

EUROPEAN MARINE BOARD

Mapping Mediterranean key marine habitats

From fragmented records to a basin-wide
evidence base for conservation and restoration

Vasilis Gerovasileiou

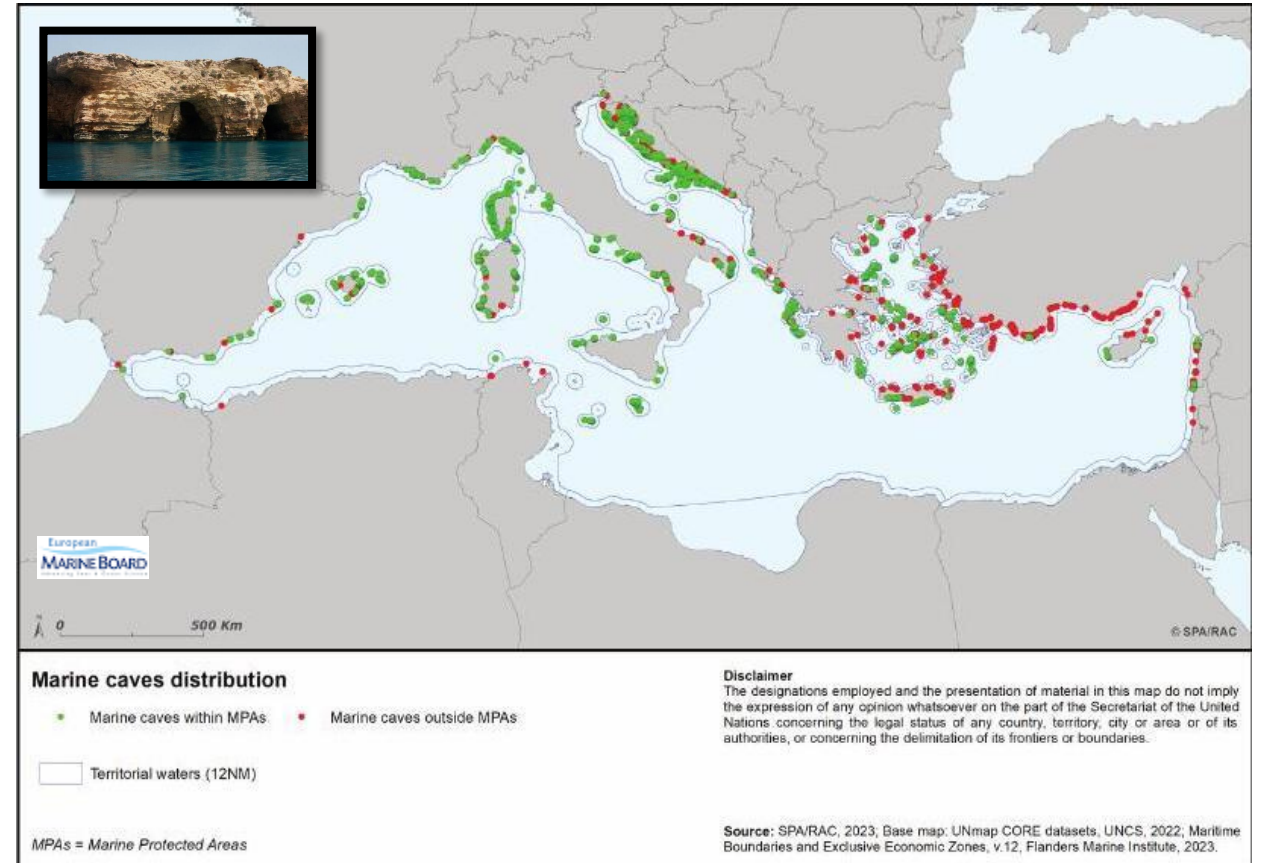
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European Marine Board
Third Thursday Science Webinar



Mediterranean
Action Plan
Barcelona
Convention



Habitat maps turn legal targets into management decisions

WHERE

Locate habitat extent & gaps

STATUS

Quantify coverage & MPA overlap

WHAT NEXT

Target surveys, management & restoration

Why policy needs maps

Legislation and action plans need reliable maps to set targets, identify priorities and measure progress. These maps support conservation planning, management and restoration.

The central question

Our question was whether scattered records could be combined into a regional baseline while clearly showing its uncertainties.

Three iconic habitats expose three different mapping problems



Posidonia oceanica

Extensive meadows • usually mapped as polygons

© George Rigoutsos / WWF Hellas



Coralligenous & maërl beds

Patchy & complex mosaics • represented mainly as areas

© SPA/RAC – University of Sevilla



Marine caves

Discrete geomorphological features • mapped as points

© Vasilis Gerovasileiou

conservation priorities • different geometries • different detectability • different uncertainty

Benthic habitats underpin Mediterranean biodiversity and resilience

BIODIVERSITY

Nursery, feeding, refuge and settlement space

FUNCTION

Primary production, bioconstruction and nutrient cycling

RESILIENCE

Carbon storage, coastal protection and climate refugia

Habitat loss changes more than a map

Habitat loss reduces ecological functions, fragments populations and weakens the capacity of the marine ecosystem to absorb disturbance.

WHY THESE THREE HABITATS?

Three priority habitats in Mediterranean and European policy

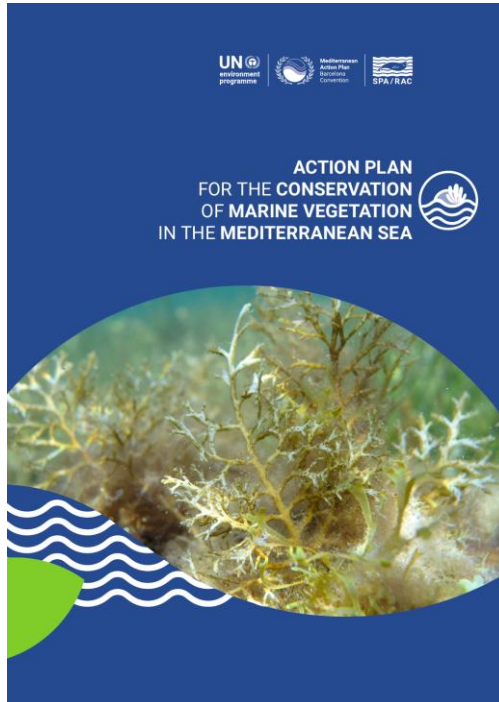
ECOLOGICAL DISTINCTIVENESS	HABITAT	REGIONAL POLICY LINK
Endemic foundation species	<i>Posidonia oceanica</i>	EU Habitat 1120* • Marine Vegetation Action Plan • EU Nature Restoration Regulation
Mediterranean bioconstruction	Coralligenous formations	Part of EU Habitat 1170 • Coralligenous Action Plan • EU Nature Restoration Regulation
Unique biodiversity reservoirs	Marine caves	EU Habitat 8330 • Dark Habitats Action Plan • Specific invertebrate assemblages included in the EU Nature Restoration Regulation

Their distribution supports the Habitats Directive, the EU Nature Restoration Regulation and SPA/BD Action Plans.



