Coral-Reef Fish Index for Monitoring the WIO Regions

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CONTEXT

Rethinking coral reef assessment

- ✓ Assessing coral reef health only through benthos/corals prism is unsatisfactory.
- ✓ Need to improve
  - The reef ecosystem assessment by integrating reef fish indicators with benthic data, using robust statistical and ecological analysis.
  - The readability of fish indicators

The Mayotte example – Comoros Archipelago

- ✓ 23 years of GCRMN data (2001-2024)
- ✓ Multidisciplinary work highlight the value of long-term monitoring
- ✓ Pilot project proposed to Mayotte Marine Park in 2024, complementary to current multi-criteria approaches (structural and/or functional indicators)
- ✓ This approach can be adapted by other managers & scientists with long-term datasets

METHODS - Reef Fish Index

Step 1: Selection of stations and species

- Centralize and select existing databases
- Remove irrelevant stations (e.g. reef flats influenced by high tide cycles)
- Remove insufficient quality data (e.g. no species-level ID)
- Clean and harmonize taxonomy

Programs	Years	Fish communities (level)	Data on target Families and sizes
EFFET_RESERVE_PS	2009	All species	Sizes on 10 target families : ACANTHURIDAE, CAESIONIDAE, CARANGIDAE, HOLOCENTRIDAE, LABRIDAE, LETHRINIDAE, LUTJANIDAE, MULLIDAE, SCARIDAE, SERRANIDAE
TARAOCEANS	2010	10 target families: ACANTHURIDAE, CARANGIDAE, CHAETODONTIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, POMACANTHIDAE, SCARIDAE, SERRANIDAE, SIGANIDAE	Sizes on 10 target families : ACANTHURIDAE, CARANGIDAE, CHAETODONTIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, POMACANTHIDAE, SCARIDAE, SERRANIDAE, SIGANIDAE
SUIVI_MBOUZI_MAY_BELT_POISSON	2009, 2015, 2017	11 target families: ACANTHURIDAE, CARANGIDAE, CHAETODONTIDAE, HAEMULIDAE, LABRIDAE, LETHRINIDAE, LUTJANIDAE, POMACANTHIDAE, POMACENTRIDAE, SCARIDAE, SERRANIDAE	Sizes on 5 target families : CARANGIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, SERRANIDAE
ORC_MAYOTTE_BELT_POISSONS	2005, 2008		
SUIVI_MBOUZI_MAY_BELT_POISSON	2018	All species	Sizes on 5 target families : CARANGIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, SERRANIDAE
ORC_MAYOTTE_BELT_POISSONS	2018		
SUIVI_MBOUZI_MAY_BELT_POISSON	2020, 2021, 2022, 2023	All species	Sizes on 7 target families : ACANTHURIDAE, CARANGIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, SCARIDAE, SERRANIDAE
ORC_MAYOTTE_BELT_POISSONS	2019, 2020, 2021, 2022, 2023		
ORC_MAYOTTE_BELT_POISSONS	2000	All species	no sizes
ORC_MAYOTTE_BELT_POISSONS	2001, 2011	All species (with SCARIDAE - Genius (Scarus spp)	sizes for all species
ORC_MAYOTTE_BELT_POISSONS	2013	11 target families: ACANTHURIDAE, CARANGIDAE, CHAETODONTIDAE, HAEMULIDAE, LABRIDAE, LETHRINIDAE, LUTJANIDAE, POMACANTHIDAE, POMACENTRIDAE, SCARIDAE, SERRANIDAE	Sizes on 6 target families : CARANGIDAE, HAEMULIDAE, LETHRINIDAE, LUTJANIDAE, SCARIDAE, SERRANIDAE

