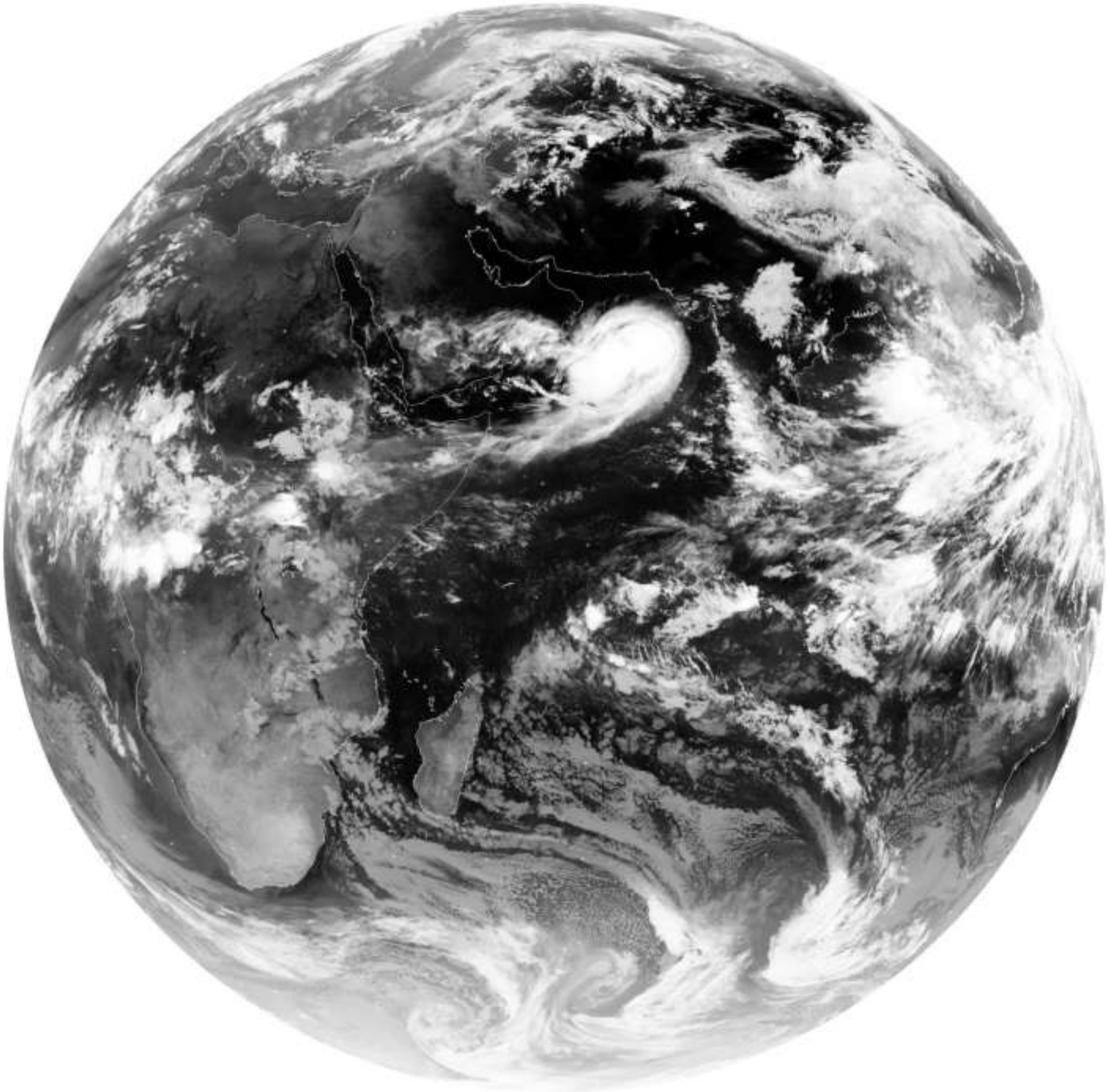
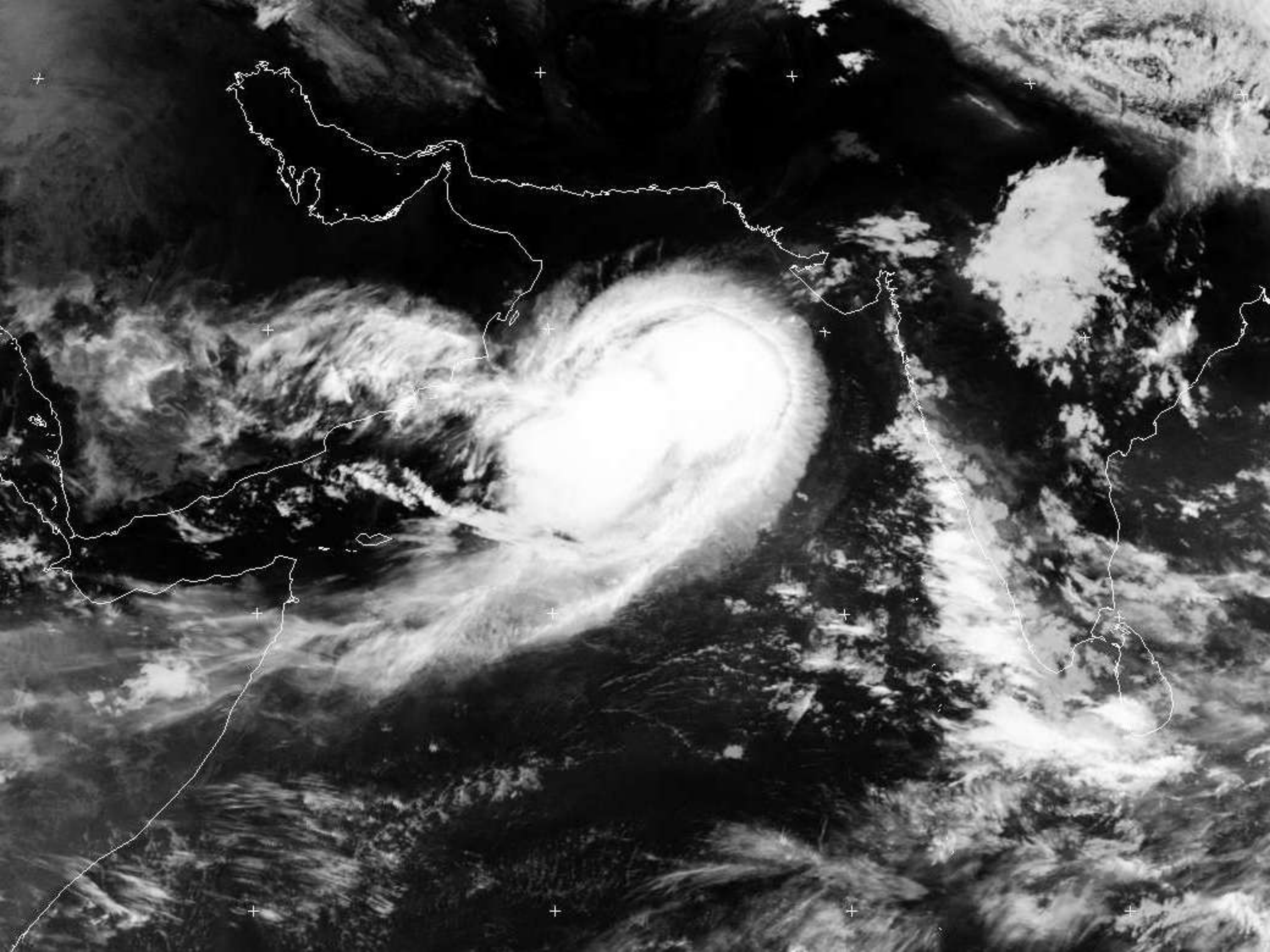
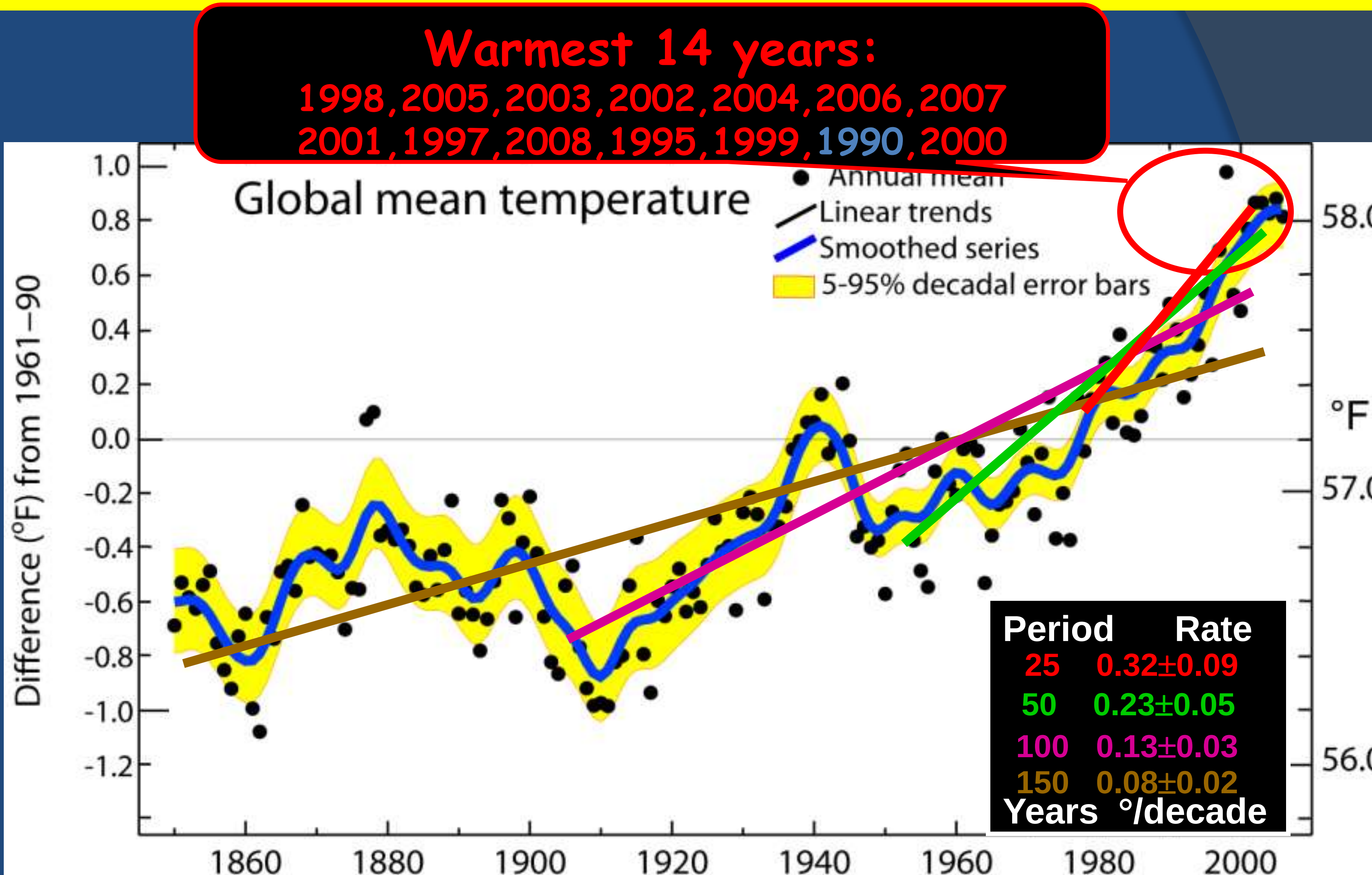
Muhammad Moazzam Khan
Technical Advisor (Marine Fisheries)
WWF-Pakistan

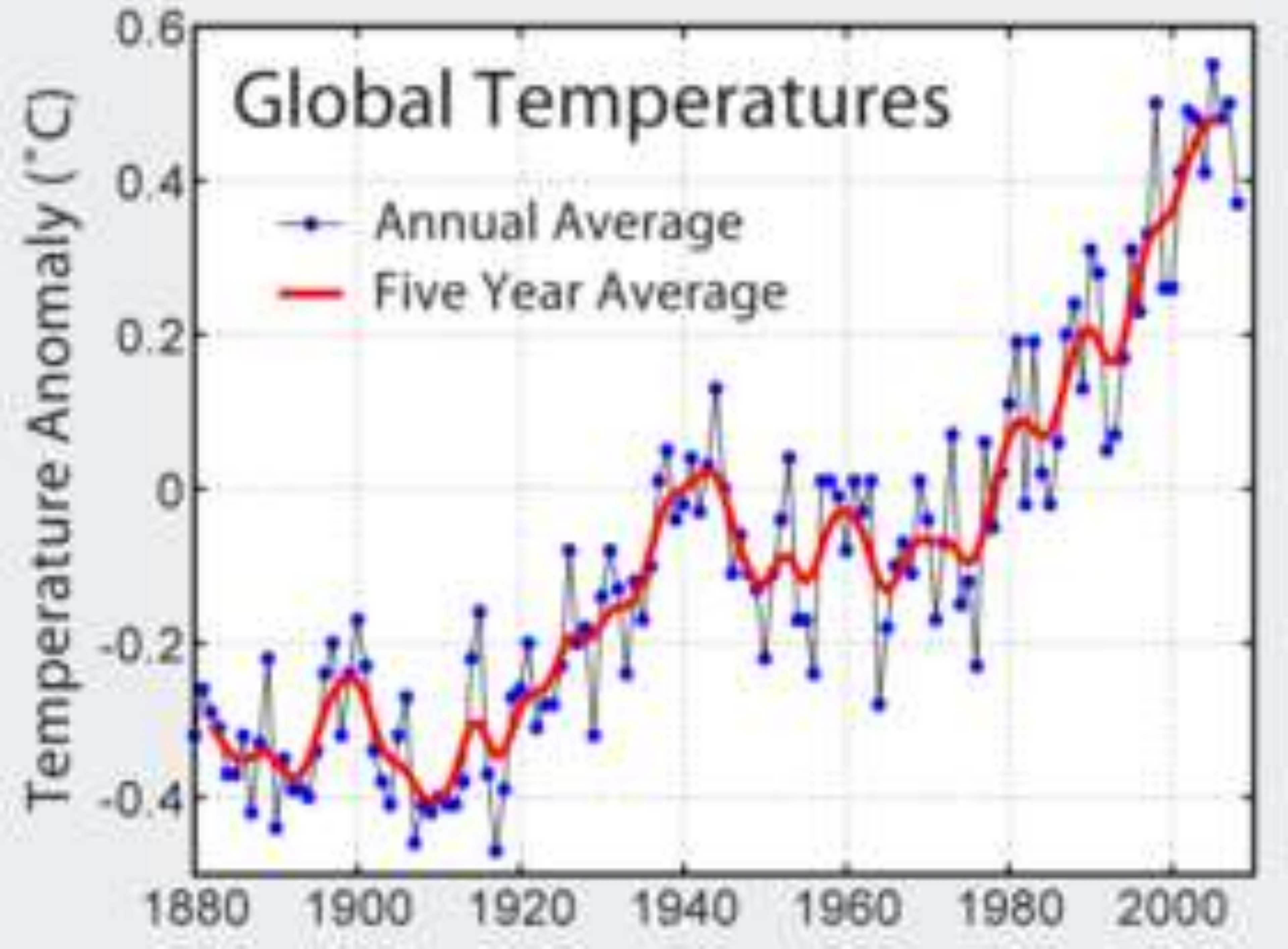
PHYSICAL AND ECOLOGICAL IMPACTS OF CLIMATE CHANGE RELEVANT TO MARINE AND INLAND FISHERIES



