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4 **A new approach to assess marine opportunity costs and monetary**
5 **values-in-use for spatial planning and conservation; the case study of**
6 **Gulf of Naples, Mediterranean Sea, Italy.**

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16 **Abstract**

17 Conservation actions (as Marine Protected Areas) are key tools to maintain coastal ecosystems.
18 However, many reserves are characterized by several problems related to inadequate zonings that
19 preclude important areas from economic activities, determining a strong hostility by local
20 populations. Thus, estimations of marine economic values-in-use are needed for protection of
21 marine ecosystem in order to find the best compromise between conservation priorities and local
22 population needs. Algorithms to estimate monetary values of the main human activities in marine
23 territories (large scale and small scale fishings, aquaculture, beach resorts, yachting, diving and
24 commercial shipping) are here implemented using Gulf of Naples (centre Tyrrhenian sea, Italy) as
25 study area example. These algorithms are based on different sources data (questionnaires,
26 monitoring activities, official local authority reports, web and scientific literature). They can also be
27 compared with each other being their outputs all expressed in the same measure unit. During the
28 models development process a new flexible approach, called “Systematic Costs Assessment”
29 (SCA), to assess opportunity costs in systematic conservation planning process was developed and
30 applied. Results show that the total turnover in the Gulf of Naples is 3,950,753,487 € per year and
31 747,647,887 € per year excluding small scale fishing estimation, and one hectare of marine territory
32 is worth 40,672 € and 7,696 € per year excluding small scale fishing activity. In particular,
33 excluding small scale fishing activity, beach resort and yachting show the highest values referred to

one hectare of marine territories. In conclusion, SCA is a flexible approach where no long and costly sampling campaigns are always needed, provided that two assumptions have to be taken into account, in order to estimate credible values-in-use costs: i) do not use economic activities data and ecosystem services data in the same assessment layer, since it could lead to costs overestimation and ii) SCA method are efficient when used by operators with strong knowledge of the study area, since they are able to recognize parameters affecting economic activities of local population.

Keywords: opportunity costs, marine values-in-use, spatial conservation planning, stakeholders, socioeconomic data, MPAs.

1 Introduction

The coastline is the border line separating and connecting landscape and seascape. Coastal zones are characterized by environmental gradients with high biodiversity due to a large number of species and varieties of habitats, higher along the coast than in other zones of marine territories. This is especially the case in the Mediterranean, where fishing and touristic practices are mostly confined to a narrow strip of continental shelf (Papaconstantinou and Farrugio, 2000).

Human populations and their demands for land, energy, and natural resources are exponentially growing, creating pressures on ecosystems that are not expected by conventional approaches to natural resource management (Leisinger et al., 2002). Ecosystem-Based Management (EBM) approach (Katsanevakis et al., 2011) is developed to tackle this problem from a holistic point of view, involving management of species, habitats and human activities. Ecosystem management is best thought as “the process of ecosystem-based management of human activities” (Grumbine, 1991; Kay and Schneider, 1994) using appropriate management and protection tools, such as Marine Protected Areas (MPAs) (Browman and Stergiou, 2004; Halpern et al., 2010; Rassweiler et al., 2012). Protection tools guarantee the conservation of marine biodiversity, increase commercial fish sizes and biomass (e.g. Fenberg et al., 2012; Guidetti et al., 2008), produce economic benefits and enhance visitors flows through sustainable practice of marine activities, such as diving and yachting (Badalamenti et al., 2000; Lopes et al., 2015; McCook et al., 2010).

Nevertheless, many MPAs are inefficient to pursue their own conservation and sustainable objectives. Indeed, relevant sites characterized by high number of species (Appolloni et al., 2017; Di Donato et al., 2006; Russo et al., 2005) or by important species for ecosystem functions (Donnarumma et al., 2018; Frascchetti et al., 2005) are located in areas of partial protection. At the same time, management efforts are often vain since local populations often consider protection policy tools simply linked to biodiversity conservation (Badalamenti et al., 2000).

