



High occurrence of Jellyfish (*Catostylus perezii*, Ranson 1945) in proximity to industrial development, Gulf of Kutch/ Kachchh, India

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Here, the mass occurrence of Jellyfish, *Catostylus perezii*, Ranson 1945 is reported from the coastal waters of Gulf of Kutch/ Kachchh, Gujarat, India. Although high productivity is a possible reason the presence of man-made infrastructures like thermal power plants and ports are further highlighted. A further assessment of the effects of these structures on marine life is suggested in this article.

[**Key words:** High productivity, Port, Power plant, Scyphozoa]

Introduction

The gelatinous zooplanktons mysteriously appear (and disappear) at unpredictable times and are usually considered the dark side of ecology¹⁻³. Their large size, rapid growth, transparency, and buoyancy, together with the absence of hard structures, set these animals apart as a distinct ecological category based on predation-protection strategies⁴. Jellyfish form amazing population blooms, and there is undeniable evidence that jellyfish blooms are becoming more frequent and widespread, and their swarms have enormous ecological, economic and social impacts³. For example, they have been associated with the decline of commercial fisheries; disturbances in the cooling water intakes of coastal industries and ships and reduce the amenity of coastal waters for tourists⁵⁻⁷. Jellyfish outbursts are now related to many anthropogenic activities such as climate change, eutrophication, and overfishing^{6,8,9}. Sometimes regarded as trophic dead-ends due to the few obligate predators, there lies a need for regular monitoring.

Within the Indian sub-continent, twelve species of scyphozoan jellyfish have been reported¹⁰, while information within the Gulf of Kutch/ Kachchh (GoK; Gujarat) region remains limited with just one report as per a recent review¹¹ (Table 1). New studies have, however, filled in significant knowledge gaps indicating an increased number of jellyfish swarming in the area¹²⁻¹⁴. In the present study, the high

occurrence of *Catostylus perezii*, Ranson 1945 (Cnidaria: Scyphozoa) in the Gulf of Kutch region in proximity to a thermal power plant is discussed along with information on the jellyfish blooms along the coast of India. It is vital to note that species within this genus are known to be medically important¹⁵ and have applications in biomaterial science¹⁶. *C. perezii* is also a commercially exploited species in the nearby regions¹⁷.

Materials and Methods

During regular field visits to coastal places of the northern GoK, particularly in the third and last week of December 2018, plenty of jellyfishes were lying stranded on the beaches near Kathada, (Figs. 1, 2). Several specimens were collected and preserved in 5 % formaldehyde for further assessment and were identified following Riyas *et al.*¹². The observation was photographed with a digital camera (Samsung SM-960F). Jellyfishes were further observed to be moving along with the water current. In Kathada, 10 (1×1 m) quadrats were laid, and the abundance data was calculated. Linear regression was done from the collected specimens to find a correlation between bell diameter and oral arm length. Fishermen further reported entanglements as a bycatch in the region and on the beaches near Nanalayza, Panchotiya and Sanghi Jetty in Kaharo creek water (Fig. 1). The study area lies ~ 35 km from a

