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Dinoflagellate Blooms and Spinning Fish Coincide with *Sargassum* Inundation, Nitrogen Enrichment and Ocean Warming in the Florida Keys, USA

Harmful algal blooms (HABs) negative impacts on public health, recreation, tourism, fishery, aquaculture, and ecosystems have increased worldwide over the last decades [1]. In subtropical Florida, blooms of cyanobacteria (*Microcystis*, *Synechococcus*, *Lyngbya*), red tides (*Karenia brevis*), brown tides (*Aureoumbra lagunensis*), golden tides (pelagic *Sargassum*) and a variety of benthic macroalgae (*Laurencia*, *Gracilaria*, *Dictyota*, *Wrightiella*, *Cladophora*, *Caulerpa*) have increased in severity in the wake of human population growth over decades. This article provides a brief background of the HABs that have developed in the coastal waters of the Florida Keys (“the Keys”), an island archipelago downstream of the Everglades in southernmost Florida. The coastal waters of the Keys were historically oligotrophic and encompass the majority of the third-longest coral reef in the world, the Florida Reef Tract, which extends 563 kms from the St. Lucie Inlet

on the east coast to the Dry Tortugas National Park west of Key West, FL. The sequence of HABs reached a new level of risk in the Lower Keys in 2023/2024 when unprecedented observations of “spinning fish” and fish kills, most notably the critically endangered small-tooth sawfish (*Pristis pectinata*), were increasingly reported on social media, local U.S. and national news outlets (<https://x.com/NBCNightlyNews/status/1773861243754873069?mx=2>).

Local nutrient pollution from human waste, mainly from leaking septic systems, was first identified as a driver of excessive phytoplankton and macroalgal HABs in the Keys during the 1980s. The resulting eutrophication contributed to low dissolved oxygen and the early stages of seagrass and coral reef die-off [2]. HAB events increased dramatically in the early and mid-1990s when water managers adopted policies to increase freshwater flows from Lake Okeechobee south to Florida Bay and the Keys to re-

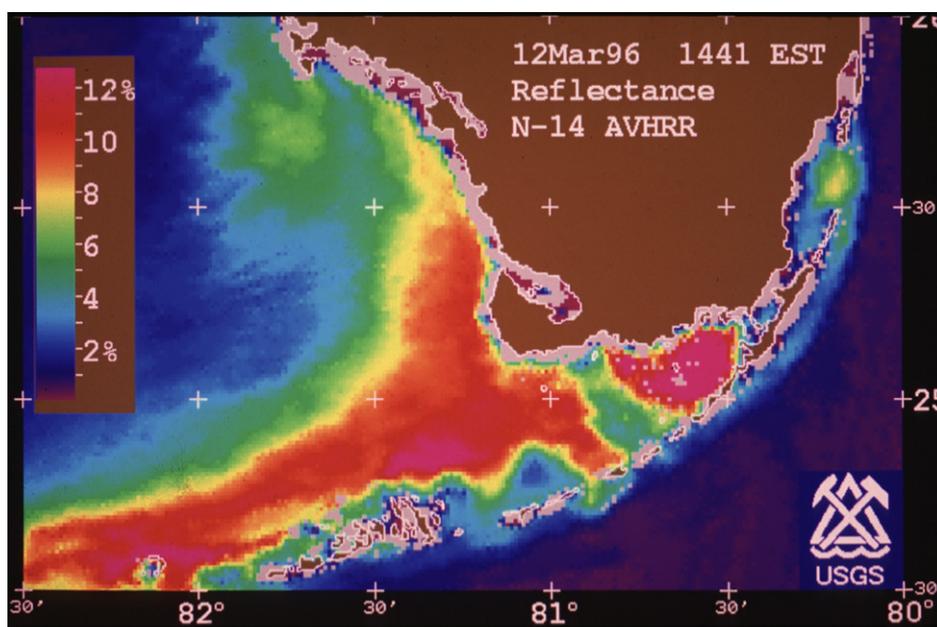


Fig. 1. AVHRR reflectance image from March 12 1996 showing a high-turbidity plume from Shark River Slough extending beyond the Lower Florida Keys towards the Dry Tortugas.

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Fig. 2. Dead brain coral (*Pseudodiploria strigosa*) overgrown by the green macroalga *Cladophora vagabunda* in June, 2008 at the Rock Pile, Lower Florida Keys. Photo: Brian E Lapointe.

duce salinity. This policy was controversial as there was no scientific evidence that high salinities were causing either the die-off of seagrasses or hard corals in the Florida Bay and Keys region. The increased runoff was mostly from Shark River Slough in the western Everglades, with smaller flows coming from Taylor Slough into central Florida Bay (Fig. 1). The increased nitrogen-rich ($\sim 1.5 \text{ mg}\cdot\text{L}^{-1}$ Total N) and skewed stoichiometry (N:P $\sim 250:1$) of the Everglades runoff had the unintended consequences of triggering widespread blooms of *Synechococcus*, *Karenia brevis*, and macroalgal overgrowth and die-off of hard corals [3] in southern Florida Bay (Fig. 2). The resulting nutrient-enriched green water flowed downstream from Florida Bay through the tidal channels of the Keys to the ocean side and was followed by a 38% loss of living hard coral cover in the Florida Keys National Marine Sanctuary between 1996 and 2000 [4]. In 2003, the Pew Oceans Commission reported the Florida Keys a U.S. Dead Zone as a direct result of the increasing anthropogenic nutrient loads and resulting oxygen depletion during the 1990s [5]. Large-scale cyanobacterial blooms and die-offs of sponges and hard corals returned to the Florida Bay–Florida Keys region in 2013 following heavy rainfall and increased Everglades runoff following completion of the C-11 Spreader Canal Western Project, which was intended to raise water levels in the eastern Everglades to further increase freshwater flows into central Florida Bay.

The Lower Florida Keys can be directly impacted by the increased flows and turbid plume waters from Shark River Slough and Taylor Slough (Fig. 1), which, combined with local wastewater nutrient pollution, supports widespread blooms of phytoplankton and various red, green and brown macroalgae that overgrow turtle grass (*Thalassia testudinum*) meadows in the shallow channels of the Lower Keys (Fig. 3). The cumulative enrichment of nitrogen and phosphorus at three sites in Pine Channel between Big Pine Key and Upper Harbor Key exceeded established Florida Numeric Nutrient Criteria in 2012/2013, when total dissolved nitrogen (mean TDN= $19.9 \mu\text{M}$;

max of $46.5 \mu\text{M}$) and total dissolved phosphorus (TDP= $0.30 \mu\text{M}$; max of $0.5 \mu\text{M}$) were highest in winter 2013 [6]. The high nutrients supported extensive epiphytic blooms of the red filamentous macroalga *Spyridia filamentosa* on the seagrass *T. testudinum* (40–65 % cover) and were highest at Upper Harbor Key, the site most impacted by runoff from Shark River Slough. The seawater TDN:TDP ratios during the study were also high (mean= $65:1$; max= $90:1$) among the three sites, indicating that the excess nitrogen skewed the high N:P stoichiometry in Pine Channel during the study [6].

Beginning in fall 2023 and continuing into spring 2024, observations of unprecedented “spinning fish” behavior in Pine Channel and the Lower Keys were reported on social media and local news outlets. The first abnormal behavior and mortality of the critically endangered small-tooth sawfish were reported in January 2024 (at Boca Chica beach) and as of July 31, at least 54 died. In addition to the small-tooth sawfish, over 80 species were impacted, including tarpon (*Megalops atlanticus*), snook (*Centropomus undecimalis*), bonefish (*Albula volpes*), goliath grouper (*Epinephelus itajara*), yellowtail snapper (*Ocyurus chrysurus*), flying fish (*Exocoetus volitans*), mutton snapper (*Lutianus analis*) cubera snapper (*Lutjanus cyanopterus*), rainbow parrotfish (*Scarus guacamaia*), southern stingray (*Hypanus americanus*), white mullet (*Mugil curema*), bull shark



Fig. 3. Macroalgae bloom (*Dictyota*, *Wrightiella*, *Laurencia*) overgrowing turtle grass (*Thalassia testudinum*) in Pine Channel, Lower Florida Keys. Photo: Brian E Lapointe.

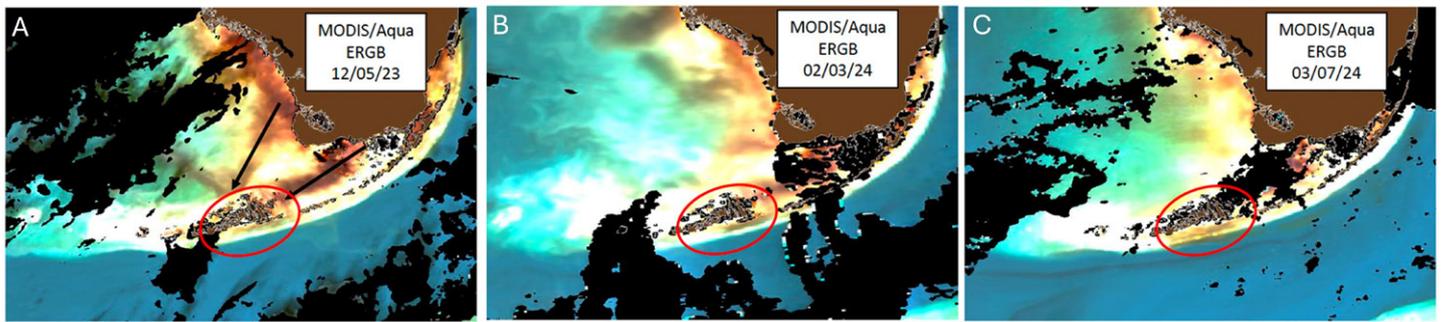


Fig. 4. MODIS/Aqua ERGB satellite imagery showing ENSO-related discharges from the Everglades in the Lower Florida Keys (red circle) on December 5, 2023, February 3, 2024, and March 7, 2024.

(*Carcharhinus leucas*) and many more [7]. Crustaceans were also affected, including blue crab (*Callinectes sapidus*), Caribbean spiny lobster (*Panulirus argus*), horseshoe crab (*Limulus polyphemus*), spider crab (*Maguimithrax* spp.), and stone crab (*Menippe mercenaria*) [7]. The Florida Department of Environmental Protection conducted water testing for more than 250 chemicals, reporting that most were below detectable limits and none were present at biologically significant concentrations. Dissolved oxygen, salinity, pH and temperature were not suspected to be the cause of the unusual fish behavior or kills. Testing of water, benthic algae, and fish tissue did not detect red tide toxins (brevetoxins produced by *Karenia brevis*), cyanobacterial toxins, or saxitoxins as potential causes [7].

Researchers from Florida Gulf Coast University reported elevated levels of the benthic dinoflagellate *Gambierdiscus* sp. in water of the Lower Keys in early 2024 at concentrations of 1,000 cells·L⁻¹, well above their baseline levels averaging 39 cells·L⁻¹ measured during the previous decade [8]. A more extensive survey of over 150 samples of water, seagrass (*T. testudinum*), and macroalgae (*Dictyota*, *Halimeda*, *Laurencia*) was conducted in spring 2024 to quantify *Gambierdiscus* cell densities and other co-occurring benthic dinoflagellates. A comparison with baseline samples collected previously in the Keys between 2011 and 2023 indicated that *Gambierdiscus* cell densities were, on average, sevenfold higher at sites exhibiting erratic fish behavior in 2024 compared to baseline levels. The researchers suggested that exposure to ciguatoxins produced by the benthic *Gambierdiscus* bloom could partly explain the unusual fish behavior in 2024 [8].

Toxin testing was performed by researchers from the Dauphin Island Sea Lab and University of South Alabama. In vitro assays, targeted liquid chromatography-tandem mass spectrometry (LC-MS/MS), and untargeted LC-high resolution mass spectrometry (LC-HRMS) revealed the bioactivity and presence of a variety of benthic algal toxins in whole water, epiphytic microalgae (20–200 μm) and the tissues of symptomatic fish [9]. Subsequent chemical partitioning and assay-guided fractionation identified ciguatoxins, gambierones, and okadaic acid in water samples. A complex suite of these toxins was also identified in fractionated microalgal extracts. Increased toxin diversity was found at sites in the Lower Keys where fish were most affected, including the detection of portimines in algae and fish, though no known source was identified in preserved samples. Preliminary water-borne exposure in the lab to algal extracts containing toxin mixtures resulted in fish behaviors akin to those observed in the field, prompting further investigations into the components and mechanisms involved [9].

Based on the previous nutrient research in Pine Channel [6], we hypothesized that the bloom of toxic benthic dinoflagellates could be partially linked to unusually high levels of nitrogen enrichment and skewed N:P stoichiometry. South Florida experienced heavy dry-season rainfall in November and December 2023, leading to extreme ENSO-related runoff from both Shark River Slough and Taylor Slough. Remote sensing with MODIS/Aqua imagery showed plumes of discolored water from these discharges impacting the Lower Keys on December 5, 2023, February 3, 2024, and March 7, 2024, spanning the period of unusual fish behavior (Fig. 4; A,B,C). On March 3 and 4, 2024,

local citizen scientists and lead author Lapointe collected water samples for analyses of dissolved nutrients (total dissolved nitrogen, TDN; total dissolved phosphorus, TDP) and dinoflagellate abundance. Water samples were collected from nine sites that included the Newfound Harbor Reef, two sites in Pine Channel, three sites in Bow Channel, and two residential canals, one on Little Torch Key and another on Cudjoe Key. Water temperatures were unusually warm for late winter (25.8–27.7°C) and water samples showed unusually high cell densities (1,000s of cells·L⁻¹) of benthic dinoflagellates. TDN concentrations (mean=29.7 μM, max= 52.1) were much higher (+50%), while TDP concentrations were much lower (-57%; mean=0.13 μM; max=0.23 μM) than the 2012/2013 study [6]. This resulted in extremely skewed TDN:TDP ratios (mean=271:1; max=557) that were fourfold higher than in the 2012/2013 study [6], coinciding with the peak of the 2024 fish spinning event.

