
Image © 2012 GeoEye
385 m
Fecha de las imágenes: 4/8/2012
39°28'56.88" N 2°43'57.33" E elev. 4 m
Alt. ojo 1.62 km
Google earth

RED ELÉCTRICA DE ESPAÑA

Renewables Grid Initiative

Developing transmission electricity grids, protecting our seas
Expert workshop on innovative approaches to seagrass protection
with a focus on the Posidonia oceanica
25 – 27 September 2017, Palma de Mallorca, Spain

Seagrass ecosystems – the special case of *Posidonia oceanica*

Jorge Terrados, IMEDEA (CSIC-UIB)

- Brief review of *Posidonia oceanica* main characteristics

What makes it so special?
Why is the protection of *P. oceanica* important

- Transplanting of *P. oceanica* associated to Rómulo2 project

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Posidonia oceanica (L.) Delile

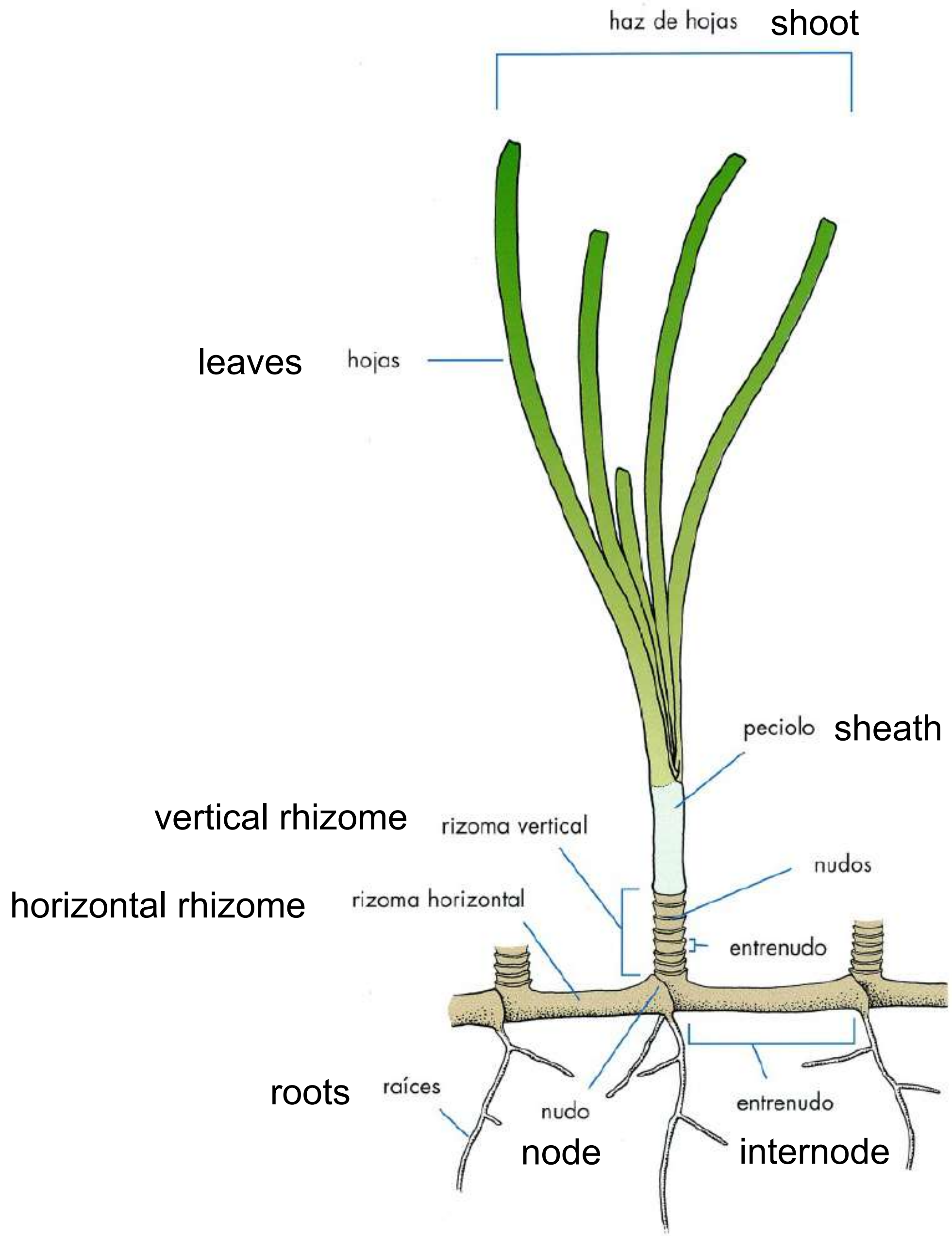
Endemic species to the Mediterranean Sea

Up to 40-45 m depth

Cover: 23% (15% - 50%) of 0-50 m seafloor

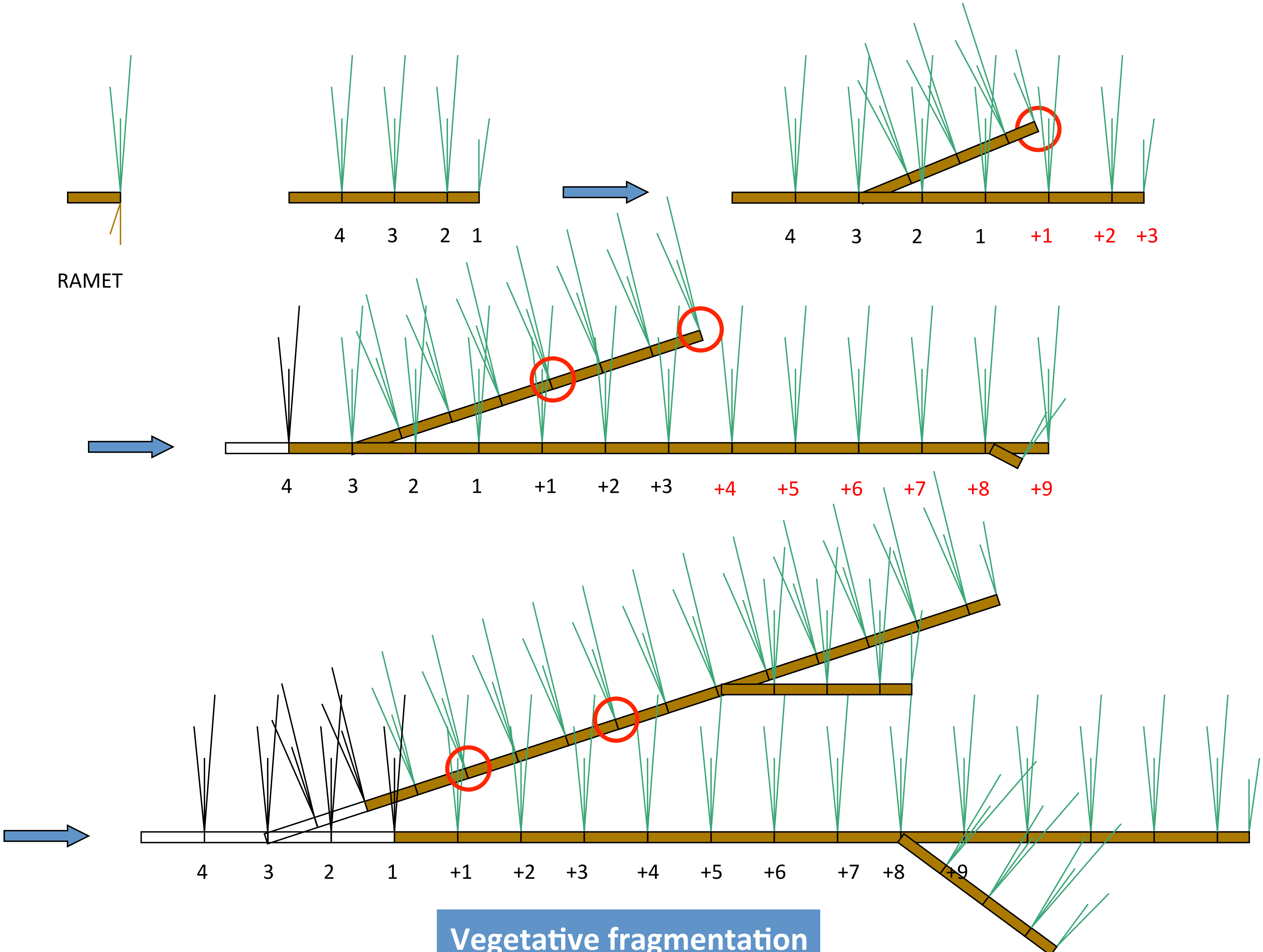
Mediterranean Sea: 25.000-45.000 km^2
Spain: 1159 km^2
Balearic Islands: 633 km^2

Pasqualini et al. 1998
Procaccini et al. 2003
Ruiz et al. 2015



Esquema de un «ramet» de una fanerógama marina (DIBUJO: J. CORBERA)

