ENVIRONMENTAL VARIATIONS AND IMPACTS ON FISH BIOLOGY: NEW THREATS TO AQUATIC SUSTAINABILITY

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Session – Fishery Biology, Toxicology, Environment
Impacts on small pelagics – Case study of Indian oil sardine collapse

CHANGING SEASONS AND MORE FREQUENT EPISODES OF EXTREME EVENTS (CLIMATE THREAT)

Significance of small pelagic fishes

Fig World marine fish landing and total landing of the Herring-anchovy-sardine group in million tonnes

Small pelagic fishes: Herrings, Anchovies and Sardine (HAS) in FAO contributed to world fish landings highest - 42.7% of the world marine fish production in 1964 lowest 19% in 2014. Large fluctuations in abundance related either to environmental variations or due to fishing or a combination of both.
• Significance of Indian oil sardine; southwest coast

The Indian oil sardine—a globally important species

Now Indian production higher than several other regions for other sardine species

• India—major contributor

• Among Sardinella species, OS is the major resource—globally
El Niño and Peruvian anchovy *Engraulis ringens*

- huge *schools* within 80 km, longevity 3 years, reaching 20 cm Lm at about one year age and 10 cm
- 13.1 million tonnes in 1971; severely impacted by
- **In October 2015**, an El Niño year, of 3.38 mmt was estimated surveyed by The Peruvian Marine Research Institute, only 2 million metric tons were of reproductive age; 5 million metric tons are needed to open fisheries,
DROUGHT LIKE SITUATION IN THE SEA

Sardine failed to mature
Poor recruitment
Spawning biomass declined

http://www.nasa.gov/earth
Temperature variation in sardine habitat. The average seawater temperature in sardine habitat was 29.8 deg C during 2015, which is nearly 1.1 deg C higher than the avg observed (28.6 deg C) for the last 5 years.
Positive SSTA exceeding 0.6°C dominated in the tropical Indian Ocean.

There was a substantial warming in the tropical Indian Ocean, partially due to influences of the 2015 El Nino.
Hypoxic condition extending from near shore area up to 20 to 30 m depth

**Second upwelling**
- Negative aspect of upwelling is low oxygen condition which can lead to “stressed environment” and lead to **avoidance** of the area. The intensity of hypoxia has been found to vary.
PACIFIC SARDINE POPULATION IN COLLAPSE

2006: ~ 1.8 million metric tons
2017: ~ 86,000 metric tons

Decrease in spawning population from 2012 to 2016
Cascading effect in the trophic chain

Ocean Animals Depend on a Healthy Sardine Population

Since 2010, brown pelicans have been suffering reproductive failures due to a lack of prey, including sardines.

More than 9,500 starving California sea lion pups and yearlings washed up on beaches from 2013-2016.

Fleshfooted Shearwater flock feeds Oil sardine *Sardinella longiceps* during 2014

Pic courtesy - Dr R Jeyabaskaran
The way forward

Present
• Only limited fisheries management programs and governance
• No preparedness to face fishery collapses
• MLS implemented in Kerala; but yet to be implemented in other states

What can be done
• Very effective FMP (especially good governance) in all maritime states
• Effective predictions to be developed on climatic factors and eggs and larval studies
• International research collaborations for capacity building on these themes
• Develop schemes to financially support small scale fishers during fish biomass decline due to natural calamities like in agriculture

Impacts of extreme events on other resources
2016-Rainfall- deficit year

Percentage deviation from normal rainfall during 2016

Extremely low rainfall led to poor water flow, river discharges. Affected planton production and even intrusion of jellyfishes in estuaries during March April.Itself threat to estuarine fauna recruitment.

Jelly fishes in backwaters

- Usually seen during peak summer, but now even during late post monsoon
- A threat to fish larvae
- Low fish catch, economic loss
- Menace to farmers
Jelly fish blooms in coastal /inshore fishing areas

JELLY FISH MENACE

Changes in jellyfish populations

*Source: L. Bue et al. 2012*
### A global regime shift from a fish to a jellyfish ocean

#### Why blooms occur
- **Ecological imbalance** due to removal of top predators
- **Eutrophication** of coastal waters due to urbanization
- **Low oxygen**
- **New structure** where polyps can attach

#### What happens during blooms
- **Endanger fish stocks**: high impact on fish eggs and larvae, either directly or by competing for the same food sources
- Further **reduce resilience** of already affected fish stocks
How jellyfish blooms affect fish resources

- Salmon production vs *Chrysaora fuscescens*, off the Pacific Northwest coast.
- There was a significant, negative correlation between jellyfish biomass and the strength of adult salmon returning to the Columbia River.
- Low feeding: feeding incidence showed that salmon stomachs were less full at locations with higher sea nettle biomass.

