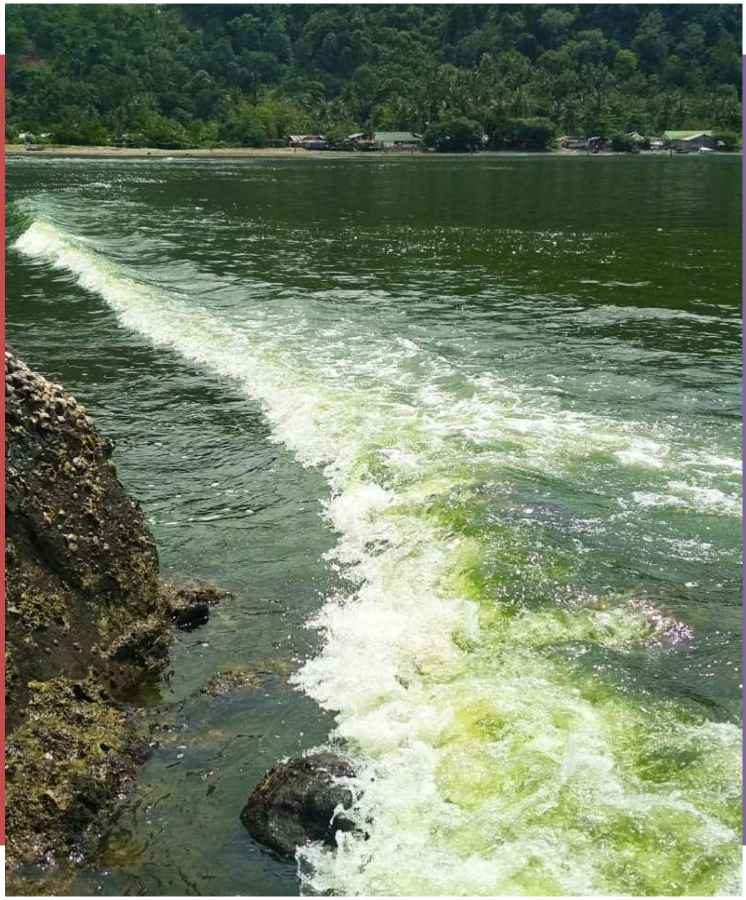
Harmful Algal Blooms (HABs) and Ciguatera Indonesia Studies in Lombok

Indonesian Ciguatera Science Team

Arief Rachman, Suhendar I. Sachoemar, Riani Widiarti, Diswandi, Ratu Siti Aliah, Hanny Meirinawati, Ekky Ilham Romadhona, Muhammad Faza Fadhillah, Suci Lastrini, Muhami, Novi Megawati, Setiarti Sukotjo, Shinta Leonita, Haryanti Subandar

Harmful Algal Blooms (HABs)

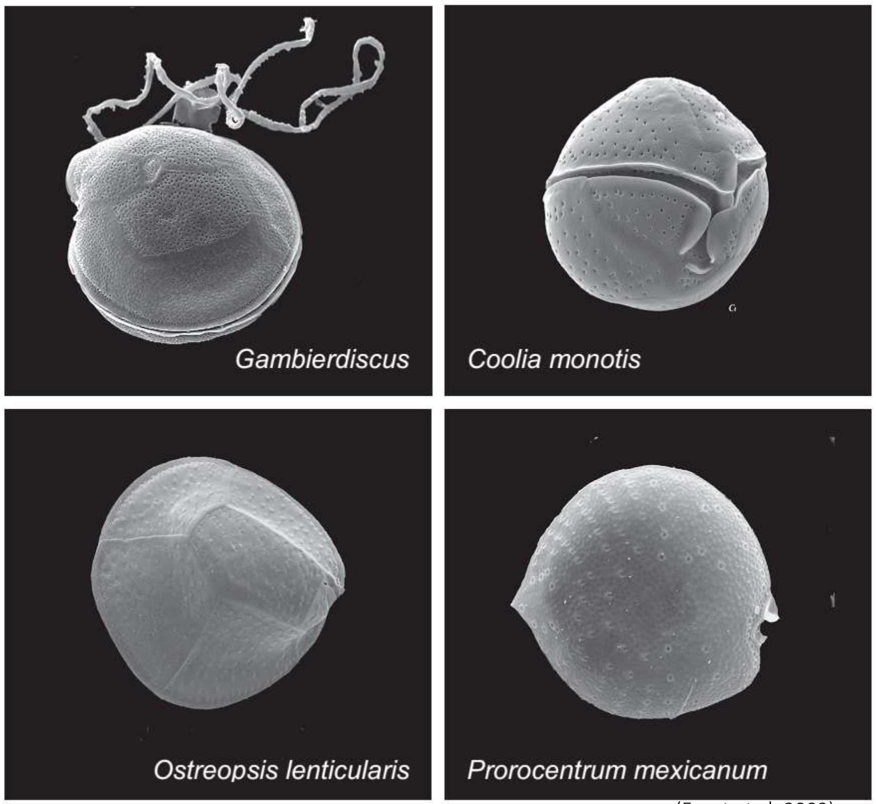
- Harmful Algal Blooms (HABs) → rapid and uncontrolled growth of microalgae species in the water that could damages the aquatic ecosytems → one of the 10 Plagues of the Seas
- The occurrence of HABs → could threaten the ecosystem balance and the life of coastal communities (Duarte et al., 2014)



Harmful effects of algal blooms (GEOHAB, 2000)

- Ocean discoloration
- Mass fish mortality/fish kill
- Toxin contamination of seafood products
- Altering/disrupting the balance of the ecosystem
- Danger to the health of humans (poisoning cases could lead to death)
- Damages to the economy of coastal communities

Ciguatera Fish Poisoning (CFP)



(Faust et al. 2009)

Four benthic dinoflagellate genus are commonly associated with CFP cases: *Gambierdiscus, Ostreopsis, Prorocentrum, Coolia*

- Ciguatera Fish Poisoning → poisoning disease in human or marine mammals due to consumption of reef fishes that are contaminated by ciguatoxin (CTX) produced by several species of benthic dinoflagellates → *Gambierdiscus toxicus* and other associated species → *Ostreopsis ovata, Prorocentrum lima, P. concavum, P. mexicanum (rhathymum)*, and *Amphidinium carterae* (Burkholder 1998; Lehane and Lewis 2000)
- Known symptoms of CFP (deSylva 1994; Lehane dan Lewis 2000) :
  - diarrhea
  - nausea
  - vomitting
  - stomachache
  - reversal of cold-hot sensation
  - muscles and joints pain
  - tingling (often painful)
  - numbness on lips and tongue
  - itch
  - hypotension (low blood pressure)

Records of benthic dinoflagellate species associated with CFP

Benthic dinoflagellates which could potentially caused CFP → *Amphidinium* sp., *G. toxicus*, *O. ovata*, *O. siamensis*, *P. lima*, *P. concavum*, dan *P. rhathymum, Gambierdiscus sp.*, *Ostreopsis sp* → have been reported and studied from several places in Indonesia:

- Seribu Island
- Belitung Island
- Bali coastal waters
- West coast of South Sumatera
- Bintan Island
- Padang coastal waters
- Lampung Bay
- Weh Island coastal waters
- Gili Matra

Widiarti 2002, Widiarti 2010, Skinner et al. 2011, Widiarti 2011, Thamrin 2014, Dwivayana 2015, Eboni et al. 2015, Oktavian et al. 2015, Seygita et al. 2015, Widiarti & Pudjiarto 2015, Widiarti et al. 2016a, Widiarti et al. 2016b, Widiarti & Adi 2016, Widiarti et al. 2019

