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Fisher perceptions on impacts of jellyfish swarming on fishing operations along the Gujarat coast, India

Tarachand Kumawat[1,5]*, R. Saravanan[2], K. Vinod[3], K. K. Joshi[4], A. K. Jaiswar[5], G. Deshmukhe[5] and L. Shenoy[5]

[1]Regional Station of ICAR-CMFRI, Veraval - 362 269, Gujarat, India.
[2]Regional Centre of ICAR- CMFRI, Mandapam - 623 520, Tamil Nadu, India.
[3]Regional Station of ICAR- CMFRI, Kozhikode - 673 005, Kerala, India.
[4]ICAR-Central Marine Fisheries Research Institute, Kochi - 682 018, Kerala, India.
[5]ICAR-Central Institute of Fisheries Education, Mumbai - 400 061, Maharashtra, India.

*Correspondence e-mail: tarachand.kumawat@icar.gov.in

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Original Article

Abstract

The study provides local perceptions on the regional challenge caused by jellyfish hindrances in fishing operations and the potential causes of abnormal jellyfish swarming along the Gujarat coast, India. A semi-structured questionnaire framework was used along with an enumeration-based schedule to collect the data during 2017-2020. The data were collected through surveys and interviews from different fishing units along the Gujarat coast. The results have shown that distant fishing and need of extra hauls to be the highest impacted factors followed by increased fish sorting time, reduced fish catches, clogging of fishing gears, prevention of fishing in some cases, and mild painful stings. There was no significant difference in views on jellyfish hindrances ($p > 0.05$; Kruskal-Wallis test) among the respondents operating the trawlers, gillnetters and bag-netters. However, it has a high degree of impact and hence necessitated the need for prioritizing the potential causes of abnormal swarming namely overfishing followed by climate change, eutrophication, translocation, and habitat modifications. By this study, we propose to use the precautionary principles (based on prioritized ranking for management actions) to manage the harmful jellyfishes and simultaneously harvest the useful jellyfishes as the general approach in dealing with jellyfishes in the northern Arabian Sea along the Gujarat coast, India.

Keywords: *Arabian Sea, jellyfish hindrances, ethnobiology, fishery impact*

Introduction

Jellyfish swarming is a natural phenomenon observed in healthy ecosystems (Graham *et al.*, 2001). Of late, a series of reviews (Bosch-Belmar *et al.*, 2020) have shown an increase in impact of jellyfishes on fishing operations for the past 50 years, with an increasing frequency and severity around the world (Condon *et al.*, 2013). Following a similar trend jellyfishes have been increasing in the Indian large marine ecosystem (Brotz *et al.*, 2012) with evidences of mass deposition at the bottom of the Arabian Sea, indicating events of blooming (Billett *et al.*, 2006). Decomposition of discarded and deposited jellyfishes may have a cascading effect on benthic ecosystems (Sweetman *et al.*, 2016). Jellyfishes outnumber other fishes in heavily fished ecosystems indicating fishing down marine food web (Lynam *et al.*, 2006). Hence, assessments have recommended a routine monitoring of regional ecosystems before a jellyfish-associated crisis arises in the future (Brodeur *et al.*, 2016).

Jellyfishes were reported as unusual (Mohan *et al.*, 2011) or miscellaneous in the fisheries catch statistics of India with very few studies to substantiate the point (Brotz, 2016). The impact of jellyfishes on fisheries of the Travancore waters was considered a pioneering study in India (Nair, 1951). The state of Gujarat is known for its highest marine capture fish production

(7.80 lakh t) in India, mainly coming from a highly mechanized fishing sector supported by trawlers, gillnetters and bag-netters (CMFRI, 2019). In previous studies undertaken at Veraval (Panda and Madhu, 2009) and Jakhau, Gujarat (CMFRI, 2010), high volumes of Jellyfishes were reportedly caught in trawlers as by-catch. However, there is a lack of detailed account on jellyfish swarming in Gujarat coast and about the nature, magnitude and type of impacts it could have on the fishing operations in the area. Therefore, considering the prevailing information gap, a preliminary investigation on jellyfish hindrances in fishing operations was carried out and the perception of fisher folk on the potential causes of abnormal swarming and it's impacts along the Gujarat coast was documented. Fishers are the primary stakeholders affected by jellyfish swarming; their perceptions are invaluable and can act as a key factor in aiding the decision-making processes and management actions. Results of this preliminary investigation can act as baseline information supporting future research in Jellyfishes.

