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Multi-Criteria Decision Analysis as a tool to extract fishing footprints: application to small scale fisheries and implications for management in the context of the Maritime Spatial Planning Directive

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Abstract

In the context of the Maritime Spatial Planning Directive and with the intention of contributing to the implementation of a future maritime spatial plan, it was decided to analyze data from the small scale coastal fisheries sector of Greece and estimate the actual extent of its activities, which is largely unknown to date. To this end, we identified the most influential components affecting coastal fishing in terms of its distribution and intensity: fishing capacity, bathymetry, distance from coast, Sea Surface Chlorophyll (Chl-a) concentration, legislation, maritime traffic activity, trawlers and purse seiners fishing effort and no-take zones. By means of Multi-Criteria Decision Analysis (MCDA) conducted through a stepwise procedure, the potential fishing footprint with the corresponding fishing intensity was derived. The method provides an innovative and cost-effective way to assess the impact of the, notoriously hard to assess, coastal fleet. It was further considered how the inclusion of all relevant anthropogenic activities (besides fishing) could provide the background needed to plan future marine activities in the framework of Marine Spatial Planning (MSP) and form the basis for a more realistic management approach.

Keywords: Small-scale fisheries, MCDA, AHP, Fuzzy logic, GIS, Mediterranean Sea, MSP.

Introduction

Worldwide, the size of coastal fisheries has been continuously increasing over the past decades involving nearly 80% of fishing vessels (FAO, 2014). In Europe alone, approximately 100,000 crew are involved in its activities with 87% of the European Union's (EU) fleet being composed of small-scale coastal vessels less than 15 meters long (IFREMER, 2007). Despite their relatively small size compared with the open sea platforms, coastal areas currently face disproportionate fishing pressure. Moreover, their ecological features and dynamics are heavily influenced by adjacent terrestrial ecosystems and basin-wide processes (especially riverine inputs) making them a very volatile environment. Their capacity to provide a rich variety of marine natural resources has sustained human livelihood for millennia. However, overcapacity of the coastal fleets may jeopardize the viability of fisheries on which many coastal communities depend for their economic well-being and at the same time play a significant role in the deterioration of the coastal environment.

Although small scale coastal fisheries have a limited spatial range of activities, their particular association with specific coastal ecosystems, with their great diversity and the technical heterogeneity of the fishing methods/tactics applied, make them a very complex sector for monitoring and management. Moreover, in coastal maritime areas, many activities compete for the same space and resources: fishing grounds, aquaculture farms and marine protected areas exist alongside maritime infrastructures such as cables, pipelines, shipping lanes and oil, gas or wind installations. With rapidly increasing demand for maritime space for new activities, from renewable energy to aquaculture installations, better and coherent planning of maritime activities is needed. To avoid potential conflicts between such diverse uses, create a stable environment attractive to investors (thereby contributing to sustainable growth) and ensure the preservation of resources and ecosystems, there is a need for spatial planning and coordination of the various activities taking place at sea.

Since the dawn of modern fisheries, the Greek narrow coastal area zone has faced a continuous 'race for fish', often over the same resources; the numerous small-scale coastal vessels confront their main rivals on a daily basis: the industrial fleet of trawlers and purse-seiners. Fishing, alongside many other human activities (recreation-tourism industry, shipping lanes-maritime traffic, aquaculture farms, oil drilling), exert significant pressure on the coastal marine environment. This pressure is partially alleviated through the established Marine Protected Areas (MPAs), which are generally perceived by the wide audience and the scientific community as a 'sanctuary' for marine life. However, the perceptions of fishers are not always in agreement; they tend to believe that they are losing more than they are gaining and prefer different locations for the MPAs (Jentoft *et al*., 2012).

The recently adopted Directive for MSP in the EU (EU, 2013), sets a framework for drawing up national maritime spatial plans to identify all existing human activities, taking into account land-sea interactions, and the most effective way of managing them.

In the context of the MSP Directive and with the intention of contributing to the implementation of a future maritime spatial plan, it was decided to analyze data from the small-scale coastal fisheries sector of Greece. The potential fishing footprint/intensity was derived by means of MCDA with the aspiration to serve as a valuable source of information for efficient spatial planning. It was further considered how the inclusion of all other relevant anthropogenic activities (besides fishing) could provide the background needed to plan future marine activities in the framework of MSP and form the basis for a more realistic management approach.

Materials and Methods

Study area

The inner Ionian archipelago with its adjacent gulfs (W. Greece) comprises a European coastal area where all the aforementioned components coexist. It was selected as an ideal study area for applying MCDA as a tool to derive an indirect fishing footprint and identify regions of high fishing pressure. The eastern boundaries were defined by the Korinthiakos Gulf and the western boundaries by the 2000 m depth contour (Fig. 1). Since the conservation of the cetacean populations in the area is one of the priorities for management (ACCOBAMS, 2007), and as Cuvier's beaked whales actively forage down to 2000 m depth, we have included the entire distribution range of this species in the study area, by defining the 2000 m depth contour as the natural western and southern boundaries of the study region. The region reports one of the highest number of strandings for the species in the Mediterranean (Podesta *et al*., 2005), and entanglement in the nets of small-scale fisheries is considered as a source of mortality (Taylor *et al*., 2008). Southwards, we extended the study region to include the Strofades Islands, a protected area of high conservation value, which is part of the National Marine Park of Zakynthos. The northern limits of the study area were defined by 38° 53′ latitude and the south-eastern limits

