MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

CENTRO DE ESTUDIOS AVANZADOS
DE BLANES (CEAB)

# DELIVERABLE A2 LIFE BLUE NATURA: RESULTS OF SAMPLING IN ANDALUSIAN SEAGRASSES

# ENTREGA A2 LIFE BLUE NATURA: RESULTADOS DE LOS MUESTREOS EN PRADERAS DE FANERÓGAMAS MARINAS DE ANDALUCÍA

LIFE BLUE NATURA

Life

GAME
GROUP OF AQUATIC
MACROPHYTE ECOLOGY

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## INTRODUCTION

Life Blue Natura samplings on Andalusia seagrasses took place during two field missions. The first one was in October 2016, between the 3th and the 12th, and the second field mission took place in October 2017, between the 11th and the 22th. The main objective was to obtain the samples planned in order to catch the natural spatial variability of carbon stocks and fluxes in Andalusian seagrasses, as well as the effects on those stocks and fluxes of Posidonia oceanica meadows degradation through erosion and chemical poisoning, and of seagrass recovery through recolonization. We obtained 74 cores in total, 20 cores more than the 54 cores initially planned, despite we couldn't sample at the *Cymodocea nodosa* meadow at the Natural Park of El Estrecho. Neither could be sample the relict meadows of *Zostera marina*, which are almost extant in Andalucia, and only form small patches.

A secondary objective was to disseminate the importance of seagrasses in climate change mitigation and adaptation. This objective was also fulfilled through a talk to divers (October the 8th 2016), a talk to university students on board of the García del Cid research vessel (October the 19th 2017), one TV broadcast (second campaign) and news in paper (2) and digital journals (8, annex E.1.3).

## SEAGRASS BLUE CARBON SAMPLING STRATEGY

In this sampling strategy we sought to capture the seagrass carbon stocks and fluxes variability due to species (*Cymodocea nodosa*, *Zostera spp.* and *Posidonia oceanica*), geography (Atlantic, Mediterranean and Alborán seas), environmental factors (depth, substrate) and plant health state.

Most of blue carbon in seagrasses is accumulated in their sediments. Nevertheless, the IPCC protocols for carbon sinks and emissions always include the evaluation of the carbon pool sequestered in the plant standing stocks (above and belowground plant biomass). Therefore, at each selected station we obtained a minimum of 3 replicate cores (18 to 590 cm long) and 3 replicate biomass samples (within quadrats of 20x20cm, up to 2 cm thick belowground, Fig. 1 up).

In total, we collected 68 cores, of which 13 were vibrocores, and 55 were manually collected.

We also took samples of the various dominant plant species growing in each area, in order to measure the primary producers isotopic signal (to try establishing the main particulate organic carbon – POC – contributors to the sink; Fig. 1 below).



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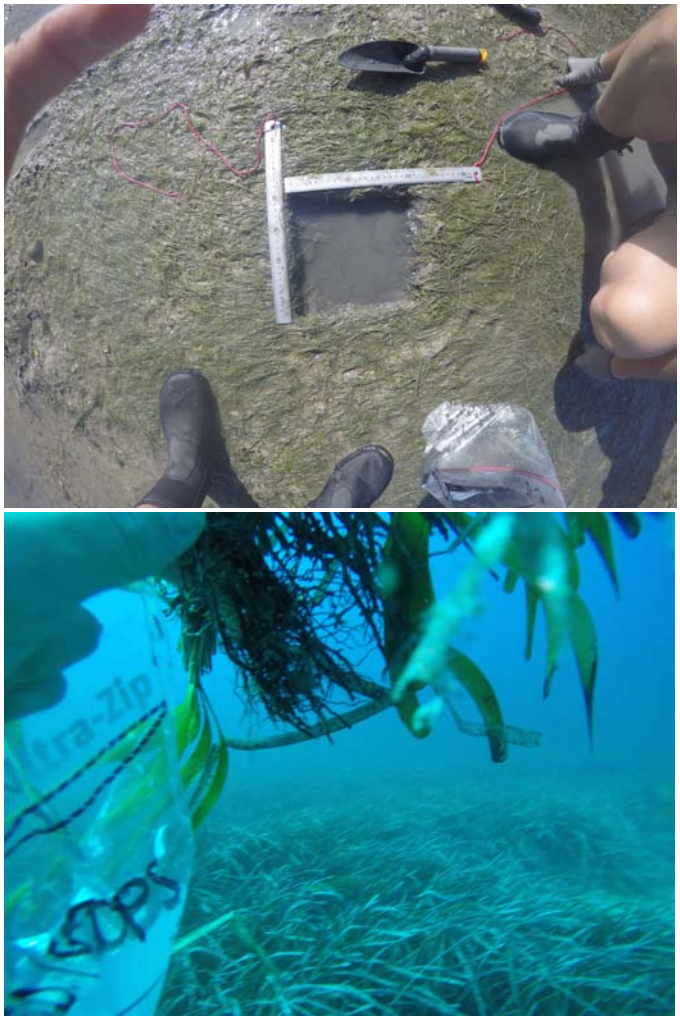

Fig. 1. Above: hole left in the SA.ZN-D station after biomass sampling. Below: some plant samples collected at TE.D station for analysing the primary producers $^{13}C$ and $^{15}N$ isotopic signals.

Cores were taken as described in the following **protocol**:

**Material for manual coring:**

- 1.5m /3m-long strong PVC pipe, of at least 5cm inside diameter (we use 6.9cm inside diameter) and 0.5cm thick walls with a sharpened attacking edge. If the sediment is sandy, a core-catcher is also fitted to the corer bottom to minimize sediment loss during corer lifting. If the sediment is very fine it is usually not necessary, and if it is rich in fibers (like in the mat), it may be problematic.
- 1 metal rode
- 1 large mace with a heavy metallic head



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- One strong metal cap, with holes in order to let air circulate, or a wooden piece, in order to receive the mace hits
- A folding meter, in order to measure core compression and penetration
- 2 caps to close the corer at the bottom and the top
- Waterproof tape to seal the corer ends
- Two 3.4 meters-long, 1.5 cm-diameter rope
- 1 4-legs ladder
- Submersible data tables on water resistant paper and/or plates
- Diving gear

**Coring Procedure** (minimum 2 people):

-Select the place. Write down the station, core label and pipe length in the field data sheet, as well as any pertinent field observation (Fig. 2).

Fig. 2. Water resistant field data sheet at RO.S.

- Present the pipe perpendicular to the soil surface, insert the rode and place the metal cap/ wood plate on the core top. One person hammers on the core top, and the second person maintains the core vertical, and twirls it (around 180ºC) between 2 hammer hits, in order to help the sediment enter the pipe, as it penetrates in the soil (Fig. 3).



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Fig. 3. Introducing a PVC pipe in the sediment at RO.S-C

- When the pipe has entered to the desired depth (leave at least 10cm below the rode, in order to facilitate core recovery), measure and write down the distance of the pipe top to the soil surface at both sides of the pipe wall (Fig. 4), in order to measure sediment compaction inside the pipe (core compression)[1].

Fig. 4. Measuring distance of the pipe top to the sediment surface inside and outside the core at Cadiz bay.

- Remove the rode, place a cap on the pipe top and seal it, as well as the holes for the rode, in order to prevent air pressure to push the sediment outside the pipe while lifting it out (Fig. 5).



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Fig. 5. Sealing the core top before extracting the core.

- Make a clove hitch knot with the rope around the pipe (Fig. 6). Each person holds one rope end around their waist in squat position. Then, at the same time, both people pull-up, by lifting their legs. Repeat the process until the pipe bottom near the soil surface.


Fig. 6. Making a clove hitch knot before extracting the core from the sediment.

-When the core bottom is outside, place immediately the bottom cap, in order to prevent sediment loss, and seal it well placing waterproof tape around (Fig. 7).



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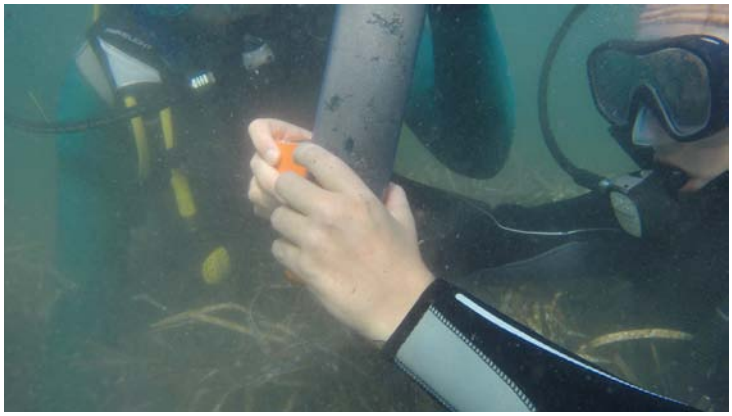

Fig. 7. Sealing the core bottom after extracting the core from the sediment.

- Open the pipe top, measure again the inside distance of the top sediment to the pipe top in order to note if there has been any sediment loss or compaction during core lift.

- There are other methods, like piston coring, vibrocoring, or Eijkelkamp coring which help minimizing core compression. We used the universal gravity core approach, which may produce some core compression (sediment compaction inside the pipe) or nail effects (loss of some soil layers). In addition, we contracted a firm to extract long-cores with a vibrocoring device, from the GdeC research vessel (Fig. 8).


Fig. 8. Extracting a long vibrocore from the García del Cid research vessel.

- The vibrocores were cut in 1m long sections in order to facilitate their transport and storage (Fig. 9).



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- If the core is to be transported whole to the laboratory, cut the pipe top 2-4cm from the sediment top (Fig. 9).

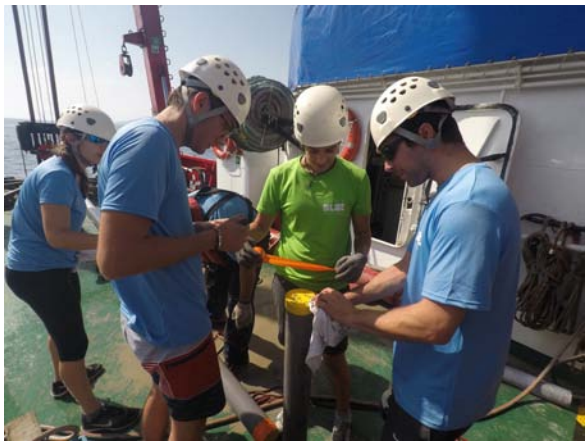

Fig. 9. Cutting the vibrocore in 1-m sections, and sealing it for transport and storage.

- Cut a piece of foam or sponge to fill the remaining space between the sediment top and the top pipe border. Place again the core cap at the pipe top and seal again with waterproof tape. In doing so, the core sediment is immobilized and can be transported horizontally to the lab, where it will be open and subsampled (Fig. 10).

Fig. 10. Pipe cut near the core top, in order to maintain it compacted for transporting horizontally.

-If the core is to be subsampled in the field, open the selected pre-drilled holes along the cores, taking into account where the top sediment surface is placed. Insert pre-cut 3cm wide syringes in the sediment while pulling out the syringe piston. Place the desired sediment volume in a subsample vial, and note the volume taken (Fig. 11).



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Fig. 11. Core subsampling at the GdeC research vessel lab. The cores were transported vertically.

Whenever possible (when a suitable escarpment was present, something occurring only in the case of large Posidonia mats), core subsamples were taken directly in the field from vertical sediment profiles (Fig. 11).

Fig. 12. Inserting the cores horizontally along the dead matte profile at RO.S-C.



