History of Expeditions in the Indian Ocean

B. Praveen Kumar, M. S. Girish Kumar and many colleagues from INCOIS

Objectives of this talk

- To provide a brief idea of how oceanography as a science evolved world over
- …. With a focus on Indian Ocean Oceanographic Research
- Of course, we all are oceanographers, and its worth knowing what our predecessors had done ….

Ocean Expeditions - timeline

Early History

- Primarily for the requirements of daily survival
- Gathering food, fishing
- Trading
- Migrating to more promising regions (discover new lands)

Middle ages

- Conquest of new territories
- Enrichment of government treasuries
- Enhancement and projection of political power

Modern Era

- Exploiting marine food, energy, and mineral resources
- Understanding climate change
- Minimizing the impact of natural disasters such as tsunami, hurricanes
- Assessing humanity's impact on our environment
- Understanding earth processes such as biogeochemical cycling, plate tectonics, etc.

Early explorations around the world

Before 2500 BC

- **There is no clear information about who the first people were to explore the oceans, nor when.**

- **the people who ventured out into the oceans for daily survival, are the first oceanographers. They were curious about the ocean, they observed it, learned its processes, and made use of the ocean's rhythm for the benefit of their voyages.**

- **As per historical evidence, the earliest recorded sea voyage was undertaken by ancient Egyptians around 3200BC.**

Early explorations around the world

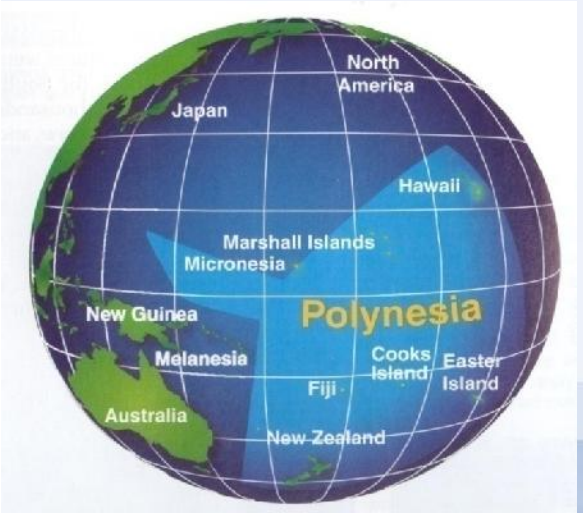
Before 2500 BC | **2500 BC- 900 BC**

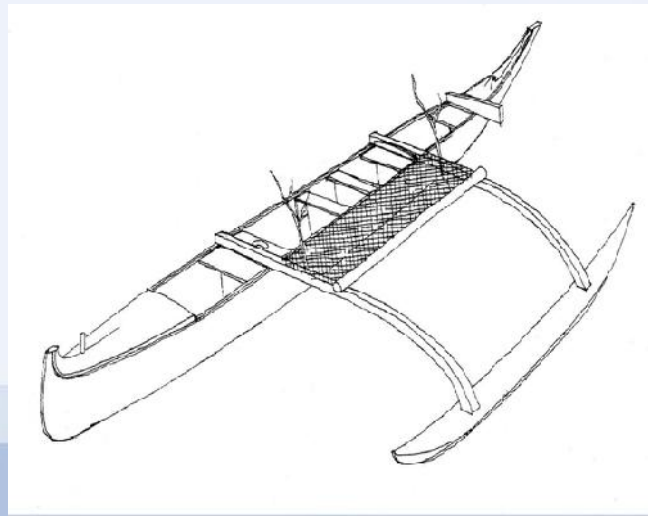
Polynesian Expeditions

•The Polynesians were the first known people to undertake regular, long-distance open ocean seafaring beyond sight of land.

•One of the great achievements of early seafaring cultures, and it marks the start of regular oceanographic explorations by people who lived in harmony with the ocean.

• celestial navigation, double canoe & out trigger type boats …





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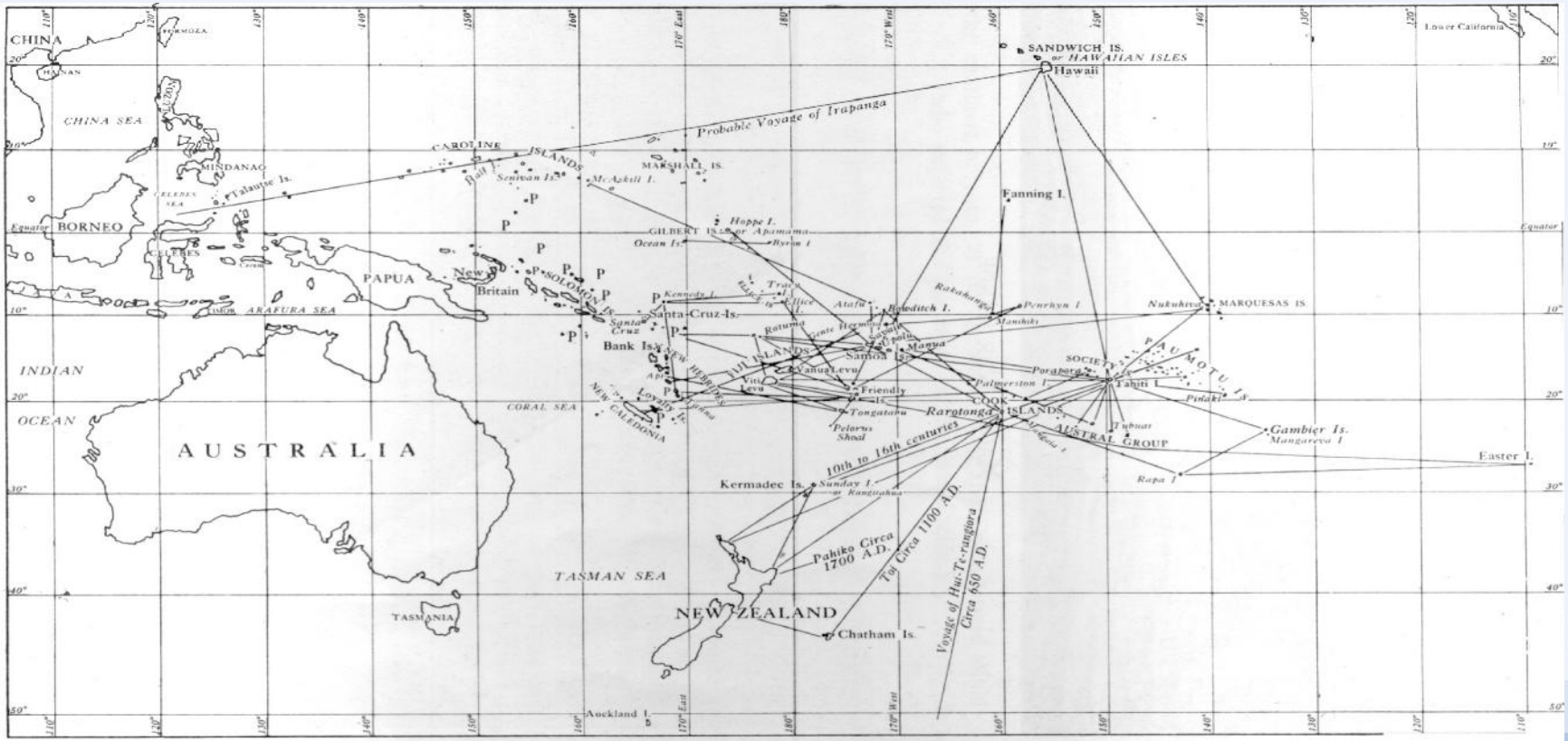


