ORV- Sagar Kanya

SK-322 Cruise Report
(July 29th 2015 to August 14th 2015)

Geo-scientific Studies of the Exclusive Economic Zone

NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH
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(GOA)-403804
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1. INTRODUCTION

Judicious utilization of offshore resources is very vital for the economic prosperity of any country in the world. The control over the oceans is regulated by the Law of the Sea convention of 1982, which came into force on November 16, 1994 and it defines oceanic jurisdiction for all countries. This Law extends the legal right to the coastal countries to exploit, develop, manage and conserve all resources to be found in the water and in the sub-soil of an area extending 200 nautical miles from its shore i.e. Exclusive Economic Zone (EEZ).

**Utilities:**
The Exclusive Economic Zone (EEZ), about 200 nautical miles from coast, the zone outside the territorial water of the country over which a country is permitted to do economic activities like fishing and is entitled to explore and exploit the natural resources of the area.

The detailed map of the EEZ shall be useful in the following purposes:

(i) Fishermen for fishing operations using deep trawl or bottom fishing gear,
(ii) Petroleum, natural gas and mineral exploration as well as exploitation,
(iii) Development and assessment of mineral resources,
(iv) Telecommunication industry for lying cables,
(v) Sub-sea pipe lines for geological hazard assessment,
(vi) Effective disposal of waste and reducing pollutants,
(vii) Ocean engineers for constructing and maintaining structures of port and harbor.
Indian EEZ:
India has an Exclusive Economic Zone (EEZ) with an area of about 23,05,143 km$^2$ along its 7516 km coastline (including the coastline of Andaman and Nicobar Islands and Lakshadweep Islands) as shown in figure-1. This constitutes about two-third of the land area of the country. Realizing the need to be cognizant about the enormous potentials of our country’s EEZ, the Government of India has decided to prepare a comprehensive map of entire EEZ of India and National Centre for Antarctic and Ocean Research (NCAOR), Goa has been appointed as the nodal agency for the implementation of this programme.

![Indian EEZ map with the satellite bathymetry data, costal line of India and EEZ boundary of India](image)

**Figure 1: Indian EEZ map with the satellite bathymetry data, costal line of India and EEZ boundary of India**

2. AREA OF OPERATION

The present cruise SK-322 survey was carried out in Arabian Sea. The total area covered is ~13,344 km$^2$. Figure-2 shows shows the area location and track lines.
3. PLANNING OF SURVEY LINES
The survey lines are planned north to south and vice versa. The spacing between the adjacent lines not linear, due to depth is varying from 133 m-4284 m. The lines interval is 3.0 km to cover the achieve area, as shown in figure 2, 4.

4. OBJECTIVE
The primary objective of the SK-322 cruise was to undertake multibeam bathymetric survey in Arabian sea within the EEZ of India as shown in figure-3. In figure 4 shows the bathymetry data with track lines. And in figure-5 shows the Sound Velocity Profile (SVP) locations, Gravity Core (GC) locations.
Figure 3: SK-322 cruise coved area boundaries and processed bathymetry data map with EEZ boundary. Blue color indicates deeper features and red color indicate shallow features.

Figure 4: Processed Bathymetry map with track lines with Indian EEZ boundary.
5. CRUISE ITERNERY

The scientific team embarked onboard the vessel at Mormugao Port, Goa on 29th July 2015. After the successful completion of the survey the vessel returned to Mormugao Port, Goa on 14th August 2015.

- **Departure**: Goa, 29.07.2015
- **Arrival**: Goa, 14.08.2015

6. LIST OF PARTICIPENTS

A total of 20 scientific personnel participated in the cruise and are listed as under:

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<th><strong>NCAOR, GOA</strong></th>
<th><strong>Yogi Vemana University, Kadapa</strong></th>
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<tr>
<td>1. Suman Kilaru</td>
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<td>2. Jaggu Naidu Gulivendula</td>
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<td>5. Viswanatha Vachaspati</td>
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7. METHODOLOGY AND SURVEY EQUIPMENTS

a. Methodology:

The Multibeam survey was carried out using standard Survey practices. The track lines were planned in order to obtain about 20% coverage at average speed of 5-7.5 knots. Navigational and attitude information is provided by C-NAV DGPS system. Ship track was maintained within ±20 m.

b. Equipment details:

