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Economic assessment of ecosystem services: Monetary value of seagrass meadows for coastal fisheries

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ABSTRACT

Estimation of the economic value of ecosystem services is particularly incipient in the marine realm, where numerous services still need to be evaluated. Seagrasses deliver essential services to humans. In this paper, we determined the economic value of *Cymodocea nodosa* seagrass meadows for local fisheries at the oceanic island of Gran Canaria (eastern Atlantic). Large-sized fishes, which constitute the fishable fraction, were seasonally sampled through 2011 by means of visual censuses at 12 seagrass-dominated sites. The total fish biomass was 907.6 kg (894.55 kg of commercially-targeted fishes). By using standard market prices, we estimated that the monetary value of this biomass averaged 866 € ha^{-1}; at the island-scale, this value adds up to 606 239 €, when considering the area covered by *C. nodosa*. Small-sized fishes (mostly juveniles that replenish fisheries) were also seasonally sampled, through a seine net, at the same 12 seagrass-dominated sites. Eight nearshore fish species with commercial interest used seagrass meadows as 'nursery grounds'. Estimates of secondary production revealed that this fish production monetarily averaged 95.75 € ha^{-1} y^{-1} when considering standard market prices; this value adds up to 67 030.30 € y^{-1} at the island-scale, when considering the area covered by *C. nodosa*. This study provides complementary assessments of the key economic contribution of seagrass meadows for coastal fisheries as both 'fishing' and 'nursery' grounds. This is a way to promote the social perception of the key role that seagrasses play on the coast and, therefore, the necessity of incorporating seagrasses into conservation legislative frameworks.

1. Introduction

Habitats dominated by seagrasses provide essential functions and services to ocean ecosystems and human well-being (Duarte et al., 2008; Boström et al., 2011). The value of the world's seagrass meadows has been estimated at US$ 19 002 ha^{-1} y^{-1} based on some ecosystem functions (Constanza et al., 1997); recently, the value of the endemic Mediterranean species *Posidonia oceanica* has been established, based on different services, at 172 € m^{-2} y^{-1} (Vassallo et al., 2014). Not surprising, seagrasses are included in several conservation legislative frameworks, e.g. the European '92/43/CEE Habitats Directive', particularly because seagrass meadows are showing acute regression trends, primarily in areas of intense human development (Waycott et al., 2009).

Among other functions, seagrass meadows provide food and habitat for a wide range of invertebrates and vertebrates, as a result of their large primary production and canopy-structure (Connolly and Hindell, 2006; Boström et al., 2006; Thomsen et al., 2010). In particular, seagrass meadows have been routinely viewed as crucial 'nursery' grounds for juveniles of many fish species, including commercially-exploited species (Pollard, 1984; Gillanders, 2006; Bertelli and Unsworth, 2013); this results from the large structural complexity (Gullström et al., 2008) and abundance of trophic resources (Bell and Pollard, 1989) provided by seagrasses. Seagrass-associated fishes include adult and sub-adult populations of resident (Hyndes et al., 2003; Berkström et al., 2013) and transient species (Verweij et al., 2006; Vaslet et al., 2013) that directly forage within seagrass canopies (i.e. as 'feeding' grounds), as well as large quantities of fish recruits (i.e. as 'nursery' grounds, Nagelkerken et al., 2000; Beck et al., 2001; Blandon & zu Ermgassen et al., 2014) that may reside, as adults, in seagrass meadows, or experience ontogenetic migrations to other nearshore habitats, e.g. adjacent reefs (Cocheret de la Morinière et al., 2002; Aguilar-Perera and Appeldoorn, 2008; Berkström et al. 2013).

A method for streamlining ecological information into management frameworks considers provision of 'goods and services' by ecosystems, i.e. the so-called 'ecosystem services' jargon (Granek et al., 2011; Townsend et al., 2011). This strategy, despite some

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apparent pros and cons (Koch et al., 2009), is actually perceived as a respected tool for ecosystems management (Barbier et al., 2011). Provision of ecosystem services depend on ecosystem functions; where the former benefits a group of humans and can be economically quantified, the latter represent an ecological process that underpins an ecosystem service (Barbier et al., 2011). Attributing any natural capital a monetary value is risky and difficult and can be approached via different methods; for example, the economic valuation of recreational services around artificial reefs may be estimated through the Travel Cost Method (TCM) and the Contingent Valuation Method (CVM) (Cheng et al., 2013). Recent efforts point out towards this direction as a way of connecting nature and human welfare, so society and organizations involved in the management of marine ecosystems can understand the necessity of appropriately managing nature (Lange and Jiddawi, 2009; Granek et al., 2011). Pragmatically, managers and stakeholders may take decisions on an appropriate cost-benefit principle. Such a simple economic metric is convenient to justify sustainability policies over long-term scales.

