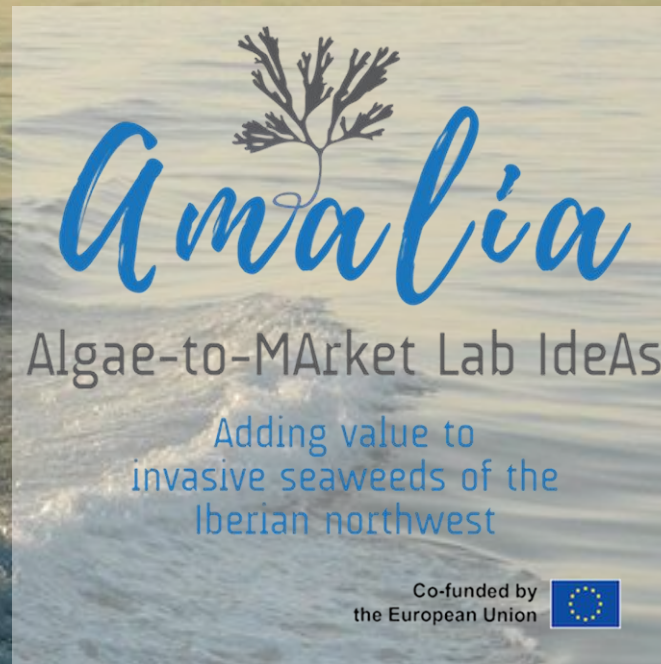


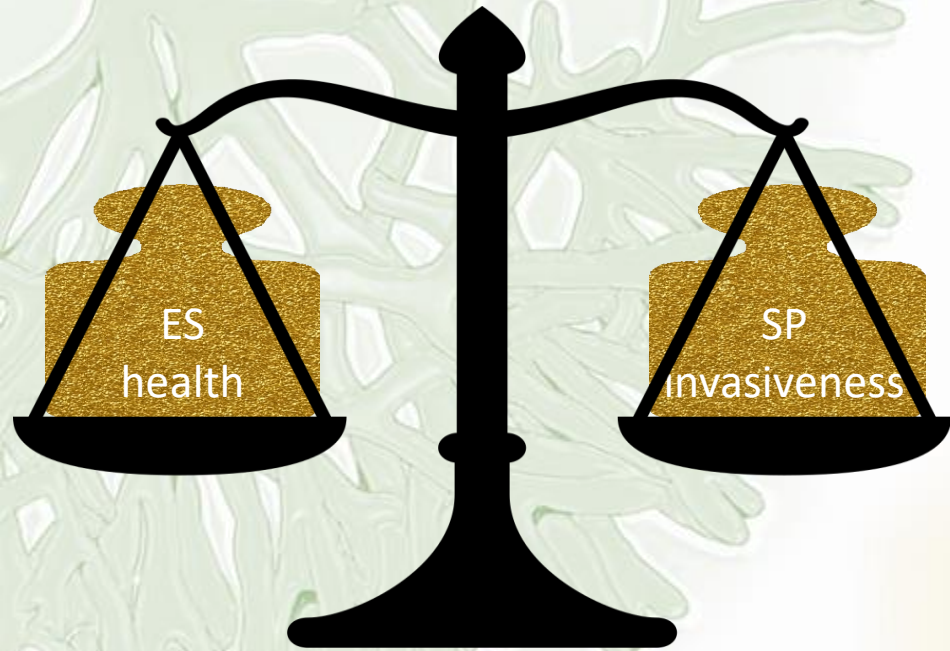
The effect of protection and wave-exposure of two marine protected areas have opposite trends on macroalgae invasiveness.

Andreu BLANCO, Jesús S. TRONCOSO, Celia OLABARRIA, Marco F.L. LEMOS



INTRODUCTION

Effects of the invasion



MAIN IMPACTS

- Loss of genetic diversity
- Alteration of ES functioning
- Alteration of community structure
- Impoverishment of ES services