7.2.1 SeaBeam-3012 Multibeam Echosounder System:

SeaBeam-3012 Multibeam Echosounder onboard ORV-Sagar Kanya was utilised to carry out the surveys in Off-Chennai region in Bay of Bengal. The SB-3012 is a 12 kHz, 201 beam sonar system, has a beam width of 2° at nadir and is capable of measuring depths ranging from 200 m to 11000 m. Brief technical specification of the SB-3012 MBES system are as follows:

Manufacturer : L3-Communications Elac-Nautik GmbH, Germany

Number of Beams : 201
Swath Coverage: 140°, 2° × 2° (5.5 × Depth), ~20 dB backscatter

Depth: 200 to 11,000 m

Frequency of Operation: 12 kHz

Max. Source Level: 2° = 241 dB/mPa

Pulse Length: 2, 3, 5, 7, 10, 14, 20 ms

Side Lobe Suppression: > -30 dB

Technology: Full motion compensation (Sweptbeam technology)

Acquisition Software: Hydrostar

Data Processing Software: EIVA

The complete Multibeam system complex comprises of many sub systems:

a. Surface Sound velocity (SSV): The surface sound velocity profiler is an underway ocean surface profiling system that collects the water sound speed continuously.

b. Gyro & Motion Sensor: Multibeam system uses IXSEA-Octans sensor for Gyro and motion input. Octans is an IMO compliant survey grade gyrocompass with an integral motion sensor.

c. Positioning System: The C-NAV DGPS subsystem is used for positioning accuracy. C-Nav GcGPS corrections are similar to other wide area DGPS system such as the Federal Aviation Administration’s (FDA) wide area augmentation system (WAAS). The C-Nav GPS receiver can accept two (2) different GcGPS correction service message formats. The C-Nav, dual frequency, GPS equipment receives either of these corrections broadcast from the communications satellite, applies them its own observed refraction corrected C/A code, dual frequency observations, and performs a navigation solution. The resulting corrected GPS position; velocity and time (PVT) are output from the C-Nav equipment to other subsystems on the platform/vehicle/vessel to support the navigation positioning control requirements.

d. Network Time Server with GPS Synchronized Time Base: LANTIME (local area network timeserver) provides a high precision time base to a TCP/IP network (stratum-1-server). The NTP (network time protocol) is used to synchronize all NTP clients with the reference. LANTIME/GPS is a set of equipment composed of a satellite controlled clock GPS167, a single board computer with integrated network board and a power supply, all installed in a metal 19” on the single-board computer flash disk. Four push buttons and a 2 x 40 character LC display can be used configure and monitor the time server. After the network connection has been bestialized, the timeserver can also be configured and monitored remotely from a work station via TELNET or FTP.
e. Network Time Protocol (NTP): NTP is a common method for synchronization of hardware clocks in local and global networks. Timeservers synchronize themselves by a reference time source, such as a radio controlled clock, GPS-receiver or modem time distribution. Stratum-1-server distribute their time to several clients in the network which are called stratum-2. A high precision synchronization is feasible because of the several time references. Every computer synchronizes itself by up to three valued time sources. NTP enable the comparison of the hardware times and the adjustment of the own clock, a time precision of 128 ms, often better than 50 ms is possible.

7.2.2. Conductivity Temperature & Depth (CTD)
As the Sound Velocity Profiler (SVP) depth display was working, for this Sound Velocity Profiler attached with the CTD cast. The vertical structure of sound velocity was derived using SVP and CTD Cast. CTD is used to study various parameters like temperature, conductivity, pressure etc. at various depths. The SBE-911plus was utilized to measure conductivity, temperature, and pressure in depths up to 6,000 meters. The sketch diagram of deployment of CTD as shown in figure 6.

7.2.3: Gravity Coring:
Gravity corer was used for sediment sample collection at one location. The corer consists of an open-ended tube with lead weight (~700kgs). The corer is lowered into the seabed and generally penetrates to a depth of up to 5-6 m. Gravity core lowering as shown in figure 7.
8. SCIENTIFIC OBSERVATION AND OTHER WORK DURING THE CRUISE
   a. During the cruise, the MB data was processed with CARIS and Mapped.
   b. Gravity core was collected at two locations and sample recovered of GC-1 ~4.3 m, GC-2 ~5.2 m. The sediment core was sub-sampled at 1cm interval up to 100 cm, 2 cm up to 200 cm and remaining core at 5cm interval.