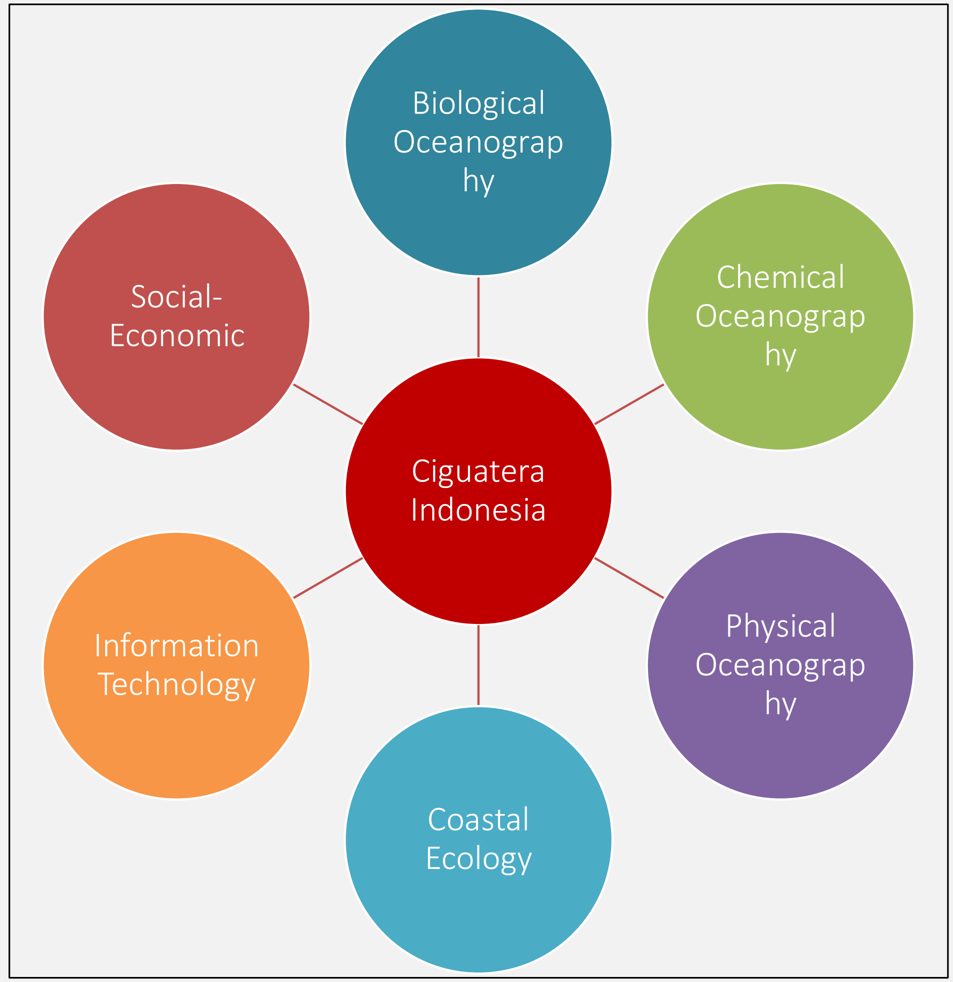
bHABs and CFP → not yet considered as a major threat to Indonesian coastal communities or ecosystems (no formal report or huge cases) → lack of awareness and studies

Potential threats of harmful algal blooms (HABs) and ciguatera fish poisoning (CFP) in the marine tourism park of Gili Matra islands, Indonesia

A part of the Ciguatera Indonesia project 2022 - 2023

"Multidiscipline and beyond borders"

"Ciguatera Indonesia" → research collaboration beyond institutional and country borders which involving researchers, academics, experts, and university students from many different disciplines



HABs and CFP study of the Ciguatera Indonesia

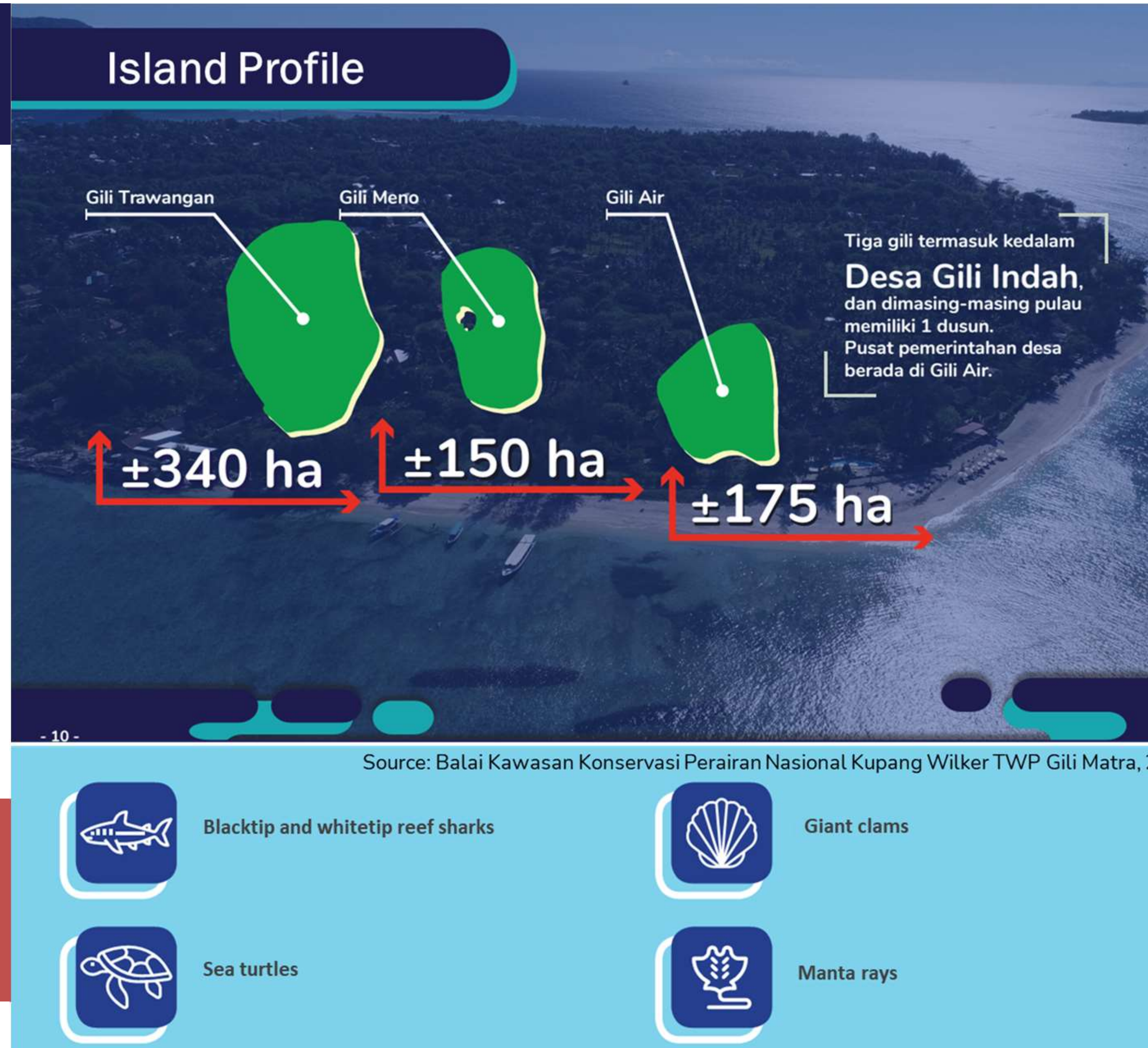
Identify the potentially harmful phytoplankton and benthic dinoflagellate species which could cause HABs and CFP along with their relationship with habitat condition

Estimate the level of anthropogenic pressures and potential economic loss that might be caused by HABs and/or CFP

Disseminate information and increase the local public awareness on the potential danger of HABs and CFP

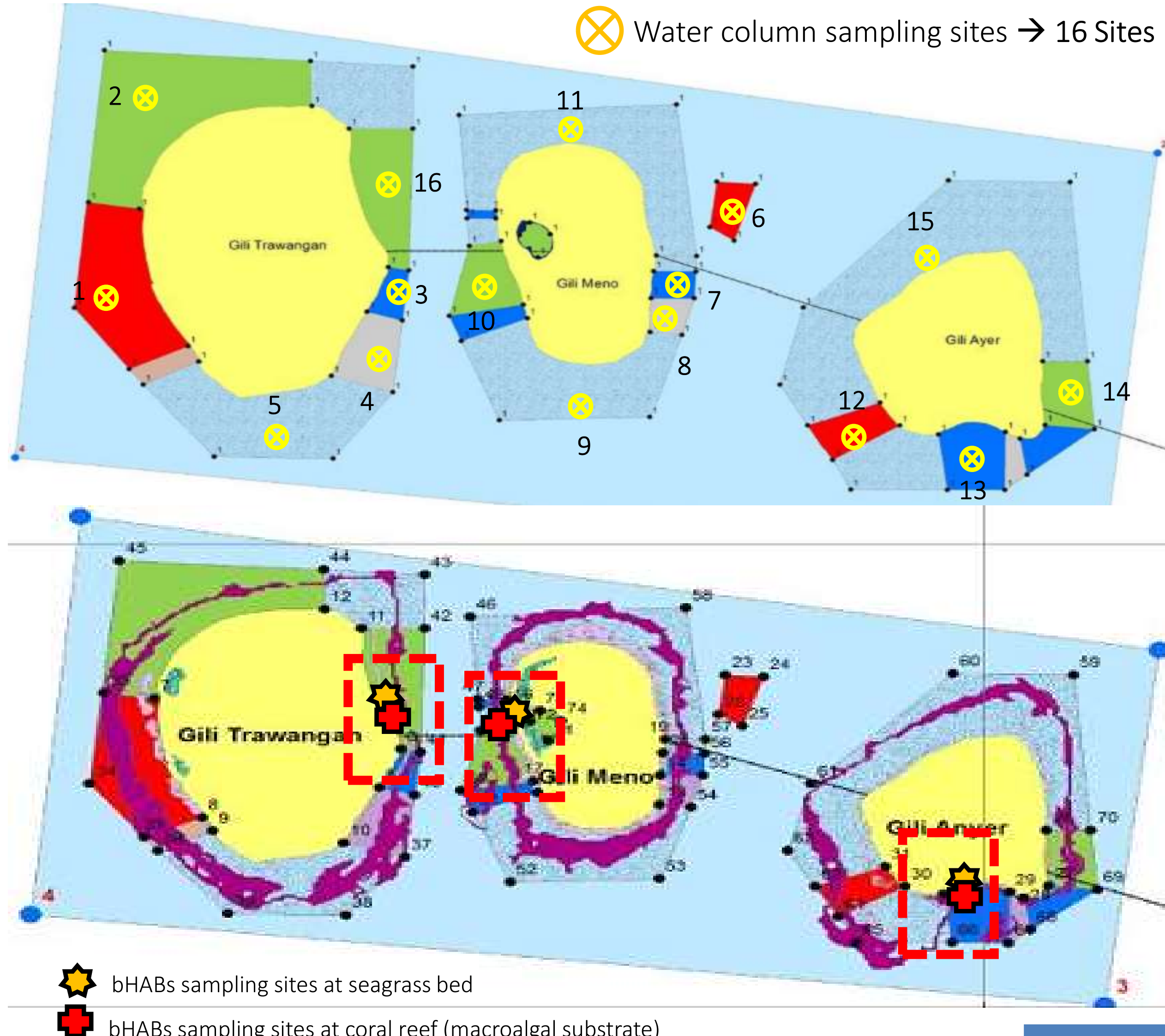
Gili Matra Marine Tourism Park (Taman Wisata Perairan/TWP) → Gili Trawangan, Gili Meno, Gili Air