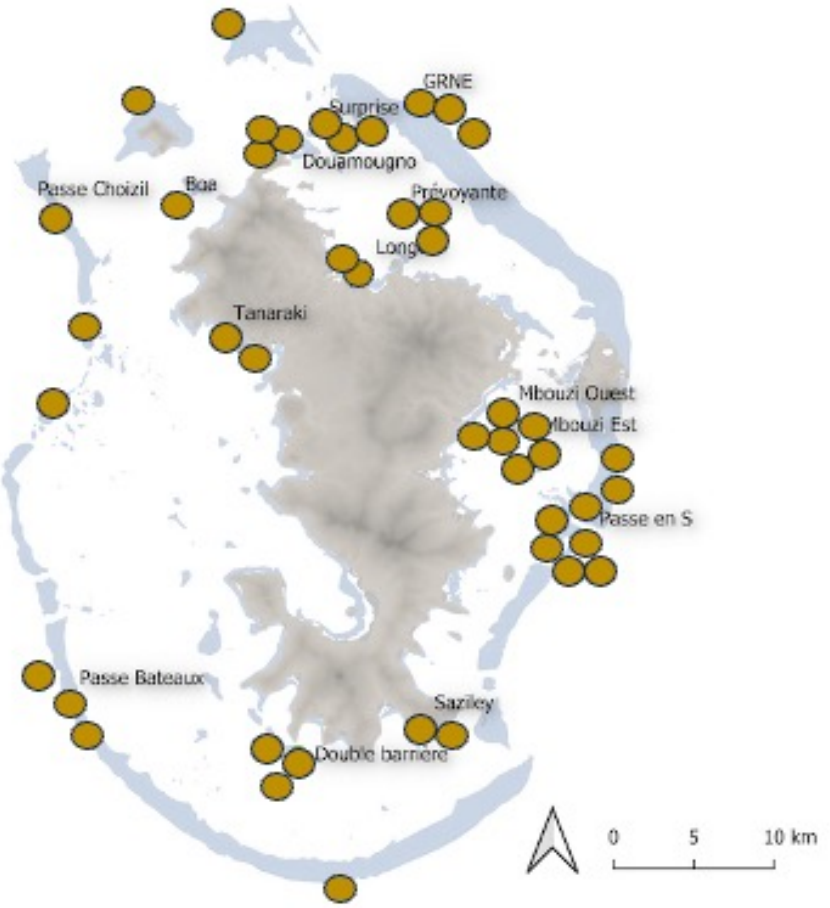
METHODS - Reef Fish Index

-> Stations and fish species selected

- **366** belt transects (50 x 5 m)
- **44** reef stations:

21 Barrier reef, 13 Fringing Reef, 10 Inner reef

- **18 565** observations
- **411** fish species recorded
- **22 years** of monitoring (2001-2023)
- High level of **expertise**



