GEOTRACES (India) Programme
&
Its Extension to Bio-GEOTRACES

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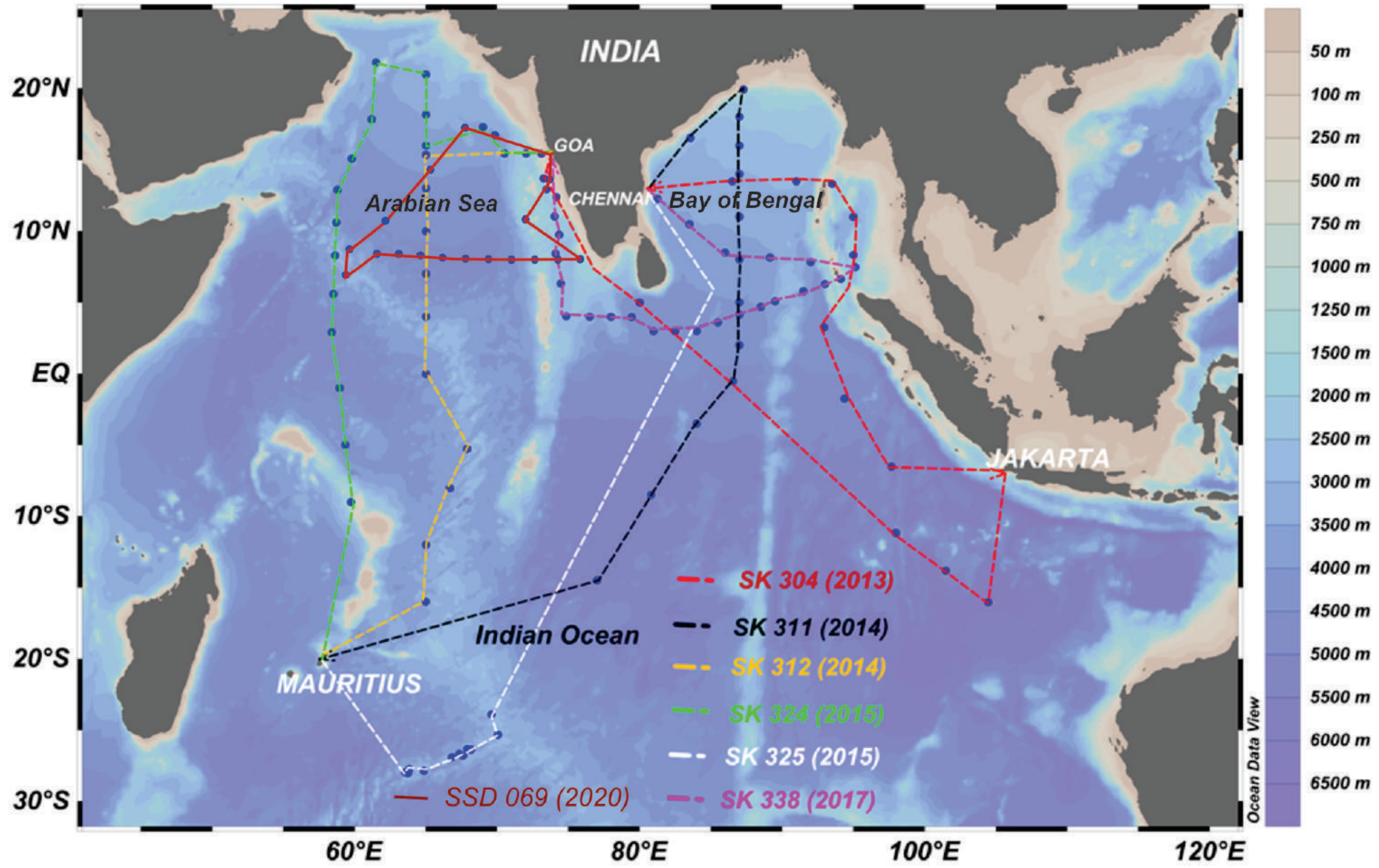
GEOTRACES
An International Study of the Marine Biogeochemical Cycles of Trace Elements and their Isotopes

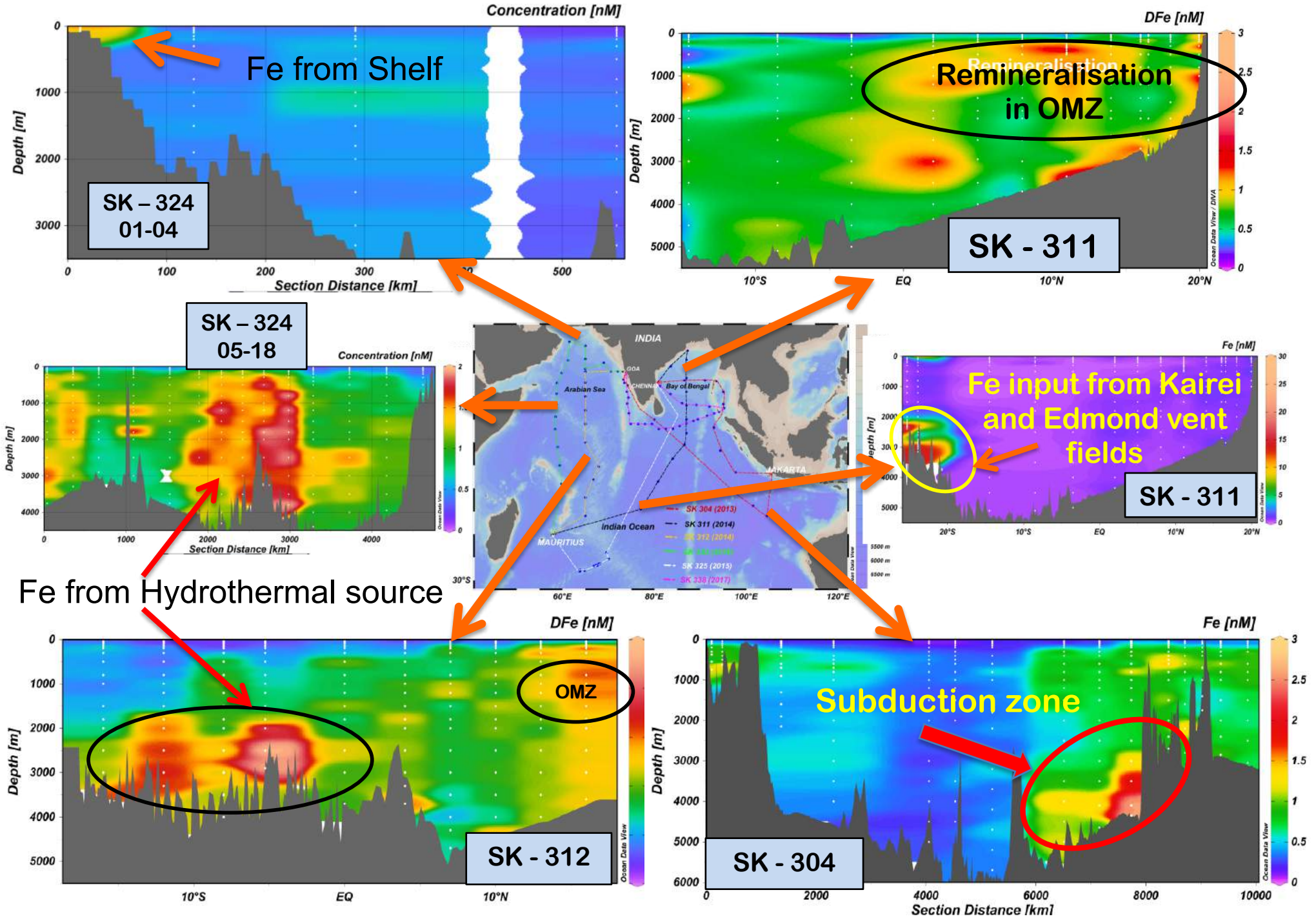
Government of India
Ministry of Earth Sciences

