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MPA – Ecological Assessment & Monitoring
CASE STUDIES

Mytilene ~ 2017

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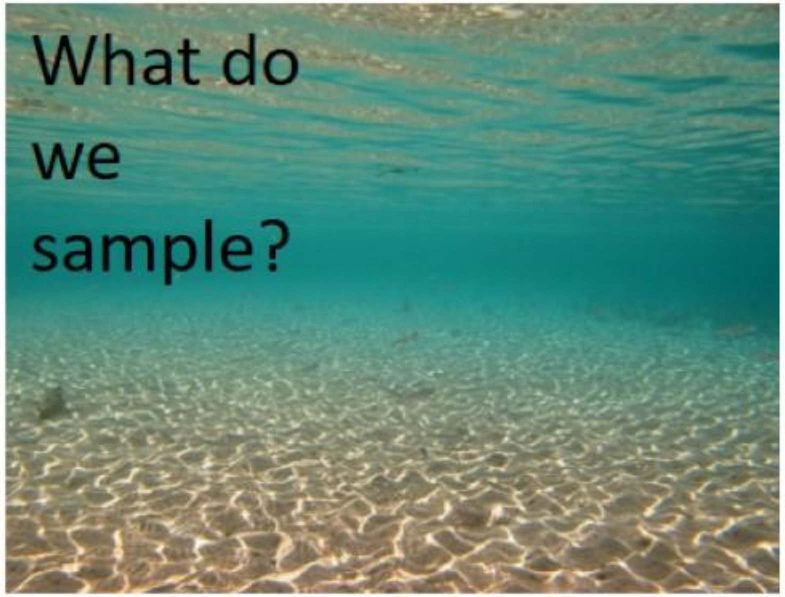
What do we sample?

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MPA – Ecological Assessment & Monitoring

Plankton:

generally small in size – difficult to observe & study

short life-cycle

drift with currents – do not remain in the affected area

high reproductive capacity – can repopulate fast & easy

Nekton (mainly fish):

large in size – easy to observe & study

highly mobile – able to relocate to better conditions

But of interest for consumption!

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Benthos:

All organisms that exist near, on or inside the seabed.

Suprabenthic: organisms living very close to the substrate but without actual contact

Epibenthic: living on and in close contact with substrate

Endobenthic: living within the substrate

Nectobenthic: actively moving (swimming) along the seabed – mainly fish

Benthos can also be classified according to their ability to move:

Sessile: attached on the substrate

Vagile / Motile: moving around.

Why Benthos is best for MPA assessment & monitoring?

- Offers the largest amount of information within a given area
- Benthic organisms, especially sessile or those that move very slowly have no / limited ability to escape from environmental changes
- They remain within the affected environment and they either:
    - Survive
    - Present signs of stress (e.g. reduce in number or size, develop injuries / lesions)
    - Disappear from the area

Case study 1

Research Article

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
The journal is available on line at http://www.medit-mar-sc.net
DOI: http://dx.doi.org/10.12681/mms.1802

Setting an ecological baseline prior to the bottom-up establishment of a marine protected area in Santorini Island, Aegean Sea

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MPA – Ecological Assessment & Monitoring

Case study 1 *Salomidi et al. 2016 – Mediterranean Marine Science*

Aim: Ecological assessment of candidate MPA sites and control sites.

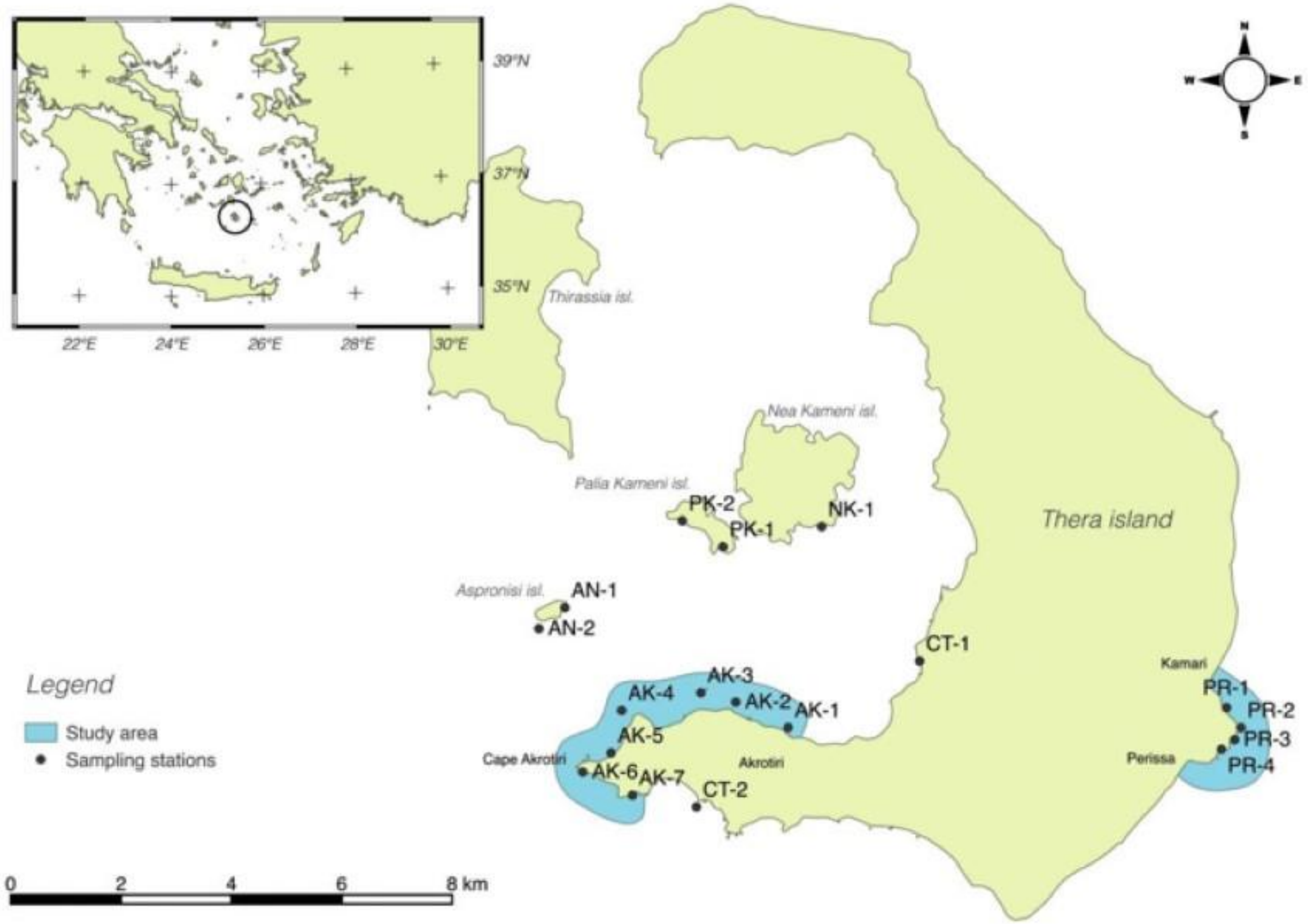

Fig. 1: Map indicating stations along the coasts of Perissa Rock (PR) and Akrotiri Peninsula (AK) (shaded polygons), and several scattered control sites (CT-1, CT-2, NK-1, PK-1, PK-2, AN-1, AN-2).

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Posidonia oceanica meadows (Habitat type 1120*) sampling

Case study 1 — *Salomidi et al. 2016 – Mediterranean Marine Science*

Assessment:

- Fish community structure on rocky reefs (quantitative – 5,15 m)
- Rocky reef health status (quantitative – 1,5,15 m)
- Sea urchin density on rocky reefs (quantitative – 5,15 m)
- *Posidonia oceanica* health status (quantitative – 15 m)
- Biodiversity assessment (qualitative – 5,15 m)

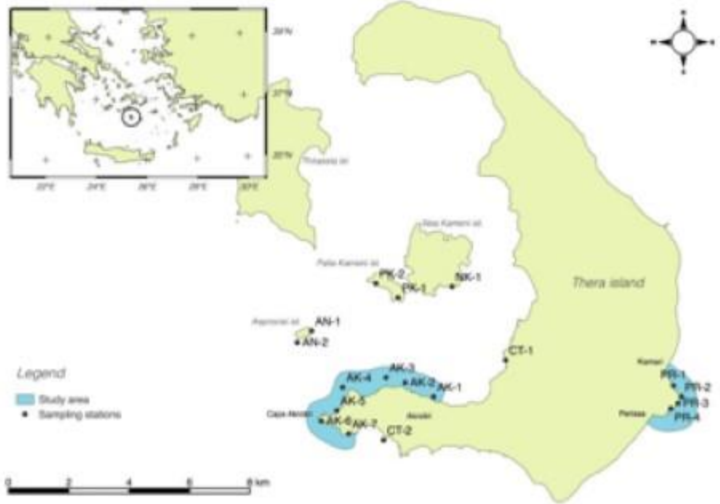


Fig. 1: Map indicating stations along the coasts of Perissa Rock (PR) and Akrotiri Peninsula (AK) (shaded polygons), and several scattered control sites (CT-1, CT-2, NK-1, PK-1, PK-2, AN-1, AN-2).

Assessing *Posidonia oceanica* health status

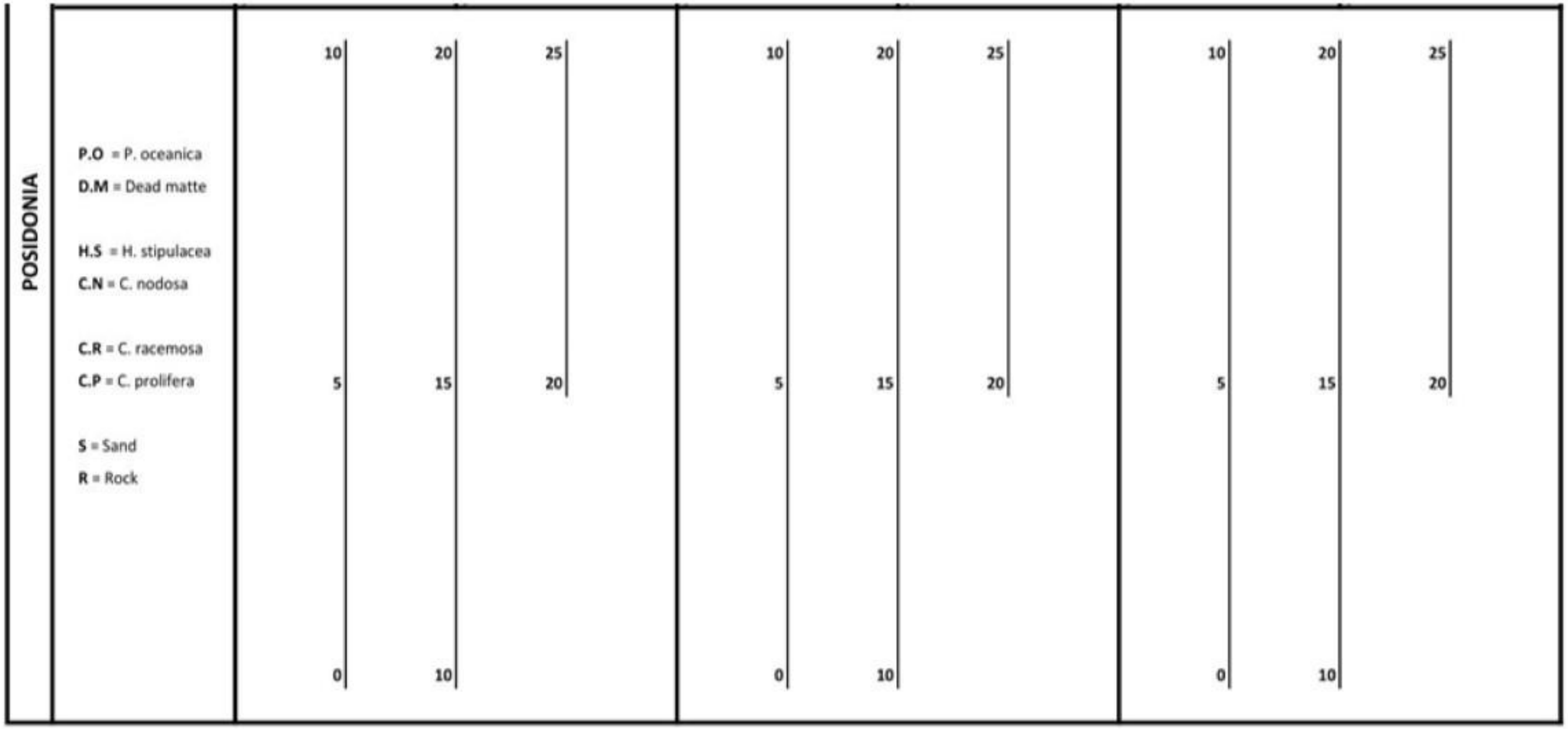
<u>1. Meadow cover (%):</u> percentage cover of *Posidonia oceanica meadow*