- An important conservation and tourism area to the local people and marine biota in the coastal area of West Lombok
  Conservation area → 2.273,56 ha
  Important coastal ecosystems:
  - Mangrove
  - Coral Reef
  - Seagrass
- Ecologically vital to some protected and charismatic rare species, such as :
  - Hiu Sirip Hitam (Blacktip reef shark)
  - Hiu Sirip Putih (Whitetip reef shark)
  - Penyu (Sea turtle)
  - Kima (Giant clam)
  - Pari Manta (Manta rays)

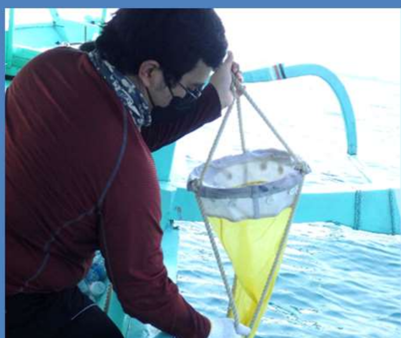


Sampling Sites

- Gili Matra Marine Tourism Park (Taman Wisata Perairan/TWP) → Gili Trawangan, Gili Meno, Gili Air
- An important conservation and tourism area to the local people and marine biota in the coastal area of West Lombok
- 16 water column sites → plankton, water physical-chemical properties
- 6 permanent sites → benthic dinoflagellates from macroalgal and seagrass beds (natural and artificial)