Estimation of the economic value of ecosystems is particularly incipient in the marine realm, where numerous ecological services still need to be evaluated (Lange and Jiddawi, 2009). Empirical evaluations of the economic value of seagrass meadows are yet to be performed for a wide array of species and locations (Bertelli and Unsworth, 2013). Some studies have estimated the economic value of seagrass meadows as 'fisheries' grounds following different strategies. In Indonesia, for example, the mean value of seagrass meadows has been established at *ca.* 113 US\$ ha^{-1} y^{-1} (Unsworth et al., 2010); in South Australia, seagrass meadows support fisheries with a value of 100 US\$ million y^{-1} (the area covered by seagrasses is 85 10^8 m^{-2}, McArthur and Boland, 2006); the value of temperate seagrass meadows across Australia has been estimated at A\$ 230 000 ha^{-1} y^{-1} (Blandon et al., 2014).

The seagrass *Cymodocea nodosa* ranges from the Mediterranean Sea into the contiguous eastern Atlantic, including the Macaronesian oceanic arquipelagos of Madeira and the Canary Islands. Meadows constituted by *C. nodosa* are found on shallow soft substrates throughout the Canaries (Barberá et al., 2005), where a diverse range of organisms find shelter and food, e.g. invertebrates (Tuya et al., 2001; Gardner et al., 2013), as well as fish assemblages (Espino et al. 2011a, 2011b). In this study, we aimed to determine the economic value of *C. nodosa* seagrass meadows for local fisheries at the oceanic island of Gran Canaria. Two approaches were adopted. Firstly, we estimated the biomass (per area and year) of large-sized (mainly adult and sub-adult) fish populations inhabiting seagrass meadows, particularly that accounted by commercially-targeted species. Secondly, we estimated the annual production of juvenile fishes of commercial species. In both cases, we aimed to finally provide a monetary value by transforming biomasses and production rates into their corresponding financial value per area (ha) and year. It is worth noting, therefore, that our strategy provide complementary assessments of the value of seagrass meadows for local nearshore fisheries by separating the fishable fraction (large-sized fishes) from the production of recruits (small-sized fishes) that fuel nearshore fisheries.

2. Materials and methods

2.1. Study area

Three monospecific seagrass meadows (*ca.* 5–10 ha, 70–80% of seagrass coverage, 6–15 m depth; www.sebadales.org) constituted by the seagrass *Cymodocea nodosa* were selected at Gran Canaria Island (Fig. 1). Two meadows were located in the southeast side of the island, *ca.* 2 km apart, while the other meadow was located in the southwest part of the island. Each meadow was seasonally visited at four times through an entire annual cycle: February 2011, May 2011, August 2011 and November 2011. At each sampling date, 4 sites were randomly selected within each of meadow to assess the abundance and size structure of associated ichthyofauna.

2.2. Adult fishes: field evaluation

Large-sized (mostly adults and sub-adults) fishes were sampled by means of visual censuses through 25 m long × 4 m wide strip transects (100 m^2). Counts were carried out randomly during daytime hours (typically between 10:00–12:00). The abundance and size of all fish species within 2 m at each side of each transect were recorded on waterproof paper by an SCUBA diver, following standard procedures for the study region (Tuya et al., 2004, 2006a). Counts ($n = 6$) were performed at each of the four sites per seagrass meadow and sampling occasion (within 2 days); this yielded a total of $N = 288$ visual counts (28 800 m^2 of inspected seabed for the overall study).

2.3. Juvenile fishes: field evaluation

Small-sized (mostly juveniles) fishes were sampled through a 6 m long, 4 m wide, 0.5 m high seine net with a mesh size of 1 mm. The net was towed over the seabed by two SCUBA divers following a 25 m transect. This technique captures small fishes that have reduced swimming capacities; this procedure has proven to be effective in capturing juvenile fishes in the study area (Espino et al., 2011a). Trawls ($n = 3$) were carried out during daylight hours at each of the four sites per seagrass meadow and sampling occasion. Captured fishes were kept in formalin for subsequent analyses in the lab.

