GIS as a tool for an Ecosystem Approach to Fisheries Management – the case study of sardine fishery in Portugal

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Introduction

The European sardine (*Sardina pilchardus*) is an economically and socially significant fishery resource in Portugal and Spain [1]. However, it has been in severe decline in the Iberian Peninsula coastal waters [2] leading to advice zero catch in 2018 [3]. Clupeoid fish species usually show high variability in the recruitment process related to environmental conditions [4]. In addition, it has been suggested that biotic interactions might play a role in sardine decline [5]. This emphasized the necessity to develop an Ecosystem Approach to Fisheries Management (EAFM) strategy for the purse seine fishery, considering both environmental variables and biotic interactions. One of the tool, that is recommended in EAFM is the use of Geographic Information Systems (GIS) [6].

Objectives

This study aims to demonstrate that GIS can be a useful tool to support sardine fishery management in the context of an Ecosystem approach. To do so, a GIS analyses were used to identify the areas that are:

- of the highest importance for sardine conservation,
- the most crucial for purse seine fisheries,
- the most suitable to preserve essential sardine habitats, whilst reducing the negative effect on fishing activities.

Methods

- A set of criteria that represent an ecosystem approach and are of importance for sardine conservation and the fisheries industry were selected [Fig. 1].
- Then combination of GIS and Multi-criteria decision making (MCDM) method with the weighted linear combination (WLC) was applied to find conservation priority areas.
- The method was performed for 5 scenarios that vary depending on management targets and applied weighting factor :

  A. Baseline – no weights
  B. Nurseries protection – Aims to protect nurseries grounds;
  C. Spawning areas protection – Aims to protect spawning grounds
  D. Fishery profit driven – Aims to exclude from protection highly profitable fishing areas
  E. Safeguarding dependent fishing communities – Aims to exclude from protection areas where fishermen are highly dependent on sardine fishery.

- Weights were chosen using the Analytical Hierarchy Process (AHP) method [7].
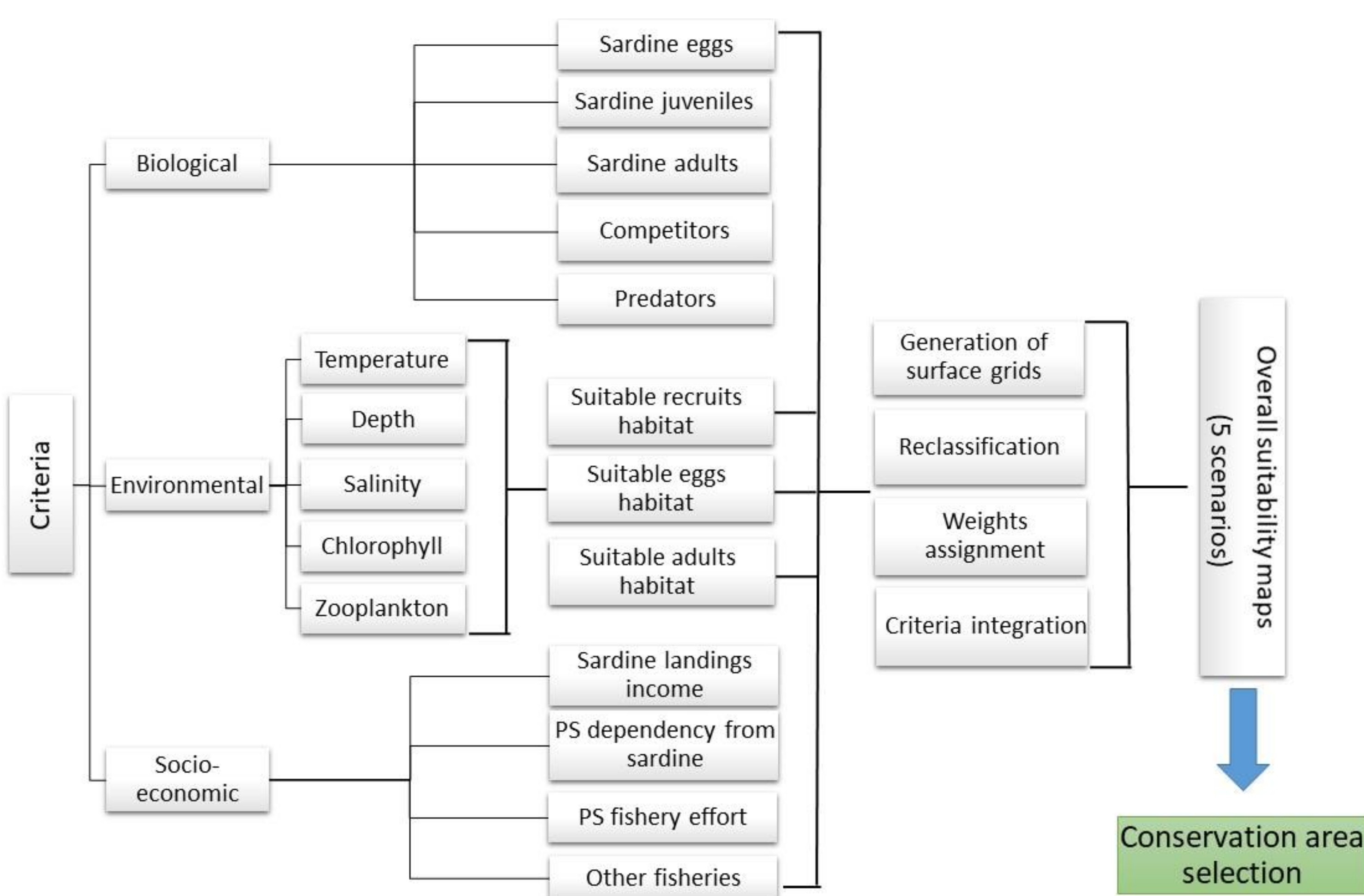- Sensitivity analysis (SA) with a one-at-a-time (OAT) method [8] was performed.

