CINEA/EMFAF/2021/3.1.2/03/SC04/SI2.881222

Specific Contract 2021/3.1.2/03/SC04

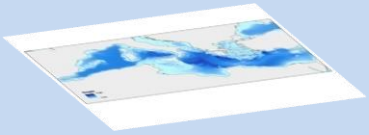
Hosting, maintenance and further development of the Regional Database for the Mediterranean and Black Seas

Med&BS RDBFIS

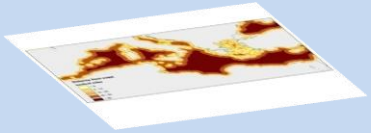
Mapping spatial distribution of SSF in data limited cases: An overview of Multi-Criteria Decision Analysis.

Presenting: Irida Maina

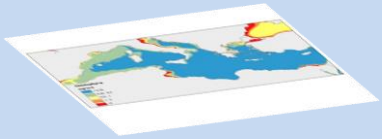
Criteria
(Spatio-temporal Data)



Bathymetry



Distance from coastline



Environmental conditions

Fisheries restricted areas

AHP → FM → Suitability index

Analytic Hierarchy Process

Fishing fleet by registration/home port
(Spatio-temporal data)

Fishing vessels length*GT → Interpolation → Vessels activity indicator index

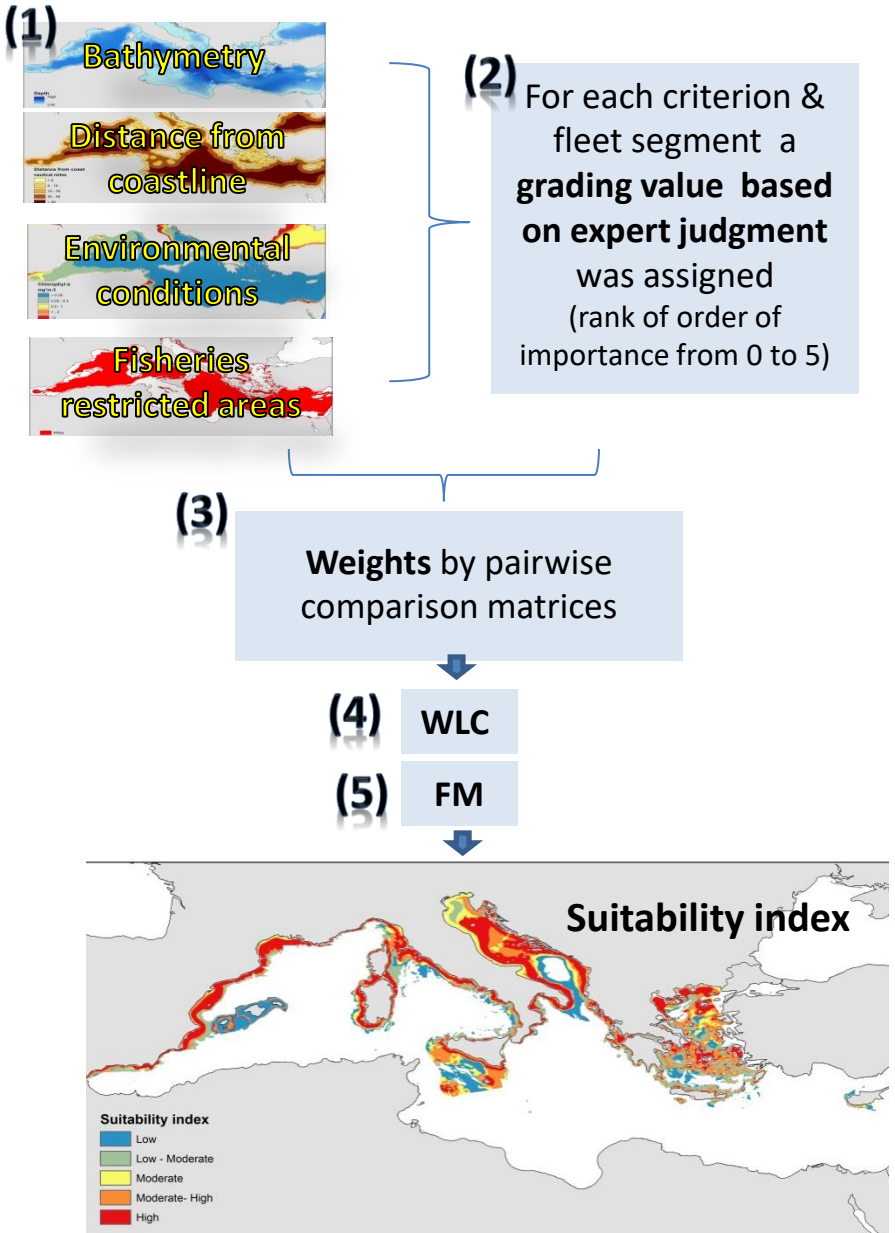
Fuzzy Membership

FM → Activity index

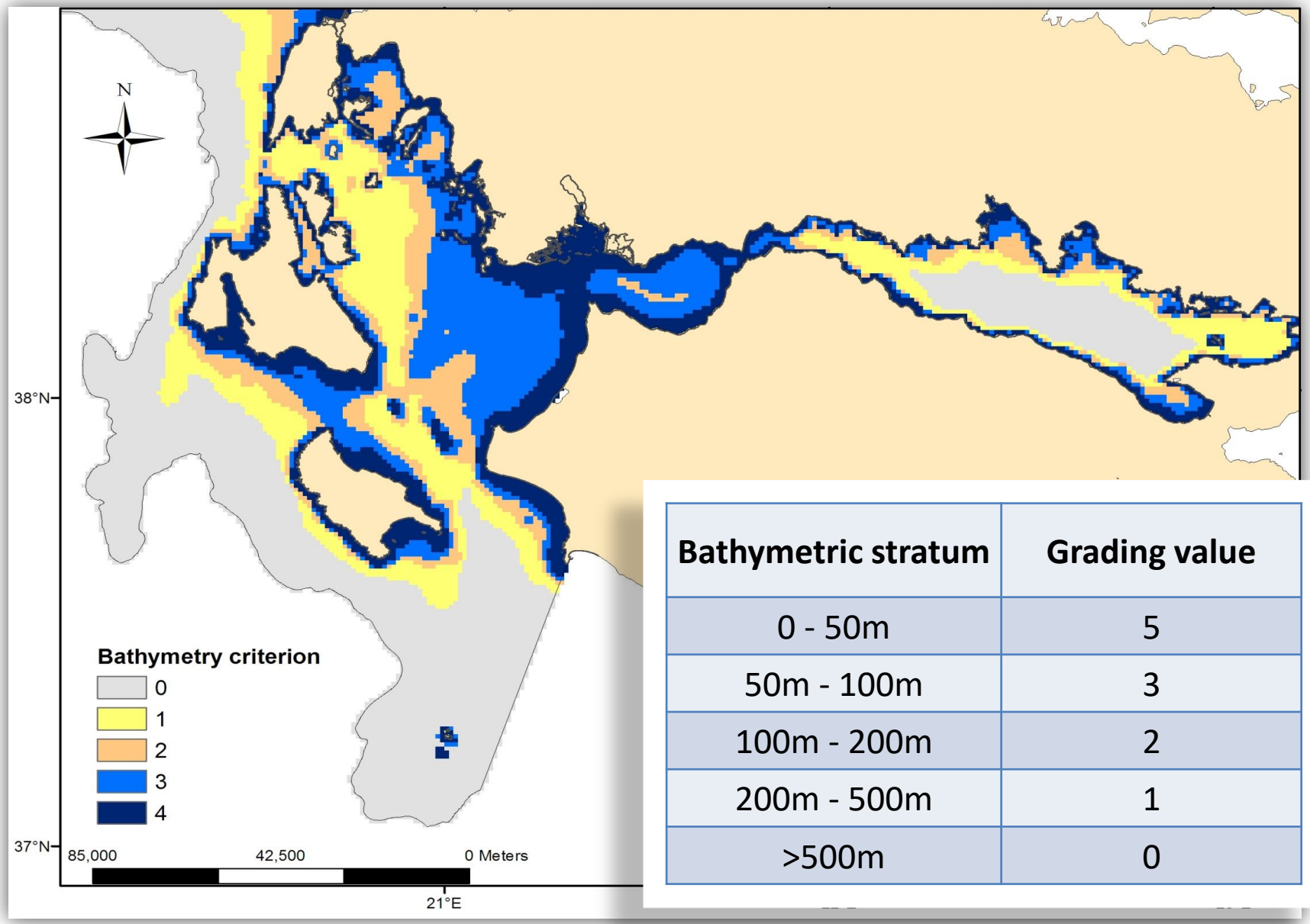
Suitability index + Activity index → Fishing pressure index

Suitability index (Sc)