INTRODUCTION

Biotic Resistance Hypothesis

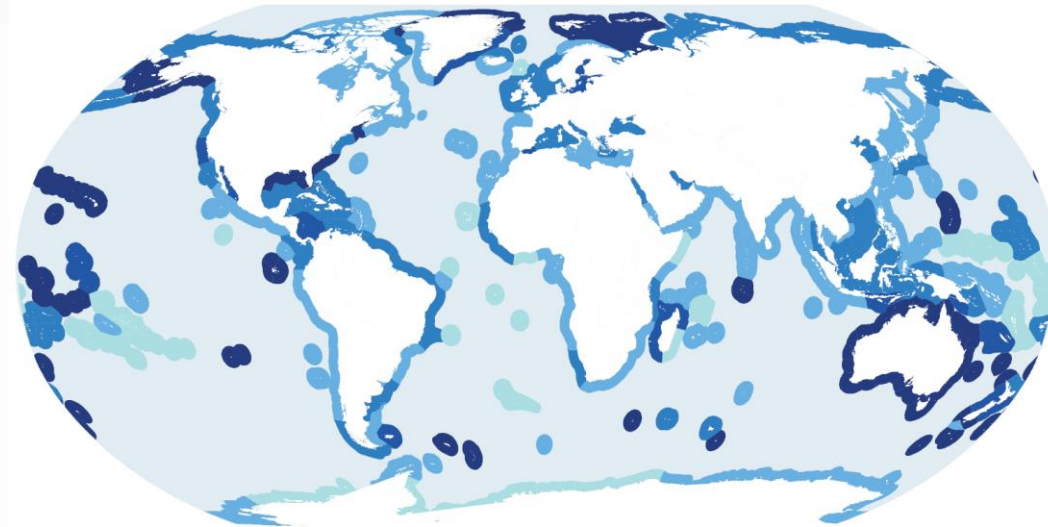
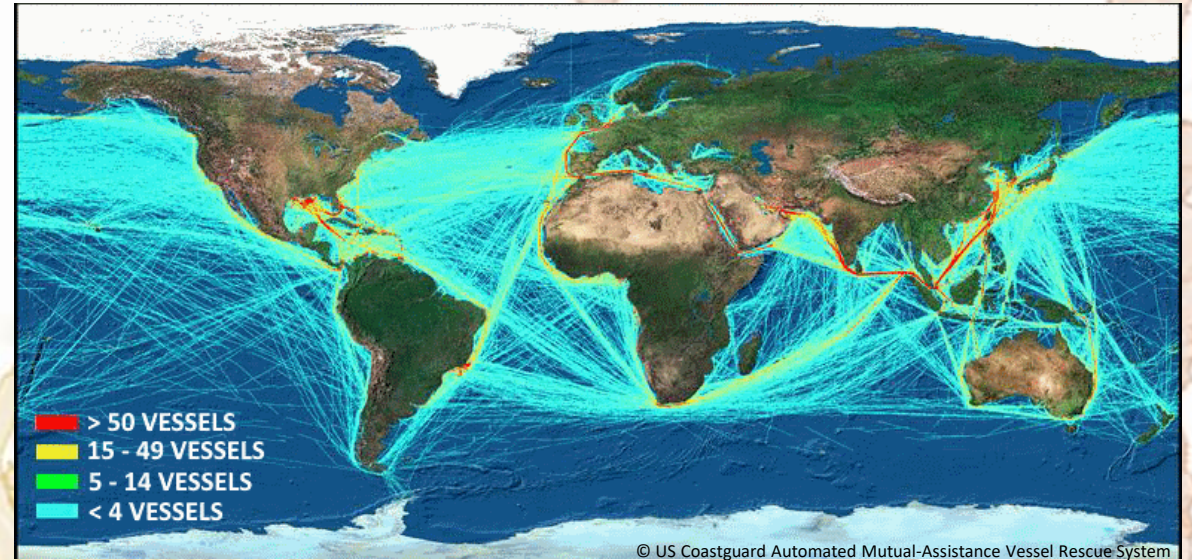
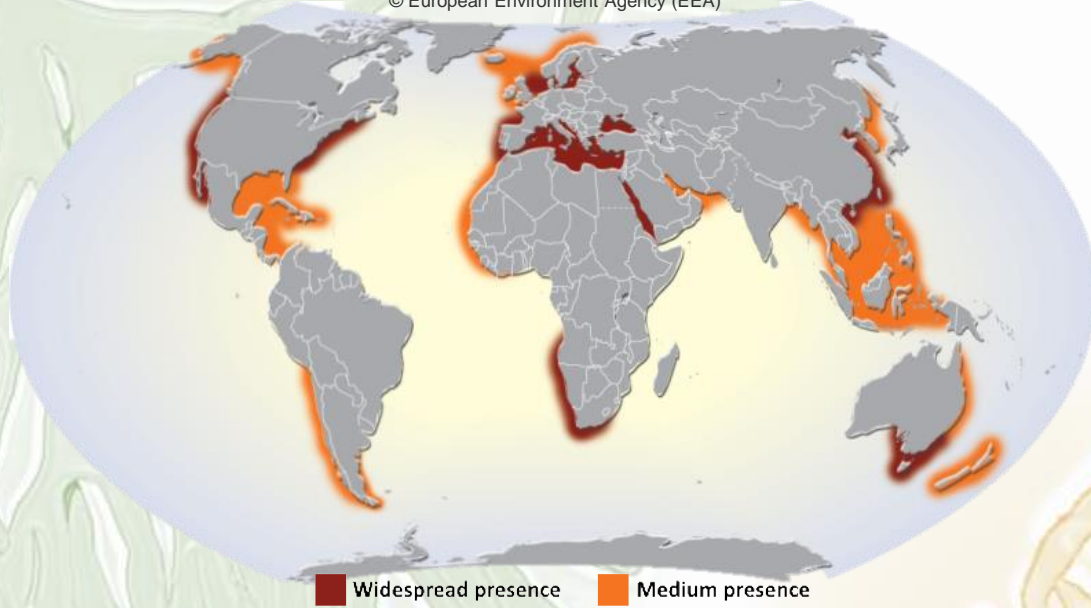


Island Susceptibility Hypothesis



INTRODUCTION

Invasive Marine Species Hotspots
© European Environment Agency (EEA)

