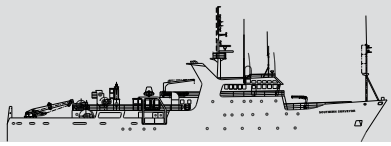


MARINE
NATIONAL FACILITY

2008 program

RV *Southern Surveyor*

CSIRO

voyage summary SS06/2008

SS06/2008

Morphology and Chronostratigraphy of fossil reefs around Lord Howe Island

Itinerary

Depart: 16/04/2008
PORT OF DEPARTURE Sydney, Australia

Return to port: 29/04/2008
PORT OF RETURN Noumea, New Caledonia

RESPONSIBLE LABORATORY

University of Wollongong (in collaboration with Geoscience Australia) Wollongong, NSW 2522 Australia

CHIEF SCIENTIST(S)

Professor Colin D. Woodroffe, University of Wollongong
Dr Brendan Brooke, Geoscience Australia

OBJECTIVES AND BRIEF NARRATIVE OF VOYAGE

Scientific Objectives

The Lord Howe Island Marine Park is a unique example of a seamount ecosystem in the Tasman Sea, and this project aims to extend habitat and sedimentological surveys of this important area. The data collected in this survey will form a key seamount dataset for the Commonwealth Environmental Research Facilities (CERF) Marine Biodiversity Research Hub that is investigating the utility of seabed biophysical data for the prediction of patterns of marine biodiversity in the Australian marine jurisdiction.

Voyage Objectives

This research aims to extend our understanding of seamount habitats in the Tasman Sea, specifically mapping the bathymetry and substrate of environments around Lord Howe Island and Balls Pyramid.

The overall voyage objectives are [priority]:

- to undertake substrate and benthic habitat mapping of the marine park [1]
- to map the extent of the fossil reef around Lord Howe Island [1]
- to look for a comparable feature on the smaller Balls Pyramid platform [2]
- to determine reef morphology in detail using swath mapping [1]
- to explore stratigraphy by sub-bottom profiling and shallow core recovery [1]
- to sample adjacent sedimentary environments by grab sampling or piston coring [2]
- to recover dredge and sled samples from shelf-margin sites [2]
- to recover and redeploy ADCP at 31˚24.000 S, 159˚04.870 E (57m depth) [1]

Results

Substrate and benthic habitat mapping of the marine park

Almost the entire shelf on which Lord Howe Island sits was swath mapped using the EM300. A Reson 8101 swath system was also installed on the vessel and collected higher-resolution data, but this has yet to be analysed to determine its effectiveness. The 3-dimensional topography of the mid and outer shelf provides a most valuable foundation for more detailed determination of habitat types and benthic ecology. A towed underwater video camera was used to record the sea floor on one camera tow, and further benthic analysis was undertaken with grab samples and benthic sled. Technical problems with the camera and deterioration in weather conditions prevented further camera deployment.

Map the extent of the fossil reef around Lord Howe Island

The swath mapping clearly defines the extent of the fossil reef across the shelf surrounding Lord Howe Island. The outer margin of a reef feature has been determined, and the inner margin of this, where lagoonal sands are found, has been determined, except for areas too close inshore for the vessel to approach.

Look for a comparable feature on the smaller Balls Pyramid

One transect of swath was acquired across Balls Pyramid to look for a comparable feature to the fossil reef on this smaller platform. Further swaths on this platform could not be conducted because of time and weather constraints. Initial interpretation suggests that there are features similar to those on the Lord Howe shelf, and further mapping of this sort could usefully define habitats on Balls platform.

Determine reef morphology in detail using swath mapping

The swath data will provide an invaluable dataset for a much more detailed determination of the morphology and hence the past environments on the fossil reef around Lord Howe Island.

Explore stratigraphy by sub-bottom profiling and shallow core recovery

The Topas sub-bottom profiler was run for most of the profiling across the platform. Good penetration was achieved over some of the sandy lagoon areas with several reflectors apparent. The Topas did not provide differentiation of the reef limestone thickness or the topography of the underlying basalt, but further analysis may indicate clearer resolution of bottom types. A sparker system was deployed on two occasions but failed to produce a signal. The underwater rock corer was deployed at 6 sites during the two days when sea conditions were calm enough to work safely on the aft deck and for the vessel to be held stable with the dynamic positioning system. Core recovery from these sites was successful, although the porous nature of the limestone meant that recovery was considerably less than penetration. The limestone samples that were recovered are particularly significant because they confirm the hypothesis that the prominent feature on the shelf is a fossil reef. The cores included fossil coral material, as well as a range of other fossil reef organisms.

