Temporal patterns of the seagrass *Cymodocea nodosa* and depth-related patterns of the green algae *Caulerpa prolifera* in the Canarian Archipelago

1) *Cymodocea nodosa*

2) *Caulerpa prolifera*

1) “Temporal patterns of the seagrass *Cymodocea nodosa* in the Canarian Archipelago”

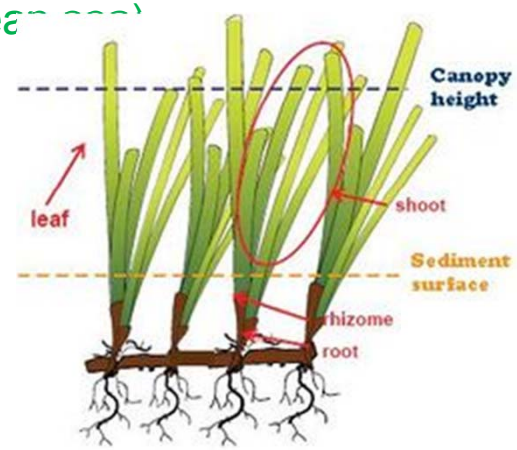
Aim of the study: To reveal the historical tendencies of *Cymodocea nodosa* across the entire Canarian archipelago.

- Population trend over the past **23 years**
- **3 attributes**: shoot density, coverage, shoot length

First study on temporal population trends of *Cymodocea nodosa*, the most important seagrass at the Canarian Archipelago scale.

Cymodocea nodosa biology and importance of its status knowledge

- Marine **spermatophyte** species
- **Distribution:** Mediterranean Sea, eastern Atlantic coasts, Macaronesian oceanic archipelagos of Madeira and the Canaries
- **Habitat:** in sandy sediments from intertidal zone up to 30 m.
- **Seasonal pattern:** summer peak in shoot density and biomass (Canaries and mediterranean seas)



- function as **habitat engineer**: fundamental role in Canarian coastal marine ecosystem:
- Seagrass meadows **all over the world** are experiencing a **rapid decline**
- **anthropogenic pressures** on the coast believed to be a fundamental reason of the current deterioration of seagrasses all over the world
- **many disturbance** (water contamination, increased turbidity and eutrophication, mechanical damages on the bottom, alterations of the habitat due to coastal works)

