

THE GIREL PROJECT

**Biomimetic Artificial Reefs Enhance Long-Term Nursery Functionality
within Industrial Port Infrastructures**

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CONTEXT

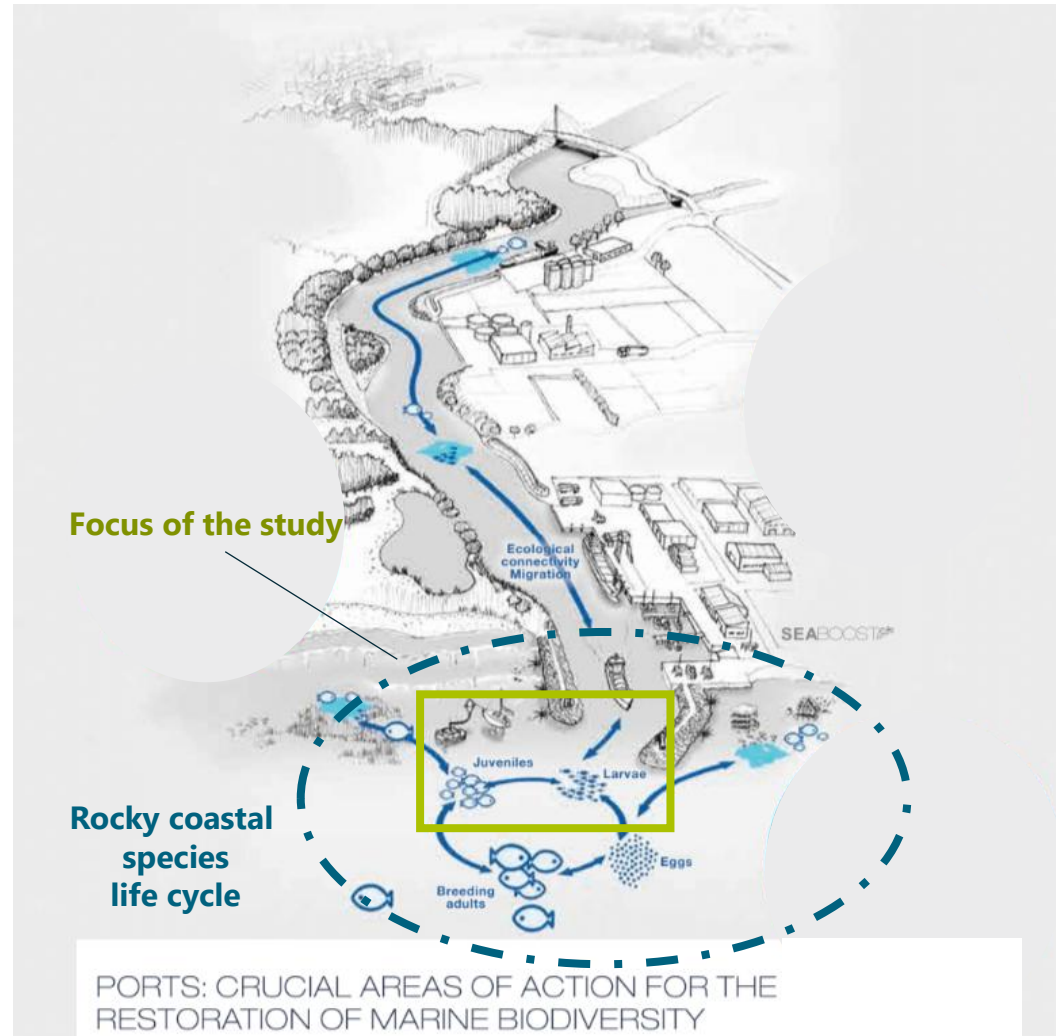


- Coastal ecosystems are rich systems and shallow habitats, such as seagrass beds, serve as fish nurseries (Cheminée et al., 2021)
- The artificialisation of the coast has led to a decrease in favorable nursery habitats and changes in fish assemblages (Guidetti et al., 2002)
- The port of Marseille is the largest port in France (400ha)
- Previous complexifications trials of maritime infrastructures have shown encouraging results with an increase in nursery functions (e.g. Joubert et al., 2023)
- Long term effect of habitat complexification to increase the nursery function for fish?





NURSERY FUNCTION OF URBAN COASTLINE



Benefits in and outside ports



Sheltered areas



Diverse and complementary habitat features



Areas of transit and migration routes

DEPLOYMENT ZONES

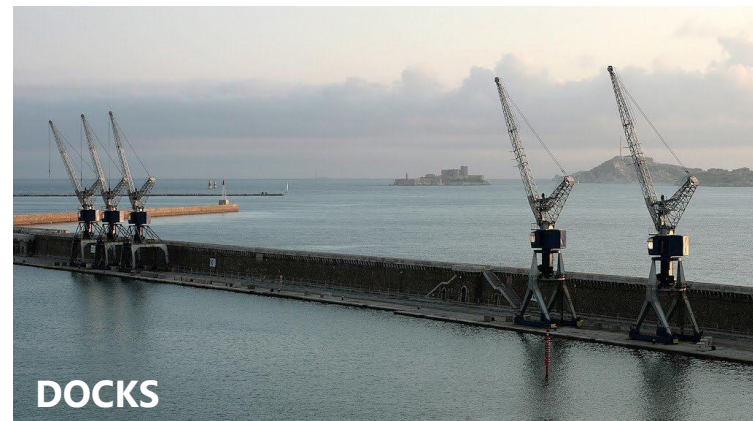
2014 => Habitat complexification



Ifremer
Dr Marc Bouchoucha



BREAKWATER



DOCKS



Giant Urchins on Breakwaters (3 sites, 9 stations)



Artificial Seagrass on Docks (3 sites, 9 stations)



WHAT HAPPENED SINCE 2014?



???