Table 1 — List of Jellyfish blooms across Indian coastal waters

Jellyfish species*	Locality	Year of occurrence	Potential cause	References
<i>Pelagia noctiluca</i>	Rushikulya estuary (19°23'43" N; 85°05'23" E) (Odisha, ECI)	November, 2012 – February, 2013	Wind-current tide action, water pollution, climate change	Baliarsingh <i>et al.</i> ^{11,37}
<i>Crambionella stuhlmanni</i>	Visakhapatnam (17° 42' 46.62" N; 83°19' 23.2" E) (Andhra Pradesh, WCI)	February, 2015	Tropical cyclone Hudhud	Deccan Chronicle ³⁹ ; Baliarsingh <i>et al.</i> ¹¹
<i>Physalia physalis</i> ⁺	Goa (15°15'1.15" N; 73°55'12.9" E) (WCI)	October, 2015	--	Baliarsingh <i>et al.</i> ¹¹
Rhizotomatidae	Jakhau (23°14'3.12" N; 68°34'5.02" E) (Gujarat, WCI)	November – December; April – May	--	Cadalmin ³² ; Baliarsingh <i>et al.</i> ¹¹
<i>Physalia physalis</i> ⁺	Mumbai (19°6'34.45" N; 72°49'24.1" E) (Maharashtra, WCI)	July – August, 2018	--	Baliarsingh <i>et al.</i> ¹¹
<i>Crambionella orsini</i> ; <i>Cyanea</i> sp., <i>Chrysaora caliparea</i> ; <i>Netrostoma coeruleus</i>	Kollam coast (8°45' & 9°07' N; 76°29' & 77°17' E) (Kerala, WCI)	--	Eutrophication, overfishing, artificial structure creation, climate change	Biju Kumar <i>et al.</i> ³⁴ ; Biju Kumar & Anitha ⁴¹
<i>Crambionella stuhlmanni</i> ; <i>Chrysaora quinquecirrha</i>	Chennai coast (Tamil Nadu, ECI)	June – August (1981-1985)	--	James <i>et al.</i> ³⁶
<i>Crambionella stuhlmanni</i> ; <i>Crambionella buitendijki</i> ^{**} ; <i>Chrysaora quinquecirrha</i>	Madras Atomic Power Station (12°33' N and 80°11' E) (Chennai, Tamil Nadu, ECI)	October, 1996 (Maximum quantity)	Reversal of coastal water currents during monsoon seasons	Masilamoni <i>et al.</i> ³⁵
<i>Crambionella orsini</i> ; <i>Lychnorhiza malayensis</i> ; <i>Chrysaora caliparea</i> ; <i>Netrostoma coeruleus</i> ; <i>Cyanea nozakii</i>	Kerala coast: Neendakara (8°56' N; 76°32' E), Kochi (9°58' N; 76°12' E), Puthiyappa (11°19' N; 75°44' E), Thaikadapuram (12°11' N; 75°06' E). (South-eastern Arabian Sea, WCI)	<i>C. orsini</i> : Beginning of monsoon to non-monsoon, 2016/2017. <i>L. malayensis</i> , <i>N. coeruleus</i> : August – October 2016/2017.	Positive correlation with nutrient parameters <i>viz.</i> phosphate, silicate, and Chl- <i>a</i>	Riyas <i>et al.</i> ²⁵
<i>Pelagia noctiluca</i>	Gulf of Mannar: Hare Island (09°11.779' N, 079°04.420' E); Manoli Island (09°13.15' N, 079°07.33' E).	October, 2018	Rise in SST; low salinity due to precipitation	Ramesh <i>et al.</i> ³⁸
<i>Porpita porpita</i> ⁺	Puri (19°47'50.53" N; 85°50'7.12" E) (Odisha, ECI)	May, 2018	--	Baliarsingh <i>et al.</i> ¹¹
<i>Porpita porpita</i> ⁺	Kavaratti island (N 10°34.6333' and E 72°38.4418') (Lakshadweep, atolls)	December, 2021	High SST (climate change), wind driven	Marimuthu <i>et al.</i> ⁴²
<i>Porpita porpita</i> ⁺	Konark-Astaranga coastline (19°57'10.66" N; 86°21'35.1" E) (Odisha, ECI)	April – May, 2016	Climate change	Baliarsingh <i>et al.</i> ¹¹ ; Sahu <i>et al.</i> ⁴³
<i>Porpita porpita</i> ⁺	Windfarm beach, Mandvi, Kutch (22°49'23.34" N; 69°20'28.57" E), WCI.	August, 2021	--	Shah & Shah ¹³
<i>Catostylus perezii</i>	Veraval coast, Gujarat (20°55'19.3" N, 70°19'59.9" E), WCI.	April, 2017	--	Riyas <i>et al.</i> ¹²
<i>Catostylus perezii</i>	Kathada Beach, Gulf of Kutch, WCI.	December, 2018	High productivity, anthropogenic factors?	Current study