1. Creation of **spatial information for each criterion**
2. Calibration of each criterion according to a **scale of evaluation** and formation of the **hierarchical structure** of the multiple criteria problem
3. Selection of the optimal result by simulation pairwise comparisons of importance of pressures as a measurement method of the **Analytic Hierarchy Process (AHP)**
4. Implementation of the **Weighted Linear Combination (WLC)** method to estimate suitability indexes
5. Standardization at a scale from 0 to 1 with linear **Fuzzy Membership** function

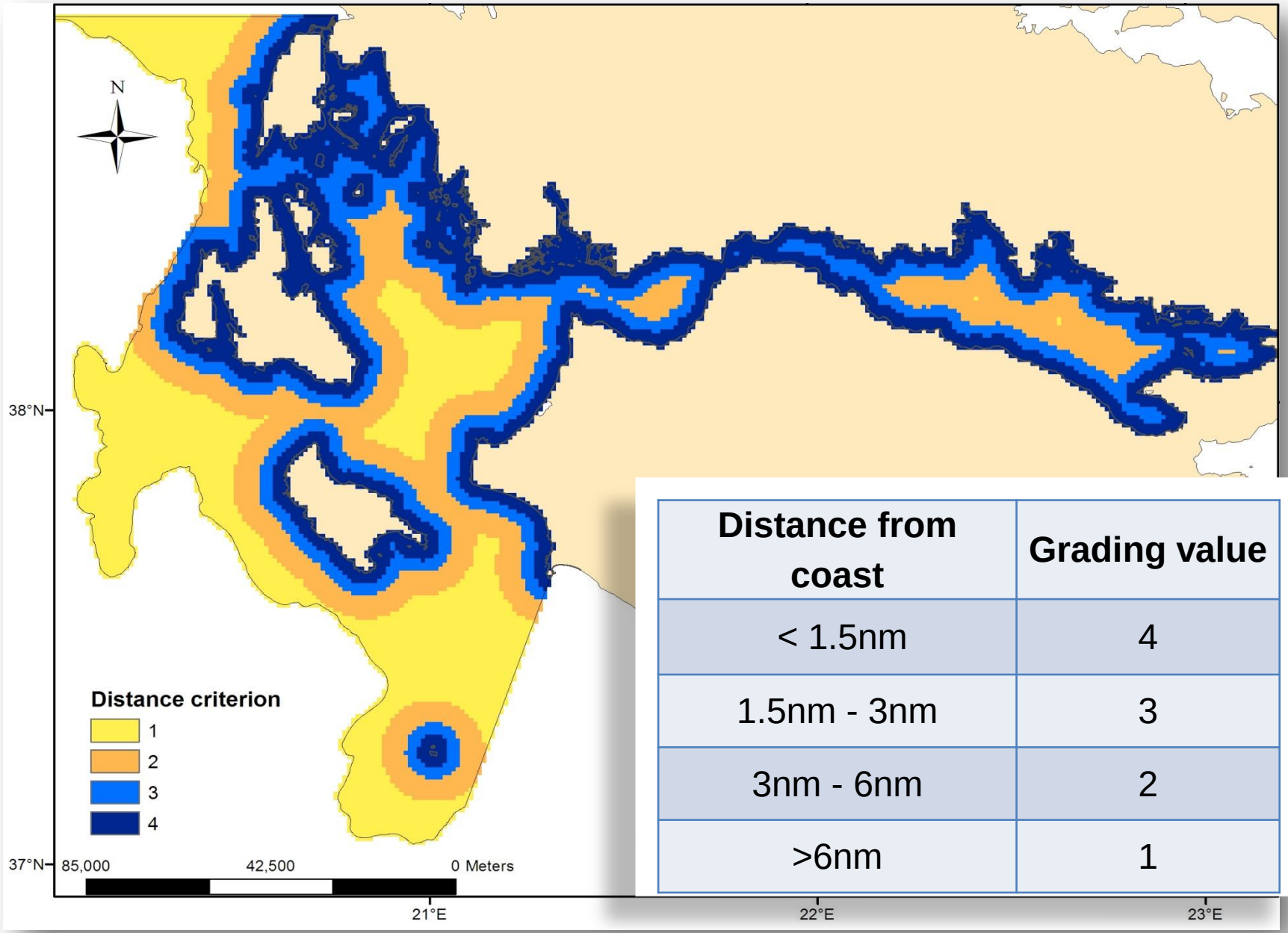


BATHYMETRY CRITERION



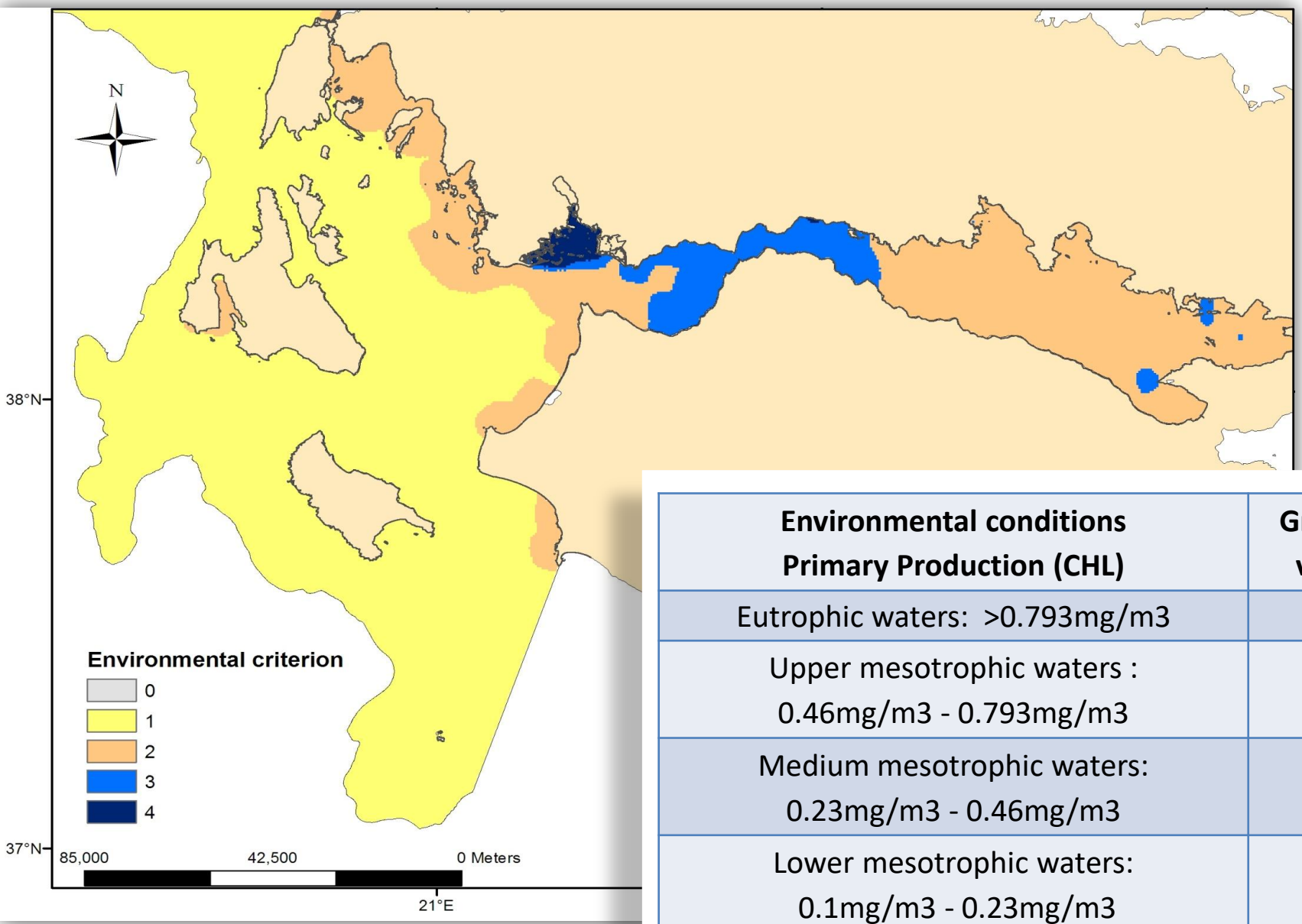
Bathymetric stratum	Grading value
0 - 50m	5
50m - 100m	3
100m - 200m	2
200m - 500m	1
>500m	0