Assessment method:

Non-destructive Line Intercept Trasect (*Montefalcone et al. 2007 – Marine Pollution Bulletin*)

Three transect lines (25 m) in three random directions at 15 m depth.

Using a measuring tape along the transect, record the points where key attributes of benthic cover change (e.g. *P. oceanica,* sandy bottom, rock, dead matte)



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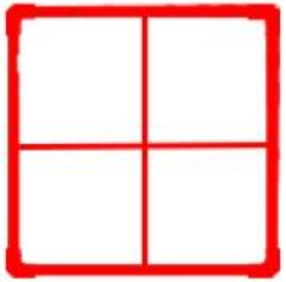
Assessing *Posidonia oceanica* health status

2. Shoot density: Number of shoots per m^2

3. Plagiotrophic growth of rhizomes (%): Percentage of rhizomes with plagiotrophic zones versus rhizomes with an erect growth.

Indicates whether the meadow is stable, regressing or expanding.

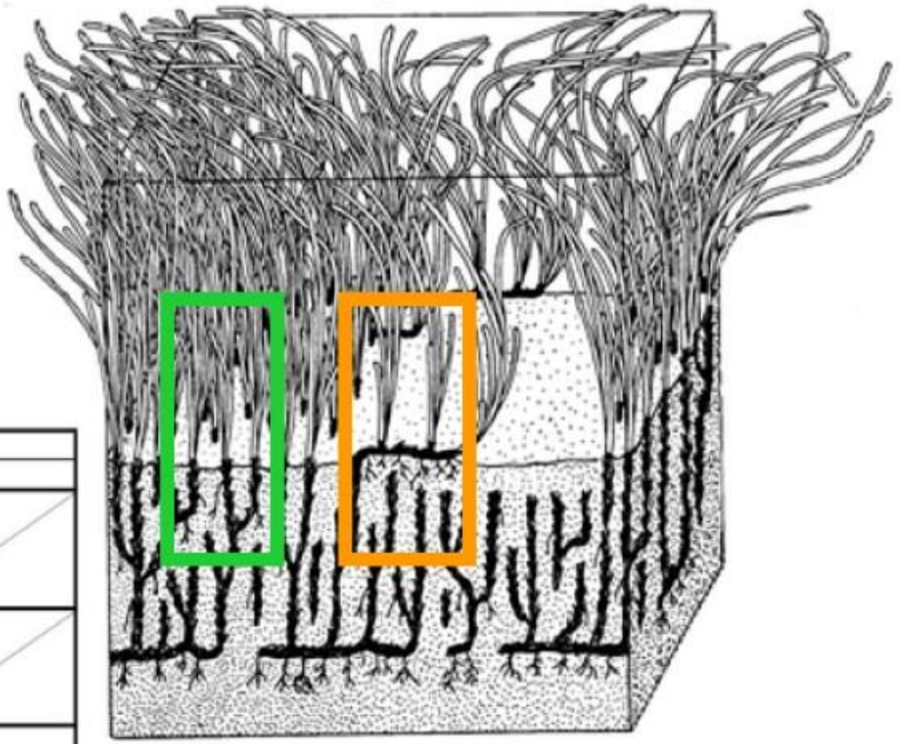
Assessment method: Counts within quadrats at 15 m depth (*Boudouresque et al. 2016 – Hydrobiologia)*



plagiotrophic

orthotrophic

Boudouresque et al. 2016 - Hydrobiologia



TRANSECT	A		B		C	
QUADRAT	1		2		3	
COMMENTS						

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Assessing *Posidonia oceanica* health status

<u>4. Lower limit typology:</u> Characterizing the deepest part of the meadow based on a standard typology (*Pergent et al. 1995 - Mésogée*)

Assessment method: *In situ* observation of the presence of dead *P. oceanica* shoots and plagiotrophic rhizomes at the lower limit.

Five types of lower limit quality status states have been described:

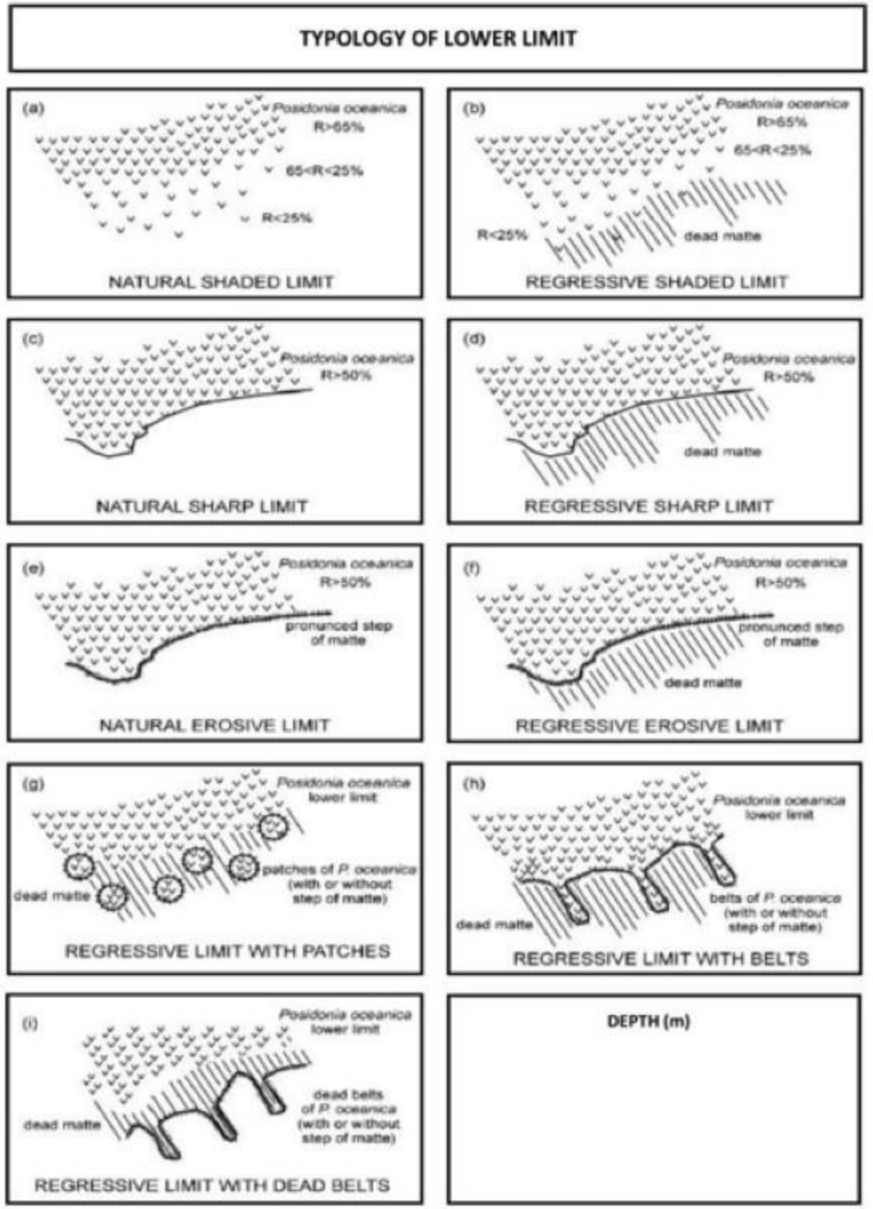
•Progressive = High

•Erosive = High

•Sharp = Moderate

•Sparse = Poor

•Regressive = Bad



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5. Conservation index: (Montefalcone, 2009 – Ecological indicators)

Calculated according to the following formula

$$CI = P / (P+D)$$

where,

CI: the Conservation index

P: the % cover of living *P. oceanica*

D: the % cover of dead *P. oceanica*

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Assessing *Posidonia oceanica* conservation status

Metrics	Impact / Stress	Expected response
1. Meadow cover 2. Shoot density 3. Plagiorophic growth 4. Lower limit ttypology 5. Conservation Index	Reduction of light availability, Burial, Direct elimination due to trawl fishing, anchoring, aquaculture, coastal construction, etc	1. Cover decrease 2. Shoot density decrease due to shoot mortality 3. Increase in the percentage of plagiotrophic rhizomes 4. Change to different type of lower limit 5. Decrease to lower value.

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Assessing *Posidonia oceanica* conservation status

Reference values of the *Posidonia oceanica* health status

Metric	*High* (5)	*Good* (4)	*Normal* (3)	*Poor* (2)	*Bad* (1)
Shoot density (shoots m^{-2})	>492	492-372	372-253	253-134	<134
Plagiotropic growth of rhizomes (%)	-	-	<30	30-70	>70
Lower Limit Typology	Progressive / Erosive	Sharp+	Sharp-	Sparse	Regressive
Conservation Index	> 0.9	0.9 - 0.7	0.7 - 0.5	0.5 - 0.3	< 0.3
The vitality index corresponds to the average of the four metrics (max= 5, min= 1).					

According to *Salomidi et al. 2016 – Mediterranean Marine Science*, modified from UNEP/MAP-RAC/SPA, 2011

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Assessing *Posidonia oceanica* conservation status

Posidonia oceanica health status metrics

Metric	*High* (5)	*Good* (4)	*Normal* (3)	*Poor* (2)	*Bad* (1)
Shoot density (shoots m^{-2})	>492	492-372	372-253	253-134	<134
Plagiotropic growth of rhizomes (%)	-	-	<30	30-70	>70
Lower Limit Typology	Progressive / Erosive	Sharp+	Sharp-	Sparse	Regressive
Conservation Index	> 0.9	0.9 - 0.7	0.7 - 0.5	0.5 - 0.3	< 0.3

The vitality index corresponds to the average of the four metrics (max= 5, min= 1).