⁺Not a true Jellyfish; ^{*}Species names updated from WoRMS; ^{**}Information not available on WoRMS; ECI: East Coast of India; WCI: West Coast of India; List may be non-exhaustive; Reports without identification not shown

thermal power plant (Fig. 1). Chlorophyll maps were created through Sentinel Applications Platform (SNAP Ver. 7). Level 1 full resolution products secured by Sentinel 3 Ocean and Land Color Instrument (OLCI) were downloaded from the Copernicus Online Data Access (CODA) and

atmospheric correction was done through the Case 2 Regional Coast-Color (C2RCC) algorithm¹⁸. Clouds were masked and uncertainty values were incorporated through polychromatic blending. The created image was downloaded as KMZ and superimposed on Google earth engine (Fig. 3). For Sea

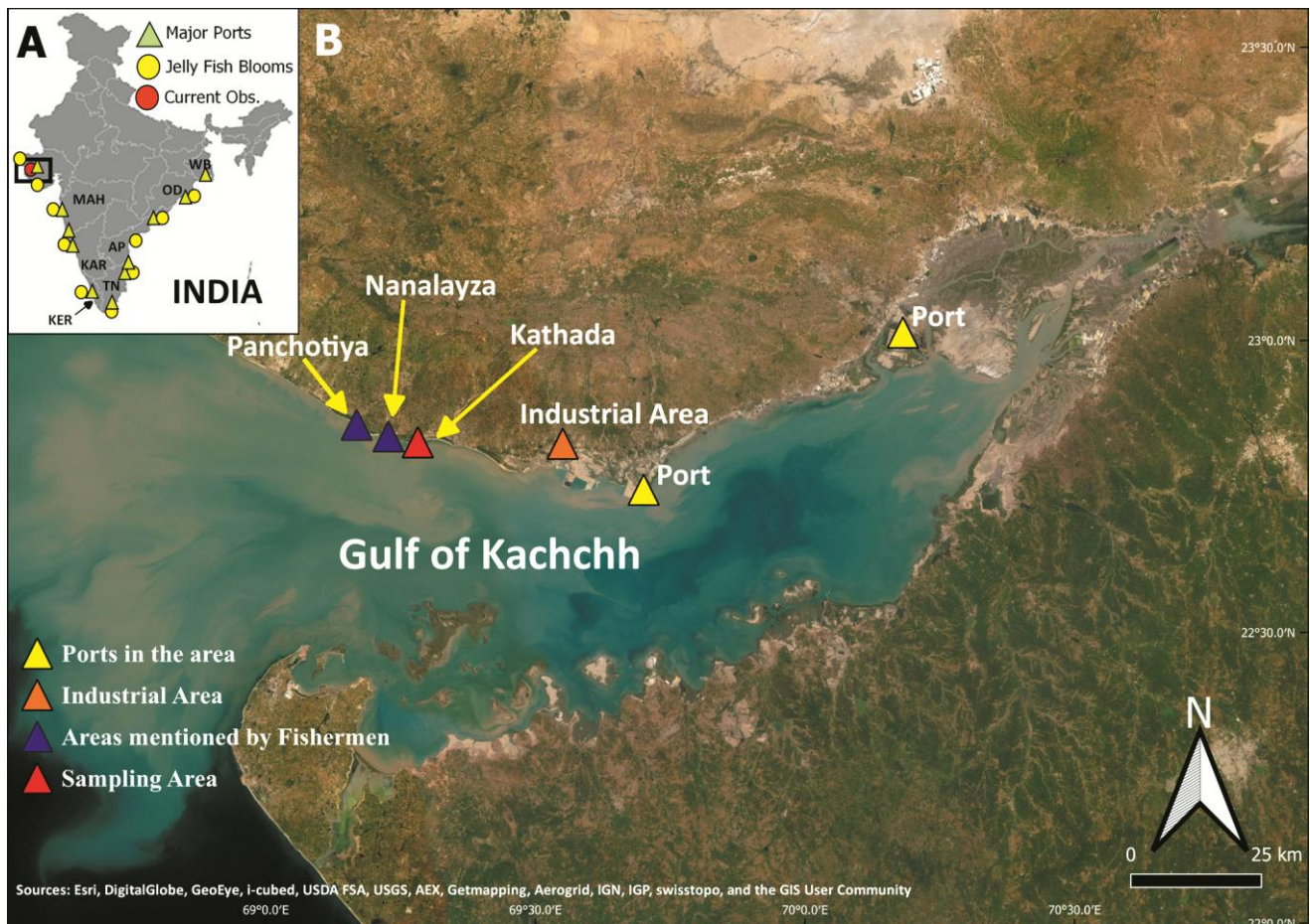


Fig. 1 — A) India map showing other areas with reports of jellyfish blooms (Yellow circles). Yellow triangles: Major ports across the Indian coast; Black box: Gulf of Kutch. B) Current Study area – Gulf of Kutch/ Kachchh (GoK): a) Red Triangle: Location of data collection; b) Blue Triangle: Location where fishermen mentioned the presence of species; c) Orange triangles: Industrial area; d) Yellow Triangles: Port (Abbv. MAH: Maharashtra; KAR: Karnataka; KER: Kerala; TN: Tamil Nadu; AP: Andhra Pradesh; OD: Odisha; WB: West Bengal)

Surface Temperature (SST) analysis, level three monthly averaged nighttime SST data were obtained from MODIS satellite (4 km resolution) in NetCDF format, directly uploaded and visualized in QGIS¹⁹ (Ver. 3.18) (Fig. 4). The colour pattern was manually modified for clarity.

