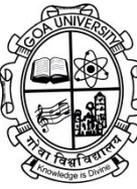


A Monsoonal Estuary and its Adjoining Shelf on the West Coast of India as a Unified System

Satish R. Shetye
satishrshetye@gmail.com



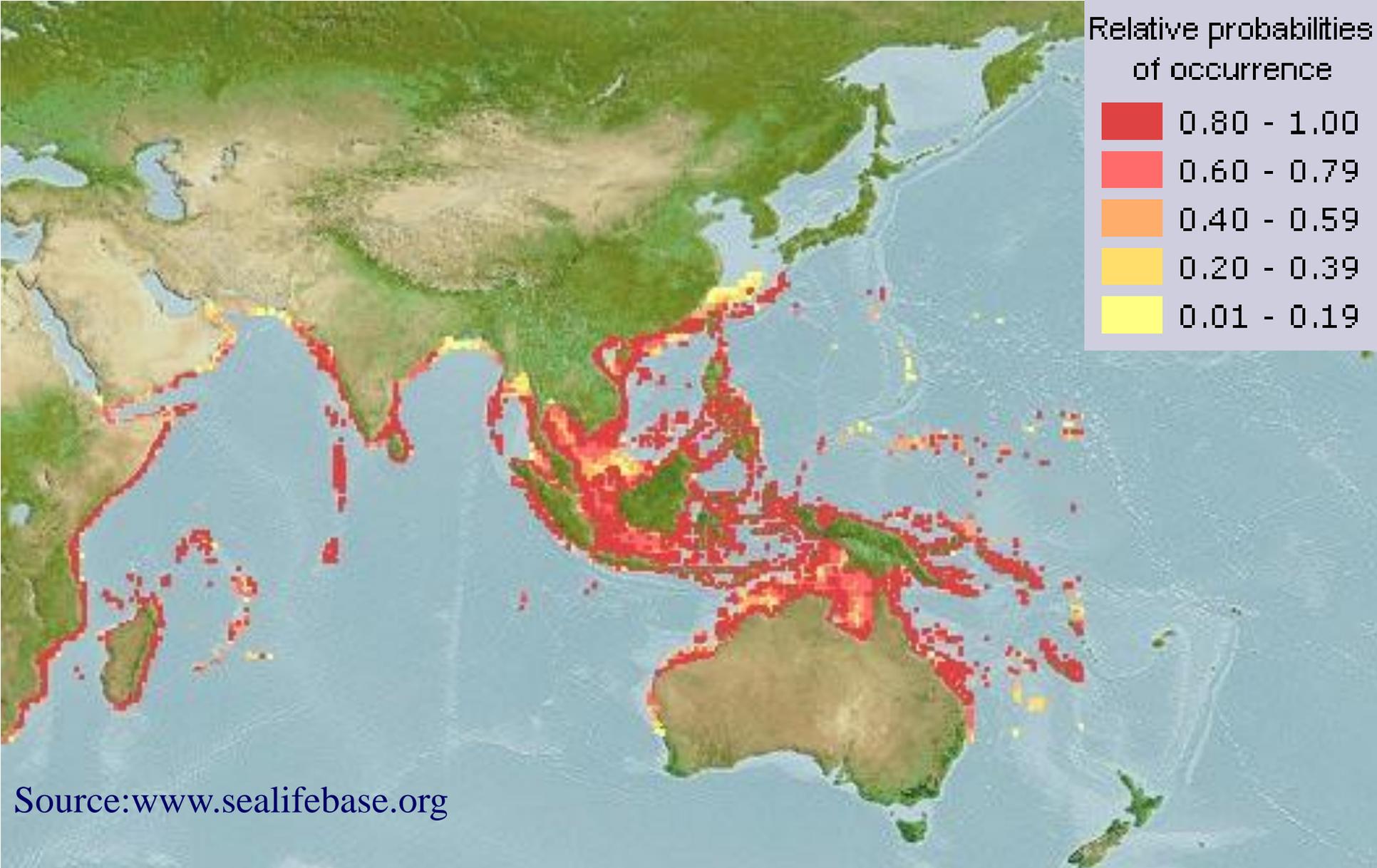
- Oceanographic research specifically to support fishery is new to Indian Oceanography. Project FINDER launched ~5 years ago is therefore a welcome development.
- FINDER studies dynamics and biogeochemistry in and around temperature gradient filaments that Indian fishing community uses to identify potential fishing zones.
- This talk proposes another study to support an important fishery in India: **Indian white prawn**. The proposed study is also of interest to physical oceanography of the region.

Indian white prawn



Found from the Indo-West Pacific: East and South East Africa to South China, Papua New Guinea and North Australia .

Source: FAO



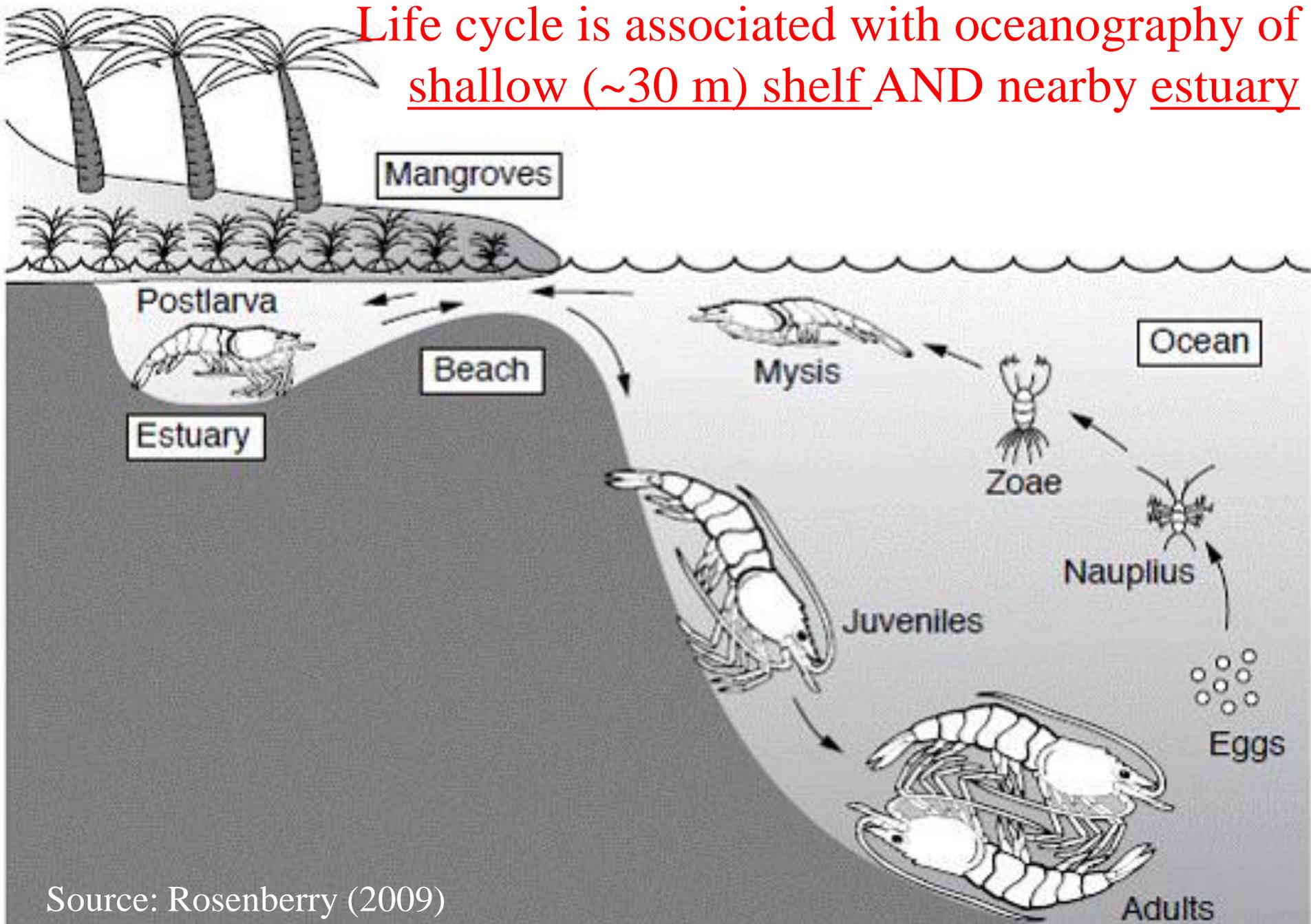
Source: www.sealifebase.org

Found in the areas visited by the tropical rain belt (ITCZ) at least a part of the year (Monsoonal)

- found at depths of **2 to 90 m** inhabiting bottom mud or sand
- most abundant in shallow waters of less than **30 m** depth
- the adults are marine and **breed offshore**
- postlarvae and juveniles are **estuarine**, live in brackish environment with temperature range **~18-35 °C** and salinities of from **5 to 50 ppt**
- optimal salinity for juvenile is **10 to 15 ppt**
- has an **offshore planktonic larval phase**
- an **estuarine, benthic postlarval, juvenile phase**
- and an **inshore ocean adult and spawning phase**

- generally spawn on the surface at water depths of **~ 7-40 m**
- postlarvae move towards the coast and enter **estuaries and mangrove swamps** that serve as **nursery grounds**.
- females commence breeding when 2.7-3.5 cm long, **5-6.5 month old**; males attain sexual maturity when 2.8 to 3.4 cm long
- full life span is about **2 years**
- **spawns most months of the year**, with two annual spawning peaks
- juvenile have **limited mobility**; movement is **influenced by currents**.

Life cycle is associated with oceanography of shallow (~30 m) shelf AND nearby estuary



Source: Rosenberry (2009)

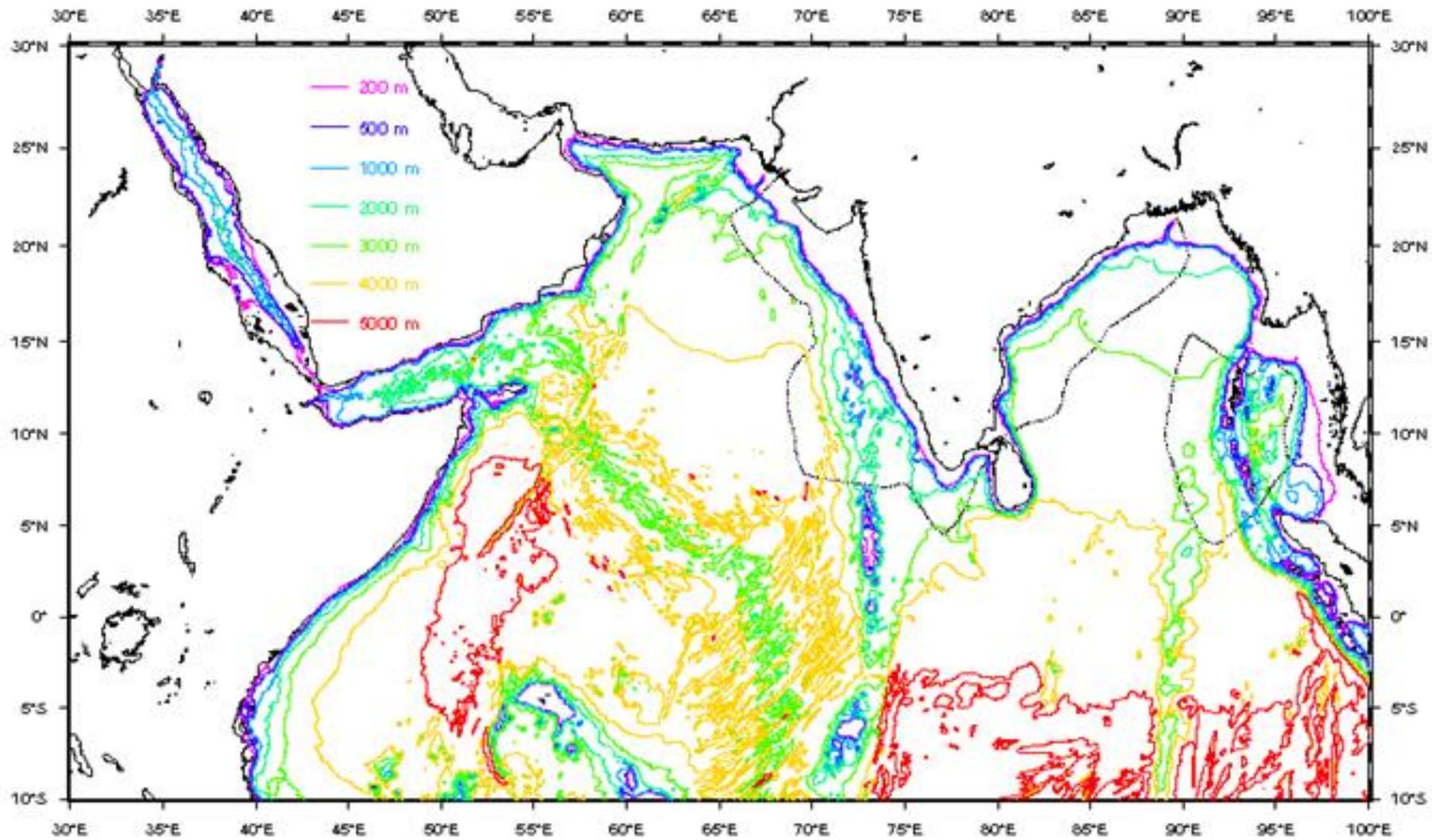
- Indian white prawn being an important commercial fishery on the **west coast** of India, should have studied oceanography of the **near coast shelf, adjoining estuary/ies** **and** **interaction/ exchange of mass** between the two.