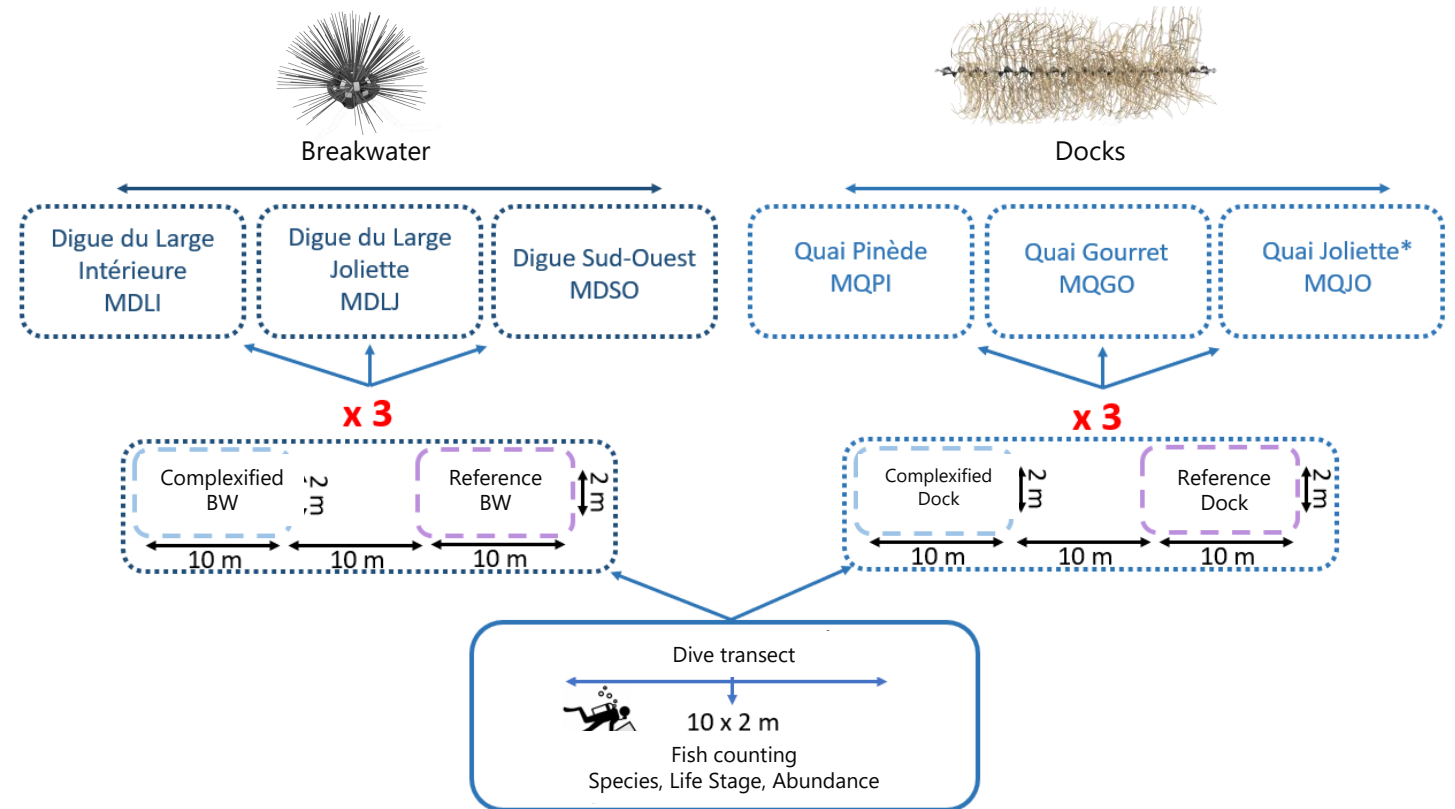




MONITORING METHODOLOGY

ECOLOGICAL MONITORING

- UVC Transects Scubadiving
- 2 Seasons : Summer / Autumn
- t+1year / t+8 years
- 5 sites
- 3 replicates of 20 m² per site
- Comparison with local reference
- Transects of 10 m x 2 m (20 m²)
- Focus on juvenile of fish





MONITORING METHODOLOGY

TECHNICAL MONITORING

■ Visual control



SEABOOST 

■ Material aging studies

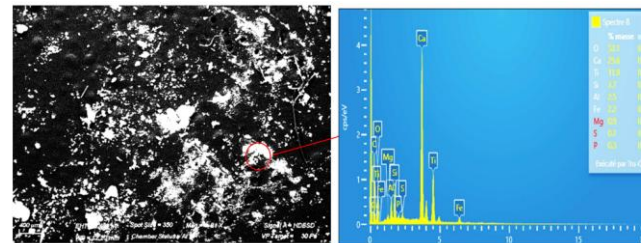
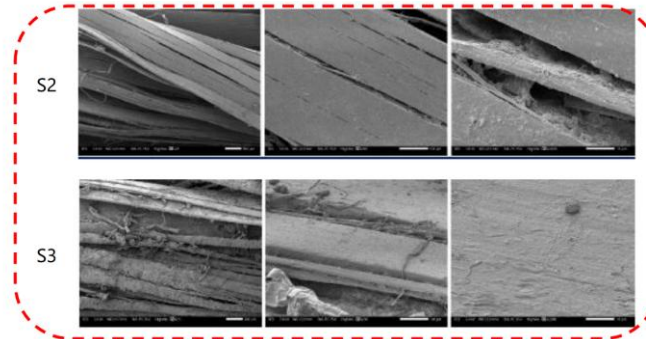


Fig.8 – Image MEB (x21) en mode BSE du résidu sec de l'échantillon « Carde Seaboot » (IX23-823)
Fig.9 – Analyse élémentaire moyenne par spectrométrie X à dispersion d'énergie (20 keV) d'un point de l'échantillon « Carde Seaboot » (IX23-823)



■ Maintenance test

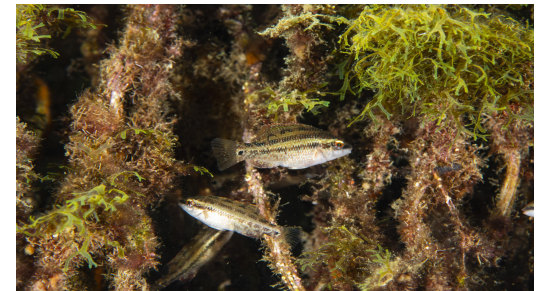


SECTION 01.



