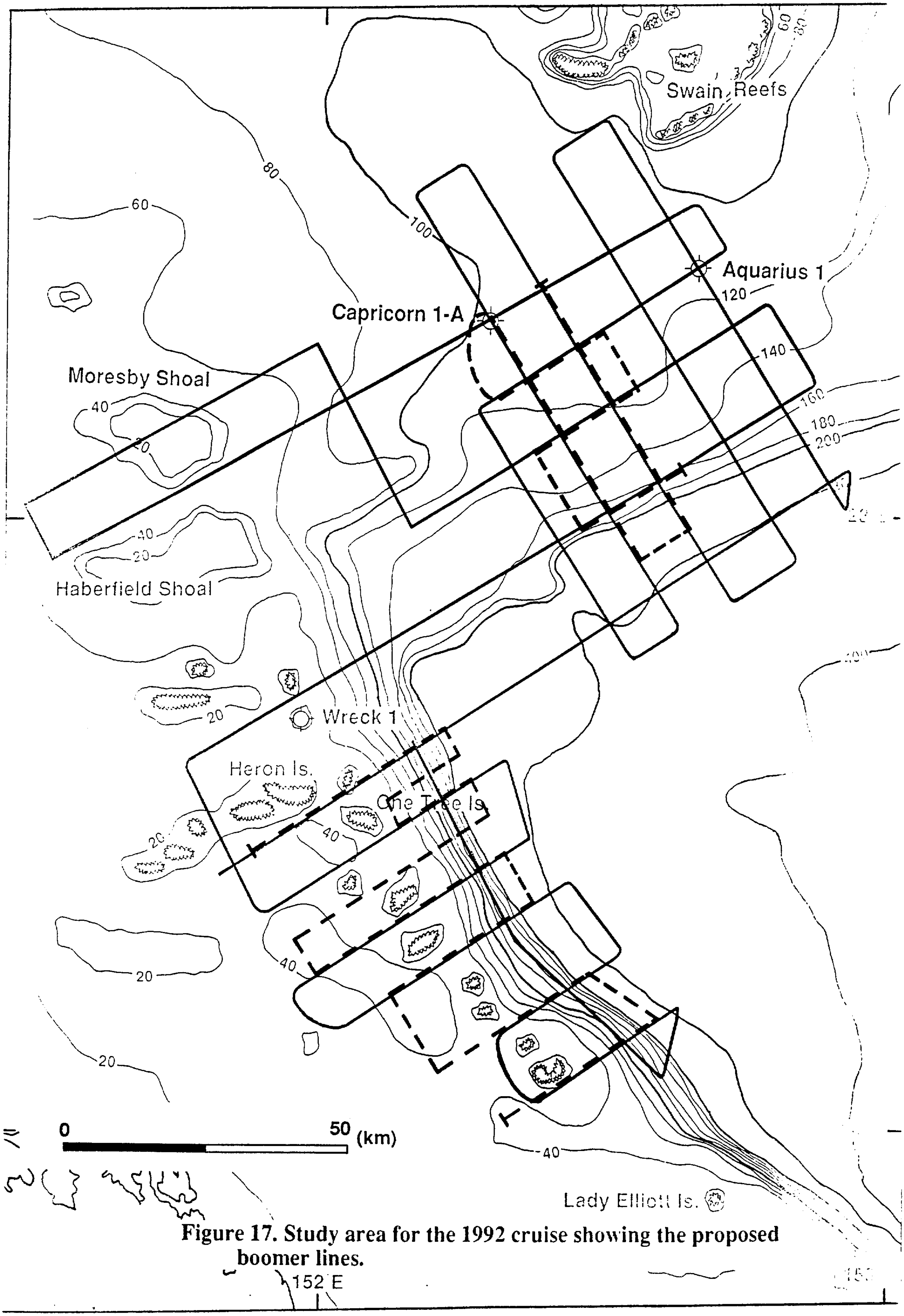

Figure 17. Study area for the 1992 cruise showing the proposed boomer lines.