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**Core opening and subsampling**

The detailed core opening and subsampling protocol, is available in annex C1-C2.2.

The whole cores were cut (Fig. 13) and the hemicores α were subsampled, usually in 2-cm slices (Fig. 14). A few where cut and subsampled every cm. The horizontal cores taken on the dead mat escarpment were open and sufficient material for analysis was taken from the inner part (Fig. 15).

Each subsample collected in the field or in the lab was placed in a pre-weighted and labelled plastic vial (Figs. 14 and 16), weighted, dried, and weighted again (in order to measure sediment water content and bulk density obtained). In our experience, when sediment samples are rich in silt and clay, it is better to freeze-dry them, instead of drying them at the stove, in order to disaggregate them later with less difficulty. However, in open-sea seagrass sites the sediment grain size was usually sandy and therefore drying in a stove was easy.

Fig. 13. Opening a core at UB corelab.


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Fig. 14. Subsampling hemicore DE.I_D-α in 2 cm-thick slices.

Fig. 15. Horizontal cores open to take sample from the inner sediment part.

As a general rule, all of the subsamples from the top 30 cm of the core entered in the treatment and analysis phase, while for the rest of the core, only alternate subsamples were treated and analysed. Some cores were analysed in more detail.



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## SEAGRASS SAMPLING RESULTS AND INVENTORY

**The sample code:**

Each subsample is labelled and stored with a code, which helps to identify it in all analyses. This code indicates the site, subsite (if there are subsites), the station, the core, and the core depth, in centimeters (Fig. 16).

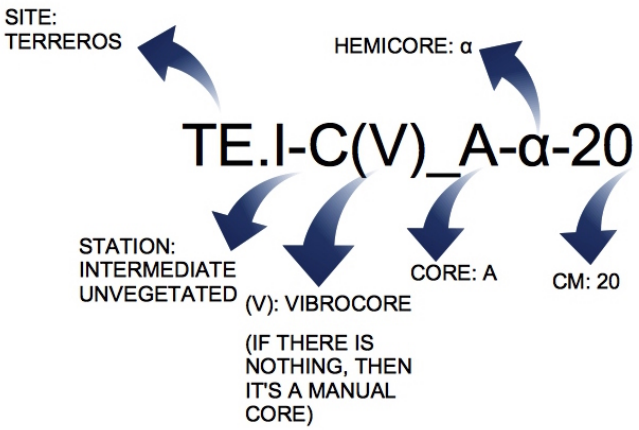


Fig. 16. Example of sample code, and its meaning, when the subsample belongs to a vertical profile taken directly in the field. The (V) indicates that it is a vibrocore. Horizontal core samples vary slightly from this code: RO.S_P1-IV, where P1 means profile 1, and the roman number IV means that this sample belongs to the horizontal core number 4, from the top to the bottom of the profile.


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**SITE: SAN JUAN DE LOS TERREROS**
**SEAGRASS SPECIES: *POSIDONIA OCEANICA***
**CATEGORIES: HEALTHY MEADOW, SHALLOW, INTERMEDIATE AND DEEP, AND UNVEGETATED**
**3 STATIONS (FIG. 17)**

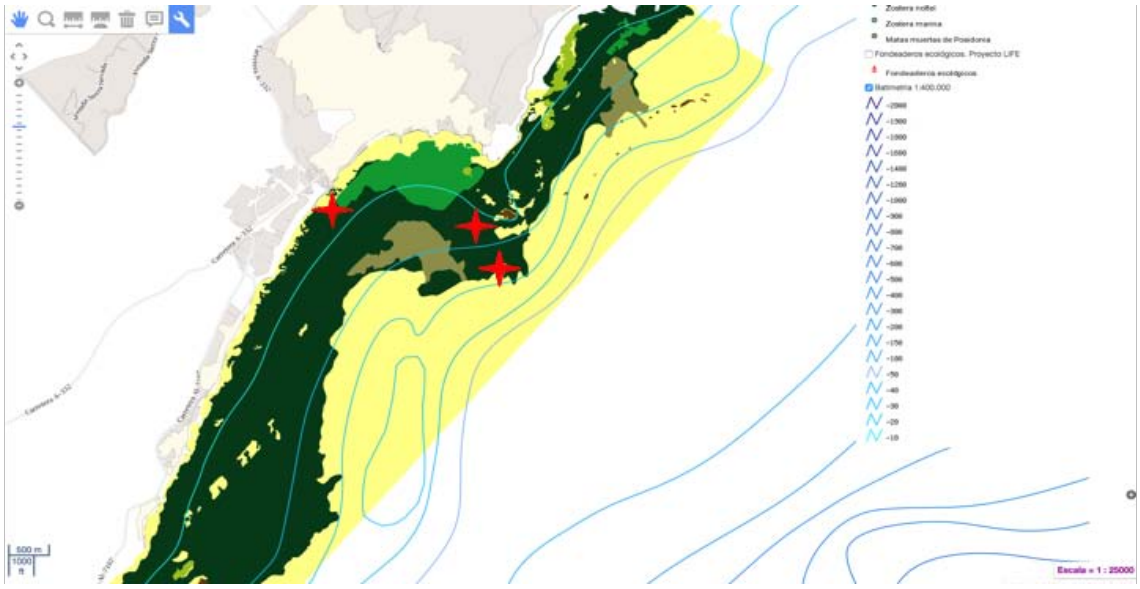

Fig. 17. Map of the seagrass meadows and stations at San Juan de los Terreros (above). View of the research vessel García del Cid and the Terreros Islet, used during the second campaign (left).



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**STATION TE.S**

Shallow (5m depth), healthy *Posidonia oceanica* meadow, growing on sandy substrate (Fig. 18).

- Geographic coordinates (WGS84):
  37º 20' 59,0" N  1º 40' 48,1" W
- Sampling date: 10/10/16
- Total number of cores: 3
- Total number of sediment subsamples: 163
- Biomass samples: 3
- Plant bags for isotopes: 1
- Shoots for lepidochronology: 6

- Data in: TE_S.xlsx  Fig. 18

Fig. 18: Cores B and C collected at TE.S

Core TE.S_A:
Compressed length: 73 cm section (Fig. 19)
Number of subsamples: 73
Core open and subsampled each cm in the lab.

Fig. 19. Hemicore TE.S_A-β

Core TE.S_B:
Depth:
Compressed length: 70 cm
Number of subsamples: 8
Subsampled in the field mission

Core TE.S_C:
Depth:
Compressed length: 45 cm
Number of subsamples: 6
Subsampled in the field mission.



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**STATION TE.I**

Medium-depth "healthy" seagrass meadow, South of Terreros Islet. However, the shoot density was very low, and the sediment muddy, although the plant shoots looked healthy. Areas with lots of Posidonia fallen leaves accumulated. Live matte borders around 40 cm above the sand.

- Geographic coordinates:
  37º 21' 3.4''N 1º 39'36.2''W
- Depth: 11.4 m
- Sampling date: 13/10/17
- Total number of cores: 5 (2 vibrocores)
- Total number of sediment subsamples: 74
- Biomass samples: 3 + 3
- Plant bags for isotopes: 1, 6 species.
- Vertical shoots for lepidochronology: 6+6

- Data in: TE_I.xlsx

Fig. 20. Panoramic view of the TE.I station

Core TE.I(V)_A
Compressed length: 528 cm sampled (field pipe length 573 cm) (Fig. 21)
Number of subsamples: 43

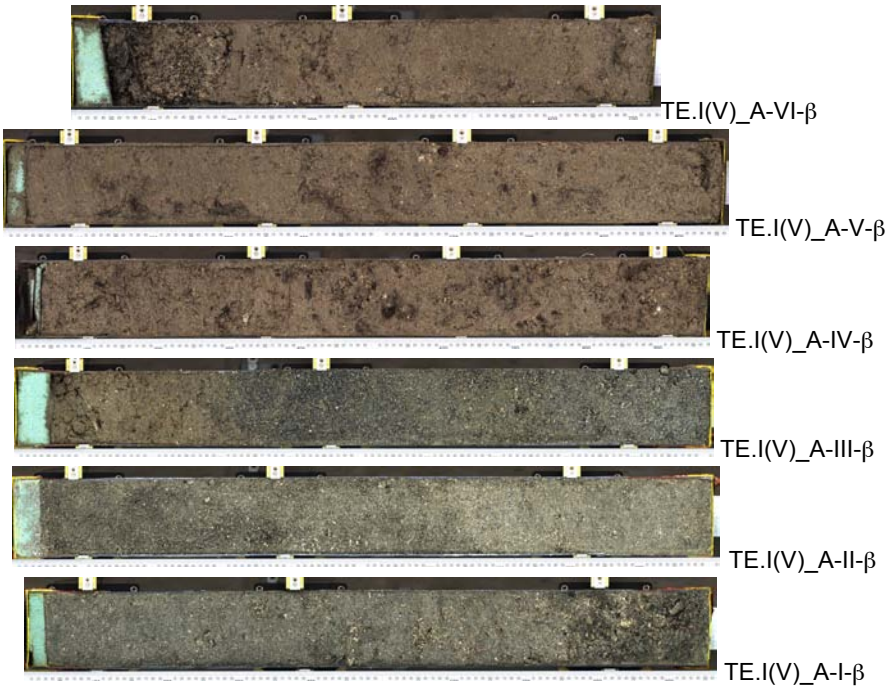


Fig. 21. Hemicore TE.I(V)_A-β, sections I (bottom) to VI (top). We can observe that we catched the whole sediment carbon sink profile (c.a. 3m). Horizon C reached.



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Core TE.I_B
Compressed length: 101 cm
Number of subsamples: 7
Subsampled in the vessel

TE.I_C
Compressed length: 90 cm
Number of subsamples: 8
Subsampled in the vessel

Core TE.I(V)_C
Compressed length: 430 cm
Number of subsamples: 10
Subsampled in the vessel

Core TE.I_C.C
Core taken in another sub-station (around 150 meters away), at 10.5m depth (37º20'51.9''N 1º 39'19.3''E), where we took additional biomass and vertical shoots, but no cores, inflorescences observed)
Compressed length: 45 cm
Number of subsamples: 6
Subsampled in the vessel.


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**STATION TE.I-C**

Un-vegetated area (around 60 $m^2$), next to TE.I, at intermediate depth (12.5m), where we took 2 manual cores. The vibrocore (37º 20.995'N 1º39.540'E, vessel GPS, 13m depth, vessel sonar) catched some organic matter and *P. oceanica* leaves. Therefore the vibrocore may in fact correspond to sediment from the meadow border. Moreover, the manual cores also show rest of *Posidonia* organic matter under a layer of around 40 cm of sand, which indicates that this area was vegetated in the past by *P. oceanica* meadow.

- Geographic coordinates (WGS84):
  37º 21' 1.6''N 1º 39' 35.0'W
- Depth: 12.5m -13 m
- Sampling date: 13/10/17

- Total number of cores: 3 (1 vibrocore)
- Total number of sediment subsamples: 145
- Biomass samples: 0
- Plant bags for isotopes: 0
- Vertical shoots for lepidochronology: 0

- Data in: TE I-C.xlsx Fi. 22

Fig. 22. Panoramic view of the station TE.I-C.

Core TE.I-C_B
Compressed length: 138 cm (Fig. 23)
Number of subsamples: 69

Fig. 23. Hemicore TE.I-C_B-β.

Core TE.I-C_C
Compressed length: 105 cm
Number of subsamples: 49
Subsampled in the vessel.

Core TE.I-C(V)_A
Compressed length: 457 cm
Number of subsamples: 27
Subsampled in the vessel.