MAIN RESULTS IN NUMBERS

- 72 replicates / ~35 hours of UVC
- 7 103 juvenile of fish of 33 sp.
- 3 214 in 2014, 3 889 in 2022
- Commercial Port infrastructures play a nursery function for fish
- Complexification stations still operational & efficient

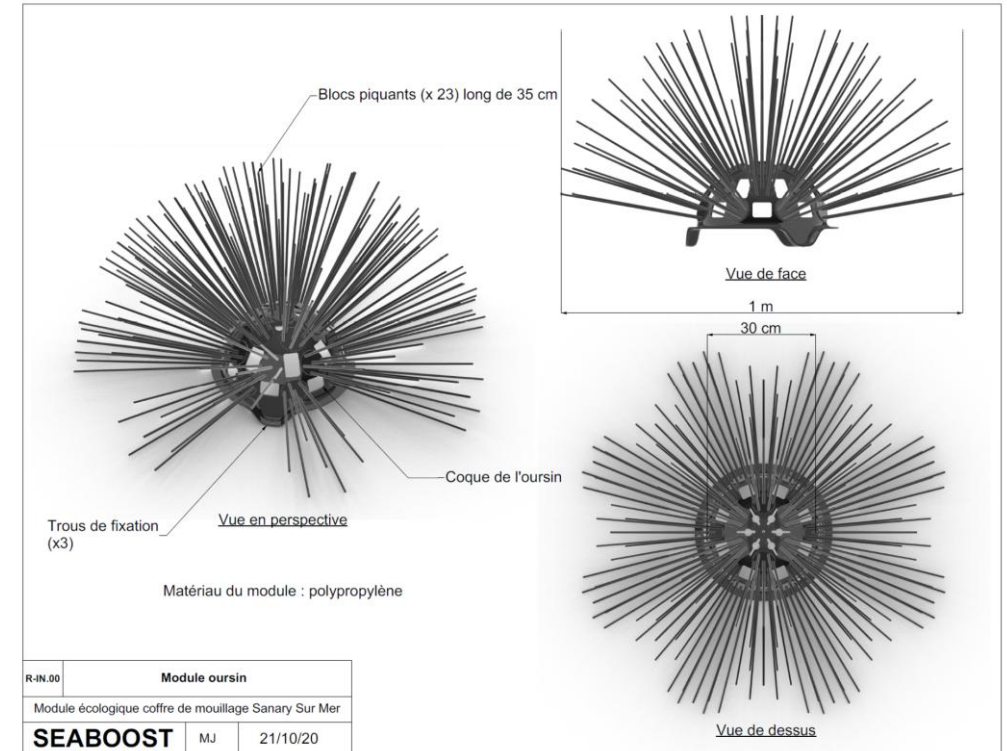




BREAKWATER COMPLEXIFICATION

- Increase microcomplexity in breakwaters
- « Giant urchins »
- 240 units around 1 m diameter (PP)
- **2014** study : increase diversity locally during the first year

Lieu	Marseille			Fos sur Mer
Code station	MDLG (Poste 123)	MDSO (Poste 190)	MDLJ (Poste 100)	FDG (Gloria)
Number of units per site (Juin 2014)	60	60	60	60







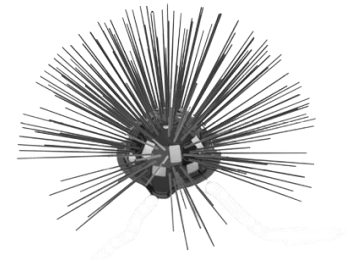






BREAKWATER COMPLEXIFICATION

- Technical durability **not exceeded after 8 years** despite lack of maintenance
- 83% of sea urchin modules still in place
- Loss mainly at one site Digue du Large (crushing by rock movements)
- 99% of spines still in place on the remaining sea urchins (no macroloss)
- <1 macro-waste per station of 20 sea urchins on average
- Anchoring systems not corroded and operational