Sample adjacent sedimentary environments by grab sampling or piston coring

Sedimentary environments were sampled using the Smith-Macintyre grab sampler. Determination of soft sediment bottom from swath and Topas records meant that recovery was possible at most sites where the grab sampler was deployed. At the majority of sites three replicate grabs were recovered for benthic ecology, but at several sites only a single sample for sediment analysis was recovered. We did not bring the piston corer on this voyage, and on the basis that grab samples were predominantly coarse sand, decided that it was not appropriate to use the gravity corer as this seemed unlikely to recover a useful length of core.

Recover dredge and sled samples from shelf-margin sites

The benthic sled was used at 6 sites, one of those being the site at which the towed underwater video camera has been deployed. This provided further samples of benthic organisms to supplement the benthic grab samples. The rock dredge was not deployed as the swath and Topas provided preliminary indications of bottom type.

Recover and redeploy ADCP

The ADCP that had been moored on the seafloor at station 23 to the north of the shelf did not respond to the acoustic release, and it was necessary to return to the site and recover it with a grapple later in the cruise. It was so encrusted with worm tubes that it was decided not to redeploy the ADCP.

Voyage Narrative

The RV Southern Surveyor left Sydney on the morning of 16 April and sailed to the shelf around Lord Howe Island. Research at the island commenced on the morning of Friday 18 April after a relatively rough transit. The EM300 swath mapper was used to map the topography of the seafloor throughout the eight days that we were working on the Lord Howe Island shelf. The Reson 8101 shallow-water swath system, installed on the vessel and deployed through the moonpool, was also operated although issues of software incompatability mean that it has not been possible to assess the quality of data from that swath mapper while in the field. The Topas sub-bottom profiler was

also operated over the entire shelf and provided an indication of bottom roughness, enabling differentiation of rocky substrate from those areas which had a sandy bottom. Grab samples were collected using the Smith-Macintyre grab sampler; three replicate samples were taken for benthic ecological analysis at most sites, but at several a single grab was taken for sediment analysis. Several instruments failed to function when first deployed. This included the first attempts to use the underwater camera, the sparker system, the acoustic release on the moored ADCP and the submersible rock corer. After adjustments, the underwater camera was used to acquire a video of the seafloor at a site off the west of the island. Sea conditions limited the deployment of several pieces of equipment for the first few days of fieldwork, with swells of 4 metres, with sets of up to 6 metre waves and gale force winds, with the weather complicated by the influence of Lord Howe Island itself. On Tuesday 22 April and Wednesday 23 April the seas were somewhat less unfavourable, and we were able to deploy the submersible rock corer off the rear of the vessel to recover short cores of reef limestone and to confirm that the prominent features that we had been mapping were indeed fossil reefs. The weather subsequently deteriorated and no further deployment of the submersible corer was possible. The benthic sled was deployed at six sites to the west of Lord Howe Island and several further grab samples were obtained. Throughout the voyage the EM300 swath mapper continued to be used to map swath lines across the shelf, and overnight the shelf margin at each of the major corners of the shelf were mapped. On conclusion of this mapping, a brief swath profile was undertaken across the shelf surrounding Balls Pyramid. A strong swell and gale-force winds then necessitated departure from Lord Howe on the transit to Noumea.

Summary

Despite adverse weather conditions on arrival and during the latter part of the cruise at Lord Howe Island, and the malfunction of several pieces of equipment, we made significant progress towards achieving the goals of this voyage. At the conclusion of the voyage we had mapped most of the Lord Howe shelf, and the data acquired using the EM300, together with other datasets available to us, will enable a valuable first assessment of habitats in that part of the marine park that surrounds Lord Howe Island. The rock coring provided evidence that the feature that dominates much of the platform is a fossil reef, and the material recovered should allow better determination of the reef history of this unique site at the southern limit to reef development and insights into a time when reefs were much more prolific here. Benthic ecology was examined at several sites, with some weather limitations as to how much of the shelf could be sampled. Although the malfunction of some equipment or constraints through deteriorating weather conditions limited many of the deployments, the results will be of great significance in terms of the palaeoecology of these reefs, and provide an important basis upon which to design further management of the marine park.

