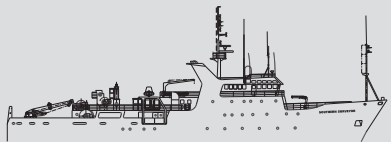


MARINE
NATIONAL FACILITY

RV *Southern Surveyor*

2009 program

CSIRO

voyage summary SS03/2010

SS03/2010

Physical forcing of productivity on the Kimberley Shelf

Voyage period
Start: 14/04/2010
End: 05/05/2010
Port of departure: Broome, Australia
Port of return: Port Hedland, Australia

Responsible laboratory
CSIRO Marine and Atmospheric Research
Castray Esplanade, Hobart Australia

Chief Scientist(s)
Peter Thompson CSIRO Marine and Atmospheric Research

Scientific Objectives:

1. Quantify the role of physics (internal waves and tides) at the shelf edge in supplying nutrients to the shallow coastal sea of the Kimberley region.
2. Test the relative importance of nutrients from riverine input, benthic remineralization and deep water incursions at the shelf break, to regional production.
3. Investigate the relative roles of turbidity (underwater light), water column stability and nutrients to primary production, zooplankton and fish larvae across an estuarine, shelf and offshore gradient.
4. Provide the first biophysical oceanographic characterisation of the Kimberley shelf region (multispectral sensors).
5. Ground truth remotely sensed products for this region.
6. Deploy a physical mooring at the shelf edge.
7. Provide the data sources to develop a biophysical model for the Kimberly shelf region allowing scenario testing for river flow and climate variability (this work to be done as part of an associated project within WAMSI).

Voyage Objectives:

1. The deployment of a mooring near the shelf edge to capture high frequency temporal variation in physical parameters.
2. 4 transects from the coast to ~ 2000m deep water. The centre transect from King Sound will be repeated 2 times. The first transect is to coincide with the April 14 spring tide and again 7 days later during the neap tide. Designed to observe variation caused by the spring-neap tidal forcing.
3. Stations on the shelf (50m), at the shelf break (200m) and in the deeper ocean (1000m) to be occupied for 12h on all transects. This is to investigate the maximal variation caused by the very substantial (~10m) semi diurnal tidal forcing.
4. Typical sampling at all 12h stations to include:
   a. Repeat CTDs at ~ hourly intervals.
   b. 3 bongo net tows near T=0
   c. 1 neuston net tow at the surface
   d. 1 EZ net tow at multiple depths
   e. 1 profile of optical properties to ~100m
   f. Floating/profiling hyperspectral radiometer.
   g. 1 sled tow (shot) for benthic sampling
   h. 1 deployment of the coring device (gives 4 replicate cores)
   i. 3 bongo tows near T=12
5. One or more stations inside King Sound.

Results

1. The deployment of a mooring near the shelf edge was conducted on the second day of the voyage and recovery occurred very close to the end of the voyage resulting in the maximum data record. Deployment and recovery were handled well by ship's crew.

2. As on most voyages operations became faster with practice. The proposed sampling regime was arduous and was dependent upon excellent support and flexibility from the officers and crew to be efficiently executed. In addition we were fortunate to have excellent weather. The combination of these factors meant we completed 5 transects from shore to 2000m water depth and some additional sampling.

3. All proposed stations were occupied for an appropriate length of time to complete all sampling.

4. Some problems with equipment occurred. Some were rectified, others not.

    a. In general, it was possible to collect CTD profiles at ~ hourly intervals. The CTD did fail several times due to poor connections but these were overcome with a combination of re-terminating the communications cable and switching to a different winch and cable.

    b. The bongo net worked perfectly although some software problems manifested themselves on day 1 but were overcome within 24h.

    c. The neuston net worked perfectly and all planned samples were collected.

    d. The EZ net did not work properly from the first deployment although we did manage 4 deployments before it failed completely. Our research into larval fish was compromised.

    e. Based on previous work (SS052007) a much better and more sophisticated package of many optical instruments was used to characterize the water column and this worked well.

    f. The new profiling hyperspectral radiometer was successfully deployed from the ship's bow.

    g. Although based on a proven design the new benthic sled required some modifications to be successfully used. These were carried out at sea and the proposed number of tows (6) were successfully conducted.

    h. In spite of the fact that it had been successfully tested off Perth our new commercial coring device was less successful than anticipated. A number of attempts were made to retrieve intact cores to measure benthic fluxes of nutrients but only 3 cores were retrieved intact. We are working to improve the performance of this instrument.