2.4. Adult fishes: mathematical procedures and monetary assessment

By using standard length–weight relationships, we converted abundance and size structure data into biomasses. In most cases, we

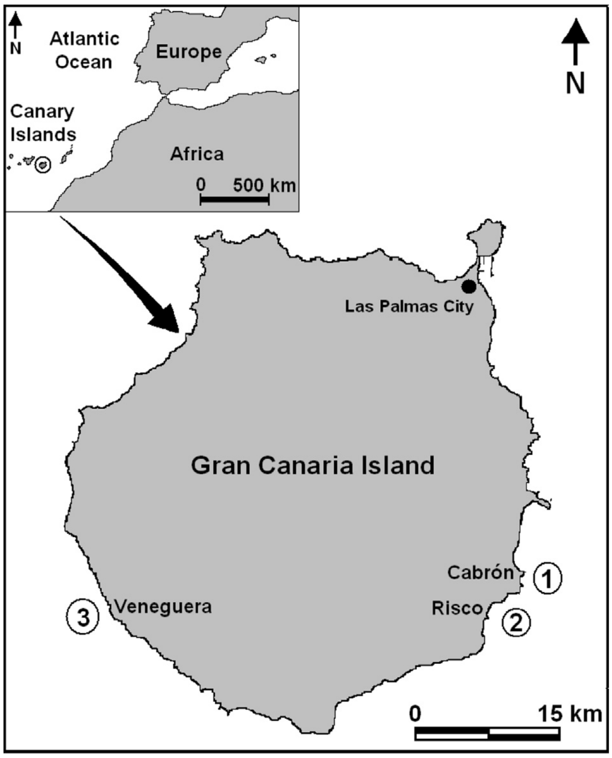

Fig. 1. Study area at Gran Canaria Island, including location of the 3 seagrass meadows where fish collection data took place.

Table 1
Monetary assessment of large-sized, commercially-targeted, fish species registered in 2011 at 12 seagrass sites off Gran Canaria Island via visual counts ($N = 288$). For each species, information on their mean abundances, sizes, biomasses, fishing mortality rates and their corresponding monetary assessments (per ha and at the island-scale) and year are provided. Minimum legal sizes are according to González et al., 2012. F: fishing mortality rate for each fish species.

Species	Habitat-residency	Mean abun. (ind 100 m^{-2})	Mean size (cm)	Legal size (cm)	kg ha^{-1}	F	Exploited biomass (kg ha^{-1})	Commercial value (€ kg^{-1})	Monetary value (€ ha^{-1})	Monetary value at the island-scale (€ y^{-1})
Atherina presbyter	Pelagic-Transient	2.6	11	7	2.55	0.70	1.785	6	10.71	7 497
Boops boops	Pelagic-Transient	30.16	12.35	11	75.87	0.70	53.109	4.5	238.9905	167 293
Bothus podas	Benthic-Resident	0.1	8.45	–	0.08	0.5	0.04	10.99	0.4396	307,72
Chromis limbata	Pelagic-Transient	0.1	11	–	0.23	0.5	0.115	3.9	0.4485	313,95
Diplodus annularis	Benthic-Resident	2.14	14.97	–	15.68	0.37	5.8016	7.99	46.3547	32 448.3
Diplodus sargus cadenati	Benthic-Transient	0.02	18.33	22	0.3	0.37	0.111	7.99	0.8869	620.823
Diplodus vulgaris	Benthic-Transient	0.09	8.7	22	0.23	0.37	0.0851	7.99	0.6799	475.964
Lithognathus mormyrus	Benthic-Transient	0.01	25	25	0.22	0.37	0.0814	6.99	0.5689	398,29
Mullus surmuletus	Benthic-Transient	0.74	15.02	15	4.51	0.7	3.157	11.99	37.8524	26 496.7
Pagellus erythrinus	Benthic-Transient	0.47	9.31	22	0.57	0.76	0.4332	12.99	5.6272	3 939.09
Pagrus pagrus	Benthic-Transient	0.05	8.85	33	0.05	0.24	0.012	12.99	0.1558	109.116
Pegusa lascaris	Benthic-Resident	0.01	25	20	0.12	0.5	0.06	11.99	0.7194	503.58
Pomatomus saltatrix	Pelagic-Transient	0.01	80	–	5.12	0.3	1.536	5.99	9.2006	6 440.45
Pseudocaranx dentex	Benthic-Transient	0.11	24.16	40	8.35	0.40	3.34	6.99	23.3466	16 342.6
Sarda sarda	Pelagic-Transient	0.02	70	40	8.31	0.3	2.493	5.99	14.9330	10 453.1
Sardinella aurita	Pelagic-Transient	17.27	12.95	11	30.23	0.70	21.161	3.99	84.43239	59 102.7
Sardinella maderensis	Pelagic-Transient	9.03	18.27	11	73.32	0.70	51.324	3.99	204.7828	143 348
Serranus cabrilla	Benthic-Resident	0.01	7.5	15	0.01	0.40	0.004	10.99	0.0439	30.772
Serranus scriba	Benthic-Resident	0.01	19.5	18	0.15	0.40	0.06	10.99	0.6594	461.58
Sparisoma cretense	Benthic-Transient	2.24	12.76	20	13.61	0.40	5.444	11.99	65.2735	45 691.5
Sphyraena viridensis	Pelagic-Transient	0.09	77.6	–	20.13	0.3	6.039	6.99	42.2126	29 548.8
Spondyliosoma cantharus	Benthic-Transient	4.05	10.98	19	9.78	0.84	8.2152	7.99	65.6394	45 947.6
Stephanolepis hispidus	Benthic-Transient	0.07	12.85	15	0.27	0.5	0.135	9.99	1.3486	944.055
Synodus saurus	Benthic-Resident	0.14	18.48	–	1.36	0.40	0.544	3.99	2.1705	1 519.39
Xyrichtys novacula	Benthic-Resident	1.54	12.43	–	4.3	0.5	2.15	3.99	8.5785	6 004.95
								Total	866.05€	606,239 €

