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The Coherence of the European Union Marine Natura 2000 Network for Wide-Ranging Charismatic Species: A Mediterranean Case Study

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The Natura 2000 (N2k) network is an important site-based protection tool for the protection of biodiversity in Europe. However, for highly mobile and adaptable marine species, such a tool might not be the most effective way to achieve conservation objectives, unless this includes a broader consideration of the direct threats to these species throughout their range. Considering that the N2k network requires that a "*significant proportion*" of 60% of the population be under protection, this creates a challenge for the conservation of these wide-ranging species. This paper reviews the efficacy of the N2k network as it is presently implemented within the Adriatic Sea for the conservation of two highly mobile marine species—the common bottlenose dolphin and the loggerhead turtle. In particular, it considers the appropriateness of the current Sites of Community Importance (SCIs) in the region and the relevance of the existing marine N2k network for the conservation of these species. It provides new insights on the approach used to evaluate SCI designations highlighting important weaknesses in the system, including threat identification after SCI designation, and the relevance of SCI size in relation to management commitments. Data from two basin-wide aerial surveys were used to define areas of relative high density of these species, in comparison to other areas in the basin. Given the ambitious 60% conservation target of the N2k network, analysis shows that site-based protection tools are unlikely to be sufficient to protect a "significant proportion" of either species, unless very large areas are designated as SCIs. However, given that the main threats known to affect these species in this region (i.e., fishery bycatch and seismic surveys) are present throughout the basin, these large SCIs would still have limited conservation success without implementing other wide-scale mitigation measures. For these two species, the Member States and the European

Union authorities should give higher priority to the implementation of another pillar of the Habitats Directive, mitigating accidental catches in fishing gear and other human-induced mortalities. This should take into consideration the full effects of these mortalities on the populations of these two species through regular transboundary monitoring programs.

Keywords: marine protected areas, Natura 2000, aerial surveys, cetaceans, marine turtles, *Tursiops truncatus*, *Caretta caretta*

INTRODUCTION

The Natura 2000 (N2k) network of the European Union (EU) consists of Special Areas of Conservation (SACs) designated under the Habitats Directive (Council directive 92/43/EEC, HD) and Special Protection Areas (SPAs) under the Birds Directive (Council directive 79/409/EEC, BD). The overall conservation objective of the network is to "*. . . maintain or restore, at favorable conservation status, natural habitats and species of wild fauna and flora of Community interest*" (Article 2, HD). Given the working definition of "*favorable conservation status*," this means protecting at least 60% the populations (Anonymous, 1997). The N2k is one of the World's most extensive networks of protected areas, which currently includes over 27,500 terrestrial and marine sites, covering almost 19% of the territorial waters of EU member states but <4% of their EEZs (Agnesi et al., 2017).

When evaluating the need for the designation of marine N2k sites for species listed in Annex II of the HD and identifying Sites of Community Importance (SCI), which are the first step for SACs designation, national administrations must follow the framework laid out in Article 4 and Annex III. Stage 1, must take into account the overarching objective to set up "*a coherent European ecological network of special areas of conservation*" that will enable "*the species' habitats concerned to be maintained or* [. . .] *restored at a favorable conservation status in their natural range*" (HD Article 3).

Thus, the only two key factors that need to be considered to achieve this objective are the species and its habitat. Once an SCI has been adopted and published in the Union list by the European Commission, it becomes part of the N2k network and the relevant Member State (MS) shall designate it as a SAC "*within 6 years at most*." It is only at this point that aspects related to threats become important, as priorities for designation of a SCI into a SAC are formally established "*in the light of the threats of degradation or destruction to which those sites are exposed*" (HD Article 4.4).

The bottlenose dolphin (*Tursiops truncatus*) and the loggerhead turtle (*Caretta caretta*) are wide-ranging aquatic species listed in Annexes II and IV of the HD. The loggerhead turtle is also a priority species, with known nesting and feeding areas within the Mediterranean region (Casale and Margaritoulis, 2010). According to Article 1(k) of the HD, sites selected for wide ranging species, "*shall correspond to the places within the*[ir] *natural range*" with "*the physical or biological factors essential to their life and reproduction*." Additionally, Article 4.1 of the HD requires that for aquatic species, such sites can "*be proposed only where there is a clearly identifiable area* [emphasis added]" encompassing those factors.

The EU authorities encourage MSs to coordinate through the existing Regional Seas programs when working with other MSs and third countries (EC, 2005). Within the Mediterranean Sea the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona, 1976; amended in 1995), particularly the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA Protocol; Barcelona, 1995). The Barcelona Convention also lists the bottlenose dolphin and loggerhead turtle as threatened species requiring parties to adopt cooperative measures for their conservation. It has also adopted the criteria for ecologically or biologically significant areas (EBSAs) of the Convention on Biological Diversity several of which include the waters of the Adriatic Sea (decisions COP-09-DEC-20 and COP-12-DEC-22; Fortuna C. et al., 2014).

The Adriatic Sea, although representing only 5% of the surface area of the Mediterranean Sea, includes the largest continental shelf in the region, which makes it ecologically important for these two species. From the policy perspective the Adriatic Sea has been identified of particular importance for coordination the of MSs and third countries as it has been identified as a sub-region of the Marine Spatial Planning DirectiveEU Marine Strategy Framework Directive (MSFD; 2008/56/EC). The MSFD promotes a wider ecosystem-based approach to marine management identifying that Good Environmental Status cannot be achieved within national borders but only in a wider, regional context (van Hoof et al., 2014). In addition, the macro-regional EU Strategy for the Adriatic and Ionian Region (EUSAIR) was launched in 2014 by the European Commission to coordinate the future of the region, including an environmental quality pillar, which focuses on the marine environment and transnational terrestrial habitats and biodiversity (EC, 2014).