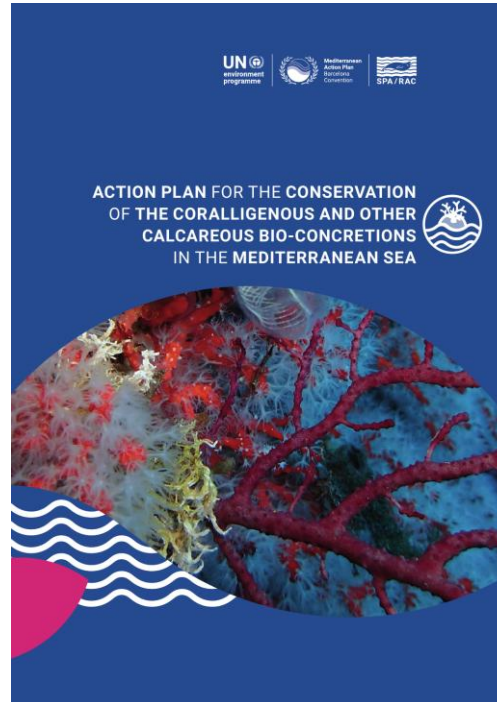
SPA/BD Protocol
Specially Protected Areas and Biological Diversity Protocol of the Barcelona Convention

Regional policy framework for the three habitats



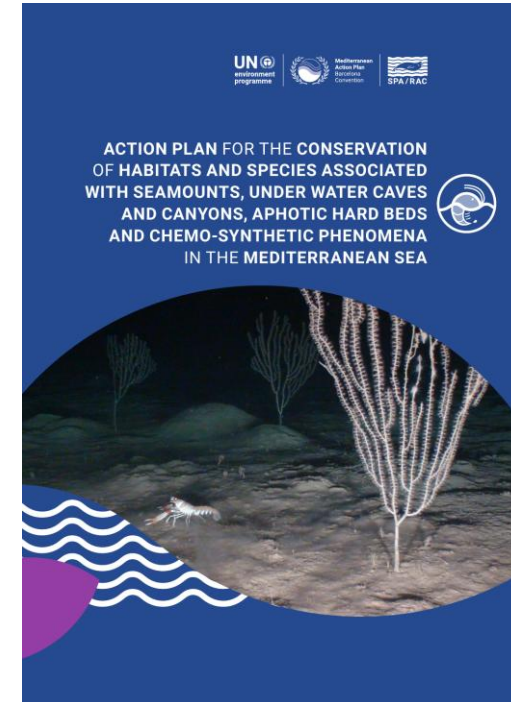
Marine vegetation

Initial adoption 1999
latest update 2019



Coralligenous & maërl

Initial adoption 2008
latest update 2025



Dark habitats

Initial adoption 2013
latest update 2021

Distribution maps support the implementation of the Action Plans by guiding monitoring, protection & management.

The Barcelona Convention provides the legal framework

1976

Barcelona Convention adopted

1995

Amended to include the coastal region

7

Implementing Protocols

22

Contracting Parties: 21
countries + EU

UNEP/MAP – Barcelona Convention system

- The Mediterranean's principal regional, legally binding framework for protecting the marine environment and coastal region while supporting sustainable development.
- In this study, it provided the framework for contacting the countries and validating their habitat data.



Mediterranean
Action Plan
Barcelona
Convention

SPA/RAC is the biodiversity component of the UNEP/MAP system

SPA/RAC



**Specially Protected Areas Regional
Activity Centre**

Established in Tunis in 1985 by
decision of the Contracting Parties

- **Regional biodiversity work**

Inventories and mapping of marine habitats and protected areas.

- **Support for countries**

Action Plans, technical guidance and capacity building.

- **Project role**

SPA/RAC commissioned, coordinated and financially supported this mapping assessment. It also connected our scientific team with national authorities and the policy process.



**Mediterranean
Action Plan**
Barcelona
Convention



<https://spa-rac.org/>

National Focal Points opened access to national data and expertise

SPA/RAC

Coordinated outreach

21 coastal states

Engaged via their National Focal Points

Regional integration

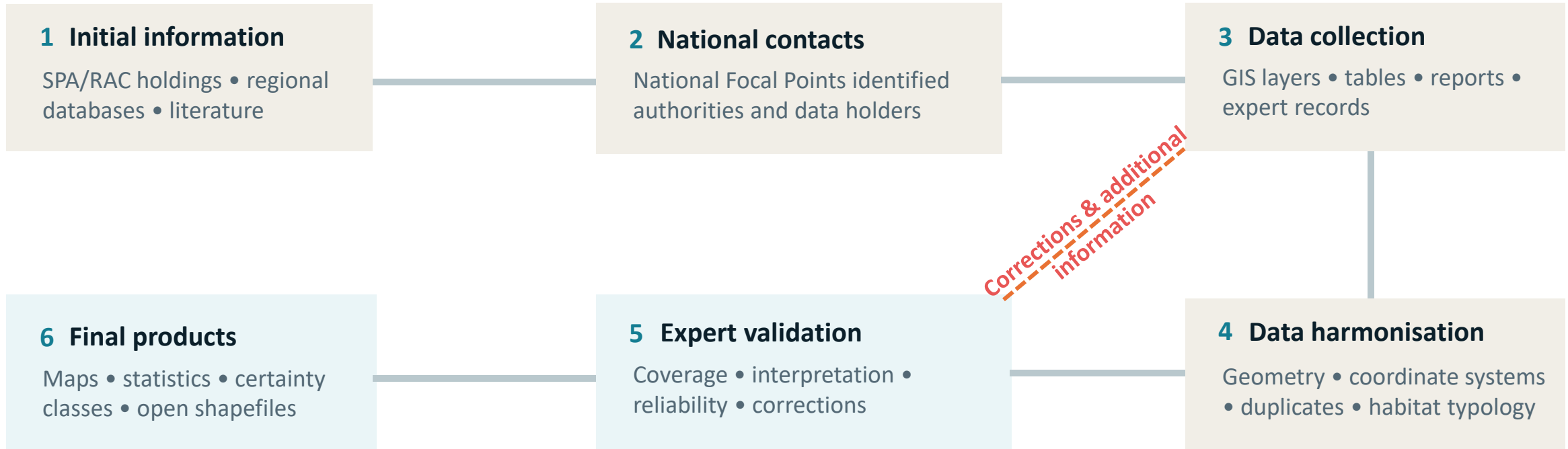
Reviewed data were standardised into comparable maps

The partnership enabled:

- 1 Access to country datasets
- 2 Verification of submitted data
- 3 Evaluation of coverage and reliability

