



Acoustic remote sensing of benthic habitats: underwater vegetation

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Acoustics

- Acoustic methods are one type of remote sensing technique.
- Why acoustic remote sensing?
 - **Mapping of large areas in less time, comparing to direct methods;**
 - **Are much less (or not at all) affected by water turbidity and water depth, contrarily to another remote sensing methods (optical).**
- The acoustic methods require validation through ground truth.
- Acoustic ground discrimination systems have been used with success to discriminate benthic habitats characterised by different superficial sediment types, although their use to study the distribution of coral biotopes and aquatic vegetation has also been reported.

Aims

- Investigate if a single-beam acoustic ground discrimination system could distinguish between:
 - Different sediment types (mud and sand);
 - Bare from vegetated seabed.

- Test which frequency (50 or 200 kHz) can be the most useful to distinguish between sediment types and vegetation coverage.

Study Area

- Mar Menor is a shallow coastal lagoon, located in the southwest Mediterranean sea (Spain).
- Muddy bottoms predominate and are covered by a dense meadow of the macroalgae *Caulerpa prolifera* (Forsskål) J.V. Lamouroux.
- The expansion of *C. prolifera* contributed to a silting up of the superficial sediment, due to fine particles trapped by the root system.

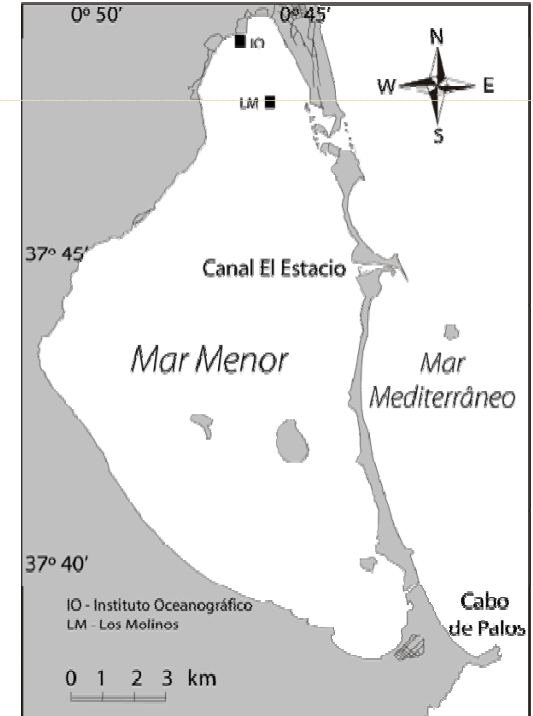
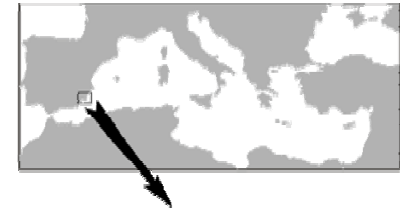


Figure 1. Mar Menor, showing the location of the study areas, Los Molinos (LM) and the Oceanographic Institute (IO).

Sampling

- **LM:** 2 areas (LMA and LMB) with 4 sampling sites each one.
- **IO:** 1 area (IO) with 3 sampling sites (IO1, IO2, IO3). Site IO3 was selected for removal of the macroalgae by diving and handpicking the algae, because muddy bottom areas could not be found anywhere.