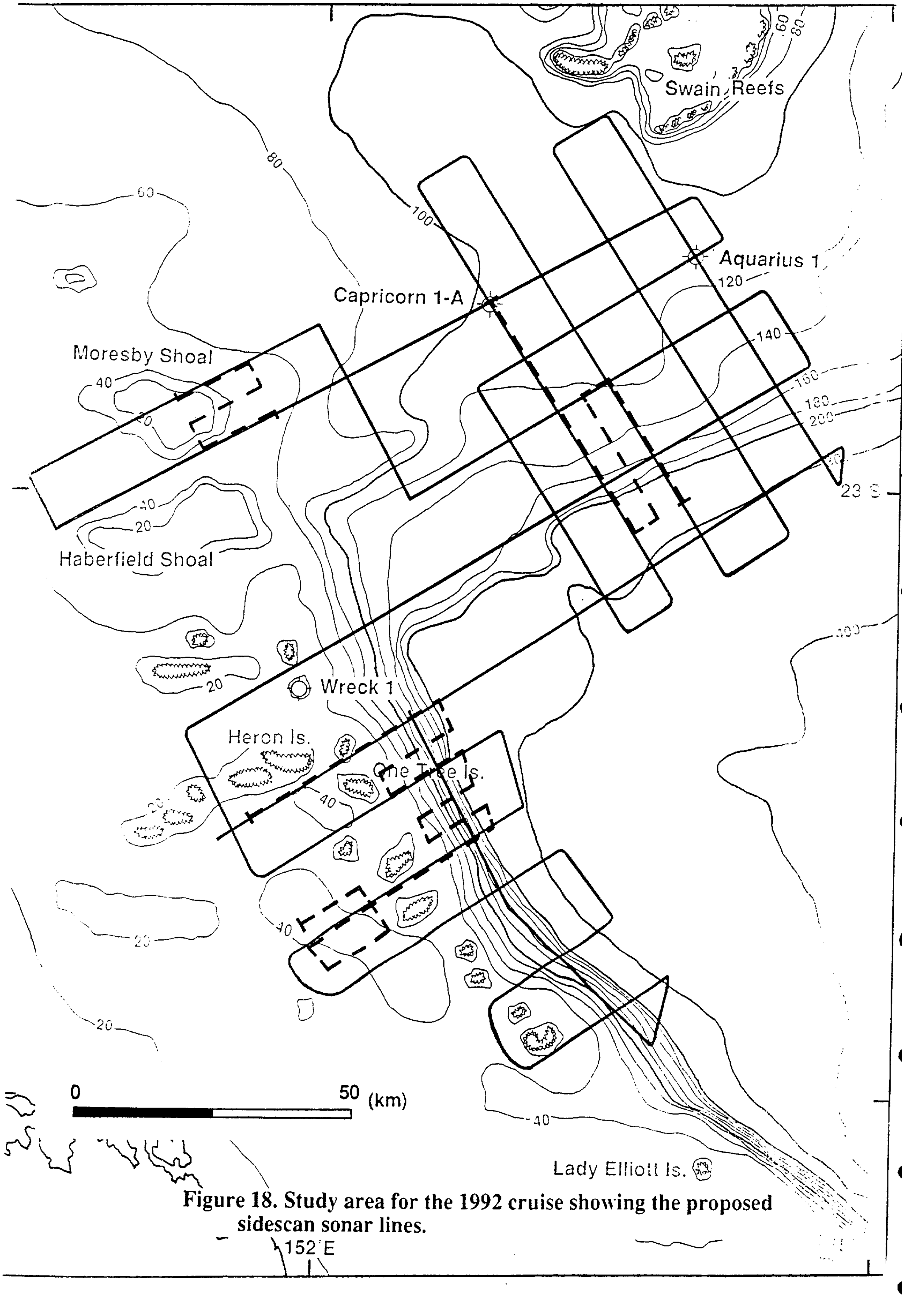

Figure 18. Study area for the 1992 cruise showing the proposed sidescan sonar lines.