Seagrass ramet



Vegetative fragmentation

Posidonia oceanica , a slow-growing seagrass

- Rhizome elongation: 0.5-1 , 3-4 cm per year
- Branching rate: 0.5 % per node and year

Marbà y Duarte 1998

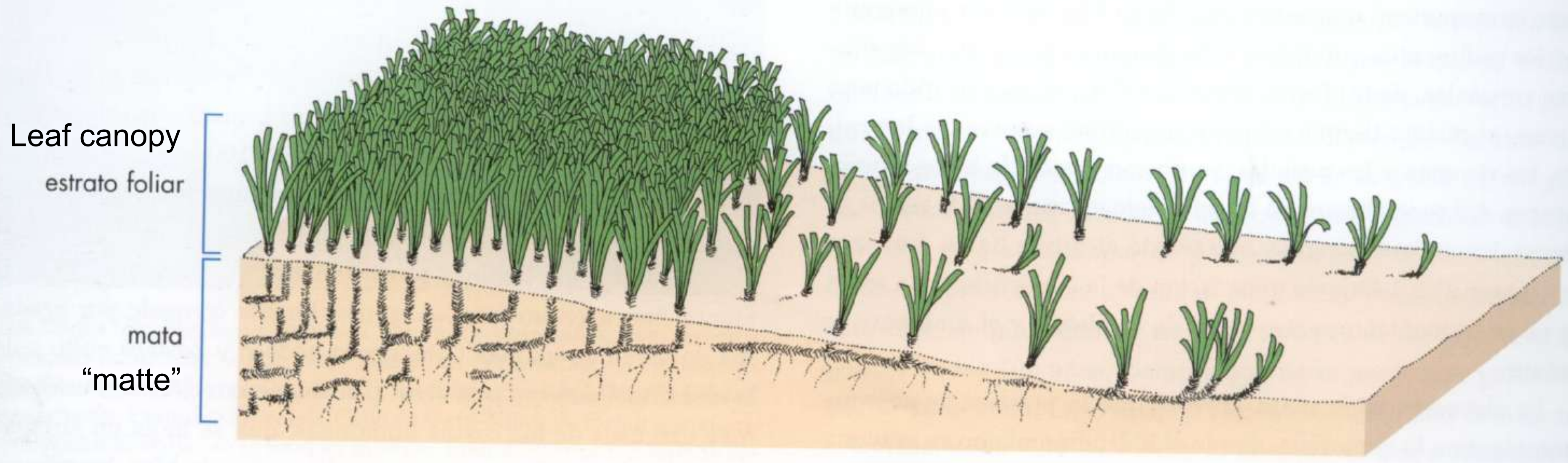
Table 2. Mean rhizome diameter (RD, in mm), horizontal internodal length (HINTL, in mm), vertical internodal length (VINTL, in mm), spacer length (SL, in cm), horizontal rhizome elongation rate (HE, in cm yr^{-1}), and vertical rhizome elongation rate (VE, in cm yr^{-1}) of seagrass species. Values in parentheses show the ranges of the variables per species when more than 1 stand was examined. CV: coefficient of variation

Species	RD	HINTL		VINTL		SL		HE		VE	
Amphibolis antarctica	2.80	7		9	(5–12)	3.86		20	(5–35)	24	(7–32)
Amphibolis griffithii	2.19	10		10		6.16		4		16	(5–34)
Cymodocea nodosa	2.37	25	(6–53)	1.4	(0.1–2.5)	2.77	(1.1–5.5)	40	(7–204)	1.4	(0.1–16)
Cymodocea rotundata	2.44	29		2	(0.5–5)	4.8		210	(34–411)	1.5	(1.1–3.3)
Cymodocea serrulata	2.78	38	(35–39)	5	(4–7)	5.30		153	(79–216)	13	
Enhalus acoroides[a]	14.1	5				6.68		3	(0.9–5)		
Halophila descipiens[a]	0.8							215			
Halophila hawaiiana[a]	1.2	10						89			
Halophila ovalis[a]	1.3	17				1.7		356	(141–574)		
Halophila stipulacea[a]	1.12	16									
Heterozostera tasmanica	1.74	20		7		2.07		103	(56–150)	9	
Halodule uninervis	1.37	21	(9–33)	5	(1–7)	2.7		101	(28–138)	4	
Halodule wrightii	1.64	20.2		1.2		2.02		223	(81–365)	3	
Posidonia angustifolia	5.99	18		10		7.5		12		5	(1–11)
Posidonia australis	7.21	15	(14–17)	1.5		6		9	(9–10)	1	(0.4–6)
Posidonia oceanica	9.7	3	(1–4)	1	(0.4–2)	2.81	(1.2–5.3)	2	(1–6)	1	(0.1–4)
Posidonia sinuosa	5.5	11	(8–14)	3	(2–4)	4.47	(3–5.9)	4	(2–6)	0.8	(0.2–8)
Phyllospadix scouleri	6.5							17			
Phyllospadix torreyi[a]	5							26			
Syringodium filiforme	2.77	23	(16–31)	6		3.06		123	(52–182)	4	
Syringodium isoetifolium	1.74	27	(25–28)	11	(8–13)	3.7		109	(75–135)	9	
Thalassia hemprichii	3.63	4	(4–7)	1	(0.5–3)	6.9		54	(21–88)	3	(2–5)
Thalassia testudinum	5.96	15	(5–43)	2	(7–18)	7	(5.8–7.1)	69	(22–152)	4	(2–20)
Thalassodendron ciliatum	5.6	8	(6.7–10)	3		3.32	(2.7–4)	16		10	(5–10)
Thalassodendron pachyrhizum	5.64	5		6	(5.2–7.35)	1.9		3	(3–6)	5	(2.8–12)
Zostera marina[a]	3.5	11	(9–12)			6.08		26	(22–31)		
Zostera noltii[a]	1.6	12	(3–20)			2.07		68	(10–127)		
Across species CV (%)	80	58		74		45		111		89	
Within species CV (%)		36		53				72		45	

[a]Species without vertical rhizome

Posidonia oceanica forms submarine meadows

Esquema de una pradera de *Posidonia oceanica* en el que se muestra el estrato foliar y el hipogeo («mata»), y rizomas ortotropos (verticales), que predominan en la zona donde la pradera debe crecer en vertical para compensar la sedimentación, y plagiotropos (horizontales), que predominan en el borde de la pradera (DIBUJO: J. CORBERA, MODIFICADO DE MEINESZ Y LAURENT, 1978)

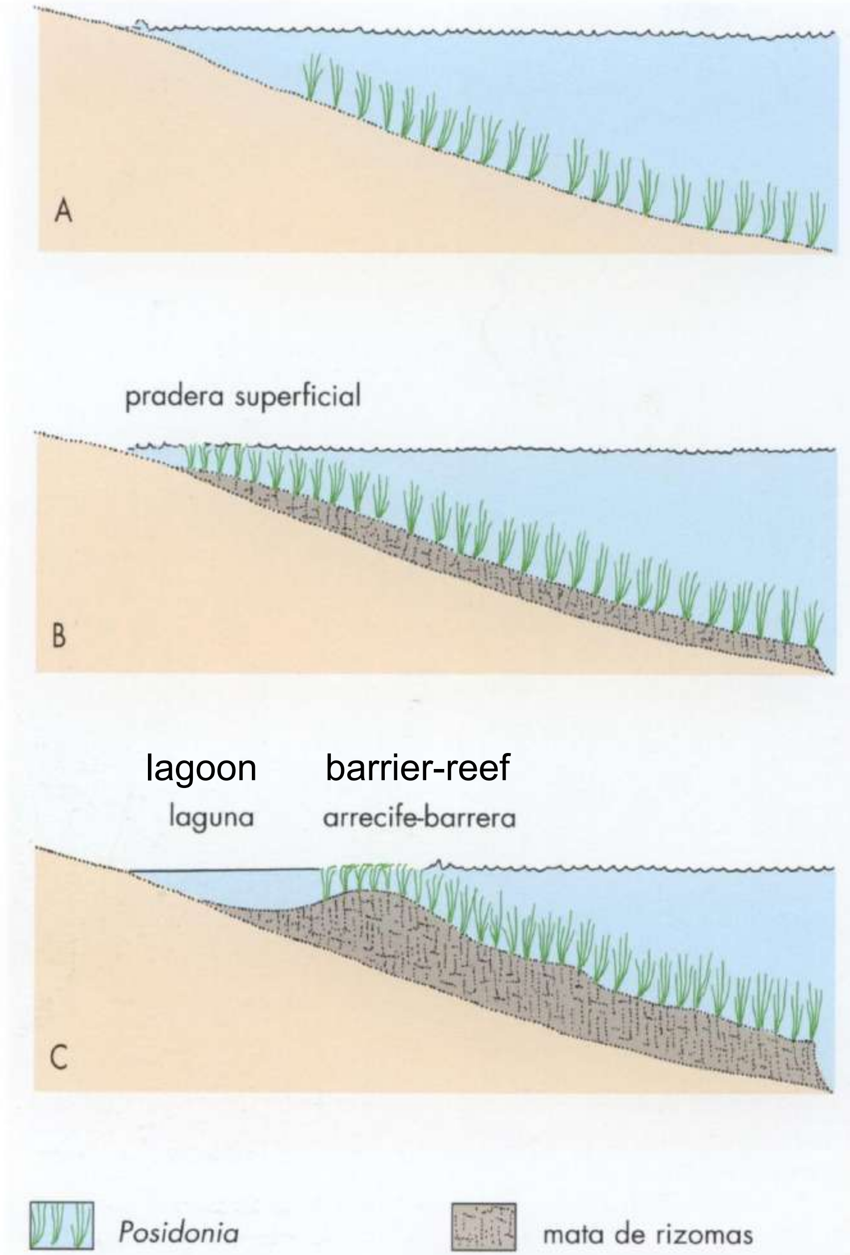


Luque & Templado 2004

Posidonia oceanica
forms its own substratum, "matte"