At present, there are 77 fully or partially marine N2k sites (either SCI or SAC) within the Adriatic Sea, at different stages of designation (http://natura2000.eea.europa.eu/; data extracted from N2k Standard Data Forms, downloaded in May 2018) of which 29 list either one or both of these species (see **Table 1**). Currently, Croatia does not list the loggerhead turtle for any existing site, and Slovenia does not list either species for any existing site.

Given the transboundary nature of these species, the four criteria from the Habitats Directive used to assess the relative importance of sites for species in Annex II, were applied at the level of the Adriatic Sea rather than the usual national scale, as the national scale would be meaningless. The N2k criteria are: (1) "*Size and density of the population of the species present on the site in relation to the populations present within a national territory*" (B.a); (2) "*Degree of conservation of the features of*

TABLE 1 | Adriatic Sea Natura 2000 sites listing the bottlenose dolphin and the loggerhead turtle.

Site name and code	Area	Bottlenose dolphin		Loggerhead turtle	
		Abundance	Population	Abundance	Population
ITALY					
Special areas of conservation: *N = 8; Total area = 103.8 km²* *(Bottlenose dolphin 34.7 km²; Loggerhead turtle: 103.8 km²)*					
Aree Carsiche della Venezia Giulia [Kartstic areas of Venezia Giulia], IT3340006	2.4 km²	Common	2% ≥ *p* > 0%	Present	Insignificant
Carso Triestino e Goriziano [Triestian & Goritian karst], IT3340006	1.9 km²	Common	2% ≥ *p* > 0%	Present	Insignificant
Valle Cavanata e Banco Mula di Muggia [Cavanata basin and Muggia bank], IT3330006	6.1 km²	Present	insignificant	Present	Insignificant
Cavana di Monfalcone, IT3330007	0.2 km²	–	–	Present	Insignificant
Foce dell'Isonzo—Isola della Cona [Isonzo delta—Cona Island], IT3330005	11.7 km²	Rare	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
Laguna di Marano e Grado [Grado and Marano lagoon], IT3320037	11.5 km² +	Rare	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
Litorale di Porto d'Ascoli [Porto d'Ascoli littoral], IT5340001	1.0 km²	Present	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
Litorale Brindisino [Littoral of Brindisi], IT9140002	68.9 km²	–	–	Present	Insignificant
Sites of community importance: *N = 13; Total area = 216.5 km²* *(Bottlenose dolphin 91.1 km²; loggeerhead turtle 216.5 km²)*					
Area marina di Miramare [Miramare Marine Protected Area], IT3340007	0.2 km	Present	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
Trezze San Pietro e Bardelli, IT3330009	23.8 km²	Present	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
Relitti di Posidonia presso Grado [Posidonia relicts in Grado], IT3330008	0.01 km²	Present	insignificant	Present	2% ≥ *p* > 0%
Tegnùe di Porto Falconera [Porto Falconera reefs], IT3250048	6.2 km²	Present	insignificant	Present	Insignificant
Tegnue di Chioggia [Chioggia reefs], IT3250047	26.6 km²	Present	insignificant	Present	Insignificant
Sacca di Goro, Po di Goro, Valle Dindona, Foce del Po di Volano [Goro embayment, Didona basin, Po Delta of Volano], IT4060005*	29.7 km²	–	–	V. rare	Insignificant
Bosco di Volano [Volano wood], IT4060007*	1.2 km²	–	–	Present	Insignificant
Vene di Bellocchio, Sacca di Bellocchio, Foce del Fiume Reno, Pineta di Bellocchio [Vene of Bellocchio, Bellocchio embayment, Reno delta, Bellocchio Pinewood], IT4060003*	3.1 km²	–	–	Present	Insignificant
Ortazzo, Ortazzino, Foce del Torrente Bevano [Ortazzo, Ortazzino and delta of Bevano creek], IT4070009*	1.8 km²	–	–	Present	Insignificant
Relitto della piattaforma Paguro [Dismissed Paguro platform], IT4070026	0.7 km²	Present	insignificant	Present	Insignificant
Torre del Cerrano [Cerrano Tower], IT7120215	33.5 km²	Very rare	insignificant	V. rare	Insignificant
Torre Guaceto e Macchia S. Giovanni [Guaceto Tower and S. Giovanni bush], IT9140005	75.8 km²	–	–	Present	Insignificant
Torre Veneri [Veneri Tower], IT9150025	13.9 km²	–	–	Present	Insignificant
Special Protection Area: *N = 1; Total area = 5.5 km²*					
Torre Guaceto [Guaceto Tower], IT9140008	5.5 km²	–	–	Present	2% ≥ *p* > 0%
Proposed site of community importance: *N* = 1; Total area = 0.4 km²					
Costa del Piceno—San Nicola a mare [Piceno coast—St Nicholas at sea], IT5340022	0.4 km²	Present	2% ≥ *p* > 0%	Present	2% ≥ *p* > 0%
CROATIA					
Sites of community importance: *N = 6; Total area = 3,638.6 km²*					
Akvatorij zapadne Istre [western Istrian archipelago], HR5000032	763.0 km²	Rare	15% ≥ *p* > 2%,	*NIG*	*NIG*
Cres-Lošinj [Cres-Lošinj archipelago], HR3000161	525.7 km²	Rare	15% ≥ *p* > 2%,	*NIG*	*NIG*
[Archipelago of] *J. Molat-Dugi-Kornat-Murter-Pašman-Ugljan-Rivanj-Sestrunj-Molat* [islands], HR3000419	580.5 km²	Rare	15% ≥ *p* > 2%,	*NIG*	*NIG*
Nationalni park Kornati [Kornati National Park], HR4000001	165.7 km²	Common	2% ≥ *p* > 0%	*NIG*	*NIG*
Viški akvatorij [Vis archipelago], HR3000469	518.8 km²	*NIG*	15% ≥ *p* > 2%,	*NIG*	*NIG*
Lastovski i Mljetski kanal [Lastovo and Mljet channel], HR3000426	1085.0 km²	Rare	15% ≥ *p* > 2%,	*NIG*	*NIG*