Map of Mayotte Island and selected stations

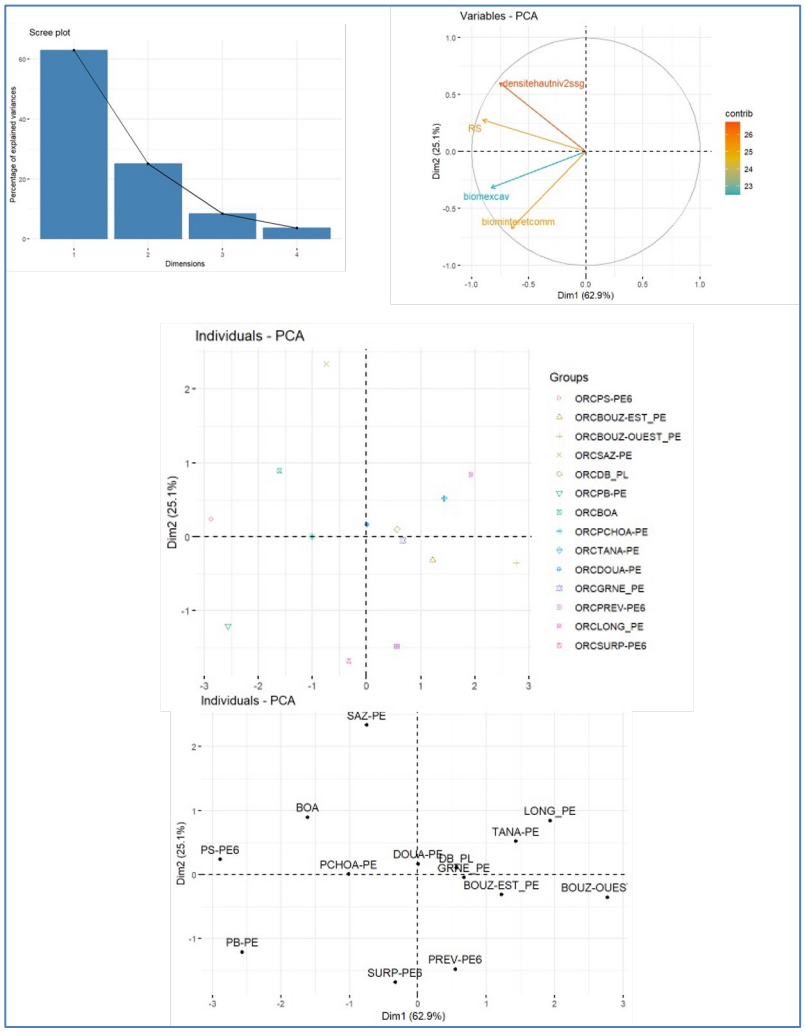
METHODS - Reef Fish Index

Step 2 : Variable selection

Scientific questions ?	Variables	Remarks
Fish biodiversity is important ?	**Total species richness**	Total number of species
The fish communities present a well balanced trophic structure ?	**Abundance of high-trophic species- Option 1**	Piscivores & Mobile Invertebrate grazers
	Abundance of high-trophic species- Option 2	Piscivores & Mobile & Sessile Invertebrate grazers
	Abundance of low trophic species- Option 1	Détritivorous = species to Genius Ctenochaetus (Acanthuridae Family)
	Abundance of low trophic species- Option 2	Détritivorous = species to Genius Ctenochaetus & Grazers detritivorous (Acanthurus sp - Acanthuridae Family)
Are the fish species that promote reef resilience have a satisfactory level ?	**Herbivorous biomass**	All herbivorous
	Scaridae biomass	All Scaridae
	Scavengers Biomass	Scavengers (big species to Genius Chlorurus & Cetoscarus)
Are fishery resources well preserved ? / The fish population are impacted by fishing ?	**Biomass of important commercial species**	Carnivorous species - size max > 40 cm / 5 Families (Carangidae, Haemulidae, Lethrinidae, Lutjanidae, Serranidae)
	Biomass of sensitive species to fishing pressure	4 sensitive species to fishing pressure (Plectropomus laevis, Cephalopholis argus, Lutjanus bohar, Monotaxis grandoculis)
	Groupers Biomass	Serranidae (size max > 40 cm)

- Remove **dependent variables** (strong correlations)
- Remove **stable** variables (no variation over time by station)
- Keep **one variable** per ecological function (avoid functional redundancy)
- Consider different **measurement units:** species richness, density, biomass

METHODS - Reef Fish Index



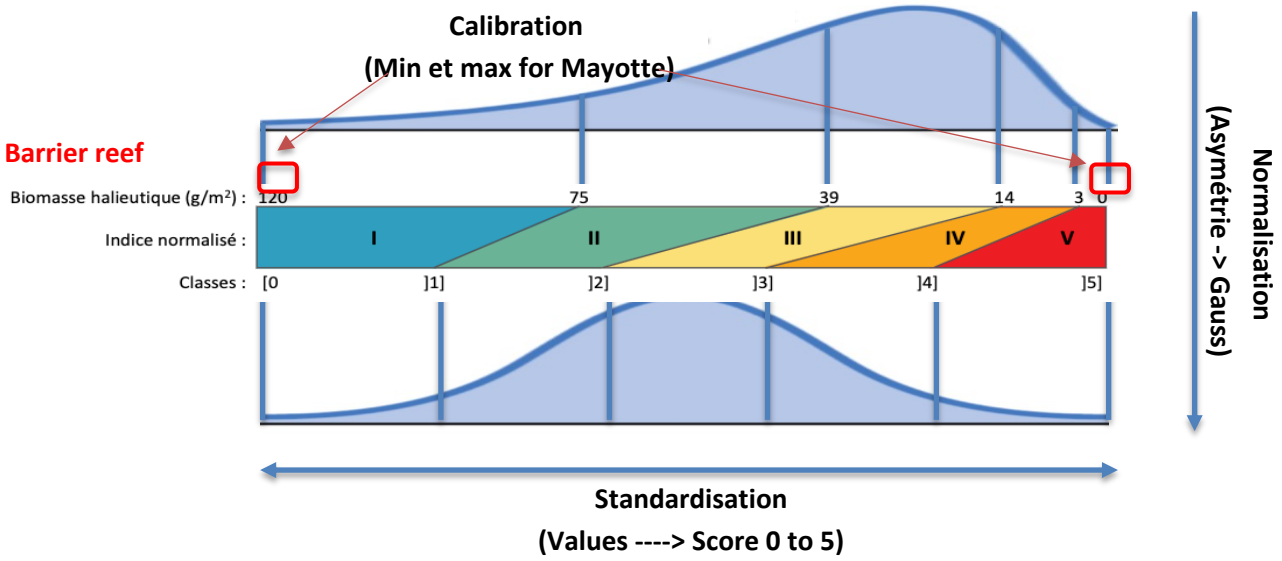
-> Fish variables selected

- **Total fish species richness (S)** -> snapshot of biodiversity
- **Density of carnivorous species** (ind./100 m²) -> trophic balance
- **Biomass of herbivorous excavators** (g/m²) -> ecological resilience
- **Biomass of commercial species** (g/m²) -> fisheries & fishing impact

METHODS - Reef Fish Index

Step 3 : Normalisation and standardisation of variables

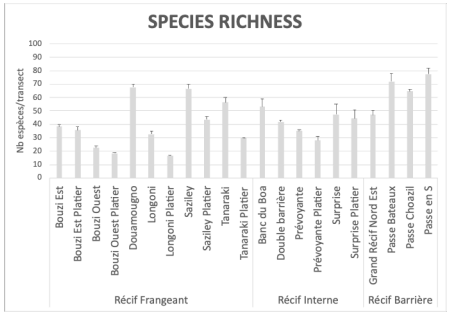
Calibration based on the minimum and maximum values of **Mayotte reference system**