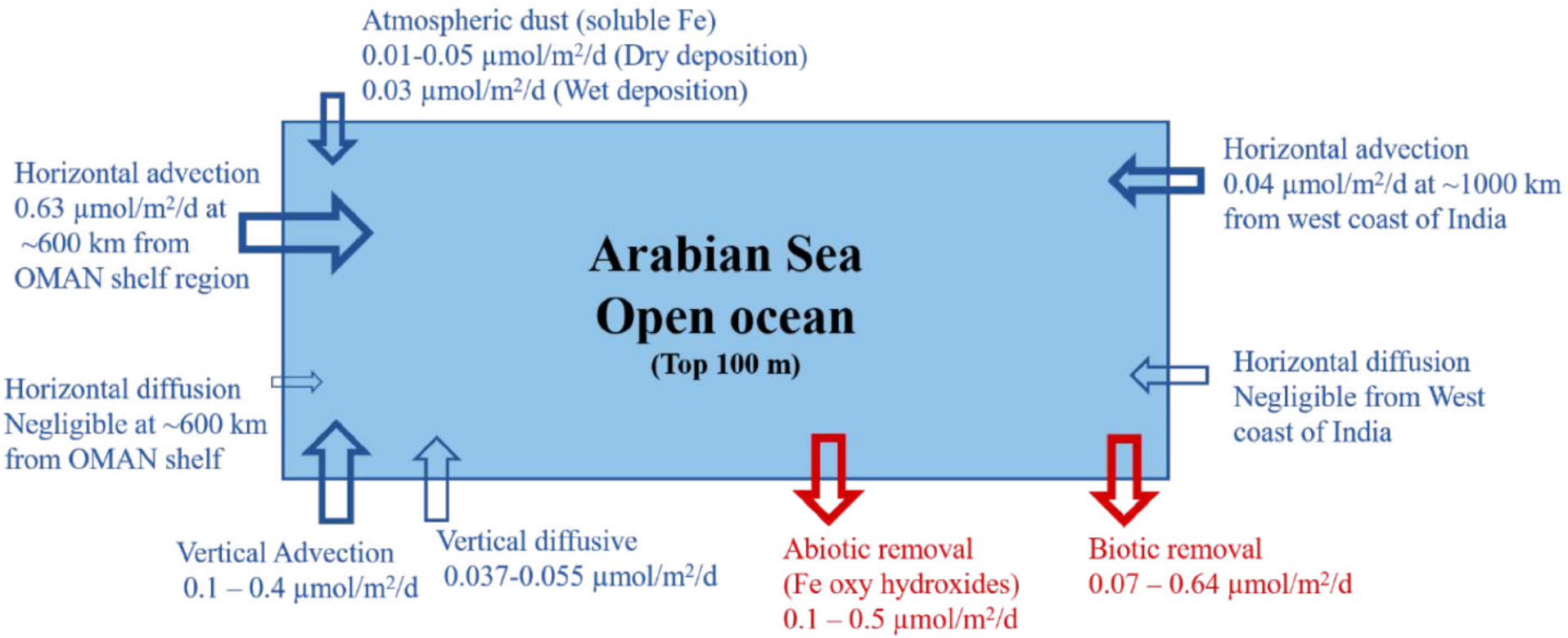
IIOE-2, 14April2021

GEOTRACES India: Completed cruises

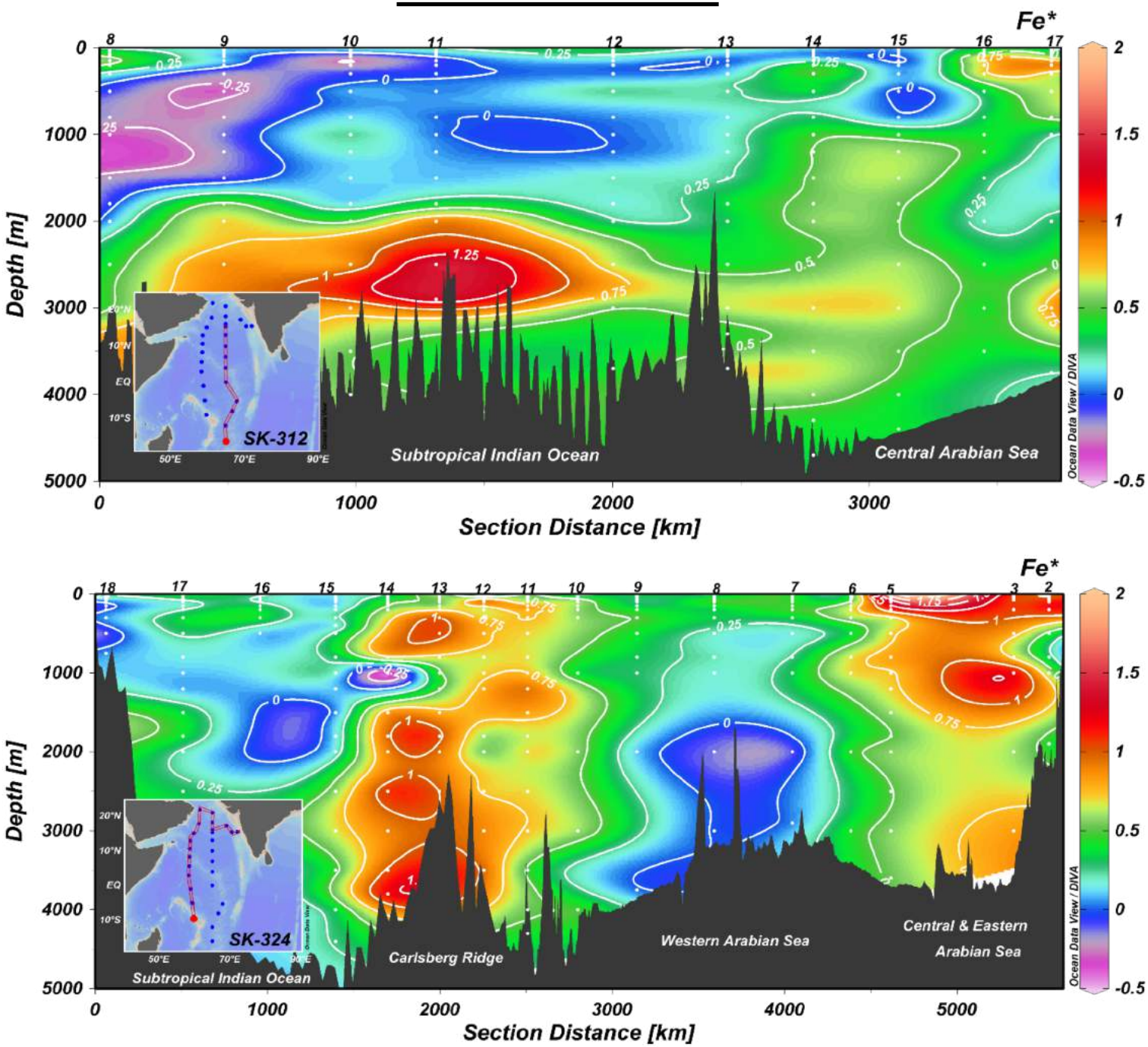


Sources of Dissolved Fe in the Indian Ocean and productivity

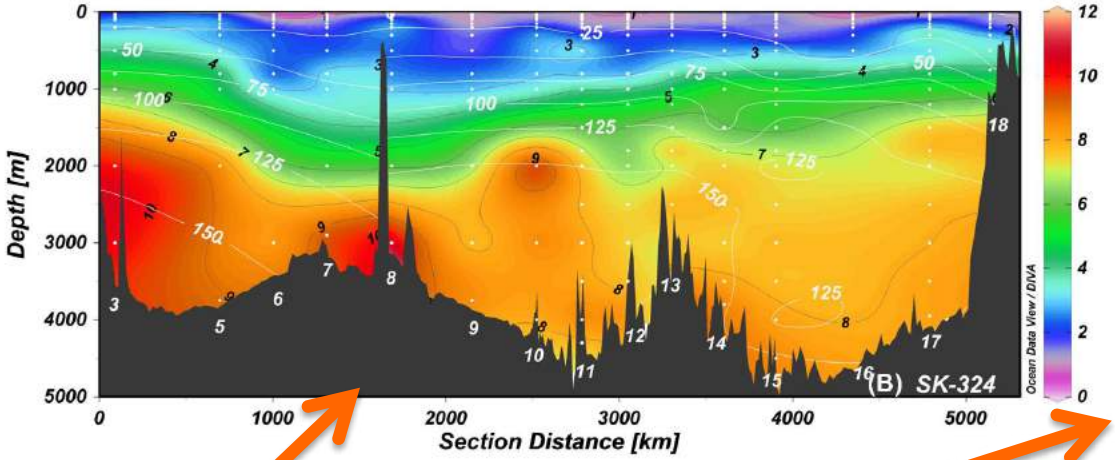


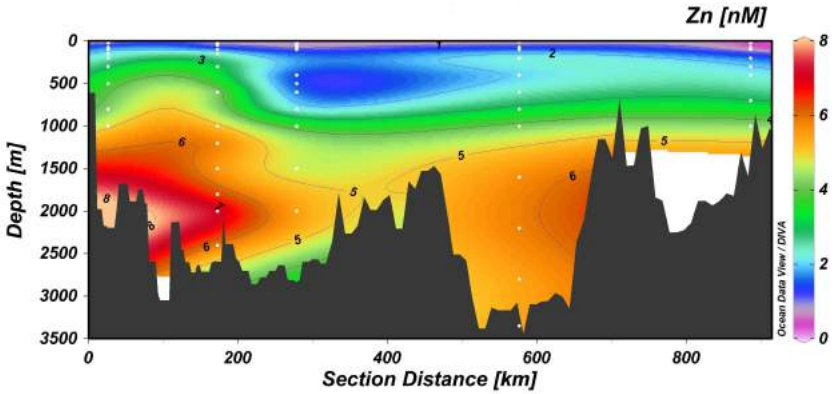

Atmospheric dust (soluble Fe)
0.01-0.05 µmol/m²/d (Dry deposition)
0.03 µmol/m²/d (Wet deposition)
Horizontal advection
0.63 µmol/m²/d at
~600 km from
OMAN shelf region
Arabian Sea
Open ocean
(Top 100 m)
Horizontal advection
0.04 µmol/m²/d at ~1000 km
from west coast of India
Horizontal diffusion
Negligible at ~600 km
from OMAN shelf
Horizontal diffusion
Negligible from West
coast of India
Vertical Advection
0.1 – 0.4 µmol/m²/d
Vertical diffusive
0.037-0.055 µmol/m²/d
Abiotic removal
(Fe oxy hydroxides)
0.1 – 0.5 µmol/m²/d
Biotic removal
0.07 – 0.64 µmol/m²/d