DISTANCE FROM COAST CRITERION



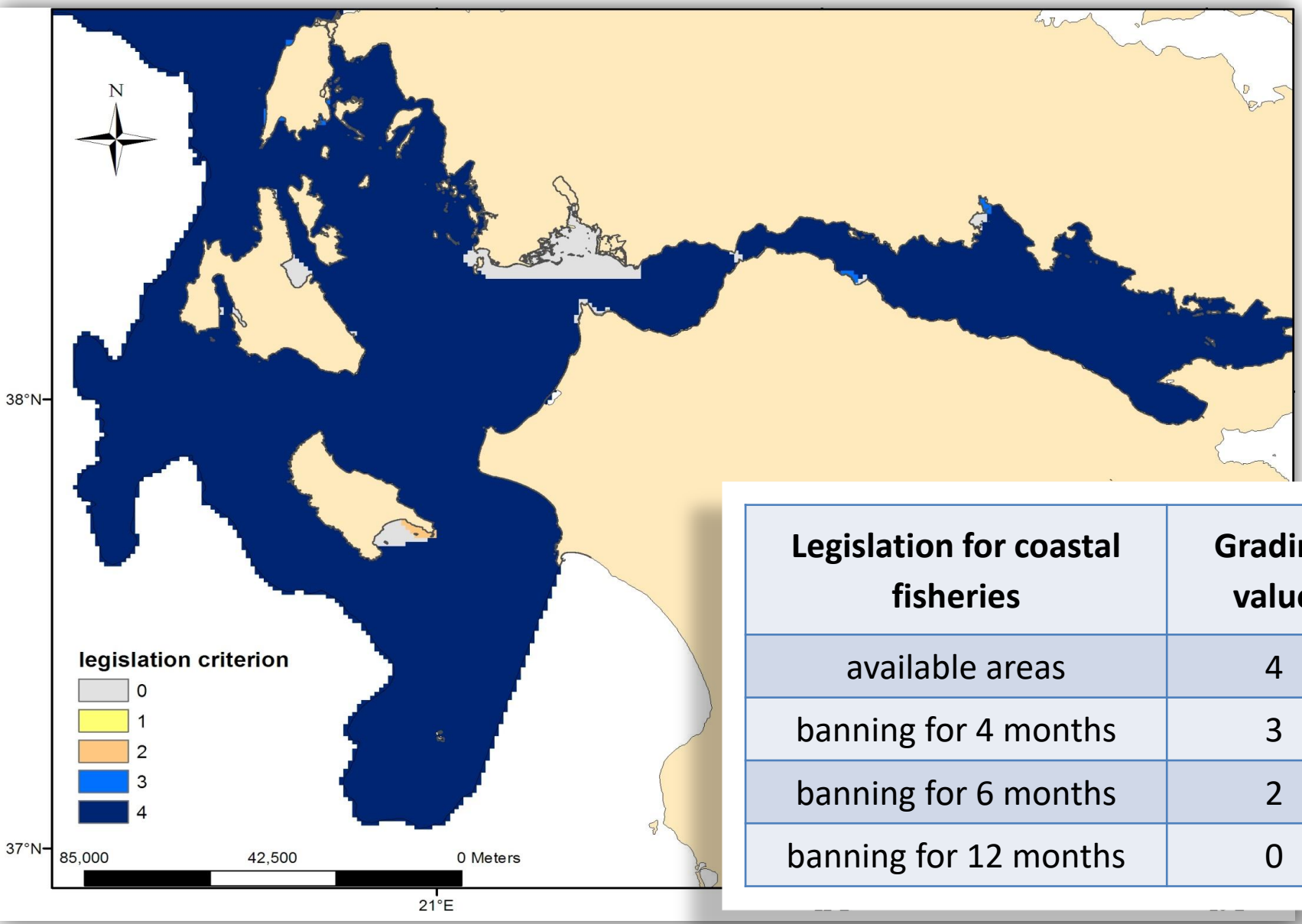
Distance from coast	Grading value
< 1.5nm	4
1.5nm - 3nm	3
3nm - 6nm	2
>6nm	1

ENVIRONMENTAL CRITERION (chlorophyll-a)



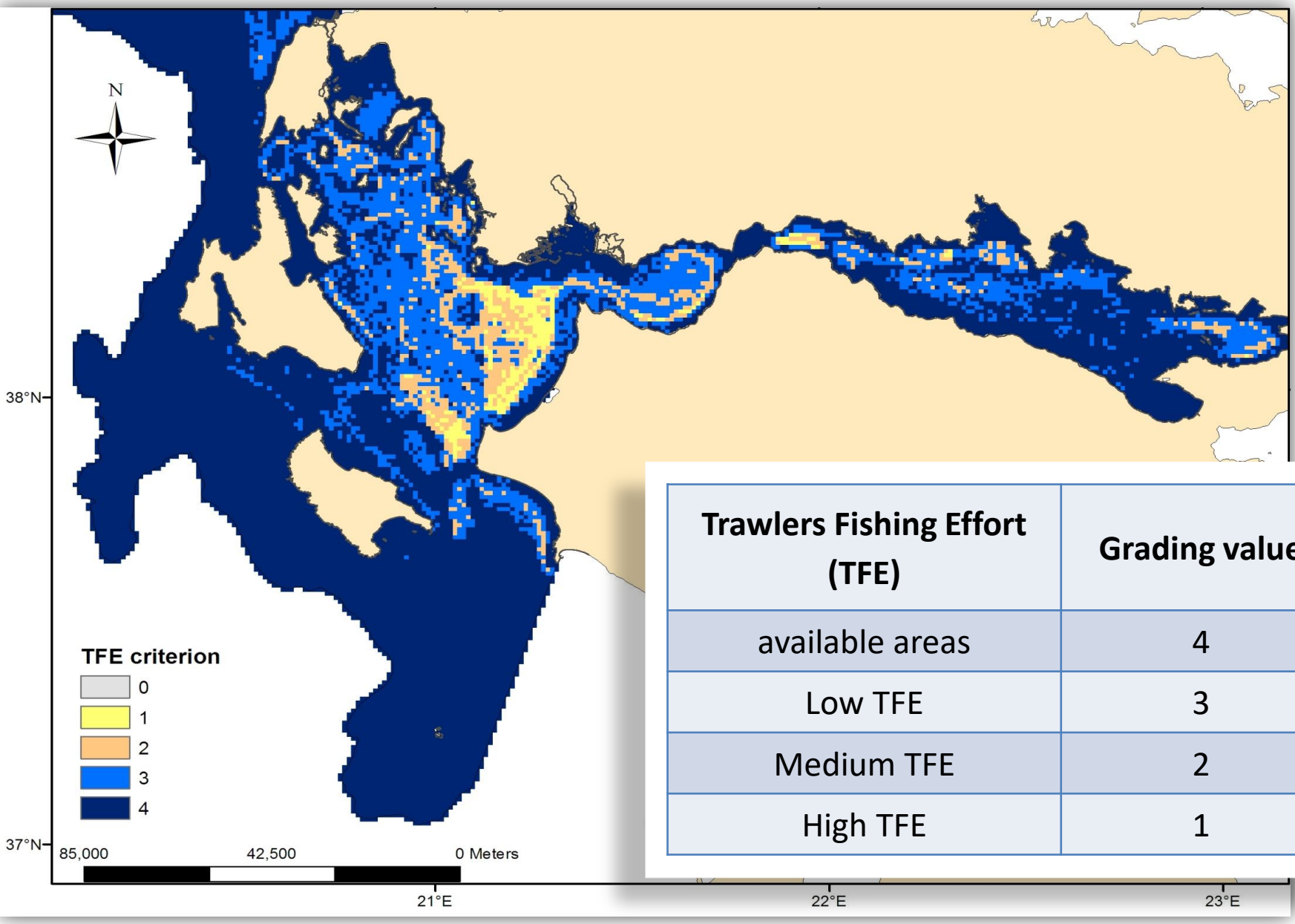
Environmental conditions Primary Production (CHL)	Grading value
Eutrophic waters: >0.793mg/m3	4
Upper mesotrophic waters : 0.46mg/m3 - 0.793mg/m3	3
Medium mesotrophic waters: 0.23mg/m3 - 0.46mg/m3	2
Lower mesotrophic waters: 0.1mg/m3 - 0.23mg/m3	1