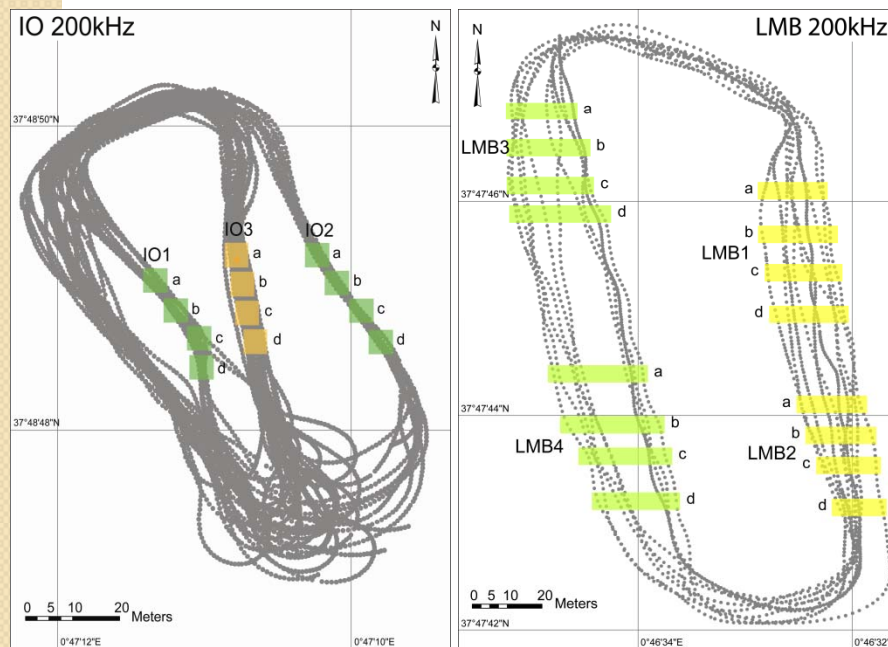


Fig 2. The 200 kHz acoustic survey lines are shown for IO and LM, area B. Rectangles identify the site replicates for the acoustic sampling area, the sediment grain-size and the algae biomass. Acoustic survey ; muddy bottom with *Caulerpa* and without *Caulerpa* ; sandy bottom with *Caulerpa* and without *Caulerpa* .

Sampling

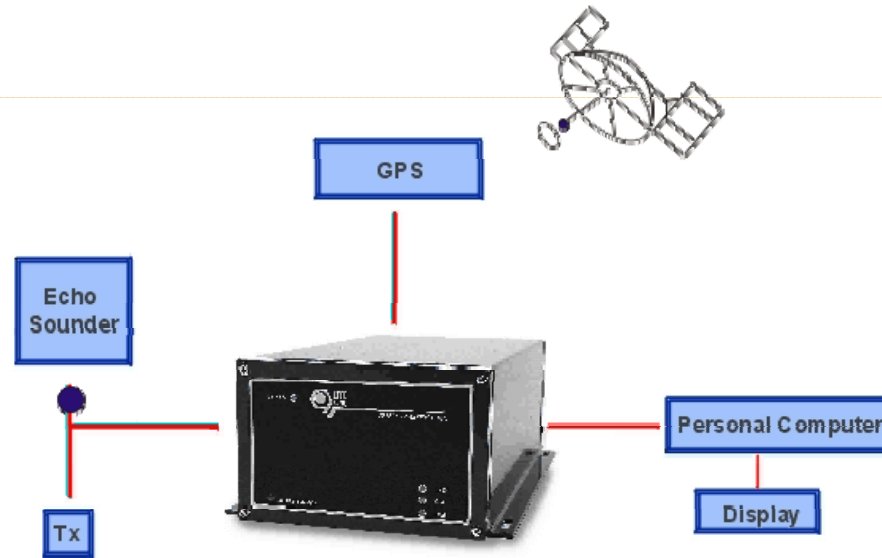
- All the sediment and macroalgae samples were obtained by scuba diving.



- The algae (leaves and root systems) were handpicked from an area of [20 x 20 cm] and placed in 1 mm mesh bags. The sediment samples were collected with a corer or a shovel, depending on the sediment compactness, and placed in plastic bags.

Sampling

- The acoustic survey was run with the seabed classification system QTC VIEW Series V connected to a dual frequency echosounder, Hondex 7300II (50 and 200 kHz).



Data Analysis

- The two acoustic datasets (50 kHz and 200 kHz), for each area, were processed separately by the software QTC IMPACT v3.4 that, using a series of algorithms, describes each echo by 166 variables (the Full Feature Vectors, FFV file).
- Within the GIS environment it is possible to visualize the position of the acoustic survey lines and the grain size and biomass samples.



Eco	Lat	Lon	Depth	166 features
1				
2				
...				
n				
Average				

Site	Replicates	166 features
IO2	IO2a	
	IO2b	
	IO2c	
	IO2d	

Data analysis

Site	Replicates	Grain size
IO2	IO2a	
	IO2b	
	IO2c	
	IO2d	

Site	Replicates	Biomass
IO2	IO2a	
	IO2b	
	IO2c	
	IO2d	

- The grain size and the acoustic data (50 and 200 kHz) were submitted to a multivariate analysis (PERMANOVA) with the software PRIMER v6, under the following null hypothesis:

H₀1: No significant acoustic differences exist between bare sandy and muddy bottom areas

H₀2: No significant acoustic differences exist among low, medium and high algal biomass areas

- Values of $p \leq 0.05$ reveal that groups differ significantly.