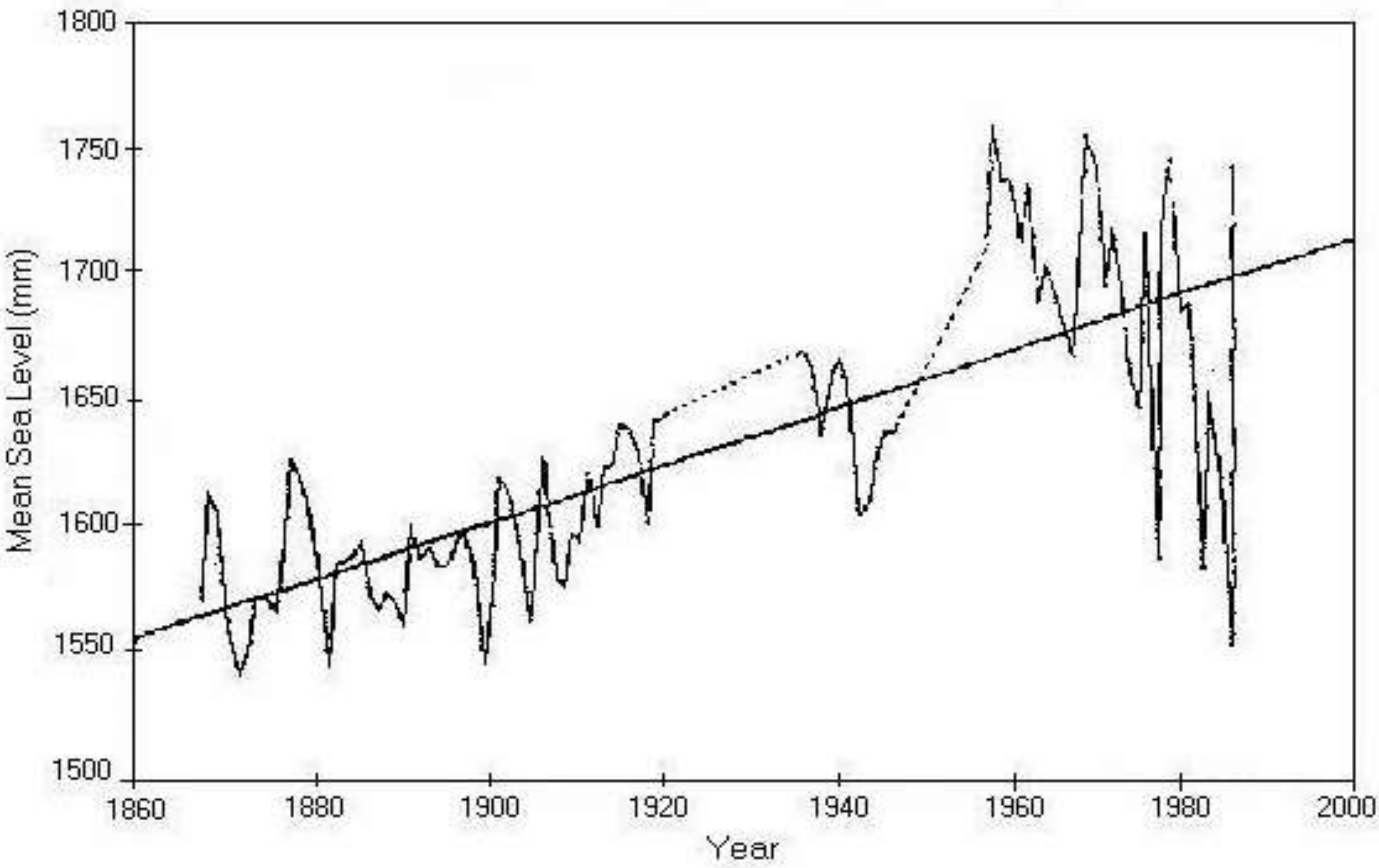


Global mean temperatures are rising faster with time



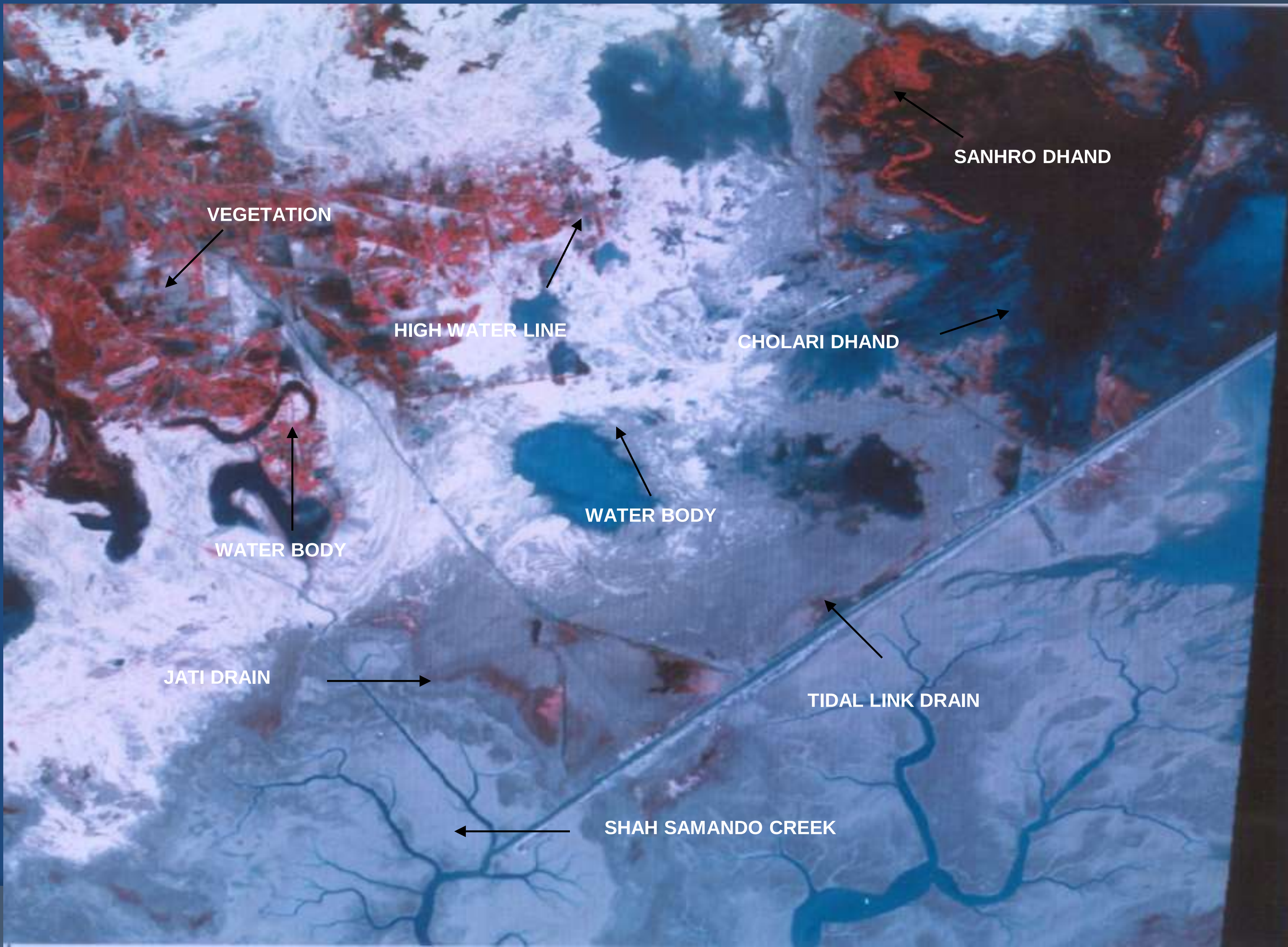

Global Temperatures
Annual Average
Five Year Average
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
1880
1900
1920
1940
1960
1980
2000

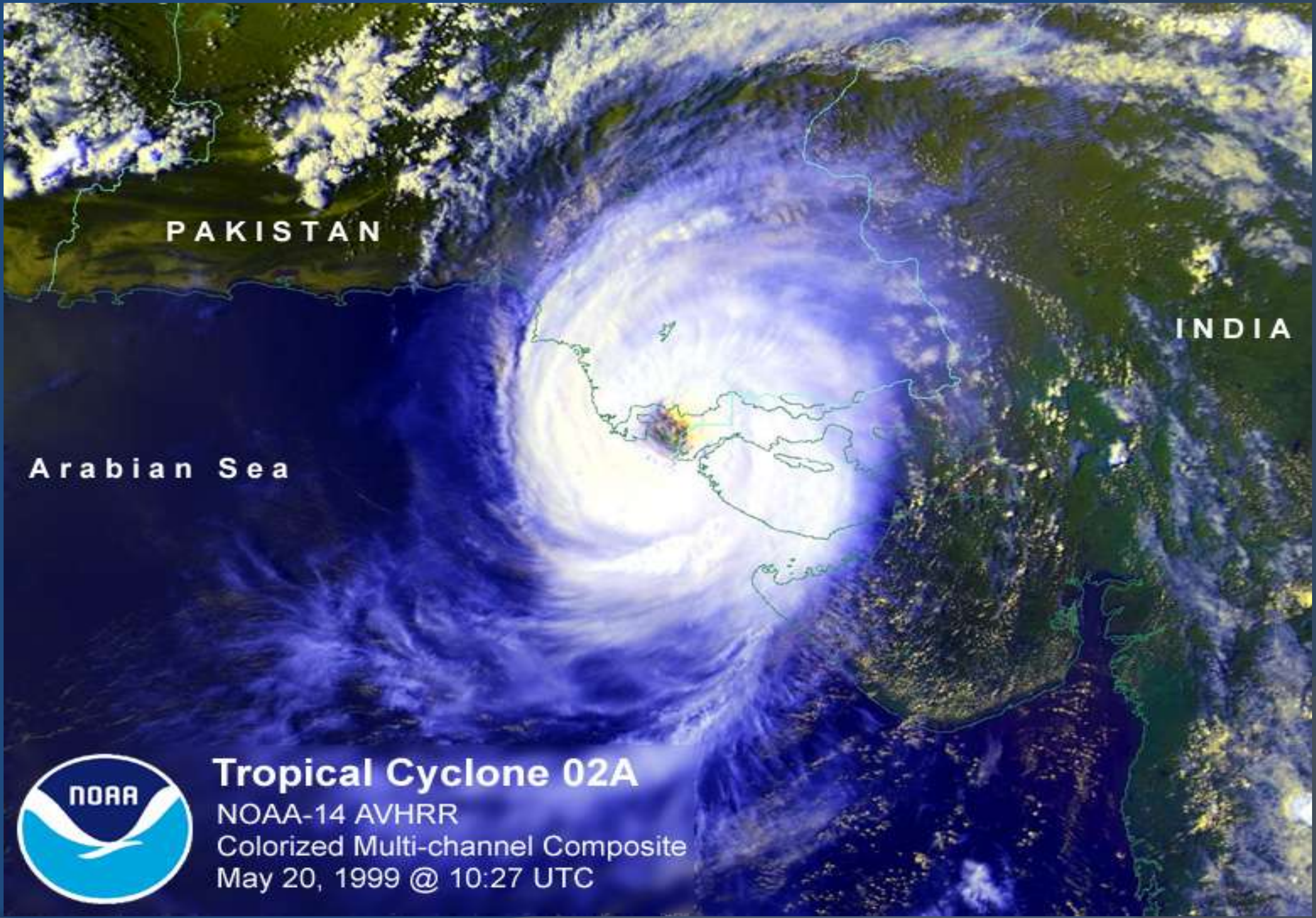
Mean sea level rise at Arabian Sea



It is found in coastal waters usually forming small schools. It is primarily caught by gillnet, however, at time it is harvested by purse sei

Saltwater intrusion in the estuaries




PAKISTAN
INDIA
Arabian Sea
NOAA
Tropical Cyclone 02A
NOAA-14 AVHRR
Colorized Multi-channel Composite
May 20, 1999 @ 10:27 UTC