According to *Salomidi et al. 2016 – Mediterranean Marine Science*, modified from UNEP/MAP-RAC/SPA, 2011

Posidonia oceanica health status metrics in Santrorini. Mean values (± SE) of each metric per sampling site. (*Salomidi et al. 2016 ~ MMS*).

Sampling Site	Lower Limit type	Meadow Cover (%)	Conservation Index (CI)	Shoot density (shoots m^{-2})	Plagiotropic growth of rhizomes (%)	Synthesis (Mean metric values)
AK-2	Erosive	92.0 ± 6.1	0.97 ± 0.01	289.6 ± 41.3	27.2 ± 6.8	4.0 (*good*)
AK-5	Erosive	55.3 ± 5.9	0.82 ± 0.38	514.6 ± 33.1	12.0 ± 2.1	4.2 (*good*)
AK-6	Progressive	68.4 ± 6.2	0.81 ± 0.11	418.7 ± 19.9	15.5 ± 3.4	4.0 (*good*)
AN-2	Progressive	64.8 ± 5.1	0.94 ± 0.03	637.5 ± 40.3	12.7 ± 2.5	4.5 (*good*)
CT-1	Erosive	95.6 ± 4.4	0.96 ± 0.04	310.4 ± 43.6	11.8 ± 4.5	4.0 (*good*)
CT-2	Progressive	71.3 ± 3.2	0.93 ± 0.04	581.3 ± 30.3	12.3 ± 1.1	4.5 (*good*)
PR-2	Progressive	71.2 ± 3.3	0.93 ± 0.04	364.6 ± 29.7	27.3 ± 7.0	4.0 (*good*)
PR-4	Progressive	41.2 ± 12.5	0.86 ± 0.08	404.3 ± 67.1	34.5 ± 8.7	3.7 (*good*)

Rocky reefs (Habitat type 1170*) sampling

Case study 2

Marine Pollution Bulletin 117 (2017) 311–329

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

ELSEVIER

An ecosystem-based approach to assess the status of Mediterranean algae-dominated shallow rocky reefs

CrossMark

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Rocky reefs (Habitat type 1170*) sampling

Case study 2

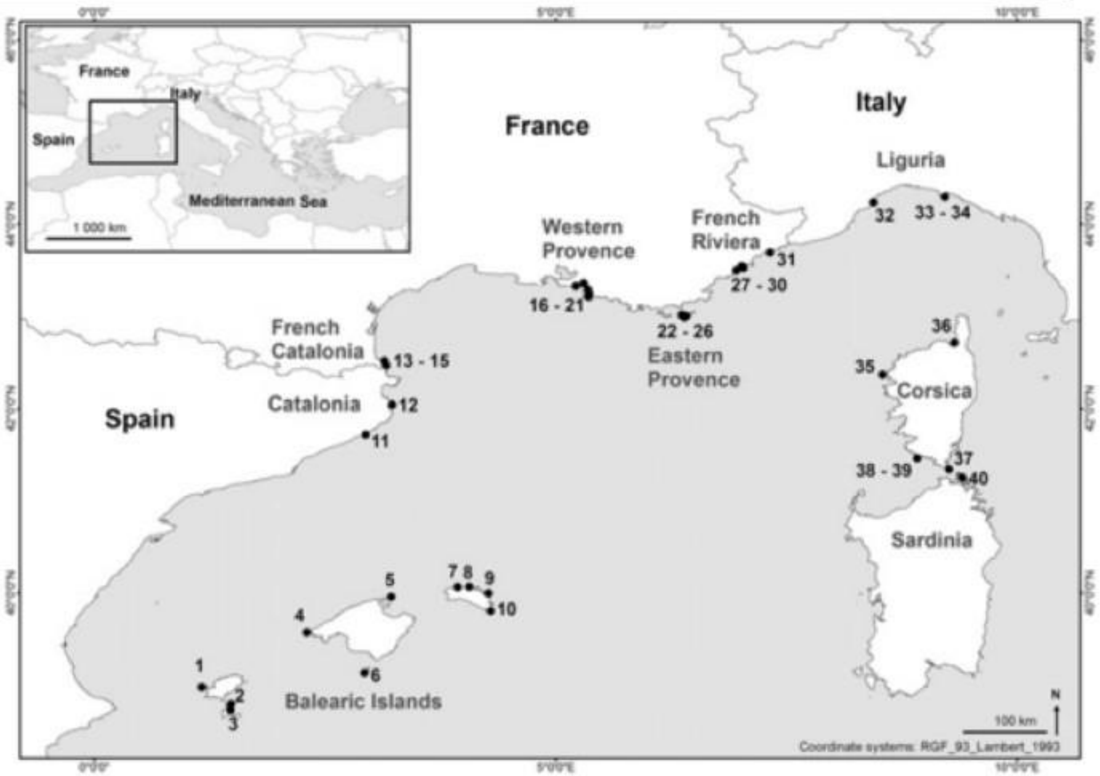
Each site is defined by:

•Extend of rocky reef: ~ 2 hectares

•Depth: 1-10 m

•Different protection status: multi-purpose MPAs, no-take zones, Natura 2000 sites / “paper parks”.

•Different substrate type: natural or artificial.



* Waters <1 m where exclduded because in this zone conditions are highly variable conditions;

* Waters >10 m were excluded because this zone receives less than 10% of surface radiation in this geogrphic region.

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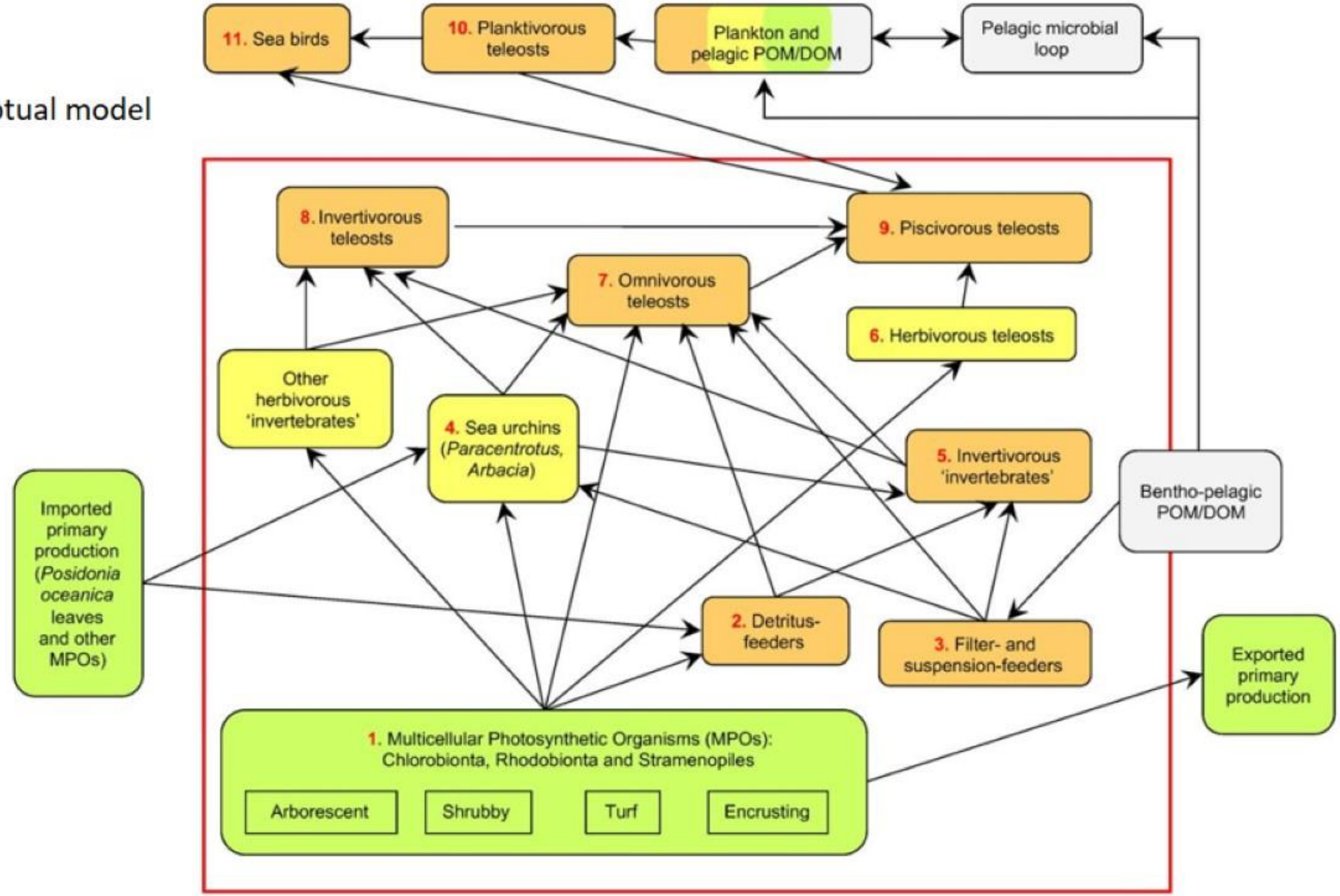
Rocky reefs (Habitat type 1170*) sampling