The HD defines population categories: A, 100% ≥ p > 15%; B, 15% ≥ p > 2%; C, 2% ≥ p >0%; D, non-significant population. There are no management obligations if a population is listed as insignificant at a site. Sites marked with an asterisk are also SPAs. NIG: No information given. Data was extracted from Natura 2000 Standard Data Forms (http://natura2000.eea.europa.eu).

the habitat which are important for the species concerned and restoration possibilities" (B.b); (3) "*Degree of isolation of the population present on the site in relation to the natural range of the species*" (B.c); and (4) "*Global assessment of the value of the site for conservation of the species concerned*" (B.d).

The existing Adriatic N2k sites in which bottlenose dolphins and/or loggerhead turtles occur are diverse and reflect the substantially different approaches used by Italy and Croatia for their designation. As shown in **Table 1** (based on N2k Standard Data Forms available from: http://natura2000.eea.europa.eu), Croatian SCIs are much larger (ranging between 166 and 1,085 km^2 and encompassing around 11% of the territorial waters) and were established specifically for the conservation of the bottlenose dolphin. The Italian sites in contrast, were established based on the presence of several habitat types and different species, including the bottlenose dolphin, the loggerhead turtle, and marine and coastal bird species (some are also SPAs). They are much smaller, ranging from 10,000 m^2 to about 70 km^2, and together, they cover about 1% of the Italian territorial waters in the Adriatic Sea. Within these sites, the proportions of the populations of the two species present in respect to national waters were self-assessed as insignificant (in 6 for bottlenose dolphins and 16 for loggerhead turtles), therefore, not requiring any management action, according to the rules of the HD (Anonymous, 1997, 2007).

An essential criterion to consider when designating N2k sites is the degree of isolation of different populations (criterion B.c). The Mediterranean bottlenose dolphin meta-population is highly structured with a clear differentiation between the eastern and the western Mediterranean (Natoli et al., 2005). Recent studies (Gaspari et al., 2013, 2015) have rejected the hypothesis of a single stock within the Adriatic. Genetic evidence suggests the existence of three broad management units within the Adriatic Sea: the north-eastern, the north-western, and central-south Adriatic-Ionian sub-populations (Gaspari et al., 2013, 2015), notwithstanding the importance of local groups identified through photo-identification studies showing strong site fidelity (Bearzi et al., 1997; Fortuna, 2006; Genov et al., 2008; Pleslić et al., 2013). This structure approximates the physiography of the Adriatic (Artegiani et al., 1993).

The loggerhead turtle population structure in the Mediterranean is also complex, with three independent Regional Management Units (RMUs: the Mediterranean, the North West Atlantic and the North East Atlantic; Wallace et al., 2010). The individuals belonging to Mediterranean RMU, which reproduce in the region, are additionally classified into seven independent units (Shamblin et al., 2014). The Adriatic Sea is almost exclusively frequented by individuals of Mediterranean origin, with rookeries from Western Greece and Western Turkey providing the greatest contribution. Loggerhead turtles appear to be "randomly" distributed across the Adriatic Sea regardless of origin, and it is not possible to define an "Adriatic population" (Tolve et al., 2018).

This paper reviews the efficacy of the N2k framework as presently implemented for the conservation of these two wide-ranging transboundary marine species within the Adriatic Sea. In particular the terms of (i) the appropriateness of criteria laid down in Annex III of the HD for identifying potential SCIs in relation to its Article 4; and (ii) the relevance of the existing and potential new marine N2k sites to their conservation. The analysis is based primarily upon data collected on the distribution and abundance of the two species obtained through two basin-wide aerial surveys carried out in the summers of 2010 and 2013.

MATERIALS AND METHODS

Systematic data on the distribution and abundance of cetaceans and sea turtles throughout the Adriatic were collected during two aerial surveys carried out in the summers (31 July−9th September) of 2010 and 2013 (Fortuna C. M. et al., 2014; Holcer et al., 2015).

The survey design (equally spaced parallel transects and equal coverage probability for the three strata) followed standard line-transect distance-sampling methods (Buckland et al., 2004) using the software package Distance 7.0 (http://www.ruwpa.st-and.ac.uk/distance/; Thomas et al., 2009). A twin-engine aircraft (*Partenavia* P-68), equipped with bubble windows to allow visibility directly below the plane, was used (target altitude and ground speed 200 m and 185 km/h, respectively). Experienced researchers were employed for data collection. Data analysis was restricted to sightings and effort in good visibility and Beaufort state $\leq$3.