LEGISLATION CRITERION



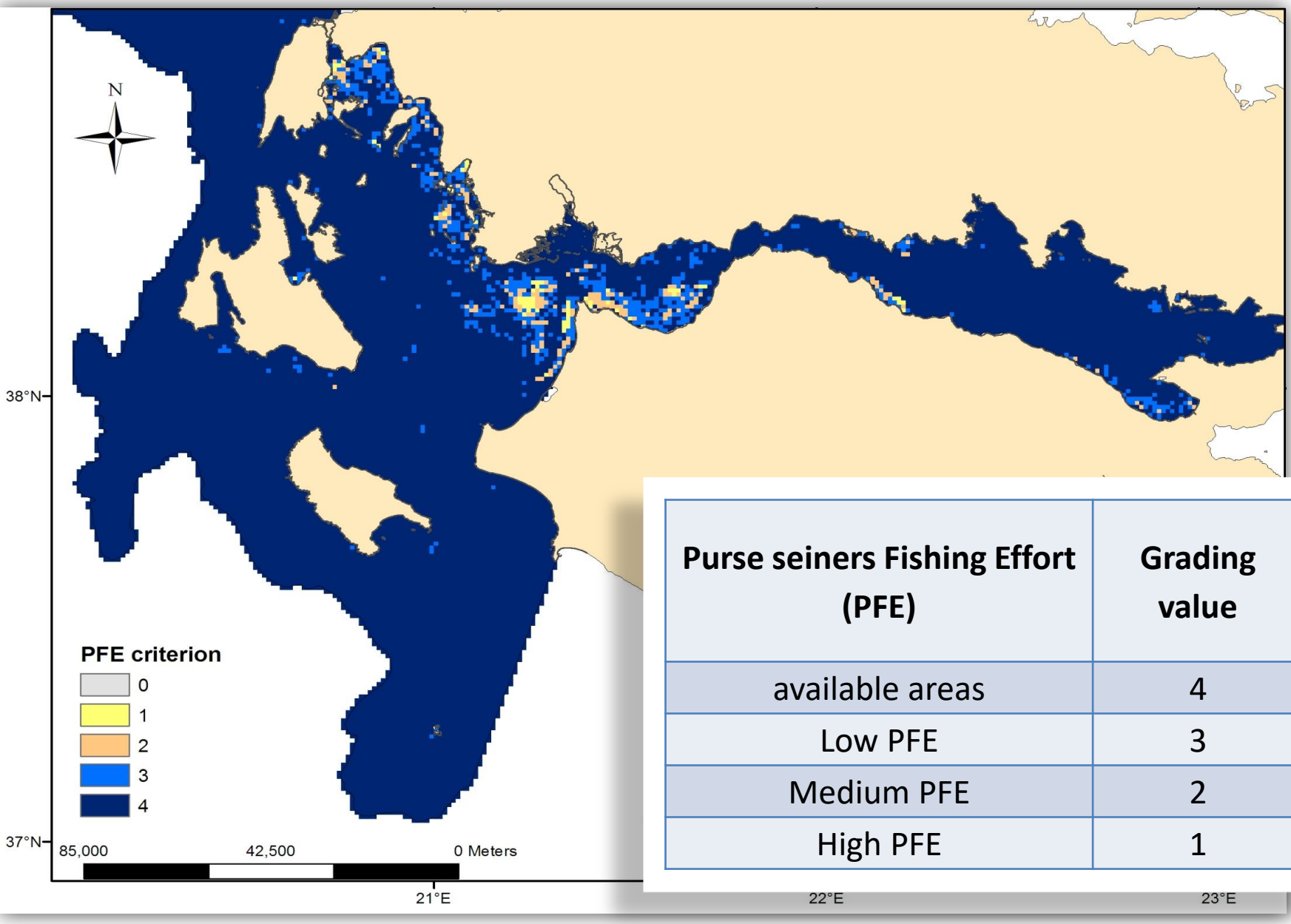
Legislation for coastal fisheries	Grading value
available areas	4
banning for 4 months	3
banning for 6 months	2
banning for 12 months	0

TRAWLERS FISHING EFFORT CRITERION



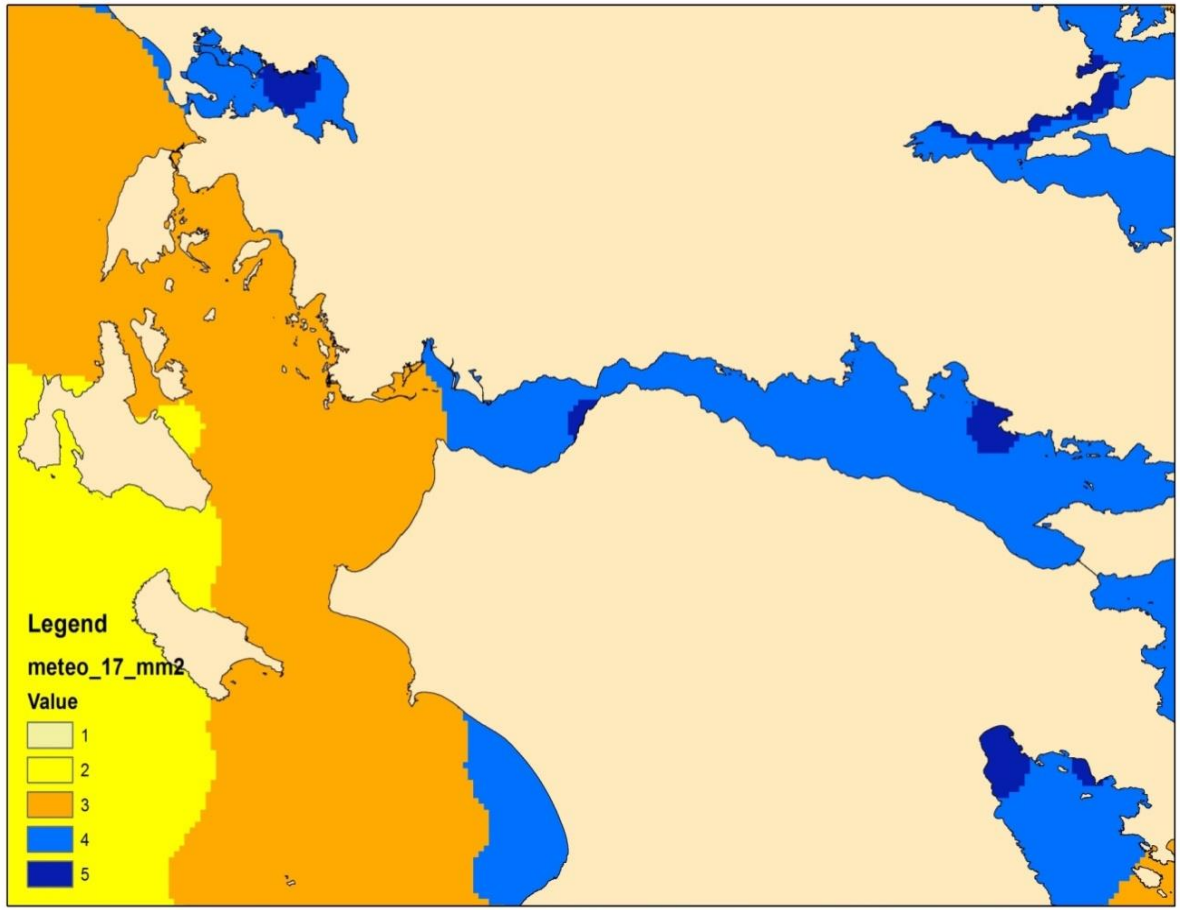
Trawlers Fishing Effort (TFE)	Grading value
available areas	4
Low TFE	3
Medium TFE	2
High TFE	1

PURSE SEINERS FISHING EFFORT CRITERION



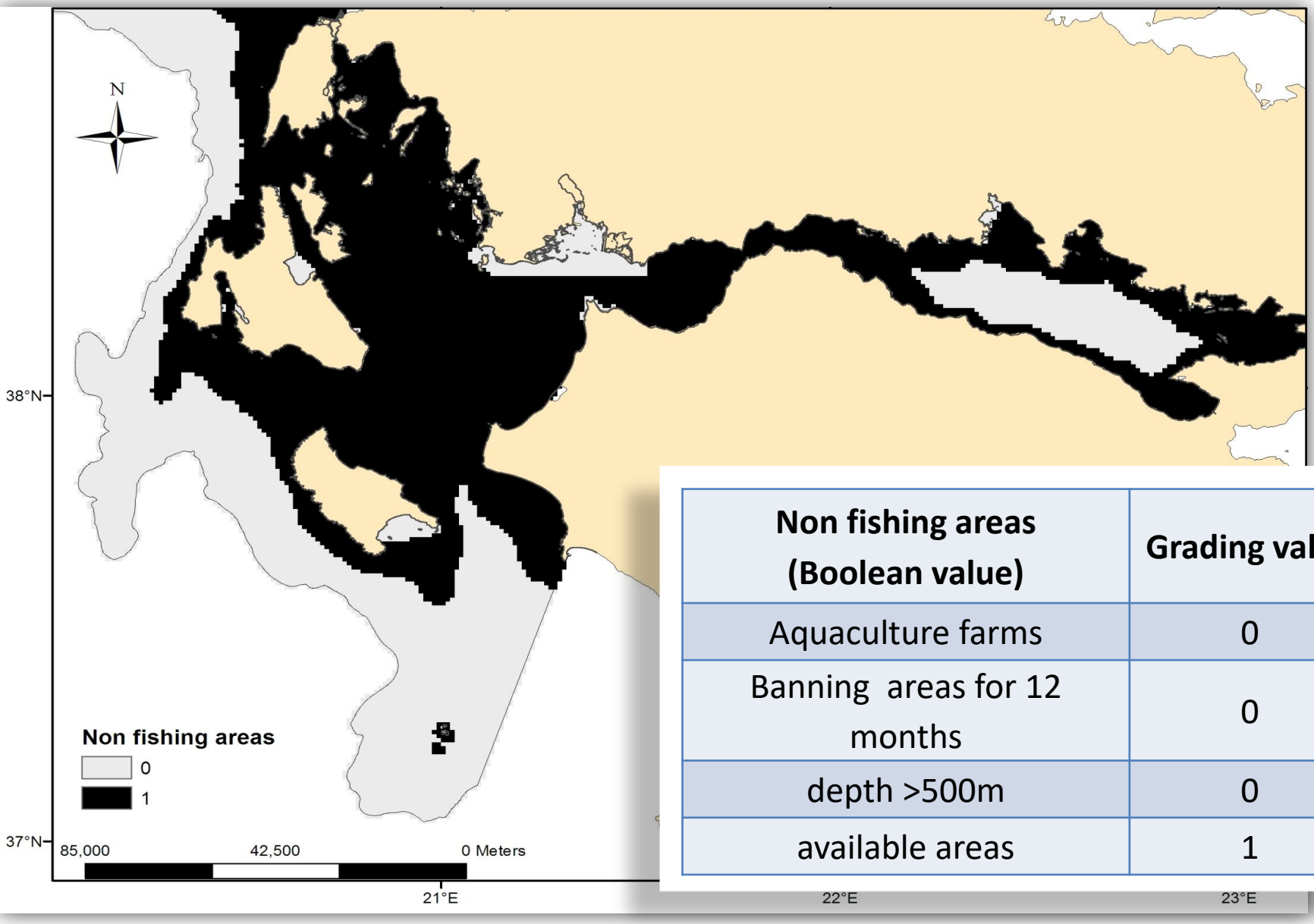
Purse seiners Fishing Effort (PFE)	Grading value
available areas	4
Low PFE	3
Medium PFE	2
High PFE	1