Given the high abundance of benthic dinoflagellates in the water column in March 2024, Pine Channel and Upper Harbor Key sites were resampled on April 3rd 2024. This sampling included seawater nutrient analysis and removal of epiphytic dinoflagellates from various macroalgae following the methods of Bomber et al. [10]. Cell densities are reported as cells·gDW⁻¹ based on dry weight (DW) of the macroalgae processed at 65°C for 48 hour in a lab oven. Water temperature remained warm in April (25.3–27.9°C), and TDN, TDP, and TDN:TDP ratios in Pine Channel and Upper Harbor Key were still skewed high (means=24.8 μM, 0.14μM, 224:1). In Pine Channel, dense blooms of *Prorocentrum* were epiphytic on *Cladophora vagabunda* (17 x 10³ cells·gDW⁻¹), *Laurencia intricata* (7.8 x 10³ cells·gDW⁻¹),

and *Digenea simplex* (4.6×10^3 cells-gDW⁻¹), with lower densities of *Ostreopsis* (3×10^3 cells-gDW⁻¹) and *Gambierdiscus* (2.9×10^3 cells-gDW⁻¹) on *Digenea simplex*.

Further sampling was conducted on June 8th 2024 at the Newfound Harbor Reef and Pine Channel sites. TDN, TDP, and TDN:TDP ratios continued to be skewed high at the sites (27.1µM, 0.07µM, 421:1), with very warm temperatures (31.6–32.2°C). Mats of pelagic *Sargassum natans* I, *Sargassum natans* VIII, and *Sargassum fluitans* III were floating at the water surface at Newfound Harbor Reef and were sampled for epiphytic dinoflagellates, along with several benthic macroalgae from Pine Channel. *Prorocentrum lima* (Fig. 5A) was the most abundant dinoflagellate found on all macroalgae at both sites, with maximum densities on *Caulerpa paspaloides* (7.3×10^3 cells-gDW⁻¹), followed by *S. fluitans* III (2.5×10^3 cells-gDW⁻¹), *S. natans* I (2.3×10^3 cells-gDW⁻¹), *Laurencia* spp. (1.7×10^3 cells-gDW⁻¹), *S. natans* VIII (920 cells-gDW⁻¹), and the benthic *S. pteropleuron* (491 cells-gDW⁻¹). *P. hoffmannianum* (Fig. 5B) was most abundant on *Caulerpa paspaloides* (5×10^3 cells-gDW⁻¹) followed by benthic *S. pteropleuron* (2×10^3 cells-gDW⁻¹) and *S. fluitans* III (1.5×10^3 cells-gDW⁻¹). *P. mexicanum* was also abundant on *C.*

paspaloides (2.4×10^3 cells-gDW⁻¹) with lower densities of *Coolia* (318 cells-gDW⁻¹) on *S. fluitans* III.

Densities of toxigenic *Prorocentrum* epiphytic on macroalgae at Newfound Harbor Reef and Pine Channel in June 2024 were similar to those reported for *Gambierdiscus* in the Lower Keys in winter 2024 (8), but notably high compared to previous ciguatera fish poisoning (CFP) studies. Reports of dinoflagellates associated with CFP in the Florida Keys since the 1970s include *Gambierdiscus toxicus*, *Prorocentrum lima*, *P. mexicanum*, *P. concavum*, *P. emarginatum*, *Ostreopsis heptagona*, *O. siamensis*, and *Coolia* spp. [11]. Reported cell densities on pelagic *Sargassum* in the 1980s were lower than those we measured in 2024. For example, between 1983 and 1986 *Prorocentrum lima*, *P. mexicanum*, and *P. concavum* were the most abundant dinoflagellates rafting on *Sargassum natans* in the nearby Straits of Florida with mean densities of 176, 88, and 60 cells-g WW⁻¹, respectively [10]. Considering that the dry weight of *Sargassum* is ~20% of its wet weight, the mean cell density of *P. lima* on *Sargassum fluitans* III and *S. natans* I converted to cells-g WW⁻¹ was almost threefold higher in 2024 than in the 1980s. The high overall dinoflagellate densities of *Prorocentrum* (4.6 to 17×10^3 cells-g DW⁻¹) on benthic *Cladophora*, *Laurencia*, and *Digenea* in Pine Channel in 2024 were similar to densities of *P. lima* on macrophytes in the Fleet Lagoon, UK and other European studies [12].

A review of CFP case studies in the 1950s suggested that these toxigenic events are often associated with disturbed coral reef environments, particularly those impacted by heavy runoff and turbid water [13]. This condition existed in the Lower Keys during winter and spring 2024 when runoff from Shark River Slough and Taylor Slough formed discolored plumes of runoff impacting the Lower Florida Keys (Fig. 4; A,B,C). The salinity of the discolored water at the Newfound Harbor Reef site on the oceanside of the Lower Keys on March 3 2024 was 32.5 psu, confirming the influence of freshwater runoff. The ENSO-related Everglades discharges in winter, combined with local runoff, resulted in extremely high TDN concentrations (mean=29.7 µM, max= 52.1) and TDN:TDP ratios (mean=271:1;

max=557) at the nine sites in the Lower Keys.

Could the combination of exceptionally high TDN, TDN:TDP ratios, warm winter-spring temperatures (24.7–27.9°C) and excessive *Sargassum* inundation (providing a large surface area of substrate for the benthic dinoflagellates) help explain this toxic dinoflagellate bloom and the coincidental spinning fish and mortality event? Batch culture experiments with *Prorocentrum hoffmannianum* run at two temperatures (21 and 27°C) under N-limited (N:P = 0.81) and P-limited (N:P =735:1) conditions showed increased growth and toxin production (okadaic acid) under strong P-limitation at 27°C [14]. These experimental conditions are very similar to those of the Lower Keys in winter and spring 2024 and help explain this unprecedented bloom involving a variety of benthic dinoflagellates that produced multiple lipid-soluble and water-soluble toxins in an unprecedented “toxic cocktail” [9]. This event also followed decades of benthic macroalgal blooms in the Lower Keys that provide more surface area for benthic dinoflagellates, as well as excessive *Sargassum* inundation from the Caribbean region since 2014 [15]. The threefold increase in *Sargassum* biomass in the Atlantic basin [15], combined with a threefold increase in cell density of *Prorocentrum* on *Sargassum*, could have provided a ninefold increase in loading of seed populations of *Prorocentrum* into the Florida Keys. Continued monitoring and research is needed to better understand the “perfect storm” of interacting factors supporting this HAB event and how they could impact the future of fisheries, tourism, and human health in the Florida Keys.

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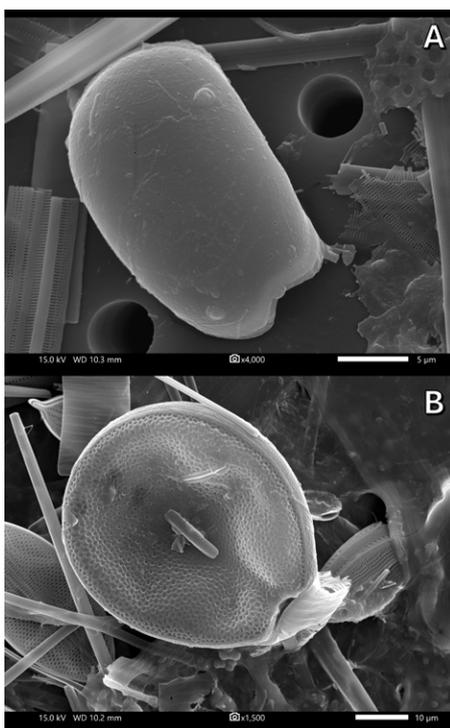


Fig. 5. Scanning electron microscopy micrographs of epiphytic *Prorocentrum lima* (A) and *P. hoffmannianum* (B) from macroalgae collected in the Lower Florida Keys, 2024. Courtesy of Steve Morton and Andrew Shuler.



Fig. 6. Pelagic Sargassum inundation at Bahia Honda State Park, March, 2023. Photo: B E Lapointe.

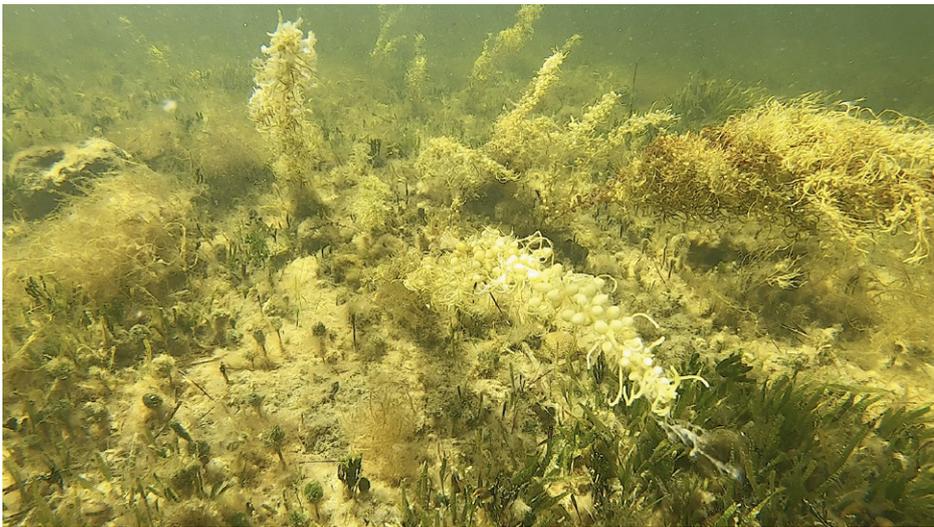


Fig. 7. Benthic Sargassum pteropleuron in Pine Channel, May, 2024. Photo: B E Lapointe.



Fig. 8. Macroalgal overgrowth (*Halimeda* spp., *Dictyota* sp.) of the Newfound Harbor Reef, May, 2020. Photo: B E Lapointe.

with seawater nutrient processing and analysis. This research would not have been possible without the collaboration with Steve Morton and Andrew Shuler at the HAB Monitoring and Reference Branch, National Centers for

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Tingui: the sickness by exposure to marine aerosols in the Northeast of Brazil

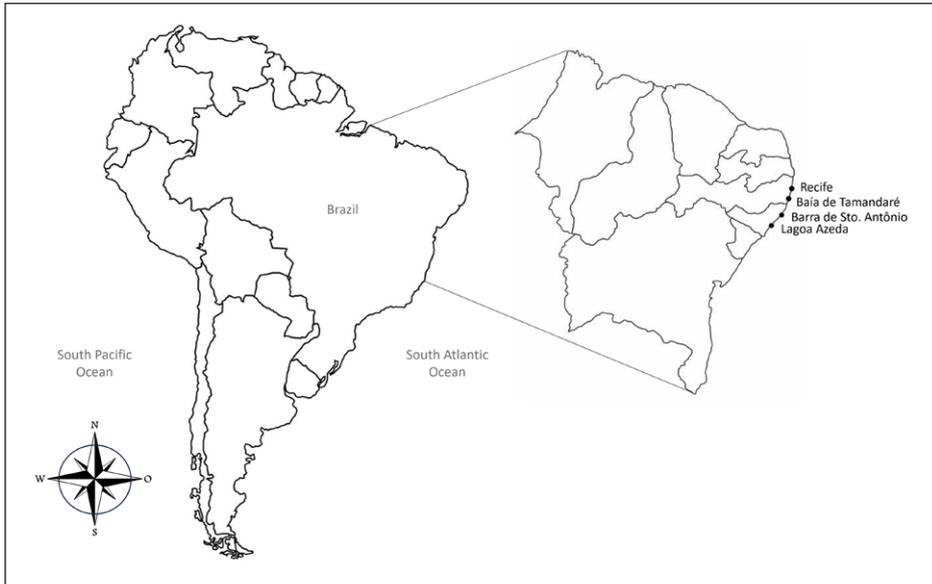


Fig. 1. Map of Brazil showing the municipalities of Recife, Tamandaré, Barra de São Miguel, Lagoa Azeda, and Porto Seguro in Northeast Brazil.

In Tamandaré Bay ($8^{\circ}47'20''$ S, $35^{\circ}06'45''$ W, Fig. 1), on the northeastern coast of Brazil, a peculiar toxic event occurs in which people exposed to marine aerosols become ill. Symptoms begin with respiratory problems (runny nose, sneezing), epistaxis, eye irritation, cough, and asthenia, progressing to fever, muscle, joint, and post-orbital pain. Some patients may experience gastrointestinal symptoms, and in a few cases, the illness may lead to depression and drowsiness [1]. These events were first reported by physician Fred-erico Barbosa, who called the condition

“Tamandaré fever” in the summer of 1943, when hundreds of soldiers from a military base near the beach fell ill with *tingui*, a syndrome well known to the local community at that time. Tingui is a word from the Tupi language group that may have different etymologies [1]. The ancient Tupi word “*tingy*” or “*tingyry*” means “*seasickness liquid*” [2], while the word “*tinguy*” refers to a plant from the Sapindaceae family used to poison freshwater fish but considered harmless to humans [3]. Other possible etymologies for the word refer to foam or foamy water [4].