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**STATION TE.D**

Deep, healthy *P. oceanica* meadow station. Sampled only with vibrocore. One of the vibrocores (C), fall on un-vegetated sediment. *Posidonia* leaves are heavily epiphyted. Thin matte, "good quality", calcareous algae.

Geographic coordinates:
37º 20' 37.0''N 1º 39' 10.6''W
Sampling date: 13/10/17

Total number of cores: 3(V)
Total number of sediment subsamples: 46
Biomass samples: 3
Plant bags for isotopes: 1
Vertical shoots for lepidochronology: 6

Data in: TE_D.xlsx Fig. 24

Fig. 24. Watching were the vibrocore falls.

Core TE.D(V)_C
Blind core (nobody in the water bottom checking where did it fall). Maybe fall in an un-vegetated area. The top was altered, although with Posidonia leaves. The 20 cm closer to the core bottom, fine gravel (Fig. 25)
Compressed length: 495 cm
Number of subsamples: 29
Subsampled the hemicore α

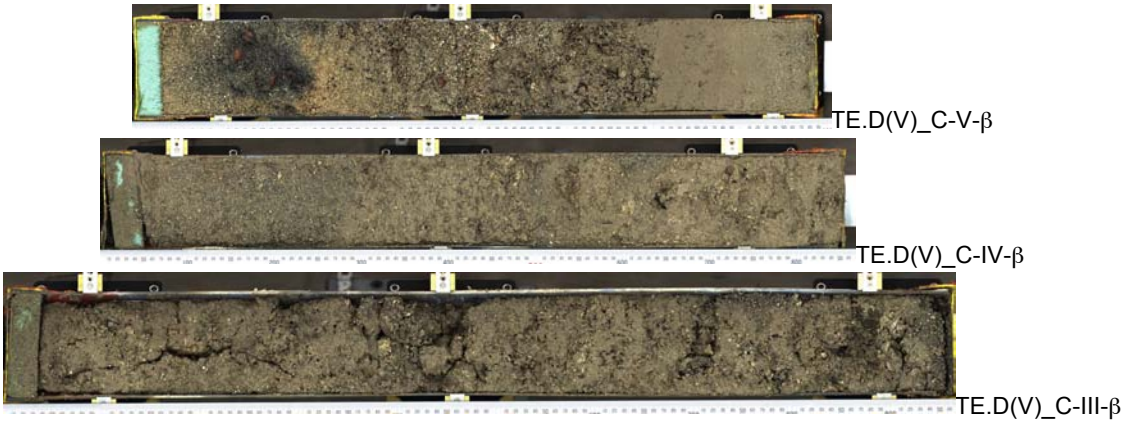


Fig. 25. Hemicore TE.D(V)_C-β.


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Core TE.D(V)_A:
Fall around 10 meters from the meadow edge, at 18 meters depth. Much water and two possible tops. Gravel at the base. Vibrocoring device head broken
Compressed length: 390 cm subsampled, 420 cm measured in the field.
Number of subsamples: 9
Subsampled in the vessel

Core TE.D(V)_B:
Blind core (nobody in the water bottom checking where it did fall), taken at 15m depth. Much water, but structure looks ok. First 40-50cm altered. Gravel and stones at the bottom.
Compressed core length: 290 cm subsampled, 350 cm measured in the field
Number of subsamples: 8
Subsampled in the vessel


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**SITE: VILLARICOS-DERETIL**
**SEAGRASS SPECIES: *POSIDONIA OCEANICA***
**CATEGORIES: CHEMICALLY DEGRADED MEADOW, INTERMEDIATE DEPTH**
**1 STATION (FIG. 26)**

Fig. 26. Aerial view of the Villaricos coastline, with the Villaricos town (front) and of the Deretil factory (rear). The station TE.I is in front of the factory, at 15 meters depth.

**STATION DE.I**

Geographic coordinates (ETRS89 huso 30S):
Y=4123912 X=610122
Sampling date: 11/10/17

Total number of cores: 4
Total number of sediment subsamples: 323
Biomass samples: 3
Plant bags for isotopes: 2
Vertical shoots for lepidochronology: 6

Data in: DE.I.xlsx
Fig. 27.

Fig. 27. Sampling a dead matte at DE.I station.



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Core DE.I_C
Compressed length: 81 cm sampled, 115 cm measured in the field (Fig. 28)
Number of subsamples from hemicore α: 41
Subsampled the hemicore α

Fig. 28. Hemicore DE.I_C-β.

Core DE.I_D
Compressed length: 142 cm sampled, 152 cm measured in the field (Fig. 29)
Number of subsamples from hemicore α: 73
Subsampled the hemicore α

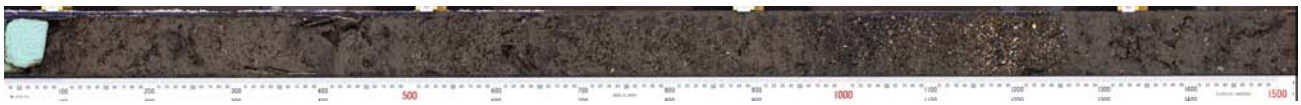

Fig. 29. Hemicore DE.I_D-β.

Core DE.I_A
Compressed length: 128 cm sampled, 159 cm measured in the field (Fig. 30)
Number of subsamples from hemicore α: 122
Subsampled the hemicore α

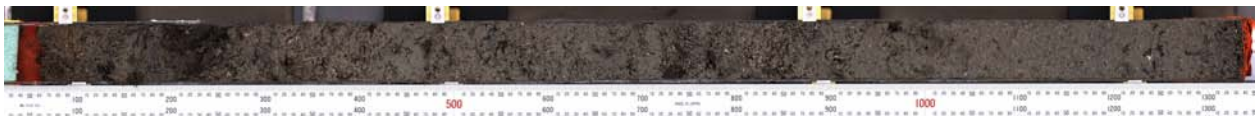

Fig. 30. Hemicore DE.I_A-β.

Core DE.I_B
Compressed length: 86 cm sampled, 112 cm measured in the field (Fig. 31)
Number of subsamples from hemicore α: 87
Subsampled the hemicore α

Fig. 31. Hemicore DE.I_B-β.

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**SITE: PALOMARES**
**SEAGRASS SPECIES: *CYMODOCEA NODOSA***
**CATEGORIES: OPEN-SEA MEADOW, MEDITERRANEAN SEA**
**2 SUB-STATIONS (FIG. 32)**

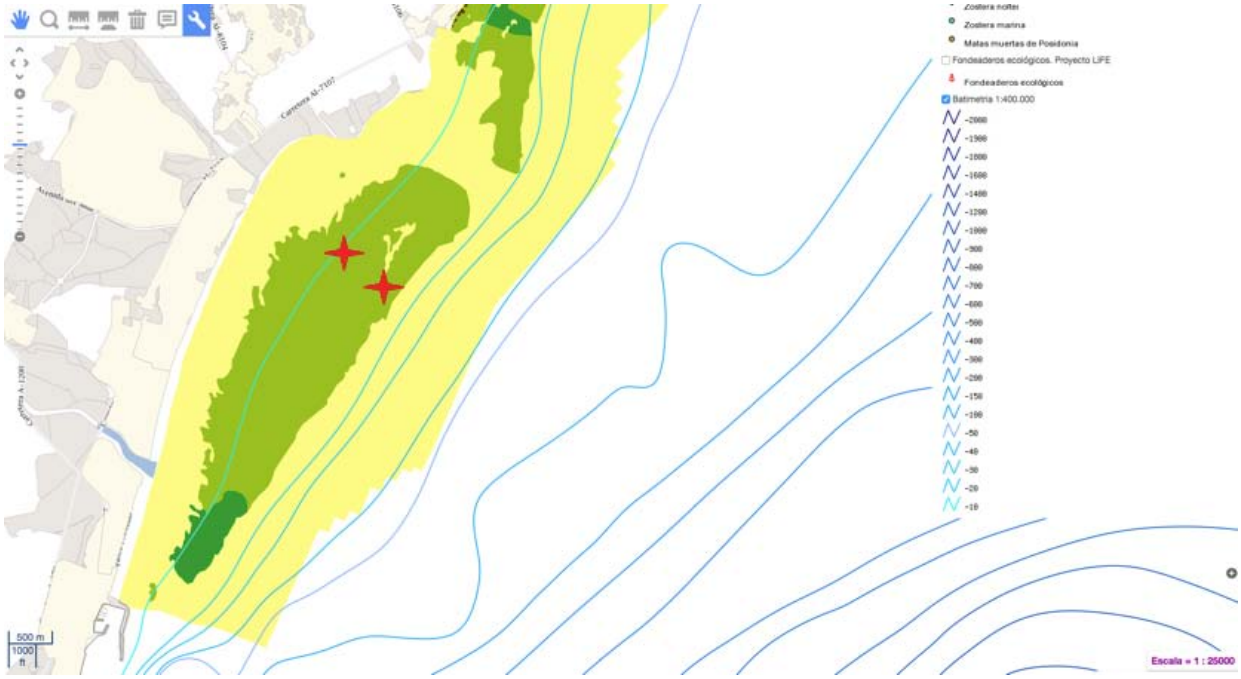


Fig. 32. *Cymodocea nodosa* meadow between Palomares and Garrucha (Almería), and sampling sites marked with red crosses.

This *Cymodocea nodosa* meadow was sampled in 2 sub-stations: one was cored manually at the 10m isobat, and the other was vibrocored near the deep border (12m).


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**STATION PA.I**

A small matte could be observed, not as thick as that observed at El Alquian (Station BA.S). However, the meadow outline revealed by the cartography, as well as the presence of *P. oceanica* at its southern end and also interspersed at the deep border, suggests that *C. nodosa* could have colonized the ancient area of a lost *P. oceanica* meadow. If this hypothesis is true, *P. oceanica* rests should be detected in the core subsamples. *C. nodosa* rhizomes appear buried around 2 cm below the surface, and only the leaves appear outside. The sediment is shiny-dark, probably by its mineralogic composition (mica crystals).

Geographic coordinates:
37º 20' 48.5''N 1º 39' 30.2'W
Depth: 10.2 m
Sampling date: 14/10/17
Total number of cores: 3
Total number of sediment subsamples: 77
Biomass samples: 3
Plant bags for isotopes: 1, 2 abundant species.

Fig. 33. View of Palomares *C. nodosa* meadow.

Geographic coordinates:
37º 12.939'N 1º 47.561'W (vibrocore)
Depth: 12 m
Sampling date: 14/10/17
Total number of cores: 1V
Total number of sediment subsamples: 12

Data in: PA_I.xlsx Fig. 33

Core PA.I_A:
Compressed length: 126 cm subsampled, 132 cm measured in the field (Fig. 34)
Number of subsamples: 63

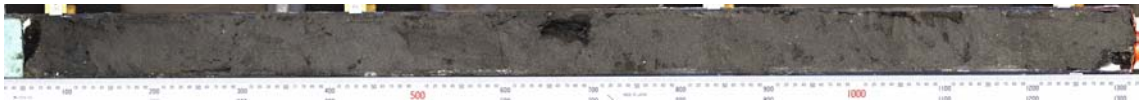

Fig. 34. Hemicore PA.I_A-β.

