# Indian Polymetallic massive sulphides Program

**Presented by**
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**(Ministry of Earth Sciences, Government of India)**

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# Outline:

- Plan of work for environmental base line studies
- Preliminary results

**The proposed environmental study broadly includes**

- ❑ Establishment of environmental baselines
- ❑ Environmental monitoring programme
- ❑ Assessment of possible impact of proposed exploration activities
- ❑ The activities will be covered in three phases: Phase I (0-5 year), Phase II (6-10 year) and Phase III (11-15 year)
- ❑ The study will be made in accordance with the Regulations and any environmental rules, regulations and procedures established by the Authority taking into account any recommendations issued by the Legal and Technical Commission.

The study will cover both benthic and pelagic environment including microbial component of the application area.

**The activities are proposed to cover :**

- Active hydrothermal sites (particularly chemosynthesis)
- Dormant/inactive hydrothermal sites

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## Sequence of Work/Study

The entire programme of work is proposed to proceed through the following steps:

i) Oceanographic and Environmental Baseline date collection.
The periods of Phase I and also Phase II will be devoted to collection of Baseline oceanographic and environmental data.

ii) Identification of Impact reference area and Preservation reference area.

By the end of Phase II (Year 10), the programme will identify/delineate

- Impact reference area
- Preservation reference areas

(iii) Assessment of Impact of Exploration activities on marine environment
In the Phase III period, it is proposed to carry out the assessment of possible impact of exploration activities on the marine environment in the Impact reference area.

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**The major activities under the programme will include:**

- Meteorological date collection
- Geoacoustic profiling
- TV and Photo profiling
- Collection of sediment/rock samples from seafloor and sub-surface
- Water column sampling
- Conductivity, Temperature and Pressure profiling
- Mooring system deployment with current meters and sediment traps for evaluation of lithogenic and biogenic fluxes

# Yearly schedule of environmental baseline data collection

| Activity | Years | | | | |
|---|---|---|---|---|---|
| | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
| Multibeam bathymetry, side-scan sonar imaging | | | | | |
| Meteorological data collection | | | | | |
| CTD measurements | | | | | |
| Water column studies and sampling for biomass | | | | | |
| Sediment-trap and mooring system deployment | | | | | |
| ADCP, MAPR surveys | | | | | |
| Data processing, analyses and interpretation | | | | | |
| Survey using unmanned submersible | | | | | |
| Synthesis of all field and laboratory data and submission of reports at the end of each year | | | | | |
| Synthesis of all field and laboratory data, and submission of an integrated environmental baseline report | | | | | |

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# Preliminary results of environmental baselines studies

**As per (ISBA/10/LTC/4; ISBA/19/LTC/8)**

Key parameters

- Geophysical studies
- Geological studies
- Physical oceanographic studies
- Chemical oceanographic studies
- Biological studies