9. DIARY OF EVENTS
   29-July-2015, day-01
   • Eight scientific team participants are Signed On 17:30 Hrs. (IST)
   • Nine scientific team participants are Signed On 18:30 Hrs. (IST)

   30-July-2015, day-02
   • One scientific team participant Signed On 12:30 Hrs. (IST)
   • All scientific team participants are Onboard @ 12:30 Hrs. (IST)
   • Vessel Sailed Out from Goa port 16:36 Hrs. (IST)

   RO Water Purifier testing details:
   • RO water purifier testing started (15°26.3’N 73°38.2’E Depth: 30 m)

   31-July-2015, day-03
   Position @ 08:00 Hrs. (IST)
   • Latitude: 15° 26.332’ N Longitude: 73° 38.321’ E
   • Speed: 0 Kts
   • Depth: 25 m
   • Vessel reached Goa port @ 16:36 Hrs. (UTC) and Sailed start @ 17.36 for MBES Survey

   RO Water Purifier testing details:
   • RO water purifier testing completed
   • Vessel
   • Vessel Sailed Out from Goa port 16:36 Hrs. (UTC) (UTC)

   01-August-2015, day-04
   Position @ 08:00 Hrs. (IST)
   • Latitude: 14°40.5’ N Longitude: 072° 36.5’ E
   • Speed: 6.2 Kts
   • Depth: 1556 m
MBES data details:
- Multibeam data collection starting time @ 2:30 Hrs. (UTC)
- Tr.Line-01 start @3:00 Hrs. (UTC) (14°57’37.7112”N 73°06’14.4750”E Depth 160 m)

02-August-2015, day-05
Position @ 08:00 Hrs. (IST)
- Latitude: 13°06.775’ N Long: 070°53.887’ E
- Speed : 6.1 Kts
- Depth : 2170 m

MBES data details:
- Tr.Line-01 end@ 03:42 Hrs. (UTC)(13°00’43.7526”N 70°53’01.7112”E Depth 2550 m)
- CTD & SVP -01 start @ 04:00 Hrs. (UTC) & end @ 07:00 Hrs. (UTC)(13°03.60’ N 070°53.560’E Depth 2483 m)
- Transit to GC-01 @ 08:30 Hrs. (UTC) (Deep sea winch power supply is failed. GC not taken) (13°05’9.2000’ N 070°56’ 1.8500” E)
- Patch_Line-01 start @ 14.20 Hrs. (UTC) (13°00’37.4342”N 70°52’54.3360”E Depth 2572 m)

03-August-2015, day-06
Position @ 08:00 Hrs. (IST)
- Latitude: 13°00.600’N Longitude : 069°35.900’E
- Speed : 6.0 Kts
- Depth : 4343 m

MBES data details:
- Patch_Line-01 end@0740 Hrs(UTC)(13°00’26.4706”N 69°04’41.0052”E Depth 4314 m)
- CTD & SVP -02 start @ 08.19 Hrs. (UTC) & end @ 12.45 Hrs. (UTC) (12°56’97.22” N 69°04’41.6160”E Depth 4326 m).
- Patch_Line-02 start @ 13.20 Hrs. (UTC) (12°56’59.6088” N 70°56’28.2538” E Depth 4321 m)

04-August-2015, day-07
Position @ 08:00 Hrs. (IST)
- Latitude : 12°56’ 59.6088” N Longitude : 70°39’03.2538” E
- Speed : 7.3 Kts
- Depth : 3086 m

MBES data details:
- Patch_Line2-end @ 04.40 Hrs. (UTC) (70°20’40.2535”E 12°5700.9678” N Depth 1544.7 m )
- GC-01 Station reached @ 07.43 Hrs. (UTC) (Due to Deep sea winch break and counter problem GC-01 started delayed )
- GC-01 start @ 10.35 Hrs. (UTC) & end @ 12.10 Hrs.(UTC) (70°56’04.6182”E 13°04’34.8516” N Depth 2134 m) (GC-01 successful, recovered – 4.3 m)
- Patch_Line3-start@13.00 Hrs(UTC) (70°56’57.4284”E 13°05’06.1398” N Depth 2161 m)
- Patch_Line3-end@22.51 Hrs (UTC) (72°00’02.2922”E 12°56’47.8954” N Depth 1602 m)
• Patch_Line4-start@23.00 Hrs(UTC) (72°00'32.2362"E 12°52'28.2240"N Depth 1630 m)

05-August-2015, day-08
Position @ 08:00 Hrs. (IST)
• Latitude: 12°32'08.2486"N Longitude: 72°00'35.8082"E
• Speed : 6.7 Kts
• Depth : 1721 m