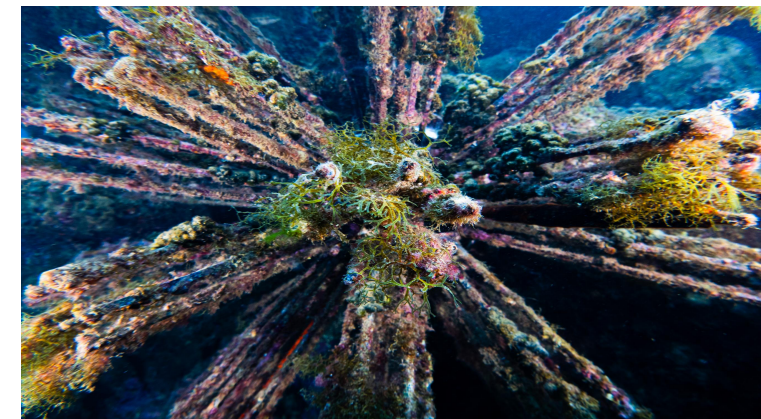
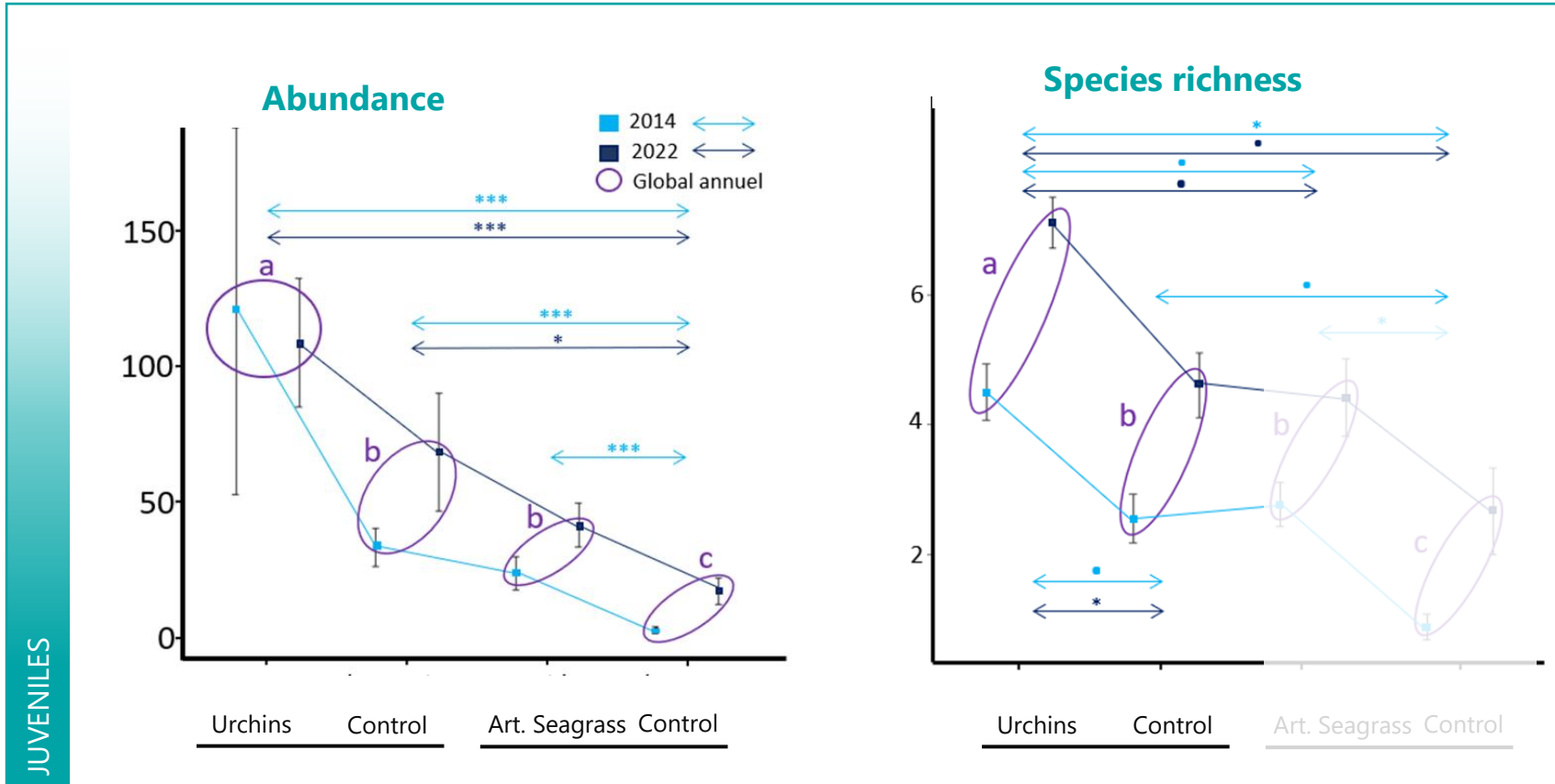
...And ecology?





BREAKWATER COMPLEXIFICATION (T+8 YEARS)

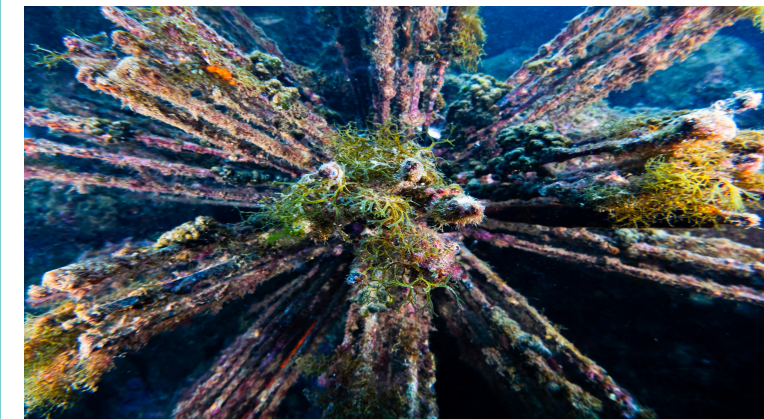
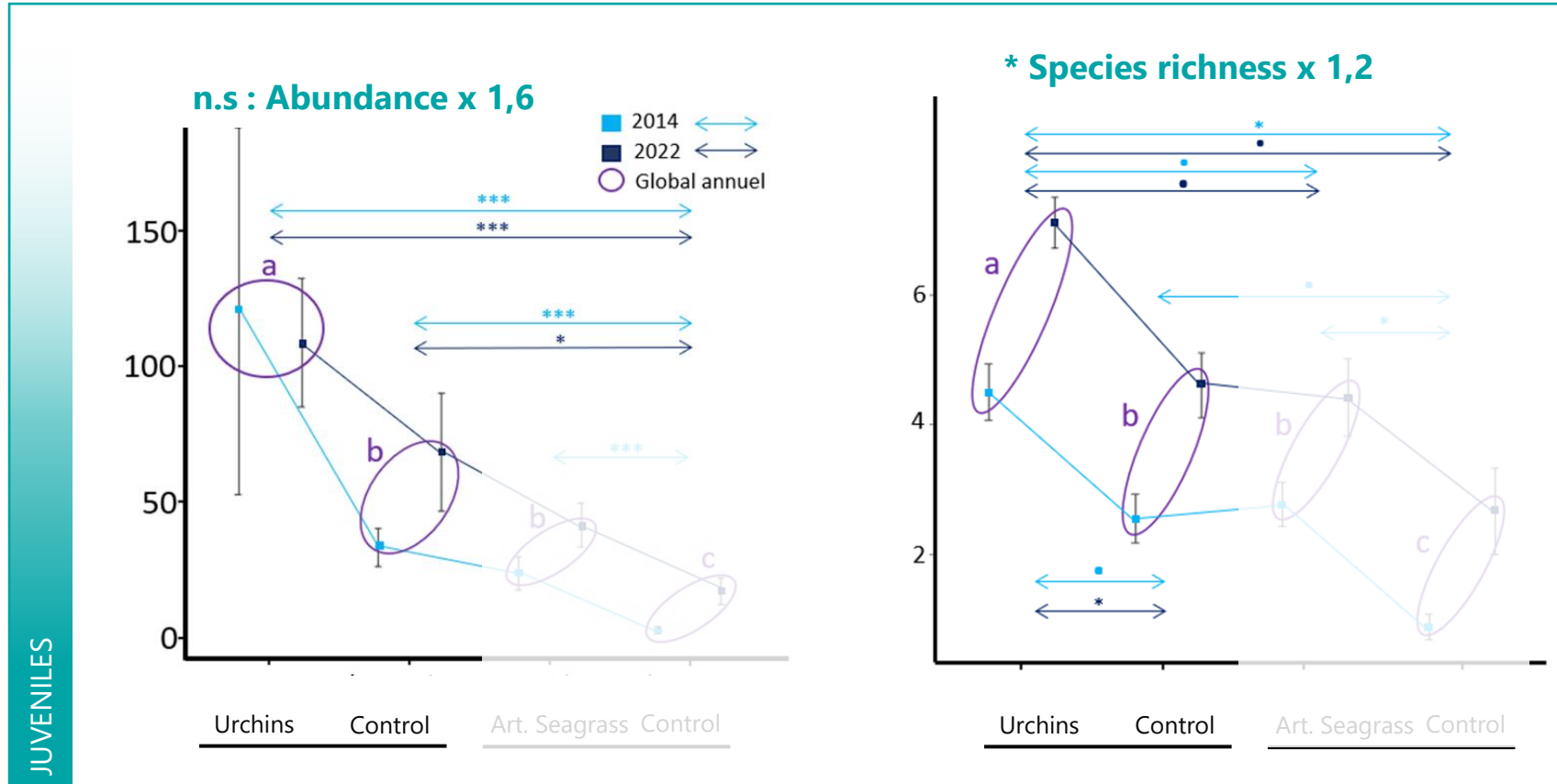
More life and juvenile on breakwaters