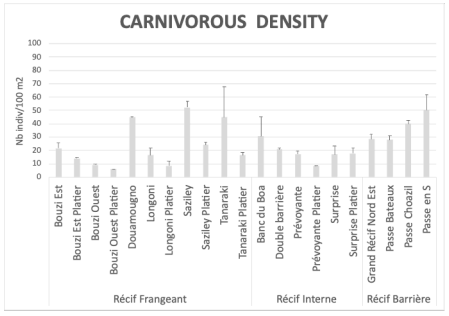


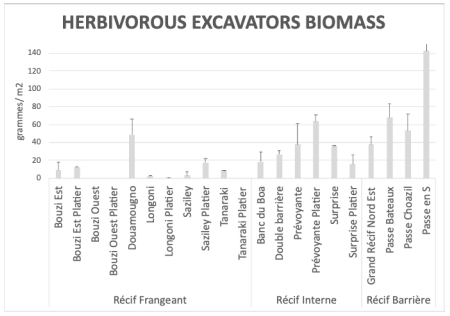
One reference system
defined for each habitats

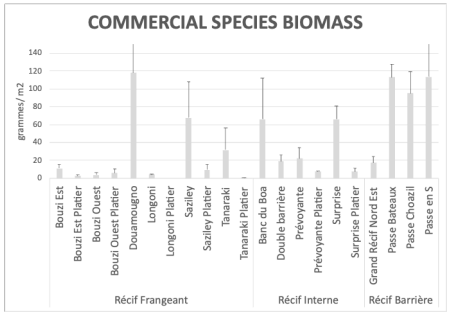
- barrier reef (BR)
- inner reef (IR)
- fringing reef (FR)

-> Fish variables selected **adapted to each habitat** of **Mayotte reference system**