Material and methods

A pamphlet in vernacular language (*Gujarati*) was used in the initial surveys. It acted as a supportive tool in acquiring availability/swarming/distribution information of jellyfishes effectively from the fishermen in a timely manner. A total of 160 fishing units were selected from different fish landing centers (Fig. 1) conforming to the percentage of registered fishing vessels in Gujarat operating in fishing activities using trawl net, gill net and bag-net (Table 1). The applied methodology consisted of a semi-structured questionnaire framework method (Reed *et al.*, 2009; Ackermann and Eden, 2011), adopted with modifications (Table 2) with an enumeration-based schedule prepared to collect data through surveys and interview of different fishing units from the Gujarat coast from November, 2017 to February, 2020.

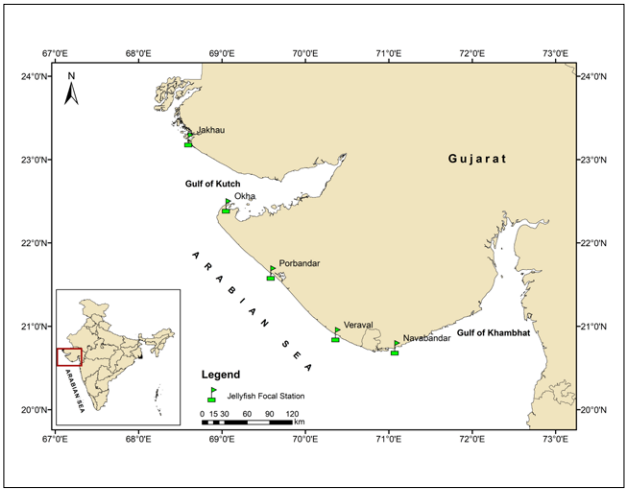

Fig. 1. Study area along the Gujarat coast.

Table 1. Fishing units selected for the survey and interviews.

Fishing operation	Crafts % in total fisheries*	Fishing units (N)
Trawl net	61	98
Gillnet	24	38
Bag-net	15	24
Total		160

*Registered fishing vessels, Gujarat (ReALCRaft, 2017; CMFRI, 2012).

Table 2. Questionnaire framework to conduct the interviews with fishers.

Date of interview	Type of fishing operation
Fishing experience (Years)	Jellyfish presence observed (Yes/No)
Question: Impact of hindrances due to jellyfish swarming during the fishing operations based on your observations (score 0 = no impact to 5 = most impactful).	
a.	Painful stings during sorting of fish catches? (0 = no pain; 1-2 = mild pain; and 3-5 = severe pain)
b.	Prevention of fishing operations? (0 = not preventing; 1-2 = temporary prevention; and 3-5 = complete prevention)
c.	Clogging of fishing gears? (0 = no clogging; 1-2 = sometimes; and 3-5: mostly)
d.	Reduction in fish catches? (0 = no reduction; 1-2 = slightly reduced; and 3-5 = significantly reduced)
e.	Increased fish catch sorting time? (0 = not increased; 1-2 = slightly increased; and 3-5 = significantly increased)
f.	Need to go to distant areas for fishing or extra hauls? (0 = not required; 1-2 = sometimes; and 3-5 = mostly)
g.	Subjective statement about your experiences:
Question: Perception about potential causes of abnormal jellyfish swarming based on your experience in fishing operations (score 0 = no relevance; 1-2 = fairly relevant cause; and 3-5 = most relevant cause).	
a.	Overfishing (results in reduced predation and competition on jellyfishes thus increasing swarming)
b.	Eutrophication (nutrient run-off favours plankton bloom results in an increase of jellyfishes)
c.	Translocations (ballast water exchange and transport on hulls result in jellyfish introductions)
d.	Habitat modification (create more habitat for polyps)
e.	Climate change (stratification support enhancement of jellyfishes)
f.	Subjective statement about your experiences:

This study used fishermen's perception about the severity of jellyfish hindrances and the potential factors causing the abnormal swarming along the coast of Gujarat. A similar method of perception analysis was used by researchers (Bosch-Belmar *et al.*, 2017; Rutkowski *et al.*, 2018; Cruz-Colín *et al.*, 2019) in the recent past and it incorporated ecological knowledge of fishers in research and resource management. The responses were analyzed through a non-parametric Kruskal-Wallis (KW) test using SPSS Software.

Results and discussion

The presence of jellyfish observed by all the respondents with fishing experience of 20-55 years was taken into account. All the respondents have experienced an increase in jellyfish swarms in the past two decades and shared their ecological knowledge. The rapid field surveys conducted to identify the

areas with known instances of jellyfish swarming or landing were observed at Jakhau, Okha, Porbandar, Veraval and Navabandar and have emerged as jellyfish focal stations. The survey results revealed that waters of Gujarat are inhabited with Scyphomedusae, Cubomedusae and Hydromedusae affecting fishing operations in numerous ways (Fig. 2). A detailed account on the results of this preliminary investigation is given below.