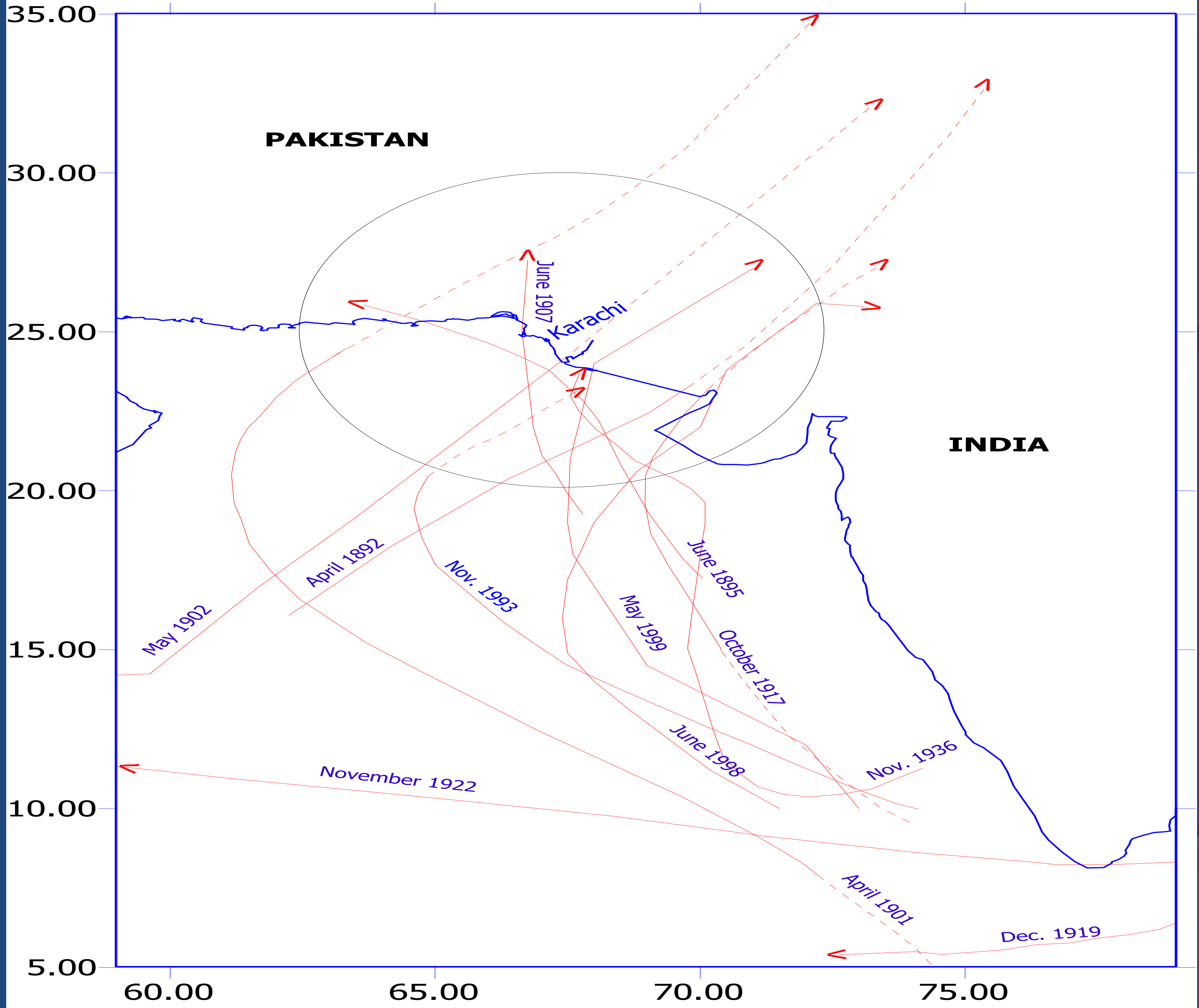
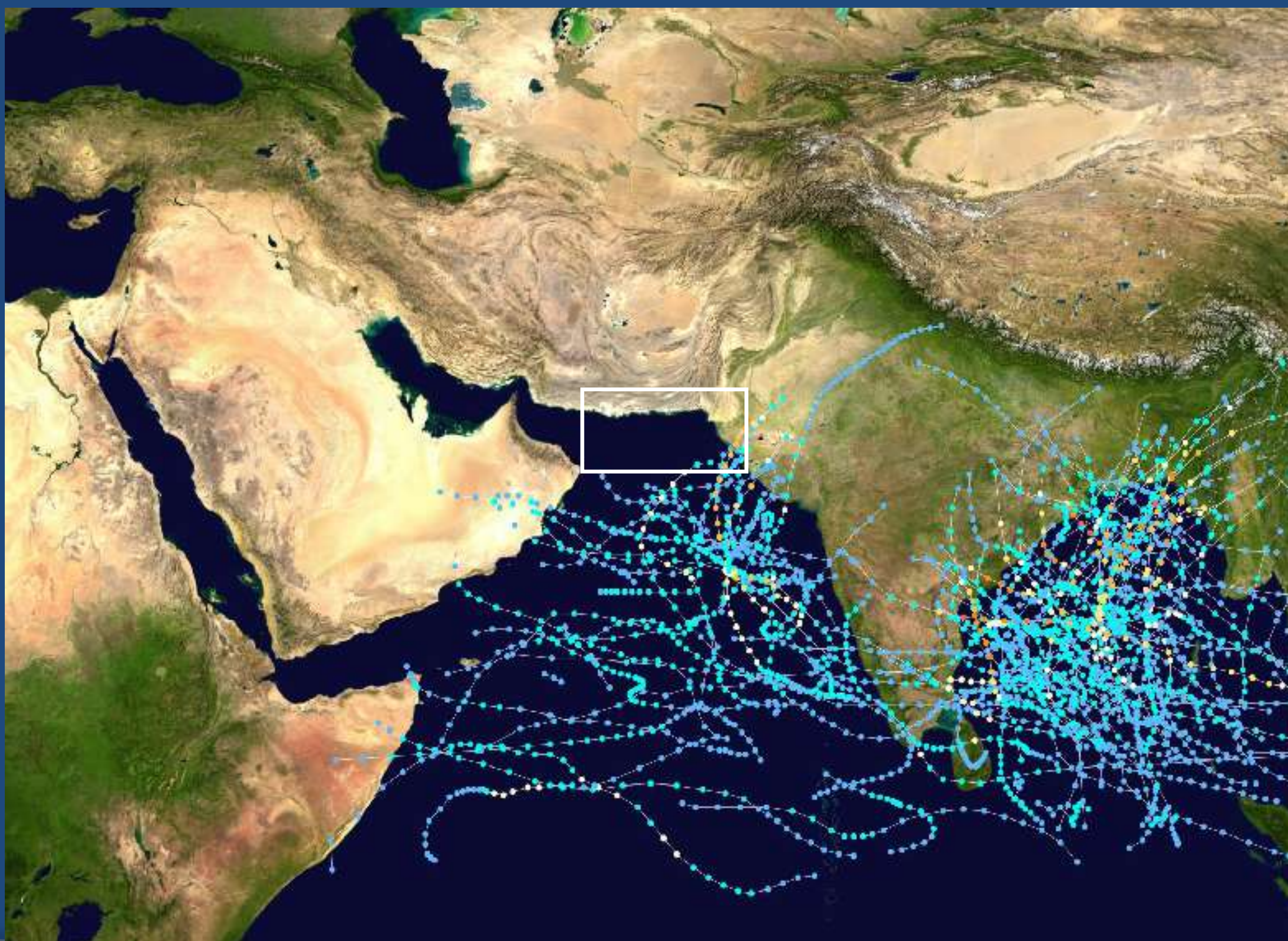


FIGURE 17. Track of Tropical Cyclones which entered circle of 300 nm radius centered on Karachi.

Tropical Cyclones

Tracks vs. Inensity

1985-2005



Tropical Cyclone Intensity Classification

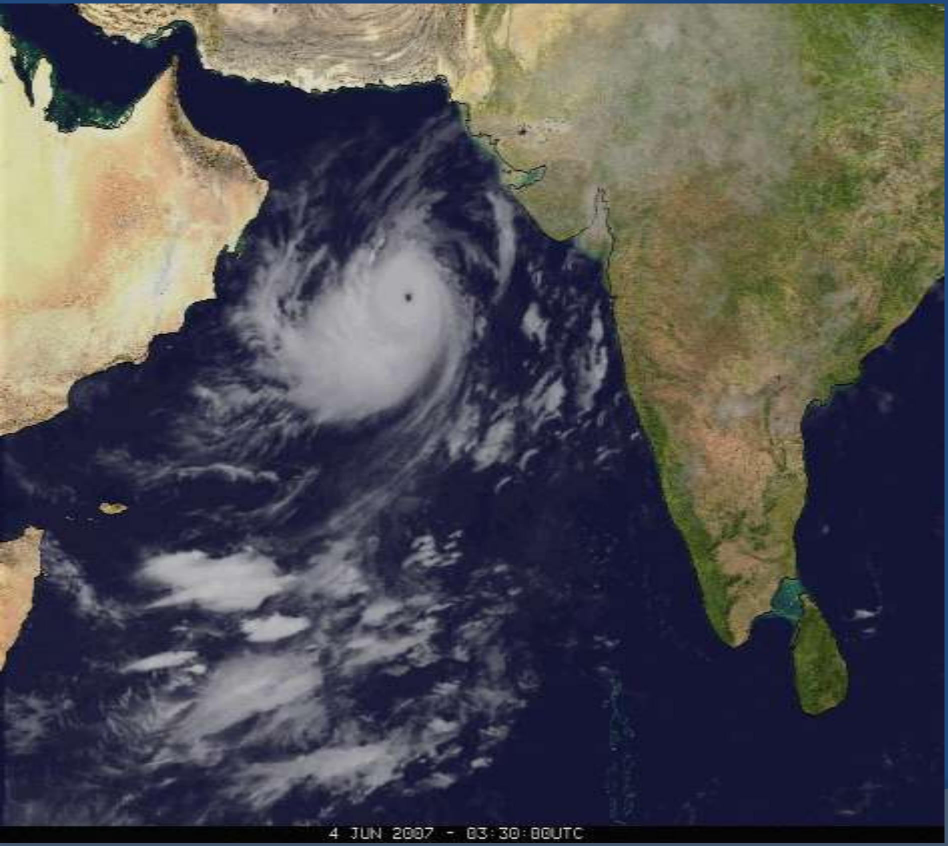
Category	Wind speed (3-min)
Depression	≤27 (≤51)
Deep Depression	28–33 (52–61)
Cyclonic Storm	34–47 (62–87)
Severe Cyclonic Storm	48–63 (88–117)
Very Severe Cyclonic Storm	64–119 (118–221)
Super Cyclonic Storm	≥120 (≥222)

2007 N. Ind Ocean Tropical Cyclones

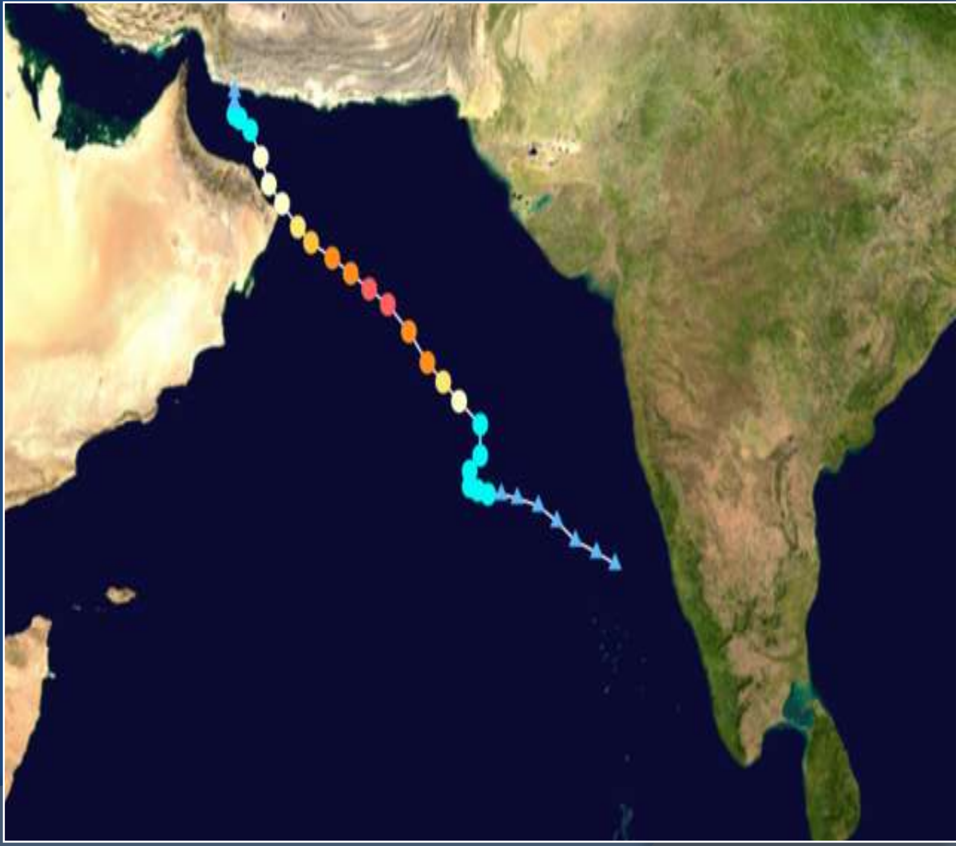
Tropical Cyclones	Cat.	Max 6-hr Sustained (Kt)	Max Gust 6-hr (Kt)	Landfall
Akash	1	65	80	05/15 BD & MYN
Gonu	5	140	170	06/06 Oman
Yemyin	TS	50	65	06/26 Pakistan
04B	TS	45	55	
05B	TS	45	55	
Sidr	4	135	165	11/15 BD

Satellite Image + Observed Track
(Tropical Cyclone Gonu)

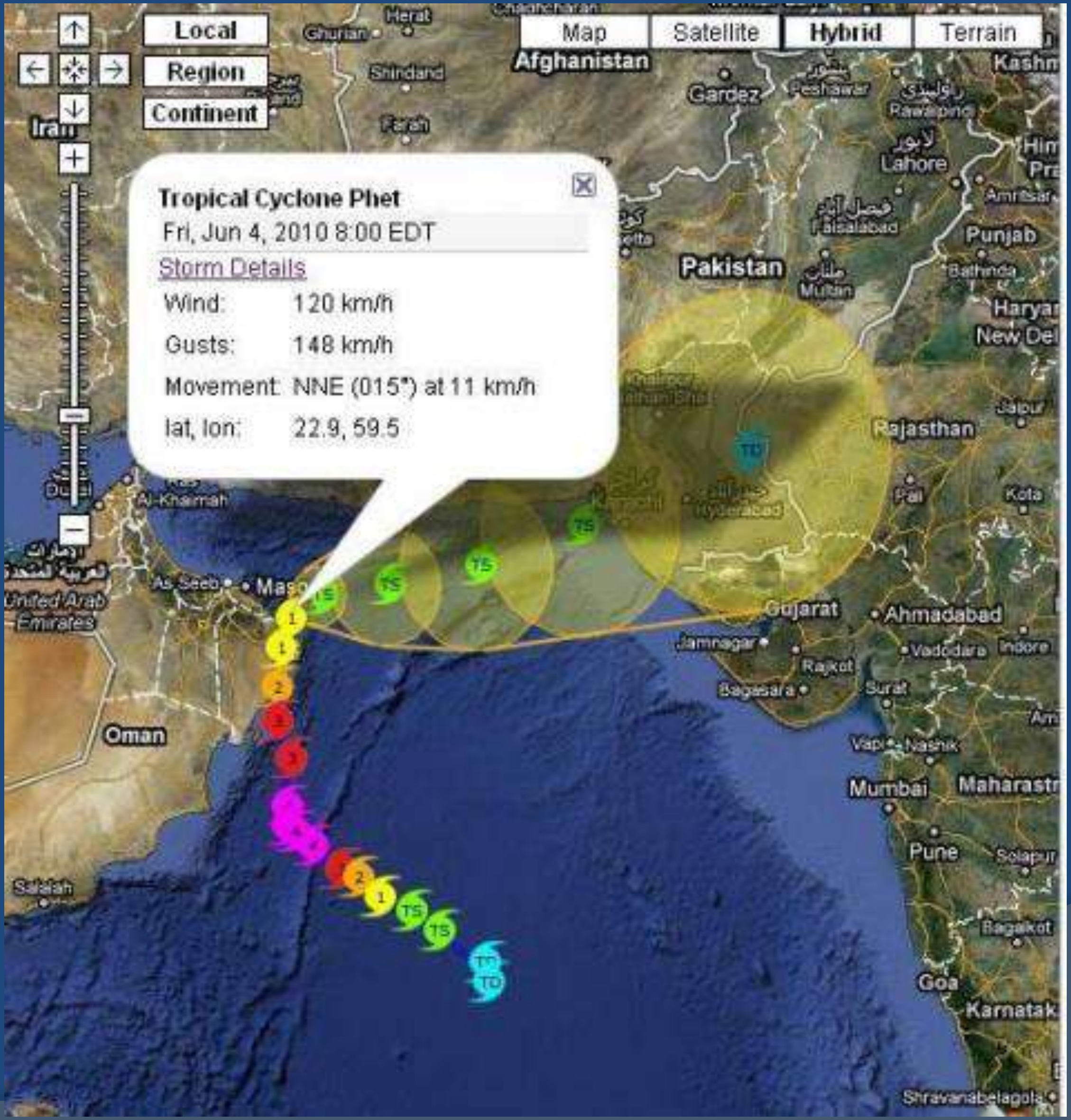
4-5 June 2007



Observed Track



CYCLONE PHET




Iran
Persian Gulf
(Arabian Gulf)
Pakistan
United
Arab
Emirates
Saudi
Arabia
Arabian Sea
Oman
100 km
N