Results

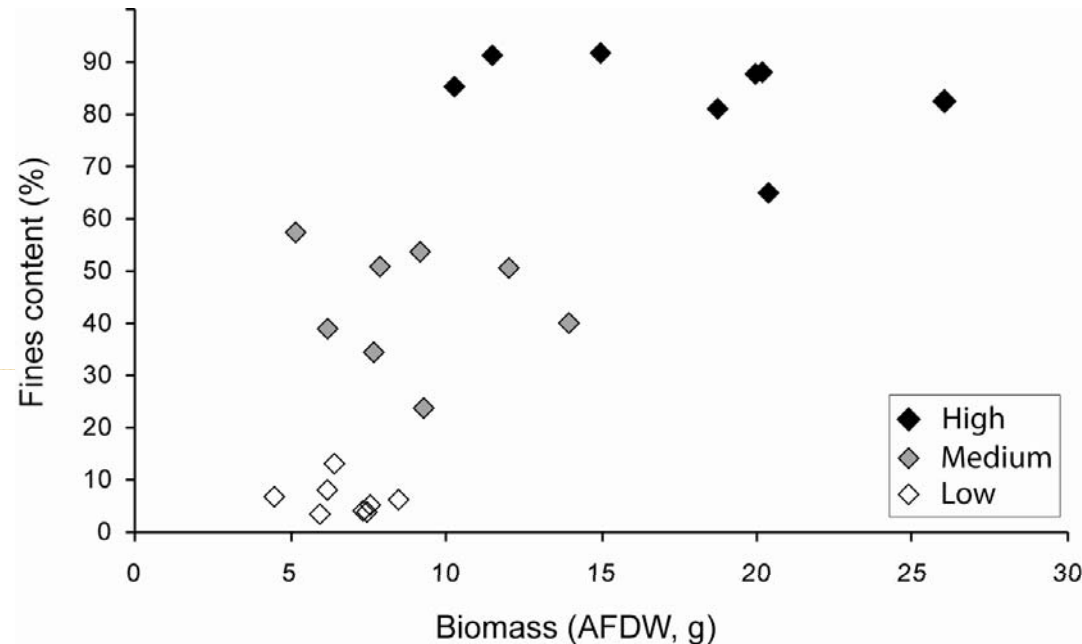


Figure 3. Relationship between sediment fines content (percentage of total sediment, dry weight) and algal biomass (ash-free dry weight).

- The samples obtained in the three areas with *C. prolifera* (IO, LMA and LMB) establish a gradient corresponding respectively to high, medium and low algal biomass/sediment fines content.
- The relationship is direct, showing a positive significant Spearman correlation ($\rho=0.72$; $p<0.01$).

Results

- ***H₀1: No significant acoustic differences exist between bare sandy and muddy bottom areas***

Table 1. PERMANOVA table of results for the test of the H₀1 between bare bottoms characterized by different sediment types. (n.s.) - non significant.

Source	<i>p</i>
Main test for sediment grain size	
Muddy vs Sandy	0.005
Main test for 200 kHz	
Muddy vs Sandy	→ 0.002
Main test for 50 kHz	
Muddy vs Sandy	→ 0.020
200 kHz with sediment grain size as covariable	
Muddy vs Sandy	→ 0.250 (n.s.)
50 kHz with sediment grain size as covariable	
Muddy vs Sandy	→ 0.441 (n.s.)

- For the two survey frequencies data, strong significant differences were found between sediment types.
- When using the sediment grain size as covariable, the difference between acoustic data of the two sediment types was no longer significant for both survey frequencies.