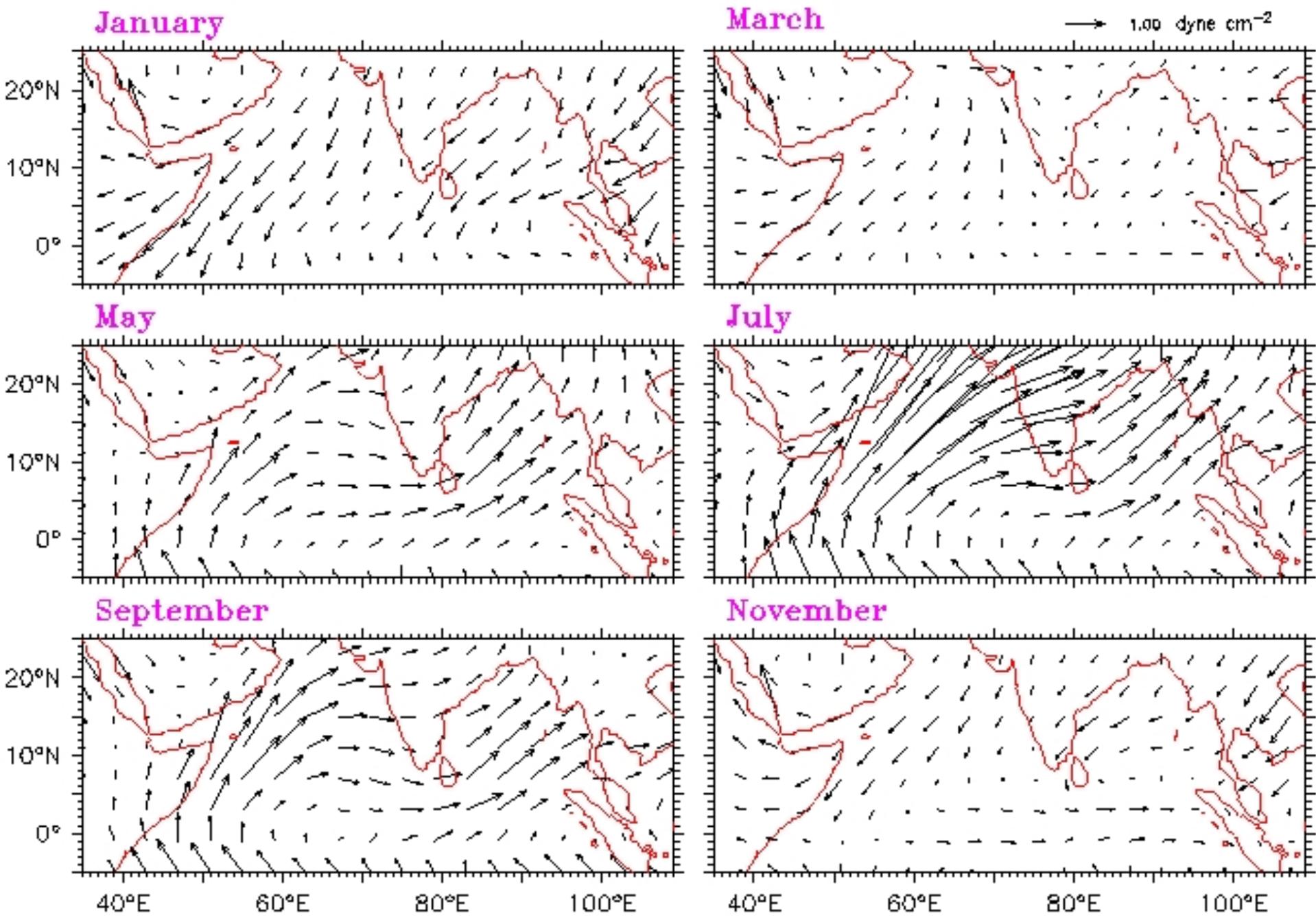
- Interaction/exchange is not known. But do know how the shelf and the estuaries behave **individually**.

- Examine dynamics of :

- near coast shelf areas on the west coast
- estuaries found along the coast

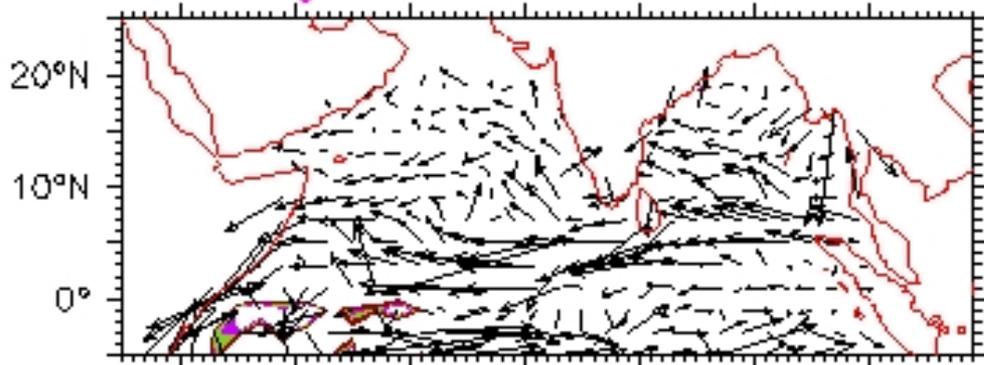
Discuss the need to study the two as a unified system



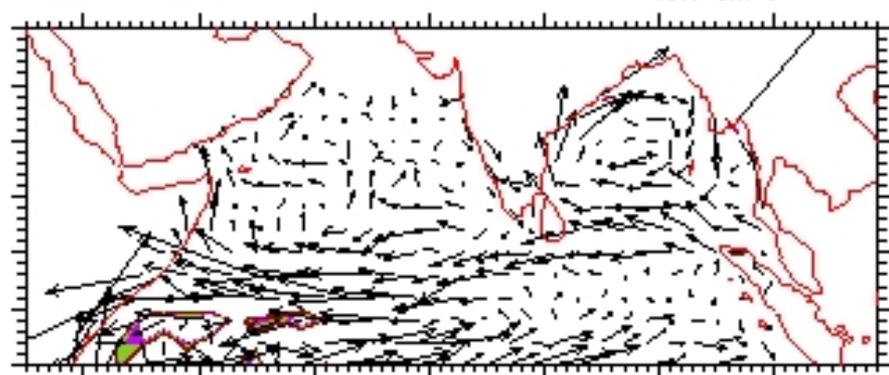


Wind stress from the climatology of Hellerman and Rosenstein (1983)

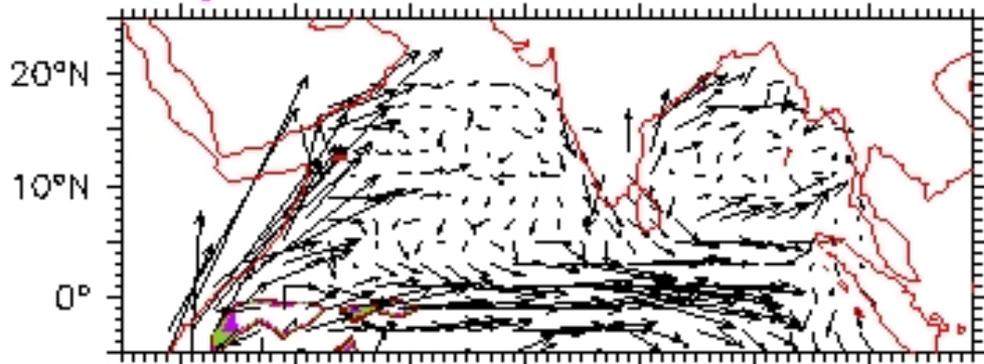
January



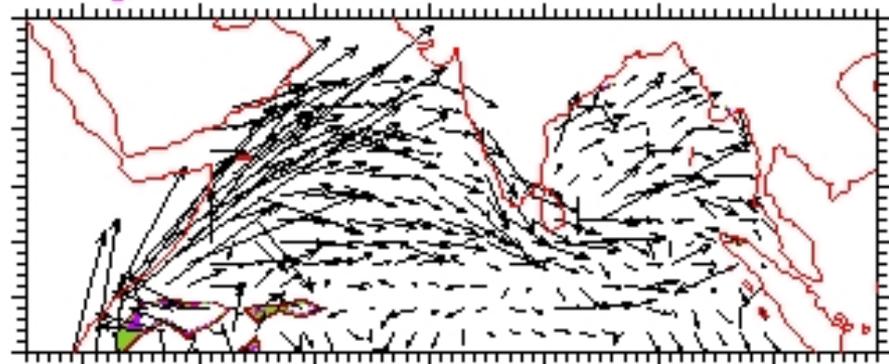
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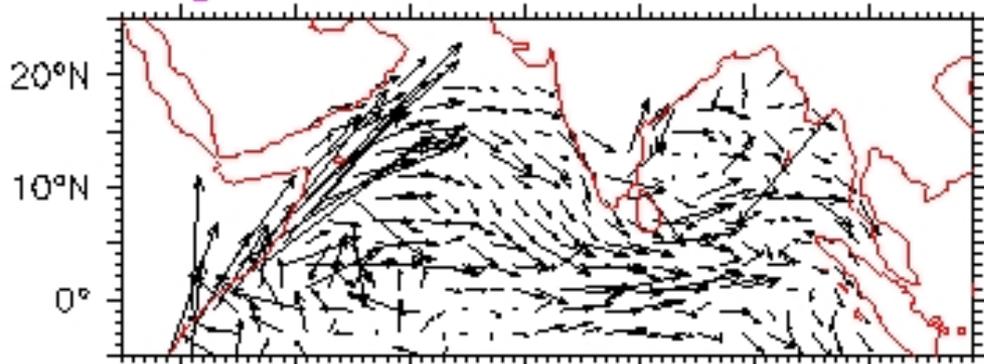
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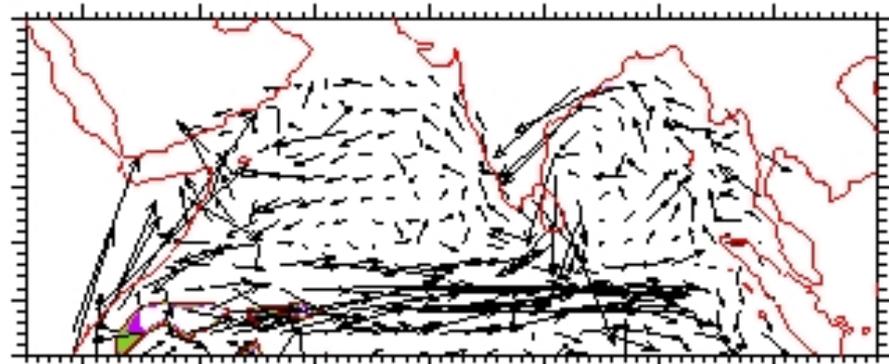
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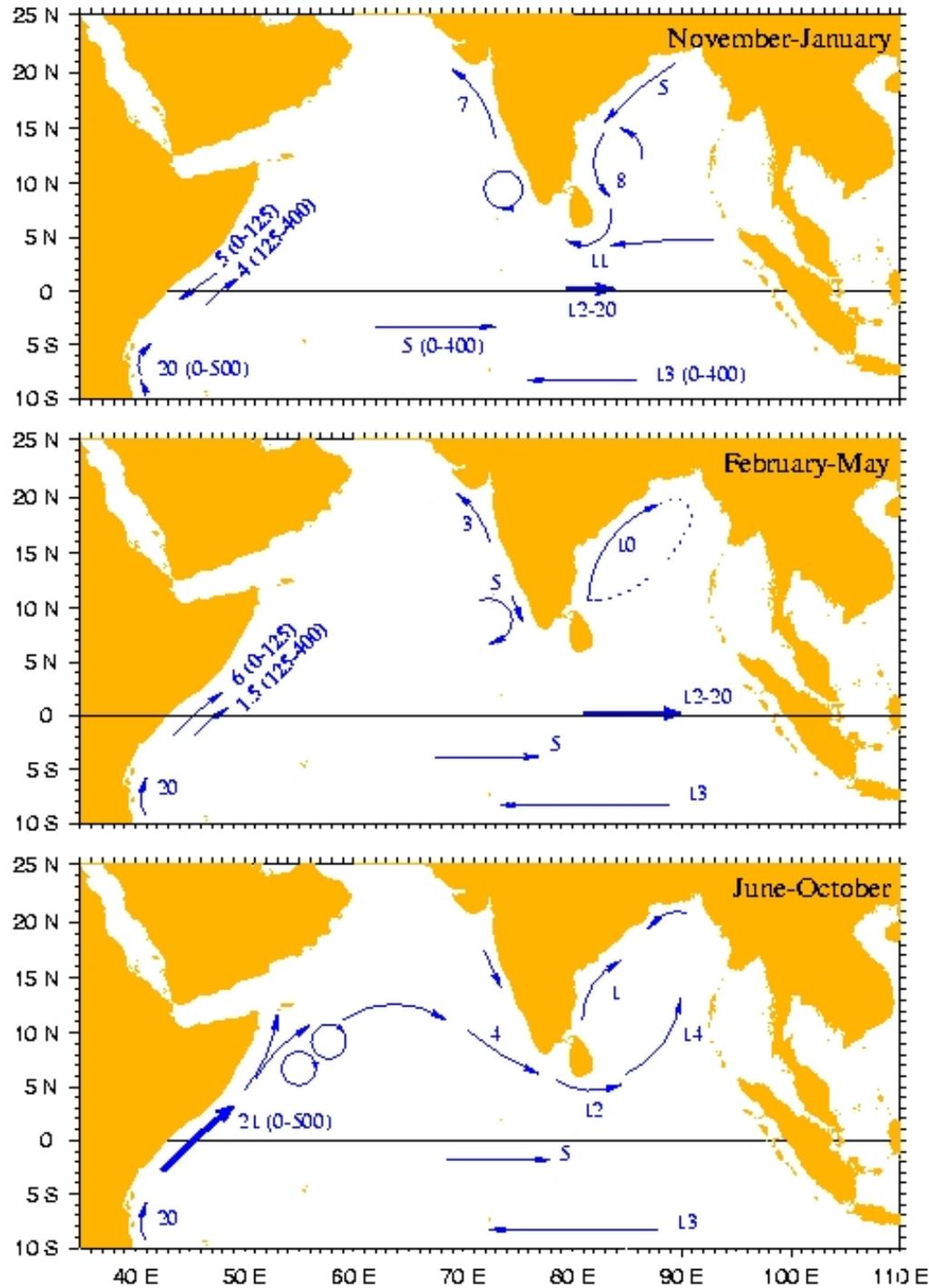
September