5. Favourable conditions made it possible to sample 5 stations inside King Sound.

Discoveries. It is too early to recount many discoveries.
Some preliminary observations include:

– strong tidal mixing is an important factor in nutrient cycling

– a much greater biomass of phytoplankton in the vicinity of King Sound than other 753 locations we have sampled in West Australia over the last 14 years.

– a complex vertical structure to the water column on the shelf outside King Sound with hypersaline water (apparently) flowing out of King Sound across the shelf at depth

– internal waves appear to be a significant factor in the vertical distribution of plankton

– there was a substantial jellyfish biomass on shelf and along the shelf edge

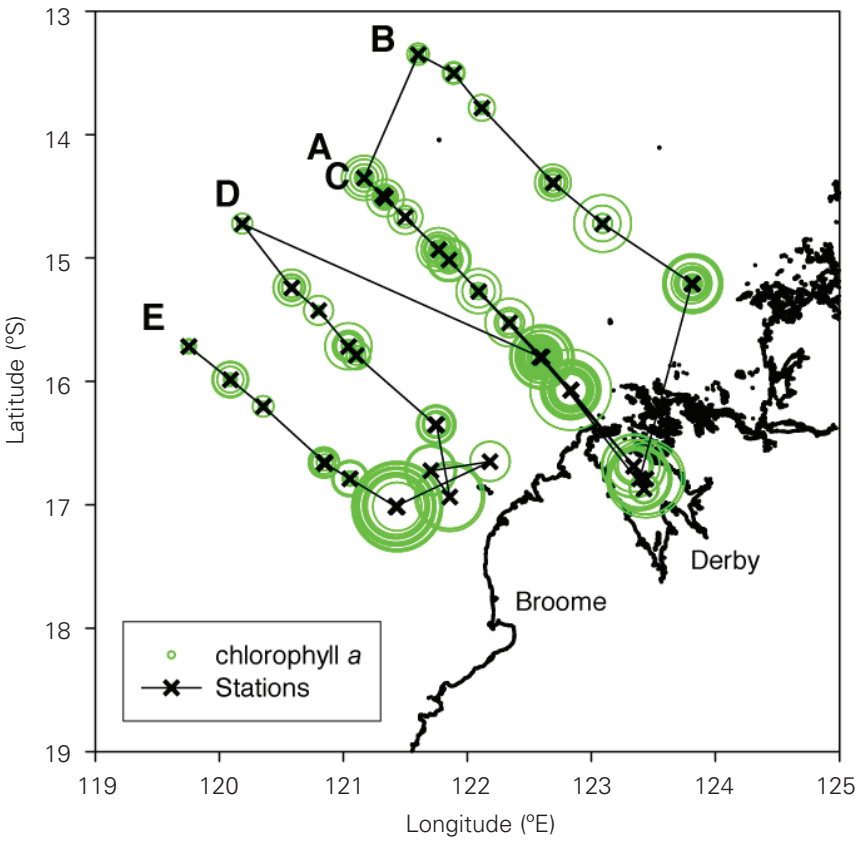


Figure above shows station locations, the 5 onshore-offshore transects (A to E), the approximate voyage and the concentrations of chlorophyll a (larger bubbles = more chla). Multiple circles at the same location represent repeat samples or different depths.

The voyage commenced at Broome on April 14, 2010. We deployed a thermistor string on a mooring at 15°43.677S and 121°05.831E at 03:53 UTC April 15th on our way to the first 2000m station on transect A. A total of 5 onshore – offshore transects were completed (A to E). On each transect there were a series of short stations (occupied for 1 to 2 hours at water depths of 2000m, 500m,100m) and longer stations (occupied for 12 to 15 hours at water depths of 1000m, 200m, 50m). At the first 2000m station a single CTD cast to 1000m collected water for nutrients at multiple depths (NO3, NO2, SiO2, PO4, NH4), phytoplankton & microheterotrophs at the surface and deep chlorophyll a maximum (DCM), size fractionated chlorophyll a at 6 depths plus picoplankton, bacteria and viruses, size-fractionated particulate nitrogen, carbon and HPLC pigments at 2 depths and 3 bongo tows with 2 size fractions. The CTD also provided irradiance, nitrate (ISUS sensor), fluorescence (chlorophyll a) and dissolved oxygen (DO).