Data collection and analysis

684 data sets
49 studies
112 meadows

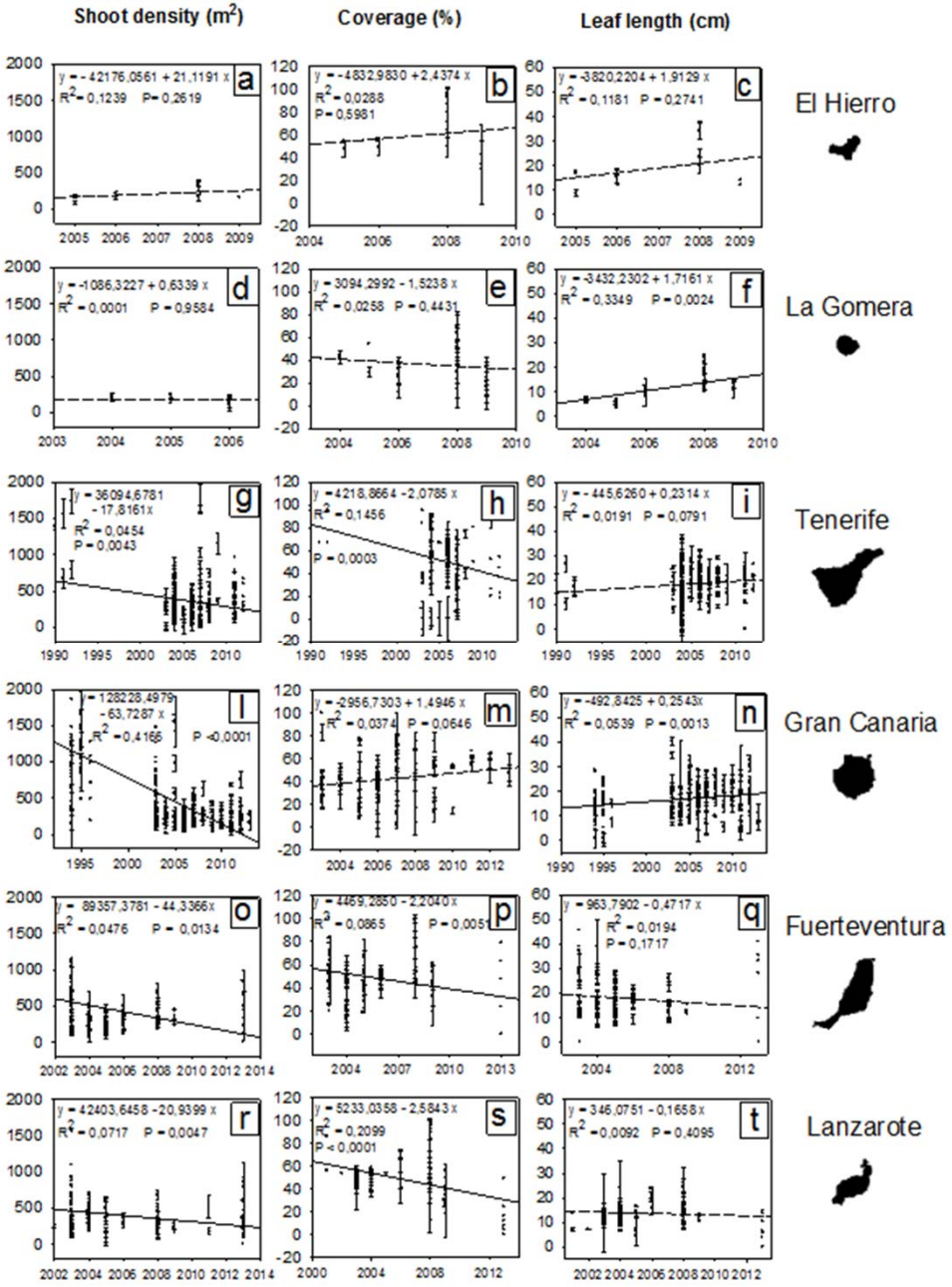
6 islands of the Canarian archipelago (exclusion of La Palma) → a period of **23 years** (1991 - 2013)

Analysis through **linear regression**

At **three dimensional scales**: “Island”, “Island sector”, “meadow”

	Time period	Studies	Surveys	sectors	meadows
Gran Canaria	1994-2013	19	231	NE-SE-S-SW-W	41
Tenerife	1991-2012	14	178	E-SE-SW-NW	27
Lanzarote	2001-2013	5	109	NE-E-SE-S	19
Fuerteventura	2003-2013	3	128	NE-E-SE-S	19
La Gomera	2004-2009	4	25	SE-S-SW	4
El Hierro	2005-2009	4	13	-	2

Island scale

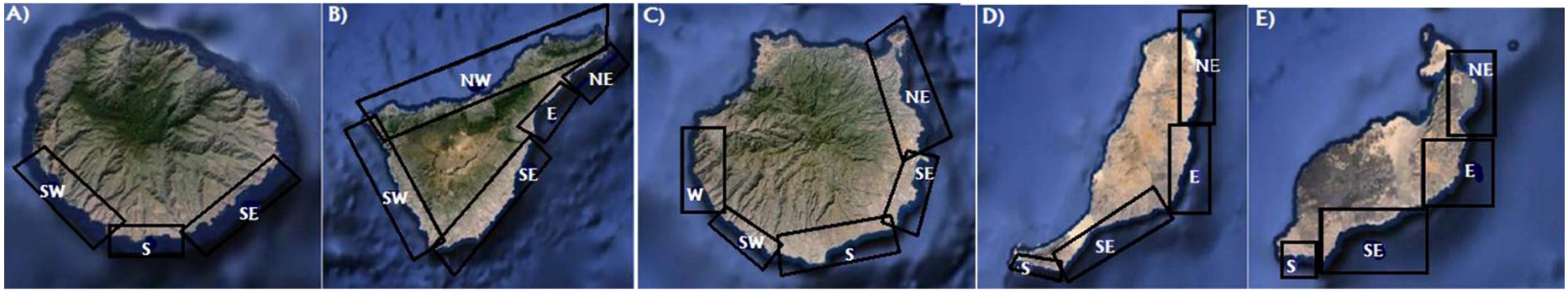


6 Islands

Shoot density: ↓ 4 cases
Coverage: ↓ 3 cases
Leaf length: ↑ 2 cases

Island sector scale

20 sectors examined over **5 islands** (exclusion of El Hierro and La Palma).