Tingui occurs during summer and affects people close to the seashore for two to three days. It is often characterized by an unpleasant odour from the sea and may or may not be accompanied by red discolorations and foam in seawater [1, 5]. Satô et al. [5] interviewed the local community of Tamandaré in 1963 and documented strong tingui events in the summers of 1955 and 1958, although no reports of red or discoloured waters were mentioned. In 1961, red discoloration was reported without a tingui event, and in 1963, red stains in seawater were linked to tingui, accompanied by an unpleasant odour in the air. The authors speculated that tingui might be caused by aerosols containing fragments or intracellular contents of *Trichodesmium erythraeum* Ehrenberg ex Gomont cells, drawing comparisons with reports of respiratory distress and other symptoms caused by exposure to aerosols during blooms of *Karenia* (then identified as *Gymnodinium*) in Venice Beach, Florida. Satô et al. [5] did not examine seawater samples from Tamandaré during the 1963 tingui event, but extensively studied a *T. erythraeum* bloom in the city of Recife, 120 km north of Tamandaré, during the same period (October 1963). In Recife, no tingui related symptoms were observed during the *T. erythraeum* bloom.

No studies have addressed the tingui since then, despite continued occurrences. In 2017, a long-term ecological research programme, “Tamandaré Sustentável” (PELD TAMS-ILTER site 18) was initiated at Tamandaré Bay, including phytoplankton monitoring. In

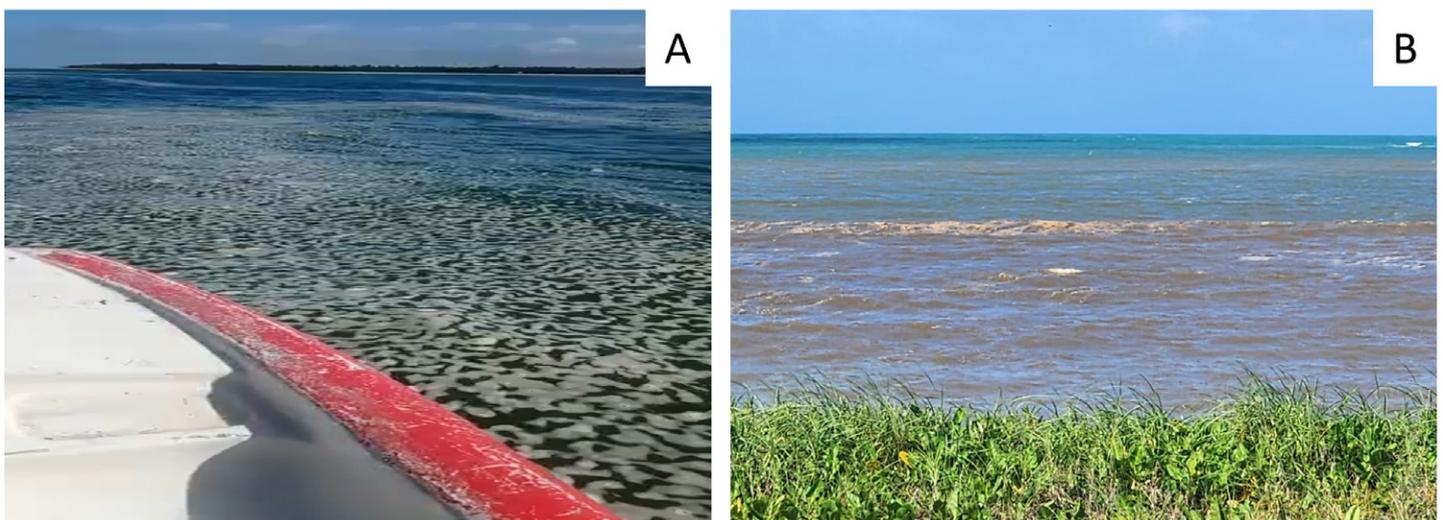


Fig. 2. Images of tingui occurrences in Tamandaré in April and May 2023, showing (A) foam and (B) an oily appearance in the water column without visible stains. Source: Thales Vidal e Mauro Maida (2023).



Fig. 3. (A) Coastal area and cliffs of Lagoa Azeda, also known as Lagoa de Jequiá da Praia, in Alagoas. (B) Temporary houses for residents, known as “ranchos,” used during the tingui period in the municipality. Source: Alagoas Mapa (2022).

May 2023, during a tingui event when foam and “oily” seawater were noticed (Fig. 2), a dinoflagellate species (not identified) was present in high abundances in water samples collected during the event. On 31 January 2024, a very intense tingui event led 338 people to seek medical assistance [6]. This number is likely underreported, as many residents and tourists are accustomed to tingui symptoms and do not seek medical care. No water discoloration was observed during this event, either from the seashore or in satellite images. On 1 February 2024, 191 people were admitted to a health unit at Barra de Santo Antônio, 80 km south of Tamandaré, with nausea, sore throat, stomach pain, cough, runny nose, nasal obstruction, and signs of conjunctivitis, after exposure to marine aerosols [7]. Water samples collected in 2024 from Tamandaré presented low phytoplankton abundance and only a few diatom species identified.

Tingui is also known to occur in Lagoa Azeda, a small fishing village, located between the sea and the cliffs (Fig. 3A), 170 km south from Tamandaré in the state of Alagoas. There, the phenomenon is well known by the local community, and residents experience symptoms such as sore throat, shortness of breath, sneezing, intense body pain, and fever. To avoid illness from marine aerosol exposure, the community moves to houses uphill (Fig. 3B), specifically built for this purpose. These houses, known as “ranchos”, accommodate fishermen’s families during these events, which last on average three days. The local population does not seek medical care, as they are ac-

customed to the symptoms. According to fishermen, there is an unpleasant odour that quickly affects people, triggering flu-like symptoms, and recovery takes two to three days. Fishermen also report that calm seas and “oily” seawater often precede intoxication events.

Studies on the species responsible for tingui and the conditions that lead to human symptoms remain scarce. However, awareness of these events and their potential consequences for human health and economic activities in these touristic areas is increasing. There is also a perception that these phenomena have become more frequent and intense in recent years, possibly due to regional environmental changes such as rising temperature anomalies associated with climate change and increased land-based discharges. During the summer, the population of Tamandaré city increases significantly due to tourism, leading to greater sewage discharge and eutrophication of coastal waters.

In upcoming summers, phytoplankton and benthic microalgae monitoring, along with documentation of tingui events, is planned under the PELD TAMS project to investigate the toxic microalgae potentially involved in these intoxications. Meanwhile, communication efforts with local environmental and health authorities, as well as residents and fishermen, are being implemented to raise awareness about tingui and establish an integrated network of individuals engaged in understanding its causes.

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Calibrating and validating the Aerobic Mortality Risk Index (IRMA): an index for predicting mass mortality of fish due to anoxia.

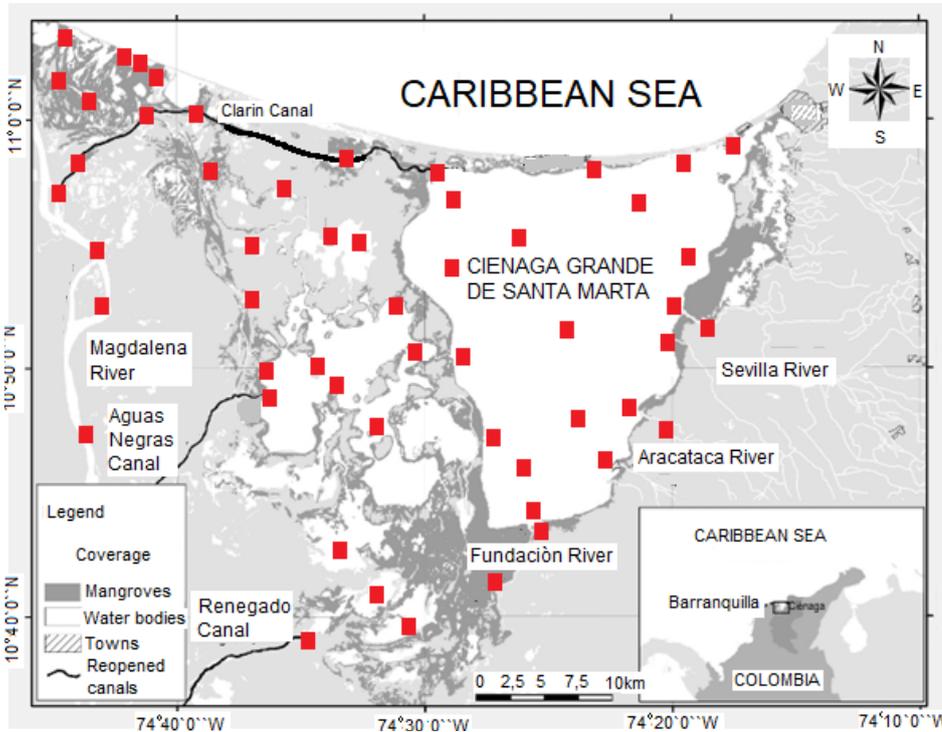


Fig. 1. Location of the Ciénaga Grande de Santa Marta (CGSM), Colombia. Source [4]. Red boxes indicate sampling sites.

Mass mortality of marine organisms are frequent events in estuaries and coastal lagoons, including the Ciénaga Grande de Santa Marta (CGSM), located in the Colombian Caribbean (Fig. 1). The CGSM is considered one of the most productive tropical coastal lagoons in the world [1]. Following a major fish kill in 1994 that resulted in enormous economic losses and serious social impacts, an alert programme for fishermen and environmental authorities was developed.

Considering the increased demand for fish supply during episodes of anoxia and based on a conceptual model explaining the eutrophication process (Fig. 2), Mancera and Vidal developed an index of mortality risk for aerobic organisms called Aerobic Mortality Risk Index (IRMA) [2]. According to the model, rising PO_4 levels stimulate excessive microalgal growth, primarily produced by atmospheric nitrogen-fixing cyanobacteria. Following this overproduction, the cyanobacterial collapse leads to hypoxia or anoxia. Although IRMA was identified as a promising model,

capable of anticipating the 1995 and 1996 mortality events, a lack of sufficient data prevented proper calibration and validation. After nearly 30 years of monitoring by INVEMAR at 33 sites of the CGSM, we resumed the construction of the index.

To estimate IRMA, we improved the algorithms developed by Mancera and

Vidal to score the fish mortality risk based on PO_4 ($\mu\text{mol.L}^{-1}$), chlorophyll (CLA, $\mu\text{g.L}^{-1}$), and dissolved oxygen (OD, mg.L^{-1}) concentrations, using values measured over the past 30 years. We weighted risk scores across the three variables according to their potential impact on fish mortality. The final IRMA value was calculated as the sum of the weighted risk scores (eq. 1), expressed as a percentage:

Where:

n is the number of variables used (3: PO_4 , CLA, OD).

$c(x)$ is the classification of variable x based on its concentration.

$f[c(x)]$ is the weighting applied to each classification.

We calibrated IRMA using fish kill events recorded at CGSM and assessed its efficiency through a confusion matrix, a valuable tool for assessing the performance of statistical models [3]. Before constructing the matrix, we ensured that the sample was balanced, meaning that the number of fish kill events (positive cases) was sufficiently comparable to non-events (negative cases). To achieve this, we used the *upSample* function from the statistical software R. This function performs sampling with replacement to equalize class distributions, ensuring fair representation across both categories (Fig. 3).

Once the sample was balanced, we built the confusion matrix, comparing the predicted classifications of the IRMA index with the actual classifications of fish mortality events. This table summarizes the performance of the

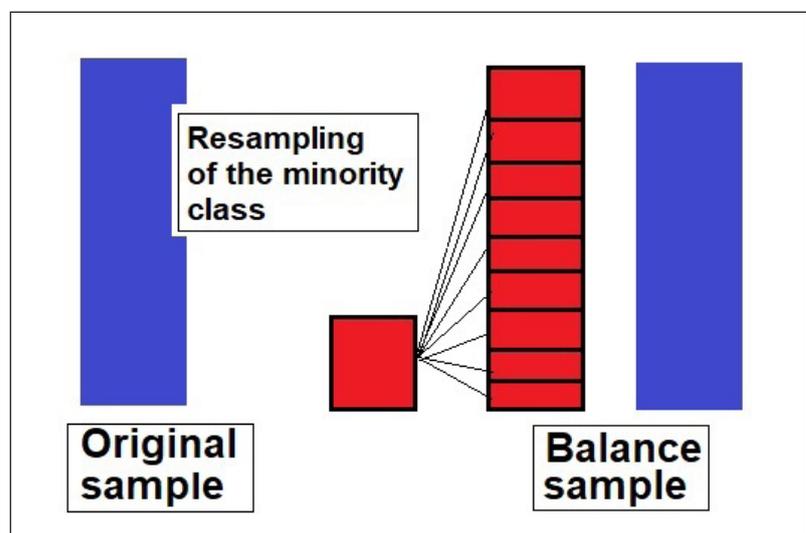


Fig. 2. Conceptual model of the Aerobic Mortality Index (IRMA).

