Climate change influences on India’s Marine Fisheries

Presented by

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Profile of Indian Marine Fisheries

Length of coastline 8,129 km
Fishing villages 3,288
Marine fishers population 3.9 million
Active fishers population 0.9 million

Landing centers 1,511
Major fishing harbours 26
Minor fishing harbours 38
How the Exploitation is Carried Out

- **5 major Gears**
  - Trawl
  - Bagnets
  - Gillnets
  - Seines
  - Hook & Line

- **Major Crafts**
  - Mechanized
  - Motorized
  - Non-mechanized

- **More than 25 craft gear combinations**

<table>
<thead>
<tr>
<th>Number</th>
<th>Catch (lakh tonnes)</th>
<th>% contribution</th>
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<tbody>
<tr>
<td>Mechanized</td>
<td>72559</td>
<td>30.8</td>
</tr>
<tr>
<td>Motorised</td>
<td>71313</td>
<td>7.8</td>
</tr>
<tr>
<td>Non mechanised</td>
<td>50618</td>
<td>0.8</td>
</tr>
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Kara (CMFRI, 3rd International Symposium on CC)
Value (in INR crores) of marine fish landings

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<tr>
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<th>2007</th>
<th>2012</th>
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<tr>
<td></td>
<td>14721</td>
<td>24890</td>
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</table>

11.51% per annum

Retail market -Gross earnings (in INR crores)

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<th>2007</th>
<th>2012</th>
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<td></td>
<td>24934</td>
<td>38562</td>
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9.11% per annum

Structural shift in the capital investment

- Traditional units
- Mechanized units

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<th>1997-98</th>
<th>2009-10</th>
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<tr>
<td></td>
<td>4117 crores</td>
<td>15,163 crores</td>
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22% pa

Private capital investment in fishing equipments

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### Indian Marine Fisheries - Percentages

<table>
<thead>
<tr>
<th>Category</th>
<th>Value/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross value</td>
<td>US$ 7.2 billion</td>
</tr>
<tr>
<td>Export Value</td>
<td>US$ 4.5 billion: ~65% marine capture</td>
</tr>
<tr>
<td>% in total exports</td>
<td>3%</td>
</tr>
<tr>
<td>Domestic markets</td>
<td>81% fresh; 5% frozen; 6% dry; 5% fish meal</td>
</tr>
<tr>
<td>Per capita fish consumption</td>
<td>2.85 kg (range 39 – 0.3)</td>
</tr>
<tr>
<td>Share in GDP</td>
<td>~1%</td>
</tr>
<tr>
<td>Share in agricultural GDP</td>
<td>4.5%</td>
</tr>
</tbody>
</table>
India Vs World – Marine Catch Trends

India Marine Fish Catch in million tonnes

World marine catch

India     Global
Continuing to grow & expand

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Estimates of carbon emission from marine fishing crafts

Different types of seines in which more than 20 fishermen are involved in fishing – they fish shoal farming small pelagic fishes
A small harbour in Vypin Island - Kerala
Figure 1. Change in composition of fishing boats (% of total number of boats) in India.
Considering global estimate, India’s emission intensity is low by about 40% per tonne of live weight landed.
Climate change impacts on fish distribution and phenology

Source: Results of network project on climate change
Sensitiveness of Fish to Temperature

• Some fish are sensitive to even 1°C rise in temperature

• However, the temperature has to increase beyond a certain threshold for a visible impact

• Generally, those with short life and quick generation turnover adapt

• They try to adapt by shifting the area of distribution; and/or effecting phenological changes

• Fishing technology masks the effects
Changes in Distribution and Phenology

• **Category 1:** Extension of distributional boundary *(Indian oils sardine)*

• **Category 2:** Change in biomass *(Indian oil sardine)*

• **Category 3:** Shift in depth of occurrence *(Indian Mackerel)*

• **Category 4:** Temporal shift in spawning *(Nemipterus japonicus)*
Oil Sardine *Sardinella longiceps*

- Coastal, pelagic, schooling fish
- Maximum size – 20cm
- Massive fishery in India; probably the largest stock in the Indian ocean
- Crucial role in marine ecosystems as a plankton feeder and as food for larger fishes
- Annual production: 3.8 lakh tonnes (15%)
- Total value: Rs. 350 crores
- Low priced; staple sustenance and nutritional food for millions
- A tropical fish with preference for SST > 28°C
Extension of northern boundary of oil sardine
(the colored lines indicate percentage of All India oil sardine production)
Distributional Changes

• With warming of the sea, the fish is able to find temperature to its preference in the northern latitudes and eastern longitudes, thereby extending the distributional boundaries and establishing fisheries in larger coastal areas.