Fig. 1. Conceptual suitability model showing applied criteria and modeling procedure for selection of the conservation in coastal Portuguese waters.

Results and Discussion

The most intensive accumulation of the biological and environmental criteria occurs in the area south of Aveiro (1), near Figueira de Foz (2), Ericeira (3) and near the Tejo estuary (4) [Fig. 2]. On the other hand, the highest accumulation of the majority of socio-economic criteria [Fig. 3 a], is in the areas (1), (2) and (3). Interestingly, the area 4 does not accumulate a high number of socio-economic features.
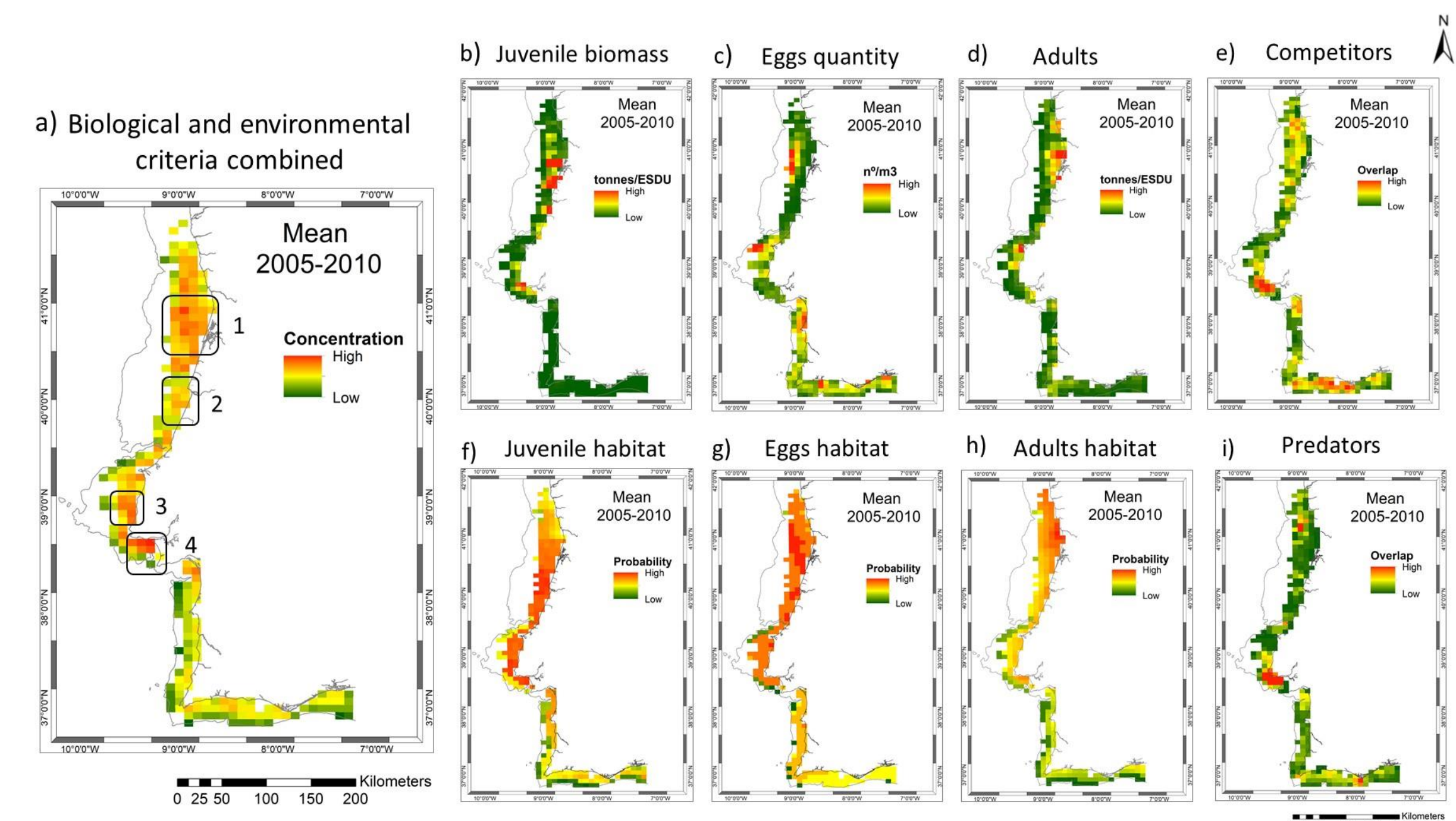