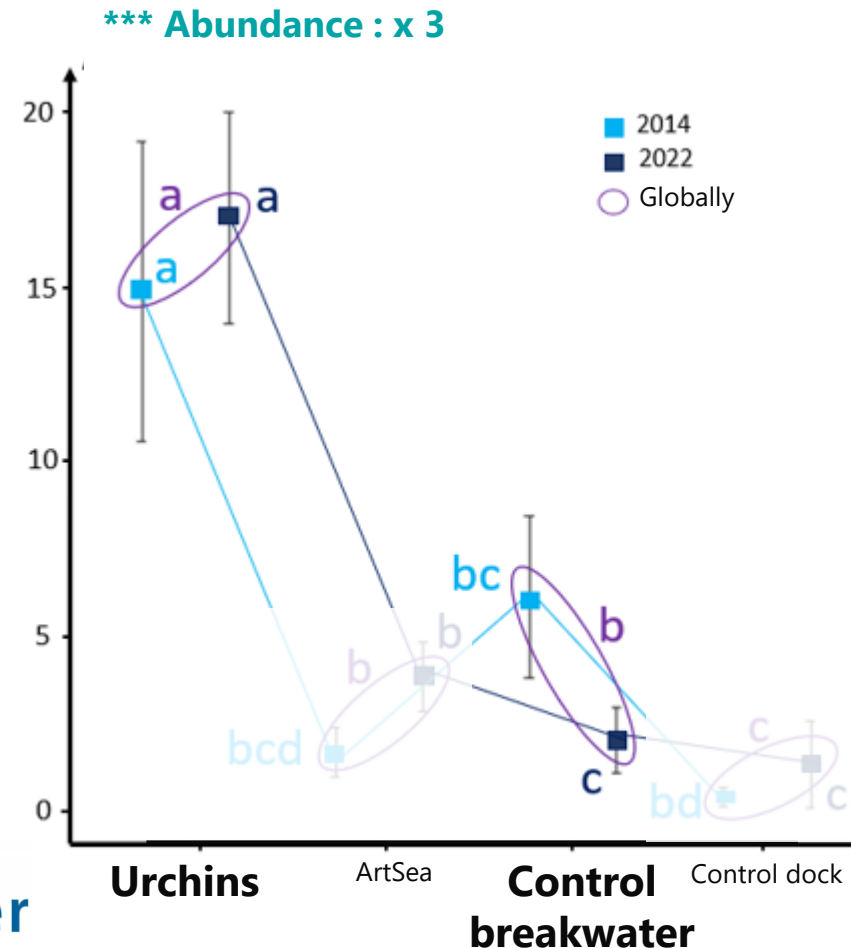
BREAKWATER COMPLEXIFICATION (T+8 YEARS)

Breakwater complexification still efficient





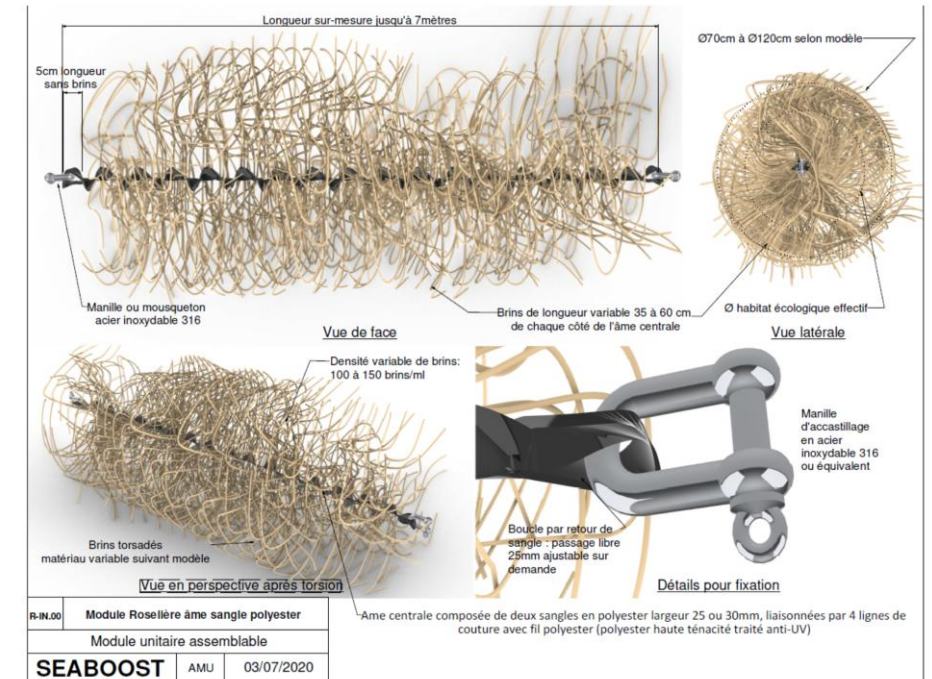
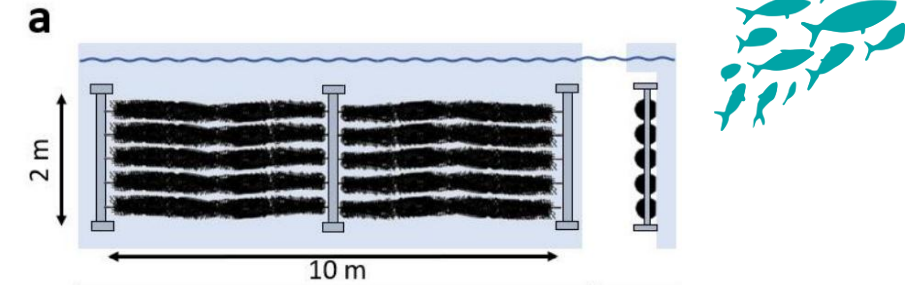
3 TIMES MORE JUVENILES OF THE LABRIDAE *SYMPHODUS OCELLATUS* ON THE SECTIONS WITH URCHINS COMPARED TO THE CONTROL BREAKWATERS