• These distributional shifts are expected to result in drastic changes in species mix and ecosystem structures and functions.

• Will this trend pave the way for species replacement?
Sardine catch has been related to several oceanographic parameters

• The IEEZ was divided into six regions such as
  • South West EEZ (SWEEEZ),
  • South East EEZ (SEEEEZ),
  • North East EEZ (NEEEEZ),
  • North West EEZ (NWEEEZ),
  • Lakshadweep EEZ (LAKEEZ) and Andaman EEZ (ANEEEZ)
AVG SCALAR WIND (m/s) across EEZ (1960-2014)

SWEEZ  SSEEZ  NWEEZ  NEEEZ  ANEEZ  LAKEEZ
Features of sardine fishery

- Fishery during commences during June -July
- Spawning June-Sep
- Rapid growth, early maturity
- Upwelling has very important role in sardine fishery and CC impacts upwelling
- Entry of spawners
- Shoals of juveniles
- Shoals of adults
- Wide annual fluctuations

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Sardine fishery fluctuations

• Upwelling helps in increasing productivity and this supports sardine spawning and recruitment
• But studies on sardine catch and upwelling has shown that if hypoxic waters are present in coastal waters before spawning this can prevent spawners from entering the spawning ground.
• Hypoxic conditions also affect larval survival

S.W MONSOON
The normal rainfall during the southwest monsoon over Kerala from 1871 to 2008 was 1924.9 mm with a coefficient of variation of 19.3%. The monthly rainfall was relatively undependable with August and September having a coefficient of variation of 41.5 and 54.1 per cent respectively
Adaptation to seawater warming – Indian mackerel (*Rastrelliger kanagurta*)

- Coastal, pelagic, tropical fish
- **Maximum size** – 32cm
- Massive fishery in India;
- Crucial role in marine ecosystems as a plankton feeder and as food for larger fishes
- **Annual production** : 1.4 lakh tonnes (5%)
- **Total value** : Rs 350 crores
- Staple sustenance and nutritional food for millions
Indian mackerel: descends to deeper waters

- Indian mackerel generally occupies surface and subsurface waters. Conventionally caught by surface drift gillnets by artisanal fishermen.
- In recent years, the fish is increasingly getting caught in bottom trawl nets operated by large mechanised boats at about 50 m depth.
- Now, about 10% of the mackerel catch is by the trawlers.
- This shows that the fish descends down to overcome warmer surface waters.
Phenological changes in threadfin breams

- One of the dominant demersal resources of India
- Maximum size: 32 cm
- Annual production: 1.2 lakh tonnes (5%)
- Total value: Rs. 360 crores
- A prolonged spawning seasonality
- **Shift in peak spawning activity towards cooler months in the last 20 years, off Chennai**

*Case study 4*
Nemipterus japonicus: Change in spawning season off Chennai

October - March
SST: 27.5 – 28 °C

April - September
SST: 29 – 29.5 °C

N. mesoprion: Change in spawning season off Chennai

October-March

April-September
Strong upwelling – low bottom water temp gives good catch of *Nemiterus japonicus*

- Very strong relation to bottom water temperature
- Catch above 2000 tonnes were recorded when the bottom water temp were less than 25 deg C (average=23.8 deg C)

Seawater temp at 10m depth and catch of threadfin breams (1996 to 2000)
Impacts of low pH on Meroplankton

• Low pH was observed during September and October in the coastal waters in some years, mainly due to anthropogenic impacts.