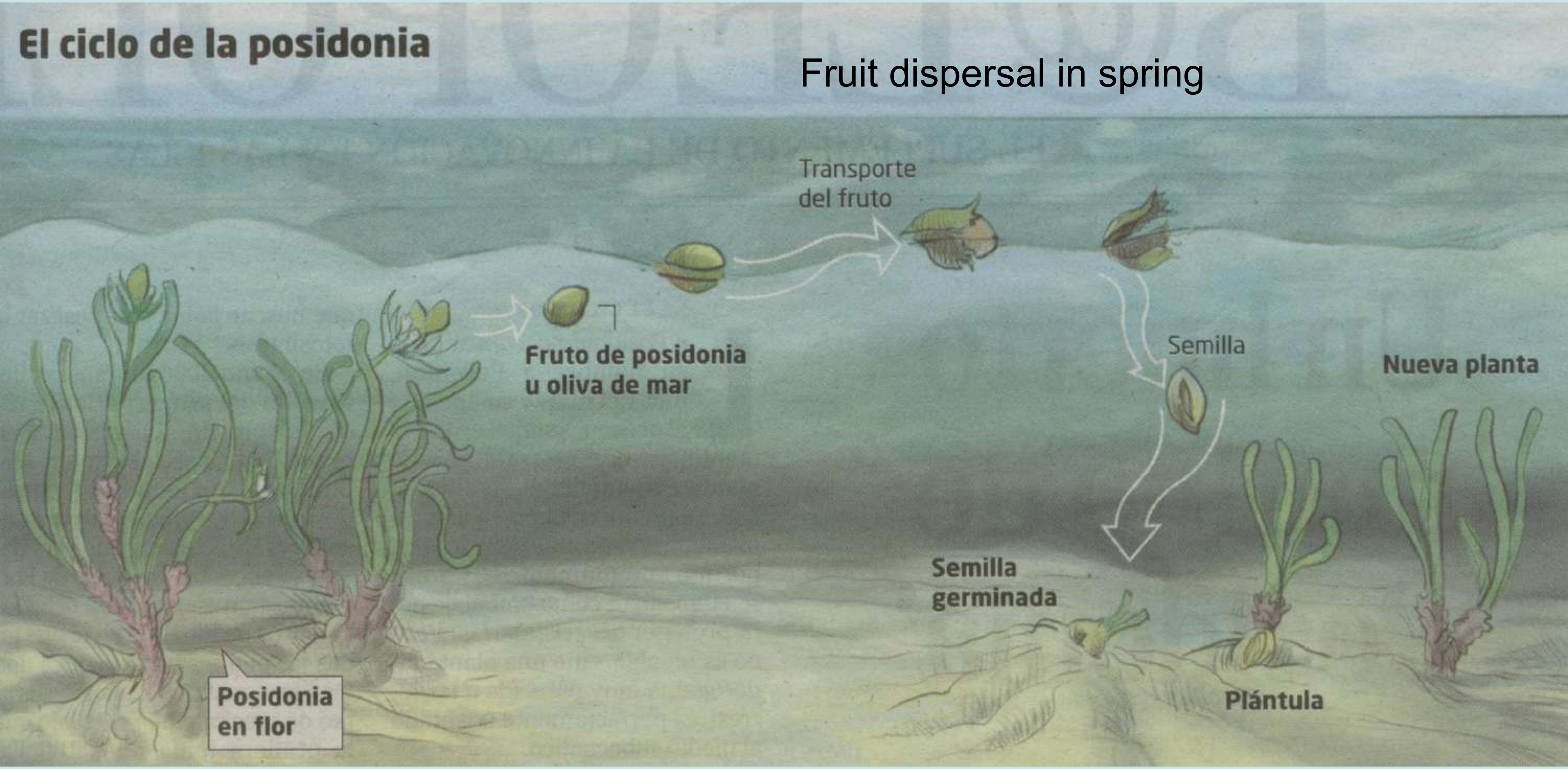
Matte formation rate < 1 cm per year
Matte thickness, up to 4m
Matte age, up to 3370 years

Mateo et al. 1997
Borum et al. 2004
Luque y Templado 2004



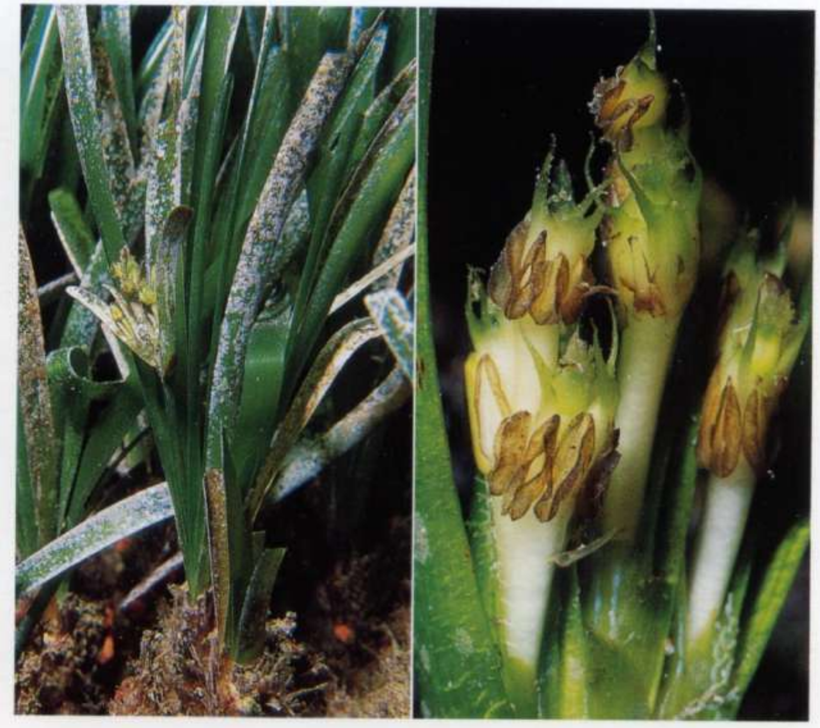
Esquema de la evolución de una pradera de *Posidonia oceanica* hasta constituir un arrecife barrera (DIBUJO: J. CORBERA, MODIFICADO DE BOUDOURESQUE Y MEINESZ, 1982)

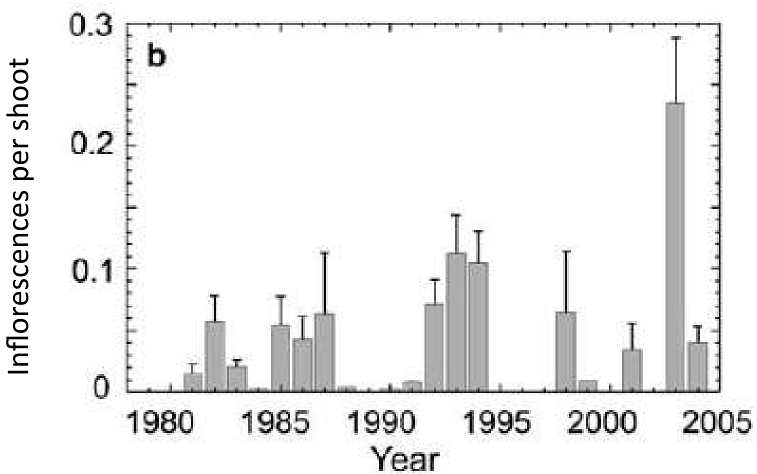
Posidonia oceanica life cycle



Flowering in autumn

Seedling establishment in summer





Díaz-Almela et al. 2006

- 0.007 inflorescences shoot^{-1} y^{-1}
Díaz-Almela et al. 2006
- 12-13 inflorescences to produce 1 fruit
Balestri y Cinelli 2003
- 10% - 50% seedling mortality
during first year of life in matte
Balestri et al 1998, Piazzi et al. 1999, Domínguez et al. 2012