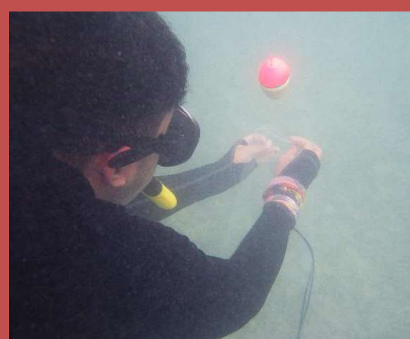


Field Sampling in Gili Matra and Lombok



Plankton sampling & water column parameters measurement

Benthic dinoflagellate sampling

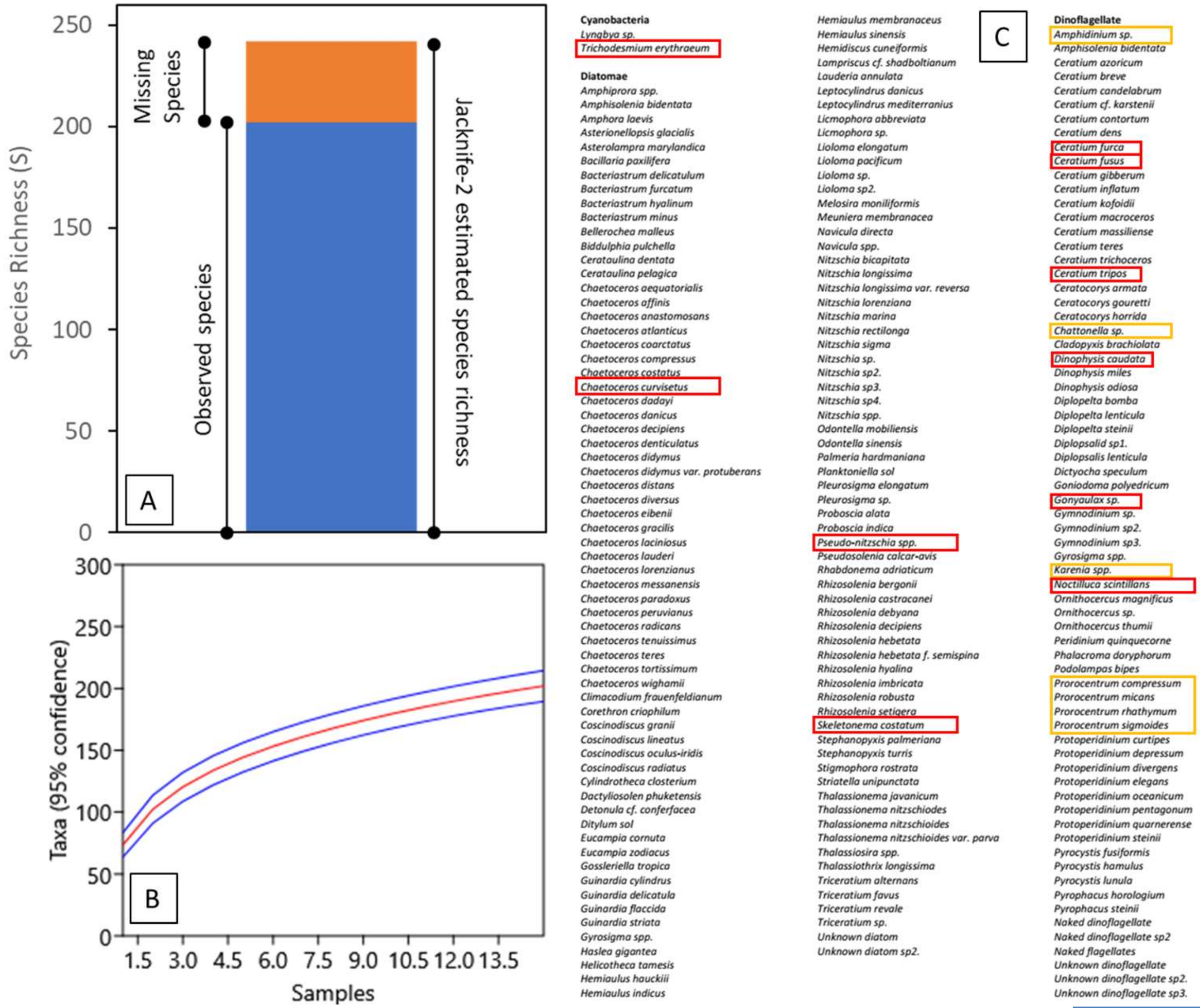


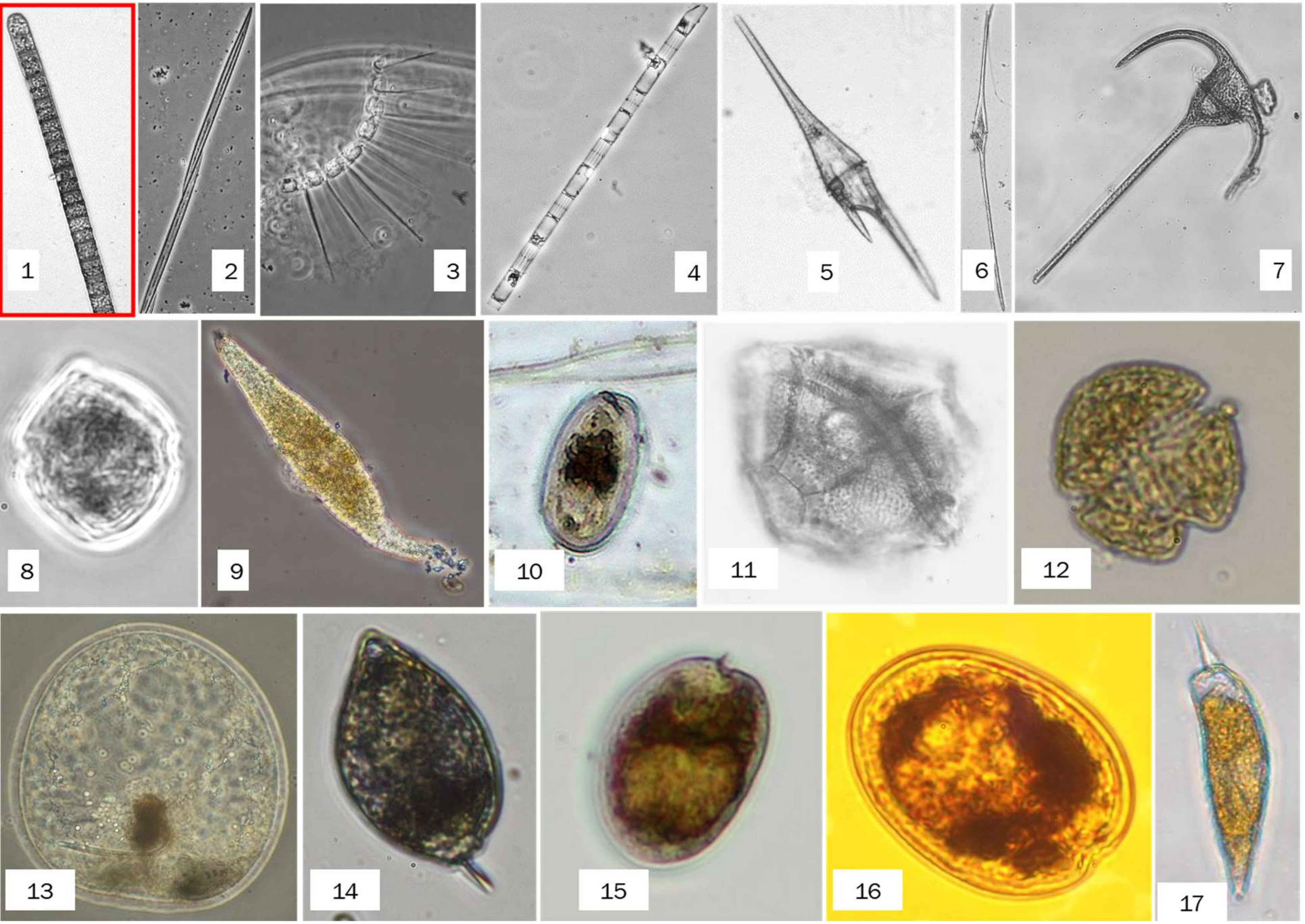
Socio-economics sampling

Fish tissue sampling

Phytoplankton density & diversity

- **In total → 202 species** of phytoplankton has been identified from the Core, Harbour, and Sustainable Fisheries zones of Gili Meno at two seasons (n =15) → **17 potentially harmful species**
- **Jacknife-2 species estimator with 1000 permutation →** estimated 215-242 species at the current sampling effort → at least 40 missing species
- **Species Accumulation Curve (SAC) →** indicating that the number of identified species was representative to the estimated real species assemblages in Gili Meno

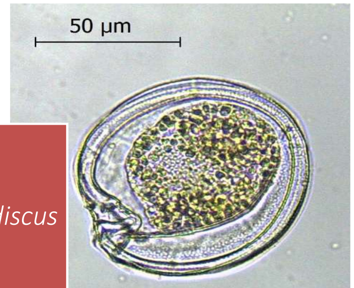




17 potentially harmful species of Gili Matra

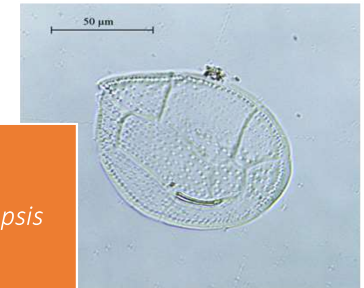
1. *Trichodesmium erythraeum* → *often blooms in Seribu Islands*
2. *Pseudo-nitzschia spp.* → *Some species produced Domoic Acid, causing Amnesic Shellfish Poisoning (ASP)*
3. *Chaetoceros curvisetus* → *several blooms cases recorded in Jakarta Bay*
4. *Skeletonema costatum* → *blooms in Jakarta Bays, particularly in wet season*
5. *Tripos furca* → *often blooms in Lampung Bay*
6. *Tripos (Ceratium) fusus*
7. *Tripos muelleri (Ceratium tripos)*
8. *Scrippsiella trochoidea*
9. *Chattonella spp.* → *Fish Killer*
10. *Amphidinium spp.*
11. *Gonyaulax spp.* → *some species cause recent blooms in Ambon Bay*
12. *Karenia spp.* → *some species produces Brevetoxin, causing Neirotic Shellfish Poisoning (NSP)*
13. *Noctiluca scintillans* → *often blooms in Jakarta Bay, Lampung Bay, fish killer*
14. *Prorocentrum micans*
15. *Prorocentrum rathymum*
16. *Prorocentrum compressum*
17. *Prorocentrum sigmoides*