66 In order to overcome these criticisms, the Systematic Conservation Planning approach was
67 developed in recent years (Margules and Pressey, 2000). This is based on the explicit definition and
68 quantification of conservation objectives to be achieved, and, at the same time, on minimization of
69 opportunity costs linked to the protection (Smith et al., 2006). Those opportunity costs can be
70 viewed either as ecosystems services lost by local population in environmental degraded areas
71 (Franzese et al., 2017, 2015; Picone et al., 2017; Vassallo et al., 2017) or in the Millennium
72 Ecosystem Assessment (MA) framework, analysing socio-ecological systems with wide influence
73 in the policy and scientific communities (Carpenter et al., 2009 and references therein) or, at least,
74 from the stakeholders points of view. In the latter case “opportunity costs” are defined as costs of
75 foregone opportunities, a measure of what could have been gained via the best use of a resource if it
76 had not been included in a reserve. In terrestrial and marine protected areas, where extractive and
77 exploitation activities are forbidden, opportunity costs are measured as the highest economic value
78 of those activities if no form of protection is applied (Naidoo et al., 2006). However, to assess the
79 opportunity costs of parcels of sea territory could be very hard since marine systems are typically
80 common-pool resources where the same parcel is used for many activities (Beck et al., 2004;
81 Ostrom et al., 1999). Those activities producing values-in-use of marine territories are classified
82 into two macro-categories: direct and indirect values of bio/environmental resources (McNeely,
83 1994, 1988). The first ones refer to consumptive (those values placed on nature products that are
84 consumed directly, without passing through a market) and productive values (those products which
85 are commercially harvest, often being the only biological resources having a clear monetary cost).
86 The latter ones, representing the greatest part of marine territories, are the indirect values,
87 concerning environmental resources that do not normally appear in national accounting systems
88 even if their exploitation has direct consequences on the value of biological resources. All values-
89 in-use have to be minimized during MPA planning in order to meet most stakeholders needs, that,
90 eventually, improve MPA efficiency. Conservationists, resource managers and social scientists
91 frequently disagree on whether it is possible to achieve a balance between social-economic and
92 ecological benefits in environmental management (Christie, 2011), however, in a multiple objective
93 process it is hard to maximize more than one value-in-use at a time (Stanley, 1995). In order to meet
94 the local needs many researchers have used only fishing activity as representative of all marine
95 economies (Klein et al., 2009; Wood and Dragicevic, 2007); however they, soon, understood that it
96 was not enough since areas having no value for fishing, could have values for other activities, such
97 as tourism (McClanahan, 1999; Russ and Alcala, 2004). Thus, in recent years some authors
98 proposed that countries aiming at protecting marine biodiversity in their territorial waters should

99 move from a single objective approach to a broader socioeconomic context incorporating multiple
100 activities (Douvere and Ehler, 2009; Ehler and Douvere, 2009; Mazor et al., 2014a).
101 There are few documented examples where different kinds of activities are combined (Giakoumi et
102 al., 2011; Green et al., 2009; Leathwick et al., 2008) since socioeconomic data are often measured
103 in different units and/or can involve difficult decisions on weighing different costs
104 Therefore, in the present investigation, models based on local data describing marine values-in-use,
105 being preferable for decision makers and planners (Carwardine et al., 2008; Naidoo et al., 2006), are
106 developed since they allow to sum activities on marine territory using the same economic unit
107 (euro) and spatial extension (one hectare). Thus, it does not assess the effect of activities on
108 ecosystems and their services to local population, but rather it might represent a way to integrate a
109 wider set of stakeholders needs in the planning processes of protected areas.
110

111 **2 Materials and methods**

112 **2.1 Study area**

113 The Gulf of Naples is located on centre south Tyrrhenian Sea and comprises 385 km of coastline
114 where face 25 municipalities, many of which are characterized by high population density.
115 The privileged geographical position makes the port of Naples one important commercial hub in
116 Mediterranean Sea. The structure of the Naples harbour offers an articulated and complex port
117 services system in which operate more than 370 companies employing with more than 5,200
118 people.
119 Geomorphological configuration, natural beauties, excellent climate, culture and tourist facilities
120 also make the Gulf area a very important tourist destination centre. Locations as: the Gulf Islands
121 (Capri, Ischia and Procida), Sorrento peninsula, Vesuvius National Park, Phlegraean Fields and
122 archaeological sites of Pompeii, Herculaneum and Pozzuoli, act as a powerful driving force of all
123 economic sectors. In addition, in order to preserve marine habitats biodiversity, chronically
124 subjected to multiple anthropogenic stressors, four Marine Protected Areas were established along
125 the coastline: the Underwater Parks of Baia and Gaiola MPAs, the Regno di Nettuno MPA and the
126 Punta Campanella MPA. Although these MPAs are established rather close to very urbanized and
127 commercially active areas leading to marine stakeholders hostilities (principally fishermen and
128 touristic managers) (Badalamenti et al., 2000) they became more and more important attractive
129 poles for many touristic activities (swimming, yachting, diving, etc.) in the last years, enriching, *de*
130 *facto*, a good part of the Gulf of Naples citizens.

131 The study area is also characterised by peculiar orographic aspects influencing wind and sea
 132 dynamics (Uttieri et al., 2011). The Vesuvius volcano (elevation: 1,281 m) and Naples hills
 133 (elevation: about 450 m) can shelter north-easterly winds blowing over the basin mostly in winter,
 134 creating jet currents responsible for rapid coast offshore water exchanges (Cianelli et al., 2012).
 135 These frequent water exchanges, helped by two deep canyons, provide a continuous supply of clean
 136 and deep water, rich in nutrients, that support high biodiversity, although the area is characterized
 137 by a strong urbanization. This in economic terms translates into intense large scale and small scale
 138 fishing activities that significantly contribute to the population richness.