shoot density: ↓ 7 cases, ↑ 3 cases
coverage: ↓ 4 cases, ↑ 1 case
leaf length: ↓ 1 case, ↑ 2

		Shoot density (m^2)	Coverage (%)	Leaf length (cm)
Gran Canaria	NE	Decreasing	No trend	No trend
	SE	Decreasing	No trend	No trend
	S	Decreasing	No trend	Increasing
	SW	Decreasing	No trend	No trend
	W	No trend	No trend	No trend
Tenerife	E	Increasing	No trend	No trend
	SE	Decreasing	Decreasing	No trend
	SW	Increasing	Increasing	No trend
	NW	Increasing	No trend	No trend
Lanzarote	NE	Decreasing	Decreasing	Decreasing
	E	No trend	No data	No data
	SE	No trend	No trend	No trend
	S	No trend	Decreasing	No trend
Fuertevent ura	NE	No trend	No trend	No trend
	E	No data	No data	No data
	SE	Decreasing	Decreasing	No trend
	S	No trend	No trend	No trend
La Gomera	SE	No trend	No trend	Increasing
	S	No data	No data	No data
	SW	No trend	No trend	No trend

Meadow scale

The meadows included had to suit, at least, one of the following **two criteria**: the presence of records collected **over >3** years and a total amount of, at least, **20 records** over time.

12 meadows examined at 4 of the 6 selected islands.
shoot density: ↓ 4 cases
coverage: ↓ 2 cases
leaf length: ↓ 1 case, ↑ 1 case

		Shoot density (m^2)	Coverage (%)	Leaf length (cm)
Gran Canaria	Pasito	No trend	No trend	No trend
	Maspalomas	No trend	No trend	No trend
	Ingles	Decreasing	No trend	Increasing
	Gando	Decreasing	No trend	No trend
	Arinaga	Decreasing	No trend	No trend
Tenerife	Granadilla	No trend	Decreasing	No trend
	El Medano	Decreasing	Decreasing	No trend
	Igueste	No trend	No data	No trend
Lanzarote	Pl. Quemada	No trend	No trend	No trend
	Guasimeta	No trend	No trend	Decreasing
Fuerteventura	Gran Tarajal	No trend	No trend	No trend
	Pl. Blanca	No trend	No trend	No trend
La Gomera	-	-	-	-
El Hierro	-	-	-	-

Resumen= prevalence of decreasing trends (exception for leaf length)

- **Island scale:**
  Shoot density: 4 decreasing
  Coverage: 3 decreasing
  Leaf length: 2 increasing

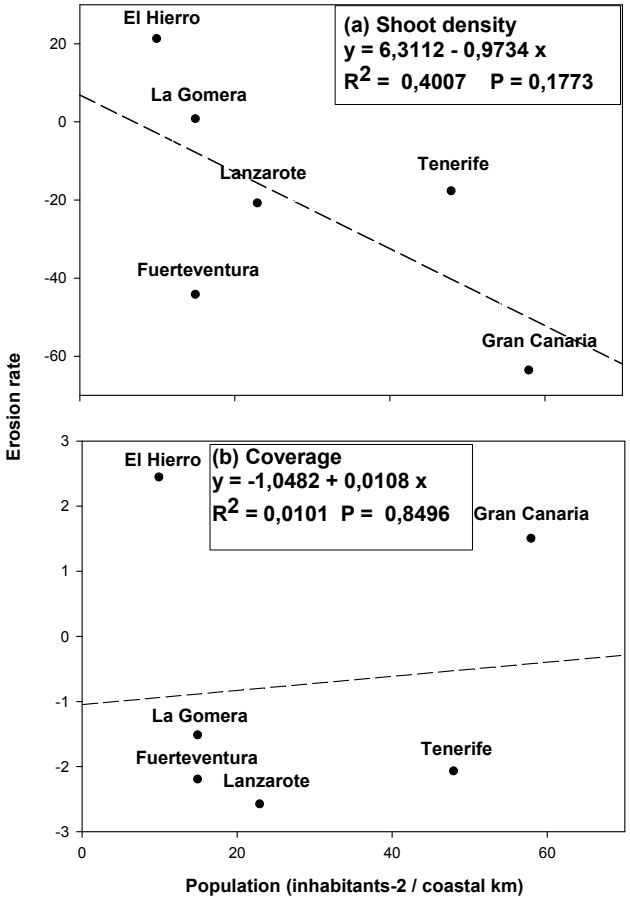
- **Sector scale:**
  shoot density: 7 decreasing , 3 increasing
  coverage: 4 decreasing, 1 increasing
  leaf length: 1 decreasing, 2 increasing