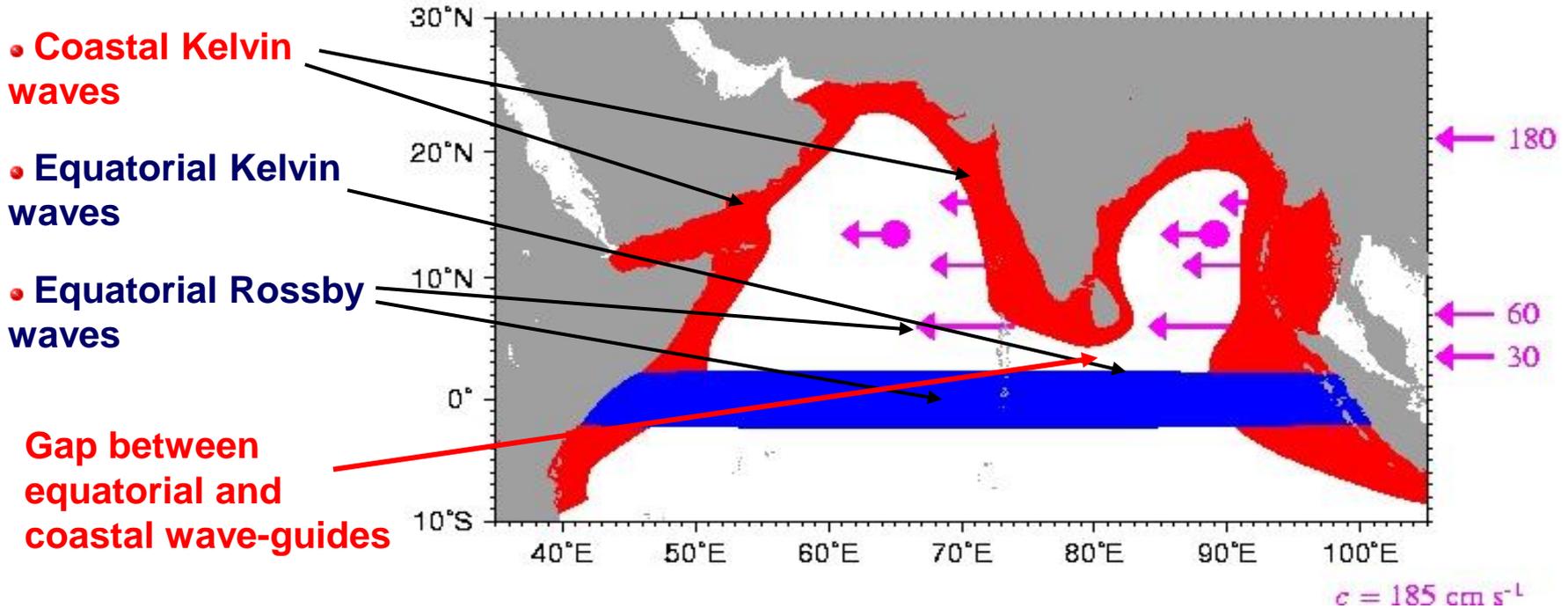
November



Ship drifts from the climatology of Cutler and Swallow (1984)



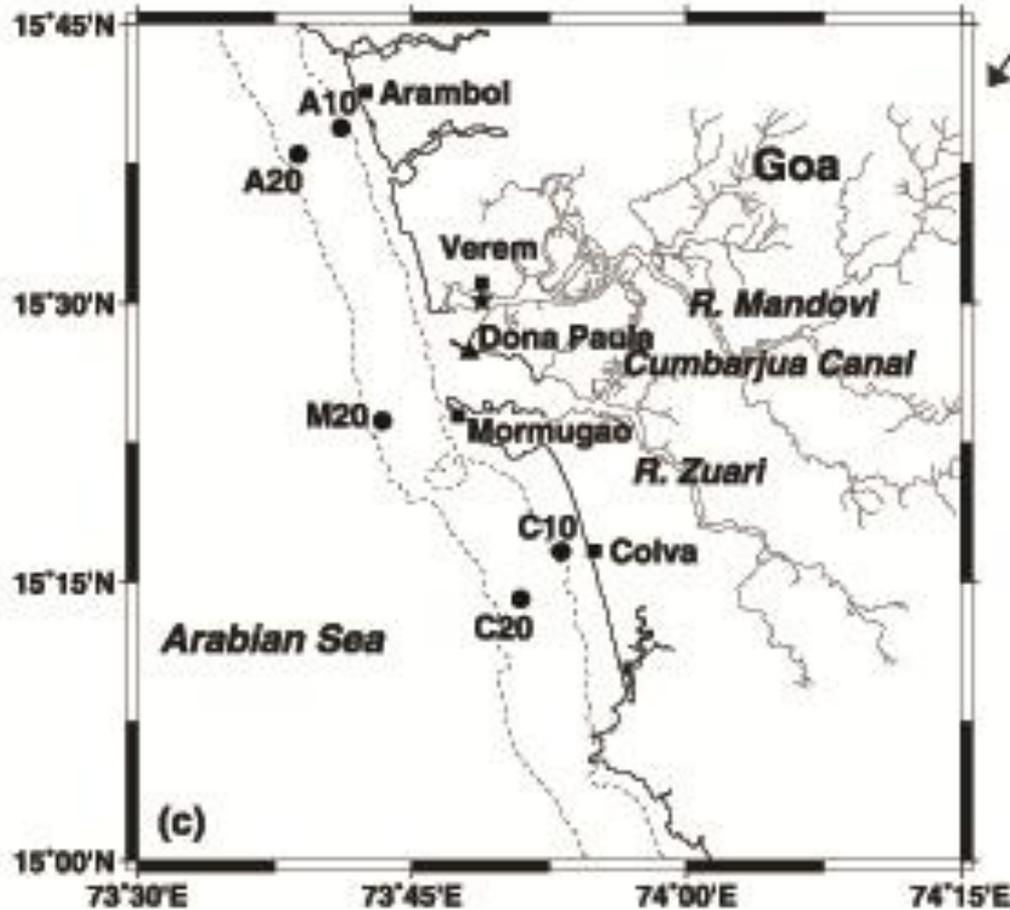
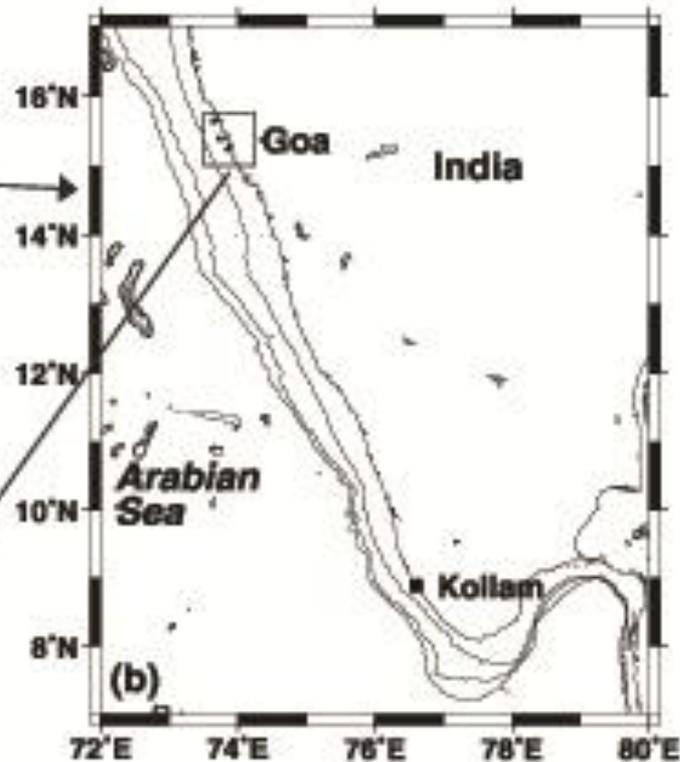
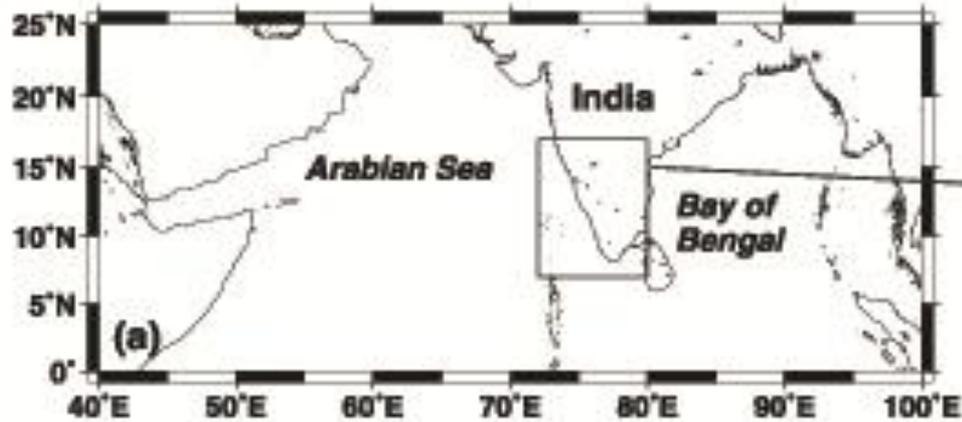
The leaky wave-guide



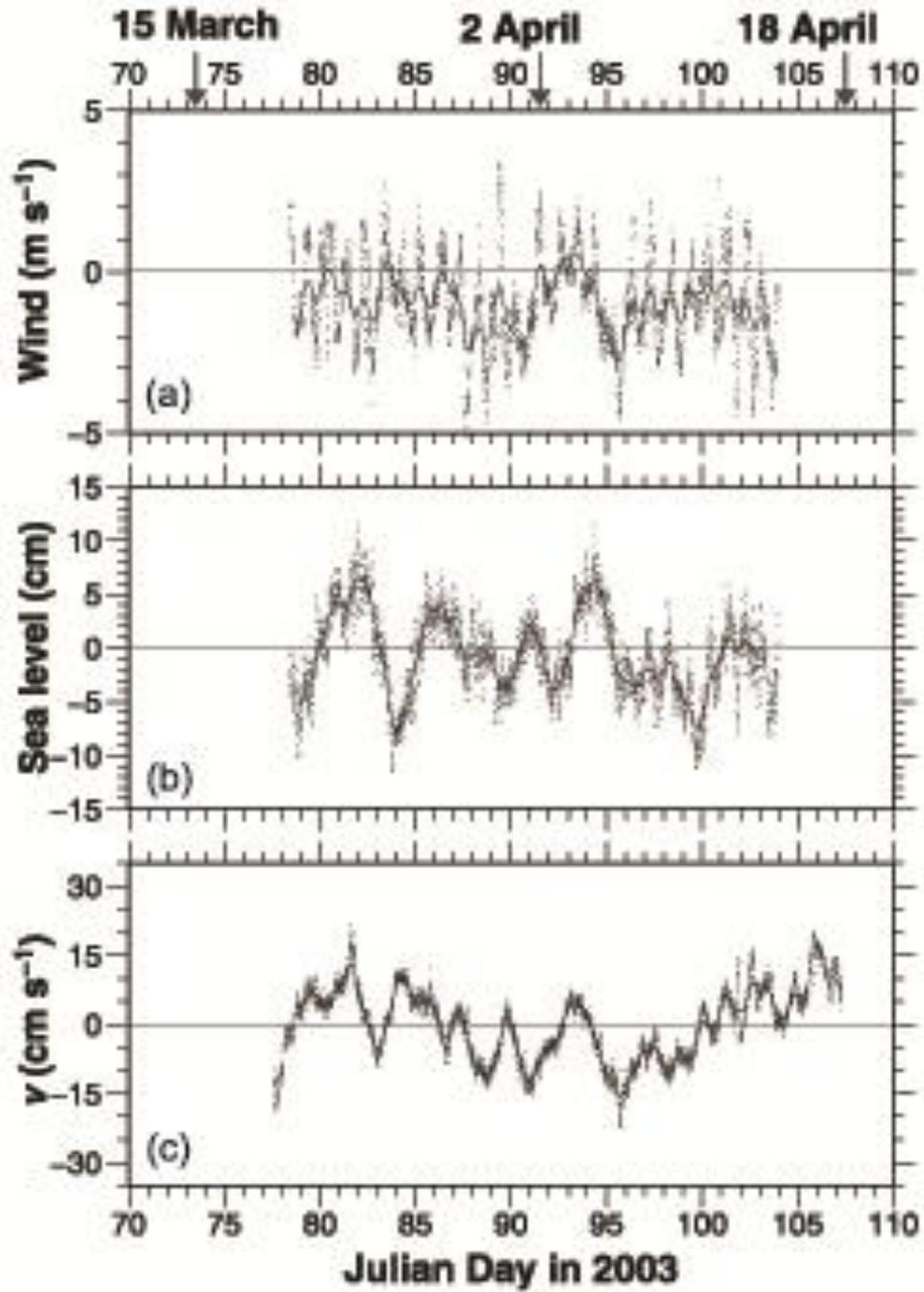
The existence of the **leaky wave-guide** merges the Arabian Sea, the Bay of Bengal, and the equatorial Indian Ocean into a **single dynamical entity**, which must be **modelled as a whole** even to simulate the **seasonal** circulation in its parts.