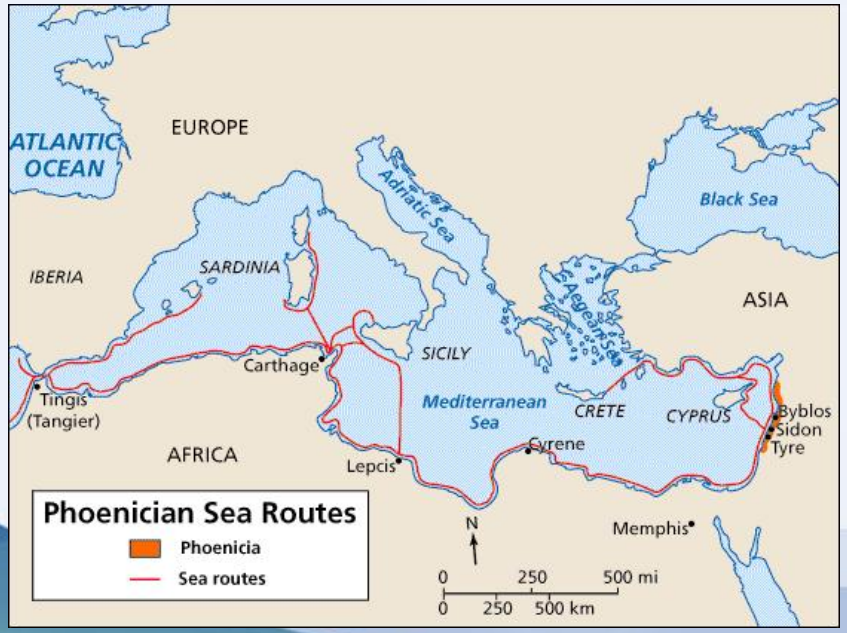
MAP SHOWING SOME RECORDED VOYAGES OF THE POLYNESIANS

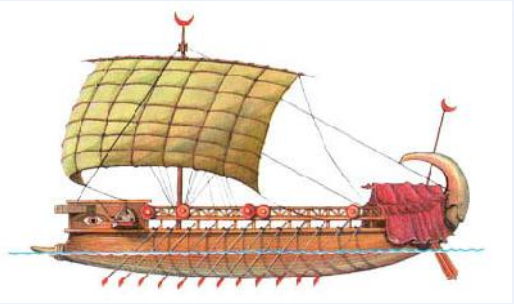
Early explorations around the world

Before 2500 BC | 2500 BC- 900 BC | 1500 BC- 500 BC

Phoenicians Expeditions

- **Phoenicia was an ancient civilization centered along the coast of modern day Lebanon, Syria and northern Israel.**
- **They travel through Mediterranean and up to England for trades for trade**
- **They preferred coastal navigation.**





http://www.barca.fsnet.co.uk/phoenecian-ships.htm

Early explorations around the world

Before 2500 BC | 2500 BC- 900 BC | 1500 BC- 500 BC | 150 BC- 1500 AD

Voyages to discover the "unknown world"

<u>150 BC</u>: Ptolemy' book "Geography"

Romans recreated a world map in 2nd century based on "Geography", called the Ptolemy's map.

First map to include latitude and longitude

Ptolemy's Map

Early explorations around the world

Before 2500 BC | 2500 BC- 900 BC | 1500 BC- 500 BC | 150 BC- 1500 AD

Voyages to discover the "unknown world"

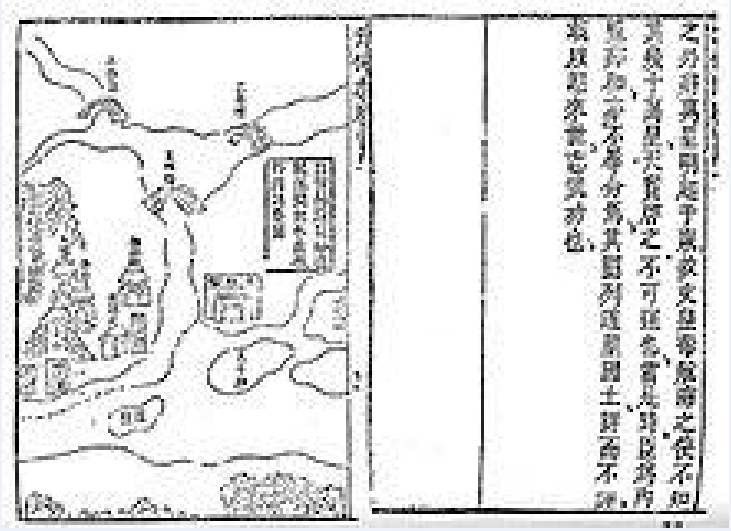
1125 AD (?): Chinese Invented Magnetic compass.

Early explorations around the world

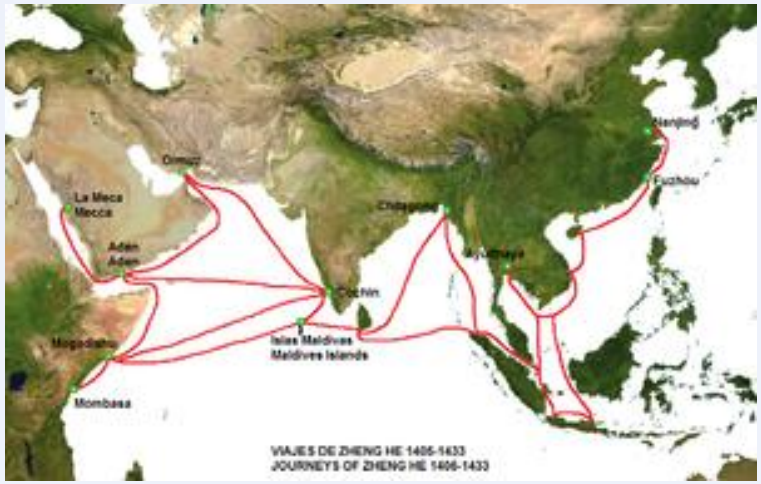
Before 2500 BC | 2500 BC- 900 BC | 1500 BC- 500 BC | 150 BC- 1500 AD

7 Great Voyages of China

- Between 1405-1433, Ming Dynasty sponsored 7 naval expeditions.
- Zheng He commanded of one of the largest fleets to explore various regions of the world
- they visited Brunei, Java, Thailand, India, Horn of Africa and Arabia
- No lasting contribution in history …



Map used in one of Zheng He's voyages



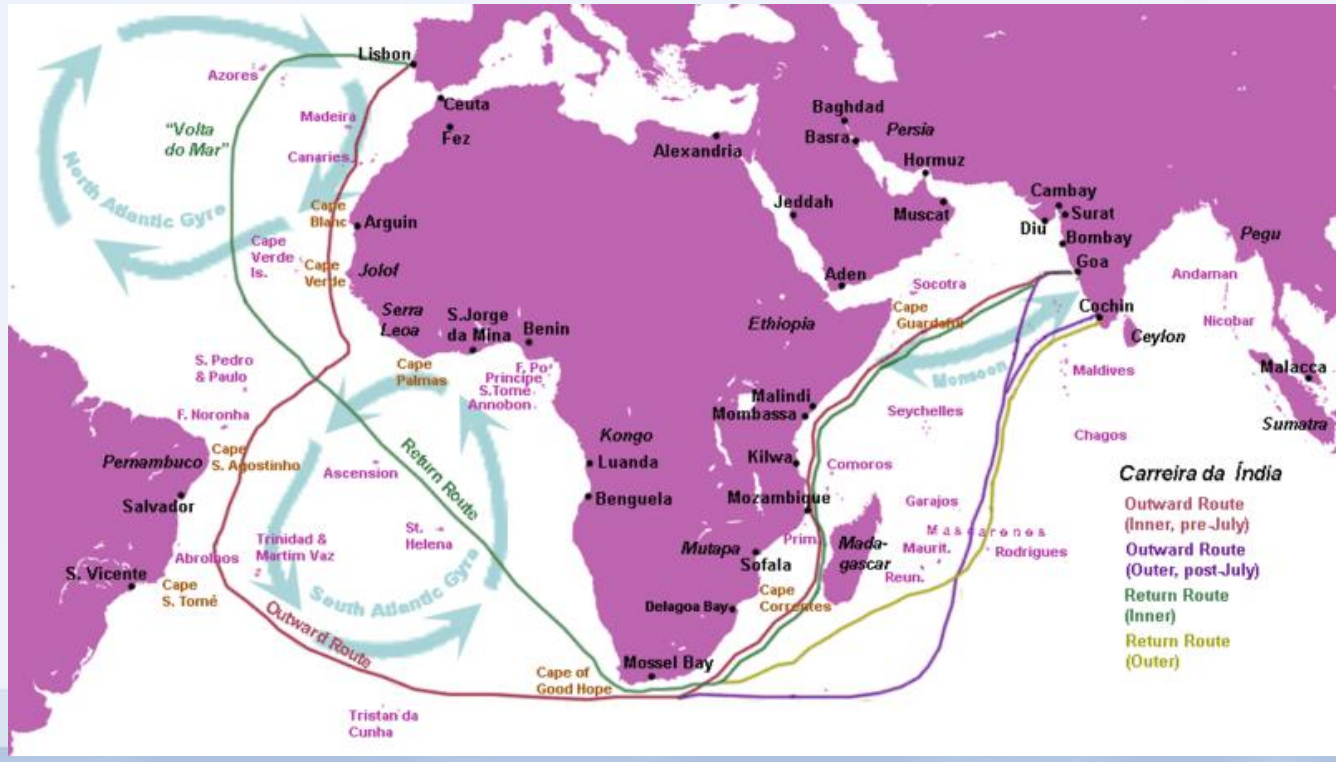
The route of the voyages of Zheng He's fleet