From there we proceeded to the 1000m station on transect A for our first 12h station. At this station we did everything as above but, at least twice. A typical 12 h station would have: repeat CTDs at ~ hourly intervals, 3 bongo net tows near T=0, 1 neuston net tow at the surface, 1 EZ net tow at multiple depths (worked only partially at early stations), 1 profile of optical properties to ~100m, 1 deployment of the profiling hyperspectral radiometer, 1 sled tow (shot) for benthic sampling, 1 deployment of the coring device (gives 4 replicate cores), 3 bongo tows near T=12. Additional samples were collected for molecular research on N cycling and amino acid specific isotopes. Samples were incubated to measure primary production (P vs I) and nitrogen uptake (NO3, NH4 N2). These 12h stations were intense work periods requiring considerable goodwill from the ship's officers and crew to be successful. Flexibility regarding scheduling of meals was necessary to stay on schedule and finish a 12 hour station on time. A number of new instruments (hyperspectral radiometer, optical package, sled and corer) were new to most members of our science team and required toolboxes to develop appropriate protocols for deployment and recovery. The 12 h stations occurred at 1000m, 200m and 50m with 1 to 2 h stations at 2000m, 500m, 100m and shallower. At the shoreward end of transect A we entered King Sound.

During the voyage we completed 5 of these onshore-offshore transects, repeating A (the repeat transect is identified as C). The weather was very good with only 3 hours lost to high winds. The strong tides in the region made it somewhat more difficult to estimate time between stations as our speed over the ground was often less than 11 knots.

A number of underway instruments were used or deployed including echo sounders (Simrad EK 500 sounder (38 and 120 KHz), Simrad EA 500 sounder (12 kHz)), radiometers, PAR sensor, conductivity, temperature, fluorescence (chla), hyperspectral radiometers and ADCP.

Summary

The voyage was hugely successful. We set an ambitious target with intensive sampling using a wide range of instruments and gear across a broad expanse of the Kimberley region including into King Sound. We used a range of conventional and novel instruments. The former will provide the background measurements that we have not previously had from this region. The latter will give new insights into processes that are important to the functioning of the ecology and support the existing biodiversity.

The Fitzroy River was flowing but not in flood and our results will not tell us the whole story of the impact of this river on the near-shore marine ecology of the region. In spite of the relatively dry seasonal conditions the near-shore biological oceanography was distinctly different from the offshore regions and the contrast appears much more intense than other regions of Australia. A significant effort to validate remotely sensed information should yield many benefits in this remote region. In terms of equipment the only failure was the EZ net. This compromised our proposed investigation of the horizontal and vertical distribution of larval fish species and their biomass. Ideally this voyage would be repeated following a stronger wet season to provide the contrasting ecology that is part of this remote region.

Project

Project name:
Within CSIRO this is an ongoing project with the initial title of *Physical forcing of productivity on the Kimberley Shelf*. It is also a contribution to the international program SIBER (Sustained Indian Ocean Biogeochemical and Ecological Research).