Shankar et al. (2002, PO)

- How important is the large scale seasonal circulation to the currents near the coast?
- The answer to this question is incomplete at present. But, some insight is available from observations made during March-April 2003



- Current meter
- ▲ Anemometer
- ★ Tide gauge
- Towns



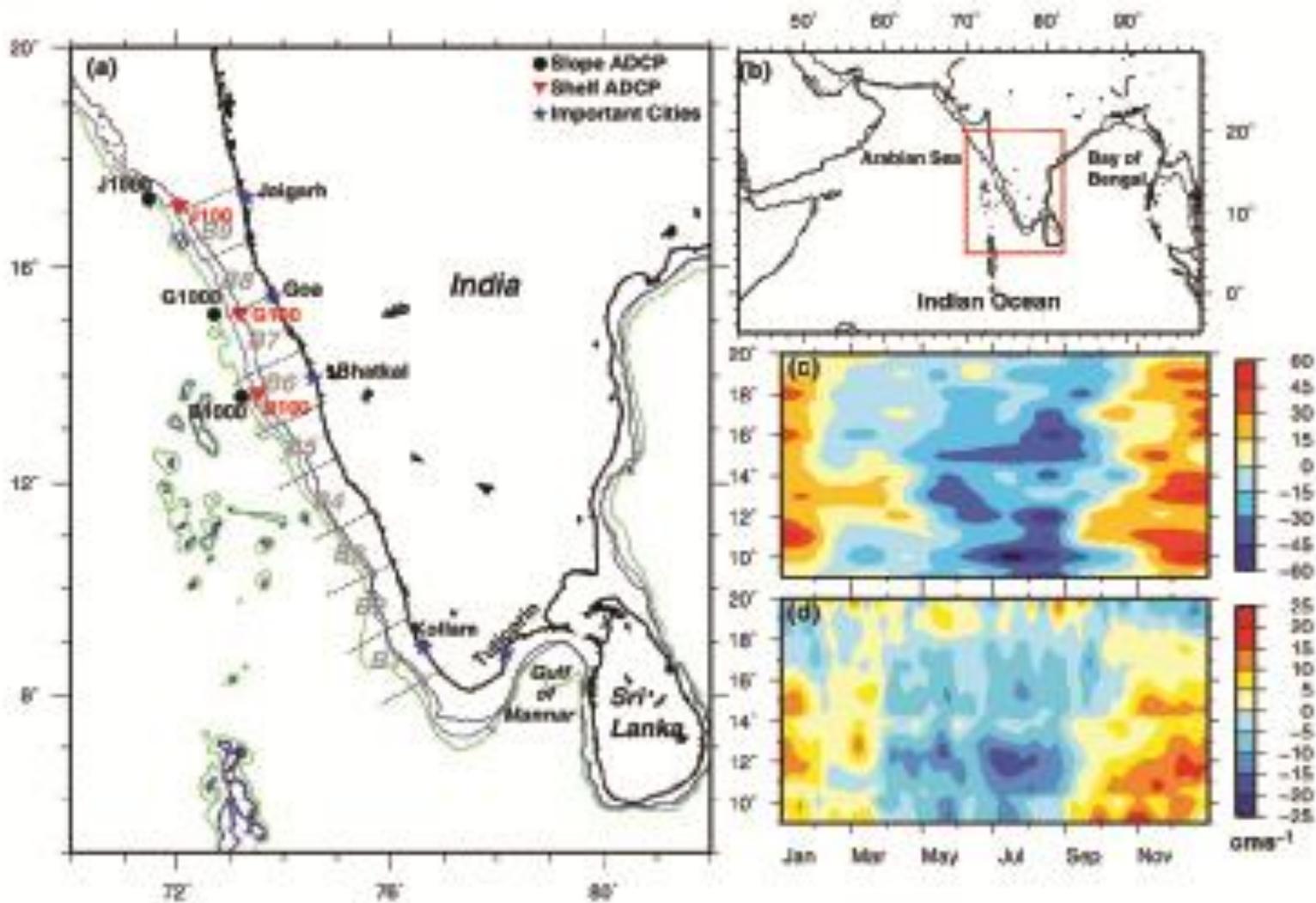


Figure 1. (a) The west coast of India showing the locations of ADCP moorings. Mooring B1000, G1000, and J1000 were on the slope at 1000 m water depth, and moorings B100, G100, and J100 were on the shelf at 100 m water depth. The dashed line divides the coast into 9 blocks of 1° each from B1 (8.5°N) to B9 (17.5°N). The bathymetry is from *Sindhu et al.* [2007]. (b) The location of region of interest in the Indian Ocean. (c) Monthly climatology of alongshore currents from ship drifts [*Mariano et al.*, 1995]. (d) Weekly climatology of geostrophic current calculated from merged altimetry (TOPEX/Poseidon and ERS1/2) data set [*Aviso*, 1996].

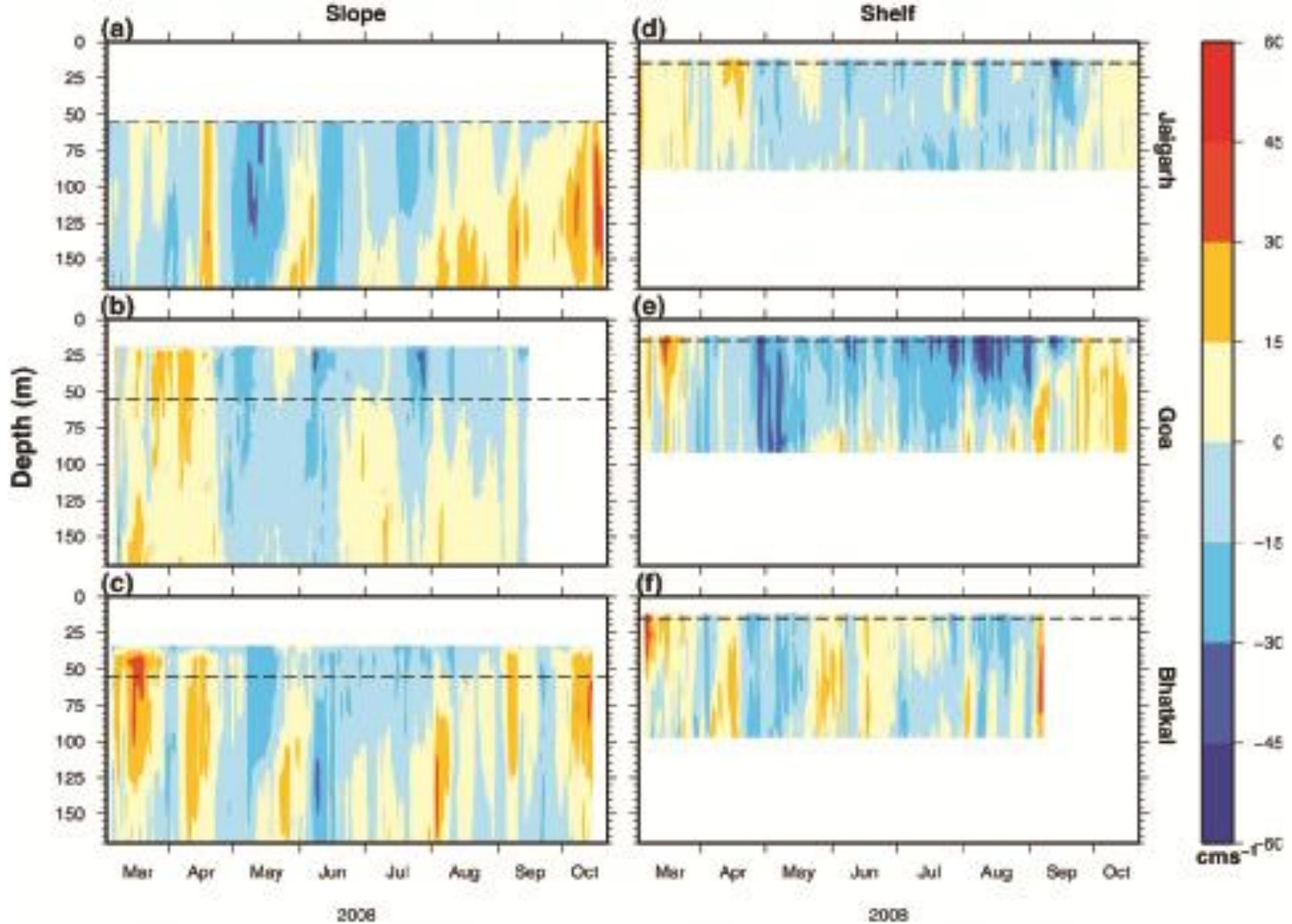
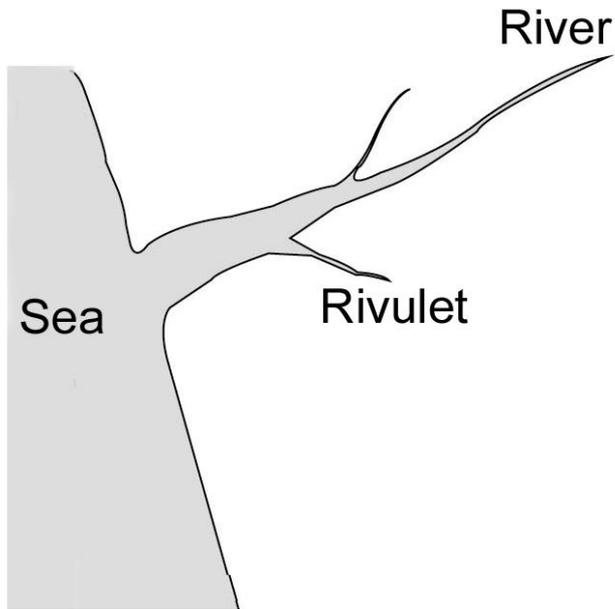


Figure 2. The 2.5-day low-passed and detided alongshore currents (positive poleward) at (top) Jaigarh, (middle) Goa, and (bottom) Bhatkal on (a–c) the slope and (d–f) the shelf. The white space implies data are not available and the dashed line shows the 55 m (15 m) water column depth on the slope (shelf).

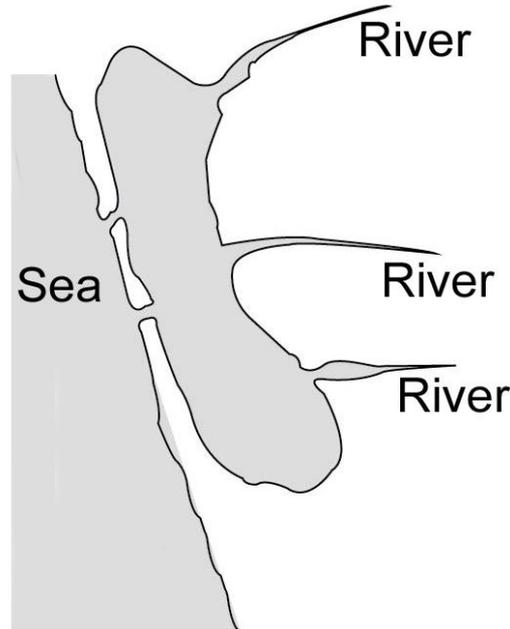
- The advective field near the coastline on the west coast has currents in the form of shelf waves that are forced locally and remotely by winds.
- Their periods vary from days to weeks.
- It is expected that the seasonal currents (with periods of months) are superimposed the days-weeks oscillations.
- Needed are long-term observations in the vicinity of the coastline.