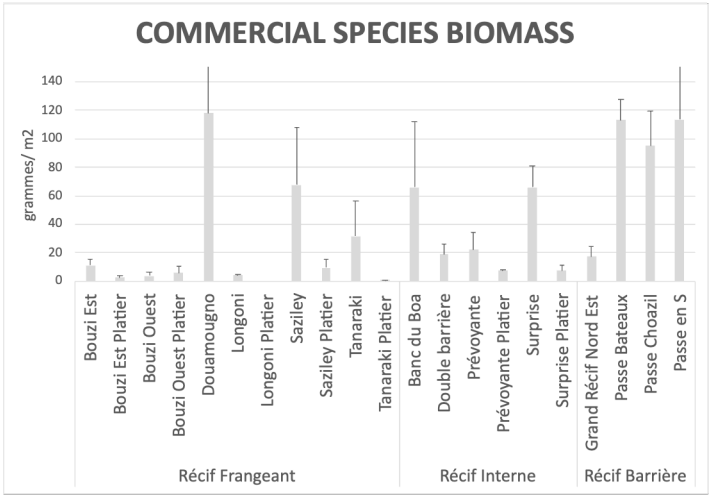




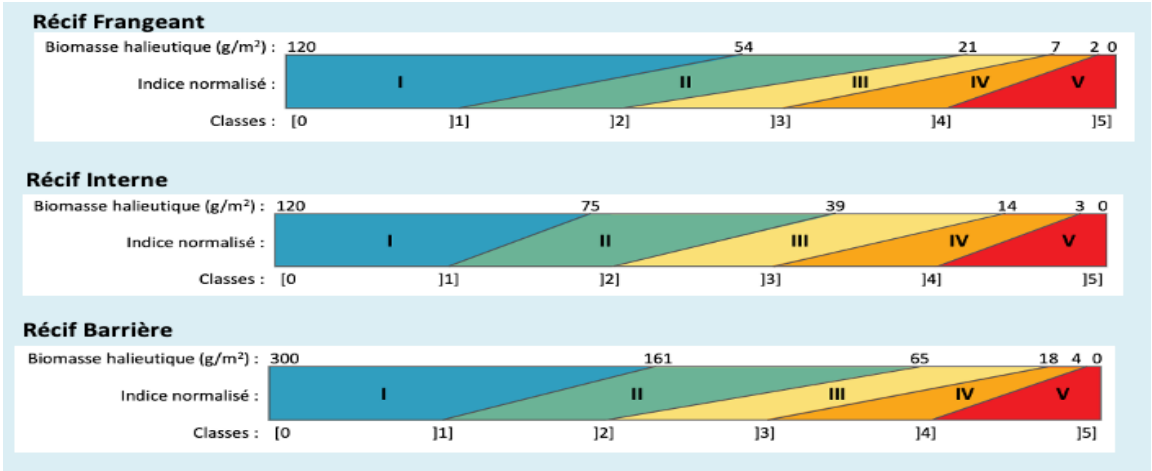




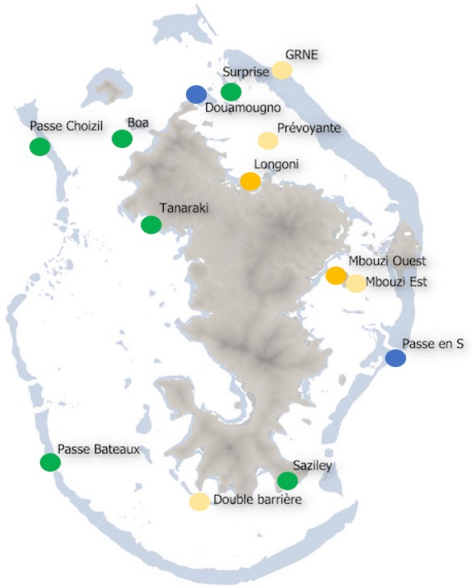
RESULTS - Reef Fish Index



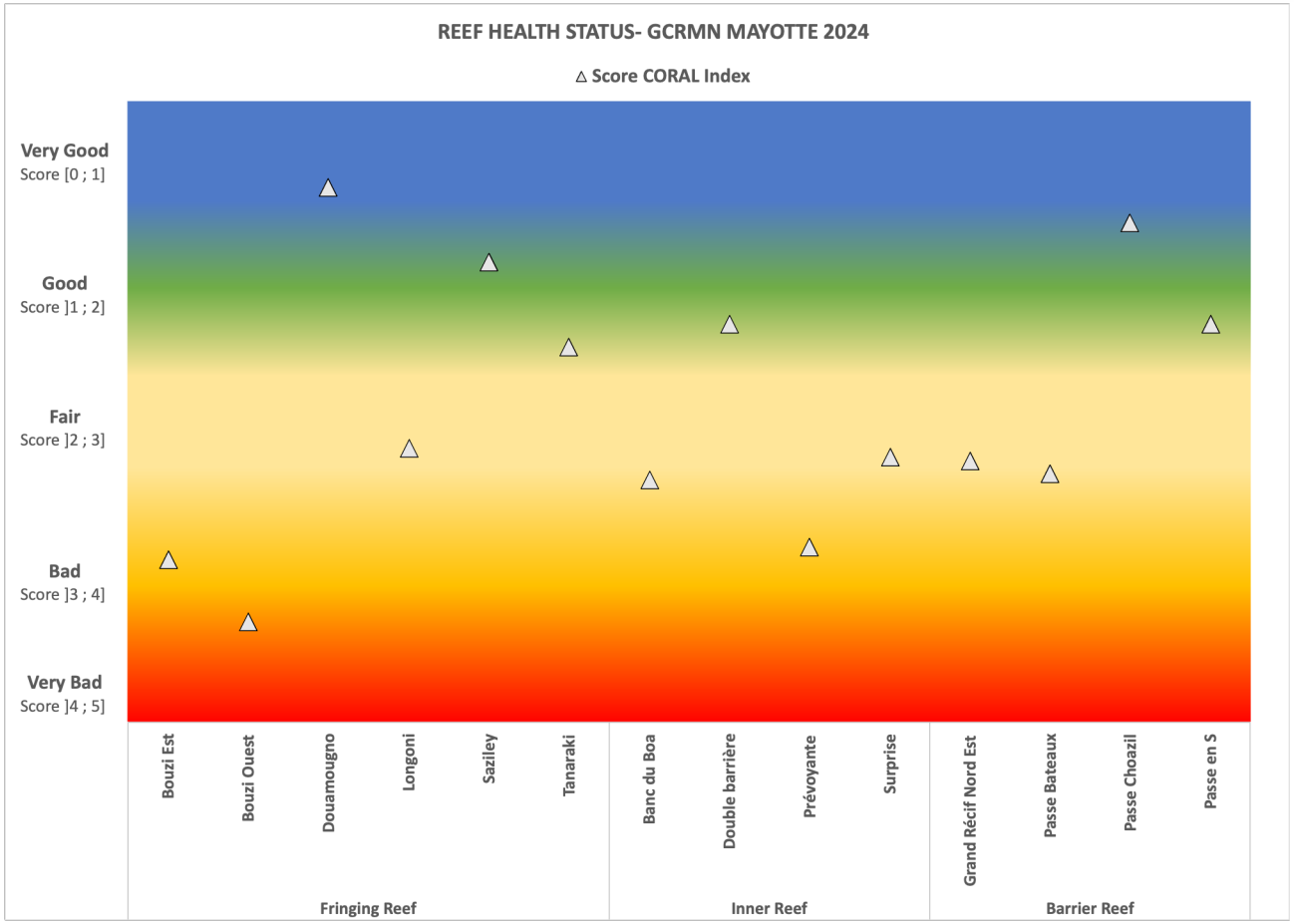
Commercial species biomass

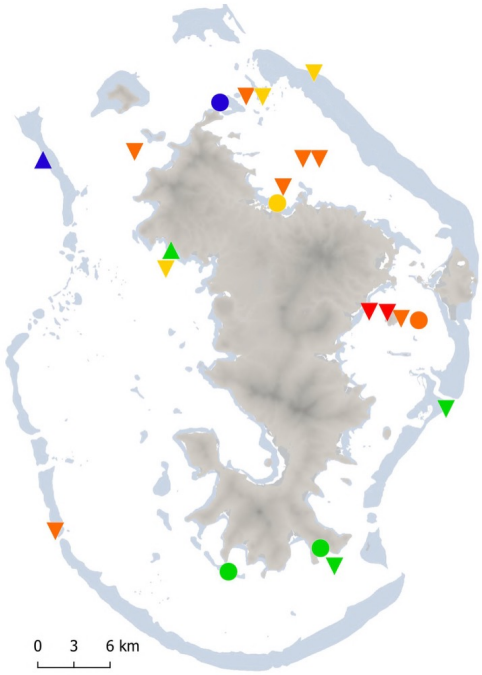


Reef Type	Station name	*Species Richness*	*Carnivorous Density*	*Herbivorous Excavators Biomass*	*Commercial species Biomass*	SCORE Reef Fish Index
Fringing Reef	Bouzi Est	2,67	2,68	1,87	2,60	**2,44**
	Bouzi Ouest	3,64	3,47	5,00	3,51	**3,91**
	Douamougno	1,13	1,63	0,01	0,02	**0,64**
	Longoni	3,02	2,97	3,24	3,44	**3,17**