- **Meadow scale:**
  shoot density: 4 decreasing
  coverage: 2 decreasing
  leaf length: 1 decreasing, 1 increasing

- **Different capacity to reveal ecological trends among the three structural parameters: Shoot length most representative; coverage secondary; leaf length doesn't show the state of conservation of the meadow, i.e. it can be a response to increased water turbidity.**

Erosion rate

No trend was ascertained by the regression models carried out to test for any **relation between change rates** in shoot density and coverage with the **number of inhabitants** by kilometer of coastal perimeter per island (fig. 13).



Discussion and conclusions

- **relevant changes** in the structure of *Cymodocea nodosa* seagrass meadows over the 23 years study period.

- prevalence of decreasing trends:

  - clear decay in shoot density for Gran Canaria, Tenerife, Lanzarote and Fuerteventura.

- **Those four islands are the most populated of the archipelago.**

- results for coverage also showed a decreasing trend.

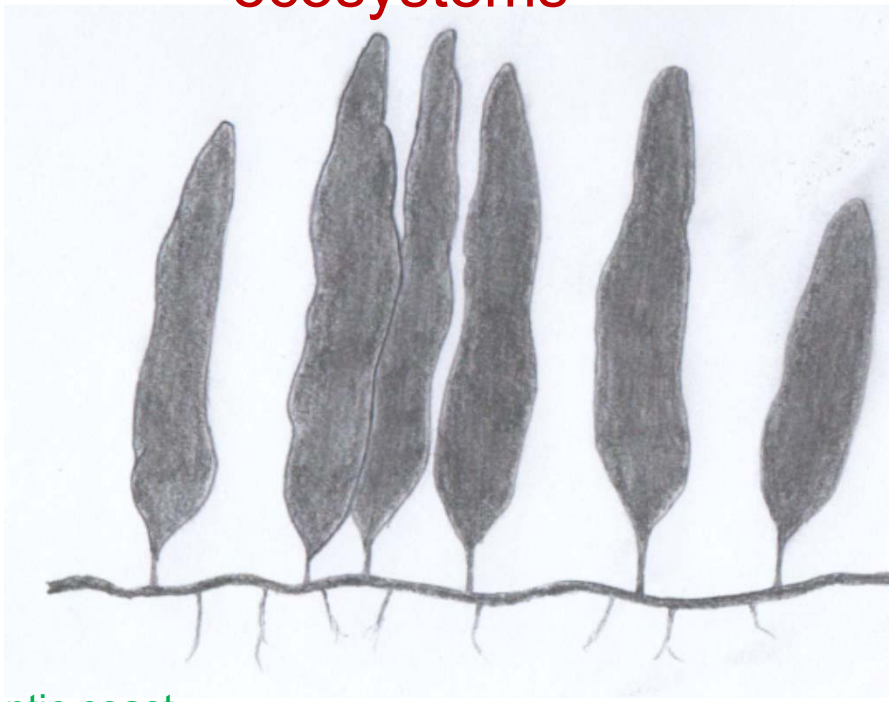
2) Changes in biological attributes of the green macroalga *Caulerpa prolifera* over a depth gradient

Aim of the study: to investigate the existence of patterns in *Caulerpa prolifera* population **changes with depth**.

Comparison of populations from **two separate areas**, collected at **two periods** of the year.