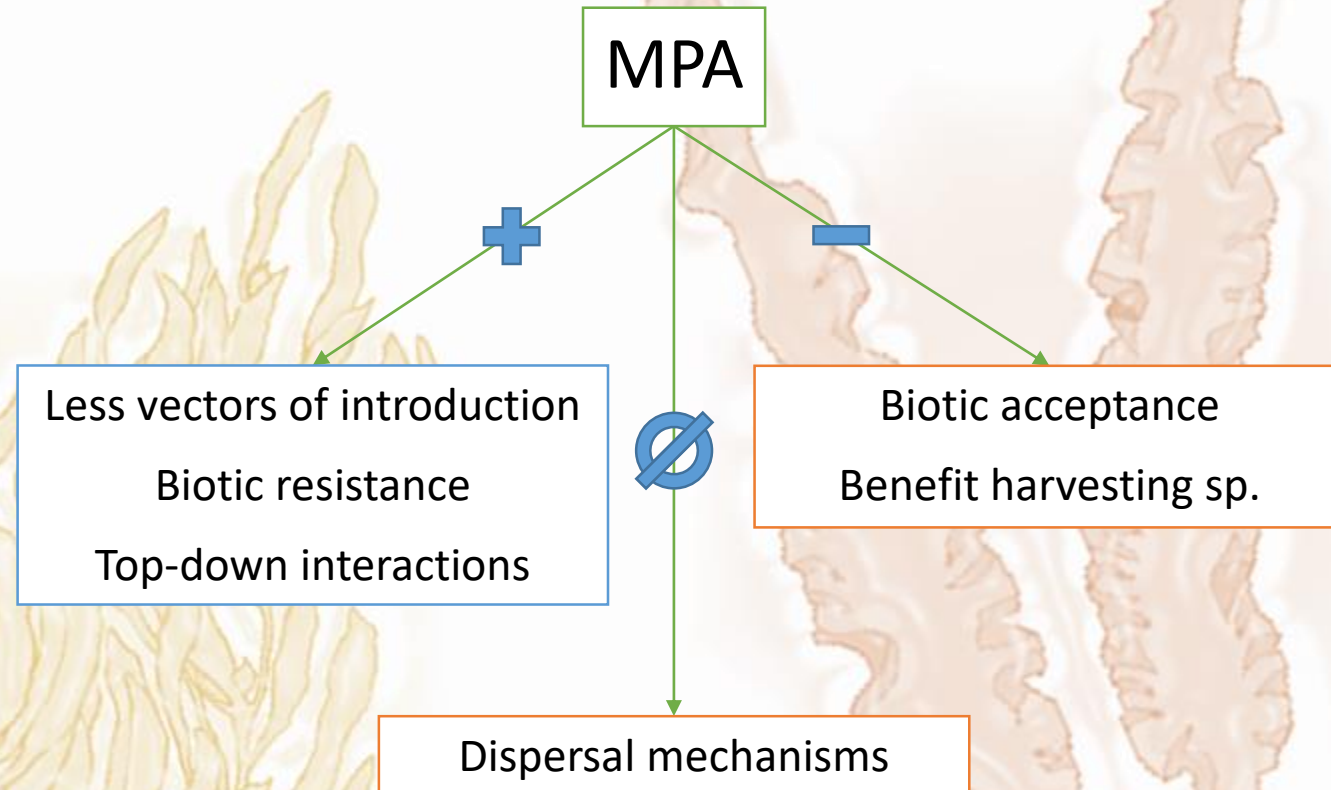


Proportion protected © European Environment Agency (EEA)