	Saziley	1,19	1,35	2,91	0,73	**1,54**
	Tanaraki	1,70	1,64	1,88	1,57	**1,69**
Inner Reef	Banc du Boa	1,87	2,02	2,08	1,23	**1,80**
	Double barrière	2,68	2,59	1,67	2,76	**2,43**
	Prévoyante	3,23	2,83	1,21	2,61	**2,47**
	Surprise	2,27	2,86	1,28	1,23	**1,91**
Barrier Reef	Grand Récif Nord Est	2,92	2,54	2,07	3,04	**2,64**
	Passe Bateaux	1,00	2,56	1,36	1,43	**1,59**
	Passe Choazil	1,58	2,07	1,67	1,62	**1,74**
	Passe en S	0,58	1,67	0,11	1,43	**0,95**



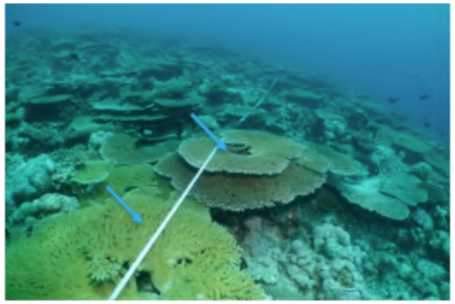
RESULTS – Coral Index

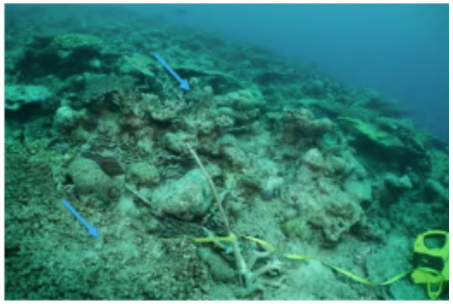




A significant deterioration due to coral bleaching in 2024:

