Supplementary material

TITLE: Mapping the footprint of untracked small-scale fisheries using multicriteria spatial analysis and optical satellite imagery

Running title: MCSA and satellite mapping of SSF

Authors: Bommarito C[1], Marsaglia L[2,3], Aglieri G[1,4], Bellù SM[5], Calò A[6,4], Cattano C[1,4], Desiderà E[6,4], Di Lorenzo M[1,4], Franzitta G[1], Giakoumi S[1,4], Guidetti P[7,4], Melià P[5], Milazzo M[5,4], Papetti C[8], Quattrocchi F[5,4], Russo S[1], Scianna C[9], Somma E[1,10], Spatafora D[1,4], Stranci F[8], Graziano MG[2], Milisenda G[1,4], Di Franco A[1,4]

Corresponding author: Claudia Bommarito, Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Sicily Marine Centre, Lungomare Cristoforo Colombo (complesso Roosevelt), Palermo, Italy, email: clabommarito@gmai.com; **Antonio Di Franco,** Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Sicily Marine Centre, Lungomare Cristoforo Colombo (complesso Roosevelt), Palermo, Italy, email: antonio.difranco@szn.it

Affiliations

[1]Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Sicily Marine Centre, Lungomare Cristoforo Colombo (complesso Roosevelt), Palermo, Italy

[2]Global Fishing Watch, DC 20036, United States

[3]Department of Biology, PhD Program in Evolutionary Biology and Ecology, University of Rome Tor Vergara, Via della Ricerca Scientific snc, 00133 Rome, Italy

[4]National Biodiversity Future Center (NBFC), 90133 Palermo, Italy

[5]Dipartimento di Elettronica Informazione e Bioingegneria, Politecnico di Milano, Via Ponzio 34/5, 20133, Milano, Italy

[6]Department of Earth and Marine Sciences (DiSTeM), University of Palermo, Via Archirafi 20-22, 90123, Palermo, Italy

[7]Department of Integrative Marine Ecology (EMI), Stazione Zoologica Anton Dohrn, Genoa Marine Center, Piazza del Principe 4, 16126 Genoa, Italy

[8]Department of Biology, University of Padova, Via Ugo Bassi 58B, 35121 Padova, Italy

[9]Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, CRIMAC - Calabria Marine Centre, C.da Torre Spaccata 87071, Amendolara (CS), Italy

[10]Department of Research Infrastructures for marine biological resources, Stazione Zoologica Anton Dohrn, Ischia Marine Centre, 80077, Ischia (Naples), Italy

Selected criteria and their ranking

Bathymetry

To determine bathymetry intervals and their grades, data of fishers' preferences from previous sampling campaigns were used. In particular, the fishers were asked the maximum bathymetry exploited during a fishing trip. The final intervals and grades assigned combined the Jenks Natural Breaks of the above-mentioned sampling data and the intervals used in Kavadas et al. (2015). The spatial bathymetry data used for mapping were retrieved from the General Bathymetric Chart of the Ocean (GEBCO), having a resolution of 0.004°, and the resolution was aligned to 0.02°. The raster of bathymetry was also used to create a polygon ranging from 1 to -600 m, to exclude land areas and deep areas not affected by small-scale fishing, due to legislation. This polygon was then applied to the raster of all the other criteria, to ensure the area considered was equal for all of them.

Weather conditions (wind)

We used wind data as a proxy for weather conditions, as interviewed fishers identified the wind as the most influential meteorological parameter in their decision-making process regarding whether to undertake a fishing operation. Wind data were retrieved from Wind Atlas,

from where only data of 2018 were used, as this was the last year in which the downloadable data covered the entire year. Since fishers defined 10 knots (5 m/s) as the average value beyond which a fishing operation was not undertaken, the intervals and their grades were determined by 1) averaging the daily wind speed, 2) counting the number of days when the wind speed exceeded 10 knots and then 3) processing them by Jenks Natural breaks.

Distance from coast

The spatial data were retrieved from the Global Fishing Watch dataset of "Distance from shore", providing, at 1 km resolution, the distance from shore (in kilometers) of every point in the ocean. The grades of distance from the coast's intervals were assigned according to the grading system applied by Kavadas et al. (2015), after confirmation with experts on the reliability of the grades, considering the Sicilian area.

Distance from port

To determine distance from port's intervals and their grades, data from previous sampling campaigns from the authors assessing the maximum distance from port undertaken during a fishing operation through fishers interviews were used, in which the fishers were asked the max. distance (in nautical miles) undertaken during a fishing trip. The final intervals and grades assigned combined the Jenks Natural Breaks of the sampling data.