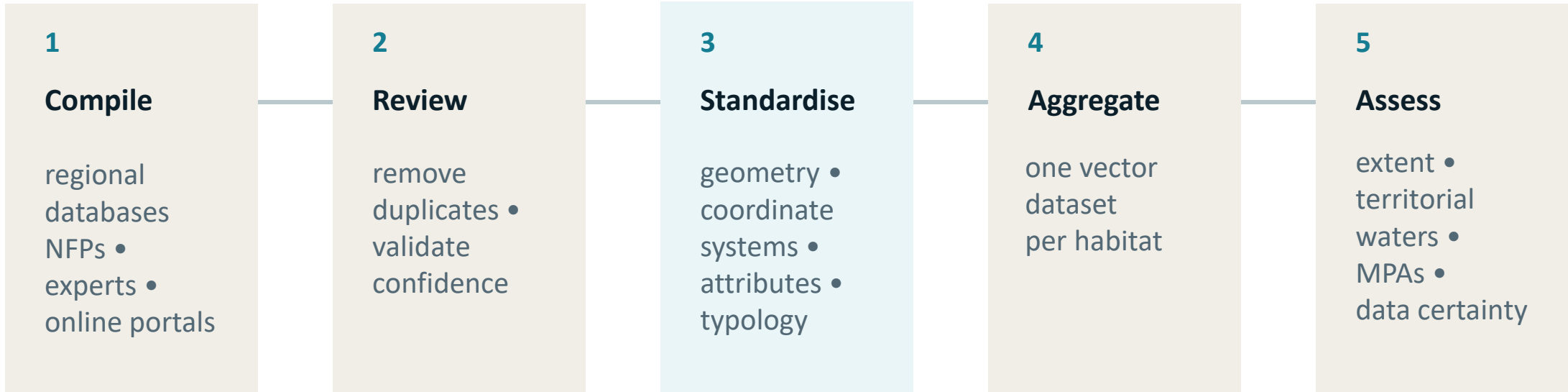
No data ≠ no habitat

How the data were gathered and validated



Validation changed the dataset: records were added, corrected, reclassified or excluded when confidence remained insufficient

From different data sources to comparable maps



Output: comparable spatial data for 21 Mediterranean coastal countries, with the original data limitations retained

Sensitive cave coordinates were displaced by $\approx 0.5-1$ km in public maps

The project combined habitat and mapping expertise

Vasilis Gerovasileiou



Marine caves

Cave inventories •
geomorphology • ecological
zonation • sensitive records

Simonetta Frascetti



Coralligenous + maërl

Biogenic habitats • ecological
complexity • monitoring and
conservation

Inés Mazarrasa



Posidonia oceanica

Seagrass ecology • spatial
distribution • ecosystem services
and condition

MAPPING & SPATIAL SYNTHESIS



Antonio Sánchez-Espinosa and the ETC-UMA team

GIS harmonisation • mapping • spatial analysis • MPA & territorial-water overlays



SPA/RAC coordinated the contacts with **National Focal Points** and linked the study to the regional policy process.

Open GIS files accompany the paper

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
www.hcmr.gr
DOI: <https://doi.org/10.12681/mms.43060>

Updated distribution mapping of *Posidonia oceanica* meadows, coralligenous assemblages and marine caves in the Mediterranean Sea: implications for conservation and restoration

Vasilis GEROVASILEIOU^{1,2}, Antonio SÁNCHEZ-ESPINOSA³, David RODRÍGUEZ-RODRÍGUEZ³,
Simonetta FRASCHETTI^{4,5,6}, Inés MAZARRASA⁷, Cyrine BOUAFIF⁸, Atef OUERGH⁹
and Dania ABDUL MALAK³

SUPPLEMENTARY FILES 2-5

The harmonised habitat layers are supplied in shapefile format

The data will also be made available by SPA/RAC through the **Mediterranean Biodiversity Platform** (<https://mbp.medchm.net/en>), providing a regional baseline for conservation, marine spatial planning and restoration.

■ Check the source data

The files contain the spatial records used for the maps and statistics.

■ Use the layers in GIS

They can be combined with protected areas, pressures and new survey data.

■ Add new validated records

Future versions can include corrections and newly available information.

Why this journal?

Published by HCMR • a public Mediterranean journal • open access • no publication charges • a natural home for a regional public dataset



Mediterranean
Marine Science



<https://ejournals.epublishing.ekt.gr/index.php/hcmr-med-mar-sc>

doi.org/10.12681/mms.43060

Common attributes, habitat classification & rules for overlapping data

■ Standard attributes

Habitat type • source and provider • year • scale • geographic coverage • certainty

■ Common classification

Aligned with the *Updated Classification of Benthic Habitat Types for the Mediterranean Region* (SPA/RAC–UN Environment/MAP, 2019).

■ Overlapping datasets

The most detailed and accurate source was prioritised. Other datasets filled gaps or refined habitat definitions.

■ Mapping coverage

Surveyed areas were identified for *Posidonia* and coralligenous habitats, helping distinguish confirmed absence from areas without mapping coverage.

Final output

Three standardised habitat-specific GIS layers

No data ≠ no habitat

Posidonia oceanica is a foundation Mediterranean endemic species

A slow-growing endemic seagrass

■ Three-dimensional habitat

Leaves, rhizomes and matte support diverse epiphytes, invertebrates and fishes.

■ Ecosystem engineer

Stabilises sediments, improves water clarity and reduces coastal erosion.

■ Blue-carbon reservoir

Long-lived below-ground matte can store organic carbon over long periods.



© George Rigoutsos / WWF Hellas

Main pressures

- coastal development and anchoring
- bottom-contact fishing
- pollution and eutrophication
- warming and marine heatwaves
- invasive species and altered food webs

Recovery is slow → prevention is especially important

Previous assessments revealed a widespread habitat

But also, immense unmapped coastline ...

≈12,247 km²

mapped basin-wide in the latest synthesis
(Telesca *et al.*, 2015 *Scientific Reports*)