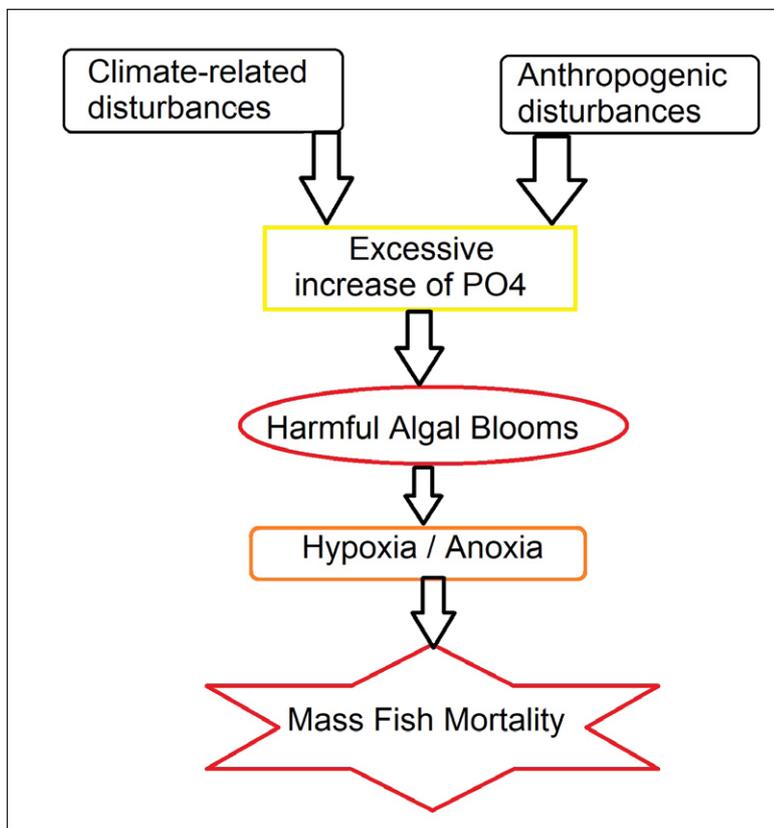


Fig. 3. Diagram of the sample balancing process using the upSampling function from the caret library in R.

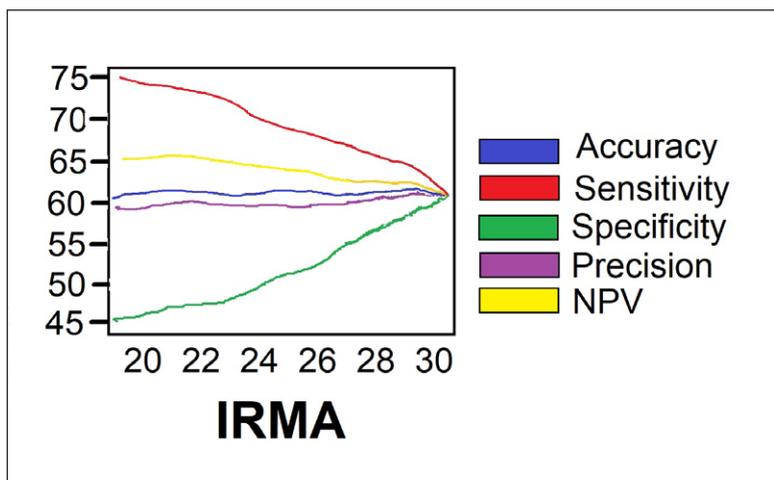


Fig. 4. Performance metrics of the Aerobic Mortality Risk Index (IRMA) as a function of different threshold values of the IRMA index.

classification algorithm by providing counts of:

True Positives (TP): Correctly predicted positive cases.

True Negatives (TN): Correctly predicted negative cases.

False Positives (FP): Cases incorrectly predicted as positive (Type I error).

False Negatives (FN): Cases incorrectly predicted as negative (Type II error).

From the values in the confusion matrix, we calculated four key metrics to evaluate the model's performance, including Accuracy, Precision, Recall, and Specificity. These metrics provide

a comprehensive understanding of the IRMA's effectiveness in forecasting fish mortality risks. We then determined a threshold value for the IRMA indicator to optimize assessment metrics, facilitating the distinction between mod-

Table 1. Classification of IRMA fish kills risk levels.

Value (%)	Risk Level
[0,10)	Low
(10,30]	Moderate
(30,40]	High
(40,)	Very high

erate and high-risk levels of fish kill events (Fig. 4). The optimized threshold value was 60%. Finally, we classified the risk levels for the occurrence of fish kill events (Table 1).

Acknowledgments

We express our gratitude to the Marine and Coastal Research Institute INVE-MAR for providing the essential data on the key variables for IRMA validation. We also extend our appreciation to Prof. Horst Salzwedel, who along with one of the present authors, undertook the arduous task of gathering 26 years' worth of news records from the CGSM.

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Unusually late occurrence of a *Dolichospermum* bloom in a Nova Scotia lake

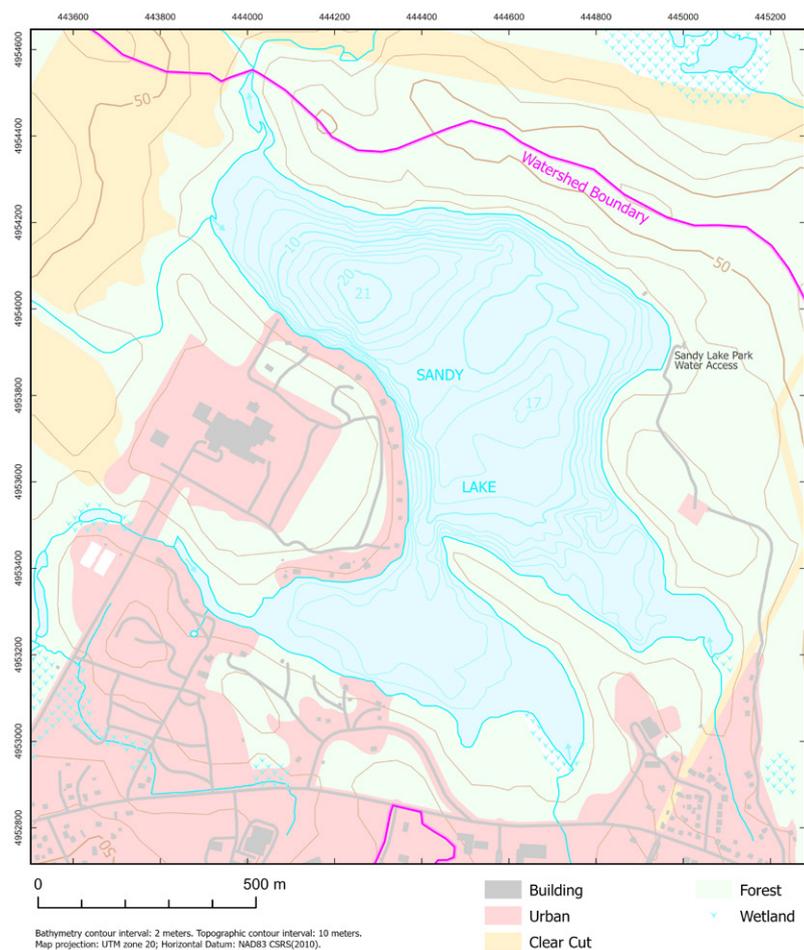


Fig. 1. Map of Sandy Lake.

Dolichospermum (formerly *Anabaena*) is a cosmopolitan buoyant N-fixing cyanobacterial genus found in Canadian lakes. *Dolichospermum* sp. can be very productive under high-P conditions with prolonged thermal stratification [1]. *Dolichospermum* blooms can lead to the production of numerous secondary cyanotoxin metabolites, including anatoxins, saxitoxins, microcystins, cytotoxins, and dermatotoxins [1]. Cyanobacterial algae blooms in Nova Scotia lakes typically occur between June and September [2]. Here, we report an unusually late *Dolichospermum* bloom in an eastern Canadian lake.

Sandy Lake is a small urban dimictic freshwater lake (74 ha, 5.1×10^6 m³, maximum depth of 22 m, 44.737750N, 63.704345W) located in Bedford, Halifax Regional Municipality (HRM) (Fig. 1). Sandy Lake has had only a single government report of an unspecified algal bloom in June 2022 [2]. Sandy Lake

is a popular destination with a swimming beach, hiking trails throughout the watershed, dog walking (and dog wading) as well as boating and angling. The Sandy Lake watershed contains a mix of businesses (a dairy cooperative, two small technology services and several small stores), residential areas and a designated protection area under consideration [3]. Annual limnological observations have been collected on Sandy Lake since 2017 by DP [4] with the help of volunteers from the Sandy Lake Conservation Association [5], and since 2022 with the support of the HRM “LakeWatchers” program [6]. There are several major roads along the southern portion of the lake (Fig. 1) treated with road salt and other de-icing chemicals in the winter [7]. Finally, the major Tantalton forest fire of 2023 [8] affected a small portion of the watershed leading to Sandy Lake.

On November 6, 2024, a resident,

D.S., noticed a distinctive array of blue-green growths floating in shallow water along the western shore of the lake (Fig. 2) and immediately collected a small sample for identification. The next day, the growth visibly disappeared. Given the very short temporal nature of this event, we were unable to sample the lake more thoroughly during the bloom event. After examining the sample under a light microscope a few days later, we were able to identify the algae as *Dolichospermum lemmermannii* (Fig. 2).

The weather on November 6th was unseasonably warm and sunny, with air temperatures reaching 20°C in the Halifax area; however, the next day, air temperatures fell to 7°C. On prior dates, volunteers measured surface water temperatures on October 2 (18.9°C) and November 3 (10.5°C). We do not have day-of-sampling water quality or toxin data because we did not have the necessary equipment ready at hand



Fig. 2. Top Left image shows the occurrence of the November 6, 2024 *Dolichospermum* bloom along the Sandy Lake shoreline. Top Right image shows the sample collected from the lake. Bottom image shows light microscopy image (100x power) of a cluster of *Dolichospermum* sp. cells from Sandy Lake (Bedford).

Table 1. Historical trends of total phosphorus for Sandy Lake, Bedford. Data compiled by D. Patriquin, from unpublished consulting reports & HRM Lakewatchers Program datasets.

Date	Surface (0.5) TP mg/L	Deep (>15 m) TP mg/L
Sept 3, 2008	11	15
May 24, 2010	10	26
August 8, 2011	6	5
August 16–23 2021	~8.0	~23
August 22, 2022	-	4.7
August 14, 2023	8.8	8.7
August 12, 2024	5.2	40

when the bloom was observed.

The last water quality profile collected for the lake was on August 12, 2024 (Fig. 3). On this date, chlorophyll-a concentrations at the surface ($6.85 \mu\text{g L}^{-1}$) were higher than Chl-a at 20 m ($1.48 \mu\text{g L}^{-1}$), while total phosphorus (TP) trends were reversed with lower concentrations at surface ($5.2 \mu\text{g L}^{-1}$) compared to 20 m (40 mg L^{-1}). Specific conductivity was higher ($170\text{--}185 \text{ mS/cm}$) in deeper layers below 16 m (Fig. 4) which also had hypoxic (DO < 2 mg/L, 9–6% saturation) and acidic (pH 6.5–6.7) conditions, compared the more oxygenated surface waters (8.3 mg L^{-1} DO, 10% saturation, $\sim 175 \text{ mS/cm}$, pH 7, respectively; Fig. 3). We also note that the TP concentration at 20 m for August 2024 is highest-ever measured for Sandy Lake compared to historical TP values (see Table 1). Hypoxic (<2–3 mg L⁻¹) and acidic conditions in deeper waters can lead to the release of internal P, Fe and Mg from sediments [9] during prolonged stratification events. We suspect that as surface water cooled to 10°C in November from 24°C in August, there was a sudden destratification event leading to deeper water containing higher TP being mixed throughout the water column. This would have led to the sudden expansion of the N-fixing *Dolichospermum* bloom very late in the season. As a result, an early-warning monitoring framework [e.g., 10] implemented over a longer seasonal period (April – November) is recommended for Sandy Lake and other urban lakes in Nova Scotia.

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Many thanks go to regular Sandy Lake Association volunteers, Ed Glover,

Derek Sarty, and Bruce S, who watch over the lake. The Saint Mary's University Environmental Science technicians, Jessica Younker and Margaret MacNeil, assisted with sampling and equipment. Greg Baker prepared the maps. Dr. Hedy

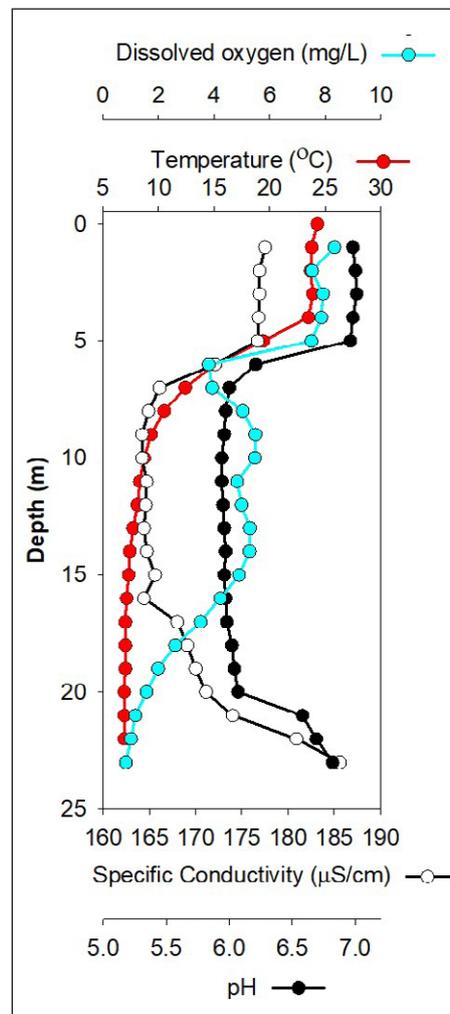


Fig. 3. A water quality depth profile for Sandy Lake (Bedford, HRM, Nova Scotia) for August 12, 2024. The colours of symbols and lines are next to the X-axis label for each corresponding parameter. Secchi depth, 2.2 m. Water quality information for surface: $5.2 \mu\text{g L}^{-1}$ total phosphorus, $6.85 \mu\text{g L}^{-1}$ chlorophyll-a, no chloride measurements. At 20 m depth: 40 mg L^{-1} TP, $1.48 \mu\text{g L}^{-1}$ Chl-a and 36 mg L^{-1} Cl.