used published data from the study region (for specific references, see Appendix 1 in Espino et al., 2011a); when a relationship was unavailable, the fishbase.org on-line portal provided the required information. Available fishing mortality rates (F) were used to estimate the amount of biomass extracted for each species by local fisheries (Table 1). Application of fishing mortality rates is relevant to avoid an overestimation of the value of seagrass meadows for coastal fisheries, as only a fraction of the available fish biomass is extracted annually. Only a few fishing mortality rates have been, however, published (*Diplodus sargus cadenati*, *Mullus surmuletus*, *Pagellus erythrinus*, *Pagrus pagrus* and *Spondyliosoma cantharus* (see Appendix 1 in Espino et al., 2011a for specific references). For some species, we used available rates for sibling species (e.g. within the same genus as *Diplodus*). For the rest of species, we used the following 'rule of thumb', according to fish life-story traits in nearshore waters off the Canary Islands (Bas et al., 1995): 0.5 for small-sized (max TL < 30 cm) benthic species; 0.4 for medium-sized (max TL < 60 cm) benthic species; 0.7 for small-sized (max TL < 30 cm) pelagic species; 0.3 for large-sized (max TL < 100 cm) pelagic species. Standard market prices for the year 2013 (€ kg^{-1}) were used to convert mean fish biomasses per area (ha) and year into a monetary assessment of each species. Total financial assessments were provided separately for pelagic and benthic species, as well as for resident and transient species (Espino et al., 2011a, 2011b). By taking into account the overall area covered by *C. nodosa* at the island of Gran Canaria (*ca.* 700 ha, Ministerio de Medio Ambiente, 2002, Appendix A), we assessed the total monetary value at the island-scale.

2.5. Juvenile fishes: mathematical procedures and monetary assessment

Small-sized fishes were identified, measured (TL ± 1 mm of precision) and wet weighted (±0.001 g of precision) in the lab. Length–weight relationships were adjusted for each fish species of commercial value via the equation: $W = aL^b$, where W is the biomass (g) and L is the total length (cm). Size-structure data (pooling all individuals from the 3 meadows and the 4 sampling periods) were obtained for each species. We then calculated productivity rates P/B (y^{-1}) by means of the 'Production by size frequency' method (Hynes and Coleman, 1968), which uses size class data to estimate secondary production. This method involves the calculation of an annual mean length-frequency distribution from samples taken throughout the year. The length-frequency distribution for each species was sorted into length intervals; the number of length intervals varied between 5 and 20, depending on each species. This was carried out through an Excel application template freely provided by Brey (2001). In addition to the 'a' and 'b' coefficients and the size-structure data directly derived from our data, longevity data (maximum age) were obtained, separately for each species, from the local literature (Appendix 1 in Espino et al., 2011a) or, alternatively, from fishbase.org. Using the mean biomasses (per area, m^2), the annual production of each fish species was calculated. We then subtracted from these biomasses that removed by the natural mortality (M) of individuals; M rates were derived from local literature sources (for references, see Appendix 1 in Espino et al., 2011a) or, when unavailable, from fishbase.org. Finally, production estimates (per ha and year) were then converted to monetary assessments using standard prices, for the year 2013, from the local market (a similar approach to Kamimura et al., 2011). Again, using the overall area covered by *C. nodosa* at the island of Gran Canaria (*ca.* 700 ha, Appendix A), we assessed the monetary value at the island-scale.