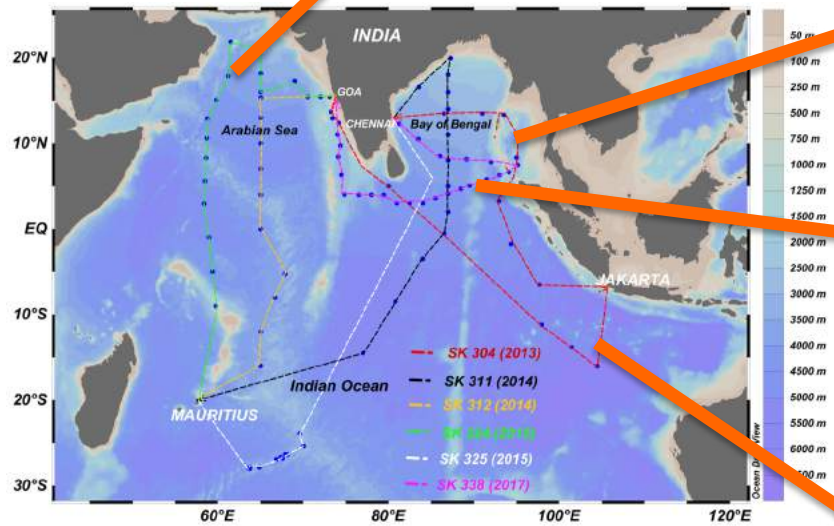
Fe Limitation

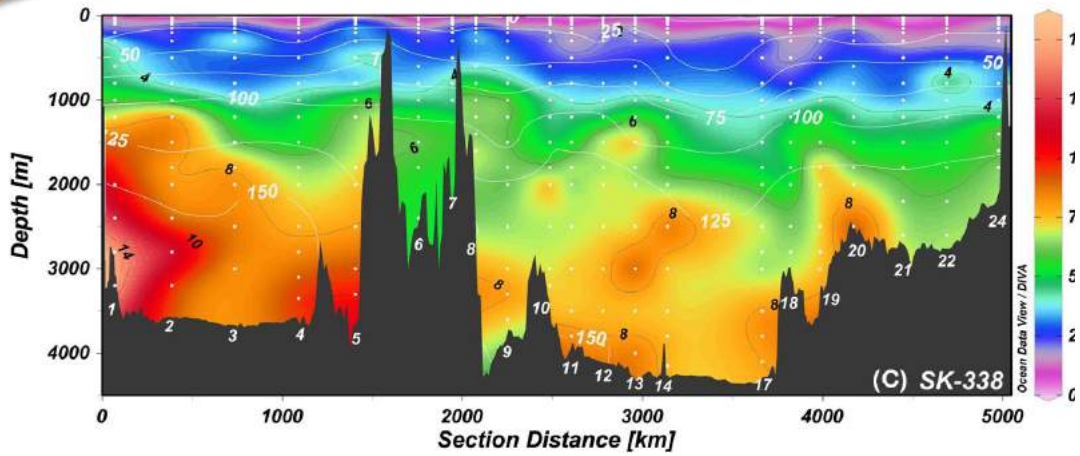


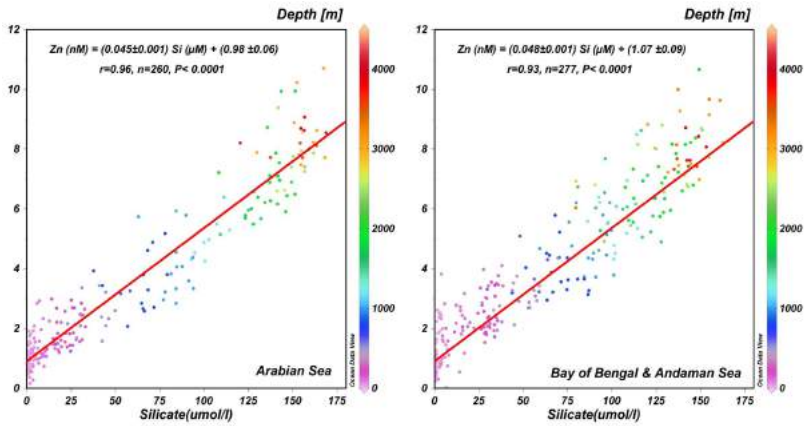
dZn in Indian Ocean

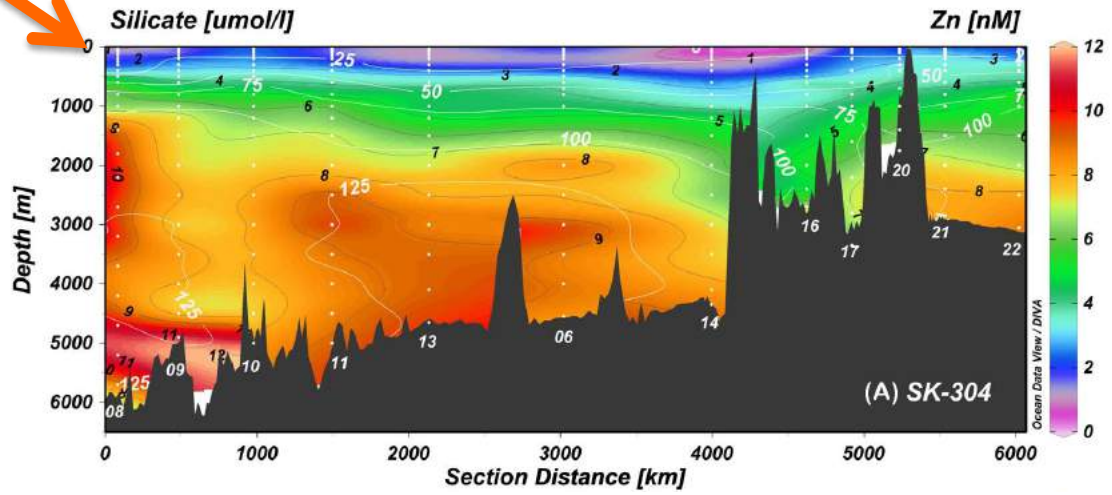




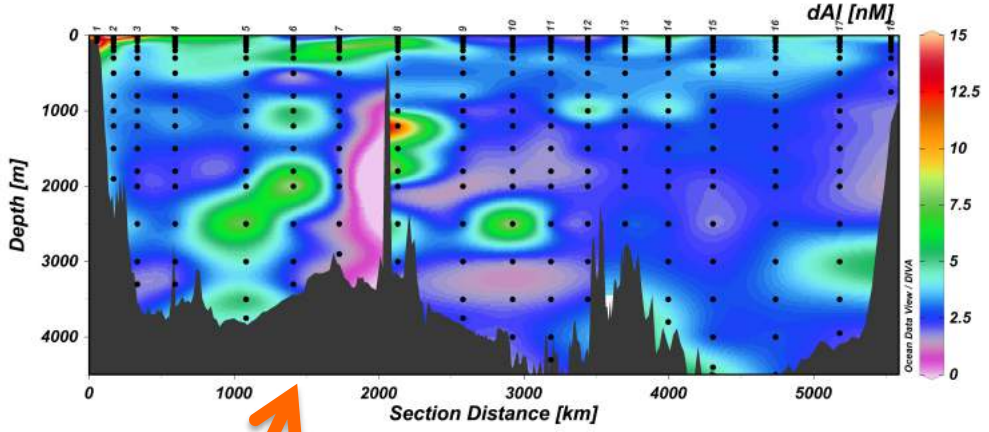


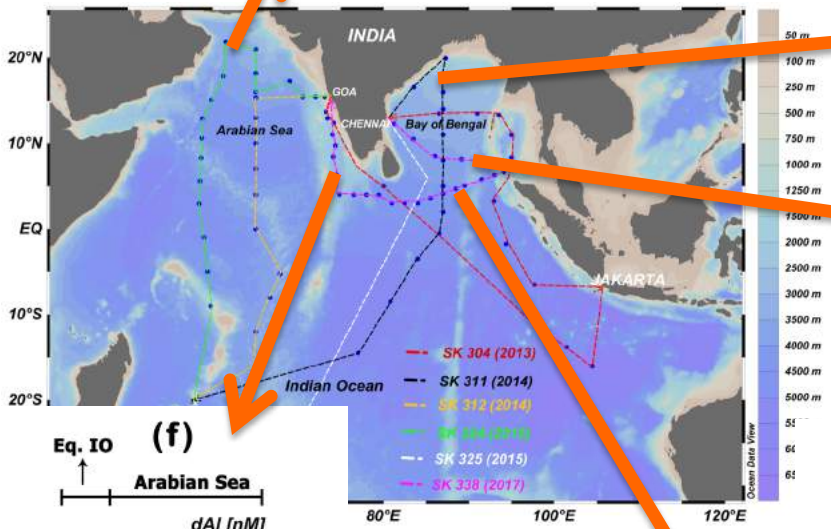


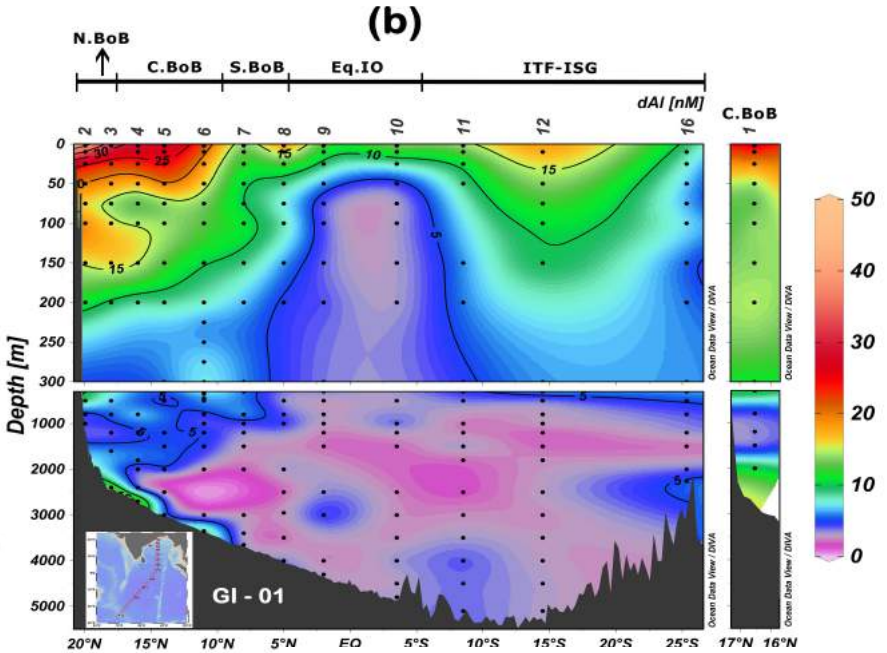


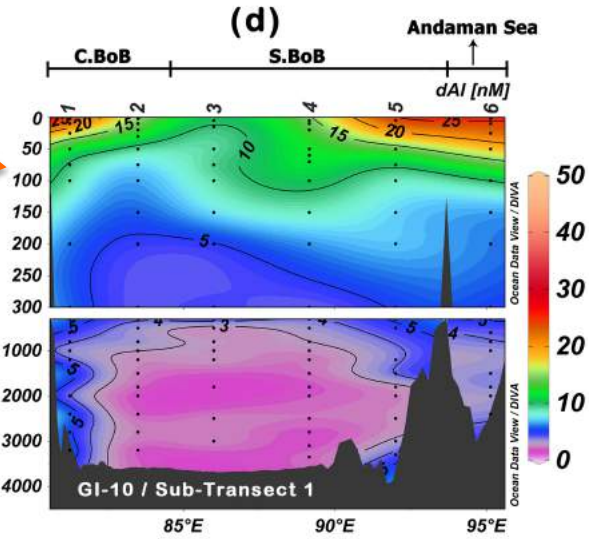


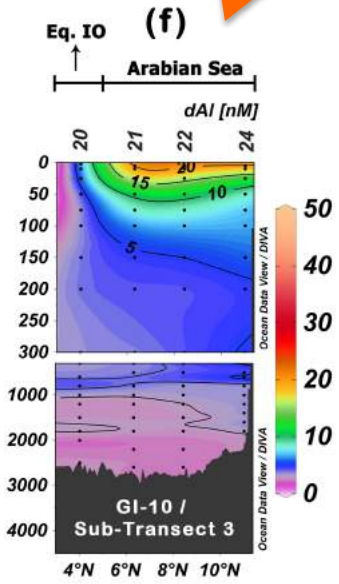
dAl in Indian Ocean

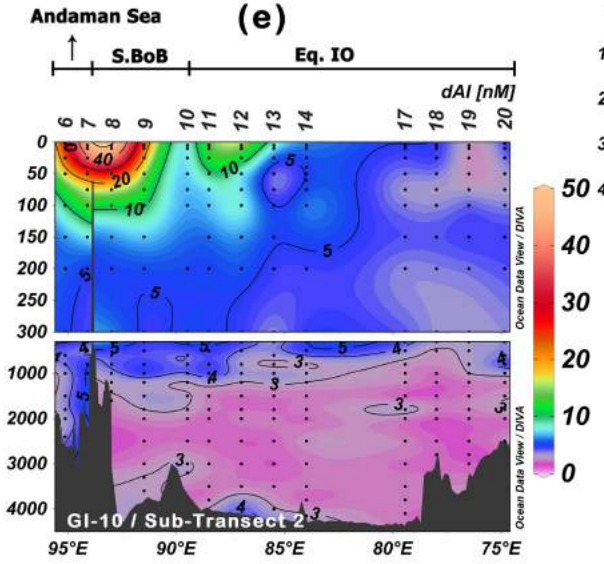


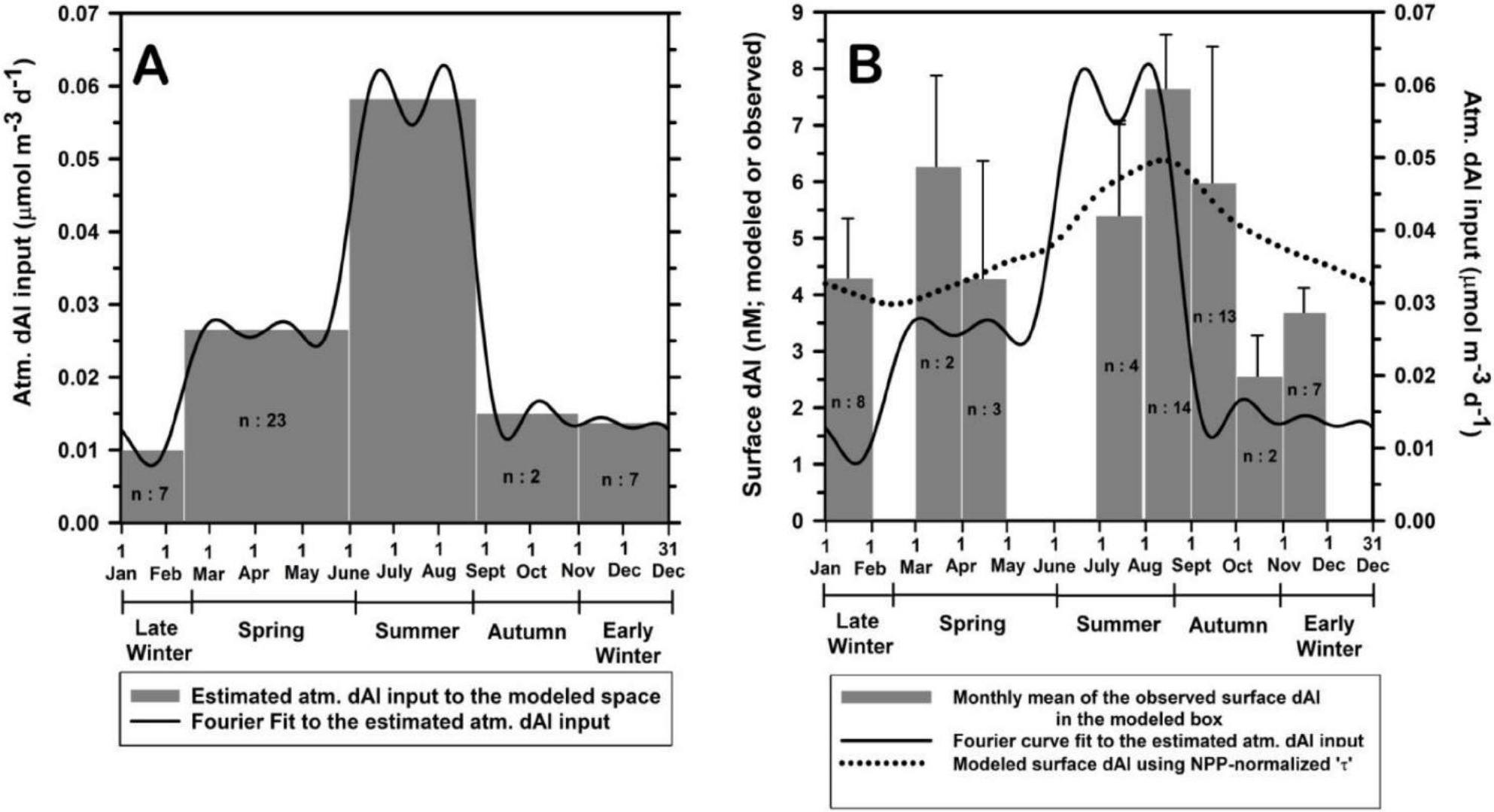




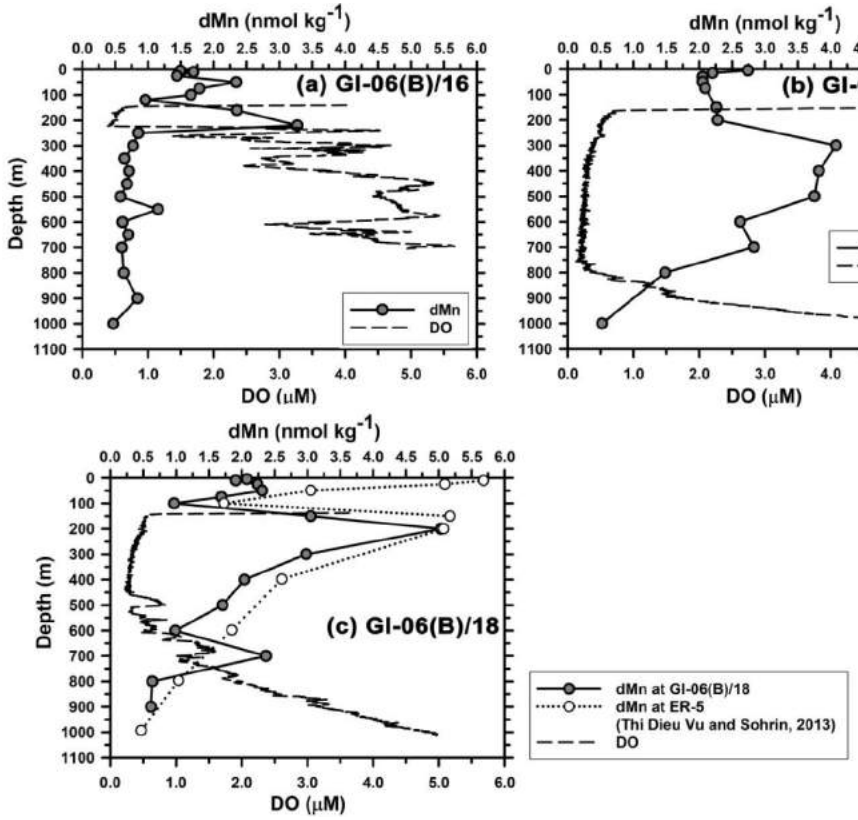


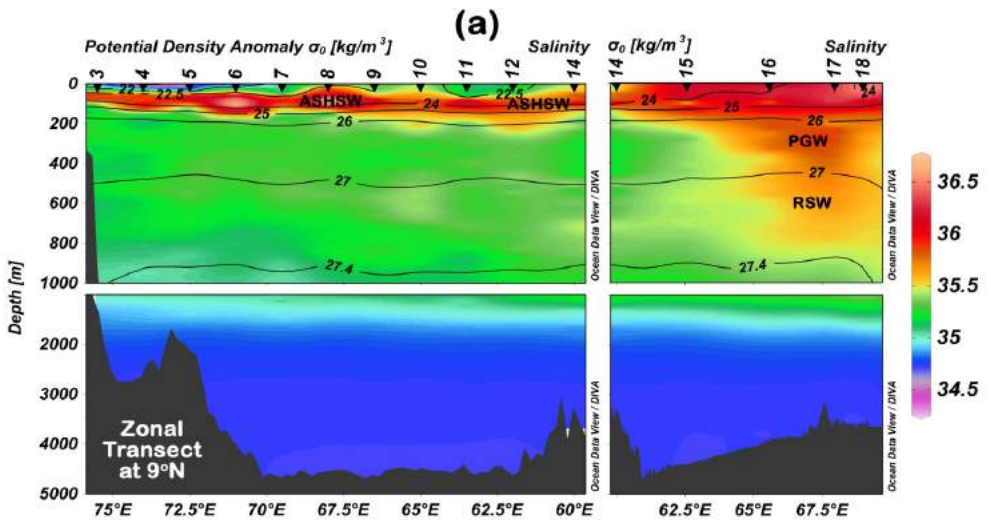


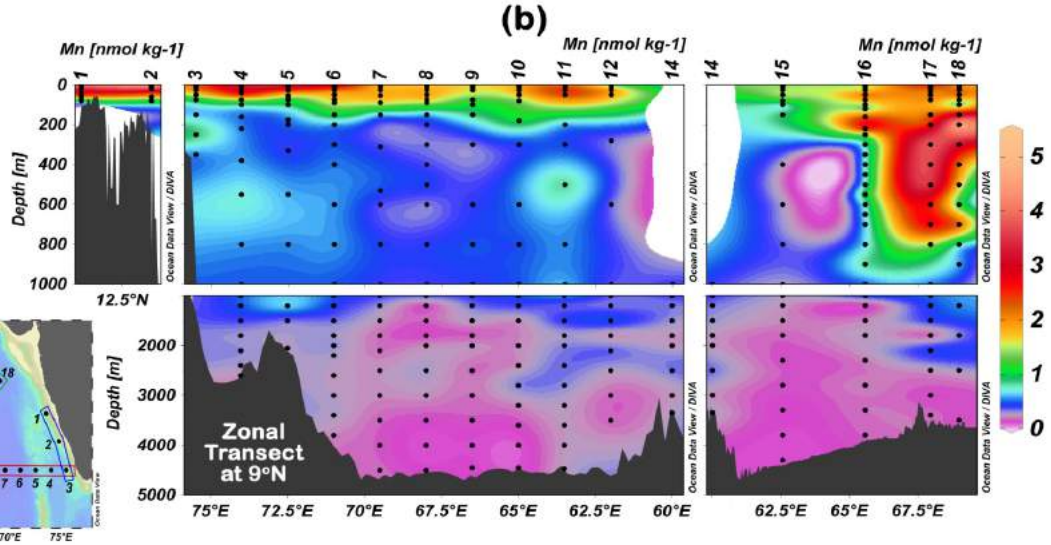


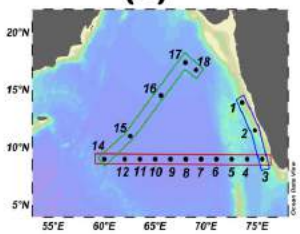

A
Atm. dAl input (μmol m-3 d-1)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
n : 7
n : 23
n : 2
n : 7
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 June
1 July
1 Aug
1 Sept
1 Oct
1 Nov
1 Dec
31 Dec
Late Winter
Spring
Summer
Autumn
Early Winter
Estimated atm. dAl input to the modeled space
Fourier Fit to the estimated atm. dAl input
B
Surface dAl (nM; modeled or observed)
Atm. dAl input (μmol m-3 d-1)
9
8
7
6
5
4
3
2
1
0
n : 8
n : 2
n : 3
n : 4
n : 14
n : 13
n : 2
n : 7
Monthly mean of the observed surface dAl in the modeled box
Fourier curve fit to the estimated atm. dAl input
Modeled surface dAl using NPP-normalized 'τ'