Early explorations around the world

Before 2500 BC | 2500 BC- 900 BC | 1500 BC- 500 BC | 150 BC- 1500 AD

Voyages to discover the "unknown world"

1498 AD: Vasco da Gama sails around the southern tip of Africa becoming the first European to reach India by sea.



Early explorations around the world

2500 BC- 9000 BC | 1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD - 1750 AD

Period of Discoveries

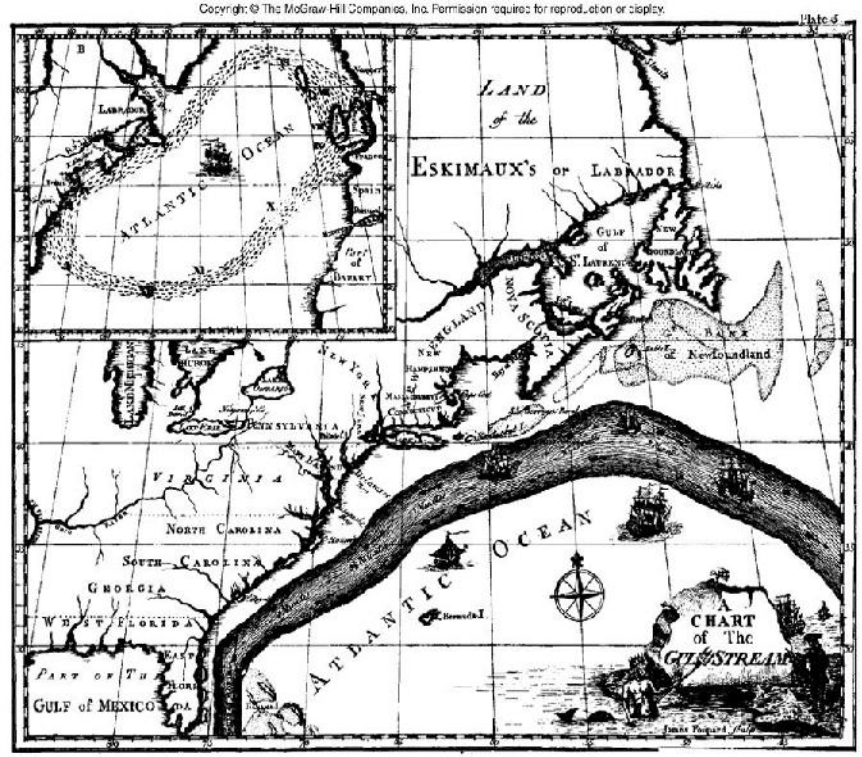
a. 1519-1521: Ferdinand Magellan circumnavigated the globe.
b. 1529: Portuguese made a world map with Pacific, China and India in proper size, and included both north and south poles
c. 1569: Mercator developed a projection for the globe; the basis of map making today.
d. 1643: Torricelli invented barometer, which helped mariners to identify an approaching storm
e. 1735: John Harrison invented chronometer

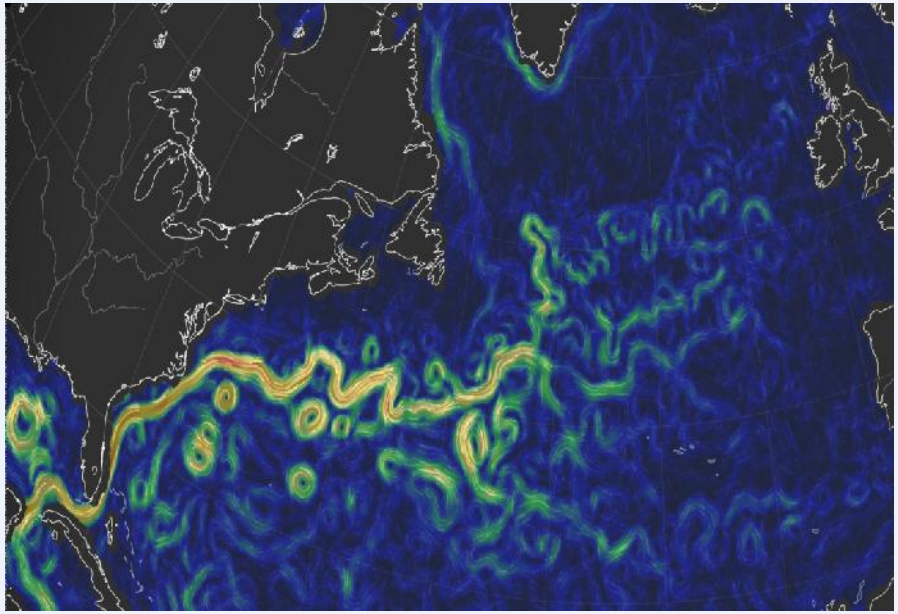
Beginning of Science Voyages

1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Scientific Oceanography

1769: Benjamin Franklin publishes the first map of Gulf Stream





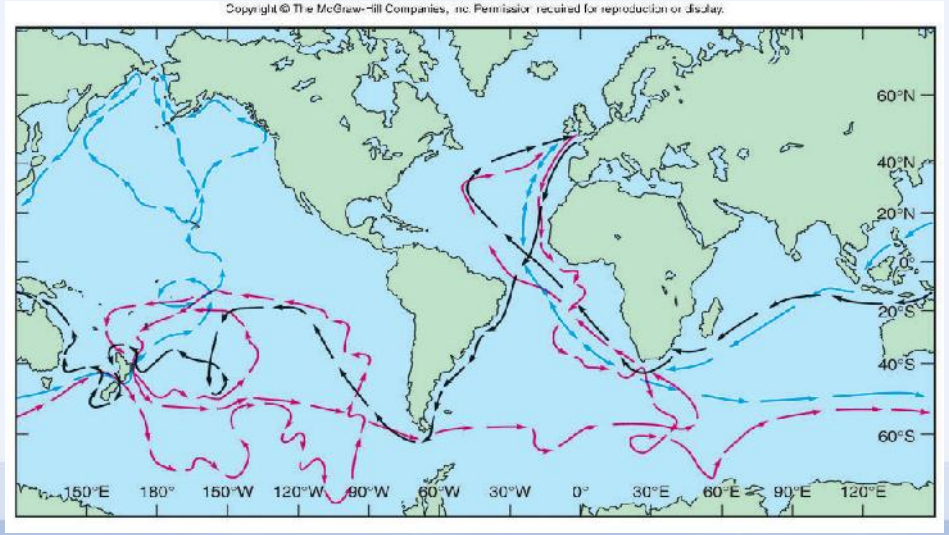
Beginning of Science Voyages

1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Scientific Oceanography

1768 – '79: Captain James Cook Ocean Voyages

a. First navigator to carry an accurate chronometer to sea.
b. Measure longitude precisely for the first time and improve existing maps dramatically.
c. Gathered extensive data on the geography, geology, currents, tides and water temperature of all the principle oceans.
d. Becoming the first mariner to Sail the polar sea of both hemispheres.