Meteorological criterion
(wind speed, temperature, total precipitation)



Meteorological criterion (estimates per hour and aggregation by month)	**Grading**
Low wind speed	5
Moderate wind speed and low precipitation	4
Moderate wind speed and high precipitation	3
High wind speed and low precipitation	2
High wind speed and high precipitation	1
Very high wind speed and extreme temperature values	0

NON FISHING AREAS



Non fishing areas (Boolean value)	Grading value
Aquaculture farms	0
Banning areas for 12 months	0
depth >500m	0
available areas	1

Creating the grading values for each criterion based on expert judgment

Information provided annually

Depth	Grading
0 - 50m	5
50m - 100m	4
100m - 150m	3
150m - 200m	2
200μ – 500μ	1
>500m	0

Distance from coast	Grading
< 1.5nm	4
1.5nm - 3nm	3
3nm - 6nm	2
>6nm	1

No take zones	Grading
Available areas	1
Banned or restricted areas	0

Information provided per quarter/year

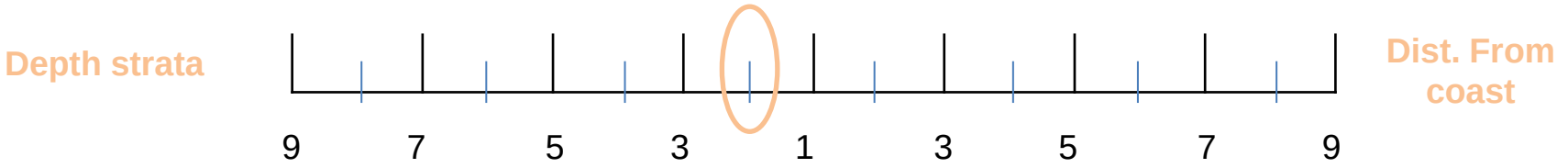
Chlorophyll-a	Grading
Very eutrophic waters: >2mg/m3	3
Eutrophic waters: >0.793mg/m3	5
Upper mesotrophic waters : 0.46mg/m3 - 0.793mg/m3	4
Medium mesotrophic waters: 0.23mg/m3 - 0.46mg/m3	2
Lower mesotrophic waters: 0.1mg/m3 - 0.23mg/m3	1

Fishing effort for purse seine	Grading
No purse seining	5
Low FE	4
Moderate FE	3
High FE	1

Fishing Effort for trawl	Grading
No trawling	5
Low FE	4
Moderate FE	3
High FE	1

Analytic Hierarchy Process (AHP)

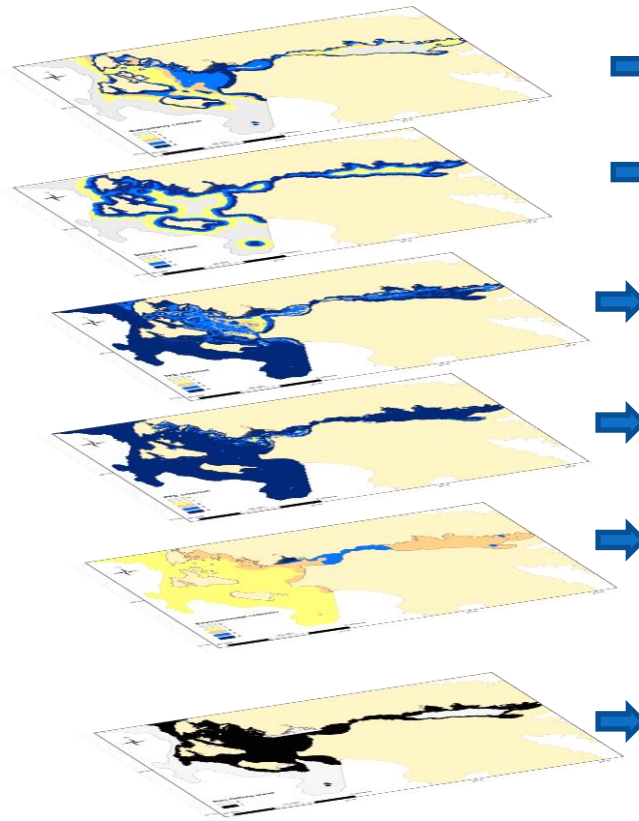
- Selection of the optimal result by simulation pairwise comparisons of importance of pressures as a measurement method of the **AHP**



	depth	dist. Coast	Legislat-ion	OTB (FE)	PS (FE)	meteo	chl-a	**weights**
depth	1	2.00	5.00	5.00	5.00	2.00	5.00	**0.313**
dist. Coast	0.50	1	6.00	4.00	4.00	1.00	4.00	**0.213**
Legislation	0.20	0.17	1	1.00	1.00	0.17	1.00	**0.049**
OTB (FE)	0.20	0.25	1.00	1	3.00	0.17	0.33	**0.058**
PS (FE)	0.20	0.25	1.00	0.33	1	0.17	0.33	**0.041**
meteo	0.50	1.00	5.88	5.88	5.88	1	5.00	**0.246**
chl-a	0.20	0.25	1.00	3.03	3.00	0.20	1	**0.079**

CR 0.05 < 0.1

Suitability Index (Sc)



Bathymetry criterion (a)

Distance from coast criterion (b)

Trawlers Fishing Effort criterion (d)

Purse seiners Fishing Effort criterion (e)

Environmental criterion (g)

Non fishing areas (h)