Core PA.I_B:
Compressed length: 95 cm subsampled, 107 cm measured in the field
Number of subsamples: 7
Subsampled in the vessel


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Core PA.I_C:
Compressed length: 80 cm, 107 cm measured in the field
Number of subsamples: 7
Subsampled in the vessel

Core PA.I(V):
Compressed length: 590 cm
Number of subsamples: 12
Subsampled in the vessel



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**SITE: AGUAMARGA**
**SEAGRASS SPECIES: *POSIDONIA OCEANICA***
**CATEGORIES: HEALTHY MEADOW, CAPE OF GATA, SHALLOW, INTERMEDIATE AND DEEP**
**3 STATIONS, (FIG. 35) ONLY MANUAL CORES, DUE TO BAD WEATHER**

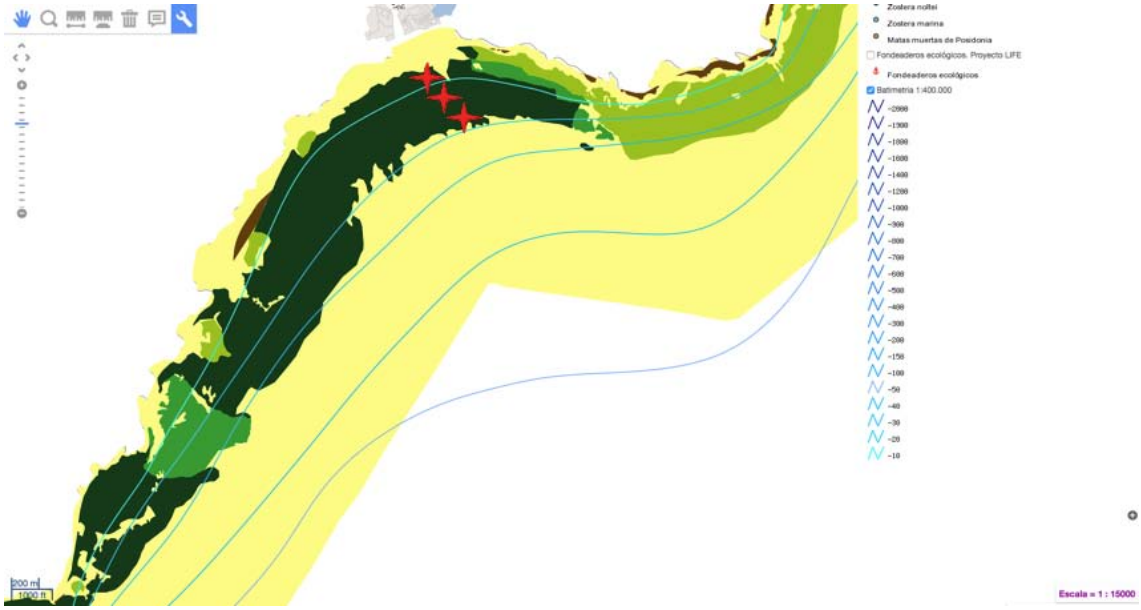


Fig. 35. Map of the seagrass meadows present at Aguamarga, and situation of the sampling stations.

**STATION AG.S**

Shallow healthy station. Very dense meadow, hard to core sediment of fine sands. Many calcareous algae (Fig. 34) on the *Posidonia* rhizomes, and many inflorescences (around 24 inf. $m^{-2}$, Fig. 35). Leaves were still long, despite we were in mid October. Water temperature: 23-25ºC. Finally we decided not to sample in the small dead matte patches formed by illegal mooring chains (station AG.X), because of the wind. We have enough samples of sediment in different dead mattes and we consider that it will be sufficient for modelling.

- Geographic coordinates:
  36º 56.261'N 1º 56.007'W
- Depth: 4.8 m
- Sampling date: 15/10/17
- Total number of cores: 3
- Total number of sediment subsamples: 166
- Biomass samples: 3
- Plant bags for isotopes: 1
- Vertical shoots for lepidochronology: 6

Data in: AG_S.xlsx Figs. 36 and 37

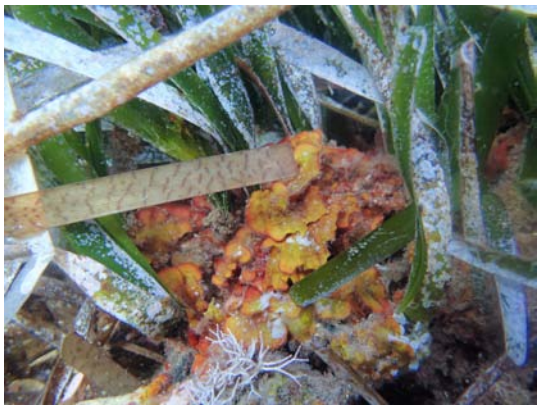

Fig. 36. Calcareous algae at AG.S station.

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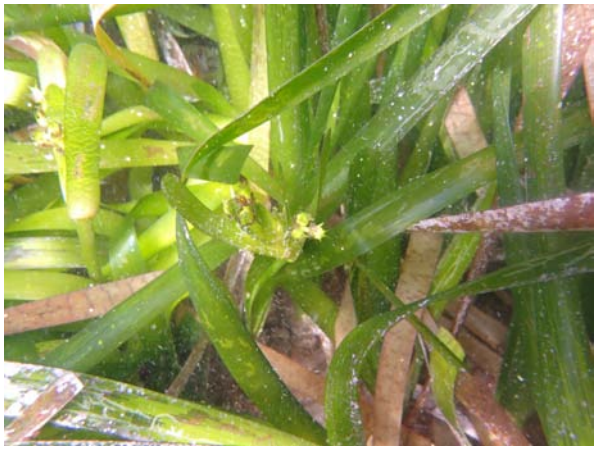

Fig. 37. Inflorescences at AG.S in October the 15th, 2018

Core AG.S_A:
Compressed length: 150 cm (subsampled) 152 cm (measured in the field, Fig. 38).
Number of subsamples: 150

Fig. 38. Hemicore AG.S_A-β

Core AG.S_B:
Compressed core Length: 72 cm (98 cm in the field)
Number of subsamples: 8
Subsampled in the vessel

Core AG.S_C:
Length: 90 cm (95 cm in the field)
Number of subsamples: 8
Subsampled in the vessel



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**STATION AG.I**

High shoot density and high epiphytic load on *Posidonia* leaves and rhizomes, but calcareous and typical of the season in a healthy meadow.

- Geographic coordinates:
  36º 56.170'N 1º 55.922'W
- Depth: 10.8 m
- Sampling date: 15/10/17
- Total number of cores: 3
- Total number of sediment subsamples: 130
- Biomass samples: 3
- Plant bags for isotopes: 1, 6 spp.
- Vertical shoots for lepidochronology: 6

Data in: AG_I.xlsx Fig. 39

Fig. 39. View of AG.I station

AG.I_A:
Compressed length: 118 cm (measured in the field and subsampled, Fig. 40).
Number of subsamples: 110

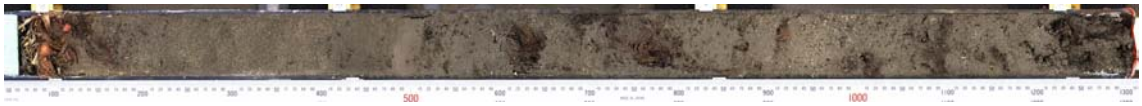

Fig. 40. Hemicore AG.I_A-β

Core AG.I_BB:
Compressed core Length: 25 cm (33 cm in the field)
Number of subsamples: 5
Subsampled in the vessel

Core AG.I_B
Compressed core length: 70 cm subsampled
Number of subsamples: 7
Subsampled in the vessel

Core AG.I_C:
Length: 90 cm (115 cm in the field)
Number of subsamples: 8
Subsampled in the vessel



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**STATION AG.D**

Near the meadow deep edge, 3 to 6 shoots in 20x20 $cm^2$, fine sand. A multicorer assay was performed, but it failed to collect sediment.

- Geographic coordinates:
  36º 55.990'N 1º 55.896'W
- Depth: 18 m
- Sampling date: 15/10/17
- Total number of cores: 3
- Total number of sediment subsamples: 71
- Biomass samples: 3
- Plant bags for isotopes: 1
- Vertical shoots for lepidochronology: 6

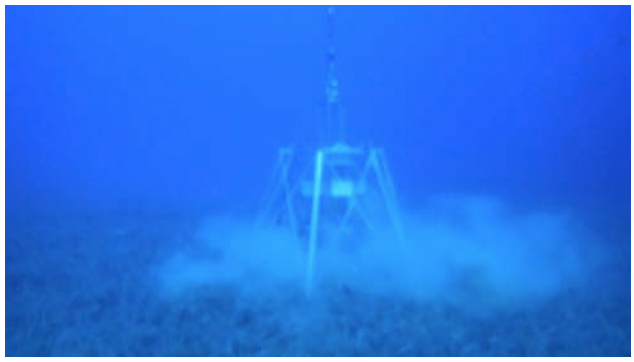

Fig. 41. Multi-corer assay at AG.D station. The device failed to take sediment.

Data in: AG_D.xlsx Fig. 41

Core AG.D_A:
Difficult to insert.
Compressed length: 124 cm subsampled (133 cm measured in the field, Fig. 42).
Number of subsamples: 61

Fig. 42. Hemicore AG.D_A-β

Core AG.D_B
Compressed core length: 20 cm (top holes not sealed and we lost most of the core)
Number of subsamples: 4
Subsampled in the vessel

Core AG.D_C
Compressed core length: 50 cm
Number of subsamples: 6
Subsampled in the vessel



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**SITE: EL ALQUIAN (ALMERIA BAY)**
**SPECIES: CYMODOCEA NODOSA**
**CATEGORIES: OPEN SEA, ALBORAN SEA, VEGETATED, UNVEGETATED, SHALLOW**
**2 STATIONS (FIG. 43)**

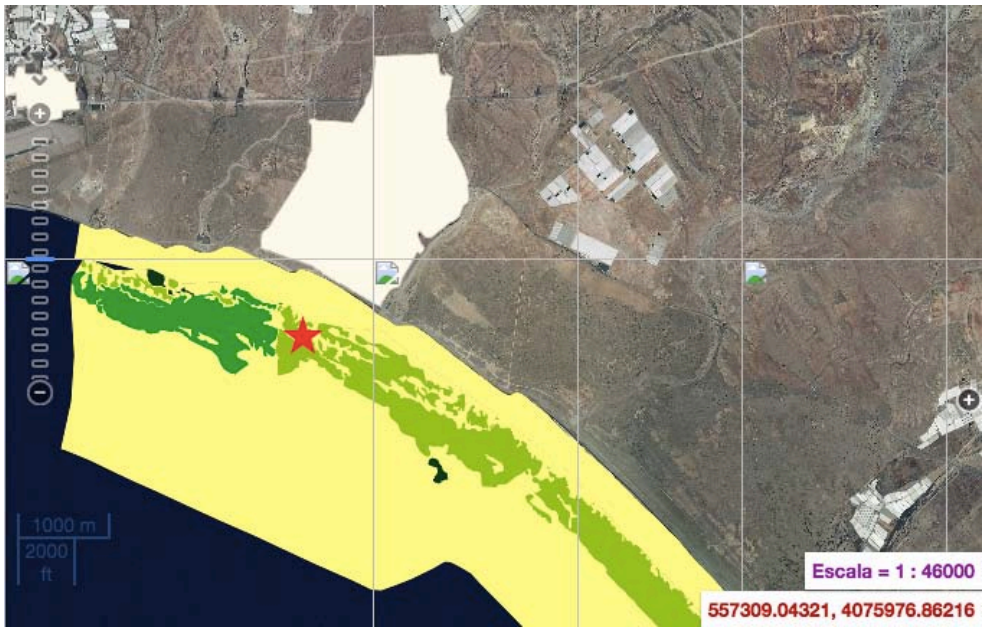


Fig. 43. *C. nodosa* meadow in the Eastern part of Almeria Bay and approximate location of El Alquian site.