In addition to the bottlenose dolphin, other small cetacean species sighted included the striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), and Risso's dolphin (*Grampus griseus*) (Holcer et al., 2015), which are all easily distinguishable from a plane flying at a height of 100 m. The category "sea turtles" within the Adriatic Sea represents almost exclusively the loggerhead turtle. The green turtle (*Chelonia mydas*), although indistinguishable from the loggerhead turtle from a plane, is primarily found in the southern Adriatic in low densities (about 1–5% of the total sightings; Lazar et al., 2004a; Fortuna et al., 2015).

For the surveys themselves, the study area was subdivided into three strata (north, central and south Adriatic) based upon bathymetry and existing knowledge of cetacean and sea turtle distribution. For this paper, additional sub-strata were also considered (**Figure 1**): (a) territorial waters (12 nautical miles (nm) from coast); (b) "Exclusive Economic Zones (and variations thereof)" and Continental Shelf Margin (CSM; mid-line); and (c) all Croatian N2k sites for bottlenose dolphins combined. The 12 nm and CSM borders were downloaded from EIONET (http://www.eionet.europa.eu/gis/) and while they do not necessarily reflect officially agreed or disputed borders, the difference is negligible in the context of this paper.

A grid of cells with resolution of 100 km^2 was built (10 $\times$ 10 km cells, projection ETRS 1989 LAEA; European Environmental Agency Standards), totaling 1,535 grid cells. The cell size was determined in relation to the size of the study area and the overall survey effort (km searched) to minimize empty cells and ensure adequate spatial replication. Data from the two aerial surveys in 2010 and 2013 were pooled and distance

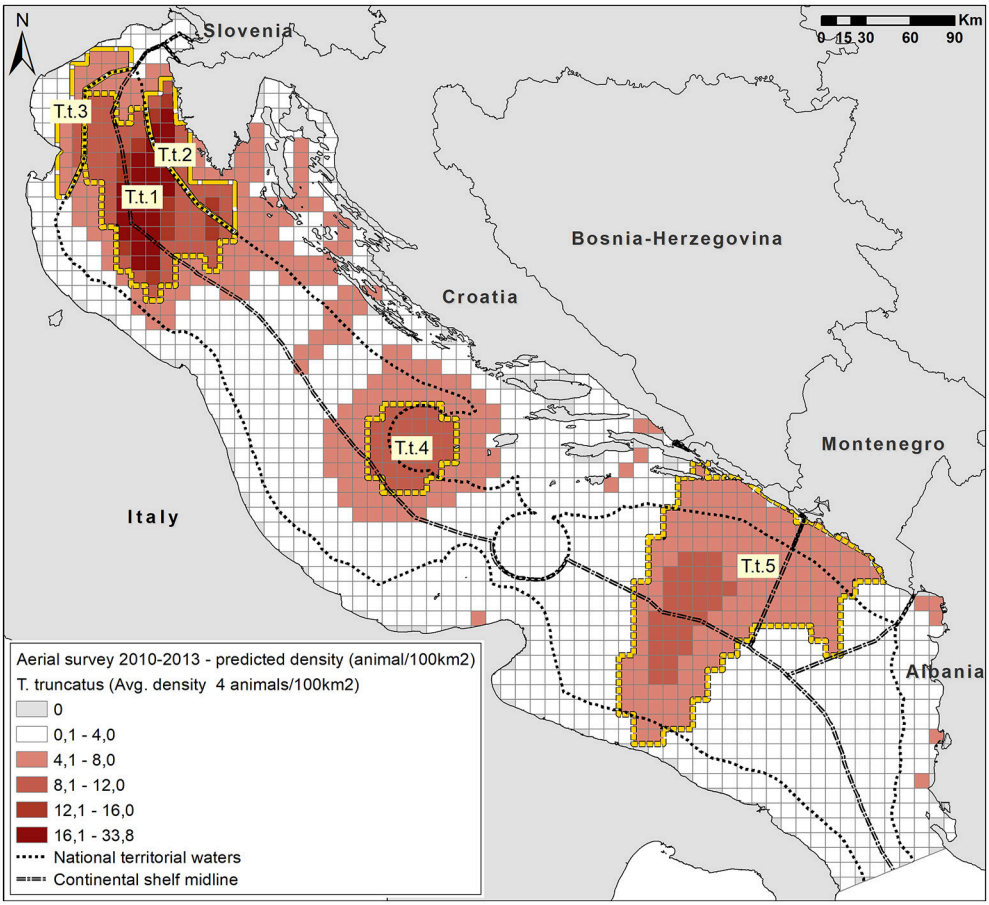

FIGURE 1 | Density Surface predicted distribution of the bottlenose dolphin in the Adriatic Sea based on 2010 and 2013 aerial survey data (darker red scale indicates higher relative density). The scales represent below average (white; L), and then up to twice (L-MD), up to three times (M-HD), up to four times (H-HHD) and greater than four times (MAXD), in shades of dark red. The proposed key areas (**Table 3**) are identified by yellow dotted (within 12 nm), dashed (over 12 nm), and dot-dashed shapes (areas within and over 12 nm).

analyses for estimating abundance (total number of animals) and density (individuals/km^2) was performed using the Distance 7.0 software. Data used were: (i) species identification, (ii) school size (best estimate), (iii) declination angle (to allow calculation of perpendicular distance of the sighting from the track-line), (iv) environmental information (including sea state, turbidity, cloud cover, etc.), (v) effort status and positional/time data. Abundance was estimated applying Density Surface Modeling (DSM) (e.g., Cañadas et al., 2018) and a prediction of abundance was extracted for the whole area and for all the strata created. Given that each grid cell was characterized by a predicted abundance, estimates for jurisdictional waters and all other sub-strata were obtained by filtering these cells according to the stratum to which they belong. Cells that were fully or partially overlapped by two strata were assigned to only one stratum, according to the higher overlap.