• The plankton community during this period showed considerable changes.
Range of surface water pH at 5 m depth, off Cochin during 2008-2013

- **pH <7**: 5.9
- **pH 7 to 8**: 70.6
- **pH > 8**: 23.5

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Change in zooplankton community structure

- **Macro zooplankton** dominated the community.
- Calciphorous zooplankton (bivalve larvae, pteropods and phyllosoma) and **micro-zooplankton** were found to be negatively impacted.
- Low biomass of micro-zooplankton can negatively affect fish recruitment.
- **Phyllosoma and bivalve larvae** were absent indicating that fishery of these shellfish stocks can be affected. August and September are the spawning months of bivalves especially mussels.
- However, **larger crustacean larvae were not affected**, indicating a size based vulnerability to ocean acidification.
Impacts on Marine Habitats – coral reefs, coastal ecosystems and livelihoods
### Bleaching events in the Indian Seas

<table>
<thead>
<tr>
<th>Location</th>
<th>Month/Year</th>
<th>Mortality/Bleaching</th>
</tr>
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<tbody>
<tr>
<td>Gulf of Mannar</td>
<td>June 1998</td>
<td>60% branching forms lost</td>
</tr>
<tr>
<td>Lakshadweep</td>
<td>May 1998</td>
<td>78% mortality</td>
</tr>
<tr>
<td>Andaman Islands</td>
<td>May 1998</td>
<td>Up to 50% dead</td>
</tr>
<tr>
<td>Nicobar Islands</td>
<td>May 1998</td>
<td>Up to 20% dead</td>
</tr>
<tr>
<td>Gulf of Kachchh</td>
<td>May 1998</td>
<td>10-30% bleaching</td>
</tr>
<tr>
<td>Palk Bay</td>
<td>April 2002</td>
<td>60% affected</td>
</tr>
</tbody>
</table>
Coastal waters- an area where small scale fishers depend on the natural resources
Artisanal fisheries

- Coastal waters provide livelihood to several artisanal small scale fishers
- Increased no. of rainy days affects livelihood
Clam fishing is an imp coastal livelihood

- Flooding leads to loss in fishing days
The whole family takes part in the harvest, post harvest and marketing. So when there is loss in fishing days it affects the whole family.
4

Vulnerability and perception of fishermen towards climate change

Results of the IDLAM -Integrated District-level adaptation and mitigation component of NICRA project
Coastal population

- More than 100 million people of the Indian population live along the 7510 km country’s coasts, with an average population density of 455 persons per km² which is about 1.5 times the national average of 324 (Census, 2001).

The fishermen perception on CC..

The assessment begins......
Alapuzha district of Kerala

The survey was done in Alapuzha district which has

• 30 fishing villages
• 20278 fishermen families.
• Traditional fishermen - 20024 (98.74% of total fishermen families) of which 10244 (50%) are below poverty line
• 51 mechanized boats, 1015 crafts with outboard and 1766 boats are non-motorised
Seawall as protection from monsoon waves – This will prevent sea erosion. Still.....

Houses are built very close to the sea thereby increasing the vulnerability to CC impacts.
Beaches are important landing centres

Country crafts with fish catch and auctioning at the landing centre

It has been observed that sea level rise of 1 mm per year could cause a recession of shoreline in the order of about 0.5 m per year.
The approach........
info on fishermen perception collected through planned surveys
Beaches are imp landing centres, and is the major site where auctioning of fish catch is done and place where crafts are berthed.

When beaches erode, or when CC impacts beaches, the fishermen are directly affected.

Noof coastal villagers involved in fish marketing in different districts of Kerala

Number of fishing crafts in which will be berthed in the beaches /coastal waters
Fishermen’s perception

1. Change in fishing ground
   - Move to distant fishing ground
   - Increased fishing cost
   - Threat to life – no protection for fishers

2. Loss in fishing days due to bad weather

Has affected Livelihood
Fishermen’s Perception

**Causes**
- Rough weather
- Abnormally high tidal amplitudes
- Sea level rise

**Impacts**
- Destruction / loss of houses
- Small landing centres are destroyed

**Affects**
- Has affected even basic facilities in fisher households
- Seawater intrusion in households
- Has affected the whole village where fishing is the main activity
Factors which increase vulnerability of fishers

| Low level of awareness about climate change | Makes fishers more vulnerable to CC impact |
| Low literacy rate                           | Unable to accept /adopt protective measure |
| Lack / inadequate level of sanitation and health care facilities | Fishers more vulnerable to spread of epidemics consequent to flood or inundations / cyclones |

Inferences from the survey

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<table>
<thead>
<tr>
<th>Factors which increase vulnerability of fishers</th>
<th>How vulnerability is increased</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lack of protection</strong> shelters, wireless weather communication tools, poor/bad roads</td>
<td>Exposes fishers to more vulnerable situations</td>
</tr>
<tr>
<td><strong>Distance between residential area and the coastline very low</strong></td>
<td>High vulnerability to sea erosion; SL rise</td>
</tr>
<tr>
<td><strong>Unplanned developmental activities</strong> (construction and destruction of habitats)</td>
<td>Has led to sea water intrusion during high tides since most villages are low lying areas</td>
</tr>
</tbody>
</table>
Floods are common and coastal villagers are affected by water logging.
More droughts—more water scarcity

• Women in coastal areas have to spend considerable energy and time to source drinking water for the family.