Sexual reproduction is highly variable in space and time

Posidonia oceanica meadows are fragile ecosystems

- *P. oceanica* has a limited capacity to recover from disturbance
- Irreversibility of damage to meadows at human time scale
- Hundreds of years of favorable environmental conditions for a meadow to be formed

100 years, time to recovery from trawling damage : *González-Correa et al. 2005*
>400 years, time to form a 50m x 50m plot: Kendrick et al. 2005

Best conservation strategy of *Posidonia oceanica* meadows

- Avoid damage
- Do not affect the environmental conditions required for persistence

Surface of *Posidonia oceanica* meadows has decreased by 5% - 20% since early 20th century

Human activities in coastal zone that drive the loss of *P. oceanica* meadows

Severity of damage

- Coastal development
- Urban and industrial pollution
- Trawling
- Fish farming
- Boat anchoring
- Dredging/dumping of sediments
- Laying of power lines and pipes
- Desalination of seawater
- Introduced species
- Global change

Extent of damage

Boudouresque et al 2009

Posidonia oceanica meadows

Ecological functions

- Habitat for a large set of organisms
- High biological productivity
- Nursery and feeding ground
- Wave attenuation and sediment stabilization
- Organic matter and nutrient cycles

Ecological services

- Coastal biodiversity
- Fisheries
- Coastal protection
- Filtering of seawater (particles, nutrients)
- Carbon sink

- Biological indicator of the status/quality of the marine environment

Transplanting seedlings and rhizome fragments of *Posidonia oceanica* to restore meadows disturbed by the laying of power lines

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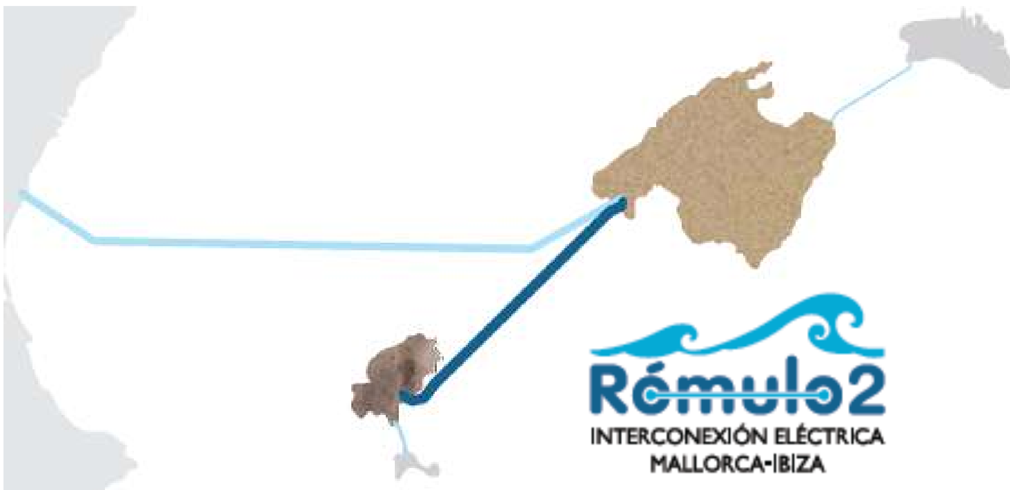

Rómulo2
INTERCONEXIÓN ELÉCTRICA
MALLORCA-IBIZA

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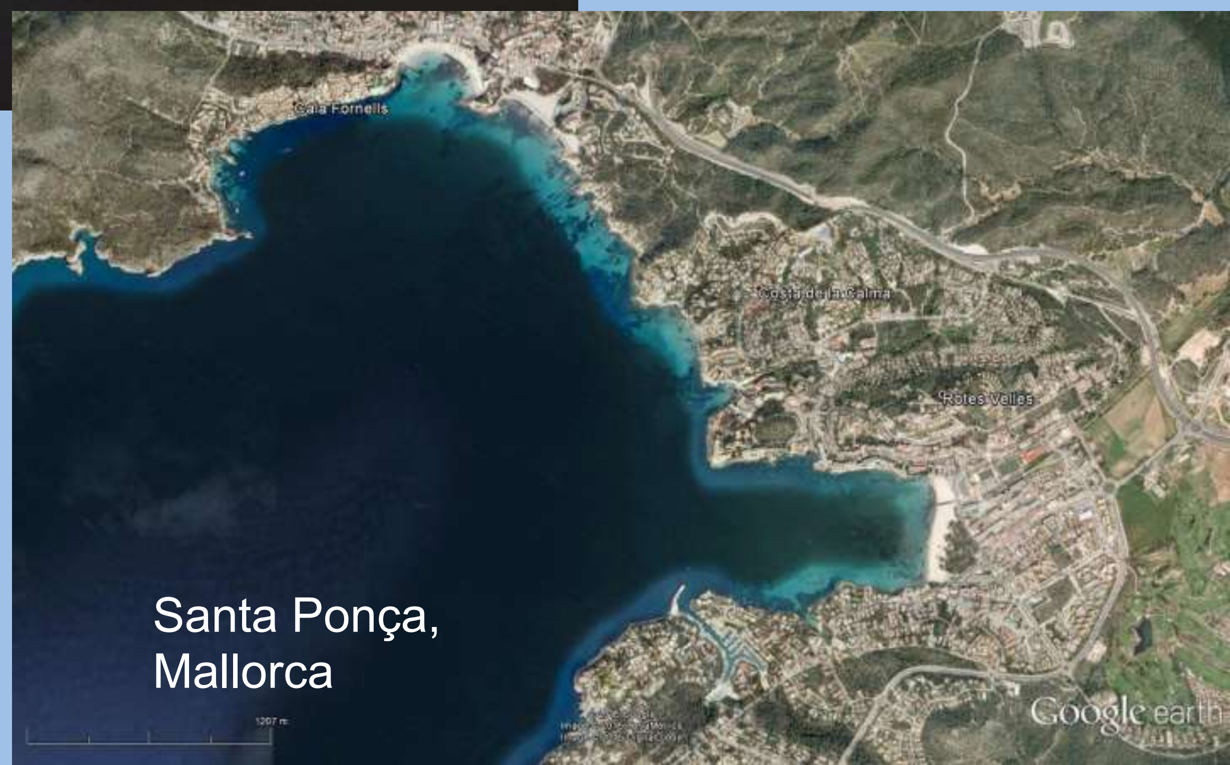
Talamanca. Ibiza


Cala Fornells
Costa de la Calma
Rotes Velles
Santa Ponça,
Mallorca
Google earth

Collection of plant material

Rhizome fragments naturally-detached from meadow

Beach-cast fruits

Culture in seawater tanks

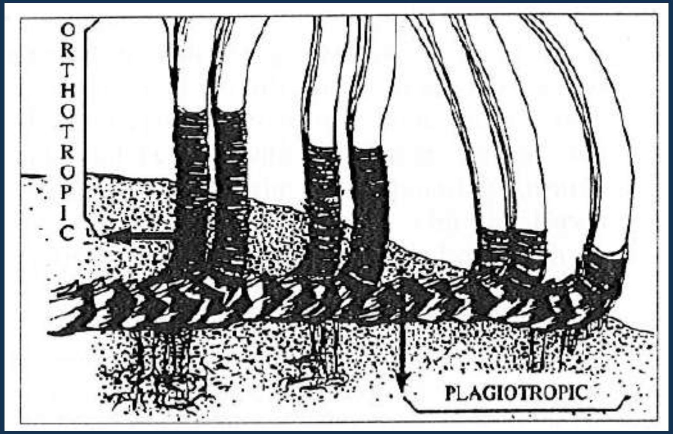
Transplanting in bottom disturbed by burial of power line

Previous experiences about transplanting of *Posidonia oceanica* rhizome fragments

- Augier et al 1996 *Ocean & Coastal Management* 30: 297-307
- Piazzi et al 1998 *Botanica Marina* 41: 593-601
- Meinesz et al 1992 *P. S. Z. N. I: Marine Ecology* 13: 163-174
- Molenaar & Meinesz 1992 *P. S. Z. N. I: Marine Ecology* 13: 175-185
- Molenaar et al 1993 *Botanica Marina* 36: 481-488
- Meinesz et al 1993 *Botanica Marina* 36: 209-216
- Molenaar & Meinesz 1995 *Botanica Marina* 38: 313-322
- Boudouresque 2002 *IFREMER Actes de colloques 29, Brest, November 8-9, 2000*
- Balestri et al 2011 *Biological Conservation* 144: 1644-1654

Factors assessed:

- Anchoring systems
- Substratum, depth
- Type of fragment (vertical vs horizontal)
- Length (rhizome) of fragment
- Number of shoots in fragment
- Depth of origin
- Transplanting season
- Spatial arrangement of transplants



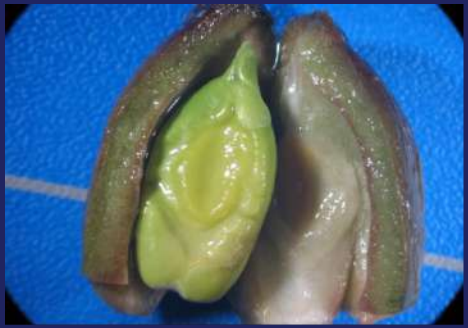
75% -100 % survivorship

Posidonia oceanica seeds can be cultured to produce seedlings

- Caye & Meinesz 1989 *International Workshop on Posidonia Beds 2. The second international workshop on Posidonia beds, Ischia, Italy, 7-11 October, 1985*.
- Buia & Mazzella 1991 *Aquatic Botany* 40: 343-362
- Bedini 1997 *Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 104: 9-15*

and transplanted to sea!