■ 0% ■ <1% ■ 1-5% ■ 5-10% ■ >10%

INTRODUCTION

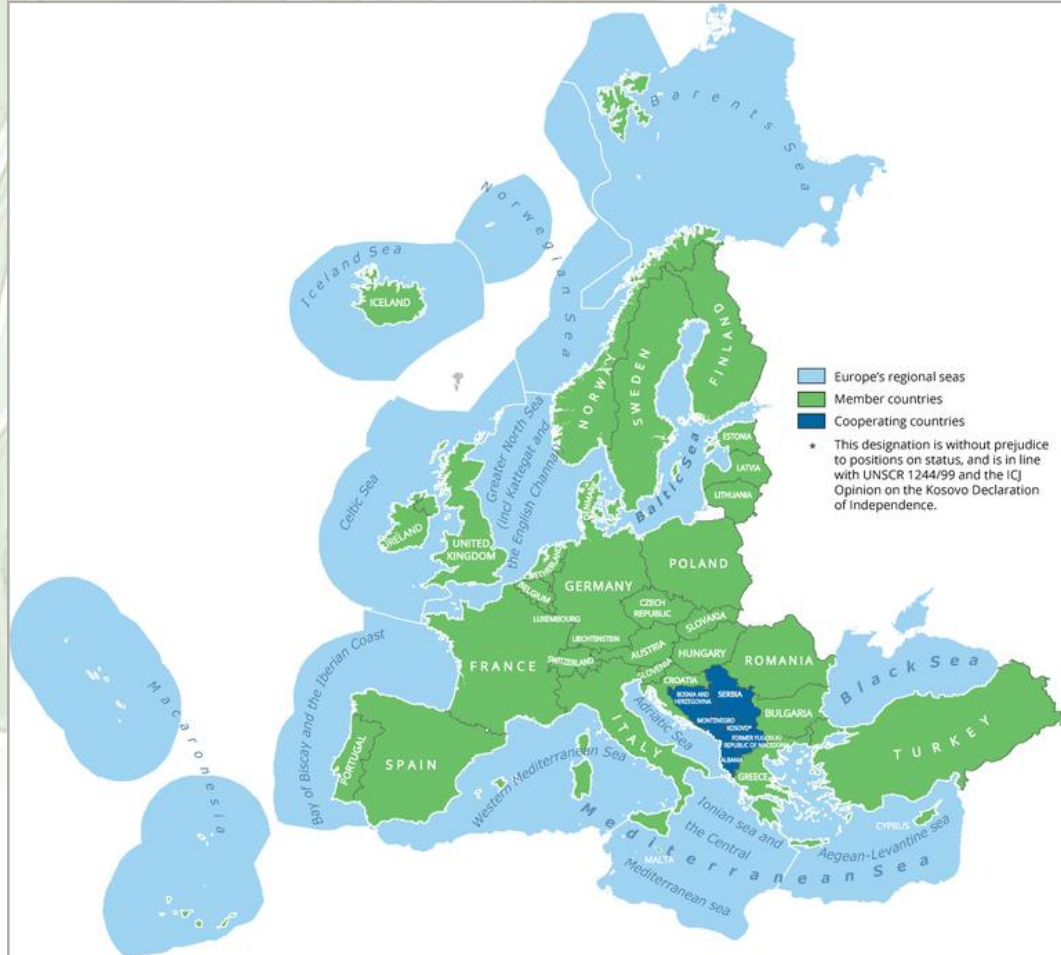
The role of MPAs



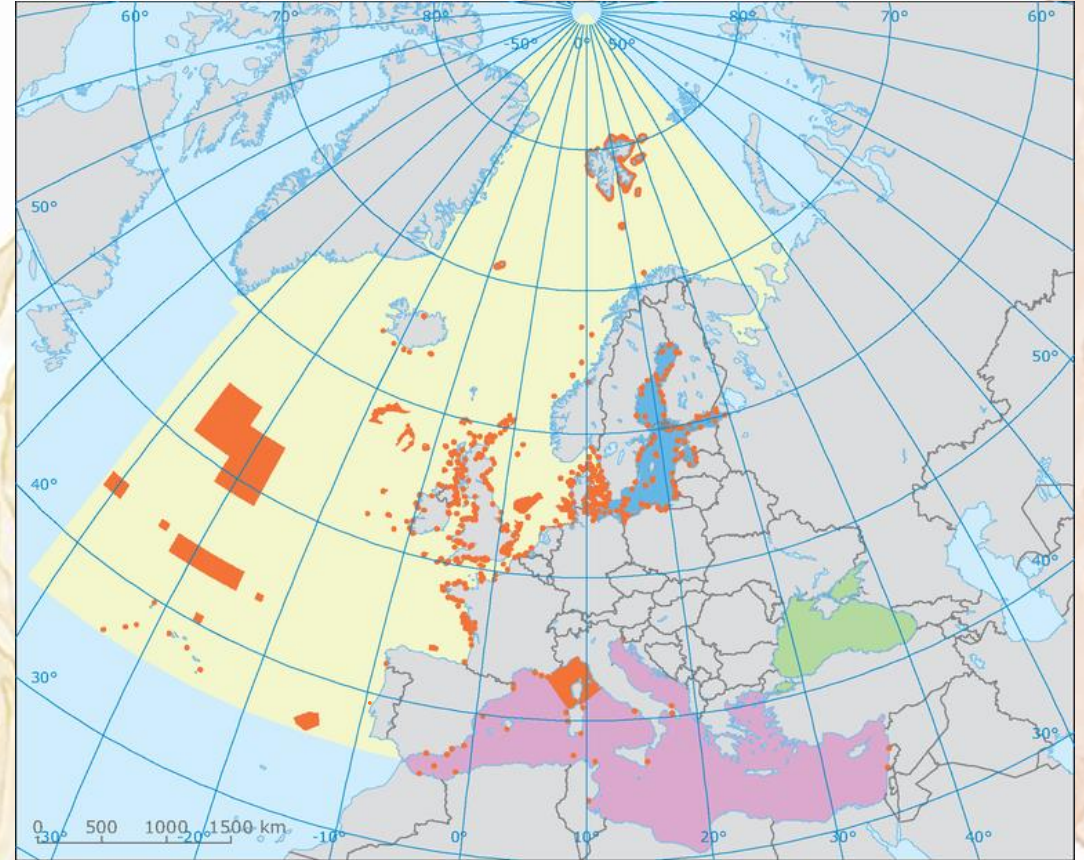
OBJECTIVE

Understand the effect of MPAs on the invasion success of the 6 major invasive macroalgae species in the W Iberian Peninsula

REGIONAL STUDY: SPAIN AND PORTUGAL



© European Environment Agency (EEA)



MPAs designated under the Regional Sea Conventions

- Regional Sea Convention MPA
- Bucharest Convention area
- OSPAR Convention area
- Barcelona Convention area
- HELCOM Convention area

© European Environment Agency (EEA)

TARGET SPECIES



Grateloupia turuturu



Asparagopsis armata
Falkenbergia rufolanosa



Colpomenia peregrina



Sargassum muticum



Undaria pinnatifida



Codium fragile ssp. fragile

EXPERIMENTAL DESIGN

Areas

Islas Atlánticas MPA

Reference

Localities

Cies 1

Cies 2

Ons

Sálvora

Ref.
Cies 1

Ref.
Cies 2

Ref.
Ons

Ref.
Sálvora

Sites

Exposed

Sheltered

E

S

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Areas

Berlengas MPA

Reference

Localities

Berlengas

Farilhoês

Ref.
Berlengas

Ref.
Farilhoês

Sites

E

S

E

S

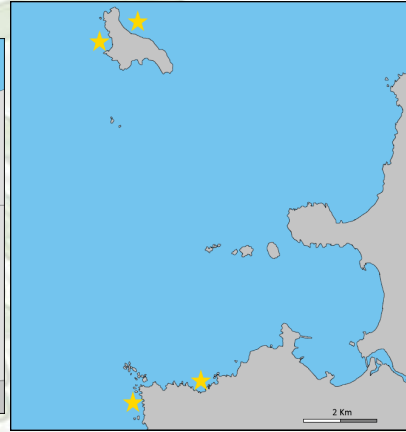
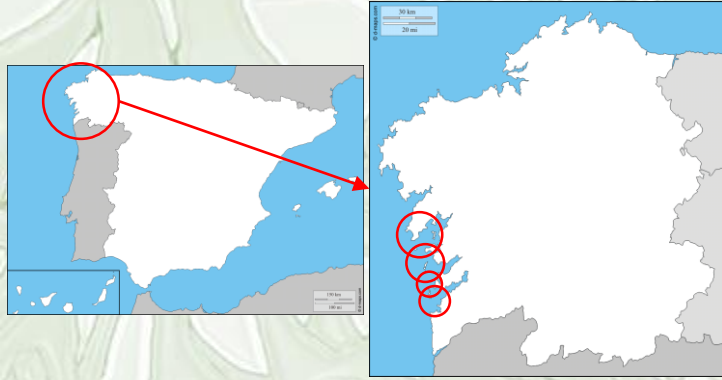
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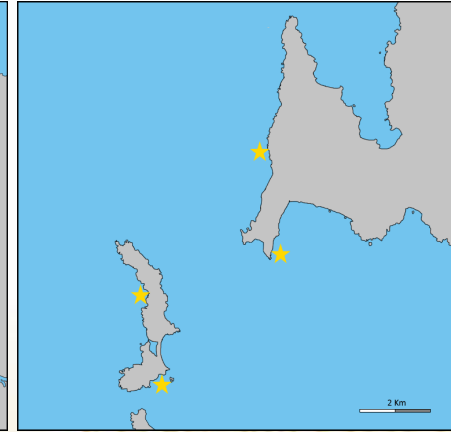
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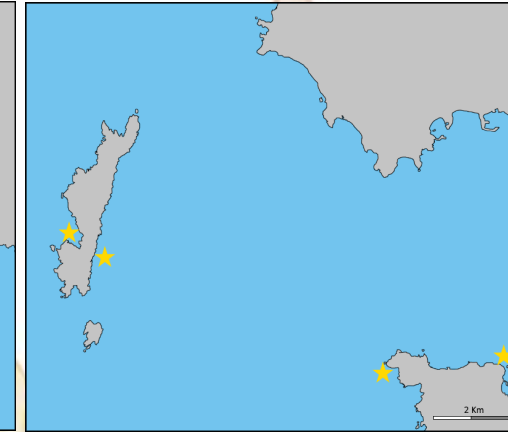
SAMPLING SITES