139 ***2.2 Data collection and computation of monetary values-in-use***

140 Some of the main activities performed in the present investigation are georeferenced and mapped at
 141 1:50,000 scale using ArcGIS for Desktop 10.1 © ESRI. For each activity, algorithms developed to
 142 assess their significance on local economies are described. Then a net of 10,454 hexagons of 10
 143 hectares each, hereafter called Costs Units (CUs), are considered and activities are summed in each
 144 CU.

145 *Large Scale Fishing (LSF)* (bathymetric range: deeper than 50m depth)

146 From July 2007 to April 2008 censuses of fish catches were carried out. The fishing gear used was
 147 trawl net, the most widely used gear for large scale fishing activity in the Gulf (Regione Campania,
 148 2014).

149 Fish prices showed by ISMEA (Institute of services for the agricultural market food, supervised by
 150 the Italian Ministry of Agriculture) were used in order to estimate monetary values of species
 151 recorded.

152 In order to estimate the total fishing area, a measure of 5m (mean width of the opening of a trawl-
 153 net), is applied to the vessels routes recorded by GPS .

154 The web site <http://www.marinetraffic.com/en/> was monitored from May to October 2015, to assess
 155 how many fishing vessels operated in the study area, for a total of 148 working days (IREPA,
 156 2011).

157 Large Scale Fishing monetary value of j-th CU (LSF_j) in each CU, are calculated as follows (Eq. 1):

$$LSF_j = \left(\frac{F \times N_{v,i}^{\circ}}{A_i} \right) \times A_{ij}$$

158

159 **Eq. 1** - Algorithm developed to assess Professional Fishing costs values-in-use.

160 F is the value of fish biomasses (in €), caught in one year, $N_{v,i}^{\circ}$ is the estimate mean number of
 161 vessels in the i-th study area, A_i is the area in hectares effectively covered by trawls in the i-th
 162 fishing area and A_{ij} is the area really covered by i-th fishing area in the j-th CU.

163 *Small Scale Fishing (SSF)* (bathymetric range: between 40m and 150m depth)

164 Coralligenous patches are selected to estimate artisanal fishing areas since they are considered hot
 165 spots for small scale fishing activities (Ballesteros, 2006; Ferrigno et al., 2017; Lo Bianco, 1909;
 166 Mazzarelli and Mazzarelli, 1918) (Ferrigno et al 2017; Ballesteros, 2006; Lo Bianco, 1909;
 167 Mazzarelli and Mazzarelli, 1918). Here many fish species having commercial values might
 168 potentially be caught. Biomass average value for each species, recorded in 21 publications on rocky
 169 bottom fish assemblages in west Mediterranean sea (Table 1) using visual census technique
 170 (Harmelin-Vivien et al., 1985), are taken into account.

Paper	Sampling area	Site
(Dufour et al., 1995)	600 m ²	France (North-West Mediterranean sea)
(Reñones et al., 1997)	250 m ²	Balearic (West Mediterranean sea)
(Garcia-Charton and Pérez-Ruzafa, 1998)	250 m ²	Spain (South-West Mediterranean sea)
(García-Charton and Pérez-Ruzafa, 1999)	250 m ²	Spain (South-West Mediterranean sea)
(La Mesa and Vacchi, 1999)	250 m ²	Italy (Southern Tyrrhenian sea)
(García-Charton et al., 2000)	250 m ²	France
(Guidetti et al., 2001)	125 m ²	Italy (Ionian Sea)
(Guidetti et al., 2002)	125 m ²	Italy (South Adriatic Sea)
(Letourneur et al., 2003)	40 m ²	France (North-West Mediterranean sea)
(Lipej et al., 2003)	100 m ²	Italy (North Adriatic Sea)
(La Mesa et al., 2004)	50 m ²	Italy (Centre Mediterranean Sea)
(García-Charton et al., 2004)	250 m ²	Balearic (West Mediterranean sea)
(Bonaca and Lipej, 2005)	100 m ²	Italy (North Adriatic Sea)
(Pérez-Ruzafa et al., 2006)	100 m ²	Spain (West Mediterranean sea)
(Azzurro et al., 2007)	125 m ²	Italy (Centre Mediterranean Sea)
(Guidetti et al., 2007)	125 m ²	Italy (North-West Tyrrhenian Sea)
(Consoli et al., 2008)	40 m ²	Italy (Centre Mediterranean Sea)
(Vacchi et al., 2009)	250 m ²	Italy-Ustica island (South Tyrrhenian sea)
(Bussotti and Guidetti, 2009)	125 m ²	Italy (Ionian Sea)
(Coll et al., 2013)	250 m ²	Balearic (West Mediterranean sea)
(Appolloni et al., 2017)	125 m ²	Italy (Centre Mediterranean Sea)

171 **Table 1** - Literature used to assess species and average biomass of commercial fish on hard bottoms
 172 (West Mediterranean Sea; Visual census technique).