Gambierdiscus

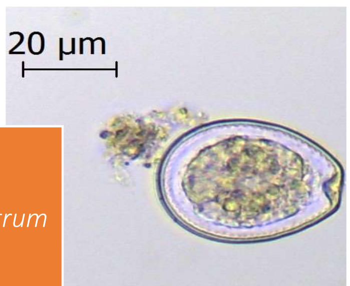


Gambierdiscus

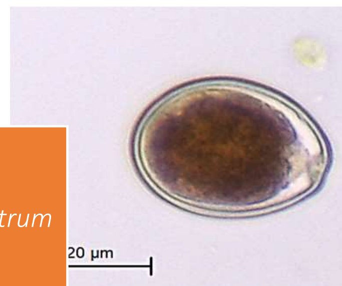
Ostreopsis



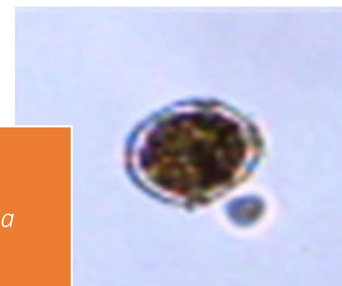
Ostreopsis



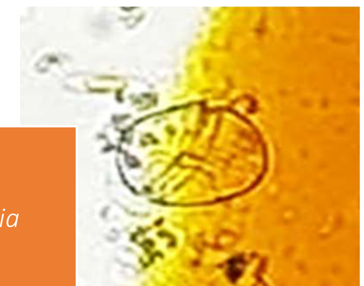
Prorocentrum



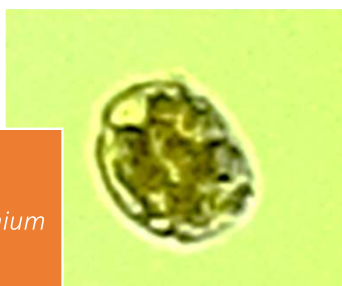
Prorocentrum



Coolia



Coolia



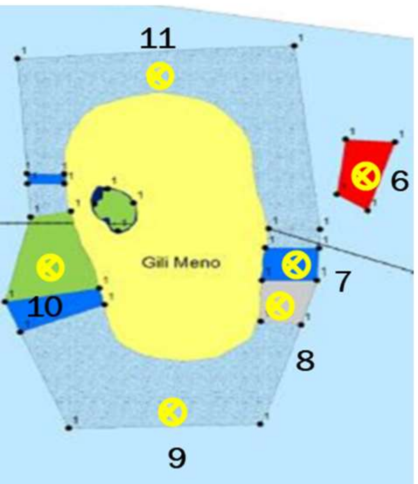
Amphidinium

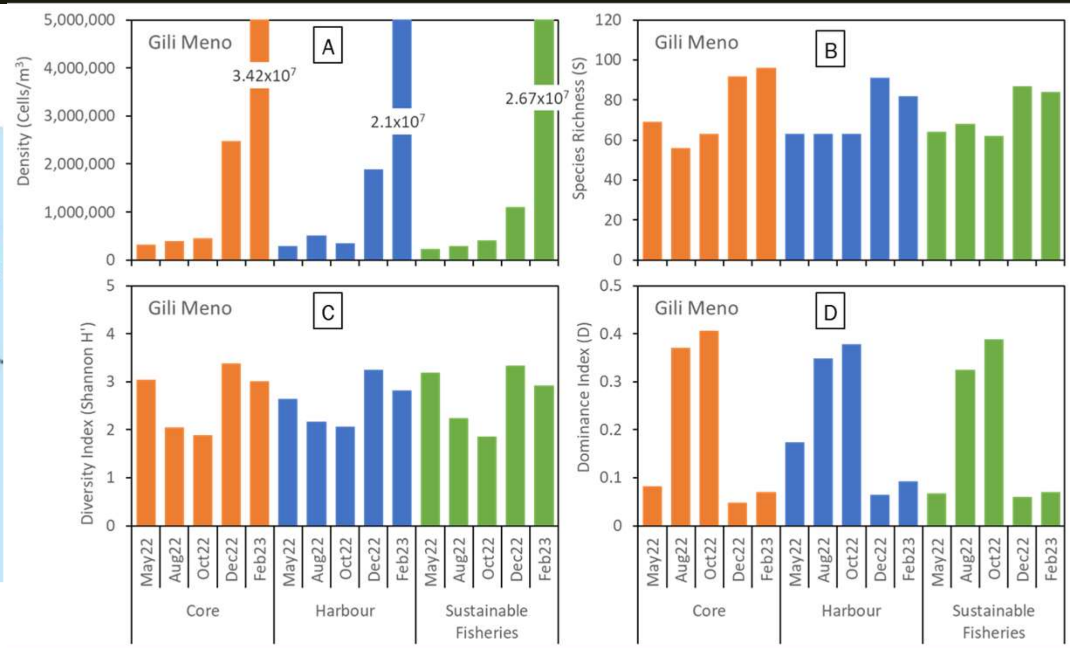
Synophysis (non-toxic)

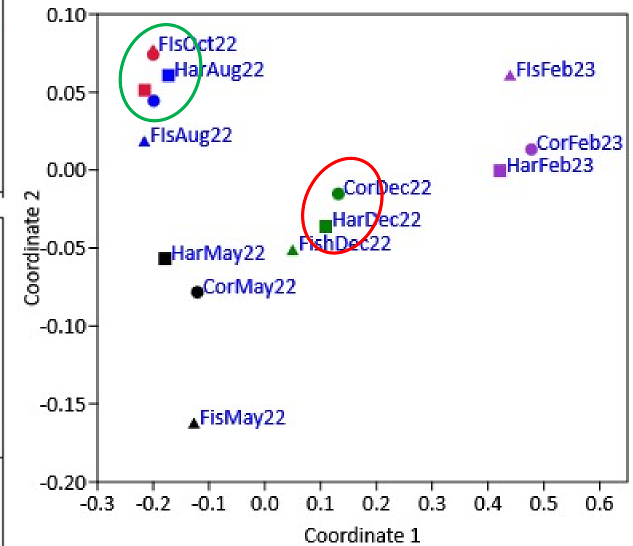
Synophysis (non-toxic)

The six genera of benthic dinoflagellates found on both natural (macroalgae, seagrass) and artificial (screen) substrates in Gili Matra

Seasonal variation in one Gili Matra island (example: Gili Meno)

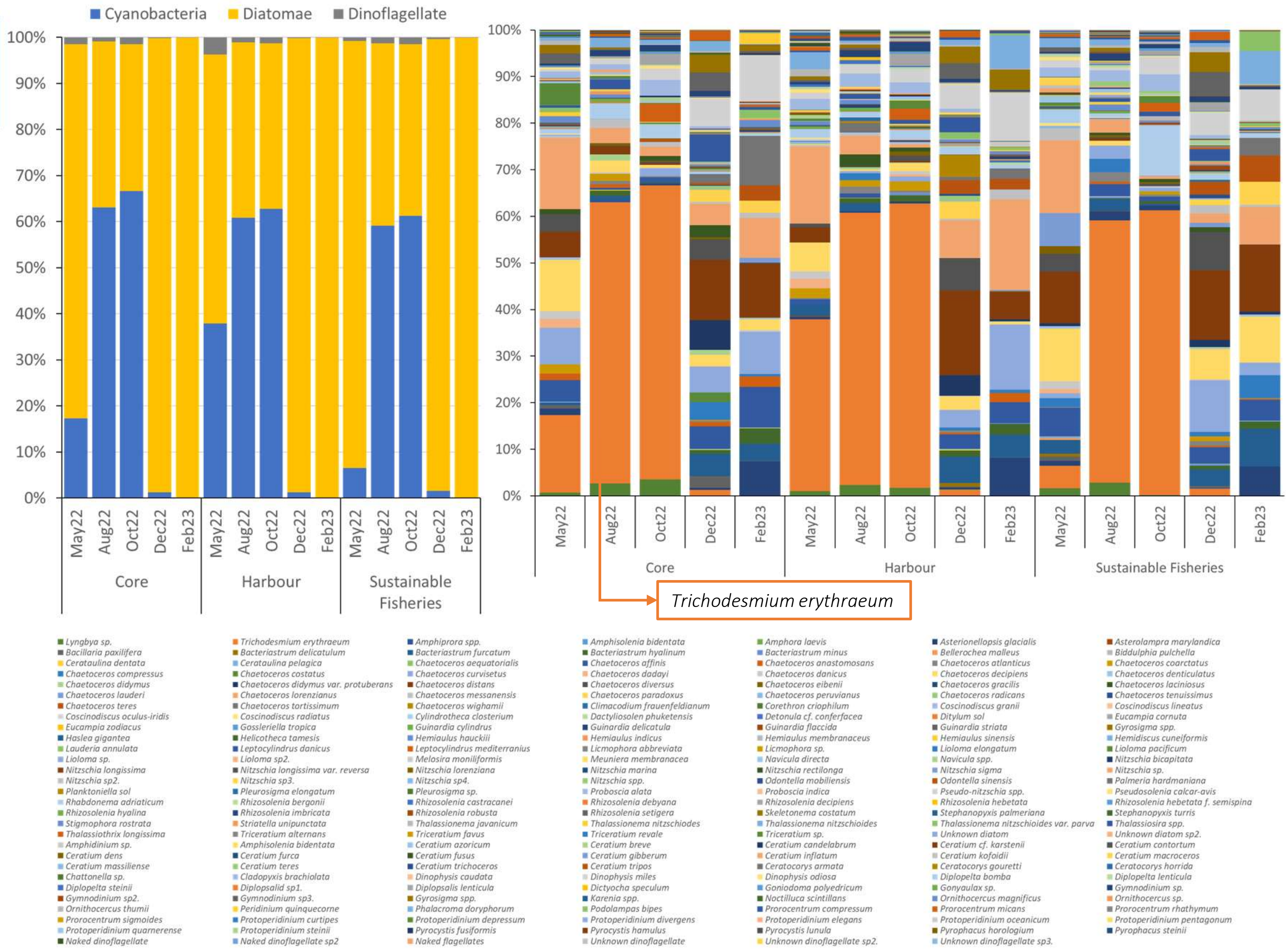






- Drastic increase in phytoplankton cell density and diversity during the start of wet season in December 2022 to February 2023
- At the same time → dominance indeks decrease significantly → no overdomination of certain species of phytoplankton
- Seasonal differences in phytoplankton communities → indicated in nMDS analysis
- Phytoplankton community in Gili Meno relatively similar during the Dry Season (Aug) and Transitional Season II (Oct) → caused by dominance of Cyanobacterial species, *Trichodesium erythraeum*
- Sustainable Fisheries (Fis) zone in Gili Meno → have unique phytoplankton community structure which differs from Harbour (Har) and Core (Cor) zones