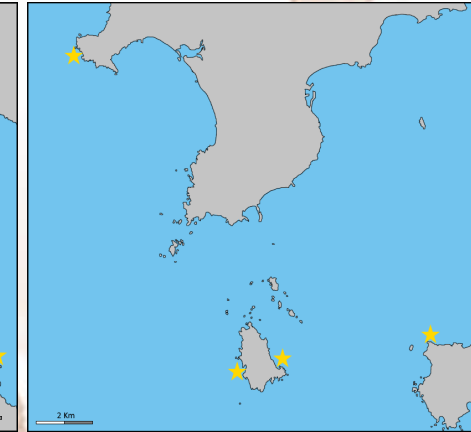
San Martiño
(Cies 1)



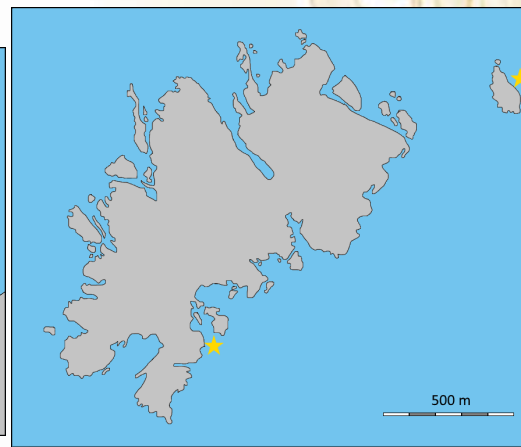
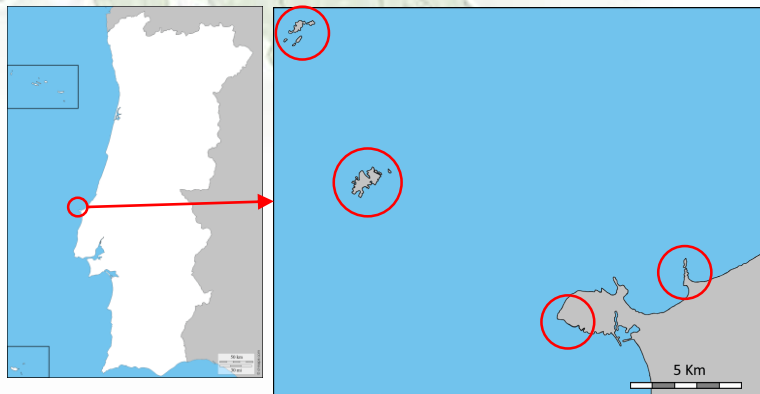
Faro- Monteagudo
(Cies 2)