Results and Discussion

Morphological details revealed the species as *Catostylus perezii*, Ranson 1945 (Cnidaria: Scyphozoa) (Fig. 2) which has a general distribution in the Arabian Peninsula extending up to the Arabian sea¹². Abundance data indicated a mean presence of > 4 jellyfish per meter square with a maximum of 9 and a total of 45 (10 quadrats pooled) (Figs. 5, 6). The species appears from January to August on the coast of Pakistan and in the nearby region of Balochistan^{17,20} and in general is seasonal, forming

large congregations, appearing, and disappearing with an annual cycle²¹. However, observations made during the present study of large congregations might be due to several factors. Firstly, the proximity to the thermal power plant could be one reason. Earlier studies have shown that some marine species residing near nuclear power plants, viz. corals, either cope or die due to long-term exposure to increased SST²². Scyphozoans globally have been shown to benefit due to climate change-induced SST rise, pollution and eutrophication^{6,7,23,24}. Secondly, most of the previous factors being interlinked, a decrease in SST can also trigger blooms²³. SST in GoK ranges between 24 – 30 °C²⁶ and current observation being the winter months of December 2018, satellite imagery clearly shows water temperature much lower compared to the outer ocean (Fig. 3). Thirdly, the highly productive nature of the Arabian Sea is another factor which can