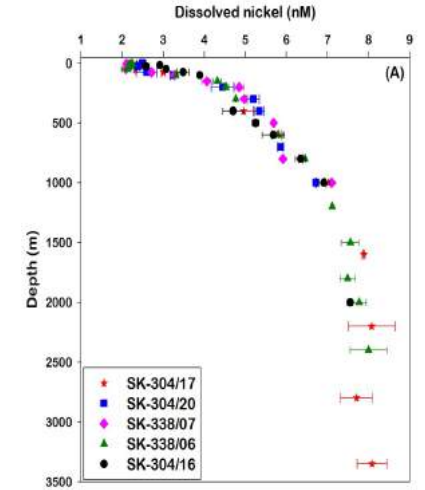
Mn in the Arabian Sea

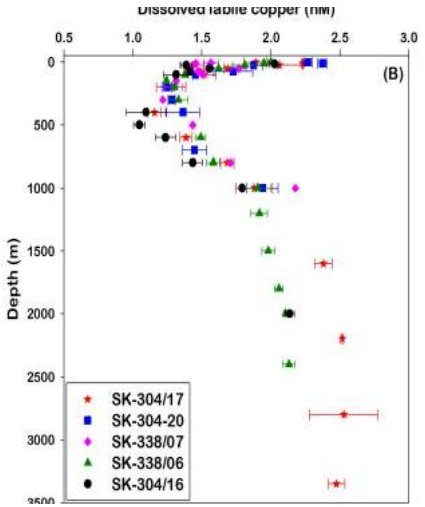


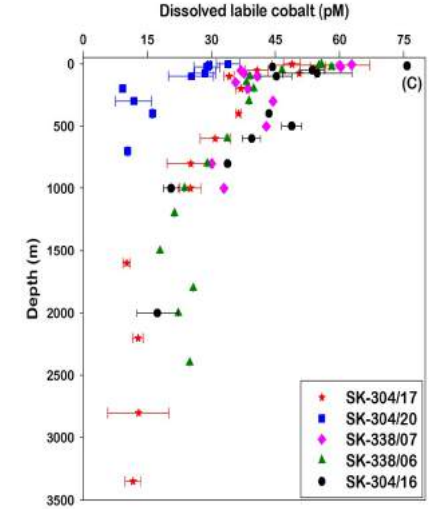


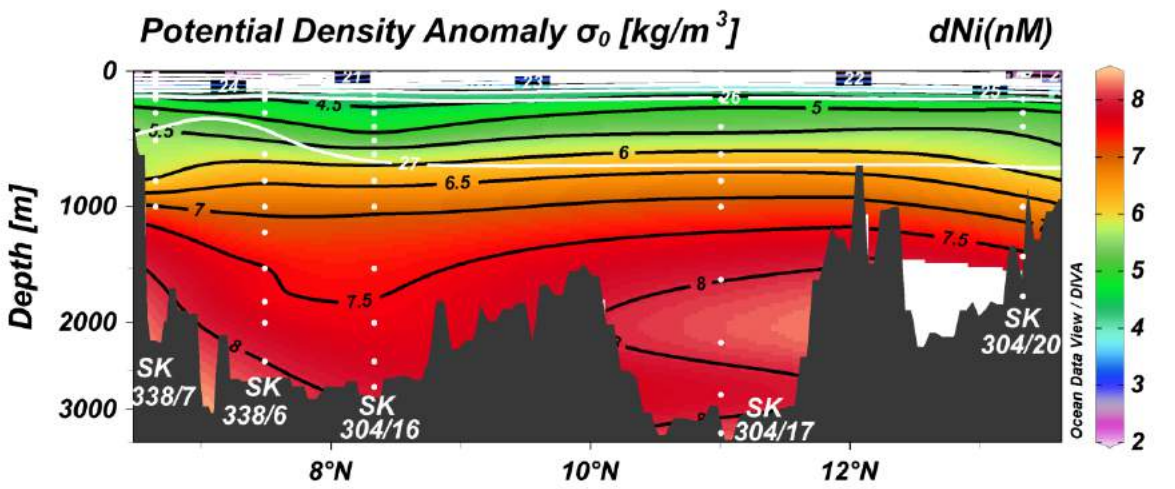


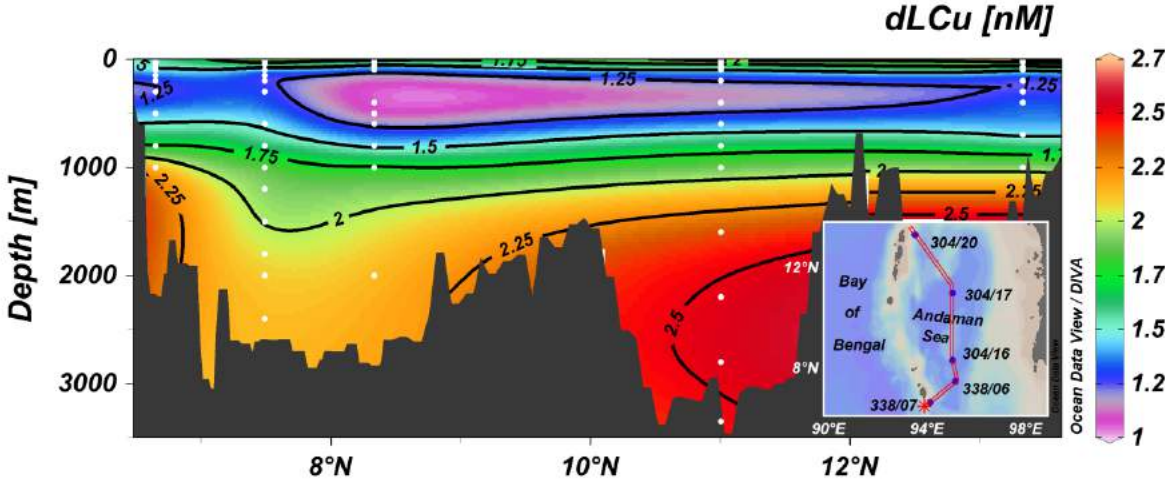


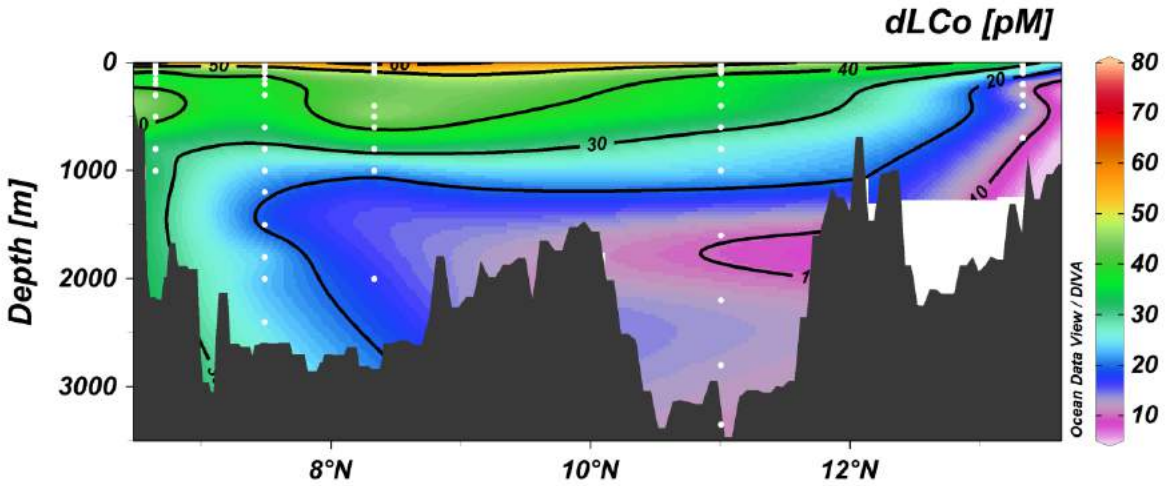

Dissolved nickel (nM)
(A)
Depth (m)
SK-304/17
SK-304/20
SK-338/07
SK-338/06
SK-304/16


(B)
Depth (m)
SK-304/17
SK-304-20
SK-338/07
SK-338/06
SK-304/16

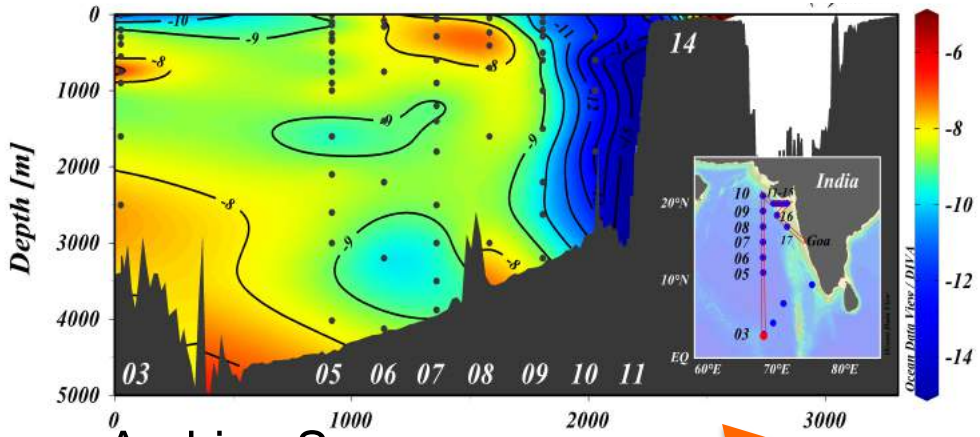

Dissolved labile cobalt (pM)
(C)
Depth (m)
SK-304/17
SK-304/20
SK-338/07
SK-338/06
SK-304/16


Potential Density Anomaly σ0 [kg/m3]
dNi(nM)
Depth [m]
SK 338/7
SK 338/6
SK 304/16
SK 304/17
SK 304/20
8°N
10°N
12°N
Ocean Data View / DIVA

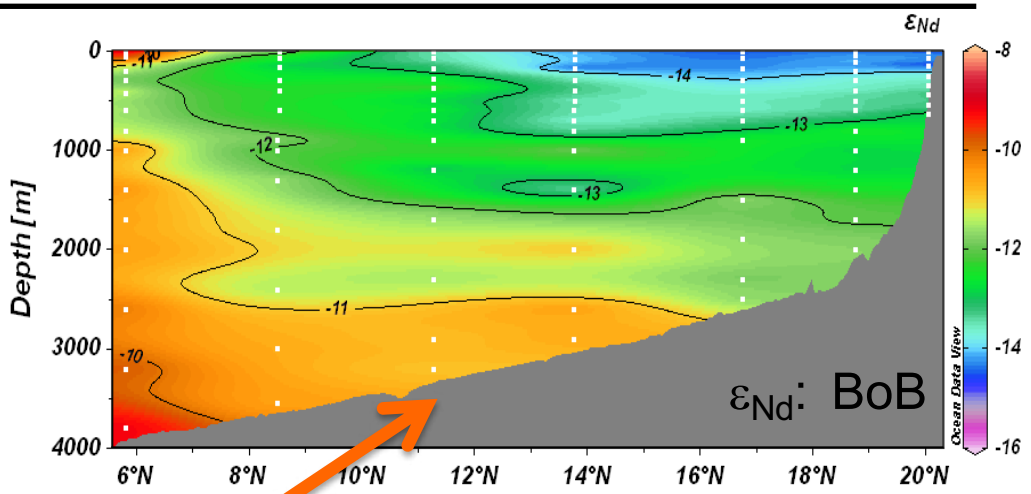

dLCu [nM]
Depth [m]
Bay of Bengal
Andaman Sea
304/20
304/17
304/16
338/06
338/07
90°E
94°E
98°E
8°N
12°N
8°N
10°N
12°N
Ocean Data View / DIVA


dLCo [pM]
Depth [m]
8°N
10°N
12°N
Ocean Data View / DIVA

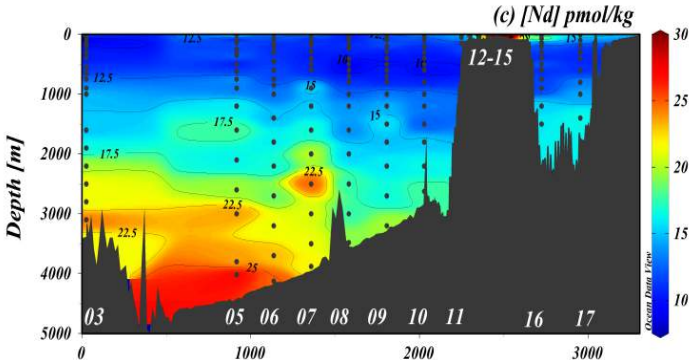
Nd isotope as water mass tracer in the Indian Ocean



