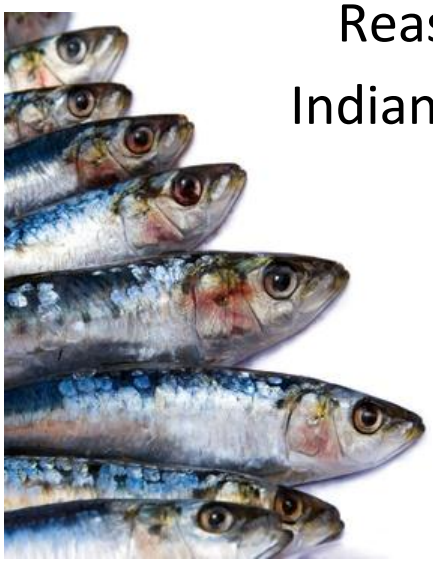
INVESTIGATION RESULTS



Reasons for drastic decline in fishery of Indian oil sardine, *Sardinellalongiceps*along Kerala coast during

2013 TO 2015

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ICAR-Central Marine Fisheries Research Institute

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Investigations on reasons for decline in oil sardine fishery along Kerala coast

About Sardine

- One of the most important pelagic fishes of Kerala. Scientifically known as *Sardinella longiceps* and commonly called as Indian oil sardine.
- Forms a fishery in India, Pakistan, Yemen, Oman, Iran and United Arab Emirates. During the period 1950 to 2014, India has been the major contributor and sardine catch form from the Indian waters has contributed 66 to 96% (average 80%) of the global oil sardine catch. Pakistan is the second biggest contributor with an average catch of 27,000 tonnes.

Importance in fishermen livelihood of Kerala

- One of the major resources caught by small scale traditional fishermen operating motorized and non mechanized crafts.
- Unlike American and European nations where sardine utilized mainly as raw material for other industries, the oil sardine is utilized as a common man's food in India. It forms one of the major sources of protein for the whole family which can be bought at an affordable price.
- The decline of sardine resources has affected about 73,000 fishermen who directly depend on this resource for livelihood.

Characteristics

- Forms large shoals and inhabits the coastal pelagic habitats and feeds on plankton
- Important forage / prey component in the trophic system in the pelagic ecosystem.
- They form the food for large pelagic like seer fishes, dolphins, and sea birds

Background on recent sardine catch decline

- The sardine catch in 2012 was 3.9 lakh tonnes which was the highest during the last two centuries and then the decline started.
- The catch declined by 46 % in 2013 (catch 2.1 lakh tonnes), then by 61% in 2014 (catch-1.6 lakh tonnes) and by 82% in 2015 reaching 68431 tonnes.
- Within a span of 5 years, the state witnessed the highest catch and lowest catch.
- During the period 1960 to 2015, the sardine stock has reached the collapsed status only once (1994.)

Public concern and the administrative response from State Fisheries Department.

- The drastic decline after 2012 affected the fishing industry very badly, especially the traditional fishermen and those fishers who had invested heavily on fishing. In a move to protect the resource, the Department restricted fishing of juveniles of fishes based on scientific advisory by CMFRI and the Minimum Legal Size (MLS) was introduced for 14 species. For sardine the MLS was 10 cm.

The CMFRI started an investigation on the reason for decline of sardine fishery since 2012.

Investigations on fluctuations in sardine fishery along Kerala

The reason for this decline was investigated by analysing the fishery related and fishery independent factors including the environmental and biological variations and the biotic pressures on the sardine population along Kerala.

The investigation used various sets of real time and satellite based data sets for the period 2010 to 2015 collected as a part of investigations of projects funded by the ICAR-CMFRI, Ministry of Agriculture and the Ministry of Earth Sciences, India and from these, the reasons for the decline in sardine catch was elucidated.

1. Changes in Fishing from 2011

Changes in gear length / depth and engine power

Period - 2011/2012/2013

- Since last two centuries, sardines have been fished from coastal waters mainly using seines.
- The length and depth of these seines increased from about 42 m x 5.2 m to 620 m x 100 m in 1990 and to about 900m x 90m in 2004. Subsequently the length and depth increased to about 1250m in 2012. **The change in gear dimension was about 2 times more than the recommended length and depth which resulted in an increased fishing area (coverage) of nearly 4 times.**
- The fishermen used outboard /inboard engines with higher horse power than the recommended. The country crafts were fitted with double engines of 9.9/ 40 HP or even 65HP while the inboard engines were above 100 (HP -100/ 120/140/150/190). Though this has not directly affected the fishery, **it has helped the fishers to reach fishing area faster and harvest larger shoals**

Increase in effort and catch per unit effort (CPUE)

- The effort in terms of no of OBRS and MRS units increased from 20152 units in 2007 to 74416 units in 2012 – **3.7 times increase over that of 2007.**
- The CPUE of Mechanized ring seine (MRS) Units increased from an average of 1.2 tonnes in 2007 to 3.2 tonnes in 2012. The **increase in catch during 2012 was primarily due to the increase in effort**.
- In fact, the increase in effort should have resulted in low CPUE if the sardine biomass was low. The CPUE was not affected in 2011 and 2012 mainly because sardine biomass was high.
- However, the sardine biomass declined in 2013, 2014 and 2015 which is clearly indicated by the **reduction in low CPUE even with reduction in effort.**

Fishing beyond conventional fishing grounds

- Sardine have been fished within the 30m depth zone along the coastline during last two centuries .

- During 2012 -13, fishermen have fished in areas beyond the conventional fishing area upto 55 m mainly during March to May which is the period when sardines mature and become ripe for spawning.