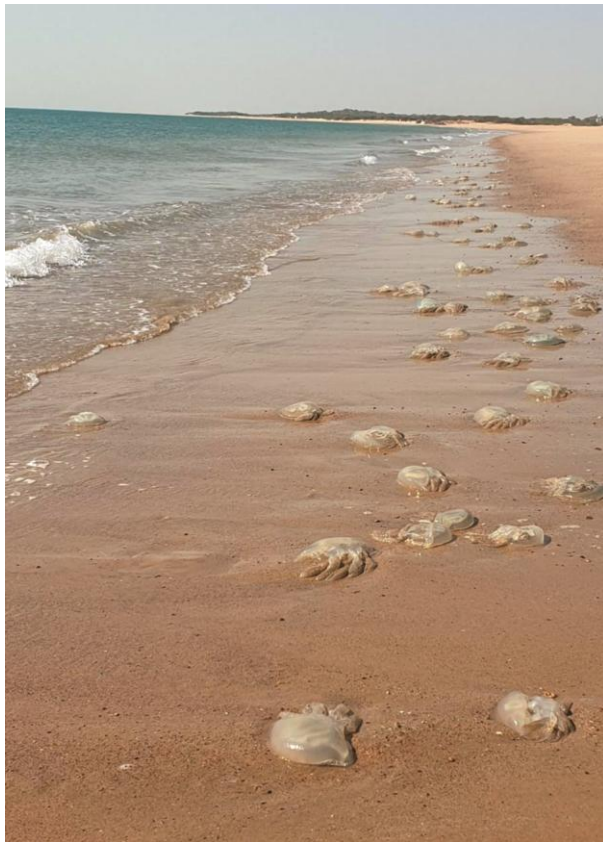


Fig. 2 — Stranding of jellyfishes (*Catostylus perezii*, Ranson 1945) on the Kathada beach along GoK, west coast of India

propel outbreaks. Being a highly productive region due to upwelling and convective mixing²⁷, an increase in phytoplankton blooms in the region²⁸ might lead to high jellyfish and ctenophores presence as they are chief consumers of zooplankton, including fish larvae, hence, a potential competitor of fish²⁸. Sentinel 3 OLCI imagery has clearly shown the high chlorophyll content in the entire Gulf region, ranging from 0.05 – 33 mg m⁻³ (Uncertainty: 0.025 – 3.5 mg m⁻³), and to our knowledge is the first known study to use 300 m resolution Sentinel 3 data in this region (Fig. 3). Even within the Southeastern Arabian Sea, increase in chlorophyll-*a* content has accounted for an increase in jellyfish abundance²⁵. Lastly, ballast water discharge from the nearby ports may enhance the invasion of jellyfish in this area as two major ports are in a vicinity of 50 – 100 km (Fig. 1).

Along the coastal water of India (Table 1), jellyfishes are prominent and less studied faunal group. However, the literature related to jellyfish blooms is increasing slowly. The first incident of such bloom was reported in Mumbai (Arabian Sea), where the outburst of ctenophores and medusa was observed coinciding with the enhancement of Pomfret catch²⁹ during October – December of 1959. Panda & Madhu³⁰ studied landing patterns of jellyfish in different trawling units on the Veraval coast