Damage in Oman

RAIN IN BALOCHISTAN BY PHET

AREA	Rain (in mm)
GWADAR	370
JIWANI	208
PASNI	139

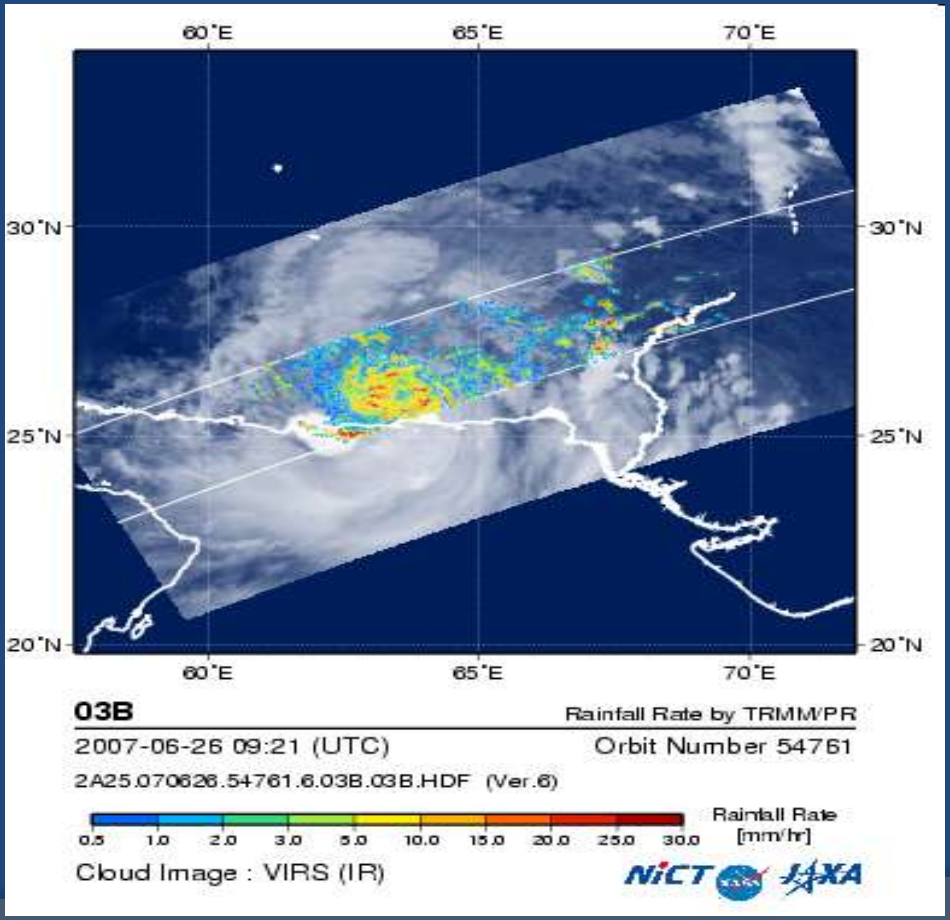

Cyclone (FHET) hit Makran Coast, PWP-MCWC.

DEATH TOLL BY CYCLONE PHET

DEATH TOLL	
PAKISTAN	15
OMAN	24
INDIA	05
TOTAL	44

Tropical Cyclone Yemyin

Rainfall Rate

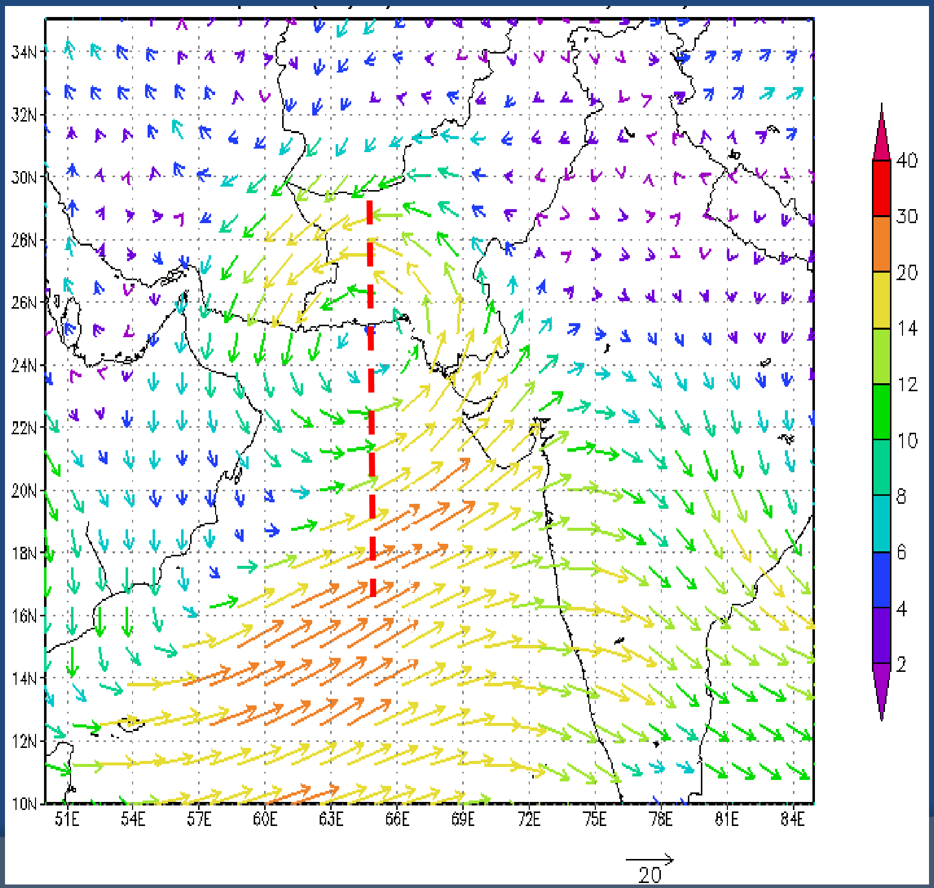


Observed Track

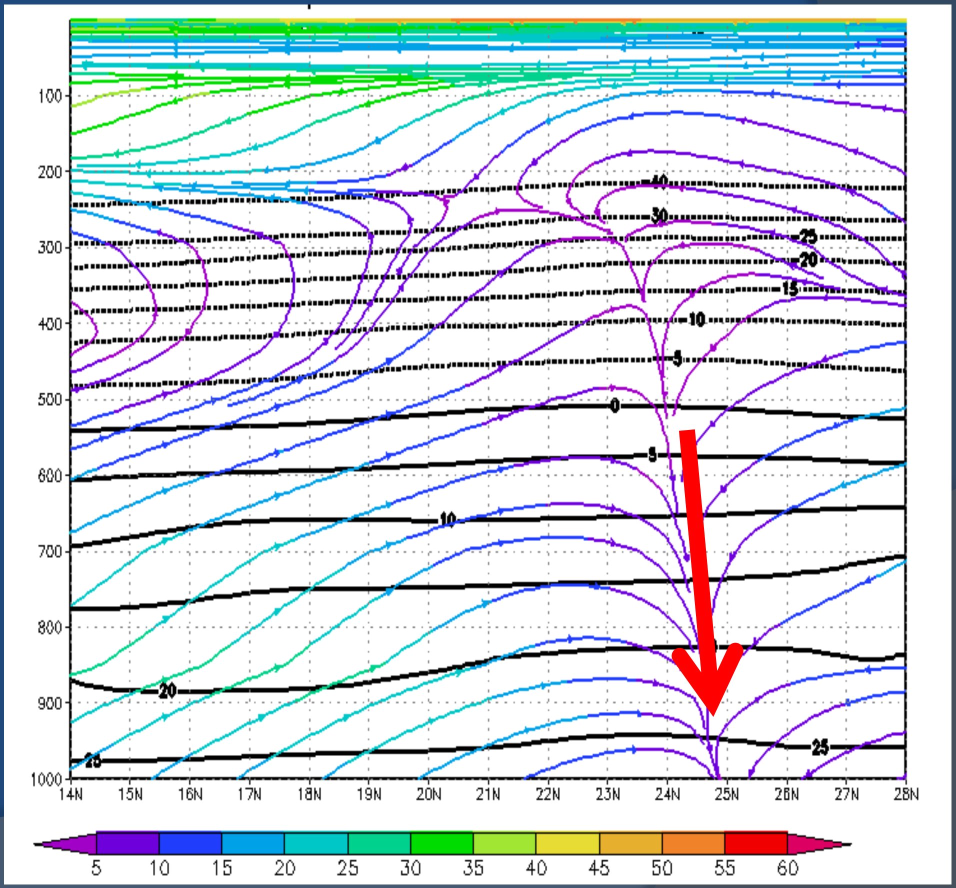
Yemyin before Landfall

JRA-25 Analysis

Wind speed (m/s) + direction at 700 hPa
00 UTC 26-06-2007

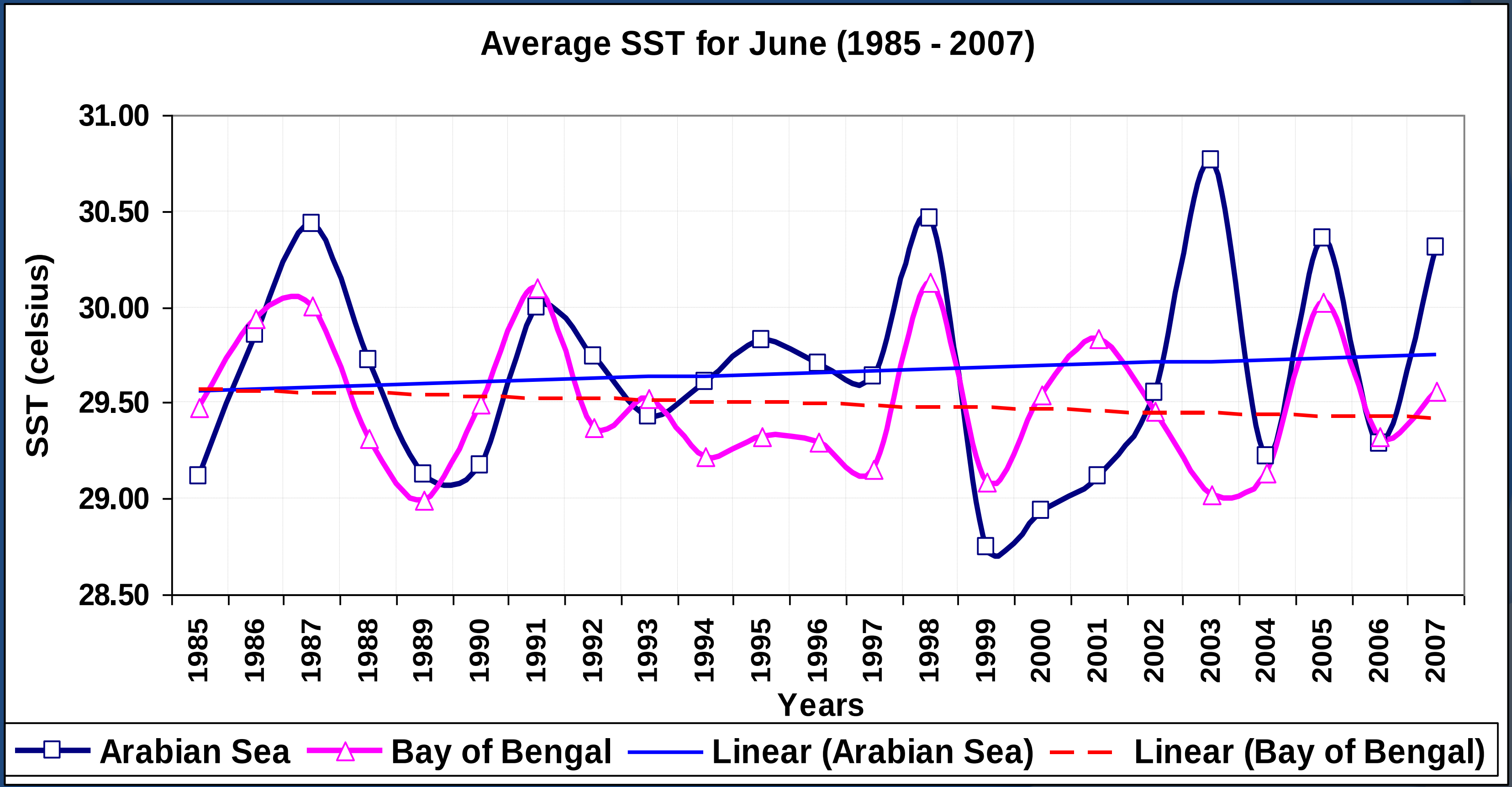


Air Temp & Wind Vertical Profile 64E
00 UTC 26-06-2007



Time Series (1985-2007) for SST

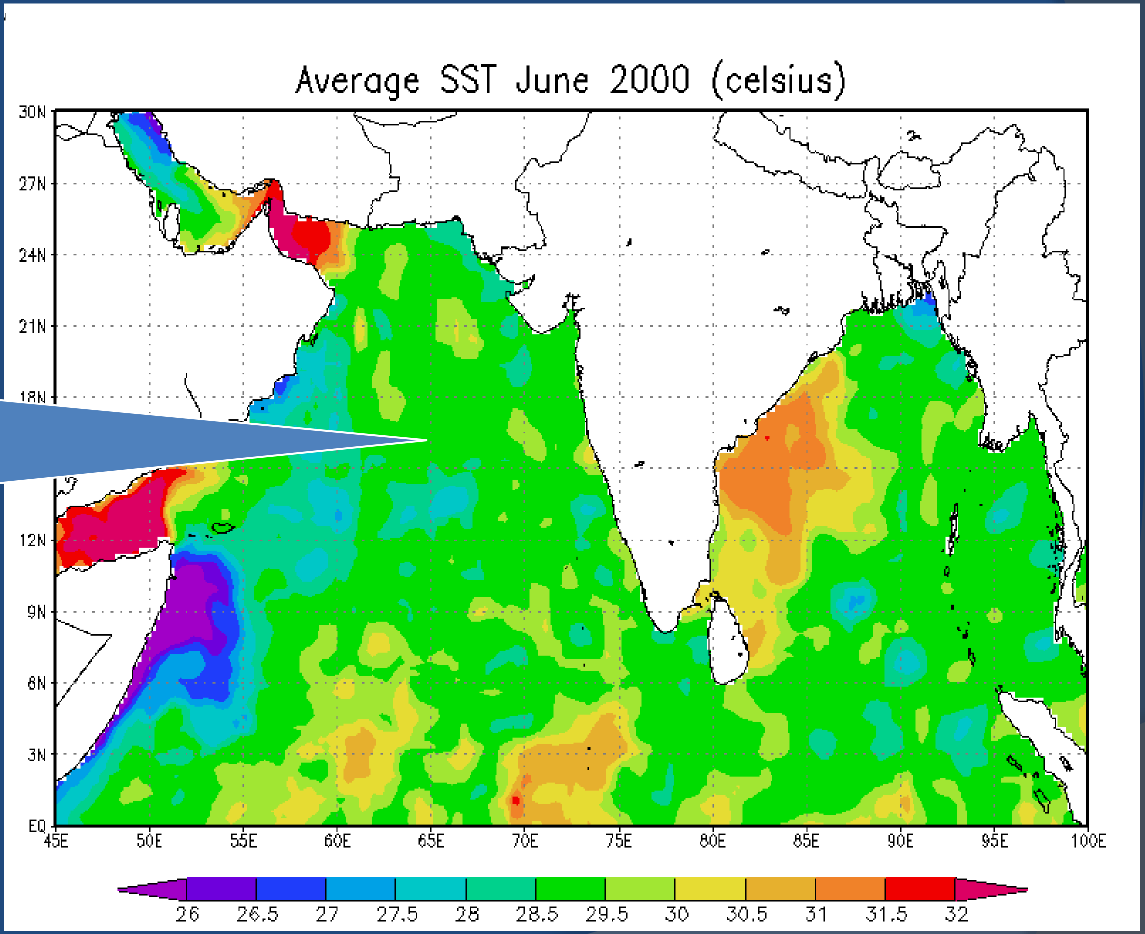
Arabian Sea & Bay of Bengal



Comparison of Sea Surface Temperature for Bay of Bengal and Arabian Sea

(2000 - 2007)