3. Results

3.1. Adult fishes: abundance, biomass and monetary assessment

A total of 22 582 individuals were visually counted for the overall study, including 44 fish species (Appendix B); 37 species (84.1% of total individuals) have commercial relevance in the study area. A total of 25 commercially-targeted species were present with >5 ind for the overall study, and so considered in further economic evaluations (Table 1). The other species had very low abundances (<0.01 ind 100 m^{-2}), so they were ignored for the economic assessment due to their negligible contribution. The total fish biomass was 907.6 kg, including 894.55 kg of commercially-targeted fishes, what gives a mean fish biomass of 310 kg ha^{-1} y^{-1} for commercially-targeted fishes. The monetary value of this biomass was 866 € ha^{-1} y^{-1}. At the island-scale, considering the entire area covered by the seagrass, this value adds up to 606 239 € y^{-1} (Table 1). Pelagic species provided a total mean biomass of 215.53 kg ha^{-1} y^{-1} and an associated value of 605.2 € ha^{-1} y^{-1}, whereas benthic species supplied a total mean biomass of 95.08 kg ha^{-1} y^{-1} and an associated value of 260.8 € ha^{-1} y^{-1}. The majority of the economic value corresponded to transient species (807 € ha^{-1} y^{-1}), while resident species only accounted for 59 € ha^{-1} y^{-1}. On a species-level, 7 species accounted for *ca.* 85% of the financial value of the fish standing stocks; the most valuable fishes were 3 pelagic, schooling, species: *Boop boops*, *Sardinella maderensis* and *Sardinella aurita* and 4 benthic species: *Diplodus annularis*, *M. surmuletus*, *Sparisoma cretense* and *S. cantharus* (Table 1).

3.2. Juvenile fishes: abundance, production and monetary assessment

A total of 3 517 individuals were captured for the overall study, including 32 fish species (Appendix C); 8 species of commercial relevance (*ca.* 82% of total individuals) used *C. nodosa* seagrass meadows off Gran Canaria Island as 'nursery grounds' (Table 2). The monetary value of the production of this fish biomass was estimated at 95.75 € ha^{-1} y^{-1}. At the island-scale, considering the entire area covered by the seagrass, this value adds up to 67 030.30 € y^{-1} (Table 2). Two fish species accounted for *ca.* 83% of the financial value of seagrass meadows as 'nursery grounds': *S. cretense* (40.07 € ha^{-1} y^{-1}) and *M. surmuletus* (39.67 € ha^{-1} y^{-1}).

4. Discussion

This study has demonstrated that *C. nodosa* seagrass meadows in Gran Canaria Island support fish assemblages of commercial value, contributing both as 'fishing' and 'nursery' grounds. Seagrass meadows constituted by *C. nodosa* have declined in Gran Canaria Island in the last decade (Tuya et al., 2014a). However, the 3 meadows that we selected did not differ in mean shoot density and meadow cover (the main seagrass structural demographic descriptors) between 2003 and 2011 (Tuya et al., 2014a). Hence, our results are representative of standard conditions at the studied meadows. Since some previous areas previously covered by *C. nodosa* have been replaced by the green rhizophytic alga *Caulerpa prolifera*, some of the ecological functions of *C. nodosa*, e.g. provision of habitat for nearshore fishes, have decreased (Tuya et al., 2014b), so our results may temporally change.

Our observations reinforce the idea of the paramount role of seagrass meadows as habitats for nearshore fishes from temperate to tropical latitudes (reviewed by Connolly and Hindell, 2006; Gillanders, 2006). Our strategy evaluated two complementary elements of the ecosystem services provided by seagrasses, which target different aspects of nearshore fisheries. Firstly, we assessed the value of the direct extraction of fishery resources from seagrass meadows, i.e. the value of seagrasses as 'fishing' grounds. Secondly, we evaluated the value of the production of new individuals that contribute to replenish coastal fisheries, i.e. the value of seagrasses as 'nursery' grounds. Rather than summing up the value of both approaches, they provide a notion of different aspects of the services provided by seagrass meadows. The replenishment of nearshore fisheries is fuelled by the production of new individuals. It is therefore virtually impossible to disentangle both functions, as the value of seagrasses as 'fisheries' grounds are supported by the previous production of individuals. This is important to avoid a misperception of the value of seagrasses as 'nursery' grounds.