Applying estimated abundance after DSM shows the total number of bottlenose dolphins and loggerhead turtles present in a "generalized summer snapshot" for each sub-stratum. These abundance estimates were rounded to the nearest hundred and remain uncorrected for availability bias (i.e., animals that were underwater and not visible) and perception bias (i.e., animals at/or near the surface, but missed by observers). Thus, these estimates are lower than the true abundance and should be seen as only indices of relative abundance rather than absolute per stratum.

To map areas of higher density, we used the average density estimated for the entire Adriatic (2010–2013 pooled dataset) as an example reference value. For each species, densities categories were created as follows: (i) low density (densities below the Adriatic average, LD); (ii) low to medium densities (between the average and twice, L-MD); (iii) medium to high densities (two to three times the average, M-HD); (iv) high to highest (three to four times the average, H-HHD); (v) maximum densities (over four times the average, MAXD). For comparative purposes and to illustrate levels of variation, annual density maps were also prepared.

Using relative densities instead of absolute numbers does not affect the overall results or create biases in strata comparisons. Correction factors for availability and perception bias are simple multipliers that would be added to the uncorrected numbers

and thus would have affected the density and abundance in all strata equally. Hence the ratio between strata would stay the same. As data in both surveys were collected by the same crew (constant perception bias), from the same platform (Partenavia P-68), using the same methods, during the same season (no behavioral changes affecting availability bias expected), this should guarantee that perception and availability bias were constant throughout the study.

RESULTS

The density and abundance estimates for the two species in summer are shown in **Table 2**. The estimated summer density distribution of bottlenose dolphins and loggerhead turtles are shown in **Figures 1**, **2**. The results are for the analysis of the combined 2010 and 2013 datasets.

Those sub-strata with a bottlenose dolphin density higher than the Adriatic average (0.042 dolphins/km^2) were the North Adriatic (0.057 dolphins/km^2), Croatian and Montenegrin territorial waters (0.046 and 0.049 dolphins/km^2, respectively), Croatian CSM (0.056 dolphins/km^2) and Croatian SCIs (0.048 dolphins/km^2).

Loggerhead turtle densities were double the Adriatic average (0.203 turtles/km^2) in the North Adriatic (0.405 turtles/km^2) and slightly over the average in the Croatian CSM (0.251 turtles/km^2).

The North Adriatic is the most important stratum for both species (about 47% and 69% of the total Adriatic bottlenose dolphins and loggerhead turtles, respectively; **Table 2**). Territorial waters of EU Member States included about a third of the total numbers of both species whilst about 90% of both species were found in jurisdictional waters of EU Member States (Croatian CSM, plus Italian and Slovenian territorial waters). The Croatian CSM hosted 57% of the Adriatic bottlenose dolphins and 53% of the loggerhead turtles. The Croatian SCIs designated for the bottlenose dolphin included about 12% of the putative sub-populations frequenting Croatian territorial waters, 7% of the North Adriatic sub-population but only around 3% of the total Adriatic population. Italian territorial waters included only 7% of the entire Adriatic bottlenose dolphin population. Given their reduced size, Slovenian waters were confirmed relatively unimportant for both species.

There were an estimated 5,700 bottlenose dolphins (C.I. 4,300–7,600) and 27,000 loggerhead turtles (C.I. 24,000–31,000) in the Adriatic Sea. As noted above these are underestimates as they are not corrected for availability or perception bias.

Density values, Summer patterns for combined years (**Figures 1**, **2**) and annually (**Figures 3**, **4**) helped identifying key areas for bottlenose dolphins and loggerhead turtles (**Tables 3**, **4**). The summer distribution of the bottlenose dolphin (**Figure 3**) was less consistent than that for the loggerhead turtle (**Figure 4**), at least for the 2 years of the survey.

DISCUSSION

Implementing a Policy

N2k network is an important EU tool for site protection and there is evidence that it can work well for many terrestrial species (e.g., Trochet and Schmeller, 2013), provided that appropriate protection measures are put in place and implemented. Nevertheless, for highly mobile generalist marine species, the concept of a network of marine protected areas (MPAs) may not be the most effective conservation approach. This is especially so when threats extend throughout the range of these species and conservation objectives are extremely ambitious (i.e., protection of a "significant proportion").

The effectiveness of spatial conservation measures depends on the combination of factors, such as the ecology of the species and their life cycles, the extent of the area protected, and the quality and level of enforcement of management measures undertaken to reduce the impact of threats on populations (Agardi et al., 2011; Hooker et al., 2011; Di Franco et al., 2018). Recognizing that there are limited resources devoted to conservation of nature, it becomes fundamental to prioritize actions (Wilson et al., 2007; Bottrill et al., 2008). For highly adaptable and generalist species, such as the bottlenose dolphins (Bearzi et al., 2009), it would seem appropriate to prioritize the management of at least those anthropogenic activities that have a measurable impact on their populations (i.e., fisheries and seismic exploration) throughout their entire range instead of focusing solely on MPAs (Wilson et al., 2007).