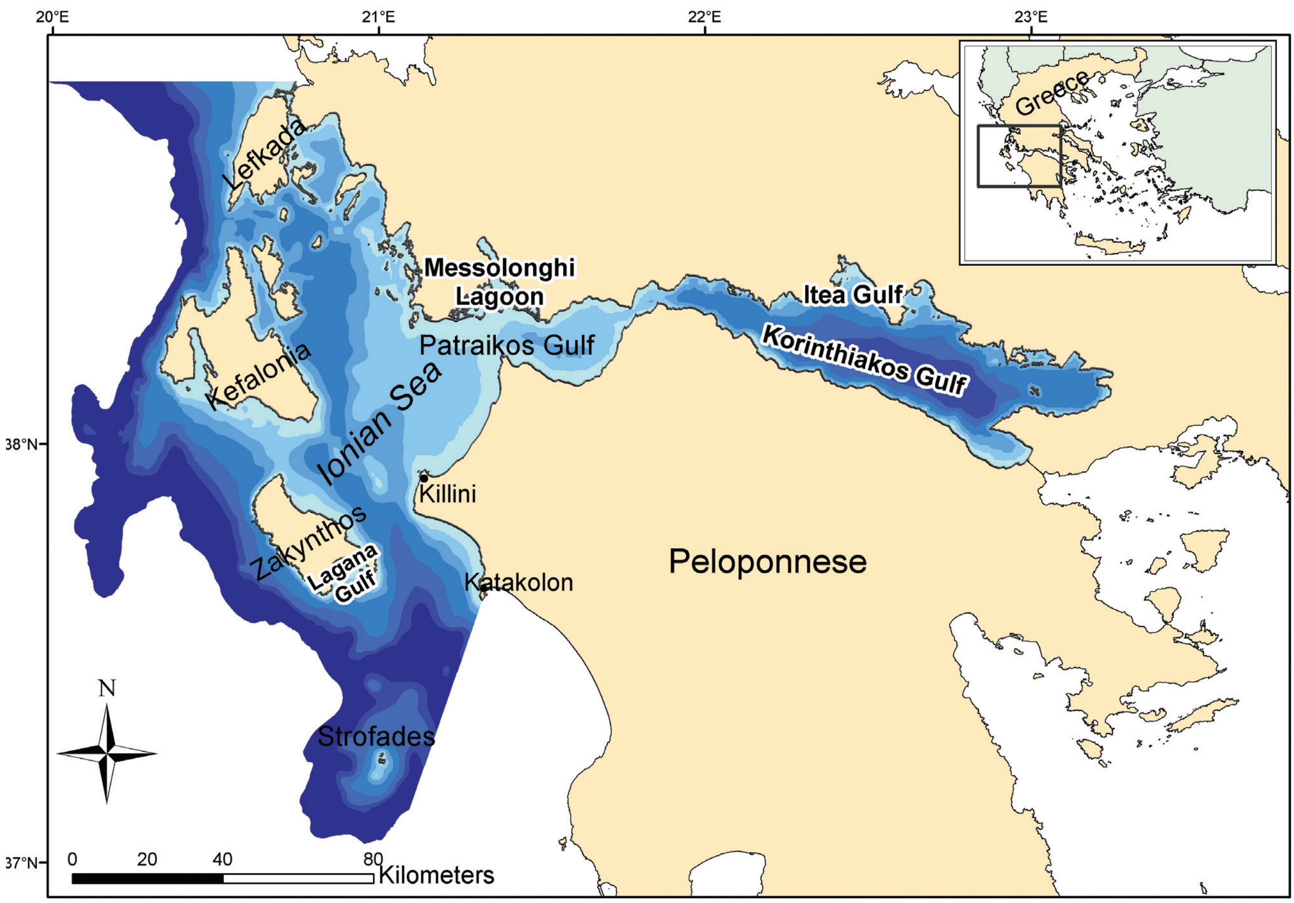

Fig. 1: Map of the study area.

by a straight line joining Cape Katakolon on the western coast of the Peloponnese with the 2000 m contour south of Strofades Islands. Overall, the study area contains ten marine NATURA 2000 sites and two national parks: the aforementioned National Marine Park of Zakynthos and the National Park of Messolonghi - Etoliko Lagoons.

Fisheries

The Greek fishing fleet is the largest European fleet accounting for 20% of the total EU-27 (EU Fleet Register[1]). Moreover, the small-scale coastal fisheries sector comprises an impressive 95% of the entire Greek fishing fleet (SoHelFi, 2007). This enormous development of the coastal fleet stems from the fact that there is an extended coastal zone of about 16,000 Km, with hundreds of small isolated ports along the coastline and 6,000 islands, providing limited employment opportunities. There are very few legal limitations in the geographical/bathymetrical range of activities for these vessels. However, their limited capacity usually confines them to the vicinity of land, within the 6 nautical miles Greek territorial waters. As a final point, their fishing footprint is largely unknown; the rules for keeping logbooks as a source of data are quite non-restricting (EU, 2006) and due to their small size (<12 m) they are not required to bear any vessel identification system such as AIS or VMS (EU, 2009a, b).

According to the 2014 national fleet register, 1539 fishing vessels (out of a national total of 15729), have been operating from 23 ports within the study area: 17 trawlers, 25 purse seiners, and 1497 coastal fishing vessels using static nets and long lines. The share of the local small-scale coastal fleet landings exceeded 40% of total landings during the past decade (Kavadas *et al*., 2013). The main fishing gears employed were: nets (trammel, gill and combined), long lines (bottom or surface), boat seiners and traps. However, at local scale, various techniques were identified, namely, the use of uncharacteristic or modified gears; targeting specific species during a specific season (e.g. the use of tubes for catching octopus). The target species and consequently the gears they use are also highly dependent on the season and area. It is a common practice for all the vessels to change métier several times during the year, according to which métier is more profitable in a specific area, and during a specific period. As a rule, small-scale coastal fisheries are not regulated through any spatio-temporal delineation of fishing grounds (as is the case for trawlers and purse seiners) and, consequently, do not leave natural refuges for the targeted species. Taking into account the enormous number of vessels, and continuous technological development, vessels are becoming more and more efficient, increasing their catchability, and apparently have a substantial impact on fish stocks.

1. http://ec.europa.eu/fisheries/fleet/index.cfm

Data and Analyses

One of the methods gaining recognition in fisheries management is MCDA (McDaniels, 1995; Belton & Stewart, 2002). It involves the simultaneous use of multiple criteria and information sources (both qualitative and quantitative). It is typically applied in the decision-making process to: (i) generate priority ranking of issues for use of management resources and (ii) compare relative performance of different management options across a number of competing fishery objectives or differing stakeholder preferences. MCDA primarily aims at highlighting conflicts and deriving a way to reach a compromise through a transparent process. In particular, the synergetic capabilities of GIS and MCDA can be thought of as a process that transforms and combines geographical data and value judgments to obtain information for decision-making, providing benefits for advancing theoretical and applied research (Malczewski, 1999). In our case, MCDA has been employed to estimate a fishing pressure index (FP_c) for the small-scale fishery in the study area, taking into account several interactions with other anthropogenic or environmental factors. Several methods and processes such as the Analytic Hierarchy Process (AHP), Fuzzy logic, and a spatial clustering process were applied in an effort to solve the multiple criteria problem. FP_c was perceived as the fuzzy product of two indices (Suppl. S.3.2): the coastal fishery suitability index (S_c) and the activity index (A_c) based on the spatial distribution of registered coastal fishing vessels in the study area:

$$FP_c = S_c * A_c$$

A general overview of the criteria and methods of the proposed MCDA tool is given in Figure 2.