**STATIONS BA.S and BA.S-C**

BA.S: *Cymodocea nodosa* meadow forming a matte elevating around 50-70cm above the sediment.
BA.S-C: Sand area adjacent to the *C. nodosa* meadow.

Geographic coordinates (WGS84):
36º 49' 39,1"N 2º 23' 14,0"W
Sampling date: 7/10/16

Total nº of cores: 6
Total nº of sediment subsamples: 182

Biomass samples: 3
Plant bags for isotopes: 1

Data in: BA_S.xlsx
BA_S-C.xlsx Fig. 44

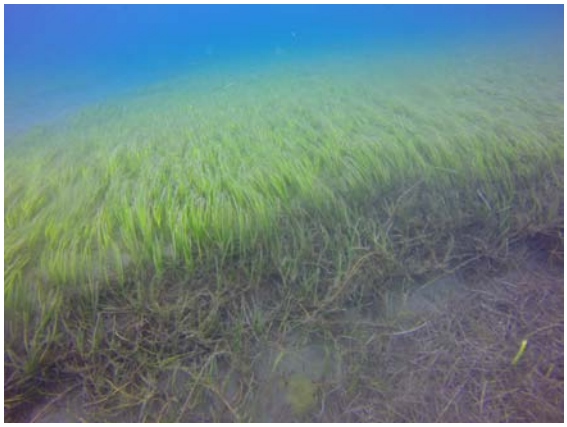

Fig. 44. Panoramic view of BA.S and BA.S-C (behind)


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SUB-STATION BA.S:
Core BA.S_A:
Compressed length: 107 cm subsampled (114 cm measured in the field, Fig. 45)
Number of subsamples: 106
Subsampled the hemicore α.

Fig. 45. Hemicore BA.S_A-β.

Core BA.S_B
Compressed length: 95 cm subsampled, 108 cm measured in the field
Number of subsamples: 8
Subsampled in the field

Core BA.S_C
Compressed length: 85 cm subsampled, 106 cm measured in the field
Number of subsamples: 8
Subsampled in the field mission

SUB-STATION BA.S-C:
Sand patches between *C. nodosa* reefy meadows (Fig. 46).

Fig. 46. BA.S-C sand area, adjacent to the meadow, with plant rests.



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Core BA.S-C_A
Compressed length: 87 cm subsampled, 93 cm, measured in the field (Fig. 47)
Number of subsamples: 44
Subsampled the hemicore α

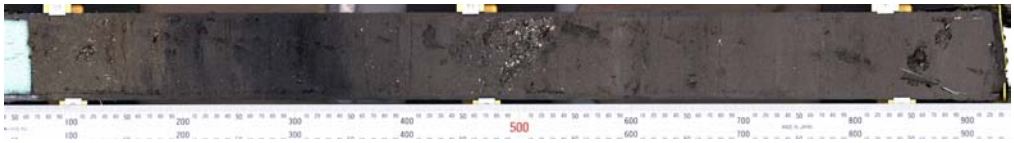

Fig. 47. Hemicore BA.S-C_A-β

Core BA.S-C_B
Comepressed core length: 85 cm subsampled, 105 cm measured in the field
Number of subsamples: 8
Subsampled in the field mission

Core BA.S-C_C
Compressed length: 95 cm subsampled, 114 cm measured in the field
Number of subsamples: 8
Subsampled in the field mission


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**SITE: ROQUETAS**
**SPECIES: *POSIDONIA OCEANICA* AND *CYMODOCEA NODOSA***
**CATEGORIES: LIVE AND DEAD MATTE, DEGRADED, IN RECOVERY, SHALLOW, INTERMEDIATE**
**2 SUBSITES, 7 STATIONS (FIG. 48)**

Fig. 48. Map of the Roquetas seagrasses and approximate position of the sampling stations

**STATIONS RO.S, RO.S-C and RO.S-CN**

These three stations (Fig. 49) are in the shallowest part of the natural monument of Roquetas barrier reef. RO.S is in the area of living *Posidonia* matte. RO.S-C corresponds to an area of dead matte, while RO.S-CN is in the inner barrier reef lagoon, colonized by small seagrasses, like *Cymodocea nodosa*.

Geographic coordinates:
RO.S-CN: 36º 47' 12,2"N 2º 47' 24,4"W
RO.S-C: 36º 47' 12,2"N 2º 35' 24,2"W
RO.S: 36º 47' 15,5"N 2º 35' 20,1"W
Sampling date: 8 and 9/10/16

Total nº of cores: 9 + 2 profiles
Total nº of sediment subsamples:
120+32+79+8+7+81+7 = 334
Biomass samples: 6
Plant bags for isotopes: 2

Data in: RO_S.xlsx
RO_S-C.xlsx
RO_S-CN.xlsx

Fig. 49. RO.S-CN (above-left), RO.S-C (above-right), and RO.S (below)

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Core RO.S_A
Compressed core length: 81 cm subsampled, 87 cm measured in the field (Fig. 50)
Number of subsamples: 81
Subsampled the hemicore α

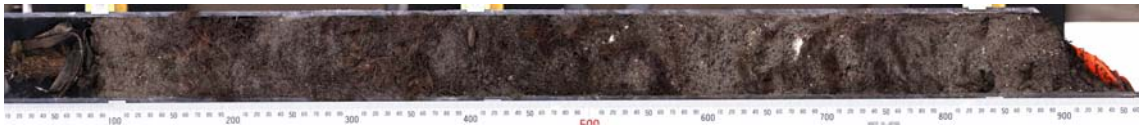

Fig. 50. Hemicore RO.S_A-β.

Core RO.S_B
Compressed length: 70 cm subsampled (87 cm cored in the field)
Number of subsamples: 7
Subsampled in the field mission

Core RO.S_C
Compressed length: 60 cm subsampled (87 cm cored in the field)
Number of subsamples: 8
Subsampled in the field mission.
Core RO.S-C_19:
Compressed length: 84 cm subsampled, 105 cm measured in the field (Fig. 51)
Number of subsamples: 79
Subsampled the hemicore α

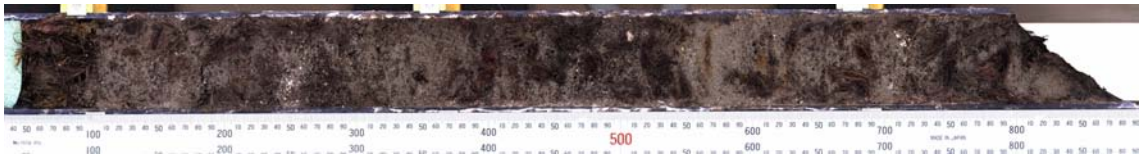

Fig. 51. Hemicore RO.S-C_19-β

Profile RO.S-C_P1:
RO.S-C_P1-III: vertical core taken at the top of the dead matte
Compressed length: 27 cm subsampled
RO.S-C_P1-IV to VIII: 5 horizontal cores inserted in the dead matte cliff at 0.5, 0.8, 1.1, 1.4 and 1.7 m depth, respectively.
Total number of the subsamples: 27+ 5 = 32


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Profile RO.S-C_P2:
RO.S-C_P2-III: vertical core taken at the top of the dead matte
Compressed length: 24 cm subsampled
RO.S-C_P2-V to VIII: 5 horizontal cores inserted in the dead matte cliff at 0.5, 0.8, 1.1, 1.4 and 1.7 m depth, respectively.
RO.S-C_P2_BOTTOM (also called RO500): vertical core inserted in the sand patch at the bottom of the dead matte profile.
Compressed length: 96 cm subsampled, 97cm measured in the field (Fig. 52)
Total number of subsamples: 24 + 5 + 91 = 120

Fig. 52. Hemicore RO.S-C_P2-BOTTOM-β, showing that under the sand, the matte continued further.

Core RO.S-C_B:
Compressed length: 55 cm subsampled
Number of subsamples: 7
Subsampled in the field.

Core RO.S-CN (also called RO100):
Compressed length: 70 cm subsampled (Fig. 53)
Number of subsamples: 59
Subsampled the hemicore α.

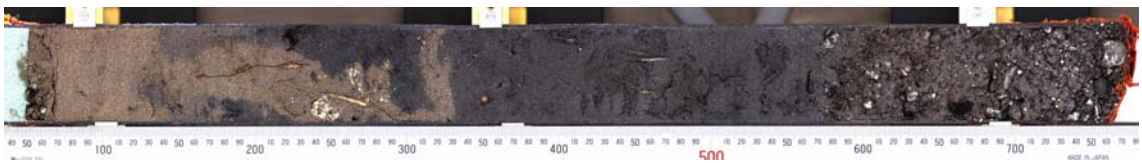

Fig. 53. Hemicore RO.S-CN-β.


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**STATION RO.I**

It cannot be considered a healthy meadow. Many horizontal shoots and no long vertical shoots present suggest that it could be a recolonizing meadow over dead matte and sand. The previous previous meadow could have been lost directly or indirectly by illegal trawling and dredging activities. Fine sand and shells, easy to insert and extract the cores.

Geographic coordinates:
36º 47.220' N 2º 34.685' W vibrocore A
36º 47.241' N 2º 34.664' W vibrocore B
36º 47.268' N 2º 34.651' W manual core C

Sampling date: 17/10/17

Total nº of cores: 3 (2V)
Total nº of sediment subsamples: 33

Biomass samples: 3
Plant bags for isotopes: 1, 4 species

Data in: RO_I.xlsx (Fig. 54)

Fig. 54. View of the RO.I station.

Core RO. I_C (RO.I_60):
Compressed length: 40 cm (Fig. 55)
Number of subsamples: 20
Subsampled hemicore α

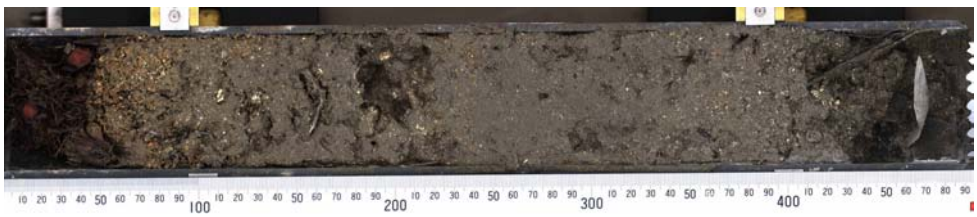

Fig. 55. Hemicore RO.I_C-β.

Core RO.I(V)_A:
Compressed length: 213 cm subsampled, 250 cm in the vessel
Number of subsamples: 6
Subsampled in the vessel

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Core RO.I(V)_B:
Compressed length: 260 cm subsampled, 540 cm in the vessel.
Number of subsamples: 7
Subsampled in the vessel.

**STATION RO.I-B**

Border of the trawled trace. Dead matte, and recolonizing *Cymodocea nodosa* at some points.