Despite the transformation of fish biomasses into a direct monetary assessment is rather simplistic, it has been proven as an effective tool in previous assessments of the value of seagrass habitats as 'fishing' grounds for coastal fisheries (Unsworth et al., 2010). In our study, the largest economic value of the fishable fraction corresponded to pelagic, mobile, species (605 € ha^{-1} y^{-1}). In particular, five species (*Atherina presbyter*, *Boops boops*, *Sarda sarda*, *S. aurita* and *S. maderensis*) accounted for *ca.* 64% of the total monetary value; these species are typically found swimming on seagrass meadows as sub-adults and adults, i.e. their mean sizes are typically larger than the minimum legal capture size (Table 1). These species are not directly linked with seagrass meadows, but move through onshore waters forming large schools; some of these species may even forage on *C. nodosa* seagrasses (Espino et al., 2008). The market value of benthic species, directly linked with the habitat, was estimated at 260.8 € ha^{-1} y^{-1}. The value of this fraction is more than twice than that registered for seagrass meadows in Indonesia (Unsworth et al., 2010). This result is particularly relevant taking into account that nearshore fishery resources are heavily exploited in the Canary Islands; for example, about 40 species are directly threated by overfishing (González, 2008). This large fishing pressure is particularly elevated in the most populated islands, e.g. Gran Canaria (Tuya et al., 2006b), where there is strong pressure by both artisanal and recreational fishers (González et al., 2012). For example, it is worth noting the low abundances of two Sparid species (*P. pagrus* and *Pagellus acarne*), which have been found at larger abundances in other islands of the Canary Archipelago (Espino et al., 2011a,b). As a result, it makes sense to 'read' these monetary values

Table 2
Monetary assessment of the production (P) of recruits of fish species with commercial interest on *C. nodosa* seagrass meadows. Data was obtained via trawls ($N = 144$) throughout 2011 at 12 seagrass sites off Gran Canaria Island. For each species, information on their biomasses, productivity (P/B) rates, Production (P) rates and their corresponding monetary assessments per area (per ha and at the island-scale) and year are provided. M: natural mortality rate for each fish species.

Species	Mean biomass (g) per ind	Mean biomass (g m^{-2})	P/B	P (g m^{-2} y^{-1})	P (kg Ha^{-1} y^{-1})	P (kg island y^{-1})	1 − M	Commercial value (€ kg^{-1})	Monetary value (€ ha^{-1})	Monetary value at the island-scale (€ y^{-1})
Bothus podas	9.0	0.1133	0.44	0.0498	0.4986	299.2	0.55	4	1.0970	767.95
Dicentrarchus punctatus	0.042	0.0058	0.454	0.0026	0.0264	15.89	0.45	8	0.0953	66.74
Diplodus annularis	3.0426	0.0456	0.436	0.0198	0.1989	119.3916	0.7	12	1.6714	1 170.04
Mullus surmuletus	8.15	0.9206	0.798	0.7346	7.3467	4 408.063	0.45	12	39.6725	27 770.81
Pagellus erythrinus	7.53	0.1199	0.447	0.0536	0.5360	321.6314	0.7	13	4.8780	3 414.65
Sparisoma cretense	12.84	0.6919	0.611	0.4227	4.2277	2 536.628	0.79	12	40.0787	28 055.10
Spondyliosoma cantharus	4.66	0.1415	0.482	0.0682	0.6821	409.293	0.5	8	2.7286	1 910.03
Xyrichtys novacula	21.21	0.4711	0.459	0.2162	2.1624	1 297.44	0.64	4	5.5357	3 875.02
								Total	95.75€	67 030.30 €

as an underestimation of the real potential value of seagrasses as 'fisheries' grounds due to stocks depletion of nearshore resources in the study area throughout the last decades (Tuya et al., 2006b).

The second approach (estimation of the value of annual recruit production) valued seagrass meadows as 'nursery' grounds. Contrary to our expectations, there is only a few available works that have economically valued the production of new fishery biomass in marine vegetated habitats via empirical approaches. For example, annual estimates of *Sebastes cheni* juvenile production oscillated between 6.54 and 9.10 US$ ha^{-1} y^{-1} in seagrasses off Japan (Kamimura et al., 2011). These values are *ca.* 4 to 5 times lower than the two most important fish species recruiting into *C. nodosa* seagrass meadows (*S. cretense* and *M. surmuletus*), which annual production was estimated at 40 and 39 € ha^{-1} y^{-1} for each species, respectively. In turn, annual production rates of both *S. cretense* (4 227 g ha^{-1} y^{-1}) and *M. surmuletus* (7 340 g ha^{-1} y^{-1}) are larger than that observed for *S. cheni* (13–18 g ha^{-1} y^{-1}) and other fishes (e.g. 12–406.820 g ha^{-1} y^{-1}, Valentine-Rose et al., 2007; Faunce and Serafy, 2008).