Beginning of Science Voyages

1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Scientific Oceanography

1831 – '36 HMS Beagle Expedition

- **Primary objective was to make hydrographic survey of the coastal region of Terra Del Fuego at southern tip of south America to improve the map used by ships sailing between Atlantic and Pacific.**
- **This expedition has become famous primarily because of Charles Darwin.**
- **Darwin's observation on the Beagle were the basis for his book Origin of Species, in the which he proposed the revolutionary theory of Natural Selection.**
- **Moreover, based on his observation he proposed the theory to explain the formation of atoll and preliminary idea about continental drift and plat tectonics.**

http://www.aboutdarwin.com/voyage/voyage03.html

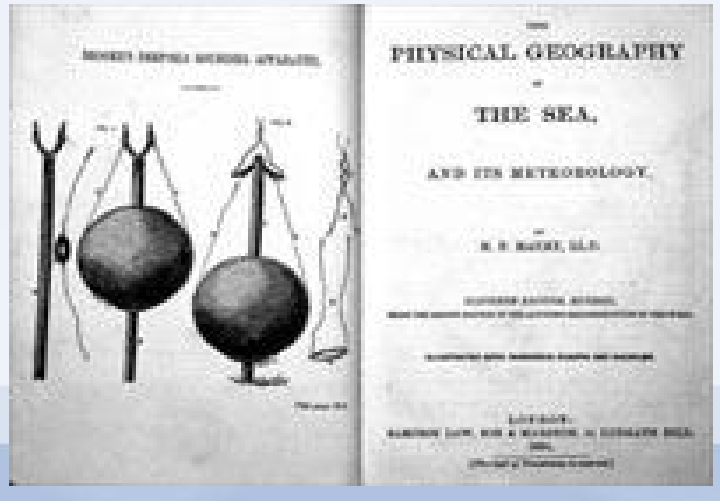
Beginning of Science Voyages

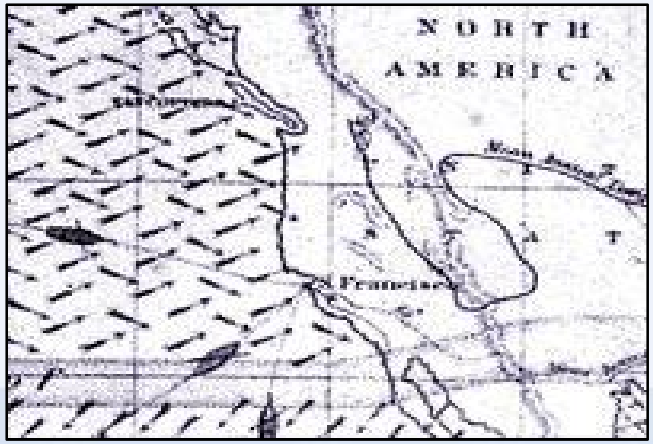
1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Mapping Current Patterns in the Oceans

Scientific Oceanography

i. Matthew Fontaine Maury, a U. S. Navy Officer in charge of the Depot of Naval Charts.
ii. Maury gathered data on wind and current patterns from numerous ships logbooks, and he published his detailed finding in 1855 in a volume entitle "The Physical Geography of the Sea"
iii. Maury also initiated cooperative efforts among seafaring nations to standardize the means by which meteorological and ocean current observations were made.
iv. Because of his many contributions, Maury has often been called the "Father of Oceanography".





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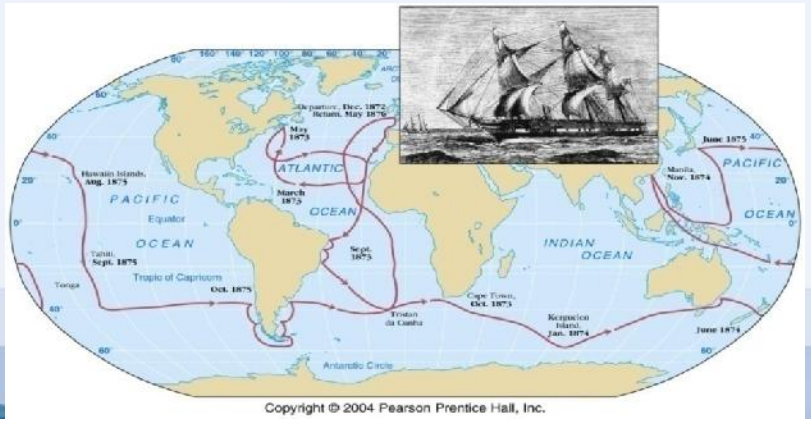
Beginning of Science Voyages

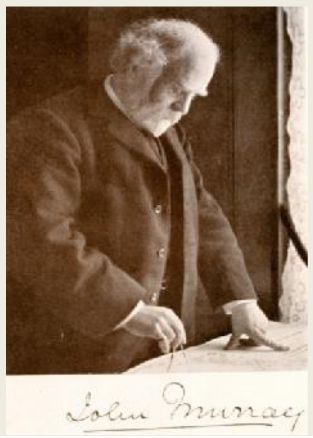
1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

1872-'76: The challenger expeditions

Scientific Oceanography

a. Modern Oceanography began with Expeditions in HMS Challenger.
b. It was the first expedition organized specifically devoted to marine science.
c. Challenger first traveled south from England to the South Atlantic, and then around the Cape of Good Hope at the southern tip of Africa.
d. It then headed across the wide and very rough seas of the southern Indian Ocean, crossing the Antarctic Circle, and then to Australia and New Zealand.
e. After that, Challenger headed north to the Hawaiian Islands, and then south again around Cape Horn, at the southern tip of South America where the Pacific and Atlantic Oceans meet.
f. After more exploration in the Atlantic, Challenger returned to England in May of 1876.





Beginning of Science Voyages

1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Scientific Oceanography

1872-'76: The challenger expeditions - outcomes

a. They gathered temp, current, water chemistry and ocean floor deposit data from 362 oceanographic stations
b. The scientific results of the voyage were published in a 50-volume, 29,500-page report that took 23 years to compile under the supervision of John Murray
c. Discoveries of one of the deepest parts of the ocean: the Marianas Trench in the western Pacific, where the seafloor (8,200 meters).
d. Initial knowledge about Mid-Atlantic Ridge.
e. first systematic plots of currents and temperatures in the oceans.
f. The Challenger Expedition's exciting discoveries encouraged other countries to take interest in the oceans and to mount their own expeditions.
g. 4700 new species of plants and animals were discovered.

Beginning of Science Voyages

1500 BC- 500 BC | 150 BC- 1500 AD | 1500 AD- 1750 AD | 1750 AD - Present

Scientific Oceanography

1888 – A research centre at Woods Hole

Later in 1930, renamed as Woods Hole Oceanographic Institution

1909: Admiral Ronald Peary reaches the North Pole

1912: Wegener proposes Continental Drift

1917: Echo Sounder was invented

Indian Ocean Expeditions

International Indian Ocean Expedition (IIOE)