Geographic coordinates:
36º 47.151' N 2º 34.793' W vibrocore B and C
36º 47.154' N 2º 34.794' W vibrocore A
Depth: 14.5 m
Sampling date: 17/10/17

Total nº of cores: 3(2V)
Total nº of sediment subsamples: 140

Biomass samples: 3
Plant bags for isotopes: 1

Data in: RO_I-B.xlsx Fig. 56

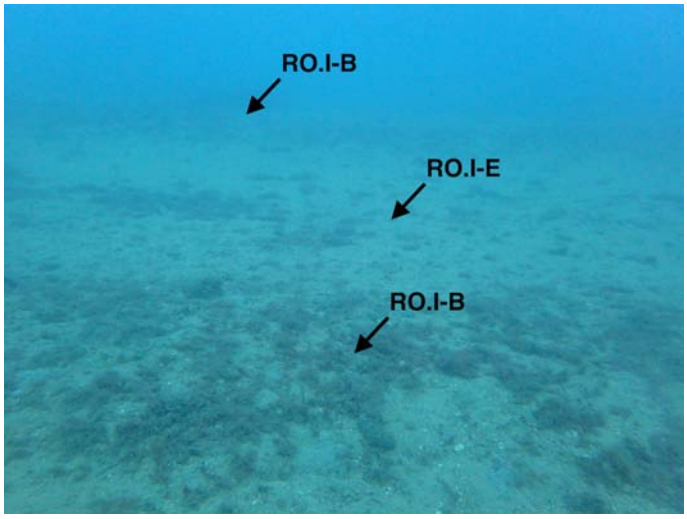


Fig. 56. View of stations RO.I-B, at the border and RO.I-C at the centre of the trawled zone.

Core RO.I-B_C:
Compressed length: 124 cm subsampled (Fig. 57)
Number of subsamples: 62
Subsampled the hemicore-α

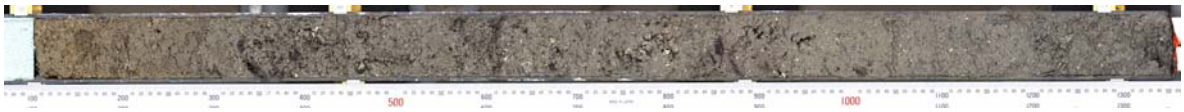

Fig 57. Hemicore RO.I-B_C-β.


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Core RO.I-B(V)_B:
Dead matte on top
Compressed length: 532 cm subsampled (Fig. 58)
Number of subsamples: 38
Subsampled the hemicores α

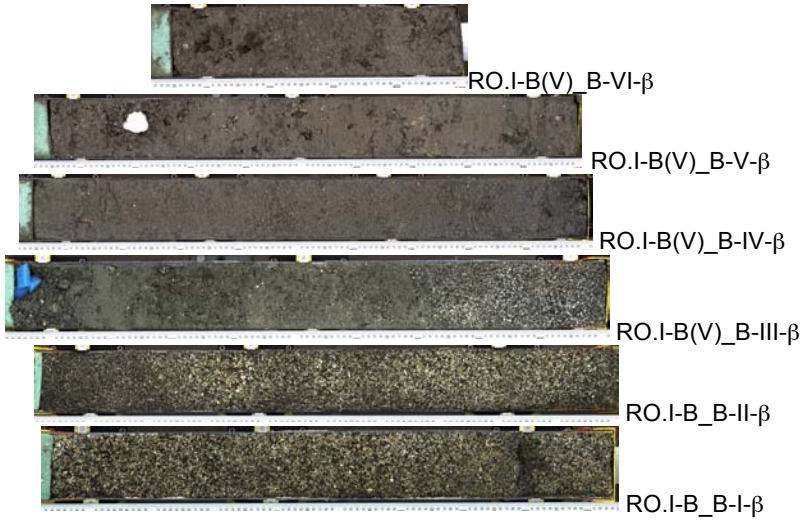


Fig. 58. Hemicore RO.I-B(V)_B-β.

Core RO.I-B(V)_A:
*C. nodosa* on top
Compressed length: 532 cm subsampled (Fig. 59)
Number of subsamples: 38
Subsampled the hemicores α


Fig. 59. Hemicore RO.I-B(V)_B-β.


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**STATION RO.I-E AND RO.I-R:**

In the trawling trace there's dead matte, silt, fine sand, *Caulerpa prolifera* algae and few *Cymodocea nodosa* plants recolonizing. There are also some small patches of *Posidonia oceanica* plants (15 to 100 shoots per patch). When we sampled shoots there for lepidochronology, we realized that these patches are not new, but must be relicts of the ancient meadow that survived trawling, because we detected really long vertical shoots, which seem to have grown upwards fast, probably escaping siltation, which is a side-effect of trawling erosion. One biomass sample is taken on a patch, and two biomass samples are taken in the eroded area.

Geographic coordinates:
We use the same as RO.I-B
Depth: 15 m
Sampling date: 17/10/17

Total nº of cores: 4
Total nº of sediment subsamples: 108

Biomass samples: 3
Plant bags for isotopes: 1
Vertical shoots for lepidochronology: 6

Data in: RO_I-R.xlsx Fig. 60
RO_I-E.xlsx

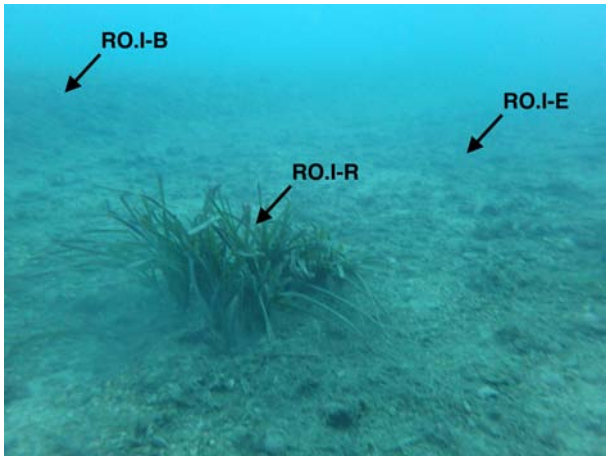

Fig. 60. RO.I-R, RO.I-E and RO.I_B stations.

Core RO.I-E:
Compressed length: 102 cm subsampled, 109 cm measured in the field (Fig. 61)
Number of subsamples: 51
Subsampled the hemicore α


Fig. 61. Hemicore ROI.I-E-β

Core RO.I-R_A:
Compressed length: 86 cm subsampled, 102 cm measured in the field (Fig.62)
Number of subsamples: 43
Subsampled the hemicore α

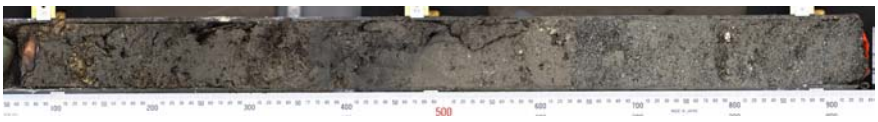
Fig. 62. Hemicore ROI.I-R-β


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Core RO.I-R_B
Compressed length: 65 cm subsampled, 92 cm measured in the field.
Number of subsamples: 7
Subsampled in the vessel

Core RO.I-R_C
Compressed length: 70 cm subsampled, 83 cm measured in the field.
Number of subsamples: 7
Subsampled in the vessel

**STATION RO.I_SHALLOW**
At 10.5 meter depth, towards the land, we took 2 vibrocores on healthy meadow

Geographic coordinates:
36º 47.432'N 2º 34.843'W Core A
36º 47.436' N 2º 34.821'W Core B
Depth: 10.5 m
Sampling date: 17/10/17

Total nº of cores: 2
Total nº of sediment subsamples: 40

Biomass samples: 0
Plant bags for isotopes: 0
Vertical shoots for lepidochronology: 0
Data in: RO_I-Shallow.xlsx

Fig. 63

Fig. 63. Vibrocore extraction.

Core RO.I-Shallow(V)_A:
Compressed length: 305 cm (Fig. 64)
Number of subsamples: 18
Subsampled the hemicore α


RO.I-Shallow(V)_A-III-β

RO.I-Shallow(V)_A-II-β
Fig. 64. Hemicore RO.I-Shallow(V)_A-β.


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Core RO.I-Shallow(V)_B:
Compressed length: 434 cm (Fig. 65)
Number of subsamples: 22
Subsampled the hemicore α

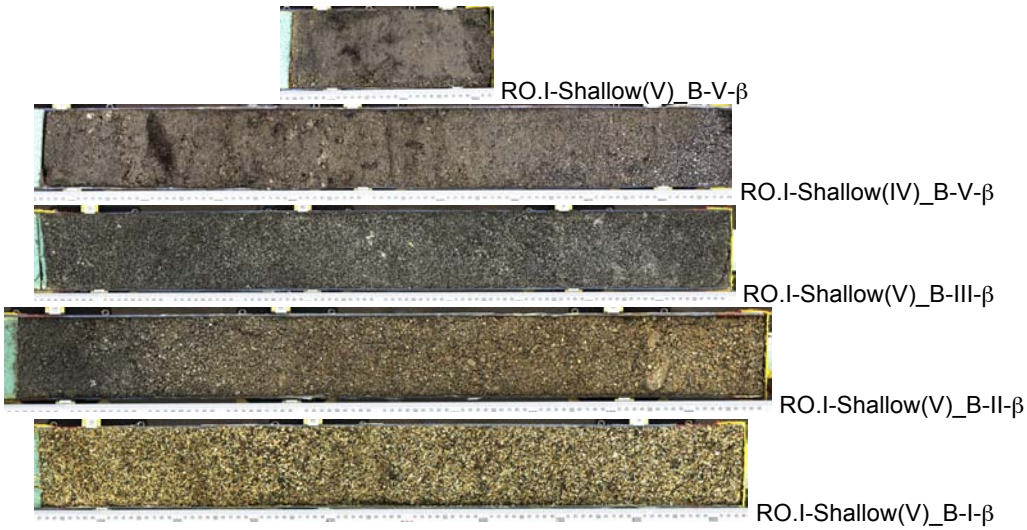


Fig. 65. Hemicore RO.I-Shallow(V)_B-β.


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**SITE: ALMERIMAR-GUARDIAS VIEJAS**
**SPECIES: POSIDONIA OCEANICA**
**CATEGORY: SHALLOW, LIVE MATTE IN EROSION**

This site wasn't initially planned. It was planned to sample in the nearby meadow of Punta Entinas, a large meadow growing on sand + rocky bottoms. However, the strong winds didn't allow us to sample there as planned. The shallow meadow of Almerimar-Guardias Viejas, not even mapped (Fig. 66) looks as an ancient barrier reef suffering an erosive declining process. There are still points where the reef reaches the sea surface. Due to the bad weather, only two manual cores could be extracted.

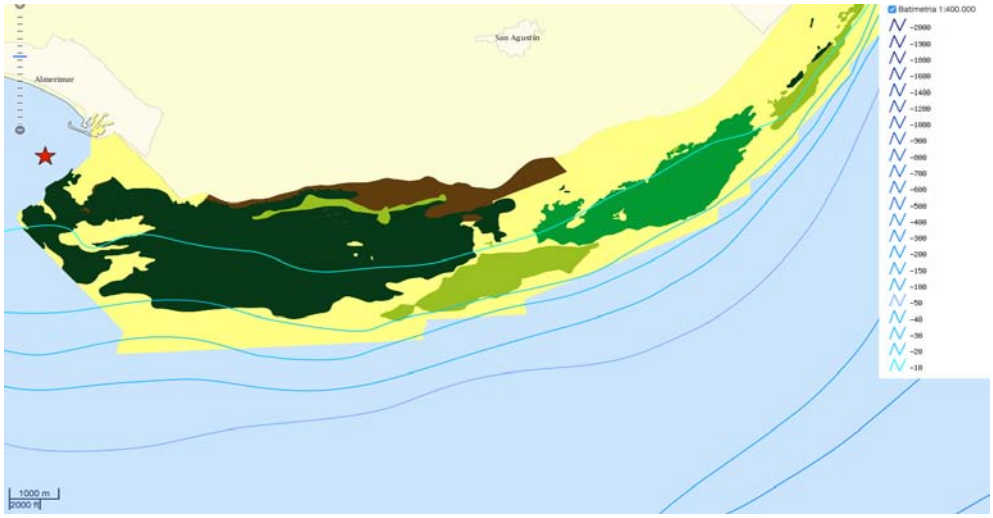


Fig. 66. Location of the Almerimar site.