In the context of the designation of N2k sites, it is a weakness that the distribution of species, in relation to the threats that they face, is considered only after the designation of a SCI. Depending on the distribution of threats, mitigation measures should be implemented on the full range of the population (as required by HD Art. 12). The establishment of only a network of MPAs will probably be inadequate. In addition, variability in annual and seasonal distribution of these species may preclude the establishment of effective "small areas" with fixed boundaries (see **Figure 3** that shows considerable annual variability for the bottlenose dolphin). This also highlights the difficulty of designating areas based upon limited datasets in time and space for such species, which has been the case for most Adriatic SCIs.

The N2k framework also establishes that, within designated SCIs, species whose populations are assessed as "non-significant" (D) do not require management actions. Management measures are only considered for species whose populations are assessed as above 0%, possibly between 2 and 15% of the national population (categories: A: 100% $\geq p >$ 15%, B: 15% $\geq p >$ 2%, C: 2% $\geq p >$ 0%). This creates an apparent loophole (see **Table 1**), where the smaller a site is, the higher the possibility that it will not to be necessary to commit to specific species related management actions once the SCI becomes a SAC, making it only a protection "on paper."

Ecology and Jurisdiction: Different Rules and Scales

Ecological Setting

The available data shows that both species are present year-round in the Adriatic Sea (e.g., Lazar and Tvrtkovic, 1995;

TABLE 2 | Uncorrected (see text) abundance and densities for the bottlenose dolphin and loggerhead turtles in the Adriatic Sea.

Stratum		Bottlenose dolphin			Loggerhead turtle		
		Abundance (N)	Relative weight	Relative density (ind/km^2)	Abundance (N)	Relative weight	Relative density (ind/km^2)
ADRIATIC		5,700 (CIs = 4,300–7,600)	100%	0.042	27,000 (CIs = 24,000–31,000)	100%	0.203
North		2,600 (CIs = 2,200–2,900)	47%	**0.057**	18,200 (CIs = 17,700–20,000)	69%	**0.405**
Central		1,100 (CIs = 800–1,500)	21%	0.034	1,900 (CIs = 1,600–2,200)	7%	0.057
South		1,800 (CIs = 1,500–2,400)	33%	0.032	6,300 (CIs = 5,000–7,500)	24%	0.114
EU 12 nm	HR	1,500 (CIs = 1,300–1,800)	27%	**0.046**	5,400 (CIs = 5,000–6,100)	21%	0.172
	IT	400 (CIs = 300–2,400)	7%	0.017	2,700 (CIs = 2,300–8,400)	10%	0.117
	SI	na	negligible	na/negligible	na	negligible	na/negligible
Non-EU 12 nm	AL	100 (CIs = 40–200)	2%	0.023	200 (CIs = 100–300)	1%	0.041
	BH	Na	negligible	na/negligible	na	negligible	na/negligible
	MN	100 (CIs = 40–200)	2%	**0.049**	200 (CIs = 100–200)	1%	0.078
EU CSM	HR	3,100 (CIs = 2,800–3,600)	57%	**0.056**	14,000 (CIs = 12,700–14,800)	53%	**0.251**
	IT	1,800 (CIs = 1,500–3,000)	33%	0.030	10,400 (CIs = 9,200–12,500)	39%	0.171
	SI	NA	Negligible	na/negligible	na	negligible	na/negligible
Non-EU CSM	AL	300 (CIs = 100–1,000)	6%	0.031	700 (CIs = 300–1,000)	3%	0.074
	BH	na	negligible	na/negligible	na	negligible	na/negligible
	MN	200 (CIs = 100–300)	4%	0.029	1,200 (CIs = 800–1,400)	5%	0.166
	All HR SCIs	200 (CIs = 100–1,000)	3%	**0.048**	700 (CIs = 600–7,00)	2%	0.185

N, total number of animals; na, not available; HR, Croatia; IT, Italy; SI, Slovenia; AL, Albania; BH, Bosnia Herzegovina; MN, Montenegro.
Numbers are rounded to the closest hundred. The relative weight is the percentage of individuals included in different sub areas in relation to the estimate of the whole Adriatic Sea. Densities marked in bold are those higher than the Adriatic average. Italy does not have an Ecologic Protection Zone in the Adriatic yet. Slovenia and Croatia have a disputed border in the Bay of Piran.

Lazar et al., 2003; Bearzi et al., 2009; Casale et al., 2012). The present data confirm that the north Adriatic, as a whole, is an important area for the conservation of both species, at least in Summer. Using the combined data and taking into account the jurisdictional boundaries, three key areas were identified for the loggerhead turtle in the north Adriatic (Cc. 1–3). These spatially overlap with three high-density areas for bottlenose dolphins (Tt. 1–3; Tab. 2). The boundaries for these key areas should be considered tentative, especially because our reference point (the Adriatic average density for each species) is also temporally variable and does not necessarily capture areas of absolute importance for these species. Identifying an appropriate reference point requires more data (at both local and regional level) and some discretionary choice in relation to the agreed conservation targets. In addition, in the context of defining robust boundaries, considering a summation of the high-density areas by year (see **Figures 3**, **4**), rather than using the combined dataset, may be a better approach.

The summer survey data confirm the north Adriatic as a key neritic habitat for loggerhead turtles. It is in fact the largest such area in the Mediterranean, frequented by turtles hatched in western Greece, Crete and western Turkey (Lazar et al., 2011; Tolve et al., 2018). Given this species' benthic feeding strategy (Lazar et al., 2011) and overwintering behavior (Hochscheid et al., 2005, 2007), the entire northern Adriatic seafloor should be considered a "critical habitat" for the Mediterranean RMU.