To this end, we identified the most influential components and criteria affecting small-scale coastal fishing (Table 1). Each criterion was assigned a grading value by expert judgment; a rank of order of importance. This ranking was based on: a series of surveys conducted by questionnaire with local fishers[2], a comprehensive literature review to identify factors driving small-scale coastal fisheries performance and finally expert knowledge. The final rankings used for all criteria under study (bathymetry, distance from coast, Chl-a concentration, legislation, marine traffic activity, trawlers and purse seiners fishing effort and no-take zones) are presented in Table 2. Detailed information on the ranking procedure can be found in the Supplementary Material section (S.1). Spatial representa-

2. CORALFISH: http://eu-fp7-coralfish.net/AFRAME: "A framework for fleet - and area-based fisheries management". 6th Framework RTD program 'Specific Support to Policies', under contract no 044168, EC, DG MARE EVOMED: http://ec.europa.eu/fisheries/documentation/studies/study_evolution_mediterranean/index_en.htm METSMAFISH: METIÉRS IN SMALL SCALE FISHERIES, JRC scientific and technical report , JRC67681

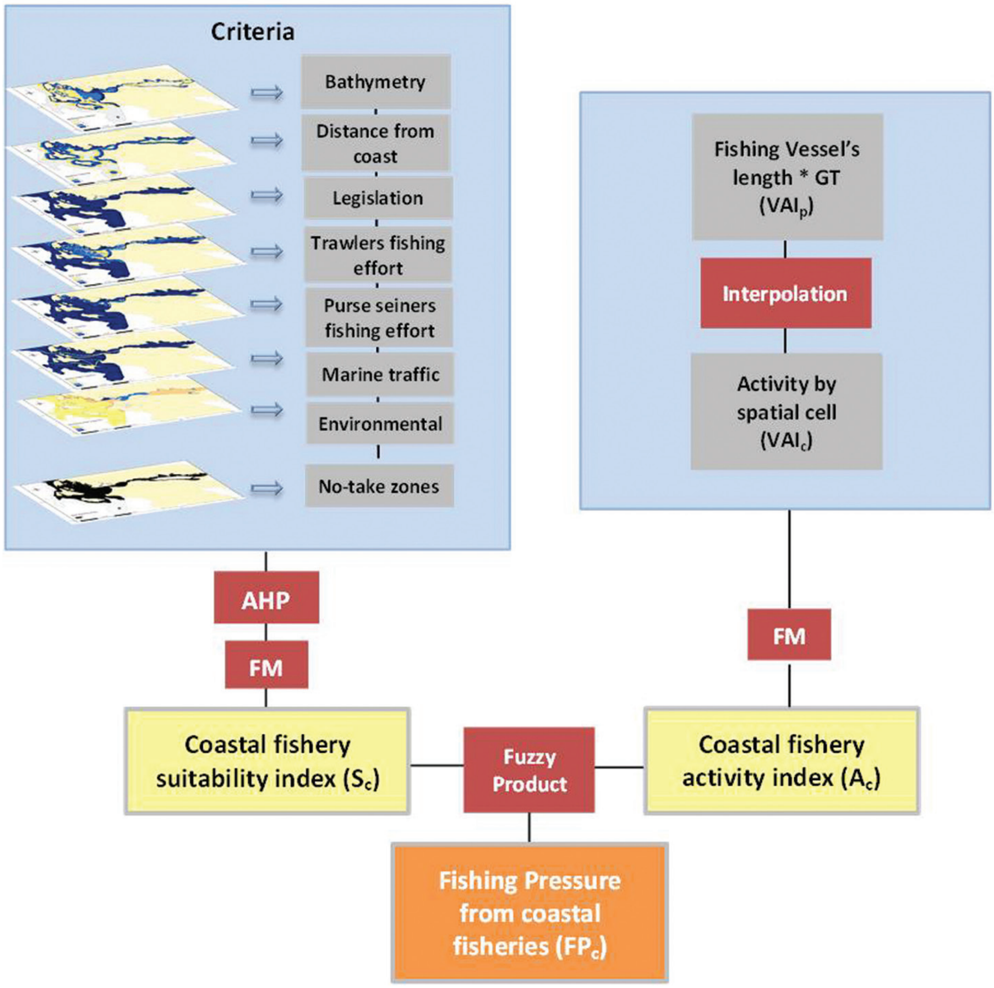

Fig. 2: Flowchart of steps and methods followed (AHP: Analytic Hierarchy Process, FM: Fuzzy Membership).

Table 1. Criteria used for each component of the case study.

Component	Criteria
Legal framework	Legislation (spatio-temporal restrictions)
	No-take zones
Environment	Bathymetry (depth in m)
	Distance from coast (n.m.)
	Sea Surface Chl-a (concentration in mg/m^3)
Competitors fishing activities	Bottom Trawl fleet effort (Days at Sea * GT)
	Purse-seine fleet effort (Days at Sea * GT)
Other	Marine traffic (intensity and proximity to land)

tion of the ranking in Table 2 is visualized in Figure 3. The study area was gridded with a spatial resolution of 1 km x 1 km. Each of these cells was assigned the corresponding values for each of the MCDA modelled criteria.

Coastal fishery suitability index (S_c)

S_c estimation from the investigated criteria proceeded in the following steps: (i) creation of spatial information and calibration of each criterion according to a scale of evaluation and formation of the hierarchical structure of the multiple criteria problem (Suppl. S.1); (ii) implementation of the AHP to estimate the relative importance of the evaluation criteria (Suppl. S.2); (iii) application of the Weighted Linear Combination method (WLC) to estimate the suitability index (Suppl. S.2); (iv) standardization on a scale from 0 to 1 with linear Fuzzy Membership (FM) (Suppl. S.3.1).