Three different kinds of Indian Estuaries

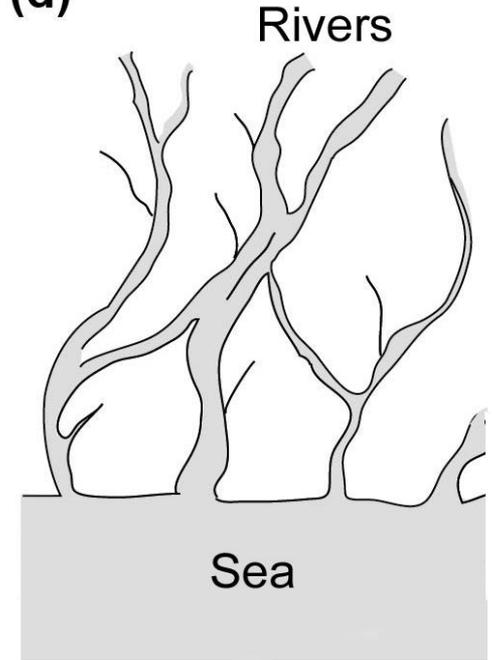
(b)



(c)



(d)

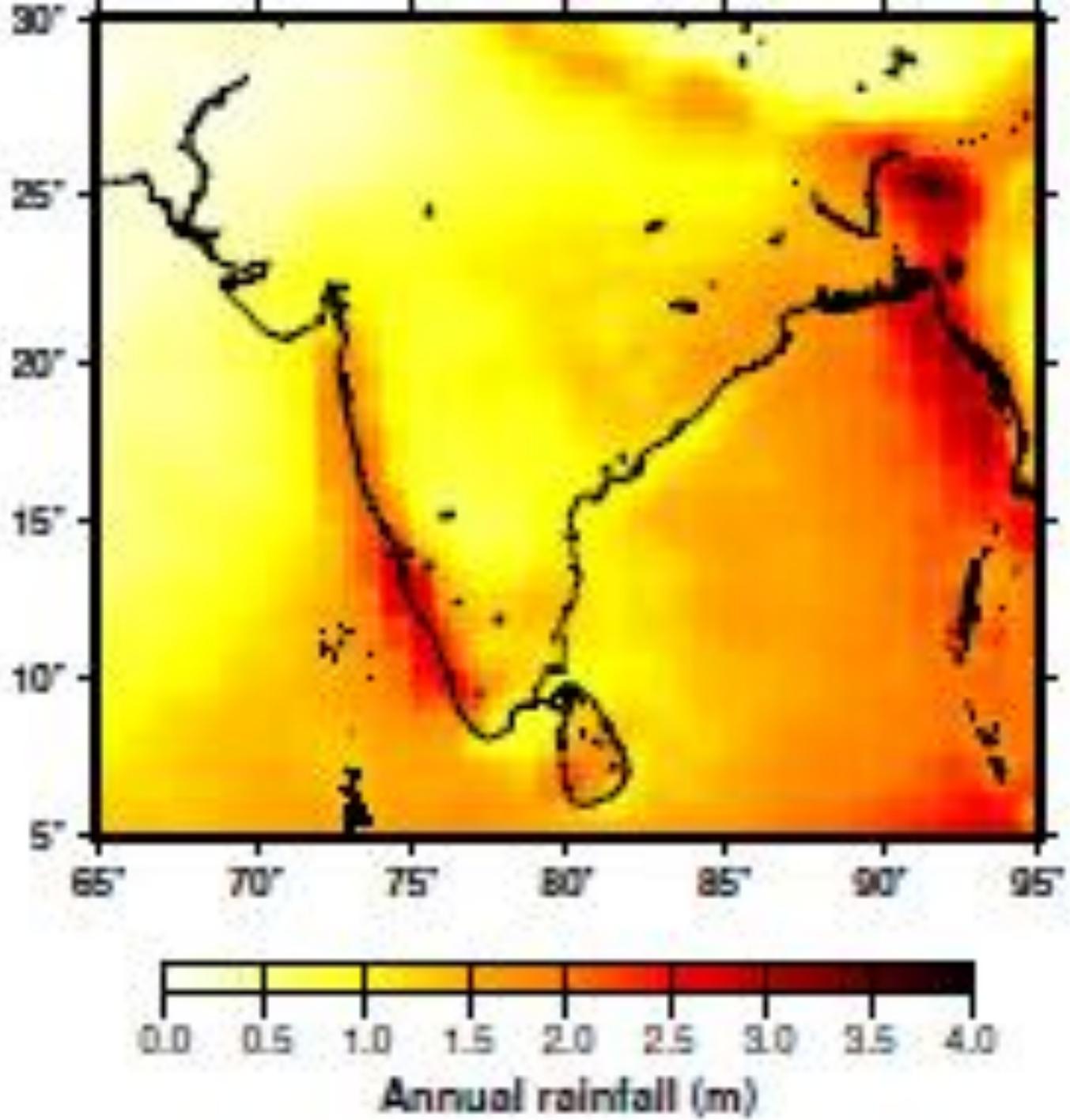


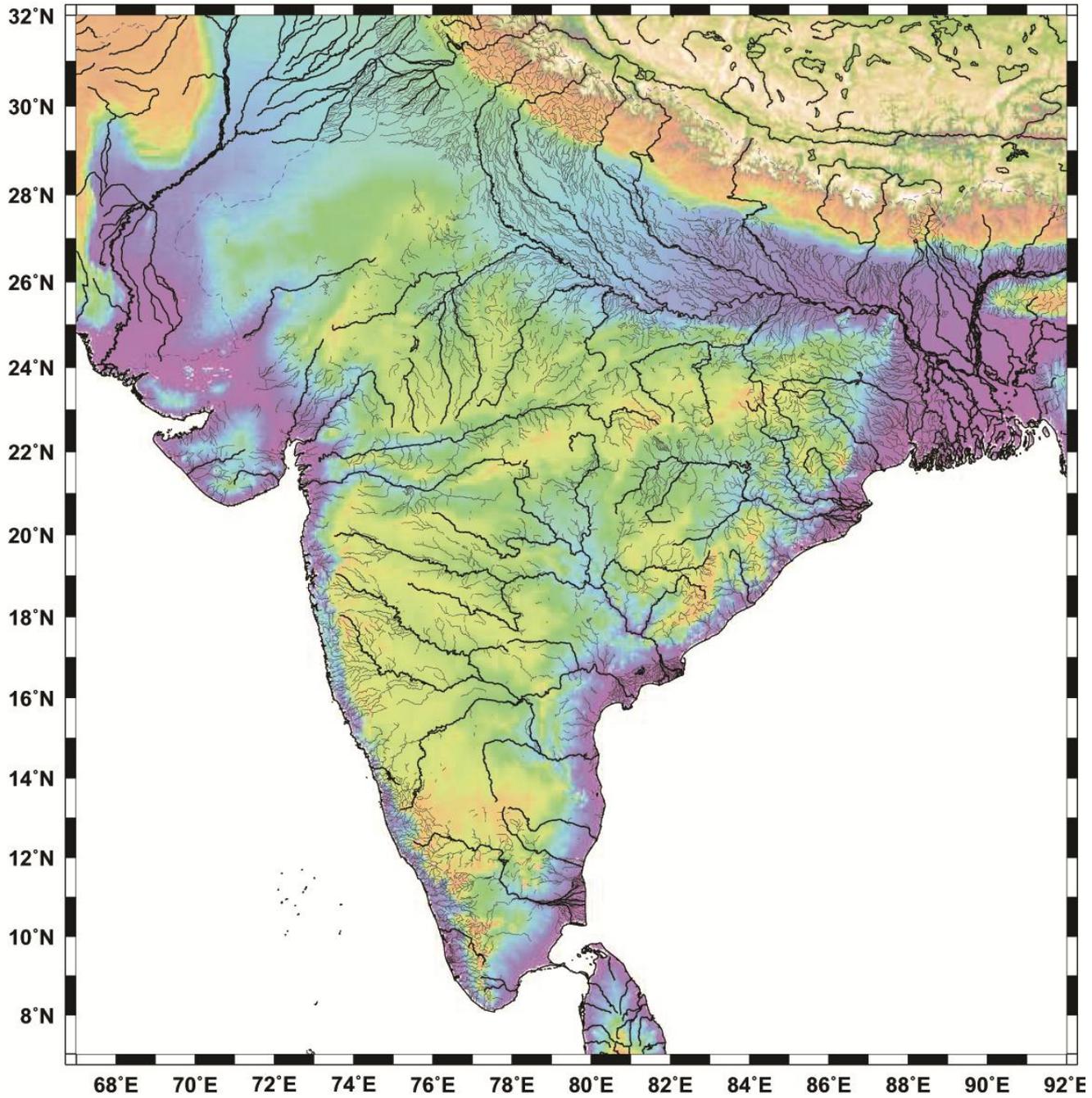
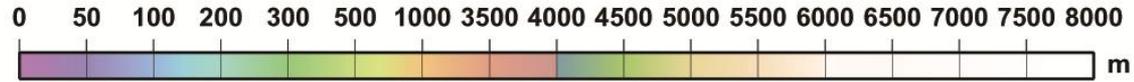
Estuary with single prominent channel:
positive & negative