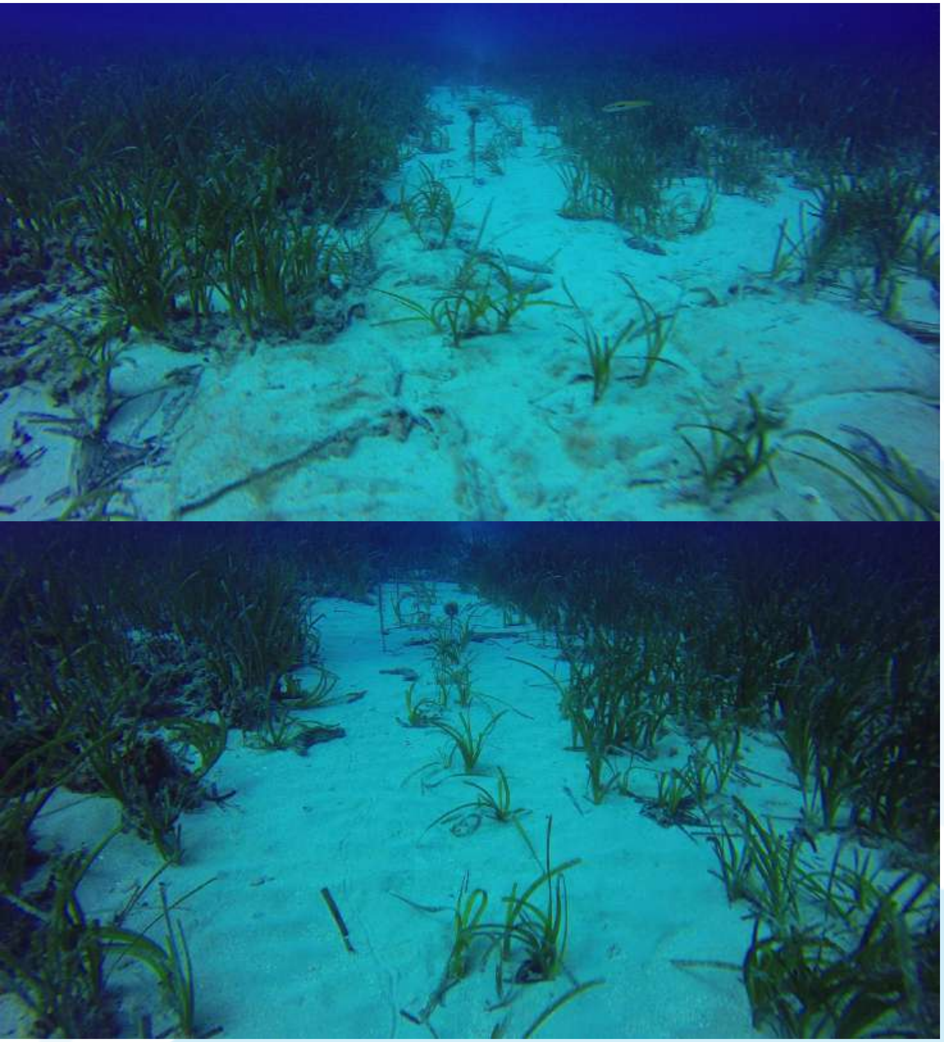
- Meinesz et al 1993 *Botanica Marina* 36: 209-216
- Balestri et al 1998 *J. Exp. Mar. Biol. Ecol.* 228: 209-225
- Domínguez et al 2012 *Restoration Ecology* 20: 180-187
- Terrados et al 2013 *Botanica Marina* 56: 185-195




AQUA LUNG



Santa Ponça trasplanting, Mallorca



Plant material used:

- Rhizome fragments (2015 , 2016)
- Seedlings (2015)

Substratum:

- Substratum after laying of power line
- Hemp bags filled with gravel

Depths: 15, 20 and 25 m

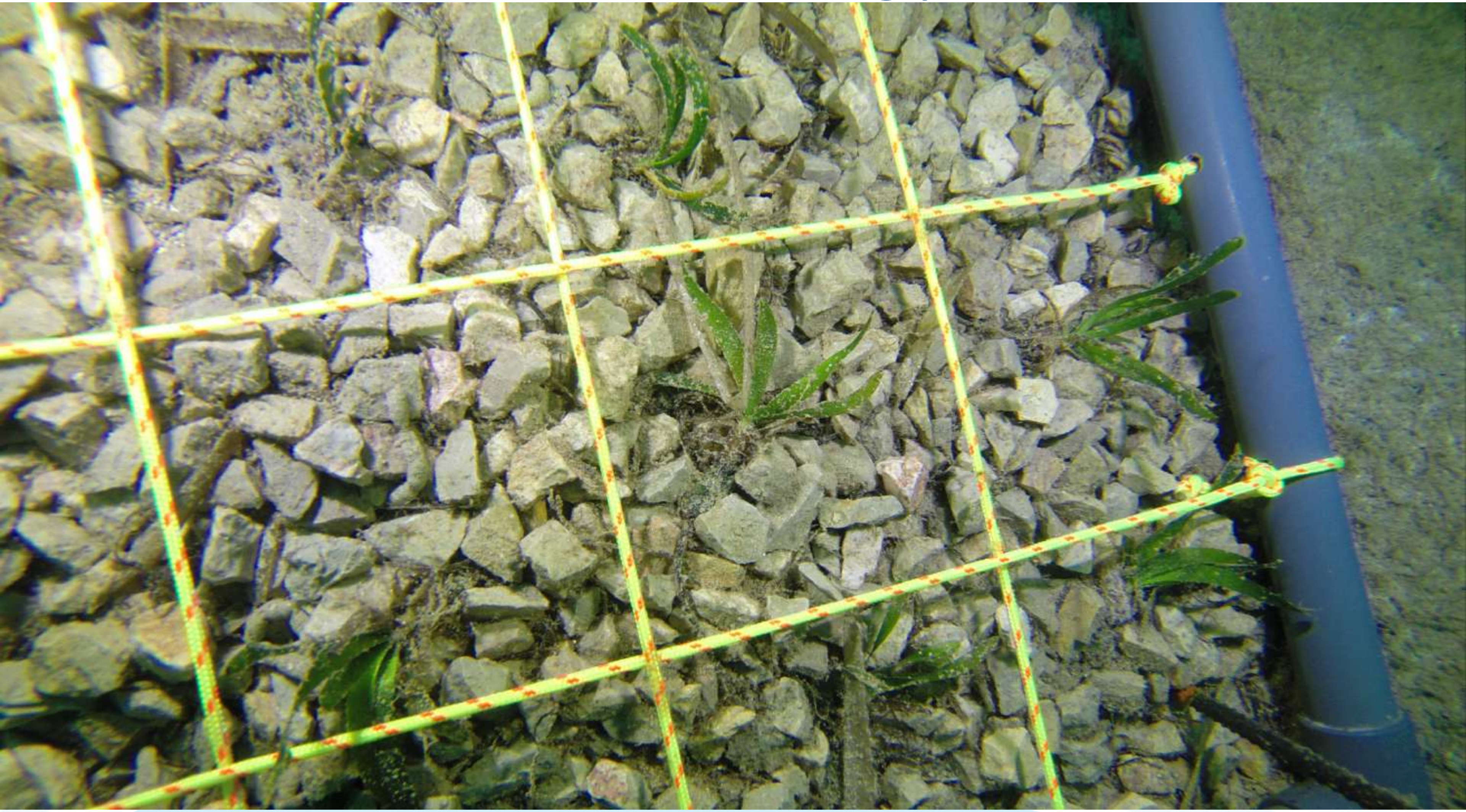
Three replicates (plots)