This is the first work investigating changes in *Caulerpa prolifera* relatively to depth in the Canary Islands

Caulerpa prolifera biology and influence on coastal ecosystems



- Clonal rhizophyte,
- Distribution: Norhwest Atlantic coast, Caribbean coasts of the northwest Atlantic, Mediterranean
- Habitat: soft bottom sediments, between 5 and 40 m depth.
- Seasonal pattern: late summer peak in thallus development and biomass.
- Features:
  - **High platicity**
  - Coenocytic cellular structure (thallus composed by a single multinucleate cell)
  - presence inside their tissues of caulerpenyne (allelopathic properties)

- function as **"ecosystem engineer"**
- **competes with seagrass** species (i.e. Cymodocea nodosa in the Canaries), which can support a more rich and complex ecosystem
- increasing in Canaries as well as in the mediterranean

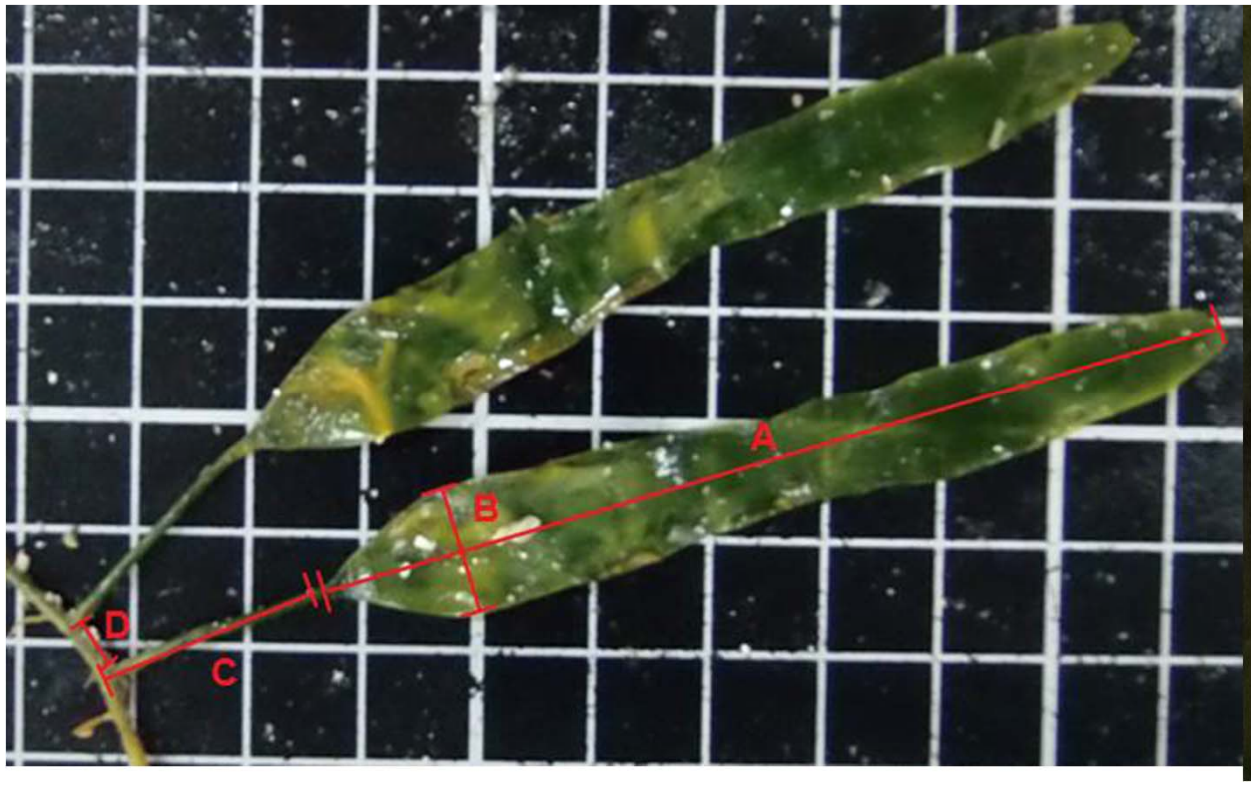
biological attributes

a) Morphology: lamina area, lamina Length, lamina width, stipe length, internode length, number of laminas