Conceptual model



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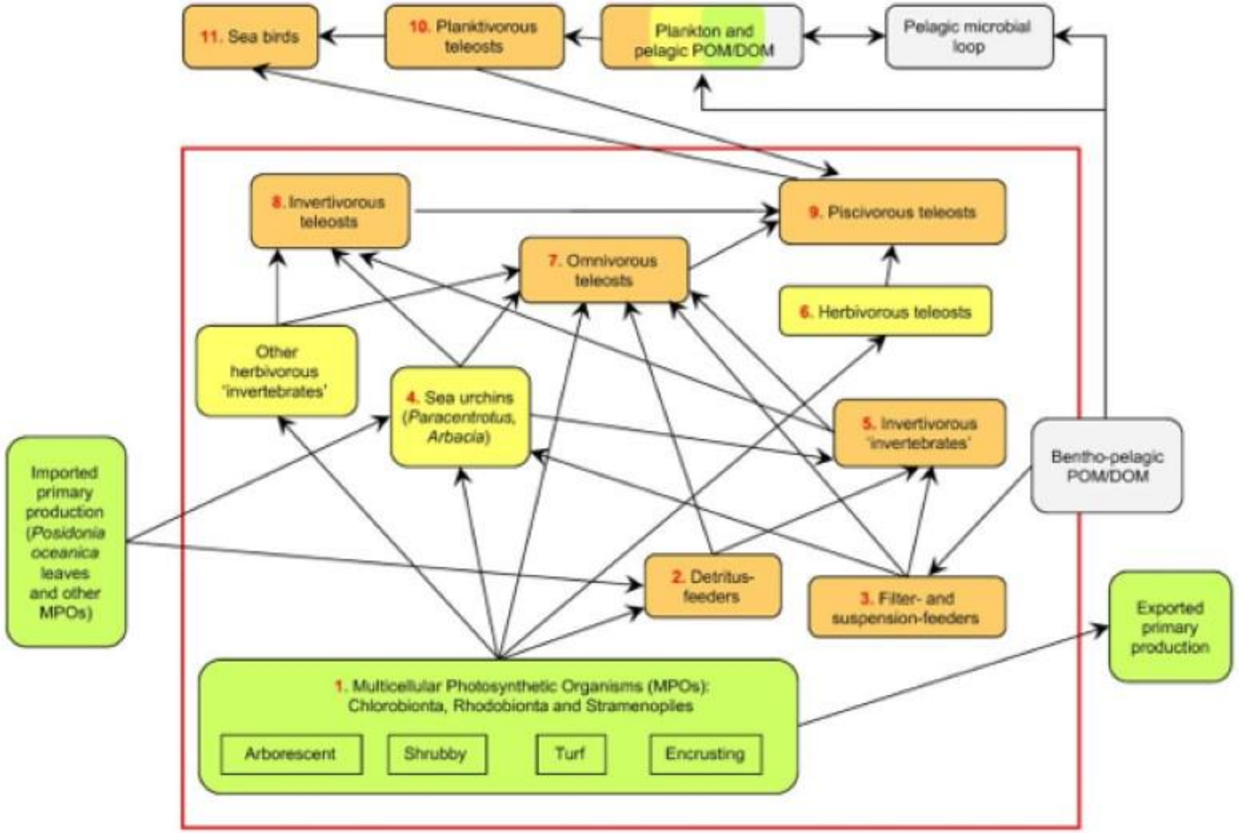
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 1: Different macroalgal species

Box 2: e.g. annelids, crustaceans, holothurians, brittle stars.

Box 3: e.g. bryozoans, sponges.

Box 4: e.g. Sea urchins

Box 5: e.g. macroinvertebrates, *Patella* spp.

Box 6: e.g. *Sarpa salpa*

Box 7: e.g. *Diplodus* spp.

Box 8: predators of invertebrates (e.g. most Labridae, *Pagurus pagurus, Sparus aurata*)

Box 9: e.g. *Conger conger, Dentex Dentex, Scorapena* spp., *Serranus* spp.

Box 10: e.g. *Chromis chromis, Spicara* spp.)

Box 11: e.g. *Phalacrocorax aristotelis desmrestii*

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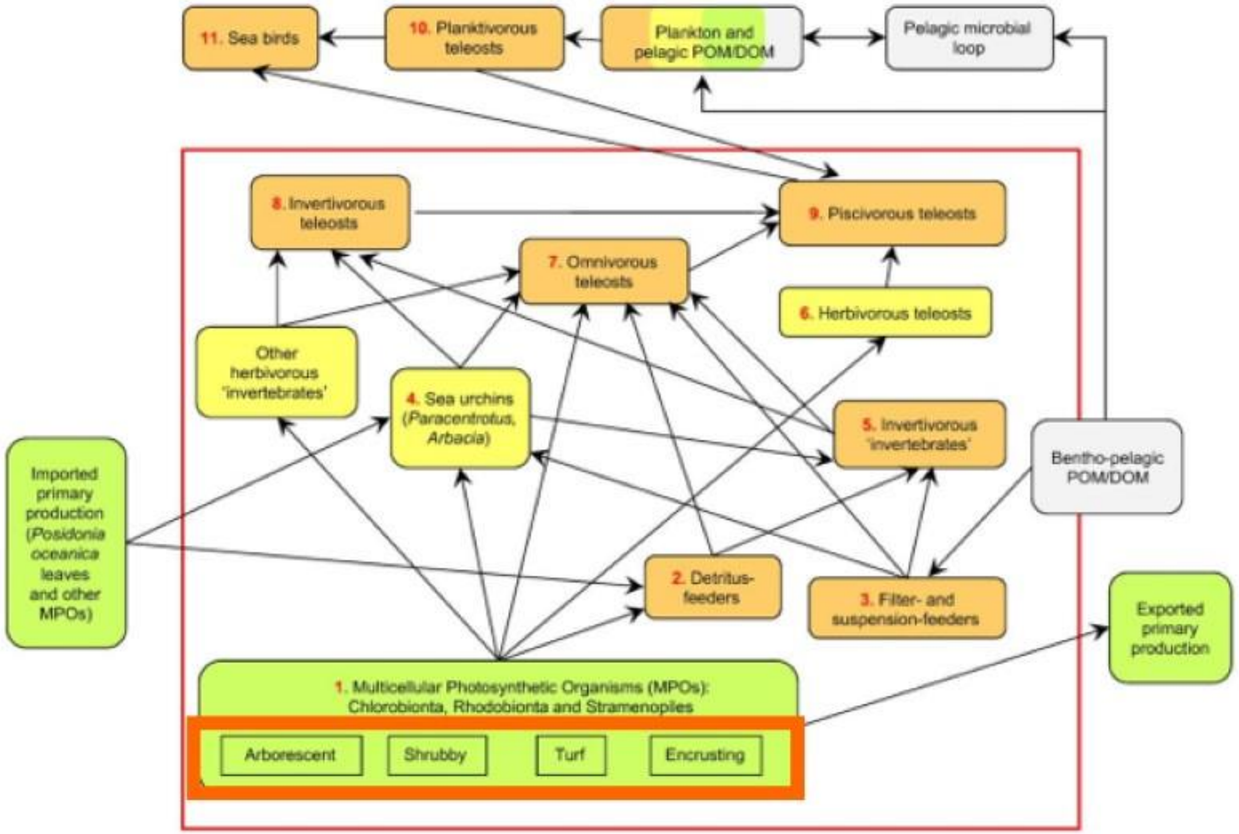
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 1: Different macroalgal species

Ecology: different morpho-functional groups as described below:

Arborescent (tree-like): Highest stratum – e.g. *Cystoseira* spp., *Sargassum* spp. These are perennial species: survive for more than one year.

Shrubby: Intermediate stratum -

Turf: Lower stratum - filamentous ephemeral species.

Encrusting: Lowest stratum - calcareous red algae that form crusts.

Descriptor: percentage cover of different strata

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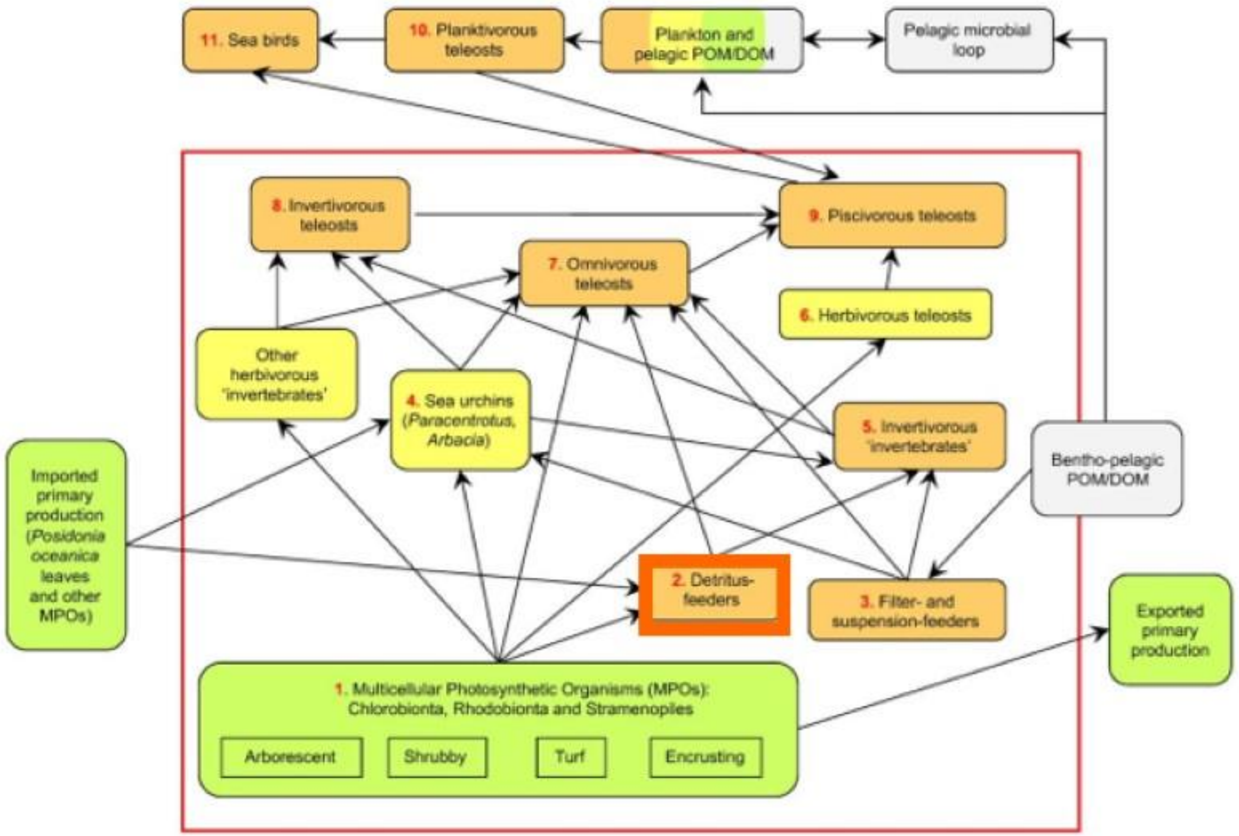
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