Kling provided an independent confirmation of *Dolichospermum* identification. Chris Kennedy, HRM Lakewatchers Program Coordinator, provided the water chemistry data from August 2024.

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Med HAB Net: A new network addressing Harmful Algal Blooms in the Mediterranean

The Mediterranean Sea is a semi-enclosed basin bordered by 23 countries across north Africa, Europe and the Middle-East. It hosts 46 toxin-producing microalgal species harmful to humans and 29 ichthyotoxic species [1], posing significant challenges to the region's aquaculture sector. Non-toxic algal blooms are also responsible for mucilage formation or water discoloration, leading to considerable impacts on tourism, the largest sector of the marine economy along the Mediterranean Sea [1]. As demand for marine resources—driven by seafood production and tourism—continues to rise, the impact of harmful algal blooms (HABs) on human activities is expected to intensify. In the context of climate change, the emergence of some harmful species in the Mediterranean is particularly alarming. These include benthic species of the genera *Gambierdiscus* and *Ostreopsis* [2].

Tackling these issues demands strong and effective international collaboration among researchers studying HABs within this shared basin. In alignment with the Barcelona Convention, Plan Bleu – Regional Activity Center of the United Nations Environmental Program (UNEP) / Mediterranean Action Plan (MAP), in partnership with the University of Côte d'Azur, and with the support of the Intergovernmental Oceanographic Commission (IOC-UNESCO) and the Food and Agriculture Organization (FAO), initiated a project to establish a network of experts across the Mediterranean region: **Med HAB Net**.

Med HAB Net (Fig. 1) was launched in June 2024 and currently comprises 38 members from 17 countries (Fig. 2). Being a self-sustaining network, the members have been meeting remotely to establish its operational framework and identify shared needs and priorities. This network aims to provide a dynamic platform for fostering scientific exchanges, facilitating data sharing, and

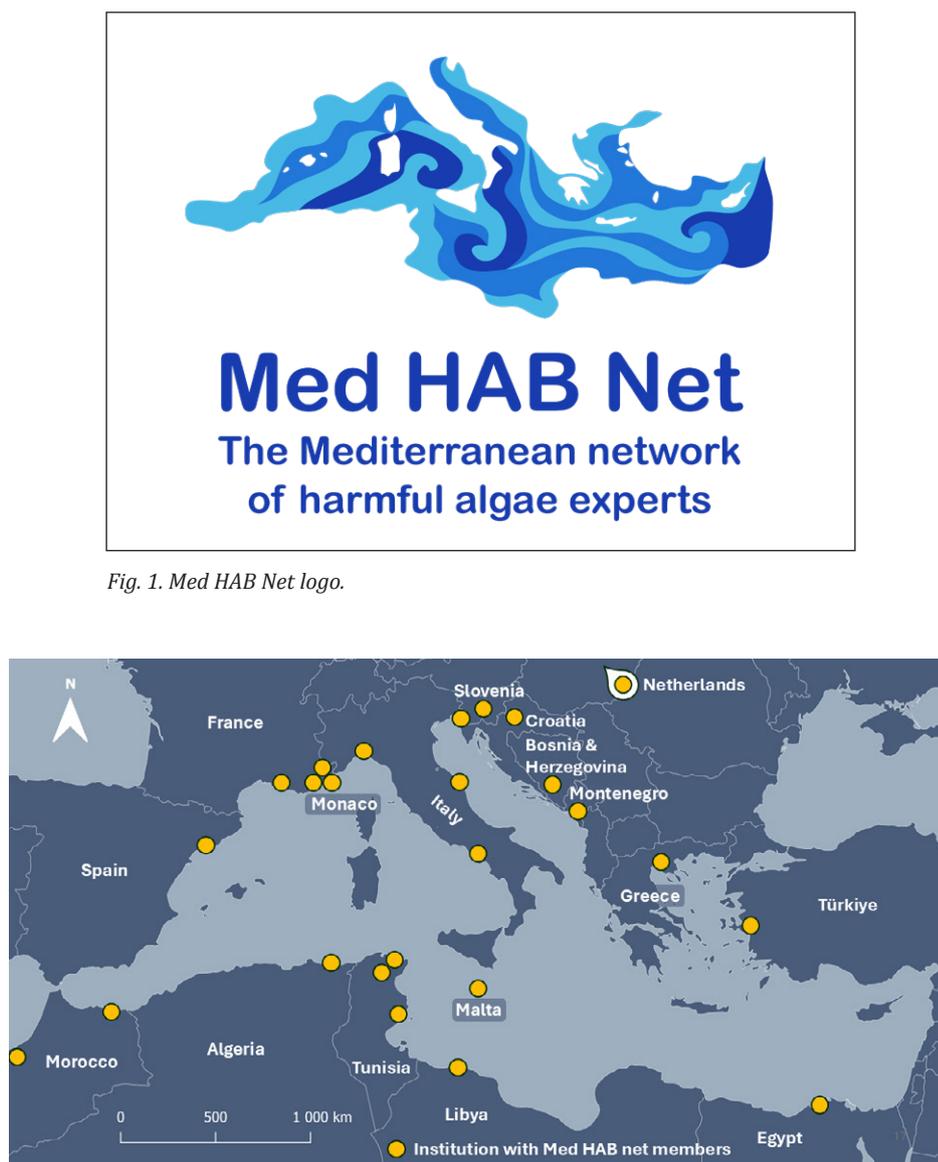


Fig. 1. Med HAB Net logo.

Fig. 2. Med HAB Net, 38 members from 17 countries as of January 2025.

promoting collaboration on joint projects and publications.

By bringing together scientists from across the Mediterranean region, Med HAB Net seeks to enhance the understanding of HAB occurrences and their impacts, while supporting food safety, food security, and sustainable economies in Mediterranean countries.

If you are interested in joining this network, please contact the corresponding author.

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GlobalHAB Scientific Steering Committee In-person Meeting

The IOC-SCOR GlobalHAB Scientific Steering Committee (SSC) members and liaisons convened for an in-person meeting on 24th–25th September at Scripps Institution of Oceanography, San Diego, California, USA (Fig. 1). Clarissa Anderson (recently appointed Chair) hosted the meeting to discuss the following objectives: 1) Review synergistic activities across regions, reports, and scientific highlights (2023–2025); 2) Establish science goals and discuss planned activities for 2025; and 3) Discuss the future of GlobalHAB beyond 2025. The committee recognizes the challenging funding landscape worldwide while also acknowledging the incredible opportunity brought to bear by the UN Ocean Decade. GlobalHAB SSC members aim to define a modern and relevant plan for tackling the ever-daunting question of HAB ecology, impact assessment, and prevention. Specifically, the SSC must continue to address challenges to advance ecological understanding of HABs in aquatic ecosystems, foster the development and adoption of strategies to respond to HABs, and reduce their societal impacts.

The committee engaged in focused discussions to review and evaluate progress, as well as to identify collaborative opportunities and objectives for sustaining international priorities in HAB research and response in the coming decade. The IOC-FAO Intergovernmental Panel on HABs (IPHAB) has requested the SSC to: 1) Review the GlobalHAB Science and Implementa-

tion Plan with a view to presenting to IPHAB-XVII what it recommends as the main elements of an international 10-year HAB science research programme after 2025, focusing on understanding HABs in the context of global sustainability; 2) Assess the ideal organization of and partnerships for such an international research program after 2025; 3) Recommend to IPHAB-XVII whether an international HAB research programme after 2025 should continue under the name GlobalHAB or under a new name, with an emphasis on delineating the functional role of the SSC in relation to the broader scientific community.

Recent GlobalHAB highlights and synergistic activities and communications at international scientific events (2023–2024) include:

- The 2nd UN Ocean Decade Regional Conference and the 11th WESTPAC International Marine Science Conference (22–25 April 2024, Bangkok, Thailand) <https://www.iocwestpac2024.com/>.
- United States National HAB Observing Network (NHABON) Community of Practice & Webinar Series (<https://iiosassociation.org/nhabon/>). NHABON Town Hall at the AGU Ocean Sciences Meeting in New Orleans, LA in February 2024 (<https://www.agu.org/Ocean-Sciences-Meeting-2024>).
- GlobalHAB International Workshop on Solutions to Control HABs in Marine and Estuarine Waters <https://iocaribe.ioc-unesco.org/en/event/1112>. Two-day workshop at the PICES 2023 conference in Se-

attle, WA, USA, jointly sponsored by GlobalHAB, NOAA, and PICES. (<https://meetings.pices.int/publications/book-of-abstracts/PICES-2023-Book-of-Abstracts.pdf>).

- Informal Consultative Process on Oceans and the Law of the Sea.
- A quantitative PCR (qPCR) workshop to foster the integration and the application qPCR/dPCR methodologies to improve HAB monitoring and develop early risk alert systems. This activity includes virtual meetings, an in-person meeting at the ICHA2023 in Hiroshima, Japan, and will continue at ICHA2025 in Punta Arenas, Chile (<https://icha2025.org/2025/01/29/qpcr-molecular-training-workshop-for-hab-species-detection-discrimination-and-quantification-13th-17th-october-2025-punta-arenas-chile/>).
- GlobalHAB, in collaboration with GESAMP and the EuroSea European project, collaborated on a White Paper on the current fundamental scientific understanding of *Sargassum* population dynamics and research gaps (<https://unesdoc.unesco.org/ark:/48223/pf0000391875>).
- Collaboration with the Harmful Algal Bloom Solutions (HAB-S) Programme, led by the IOC-FAO Intergovernmental Panel on Harmful Algal Blooms (IPHAB) (<https://oceandecade.org/actions/harmful-algae-bloom-solutions/>).
- Collaboration with the Observing Air-Sea Interactions Strategy (OASIS) Programme (<https://oceandecade.org/actions/observing-air-sea-interactions-strategy-oasis/>), endorsed by the Ocean Decade of the United Nations.
- GlobalHAB-Endorsed project meeting in Qingdao: HAB-dynamics on

both sides of the Pacific, China (22–23 October 2024) and PCM-HABs training for South East Asia mariculture stakeholders (1–11 December 2024).

Future activities and deliverables of the current SSC term include:

- A scientific publication on the monitoring of *Ostreopsis* during the last decade (2010–2024), carried out within the framework of Accord RAMOGE (<https://ramoge.org/en/ostreopsis-ovata-monitoring-programme/>).
- Webinar series on the impacts of CyanoHABs on drinking and recreational water quality.

- Presentation of the next 10-year science programme to IPHAB (Paris, March 2025).
- GlobalHAB participation in the One-Ocean Science Congress in Nice, France, 4–6 June 2025 (<https://one-ocean-science-2025.org/>) by hosting a Town Hall session ‘A Holistic Approach to Tackling the Rise of Harmful Algal Bloom (HAB) Impacts Worldwide’.
- Write a synthesis report on GlobalHAB achievements to present to SCOR.

The current term of GlobalHAB, guided by its Science and Implementation Plan, will end in 2025. Discussions at the meeting were instrumental in shaping

GlobalHAB’s response to IPHAB and potential focal points for a new plan. GlobalHAB will continue to explore and welcome community input throughout the future activities outlined above.

This meeting received in-kind institutional support, funding from SCOR, IOC, and NOAA and the SSC members’ institutions.

The next GlobalHAB SSC meeting will be held at ICHA2025 19th–24th October, in Punta Arenas, Chile.



Fig. 1. GlobalHAB Scientific Steering Committee meeting, Scripps, San Diego, September 2024. Left to Right: Back Row: Raphael Kudela, Philipp Hess (liaison IPHAB), Jorge Mardones, Henrik Enevoldsen (IOC-UNESCO), Dave Clarke, Marc Suddleson. Front Row: Clarissa Anderson (new Chair), Aifeng Li, Emily Twigg (SCOR Executive Director), Luisa Mangialajo, Silvia M. Nascimento, Elisa Berdalet (outgoing Chair), Aletta Yñiguez, Heather Raymond.

Harmful Algal Bloom (HAB) Session at the 7th Xiamen Symposium on Marine Environmental Sciences

The Harmful Algal Bloom (HAB) session, titled “Alleviating the Impact of Emerging Harmful Algal Blooms (HABs) on Coastal Ecosystems and Seafood Safety for a Sustainable and Healthy Ocean”, was held during the 7th Xiamen Symposium on Marine Environmental Sciences in Xiamen, China, from 14–17 January 2025 (Fig. 1). This session featured 39 papers, including 20 oral presentations and 19 poster presentations, showcasing a diverse range of research on emerging HAB events across the Asian Pacific region. Key topics included HAB dynamics, physiological and molecular responses of HAB species, early warning systems using novel technologies, advancements in automated monitoring and mitigation tools, and trends in the species composition, occurrence, and frequency of HABs in the region.

The session featured three invited speakers who shared their latest research findings (Fig. 2). Associate Professor Dr. Mitsunori Iwataki from the University of Tokyo, Japan, presented cases of fisheries damage caused by *Karenia selliformis*, a karenian dinoflagellate, along the coast of Western Japan in 2021, focusing on its morphology and phylogeny. Professor Dr. Nansheng Chen from the Chinese Academy of Sciences, China, highlighted the effectiveness of metabarcoding analysis in identifying diverse phytoplankton species in HABs while addressing challenges in distinguishing species and genetic diversity due to high intragenomic variations. He also emphasized the critical need for accurate interpretation of molecular markers. Dr. Kieng Soon Hii from Universiti Malaya, Malaysia, dem-

onstrated the integration of metabarcoding and machine learning to uncover the roles of both top-down (grazing) and bottom-up (nutrients) processes in shaping the dynamics of the tropical *Alexandrium minutum* blooms.