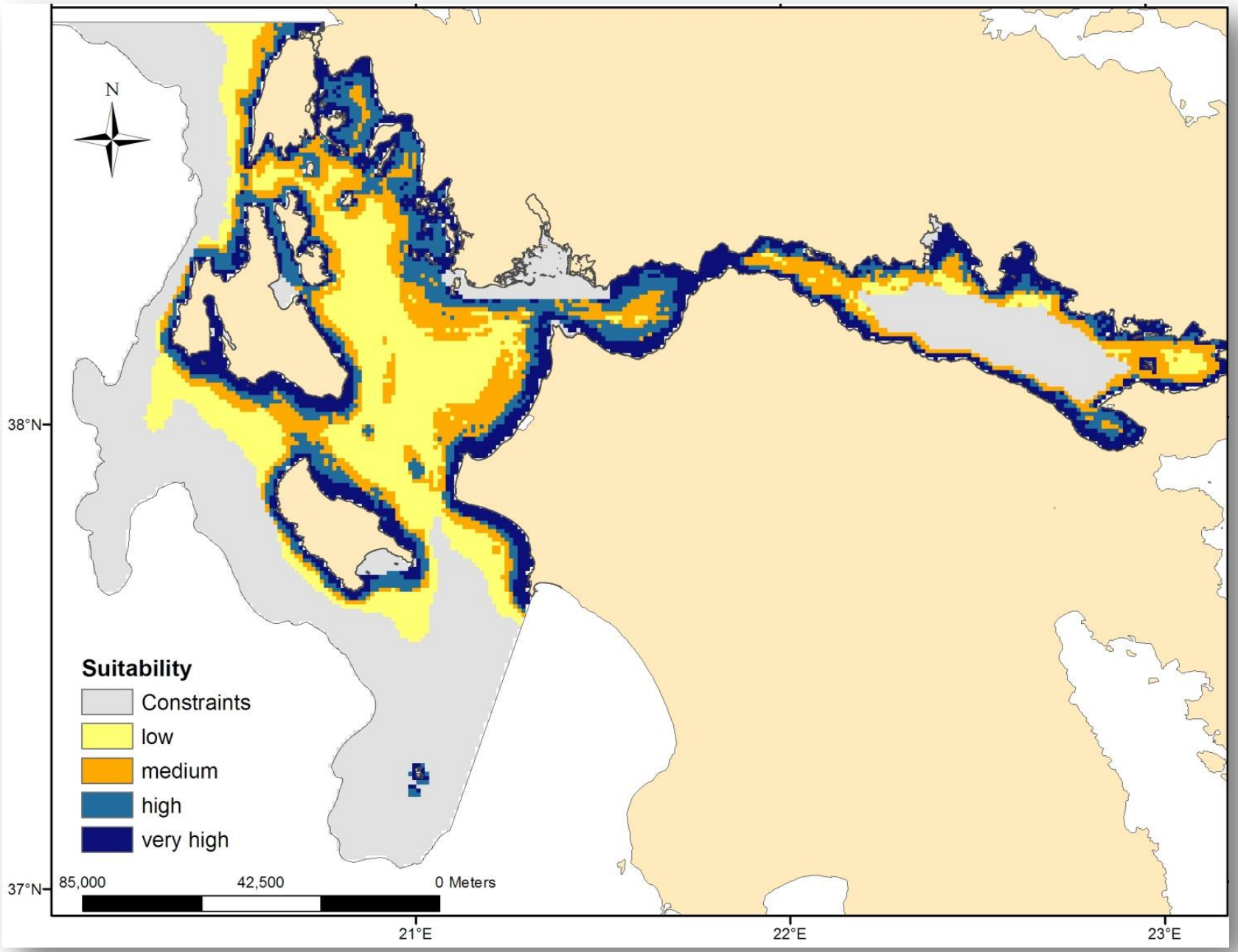
Weights by pairwise comparison

	depth	dist. Coast	Legislation	OTB (FE)	PS (FE)	meteo	chl-a	weights
depth	1	2.00	5.00	5.00	5.00	2.00	5.00	0.313
dist. Coast	0.50	1	6.00	4.00	4.00	1.00	4.00	0.213
Legislation	0.20	0.17	1	1.00	1.00	0.17	1.00	0.049
OTB (FE)	0.20	0.25	1.00	1	3.00	0.17	0.33	0.058
PS (FE)	0.20	0.25	1.00	0.33	1	0.17	0.33	0.041
meteo	0.50	1.00	5.88	5.88	5.88	1	5.00	0.246
chl-a	0.20	0.25	1.00	3.03	3.00	0.20	1	0.079

Weighted Linear Combination :

$$Sc = ((a*0.313) + (b*0.213) + (c*0.049) + (d*0.058) + (e*0.041) + (f*0.246) + (g*0.079)) * h$$

Suitability Index (Sc)



Activity index (Ac)

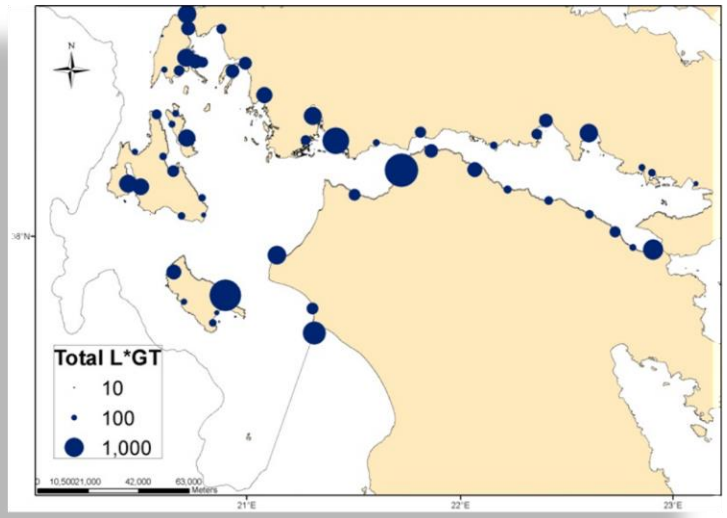
1. **Estimation of vessels activity indicator at each fishing port (VAIp):**

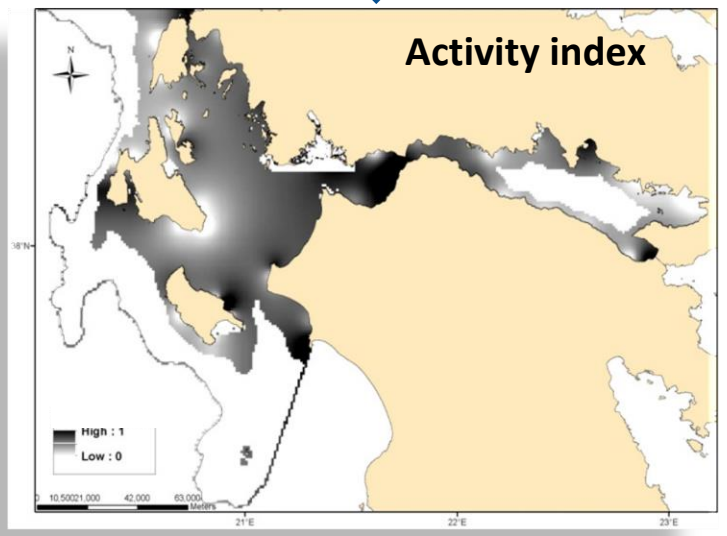
$$VAIp = \sum_{v=1}^{n} (L * GT)$$

L: Length
GT: Gross tonnage
v: vessels (n: Total number of vessels at each fishing port)

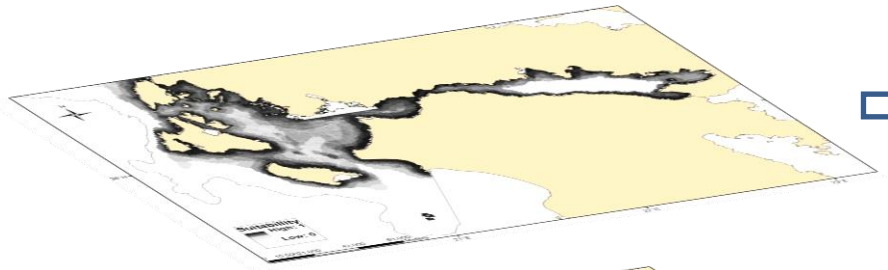
2. **Implementation of Inverse Distance Weighted (IDW) interpolation method to VAIp index**

3. **Standardization with a Fuzzy Membership Function in a scale 0 – 1 :**
   - ❑ Fuzzy Linear applies a linear function between the user specified minimum and maximum values (commonly used)

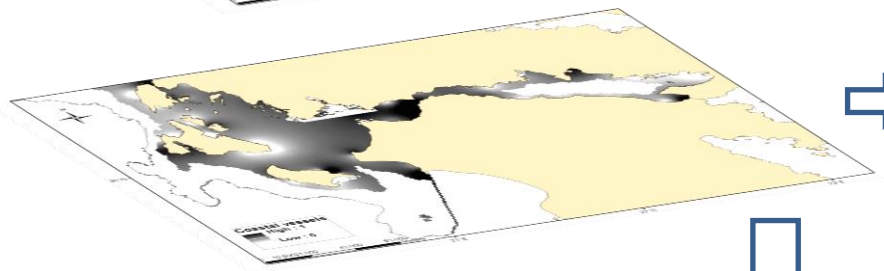




Fishing Pressure index (FPc)