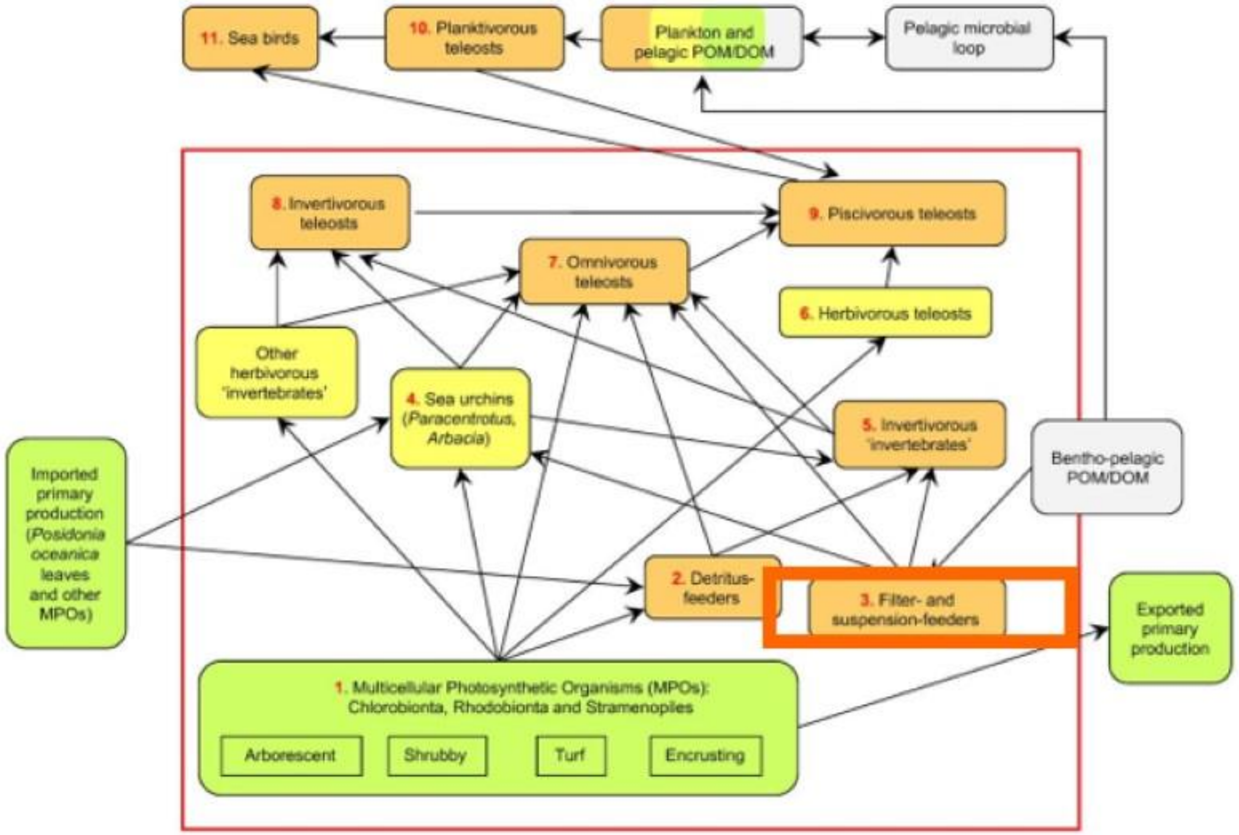
Box 2: *Holothuria* spp. abundance is related to the presence of sediment and detritus.

High in areas of increased sedimentation, rocky reefs close to soft substrates and seagrass beds, coastal construction.

Descriptor: density of *Holothuria* spp. – Number of individuals per $10m^2$

Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 3: e.g. annelids, ascidians, bryozoans, bivalves, cnidarians, barnacles, gastropods, sponges.

Ecology: benthic filter and suspension-feeders living on the substrate or as epibionts.

Descriptor: density - Number of individuals per $10m^2$

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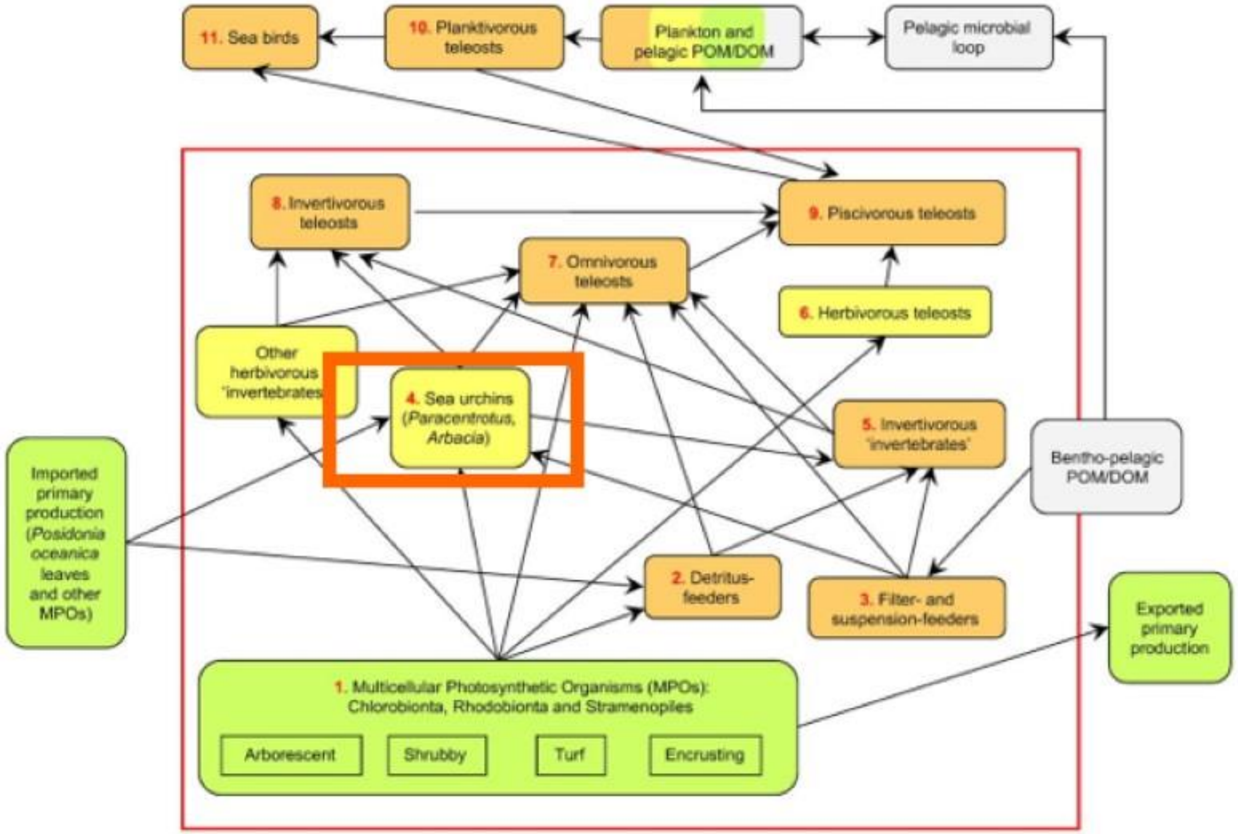
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 4: Sea urchins & the mollusc *Hexaplex trunculus*

Ecology: *Paracentrotus lividus* and *Arbacia lixula* and to a smaller extent *Sphaerechinus granularis* are the main invertebrate grazers in Mediterranean rocky reefs.

Their porous spines enable them to thrive in polluted waters and in habitats low in primary producers.

Their abundance is controlled by some fish, crustaceans, molluscs, and other echinoderms.

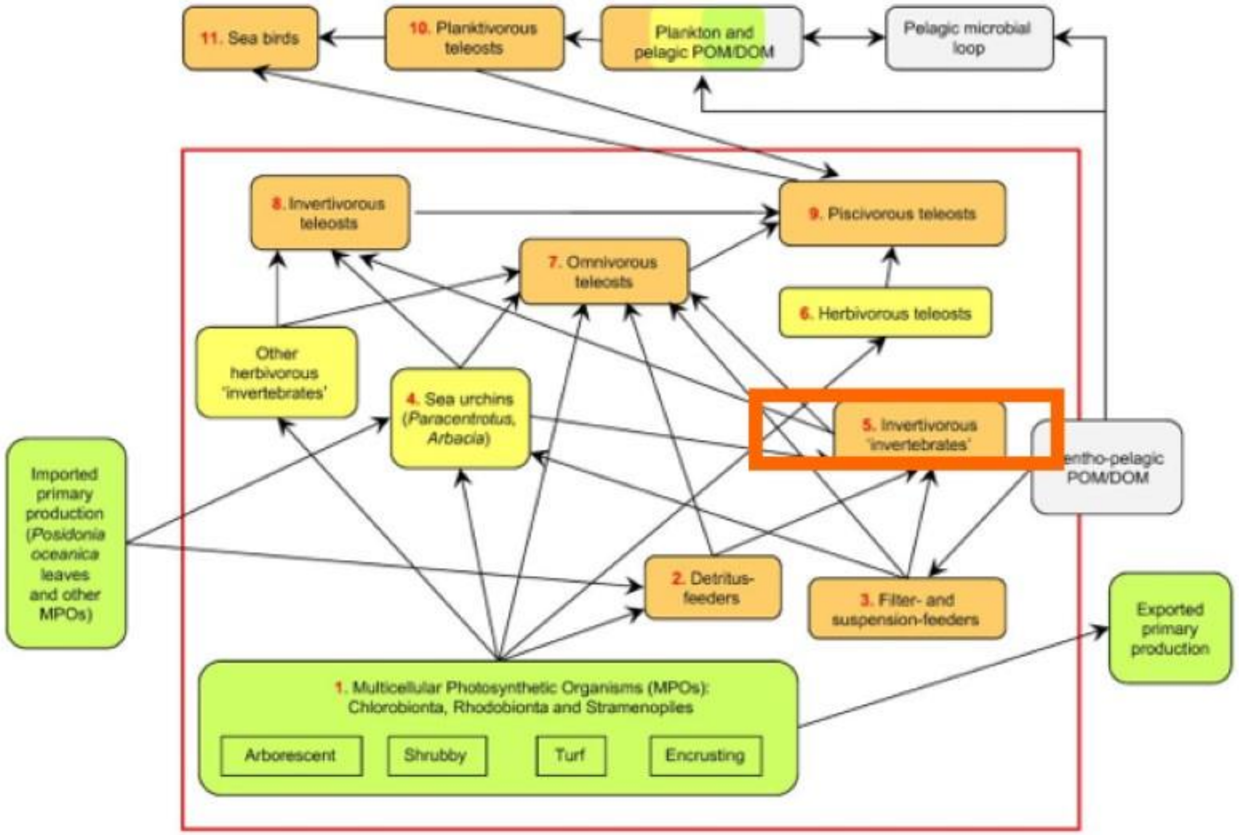
In the absence of predators, they can wipe out most algal species and create rocky barrens.

Hexaplex trunculus is common in disturbed environments.

Descriptor: density - Number of individuals > 30 cm per 1m^2 within 30 replicate samples.

Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 5: Invertebrate carnivores that eat other invertebrates (e.g. *Octopus vulgaris, Marthasterias glacialis*).

Ecology: The are more common in healthy environments.

Descriptor: density - Number of individuals per 200m^2 using transect lines.