MBES data details:
• Patch_Line4-end@05.16 Hrs(UTC) (72°03'02.0514"E 12°15'35.9650"N Depth 1689 m)
• CTD & SVP -03 start @ 05.46 Hrs. (UTC) & end @ 07.35 Hrs. (UTC)
  (72°03'19.9700"E 12°15'40.6700"N Depth 1729 m)
• Patch_Line5-start@08.34 Hrs(UTC) (72°03'00.9054"E 12°14'42.9588"N Depth 1743 m)
• Patch_Line5-end@16.26 Hrs (UTC) (72°08'05.9548"E 12°58'07.8264"N Depth 1216 m)
• Tr.Line -2 start @ 16.30 Hrs. (UTC) (72°09'06.3620"E 12°58'35.9738"N Depth 1240 m)

06-August-2015, day-09
Position @ 08:00 Hrs. (IST)
• Latitude: 13°45'24.1758"N Longitude: 71°58'10.7190"E
• Speed : 5.8 Kts
• Depth : 1546 m

MBES data details:
• Tr.Line2-end @ 12.06 Hrs. (UTC) (72°38'51.5108"E 14°28'37.7102"N Depth 1961 m)
• CTD & SVP -04 start @ 13.00 Hrs. (UTC) & end @ 15.22 Hrs. (72°39'17.7772"E
  14°28'35.0490"N Depth 1950 m)
• Line-01 start @ 16.12 Hrs. (UTC) (72°39'34.0002"E 14°28'00.3666"N Depth 1938 m)

07-August-2015, day-10
Position @ 08:00 Hrs. (IST)
• Latitude: 15°20'06.6900"N Longitude: 72°12'32.2002"E
• Speed : 6.3 Kts
• Depth : 2042 m

MBES data details:
• Line-01 end @ 13.52 Hrs. (UTC) (71°50'52.2834"E 16°07'38.8738"N Depth 1795 m)
• Line-02 start @ 14.20 Hrs. (UTC) (71°50'10.9000"E 16°07'11.7300"N Depth 1706 m)

08-August-2015, day-11
Position @ 08:00 Hrs. (IST)
• Latitude: 14°48'46.5354"N Longitude: 72°30'27.2982"E
• Speed : 7.2 Kts
• Depth : 1690 m
MBES data details:
- Line-02 end @ 05.46 Hrs. (UTC) (72°40'50.3136"E 14°28'32.8042" N Depth 1769 m)
- Line-03 start @ 06.16 Hrs. (UTC) (72°40'51.8621"E 14°27'51.8432" N Depth 1692 m)

09-August-2015, day-12
Position @ 08:00 Hrs. (IST)
- Latitude: 16°07'59.1948"N   Longitude: 71°51'48.1122"E
- Speed : 0.9 Kts
- Depth : 1776 m

MBES data details:
- Line-03 End @ 02.23 Hrs. (UTC) (71°51'48.1122"E 16°07'59.1948" N Depth 1776 m)
- CTD & SVP -05 start @ 03.24 Hrs. (UTC) & end @ 05.08 Hrs. (UTC) (71°51'48.6660"E 16°08'07.9154" N Depth 1776 m)
- Line-04 start @ 06.24 Hrs. (UTC) (71°52'58.8870"E 16°09'47.2716" N Depth 1707 m)

10-August-2015, day-13
Position @ 08:00 Hrs. (IST)
- Latitude: 14°28'32.1060"N   Longitude: 72°45'26.8308"E
- Speed : 2.4 Kts
- Depth : 1521 m

MBES data details:
- Line-04 end @ 01.24 Hrs. (UTC) (72°43'56.7400"E 14°28'40.8700" N Depth 1600 m)
- CTD & SVP -06 start @ 02.20 Hrs. (UTC) & 06 end @ 03.54 Hrs. (UTC) (72°45'33.8946"E 14°28'35.3172" N Depth 1502 m)
- Line-05 start @ 05.00 Hrs. (UTC) (72°45'26.9040"E 14°28'42.6558" N Depth 1498 m)
- Line-05 end @ 11.49 Hrs. (UTC) (72°28'41.0046"E 15°02'10.8540" N Depth 1432 m)
- GC-02 start @ 13.45 Hrs. (UTC) & end @ 14.29 Hrs. (UTC) (72°26'34.4820"E 15°00'18.9198" N Depth 517 m) (GC-02 successful, recovered -5.2 m)
- Line-05A start @ 15.30 Hrs. (UTC) (72°29'14.3454"E 15°01'19.0958" N Depth 1401 m)

11-August-2015, day-14
Position @ 08:00 Hrs. (IST)
- Latitude : 16°06'14.7174"N   Longitude : 71°56'52.8216"E
- Speed : 6.6 Kts
- Depth : 1747 m