Recently, Blandon et al. (2014) calculated the monetary value of Australian temperate seagrass meadows for nearshore fisheries by multiplying the price of each species by the annual production for age classes larger than the size of first harvest; fish abundances values were extracted from the literature. Their approach, however, considered the enhancement of fish biomass by the presence of the seagrasses, not what was actually caught, i.e. their approach did not take into account fishing mortality rates. This study estimated the value of seagrasses for onshore fisheries at $A 230 000 ha^{-1} y^{-1} (153 000 € ha^{-1} y^{-1}). Despite this represent a value 2 orders of magnitude larger than the values provided by our study, about 90% of the value was assigned to exclusively one species. Most species were economically enhanced by seagrass meadows by values between $A 800–7 000 ha^{-1} y^{-1} (530–4 600 € ha^{-1} y^{-1}). This range of economic valorization is within the same order of magnitude than our approach, even though studies differ in their geographical setting, the particular seagrass species than dominate the system and even sampling methodologies.

Overexploited fish stocks typically have reduced reproductive output (Pauly and Maclean, 2003), including eggs and larvae that may further recruit, for example, into seagrass meadows. Hence, the potential of seagrass meadows as 'nurseries' in Gran Canaria Island may be actually reduced as a result of overfishing (Tuya et al., 2006b; González, 2008), what can cause a concomitant neglected perception of their economic value. The majority of fishes that recruited into seagrass meadows (e.g. the 3 most valued species, *S. cretense*, *M. surmuletus* and *S. cantharus*) are mainly observed as adults in other coastal habitats (e.g. rocky reefs, Tuya et al., 2004). Hence, our approach additionally underestimates the value of seagrass as nurseries for coastal fishes, since the value of a fish will exponentially increase with time. This, however, requires extra data and is out of the aim of this paper.

The ichthyofauna living in seagrass meadows is considerably variable across temporal and spatial scales; for example, between the day and night or between months and seasons through annual cycles at the study region (Espino et al., 2011a, 2011b). Without a doubt, this high variability may influence the economic valorization of seagrasses as either 'fisheries' grounds or 'nursery' grounds. As a result, our data are estimates of the potential financial values of seagrasses for the nearshore fishery, which should be reassessed temporally.

Seagrasses have many other 'values' not considered in this work, e.g. C sequestration, coastal protection and nutrient recycling. Moreover, there is additional 'cultural' value through eco-tourism (e.g. SCUBA diving) that seagrass meadows support in the study region. Importantly, estimates of the economic value of seagrasses have not always included all potential services. For example, the seminal economic valorization of ecosystem services of marine vegetated habitats calculated by Costanza et al. (1997) did not included fish production, what would have notably increased their value. Fortunately, a recent economic valorization of the services provided by the seagrass *Posidonia oceanica* considered its relevance as an habitat for fishes (Vassallo et al., 2014); however, there was no separation between the dual functions that seagrasses provide as 'fishing' and 'nursery' grounds for nearshore fisheries. Promoting public support, including local, national and transnational administrations, though raising awareness of the importance of seagrass meadows is vital to boost seagrass conservation. Economic valorization of the contribution of seagrasses to fisheries productivity is a way to promote the social perception of the key role that seagrasses play worldwide and, therefore, the necessity of incorporating seagrasses into conservation legislative frameworks.

Authors' contributions

FT, RH and FE conceived the study. FT and FE designed the sampling strategy. Field work was performed by FT and FE. FT performed mathematical calculations. FT and RH managed projects associated with data collection. FT wrote the paper. All authors contributed to readjustments on previous drafts.

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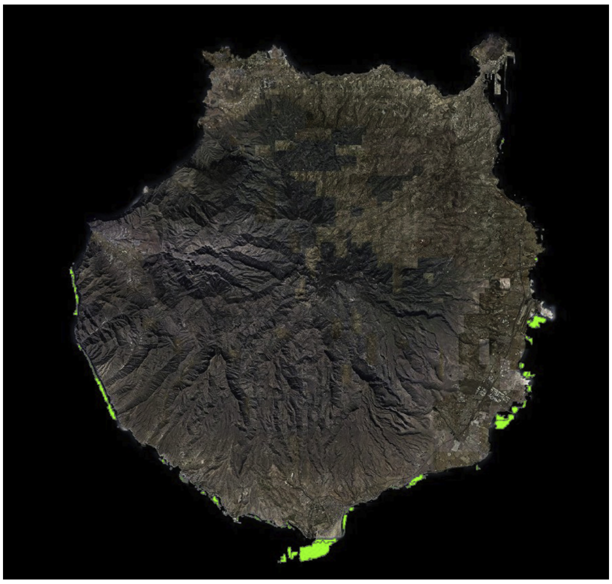
Appendix A. Distribution of the seagrass *Cymodocea nodosa* in Gran Canaria Island. The green patches denote the presence of the plant.