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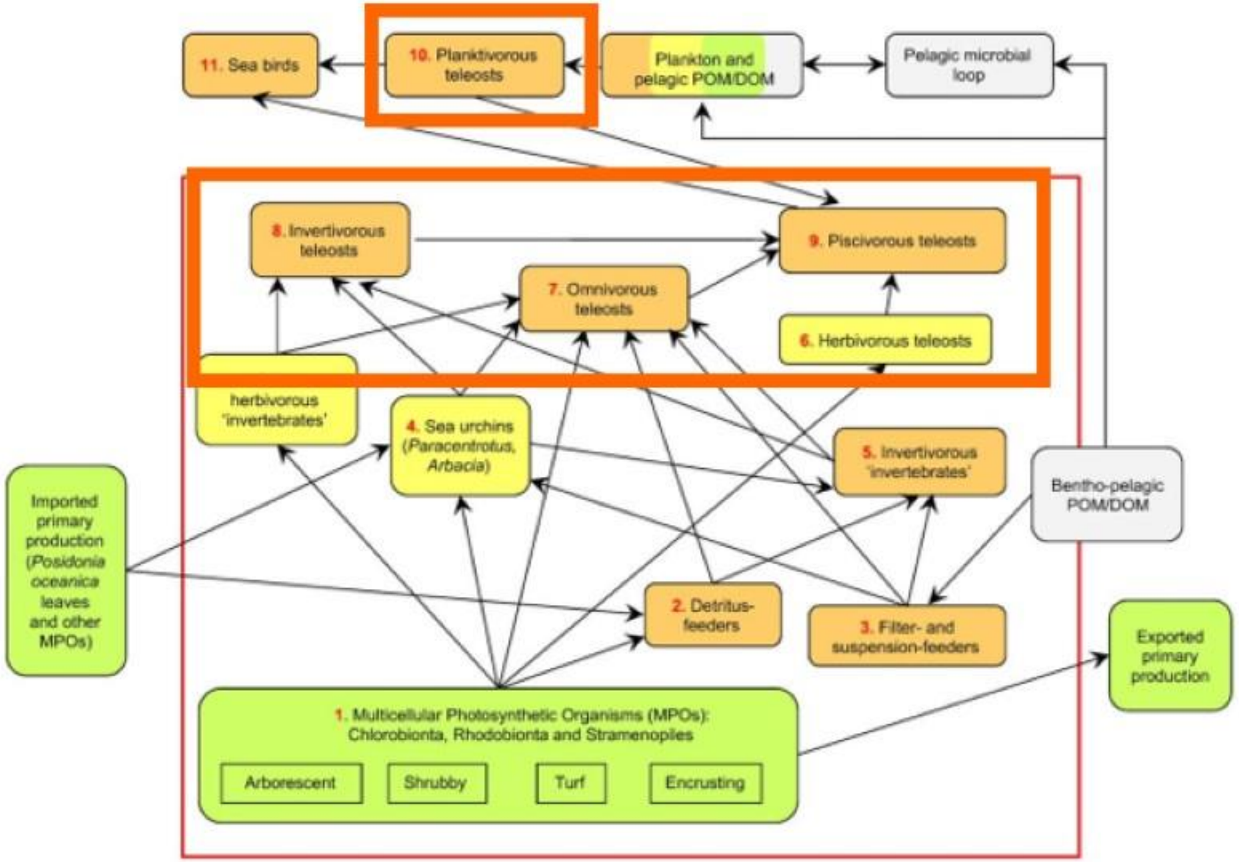
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 6-10: Teleost fish

Ecology: Their presence on rocky reefs depends on time of the day, season and depth. are more common in healthy environments.

They were grouped into 5 functional groups accroding to their trophic habits as adults:

Herbivores, Omnivores + Invertivores, Pisciovres, Planktivores.

Descriptor: Biomass per 100m^2 through visual census, along 10 replicate strip transects (25m in length × 4m width), during daytime (10:00-16:00) in the end of spring or summer.

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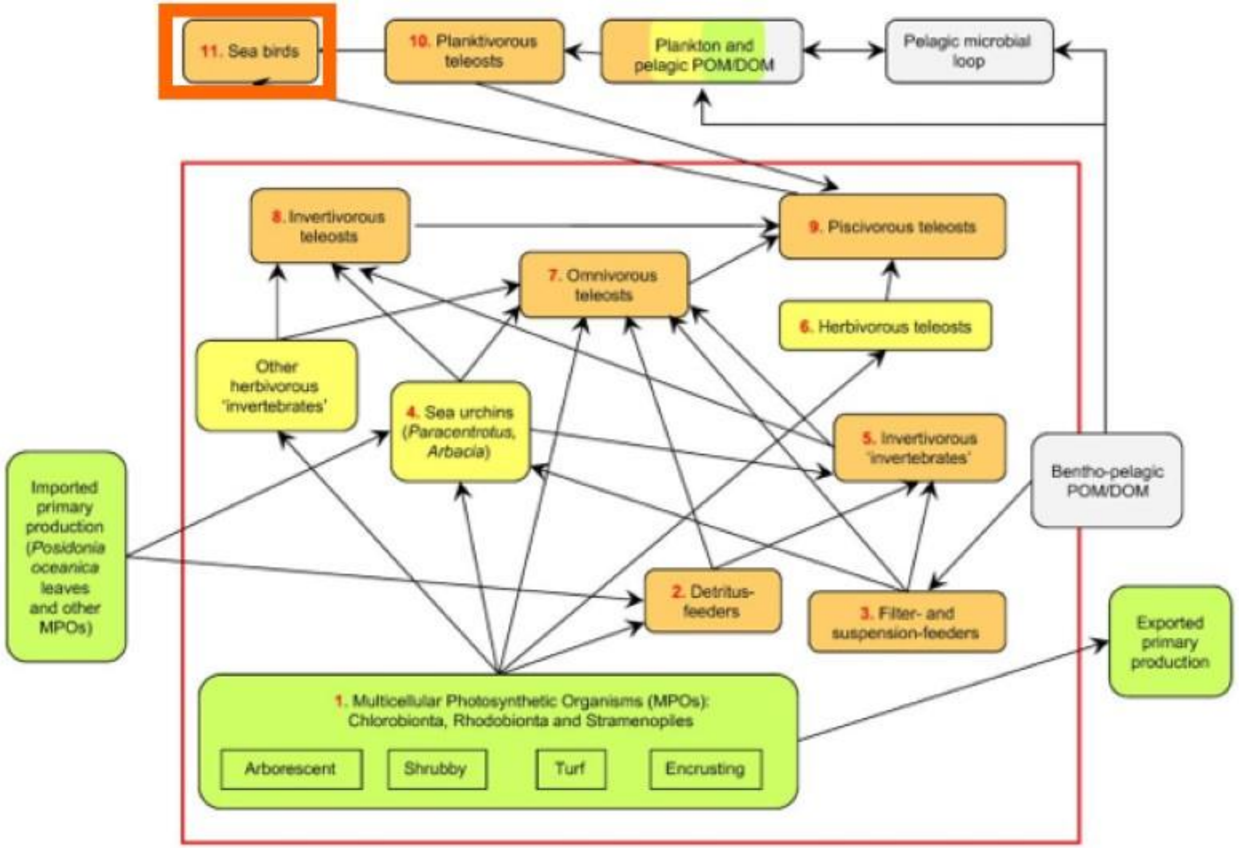
Rocky reefs (Habitat type 1170*) sampling

The functional compartments considered



Box 11: Sea birds

Ecology: *Phlacrocorax* spp. feed on planktivorous and benthic fish. *Larus* spp. feed on offshore pelagic fish, so not considered here.

Descriptor: Distance of the nearest nesting site from the study site.

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Rocky reefs (Habitat type 1170*) sampling

Relative weighting (from 1 to 15) of each functional compartment (boxes; see Fig. 1 for box number) and ranges of each parameter defined for each grade of ecosystem status. MPOs: Multicellular Photosynthetic Organisms. POM: Particulate Organic Matter. DOM: Dissolved Organic Matter. WM: wet mass. Status: 4 (very good) through 0 (very low).

Functional compartment	Weigh-ting (W)	Parameter	4	3	2	1	0
1- MPOs	15	Cover type	Arborescent perennial ≥50%	Arborescent perennial 5 to <50%	Shrubby ≥50%	Shrubby 5 to <50%	Turf Encrusting
2- Detritus-feeders	3	Density (individuals 10 m^{-2})	<0.5	0.5 to 1.0	1.1 to 2.0	2.1 to 5.0	>5.0
3- Filter- and suspension-feeders	2	Density (individuals 10 m^{-2})	<2.5	2.5 to 5.0	5.1 to 10.0	10.1 to 20.0	>20.0
4- Sea urchins	10	Density (individuals m^{-2})	0.05 to 1.0	<0.05	1.1 to 5.0	5.1 to 10.0	>10.0
5- Invertivorous invertebrates	3						
- *Octopus vulgaris*, *Marthasterias glacialis*		Density (individuals 200 m^{-2})	>1.0	0.6 to 1.0	0.3 to 0.5	0.1 to 0.2	<0.1
- *Hexaplex trunculus*		Density (individuals 10 m^{-2})	<0.5	0.6 to 1.0	1.1 to 2.0	2.1 to 4.0	>4.0
6- Herbivorous teleosts	4	Biomass kg teleosts WM 100 m^{-2}	1.1 to 3.0	3.1 to 4.0	>4.0	0.25 to 1.0	<0.25
7–8- Omnivorous and Invertivorous teleosts	4	Biomass kg teleosts WM 100 m^{-2}	>3.5	2.6 to 3.5	1.6 to 2.5	0.8 to 1.5	<0.8
9- Piscivorous teleosts	7	Biomass kg teleosts WM 100 m^{-2}	>5.0	1.0 to 5.0	0.5 to 0.9	0.4 to 0.1	<0.1
10- Planktivorous teleosts	1	Biomass kg teleosts WM 100 m^{-2}	>2.0	2.0 to 1.5	1.5 to 0.9	0.9 to 0.3	<0.3
11- Sea birds	1						
- *Phalacrocorax* spp.		Distance to the nearest nesting site (km)	<4.0	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	>17.0
- *Pandion haliaetus*		Distance to the nearest nesting site (km)	<4.0	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	>17.0

Range values of the different boxes:

from 4 (very good status) to 0 (worst status)

Rocky reefs (Habitat type 1170*) sampling

Relative weighting (from 1 to 15) of each functional compartment (boxes; see Fig. 1 for box number) and ranges of each parameter defined for each grade of ecosystem status. MPOs: Multicellular Photosynthetic Organisms. POM: Particulate Organic Matter. DOM: Dissolved Organic Matter. WM: wet mass. Status: 4 (very good) through 0 (very low).

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2- Detritus-feeders	3	Density (individuals 10 m^{-2})	<0.5	0.5 to 1.0	1.1 to 2.0	2.1 to 5.0	>5.0
3- Filter- and suspension-feeders	2	Density (individuals 10 m^{-2})	<2.5	2.5 to 5.0	5.1 to 10.0	10.1 to 20.0	>20.0
4- Sea urchins	10	Density (individuals m^{-2})	0.05 to 1.0	<0.05	1.1 to 5.0	5.1 to 10.0	>10.0
5- Invertivorous invertebrates	3						
- *Octopus vulgaris, Marthasterias glacialis*		Density (individuals 200 m^{-2})	>1.0	0.6 to 1.0	0.3 to 0.5	0.1 to 0.2	<0.1
- *Hexaplex trunculus*		Density (individuals 10 m^{-2})	<0.5	0.6 to 1.0	1.1 to 2.0	2.1 to 4.0	>4.0
6- Herbivorous teleosts	4	Biomass kg teleosts WM 100 m^{-2}	1.1 to 3.0	3.1 to 4.0	>4.0	0.25 to 1.0	<0.25
7–8- Omnivorous and Invertivorous teleosts	4	Biomass kg teleosts WM 100 m^{-2}	>3.5	2.6 to 3.5	1.6 to 2.5	0.8 to 1.5	<0.8
9- Piscivorous teleosts	7	Biomass kg teleosts WM 100 m^{-2}	>5.0	1.0 to 5.0	0.5 to 0.9	0.4 to 0.1	<0.1
10- Planktivorous teleosts	1	Biomass kg teleosts WM 100 m^{-2}	>2.0	2.0 to 1.5	1.5 to 0.9	0.9 to 0.3	<0.3
11- Sea birds	1						
- *Phalacrocorax* spp.		Distance to the nearest nesting site (km)	<4.0	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	>17.0
- *Pandion haliaetus*		Distance to the nearest nesting site (km)	<4.0	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	>17.0