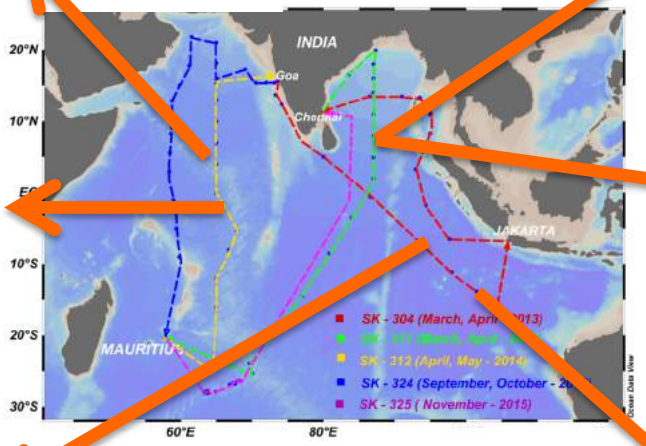
ε_{Nd}: Arabian Sea



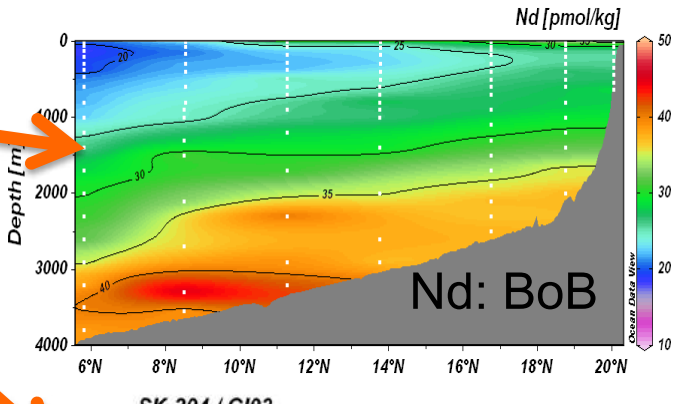
ε_{Nd}: BoB



Nd: Arabian Sea

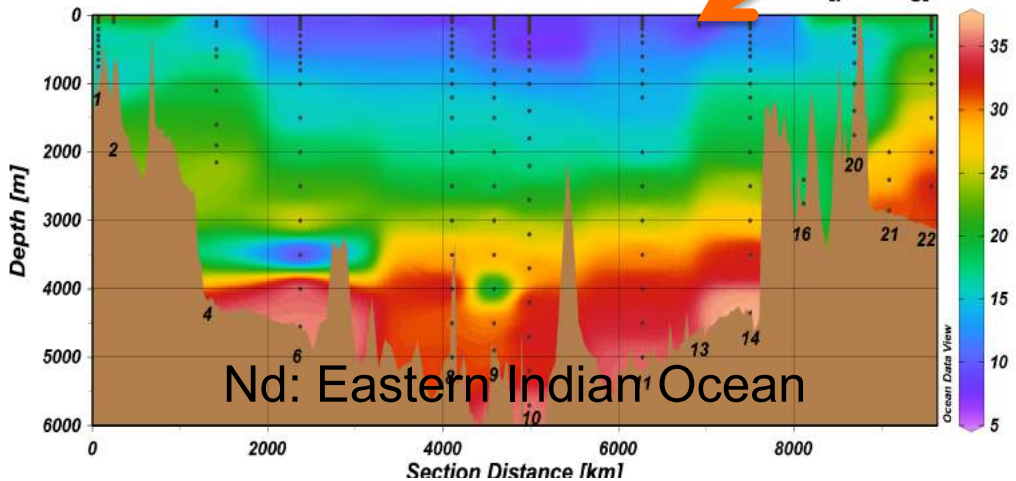


Nd [pmol/kg]

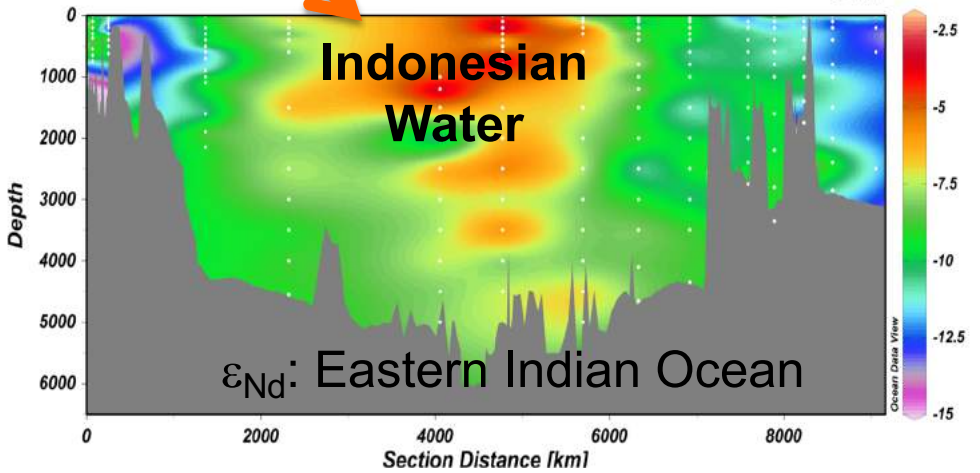


Nd: BoB

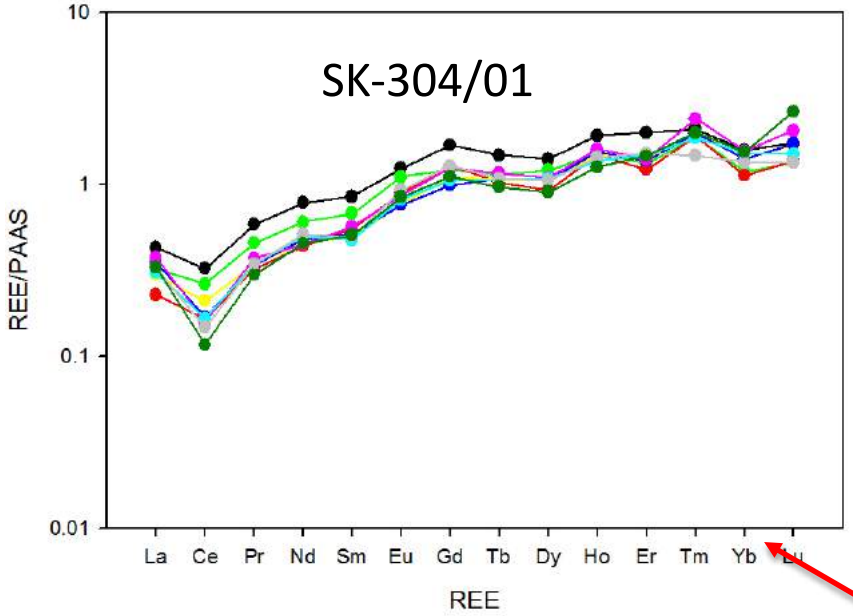
SK-304 / GI03



Nd: Eastern Indian Ocean



ε_{Nd}: Eastern Indian Ocean


SK-304/01
REE/PAAS
10
1
0.1
0.01
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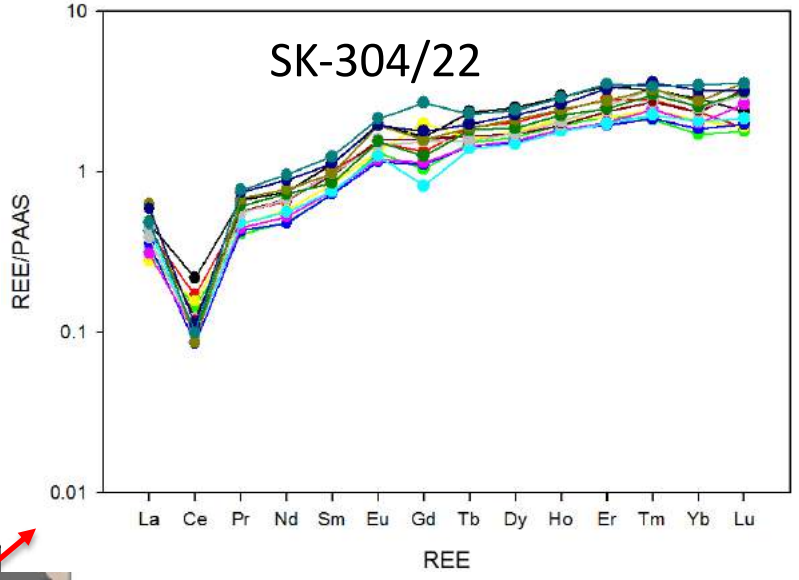
REE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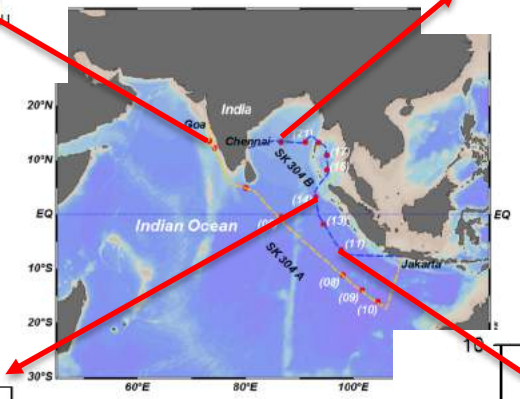
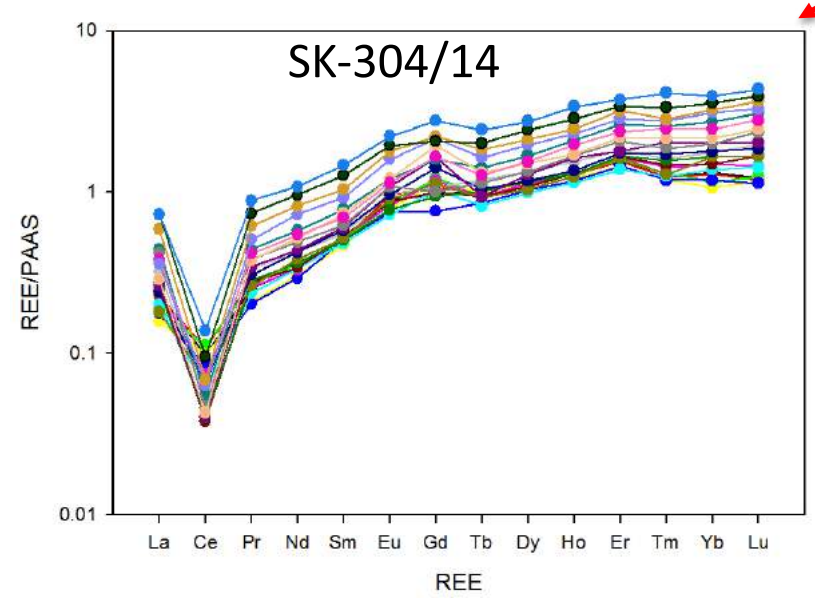

India
Goa
Chennai
SK-304 B
SK-304 A
Indian Ocean
Jakarta
20°N
10°N
EQ
10°S
20°S
30°S
60°E
80°E
100°E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REE/PAAS
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0.1
0.01
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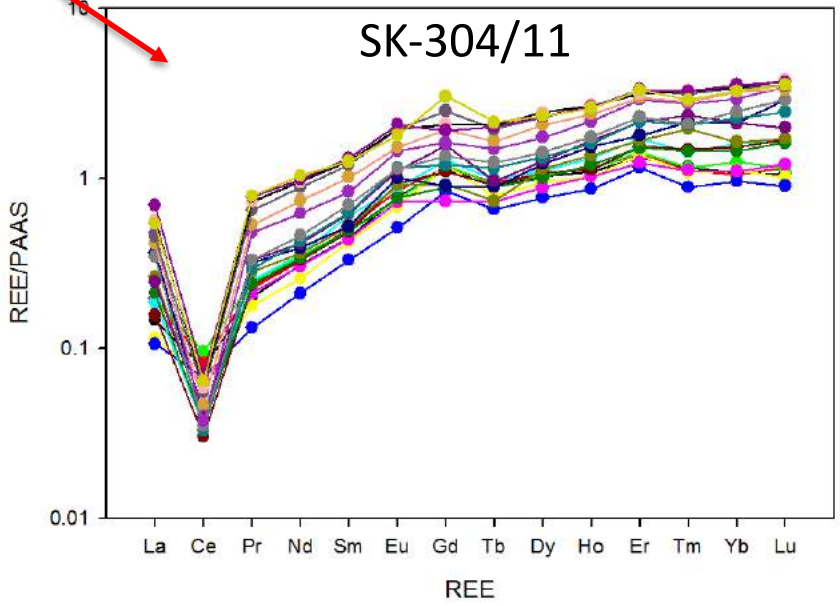
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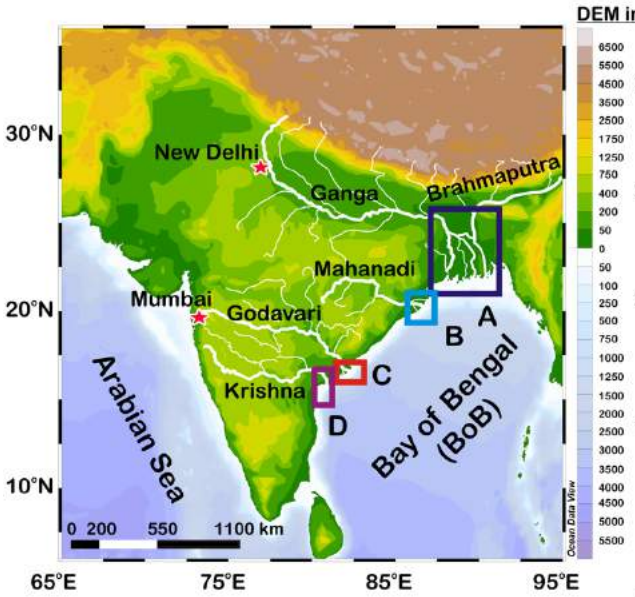
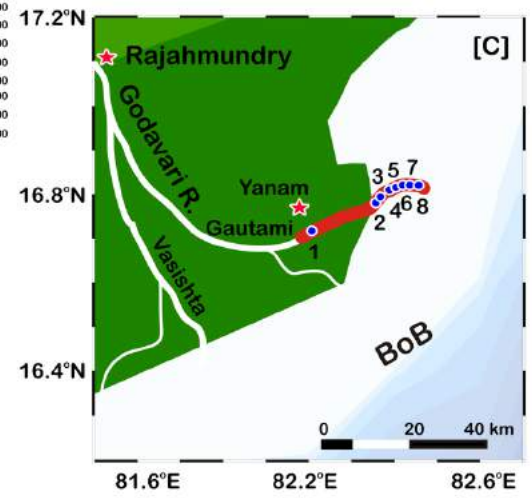
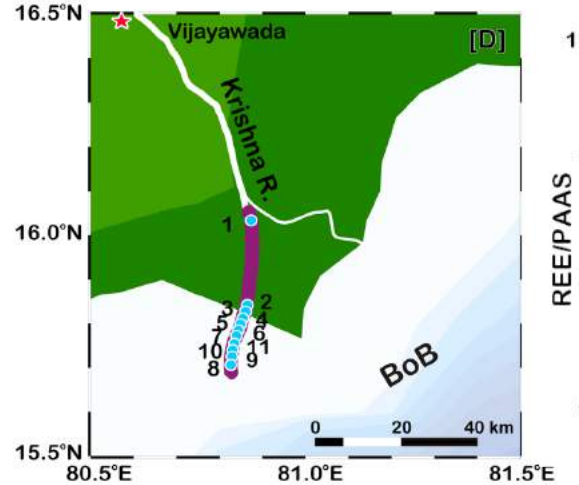
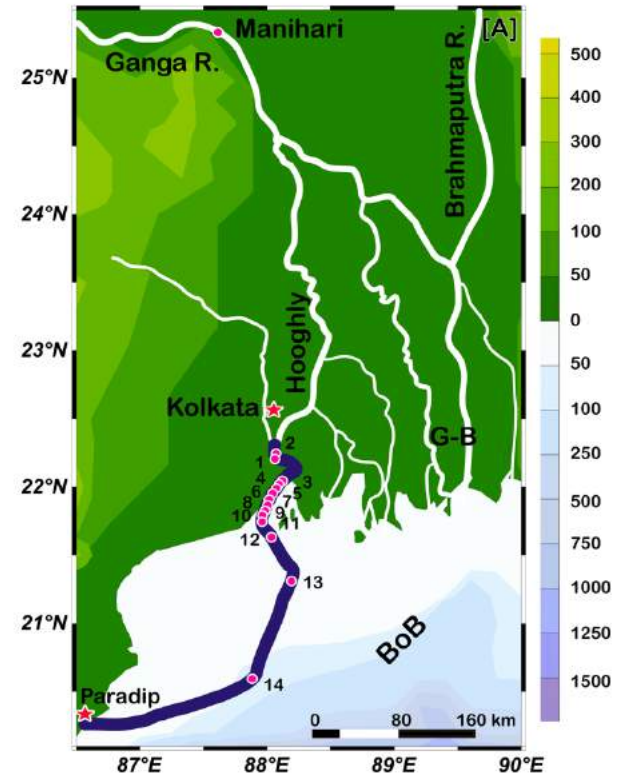
1
0.1
0.01
La Ce Pr Nd Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
REE