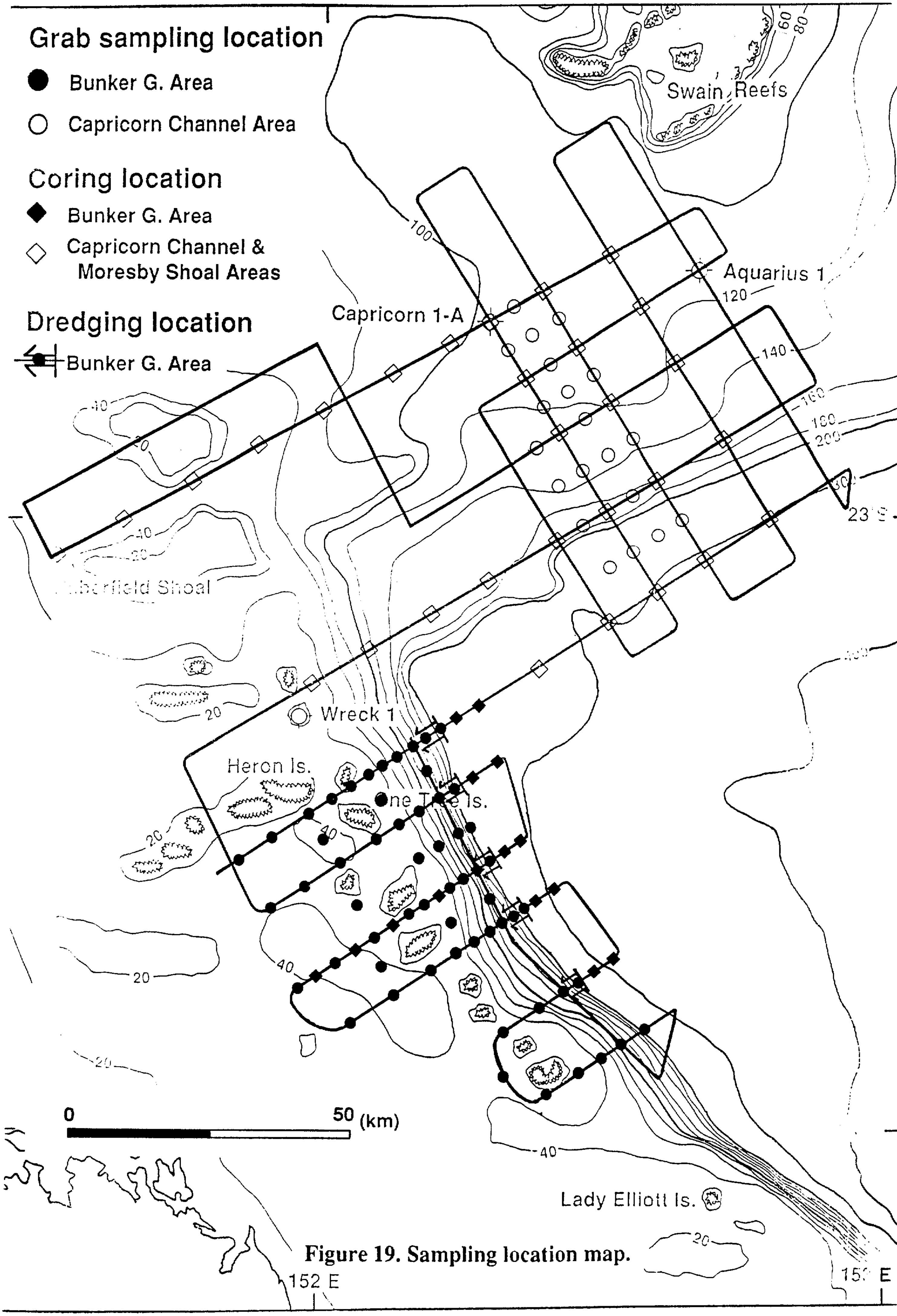

Figure 19. Sampling location map.