Results

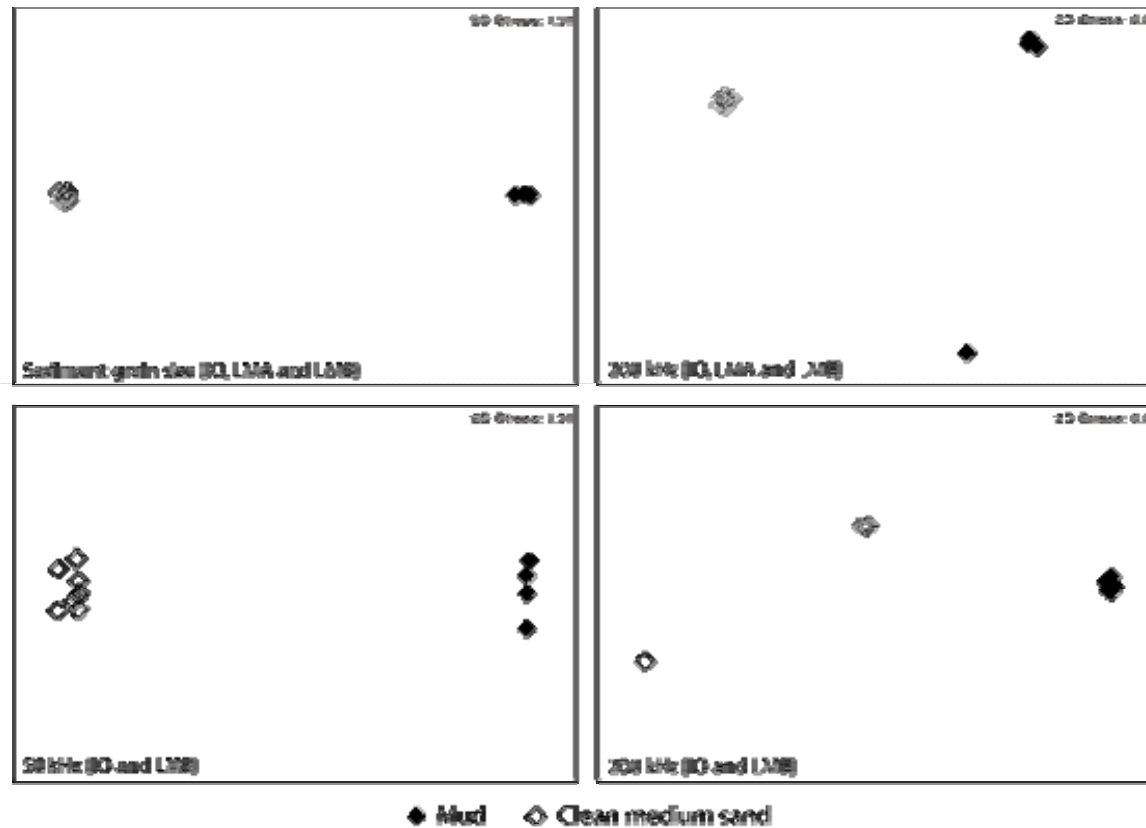


Figure 4. Ordination diagrams (NMDS) of the sedimentary (top) and acoustic data (bottom), obtained in the survey areas A and B at Los Molinos.

- A clear separation is noticed between sandy and muddy bottoms, in terms of grain size and acoustics, illustrating the PERMANOVA results just presented.

Results

- H_02 : *No significant acoustic (200kHz) differences exist among low, medium and high algal biomass areas*

Table 2. PERMANOVA table of results for the test of H_02 ; (n.s.) - non significant.

Source	200 kHz p
Main test	
Low vs medium vs high	→ 0.014
Sediment grain size as covariable	
Low vs medium vs high	→ 0.0124
Algal biomass as covariable	
Low vs medium vs high	→ 0.0708 (n.s.)
Both covariables	
Low vs medium vs high	→ 0.186 (n.s.)

- Strong significant differences were found between algal biomass areas.
- Grain size was not able to eliminate the significance between areas.
- The acoustic differences between areas disappeared when using biomass or both covariables.
- By comparison to the results obtained in the analysis of H_01 , these results indicate that the 200 kHz survey frequency is sensitive to the presence of the macroalgae.

Results

- H_02 : No significant acoustic (50 and 200kHz) differences exist among low and high algal biomass areas

Table 3. PERMANOVA table of results for the test of H_02 ; (n.s.) - non significant.

Source	50 kHz	200 kHz
	<i>p</i>	<i>p</i>
Main test		
Low vs high	→ 0.008	→ 0.037
Sediment grain size as covariable		
Low vs high	→ 0.046	→ 0.005
Algal biomass as covariable		
Low vs high	→ 0.053 (n.s.)	→ 0.1977 (n.s.)
Both covariables		
Low vs high	→ 0.2192 (n.s.)	→ 0.697 (n.s.)

- Grain size was inefficient to eliminate the significance between areas, although with a borderline p-value of 0.05 in the case of the 50 kHz data.
- Algal biomass was efficient to eliminate the significance between areas for the 200 kHz, but not in the 50 kHz survey.

Discussion/Conclusion

- The ability of both frequencies (50 and 200 kHz) to distinguish between sediment types was confirmed when comparing acoustic data from distinct bare bottoms.
- Both frequencies were able to distinguish areas characterized by different algal biomass. Nevertheless, because different algal biomass areas also corresponded to different seabed types, the sediment may act here as a confounding factor. However, in this case, it was possible to observe that, when compared with 50 kHz, the 200 kHz presented stronger sensitivity to the presence of underwater vegetation.
- The acoustic classification system (QTC VIEW Series V) presented high potential for the remote assessment of underwater vegetation, independently on the sedimentary characteristics of the bottom.



Future Work

- In the future, more work should be developed to increase the knowledge about the influence of underwater vegetation over the acoustic pulse and further investigations must be addressed to the use of acoustics the estimation of macroalgae biomass, namely studies concerning mapping and modeling seasonal biomass patterns.
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