The pelagic waters of the southern Adriatic (Cc. 4; **Figure 4**) also seem to be another important, but highly variable (**Figures 3**, **4**), habitat for loggerhead turtles. This is consistent with earlier tagging studies and dispersal models (Casale et al., 2007; Casale and Mariani, 2014). How to manage this highly variable transboundary pelagic habitat is a challenging issue.

The summer survey data confirm the north Adriatic as important bottlenose dolphin habitat, but the annual variation of local distribution can be quite large (**Figure 3**), making determining robust boundaries complex (possible examples are Tt. 1–3). The broad result is in line with the described preference of the species in the Mediterranean for habitats with depths <100 m (Bearzi et al., 2009; Gnone et al., 2011). The data also emphasize the importance of Croatian and Montenegrin territorial waters for this species, in comparison to a lower or negligible importance of Italian and Slovenian territorial waters, respectively (**Tables 2**, **3**).

A higher density area for bottlenose dolphins was found in the central Adriatic in 2013 (Tt. 4, around Jabuka/Pomo island, currently a GFCM Fishery Restricted Area; see Resolution GFCM/41/2017/3)—no such area was identified in 2010. Similarly, high density areas were seen in the southern Adriatic in both 2010 (only on the east) and 2013 (highest in the west). Designating "clearly identifiable areas" is therefore difficult (Tt. 5, based upon an analysis of the combined data does not capture the high density seen in the west in

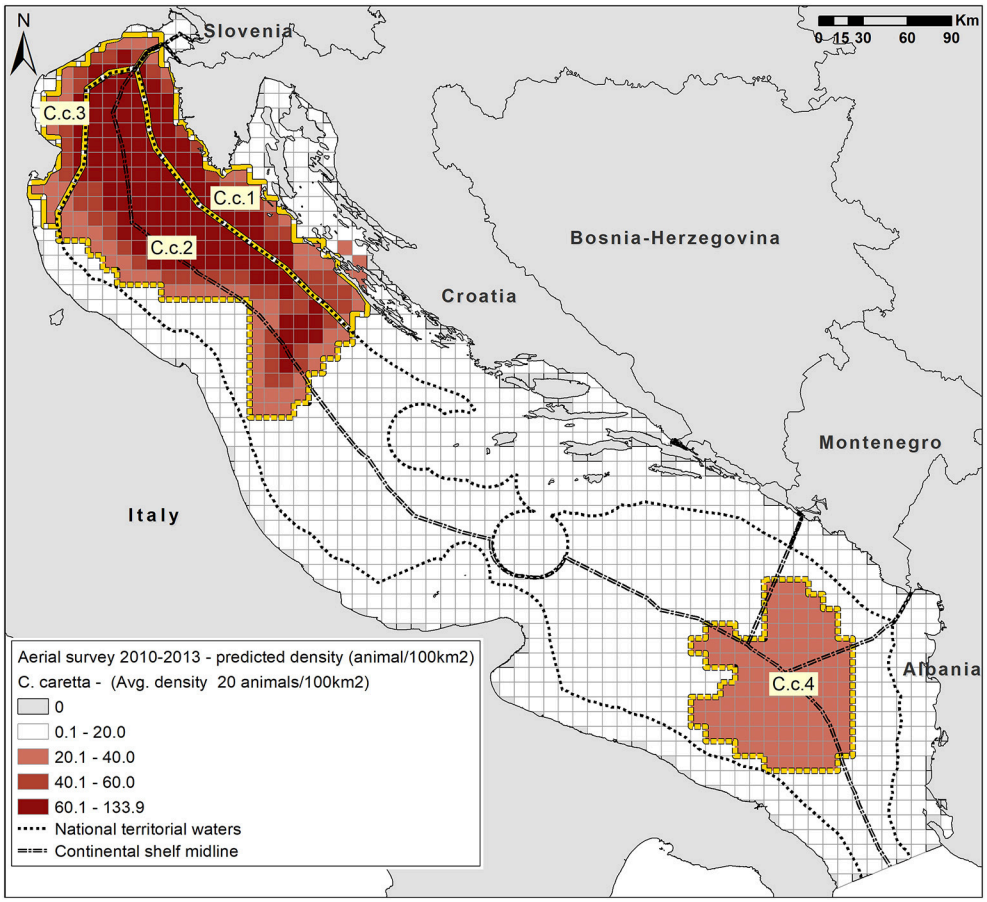

FIGURE 2 | Density Surface predicted distribution of sea turtles (mostly loggerhead turtles) in the Adriatic Sea based on 2010 and 2013 aerial surveys data (darker red scale indicates higher relative density). The scales represent below average (white; L), and then up to twice (L-MD), up to three times (M-HD), up to four times (H-HHD) and greater than four times (MAXD), in shades of dark red. The proposed key areas (**Table 3**) are identified by yellow dotted (within 12 nm), dashed (over 12 nm) and dot-dashed shapes (areas within and over 12 nm).