In addition to the invited talks, several notable studies enriched the session’s discussions. Professor Dr. Haifeng Gu from the Third Institute of Oceanography, China, provided valuable insights into the physical drivers influencing *Noctiluca scintillans* blooms near Pingtan Island, highlighting key mechanisms with crucial implications for forecasting and developing early warning systems for this species. Dr. Chun-kit Kwok from the Fisheries and Conservation Department of the HKSAR Government shared diversity data from Hong Kong’s long-term red tide monitoring programme, which has documented red tide incidents since 1975. Associate Professor Dr. Ye Liang (Nanjing University of Information Science and Technology, China) investigated the impact of homo-yessotoxins (homo-



Fig. 1. Group photo of the presenters at the HAB session.



Fig. 2. Invited speakers and oral presentations: Prof. Dr. Mitsunori Iwataki, Prof. Dr. Nansheng Chen, Dr. Chun-kit Kwok and Dr. Kieng Soon Hii.

YTX) on the economically significant abalone species, revealing that homo-YTX induces oxidative stress, disrupts antioxidant defenses, impairs metabolic and digestive functions, and triggers apoptosis, with transcriptomic analysis confirming apoptosis as the primary toxicity pathway. Dr. Jianping Li (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China) introduced an advanced fluorescence imaging flow cytometer system, FluoSieve, integrated with an image restoration CNN model IfPhytoRS, which addresses challenges in monitoring phytoplankton in complex natural seawater environments. This system enhances imaging resolution and throughput for HAB monitoring and ocean observations.

The session also included presentations by postgraduate students and early-career researchers, with the third prize for best poster presentation

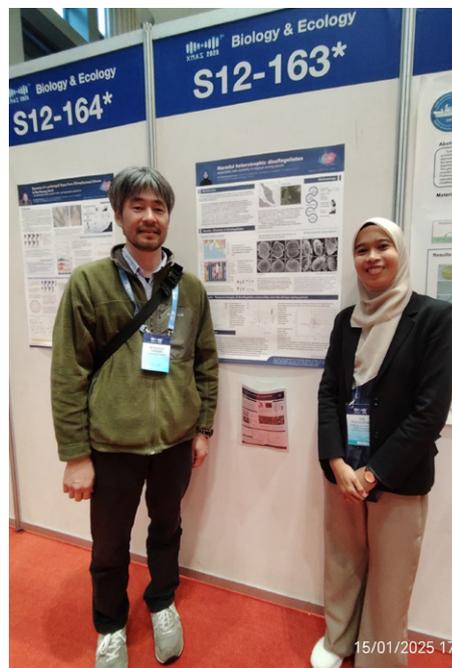


Fig. 3. Ms Siti Nursyuhada Baharudin received the third prize for the Best Student Poster Presentation Award from Prof. Dr. Mitsunori Iwataki.

awarded to postgraduate student Ms Siti Nursyuhada Baharudin from Universiti Malaya (Fig. 3). The titles and abstracts of the presentations can be accessed via <https://xmas.aconf.org/timetable.html?session=196129>. In summary, the session showcased significant advancements in regional HAB research and provided a platform to foster collaborations at both regional and international levels to tackle the growing challenges posed by HABs on regional and global scales.

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Institute of Hydrobiology successfully conducts the HAB Training Course for Developing Countries Under the “Belt and Road” Initiative

Harmful algal blooms (HABs) represent a pressing global environmental issue, posing significant threats to human health and national security worldwide. To address these challenges, the Institute of Hydrobiology, Chinese Academy

of Sciences (CAS), organized the “2024 International Training Course on the Monitoring, Prevention and Control of Harmful Algal Blooms”. Held from October 24 to November 6, 2024, in Wuhan, China, the program aimed to foster col-

laboration among countries involved in the “Belt and Road” Initiative and other developing nations. This initiative contributes to building a global community with a shared future for humanity and supports the achievement of the Unit-



Fig. 1. Lecture series and academic exchange sessions. CAS HAB Training Course 2024.



Fig. 2. Laboratory session. CAS HAB Training Course 2024

ed Nations Sustainable Development Goals.

The training course brought together an extensive pool of expertise in HAB research, featuring distinguished lecturers (Fig. 1), including: Prof. Joanna Mankiewicz-Boczek (University of Lodz, Poland), Prof. Po Teen Lim (University of Malaya, Malaysia), Prof. Deniz Ozkundakci (University of Waikato, New Zealand), Prof. Han Boping (Jinan University, China), Prof. Wu Qinglong (Nanjing Institute of Geography and Limnology, CAS, China), Prof. Yu Rencheng (Institute of Oceanology, CAS, China), Prof. Li Renhui (Wenzhou University, China), Prof. Su Yuping (Fujian Normal University, China), Prof. Zhang Junyi (Jiangnan University, China), Assoc. Prof. Zhang Caiyun and Dr. Chen

Jixin (Xiamen University, China), Dr. Liu Minlu (Third Institute of Oceanography, China), Dr. Kun Shan (Chongqing Institute of Green and Intelligent Technology, CAS, China), Dr. Peng Liang (Jinan University, China). Prof. Cao Xiuyun, Prof. Zhou Yiyong, Prof. Song Lirong (Institute of Hydrobiology, CAS, China). Additionally, prominent scientists from other Chinese research institutions included: Dr. Liu Yongding, Dr. Xu Jun, Dr. Gan Nanqin, Dr. Song Chunlei, Dr. Zhang Qi, Dr. Li Tianli, and Dr. Zheng Lingling.

The training course adopted a multidisciplinary approach, integrating academic exchanges, lectures, laboratory sessions (Fig. 2), fieldwork, on-site teaching, and social visits. Participants received certificates from Prof. Cao of the Institute of Hydrobiology during a

formal closing ceremony (Fig. 3). Participants shared their reflections, emphasizing the knowledge and insights gained through the program. This training course significantly strengthened international scientific exchange and collaboration in HAB research, particularly among Southeast Asian countries participating in the “Belt and Road” Initiative.

The course was sponsored by the Bureau of International Cooperation of the Chinese Academy of Sciences and supported by the Key Laboratory of Algae Biology, CAS, the Key Laboratory of Lake and Basin Water Safety, the Sediment Environment Professional Committee of the Chinese Society of Environmental Sciences, the Water Environment Branch of the Chinese Society of Oceanology and Limnology, and the Association Office of the Hubei Society of Oceanology and Limnology.

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Fig. 3. Group photo. 2024 International Training Course on the Monitoring, Prevention and Control of Harmful Algal Blooms.



Showing the route to ICHA 2025!

Welcome Message

Dr. Leonardo Guzmán, Chair of the Local Organizing Committee of the International Conference on Harmful Algae (ICHA 2025), welcomes you to this key event on harmful algae and aquatic toxins. Instructions for registration and abstract submission can now be found on the conference website: <http://www.icha2025.org>. This 21st edition of ICHA conference will be held at the *Dreams del Estrecho* Hotel in Punta Arenas, Chile. The conference will feature keynote lectures by international researchers, workshops, and presentations on cutting-edge techniques in harmful algal bloom (HAB) studies. Exhibition booths will be located within the hotel and adjacent spaces.

Abstracts

Attendees wishing to present their work (in oral, poster, or lightning presentation format) are invited to submit abstracts of up to 250 words. The **deadline for abstract submission is June 1, 2025**. Topics cover a wide range of areas, with 17 thematic categories, in-

cluding social sciences, the latest technologies for studying harmful algae, and the effects of HABs on ecosystems, public health, and aquaculture. This includes both freshwater and marine ecosystems.

New Features

For attendees traveling with children, a **nursery** will be available, allowing parents to fully engage in the conference without concern. Additionally, for the first time, the conference will include **outreach activities**, such as an open conversation with the local community (“scientific coffee”) on topics related to harmful algal blooms (HABs) and other scientific issues. High school students involved in scientific groups will also have the opportunity to interact with experts in various areas of harmful algae research.

Sponsors

ICHA 2025 is open to support from both the public and private sectors. Our first sponsor, **IMENCO**, is a Norwegian engineering company established in 1979. Its Chilean subsidiary has been active

in the aquaculture sector for 20 years, offering a variety of technological products and services. We thank IMENCO for being our first formal sponsor.

Registration and Fees

Members of the International Society for the Study of Harmful Algae (ISSHA) will receive discounted registration rates. **Early bird** registration, available **until May 16, 2025**, offers a lower fee. Standard registration applies after this date. Full details on registration and fees can be found on the conference website.

If you have any questions or need more information, please **contact us** at info@icha2025.org or visit our website at www.icha2025.org.

Contacts

Pamela Carbonell & Leonardo Guzmán (Chair), 21st ICHA Local Organizing Committee, Instituto de Fomento Pesquero, Puerto Montt, Chile.

Email contact person:
leonardo.guzman@ifop.cl

Confirmed qPCR Molecular Training Workshop

This invitation is for interested participants to join a five-day training workshop on qPCR molecular methods for HAB species identification and quantification from the 13th – 17th October in Punta Arenas, Chile, the week prior to ICHA2025. This workshop is being organised and conducted by an international committee of experts who specialize in qPCR detection of HAB species, where this committee is supported by GlobalHAB.

This workshop is aimed at giving participants a theoretical understanding and practical application of real time quantitative PCR and its applica-

tions in harmful algal bloom (HAB) monitoring. The course includes presentations, discussions, and practical hands-on demonstrations which covers all aspects of qPCR assay development, implementation and application, from designing and validating qPCR assays for the detection of target DNA from field and culture samples and including data analysis/result interpretation and method trouble shooting.

SYBR green and TaqMan assays will be demonstrated, focusing on key species groups of HAB microalgae (e.g., *Alexandrium*, *Azadinium*, *Ostreopsis*, *Phaeocystis*, *Gambierdiscus* and *Pseudo-*

nitzschia spp. etc). This list of target assays is flexible accordingly to the needs of the participants, who are welcome to bring their own field samples to be used during the training. After completing the course participants will be able to design qPCR assays specific for their individual regional HAB species profiles and perform qPCR experiments as well as to interpret and analyze data.

Goals of the Workshop

- To give participants a deeper understanding of qPCR and its applications
- To improve harmful algal bloom de-

tection by using molecular tools

- To explore the potential application of qPCR for the monitoring and forecasting of harmful algal blooms in (own) monitoring programs
- To provide guidance for developing own qPCR assays for desired target species

This workshop is intended for persons working in or planning to initiate harmful algal monitoring programs, for sci-

entists using or planning to apply qPCR, and are interested in and equipped to applying this molecular technology. Participation is limited to 20 participants, with a documented professional interest in phytoplankton identification by molecular biological methods.

Applications should be submitted **before 30th June 2025**, by email to:

Uwe John uwe.john@awi.de

Dave Clarke (cc): dave.clarke@marine.ie

A short letter justifying the participation and any previous molecular experience of the applicant and details of the proposed application of the knowledge gained to HAB monitoring should be submitted. A brief CV of the applicant's experience and qualifications must also be provided. The course will be taught in English, where a good knowledge of English is therefore required. There will be no registration fee, but participants will have to provide for their own travel and accommodation expenses.

Pre-announcement: ISSHA Achievement Awards – Call for nominations

The International Society for the Study of Harmful Algae (ISSHA) will soon open the call for their bi-annual achievements awards. These awards include the Yasumoto Lifetime Achievement Award to recognize long and outstanding contributions to harmful algal research, and the Patrick Gentien Young Scientist Award to recognize achievements in harmful algal research by an early career scientist. Various aspects of harmful algal research will be considered, including scientific and/or societal impact, mentoring, teaching, dissemination and public outreach.

Please help us in recognizing the accomplishments by colleagues in our



community, and consider to submit a nomination for the ISSHA Achievement Awards. The nominations will be short (one page), simple to make and can be submitted by e-mail. We aim for a wide range of nominations that reflect ISSHA's diverse community and our mission to inclusion across race, gender, age, identity and geography. Nominations can be submitted from 16 March until 16 May 2025. Information about submission will be shared through the ISSHA website (<https://issha.org/members-community/awards/>). Both the nominator and nominee need to be member of ISSHA at the time of nomination.



IOC Training Course and Identification Qualification in Harmful Marine Microalgae (November 2025)

Since 1993 the IOC has conducted training courses on harmful microalgae. The purpose has been to improve the taxonomic and identification skills of the participants for research purposes and for practical monitoring of harmful algal blooms.

From 2006 the IOC training in HAB identification has been offered within a new framework which gives accreditation. The present course includes now a practical exam at the end of the course with an IOC Certificate of Proficiency in Identification of Harmful Algae issued to participants who pass the exam. We know by experience that many of the more than 500 trainees we have had over the years have wished the courses to give accreditation, and in some countries, the IOC courses have become a reference for laboratories to be approved for carrying out regulatory monitoring for harmful microalgae.

The IOC Science and Communication Centre on Harmful Algae, University of Copenhagen, Denmark is organizing the course.

Course description

The course includes 100 hours of teaching and is divided into two parts.

Part 1) The first part of the course is an internet teaching programme on the Ocean Teacher platform giving general introductions to the various groups of harmful algae; this part is mainly for self-study and estimated to 40 hours of reading.

Part 2) The second part is a practical course in species identification (This part of the course will focus on identification of harmful algal species by light microscopy, with particular reference to the 'IOC Taxonomic Reference List

on Toxic Plankton Algae'. The use of electron microscopy will be introduced, but practical exercises are not included. During the course, a long list of species will be demonstrated either as cultures (*subject to the availability of cultures) or as preserved material). Part 2 includes 60 hours of teaching and a microscope will be available to each participant during the entire period.

Participants

The course is aimed at participants who have some years of practical experience in identification of microalgae. The number of participants is limited to 14. If there are more applicants than available seats, priority will be given to applicants who have direct research or management responsibilities with regard to the occurrence of harmful algae.