Spatial coastal fishery activity index (A_c)

An activity index for the coastal fishing fleet by registration port (VAI_p) was calculated as:

$$VAI_p = \sum_{\upsilon=1}^{n} L * GT$$

Table 2. Ranking* of the criteria taken into account in MCDA.

Bathymetry (meters)	Grade	**Marine traffic activity**	Grade
0 - 50 m	4	Absence of Marine traffic	4
50 m - 100 m	3	High coast distance from marine traffic	3
100 m - 200 m	2	Medium coast distance from marine traffic	2
200 m - 500 m	1	Low coast distance from marine traffic	1
>500 m	0		
Distance from coast (nautical miles)	Grade	**Bottom trawl fleet effort**	Grade
< 1.5 nm	4	Absence of effort	4
1.5 nm - 3 nm	3	Low	3
3 nm - 6 nm	2	Medium	2
>6 nm	1	High	1
Sea Surface Chlorophyll (Chl-a) (mg/m^3)	Grade	**Purse seine fleet effort**	Grade
Eutrophic waters: >0.793mg/m3	4	Absence of effort	4
Upper mesotrophic waters : 0.46mg/m3 - 0.793mg/m3	3	Low	3
Medium mesotrophic waters: 0.23mg/m3 - 0.46mg/m3	2	Medium	2
Lower mesotrophic waters: 0.1mg/m3 - 0.23mg/m3	1	High	1
Legislation	Grade	**No-take Zones (Boolean value 0=yes; 1=no)**	Grade
available areas	4	Aquaculture farms	0
ban for 4 months	3	Banned areas (year round)	0
ban for 6 months	2	depth >500m	0
ban for 12 months	0	available areas	1

**The higher the grade, the most "favourable" this area is for coastal fishing activities.*

where: L: Vessel Length; GT[3]: Gross tonnage; v: Vessel; n: Total number of vessels at each registered fishing port (p).

The methodology used to estimate A_c consisted of the following steps: (i) implementation of the optimal interpolation method on VAI_p to estimate values at a spatial cell level (VAI_c) (Suppl. S.4.); (ii) implementation of the optimal FM in VAI_c, to represent numerically the degree to which a given measure of criteria within a grid cell belongs to a fuzzy set (Suppl. S.3.2)

Finally, in order to identify spatial autocorrelation in the coastal FP_c, a spatial clustering process was performed through Global Moran's and Anselin Local Moran's I statistics (Moran, 1950; Anselin, 1995). This helped in identifying areas of intense fishing pressure (Cliff & Ord, 1973) (Suppl. S.5).

Results

Coastal fishery suitability index (Sc)

A pair-wise comparison matrix, necessary to measure the relative importance of weights for each criterion was produced by AHP (Table 3). S_c estimation was obtained through the WLC method using the weights (priority vector) from the aforementioned pair-wise comparison matrix (Fig. 4).

Spatial coastal vessels activity index (Ac)

The optimal interpolation method suggested by the RMSE and QQ plots, as the most suitable for A_c, was IDW. The final outcome is portayed in Figure 5. The main concentration of fishing vessels is observed in Korinthiakos Gulf (Itea Gulf and close to the port of Korinthos), in the inner part of Patraikos Gulf, in the North Western part of the Peloponnese and, in particular, the Gulfs of Kefalonia, Lefkada and Zakynthos Islands.

The results of four scenarios (S_0, S_1, S_2, S_3) were compared for each method of FM function in order to identify the method with the lowest variability. Linear FM function was selected instead of Large FM. Pearson's R values revealed that the highest deviation between S_0 and the other 3 scenarios was 0.93 for linear FM (Fig. 6B) and 0.40 for Large FM (Fig. 6A).

Fishing pressure index from the small-scale coastal fishery (FPc)

FPc was derived as the fuzzy product of the two previously calculated indices (Fig. 7). Values close to 1 indicate areas with an elevated likelihood of intense fishing pressure. Figure 7 shows that the coastal fishing fleet is operating mostly along the coastline usually up to 2.5nm. Also, the activity of coastal vessels is limited to areas where bottom trawlers and purse seiners are operating. Inspection for spa-

3. It should be considered that engine power (KW) was not used in the analysis due to non-significant correlation between length and KW; in contrast to the correlation between length and GT (Kavadas, unpublished data, analysis of Greek fishing fleet register). Moreover, questionnaires conducted in selected areas, show that engine power was the most deviating parameter (Vasilopoulou, unpublished data). Under-declaration of engine power has been recently identified in Damalas et al. (2014 - see page 113, fig.1). In addition, a significant number of fishing vessels do not satisfy Articles 61 and 62 of EC Regulation 401/2011 concerning the certification of propulsion engine power and verification and sampling plan.