PRINCIPAL INVESTIGATORS

A. Prof. Colin D. Woodroffe, School of Earth and Environmental Sciences. University of Wollongong, NSW 2522

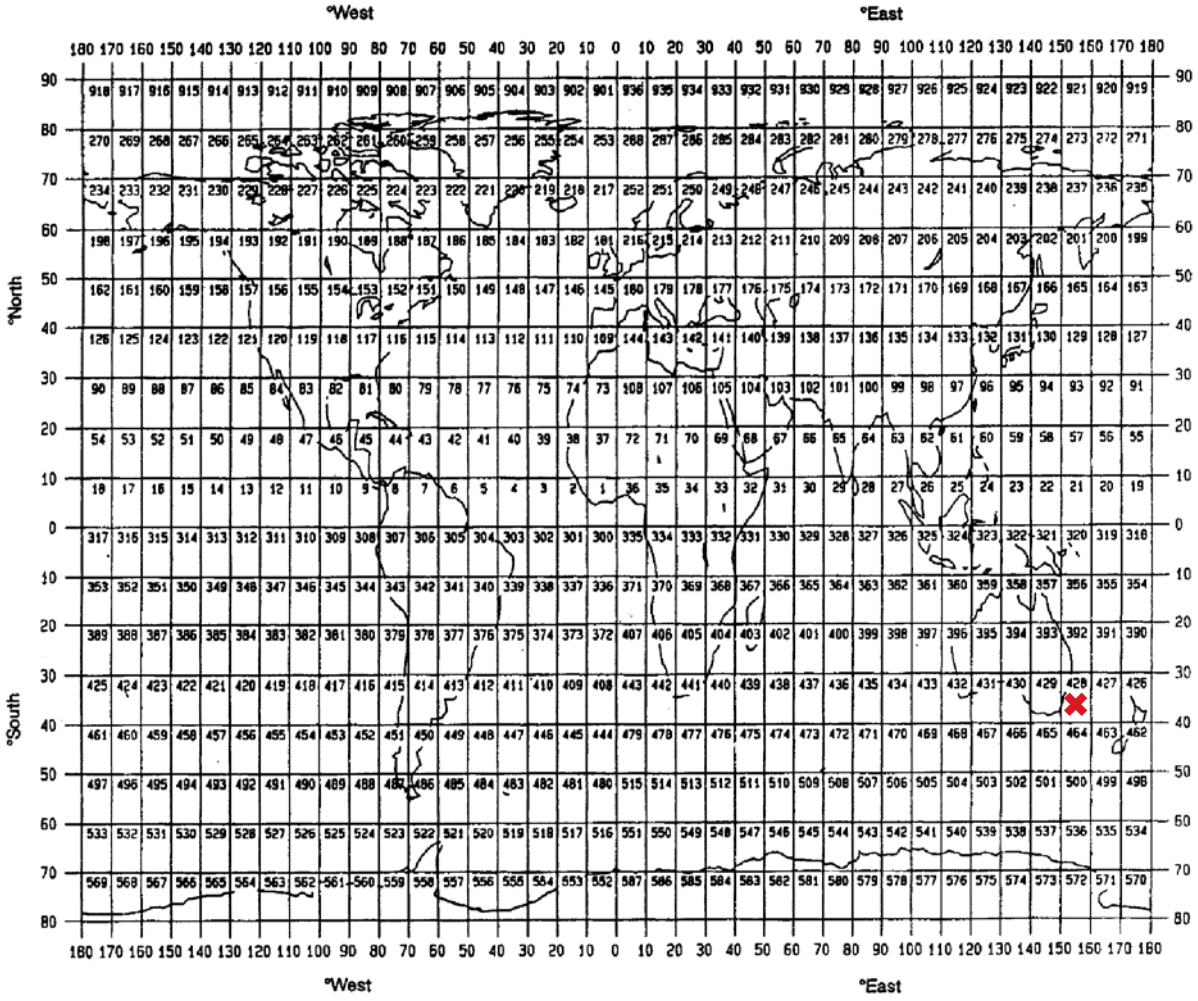
B. Dr Brendan Brooke, Geoscience Australia, P.O. Box 378, Canberra, ACT 2601