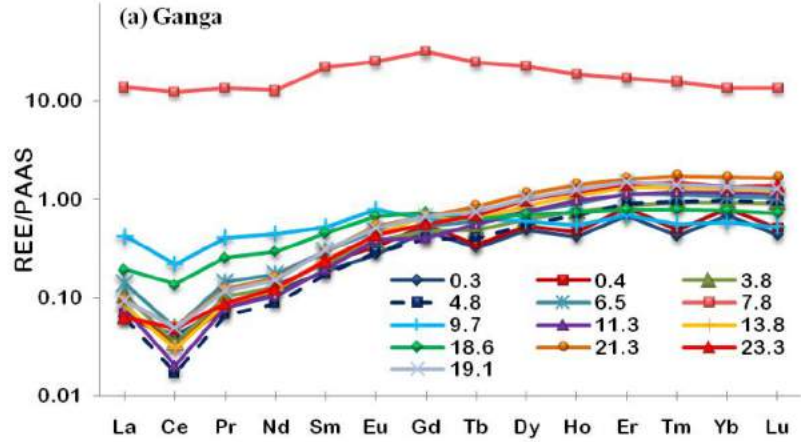
REEs in Estuaries and Indian Ocean

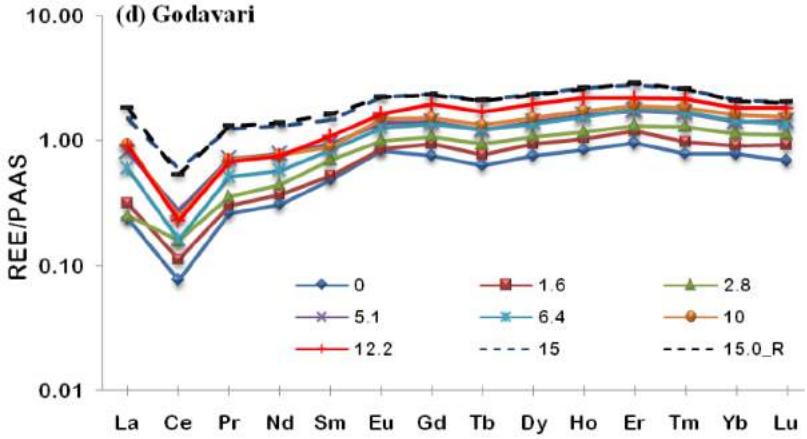


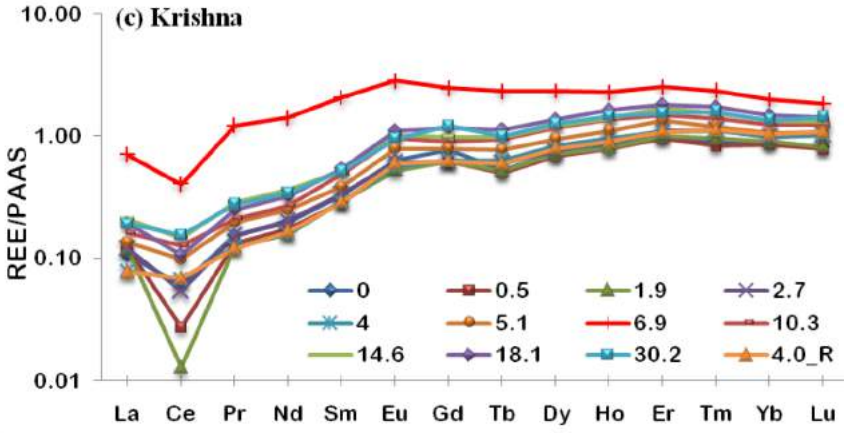


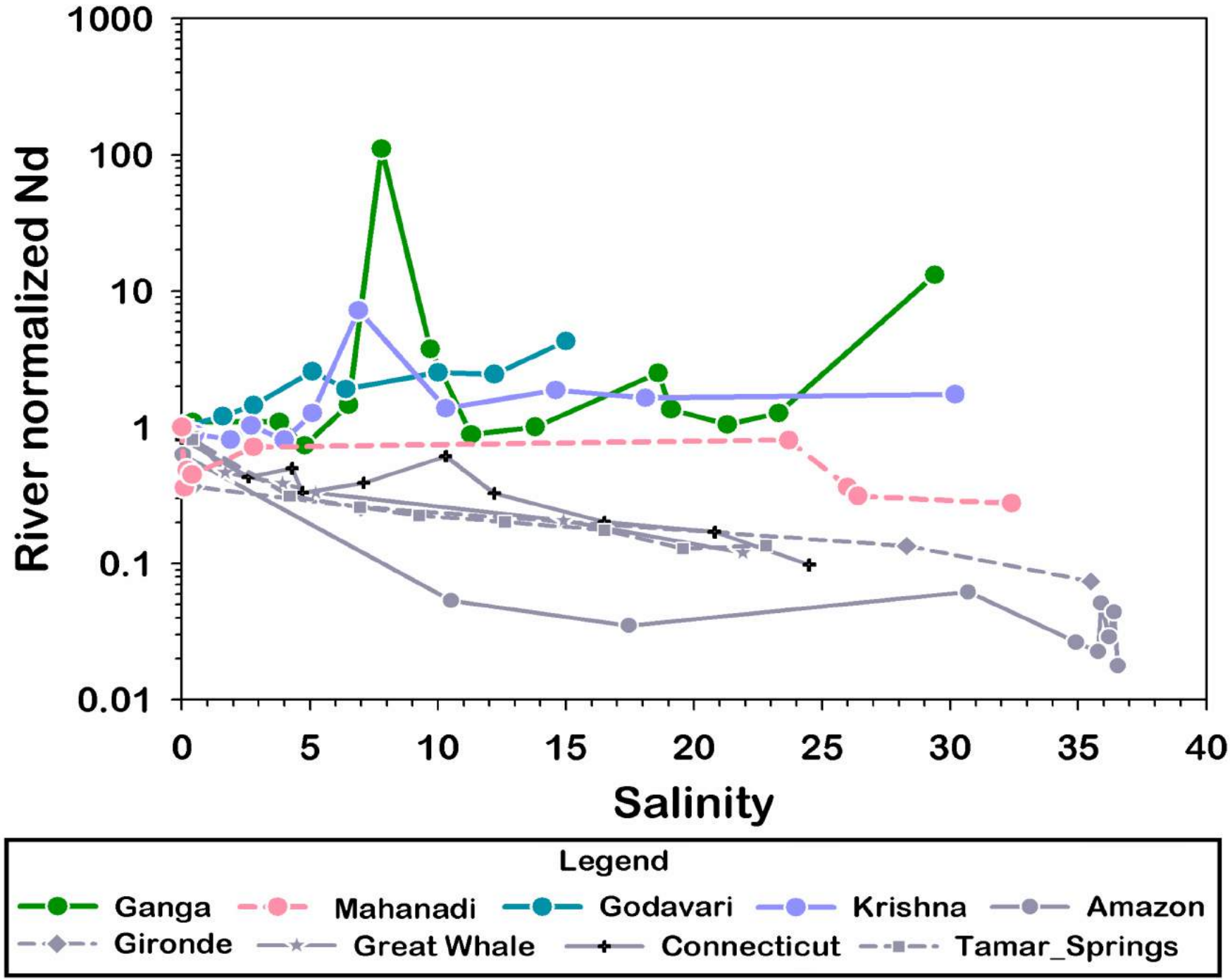


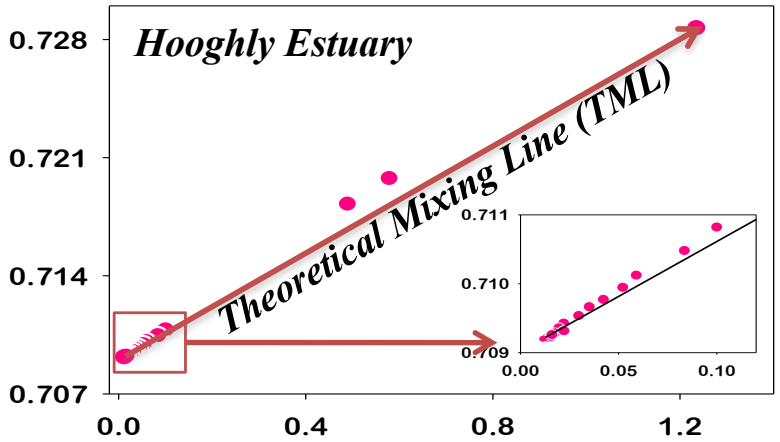


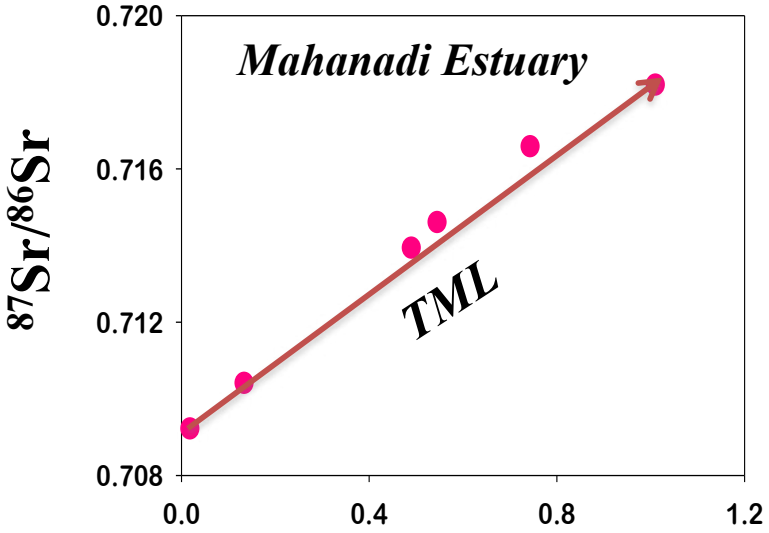


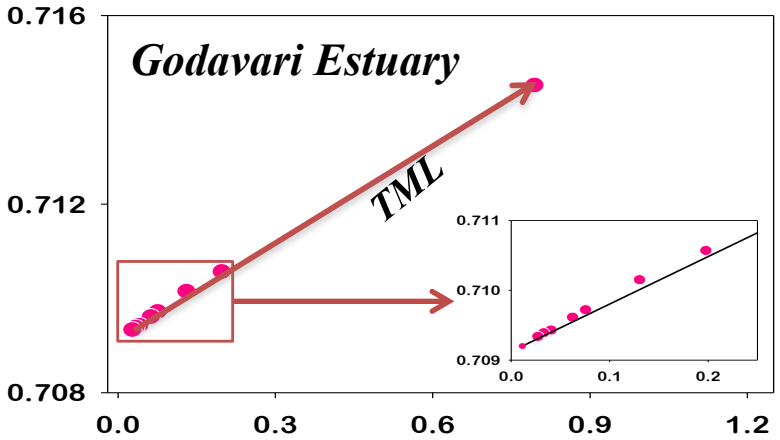


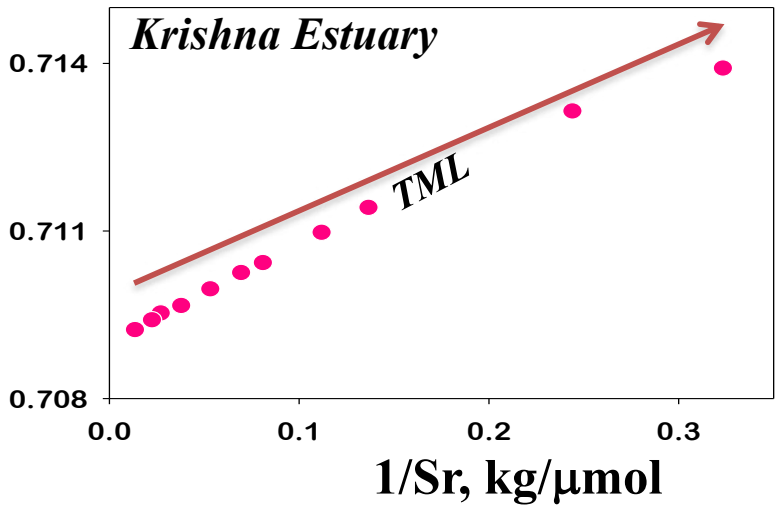


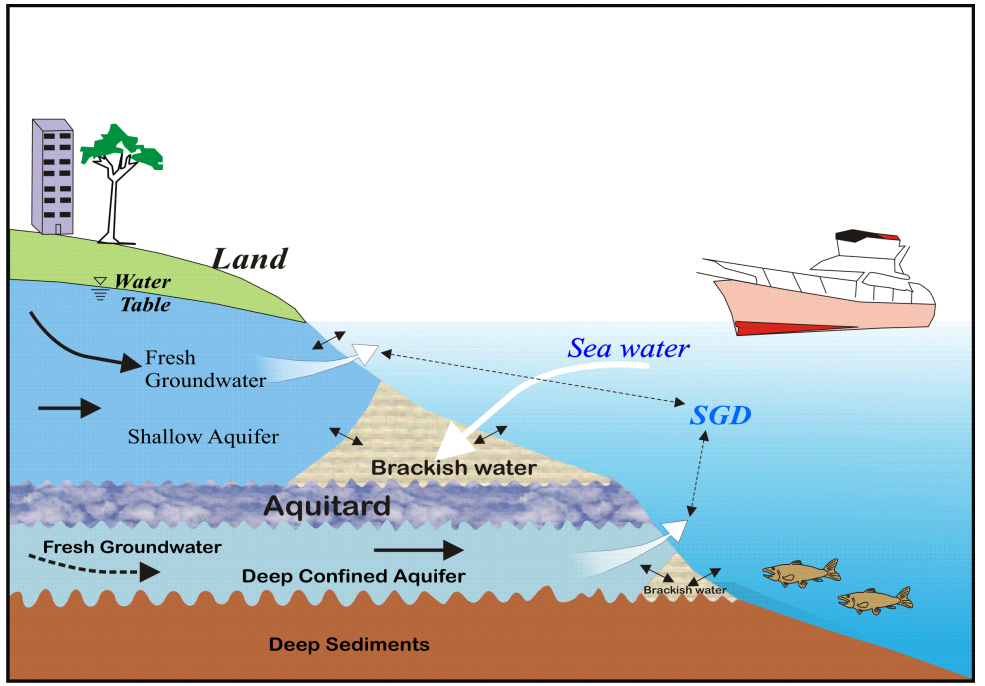

River normalized Nd
1000
100
10
1
0.1
0.01
0
5
10
15
20
25
30
35
40
Salinity
Legend
Ganga
Mahanadi
Godavari
Krishna
Amazon
Gironde
Great Whale
Connecticut
Tamar_Springs





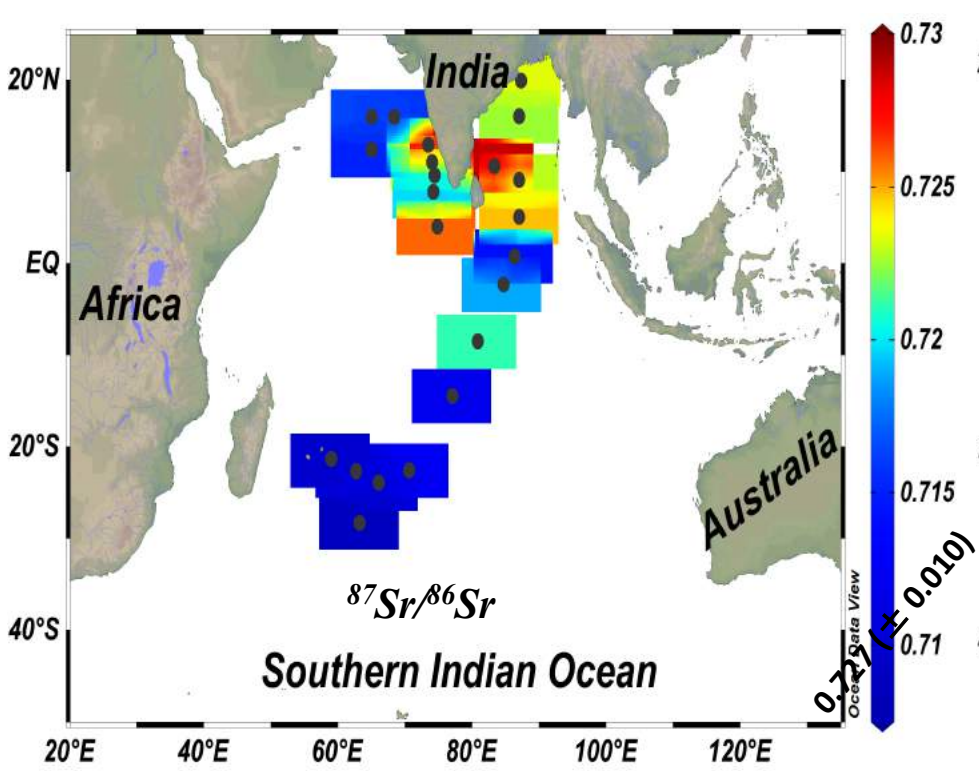


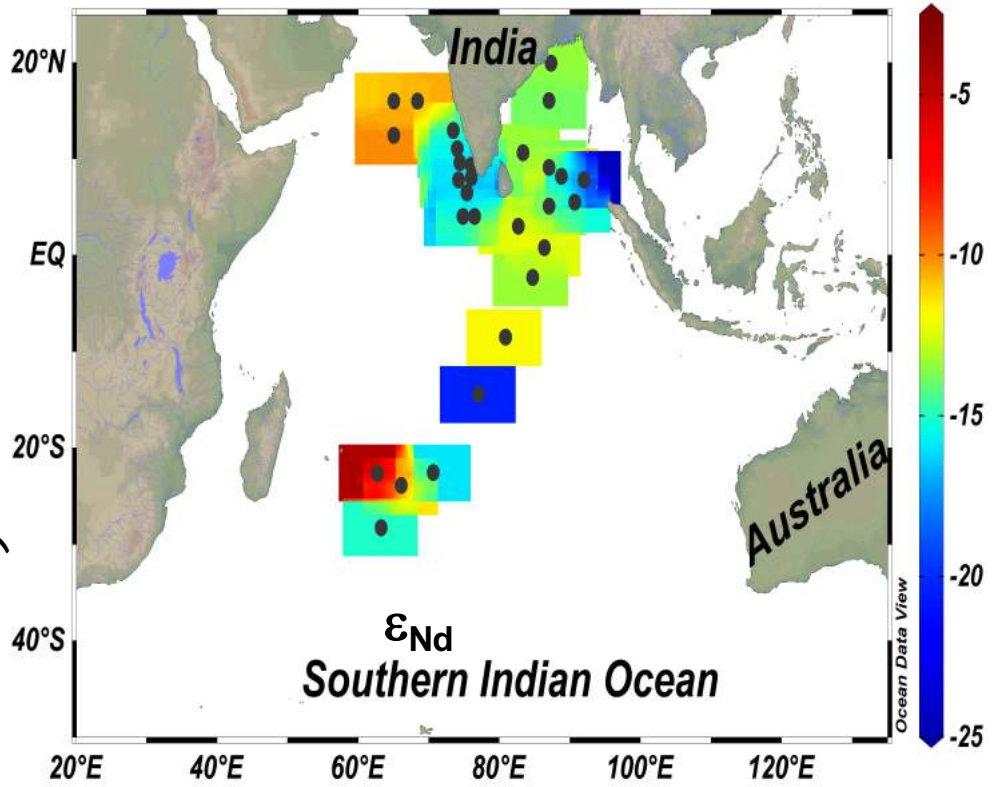