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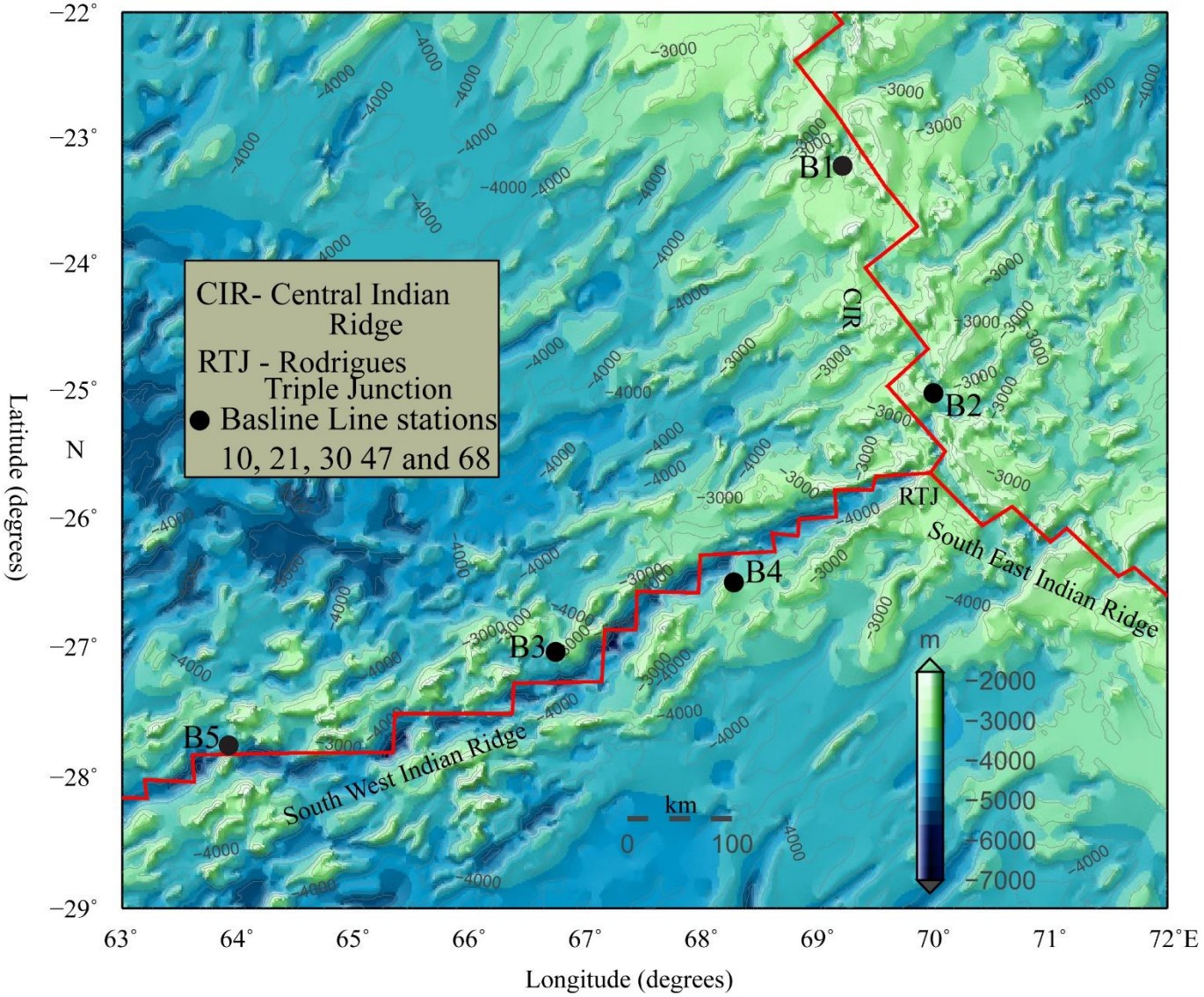
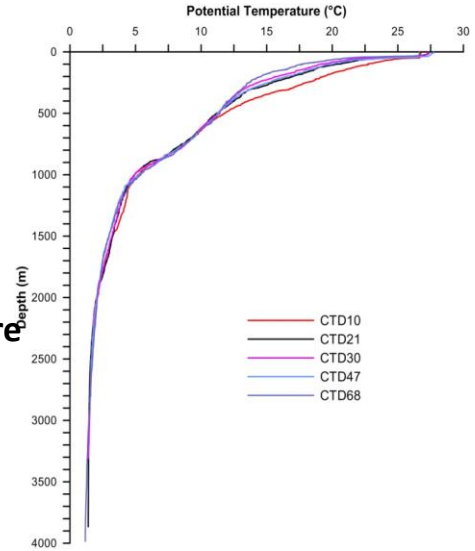