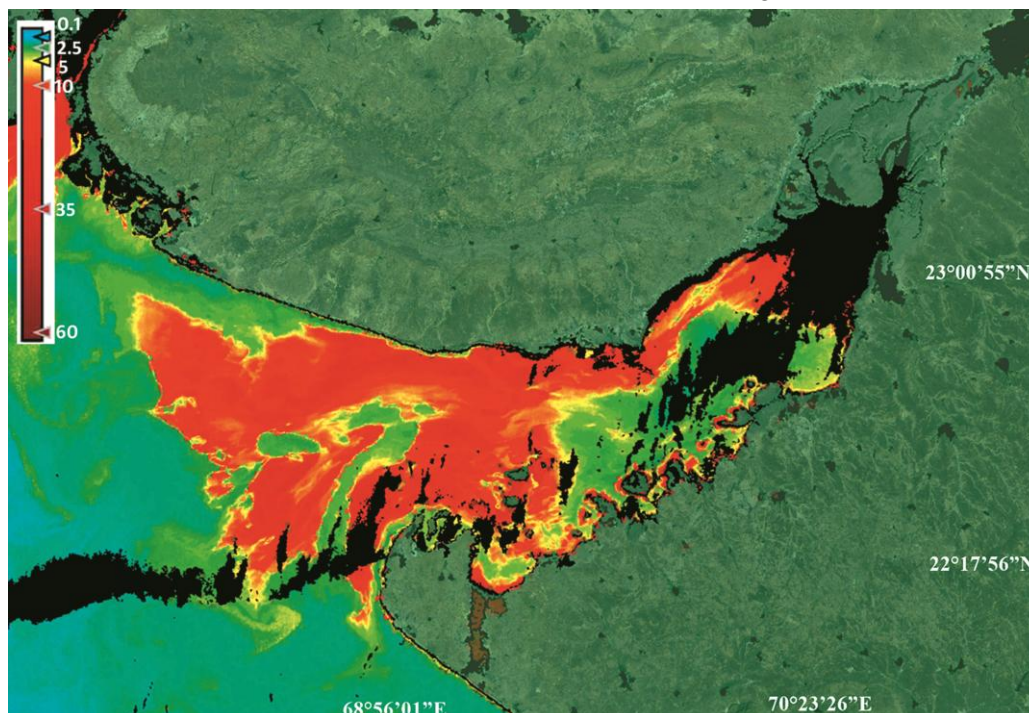


Fig. 3 — Chlorophyll concentration (mg m⁻³, top left) as of December 30, 2018, indicating high productivity in the GoK region. Black regions: cloud cover

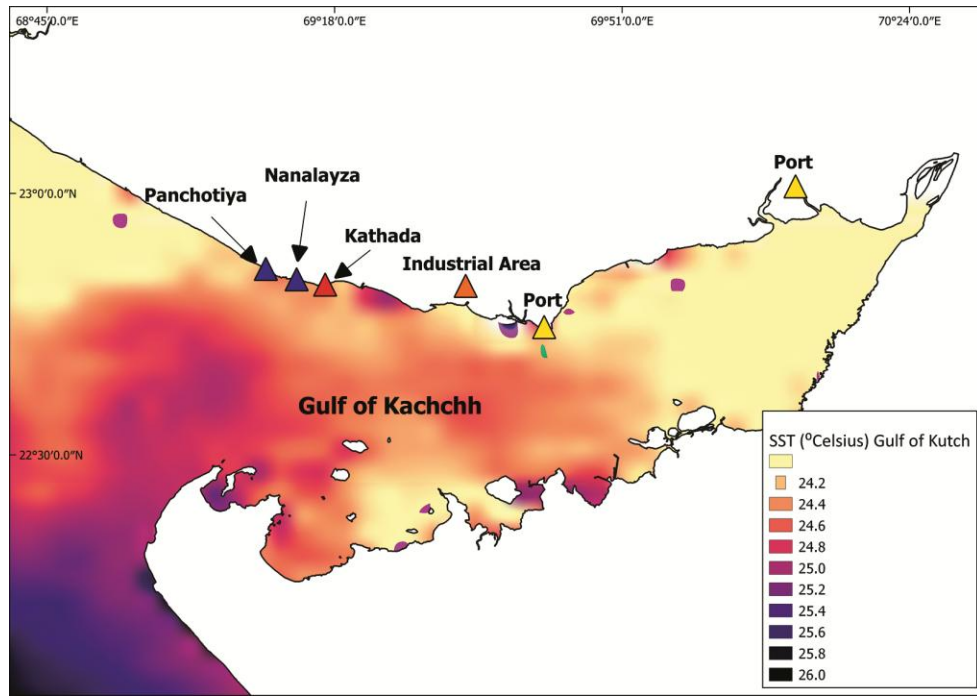


Fig. 4 — Sea surface temperature maps using AQUA-MODIS satellite imagery (Monthly Mean, December 2018)