C. Dr Matthew McArthur, Geoscience Australia, P.O. Box 378, Canberra, ACT 2601

D. Lindsay Pender, CSIRO, Marine National Facility

Marsden squares ✖

GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED



MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

Item No	PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	see page above	LATITUDE			LONGITUDE			enter code(s) from list on last page	
		deg	min	N/S	deg	min	E/W		
1	D	33	09.1	S	153	59.7	E	D06	ARGO float deployed
2	D	32	22.4	S	156	59.6	E	D06	ARGO float deployed
3	B	31	24.0	S	159	04.8	E	D71	ADCP recovered from mooring on seafloor in 57m of water (deployed October 2006), acoustic release did not activate, but recovered with grapple. Instrument not re-deployed due to benthic carbonate encrustation and inoperatibility of equipment.
4	D	24	54.7	S	164	59.7	E	D06	ARGO float deployed

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION
1	C	1	station	B09	One plankton tow at station 24BS01
2	C	1	station	B18	Zoobenthos at station 24BS01
3	C	6	stations	G01	Benthic sled deployments – see Table 4
4	C/A	39	grabs	G02	Grab samples for benthic and sediment analysis – see Table 1
5	B	6	cores	G03	Rock cores from fossil reef – see Table 2
6	C	1	tow	G08	Underwater video camera tow – see Table 3
7	B	9	days	G74	Swath mapping of Lord Howe Island shelf
8	B	9	days	G90	Acoustic Topas sub-bottom profiling of Lord Howe Island shelf

CURATION REPORT

Item No.	DESCRIPTION
Sorted material	Porifera: frozen: Queensland Museum
	Cnidaria: ethanol: Museum Victoria
	Annelida: formalin: Museum Victoria
	Crustacea: ethanol: Museum Victoria
	Mollusca: ethanol: Australian Museum
	Echinodermata: ethanol: Museum Victoria
	Ichthyoides: formalin: Museum Victoria
Unsorted material	Sediment samples will be returned to Geoscience Australia, processed and archived, presently frozen
	Bulk samples from benthic sleds and grabs will be returned to Geoscience Australia, processed, preserved in ethanol and the different fauna housed in the institutions as outlined above. Currently preserved in ethanol.
	Plankton samples will be returned to Geoscience Australia, processed and the retained material will be preserved in ethanol (currently in formalin) and lodged at Museum Victoria

GENERAL OCEAN AREA(S):

Tasman Sea

SPECIFIC AREAS:

Lord Howe Island Marine Park

PERSONNEL LIST

Scientific Participants

Prof Colin Woodroffe	SEES, UOW	Chief Scientist
Assoc-Prof Brian Jones	SEES, UOW	Senior Scientist
Dr David Kennedy	VU, Wellington, NZ	Geologist
Javier Leon	SEES, UOW	PhD student, geospatial
Dr Brendan Brooke	GA	Deputy Chief Scientist
Dr Matt McArthur	GA	Benthic Ecologist
Cameron Buchanan	GA	Swath Technician
Andrew Hislop	GA	Mechanical Technician
Gareth Crooke	GA	Mechanical Technician
Jack Pittar	GA	Electronics Technician
Ian Atkinson	GA	Science/Swath Technician
Michele Spinoccia	GA	Swath Technician
Ron Plaschke	CMAR, MNF	Voyage Manager and Ops supp
Karl Forcey	CMAR, MNF	Electronics Support
Lindsay Pender	CMAR, MNF	Computing Support

Marine Crew

Name	Role
Les Morrow	Master
John Barr	First Mate
Rob Ferries	Second Mate
Rob Cave	First Engineer
Roger Thomas	Chief Engineer
Seamus Elder	Second Engineer
Darcy Chalker	Chief Steward

Name	Role
Adam O'Connor	Chief Cook
Julie Milne	Second Cook
Tony Hearne	Boatswain
Rob Artaud	IR
John Howard	IR
Gareth Gunn	IR
Josh Liley	IR

Acknowledgements

We acknowledge the National Marine Facility and CSIRO for time on the RV Southern Surveyor, the Lord Howe Island Marine Park Authority for permission to undertake research in the marine park, the GeoQuest Research Centre for funds to cover ship-time (University of Wollongong), and Peter Harris, Dave Holdway, Ray De Graff and Rebecca Jeremenko of the Marine and Coastal Environment Group at Geoscience Australia for project and logistical support.