Arabian sea is showing higher SST values compared to Bay of Bengal since 2000

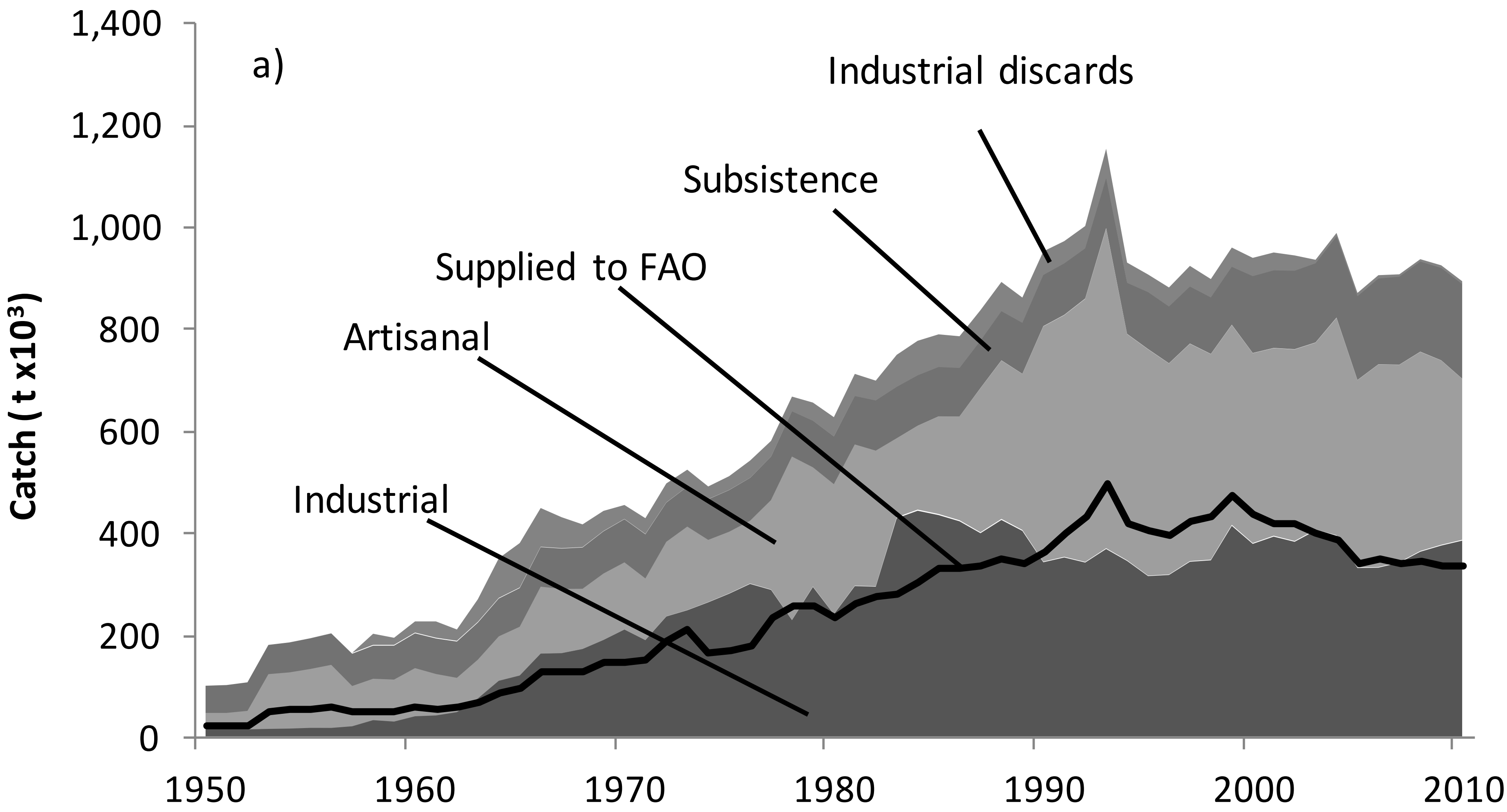


Weather Related Changes in Arabian Sea

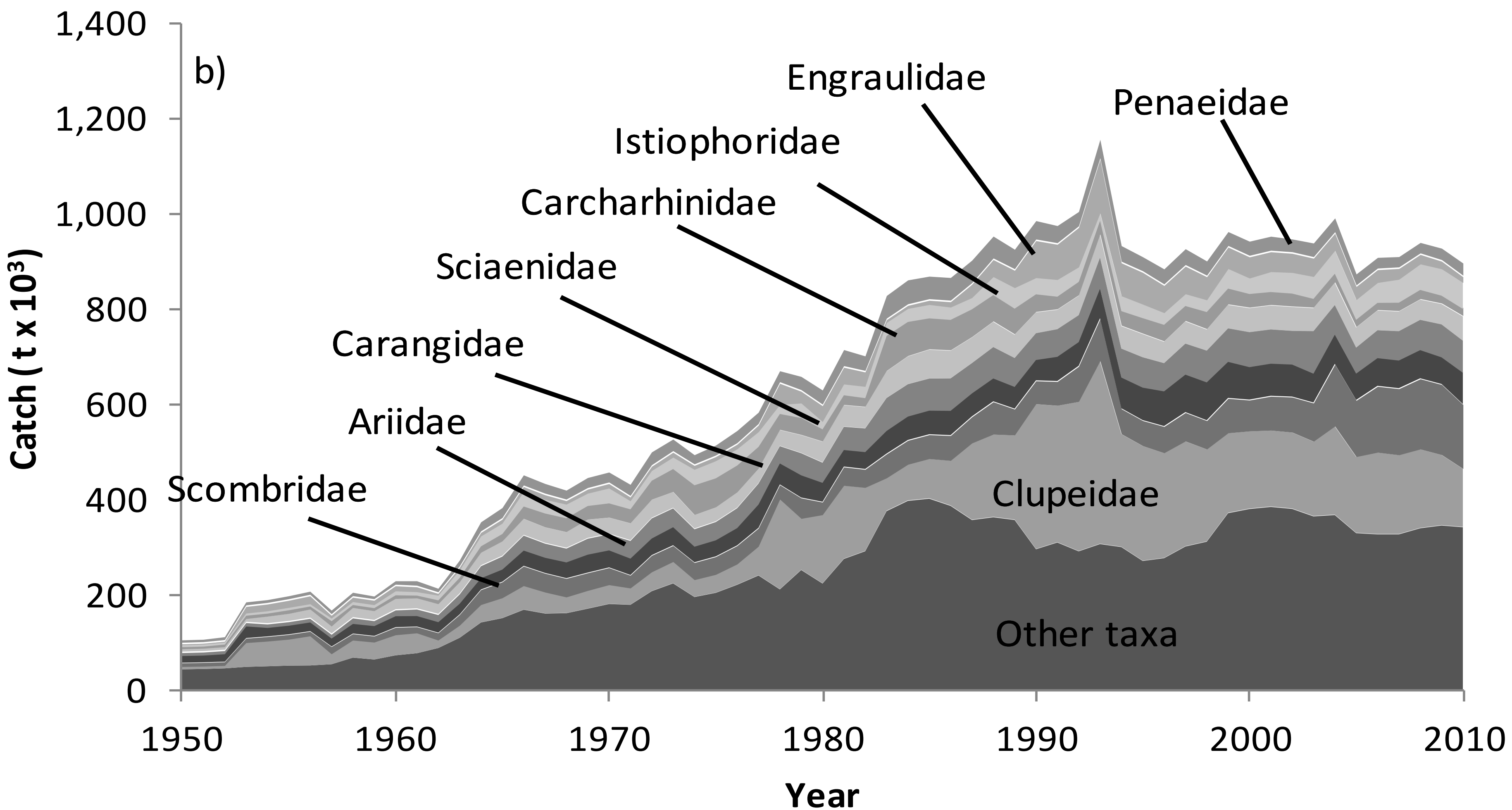
- Higher SST in North Arabian sea is giving rise to formation of more frequent and intense Cyclones
- Previously storms used to re-curve towards Rann of Kutch
- Shift of track, under climate change, towards west indicates that Sindh-Makran coast may be affected in future
- Yemyin landfall at Pasni is the recent example
- Sea Level Rise will result in more destructive storm surges

DISTRICT / TALUKA	AREA (ha)	Area Affected by Sea Intrusion (ha)			
		Fully Eroded	Partially Eroded	Total	Not Eroded
Thatta	**1,324,606**	**348,093**	**186,400**	**534,493**	**790,113**
Shah Bundar	297,707	205,940	35,055	240,995	56,712
Ghora Bari	94,686	2,986	9,867	12,853	81,833
Kharo Chan	192,902	39,147	8,944	48,091	144,811
Mirpur Sakro	300,629	4,503	20,057	24,560	276,069
Jati	357,215	49,411	112,069	161,480	195,735
Keti Bundar	81,467	46,106	408	46,514	34,953
Badin	**323,749**	**14,595**	**17,978**	**32,573**	**291,176**
Golarchi	179,798	2,764	9,736	12,500	167,298
Badin	143,951	11,831	8,242	20,073	123,878
Total	**1,648,355**	**362,688**	**204,378**	**567,066**	**1,081,289**