>21,000 km

Mediterranean coastline still associated
with major data gaps

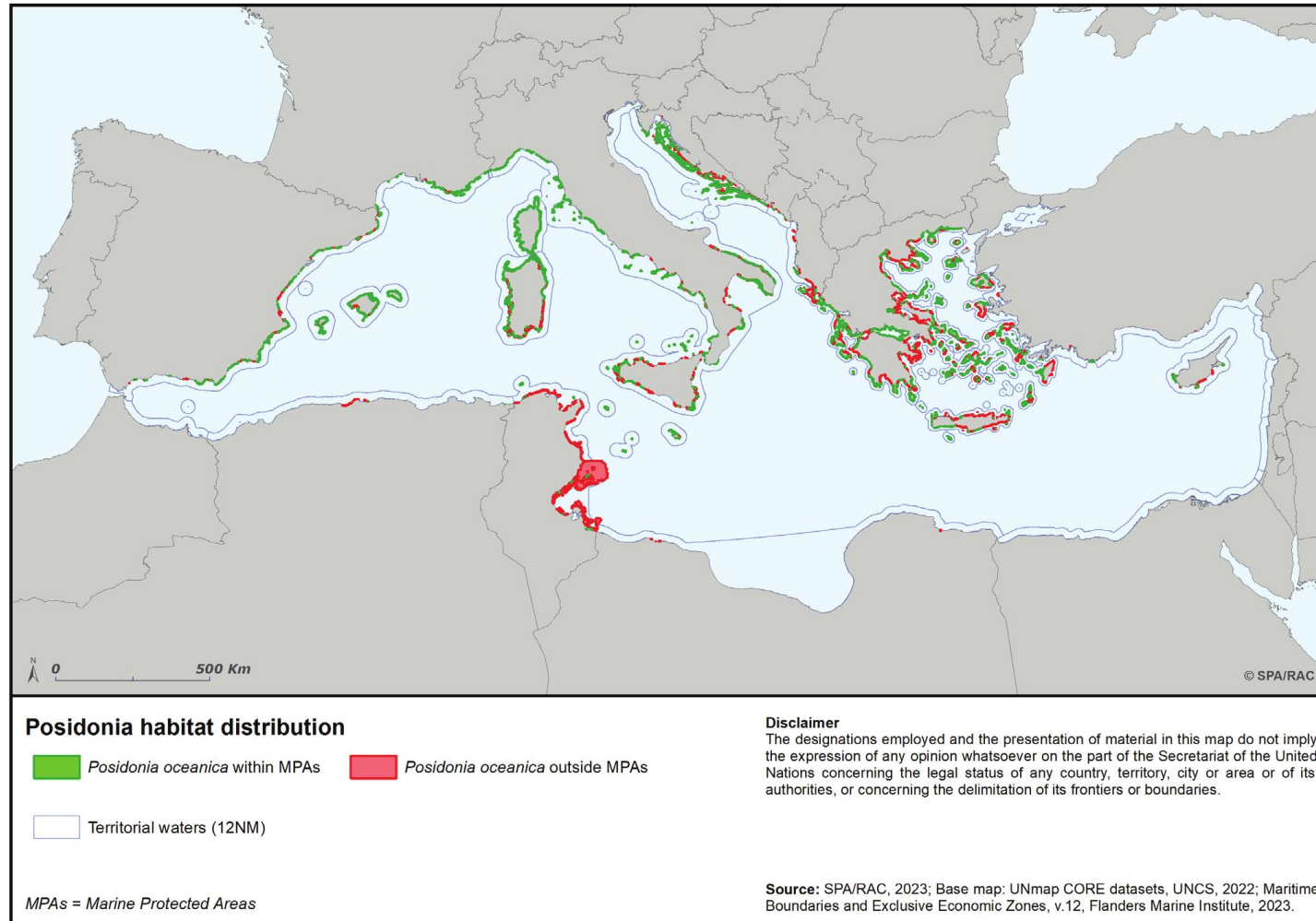
VARIABLE

Survey periods, spatial
resolutions and mapping
methods

Differences between estimates can reflect

new knowledge • improved cartographic accuracy • real ecological change

Posidonia mapping nearly doubles the previous basin-wide estimate



20,235 km²

Mapped across 15 countries

94.4%

Within territorial waters

33.7%

Inside MPAs

Country-level summary: the *Posidonia* example

Country	<i>Posidonia oceanica</i> habitats	<i>Posidonia oceanica</i> habitats within territorial waters*		<i>Posidonia oceanica</i> habitats inside MPAs		Certainty (based on data quality and availability)**
	Area (km ²)	Area (km ²)	%	Area (km ²)	%	
Albania	45	45	100	3	7.3	High
Algeria	44	44	100	0	0	Low
Bosnia and Herzegovina	-	-	-	-	-	No data
Croatia	446	446	100	287	64.3	High
Cyprus	78	78	100	46	59.1	High
Egypt	-	-	-	-	-	No data
France	786	786	100	765	97.4	High
Greece	3,264	3,233	99	1,703	52.2	High
Israel	-	-	-	-	-	No habitat
Italy	4,993	4,993	100	2,892	57.9	High
Lebanon	-	-	-	-	-	No data
Libya	8	8	100	-	-	Moderate
Malta	55	55	100	53	96.3	Low
Monaco	0.1	0.1	100	0.1	100	Moderate
Montenegro	0.2	0.2	100	0.2	45.7	Low
Morocco	-	-	-	-	-	No data
Slovenia	0.01	0.01	100	0.01	72.8	Low
Spain	1,210	1,210	100	1,020	84.3	High
Syria	-	-	-	-	-	No data
Tunisia	9,299	8,205	88.2	44	0.5	High
Türkiye	7	7	100	-	-	Low
Total Mediterranean	20,235	19,111	94.4%	6,813	33.7%	Moderate

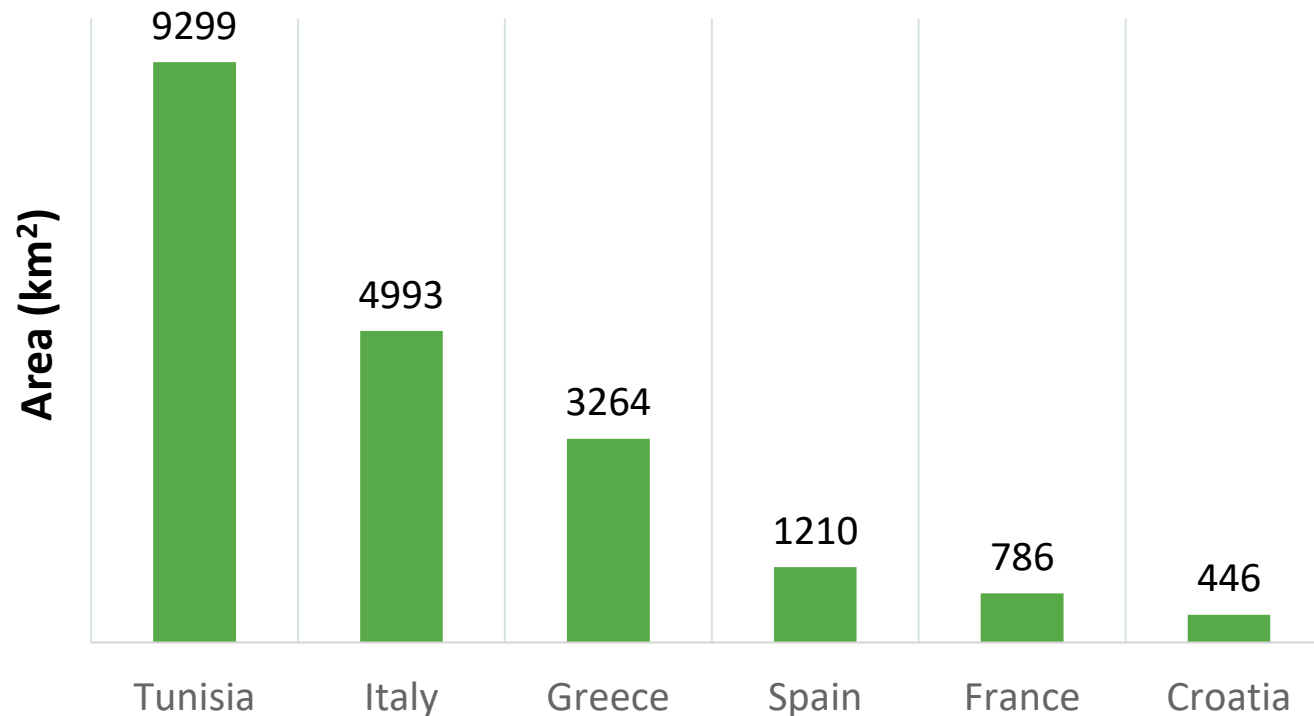
A summary table was produced for each habitat

- Mapped extent by country
- Area within territorial waters
- Overlap with MPAs
- Data certainty based on quality, availability and NFP feedback

Data certainty

- High in eight countries
- No spatial data for five countries (Bosnia and Herzegovina, Egypt, Lebanon, Morocco, and Syria)

Mapped *Posidonia* area by country



- Most of the mapped area is concentrated in six countries.
- Tunisia, Italy and Greece account for most of the mapped area.
- Differences reflect natural distribution, but also survey effort, methods and data availability.