Principal investigators

A. Dr Peter Thompson, CSIRO Marine and Atmospheric, Hobart Laboratories.

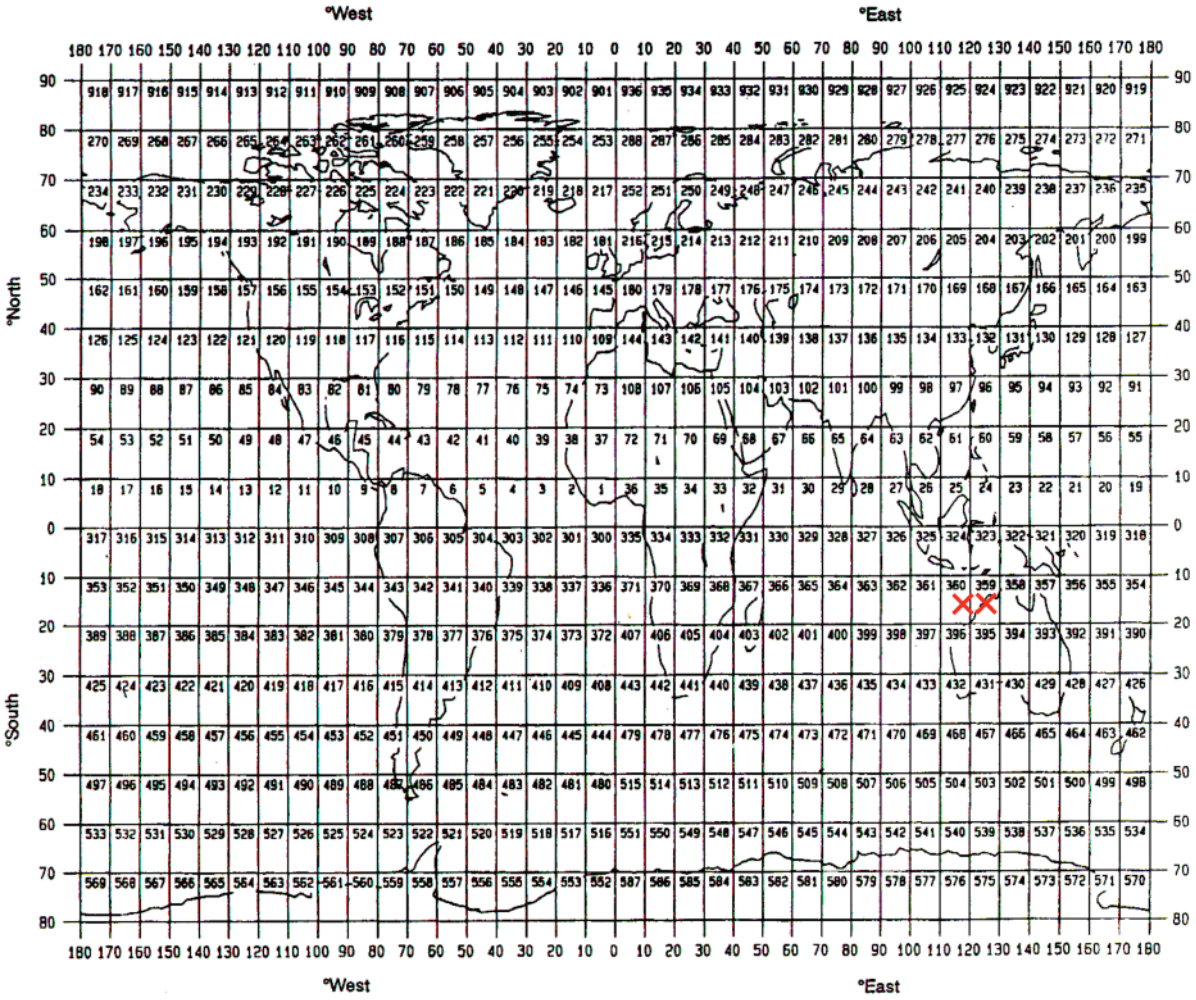
B. Ming Feng, CSIRO Marine and Atmospheric Research, Floreat Laboratories.

C. Dr Martin Lourey, CSIRO Marine and Atmospheric Research, Floreat Laboratories

D. Dr John Keesing, CSIRO Marine and Atmospheric Research, Floreat Laboratories

E. Associate Professor Lynnath Beckley, Murdoch University, WA.

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



MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS									
Item No	**PI** See page above.	**APPROXIMATE POSITION**						**DATA TYPE** enter code(s) from list on last page.	**Description**
		LATITUDE			**LONGITUDE**				
		deg	min	N/S	deg	min	E/W		
1	B	15	43	S	121	05	E	H72	Temperature sensors at ~ 10 to 20m intervals

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	A	195	casts	H10	Conductivity, temperature, depth, fluorescence, dissolved oxygen, nitrate, irradiance, transmissometer.
2	A	195	stations	H09	Water bottle stations
3	A	>1200	Samples	H22	Phosphate
4	A	>1200	Samples	H24	Nitrate
5	A	>1200	Samples	H25	Nitrite
6	A	>1200	Samples	H76	Ammonium
7	A	>1200	Samples	H26	Silicate
8	A	>60	Samples	H27	Alkalinity
9	A	>30	Samples	H21	Oxygen
10	A	195	Casts	H16	Transmissometer
11	A	195	casts	H17	Underwater light
12	A	22	days	D71	ADCP
12	A	22	days	M02	Incident radiation
13	A	~22	days	M90	Hyperspectral (256 channels from 320 to 950 nm) of sky and sea
14	A	~30	casts	D90	Multi-wavelength light absorption (2 Wetlabs ACS 9s), scattering (Wetlabs Hydroscat) particle distribution (Lisst 100X)
15	A	~500	samples	H32	For stable isotopes of plankton
16	C	~15	Pvsl curves	B01	Primary production
17	A	388	samples	B02	Extracted chla
18	A	138	samples	B02	HPLC pigments
19	A	~60	samples	B08	Preserved phytoplankton, identification, enumeration, biomass
20	A	~120	samples	B71	For Particulate organic matter
21	A	~60	samples	B72	For Lipids and amino acids for food web analysis
22	E	>180	samples	B09	Preserved Zooplankton, identification, enumeration and biomass
23	E	>15	samples	B10	Preserved Neuston, identification, enumeration and biomass
24	A	>1200	samples	B07	Pelagic bacteria and viruses, some identification and enumeration
25	D	6	Benthic tows	B20	Identification, enumeration and biomass, isotopes, lipids
26	D	6	Benthic tows	B21	Identification, enumeration and biomass, isotopes and lipids
27	C	4	cores	G04	Soft bottom cores
28	A	22	days	H11	Underway subsurface measurements of temperature, conductivity, fluorescence (chla)
29	C	~ 60	incubations	B90	15N uptake
30	E	~ 180	samples	B13	Identification, enumeration and biomass of larval fish