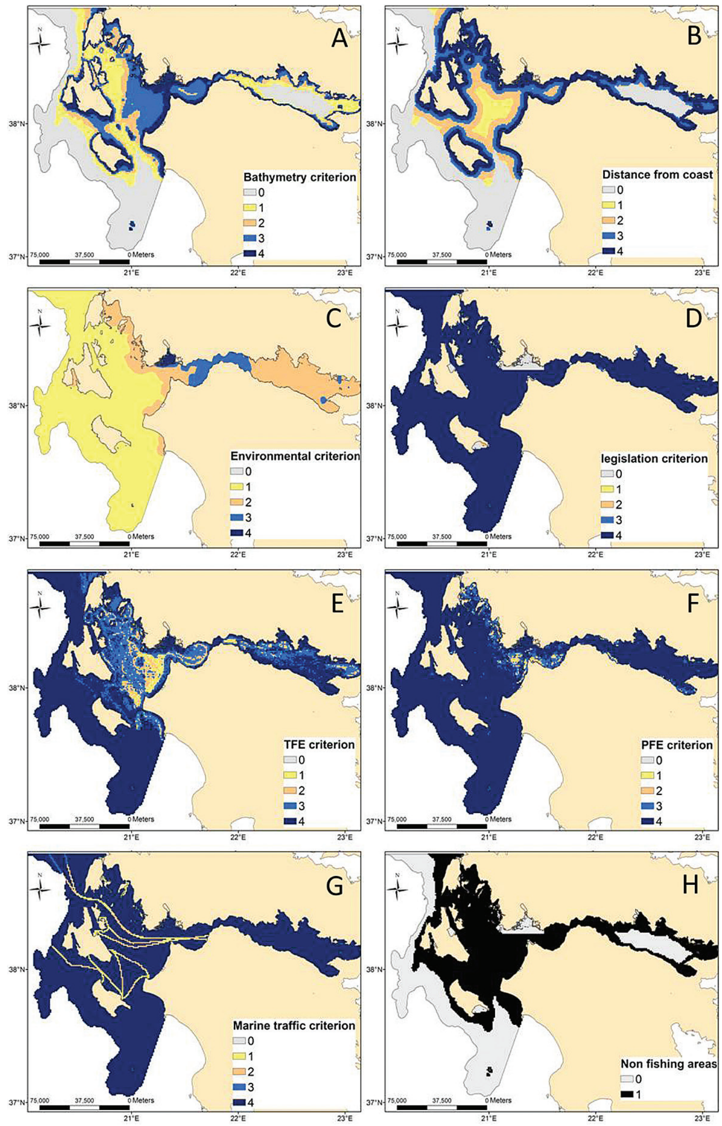

Fig. 3: Spatial representation of the criteria ranking taken into account in MCDA.

Table 3. Pair-wise comparison matrix and relative importance of weights.

	Bathymetry	Distance from coast	Legislation	Trawl effort	Purse seine effort	Marine traffic	Chl-a	**Weights**
Bathymetry	1	2.00	4.00	5.00	4.00	4.00	3.00	**0.315**
Distance from coast	0.50	1	6.00	4.00	4.00	5.00	5.00	**0.296**
Legislation	0.25	0.17	1	1.00	2.00	1.00	0.50	**0.069**
Trawl effort	0.20	0.25	1.00	1	3.00	3.00	0.50	**0.095**
Purse seine	0.25	0.25	0.50	0.33	1	2.00	0.33	**0.059**
Marine traffic	0.25	0.20	1.00	0.33	0.50	1	1.00	**0.058**
Chl-a	0.33	0.20	2.00	2.00	3.00	1.00	1	**0.109**

Consinstensy Ratio: CR= 0.09.

tial autocorrelation in the FP_c through the Global Moran's I test, revealed that the final index is strongly autocorrelated according to Moran's I value (0.898 units) (Fig. 8).

Conclusions and Discussion

Small-scale fisheries comprise quite an important part of the fishing sector throughout the Mediterranean Sea. In Greece, small-scale fisheries are of particular social and economic importance as their catches represent 47% of total production and 54% of market income (Tzanatos *et al*., 2005, 2006). The 'success' of small-scale fishing in the Mediterranean lies in the fact that small-scale vessels require low capital investment. It is

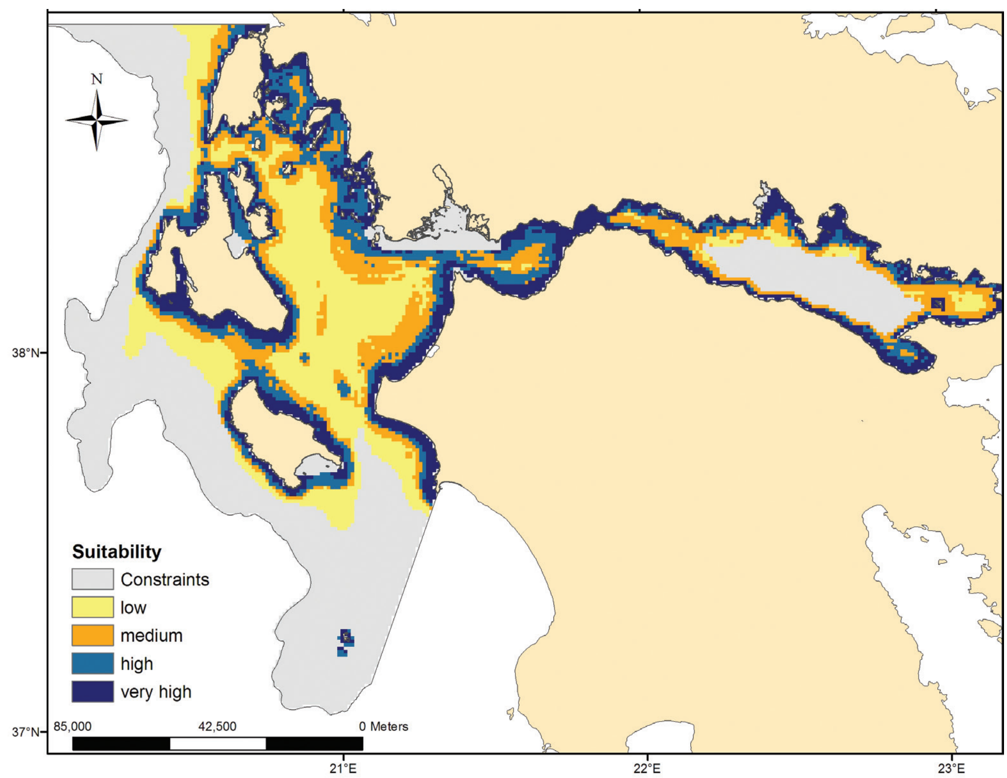

Fig. 4: Spatial representation of the Coastal fishery suitability index (S_c).

a good option for employment and provides an additional income for the coastal population, especially during winter-spring when there is no tourism activity. These vessels target almost all species. There are métiers targeting pelagic fish species (e.g. sardines, bonitos, swordfish, tunas), demersal fish species (e.g. red mullet, striped mullet, hake, common pandora), decapods (e.g. lobster, shrimp, Norway lobster), cephalopods (e.g. cuttlefish, octopus, squids) and shell fish (mussels, oysters). Some demersal species, which live on rough and rocky bottoms are exploited exclusively by the small-scale coastal fleet (e.g. *Pagellus bogaraveo* and *Epinephelus spp.*) (Petrakis *et al*., 2001). Information on the basic characteristics of the small-scale coastal fisheries is limited and in fact does not allow any comprehensive assessment. The catch composition (landings and discards), size composition of the target and by-catch species and the fishing effort per métier, are almost unknown for the majority of the métiers (SoHelFi, 2007). Each fishing practice is likely to impact exploited stocks in a particular way and, in to assess the relationship between the total fishing effort of the fleet and the resulting fishing mortalities of the exploited stocks, a separate evaluation for each fishing practice is necessary (Pelletier & Ferraris, 2000). A starting point would be to identify fishing footprints and intensity.