1959-65 **A Combined Assault on the Largest Unknown Area on the Earth**

1957: ICSU - > SIO => SCOR

Main Focuses

a) **Study the Indian Ocean Biological resc**

b) **Study the role of Indian Ocean in effe**

c) **Determine the limits to the use of oce**

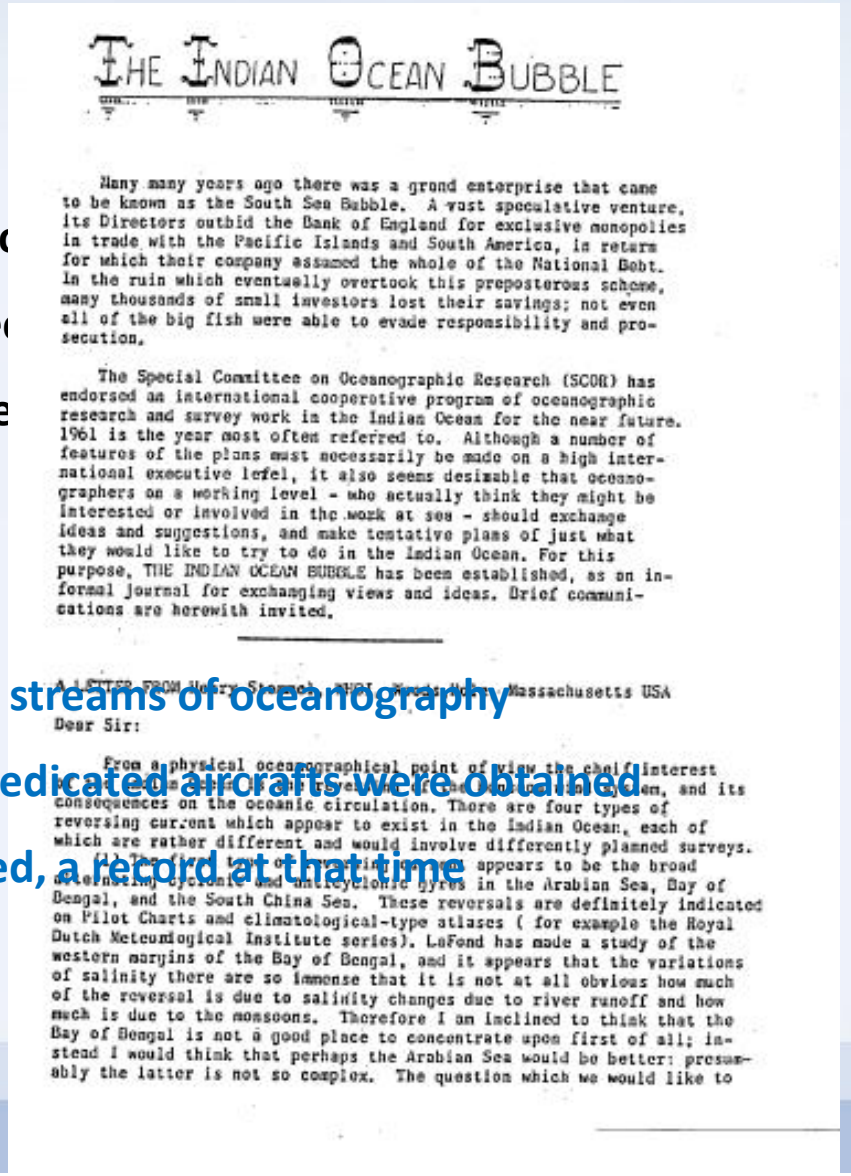
nuclear wastes

i. **20 countries, 40 ships**
   "The Indian Ocean Bubble"

ii. **Extensive collection of data from all streams of oceanography**

iii. **First time, met observations using dedicated aircrafts were obtained**

iv. **More than 9000 T/S profiles obtained, a record at that time**



THE INDIAN OCEAN BUBBLE

Many many years ago there was a grand enterprise that came to be known as the South Sea Bubble. A vast speculative venture, its Directors outbid the Bank of England for exclusive monopolies in trade with the Pacific Islands and South America, in return for which their company assumed the whole of the National Debt. In the ruin which eventually overtook this preposterous scheme, many thousands of small investors lost their savings; not even all of the big fish were able to evade responsibility and prosecution.

The Special Committee on Oceanographic Research (SCOR) has endorsed an international cooperative program of oceanographic research and survey work in the Indian Ocean for the near future. 1961 is the year most often referred to. Although a number of features of the plans must necessarily be made on a high international executive level, it also seems desirable that oceanographers on a working level - who actually think they might be interested or involved in the work at sea - should exchange ideas and suggestions, and make tentative plans of just what they would like to try to do in the Indian Ocean. For this purpose, THE INDIAN OCEAN BUBBLE has been established, as an informal journal for exchanging views and ideas. Brief communications are herewith invited.

A LETTER FROM Henry Stommel, WHOI, Woods Hole, Massachusetts USA

Dear Sir:

From a physical oceanographical point of view the chief interest [illegible], and its consequences on the oceanic circulation. There are four types of reversing current which appear to exist in the Indian Ocean, each of which are rather different and would involve differently planned surveys. [illegible] appears to be the broad alternating cyclonic and anticyclonic gyres in the Arabian Sea, Bay of Bengal, and the South China Sea. These reversals are definitely indicated on Pilot Charts and climatological-type atlases (for example the Royal Dutch Meteorological Institute series). LaFond has made a study of the western margins of the Bay of Bengal, and it appears that the variations of salinity there are so immense that it is not at all obvious how much of the reversal is due to salinity changes due to river runoff and how much is due to the monsoons. Therefore I am inclined to think that the Bay of Bengal is not a good place to concentrate upon first of all; instead I would think that perhaps the Arabian Sea would be better: presumably the latter is not so complex. The question which we would like to

International Indian Ocean Expedition (IIOE)

1959-65 **A Combined Assault on the Largest Unknown Area on the Earth**

Indian Participation

4 ships, 40 cruises …

RV Kistna

RV Varuna

RV Conch

RV Bangda

Indian Program implemented through Indian Ocean Expedition program under CSIR

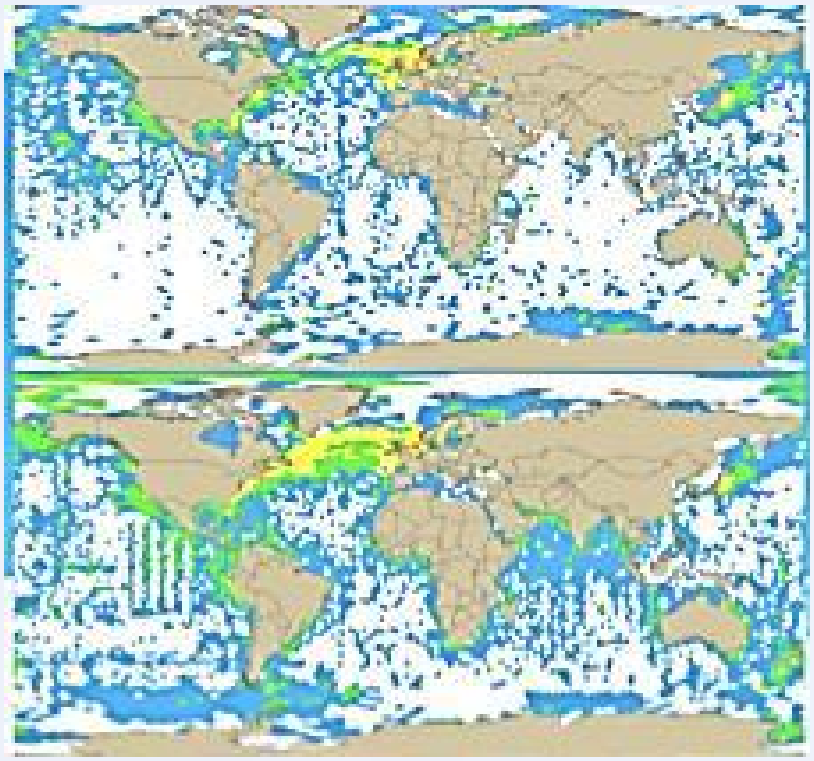
India was the lead in sorting, identification and maintenance of zooplankton collections

IOBC, Kochi

International Indian Ocean Expedition (IIOE)