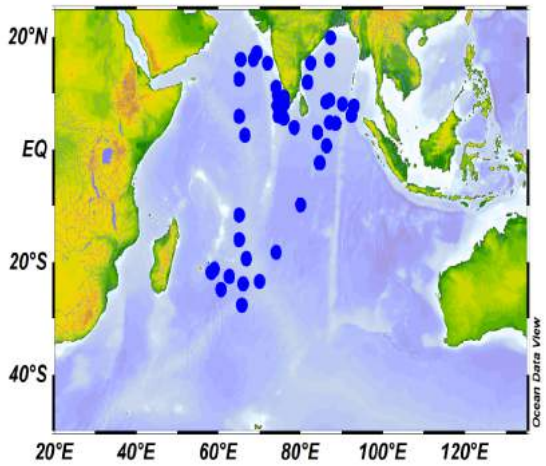


➢ **Inverse model estimates SGD flow rates in a range of 40 to 300 and 5 to 280 cm/day in eastern and western estuaries respectively**

Dust $^{87}Sr/^{86}Sr$ and ε_{Nd}







$^{87}Sr/^{86}Sr$ in existing sources

Sahara Dessert	Deccan Basalts	South Africa	Australia	Himalayan Input
0.7185	7085	0.7273	0.7362	0.7480
0.0067	0.010	0.0105	0.0169	0.1050

(Grousset et al., (1992); Singh et al., (2008); Kumar et al., (2014))

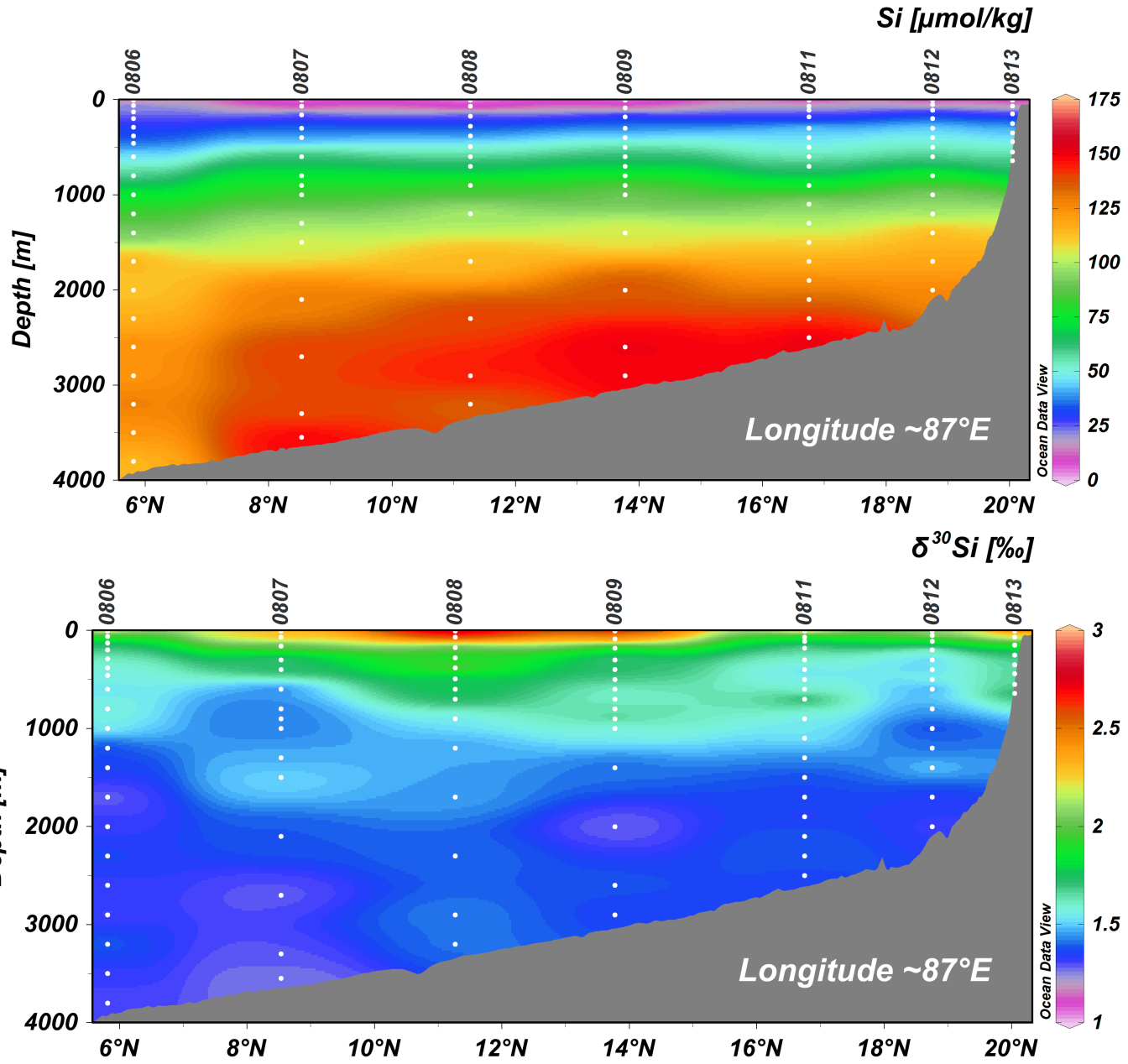
ε_{Nd} in existing sources

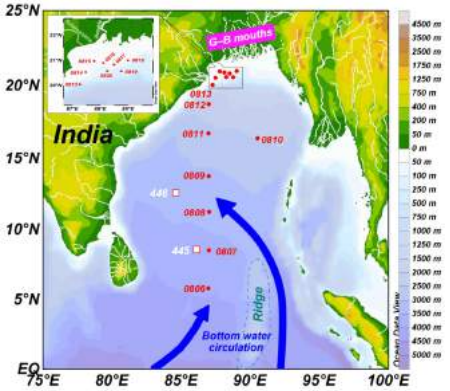
Sahara Dessert	Deccan Basalts	South Africa	Australia	Himalayan Input
-11.49	-4.85	-8.79	-7.25	-16.50
1.69	6.5	5.48	4.16	1.50