Ref: Evidence that summer jellyfish blooms impact Pacific Northwest salmon production et al., Ecosphere 2016 DOI: 10.1002/ecs2.1324

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Seas of Japan under jellyfish threat

Nomura’s jellyfish (weighing 220 kg, 2m dia was rarely encountered the Sea of Japan.

In 2005, the Sea of Japan brimmed with as many as 20 billion jellyfishes ....... In fisheries, 30 billion yen was estimated as loss.

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Pic courtesy- Dr R Jeyabaskarn

Jellfish caught in CMFRI vessel

Jelly fishes in inshore waters this year also

Pic courtesy- Dr R Jeyabaskarn
Jellyfish blooms creating oceans of slime

In the last decade enormous plagues of jellyfish have been taking over the seas. And it is our fault.

By Gaia Vince
5 April 2012

After brief fall, jellyfish blooms resurface along N Goa coastline

Ephyrae of *Chrysaura* sp.

The ephyrae of the jellyfish *Chrysaura* sp was identified on 22.5.2015; just 2 months before the bloom. Bloom observed on end of July, 2015
TROPHIC CONTROL

- In East China Sea - Forty-five functional groups were defined in the model including 32 fish (19 single species and 10 multispecies).
- The average trophic level of fishery catch was 2.71 while the mean value for all groups was 2.87.
- Study indicated trophic mutual competition and predation between large jellyfish and Stromateoidae. So utilize this information for ecosystem based management.

The way forward

- Include jellyfish research into fisheries research.
- Develop early warning systems for bloom forming species.
- Utilize jelly fish in (in collagen preparations; treat rheumatoid arthritis eg), have rich biomedical properties.
- As food- dried and chopped into noodle-like strips to be added to soups, entrepreneurial Japanese are even making vanilla-and-jellyfish ice cream.
- 80% protein and very low in fat, although the high sodium content probably outweighs their health benefits.
- Reduce eutrophication through proper control measures.
Anthropogenic impacts

HARMFUL ALGAL BLOOMS

Noctiluca scintillans blooms

Pic courtesy - Ms Lavanya
The HAB menace

The issue
• Complete disruption of normal food chain

Way forward
• Develop prediction and early warning systems
• More important — reduce eutrophication and coastal pollution which promote such HABs

Anthropogenic impacts
LITTER IN AQUATIC SYSTEMS
4.8 and 12.7 million MT enter the oceans.

Marine Debris

BY 2050 OUR OCEANS WILL HOUSE MORE PLASTIC THAN FISH

The UNEP has recently initiated a special program ‘Global Initiative on Marine Litter’. Three main industries which are affected by marine debris are fisheries, shipping and tourism and the estimated damage to these sectors in APEC region is US$1.265 million annually.

Annual production is about 50,000 tonnes

Some of the poorest fishers of India

Decrease in bivalve population can affect ecology of the whole system
Benthic habitat

• Flat fish habitat
• Egg laying habitat of gastropods, octopuses and fishes
Views of two turtles which were entangled in derelict fishing gear in Arabian sea.
1) the two were pulled near the vessel
2) one turtle freed by cutting the net
3) the second turtle also to be made free

Photographs by CMFRI crew on board an experimental fishing vessel in Arabian sea during April 2012.
Danger—chemicals leaching from plastics

- The toxicity of additive chemicals (default in manufacture) eg: phthalates (endocrine disrupting and carcinogenic), bisphenol A (endocrine disruption and cytotoxicity), brominated flame retardants (immunotoxicity, cytotoxicity, neurotoxicity, endocrine disruption), triclosan, bisphenone and organotins which can leach from the polymer into the surroundings as the bond weakly with the polymer.

The fragmentation of plastics increases leaching of these chemicals and enable more surface area for adsorption of toxic chemicals from environment.

Micro-plastic contamination in fish

The abundance of MPs recorded from the sediment samples is in the range of 96–496 particles m⁻² with a mean abundance of 252.80 ± 25.76 particles m⁻².