Fig. 2. Jellyfish from bag net hauled onboard a fishing vessel off Navabandar, Gujarat.

Jellyfish hindrances in fishing operations

The majority (95% respondents) of fishers who assigned 3-5 score have performed distant fishing to avoid jellyfishes or operated extra hauls, meanwhile 79.37% of respondents who assigned 3-5 score experienced an increase in fish sorting time. Fifty-five percent of respondents who assigned a low score (1-2) have experienced reduced fish catches, followed by 78.75% reporting the clogging of the fishing gears; 81.87% experiencing a temporary or complete prevention of fishing and a total of 91.87% getting painful stings. None of the respondents assigned zero score, which clearly depicts the degree of impact of jellyfishes on fishing operations.

The comparative mean score of jellyfish hindrances experienced by respondents points towards distant fishing or need of extra hauls as the highest impacting hindrance (mean score 4.1562 $\pm$ 0.94201) with a score ranging from 2 to 5, followed by increased fish sorting time and reduced fish catches which resulted in economic loss. Gradual descending mean scores were observed in case of clogging of gears, prevention of fishing and painful stings.

There was no significant difference ($p > 0.05$) between different types of fishing operations impacted due to jellyfish hindrances. Painful stings, clogging of gear and increased sorting time was reported more by trawlers followed by gillnetters and bag-netters. The impact of temporary or complete prevention of fishing was similar in trawlers and gillnetters compared to bag-netters. The concern of reduced fish catch was more in bag-netters followed by trawlers and gillnetters. The bag-netters had to put more effort through extra hauls or went to distant areas for fishing compared to gillnetters and trawlers, mainly due to a large number of localized jellyfish swarming in the nearby coastal waters (Table 3). Management actions were proposed based on the degree of impact (Fig. 3) and potential to deal with jellyfishes in the highly mechanised multi-species fisheries sector of Gujarat.

Jellyfish hindrances, including clogging of nets, stings, and catch loss, were reported in earlier studies from India (Govindan, 1984; James *et al.*, 1985; Kuthalingam *et al.*, 1989). The increasing populations of jellyfishes have caused nuisance to fisheries in Japan (Uye and Ueta, 2004). It is expected that the sustainability of fisheries at East Asian Marginal Seas will face immense threat due to jellyfish hindrances (Uye, 2008). A similar method of ethnobiological knowledge of fishers supported to document

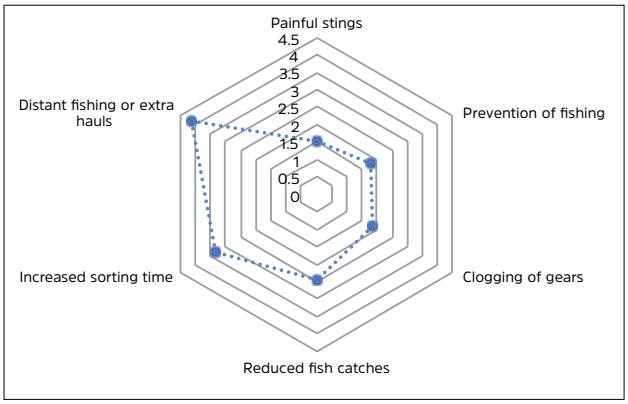

Fig. 3. The perception analysis of hindrances due to jellyfish swarming to different fishing operations based on mean score presented through prioritized ranking for management actions.

Table 3. Jellyfish hindrances in different types of fishing operations along the Gujarat coast.

Jellyfish hindrances		Mean Ranks					
Fishing type	N	Painful stings	Prevention of fishing	Clogging of gears	Reduced fish catches	Increased sorting time	Distant fishing or extra hauls
Trawler	98	84.92	81.61	83.73	82.94	84.36	76.03
Gillnetter	38	76.36	82.75	74.21	71.72	75.82	86.59
Bag-netter	24	69.00	72.40	77.27	84.42	72.15	89.10

the jellyfishes and their hindrances caused to shrimp trawls in Brazilian waters (Nagata *et al.*, 2009) and Northern California Current (Conley and Sutherland, 2015) in recent studies.

Potential causes of abnormal jellyfish swarming

The high scores of 3-5 were obtained for overfishing (94.37% of respondents) followed by climate change (90.62%) and eutrophication (81.25%), whereas the low scores of 1-2 were recorded for habitat modification (85%) and translocation (81.25%). All the respondents perceived a certain degree of relationship with these causes, and thus, none have 0 scores.