Reconstructed catch data from 1950-2010

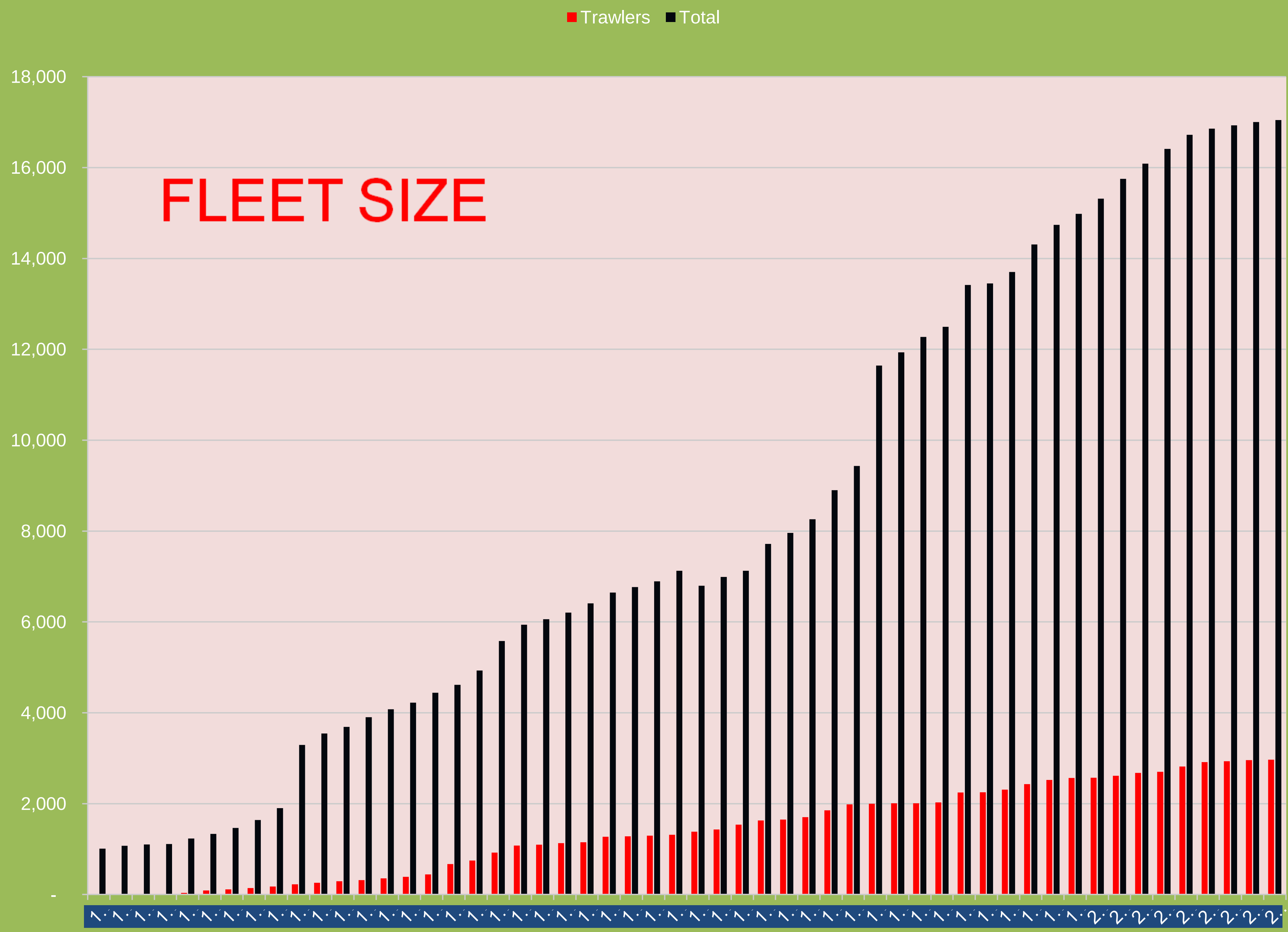


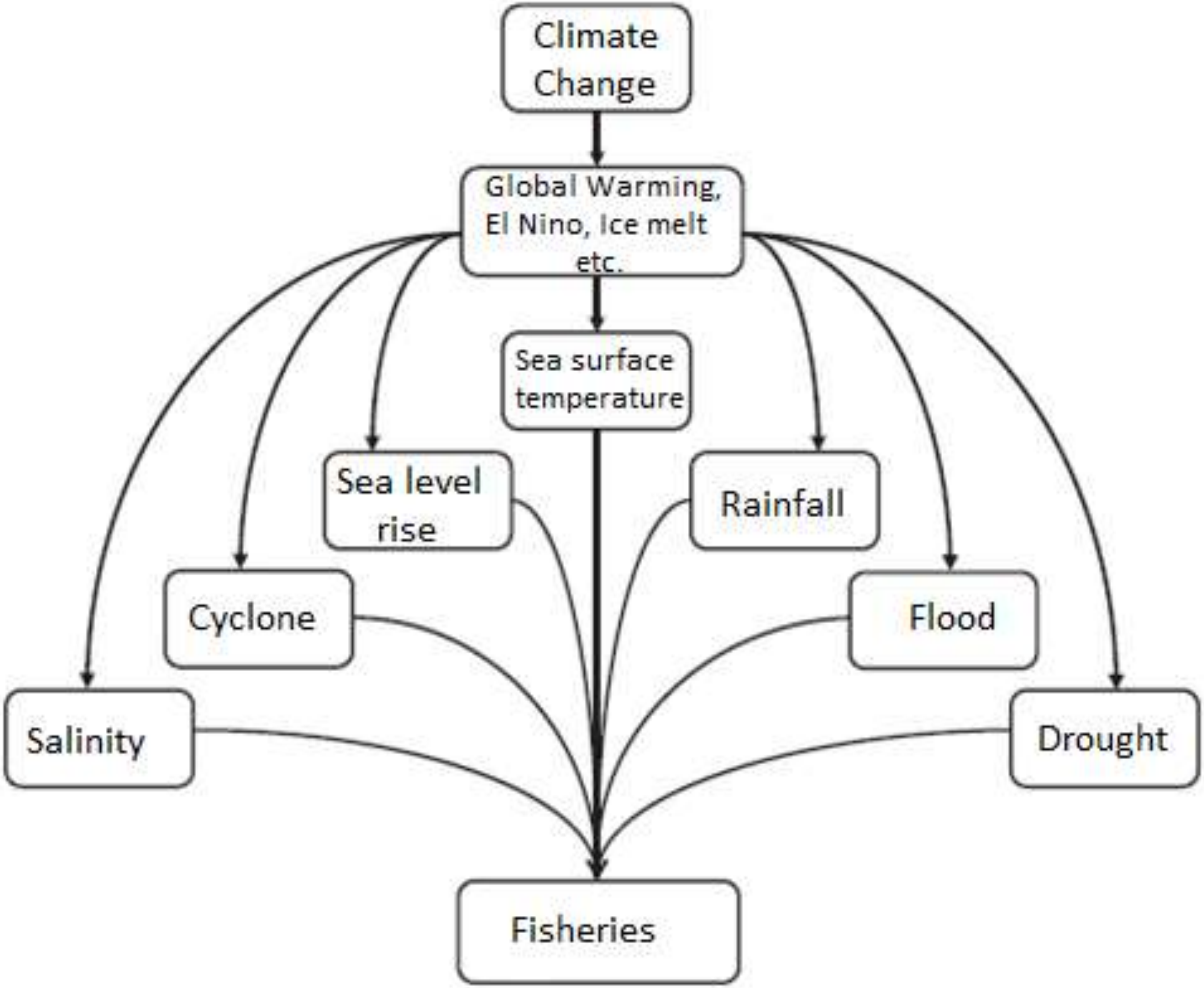
Reconstructed catch data from 1950-2010



FLEET SIZE

FLEET SIZE


Trawlers
Total
FLEET SIZE
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-


Climate Change
Global Warming, El Nino, Ice melt etc.
Sea surface temperature
Sea level rise
Rainfall
Cyclone
Flood
Salinity
Drought
Fisheries

Potential threats of Climate Change on Fisheries

- Higher seawater temperature
- Sea level rise
- Increase in frequency/intensity of cyclone
- Changes in precipitation quantity, location and timings
- El-Nino-Southern Oscillation (ENSO)

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Higher estuarine temperature	Increased stratification	Reduced fish stocks
	Raised metabolic rates. Enhanced primary production	Enhanced fish stocks and aquaculture productivity.
	Shift in location and size of the potential range of some species	Potential loss of species or alteration in species composition.
	Reduced water quality	Altered stocks and species composition
	Changes in timing and success of migration, spawning and peak abundance	Potential loss species or shift in composition

Higher seawater temperatures (0.6-0.7^{o}C increase in tropical regions)

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Changes in sea surface temperature	More frequent HAB. Less dissolved oxygen. Altered ecosystems. Altered plankton composition	Impact on abundance and species composition of fish stocks
	Enhanced primary productivity	Changes species composition
	Longer growing season. Lower mortality in winters. Enhanced growth rates	Increased production.

Higher seawater temperatures (0.6-0.7^{o}C increase in tropical regions)

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Changes in sea surface temperature	Changes in timing and success of migrations, spawning and peak abundance.	Potential loss of species or shift in composition
	Change in location and size of suitable range for particular species	Offset species composition
	Damage to coral reefs and other fragile ecosystem	Reduced recruitment and habitat damage

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Changes in precipitation, quantity, location and timing.	Changes in fish migration and recruitment patterns as well as in recruitment success.	Altered abundance and composition of fish stocks
	Changes in fish migration and recruitment pattern	Altered abundance, composition and abundance of fish stocks. Fishermen forced to migrate more and expend more effort.
	Lower water availability	Conflict with other water users.

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Sea level rise	Loss of land	Loss of aquaculture.
	Changes to estuary systems	Shifts in species abundance, distribution and composition of fish stocks
	Salt water infusion into groundwater	Damage to capture fisheries. Reduced freshwater availability to a shift to brackish water species.
	Loss of coastal ecosystems such as mangrove forests.	Reduced recruitment and stocks for capture fisheries. Worsened exposure to waves and storm surge and inundation of potential areas.

Sea level rise (2.5 to 3.0 cm increase during last 50 years in Vietnam)

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
Increase in frequency and/or intensity of storm	Large wave and storm surges. Flooding of potential areas.	Impact on recruitment and stock. Higher direct risk to fishermen and higher capital cost for infrastructure.
Draught	Lower water quality. Salinity changes	Loss of fish stocks. Lower productivity.
	Changes in river flow	Reduced fish stocks. Migration of fisherfolk.

POTENTIAL THREATS OF CLIMATE CHANGE ON FISHERIES

FACTORS	EFFECTS	IMPLICATIONS
El Nino-Southern Oscillation	Changed location and timing of ocean currents and upwelling alters nutrient supply in surface waters and primary productivity.	Changes in the distribution and productivity of open sea fisheries
	Changed ocean temperature and bleached corals	Reduced productivity especially of reef fisheries
	Altered rainfall patterns brings flood and drought	Sea impacts for precipitation trends, drought and flooding.

DISCERNABLE RESPONSES TO CLIMATE CHANGE

- Extension of distributional boundary of small pelagics
- Extension of depth of occurrence and
- Phenological changes

Vivekanandan (2011)

EXTENSION OF DISTRIBUTIONAL BOUNDARY OF SMALL PELAGICS

Indian Oil Sardinella (*Sardinella longiceps*)

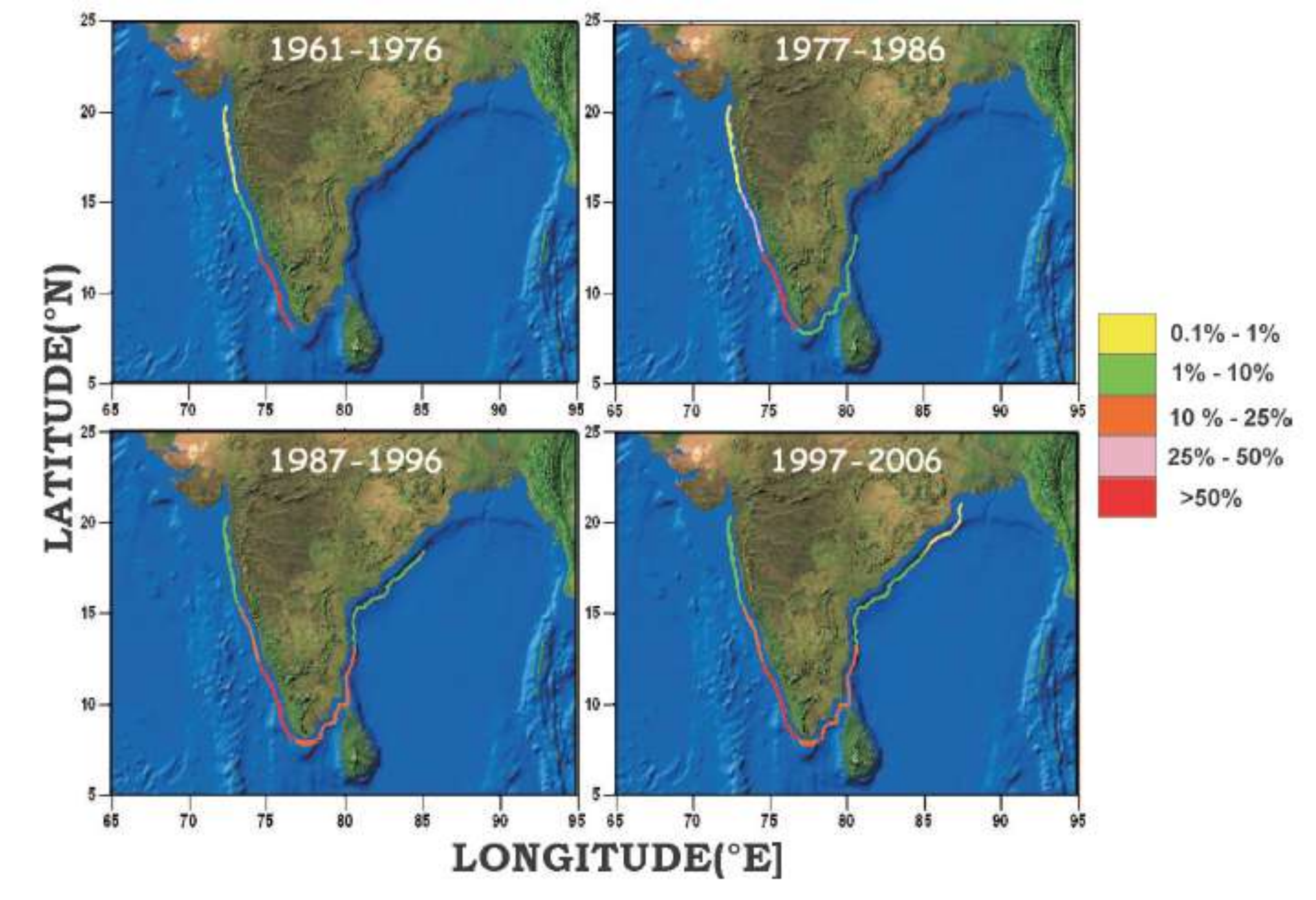
- Restricted distribution between latitude 8ºN and 14ºN and longitude 75ºE and 77ºE (Malabar upwelling zone along the southwest coast of India)
- Annual average sea surface temperature ranges from 27 to 29ºC.
- Until 1985, almost the entire catch of oil sardine was from the Malabar upwelling zone
- The catch was very low or no catch from latitudes north of 14ºN along the west coast

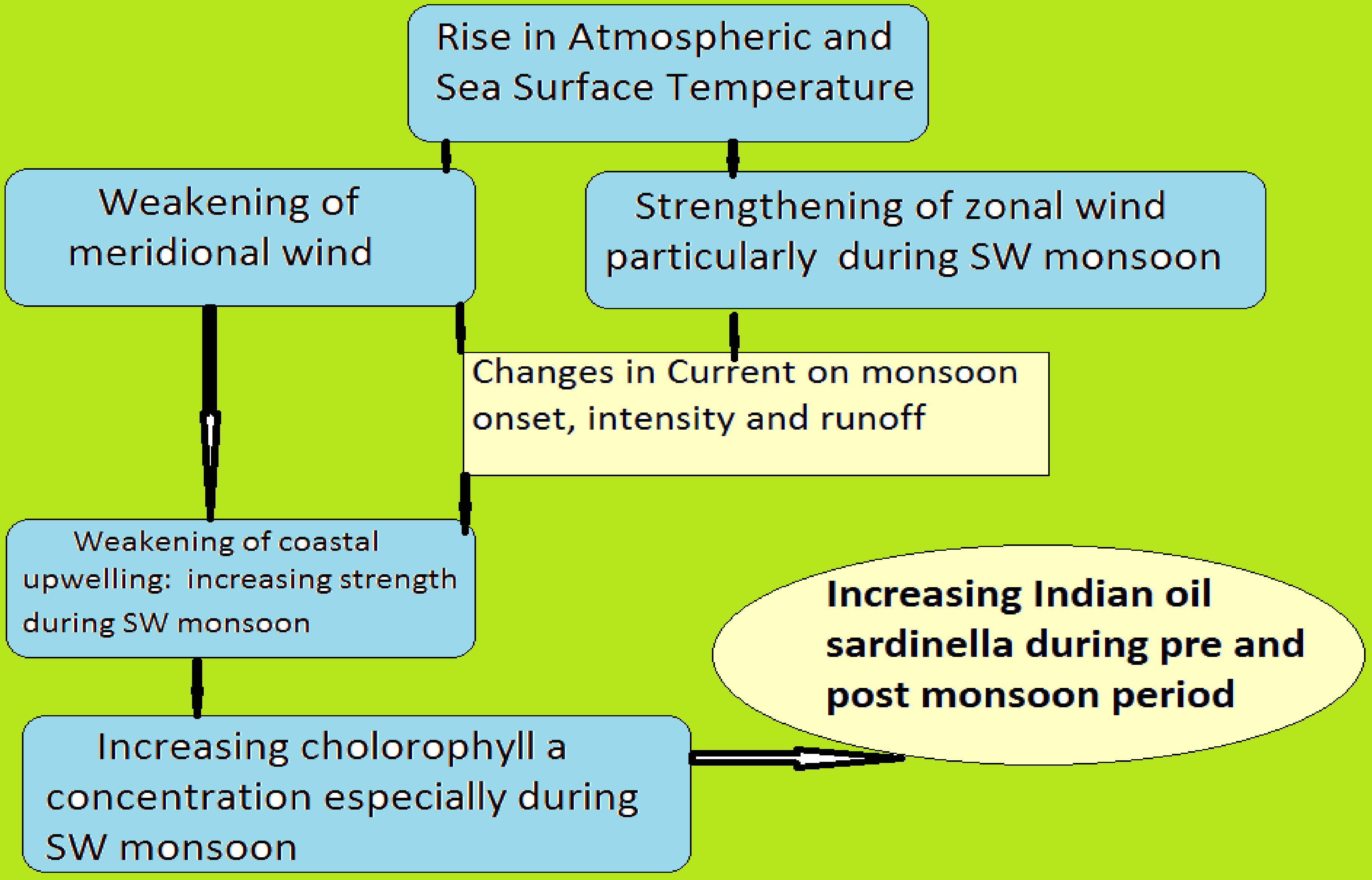
EXTENSION OF DISTRIBUTIONAL BOUNDARY OF SMALL PELAGICS

Indian Oil Sardinella (*Sardinella longiceps*)

- In the last two decades the catches from latitude above 14ºN are increasing, contributing about 15% (2006)
- Surface waters of the Indian seas warming by 0.04 ºC per decade
- Warmer tongue (27-28.5ºC) of the surface waters is expanding to latitudes north of 14ºN
- Enabling the oil sardine to extend their range to northern latitudes in both East and West coasts.