Station locations

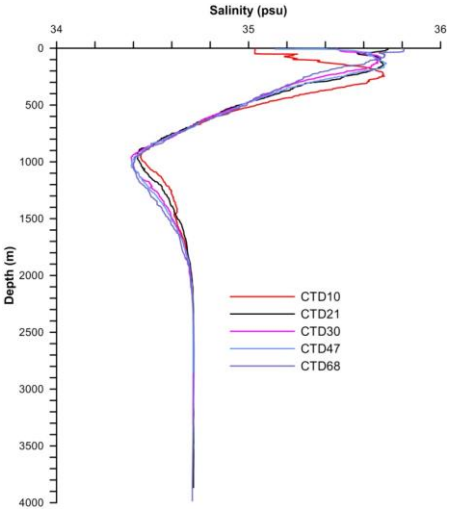
# Environmental baseline studies

## i) Physical oceanographic studies

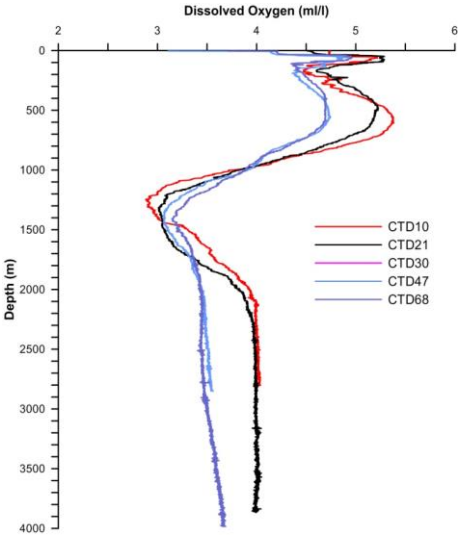
Potential temperature



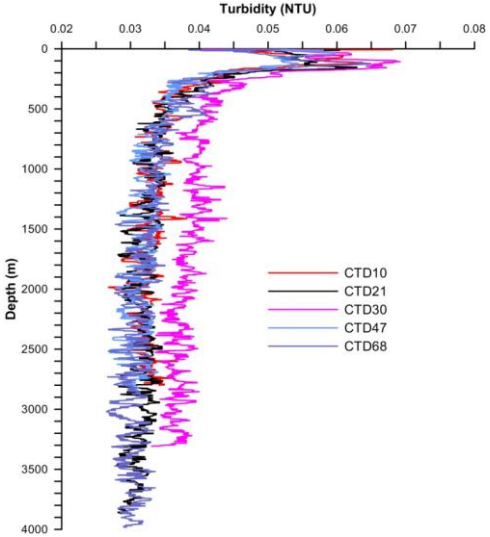

Salinity




Dissolved oxygen




Turbidity

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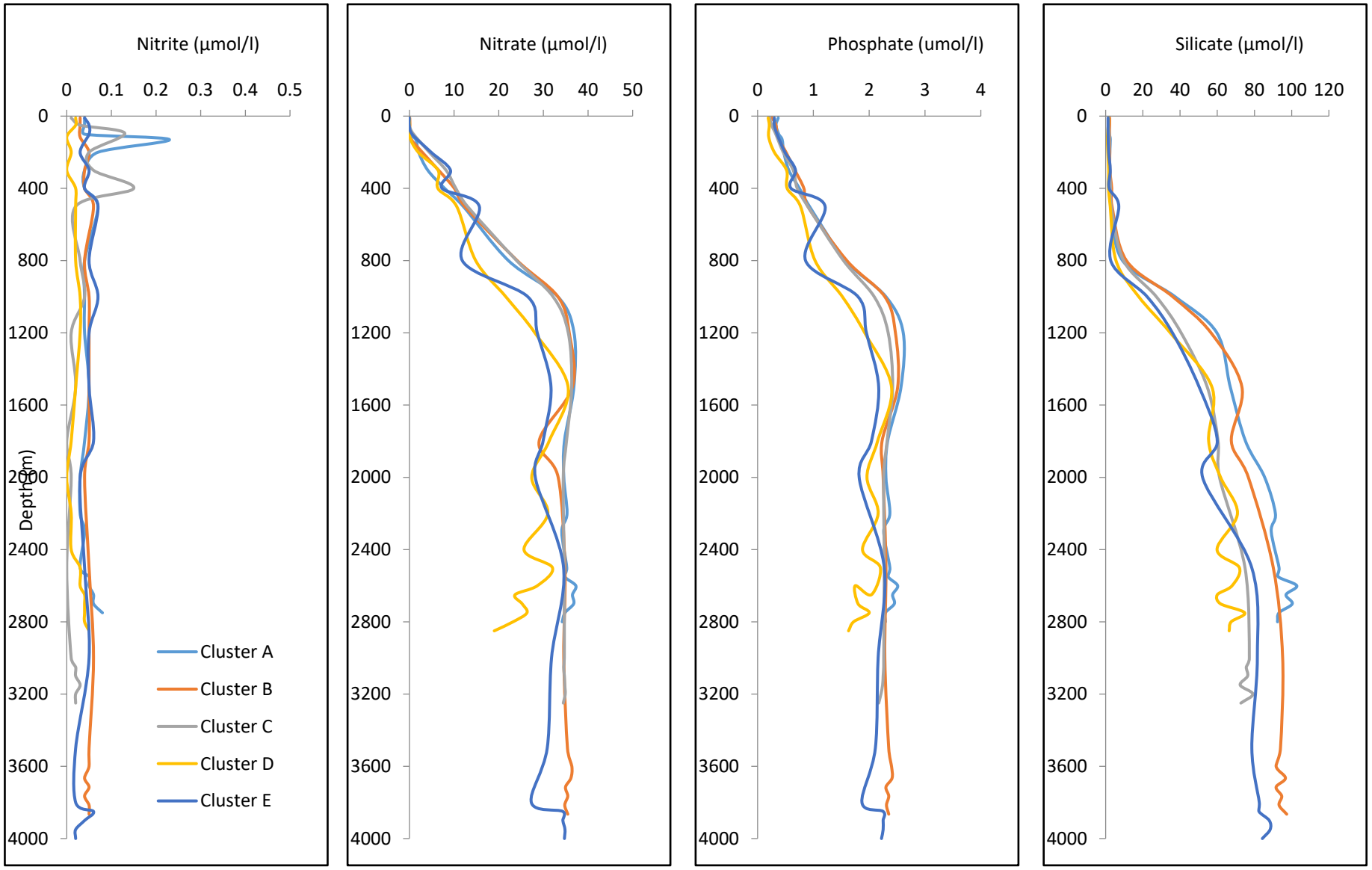
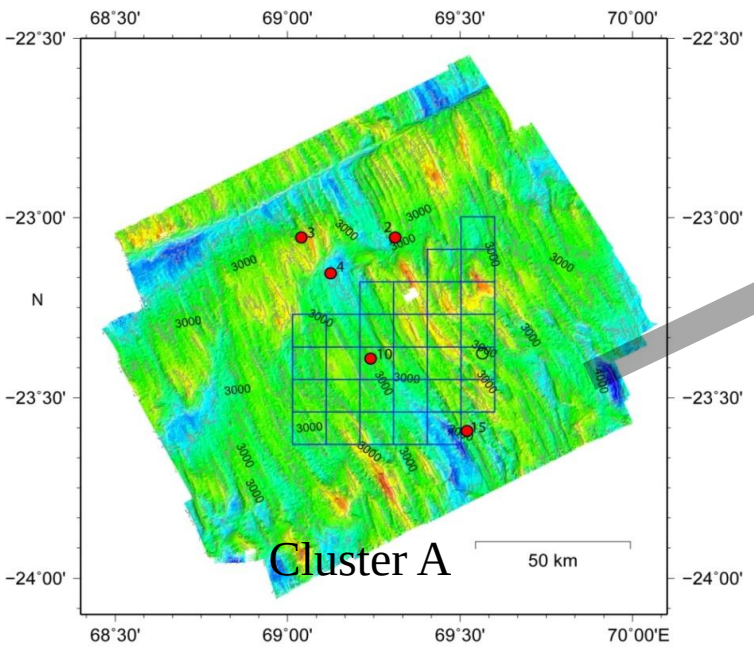
# ii) Chemical oceanographic studies