(Grousset et al., (1992); Singh et al., (2008); Kumar et al., (2014))

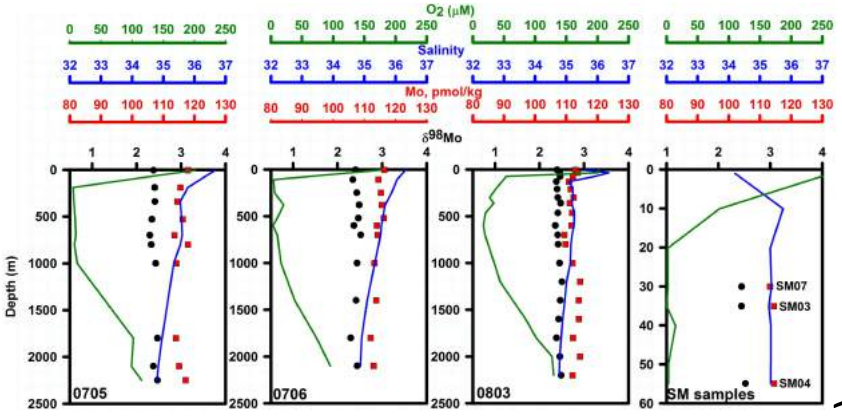
NIO

Si Isotope in BoB

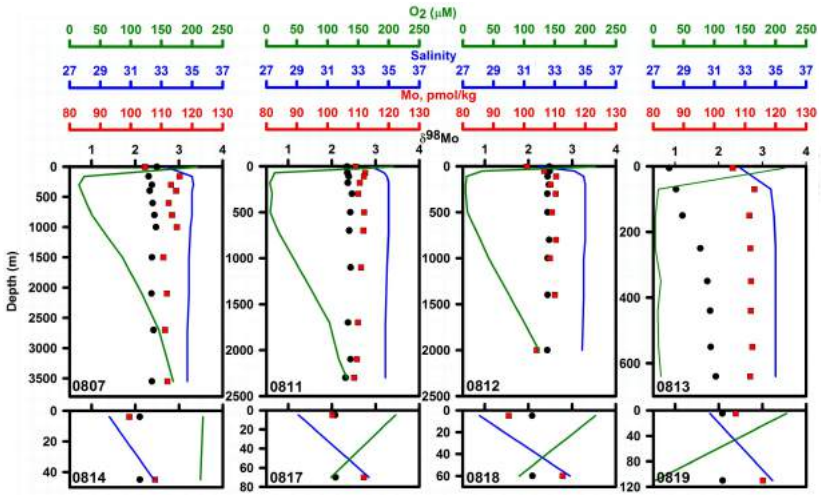




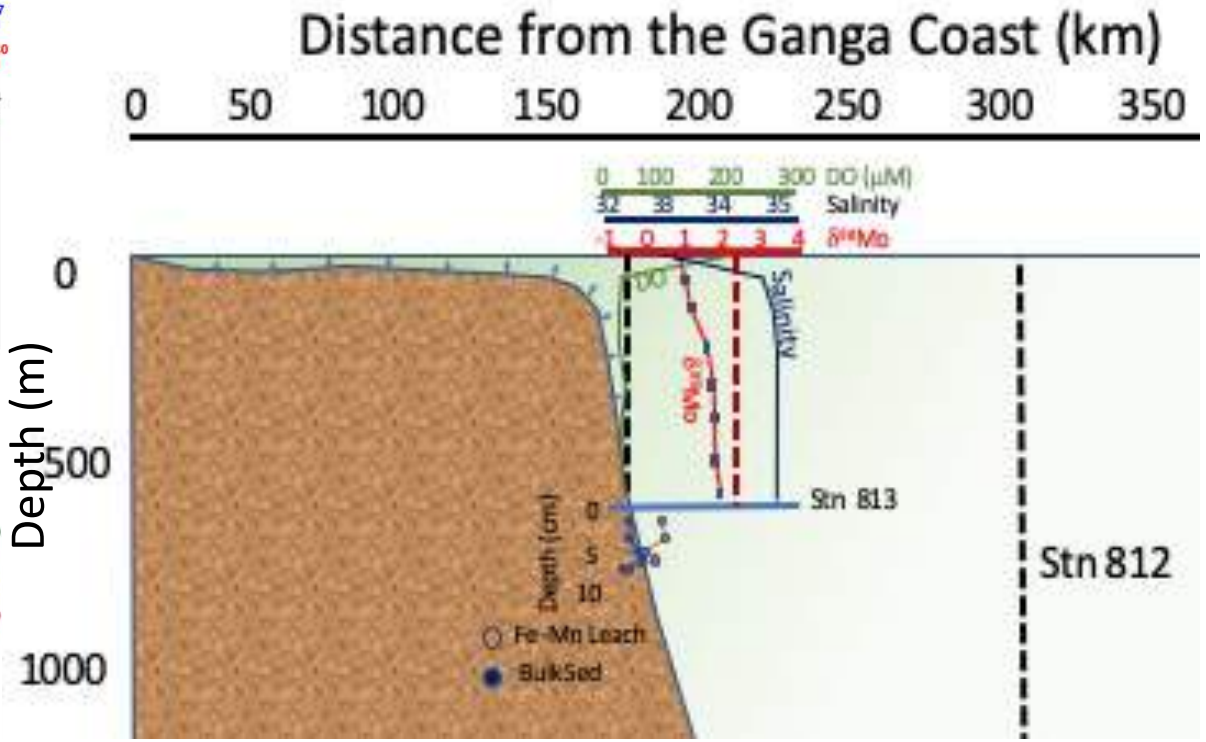
Mo isotope in Indian Ocean



Arabian Sea



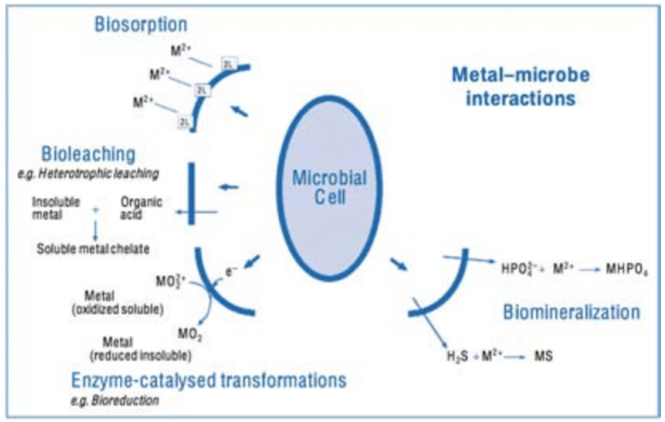
Bay of Bengal

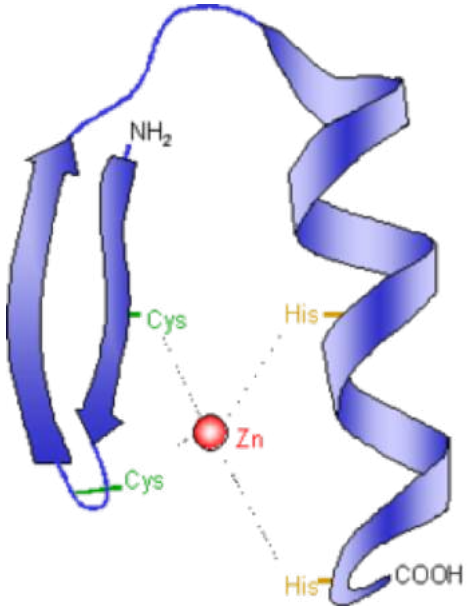


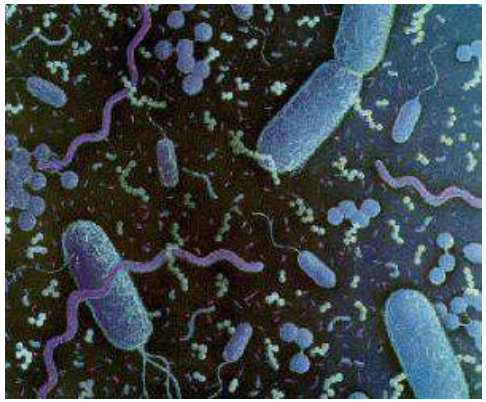
Trace metals are essential for many metabolic pathways

Metalloproteins account for nearly half of all proteins in biology

In order to understand biogeochemical cycles of Trace Elements and Isotopes (TEI) in the sea, it is essential to elucidate biological processes that influence the geochemistry and fate of trace elements in marine systems.







Limited reports are available on interactions of trace metals with biotic life in Indian Ocean waters

"TraceBioMe"

Interactions between trace metals and marine biota in Indian Ocean and its implications in nutrient cycling

- How microbes have evolved in response to the availability or limitation of key nutrients and explore which organisms may be contributing to biogeochemical cycles in different parts of the global ocean is an interesting area to explore

- Marine microbial community structure and the functions encoded within their genomes might be related to trace metal availability in the ocean

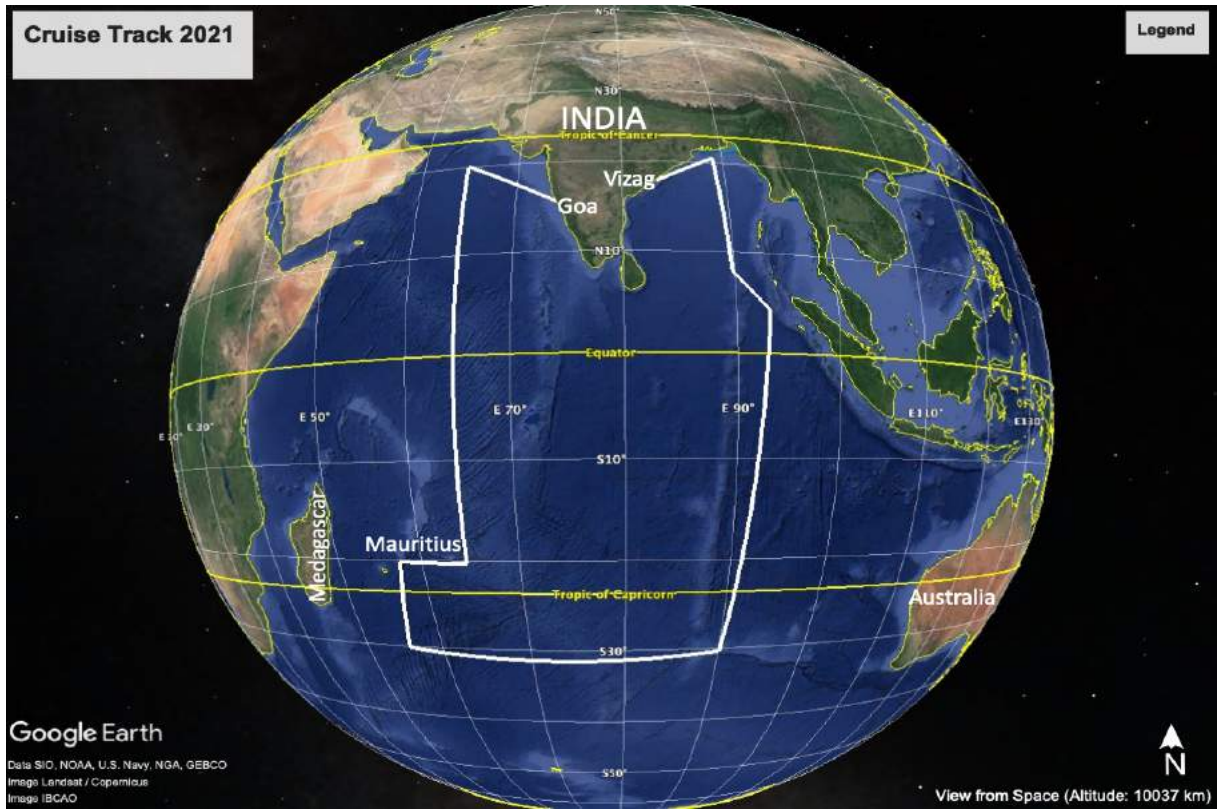
- With the advent of modern sequencing tools, it will be interesting to look into the effects of these trace metals on the biota present and their metabolic reactions

'Omic' technologies: genomics, transcriptomics, proteomics and metabolomics

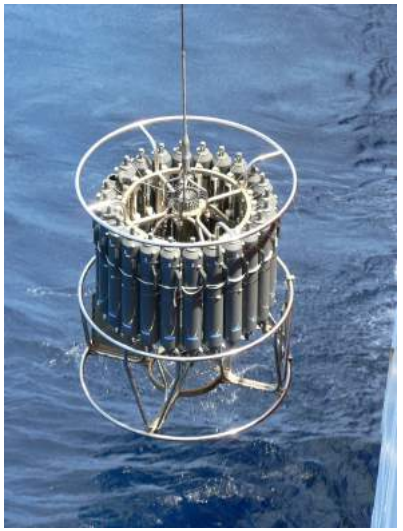
Objectives

- Analyze the levels and sources of trace metals and their isotopic forms in the water column, biota and sediments
- Investigate Nd, Hf, Th, Pa in order to understand the circulation of the waters
- Describe the biotic component using conventional and modern molecular tools
- Global transcriptome and metagenome analysis of the water and sediment samples
- Evaluate the impact of varying levels of trace metals on a select set of biota in the laboratory using simulated conditions and the proteins/enzymes by these organisms
- Creation of an online interactive database for the type of microbial life and the transcripts obtained from the study area in conjecture with the trace metal levels

Cruise duration : 15 March to 15 June 2021



Cruise Track



Clean CTD

Sindhu Sadhana

THANK YOU