Coralligenous habitats and maërl beds

CORALLIGENOUS

Biogenic structures built through the balance of calcareous algal growth, animal accretion and bioerosion.

Commonly develops on dimly lit hard bottoms and supports complex, long-lived assemblages.



Photo © Thanos Dailianis / HCMR

MAËRL / RHODOLITH BEDS

Unattached living coralline algae form mobile beds that create heterogeneous sedimentary habitats.

Both systems act as biodiversity hot-spots and are highly sensitive to abrasion, sedimentation and bottom fishing.



Photo © Enric Ballesteros

Previous estimates: models and observations

2,763.4 km²

Modelled coralligenous outcrops
(Martin *et al.*, 2014 *Scientific Reports*)

1,654.5 km²

Modelled maërl beds
(Martin *et al.*, 2014 *Scientific Reports*)

PATCHY

Fine-scale habitat below many
regional map resolutions

- **Models and observations answer different questions**

Models estimate potential distribution; validated records document known occurrence

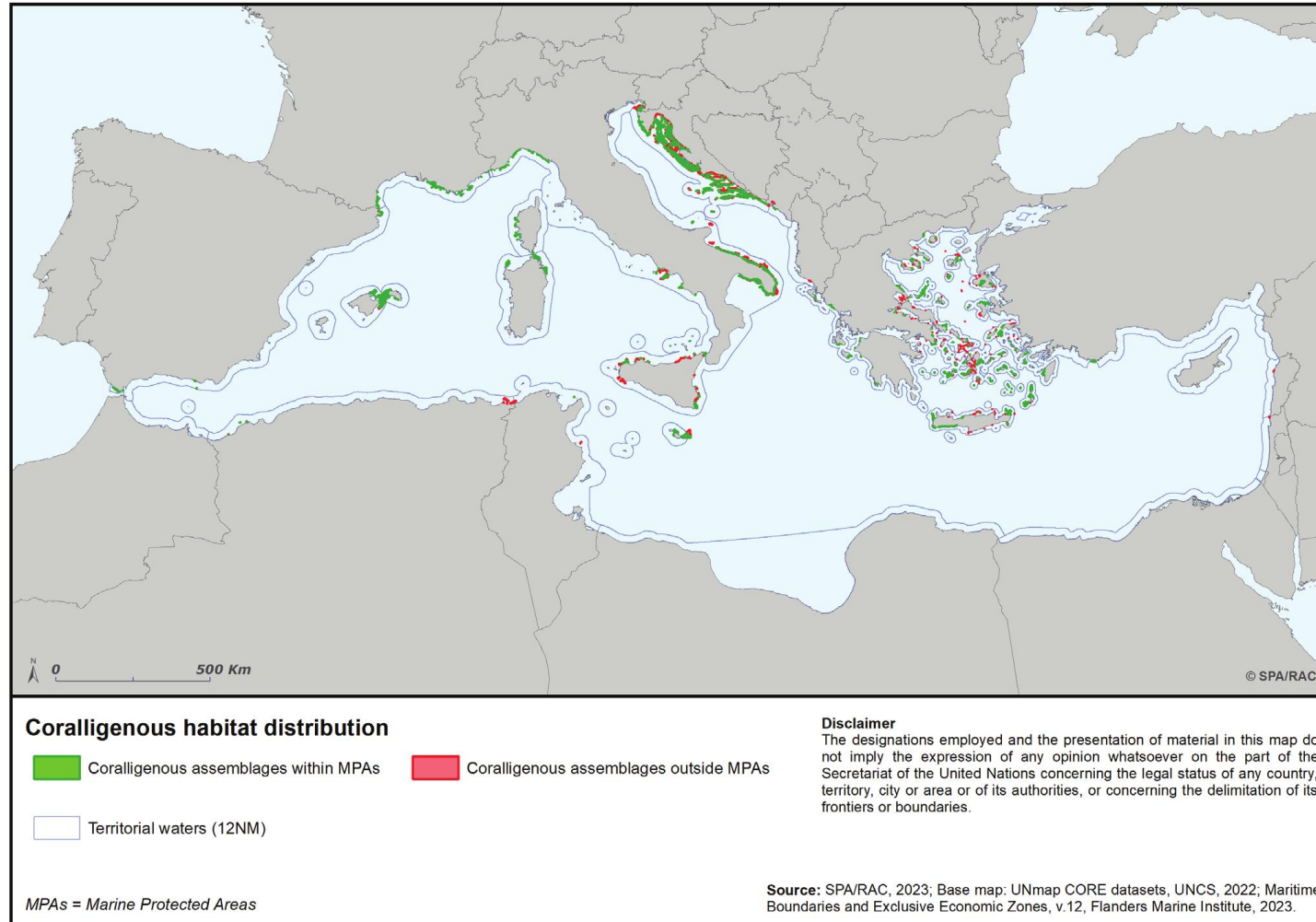
- **Why estimates may differ**

Mapping resolution • data validation • exclusion of records with insufficient reliability

- **Classification remained inconsistent**

Countries used different combinations of geomorphology, dominant taxa and assemblages

Updated distribution of coralligenous assemblages and maërl beds



2,889.5 km²

Mapped across 13 countries

92.1%

Within territorial waters

67.1%

Inside MPAs

Country-level summary: coralligenous assemblages and maërl beds

Country	Coralligenous assemblages	Coralligenous assemblages within territorial waters*		Coralligenous assemblages inside MPAs		Certainty (based on data quality and availability)**
	Area (km ²)	Area (km ²)	%	Area (km ²)	%	
Albania	0.1	0.06	100	-	-	Low
Algeria	50.7	50.7	100	0.33	0.6	Low
Bosnia and Herzegovina	-	-	-	-	-	No data
Croatia	406.2	406.2	100	263.5	64.9	High
Cyprus	-	-	-	-	-	No data
Egypt	-	-	-	-	-	No data
France	40.0	40.0	100	39.98	99.8	High
Greece	79.1	77.5	98	72	91	Moderate
Israel	1.2	1.2	100	-	-	Low
Italy	833.0	833.0	100	513.1	61.6	High
Lebanon	0.3	0.3	100	-	-	Low
Libya	-	-	-	-	-	No data
Malta	458.3	230.88	50.4	278.95	60.9	Low
Monaco	-	-	-	-	-	No data
Montenegro	0.5	0.5	100	0.4	69.9	Low
Morocco	-	-	-	-	-	No data
Slovenia	267.4	267.4	100	31.5	11.8	Low
Spain	741.6	741.6	100	738.4	99.6	Moderate
Syria	-	-	-	-	-	No data
Tunisia	11.1	11.1	100	0.1	0.7	Low
Türkiye	-	-	-	-	-	No data
Total Mediterranean	2,889.5	2,660.5	92.1	1,938.2	67.1	Moderate