Colin D. Woodroffe

Chief Scientist

Appendix 1 – Science Report

Voyage SS06/2008

Morphology and Chronostratigraphy of Fossil Reefs around Lord Howe Island

Colin D. Woodroffe, University of Wollongong
Brendan Brooke, Geoscience Australia

Itinerary

Departed Sydney 1000hrs, Wednesday 16 April, 2008
Arrive Noumea 0800hrs, Tuesday 29 April, 2008

Contribution to Australia's national benefit:

Coral reefs are sensitive indicators of climate and fossil reefs preserve a record of past climate conditions that enable the reconstruction of their response to past climate change. The Lord Howe Island reefs are especially sensitive, being at the latitudinal limit to reef formation. The fossil reefs that were studied as part of this research cruise will provide insights into the palaeoclimatology of this part of the Tasman Sea. We have collected samples that will provide invaluable data on the history of reef development and the environmental conditions under which former reefs flourished. Our studies represent detailed benthic surveys of a little known part of the Lord Howe Marine Park. Mapping of the substrate will provide a firm foundation for management of shallow marine ecosystems, and the palaeoenvironmental reconstructions support our understanding of reef response to climate change.

As a result of this voyage:

We have a better understanding of the former extent of reefs at this sensitive southern latitudinal limit to reef growth, the nature of sediment production on the shelf and the associated benthic ecology.

We have found that the former reefs around Lord Howe Island were much more extensive than those that exist there today. Reefs are sensitive to global climate change especially periods of warming, and these former reefs may provide an analogy for how reefs respond to future climate change.

We have mapped the morphology of the shelf surrounding Lord Howe Island with a high degree of resolution, and the digital relief model of shallow marine environments will provide a valuable guide for more detailed assessment of benthic communities.

We have commenced a program of determining sediment production and reef growth history at this key latitudinal site that can provide a foundation for the better management of the marine park.

Table 1. Smith-Macintyre grab sample sites (G02; PI = C)

Sample no	Lat	Long	Depth (m)	Material
01GRSM01	31:31.00S	158:59.46	48	Rhodoliths and medium sand
01GRSM02	31:30.96S	158:59.48E	48	Rhodoliths and medium sand
01GRSM03	31:30.99S	158:59.52E	48	Rhodoliths and medium sand
01GRSM04	31:30.99S	158:59.51E	48	Rhodoliths and medium sand
02GRSM01	31:33.89S	159:02.24E	42.5	Gravelly sand
02GRSM02	31:33.89S	159:02.19E	42.5	Gravelly sand
02GRSM03	31:33.86S	159:02.18E	42.5	Gravelly sand
03GRSM01	31:31.03S	158:57.41E	77	Coarse-medium sand with rhodoliths
03GRSM02	31:31.00S	158:57.39E	77	Coarse-medium sand with rhodoliths
03GRSM03	31:31.00S	158:57.38E	77	Coarse-medium sand with rhodoliths
03GRSM04	31:31.04S	158:57.42E	77	Coarse-medium sand with rhodoliths
04GRSM01	31:30.30S	159:02.77E	27	Medium-fine sand
04GRSM02	31:30.30S	159:02.81E	27	Medium-fine sand
04GRSM03	31:30.26S	159:02.75E	27	Medium-fine sand
05GRSM01	31:28.61S	159:03.48E	60	Coarse sand and coral rubble
06GRSM01	31:29.55S	159:02.82E	44	Fine sand
06GRSM02	31:29.54S	159:02.83E	44	Fine sand
06GRSM03	31:29.54S	159:02.80E	44	Fine sand
07GRSM01	31:32.57S	159:08.49E	61	Medium-fine sand with basalt granules
08GRSM01	31:33.35S	159:02.24E	25	Coralline algae and coral
10GRSM01	31:34.62S	159:00.22E	71	Coarse sand
10GRSM02	31:34.60S	159:00.19E	71	Coarse sand
10GRSM03	31:34.60S	159:00.20E	71	Coarse sand
11GRSM01	31:26.87S	159:06.50E	61	Coarse sand
12GRSM01	31:24.01S	159:03.68E	70	Coarse sand
12GRSM02	31:24.01S	159:03.66E	70	Coarse sand
12GRSM03	31:24.01S	159:03.68E	70	Coarse sand
16GRSM01	31:37.08S	159:07.20E	77	Coarse sand
17GRSM01	31:37.56S	159:07.23E	44	Fossil coral clasts with red algae
18GRSM01	31:37.00S	159:10.50E	56	Sandy gravel
19GRSM01	31:32.81S	159:11.99E	77	Coarse sand
20GRSM01	31:33.29S	159:09.90E	40	Gravelly sand
20GRSM02	31:33.33S	159:09.90E	40	Gravelly sand
20GRSM03	31:33.33S	159:09.88E	40	Gravelly sand
30GRSM01	31:29.48S	159:07.81E	40	Coarse sand and coral rubble
30GRSM02	31:29.48S	159:07.81E	40	Coarse sand and coral rubble
30GRSM03	31:29.48S	159:07.81E	40	Coarse sand and coral rubble
31GRSM01	31:29.29S	159:09.28E	70	Medium-coarse sand
31GRSM02	31:29.28E	159:09.32E	68	Medium-coarse sand