SEASON → DRIVES THE CHANGES IN PHYTOPLANKTON COMMUNITY STRUCTURES IN GILI MATRA

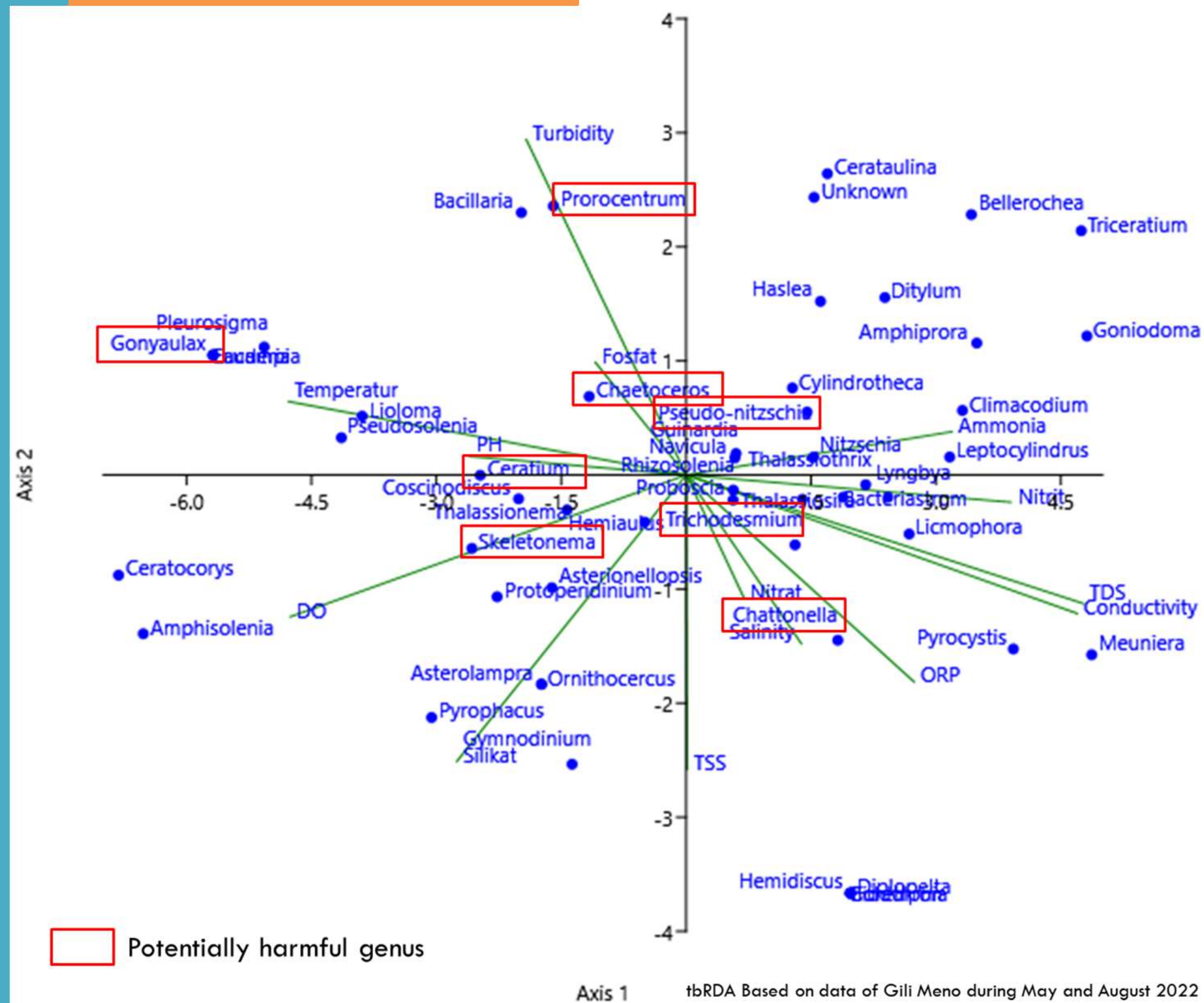


Community Structure

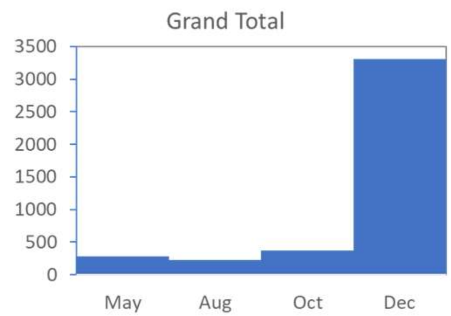
- Evidence of cyanobacterial dominance in Gili Matra (Meno) → *Trichodesmium erythraeum* dominating the marine ecosystems during Dry Season (Aug) and Transitional Season II (Oct)
- *T. erythraeum* is categorized HABs species → have recorded blooms in highly eutrophic area such as Jakarta Bay and Seribu Island.
- Seasonal changes influence the shift in dominance → diatom-dominance in Wet and Transitional Season I followed by cyanobacterial-dominance in Dry and Transitional Season II

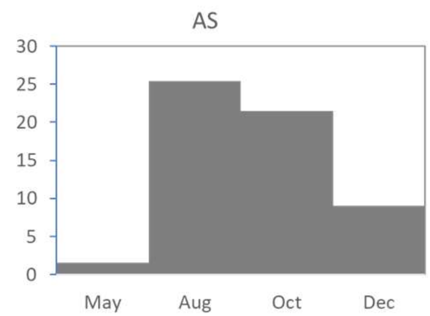
Parameters affecting the density of phytoplankton genera in Gili Matra

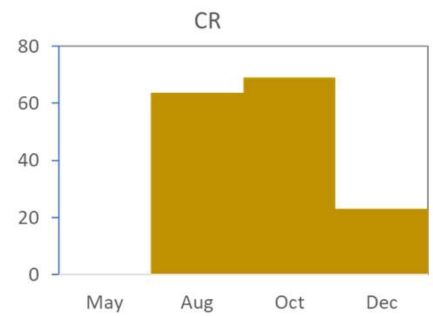
- Most dominant genus → *Trichodesium* → abundant at waters with higher salinity and nitrates concentration
- Common and abundant diatoms → *Chaetoceros* → more abundant at warmer and turbid water, which rich in phosphate
- Some potentially harmful genus:
  - *Ceratium/Tripos* → more abundant at higher temperature and pH and did not strongly affected by any nutrient concentration
  - *Chattonella* → prefer nitrate-rich high salinity water, similar with *Trichodesmium*
  - *Pseudo-nitzschia* → more abundant at ammonia-rich waters
  - *Prorocentrum* → more abundant at turbid waters, which also rich with phosphate



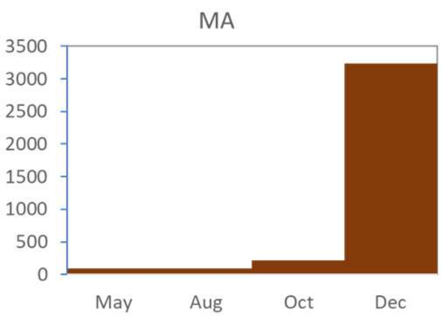
Benthic dinoflagellate population dynamics

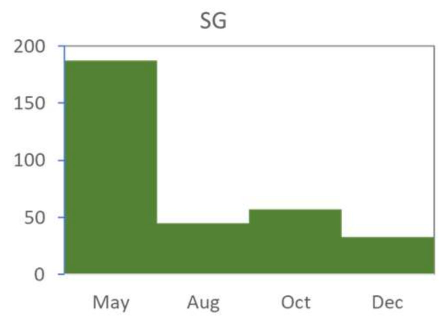


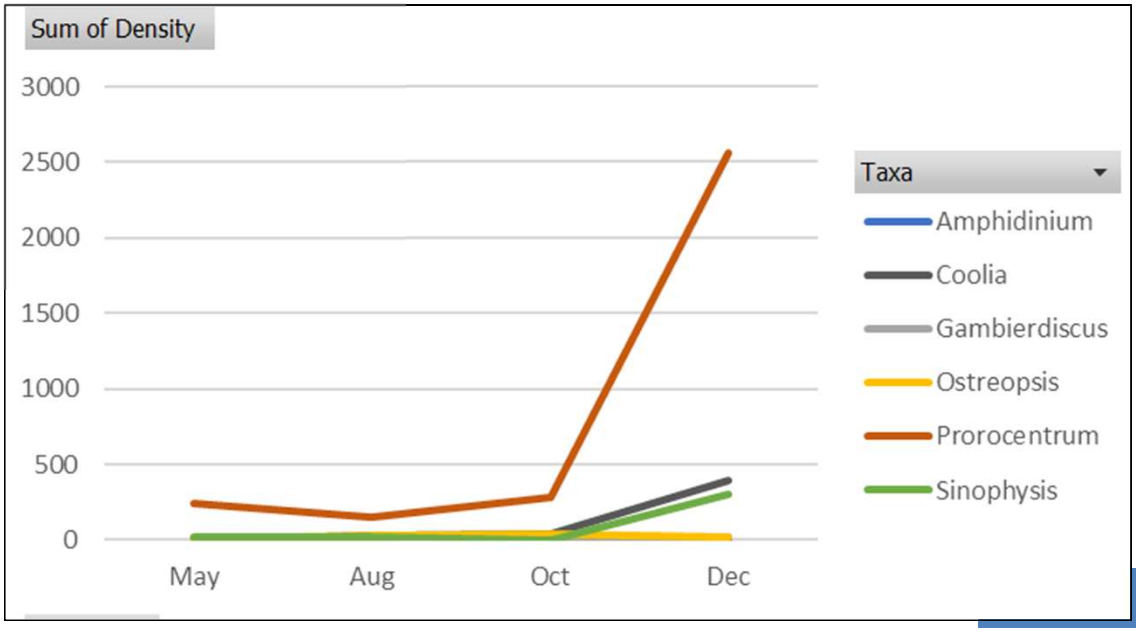




- Similar to phytoplankton → drastic increase in benthic dinoflagellate cell density in macroalgal (MA) substrate also observed in wet season (December 2022)
- Opposite trends → observed in benthic dinoflagellates on seagrass (SG)
- Trends in benthic dinoflagellates in artificial substrate (AS) and coral rubble (CR) → similar