Fig. 2. Biological and environmental criteria combined showing four areas, having their highest concentration, highlighted: (1)-Aveiro; (2)-Figueira de Foz; (3)-Ericeira; (4)-Tejo (a). Maps showing means of each biological and environmental criterion separately (b-i).
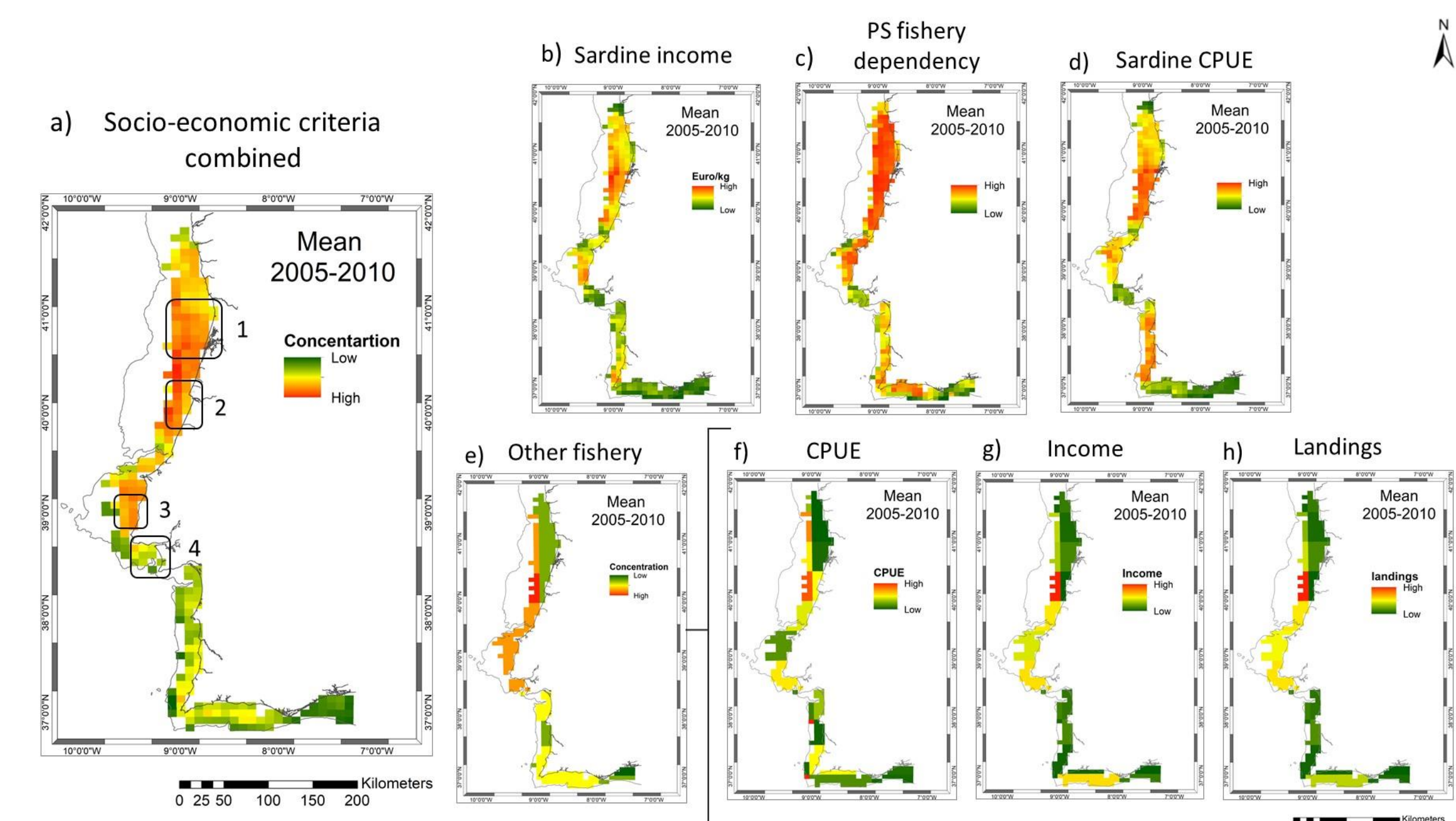

Fig. 3. Socio-economic criteria combined showing four areas of interest (areas having the highest concentration of biological criteria) highlighted: (1)-Aveiro; (2)-Figueira de Foz; (3)-Ericeira; (4)-Tejo (a). Maps showing means of each socio-economic related criteria separately (b-e).