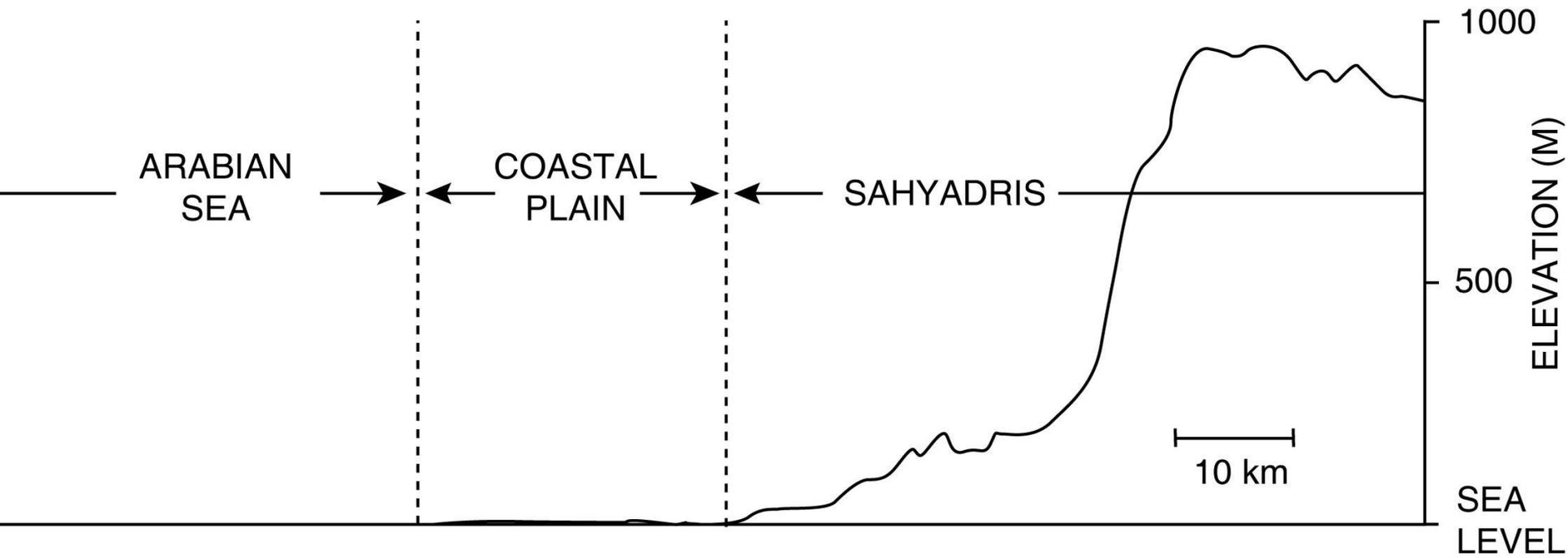
Estuarine lake

Delta-front estuarine complex

Monsoonal character except for the negative estuaries







15°36'N

15°24'N

15°12'N

**Arabian
Sea**

0 — 5 km



73°48'E

74°00'E

74°12'E

Panaji

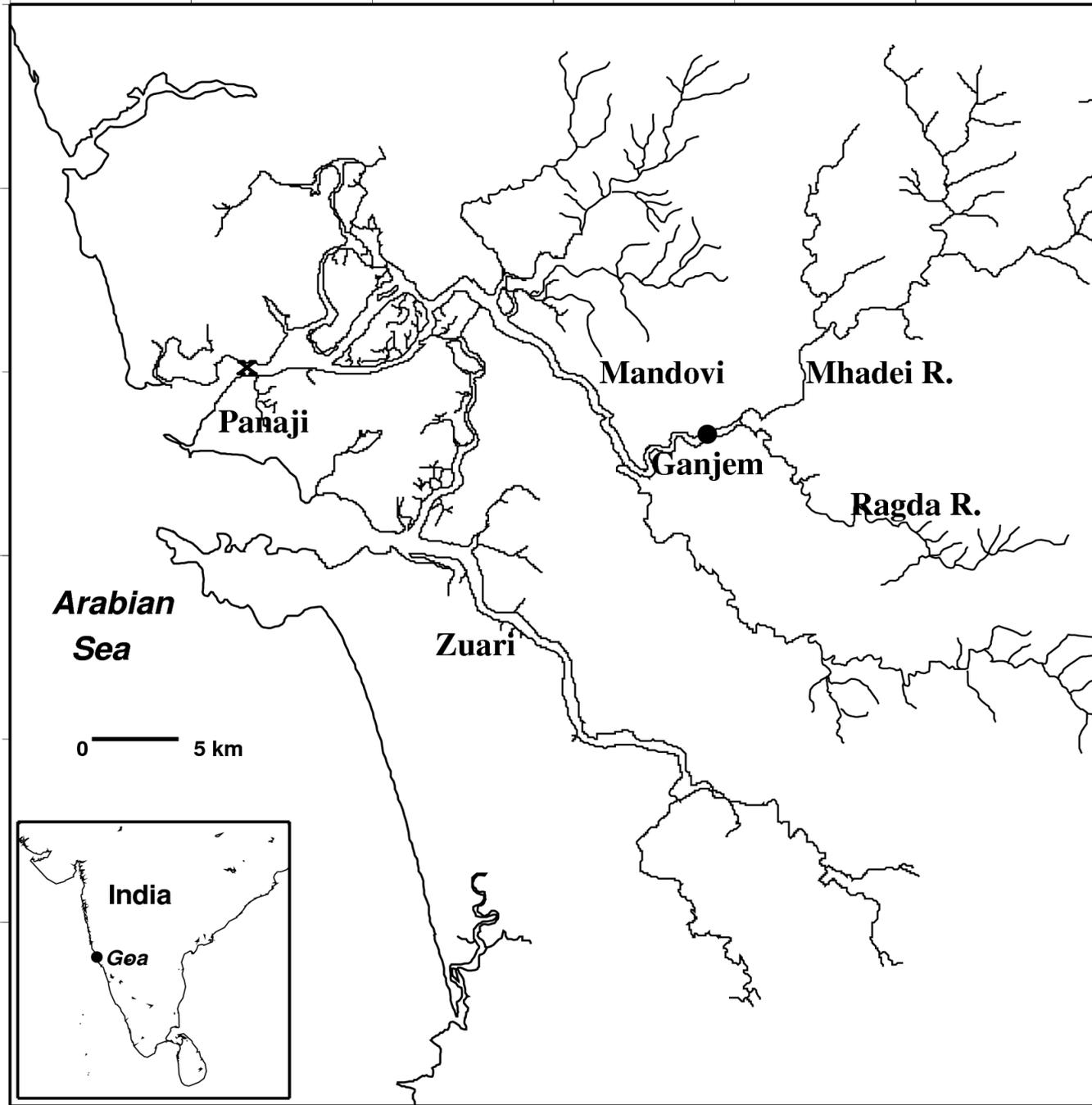
Mandovi

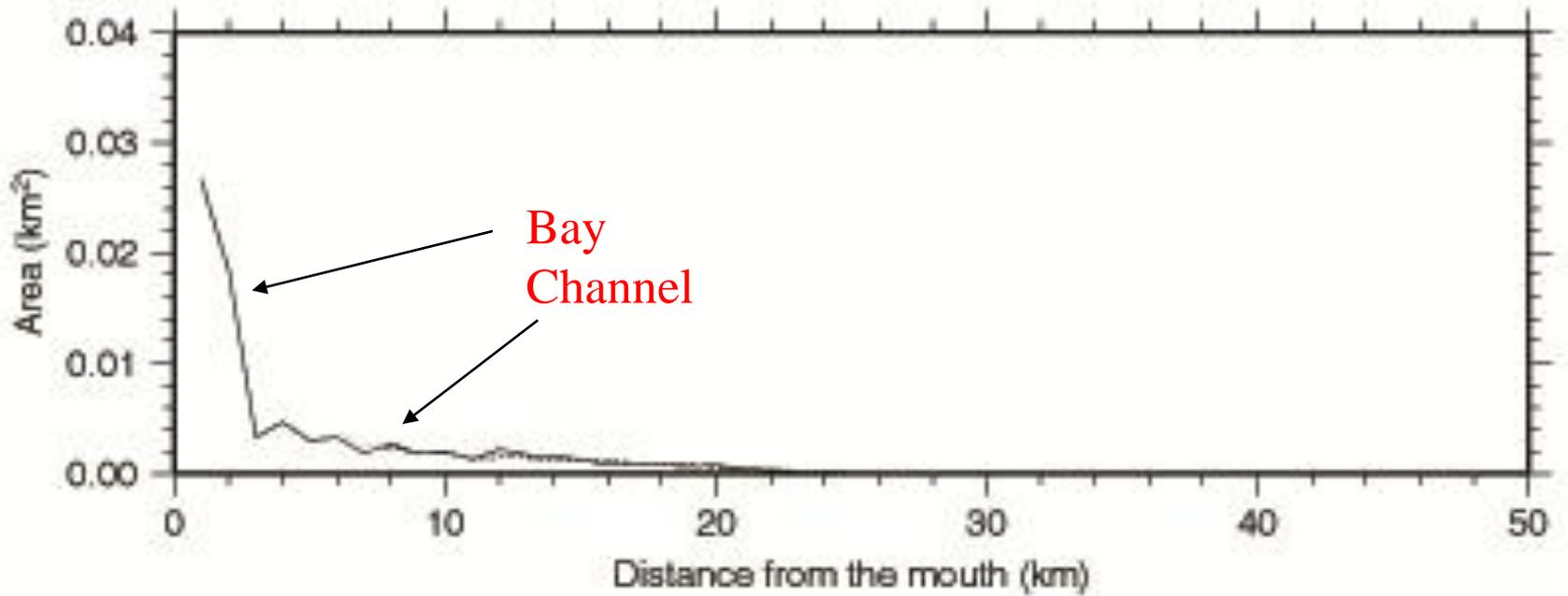
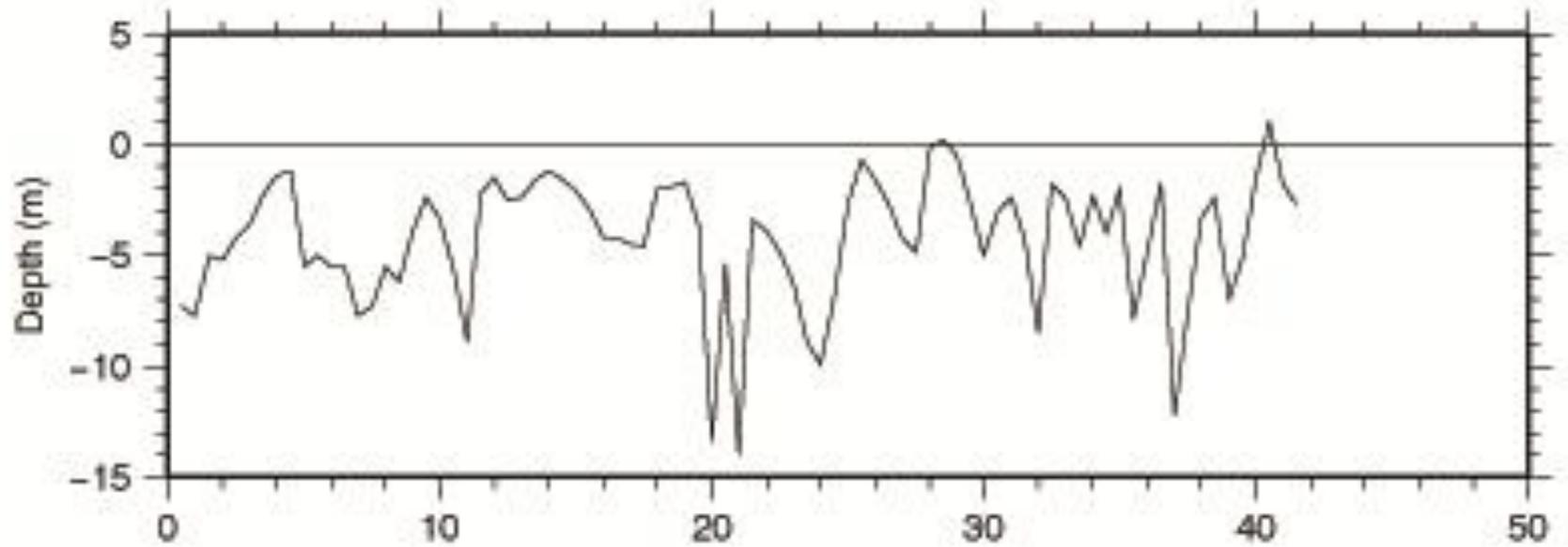
Mhadei R.

Ganjem

Ragda R.