b) Biomass: total biomass, below ground biomass, above ground biomass

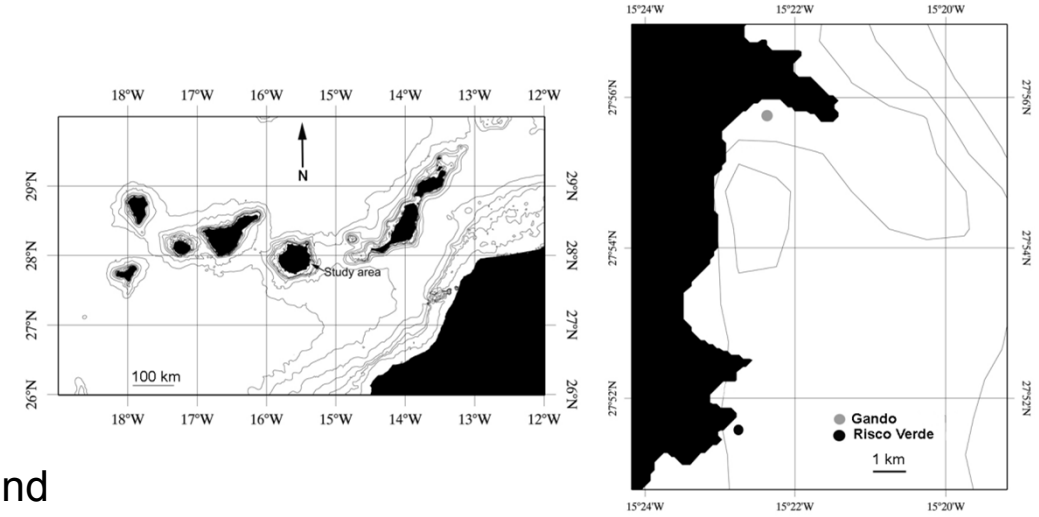
c) Fooling epifauna: number of polichetos

d) **Grazieng activity:** number of bites



Materials and methods

Sampling at **2 separate areas** (Risco Verde and Gando) located ca. 8 km apart from each other.



2 different periods of the year:

- early summer (May 2013) and
- late summer (September 2013).

At both sites and times, **samples (n=5)**
randomly collected at **5, 10, 15 and 20 m depth**.

For each sample, **10 sub-samples**

Sampling was carried out by a **SCUBA diver**, who haphazardly located **0,0125m2 quadrats** on the bottom.

Statisticasl analysis

3-way ANOVAs:

- “Depth” (fixed factor),
- “Sites” (random factor, orthogonal to “Depth”)
- “Times” (random factor, orthogonal to the previous factors).

SNK tests (test a posteriori) resolved **differences between pairwise depths** separately for each site and time when **significant (p-value < 0.05) second-order interactions** were detected.

Secondly, to test for a positive or negative **correlation** between ***Caulerpa prolifera*** and ***Cymodocea nodosa***, a **linear regression** model was applied for the values of the total biomass of each species.

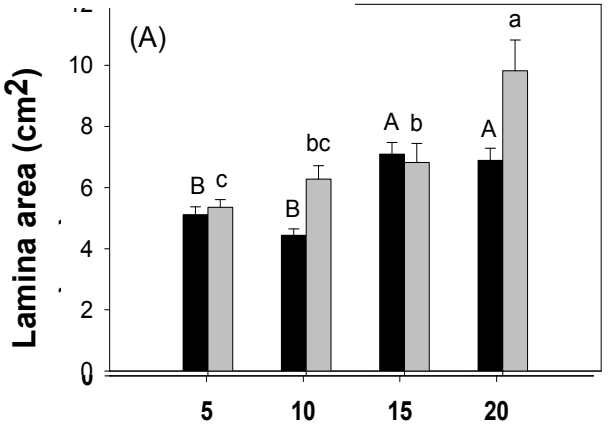
Results

- Cle

Only results from Gando were considered: we couldn't test for spacial variability, just temporal variability

- **Mo. phology**

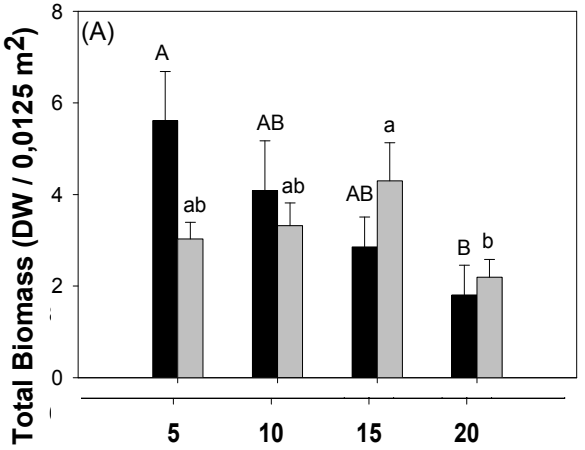
- ↑lamina area
- ↑lamina length
- ↑lamina width
- — stipe length
- — internode distance



Biomass

- observed **variation in total biomass peak**:

  In May peak at 5 m; in september peak at 15 m



Fooling epifauna

- **no clear pattern** for polychaeta was revealed

Grazing

- **constant trend** over the depth gradient

Discussion and conclusions

Morphology

increased dimension of photosynthetic laminas with increasing depth (a predictable pattern due to the minor light availability with increasing depth, which implies a bigger effort for Caulerpa prolifera during photosynthesis):

- ↑lamina area
- ↑lamina length
- ↑lamina width
- — stipe length
- — internode distance

} no influence of light intensity on those two parameters were founded, an observation that disagree with what was expected

Discussion and conclusions

Biomass

the observed **variation in biomass peak** can be a **consequence of light intensity**, a parameter that gradually decrease with depth:

In May peak at 5 m; in september peak at 15 m

- Lower solar radiation = optimum at shallowest level
- Higher solar radiation = optimum at the deeper level

response in accordance with the *Caulerpa prolifera* typical **sciaphilic-like behavior** (Vergara et al., 2012).

Fooling epifauna

- **no clear pattern** for polychaeta was revealed suggesting that this epifaunal anellidae found its optimal condition unvaryingly all over the Caulerpa prolifera depth range of distribution.

Grazing

- **homogeneous** over depth as the number of fish bites follows a constant trend over the depth gradient, therefore our results suggest that **depth doesn"t have influence** on the intensity of grazing activity.

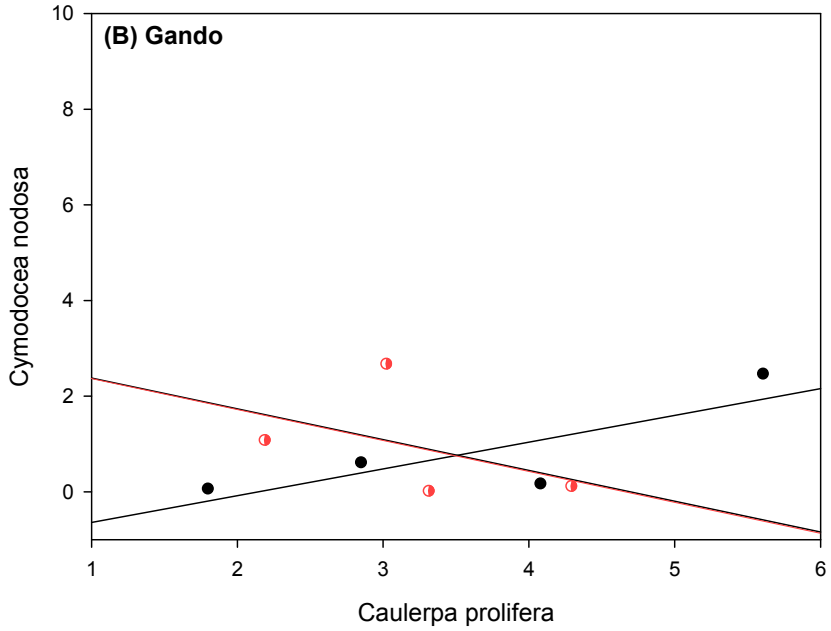
Interaction between *Caulerpa prolifera* and *Cymodocea nodosa*

Relation between the biomass of the two species:

- in May no interaction was revealed
- in September major values for Caulerpa prolifera biomass parallel to minor values in Cymodocea nodosa biomass

Results suggest a negative interaction.

Just an hypothesis, variables that can influence changes in biomass are wide.



Resumen, conclusions and suggestions

1) Cymodocea nodosa: clear DECLINE probably due to human pressure → need of effort on research in this topic and urgence of a mayor effort on coastal managment and protection of this natural heritage

2)Caulerpa prolifera: clear influence of depth on biologiocal attributes. This work represents a further step to understand the biology of this species itself.

Identification of possible negative interaction between *Caulerpa prolifera* and *Cymodocea nodosa* → need to investigate the reasons of *Caulerpa prolifera* widening often parallel to the decrease in Cymodocea nodosa meadows in the same area.

Both studies should be included as scientific publications

Gracias!