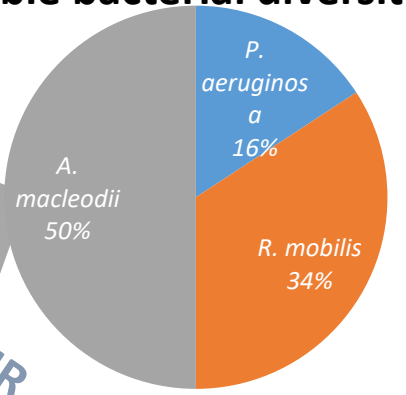



**Nutrients (Nitrite, Nitrate, Phosphate and Silicate) profiles**

# Biological Studies

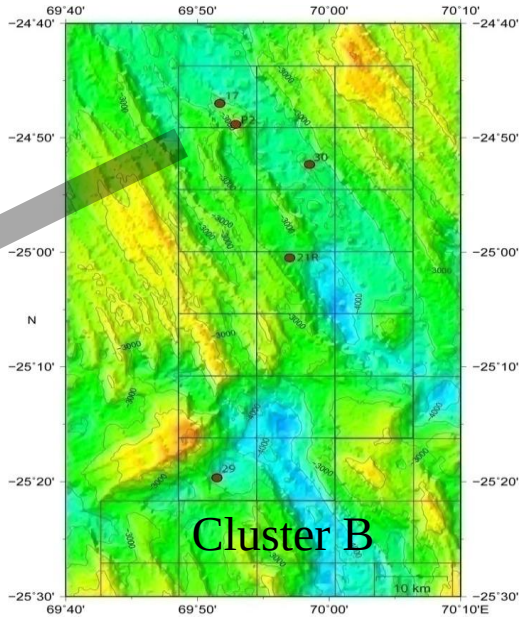
## Culturable bacterial diversity

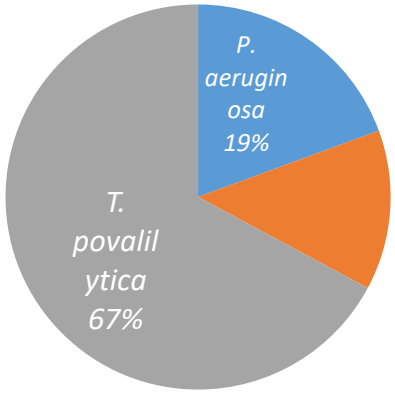