Suitability index **(Sc)**



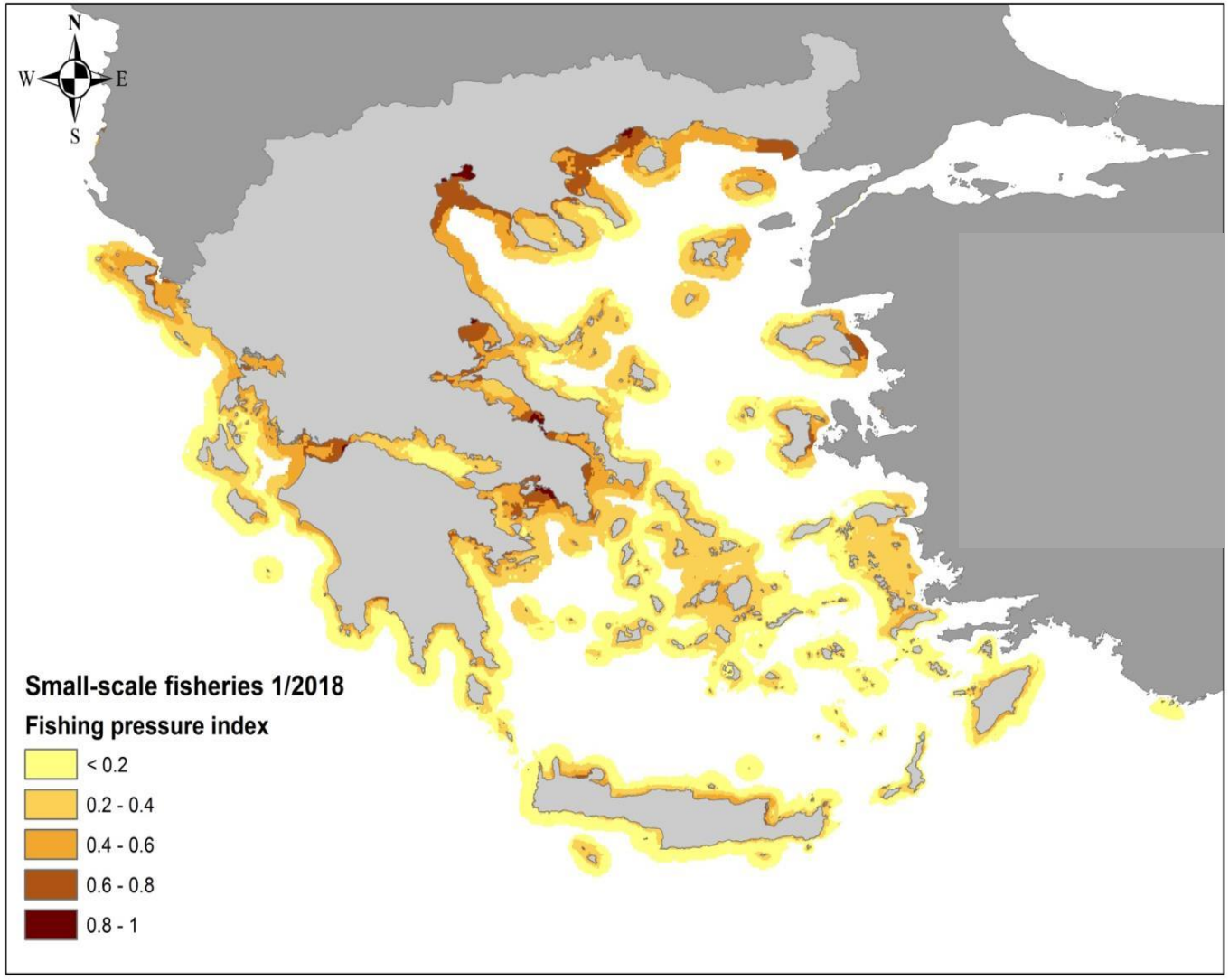
Activity index **(Ac)**

FPc = Sc*Ac

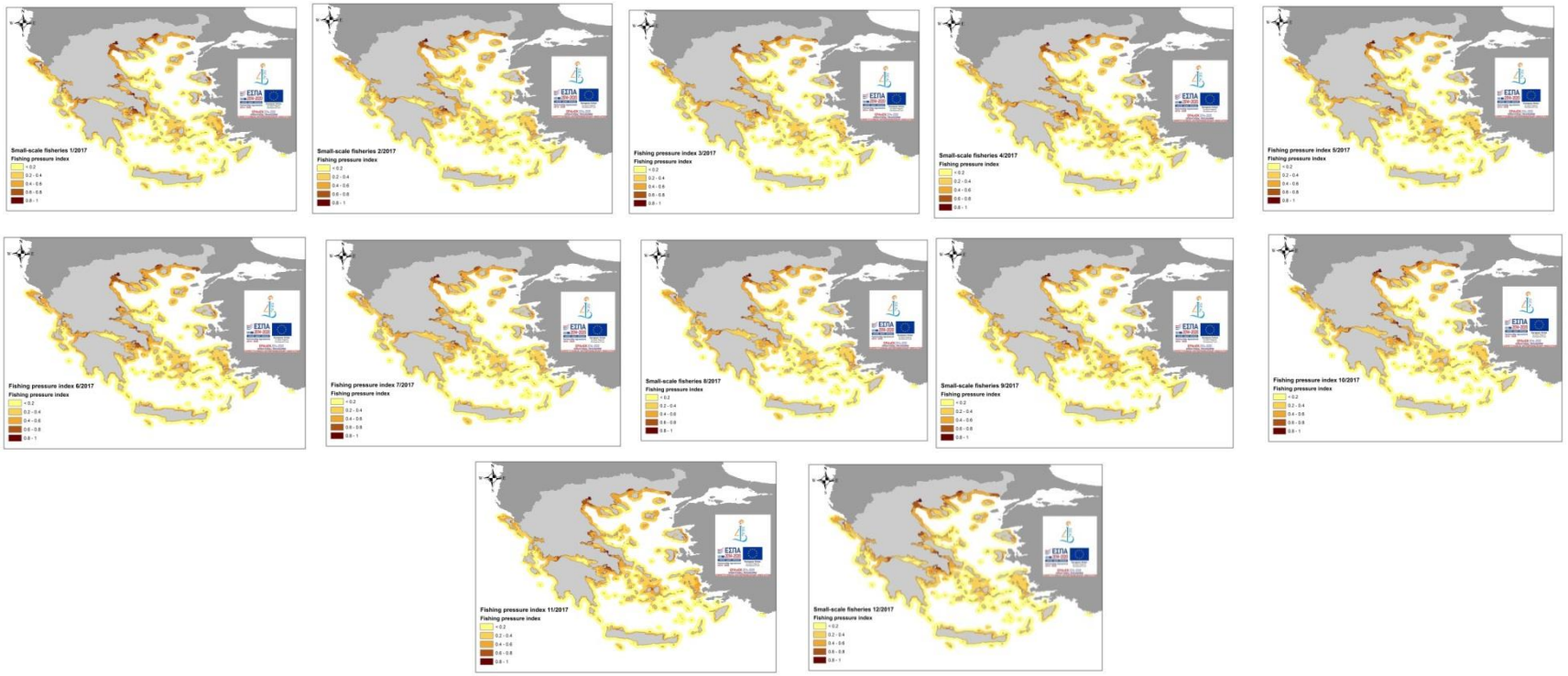
Fuzzy overlay: Fuzzy Product

Results transformed to a scale 0-1 based on a linear FM function

Fishing pressure index for small-scale fisheries

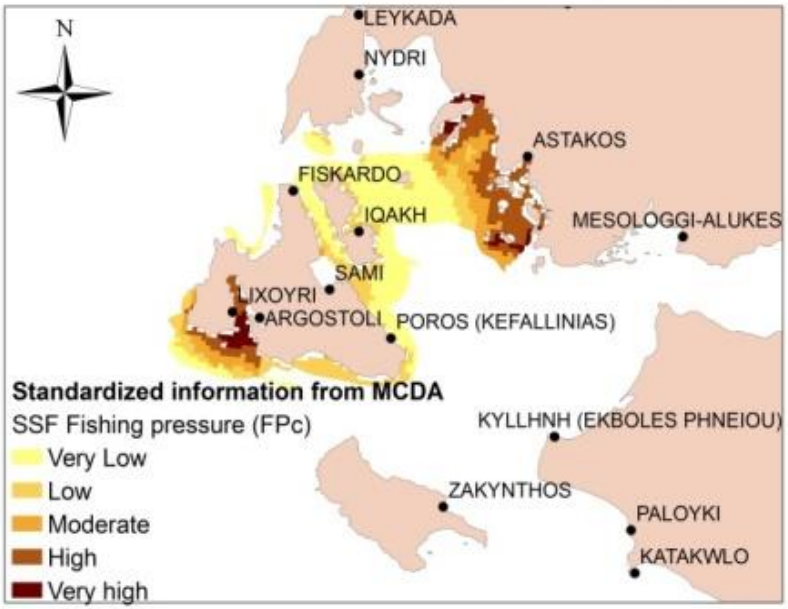


An example of fishing pressure index estimation for SSF in a monthly scale for 2017