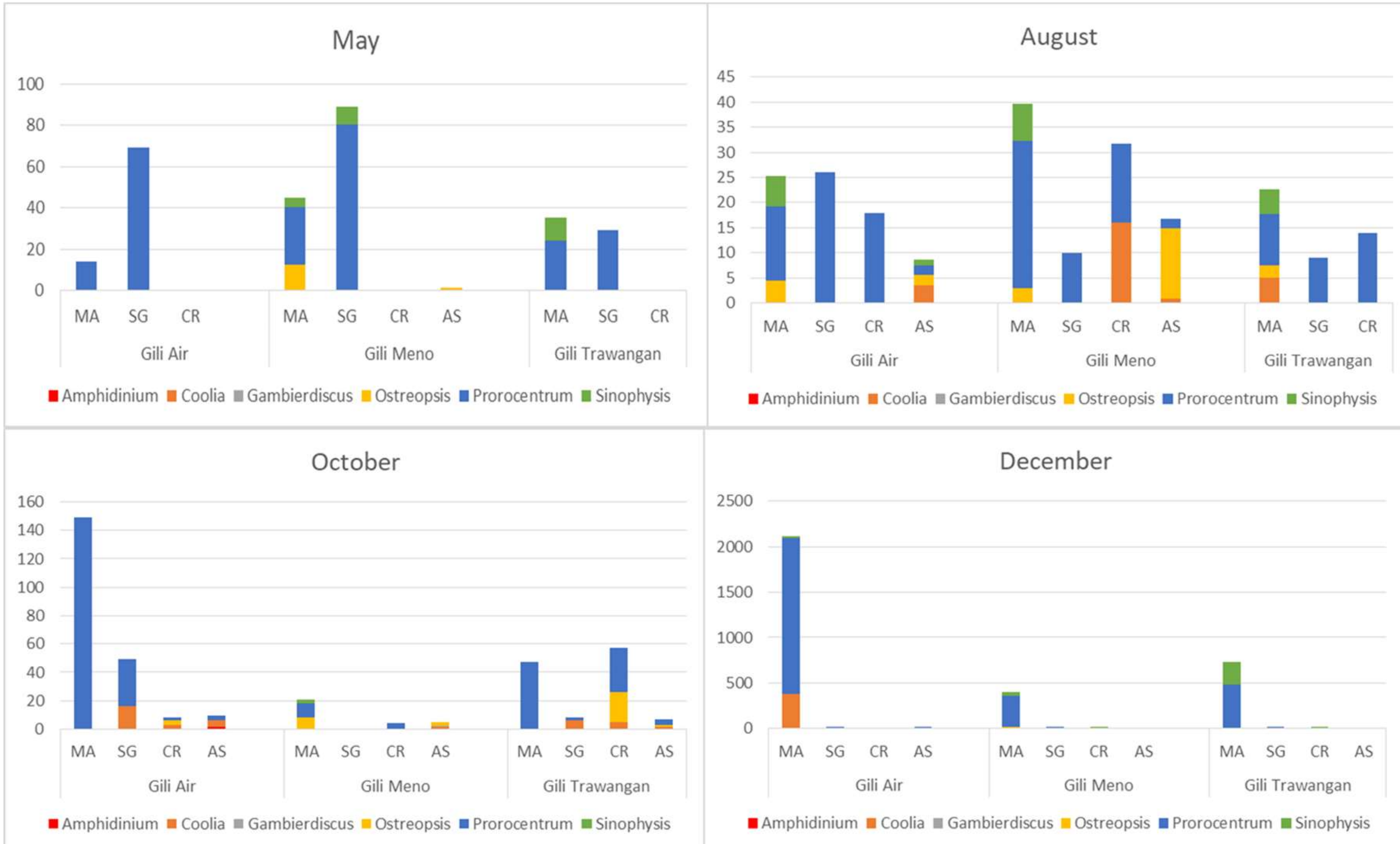




- In general → cell density for all benthic dinoflagellates genus → increased during wet season (December 2022)
- The density of potentially toxic genera *Gambierdiscus* → very low
- The most common and abundant genera → *Prorocentrum* → also known to commonly abundant in macroalga substrates in other area, such as Seribu Island

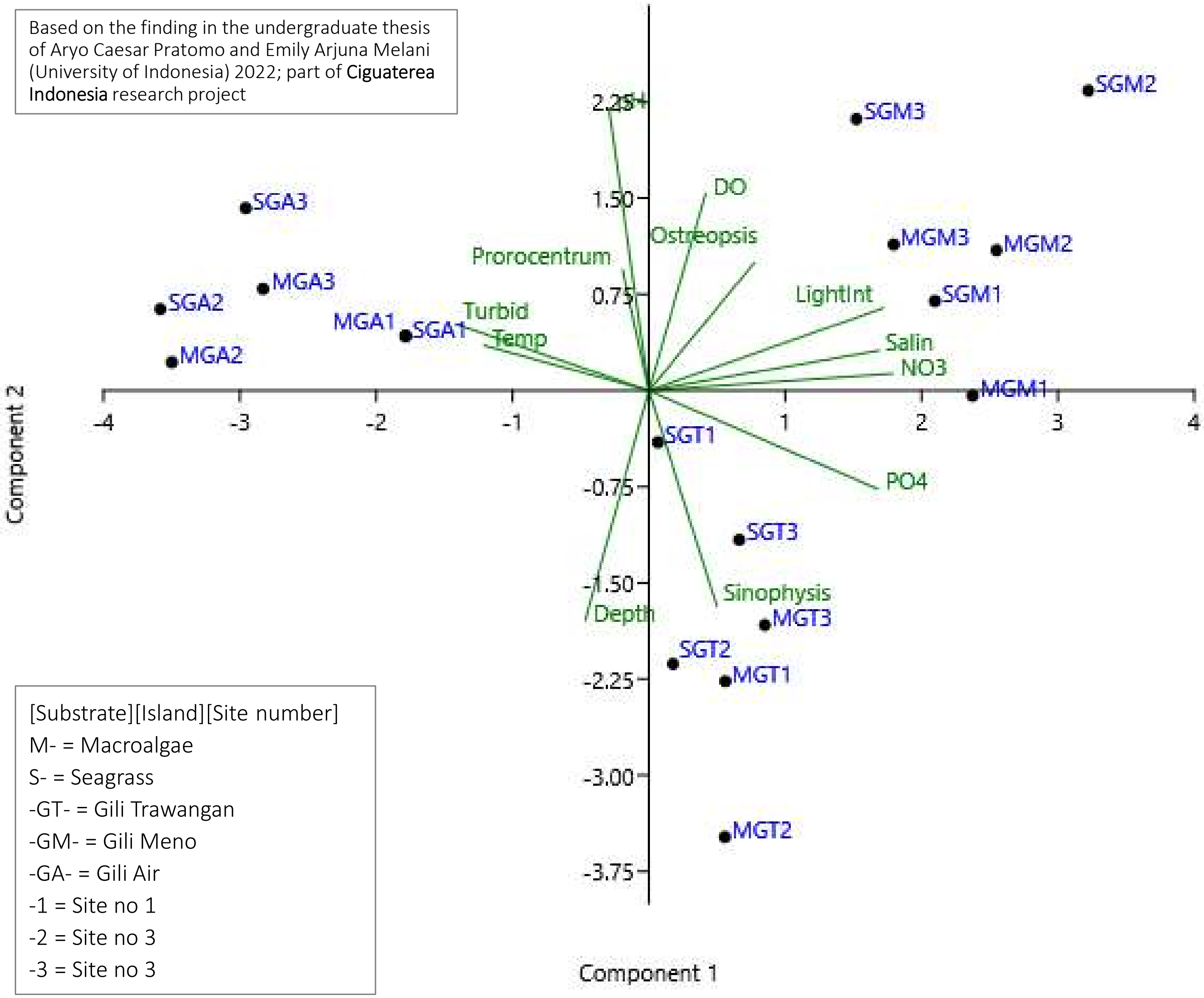
Substrate preference

- Benthic dinoflagellates were found in any kind of substrates
- *Prorocentrum* → the most abundance dinoflagellate → especially on macroalgae and sea grass substrates → usually together with *Sinophysis*.
- *Ostreopsis* and *Coolia* → were often found on non-living substrates → coral rubble and artificial substrate.
- *Gambierdiscus* and *Amphidinium* density → were the lowest among all targeted genera