173

Commercial species are considered according to Guidetti et al. (2014). When abundances data are recorded in a publication, biomasses are estimated using population size-structure and length-weight relationship (Froese and Pauly, 2012). Fish prices reported by ISMEA are used in order to estimate monetary values of species recorded. 148 working days (IREPA, 2011) are considered. Finally, for each CU monetary value of j-th CU (SSF_j) is calculated following Eq. 2:

$$SSF_j = \frac{F_{ha} \times A_{ij}}{\text{Log}_2(\text{Cost}_{di} \times N_v^{\circ})}$$

Eq. 2 - Algorithm developed to assess Artisanal Fishing costs values-in-use.

F_{ha} is the value of fish biomasses expressed in €/ha. To estimate the numbers (N_v°) of vessels, fishing boats (“gozzo”), characterized by presence of fishing gears on board, as nets, long-lines and winches and captured in the summer satellite pictures of ©Google Earth (pictures examples are reported in Sup 1.1), are counted.

A_{ij} is the area, in hectares, really occupied by a i-th coralligenous patch in the j-th CU.

Cost_{di} is cost distance from the ports where “gozzo” are present calculated using the Cost Distance tool of ArcGIS for Desktop. Distance from port or coast is a representative measure of fishing pressure according to numerous studies, especially for small scale fishing (Caddy and Carocci, 1999; Pauly and Gelchu, 2007; Stelzenmüller et al., 2008). Here, the study area is used as a dataset of the cost; thus, the distance of a site from the nearest port is not calculated in a straight line, but taking into account the obstacle that land poses to navigation and marine currents.

Aquaculture (Acq) (bathymetric range: not over than 20m – 25m depth)

Aquaculture facilities are mapped and georeferenced by navigational charts digitalization.

Campania aquaculture data recorded in Prioli et al., (2001) and Carillo and Spagnolo, (2008) are considered.

Only mussel farms are taken in costs assessment, since *Mytilus galloprovincialis* (Lamarck 1819) is main farmed species in the Gulf of Naples.

For each CU aquaculture facility monetary value of j-th CU (Acq_j) was calculated as follows (Eq. 3):

$$Acq_j = F \times A_{ij}$$

Eq. 3 - Algorithm developed to assess Aquaculture facilities costs values-in-use.

203 F is the value of mussels biomasses expressed in €/ha, and A_{ij} is the area in hectares that the i-th
204 aquaculture facility really occupied in the j-th CU.

205 *Beach resort (B)* (bathymetric range: supra- and meso-littoral)

206 In order to map and georeference the mainly frequented beach areas, August 2014 ©Google Earth
207 satellite pictures are considered (pictures examples are reported in Sup 1.2). In each area open
208 beach umbrellas are counted and 90 working days are also considered.

209 Algorithm used to assess monetary value of j-th CU (B_j) is shown in Eq. 4:

$$B_j = \left(\frac{N_{u,i}^\circ}{A_i} \right) \times A_{ij}$$

210

211 **Eq. 4** - Algorithm developed to assess bathing activity costs values-in-use.

212 Where $N_{u,i}^\circ$ is the number of open beach umbrellas counted on i-th beach area, A_i is the area, in
213 hectares, of the i-th bathing site, A_{ij} is the area really occupied by the i-th bathing site in the j-th
214 CU.

215 Sixtyseven questionnaires were submitted to beach resorts managers operating in the Gulf in the
216 summers 2016 and 2017 (Sup 2.1) in order to verify that the average cost of 20 € per day, for a
217 beach umbrella and two sunbeds, as previously suggested by Italian Consumers Defence and
218 Orientation Association (ADOC), could be correct. Areas without beach resorts, but used as bathing
219 sites, are also considered having the same values of beach resorts.

220 *Yachting (Y)* (bathymetric range: not over than 20m depth)

221 August 2014 ©Google Earth satellite pictures are considered (Sup 1.3) in order to map and
222 georeference the mostly frequented yachting sites. These images are also used to estimate the costs
223 of each site through counts of yachts.

224 Algorithm used to assess monetary value of j-th CU (Y_j), is shown in Eq. 5:

$$Y_j = \left(\frac{N_{y,i}^\circ \times \text{Log}_2(\text{Cost}_{d,i})}{A_i} \right) \times A_{ij}$$

225

226 **Eq. 5** - Algorithm developed to assess yachting costs values-in-use.