The comparative mean score of jellyfish swarming perception experienced by respondents has shown overfishing as the most potential cause of abnormal swarming (mean score 4.1562 ± 0.94866) with a minimum 2 to maximum five scores followed by climate change and eutrophication. The increase in jellyfishes due to translocation followed by habitat modifications accounted for less than two mean scores.

There was no significant difference ($p > 0.05$) between the perceptions of respondents engaged in different types of fishing operations for potential causes of abnormal jellyfish swarming. Climate change and eutrophication were prioritized by gillnetter respondents, followed by trawlers and bag-netter respondents. Interestingly, overfishing and translocation were prioritized by the bag-netters compared to trawlers and gillnetters, who were more concerned about avoiding any operational conflicts. The habitat modification was appropriately prioritized by the trawlers, followed by bag-netters and gillnetters (Table 4).

Management actions were proposed based on the degree of perceptions presented through prioritized ranking (Fig. 4), which may support while dealing with potential causes of the abnormal jellyfish swarming along the Gujarat coast. Similar direct observations on possible causes of jellyfish blooms, including translocation, eutrophication, overfishing, habitat modifications, and climate (Purcell *et al.*, 2007; Richardson *et al.*, 2009), were linked through large-scale studies (Dong *et al.*, 2010; Kogovšek *et al.*, 2018). The increasing jellyfishes were observed to benefit from climate change and overfishing

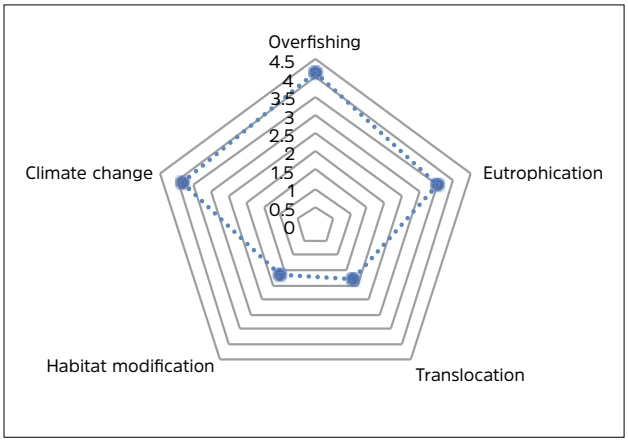

Fig. 4. The perception analysis of potential causes of abnormal jellyfish swarming based on mean score presented through prioritized ranking for management actions.

in the Irish Sea (Lynam *et al.*, 2011). The direct consequences of these factors can increase in the future (Purcell, 2012), leading to more frequent and mass swarming. Some of the observations claim that coastal protection provides habitat for jellyfish polyps and thus causes jellyfish blooms (Duarte *et al.*, 2013). Fishers are left with options such as to either go to distant areas for fishing or to start catching jellyfishes. In this case, the large vessels choose the first option to go far from the jellyfish swarming areas, and small vessels might choose to catch jellyfishes, but both are worried about a more gelatinous future.

We are proposing precautionary principles (based on prioritized ranking for management actions) on harmful jellyfishes and harvesting of useful jellyfishes as the general approach in the current scenario. However, this should not be considered as a solution to the hindrances, as suggested by Gibbons *et al.* (2016). The role of swarming jellyfish in the trawling areas was studied along the Israel coast and suggested a co-management approach for the sustainability of the fish stocks (Angel *et al.*, 2016). The fishers are aware of jellyfishes and call them different names such as Jhar, Vadli, Aor, Sharku, Dobla, and Thaubla, depending upon their characteristics, shape, size, or color. Based on such identifications, fishers decide either to discard them or to harvest them for commercial purposes. Harvest of edible jellyfishes supports the small-scale, season-based

Table 4. The comparative swarming perception for potential causes among different types of fishing operations.

Swarming perception		Overfishing	Eutrophication	Translocation	Habitat modification	Climate change
Fishing type	N	Mean Ranks				
Trawler	98	81.62	80.44	80.14	81.17	80.04
Gillnetter	38	75.32	82.99	80.55	78.61	84.13
Bag-netter	24	84.15	76.81	81.88	80.75	76.62

jellyfish fishery at Jakhau and Okha. Additional investigations on similar aspects (e.g., species diversity, spatiotemporal distribution, by-catch estimation, monitoring and forecasting of swarms, or sustainable harvesting and processing methods) are essential for understanding their dynamics and managing the resources effectively.

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