Dates

Part 1 will be available on the 'International Oceanographic Data Exchange' (IODE) teaching platform 'Ocean Teacher' from October onwards; part 2 takes place from 18–29 November 2025.

Venue

IOC Science and Communication Centre on Harmful Algae, Department of Biology, University of Copenhagen, Denmark, c/o Danhostel, Lejrskolevej 4, 3400 Hillerød.

Application

Dead-line for application is 15 June 2025, see link to application form <https://oceanexpert.org/document/31761>.

Language

English

Course lecturers

Dr. Santiago Fraga, Dr. Jacob Larsen, Dr. Nina Lundholm, Professor Øjvind Møstrup.

Enquiries may be sent to Jacob Larsen, jacobl@bio.ku.dk

Price

The course is organized on a cost-recovery basis. The price of the course is 4200 EUR and it is a package deal, which covers all expenses during the course period, see also link below; thus

- Accommodation, arriving to the course venue on 18 November, check-in from 16.00, and check-out on 29 November at 10.00
- All meals during the course, starting with an evening meal upon arrival on 18 Nov. and finishing with breakfast on 29 Nov
- Access to the distant learning programme on Ocean Teacher which will be available two- months prior to the practical course
- Teaching material including hard copies or pdf-versions of several taxonomy books, IOC Manuals and Guides and conference proceedings which will be distributed during the practical part of the course.

Information on the teaching material and programme can be found at <https://oceanexpert.org/event/4683>

Contact persons

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Jacob Larsen jacobl@bio.ku.dk

Review: Sargassum white paper 2024

In 2011, the scientific community was totally flabbergasted by an unexpected and unprecedented beaching of enormous amounts of pelagic *Sargassum* along the shores of the Caribbean coasts and tropical West Africa. Before that year, beaching of pelagic *Sargassum* was a common occurrence in the Caribbean basin and the Gulf of Mexico, typically at the end of the year when the easterly trade winds pushed floating algae from the Sargasso Sea westward. However, amounts were negligible to moderate most of the time.

Due to the magnitude of the influx—both in terms of amount of beached seaweed and the geographical extent—a significant body of research has since emerged to understand the underlying causes of this phenomenon. Much to the dismay of local communities, the 2011 influx marked the beginning of the “new normal”, with annual *Sargassum* inundations affecting most Caribbean coasts, and biomass peaks occurring every three to four years.

In 2021, a first white paper on *Sargassum* was released by UNEP-CEP. This document focused on the effects of *Sargassum* influxes on economic activities and coastal ecosystems, as well as initiatives developed to mitigate these impacts and convert the biomass into a resource for blue economy.

In 2024, a second white paper on *Sargassum* was released by the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) [1]. This new document aims to complement the first white paper by focusing on the current understanding of the geographical and temporal variations of *Sargassum* influxes and the factors influencing them at oceanic and sub-regional scales. Additionally, it highlights existing knowledge gaps and challenges in addressing them.

The document is based on an extensive literature review covering three major topics:

1) Spatial and temporal variability of *Sargassum* distribution and biomass

This section presents current methods for detecting *Sargassum* biomass, using satellite and other remote sensing tech-

nologies, as well as more traditional ship- and land-based estimations. The authors review knowledge on *Sargassum* influxes before 2011 and their sources (referred to as *Sargassum* loop). Prior to 2011, holopelagic *Sargassum* was largely restricted to the Sargasso Sea, with its movements governed by the Gulf Stream and trade winds, which transported it toward the Gulf of Mexico and Caribbean before returning to the western North Atlantic. The paper then analyzes the current situation (the Great Atlantic *Sargassum* belt, post 2010–2011), which originated due to an anomaly in the North-Atlantic Oscillation (NAO) that initially pushed *Sargassum* from the Sargasso Sea eastward and then southward, establishing a new population in the equatorial Atlantic. This shift has been responsible for the recurrent blooms since 2011.

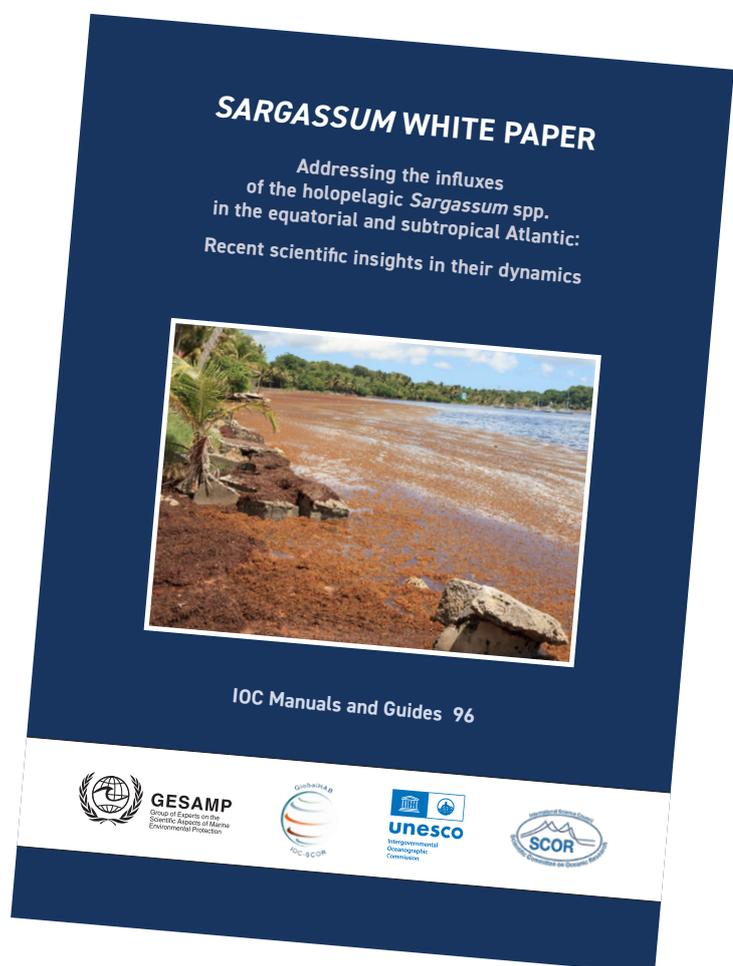
The authors also discuss biomass variations in time and space since 2011. Peak abundance typically occurs between May and July, while minimum

landings and coverage are recorded between October and December. In addition to seasonal fluctuations, inter-annual biomass variations have been observed. Since 2011, there has been a general increase in the algae influx, with 2013, 2018 and 2022 being peak years, whereas some years, such as 2015, exhibited little proliferation. Peak years may be the result of a large residual population in the equatorial Atlantic during winter months.

Finally, changes in the taxonomic composition have been noted, with three dominant morphotypes: *Sargassum fluitans* III, *Sargassum natans* I and *S. natans* VIII. Historical records reported *Sargassum natans* I as the dominant form in the Sargasso Sea. However, since 2011, a shift has occurred with *Sargassum natans* VIII nearly disappearing from recent blooms, which are now dominated by *S. fluitans* III.

2) Linkages between physical factors and bloom events

This section highlights the lack of data on beach-cast biomass since 2011. Only a few beaches across the Caribbean basin and West African coast have been monitored to estimate wrack biomass.





Images of Sargassum overgrowth in Serranilla Cay, San Andrés Archipelago (Colombia), Caribbean Sea. Photos: Brigitte Gabio.

Some efforts to fill in these gaps have relied on remote sensing images and citizen science initiatives.

To improve forecasting capabilities and support policymakers and stakeholders in local management strategies, substantial effort has been dedicated to understanding how wind and ocean currents influence the distribution and accumulation of algal biomass. The *Sargassum* belt lies in a region with complex circulation patterns, where atmospheric features such as the Intertropical Convergence Zone (ITCZ) and the North Atlantic Subtropical High (NASH) influence wind flows, adding further complexity to the movement dynamics of pelagic masses. These dynamics remain only partially understood.

3) Drivers of continued proliferation of *Sargassum* in the Tropical Atlantic

Winds and currents affect the aggregation of floating *Sargassum*, which may form clumps, windrows, windrows with small or large patches, or even large quasi-circular patches hundreds of meters in diameter. These aggregations can also shift vertically in the water column, resurfacing when plants are young, or sinking when the thalli are older, with their air vesicles damaged and loaded with epiphytes. Hurricanes have been suggested as potential driv-

ers of *Sargassum* growth by increasing water nutrient loading through enhanced land runoff and deeper vertical mixing; however, their positive effect on *Sargassum* remains unproven.

Seawater temperature is another key factor influencing *Sargassum* growth. The three dominant morphotypes exhibit similar, though not identical, optimal temperature ranges, (22–28 °C), with growth rates declining above 30 °C. Therefore, temperature alone is not the primary factor shaping morphotype competition and biomass variations. Nutrients sources in the *Sargassum* belt are diverse, including inputs from Sahara dust, river discharge, and upwelling along the West African coast. While these nutrition sources contribute to *Sargassum* growth, bloom intensity appears to be primarily driven by anomalous patterns in regional winds and currents.

The final section of the white paper addresses knowledge gaps, as identified by the local scientific community, stakeholders and private sector actors.

While understanding of the *Sargassum* phenomenon has significantly advanced, several critical gaps remain, including:

- Methodology limitations, such as inadequate resolution in satellite sensors for detecting small clumps, or

minimizing cloud cover interference. Furthermore, high-tech methodology should complement and not replace more standard land-based studies, which are lacking in most affected areas.

- Lack of experimental studies to elucidate: i) complex interactions between wind, currents, waves and swells; ii) how different physical conditions affect growth and dispersion of *Sargassum* under different climate change scenarios, as well as iii) the role of nutrient availability on *Sargassum* growth.
- Limited funding and research collaboration, both within and among countries. There is strong need for increased research in basic science to improve understanding of *Sargassum* physiology.

References

1. GlobalHAB & GESAMP 2024. *IOC Manuals and Guides 96. UNESCO-IOC-GE-SAMP, Paris, 61 pp.* 10.5281/zenodo.13935854

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Interview with Marina Montresor

Marina Montresor, a renowned researcher in the field of harmful algal blooms (HABs), has dedicated her career to uncovering the mysteries of these fascinating and sometimes dangerous microorganisms. From her early days studying plankton in Padua to her groundbreaking work on *Pseudo-nitzschia*, her contributions have significantly shaped our understanding of HABs. In this interview with Kenneth Mertens, she reflects on her journey, shares insights from her most pivotal discoveries, and discusses how advancements in technology and international collaborations have transformed the field of harmful algae research.

Can you tell us about the early days of your career and how you became interested in harmful algal blooms (HABs)?

My initial training was in plankton identification using classical microscopy in Padua. I then moved to Naples with a fellowship funded by the Stazione Zoologica Anton Dohrn (SZN). My first exposure to HAB species came during a period I spent in Woods Hole at Don Anderson's lab. It was there that I got the opportunity to go out into the Gulf of Maine, which made me realise the potential of pursuing a larger-scale project on HABs. In Naples, I worked with Carmelo Tomas, who trained me in culturing methods and gave me guidance on how to carry out research. Later, I worked with Donato Marino, who fo-



Marina Montresor

ocused on taxonomy and ecology. Adriana Zingone, also a young researcher at the time, was there as well. We began looking at *Alexandrium* species, using light and electron microscopy to study *A. minutum* and the *A. tamarense* complex, a paper we presented at the ICHA conference in Lund [1]. From there, we moved on to studying *Dinophysis*, particularly *Dinophysis acuminata* and *D. sacculus*. Adriana and I spent hours at the microscope, meticulously examining the sulcal plates, and describing the morphological continuum [2]. These early years were focused on classical morphological work, as molecular tools were not available then.

Who were your most influential mentors or collaborators when you began working on harmful algae?

Don Anderson, Carmelo Tomas, and Donato Marino were crucial mentors for me. Donato, who led the lab in Naples, passed away too soon, unfortunately. Additionally, Barrie Dale had a significant impact. He visited Naples for one of the Advanced Phytoplankton Courses and gave lectures on dinoflagellate cysts. I have fond memories of sampling around the Gulf of Naples with Barrie, where he showed me his "sediment-sucking" device. It was an adventurous day, asking fishermen for help, crossing fences to sample in brackish lagoons, and later learning how to sieve the samples in the lab. Barrie introduced me to working with dinoflagellate cysts, a topic I pursued for many years (e.g. [3] and various publications describing the vegetative stages produced by the germination of cyst morphotypes). Together with Giuseppe d'Onofrio, we published the first paper in which the diversity of species that produce calcareous cysts was explored integrating morphological information of both vegetative cells and cysts and ITS rDNA sequences [4]. Later, Wiebe Kooistra joined us, leading to our discovery of cryptic diversity in *Scrippsiella trochoidea* [5] and in different diatoms [6], underscoring the importance of molecular work.

What have been the most significant discoveries you've made in your work on harmful algae?

One key paper by my PhD student, Alberto Amato, explored the biological



Fig. 1. Marina Montresor and Carmelo Tomas during her fellowship at Stazione Zoologica.