However, despite the high significance of small-scale fisheries in the Mediterranean Sea, there is no actual estimate of their fishing footprint and fishing effort intensity on a spatial scale. With the intention to achieve the goal of Maritime Situational Awareness (the capability of understanding events, circumstances and activities within and impacting the maritime environment; Hodgson & van de Velde, 2008), the EU took a step towards identifying the actual extent of fishing activities in EU waters (EU 2002, 2009a, b) by requesting that all EU fishing vessels of overall length exceeding 12 m be fitted with vessel identification systems, such as the Vessel Monitoring System (VMS - 1 January 2012) and Automatic Identification System (AIS - 1 May 2014). Obviously, the vast majority of small-scale vessels do not meet these criteria. Moreover, use of VMS data has been quite controversial and some national organizations are not as willing to share information; these data are often unavailable to end-users, the scientific community and to broad-scale conservation planning (Coll *et al*., 2013). In addition, the recent EU Council Regulation (EU, 2009a), protects the confidentiality rights of individual fishers, thus making access to high-resolution fishing effort data unavailable to the scientific community (Hinz *et al*., 2013).

A way of obtaining such valuable information on fishing events, circumstances and activities and start understanding how they impact the coastal environment, was presented in this study. In the absence of actual records of fishing activity, an indirect estimate was made through the identification of the most influential components affecting small-scale coastal fishing. The methodology proposed combines MCDA methods (AHP, Fuzzy logic) and the geospatial tools of GIS (WLC, spatial interpolation). Most of all, it provides an innovative and cost-effective way to assess the impact of the, notoriously hard to assess, small-scale coastal fleet. The results, produced in the form of a spatial grid, seem quite promising and areas of

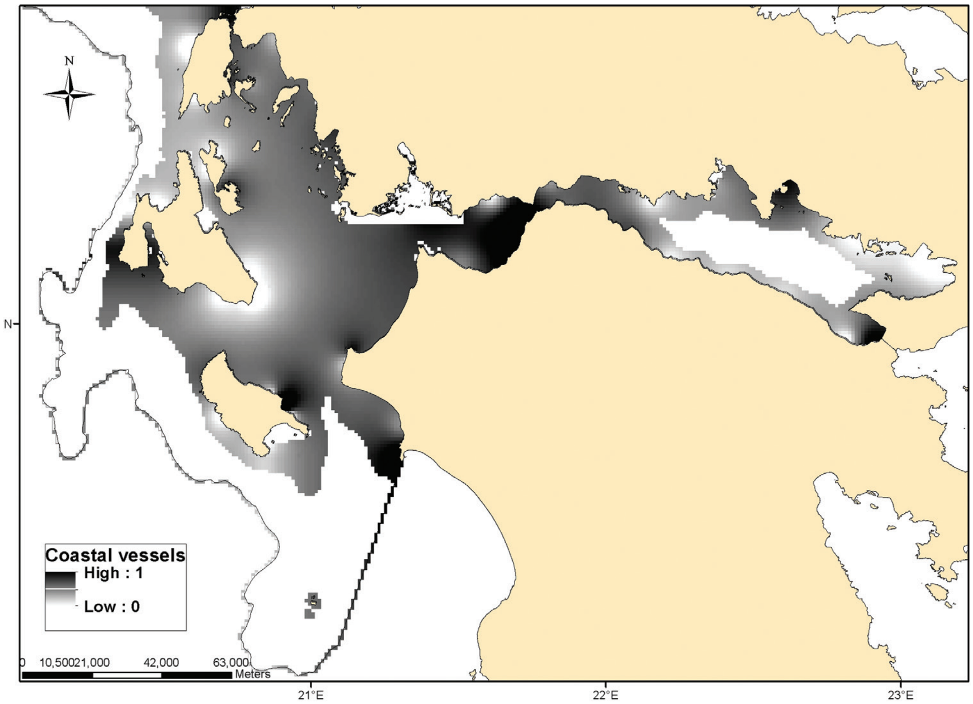

Fig. 5: Spatial representation of coastal vessels activity indexes (Ac).

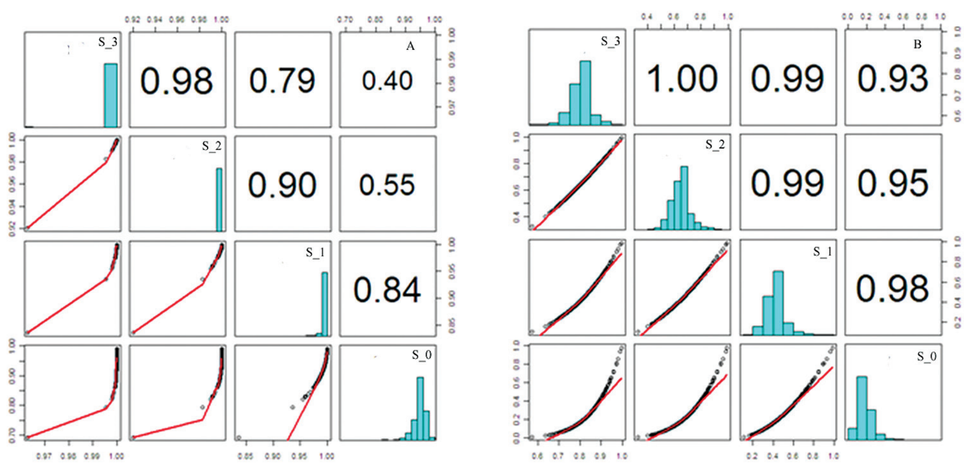

Fig. 6: Scatterplot matrices for Large (A) and Linear (B) FM functions.

high fishing effort were identified. From a fisheries management perspective, special attention has to be drawn to areas that host fish populations in abundance. From the resultant fishing pressure maps it was effortlessly deduced that the favourable fishing grounds for the small-scale fleet coincided with recently identified nurseries of valuable commercial species, such as the European hake (Issaris *et al*., 2012). These nursery grounds were mainly confined to the inner Ionian Archipelago, while a relatively small area was also present in Patraikos Gulf; all nursery areas were located in front of major river mouths.