MBES data details:
- Line-05A end @ 03.13 Hrs. (UTC) (71°54'50.6460"E 16°10'20.4546"N Depth 1697 m)
- Line-06 start @ 03.38 Hrs. (UTC) (71°56'28.7622"E 16°11'19.4354"N Depth 1650 m)
- Line-06 end @ 19.57 Hrs. (UTC) (72°47'01.9721"E 14°28'36.6214"N Depth 1338 m)
- Line-07 start @ 21.32 Hrs. (UTC) (72°48'56.0040"E 14°27'57.4734"N Depth 837 m)
12-August-2015, day-15

Position @ 08:00 Hrs. (IST)

- Latitude : 14°51'42.4710"N Longitude : 072°37'23.6160"E
- Speed : 4.9 Kts
- Depth : 643 m

MBES data details:

- Line-07 end @ 02.39 Hrs. (UTC) (72°37'04.2942"E 14°52'22.7346" N Depth 548 m)
- Line-07-Tr.01start@02.44 Hrs(UTC) (72°36'51.2670"E 14°52'01.4814" N Depth 658 m)
- Line-07-Tr.01end@03.12 Hrs(UTC)(72°35'48.2076"E 14°49'52.4124" N Depth 1003 m)
- Line-07-P01 start@03.13 Hrs(UTC) (72°35'51.2280"E 14°49'45.4156" N Depth 1005 m)
- Line-07-P01 end@ 04.51 Hrs. (UTC) (72°38'01.1706"E 14°42'20.6994" N Depth 774 m)
- Line-07-P02 start@04.53 Hrs. (UTC) (72°37'57.1428"E 14°42'25.6518" N Depth 718 m)
- Line-07-P02 end@ 06.00 Hrs. (UTC) (72°35'02.0500"E 14°47'46.3914" N Depth 977 m)
- Line-07-Tr.02 start@06.02 Hrs(UTC)(72°35'02.6538"E 14°47'53.8242" N Depth 1031 m)
- Line-07-Tr.02 end@07.56 Hrs(UTC) (72°41'57.3954"E 14°41'02.9590" N Depth 940 m)
- Line-07-P03 start@07.58 Hrs. (UTC) (72°42'13.5038"E 14°40'49.2322" N Depth 987 m)
- Line-07-P03 end @11.00 Hrs. (UTC) (72°37'13.7946"E 14°51'57.8040" N Depth 614 m)
- Line-07A start @ 11.02 Hrs. (UTC) (72°37'11.8836"E 14°52'07.3080" N Depth 558 m)
- Line-07A end @ 02.15 Hrs. (UTC) (71°57'59.4876"E 16°12'29.6508" N Depth 1582 m)

13-August-2015, day-16

Position @ 08.00 Hrs. (UTC)

- Latitude : 16°13'37.2294"N Longitude : 071°59'20.0476"E
- Speed : 6.0 Kts
- Depth : 1453 m

MBES data details:

- Line-08 start @ 02.54 Hrs. (UTC) (16°13'34.1112"N 71°59'33.0729"E Depth 1444 m)
- Line-08 end @ 13.08 Hrs. (UTC) (15°09'08.9772"N 72°30'52.9956" Depth 1484 m)
- Tr.Line-03 start @ 13.09 Hrs. (UTC) (15°09'11.5416"N 72°31'01.9722" Depth 1479 m)
- Tr.Line-03 end @ 16:00 Hrs. (UTC) (15°13'21.1956"N 72°49'58.4454" Depth 370 m)
- Vessel sailing start @ 16:01 Hrs. (UTC) towards Mormugao Port, Goa

14-August-2015, day-17

- Vessel reached Mormugao port, Goa @ 08:00 (IST)
10. ACKNOWLEDGEMENT

The Chief Scientist and participants of SK-316 place on record their deep sense of gratitude to Director, National Centre for Antarctic and Ocean Research, for assigning responsibilities for EEZ survey cruise. Team is also thankful to Dr. John Kurian P., Mr. Abhishek Tyagi and Mr. M. M. Subramaniam for their support for the success of SK-322 cruise. The Scientific team also wishes to thank the Master and crew of the vessel for their co-operation during the cruise. The support and co-operation rendered by NORINCO personnel is appreciated.
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**Annexure-II**

**DETAILS OF CTD AND SVP OPERATIONS**

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**Annexure-III**

**DETAILS OF SEDIMENT SAMPLING**

*Gravity Core Locations:*

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