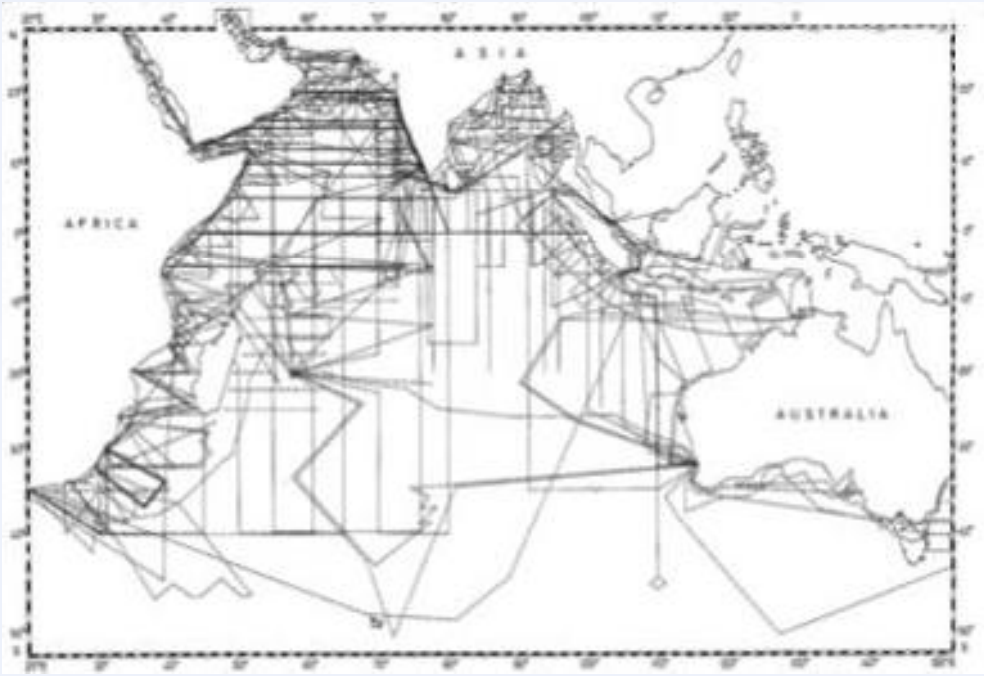
1959-65 **A Combined Assault on the Largest Unknown Area on the Earth**

Pre-IIOE



IIOE

IIOE 1959-65 transects



Courtesy: Louise Wicks

International Indian Ocean Expedition (IIOE)

1959-65 **A Combined Assault on the Largest Unknown Area on the Earth**

Benefits:

India benefited much ….

Oceanography evolved more as a science that could get government support and funding

A Scientific foundation for oceanographic research in India

Establishment of NIO and its regional centres

The Monsoon Experiment (MONEX)

1979 **A research expedition under Global Atmospheric Research Program (GARP)**

Main Objective

The determination of the components of heat sources and sinks at the earth's surface, within the atmosphere, and at the top of the atmosphere, and to evaluate their role in the annual cycle of the planetary-scale monsoonal circulations.

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Indian Ocean Component of MONEX

Arabian Sea

a. Low-Level jet; To define the dynamical state of the jet at four key oceanic locations along its axis.
a. West coast rainfall and effect of orography on rainfall.

Bay of Bengal

a. To examine the structure and dynamics of monsoon depressions; monsoon troughs; and associated convective and mesoscale phenomena

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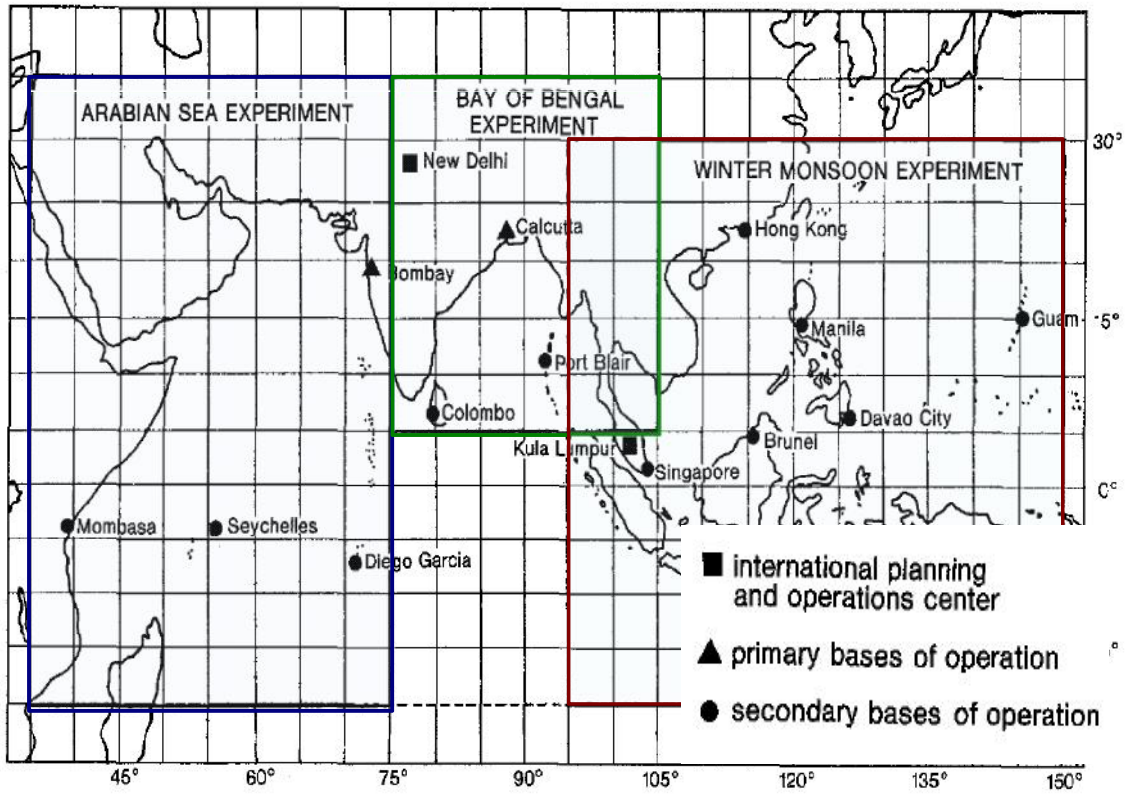
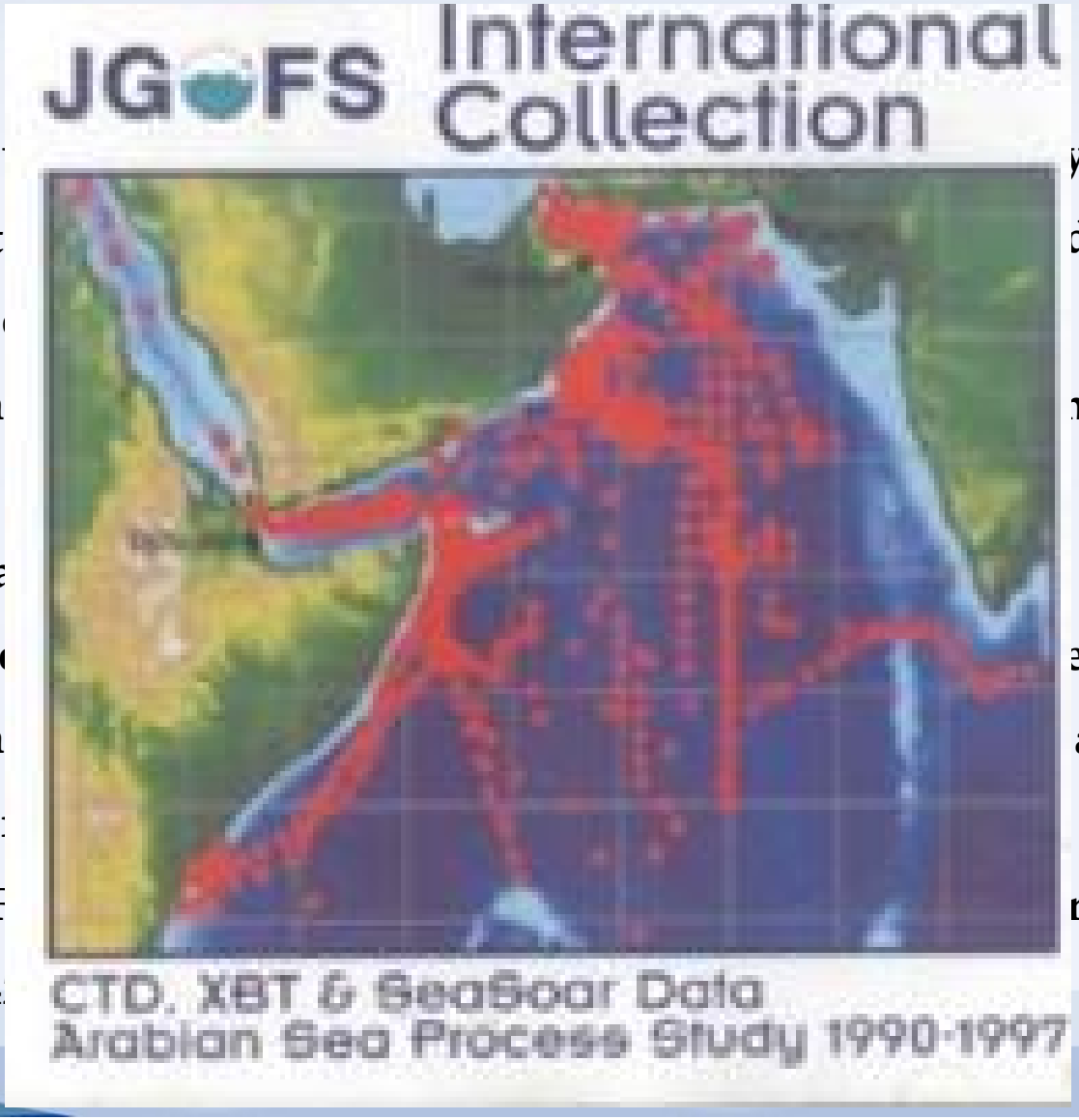