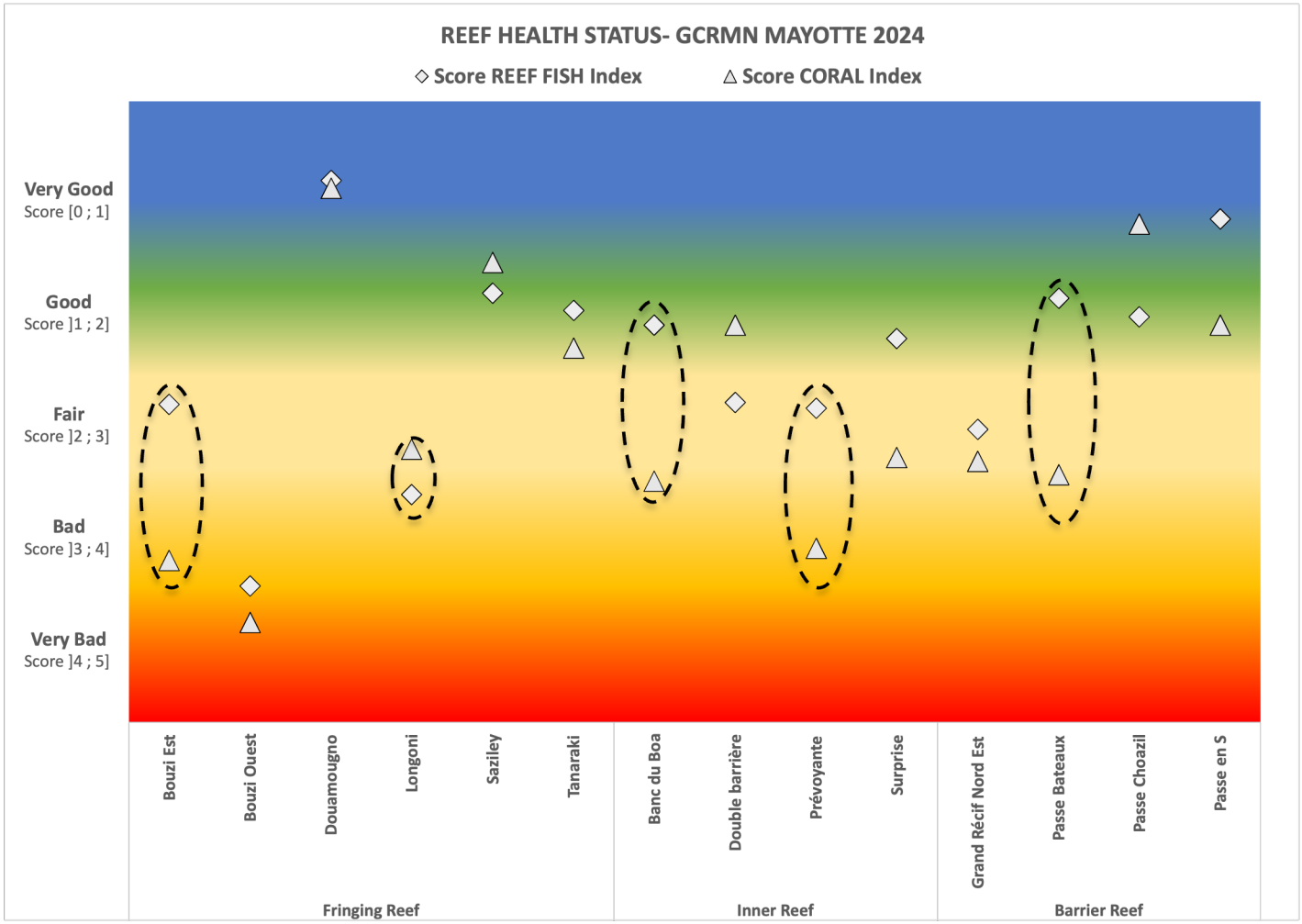
- Global coral cover loss in 1yr: 49% -> 28%
- Strongest impact in the southern reef sector