227 $N_{y,i}^\circ$ is the number of yachts counted in each i-th yachting spot and $\text{Cost}_{d,i}$ is the cost distance from
228 the ports where yachts are present, calculated using the Cost Distance tool of ArcGIS for Desktop.
229 The study area is used as a dataset of the cost. A_i is the area, in hectares, of the i-th yachting spot
230 and A_{ij} is the area really occupied by the i-th spot in the j-th CU. Unfortunately, it was not possible

231 to obtain information from official reports being very few the ports with a formal price list. Most of
 232 them make a quote at the time of reservation request, depending the economic proposal on actual
 233 factors, leaving wide space to negotiations. However, it is possible to obtain a realistic figure of the
 234 average annual mooring cost consulting the internet (such as portbooker.com or specific harbours
 235 web sites) and asking for a quote. Following this procedure it appears that the considered average
 236 annual mooring costs for a 12 m long yacht is 7,000 € per year.

237 *Diving (D)* (between 10m and over 40m depth)

238 Interviews to diving centres staffs operating in the study area were carried out between 2014 and
 239 2015 (Sup 2.2). One hectare area around each spot is also considered. Algorithm to assess monetary
 240 values (D_i) of each dive spot is reported in Eq.6:

$$D_j = \frac{N_{div,j}^{\circ}}{DD_j \times \text{Log}_2(\text{Cost}_{d,j}) \times 1ha}$$

242 **Eq. 6** - Algorithm developed to assess diving costs values-in-use.

243 $N_{div,j}^{\circ}$ is the average season number of divers in the j-th spot, $\text{Cost}_{d,j}$ is the cost distance from the
 244 diving centre ports to the j-th dive spot and DD_j is the difficulty degrees of the j-th dive spot,
 245 according to the planned maximum depth set by diving schools:

- 246 ▪ high difficulty, dives over 40 m depth;
- 247 ▪ medium difficulty, dives between 40 m and 18m depth;
- 248 ▪ low difficulty, dives between 17 m and 5m depth.

249 One dive average price, gathered from diving centres websites, of each spot is considered.

250 *Commercial Shipping (CS)* (depth is chosen such as vessels risk of getting stuck is minimal)

251 Commercial nautical routes are mapped and georeferenced by ©Google Maps imagines (examples
 252 are reported in Sup 1.4). Resulting map were also submitted to the main shipping companies:
 253 CAREMAR, SNAV and ALILAURO, to confirm its accuracy. To estimate the total area, a measure
 254 of 500 m is applied to the vessels routes in order to consider uncertainty due to navigation (Halpern
 255 et al., 2008).

256 Algorithm used to assess monetary value of j-th CU (CS_j) was calculated as in Eq. 7:

$$CS_j = \left(\frac{N_{r,i}^{\circ} \times N_{p,k}^{\circ}}{A_i} \right) \times A_{ij}$$

258 **Eq. 7** - Algorithm developed to assess commercial shipping costs values-in-use.

259 $N_{r,i}^{\circ}$ is the seasonal number of routes for the i-th destination; $N_{p,k}^{\circ}$ is the maximum number of the k-
 260 th vessel for each shipping company, A_i is the area, in hectares, occupied by the i-th route in study
 261 area, A_{ij} is the area really occupied by the i-th route in the j-th CU. The summer season 2015 (most
 262 expensive period) prices per person and number of routes for each destination were derived from
 263 the website www.traghettilines.it.

264 **3 Results**

265 **3.1 Activities monetary values-in-use.**

266 *Large Scale Fishing (LSF)*

267 LSF nautical routes are shown in Figure 1a. Two main areas are detected: one inside the Gulf
 268 (11,507.42 ha) and one outside the Gulf (7,440 ha). Areas really occupied by fishing routes are: 244
 269 ha in the inner part and 193 ha in the outer part of the Gulf. 5 (± 2) and 3 (± 1) fishing vessels per day
 270 are respectively estimated in the inner and outer part of the Gulf. Monetary values in the inner and
 271 outer part are respectively 9,247.96 €/ha per year and 2,695.95€/ha per year. A total turnover of
 272 4,336,430 € per year is also assessed.

273 *Small Scale Fishing (SSF)*

274 856 coralligenous patches are detected (Figure 1b). Although they are scattered in the whole Gulf,
 275 the 86% are located within 1 nm from shore. Species, average biomass reported in literature and
 276 prices considered to estimate monetary values are shown in Table 2.
 277 Coralligenous hard bottoms cover 1,616.083 ha, with a potential monetary value estimation equal to
 278 2,001,941 €/ha per year and total turnover of 3,203,105,600 € per year.