W: Relative weight (importance) of each box in ecosystem functioning from 5 (high) to 1 (low)

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Rocky reefs (Habitat type 1170*) sampling

$$EBQI = \left[\sum_{i=1}^{13} (W_i \times S_i) / \sum_{i=1}^{13} (W_i \times S_{\max}) \right] \times 10$$

EBQI: Ecosystem Based Quality index

W_i: Weighting of the i

S_i: The status of the box I

S_{max}: The highest possible grade for a box

i: the number of the box

For practical purposes the EBQI is converted to a scale from 0-10

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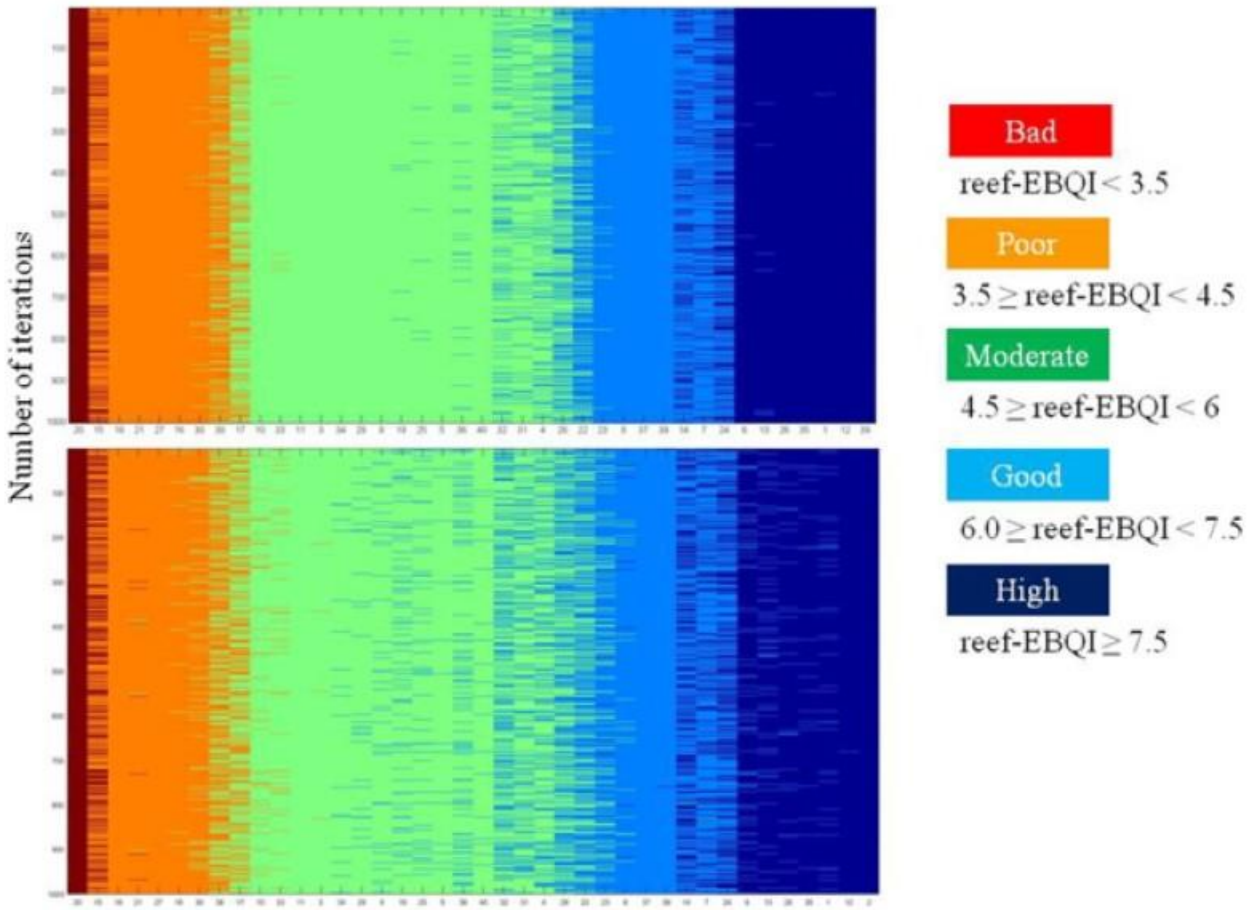
Rocky reefs (Habitat type 1170*) sampling

Five ecological status classes, from high to bad were set based on the Water Framework Directive



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Rocky reefs (Habitat type 1170*) sampling

Site	Water body	Reef EBQI		CARLIT index	
		EBQI	Ecological status	EQR	Ecological status
13	FRDC01	7.40	Good	0.58	Moderate
14	FRDC01	6.85	Good	0.58	Moderate
15	FRDC01	3.10	Bad	0.58	Moderate
16	FRDC05	3.95	Poor	0.61	Good
17	FRDC05	4.55	Moderate	0.61	Good
18	FRDC06a	3.58	Poor	0.43	Moderate
19	FRDC06b	5.65	Moderate	0.64	Good
20	FRDC06b	2.18	Bad	0.64	Good
21	FRDC07a	3.70	Poor	0.80	High
22	FRDC07h	6.10	Good	1.00	High
23	FRDC07h	6.35	Good	1.00	High
24	FRDC07h	6.95	Good	1.00	High
25	FRDC07h	5.65	Moderate	1.00	High
26	FRDC07h	7.50	High	1.00	High
27	FRDC08d	3.90	Poor	0.93	High
28	FRDC08e	5.95	Moderate	0.82	High
29	FRDC08e	5.50	Moderate	0.82	High
30	FRDC08e	4.15	Poor	0.82	High
31	FRDC09d	5.83	Moderate	0.43	Moderate
35	FREC04ac	7.50	High	0.96	High
36	FREC01c	7.65	High	0.69	Good
37	FREC03ad	6.53	Good	0.80	High
38	FREC03eg	4.38	Poor	0.94	High
39	FREC03eg	6.63	Good	0.94	High

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Sampling fish populations

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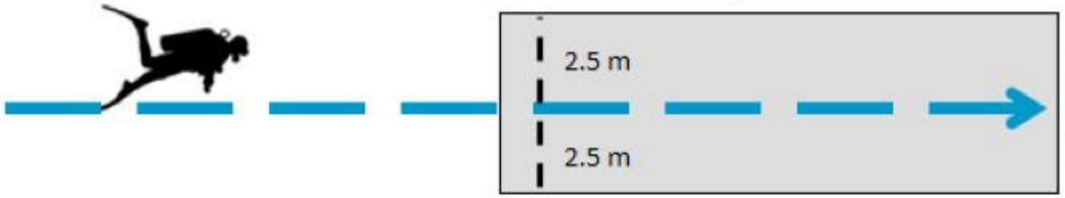
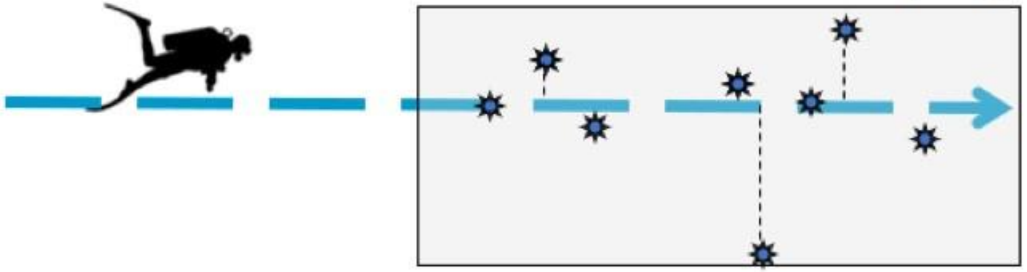
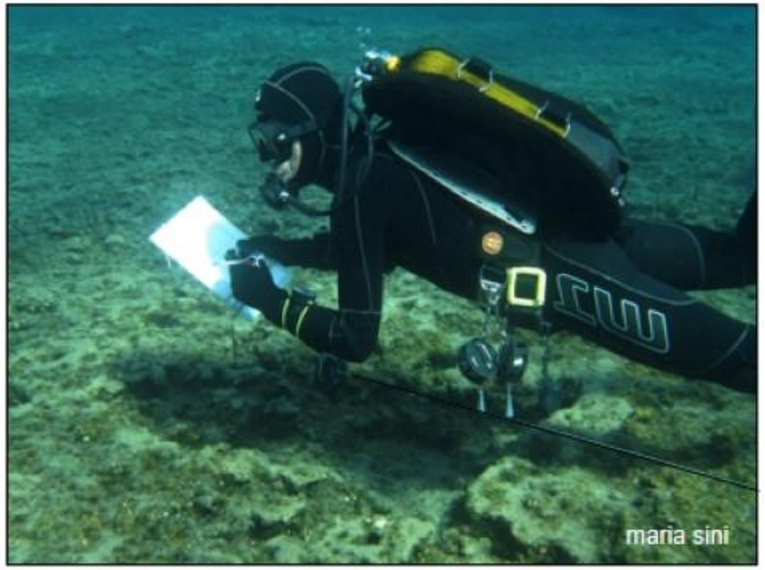
Sampling fish populations – visual census

Strip transects



Line transects (Distance sampling)





Records of:

Species

Number (Density)

Size (Total length)

STATION: DATE: GPS:	Transect 1 Depth	Transect 2 Depth	Transect 3 Depth ....
Diplodus sargus – Σαργός			
Diplodus vulgaris – Καρακέλος			
Sarpa salpa - Σάλπα			
Sparisoma cretense - Σκάρος			
Siganus luridus – Γερμανός			
Siganus rivulatus			
Epinephelus costae - Στήρα			
Epinephelus marginatus -Ροφός			
Other – άλλα			

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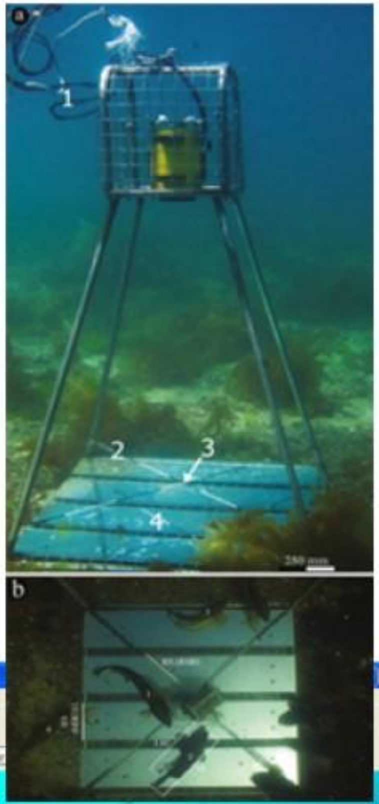
Sampling fish populations – stereo photography and video

www.scielo.br



Analysis software

www.seagis.com.au

Records of:

Species

Number (Density)

Size (Total length)

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Records of:

Species

Number (Density)

Size (Total length)