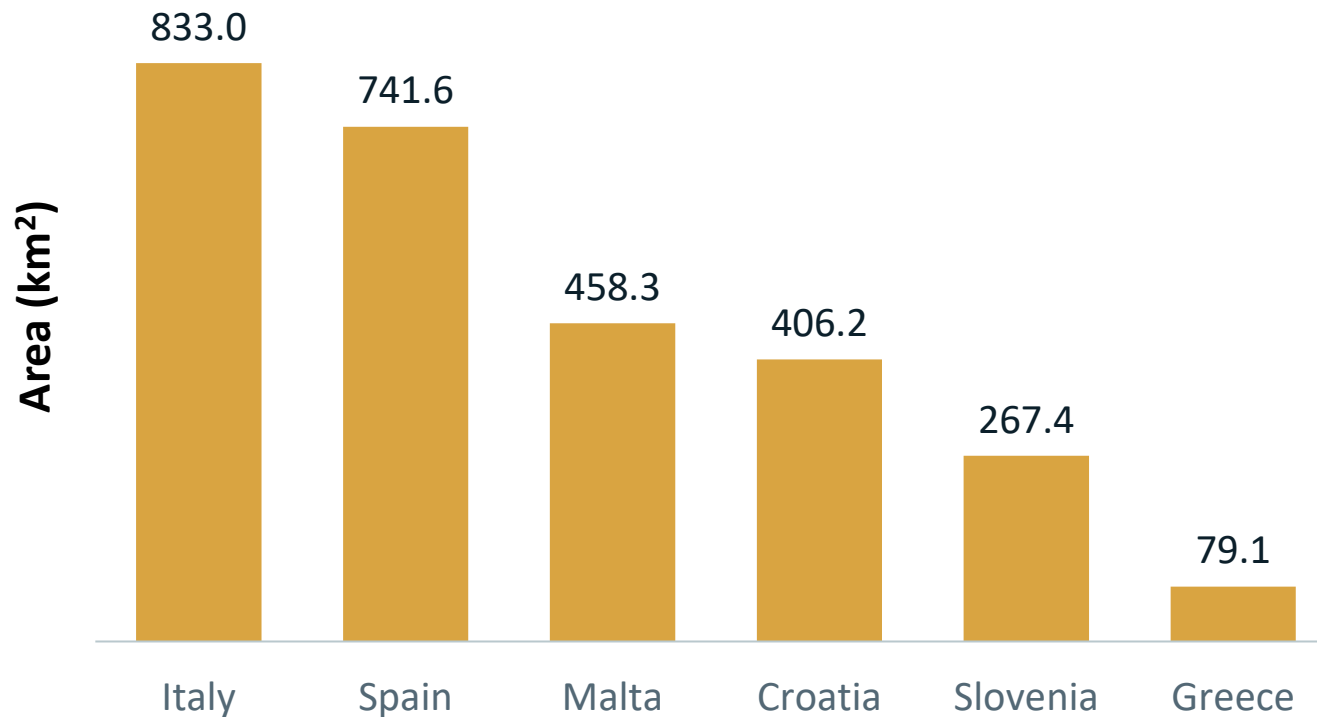
Data certainty

- High in three countries: Croatia, France and Italy
- Moderate in Greece and Spain
- No spatial data for eight countries

Current distribution

- Concentrated in the Central and Western Mediterranean
- Important coverage in the Adriatic Sea
- Major gaps in North Africa and the Eastern Mediterranean
- These patterns reflect differences in research effort and data availability, rather than the absence of the habitats

Mapped coralligenous and maërl area by country



- Most mapped area is concentrated in six countries.
- Italy and Spain account for more than half of the mapped area.
- Differences reflect mapping effort, data availability and habitat distribution.

Marine caves are biodiversity reservoirs and refuge habitats



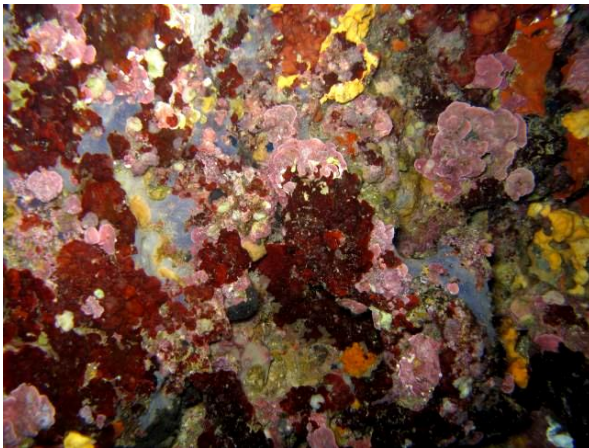
ENTRANCE

SEMI-DARK

DARK

■ Light declines

Algae disappear and suspension feeders become dominant.



■ Confinement increases

Water renewal and food supply generally decrease.



■ Distinct assemblages develop

Sponges, corals, bryozoans, serpulids and brachiopods form specialised assemblages.



Photos © Vasilis Gerovasileiou

**Marine caves harbour rare, cave-exclusive and deep-water-affinity species.
Their low resilience calls for specific protection.**

(Gerovasileiou & Bianchi, 2021 *OMBAR*)

Cave knowledge was detailed locally but fragmented regionally

ECOREGIONAL PATTERNS

Earlier syntheses described broad Mediterranean patterns at the ecoregion level (Giakoumi *et al.*, 2013 *PLoS ONE*)

LOCAL INVENTORIES

Detailed inventories existed for parts of Italy, Greece, Croatia, France and Spain