Distribution of Indian Oil Sardinella



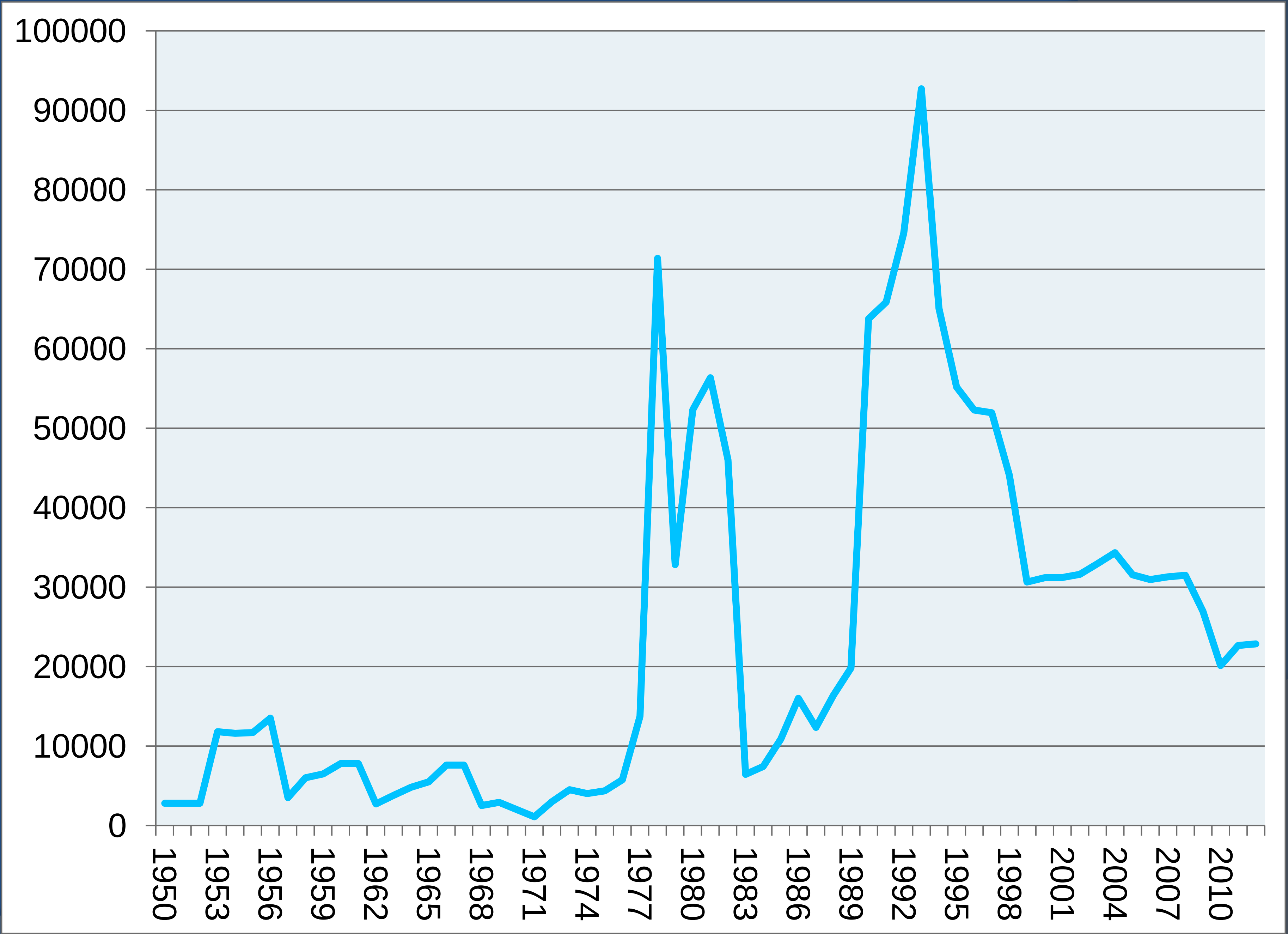


CLIMATE RELATED EVENTS RESULTING IN INCREASED OIL SARDINELLAS PRODUCTION

EXTENSION OF DISTRIBUTIONAL BOUNDARY OF SMALL PELAGICS

Indian Oil Sardinella (*Sardinella longiceps*)

- Although Indian oil sardinella fisheries seems to be an important component of the small pelagic fisheries of Pakistan. However, recent increased landings especially along Gwader coast may be attributed to climate change !!!


100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010

INDIAN OIL SARDINELLA FISHERIES-GWADER

EXTENSION OF DISTRIBUTIONAL BOUNDARY OF SMALL PELAGICS

Indian mackerel (*Rastrelliger kanagurta*)

- Northwest coast of India

1961-1976 contributed about	7.5%
1997-2006 contributed about	18%

- Northeast coast of India

1961-1976 contributed about	0.4%
1997-2006 contributed about	1.7%

EXTENSION OF DISTRIBUTIONAL BOUNDARY OF SMALL PELAGICS

Indian mackerel (*Rastrelliger kanagurta*)