Zuari

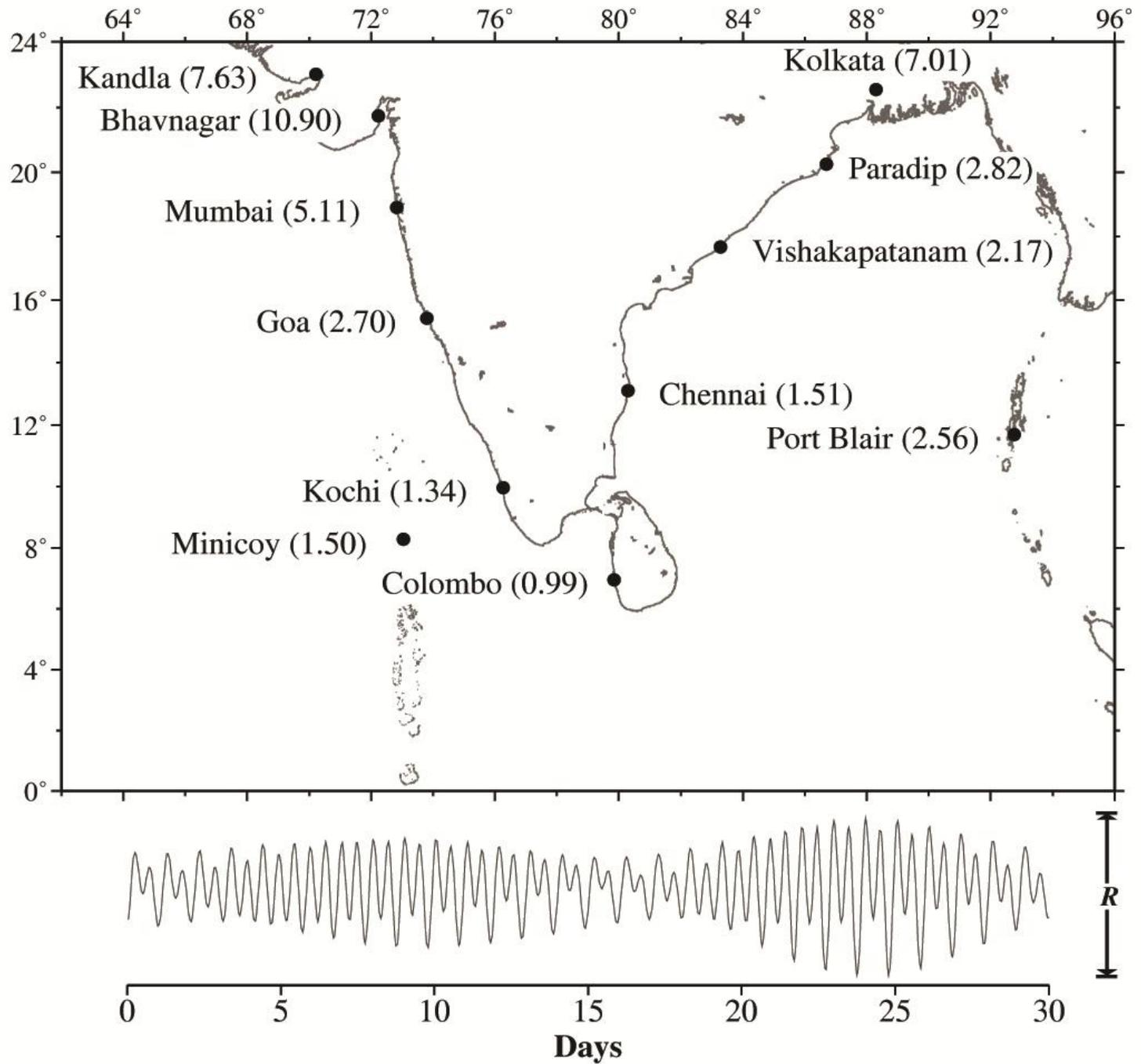




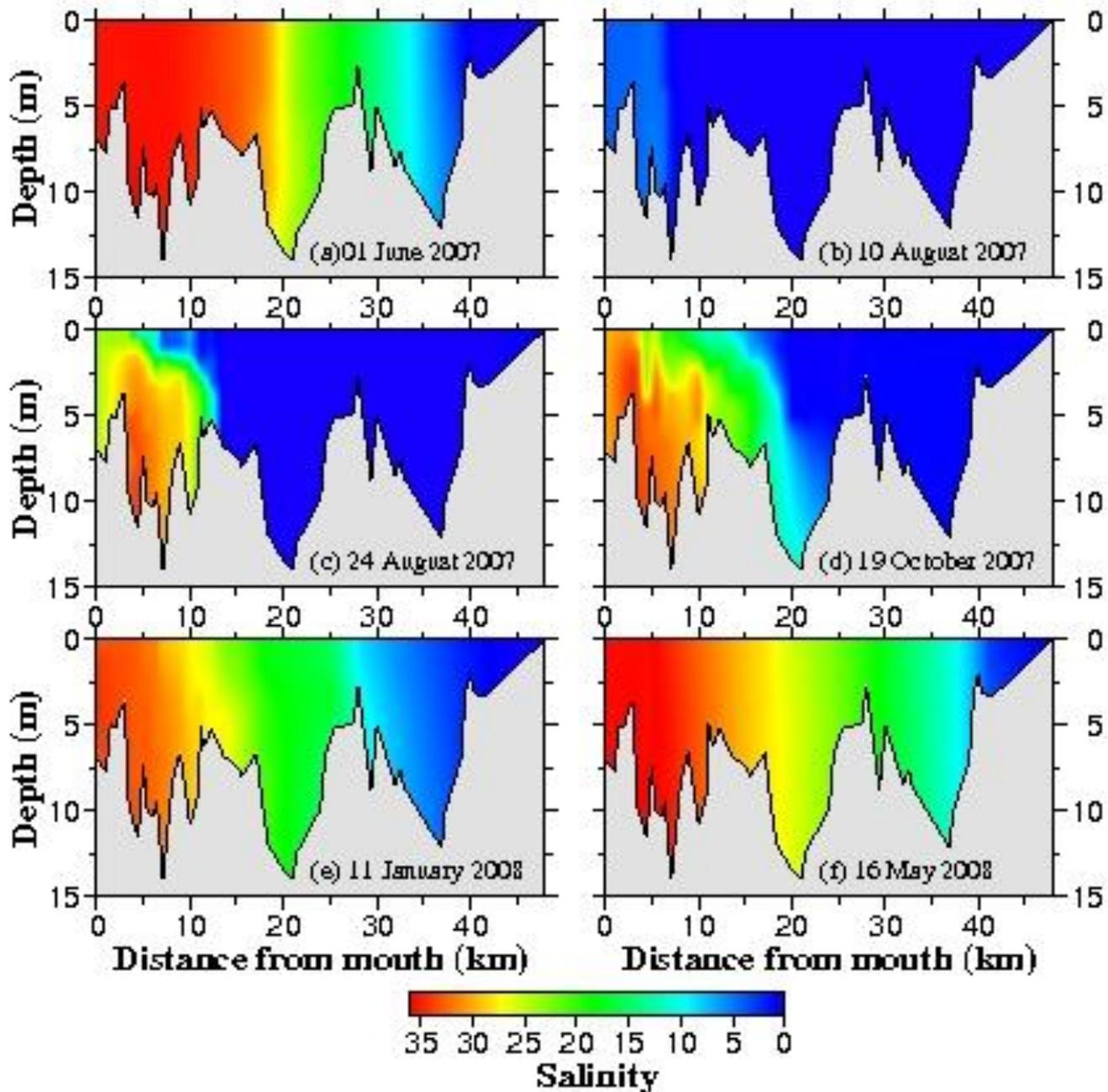
Length	50 km
Width at the mouth	3.7 km
Width 4 km from the mouth	1.0 km
Width at the head	0.1 km
Depth at the mouth	7 m
Depth at the head	1 m
Volume with respect to mean sea level	$160 \times 10^6 \text{ m}^3$
Catchment area	1895 km^2
Runoff at the head during (June-October)	$258 \text{ m}^3 \text{ s}^{-1}$
Runoff at the head during (November-May)	$6 \text{ m}^3 \text{ s}^{-1}$
Tidal range at the mouth (Spring)	2.3 m
Tidal range at the mouth (Neap)	1.5 m

Vijith, Sundar and Shetye (2009)

Tides



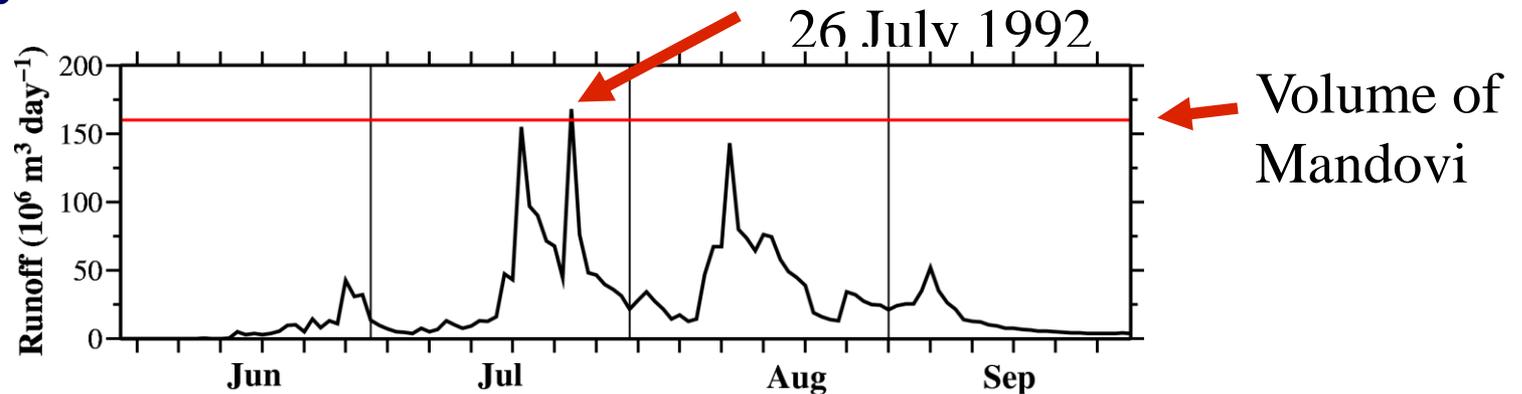
*Oscillations
with periods
bunched
around two
periods:
12.5 hours
(semi-diurnal)
24 hours
(diurnal)*



Vijith, Sundar and Shetye (ECSS, 2009)

Runoff

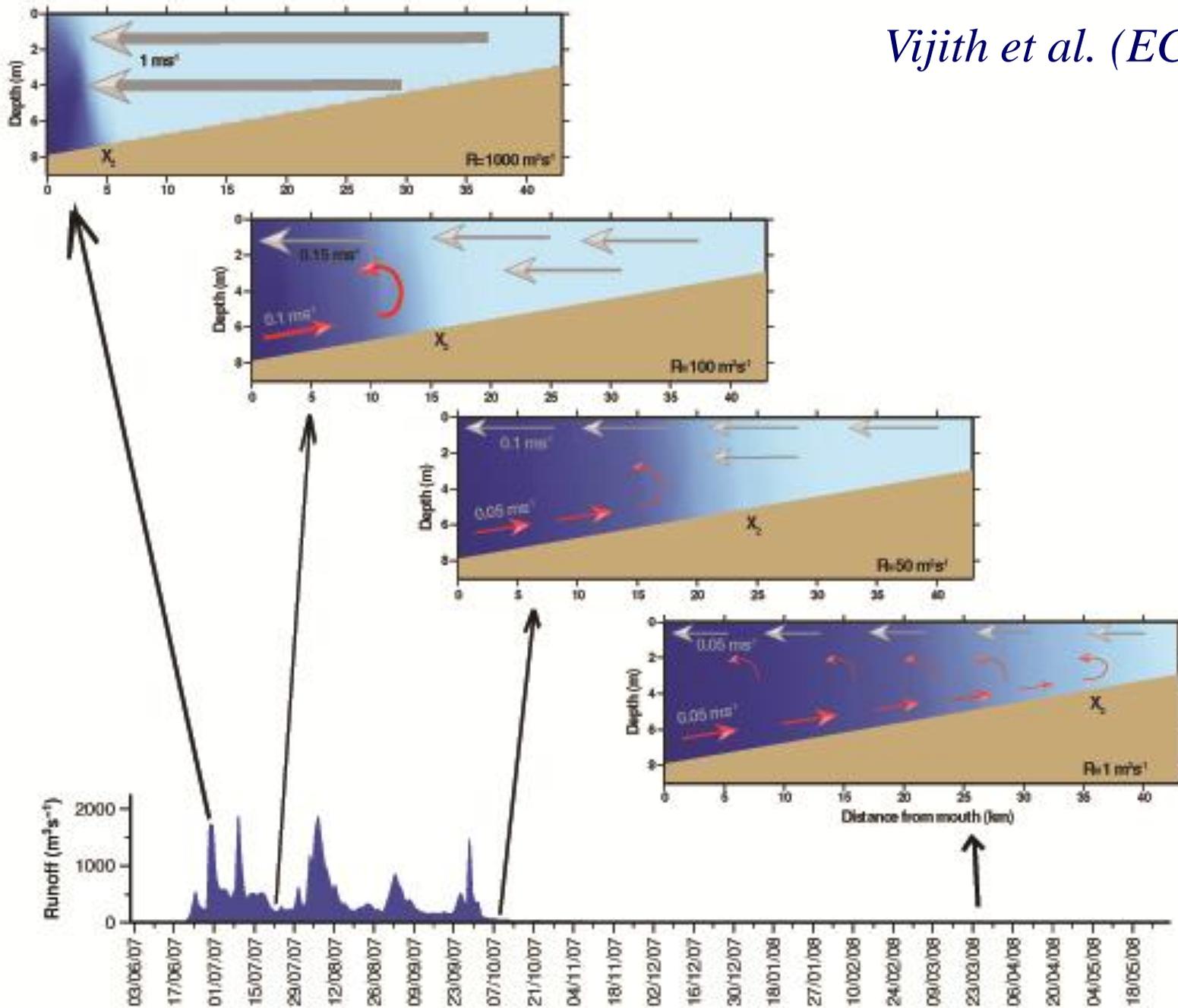
- Spikes during spells of active monsoon
- Lulls during breaks in the monsoon
- Runoff doubles from head to mouth
(*Suprit and Shankar, 2008*)
- On 26 July 1992 runoff at the head is equal to volume of the estuary; such events are not rare.



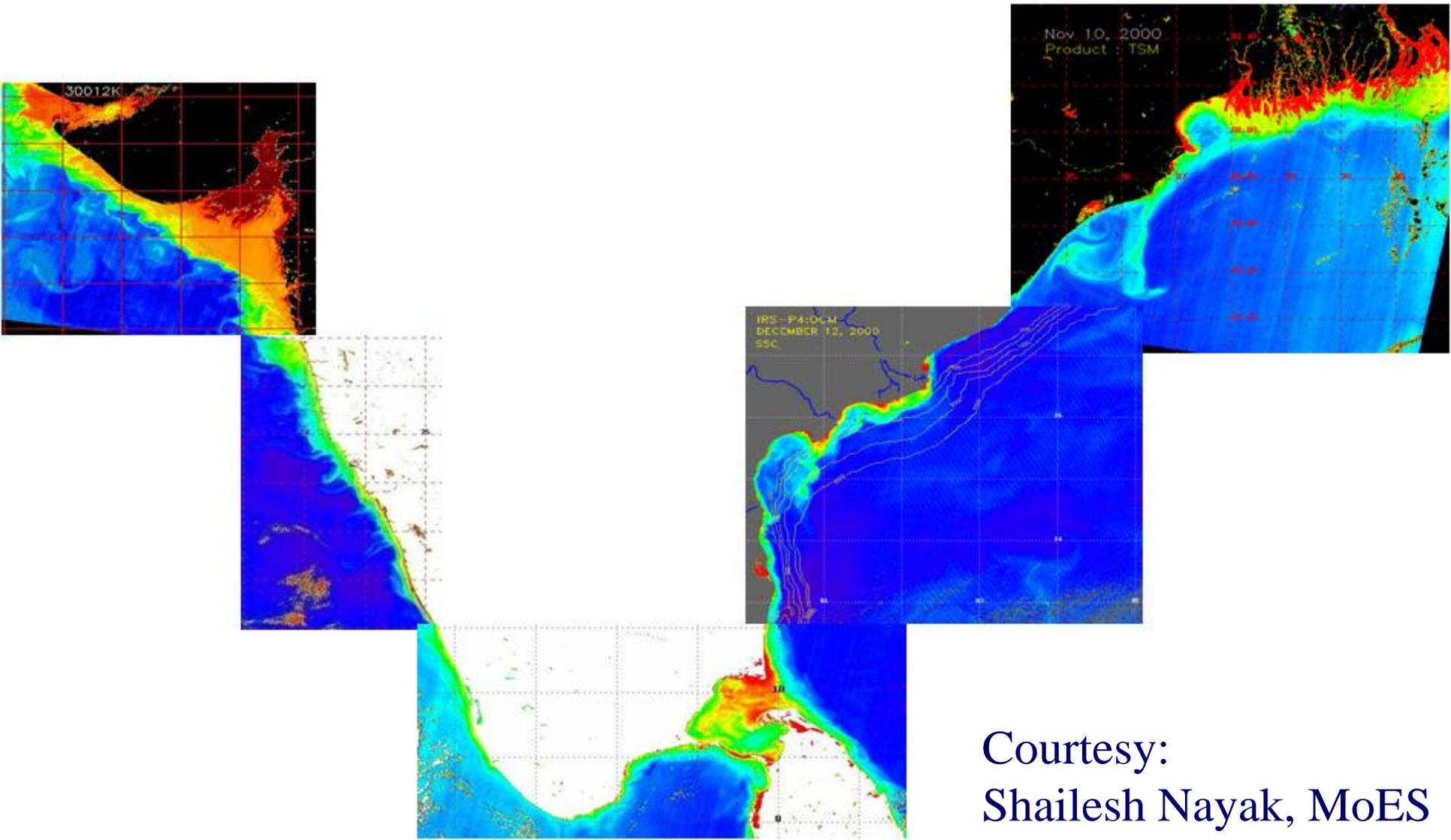
- Little runoff beyond the ISM (November-May)
- Total annual runoff is 40 times volume of the estuary