CIR

2880 m




2457 m

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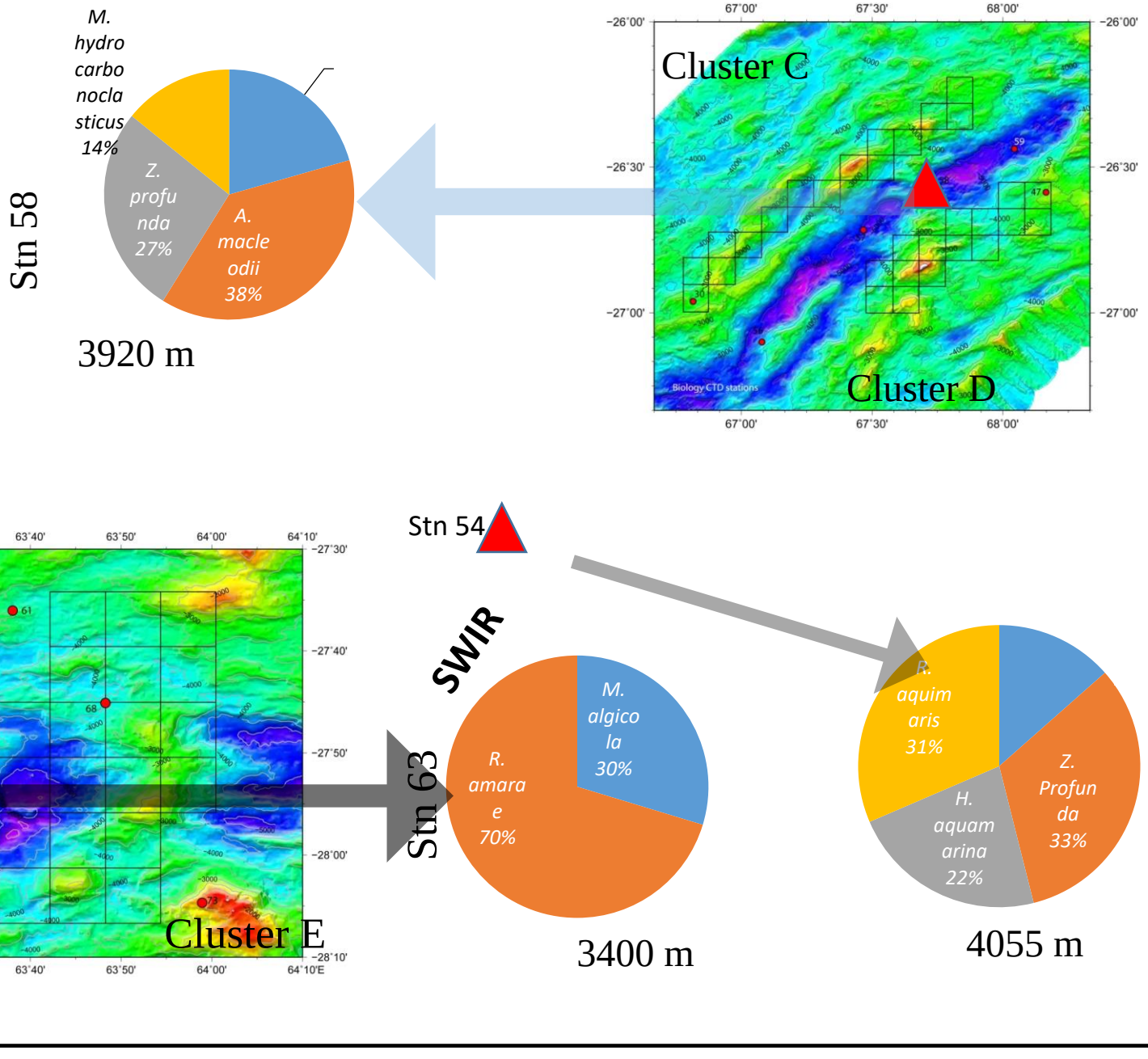
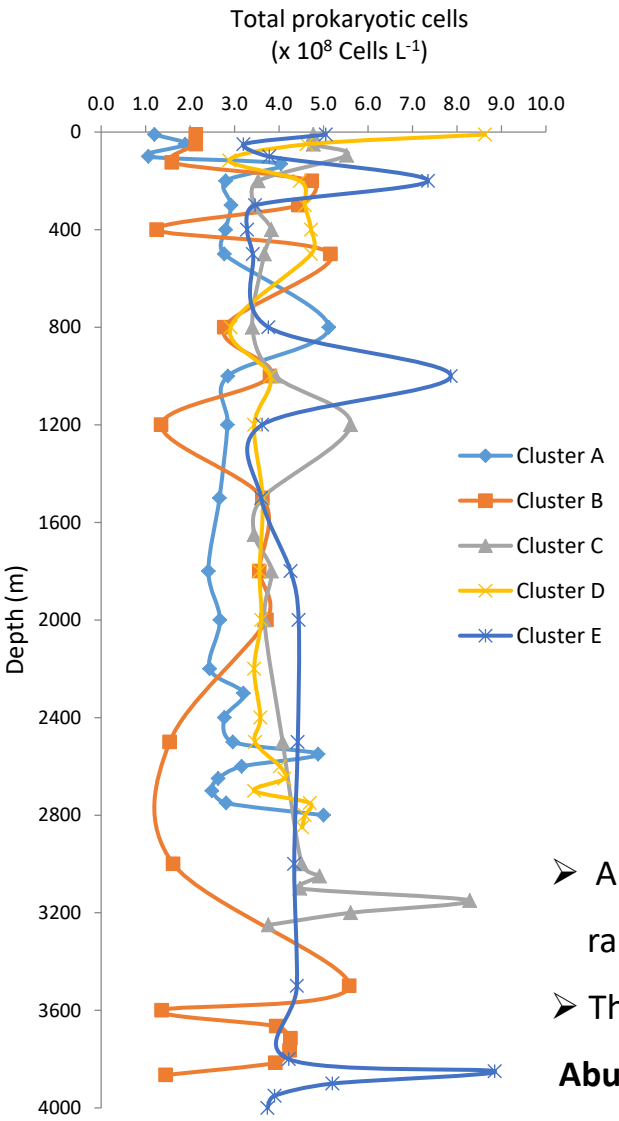
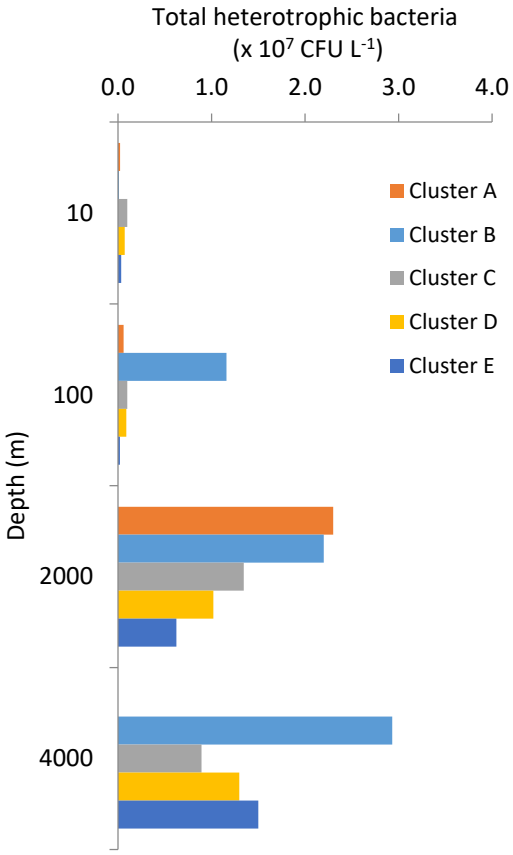
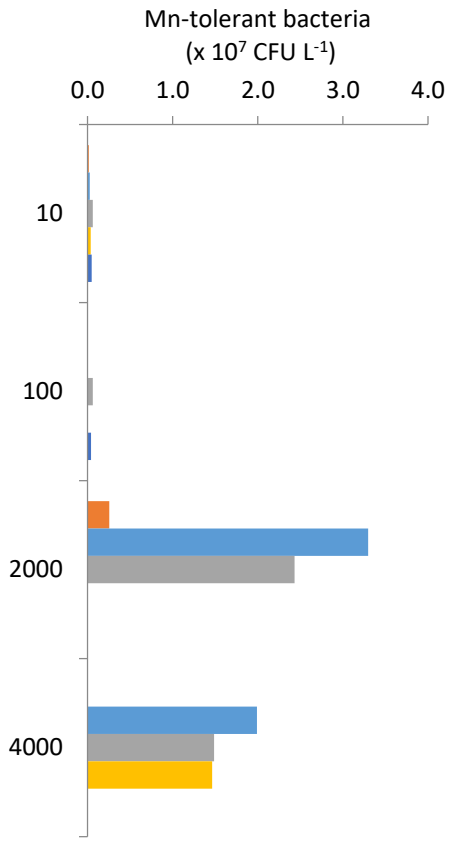