Appendix B. Mean (+SE) abundance of fishes at 12 seagrass sites off Gran Canaria Island through an annual cycle (N = 288 visual counts).

Species	Mean	SE
Abudefduf luridus	0.02778	0.01086
Atherina presbyter	2.60417	2.59966
Aulostomus strigosus	0.00694	0.00489
Boops boops	30.15972	6.93989
Bothus podas	0.10417	0.01929
Canthigaster capistrata	1.93403	0.14458
Chelidonichthys lastoviza lastoviza	0.00694	0.00693
Chromis limbata	0.10417	0.10399
Dasyatis pastinaca	0.03472	0.01185
Diplodus annularis	2.14236	0.79717
Diplodus sargus cadenati	0.02083	0.01293
Diplodus vulgaris	0.09375	0.03191
Gnatholepis thompsoni	0.00347	0.00347
Gobius niger	0.00347	0.00347
Heteroconger longissimus	1.08681	0.27289
Lithognathus mormyrus	0.00694	0.00693
Microchirus azevia	0.00347	0.00347
Mullus surmuletus	0.73611	0.20133
Myliobatis aquila	0.00347	0.00347
Pagellus erythrinus	0.46528	0.16945
Pagrus pagrus	0.04514	0.02465
Pegusa lascaris	0.00694	0.00489
Pomatomus saltatrix	0.01042	0.01040
Pseudocaranx dentex	0.11111	0.07369
Sarda sarda	0.02083	0.01548
Sardinella aurita	17.27431	6.69674
Sardinella maderensis	9.02778	4.66694
Scorpaena porcus	0.00347	0.00347
Serranus atricauda	0.00347	0.00347
Serranus cabrilla	0.00694	0.00489
Serranus scriba	0.01389	0.00690
Sparisoma cretense	2.23611	0.31850
Sphoeroides marmoratus	0.56944	0.04991
Sphyraena viridensis	0.08681	0.06969
Spondyliosoma cantharus	4.05208	1.17796
Squatina squatina	0.00694	0.00489
Stephanolepis hispidus	0.06597	0.02017
Symphodus trutta	0.00694	0.00489
Syngnathus acus	0.00347	0.00347
Synodus saurus	0.14236	0.02228
Synodus synodus	0.01042	0.00598
Thalassoma pavo	0.00347	0.00347
Trachinus draco	0.10764	0.02187
Xyrichtys novacula	1.53819	0.24951
Unindentified juveniles	3.50694	2.14763

Appendix C. Mean (+SE) abundance of fishes at 12 seagrass sites off Gran Canaria Island through an annual cycle (N = 144 trawls).

Species	Mean	SE
Boops boops	0.0486	0.0373
Bothus podas	0.4722	0.0737
Canthigaster capistrata	0.8451	0.1205
Chelidonichthys lastoviza lastoviza	0.0069	0.0069
Dicentrarchus punctatus	5.2083	5.2083
Diplodus annularis	2.7222	2.4716
Diplodus vulgaris	0.0069	0.0069
Gobius niger	0.0278	0.0169
Mullus surmuletus	4.5418	4.2137
Mycteroperca fusca	0.0139	0.0098
Nerophis ophidion	0.1111	0.0313
Opeatogenys cadenati	0.0208	0.0119
Pagellus erythrinus	0.6042	0.2850
Pagrus auriga	0.0069	0.0069
Pegusa lascaris	0.0069	0.0069
Scorpaena maderensis	0.0069	0.0069
Scorpaena porcus	0.0417	0.0167
Serranus atricauda	0.0069	0.0069
Serranus cabrilla	0.0069	0.0069
Sparisoma cretense	2.1667	0.2520
Sphoeroides marmoratus	0.7639	0.1445
Spondyliosoma cantharus	3.4514	1.3898
Stephanolepis hispidus	0.1181	0.0287
Symphodus mediterraneus	0.0069	0.0069
Symphodus trutta	0.0972	0.0373
Syngnathus acus	0.0417	0.0194
Syngnathus typhle	2.0903	0.2766
Synodus saurus	0.0417	0.0167
Synodus synodus	0.0699	0.0274
Trachinus draco	0.0139	0.0098
Uranoscopus scaber	0.0069	0.0069
Xyrichtys novacula	0.8611	0.1261

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