Residual estuarine circulation in a monsoonal estuary

Vijith et al. (ECSS, 2016)

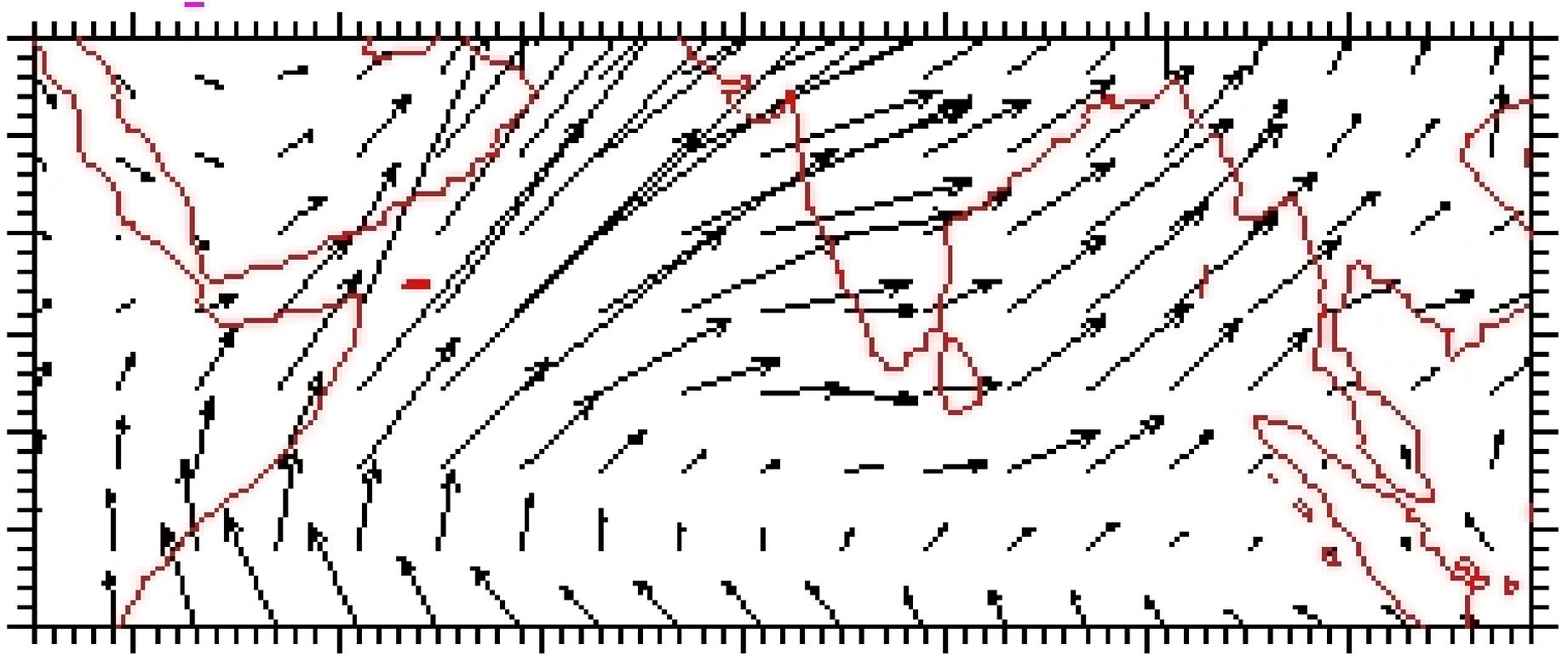


During ISM (June-September) the sediment (and other material) laden low salinity water from the mouth of the estuary forms a plume hugging the coast on the shelf.



Courtesy:
Shailesh Nayak, MoES

- do winds play a role in the exchange of material between the plume and the estuary?



Cross shore winds are an order of magnitude larger than the alongshore winds. The former have been ignored in 'large scale' dynamics.

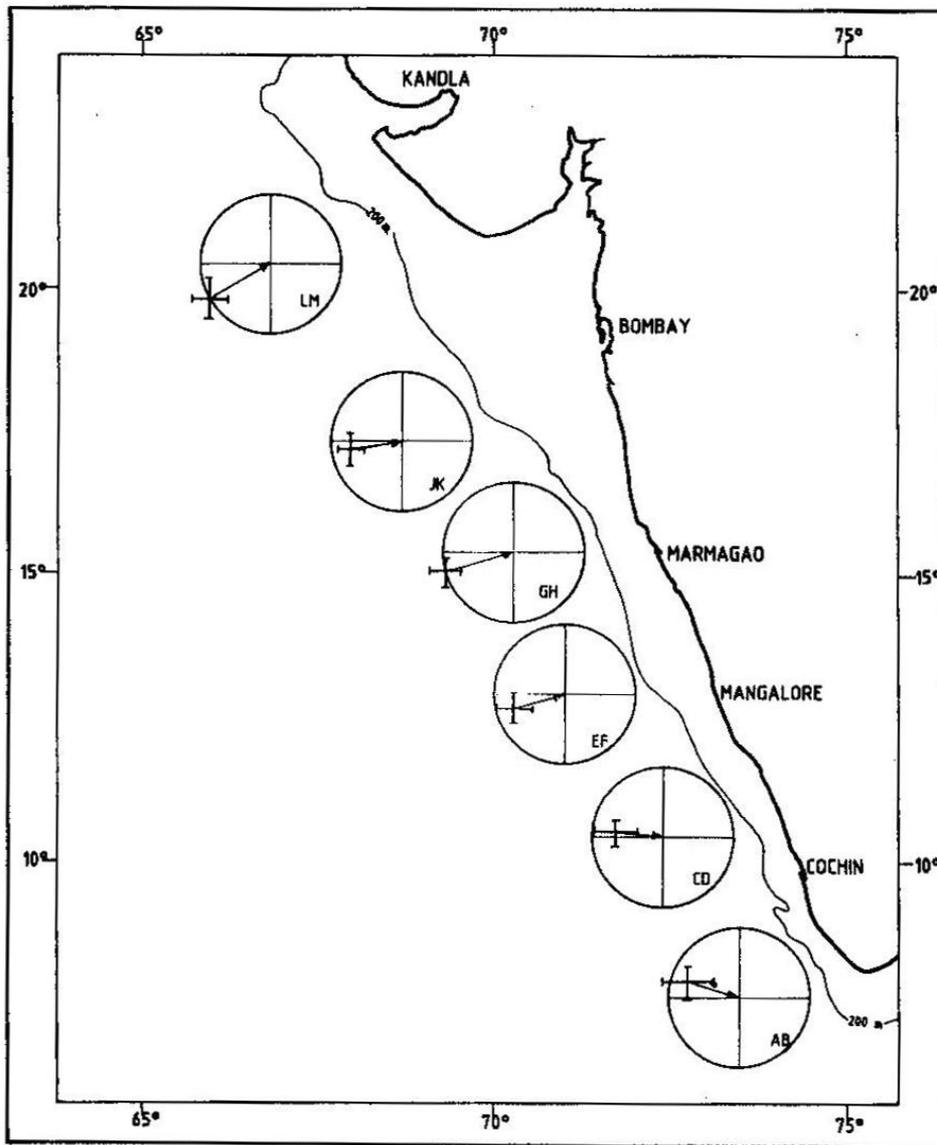
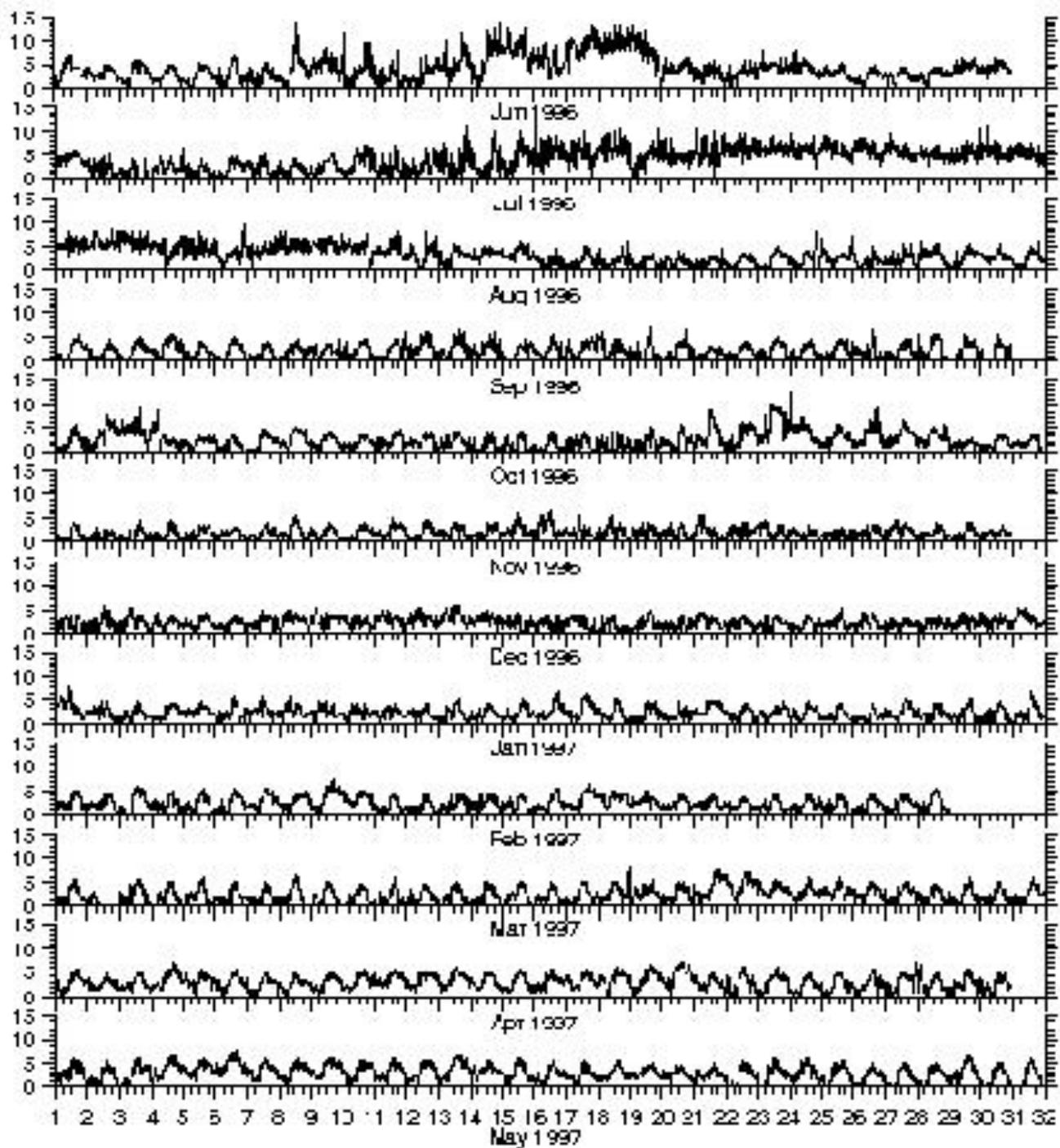


Figure 4. Mean wind vectors recorded during the cruises. Each circle represents the wind speed of 10 m/s. Each vector represents the average wind over two consecutive legs indicated by the letters within the circle. Standard deviation of the eastward and the northward component of the mean vector are also shown.

Shetye et al. (JMR, 1990)



What role do cross-shore winds play in the dynamics of the plume and in exchange of water between the plume and an estuary on the coast?

This is a question that has not yet been addressed.

The answer to it is important not only to understand the movement of the juvenile in prawn fishery, it is also important for understanding physical oceanography of the region.

We need both model studies and observations to examine the estuaries and the plume along the west coast as a unified system.

- Length of the coastline ~ 2000 km
- Shelf width (southern end) ~ 50 km
- Shelf width (northern end) ~ 350 km
- Number of estuaries (Google Earth) ~ 60
- Av. alongshore distance between estuaries ~ 30 km
- Width of the plume ~ 25 km
- Estuary: channel width at the mouth ~ 1 km
channel width near the head ~ 0.1 km

Some key questions:

- Is the exchange between estuarine and plume waters primarily tidal, or do winds, cross-shore winds in particular, play a role too?
- What role do winds play in dynamics of the plume?
- How does exchange between the shelf and the estuarine waters change from wet to dry season?

These questions are important not only for Indian white prawn fishery, but to the physical oceanography of the west coast shelf too.

Summary

- While progress has been made in understanding dynamics of the shelf waters and estuaries on the west coast of India, some outstanding questions remain to be addressed concerning the plume that hugs the coastline during the wet season (Indian Summer Monsoon) and its interaction with the large number of small estuaries found on the coast.
- Addressing these questions, which are of interest to both physical oceanography and fishery of the region, will require observations and modelling studies that cover both the shelf and the estuaries.

Thank You