Dr.V.KRIPA Principal Scientist CMFRI
Macro-plastic contamination in fish

Pic courtesy: Dr V V Singh/Mumbai RC CMFRI
Pic courtesy: Dr Bindu Sulochanan CMFRI
Way forward

1. Awareness campaigns----student blue/green brigades
2. Collection Mechanism
3. Segregation
4. Efficient Transportation
5. Treatment facilities
6. For fishermen -Incentives – for litter reduction
7. Implementation of Rules and regulations

The way forward

• CRZ – not targeting marine litter
• The Ministry of Environment and Forest (MoEF) has issued MSW management and handling rules for scientific MSWM –but this has not targeted marine debris.
• Hence –there should be a

National Marine Debris Management Strategy
Anthropogenic impacts

HABITAT ALTERATION

- policies may be designed, employing instruments such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and the CDM (Clean Development Mechanism)

Ghosh Susanne Schmidt, Thomas Fickert and Marcus Nüsser, 2015, 7(2), 149-169; doi:10.3390/d7020149

Indian Sundarban Mangrove Forests: History, Utilization, Conservation Strategies and Local Perception
Important breeding ground and nursery of valuable biota

Tilapia – parental care

Karimeen – Pearl spot

Eggs of Pearl spot

Dr. V. KRIPA Principal Scientist CMFRI

Life Cycle of Penaeid Shrimp

Dr. V. KRIPA Principal Scientist CMFRI
Many species have already become extinct, particularly in tropical areas. This loss of biodiversity impacts food resources, such as fish stocks.

**In Canada**

- 625 Canadian scientists signed a letter protesting 2012 changes to the Fisheries Act stating: Habitat destruction is the most common reason for species decline.
- NO HABITAT, NO FISH, THE SCIENCE IS CLEAR

**What can be done in India**

- Clear enforceable habitat protection provisions will help protect fish and fisheries.

Oil and Grease

Dr.V.KRIPA Principal Scientist CMFRI
Global crude oil flows

- 2nd LARGEST CONSUMER IN ASIA-PACIFIC REGION
- 70% OF WORLD OIL DEMAND FERRED ALONG INDIAN COASTLINE
- INDIGENOUS PRODUCTION = 35 MMTPA
- IMPORT = 200 MMTPA

Credit: Former DIG ANISH A HEBBAR, TM

MSC Chitra

- Collision on 07 Aug 2010
- Off Mumbai
- 800 tons

Credit: Dr.V.KRIPA Principal Scientist CMFRI
MSC Chitra

- Affected 33 Fishing villages in 3 districts
- Prohibition on landing of contaminated fish by Mumbai Municipal Corporation
- Fishing effort by mechanized vessels for August 2010 decreased by 29% and landings declined by 6% while the non-mechanized fishing recorded 49% decline in landings
- 60 fish markets across Mumbai empty for the week consequent to the spill
- Fisheries loss rupees 60-80 crore
- Fish from other states not allowed to enter Mumbai
- Stocked frozen fish sold at low price to clear the stock

Small scale Fishermen

Impact of oil pollution in Gulf of Mexico
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<td>Landing centers</td>
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<td>Non-motorised vessels</td>
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**Gill netters**

Major group of stakeholders who will be affected

**Bottom-dwelling fish**
Protected Species - Indian Wildlife Protection Act 1972

- All marine mammals, corals, gorgonids, sea cucumber, sponges & sea horses
- 7 sharks
- 2 rays
- 1 skate
- 1 giant grouper
- 4 bivalves
- 1 cephalopod
- 19 gastropods

Almost all these are demersal or bottom dwelling; molluscs with mostly limited movement; Hence more vulnerable to oil pollution. If not cared can also lead to extinction.

The way forward

- **Spatial Maps** of critical habitats along the Indian coasts and the route of oil tankers. - So that precaution can be taken
- **Map of vulnerable resource** abundance and make it available to oil tankers
- More research on the **impacts** of resources and ecosystem
- How plankton and benthos are affected
To conclude......
Ocean Health Index – India 2016

Score 66; 130th rank out of 221 EEZ

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<th>Score</th>
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Score 66; 130th rank out of 221 EEZ

There should be good FMP and governance

Fish populations essential for food and jobs have crashed by 50% in the last 4 decades.
So...the way forward: Each nation should chart out specific plans to improve their OHI

Thank you all