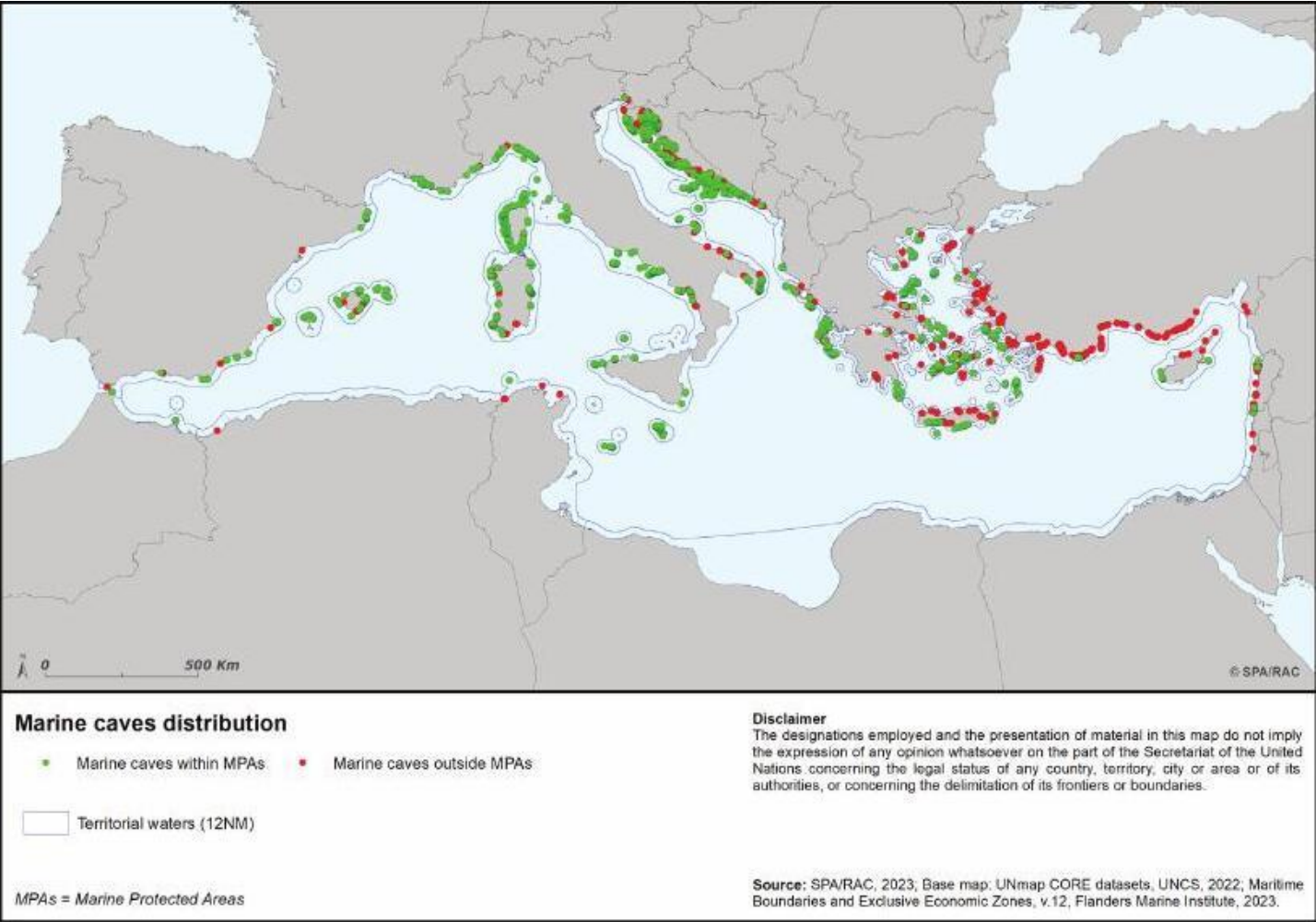
REGIONAL GAP

No systematic country-level assessment or consistent estimate of MPA overlap across the basin

Cave mapping remains difficult

Small entrances, deep or fully submerged caves, offshore islets and extensive rocky coastlines make caves difficult to locate. As a result, even high-quality national inventories are unlikely to be complete.

The first country-level Mediterranean cave inventory



2,926

Reported caves in 15 countries

99.6%

Within territorial waters

68.6%

Inside MPAs

Marine cave distribution and protection across the Mediterranean

Country	Marine caves	Marine caves within territorial waters*		Marine caves inside MPAs		Certainty (based on data quality and availability)**
	Number	Number	%	Number	%	
Albania	4	4	100	4	100	Moderate
Algeria	1	1	100	-	-	Moderate
Bosnia and Herzegovina	-	-	-	-	-	No data
Croatia	541	541	100	391	72.3	High
Cyprus	17	17	100	10	58.8	High
Egypt	-	-	-	-	-	No data
France	158	158	100	146	92.4	High
Greece	633	624	98.6	455	71.9	High
Israel	3	3	100	1	33.3	Moderate
Italy	1,009	1,009	100	844	83.6	High
Lebanon	95	95	100	6	6.3	Moderate
Libya	-	-	-	-	-	No data
Malta	33	33	100	33	100	Low
Monaco	-	-	-	-	-	No data
Montenegro	7	7	100	4	57.1	Moderate
Morocco	5	5	100	5	100	Moderate
Slovenia	-	-	-	-	-	No data
Spain	124	124	100	106	85.5	High
Syria	-	-	-	-	-	No data
Tunisia	24	24	100	1	4.2	Moderate
Türkiye	272	270	99.3	1	0.4	High
Total Mediterranean	2,926	2,915	99.6	2,007	68.6	Moderate

Data certainty

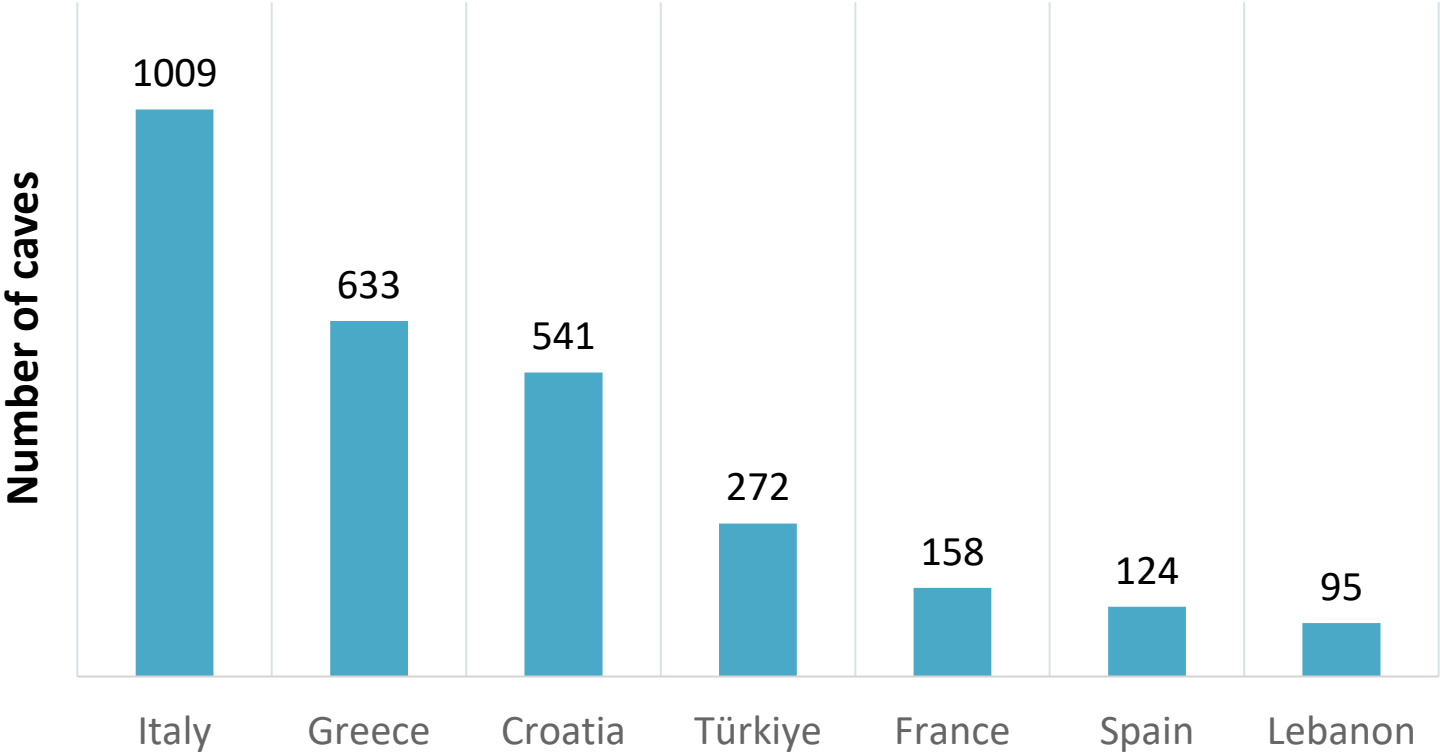
- High in seven countries
- Moderate in seven countries
- Low in Malta
- No spatial data for six countries