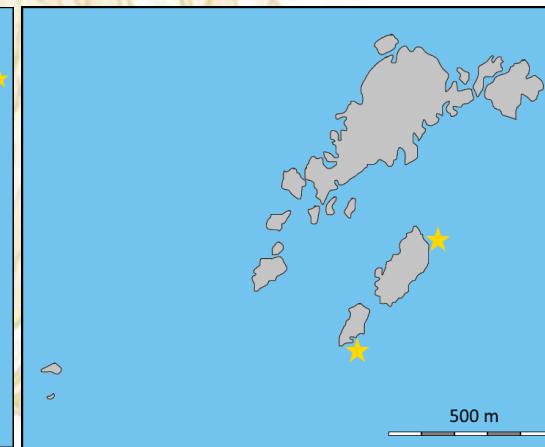
Ons



Sálvora



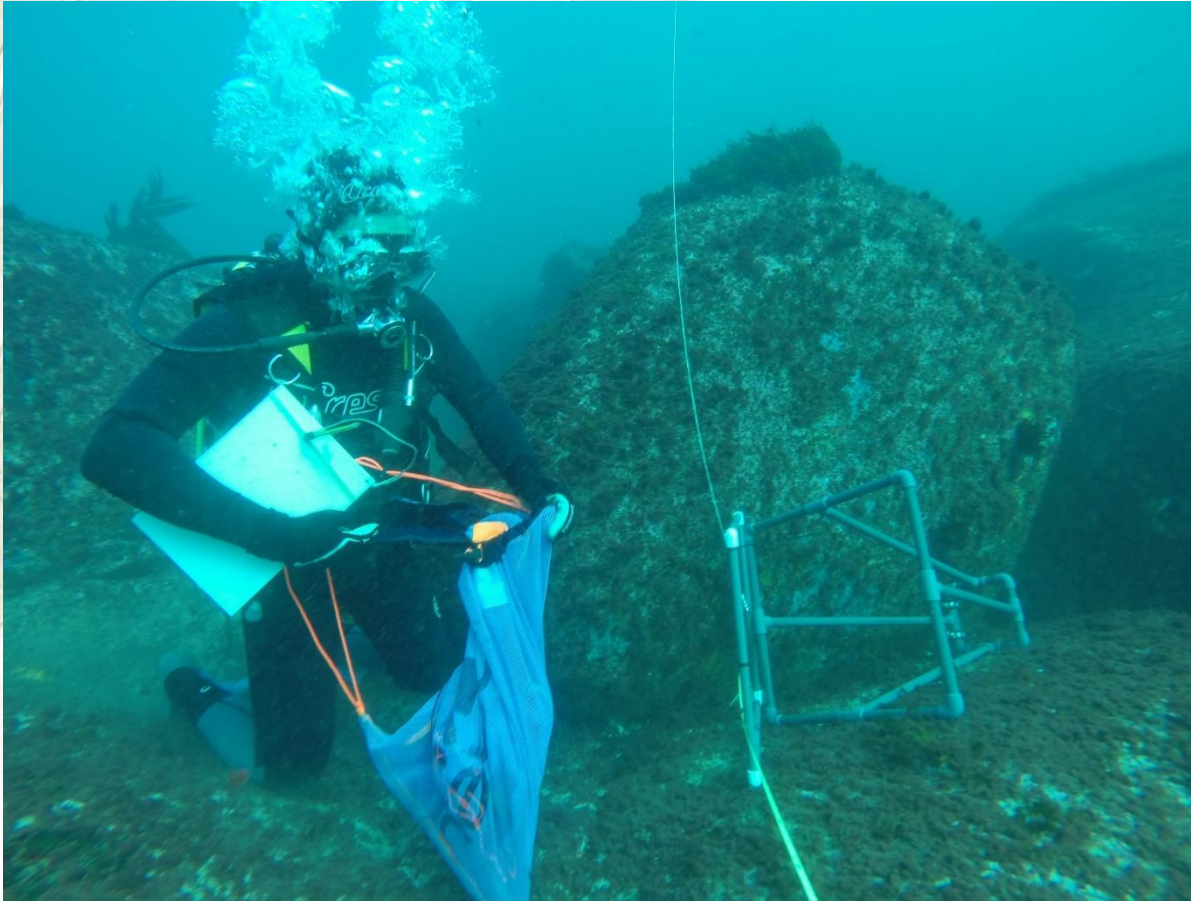
Berlengas



Farilhoês



METHODOLOGY



ILLAS ATLANTICAS NATIONAL PARK
Spain (Slightly steep to flat sea floor)



BERLENGAS MARINE RESERVE
Portugal (Highly steep to cliff sea floor)

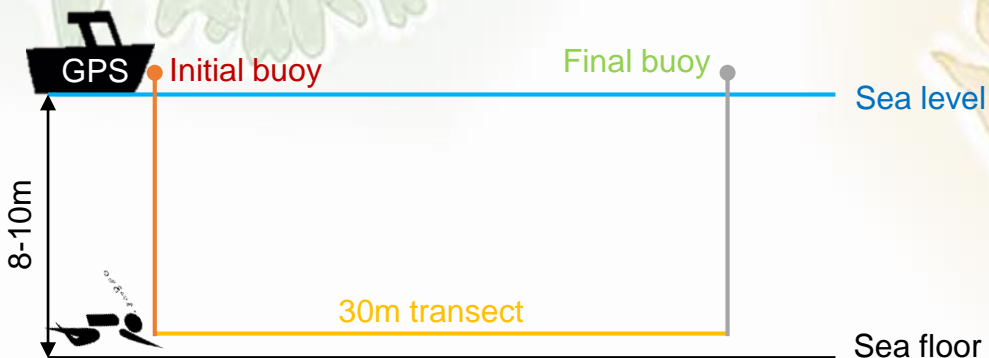
METHODOLOGY

ILLAS ATLANTICAS NATIONAL PARK

One transect of 30 m parallel to the coast-line at 5 m depth.

Photographs of quadrats (50 x 50 cm): Estimation of functional group diversity

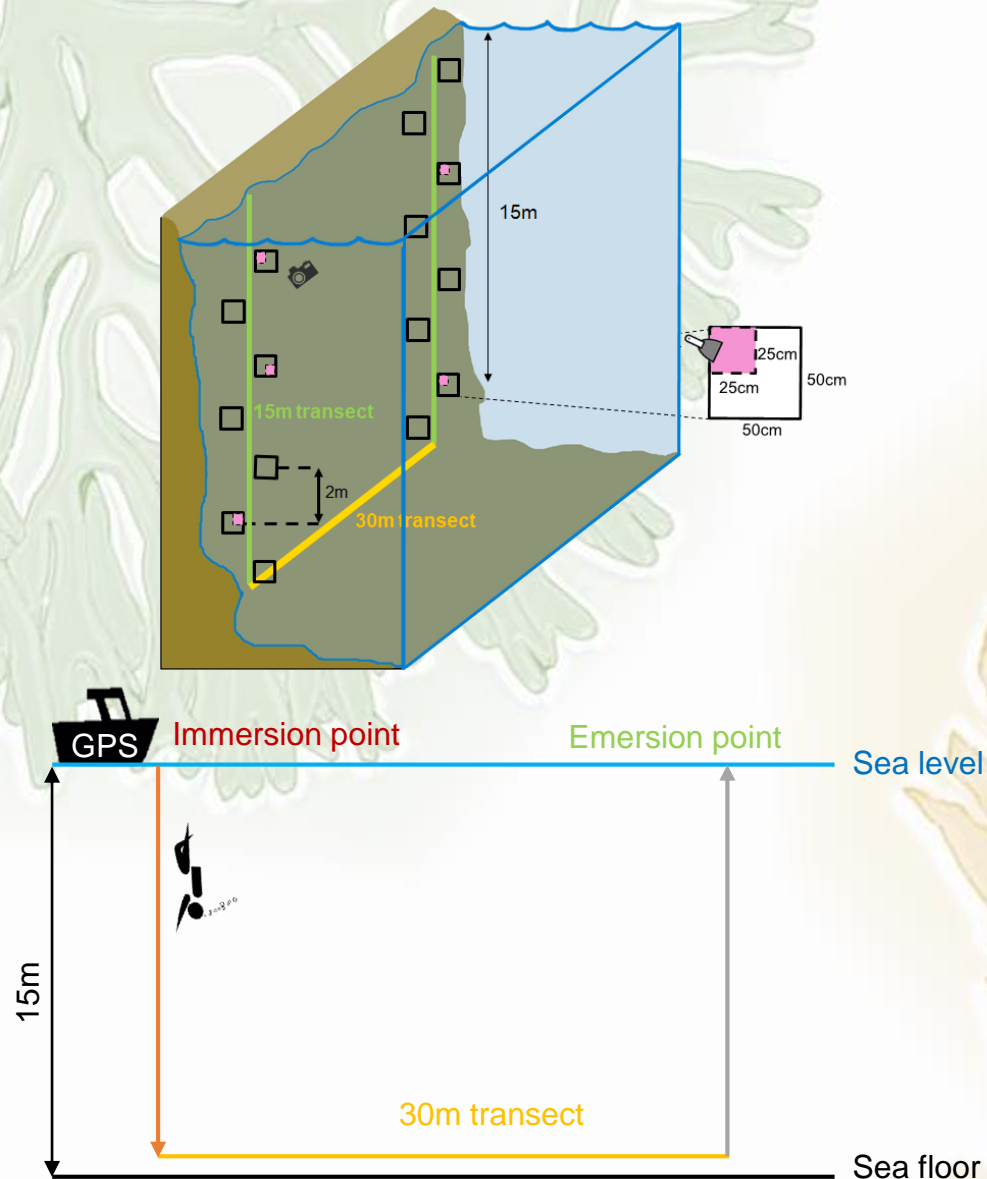
GPS position was recorded at the beginning and at the end of the transect (datum type WGS84).