279

Scientific name	Biomass (kg)	Price (€/kg)
<i>Boops boops</i> (Linnaeus, 1758)	108.32 (± 119.98)	1.492857
<i>Mugilidae sp.</i>	46.44 (± 84.23)	2.457571
<i>Conger conger</i> (Linnaeus, 1758)	11.38 (± 14.57)	1.631556
<i>Dentex dentex</i> (Linnaeus, 1758)	119.41 (± 122.31)	24.07366
<i>Dicentrarchus labrax</i> (Linnaeus, 1758)	133.07 (± 192.04)	21.28034
<i>Diplodus annularis</i> (Linnaeus, 1758)	4.54 (± 6.56)	6.572907
<i>Diplodus puntazzo</i> (Cetti, 1777)	33.87 (± 69.45)	9.669583
<i>Diplodus sargus</i> (Linnaeus, 1758)	101.58 (± 268.54)	3.72
<i>Diplodus vulgaris</i> (Geoffroy Saint Hilaire, 1817)	57.80 (± 47.12)	3.72
<i>Epinephelus costae</i> (Steindachner, 1878)	98.20 (± 102.19)	20.04017
<i>Epinephelus marginatus</i> (Linnaeus, 1758)	375.54 (± 620.57)	20.04017
<i>Labrus merula</i> (Linnaeus, 1758)	19.69 (± 15.35)	5.161
<i>Labrus viridis</i> (Linnaeus, 1758)	7.77 (± 8.02)	5.161
<i>Muraena helena</i> (Linnaeus, 1758)	19.24 (± 26.06)	1.731667
<i>Oblada melanura</i> (Linnaeus, 1758)	54.47 (± 58.46)	2.831563
<i>Pagellus erythrinus</i> (Linnaeus, 1758)	4.22 (± 5.4)	19.18036
<i>Pagrus pagrus</i> (Linnaeus, 1758)	11.20 (± 10.86)	19.18036
<i>Phycis phycis</i> (Linnaeus, 1766)	1.57 (± 2.59)	3.112581
<i>Pomadourys incisus</i> (Bowditch, 1825)	16.32 (± 23.06)	8.47375
<i>Sarpa salpa</i> (Linnaeus, 1758)	149.45 (± 91.67)	2.42375
<i>Sciaena umbra</i> (Linnaeus, 1758)	75.34 (± 141.66)	15.16214
<i>Scorpaena notata</i> (Rafinesque, 1810)	0.90 (± 0.79)	5.161
<i>Scorpaena porcus</i> (Linnaeus, 1758)	2.45 (± 3.15)	12.964
<i>Scorpaena scrofa</i> (Linnaeus, 1758)	4.8 (± 6.8)	13.59629
<i>Seriola dumerilii</i> (Risso, 1810)	640.09 (± 1205.29)	11.93192
<i>Serranus cabrilla</i> (Linnaeus, 1758)	30.13 (± 24.48)	5.161
<i>Serranus scriba</i> (Linnaeus, 1758)	25.13 (± 24.04)	5.161
<i>Sparisoma cretense</i> (Linnaeus, 1758)	22.59 (± 90.22)	5.161
<i>Sparus aurata</i> (Linnaeus, 1758)	800.7 (± 48.4)	12.44647
<i>Spondilylosoma cantharus</i> (Linnaeus, 1758)	38.67 (± 24.85)	8.47375
<i>Symphodus tinca</i> (Linnaeus, 1758)	20.58 (± 22.3)	5.161

Table 2 - Species, biomass and price estimated, respectively, from literature and ISMEA data.

283 *Aquaculture (Acq)*

284 In the Gulf of Naples 12 mussels aquaculture facilities, all in the inner part of the Gulf, are present
285 (Figure 1c) Altogether they cover 209.816 ha, with an estimated monetary value equal to 25,000
286 €/ha per year and total turnover of 5,245,400 € per year.

287 *Beach resort (B)*

288 In the Gulf of Naples 117 beaches are recorded (Figure 1d). They cover 104 ha of land with an
289 average of 268 beach umbrellas/ha; assuming an average payment of 20€ per day per beach
290 umbrella, an estimated monetary value of 482,400 €/ha per year and total turnover of 50,169,600 €
291 per year is expected.

292 *Yachting (Y)*

293 In the Gulf of Naples 61 areas used for recreational yachting activities are present (Figure 1e). They
294 cover a total area of 294.126 ha and an average 21 yachts/ha are counted. An estimated monetary
295 values of 145,453 €/ha per year and a total turnover of 42,781,509 € per year is expected.

296 *Diving sites (D)*

297 Gulf of Naples hosts 71 official dive spots. Low difficulty dives are mostly carried out in 31 sites
298 along the inner north-west side of the Gulf; 22 medium difficulty diving sites are mostly located
299 along the east side of the Gulf and around north-west islands; 18 high difficulty dives are scattered
300 in the whole Gulf (Figure 1f). 88% of all dive sites are within 1nm from the coast. Without taking
301 into account dives performed for the achievement of diving licences, an estimate monetary value of
302 25,034.07 €/ha per year and total turnover of 1,777,418.97 € per year can be assessed.

303 *Commercial Shipping (CS)*

304 In the Gulf of Naples 22 tourists commercial shipping routes, used to bring locals and tourists either
305 to Gulf islands or to other Italian regions (i.e. Sicily or Sardinia), are present (Figure 1g). Routes
306 cover 52,625.78 ha with a potential monetary value equal to 12,224.76 €/ha per year and total
307 turnover of 643,337,530.31 € per year.