The three main requirements for the sustainable development of small-scale fisheries are: (i) the simultaneous present and future well-being of the bio-ecological system, (ii) the human system and (iii) the management process (IFREMER, 2007). The sizeable overlap between fishing activities and important conservation areas, identified in the study area, needs to be addressed in the framework of a general maritime spatial plan, rather than through piecemeal management by fragmented local authorities. Ecosystem-based marine spatial management (EB-MSM) is an approach that recognizes the full array of interactions within an ecosystem, including human uses, rather than considering single issues, species, or ecosystem services in isolation. MSP and ocean zoning are emerging concepts that can support EB-MSM. Although initially the concept of MSP was to develop MPAs, recently attention has been placed on planning and managing multiple uses of maritime space. However, a fundamental requirement is that areas with conflicting uses must be specified. EB-MSP aims to bridge the gap between science and practice and help in addressing the current need for more practical tools

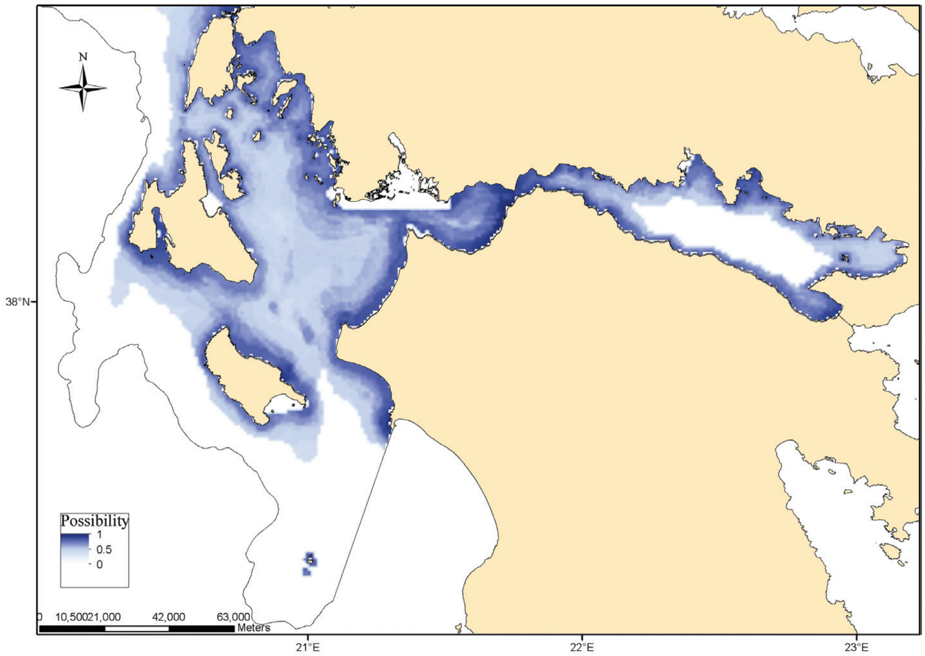

Fig. 7: Spatial representation of the Fishing pressure index from the small scale coastal fishery (FP_c).

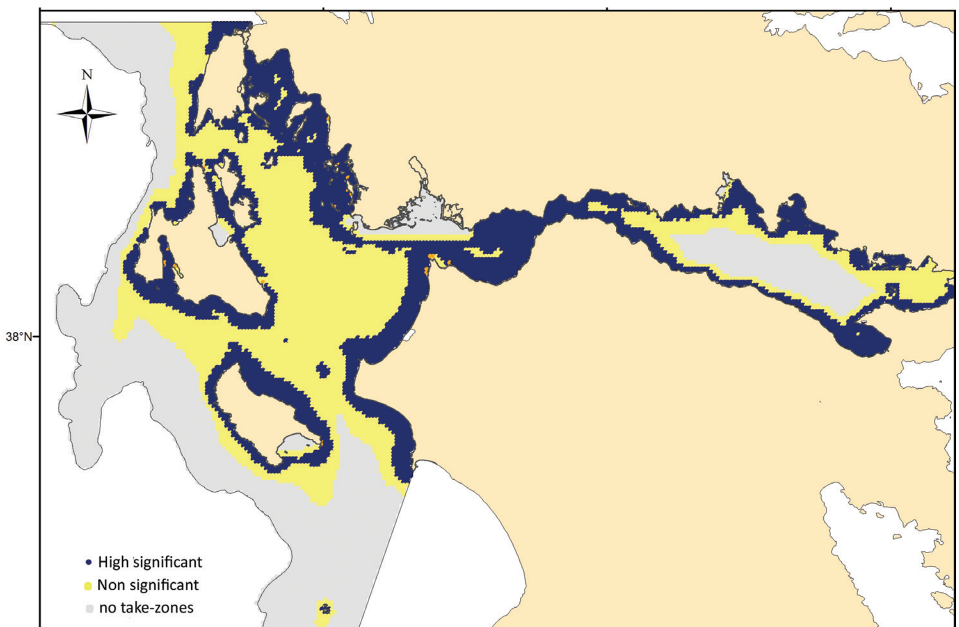

Fig. 8: High values of the FP_c index as estimated by Local Moran's I test.

that promote the implementation of ecosystem-based management (Katsanevakis *et al*., 2011).

Fisheries are a "thorny" component in MSP, since their beneficial contribution to the welfare of local communities is frequently accompanied by undesirable effects on the marine environment. An increasing number of countries are using MSP to achieve both sustainable use and biodiversity conservation in ocean and coastal areas; however, fisheries are not always considered. One of the few EU paradigms on how MSP can facilitate synergies between sectors and achieve multi-use of marine space comes from Lyme Bay (UK)[44], where fishermen and conservationists worked through an agreed code of practice on the protection of the reefs and the provision of high added-value sea food.

4. MSP workshop series: 2. Fisheries and Aquaculture. Vilnius, Lithuania, 15th November 2013. Available at: http://www.amiando.com/MSPworkshops_Vilnius.html

In conclusion, this study provided a 'tool' for producing fisheries footprints and corresponding fishing effort for future incorporation in the MSP process, especially when primary data on vessel locations are not available. As a word of criticism, due to the obvious lack of information on small-scale fisheries, surrogate approximations were used mainly based on expert judgment. In that sense, these results do not provide a conclusive depiction of fishing activities in the study area, but rather a first approximation, which can and should be continuously improved and updated. It is fairly easy to expand the methodology by taking into account other non-investigated components or, above all, validate it against actual observations, which will need dedicated surveys on-board small-scale vessels. Therefore, this study can be considered a baseline, upon which future scientific efforts should build.