• The most disastrous drought was noticed in the year 1953 during the decade 1951-60 for the first time, followed by 1983, 1991 and 1996 in recent decades.

• The occurrences and intensity of droughts were increasing in the recent decades.

More stress for coastal women to source water for families
Water scarcity

• The analysis of decadal water level trend (1996-2005) indicates that 13% and 30% of monitoring wells are showing declining trend of more than 0.1 m/yr for pre-monsoon and post monsoon data respectively (CGWB data)
• Indicates more stress for coastal fisher families who depend on ground water
• Government is promoting rainwater harvesting schemes
Adaptation and mitigation

• Mangrove restoration
• Strengthen basic amenities in coastal villages (drinking water, good sanitation etc)
• Increase disaster preparedness
Traditional fish culture

- Of the four main activities in traditional fish farming, only one activity uses energy.

• Source of feed: natural feed

• Seed: sourced from nature

• Harvest: no power used

• Post-harvest: ice used for preservation, transportation by road
Coir making is a good additional alternate avocation option in some villages of Kerala

* Identify alternate avocation for villagers to compensate for loss in fishing days
* This will vary from in different villages and will depend on availability of raw material
Coastal areas are important breeding ground and nursery of valuable biota.

By improving habitats, the ecosystem productivity can be increased which will increase the income earned by coastal fishers; which can to some extent reduce vulnerability and loss of fishing days.
Involving younger generation in restoration programs
Involvement of villagers is important
Mangrove planting in shallow extensive and semi-intensive shrimp ponds to abate stress due to high temperatures

Supporting artisanal aquaculture activities
The major **Climate Preparedness activities** (CPAs) recommended as management advisories for increasing the preparedness of coastal villages to impacts of CC

<table>
<thead>
<tr>
<th>Climate Preparedness Activity (CPA)</th>
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<tbody>
<tr>
<td><strong>1</strong> Increase awareness among fishers on climate change and related threats to the livelihood</td>
</tr>
<tr>
<td><strong>2</strong> Increase the adaptation and preparedness through proper scientific interactions and trainings</td>
</tr>
<tr>
<td><strong>3</strong> Strengthen alternative avocations available across the different fishing villages to negate the risks and uncertainties of CC</td>
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<td>8</td>
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<td>9</td>
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</tbody>
</table>
Disaster management in India

• The natural disaster management system in the country is very good.
• Can get warning on state of sea
• Advice fishermen to abstain from fishing
Cyclone *Phailin* in India

- **Phailin** became a very severe cyclonic storm on October 10, 2013, equivalent to a category 1 hurricane.
- Around 12 million people affected.
- As part of the preparations, 600 buildings were identified as cyclone shelters and people were evacuated from areas near the coast, including Ganjam, Puri, Khordha and Jagatsinghapur districts in Odisha.
- The cyclone prompted India's biggest evacuation in 23 years with more than 5,50,000 people moved up from the coastline in Odisha and Andhra Pradesh to safer places.

Affected villages
Natural Disaster management in India
Shifting fishers to safer places during cyclone
Big disasters are well managed. But factors affecting daily life has to be given more importance

Fishermen

- More awareness programs
- Alternate avocation for adapting to CC

Planners

- More planning for protecting the target group from impacts of CC
- Disaster mang. programs

Community

- Develop towards green economy
- Reduce carbon foot print for posterity
Future work

• We are on the way towards developing climate models for fisheries resources
• Have data and we need more collaboration
• Need more guidance on ocean acidification related work
• Overall impacts on marine ecosystem services is being evaluated
Thank you PICES for sponsoring and for the invitation and for the opportunity for presenting India’s research highlights on impacts of CC on marine fisheries