- Southeast coast of India

1961-1976 contributed about	10.6%
1997-2006 contributed about	23.2%

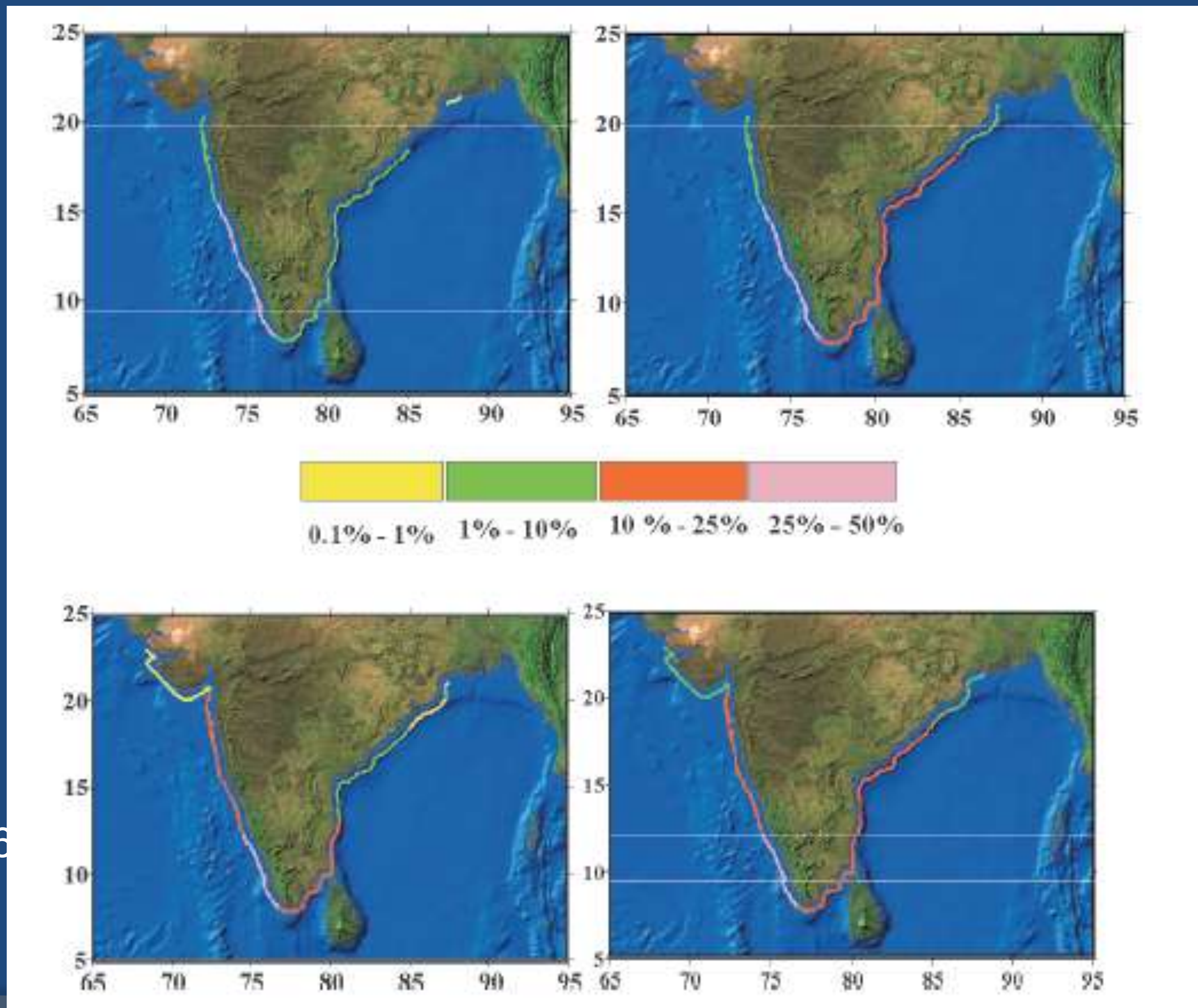
- Southwest coast of India

1961-1976 contributed about	81.3%
1997-2006 contributed about	56.1%

Distribution Range of Indian Mackerel

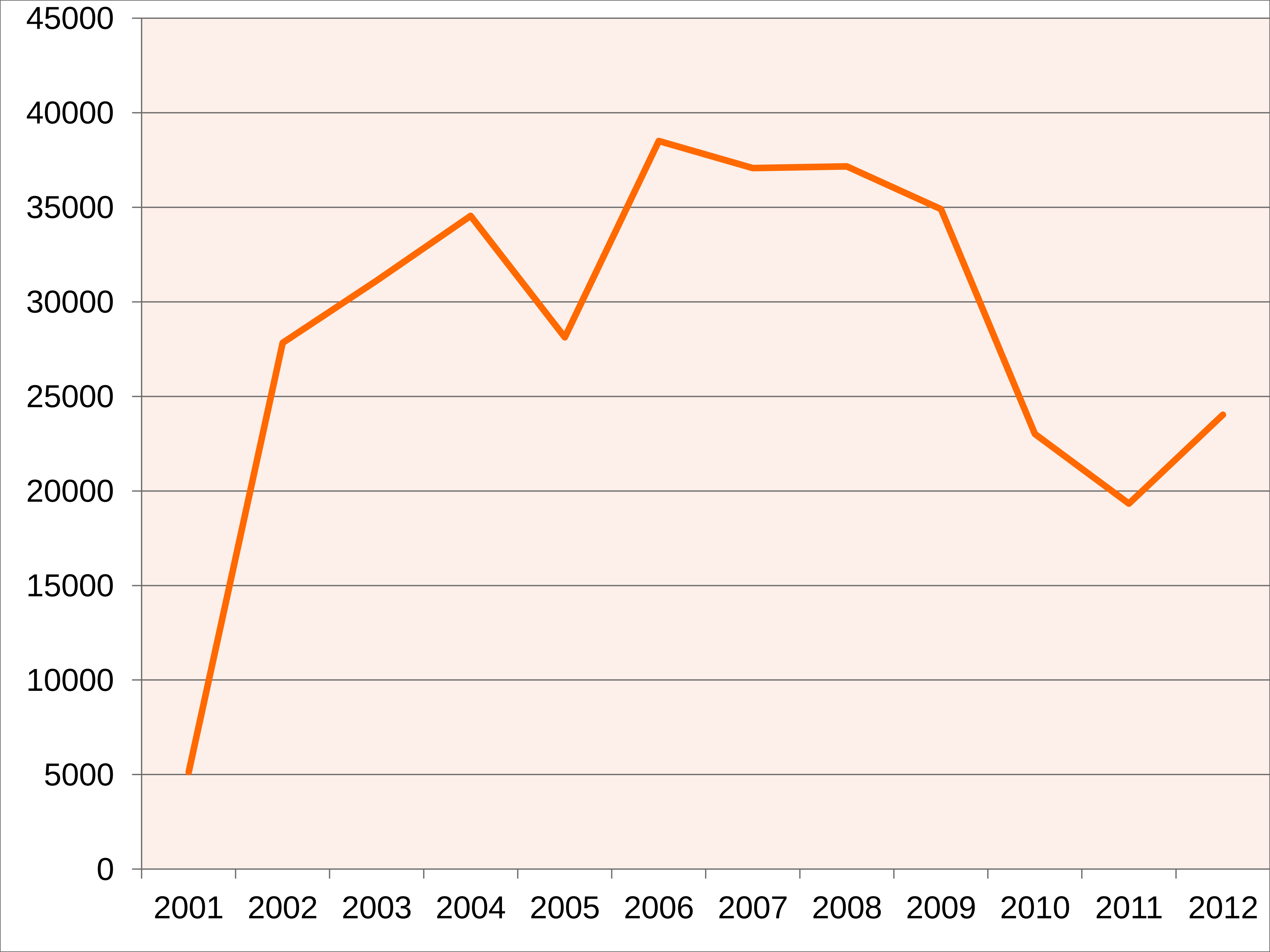
1961-1976

1977-1986



1997-2006

1987-1996


45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

INDIAN MACKEREL FISHERIES-GWADER

EXTENSION OF DEPTH OF OCCURRENCE

Indian mackerel (*Rastrelliger kanagurta*)-India

- During 1985-89

  Pelagic gear contributed 98%

  Bottom trawler contributed 2%

- During 2003-2007

  Pelagic gear contributed 85%

  Bottom trawler contributed 15%

EXTENSION OF DEPTH OF OCCURRENCE

Indian mackerel (*Rastrelliger kanagurta*)-
Pakistan

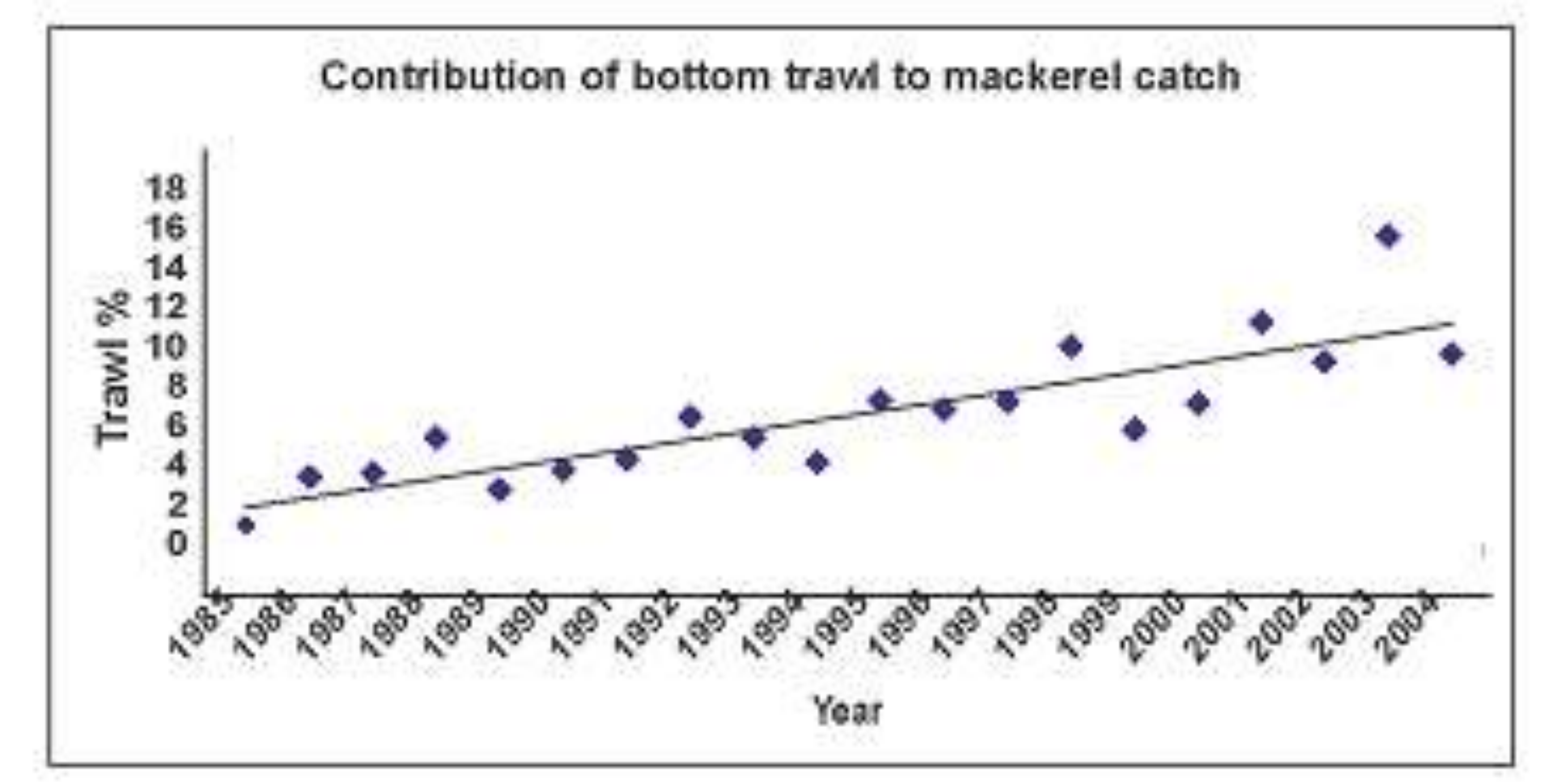
- During 1993-2004

Pelagic gear contributed	100%
Bottom trawler contributed	0%

- During 2005-2013

Pelagic gear contributed	88%
Bottom trawler contributed	12%

EXTENSION OF DEPTH OF OCCURRENCE



EXTENSION OF DEPTH OF OCCURRENCE

Indian mackerel (*Rastrelliger kanagurta*)

- Two possibility:
  - mackerel are being displaced from the pelagic realm due to warming of the surface waters.
  - Sea bottom temperatures are increasing, therefore, the boundary of distribution to depths is increasing.
- Catch quantities of the mackerel from the pelagic gear are also increasing.
- It is vertical *extension of distribution, and not a distributional shift.*

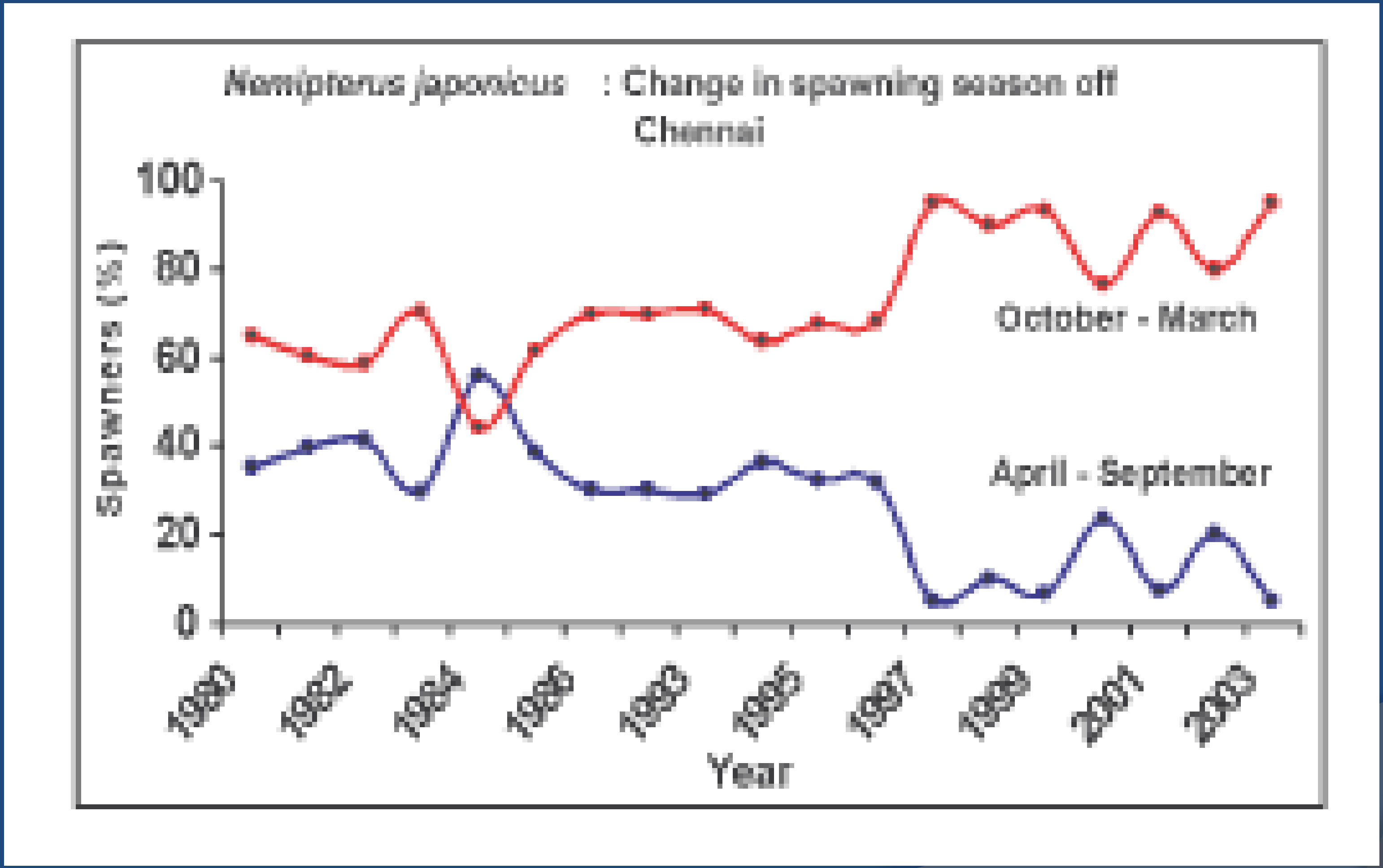

THREADFIN BREAM

PHENOLOGICAL CHANGES

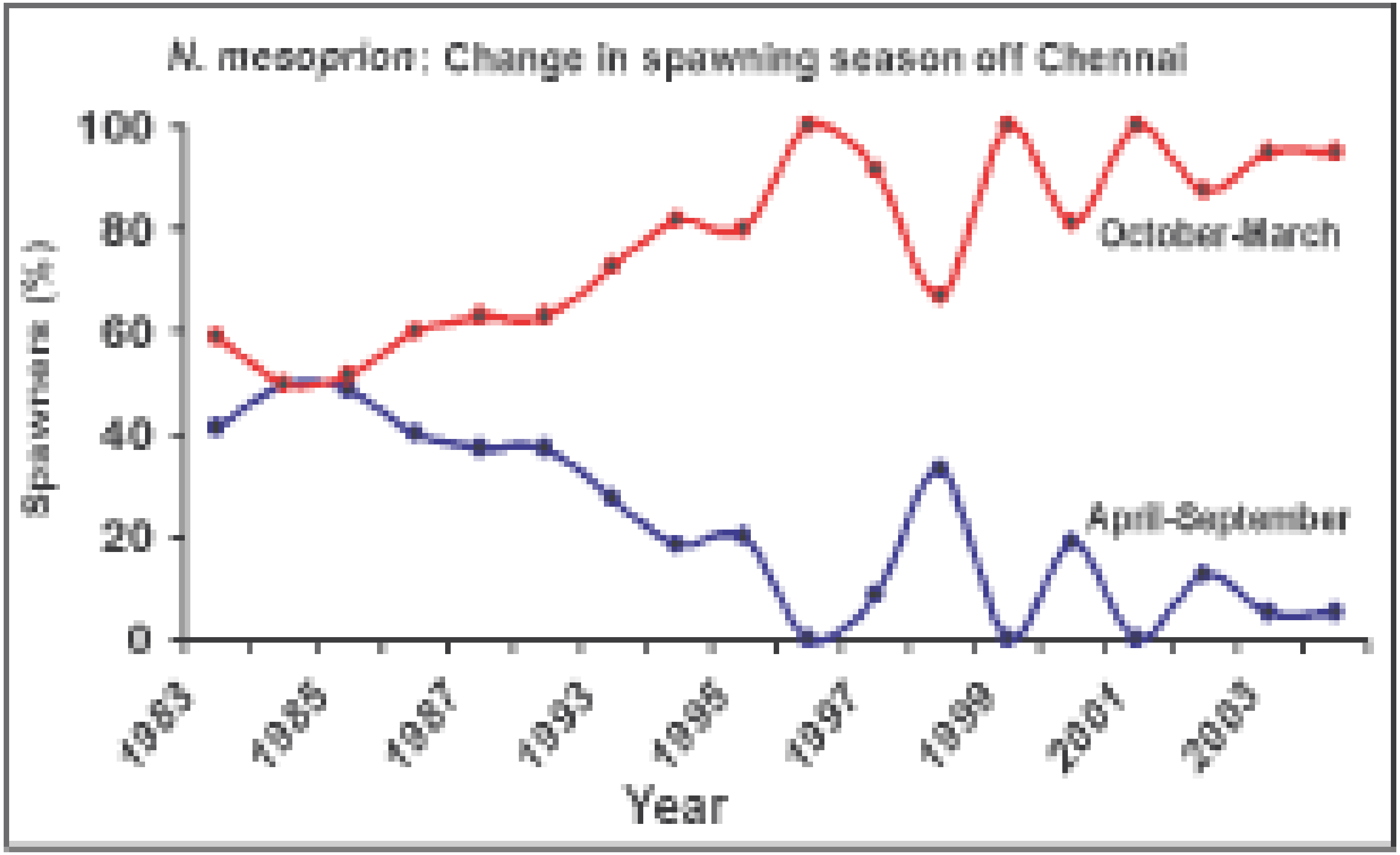
Threadfin Bream (*Nemipterus japonicus and N. mesoprion*)

- In 1980's percent occurrence of spawners
  - Decreased during April-September (Warm Period) 40 % (29.0^oC)
  - Increased in the October-March (Cool Period) 60 % (29^oC)
- In 2000's percent occurrence of spawners
  - Decreased during April-September (Warm Period) 15 % (27.5^oC)
  - Increased in the October-March (Cool Period) 85 % (28.0^oC)

PHENOLOGICAL CHANGES



PHENOLOGICAL CHANGES



ECONOMIC EFFECTS OF CLIMATE CHANGE

- Production and marketing cost could increase
- Buying power and export decreases
- Danger from harsher weather conditions rise
- Small scale fishing communities face greater uncertainty as availability, access, stability and use of seafood and supplies diminish and work opportunities dwindle

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
Uncertainties of fish availability and supply	Develop knowledge base for climate change and fisheries and aquaculture
	Predict medium and long term probabilistic Production
	Assess the adaptation capacity, resilience and vulnerability of marine production systems
	Adjust fishing fleet and infrastructure capacity
	Consider the synergistic interactions between climate change and other issues such as overfishing and pollution.

Allison et al., 2004; Handisyde et al., 2005; FAO, 2008, Vivekanandan (2011)

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
New challenges for risk assessment	Consider increasing frequency of extreme weather events
	Consider past management practices to evolve robust adaptation systems
	Identify and address the vulnerability of specific communities
	Consider gender and equity issues

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
Complexities of climate change interactions into governance of frameworks to meet food Security	Recognition of climate-related processes and their interaction with others
	Action plans at national level based on • Code of Conduct for Responsible Fisheries • Integrated ecosystem approach to fisheries and aquaculture management plans, • Framework for expansion of aquaculture • Linkage among cross-sectoral policy frameworks such as insurance, agriculture, rural development and trade

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

<table>
<tr><th>Concerns</th><th>Adaptive mechanism</th></tr>
<tr><td rowspan="2">Complexities of climate change interactions into governance of frameworks to meet food Security (Cont.)</td><td>Action plans at regional level by
Strengthening regional organizations and place climate change agenda as a priority
Addressing trans-boundary recourse use,
Evolving common platforms and sharing the best practices</td></tr>
<tr><td>Action plans at international level by
Linking with mitigation activities
Enhancing co-operation and partnerships,
Applying international fishery agreements.</td></tr>
</table>

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
Fisheries and aquaculture may be more vulnerable in conflicts with other sectors	Action plans should involve not only fisheries institutions/departments, but also those for national development planning and finance
	Sharing and exchange of information with other sectors
	Existing management plans for fisheries and aquaculture need to be reviewed and further developed by considering climate change

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
Financing climate change adaptation and mitigation measures	Fishermen, processors, traders and exporters should increase self protection through financial mechanisms
	Improving equity and economic access such as microcredit should be linked to adaptation responses
	Investment on infrastructure, such as construction of fishing harbour, should consider climate change

ADAPTATION TO CLIMATE CHANGE IN FISHERIES

Concerns	Adaptive mechanism
Financing climate change adaptation and mitigation measures (Cont.)	Financial allocation in national budget for risk reduction and prevention practices such as early warning systems and disaster recovery programmes and for relocation of villages from low lying areas
	Incentive for reducing the sector's carbon footprint and other mitigation and adaptation options.

MISCONCEPTION !

Fisheries dependent activities, rather than climate change, are responsible for decline in fish catches

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