Competitors – trawlers, purse seines and marine traffic

The methodology employed to quantify the activity of the main competitors for SSF was consistent for trawlers, purse seines vessels and marine traffic, and it relied on fishing hours (for trawlers and purse seines) and by using the R package "*gfwr*", fishing hours were retrieved from Global Fishing Watch "Global Datasets of AIS-based Fishing Effort and Vessel Presence", which calculates the fishing hours of the vessels detected at sea by analysing their AIS data. Fishing vessels are identified via a neural network classifier, vessel registry databases, and manual review by GFW and regional experts. Data is then binned into grid cells of 0.01 or 0.1 degrees and the time (in hours) is calculated by assigning an amount of

time to each AIS detection (which is the time to the previous position) and then summing all positions in each grid cell. For trawlers and purse seines vessels, the fishing hours were first summed for each spatial cell and then averaged from 2020 to 2023. For marine traffic, data from the year 2023 only were used.

Spatial restrictions

We defined the no-take zones as the spatial cells where SSF is prohibited by legislation. In our study, the no-take zones included Marine Protected Areas. The spatial data were retrieved from MAPAMED, EMODNET. Considering that legislation differs among MPA zones (SSF is prohibited in zone A and Bs and partially prohibited in zone B and C) we assigned a value of 0 to the spatial cells belonging to zone A and Bs areas where SSF is permanently prohibited, and of 0.5 to the ones belonging to zone B and C.

Table S1. Multi-Criteria Spatial Analysis (MCSA) criteria selected and validated by fishers, showing assigned weights, grade intervals (0-4), measurement units, methodological approaches for grade definition, data sources and temporal coverage.

CRITERIA	Weight	Grades'intervals	Unit	How grades'intervals were defined	Source of data	Grade	Time interval
Bathymetry max	7	0-50	meters	pre-defined classes by Kavadas et al. 2015; experts' opinion	General Bathymetric Chart of the Oceans (GEBCO)	4	2023
		50 -100	meters			3	2023
		100 - 200	meters			2	2023
		200 - 500	meters			1	2023
		>500	meters			0	2023
Wind (days on which wind exceeded 10 knots)	6	30-130	gg	natural breaks of NEWA data; experts' opinion	New European Wind Atlas (NEWA) v1.1	4	2018
		130-190	gg			3	2018
		190 - 230	gg			2	2018
		230 - 270	gg			1	2018
		> 270	gg			0	2018
Distance from the coast	5	< 1.5	nm	pre-defined classes by Kavadas et al. 2015; experts' opinion	Global Fishing Watch. 2021. Distance from Shore, Version 1.0.	4	2023
		1.5 - 3	nm			3	2023
		3 - 6	nm			2	2023
		> 6	nm			1	2023
Distance from the port	4	0-5	nm	Jenks Natural breaks of (NAME OF THE PROJECT) data; experts' suggestion	Global Fishing Watch. 2020. Distance from Port, Version 1.0.	4	2023
		5 - 10	nm			3	2023
		10 - 25	nm			2	2023
		25 - 40	nm			1	2023
		>40	nm			0	2023
Trawlers fleet effort	4	absence = < 30	h	natural breaks of GFW data; experts' opinion	Global Fishing Watch. 2025. Global Apparent Fishing Effort Dataset, Version 3.0	4	2020-2023
		low = 30 - 100	h			3	2020-2023
		medium = 100 - 250	h			2	2020-2023
		high = 250 - 1000	h			1	2020-2023
Purse seine fleet effort	3	absence = < 5	h	natural breaks of GFW data; experts' opinion	Global Fishing Watch. 2025. Global Apparent Fishing Effort Dataset, Version 3.0	4	2020-2023
		low = 5 -20	h			3	2020-2023
		medium = 20 -100	h			2	2020-2023
		high = 100 - 240	h			1	2020-2023
Marine traffic activity (excluding fishing boats, boats > 12 m)	1	absence = <5.000	h	natural breaks of GFW data; experts' opinion		4	2020-2023
		low= 5.000-20.000	h			3	2020-2023
		medium=20.000-40.000	h			2	2020-2023
		high=40.000-270.000	h			1	2020-2023

Table S2. Stakeholder agreement on MCSA criteria weights

Criteria	Weight	Agreement (%)
Depth	7	63
Weather - wind conditions	6	60
Distance from coast	5	52

Criteria	Weight	Agreement (%)
Distance from port	4	37
Competitors - trawlers	4	22
Competitors - purse seines	3	33
Marine traffic	1	78

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Criteria	Grade Category	Grade Value	Agreement (%)
Depth (m)			
	0-50	4	100
	50-100	3	100
	100-200	2	100
	200-500	1	100
Distance from port (nm)			
	0-5	4	100
	5-10	3	100
	10-20	2	67
	20-40	1	67
Distance from coast (nm)			
	0-1.5	4	80
	1.5-3	3	80
	3-6	2	80
	6-12	1	75

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