M. hydro carbo nocla sticus 14%
Z. profu nda 27%
A. macle odii 38%
Stn 58
3920 m
Cluster C
Cluster D
Biology CTD stations
Stn 54
SWIR
Stn 63
M. algico la 30%
R. amara e 70%
3400 m
R. aquim aris 31%
Z. Profun da 33%
H. aquam arina 22%
4055 m
Cluster E

# Microbial abundance in environmental baseline study locations



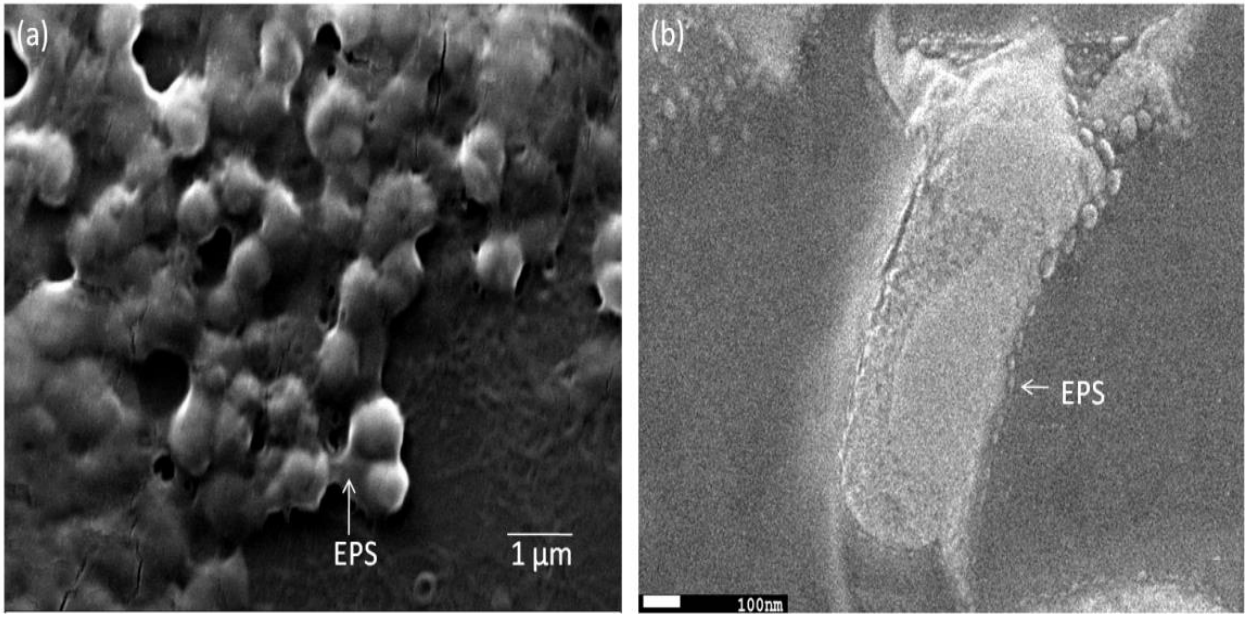




- Abundance of total heterotrophic bacteria (THB) & Mn-tolerant bacteria (MTB) ranged from $10^{6\text{-}7}$ CFU $L^{-1}$ and formed 10 % of the total prokaryotes.
- The THB and MTB were more abundant in the deeper waters ( ≥ 2000 m).