13 fragments or 25 seedlings per plot

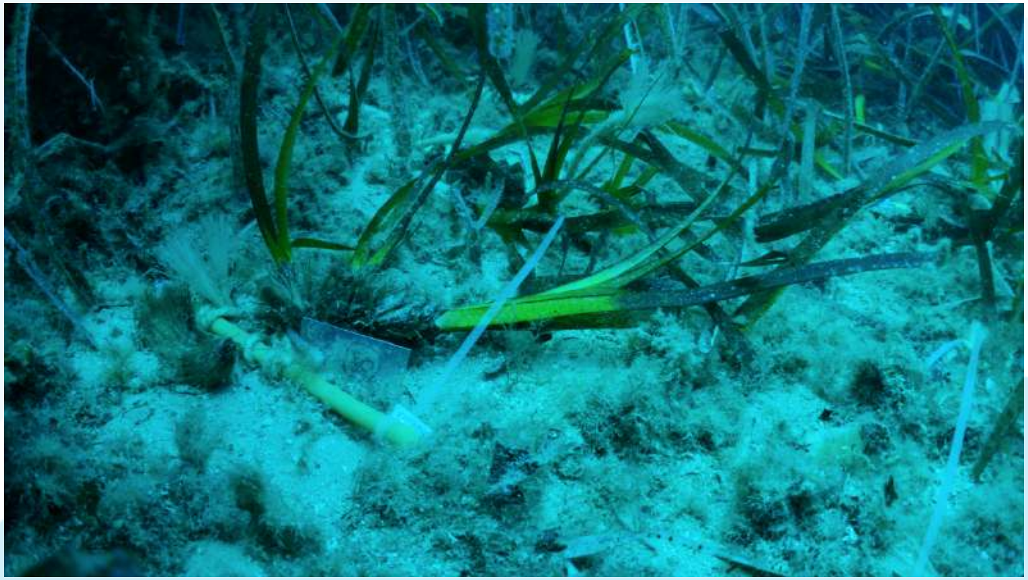
234 fragments or 450 seedlings

Seedling plots

Detail of seedling plot



Talamanca trasplanting, Ibiza



Rhizome fragments only

Four depths:

15 and 29 m (2015)
20 and 25 m (2016)

Substratum: dead matte

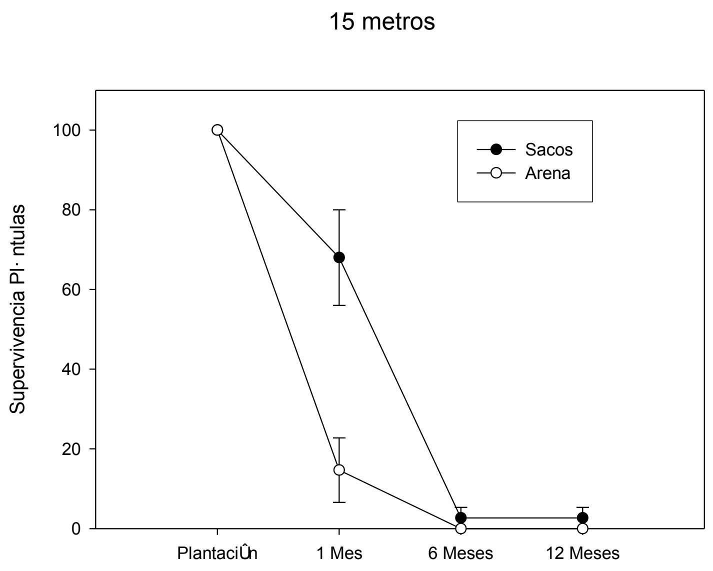
Four replicates (plots)

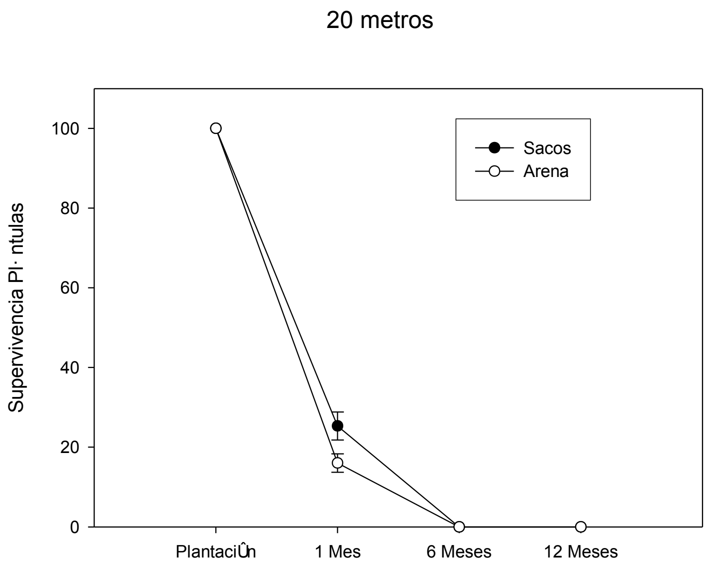
15 fragments por plot

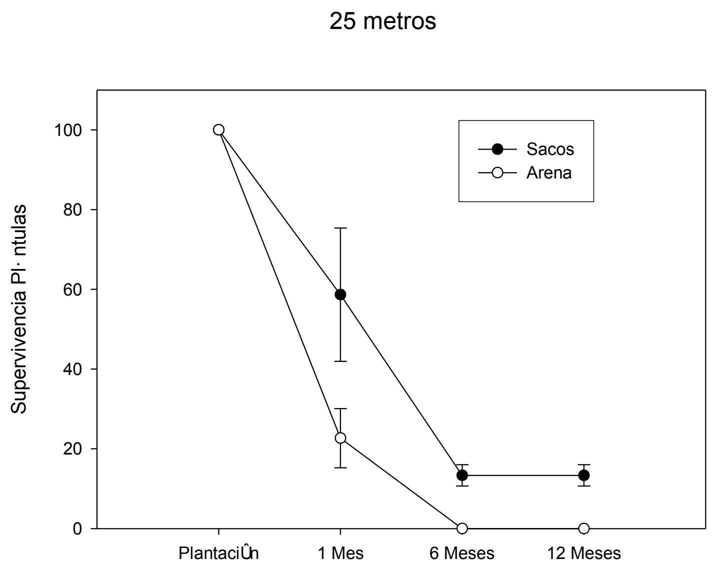
120 fragments (2015, 2016)