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Figure 1 – Commercial activities in the Gulf of Naples. a) Large Scale Fishing nautical routes and fishing areas detected in 2007-2008 (yellow) and from Marine Traffic website (May-October 2015) (red); b) Coralligenous patches: hotspots for Small Scale Fishing; c) Aquaculture facilities; d) Beach resorts; e) Harbours and anchoring sites; f) Dive spots with difficulty degrees; g) Commercial shipping routes.

3.2 Monetary marine territories values-in-use.

Sum of activities, expressed in €/ha, that occurs across Gulf of Naples are shown in Figure 2. Since all activities are expressed in €/ha per year, total turnover of seven activities is 3,950,753,487 € per year and 747,647,887 € per year without considering SSF.

Among all activities, small scale fishing and commercial shipping show the highest total estimated turnover (Figure 3a). Beach resort and yachting have the second highest turnover per year.

Opportunity costs estimated on one hectare of marine territory is worth 40,672 € and 7,696 € per year excluding SSF. Activity that gives major contribution is SSF while beach resort, yachting and diving activities have intermediate values (Figure 3b; white bars). Finally, activities that are carried out in the largest areas are, in decreasing order: CS, SSF and LSF (Figure 3b; black dots).

Figure 2- Summed monetary values in each CU.

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328 **Figure 3** – a) Total turnover of each activity expressed in € per year; b) monetary values (white
 329 bars) for each activity expressed in euro per year and area (black dots) needed for each activity.

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331 4 Discussions

332 Transboundary conservation programs are globally increasing both in terrestrial (Halpern et al.,
333 2006) and marine systems (Mackelworth, 2012). New approaches for estimating the potential for
334 collaboration success between stakeholders when taking conservation action (Levin et al., 2013) are
335 required. The lack of informative economic data at the appropriate scale represents one of the most
336 important challenges that planners face evaluating or creating a reserves network (Ban et al., 2009;
337 Green et al., 2009).

338 Estimations of values-in-use as costs are often based on expert judgements, due to lack of a
339 standard protocol for their assessment (Diakomihalis, 2007; Geselbracht et al., 2009; Moffett and
340 Sarkar, 2006). This might lead to a subjective orientation of management decision, based on
341 personal or institutional interests.

342 In order to overcome these problems and to create tools allowing to compare opportunity costs of
343 different activities, algorithms based on objective data (questionnaires, official reports, scientific
344 literature, internet information or sampling and monitoring activities) are here developed. These
345 models, along with some results of monetary estimations (e.g. artisanal fishing opportunity costs),
346 could also be applied in other sites of west Mediterranean Sea. Models transfer offers a method of
347 estimating opportunity costs in terms of monetary values-in-use for activities in marine spatial
348 planning without performing relatively expensive primary evaluation studies (Brander et al., 2007).
349 In this study, the first attempt to confer a monetary value to maritime space facing the Gulf of
350 Naples is presented. During this process, an approach to assess values-in-use costs that can be used
351 in a systematic conservation planning process (Margules and Pressey, 2000), is performed. In this
352 flexible approach, called “Systematic Costs Assessment”, highlighting the linkage with the
353 “Systematic Conservation Planning” and the need of considering activities within marine territory,
354 the basic idea is to estimate values-in-use costs from available data even if deriving from different
355 sources (i.e. sampling, as for LSF; scientific literature, as for SSF and Acq; internet tools and web
356 sites, as for B, Y, D and CS activities). Applying this method, estimations of costs (in euro) referred
357 to one hectare of marine territory for all the activities (Katsanevakis et al., 2011) can be summed
358 and mapped in the study area.

359 First of all consideration must be given about the communication of these results to end users.
360 There is little doubt that maps are powerful visual tools allowing complex information to be
361 conveyed to a wide audience (Burnett and Kalliola, 2000). Maps allow to move on from generic
362 statements, such as “fishing is an important activity in the Gulf”, to specific statements about where
363 this applies. In addition, the information is captured in a visual way that often attracts the attention
364 of decision-makers and stakeholders in a manner that statistical reports alone often do not.

365 However, as highlighted by Swetnam et al., (2011) there is the danger that a mapped scenario can
 366 be used by stakeholders in order to hamper conservation actions.

367 Some difficulties applying systematic costs assessment may arise from the evaluation of the
 368 variables affecting each activity. Indeed, variables have been considered on the peculiar empirical
 369 considerations that can be done on the activities and on the weight that these variables have on each
 370 of them. For example the term $Cost_{di}$ is here considered as the likelihood that an area is used for
 371 SSF, D and Y activities. Nevertheless, for the first two activities $Cost_{di}$ is at the denominator since
 372 the more distant fishing or diving spots are from the harbours the higher is the cost in order to reach
 373 it. This consideration is wrong for Y activity since a mooring area is more attractive if it is far from
 374 the ports, thus $Cost_{di}$ is to the nominator.