**Abundance of THB & MTB in deeper water linked to availability of hydrothermally-derived substrates like $Mn^{2+}$ which could serve as a source of energy.**

## Novel bacterial species

A novel exopolysaccharide-producing strain designated as 5.12$^{T}$, was isolated from the sediment sample of SWIR.




**The isolate was reported as novel species under the genus *Alteromonas*, for which the name *Alteromonas pelagimontana* sp. nov. was coined.**

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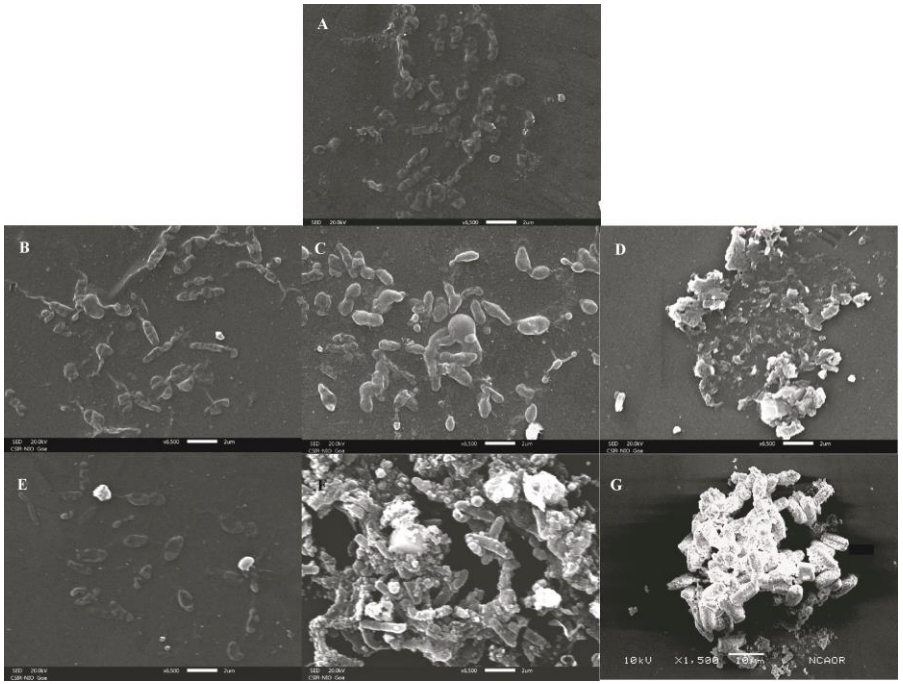
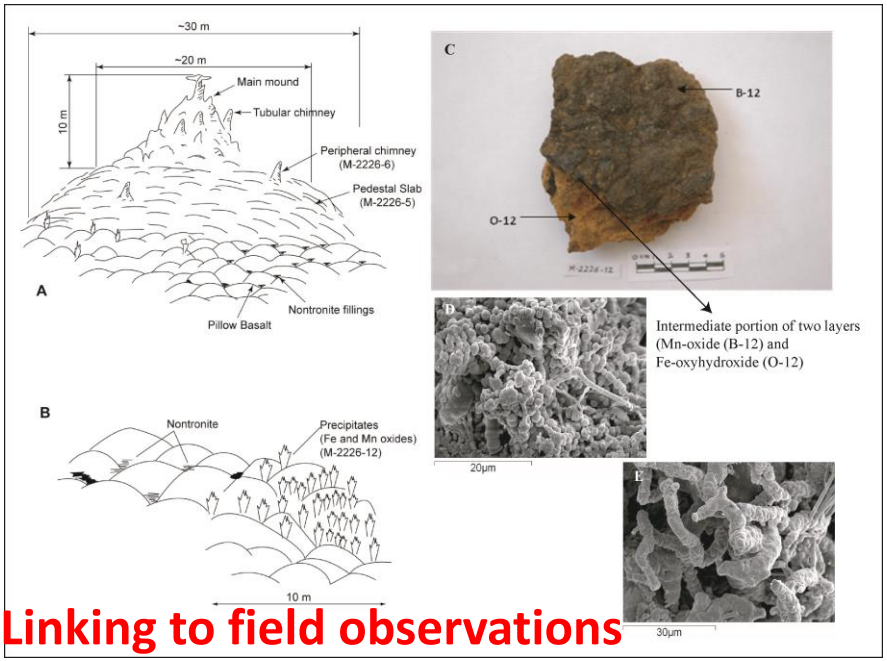
**Biological Studies** Two Mn-oxidizing bacterial strains - *Halomonas meridiana* and *Marinobacter algicola* isolated from SWIR waters were capable of transforming $Mn^{2+}$ to an insoluble oxide viz., Rhodochrosite.