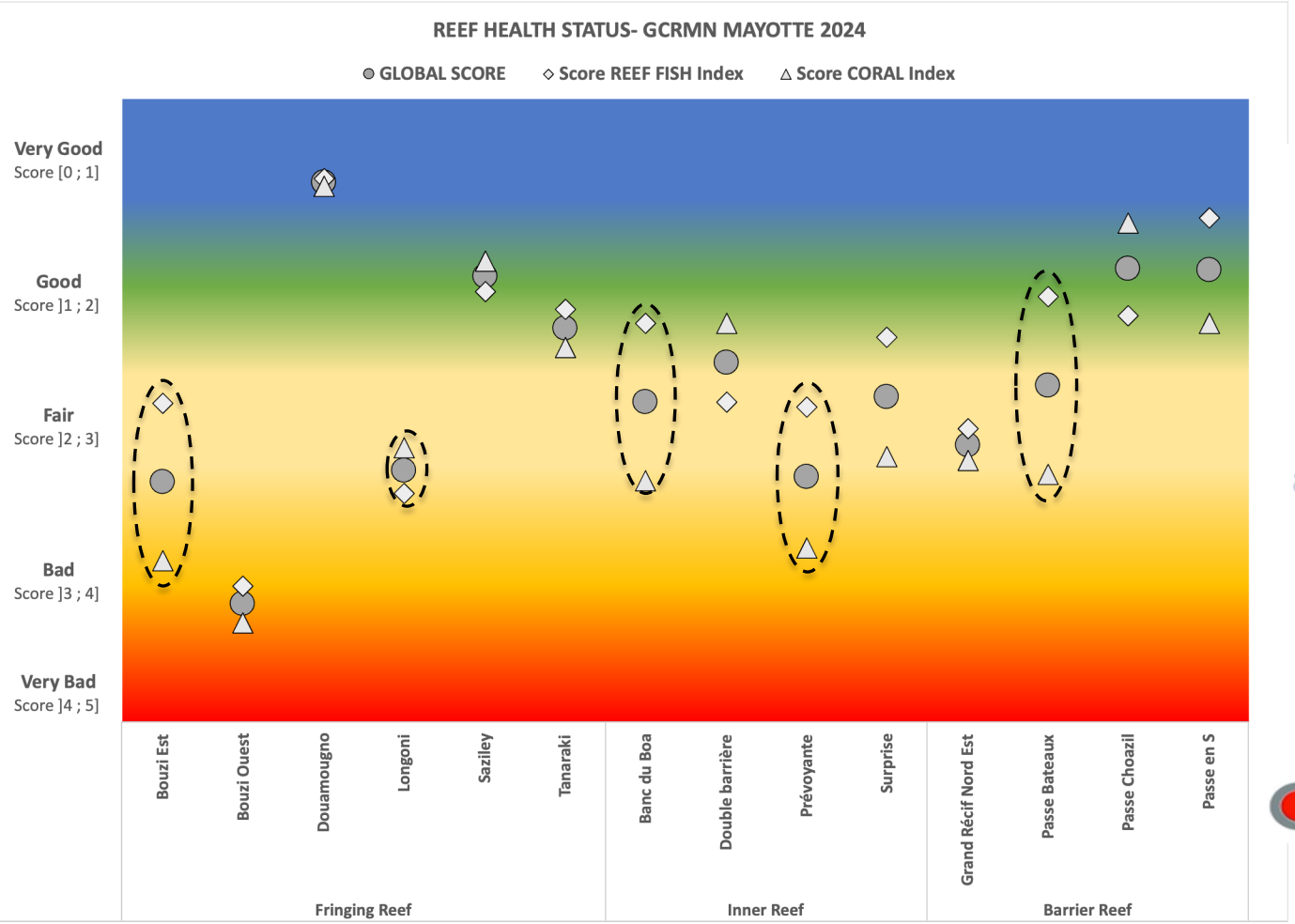
RESULTS - Corals and Reef Fish Index

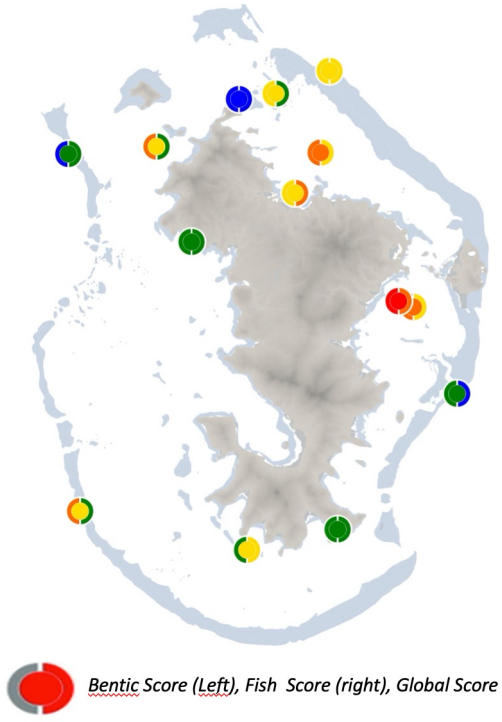
Integrated approach through average of :
- the score obtained for the « Benthos indicator » for hard substrate [1]
- the score obtained for the « Fish indicator » proposed in this study



[1]: Nicet and Pichon, 2014; Nicet 2024

RESULTS - Global score





Bentic Score (Left), Fish Score (right), Global Score (centre)

- Reef Health coral reefs in 2024 : Global Score decline mainly driven by benthos / coral index as reef fish index shows 2-3 years lag after massive coral bleaching.
- Including fish communities refines benthic-based reef health assessments, offering a more accurate ecological picture and highlighting habitat-specific issues where degradation impacts benthic and fish components with varying intensity.

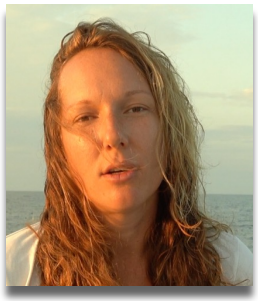
CONCLUSIONS & PERSPECTIVES

Integrated Coral Reef Fish bio-indicator

- **Robust:** statistically verified, ecologically relevant
- **Sensitive:** calibrated to the Mayotte reference system
- **Comprehensive:** combines benthic and fish data, integrating structural and functional variables
- **Adaptive:** evolves through time-dependent self-iterative calibration
- **Diagnostic:** identifies site-specific issues, showing how degradation can differently affect benthic and fish communities
- **Transposable:** applicable to other reef ecosystems with time series data

-> Reference systems must be defined **locally** for MPA management, with **potential to extend regionally** into a SWIO-wide framework for managers and scientists.

Many thanks for your attention!




Wickel J., Pinault M., Bissery C., 2024. Methodological approach for the development of a fish indicator at GCRMN stations in Mayotte island. MAREX/IFRECOR Technical report for the « Parc Naturel Marin de Mayotte » 31p.