2. How did the fishery based change affect the sardine biomass?

Over exploitation above Maximum Sustainable Yield(MSY)

As per an estimate of CMFRI based on 2005 to 2007 data the MSY of sardine along Kerala coast, is **2.3 lakhs tonnes.** So during the period 2011 and 2012, the stock was **fished above the MSY by harvesting nearly 2.5 lakh tonnes.**

Low Spawning population after 2012 (growth overfishing)

- **Excessive harvest of juveniles**: About **16,040 tonnes of juvenile**s (less than 10cm) forming 4% of the total catch were harvested in 2012 and about 4802 tonnes in 2013. This would have affected the spawning biomass of 2013, 2014 and 2015. (16,040 tonnes of less than 10cm sardine would have contributed to a biomass of 5,61,400 tonnes at 30% mortality in the subsequent years . Similarly if the 4802 tonnes of juveniles were allowed to grow, it would have supported a spawning population of 1,68,070 tonnes of sardine)
- The 10 to 14cm size group which is less than one year old sardine has always formed a major component of sardine population. However, during the period Oct 2012 to Feb 2013 about 1,17,823 tonnes were harvested. The large scale removal of this group also would have affected the potential spawning population of 2013 and 2014.

- Thus since the potential spawner groups(both juvenile and 10 to 14 cm size groups) were removed in large quantities, there was a decline in spawning biomass in the following years i.e 2013, 2014.

So by the beginning of 2013, the sardine stock off Kerala was severely affected- low biomass and less number of potential spawners

3.What happened during 2013, 2014 and 2015?

Due to low catches in 2013, indicating low biomass, the effort reduced. In spite of reduction **in effort, the CPUE continued to decline. Why was sardine biomass low?**

Key principal of ecology and biology is that -Maturation, Spawning and Recruitment should happen at the right time for a good and sustained fishery. The young ones should get plenty of food to grow and nature usually times the spawning of fishes in such a way that the habitat is rich with food during recruitment period.

The reproductive cycle of sardine along Kerala coast is-maturation -April/May , spawning (May/Jun/Jul) and recruitment by July/August . This would support a good population of fishes less of than 14cm which would lead to good spawning population in the ensuing seasons provided there is good food available and no environmental stress.

The sardine population was already affected by overfishing of potential spawners. Apart from this, decline in sardine catch during 2013 to 2015 can be attributed to the environmental changes directly caused by upwelling and monsoon and the partially successful maturation/spawning /recruitment process which are influenced by the prevailing ecological conditions.

Environmental stress and low recruitment in 2013

- **In 2013there was good maturation** in sardines, but the spawning and recruitment processes were affected by the above normal rainfall during June and July. The rainfall during June and July of **2013 was 60 and 14% more** than the normal.
- **The sardines were exposed to an unhealthy habitat and the spawning stock and juveniles were exposed to "stress" due to salinity stratification i.e extremely low salinity due to excessive river runoff in the surface waters and higher saline waters in the bottom.**
- The influx of upwelled waters with low oxygen (0.7 to 0.8 mg per litre) was found in the main sardine habitat **during August 2013.Low mixing can cause stratification and along with hypoxic conditions cause stress**

In a population which was impacted by overfishing, recruitment was severely affected by unfavourable environmental conditions. Above this, about 4802 tonnes of juveniles (=1,68,070 tonnes of sardine in the following year) were also exploited which further weakened the potential spawning stock of 2014.

Environmental changes, shift in spawning period and low recruitment in 2014

- **In 2014 there was good maturation in sardines**. However, since the monsoon was deficient during Jun/July it delayed the spawning period. **A successful spawning** as in normal years **was not observed in spite of good maturation.** Sporadic spawning was observed from April to Sep/Oct (7 months). Though spawning was observed during third week (17th and 18th of June) it was not complete.
- Moreover during June there was hypoxic condition upto 30m depth from near-shore areas which would have kept the spawners away.
- Monsoon was excess by 74% and 22% duringAug and Sep than the normal. This resulted in low saline waters and **salinity stratification which affected recruitment.**

Impact of Massive Jellyfish blooms in 2013 and 2014 on recruitment2013,2014

During June to September 2013 and 2014, in the inshore surface and column waters of the main pelagic fishing area from 5 to 40 m depth zone, blooms of four species of jellyfishes were observed. Predation by these macro-planketers would also have affected recruitment.

Low upwelling, high temperature, Lack of food, poor maturation, spawning/ recruitment- 2015

- There was NO good maturation and spawning during 2015, consequently poor recruitment.
- In 2015, the sardine habitat was severely affected by global atmospheric process. Though maturation was observed during May/June, it was not as healthy as in previous years.

- Globally, 2015 has been considered as a **warm year with high temperature and low food.** 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^{o}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.** The mean SST in the tropical Indian Ocean increased by 0.13-0.2^{o}C in 2015, becoming the warmest year since 1950. **(Ref *State of the Climate in 2015 by Xue et al.)***
- Phytoplankton density was also low (**avg 515 cells per litre) during April/May 2015 c**ompared to the high (98667 nos per litre) during 2012. This low food availability in the habitat was found **to affect maturation** which resulted in poor recruitment.
- Avoidance of normal habitats by sardine is due to the impact of highly unfavourable environmental conditions.

Thus the cumulative effect of overfishing above MSY in 2011 and 2012 including the exploitation of nearly 16,040 tonnes of juveniles in 2012 affected the sardine population/biomass. This was followed by poor recruitment in 2013 and 2014 due to environmental stress due to salinity stratification (due to excessive rains in late monsoon) and hypoxic condition (due to upwelling) in inshore sardine habitats.

Low food availability and comparatively higher temperature due to poor upwelling led to poor maturation and subsequent recruitment success. In 2015, these changes were compounded mainly by global ocean –atmospheric process like *El nino*.

Investigating Team

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