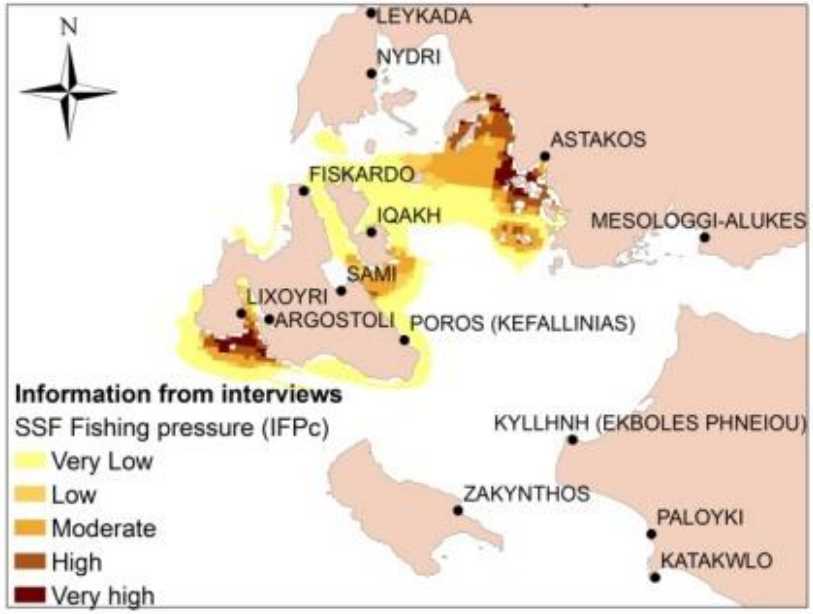


Verifying MCDA outcomes on SSF fishing pressure (<12m) based on interviews

1) MCDA approach

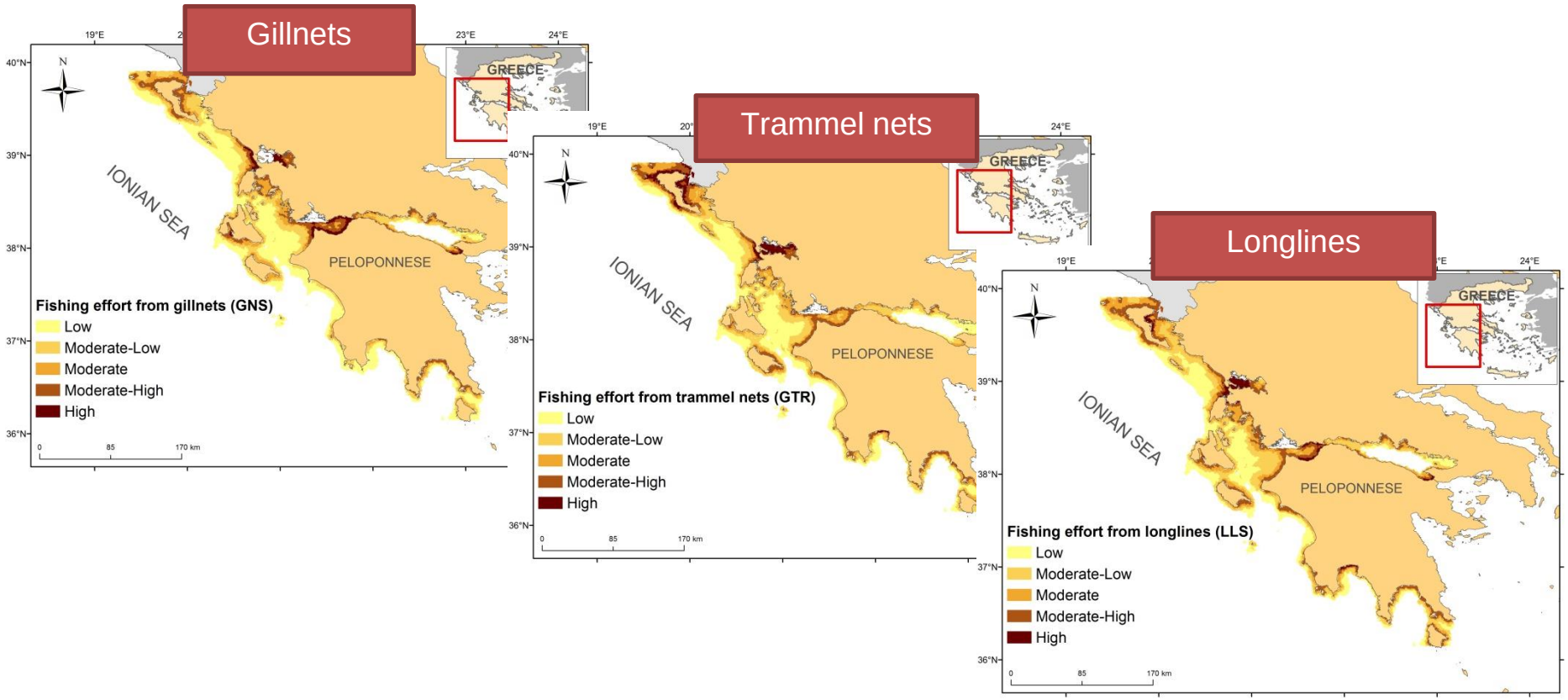


2) Information from interviews



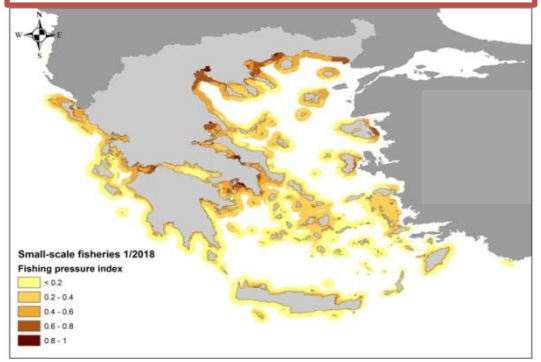
Spearman ρ	Pearson's r	linear regression		RMSE
		b	m	
0.69	0.72	0.48	0.1	0.09

Estimations of fishing pressure from Small Scale Fisheries can be applied by fishing gear or fleet segment

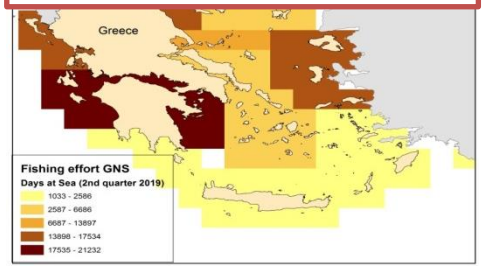


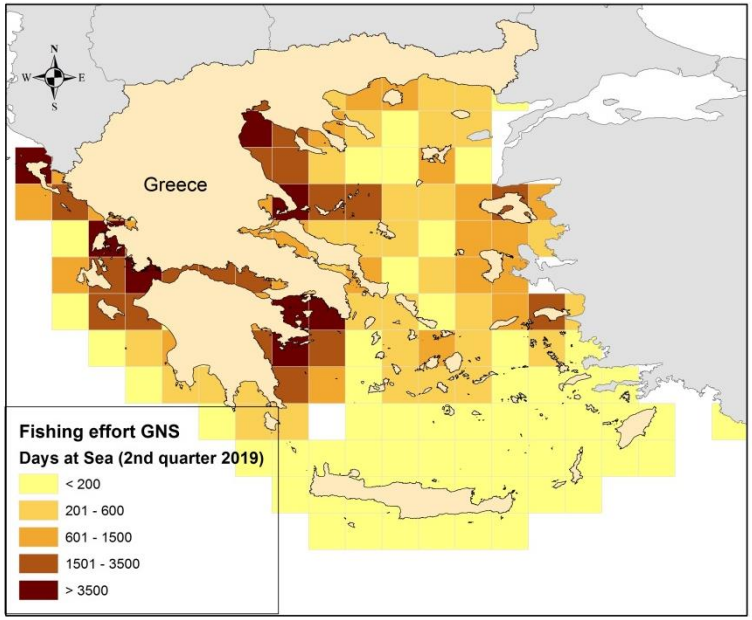
Using spatio-temporal outcomes of FPI for estimating Fishing Effort (Days at Sea) in a finer scale

Fishing pressure index by MCDA



Fishing effort estimations in coarser areas (or by country/GSA)





Fishing effort estimates in a finer spatial scale

Combining spatio-temporal outcomes of FE with predictions by species and table A (FDI) for estimating landings weight/value.

Fishing effort (MCDA + table G)

Species spatial distribution

Table A

combine

Achievements

- **MCDA** has been employed to estimate a **fishing pressure index** (FPI) for **small-scale fisheries**, taking into account several interactions with anthropogenic/environmental factors.
- **adjustments** on the input criteria have been **implemented** based on local **experts' knowledge**.
- Estimations of fishing pressure from Small Scale Fisheries can be applied by **fishing gear /fleet segment.**
- Including **criteria** that drive **spatiotemporal patterns of fishing pressure (e.g. chl-a** criterion) can be used for estimating **FPI in several spatiotemporal scales (e.g. quarter/year)**.
- **Combining** spatio-temporal outcomes of **FPI** with **Fishing Effort (FE)** by GSA/country (e.g. FDI Table G) could be used to provide **estimations of FE in a finer scale.**
- **Combining** spatio-temporal outcomes of **FE** with **predictions by species and FDI table A** can be used for **estimating landings weight/value (by species).**

The contribution of the MCDA on ecosystem-based fisheries management

- The **MCDA provides** an innovative and cost-effective way aiming to a better understanding of the **SSF spatial distribution** and potential interactions/impacts which are **unknown to date**

- The **MCDA outcomes** can be **used as input in tools in support of MSP process and for managing fishing activities**

In the framework of other projects the spatiotemporal **outcomes** derived **from MCDA** method were **used as input in**:

- **Spatial risk assessments**
- **Spatially-explicit bio-economic tools**