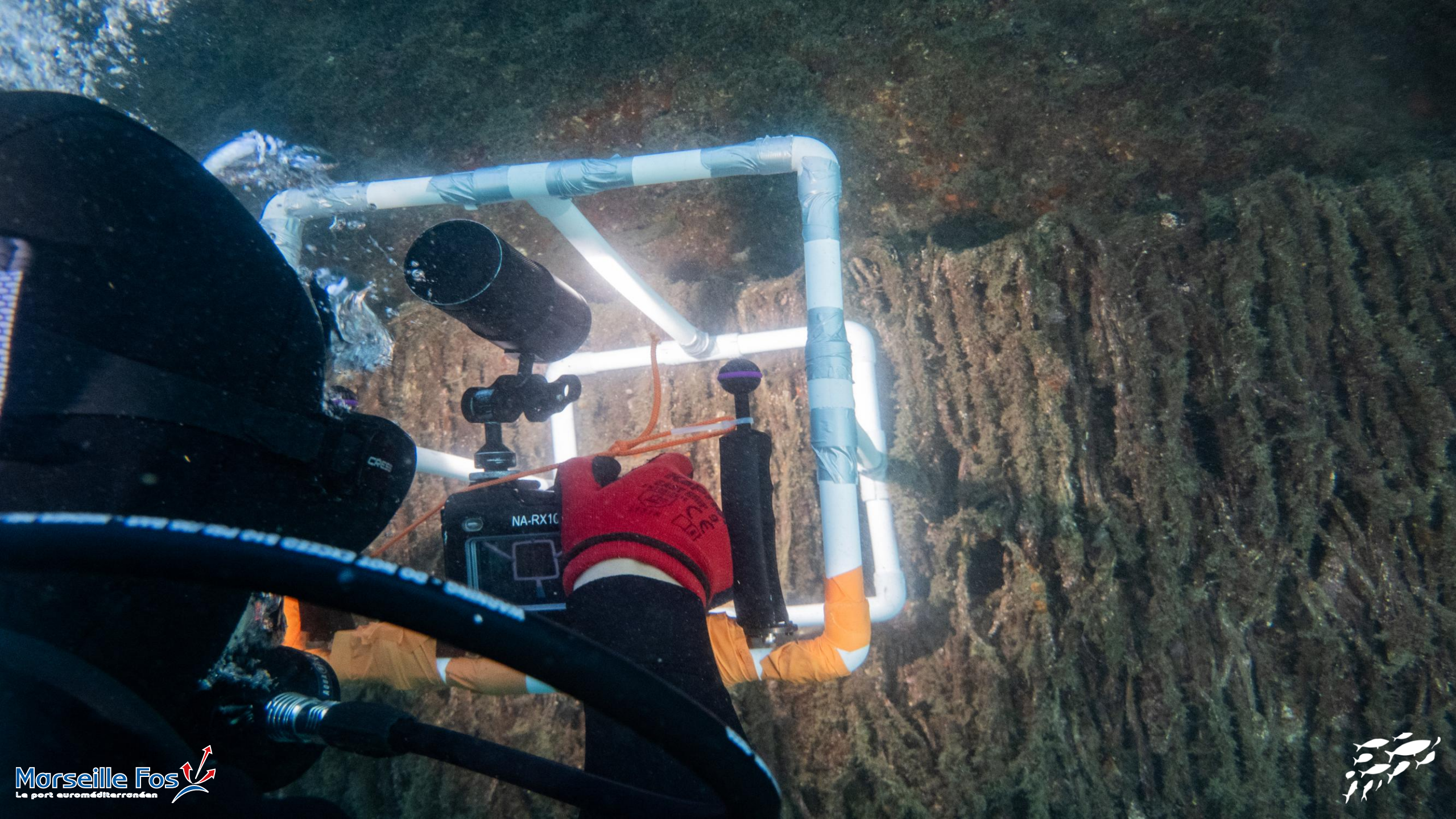
DOCKS COMPLEXIFICATION

- Increase vertically the habitat complexity
 - 90 units, 450 ml
 - 2014 > *** abundance and species richness of juvenile
- Important differences

Lieu	Marseille	
Code station	MQG	MQP
Nombre de modules Roselière® (Juin 2014)	30	30











DOCKS COMPLEXIFICATION

- Technical durability **not exceeded after 8 years** despite lack of maintenance
- **1 decomissioned station** during the experiment (No more Docks Fender / organization of public events)
- 100% of the modules still in place
- “Leef” density equivalent to initial density (no macroloss)
- Laboratory analysis shows little loss of mechanical properties and no ecotoxicological component (IRMATEC, 2022)
- Significant sedimentation and biogenic colonization change the initial 3D shape of the structure
- Anchoring systems not corroded and operational