Inclusion in MPAs

- 68.6% of all reported caves
- 100% in Albania, Malta and Morocco
- Lowest in Türkiye, Tunisia and Lebanon

Cave numbers reflect both suitable rocky coastlines and differences in survey effort.

Known cave richness tracks rocky coasts and survey effort

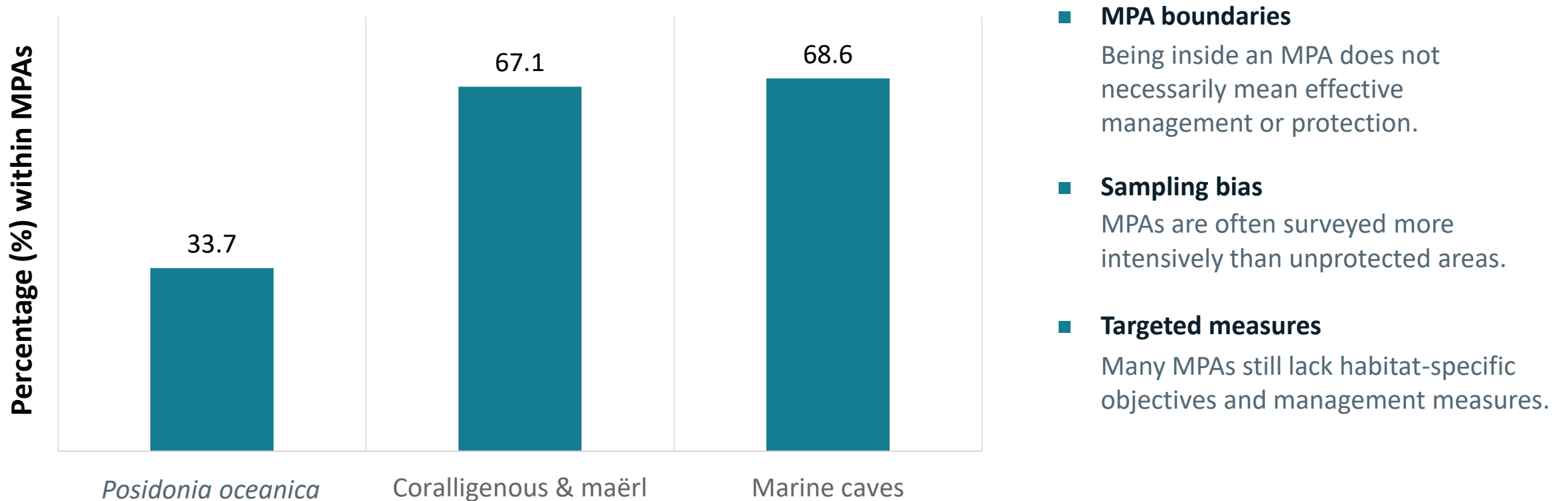


Interpretation requires caution

- **Detectability**
Shallow and semi-submerged caves are easier to detect.
- **Uneven survey effort**
Northern Mediterranean coasts have been explored more intensively.
- **Missing information**
Morphology, zonation and biological assemblages are often unavailable.

Reported caves ≠ true cave richness

MPA overlap is encouraging – but does not equal effective protection



The results show progress in formal recognition, not management effectiveness.

Restoration planning needs both habitat extent and condition

PRESENCE / EXTENT

Habitat occurrence • mapped area •
MPA overlap

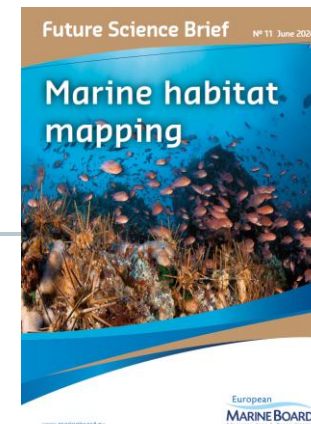
CONDITION

Ecological condition • pressures •
degradation • recovery potential

Effective restoration planning needs to connect the two

The EU Nature Restoration Regulation requires Member States to address habitat distribution and condition in national restoration plans.

How this study addresses EMB mapping priorities



REGIONAL COORDINATION

Countries,
habitat experts,
mapping
specialists and
SPA/RAC

STANDARDISATION

Common
attributes,
habitat
classification and
certainty
assessment

OPEN DATA

Published GIS
layers that can
be inspected,
reused and
updated

TRANSPARENT UNCERTAINTY

Certainty and
data gaps clearly
identified

The next step is to add habitat condition, improve biological resolution and repeat mapping over time.

A regional baseline for three key marine habitats

1	Regional compilation	Combined fine-scale data from regional databases, National Focal Points, experts and online repositories.
2	Three habitat layers	Updated distributions for <i>Posidonia</i> , coralligenous and maërl, and marine caves.
3	MPA overlap assessment	Calculated overlap with territorial waters and MPAs.
4	Open spatial baseline	Published harmonised GIS layers for reuse and future updates.
5	Remaining limitations	Reported uneven coverage, classification differences and gaps in condition data.

The result supports conservation planning, monitoring and management under the Barcelona Convention.

Priorities for Mediterranean habitat conservation and management

- | | | |
|---|---|--|
| 1 | Fill regional data gaps | Prioritise North Africa, the Eastern Mediterranean and non-EU coasts. |
| 2 | Standardise habitat classifications | Improve comparison across countries. |
| 3 | Improve reporting and condition assessment | Report pressures, ecological condition, degradation and recovery potential. |
| 4 | Strengthen MPA effectiveness | Move from boundary overlap to representative, connected and actively managed networks. |
-

THE TAKE-HOME MESSAGE

Regional maps provide a baseline for conservation and management

Their value grows when uncertainty is explicit and the data are validated, shared and regularly updated.



20,235 km² *Posidonia* meadows

2,889.5 km² coralligenous & maërl

2,926 marine caves

Special thanks to SPA/RAC, the National Focal Points, habitat experts and data holders who contributed data, knowledge and validation!

Thank you for your attention!

Vasilis Gerovasileiou

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