MA: Macro Algae, SG: Sea grass, CR: Coral Rubble, AS: Artificial Substrate

Based on the finding in the undergraduate thesis of Aryo Caesar Pratomo and Emily Arjuna Melani (University of Indonesia) 2022; part of **Ciguaterea Indonesia** research project



[Substrate][Island][Site number]
M- = Macroalgae
S- = Seagrass
-GT- = Gili Trawangan
-GM- = Gili Meno
-GA- = Gili Air
-1 = Site no 1
-2 = Site no 3
-3 = Site no 3

Relationship of target benthic dinoflagellate genera with water parameters in the Transitional Season I (May)

- The three islands of Gili Matra → have distinct and different water physical-chemical characteristics → affecting the density of target benthic dinoflagellate genera in Transitional Season I (May)
- *Sinophysis* → generally associated with deeper sites in Gili Trawangan which also contain more nutrients, particularly phosphate
- *Prorocentrum* → tend to be more abundant at Gili Air which have higher temperature, pH, and more turbid water
- *Ostreopsis* → tend to be more abundant in Gili Meno which have higher salinity and higher light intensity
- *Amphidinium* and *Gambierdiscus* → were not present in the Transitional Season I (May)

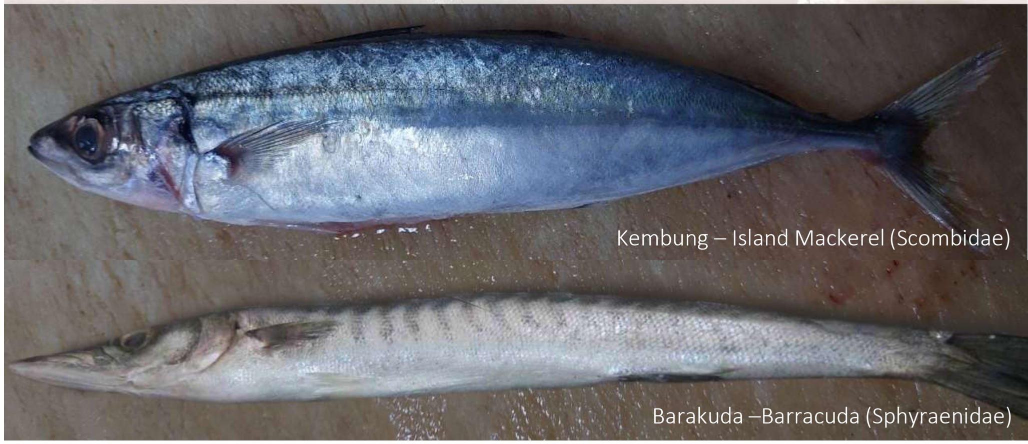
Ciguatoxin analysis (mouse bioassay)

- Ciguatoxin → was <u>NOT DETECTED</u> with mouse bioassay analysis from 31 fish samples → 13 from May 2022, 6 from August 2022, and 12 from February 2023 sampling
- Ciguatoxin concentration → might be <u>below the concentration</u> that required for the laboratory mice to show observable symptoms or lethality
- However → we can't rule out the possibility of low (or very low) concentration of ciguatoxin exist in the reef fish tissue → could be accumulate over time in higher trophic level organisms (particularly, fish and later, human)
- More detailed chemical based analysis → such as ELISA → needed to quantify the concentration of ciguatoxin (if there are any)

Analyzed fish:
- Rabbitfish (Siganidae)
- Parrotfish (Scaridae)
- Barracuda (Sphyraenidae)
- Island Mackerel (Scombidae)
- Grouper (Serranidae)
- Longtail Tuna (Scombridae)

Kakatua – Parrotfish (Scaridae)

Baronang hitam - Rabbitfish (Siganidae)



Kembung – Island Mackerel (Scombidae)

Barakuda –Barracuda (Sphyraenidae)

What to do when HABs occurred?

Check the water quality
(Hydrocolor)

Mark the location/coordinate
(Fish-GIS)

Collect the samples
(Plankton Net / Water Sampler)

Observe the species composition
(Planktoscope/Foldscope)

Inform and send the data anr/or sample the local academics/experts

+

Report the findings to the local government

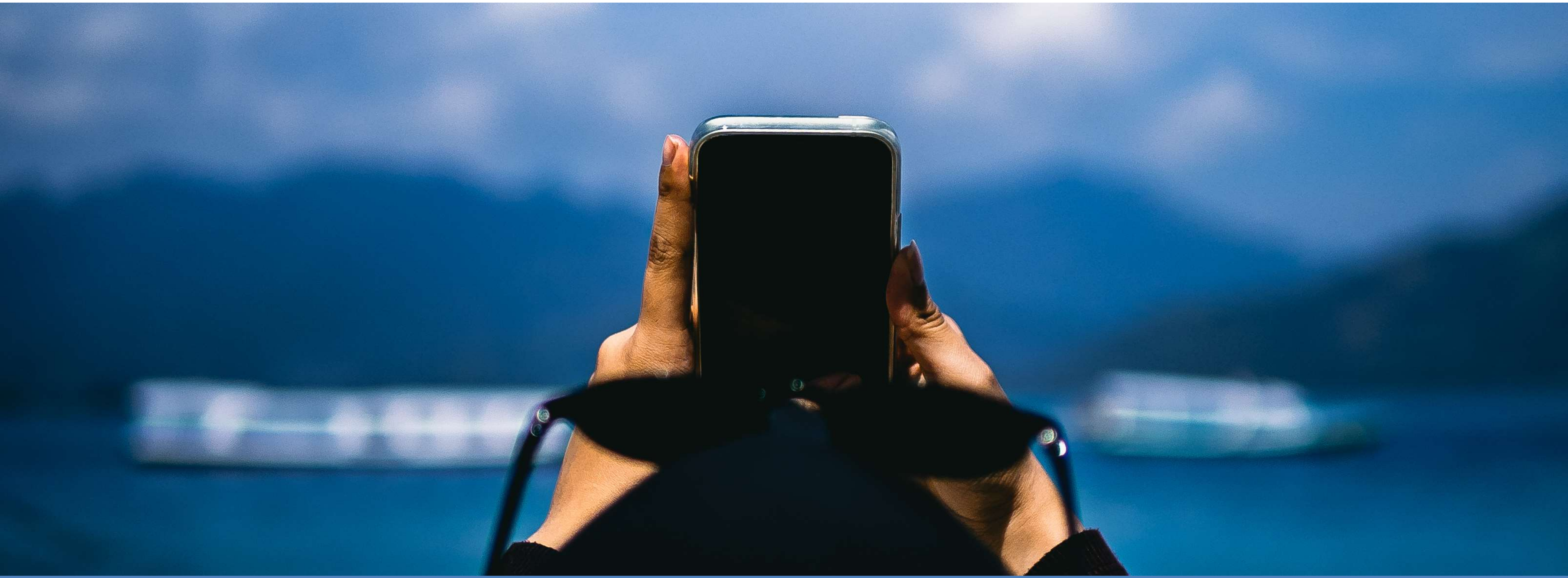
Inform those closest to you (families, friends) → DO NOT CONSUME SHELLFISH AND/OR DEAD FISH COLLECTED FROM THE HABs IMPACTED AREA

Conclusions

- There were 17 potentially harmful phytoplankton species found in Gili Matra, with *Trichodesmium erythraeum* dominates the ecosystem in Dry Season and Transitional Season II
- The 6 targeted benthic dinoflagellates were found, with *Prorocentrum* as the most abundant genera, particularly on macroalgae and seagrass
- The potentially toxic *Gambierdiscus* was found in very low density, thus currently possess small risk to cause CFP, unless coral reef and environmental deterioration progress to provide more suitable condition for bloom
- Seasonal changes heavily influenced the shift in phytoplankton community structure, with dry season generally characterized with dominance of cyanobacteria and wet season with dominance of diatoms
- No ciguatoxin was detected in the mouse bioassay of the coral reef fishes collected from Gili Matra and Northern Lombok, indicating no risk of CFP in Lombok so far
- Increasing turbidity, nutrient concentration, and disturbances to the ecosystem could trigger rapid growth of HABs species, which usually well adapted to low water quality

Acknowledgements

- We are thankful for PICES-MAFF, ITI, and BRIN for sponsoring/funding this research
- We are grateful for the support of the staffs from Program House (RP OR KM BRIN), Expedition and Exploration Fund (PEE BRIN), and local collaborators from University of Mataram (Unram) in Lombok that are really helpful to make this research works smoothly
- Thank you to Mr. Rahman, Mr. Eko, Mr. Gunawan, Mr. Fatur for their excellent services and help during our fieldworks, we really can't do our work in the field without their help and guidance on the field.



Thank you

Scribo ergo sum