Table 2. Rock core sites (G03, P=B)

Core number	Latitude	Longitude	Water depth (m)	Penetration (m)	Recovery (m)
13RDC01	31:30.18S	159:02.27E	27	2.03	0.85
14RDC01	31:30.39S	159:02.25E	27	2.58	0.75
15RDC01	31:33.35S	159:01.03E	34	0.97	0.50
15RDC02	31:33.36S	159:01.03E	34	1.43	0.40
21RDC01	31:34.10S	159:10.15E	30	1.22	0.78
22RDC01	31:34.00S	159:09.60E	24	2.72	1.20

Table 3. Camera tow (G08, P=C)

Tow no	Lat	Long	Depth (m)	Ends
09CAM01	31:34.99S	159:02.18E	35	in
	31:35.36S	159:02.02E		out

Table 4. Benthic sled sites (G01, P=C)

Sled no	Lat	Long	Depth (m)	Ends
24BS01	31:31.88S	159:00.82E	35	in
	31:31.91S	159:00.98E		out
25BS01	31:32.68S	159:01.41E	40	in
	31:32.67S	159:01.62E	38	out
26BS01	31:33.26S	159:02.11E	36	in
	31:33.29S	159:02.24		out
27BS01	31:34.73S	159:02.13E	36	in
	31:34.81S	159:02.27E		out
28BS01	31:35.43S	159:02.61E	38	in
	31:35.50S	159:02.76E		out
29BS01	31:35.17S	159:02.07E	32	in
	31:35.18S	159:02.25E	34	out

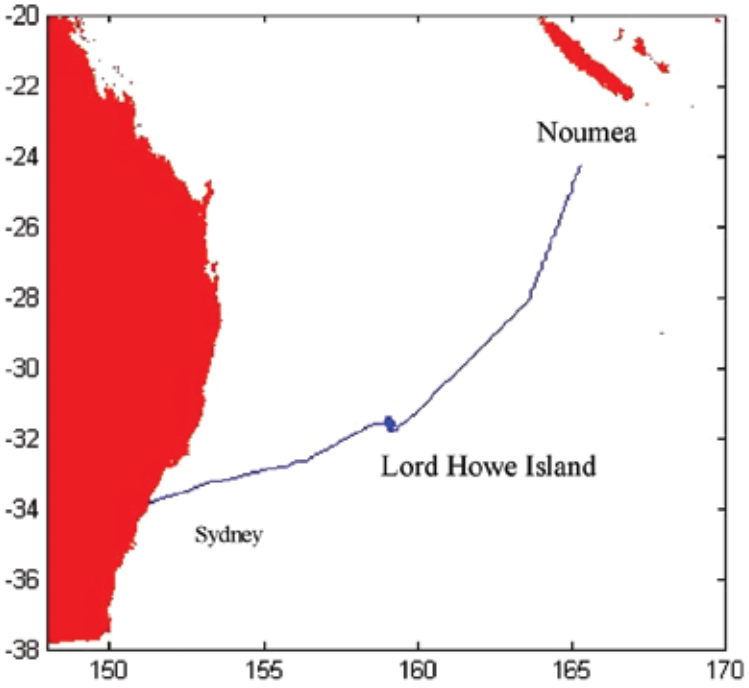


Figure 1: Ship's track Sydney to Lord Howe Island to Noumea.