Curation report

CURATION REPORT	
Item No.	**Description**
19	CSIRO Marine and Atmospheric Research, Hobart Laboratories
22	Murdoch University, WA.
23	Murdoch University, WA.
25	CSIRO Marine and Atmospheric Research, Floreat Laboratories
26	CSIRO Marine and Atmospheric Research, Floreat Laboratories
30	Murdoch University, WA.

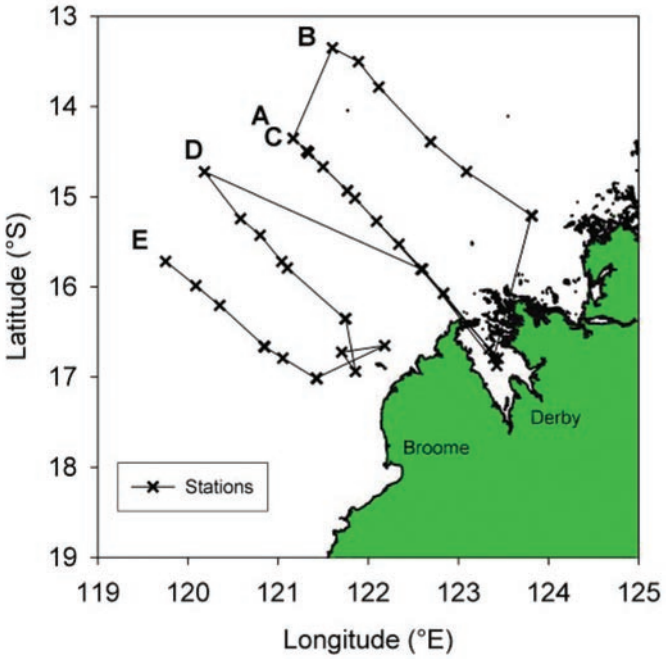


Figure showing station locations and approximate voyage track (lacking transit to ports and not entirely accurate with regard to route near land. The underway data giving position will not be available until August 2010.

General ocean area:

Indian Ocean

Personnel list

Scientific Participants

Name	Affiliation	Role
Peter Dunn	CSIRO MNF	Electronics Support/voyage manager
Anoosh Sarraf	CSIRO MNF	Computing support
Mark Rayner	CSIRO MNF	Hydrochemistry
Susan Reynolds	CSIRO MNF	Hydrochemistry
Peter Thompson	CMAR	Cruise Leader
Pru Bonham	CMAR	Phytoplankton ecology
Martin Lourey	CMAR	Deputy Cruise Leader & Nitrogen uptake
James McLaughlin	CMAR	Primary production
Joanna Strzelecki	CMAR	Zooplankton and benthic inverts
Evan Weller	CMAR	Hydrodynamics
Lynnath Beckley	Murdoch University	Watch Leader & larval fish ecology
David Holliday	Murdoch University	Larval fish ecology
Nicole Patten	UWA	Flow cytometry
Paul Daniel	CLW	Bio Optics
Nagur Cherukuru	CLW	Bio Optics

Marine Crew

Name	Role
Madeleine Habib	Master
John Barr	1st Mate
Rob Ferries	2nd Mate
Nic Fleming	Chief Engineer
Rob Cave	2nd Engineer
Seamus Elder	3rd Engineer
Tony Hearne	Bosun
Gareth Gunn	IR
Kel Lewis	IR
Jonathan Lamb	IR
Chris Softley	IR
Cassandra Rowse	Chief Steward
Jason Wall	Chief Cook
Glenn Williams	2nd Cook

ACKNOWLEDGEMENTS

Funding to support this research was provided by the CSIRO Wealth from Oceans Flagship, the Australian Institute of Marine Science, the West Australian Marine Science Institute, the University of Western Australia, Murdoch University, Woodside Petroleum & the Marine National Facility. The goodwill and support of the Marine Crew is greatly appreciated.

Peter Thompson
Chief Scientist

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