## Lab experiment




- At > 1 mM $Mn^{2+}$ (F & G), *M. algicola* cells show enlargement & clustering of cells in exopolymeric secretion (EPS).
- The EPS acts as a nucleation site for Mn-oxide deposition which occurs in the form of microspherical aggregates.

## Linking to field observations




Microspherical aggregates show striking resemblance to biogenically produced Fe-Mn oxide deposits from Lau Basin.

- *H. meridiana* & *M. algicola* play a vital role in controlling the chemistry of $Mn^{2+}$ in ridge ecosystems.

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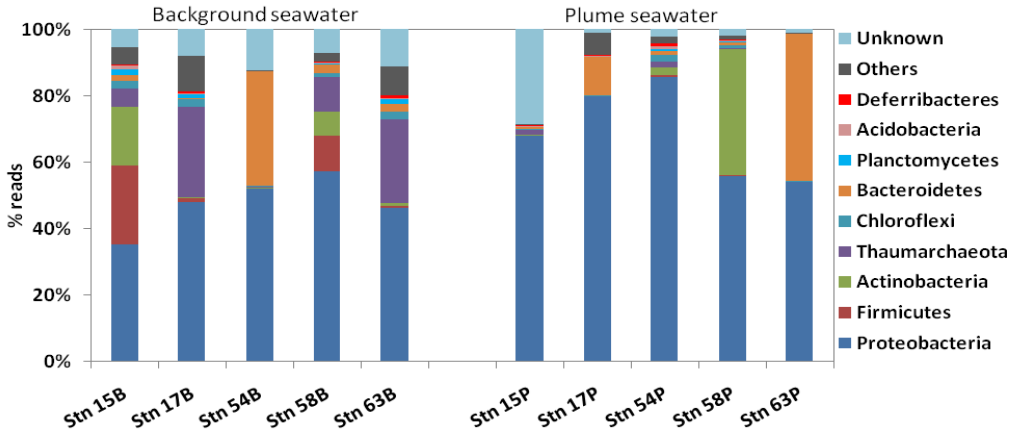
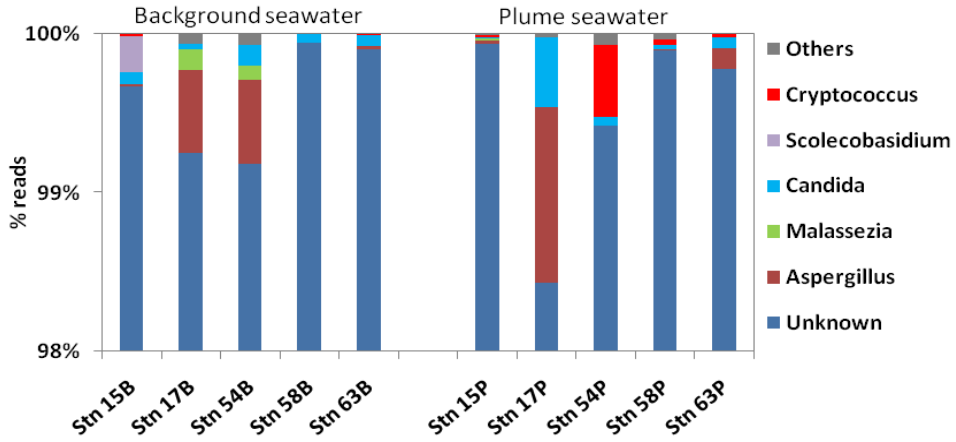
# Microbial community in plume waters




Abundance of bacterial phyla in background v/s plume seawater

## Bacteria

- Dominant phylum: Proteobacteria
  - Abundance: Ambient seawater: < 50%
  - Plume seawater: ~ 50-80%
- Other dominant phyla: Actinobacteria, Bacteroidetes and unknown phylum




Abundance of fungal genera in background v/s plume seawater

## Fungi

- Dominant phylum (overall): Unknown (> 98 %)
- Other dominant phyla in ambient seawater: Aspergillus, Scolecobasidium, Malassezia and Candida
- Other dominant phyla in plume waters: Candida, Aspergillus & Cryptococcus

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## Publications:


1. **Rupesh Kumar Sinha**, **K.P. Krishnan**, **Archana Singh**, **Femi Anna Thomas**, **Anand Jain**, **P. John Kurian** (2017) *Alteromonas pelagimontana* sp. nov., a marine exopolysaccharide-producing bacterium isolated from the Southwest Indian Ridge. *International Journal of Systematic and Evolutionary Microbiology.* doi: 10.1099/ijsem.0.002245

2. **Rupesh Kumar Sinha**, **K.P. Krishnan, P. John Kurian** (2017): Draft Genome Sequence of *Idiomarina* sp. strain 5.13, a highly stress-resistant bacterium isolated from the Southwest Indian Ridge. *Genome Announcement*. doi: 10.1128/genomeA.01747-16.

3. **Fernandes S.O., Lankalapalli S. P.**, Binish M. B., **Krishnan K. P., Kurian J**. 2018. Changes in morphology and metabolism enable Mn-oxidizing bacteria from mid-oceanic ridge environments to counter metal-induced stress. *Journal of Basic Microbiology* 1-13.

# Thank you