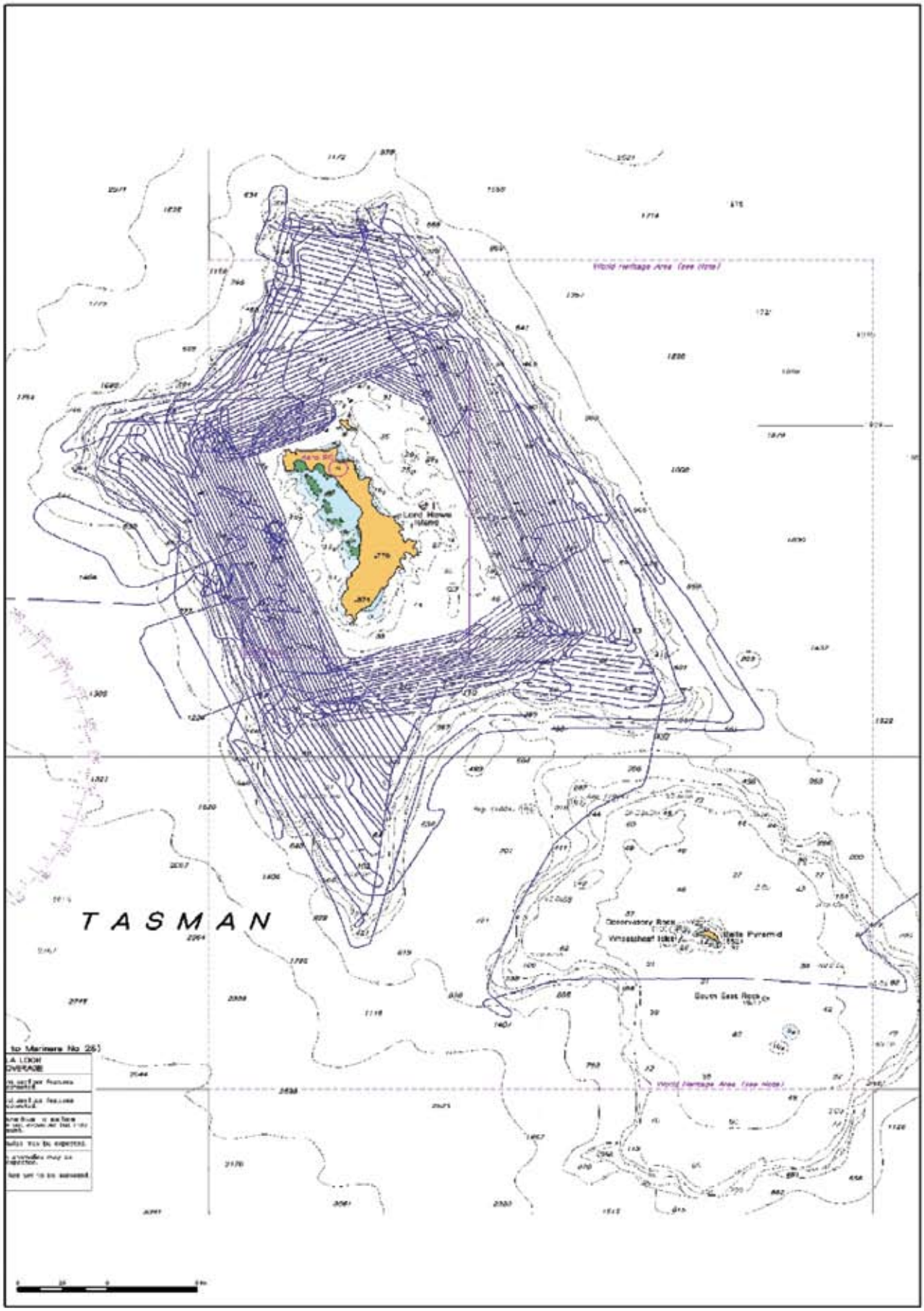


Figure 2: Track of swath and sub-bottom profiler around Lord Howe Island

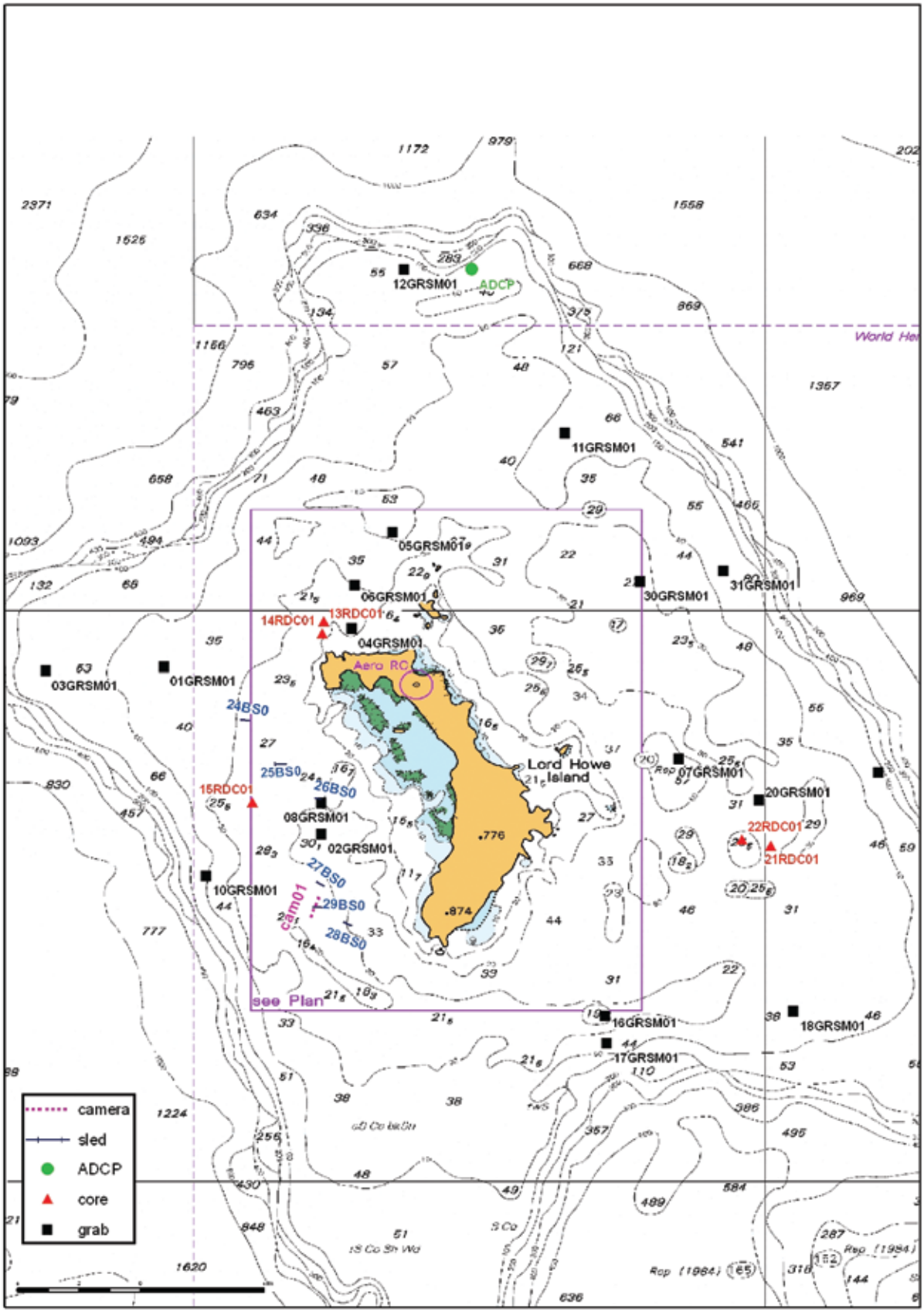


Figure 3: Map of stations around Lord Howe Island.

CSR/ROSCOP PARAMETER CODES

	METEOROLOGY
M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

	PHYSICAL OCEANOGRAPHY
H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

	CHEMICAL OCEANOGRAPHY
H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

	MARINE CONTAMINANTS/POLLUTION
P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

	MARINE BIOLOGY/FISHERIES
B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

	MARINE GEOLOGY/GEOPHYSICS
G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements