Investigating the potential of *Cymodocea nodosa* (Ucria) Ascherson as a coastal carbon sink coupling marine habitat cartographies and *in situ* non-destructive sampling

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Framework

CONTEXT: Seagrass meadows are major carbon sinks, a main focus being made on climax species like *Posidonia oceanica* (L.) Delile while other species remained little studied.

AIM: To investigate the carbon stocking capacity of *Cymodocea nodosa* (Ucria) Ascherson leaves (**Fig. 1a**) a pioneer species with a rapid turnover and an expected high carbon stocking capacity**.**

APPROACH:
- Estimation of the area covered by *C. nodosa* by mapping marine habitats**.**
- Sampling its leaves with non-destructive method for biometry as well as carbon and nitrogen analysis**.**

STUDY SITE: Calvi Bay (**Fig. 1b**), Corsica Island (Mediterranean Sea, France).

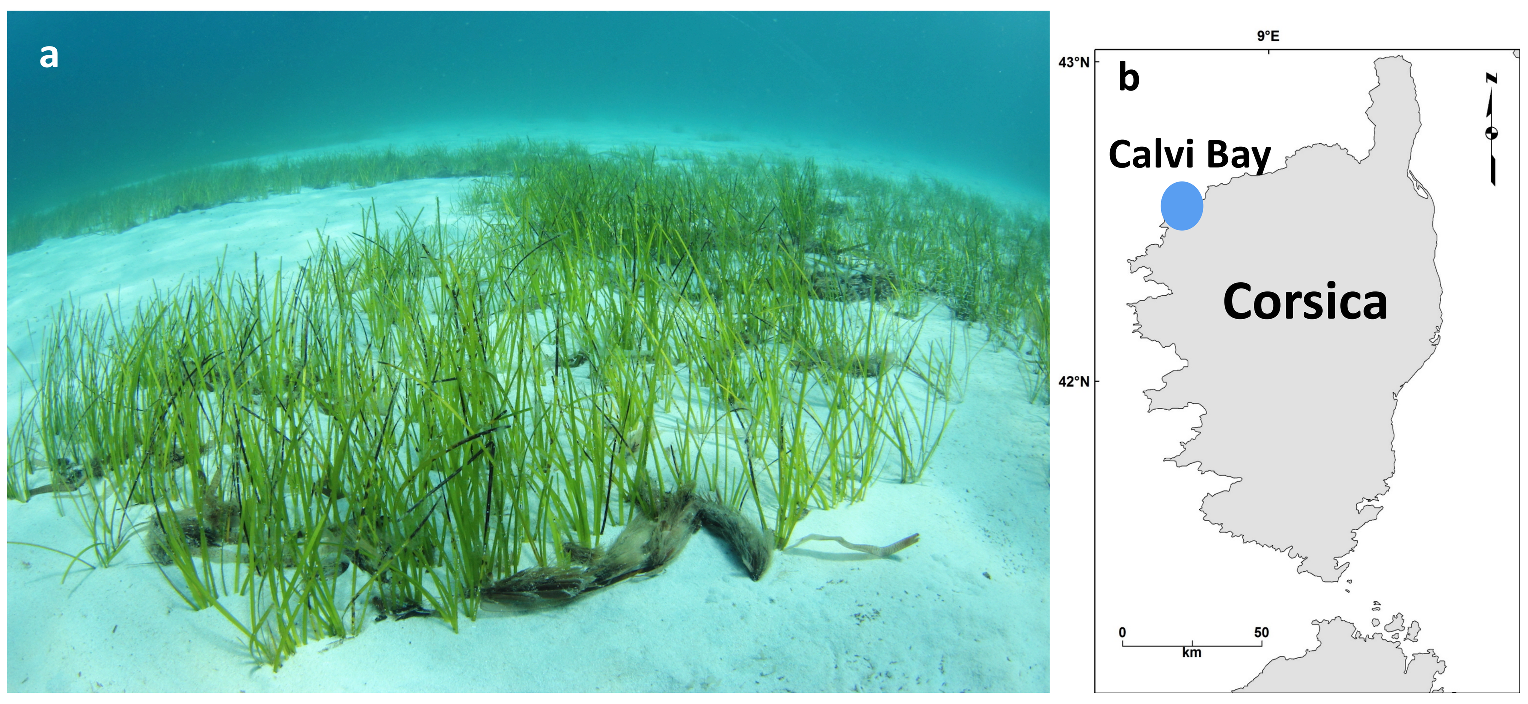

***Figure 1**: a) C. nodosa meadow in Corsica (France) (photo: A. Abadie); b) Location of the study site.*

Methods

MAPPING

Georeferenced data obtained with high resolution side scan sonar images (**Fig. 2**), aerial ortho-photographs, bathymetry and ground truths by scuba diving.

Cartographies of marine habitats are produced via Computer-aided design (CAD). The map raster is then vectorised and computed through a Geographical Information System (GIS) to calculate the area covered by *C. nodosa*.

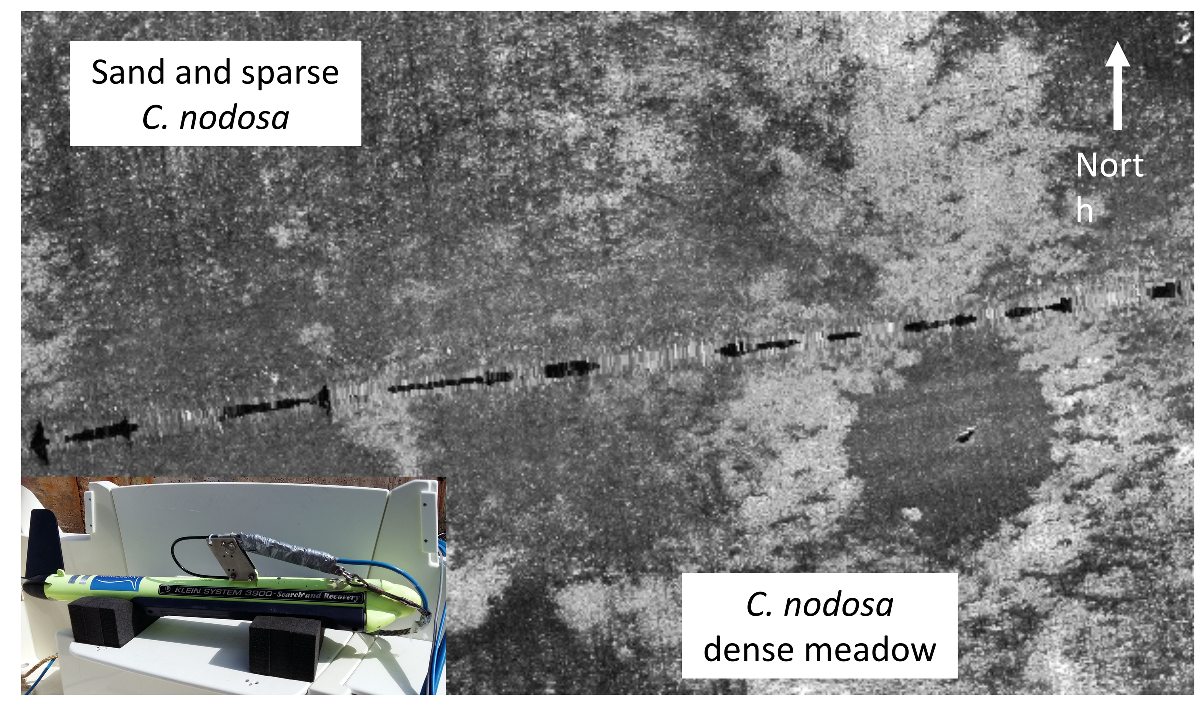

***Figure 2**: Side scan sonar image of a C. nodosa meadow in Calvi Bay.*

LEAF SAMPLING, BIOMETRY AND ELEMENTAL CONTENTS

Shoot density and non-destructive sampling (de los Santos *et al.* 2016, **Fig. 3a**) were measured in Winter and Summer **2015** by cutting leaves (**Fig. 3b-c**) at several depths (5, 11, 15 and 23 m) at different locations within the bay (Calvi Beach, Alga Bay and Oscelluccia Bay). Leaf length and epiphyte biomass are measured in laboratory. Carbon and nitrogen contents are measured with an elemental analyser (**Fig. 3d**).

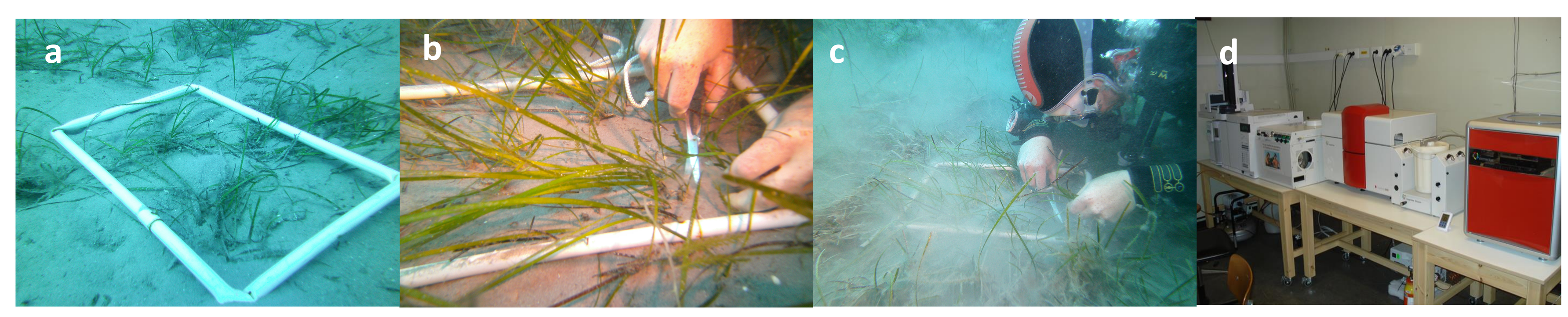

***Figure 3**: a) Measure of the shoot density; b) and c) C. nodosa leaf cutting at 20 m depth (photos: M. Leduc); d) Elemental analyzer for the measure of carbon and nitrogen contents (photos: R. Pieraccini).*

Marine habitats

In Calvi Bay, *C. nodosa* meadows cover an area of 0.498 km² (**Fig. 4**). This value seems underestimated due to the difficulty to identify on side scan sonar images sparse meadows settled on sand.

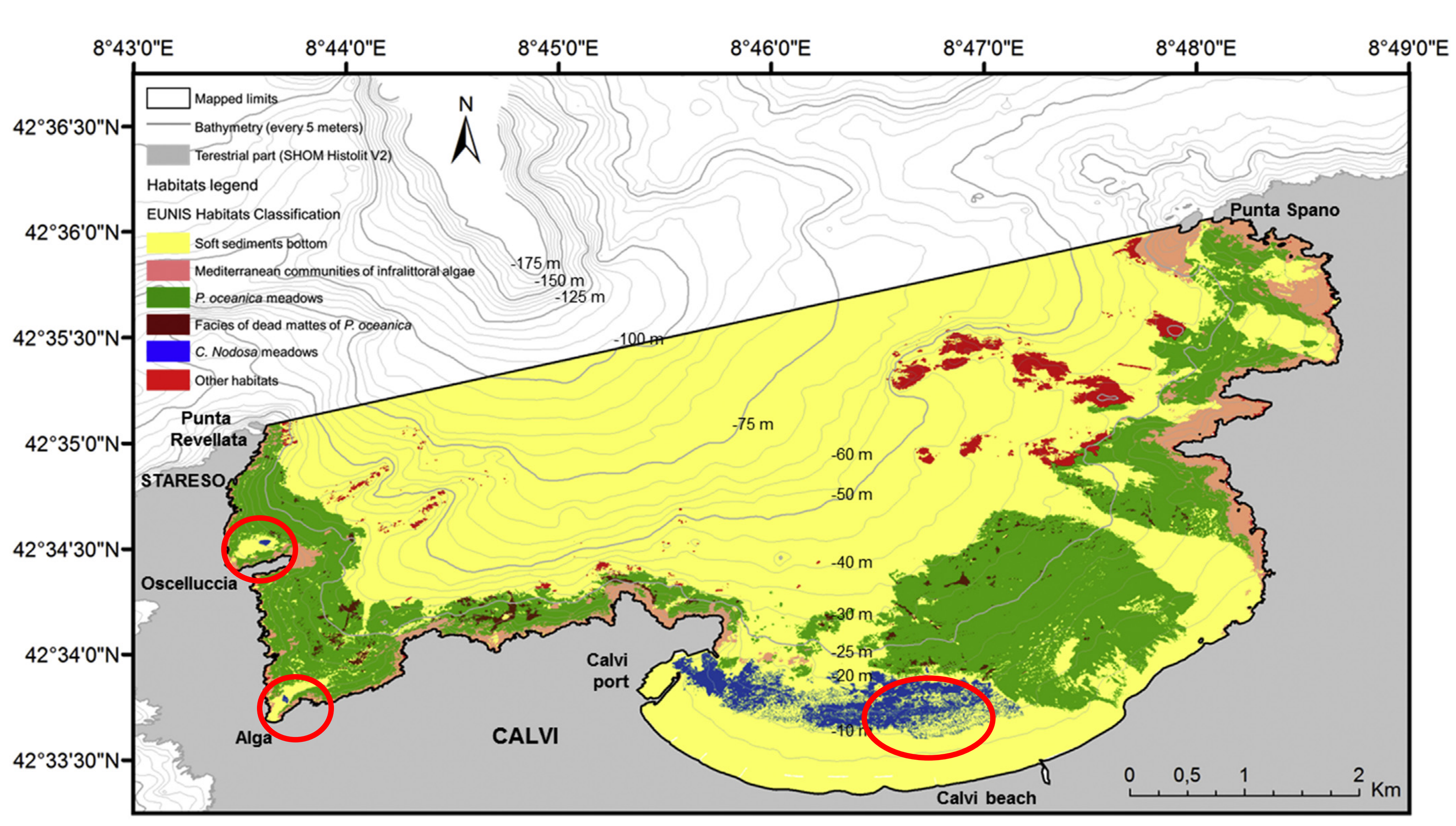

***Figure 4**: Map of marine habitats in Calvi Bay (Corsica, France). C. nodosa meadows correspond to blue polygons. Red circles show the sampling sites. Modified from Velimirov et al. (2016).*

Carbon and nitrogen stocks

The intermediate depth range (11-20 m) stores more than 60 % of the total carbon stored by *C. nodosa* in Summer and more than 80 % in Winter (**Tab. 2**). The greater storage capacity of this bathymetrical zone can be explained by its lower exposure to water movement, however with enough light to sustain the plant growth. The nitrogen storage capacity follows the same pattern, with a low lower amount of nitrogen stored in *C. nodosa* leaf biomass in Winter when leaves are exported to other marine systems by storms.

***Table 2**: Area covered by C. nodosa in Calvi Bay and the amount of carbon (C) and nitrogen (N) contained in its leaves in Winter and Summer according to the bathymetrical range.*

Depth range	Area (m²)	C Winter (kg)	N Winter (kg)	C Summer (kg)	N Summer (kg)
0 - 10 m	57 210	40,1	2,2	969,9	39,9
11 - 20 m	427 774	212,6	11,5	1 701,5	81,8
21 - 30 m	13 459	2,6	0,2	43,6	2,4
Total	**49 8443**	**255,3**	**13,9**	**2 715,0**	**124,2**

Works cited
- Agostini S, Pergent G, Marchand B (2003) Growth and primary production of *Cymodocea nodosa* in a coastal lagoon. Aquat Bot 76:185-193
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- Pieraccini R (2015) Temporal and spatial variation of *Cymodocea nodosa* in the Calvi bay; first approach. Undergraduate Program of Environmental Science, University of Genova, Genova, Italy
- Velimirov B, Lejeune P, Kirschner A, Jousseaume M, Abadie A, Pête DC, Dauby P, Richir J, Gobert S (2016) Estimating carbon fluxes in a *Posidonia oceanica* system: Paradox of the bacterial carbon demand. Estuarine, Coastal and Shelf Science 171:23-34

Morphological features

C. nodosa shows the strongest seasonal variations at the lowest depths (**Tab. 1**) in Alga and Oscelluccia. The quantity of carbon and nitrogen stored in its leaves decreases with depth (**Fig.5**) with a maximum storage at 5 m depth.

***Table 1**: Mean (± SD) shoot density, leaf and epiphyte dry biomass of* C. nodosa *at all sites in Winter and Summer 2015. Modified from Pieraccini (2016).*

SITE	Depth (m)	Leaf density (leaf.m^{-2})		Leaf biomass (gDW.m^{-2})		Epiphyte biomass (gDW.shoot^{-1}.m^{-2})	
		Winter	Summer	Winter	Summer	Winter	Summer
Alga	5	346 (± 75)	438 (± 163)	5,8 (± 1,3)	43,58 (± 22,4)	1,594	22,096
Oscelluccia	11	258 (± 85)	374 (± 57)	5,2 (± 1,7)	29,391 (± 11,9)	2,199	11,47
Calvi Beach	11	120 (± 42)	92 (± 43)	2,5 (± 0,9)	5,77 (± 2,6)	2,082	4,32
Calvi Beach	15	-	120 (± 61)	-	10,07 (± 5,8)	-	13,856
Calvi Beach	20	220 (± 163)	146 (± 111)	2,6 (± 1,9)	7,70 (± 3,1)	6,765	42,197
Calvi Beach	23	-	142 (± 41)	-	8,24 (± 2,6)	-	16,575

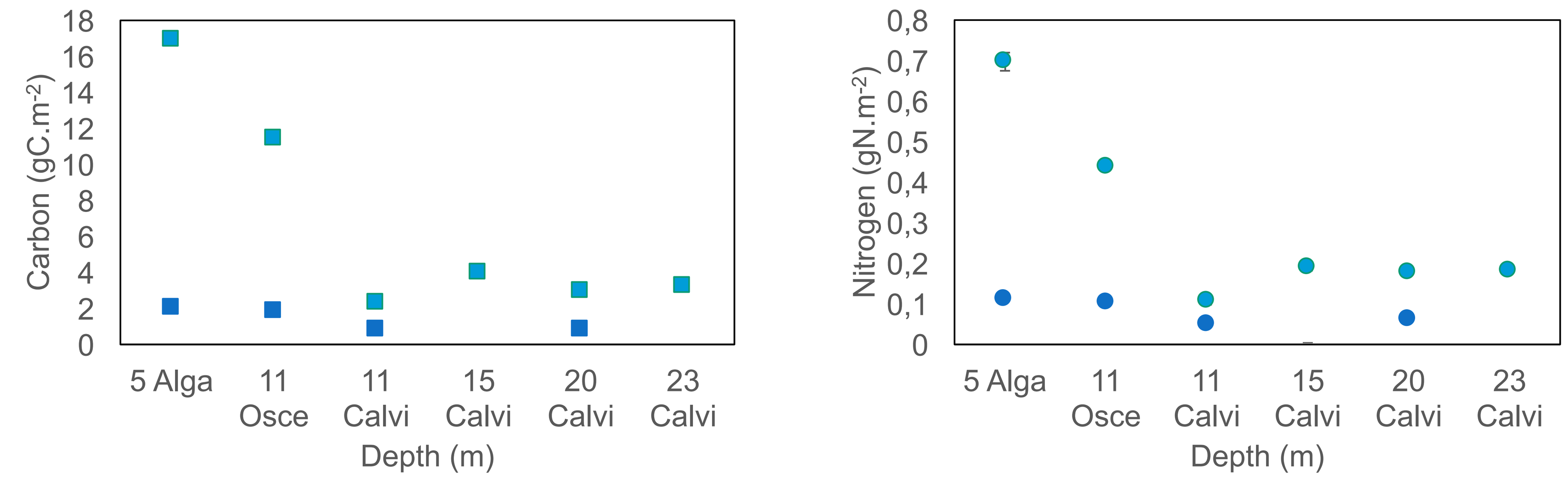

***Figure 5**: Mean carbon and nitrogen content of* C. nodosa *leaves at different depths in Winter (blue) and Summer (green).*

C. nodosa roles

IN CALVI BAY

When compared with *P. oceanica* meadows and the 900 tons of carbon stored in their leaves in Summer (Velimirov *et al.* 2016), the capacity of *C. nodosa* meadows to be a major carbon sink appears negligible. However, their capacity to act through the export of their leaves as a source of nitrogen in Winter for other nearby systems must cannot be denied.

AROUND CORSICA

C. nodosa meadow shoot densities in Calvi Bay are very low compared to other Corsican areas like Urbinu lagoon where a carbon storage capacity of 843.7 gC m^{-2} per year was reported at 1 m depth (Agostini *et al.* 2003). Moreover, the surface they cover in lagoons and coastal areas appears to be largely underestimated according to the last mapping campaign made around Corsica in 2015.

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