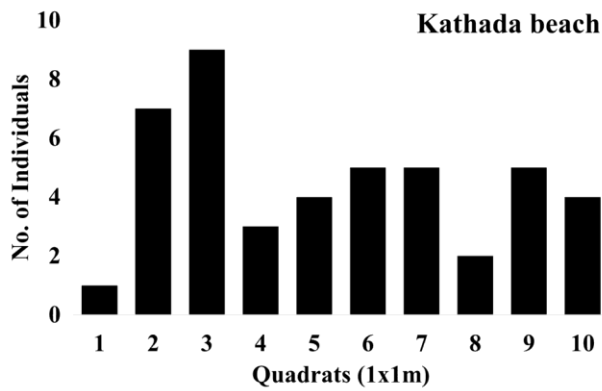


Fig. 5 — Abundance of Jellyfish in Kathada beach, GoK

(Gujarat). They observed the higher landing of jellyfish’s post-monsoon. In Jakhau (Gujarat), there are seasonal blooms that led to harvesting³¹. Bottom trawling had high jellyfish occurrence than pelagic trawling. Some pelagic trawling has given 91 % of jellyfish of the total catch. They opined that heavy fishing pressure may ascend the jellyfish population. During December on the Kerala coast, an increasing number of jellyfish species *Cyanea* spp. was observed³². According to the report, the species was observed during November – December, however, now it is observed from August onwards. Bijukumar *et al.*^{33,34} described jellyfish blooms encountered by fishermen of the Kerala coast of different types (Table 1).

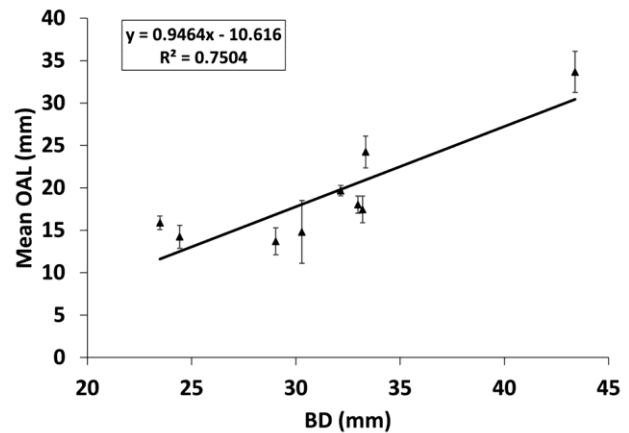


Fig. 6 — Linear regression showing a positive correlation between bell diameter and mean oral arm length (OAL)

Although not discussed in detail (Table 1), the east coast of India has also seen several outbreaks viz., in Kalpakkam coastal waters, where *Dactylometra quinquecirrha* Agassiz, 1862 (accepted as *Chrysaora quinquecirrha* (Desor, 1848)); *Crambionella stuhlmanni* (Chun, 1896); *Chiropsalmus buitendijki* van der Horst, 1907 (accepted as *Chiropsoides buitendijki* (van der Horst, 1907)) blooms have created considerable problems in powerplants^{5,35}. Year-round occurrence of *C. stuhlmanni*, *D. quinquecirrha* (accepted as *C. quinquecirrha*), is noted in the Chennai coastal waters^{11,36}. It is imperative to highlight the presence

of toxic *Pelagia noctiluca* (Forsskål, 1775) in the Rushikulya estuary (Odisha), which is known to create problems in tourism³⁷. The same toxic species has also been recently reported from Hare & Manoli Island (Gulf of Mannar Marine National park, GMMNP, South India)³⁸. Recently, off the coast of Visakhapatnam (Andhra Pradesh), the collection of 500 kg of *C. stuhlmanni* in a single haul created speculation that a tropical cyclone (Hudhud) might be responsible for its occurrence³⁹ as reported in the case of other organisms⁴⁰.

Conclusion

Although it becomes essential to understand the role of climate-driven jellyfish blooms globally, our regional observation highlights the need to assess the anthropogenic developments within the vicinity. Discharge from the nearby power plant might need to be evaluated in detail through water quality assessments to monitor the physio-chemical parameters. The need to determine invasive species through the nearby ports remains a priority. Additionally, more specimens should be analyzed for creating a more robust linear relationship in future studies. Finally, we suggest organizing citizen science programs to report blooms, which will significantly increase our knowledge on the topic within the Indian Ocean.

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Conflict of Interest

The authors declare that this work was done without any financial or competing interest.

Ethical Statement

This is to certify that the manuscript is original and has not been submitted elsewhere. This submission has been approved by all co-authors and has contributed sufficiently to share collective accountability for the results.

Author Contributions

DPB: Observation, data collection, conceptualization and writing – original draft. GT: Writing – reviewing and editing and funding acquisition. BKS: Writing –

reviewing and editing. RRD: Writing – original draft, reviewing and editing, SST and chlorophyll maps and formal analysis.

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