METHODOLOGY

BERLENGAS NATURAL RESERVE

Two vertical transects of 15 meters separated 30 m and perpendicular to the coast-line, from 0 to 15 meters depth.



Photographs of quadrats (50 x 50 cm): Estimation of functional group diversity

GPS position was recorded at the beginning and end of the transect (datum type WGS84).

METHODOLOGY

Two types of sampling (Qualitative and Quantitative)

Qualitative: *Estimation of target species abundance*

Proposed scale (based on DAFOR project)

| | | |
|----------|------------|---------|
| D | Dominant | 50-100% |
| A | Abundant | 30-50% |
| F | Frequent | 15-30% |
| O | Occasional | 5-15% |
| R | Rare | < 5% |
| N | Not seen | |

Quantitative: *Estimation of target species biomass*

G. tututuru, C. peregrina S. muticum, and U. pinnatifida

Number of indiv. in 5 quadrats recorded. Up to 30 individuals collected.

Codium spp.

Number of indiv. in 5 quadrats recorded.

Collected { Biomass = up to 30 indiv.
ID = 100 indiv. (<30%) or 50 (>30%)

A. armata and F. rufolanosa

Collected all biomass of a sub-quadrat of 25x25 cm in 5 quadrants.

STATISTICAL ANALYSES

Zero-inflated data & Poisson distribution

HURDLE MODELS

- Presence/absence
- Biomass differences once present

- Factors
- Protection: fixed (2 levels: reserve vs reference)
 - Exposure: fixed (2 levels: semi-exposed vs exposed)
 - Locality: random nested in protection (2/4 levels)

Biodiversity Pearson's correlation between FG and NIMS variables



QUALITATIVE RESULTS- Spain

| | | <i>A. armata</i> | <i>C. fragile</i> | <i>C. peregrina</i> | <i>U. pinnatifida</i> | <i>F. rufolanosa</i> | <i>G. turuturu</i> | <i>S. muticum</i> |
|-------------|-------------|------------------|-------------------|---------------------|-----------------------|----------------------|--------------------|-------------------|
| Cies1 | Exposed | D | A | N | N | A | N | N |
| Cies1 | Semiexposed | R | A | R | N | N | R | N |
| Cies2 | Exposed | O | R | N | N | A | N | N |
| Cies2 | Semiexposed | A | D | N | N | N | R | N |
| Ons | Exposed | F | O | N | N | N | R | N |
| Ons | Semiexposed | R | F | R | R | N | R | N |
| Sálvora | Exposed | O | R | N | N | N | R | N |
| Sálvora | Semiexposed | N | F | R | O | N | N | F |
| Ref_Cies1 | Exposed | D | O | N | N | N | N | N |
| Ref_Cies1 | Semiexposed | F | F | R | O | O | N | N |
| Ref_Cies2 | Exposed | O | F | N | N | D | N | N |
| Ref_Cies2 | Semiexposed | A | R | R | N | N | R | N |
| Ref_Ons | Exposed | O | A | N | N | N | R | N |
| Ref_Ons | Semiexposed | R | F | N | N | N | N | N |
| Ref_Sálvora | Exposed | O | F | N | N | A | O | N |
| Ref_Sálvora | Semiexposed | F | A | O | R | N | N | R |

QUANTITATIVE RESULTS- Spain

Number of invasive species

No effect of any of the factors studied

Total invasive species

Presence: No effect of exposure or protection

Once present, larger biomass in **OUTSIDE the MPA**

Codium fragile

Presence: No effect of exposure or protection

Once present, larger biomass **OUTSIDE the MPA**
(especially in **EXPOSED** sites).