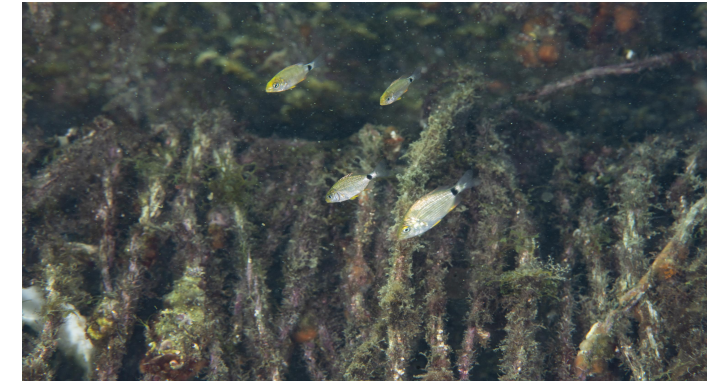
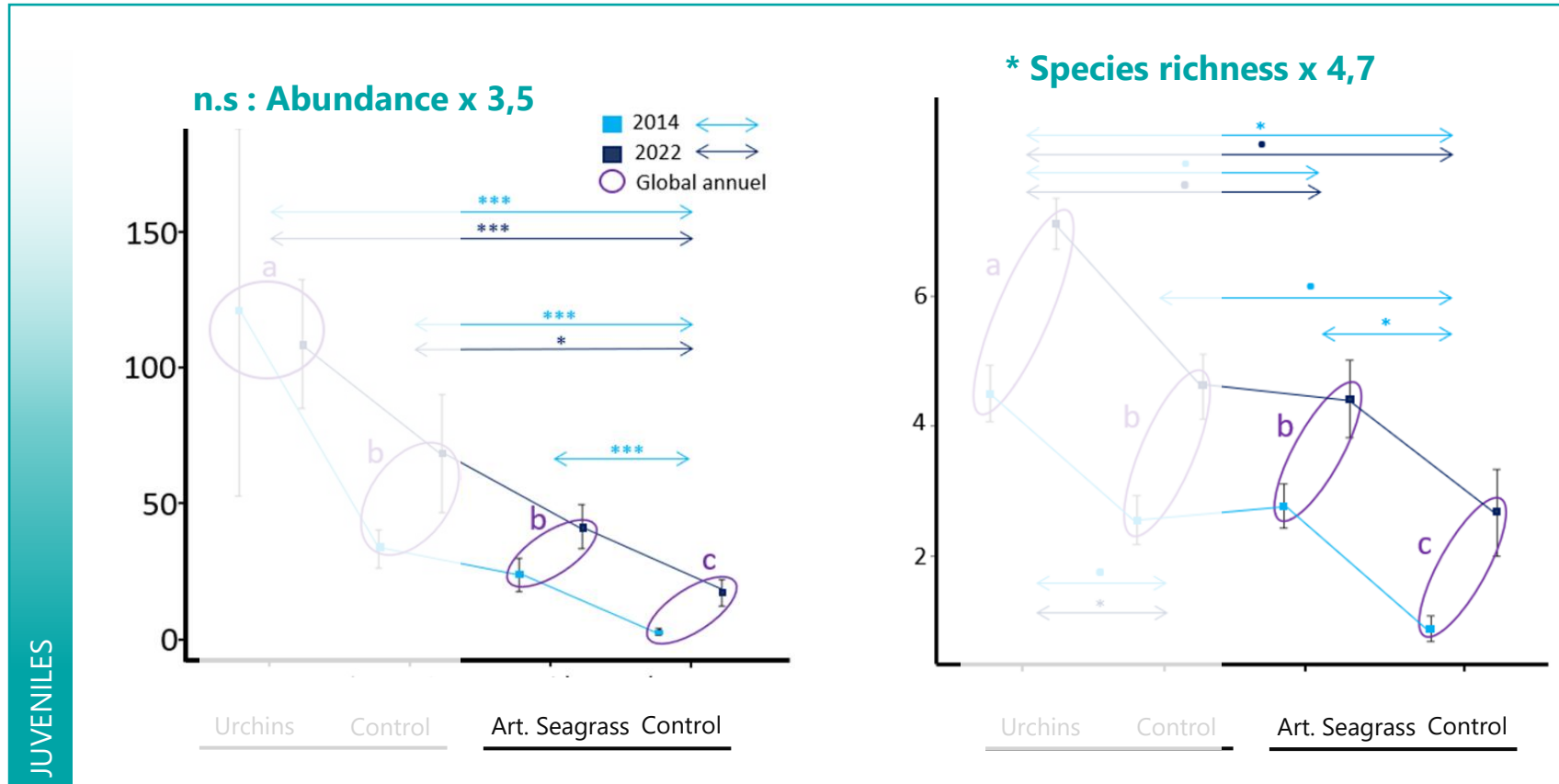
...And ecology?





BREAKWATER COMPLEXIFICATION (T+8 YEARS)