**STATION AL.S**

Geographic coordinates:

Sampling date: 16/10/17

Total nº of cores: 2
Total nº of sediment subsamples:

Biomass samples: 3
Plant bags for isotopes: 1
Vertical shoots for lepidochronology: 6

Data in: AL_S.xlsx Fig. 67

Fig. 67. Aspect of the relict meadow of Almerimar.



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Core AL.S_A:
Compressed core length: 106 cm subsampled, 115 cm in the field (Fig. 68)
Number of subsamples: 53
Subsampled the hemicore α

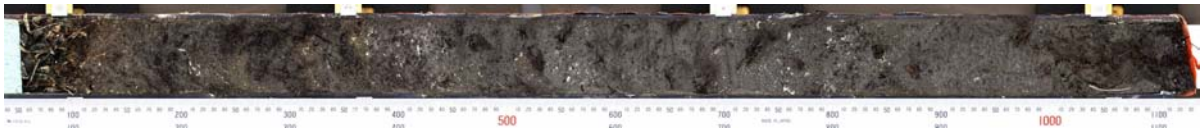

Fig. 68. Hemicore AL.S_A-β.

Core AL.S_B:
Compressed core length: 28 cm subsampled (Fig. 69)
Number of subsamples: 14
Subsampled the hemicore α

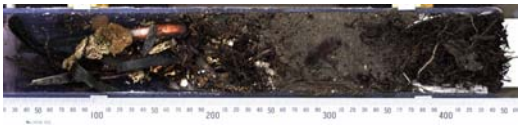

Fig. 69. Hemicore AL.S_B-β.


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**SITE: MELICENA**
**SPECIES: *POSIDONIA OCEANICA***
**CATEGORIES: SHALLOW, GRANADA/ALBORÁN MEADOWS, IN DECLINE**
**2 STATIONS**

The meadow of Melicena (Fig. 70) is representative of the meadows in the coast of Granada. They are shallow, patchy and in decline, although the causes are not well elucidated. Effluents runoff from the numerous legal and illegal greenhouses, as well as recent land movements made for their construction in this mountainous landscape; all this may have impacted meadows health through reduction in water transparency and siltation. There is also evidence that ilegal trawling also has destroyed the deeper parts of the meadows. In the Alborán sea de meadow depth limits are also naturally shallower.

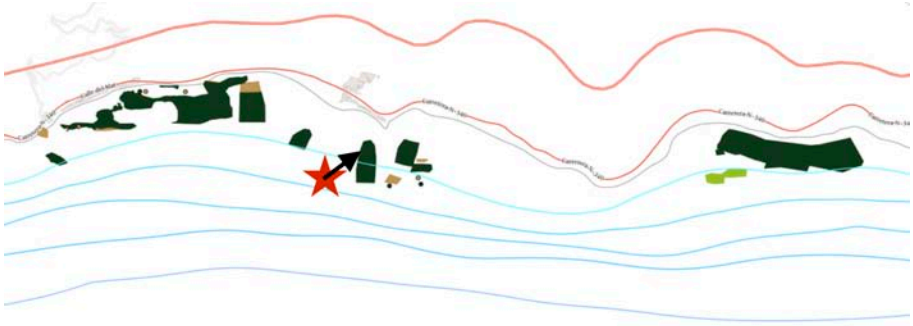

Fig. 70. Map of Posidonia meadows around Melicena (Granada).

**STATION ME.S**
ME.S: shallow, patchy, intermatte relief. 70% of cover is matte, of which 80% is dead matte, and 20% alive. The 30% of cover is fine sand, but the spike indicates that rock is near below the sediment. Calcareous algae are abundant on Posidonia rhizomes.

Geographic coordinates:
36º 44' 51.1''N 3º 14' 12.1''W
Depth: 4 – 4.2 m
Sampling date: 18/10/17

Total nº of cores: 3
Total nº of sediment subsamples: 46

Biomass samples: 3
Plant bags for isotopes: 1, 3 spp
Vertical shoots for lepidochronology: 6

Fig. 71. The storm started just returning to the vessel.

Data in: ME.xlsx Fig. 71



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Core ME.S_C:
Compressed length: 68 cm subsampled, 82 cm in the field (Fig. 72)
Number of subsamples: 34
Subsampled the hemicore α

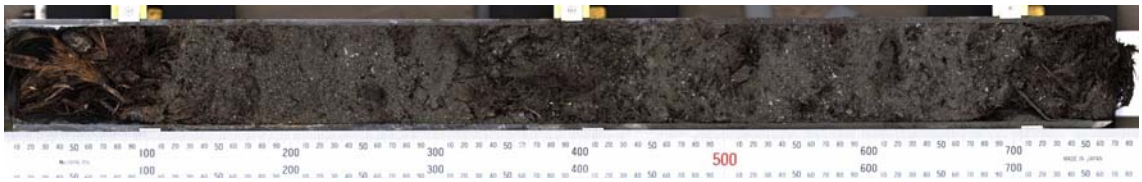

Fig. 72. Hemicore ME.S_C-β

Core ME.S_A:
Compressed length: 50 cm subsampled, 66 cm in the field
Number of subsamples: 6
Subsampled in the vessel.

Core ME.S_B:
Compressed length: 35 cm subsampled, 50 cm in the field
Number of subsamples: 6
Subsampled in the vessel.

**STATION ME.I-C:**
There were patches of *Posidonia oceanica* around, but the vibrocore poke on sand.

Geographic coordinates:
36º 44' 51.1''N 3º 14' 12.1''W

Depth: 11.8 m
Sampling date: 18/10/17

Total nº of cores: 1V
Total nº of sediment subsamples: 17

Biomass samples: 0
Plant bags for isotopes: 0
Vertical shoots for lepidochronology: 0

Data in: ME.xlsx Fig. 73

Core ME.I-C(V):
Compressed length: 340 cm subsampled,
Number of subsamples: 17
Subsampled the hemicore α

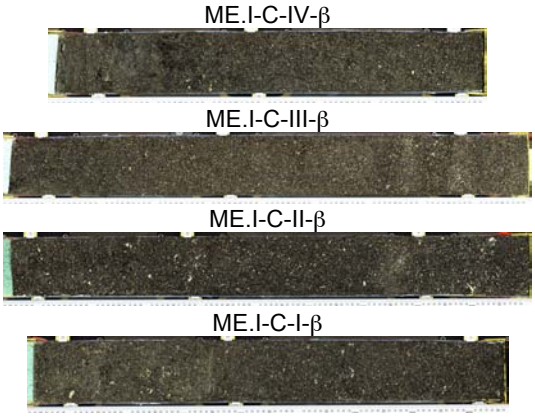


Fig. 73. Hemicore ME.I-C-β.


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**SITE CALABURRAS**
**SPECIES: *POSIDONIA OCEANICA* AND *CYMODOCEA NODOSA***
**CATEGORIES: ANCIENT DEAD MATTE, DEAD MATTE RECOLONIZED BY C. NODOSA, MÁLAGA-ALBORÁN SEA, POSIDONIA ON ROCKS**
**3 STATIONS**

Area of ancient, shallow dead matte, protected by rocks from erosion (Fig. 74), at 30-50cm depth. It is recolonized by algae (CA.S-C), and in certain points by the seagrass *C. nodosa* (CA.S-CN). At 5-7 meters depth there are patches of *P. oceanica* growing or rocks (CA.S).

Fig. 74. Aerial view of the Calaburras site and the three stations.

**STATION CA.S-C**

Geographic coordinates:
36º 29.439'N 4º 41.613'W
Depth: 0.5 - 1 m
Sampling date: 20/10/17

Total nº of cores: 3
Total nº of sediment subsamples: 68
Biomass samples: 3
Plant bags for isotopes: 1
Dead matte to date with $^{14}C$

Data in: CA.xlsx Fig. 75


Fig. 75. Dead matte covered with algae at CA.S-C.

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Core CA.S-C_A
Compressed length: 46 cm subsampled (Fig. 76)
In: 98 cm ; Out: 84 cm
Total number of samples: 23
Subsampled the hemicore α

Fig. 76. Hemicore CA-S-C_A-β

Core CA.S-C_C
Compressed length: 48.5 cm subsampled (Fig. 77)
In: 95 cm ; Out: 65 cm
Total number of samples: 24
Subsampled the hemicore α

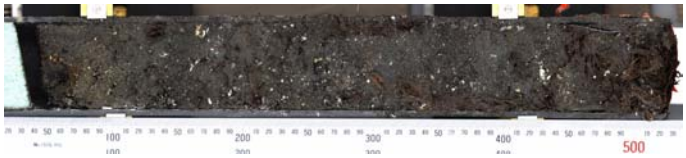

Fig. 77. Hemicore CA-S-C_C-β

Core CA.S-C_B
Compressed length: 42 cm subsampled
In: 30 cm ; Out: 10 cm
Total number of samples: 21
Subsampled the hemicore α

**STATION CA-S-CN**

Geographic coordinates:
36º 29.427'N 4º 41.621'W
Depth: 0.5 - 1 m
Sampling date: 20/10/17

Total nº of cores: 3
Total nº of sediment subsamples: 57
Biomass samples: 3
Plant bags for isotopes: 1
Dead matte to date with $^{14}C$

Data in: CA.xlsx Fig. 78

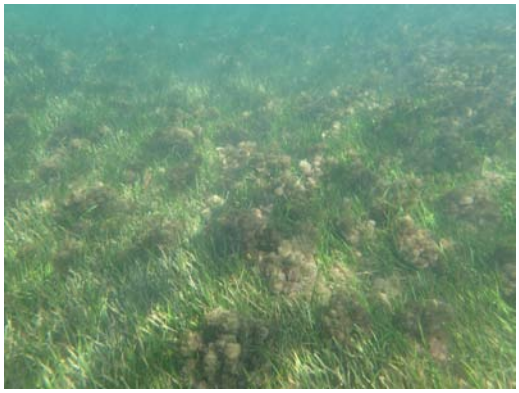

Fig. 78. Mixed meadow of *C. nodosa* and algae growing over *P. oceanica* dead matte.

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Core CA.S-CN_A
Compressed length: 31 cm subsampled (Fig. 79)
Total number of samples: 15
Subsampled the hemicore α

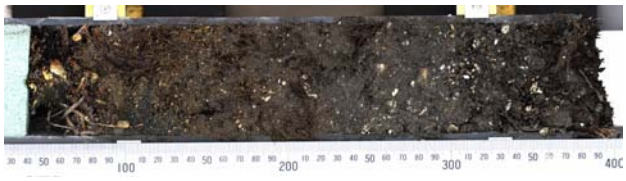

Fig. 79. Hemicore CA-S-CN_A-β

Core CA.S-CN_B
Compressed length: 27 cm subsampled (Fig. 80)
Total number of samples: 14
Subsampled the hemicore α

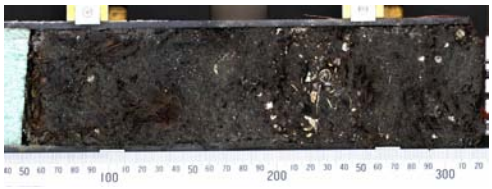

Fig. 80. Hemicore CA-S-CN_B-β

Core CA.S-CN_C
Compressed length: 55 cm subsampled (Fig. 81)
Total number of samples: 28
Subsampled the hemicore α

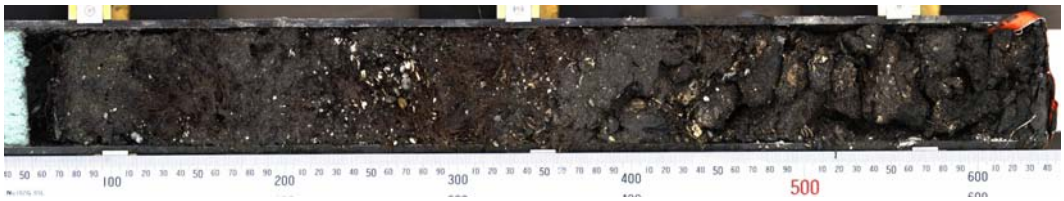

Fig. 81. Hemicore CA-S-CN_C-β



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**STATION CA.S**

*Posidonia oceanica* patches growing on rocks. We only took samples for biomass, lepidochronology and stable isotopes.