375 Others problems in estimations of costs using different data types are due to the overestimations of
 376 some activities.

377 Although our total estimations (3,950,753,487 € per year and 747,647,887 € per year without
 378 considering SSF) are coherent with costs calculated for others urbanized Mediterranean Sea areas
 379 (Mazor et al., 2014a, 2014b; Rees et al., 2010) and performed in order to assess opportunity costs
 380 in a Systematic Conservation Planning context, they represent the greatest value-in-use that could
 381 derive from anthropic activities, even though some overestimation might be possible. For example,
 382 SSF and CS perform a higher total turnover per year but their results are calculated as potential cost,
 383 and therefore they are considered, respectively, as if all commercial fish biomass could be caught
 384 and as if all the touristic vessels were always full. However, it is important to distinguish between
 385 economic values coming from activities and those arising from ecosystem services. Economic
 386 values of SSF are assessed by the whole fish assemblages that coralligenous habitat could provide
 387 to local population, while economic values of CS are assessed directly from fishing activity.

388 Calculating the total turnover on the area effectively occupied by each activity could be a way to
 389 overcome this problem. Indeed, relating commercial shipping to the area occupied, its contribution
 390 drastically decreases and activities such as beach resort and yachting, correlated to their areas,
 391 increase their weight on the estimation of costs. This problem is not overcome when SSF total
 392 turnover is related to the unit area, being its value the highest one. Thus, it is possible to conclude
 393 that the great overestimation due to the SSF inclusion in the activity, is attributable to sum together
 394 monetary values coming from ecosystem services data and from economic activities data, since the
 395 former are, obviously, some orders of magnitude higher than the latter, making them almost
 396 irrelevant.

397 A correct aspect taken into account in the present investigation is the scale at which activities are
 398 mapped for the SCA application. Most data of Gulf of Naples here applied come from the accurate

399 cartography, available at the same scale, allowing the assessment of some proxies such as cost
400 distance parameter. Scale chosen has also great importance in the selection of most activities carried
401 out in the Gulf. At a lower scale some activities would be very hard to map, such as aquaculture,
402 beach resorts and yachting activities, since they occupy very small areas; a higher scale would lead
403 to redundant or misleading information. Another important factor in favour of SCA approach
404 should be the good knowledge of the study area, since it is crucial in the selection of (i) those
405 activities that more significantly support the local population, (ii) the parameters more coherent
406 with social-economic aspects. The good knowledge of the study area will also lead to a realistic
407 figure of total estimated costs.

408 Monetary evaluation is largely demonstrative of the relative economic significance of marine
409 leisure and fishing industry. Marine policy has typically favoured only fishing industry in marine
410 planning and conservation conflicts (Laffoley et al., 2004) and valuation for alternative uses of
411 marine biodiversity is a powerful tool influencing the decision making process, being more
412 understandable by stakeholders involved in marine spatial planning process (Brander et al., 2007;
413 Rees et al., 2010), therefore the assessment of the most activities performed on marine territories
414 should be always preferable.

415 However, sometimes it is very hard to give a monetary value to an activity, especially when it
416 cannot be monetizable since it has not always a cost (e.g. some beaches and many yachting and
417 swimming sites are free) and monetary values are assessed by proxies not directly developed in
418 mapped areas. In these cases other representative estimations of such activities (i.e. how much
419 people pay using a particular area service) should still be considered important tools in marine
420 spatial planning, providing a relative value of marine leisure (Schmiing et al., 2015) and their
421 monetization have to be object of future studies.

422 **5 Conclusions**

423 Algorithms here implemented allow to create maps where monetary values-in-use can be assigned
424 (including areas of zero value) and can be used in conservation planning optimisation software.
425 For future marine conservation plans it is here suggested the use of Systematic Costs Assessment,
426 since reduces stakeholders hostility. Moreover, this approach may allow estimations on the
427 maximum investments that can be afforded for specific conservation actions facilitating
428 conservation design phase.

429 Information coming from SCA also allows to identify groups of stakeholders and to define possible
430 management options which may affect costs and benefits of marine biodiversity conservation.
431 Moreover, economic valuations of some activities, such as small scale fishing or beach resorts,

could help in the assessment of monetary losses of the local economies when some habitats are damaged or lost by human activities (e.g., overfishing, erosion). Although SCA represents a flexible approach useful in many activity assessment problems, it is evident that algorithms have to be developed taking in due account both spatial conditions in which data are available and local population cultural aspects, in order to include those important activities that can concur to economic state and to exclude unnecessary parameters. In conclusion, economic evaluations performed in the present investigation ensure that most of the geographic areas, regardless their destination uses, are properly taken into account. However, the application of SCA approach in different world areas has to be strongly recommended for a more accurate validation.

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