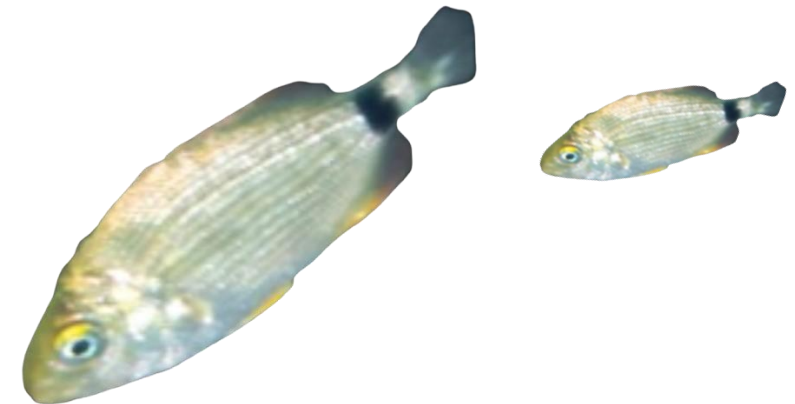
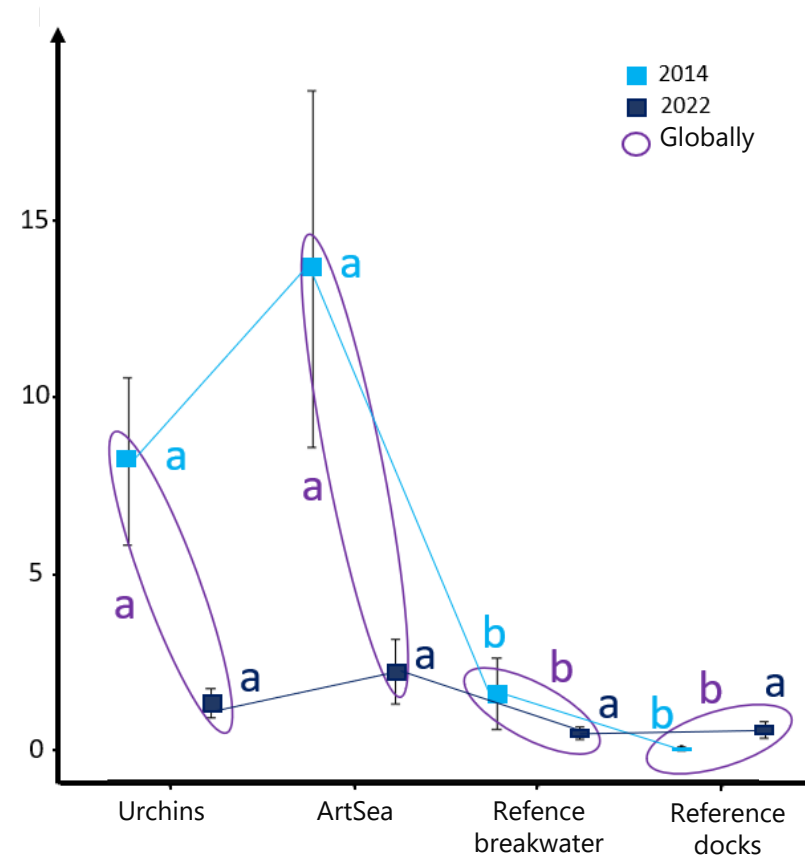
Docks complexification still efficient



NATURAL VARIABILITY IN COASTAL FISH RECRUITMENT DEPENDING ON THE SPECIES : SEABREAM *DIPLODUS ANNULARIS*



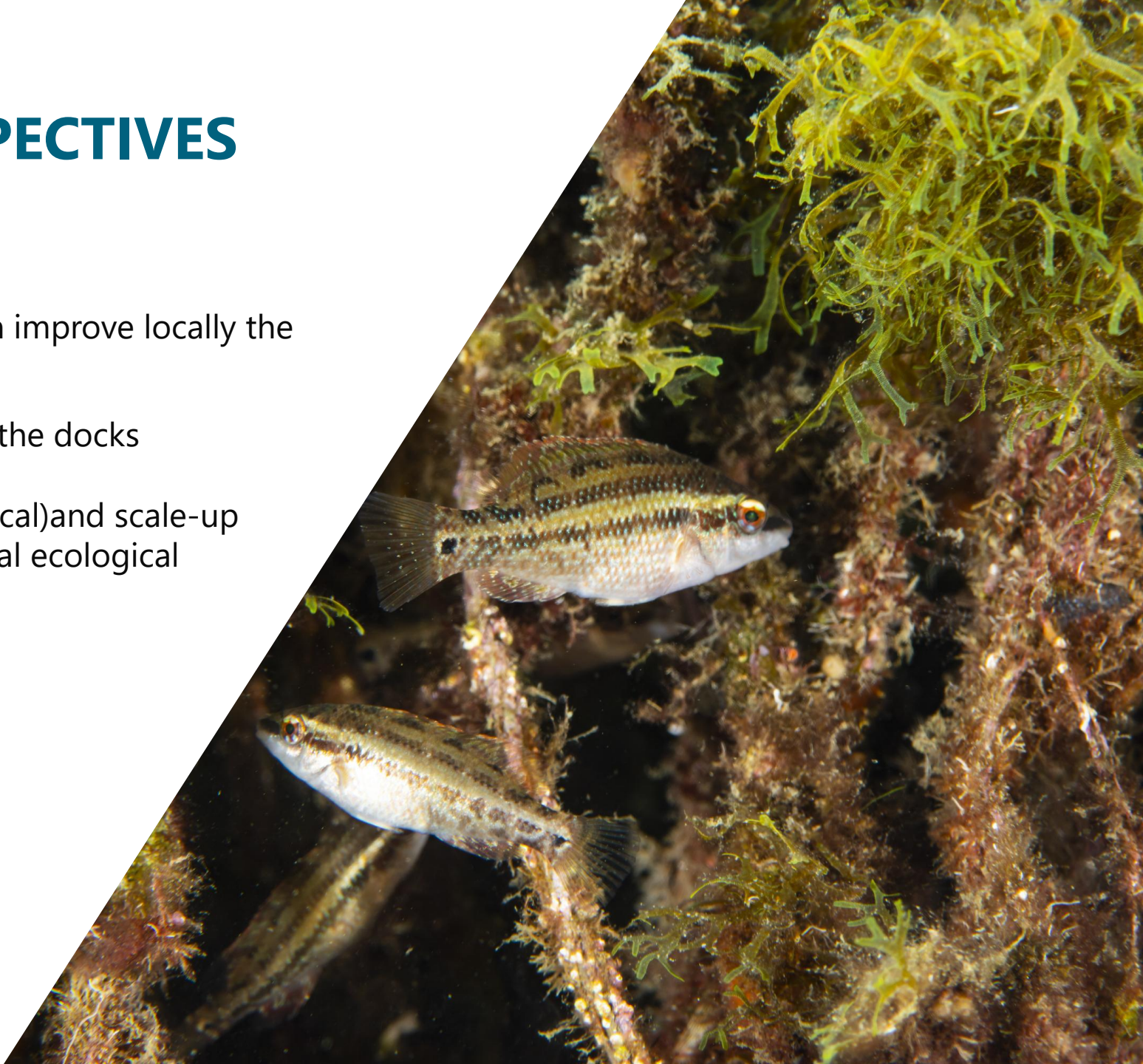
Abundance : 2014 > 2022





SYNTHESIS & PERSPECTIVES

- Complexification of port infrastructures can improve locally the nursery function for fish
- A greater leverage effect of eco-design on the docks
- Long-term monitoring (technical & ecological) and scale-up projects are needed to restore degraded coastal ecological functions (Joubert et al., 2025)



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