Geographic coordinates:
36º 29.384'N 4º 41.611'W
Depth: 3 m
Sampling date: 20/10/17

Total nº of cores: 0
Total nº of sediment subsamples: 0

Biomass samples: 3
Plant bags for isotopes: 1
Vertical shoots for lepido: 6

Data in: CA.xlsx Fig. 82

Fig. 82. Approximate location of CA.S station.

No cores taken in this station, due to the fact that plants grew directly on rocky substrate.


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**SITE: SANTIBAÑEZ LAGOON, BAY OF CADIZ (FIG. 81)**
**SPECIES: *ZOSTERA NOLTEI*, *C. NODOSA*, *CAULERPA RACEMOSA* (ALGA)**
**CATEGORIES: SMALL SEAGRASSES IN LAGOONS, ATLANTIC, SUBMAREAL SALTMARSH, HEALTHY, AFFECTED BY MARICULTURE.**

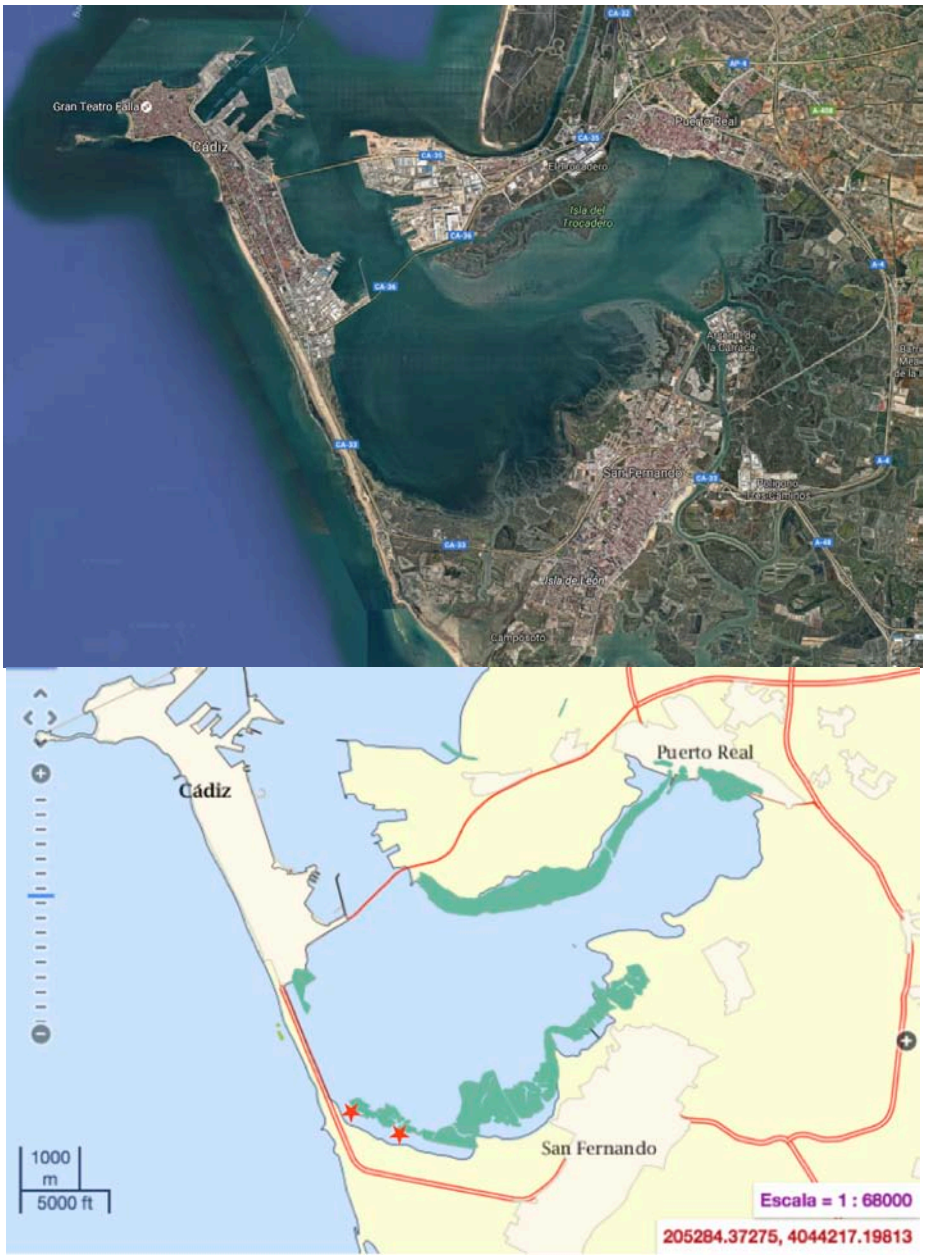


Fig. 83. Satellite image of Santibañez lagoon and map of *Z. noltei* distribution there.



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**STATIONS SA.ZN-S AND SA.ZN-D**

Area with *Zostera noltei*, at the shallow (SA.ZN-S) and deep (SA.ZN-D) intertidal. Fine sand, silt and shells. There are boats moored and this human walking on may affect the stability of meadows, which are patchy.

Geographic coordinates:
36º 28.136'N 6º 15.078'W
Depth: 0 m
Sampling date: 3/10/16

Total nº of cores: 6
Total nº of sediment subsamples: 97

Biomass samples: 6
Plant bags for isotopes: 14 (shared)

Data in: SA_ZN-S.xlsx Fig. 84
SA_ZN-D.xlsx


Fig. 84. *Zostera noltei* at the station SA.ZN-D.

Core SA.ZN-S_A:
Compressed length: 45 cm subsampled, 52 cm in the field (Fig. 85)
Number of subsamples: 22
Subsampled the hemicore α

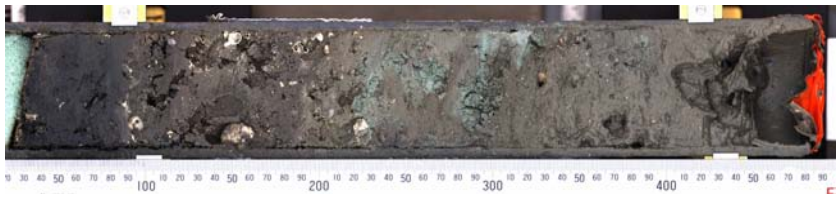
Fig. 85. Hemicore SA.ZN-S_A-β

Core SA.ZN-S_B:
Compressed length: 35 cm subsampled, 55 cm in the field.
Number of subsamples: 5
Subsampled in the field.

Core SA.ZN-S_C:
Compressed length: 50 cm subsampled, 87 cm in the field.
Number of subsamples: 6 cm
Subsampled in the field.


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Core SA.ZN-D_A:
Compressed length: 100 cm subsampled, 111 cm in the field (Fig. 86).
Number of subsamples: 50
Subsampled the hemicore α

Fig. 86. Hemicore SA.ZN-D_A-β

Core SA.ZN-D_B:
Compressed length: 95 cm subsampled, 114 cm in the field
Number of subsamples: 7
Subsampled in the field.

Core SA.ZN-D_C:
Compressed length: 70 cm subsampled,103 cm in the field.
Number of subsamples: 7
Subsampled in the field.

**STATION SA.CN**

Geographic coordinates:
36º 28.168'N 6º 15.072'W
Depth: 0.5 - 1 m
Sampling date: 4/10/16

Total nº of cores: 3
Total nº of sediment subsamples: 67

Biomass samples: 3
Plant bags for isotopes: 14 (shared)

Data in: SA_CN.xlsx Fig. 87

Fig. 87. *C. nodosa* in SA.CN, at low tide.


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Core SA.CN_A:
Compressed length: 86 cm subsampled, 102 cm in the field (Fig. 88)
Number of subsamples: 44
Subsampled the hemicore α

Fig. 88. Hemicore SA.CN_A-β

Core SA.CN_C:
Compressed length: 32 cm subsampled, 93 cm in the field (Fig. 89)
Number of subsamples: 16
Subsampled the hemicore α

Fig. 89. Hemicore SA.CN_C-β

Core SA.CN_B:
Compressed length: 82 cm subsampled, 102 cm in the field
Number of subsamples: 7
Subsampled in the field.

**STATION SA.CP**

Geographic coordinates:
36º 28.174'N 6º 15.023'W
Depth: 1 – 1.5 m
Sampling date: 4/10/16

Total nº of cores: 3
Total nº of sediment subsamples: 26

Biomass samples: 3
Plant bags for isotopes: 14 (shared)

Data in: SA_CP.xlsx Fig. 90

Fig. 90. Sampling at SA.CP in Santibañez.



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Core SA.CP_A:
Compressed length: 38 cm subsampled (Fig. 91)
Number of subsamples: 19
Subsampled the hemicore α

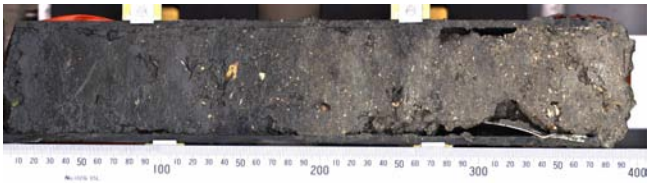

Fig. 91. Hemicore SA.CP_A-β

Core SA.CP_C:
Compressed length: 18 cm subsampled (Fig. 92)
Number of subsamples: 9
Subsampled the hemicore α

Fig. 92. Hemicore SA.CP_C-β

Core SA.CP_B:
Compressed length: 35 cm subsampled, 57 cm in the field
Number of subsamples: 8
Subsampled in the field.

**STATION SA.ZN-C**
Situated in an area of mariculture, still exploited although much less intensively now.

Geographic coordinates:
36.54811ºN 6.21020ºW
Depth: 0 m
Sampling date: 4/10/16

Total nº of cores: 3
Total nº of sediment subsamples: 65
Biomass samples: 3
Plant bags for isotopes: 14 (shared)

Data in: SA_ZN-C.xlsx Fig. 93

Fig. 93. Area of mariculture where SA.ZN-C is located.

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Core SA.ZN-C_A:
Compressed length: 100 cm subsampled, 118 cm in the field (Fig. 94)
Number of subsamples: 50
Subsampled the hemicore α

Fig. 94. Hemicore SA.ZN-C_A-β

Core SA.ZN-C_B:
Compressed length: 80 cm subsampled, 102 cm in the field.
Number of subsamples: 7
Subsampled in the field

Core SA.ZN-C_C:
Compressed length: 85 cm subsampled, 93 cm in the field.
Number of subsamples: 8
Subsampled in the field.


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