Winter MONEX:
From December 1978 to March 1979 ; which covered the eastern Indian Ocean and the western Pacific Ocean along with the land areas of Malaysia end Indonesia.

Summer MONEX:
From May-August 1979. This covered the eastern coast of Africa, the Arabian Sea, the Bay of Bengal and the adjacent land areas.

Joint Global Ocean Flux Study (JGOFS)

1987-2003



a. Primary aim ycling of carbon in the oceans, it d the sensitivity of these process
b. JGOFS was a n participants from more than 20
c. JGOFS was la
d. The Indian c ess the carbon flux in the Arabia as a source or sink for atmosphe
e. During JGOF nd biogeochemical data during 4

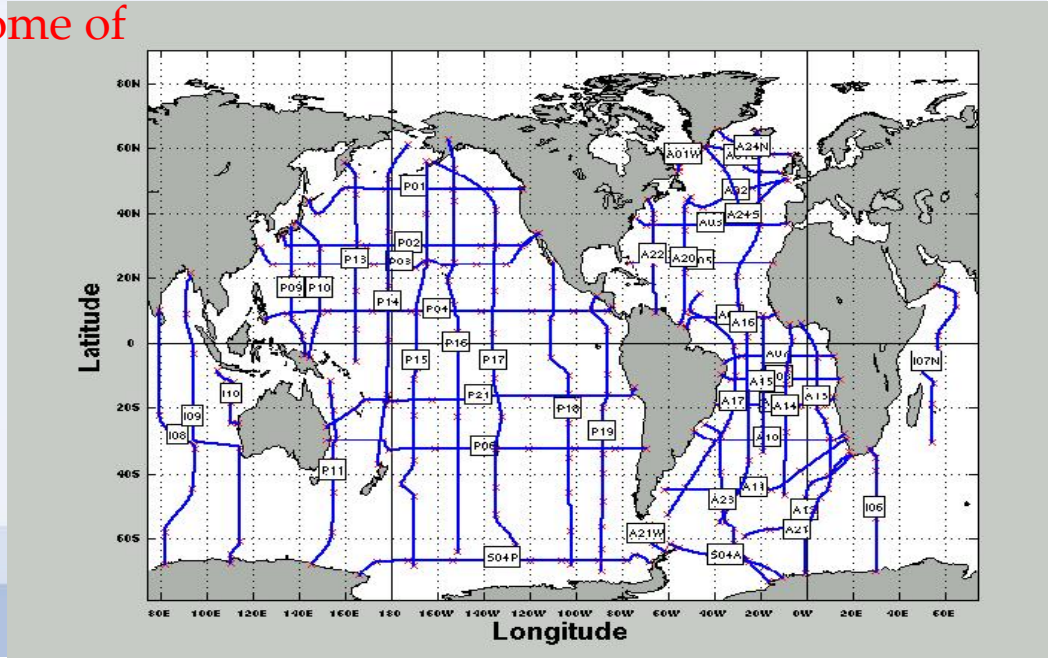
World Ocean Circulation Experiment (WOCE)

1990-2002

a. **Part of World Climate Research Program (WCRP)**
b. **Overall aim: Establish the role of oceans in Earth's climate system**
c. **Observation Phase: 1990-97, modeling and data processing phase: upto 2002**

Main Motivations

1. Spare data coverage (esp. Southern Oceans)
2. Data did exist, were not suitable for model validations
3. Concerns about the reliability of some of earlier measurements

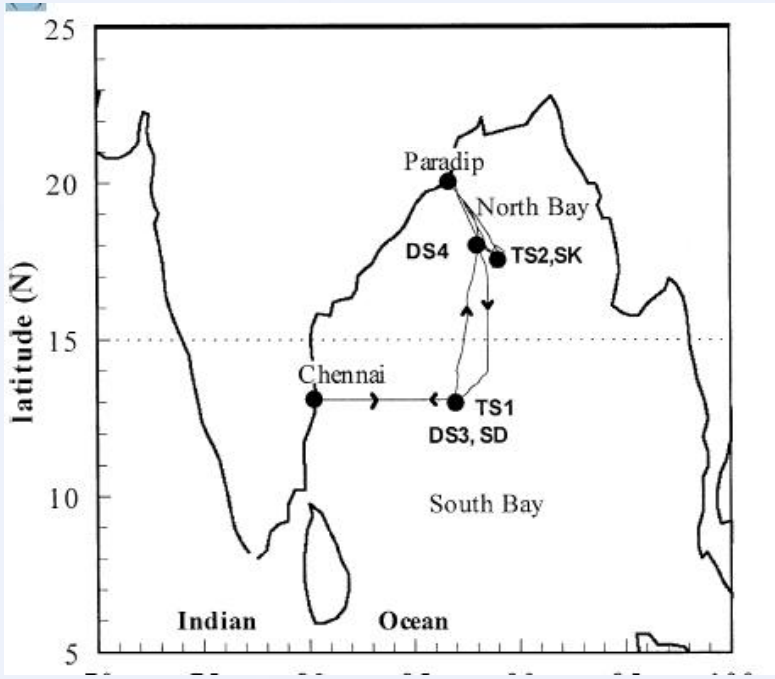


Bay of Bengal Monsoon Experiment (BOBMEX)

1999

Primary objective of BOBMEX were to document and understand nature of coupling between convective system and Bay of Bengal: the impact of convection on the ocean, the recovery after the convection attenuates, and the characteristics during calm phases when convection absent.

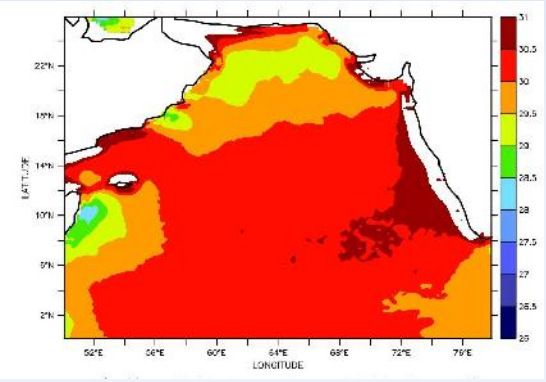
- Period: October-November, 1998 (pilot) July-August 1999
- Two time series station at TS1 and TS2, to cover active and break cycle of monsoon.