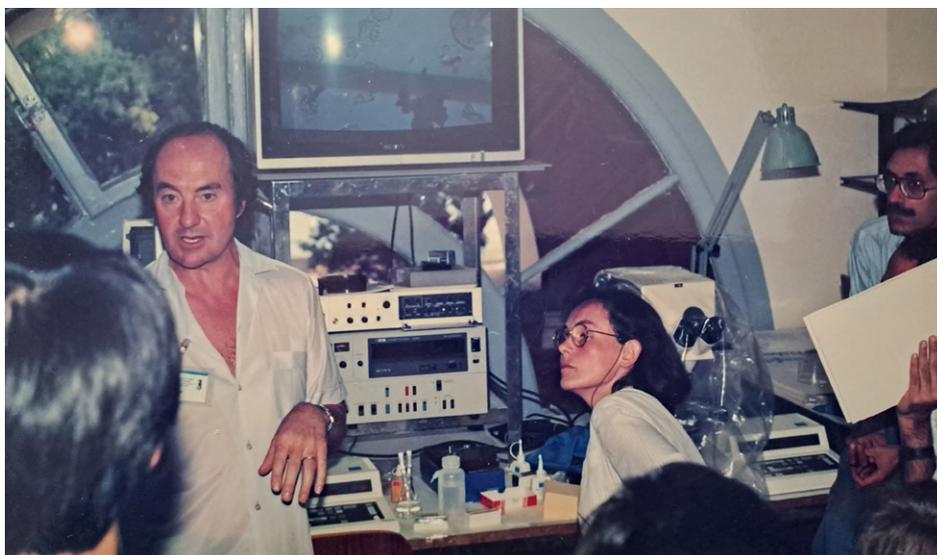


Fig. 2. Marina Montresor with Barrie Dale and Donato Marino at the Advanced Phytoplankton Course in 1990.

species concept in *Pseudo-nitzschia* [7]. Species in this genus are heterothallic - i.e., strains can have mating type plus (+) or minus (-) – and we crossed dozens of strains of different species to establish their relationships. I'm quite proud of this work, as it was new and groundbreaking. Another pivotal paper, written in collaboration with Mariella Ferrante and her group, marked a significant shift in my research towards genomic techniques [8]. One important outcome was the identification of a gene determining the mating type in *Pseudo-nitzschia multistriata*. I learned a great deal during this study that, for me, was a kind of 'detective story', from the analysis of transcriptomic data to the validation of target genes, to genetic transformation by which the *MRP3* gene was inserted in a strain of the opposite mating type and induced sex reversal.

How has the field of harmful algae research evolved since you started your career?

Over the last 30 years, I've witnessed a significant evolution in methods, from field observations and classical taxonomy to molecular tools, flow cytometry, and other cutting-edge technologies. The increased interest in HAB species, particularly for economic reasons, has led to many discoveries. This trend highlights how focused research on certain species can result in major advancements in our understanding of their biology and ecology. However, I believe that no species exists in isolation; they interact with many others, and studying these relationships is also crucial.

What were some of the major challenges you faced while researching harmful algae, and how did you overcome them?

I was fortunate to have the support of our institute, which funded the LTER monitoring site MareChiara in the Gulf of Naples back in 1984 [9], and several PhD projects. While there were challenges, particularly in terms of time and resources, I didn't face major obstacles due to the excellent collaborations within and outside the institute. In our region, there haven't been many major HAB issues, apart from *Ostreopsis cf. ovata*, which caused some closures and was mainly handled by Adriana. We

focused mostly on *Pseudo-nitzschia* as a model genus, not because it was associated with significant problems, but because it was abundant in the Gulf and we could establish *P. multistriata* as a model for genetic and genomic studies [10].

Which collaborations have been the most rewarding throughout your career?

I've been fortunate to work in Naples, where there was a collaborative team, including Adriana, Wiebe, Diana Sarno, and Mariella Ferrante, all bringing their own expertise. Undoubtedly, my collaboration with Mariella was transformative, opening up new research areas in the lab. We had and still have fruitful collaborations with the team of Wim Vyverman at Ghent University, another group actively involved in the study of diatom life cycles, which I see as a key aspect of future research. I also have fond memories of working with Anna Godhe, Anke Kremp, and Karin Rengefors, with whom I shared an interest in life cycles. We had fruitful, open discussions and collaborations, particularly on the sexual reproduction of *Skeletonema marinoi*. Thanks to an ASSEMBLE project, we were able to visit each other's labs, with me going to Gothenburg, and we later published on the life cycle and genes expressed during the sexual phase of *Skeletonema* [11].

What role do international networks, such as the GlobalHAB programme, play in advancing research on harmful algae?

International networks like GlobalHAB are essential. While we're always connected via social media, it's still vital to have formal networks that bring together respected scientists, provide updates on the latest HAB research topics, and allow to exchange best practices. GlobalHAB is invaluable in this regard.

How important are interdisciplinary collaborations in the study of harmful algae?

Interdisciplinary collaborations are absolutely essential. A single researcher, even with a PhD student, can accomplish very little on their own these days. Bringing together experts from different fields is the best approach. My expertise in ecology, diversity, and

life cycles complemented the work of population geneticists like Gabriele Procaccini and Uwe John, and genomic specialists, and allowed us to publish interesting papers (e.g., [12-15]). The key is to be open to sharing ideas.

Looking back, what are you most proud of in your career?

I'm most proud of the work on *Pseudo-nitzschia* in which, together with various colleagues and valuable PhD students and post-docs, we explored cryptic diversity, studied the life cycles in the laboratory and in the natural environment [16] and, in the most recent years, started to unveil the genetic mechanisms regulating their life cycle [17].

What are some key lessons you've learned over the years that you would pass on to the next generation of researchers?

I would advise the next generation to explore new possibilities in collaboration with colleagues who have different expertise. Collaboration is key, and it's important to teach students to discuss and share ideas. I've always enjoyed retreats and brainstorming sessions, such as the SINERGIA (=synergy) initiative, launched by Roberto Di Lauro, a former president of Stazione Zoologica, to bridge the gap between genomic approaches, used by e.g. researchers in developmental biology, and ecological studies on plankton and other organisms. Listening to molecular biologists' seminars was eye-opening and useful in expanding one's perspective.

How has your approach to harmful algae research changed from the beginning of your career to now?

Metabarcoding is a new method that has brought valuable insights, but much work remains to be done. This approach should complement classical taxonomy, not replace it. We still face challenges with the lack of reference sequences, and there are other gene regions that remain unexplored. Perhaps a future GlobalHAB synthesis paper or workshop could address this point. While new methods such as qPCR and metabarcoding are essential, we should not neglect classical taxonomy, as both approaches are necessary to fully understand these organisms and their toxins.



Fig. 3-4. Advanced Phytoplankton Course in 2015; Marina Montresor teaching dinoflagellates alongside Karen Steidinger (left) and with Jacob Larsen (right).

How have advancements in technology impacted research on harmful algae during your career? What role do you see molecular tools, such as DNA sequencing, playing in the future of harmful algae research?

Modern tools, like population genetics and genomic techniques, have opened up new avenues, allowing us to better understand different aspects of the biology of unicellular organisms. However, while genomic studies are relatively easy in diatoms, they still represent a challenge for dinoflagellates, which have huge genomes, but technologies are rapidly evolving. We should be aware there is a considerable amount of work involved in identifying key genes for specific biological processes. As an example, the study of sexual reproduction in diatoms took years of lab work in collaboration with the groups of Anne Godhe, Mariella, and Wim Vyverman. A paper on this work is in preparation, which will present the genes involved in sexual reproduction in the natural environment. This kind of work is essential, as it ties together field and lab data to provide a deeper understanding of the organisms.

In your view, what are the most pressing environmental concerns related to harmful algae today?

The study of HABs is crucial because of the increasing reliance on aquaculture, with clear economic and societal reasons for understanding them. Predicting HABs remains a significant challenge, and there should be more research into the damage these organisms cause, especially in veterinary and medical research. Toxins like domoic acid found in marine mammals high-

light the potential importance of this issue. Monitoring is key, and the development of new assays will help. It's also important for plankton monitoring to be supplemented with targeted qPCR, regionally tailored to specific needs.

How has climate change affected harmful algal blooms, based on your research or observations?

I haven't found direct evidence in my own research, but the literature suggests that HABs are spreading to new areas, such as the Arctic and the coast of China, as well as other countries. This shift is likely due to climate change. Shifts in biodiversity and nutrient availability are also contributing factors. It's a complex, multifactorial issue that involves changes in circulation patterns, nutrient availability, and temperature. We don't have much long-term data; there needs to be more long-term studies. This allows us to track changes, although expensive it is worth the investment. In Naples, there is a long-term site that was largely funded by our institute, with external contributions from projects. Bringing together research and monitoring agencies can help continue such initiatives.

What role do scientific journals like Harmful Algae play in advancing knowledge about harmful algal blooms?

It would be nice to have Harmful Algae as open access. I realize this is not easy to establish from an editorial viewpoint, but it would be important for the community.

How important do you think it is to contribute to community dissemina-

tion efforts such as Harmful Algae News?

It is important; it helps build a community. More efforts could be made through social media though.

Are there particular regions of the world where harmful algal blooms are becoming more frequent or severe?

Definitely, in the Pacific along the coast of China and the Philippines, although we don't have much information what happened in those waters in the past. And in some regions like Africa, we don't have enough information. Therefore, it is important to disseminate methodologies that are affordable for those regions, where researchers cannot afford expensive genetic methods.

Have you noticed differences in how various countries or regions approach the study and management of harmful algae?

In Italy, this could be improved. There are big regional differences since there is a national agency that is split into regional agencies. They have differences in finances and staff involvement. They mostly do toxin analysis, sometimes plankton counts, or collaborate with research institutes [18]. Sometimes they use genetic techniques, but there are lots of differences.

How has global cooperation in HAB research improved our ability to predict and respond to harmful algal events?

This is difficult, and again, long-term studies are important. The knowledge about the organisms is still limited: as an example, we do not fully understand

what causes a bloom. Obviously, phytoplankton needs light and nutrients, but often we do not find relationships between the onset and decay of a bloom and environmental factors. We should focus on the mechanisms that lead to the bloom of the individual species. Is the regulation of growth modulated internally? We don't know. I think this is the most important question, not only for HAB species but also for biological oceanography. Species do not keep constant growth rates; they switch from a period of non-growth and suddenly their division rates increase before stopping again. Why? I remember a talk by Victor Smetacek years ago where he compared the bloom to cancer cells: are there species-specific genes that can be activated upon perception of environmental or biological stimuli?

As a woman in science, have you faced particular challenges throughout your career, and how did you navigate them?

Again, I've been lucky. I was not discriminated as a woman. However, I did notice that men are better at lobbying among themselves compared to women. Women should be more proud and should stand up. I always try to support women PhDs and postdoc but on average, at least in the past, women were less self-confident.

Have you seen progress in gender equality and diversity in the field of



Fig. 6. Marina Montresor at the 'Molecular Life of Diatoms' conference (Kobe, Japan, 2017).

harmful algae research?

Maybe this should be a topic for the HAB newsletter and should be enriched with real data. I have been in evaluation panels of research projects and I think that nowadays there are more projects led by women. Women should be more proud, but not aggressive. They should try to spread more equality among them.

What has your experience been like mentoring the next generation of scientists?

That is the best part of my professional life. I enjoyed and still do mentoring. One should follow PhD students carefully, because at times they should be

redirected. But they should also be free to develop and pursue their own ideas. Nowadays, PhDs are too short (in Italy only three years) and the pressure to publish is high. Perhaps an extension to four years would allow for research to be done in a more relaxed way.

How do you view your role as a leader in the field of harmful algae research?

I think my work on life cycles has been important, and I hope it has contributed significantly.

What do you think are the biggest unanswered questions in harmful algae research?

The mechanism of blooms and their prediction, definitely, and next to that, the species concept and the evolution of species and populations. Species concepts are based on multicellular organisms, but we still do not have a sound concept for unicellular organisms.

What are some emerging trends or research areas in harmful algal bloom science that excite you?

The use of genomic tools. I was impressed with the interdisciplinary TREC project <https://www.embl.org/about/info/trec/> lead by the European Molecular Biology Laboratory (EMBL) in Heidelberg and involving several European research institutions. TREC aims at bringing together the advanced expertise in cell biology, developmental biology, genomics and imaging with the knowledge available on the diversity and ecology of microbial organisms. The TREC team visited Napoli last



Fig. 5. Marina Montresor with Miriam Seguel (left) and other participants of the Course on Dinoflagellate Cysts at the University of Concepción, Chile.



Fig. 7. Marina Montresor with Adriana Zingone, Diana Sarno, and Carina Lange.



Fig. 8. Marina Montresor at the ICHA Conference in Nantes with Uwe John, Angela Falciatore, Lisa Campbell, and Adriana Zingone.

spring and it was amazing to see their equipment on the 'mobile lab' and learn about advanced approaches. Again, an example of interdisciplinary research from which HAB research will undoubtedly benefit.

What advice would you give to someone who wants to work specifically in harmful algal bloom forecasting and prediction?

Monitoring is important. We need to know more about seasonality, and modeling is also important. Long-term studies are clearly helpful, and getting a better understanding of the organism is key.

Are there any ongoing projects or research initiatives you plan to stay involved in during your retirement?

Now I am an associate scientist to SZN. I still have ongoing collaborations with the phytoplankton team at our institute and other colleagues. Lately, together with Diana, Adriana and Wiebe, we have invested quite a bit of time in the Advanced Phytoplankton Course on Taxonomy and Systematics (APC13) that was in Naples. A lot of work, but it was rewarding to see the appreciation of the participants and the enthusiasm of all the international faculty.

Without the duties and pressing deadlines, I have more time for enjoy-

ing 'slow science', for reading and thinking. I'm also involved in outreach activities and devote some time to volunteer work.

Is there a final message or thought you'd like to share with the readers of Harmful Algae News?

Communicate, discuss, be curious. Don't be afraid of sharing ideas. If you are open-minded, people will enjoy working with you. Take care of students and contribute to their training as much as you can.

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ICHA 2025 Schedule

- ⇒ Registration opened **January 13th 2025**
- ⇒ Abstract submission opened **January 20th 2025**
- ⇒ Abstract Submission deadline **June 1st 2025**
- ⇒ Late Registration closes **September 19th 2025**
- ⇒ <https://icha2025.org/>

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