→

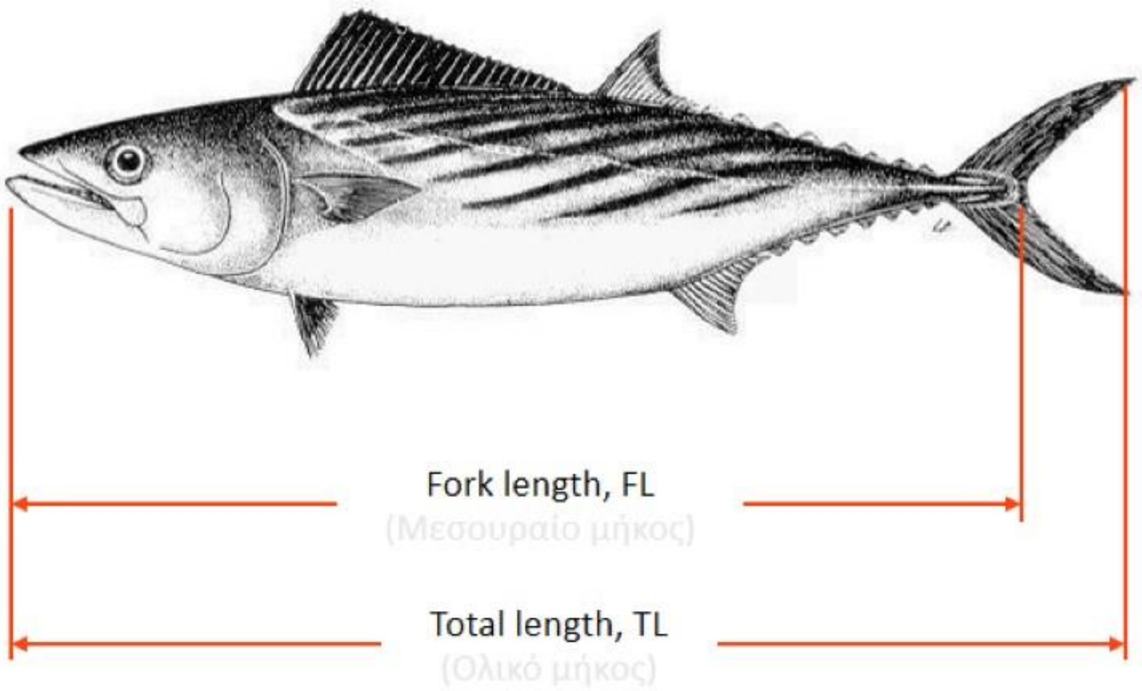
Estimate:

Biomass

Through the weight-length relationship

$$W_{[g]} = a\, L^{b}_{[cm]}$$

Estimating biomass through the calculation of the length-weight relationship



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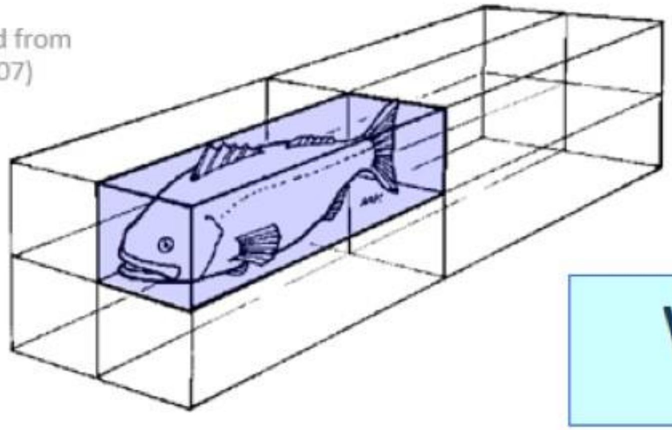
Sampling fish populations, length-weight relationship

Modified from King (2007)



Isometric growth: same growth rate in all three dimensions

This leads to a cubic relationship x^3

$$W_{[g]} = a\, L^{b}_{[cm]}$$

Allometric growth

- b=3: isometric growth (very rare in nature)
- b<3: grows faster in length than in weight ("thin")
- b>3: grows faster in weight than in length ("fat")

Approximate values

a ≈ 0.1  Fish with round body shape

a ≈ 0.01  Fish with hydrodynamic body shape

a ≈ 0.001  Fish with long body shape

King (2007). Fisheries Biology, Assessment and Management, Second Edition. Blackwell Publishing.

Estimating the parameters of the relation (a & b)

$$W_{[g]} = a\,L^{b}_{[cm]}$$

Prerequisites:

- Length and weight measurements of individual fish
- Large N (>100 individuals) – the bigger the dataset the better
- Include all length range (small and large fish)

Additional information for reporting the a & b parameters in common databases:

- Minimum – maximum values (provides information about size range)
- Locality (coordinates)

Most common method for estimation of a & b:

- Linear regression of their logarithmic values

Sampling fish populations, length-weight relationship

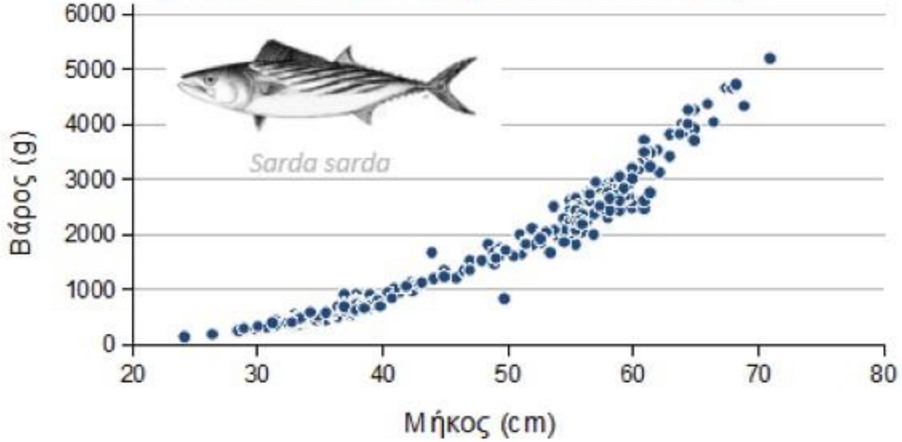
$W_{[g]} = a\,L^{b}_{[cm]}$

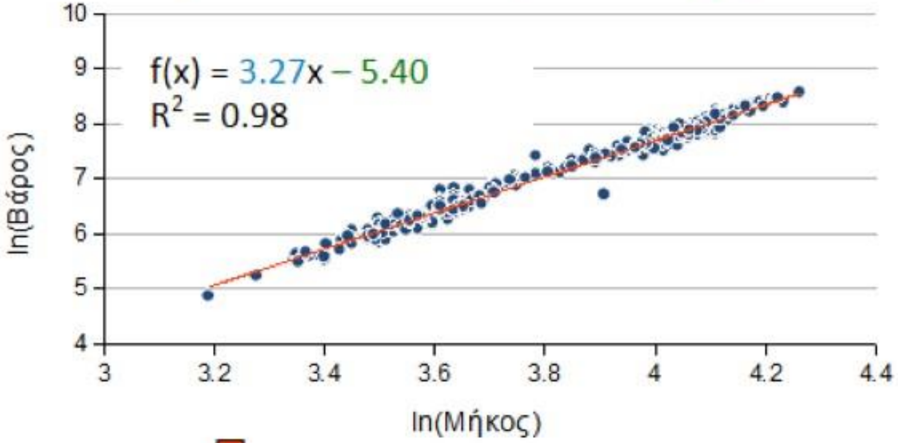
logarithm →

$\ln(W) = \ln(a) + b\,\ln(L)$

↓ Linear regression for the estimation of the intersect-a and slope-b of the graph

Μετρήσεις μήκους (L) και βάρους (W)





↓ Antilogarith of a

$a = \exp(-5.40) = 0.0045$

$b = 3.27$

Length-weight of *Sarda sarda*

$W = 0.0045\,L^{3.27}$

$N=272$, $R^2=0.98$,
$L_{min} = 24.3$ cm, $L_{max} = 71$ cm

R^2: the coefficient of determination takes values from 0 to 1

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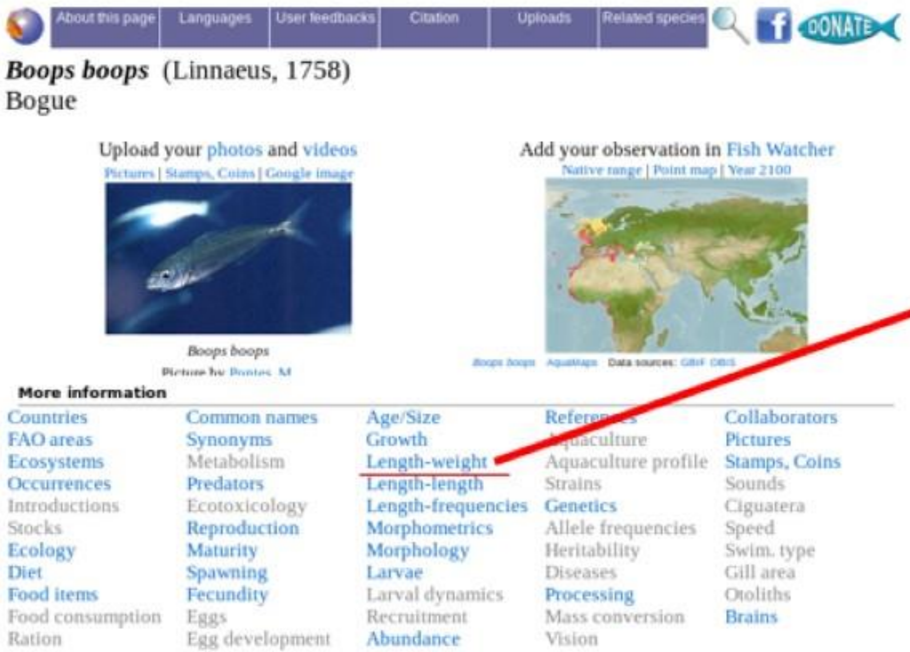
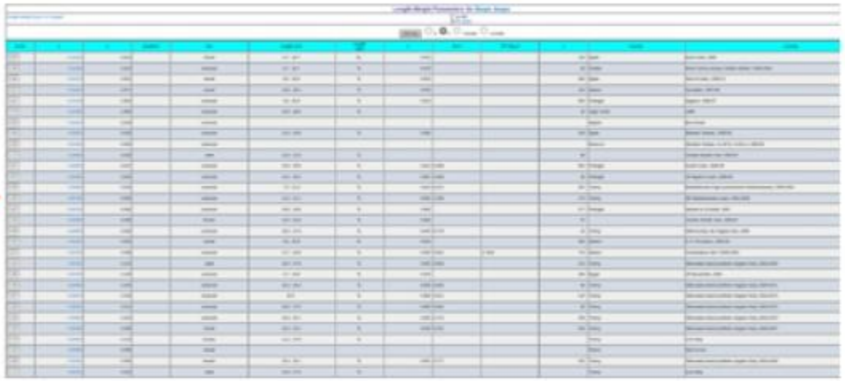
If you do not have sufficient data to estimate a & b, or you only have measurements of L

1. You check the existing literature for relevant information (e.g. Moutopoulos & Stergiou, 2002)
2. You find relevant values in open databases (e.g. www.fishbase.org)





Moutopoulos & Stergiou (2002) - Journal of Applied Ichthyology


See you next week…