Asparagopsis armata

Higher probability of presence in **OUTSIDE the MPA**

Once present, larger biomass in **OUTSIDE the MPA**



BIOTIC RESISTANCE RESULTS- Spain

8 functional groups:

- Encrusting (FG1) → + correlation with %NIMS
- Filamentous (FG2)
- Foliose (F3)
- Filiform (F4)
- Corticated calcareous (FG5)
- Corticated foliose (FG6)
- Corticated terete (FG7) → + correlation with *C. fragile*
- Leathery (FG8) → - correlation with *A. armata*

Diversity index (Simpson's) → no direct correlation with presence of NIMS

QUALITATIVE RESULTS- Portugal

| | | <i>A. armata</i> | <i>C. fragile</i> | <i>C. peregrina</i> | <i>U. pinnatifida</i> | <i>F. rufolanosa</i> | <i>G. turuturu</i> | <i>S. muticum</i> |
|---------------|-------------|------------------|-------------------|---------------------|-----------------------|----------------------|--------------------|-------------------|
| Farilhoes | Exposed | A | N | R | N | N | N | N |
| Farilhoes | Semiexposed | O | N | N | N | N | N | N |
| Berlenga | Exposed | R | N | N | N | R | N | N |
| Berlenga | Semiexposed | O | N | R | N | N | N | N |
| Ref_Farilhoes | Exposed | N | N | N | N | O | N | N |
| Ref_Farilhoes | Semiexposed | R | N | N | N | N | N | R |
| Ref_Berlenga | Exposed | F | N | N | N | N | N | N |
| Ref_Berlenga | Semiexposed | A | N | N | N | N | N | N |

QUANTITATIVE RESULTS – Portugal

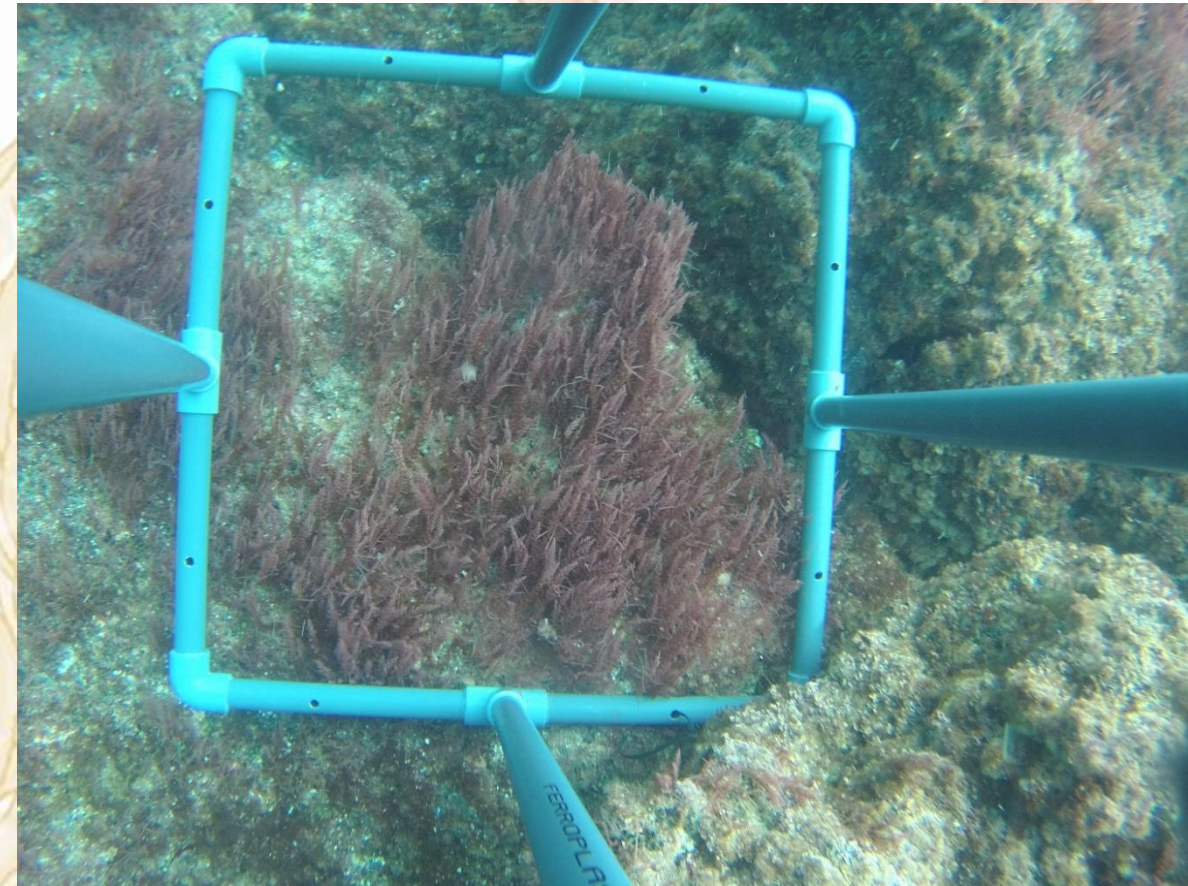
A. armata account for 91% of the total biomass of invasive species in this region.

Asparagopsis armata

Presence: Higher probability **INSIDE** the MPA

Once present, larger biomass **INSIDE** the MPA

No effect of EXPOSURE.



BIOTIC RESISTANCE RESULTS- Portugal

8 functional groups:

- Encrusting (FG1)
- Filamentous (FG2)
- Foliose (F3)
- Filiform (F4)
- Corticated calcareous (FG5)
- Corticated foliose (FG6)
- Corticated terete (FG7) → + correlation with *A. armata* biomass
- Leathery (FG8)

Diversity index (Simpson's) → - correlation with % cover of native sp.

MAIN CONCLUSIONS

- *A. armata* is one of the most invasive species present in subtidal bottoms along the western coast of the Iberian Peninsula
- The protection level has no effect on the presence of invasive macroalgae species.
- The protection level significantly reduces the biomass of invasive macroalgae species in Spain.
- Island ecosystems are not more susceptible to invasion by macroalgae
- Biotic resistance is not proved in our case study (except correlation between certain FG and *A. armata* / *C. fragile*)
- MPAs of Spain and Portugal show opposite trends in controlling invasions

Thanks for the attention