	Seismic	Boomer/ Pinger	Sidescan	Grab & Camera	Dredge	Coring	ROV
Whole area	8days 1,400km						
Bunker G. area		2days 300km	1.5day 200km	3days 80	1day 5	1.5days 15	1day
Capricorn Channel area		1.5days 250km	0.5day 100km	2days 20		3.5days 30	1day
Moresby Shoal area			0.5day 60km				1day
Total 28days	8days	3.5days	2.5days	5days	1day	5days	3days

Table 2 Proposed Operational Schedule for 1992 Cruise

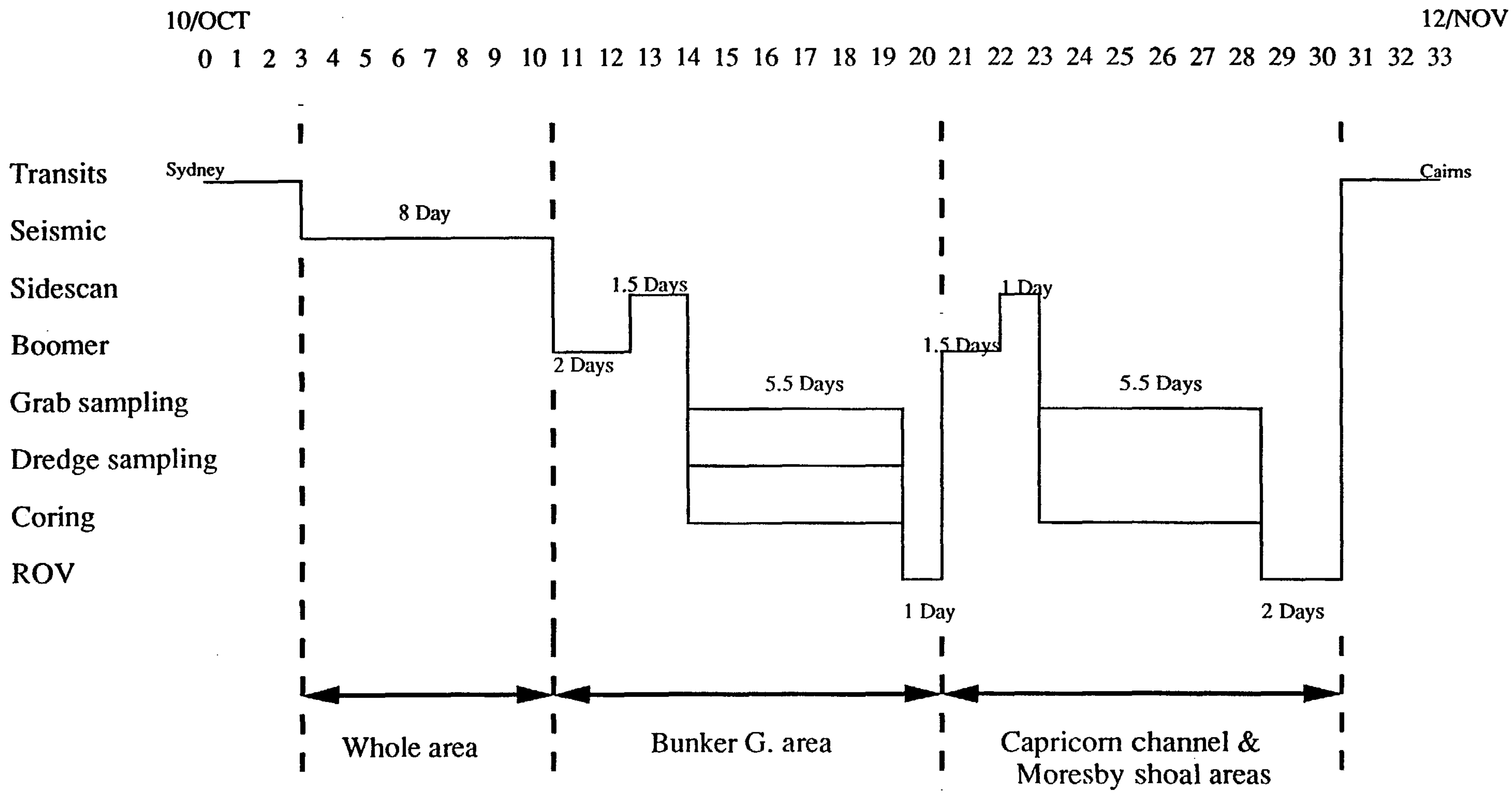

Figure 20. Proposed Schedule for 1992 Cruise