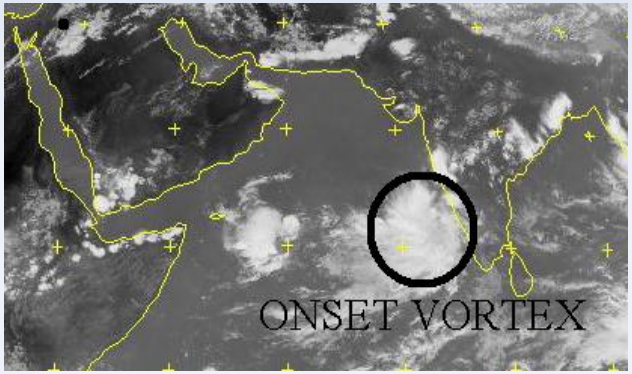


Better understanding of the active-break mechanism and associated convective characteristics …..

Arabian Sea Monsoon Experiment (ARMEX)

2002-2003





ASMWP is instrumental in the formation of monsoon onset and influences intense rainfall events on the west coast of India.

- Understand the dynamics of the formation, maintenance and the collapse of ASMWP and its impact on monsoon rainfall over the west coast of India.
- To understand the structure of off-shore vortices that produce Intense rainfall events (200 mm rainfall in 24hr), the off shore trough and mechanism of intense rainfall events.

ARMEX-I: June-August 2002 (More emphasis on Oceanographic component)
ARMEX-II: March-June 2003 (Atmospheric Perspective)

Arabian Sea Monsoon Experiment (ARMEX)

2002-2003

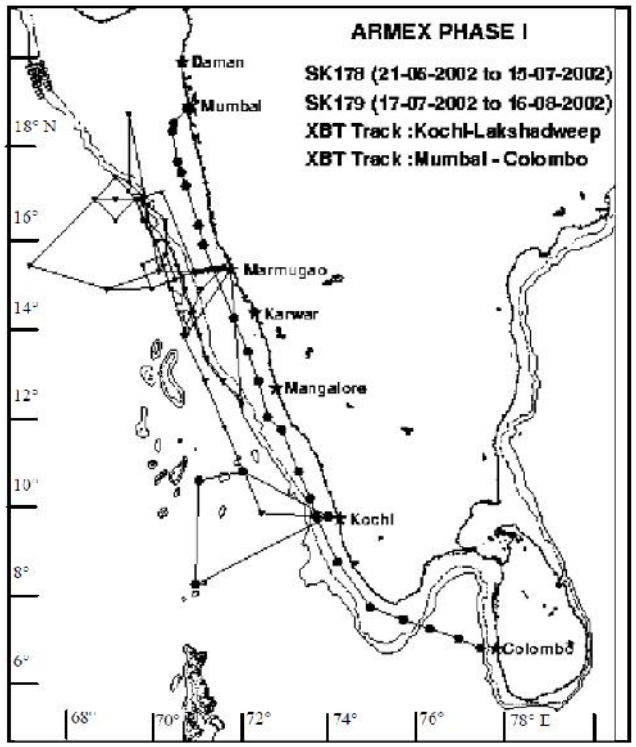


Fig. 2. Region of intensive observations and ORV Sagar Kanya cruise tracks and XBT surveys during ARMEX-I observational campaigns

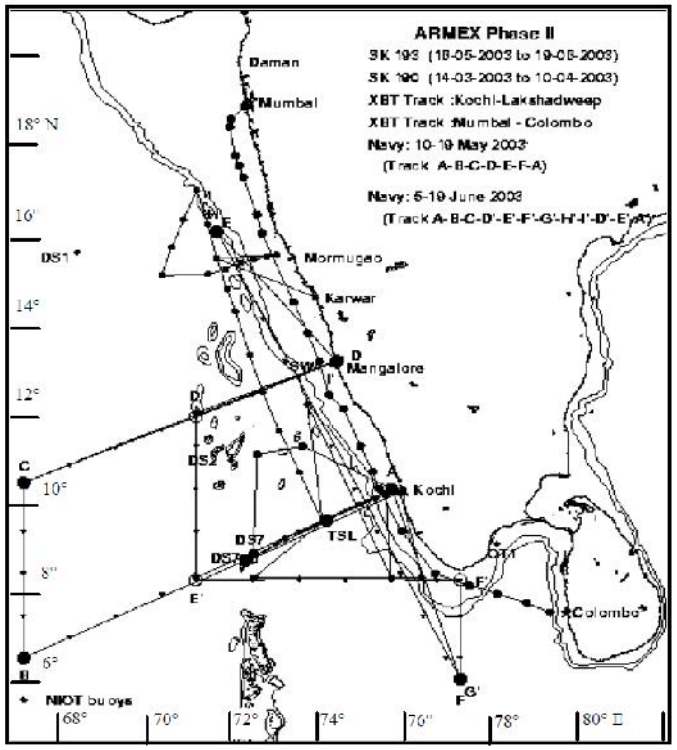


Fig. 3. Region of intensive observations, ORV Sagar Kanya and Naval ships cruise tracks and XBT surveys during ARMEX-II observational campaigns

ARMEX-I: June-August 2002 (More emphasis on Oceanographic component)
ARMEX-II: March-June 2003 (Atmospheric Perspective)

Several Recent Process oriented campaigns

2006-till date

Focus is mostly on process oriented studies to meet selected, but particularly important issues in Ocean Science

Cirene / Vasco (French) – 2006 – Thermocline Ridge region of the Indian Ocean (TRIO)

CINDY (Japanese) – 2011 – Central Equatorial Indian Ocean

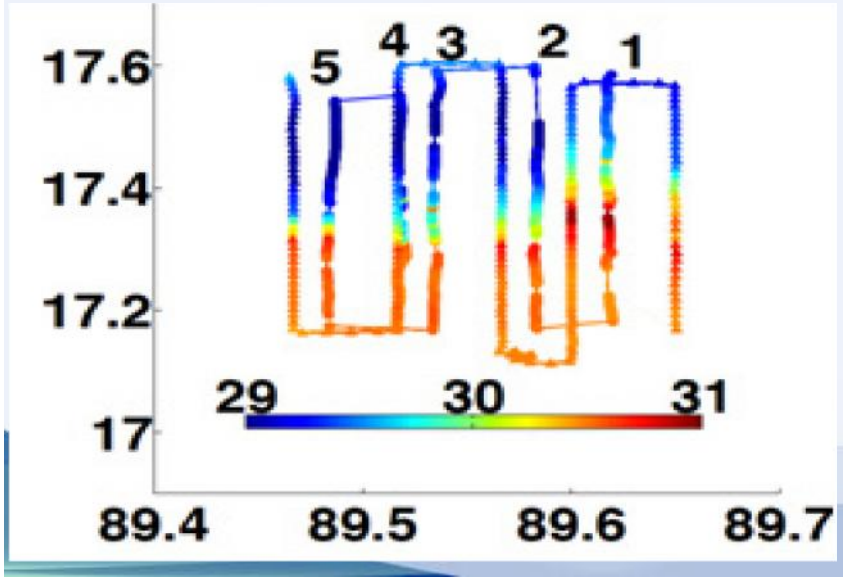
OMM / ASIRI (Indo-US Collaboration) – Northern Bay of Bengal

BOBBLE (Indo-UK Collaboration) – Southern Bay of Bengal

Several Recent Process oriented campaigns

OMM/ASIRI Program (Ongoing)

a. **Indo-US initiative to study physical processes in the near-surface ocean, surface fluxes, and air-sea interaction in the Bay of Bengal**
b. **Basin-scale pathways of river water and stirring by mesoscale (order 100 km) eddies,**
c. **contribution of mesoscale stirring to lateral exchange of salt,**
d. **small-scale (submesoscale and smaller) processes that set upper ocean stratification,**
e. **near-surface response to (varying) wind stress, heat and freshwater fluxes,**
f. **influence of ocean state (waves; depth of mixed layer, Ekman layer and subsurface warm layer; optical properties, turbulence) on surface fluxes and air sea interaction, and**
g. **mechanisms and space-time scales of mixing in the transition**



Cruise tracks of the R/V Roger Revelle (magenta, cyan, green 2013, 2014 and 2015) and Sagar Nidhi (blue, yellow 2014, 2015).