Talamanca trasplanting, Ibiza

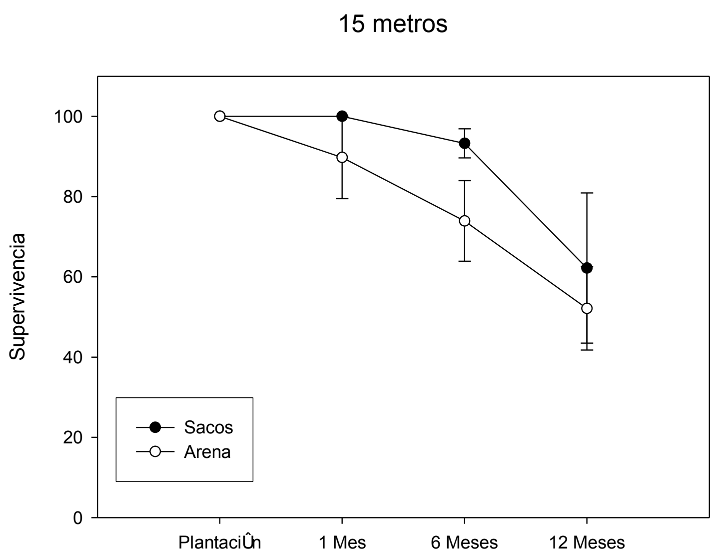
Seedling survivorship, Mallorca 2015

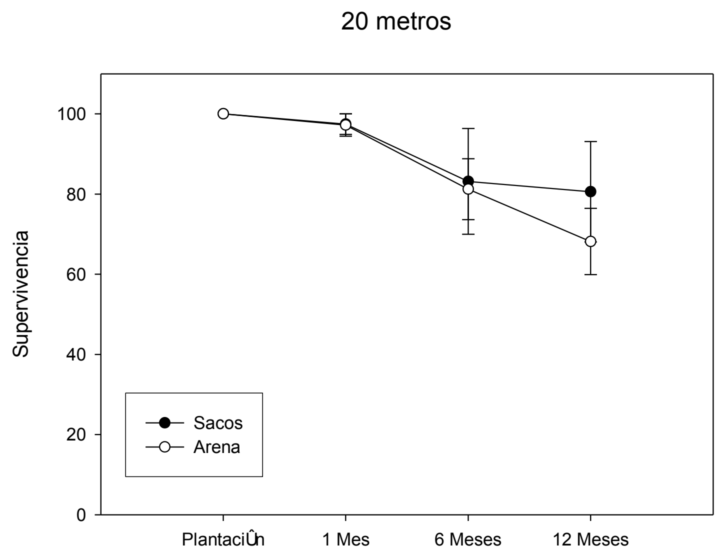


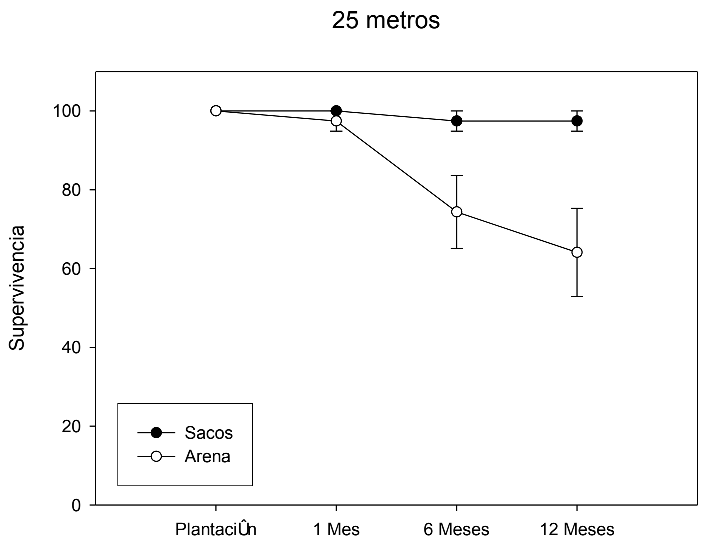




Survivorship of rhizome fragments, Mallorca 2015

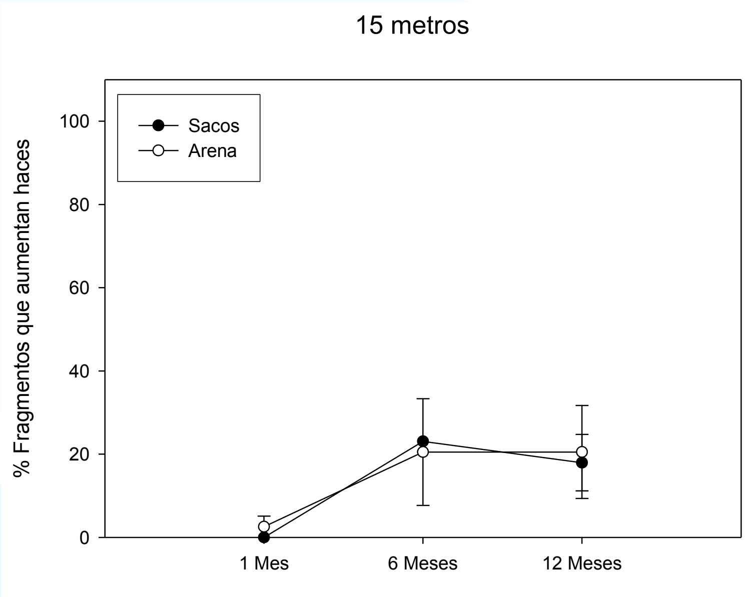


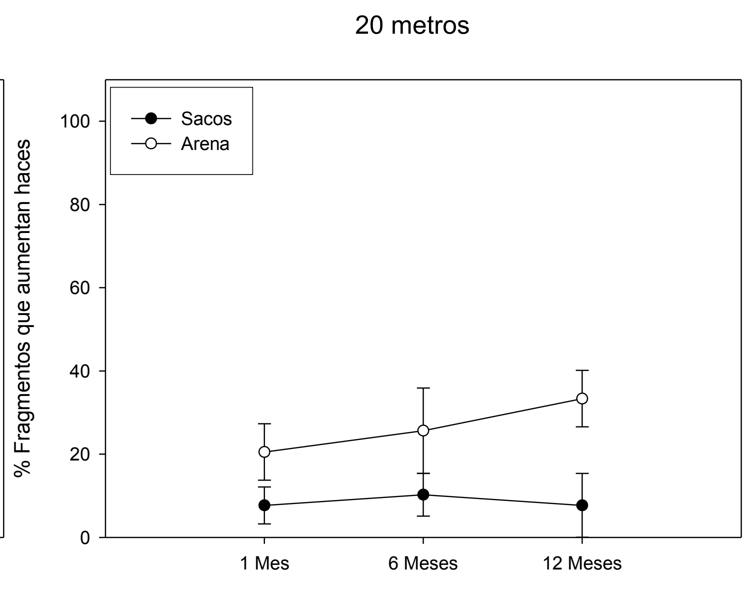


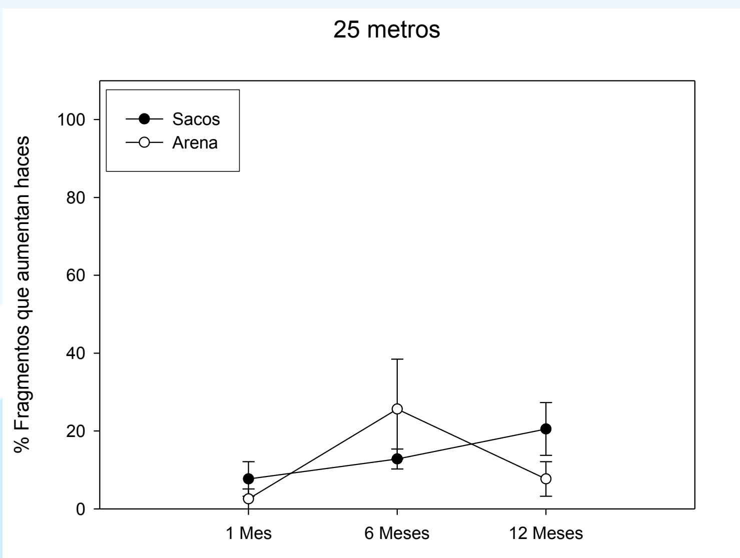


No differences between substrata ($F= 3,8168$; $p>0,05$), depths ($F= 2,1937$; $p>0,05$) or their interaction ($F=0,6039$; $p>0,05$) after 1 year. However, at 25 m depth, higher survivorship in gravel bags ($F=1666,67$; $p =0,04$)

% of proliferative rhizome fragments, Mallorca 2015

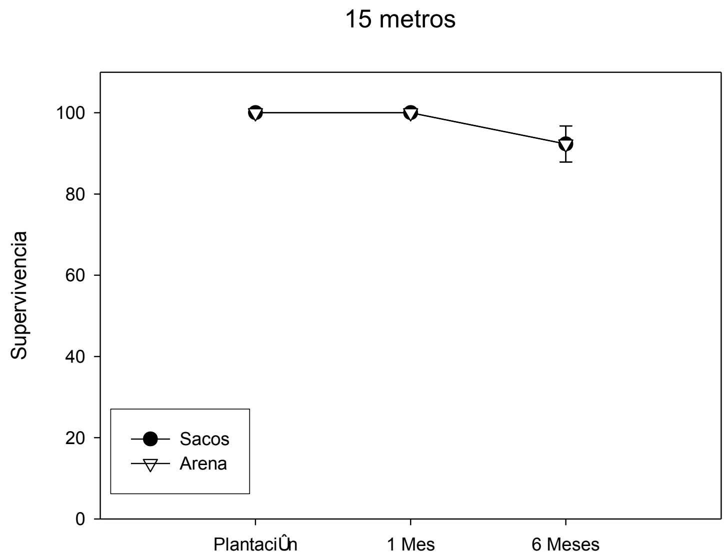


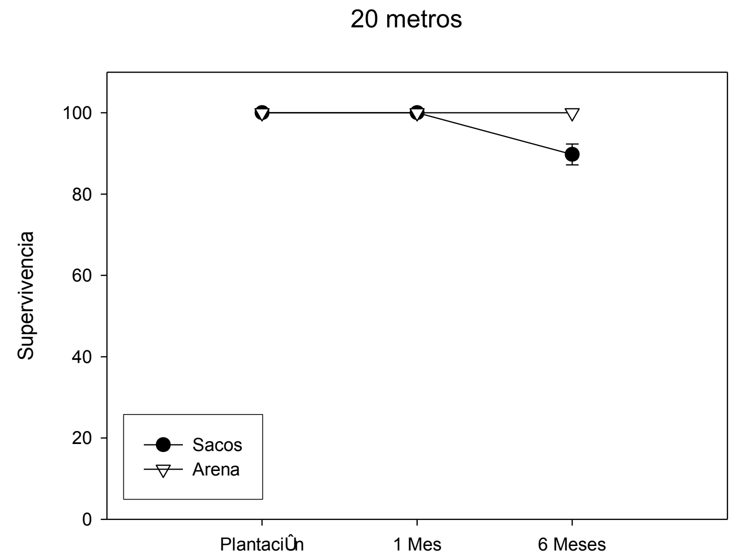


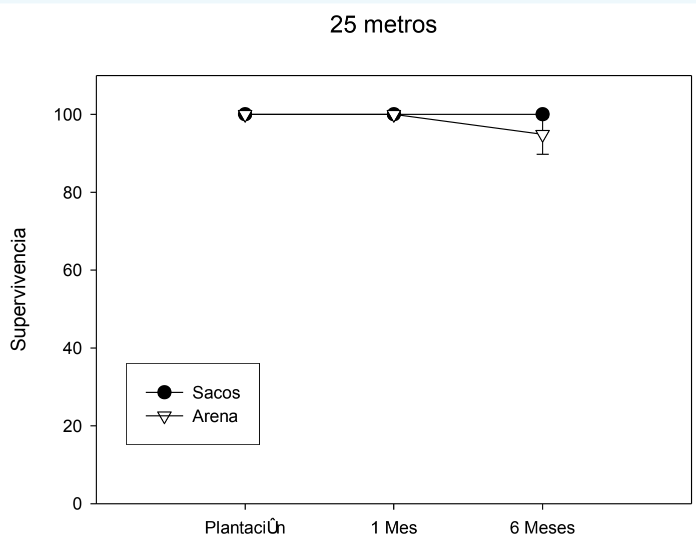


No differences between substrata and depths in the percentage of rhizome fragments with a net increase of the number of shoots after 1 year