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References

ACCOBAMS, 2007. *Report of the third meeting of the contracting parties to ACCOBAMS*. 22-25 October 2007, Dubrovnik, Croatia. Technical report 350 pp.

Anselin, L., 1995. Local Indicators of Spatial Association – LISA. *Geographical Analysis,* 27 (2), 93-115.

Belton, V., Stewart, T.J., 2002. *Multiple Criteria Decision Analysis: An Integrated Approach*. Kluwer Academic Publishers, Boston. 372 pp.

Cliff, A.D., Ord, J.K. 1973. *Spatial Autocorrelation,* Pion: London, 245-249.

Coll, M., Cury, P., Azzurro, E., Bariche, M., Bayadas, G. *et al*., 2013. The scientific strategy needed to promote a regional ecosystem-based approach to fisheries in the Mediterranean and Black Seas. *Reviews in Fish Biology and Fisheries,* 23(4), 415-434.

Damalas, D., Maravelias, C.D., Kavadas, S., 2014. Advances in fishing power: a study spanning 50 years. *Reviews in Fisheries Science & Aquaculture*, 22 (1), 112-121.

EU, 2002. Directive 2002/59/EC of the European Parliament and of the Council Regulation of 5 August 2002 establishing a Community vessel traffic monitoring and information system, as amended by Directive 2009/17/EC and Commission Directive 2011/15/EU. *Official Journal of the EU L*, 208, 10-27.

EU, 2006. Directive 1967/2006/EC of the European Parliament and of the Council Regulation of 21 December 2006 management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. *Official Journal of the EU L*, 409, 11-85.

EU, 2009a. Directive 2009/17/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system (Text with EEA relevance). *Official Journal of the EU L*, 131, 101-113.

EU, 2009b. Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. *Official Journal of the EU L*, 343, 1-50.

EU, 2013. Proposal for a directive of the European parliament and of the council establishing a framework for maritime spatial planning and integrated coastal management, COM/2013/0133 final - 2013/0074 (COD).

FAO, 2014. *The state of world fisheries and aquaculture: opportunities and challenges.* Food and Agriculture Organisation, Rome, 223 pp.

Hinz, H., Murray, L.G., Lambert, G.I., Hiddink, J.G. Kaiser, M.J., 2013. Confidentiality over fishing effort data threatens science and management progress. *Fish and Fisheries*, 14, 110-117.

Hodgson, S., van de Velde, P., 2008. *Legal Aspects of Maritime Monitoring & Surveillance Data.* Framework Service Contract, No. FISH/2006/09 – LOT2 Final Report, 140 pp.

IFREMER, 2007. *Small-Scale Coastal Fisheries in Europe*, Final report of the contract No FISH/2005/10, 447pp.

Issaris, Y., Katsanevakis, S., Pantazi, M., Vassilopoulou, V., Panayotidis, P. *et al*., 2012. Ecological mapping and data quality assessment for the needs of ecosystem-based marine spatial management: case study Greek Ionian Sea and the adjacent gulf. *Mediterranean Marine Science*, 13 (2), 297-311.

Jentoft, S., Pascual-Fernandez, J.J., De la Cruz Modino, R., Gonzalez-Ramallal, M., Chuenpagdee, R., 2012. What stakeholders think about marine protected areas: Case studies from Spain. *Human Ecology*, 40 (2), 185-197.

Katsanevakis, S., Stelzenmuller, V., South, A., Sorensen, T.K., Jones, P.J.S. *et al*., 2011. Ecosystem-based marine spatial management: Review of concepts, policies, tools, and critical issues. *Ocean and Coastal Management*, 54 (11), 807-820.

Kavadas, S., Damalas, D., Georgakarakos, E., Maravelias, C., Tserpes, G. *et al*., 2012. IMAS-Fish - Integrated Management System to support the sustainability of Greek fisheries resources. A multidisciplinary web-based database management system: implementation, capabilities, utilization and future prospects for fisheries stakeholders. *Mediterranean Marine Science*, 14 (1), 109-118.

Malczewski, J., 1999. *GIS and multicriteria decision analysis*. Wiley & Sons, New York, 393 pp.

McDaniels, T.L., 1995. Using judgment in resource management: A multiple objective analysis of a fisheries management decision. *Operations Research,* 43, 415-426.

Moran, P.A.P., 1950. Notes on continuous stochastic phenomena, *Biometrika*, 37, 17-23.

Pelletier, D., Ferraris, J., 2000. A multivariate approach for defining fishing tactics from commercial catch and effort data. *Canadian Journal of Fisheries and Aquatic Sciences*, 57, 51-65.

Petrakis, G., Holst, R., Kavadas, S., Chilari, A., Tsamis, E., 2001. *Pagellus bogaraveo gill net metier in Ionian Sea:*

Gill net selectivity, assessment and biology. Final Report, EU Contract Number: 00/046. National Centre for Marine Research-Institute of Marine Biological Resources & Con-Stat. October 2001. 55 pp.

Podesta, M., D' Amico, A., Pavan, G., Drougas, A., Komnenou, A. *et al*., 2005. A review of Cuvier's beaked whale strandings in the Mediterranean Sea. *Journal of Cetacean Research and Management*, 7 (3), 251-261.

SoHelFi, 2007. *State of Hellenic Fisheries.* Papaconstantinou, C., Zenetos, A., Vassilopoulou, V., Tserpes, G. (Eds). HCMR Publications, Athens, 466 pp.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J. *et al*., 2008. *Ziphius cavirostris*. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org (accessed on 09 August 2014).

Tzanatos, E., Dimitriou, E., Katselis, G., Georgiadis, M., Koutsikopoulos, C., 2005. Composition, temporal dynamics and regional characteristics of small-scale fisheries in Greece. *Fisheries Research*, 73, 147-158.

Tzanatos, E., Somarakis, S., Tserpes, G., Koutsikopoulos, C., 2006. Identifying and classifying small-scale fisheries métiers in the Mediterranean: A case study in the Patraikos Gulf, Greece. *Fisheries Research*, 81, 158-168.