The suitability for conservation varies with the scenario applied [Fig. 4]. Analysis indicated that some areas are suitable for conservation in more than one scenario. For example, this is a case of the area near Aveiro [Fig. 4]. This site is the most suitable for both nurseries and spawning areas protection. However, it is also one of the most conflicting areas as it is highly important for fisheries industry. It is unlikely that closure of fishing in this area might be economically and socially accepted, even though the conservation benefits might be high. Also the area near the Tejo estuary was selected as appropriate for conservation repeatedly for 4 scenarios: *baseline, nurseries protection,* and two socio-economic scenarios: *fishery profit driven* and *safeguarding dependent fishing communities.* It is an important spot for sardine recruitment but on the other hand it is not so important for the fishery. This might be an important area to consider for potential closures.
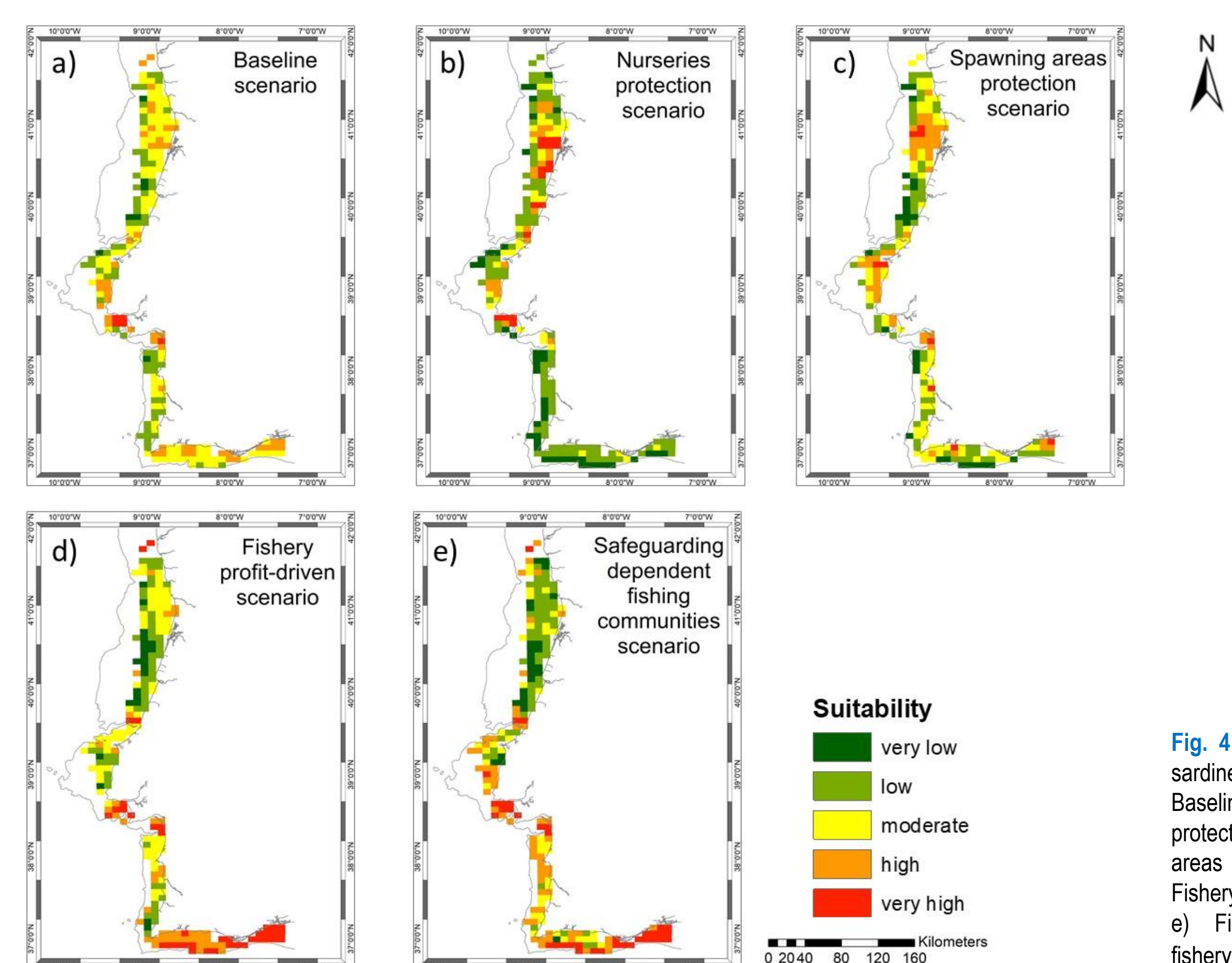

Fig. 4. Suitability classification for sardine conservation areas for a) Baseline scenario; b) Nurseries protection scenario; c) Spawning areas protection scenario; d) Fishery profit-driven scenario; and e) Fishermen dependence on fishery scenario.

Conclusion

The method proposed in the study enables synthesise existing information, visualises spatial existing problems and points out areas that require special attention and a more detailed analysis. This tool might work efficiently as a first step in decision support framework for EAFM. The priority for the future is a further development of the method, by the application of an ecosystem model to evaluate the effect of the selected conservation areas on fisheries and ecosystem.

References

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