Survivorship of rhizome fragments, Mallorca 2016

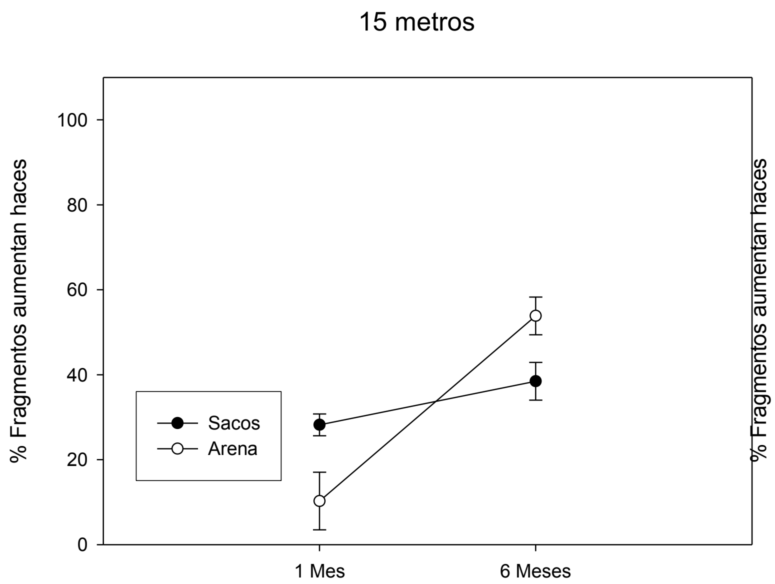


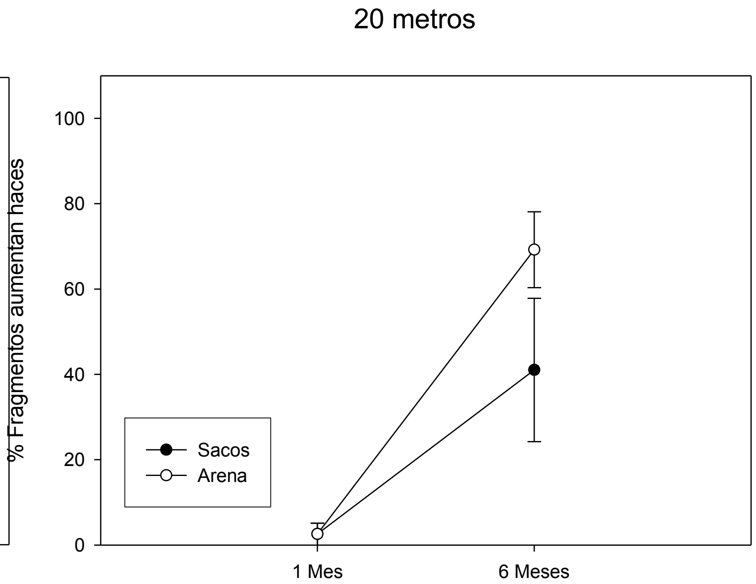


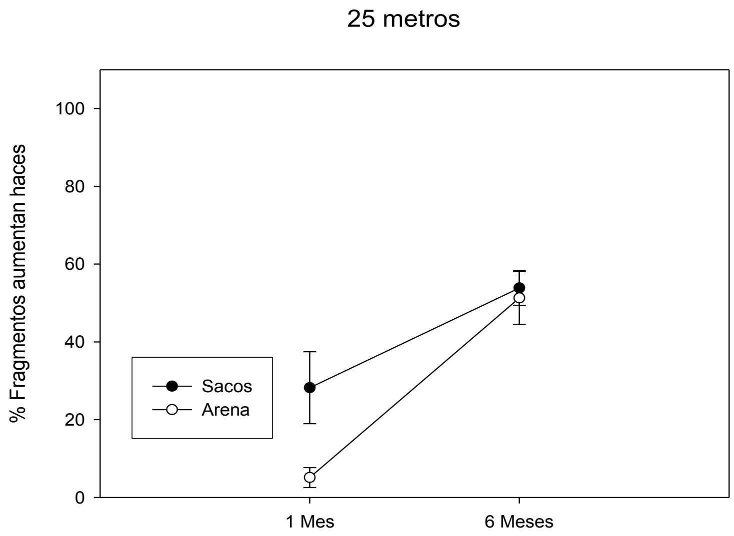


No differences between substrata (F=0,364), depth (F=1091) o the interaction of both (F=2545) after 6 months

% of proliferative rhizome fragments, Mallorca 2016

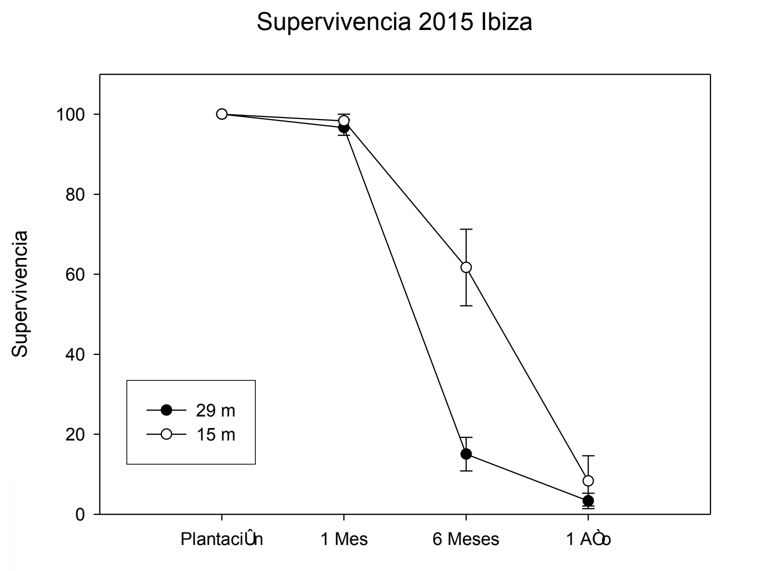


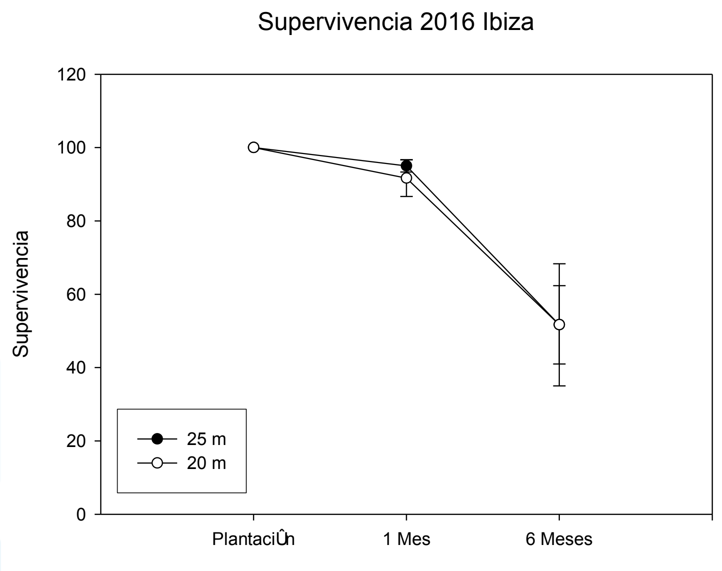




No differences between substrata and depths in the percentage of rhizome fragments with a net increase of the number of shoots after 6 months

Survivorship of rhizome fragments, Ibiza





Survivorship of rhizome fragments					
Mallorca				Ibiza	
6 months		1 year		6 months	1 year
Gravel bags	sand	Gravel bags	sand	Matte	Matte
92 % (± 10)	86 % (± 14)	80 % (± 25)	61 % (± 17)	45 % (± 27)	6 % (± 9)

Conclusions

Trasplanting of rhizome fragments of *P. oceanica* is feasible in seafloor disturbed by the laying of power lines

Trasplanting of rhizome fragments in gravel bags yields better results (survivorship) after 1 year (Santa Ponça, 25m).

Survivorship of rhizome fragments after 1 year is 61-80%, while seedling survivorsip was minimal (2.6-0 %).

18% of fragments trasplanted in 2015 were proliferative after 1 year. 51% of fragments trasplanted in 2016 were proliferative after 6 months.

Hemp bags filled with gravel might provide a better substratum for rhizome survivorship.

Fragment survivorship in Talamanca was 6% after 1 year (2015) and 45% after 6 months (2016) what makes prospects for planting there bleak

https://www.youtube.com/watch?v=IVMGjxsJR2o