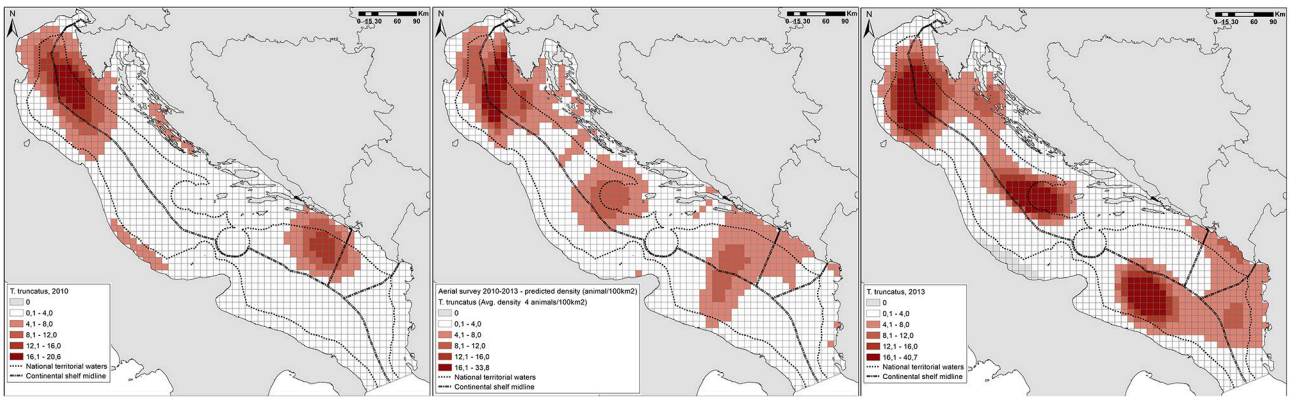

FIGURE 3 | Bottlenose dolphin densities for the data from 2010 (left); 2010–2013 (center), and 2013 (right). The scales represent below average (white), and then up to twice, up to three times, up to four times and greater than four times the average (shades of dark red).

2013). The ecological reasons for these temporally variable higher density areas are poorly understood. They could be related to food resources (especially in the more homogeneous northern Adriatic) and/or influx of specimens of the pelagic ecotype (especially in the south Adriatic; Gaspari et al., 2015).

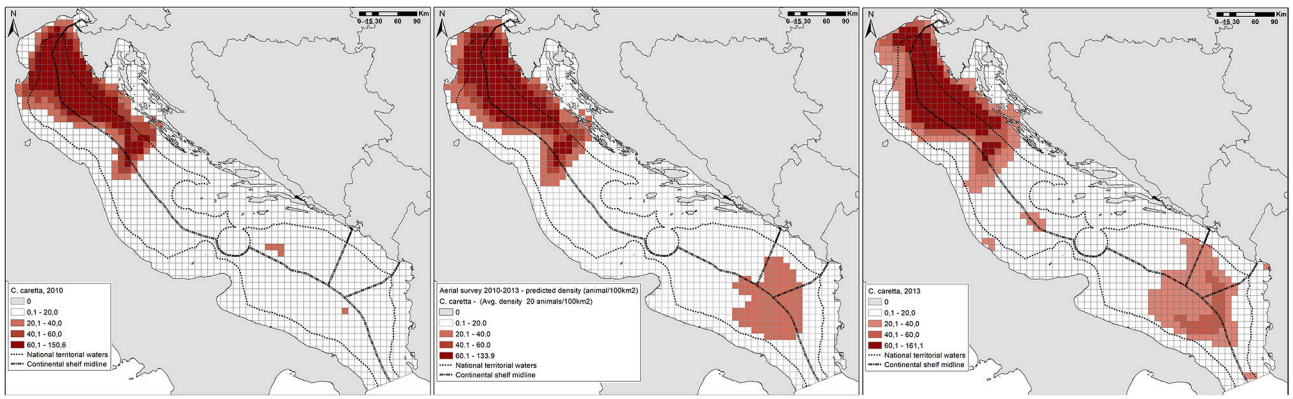

FIGURE 4 | Loggerhead turtle densities for the data from 2010 (left); 2010 + 13 (center), and 2013 (right). The scales represent below average and then twice, three times, and greater than three times average density (shades of dark red).

Jurisdictional Setting

Jurisdictional boundaries are irrelevant for these highly mobile transboundary species. Ideally, key areas should be identified without concern for jurisdiction in the expectation that the concerned countries will collaborate for conservation. However, there are several issues that complicate what appears to be simple in principle. The most obvious, in the context of the N2k framework, is that the animals are found not only within the EU waters, but also outside where the HD is not in force. While there is an obligation for MSs to apply the HD in their jurisdiction, it is not consistently applied. Each MS harmonizes their national law to the HD, which may create problems when applying the directive in a transboundary context. Also, the legal requirement to implement the HD is different in the different jurisdictions of the EU countries. For Italy, in the Adriatic, the HD requirements apply only to territorial waters and the seafloor of the continental shelf, and only for non-living resources, such as benthic habitats of species and sedentary living organisms (Anonymous, 1997, 2007). This is because Italy has not declared an EEZ within the Adriatic Sea. By contrast in 2003, the Croatian government declared an Ecological and Fisheries Protection Zone (EFPZ), extending its jurisdiction and thus also the commitment to implement the HD out to the mid-line with Italy (CSM). In practical terms, the distribution patterns described in this study for both species (**Figures 1**–**4**) emphasized the importance of offshore areas (particularly, Tt. 1, Tt. 4, Tt. 5, and Cc. 2), i.e., waters lying outside territorial waters and partially outside EU jurisdiction.

HD Article 4.1 states that N2k sites should "be proposed **only** where there is a **clearly identifiable area** representing the physical and biological **factors essential to their life and reproduction** [emphasis added]." However, for wide-ranging and behaviorally flexible species, this is difficult to apply without considerable and robust data that is seldom available and costly to obtain. Difficulties arise in selecting a "clearly identifiable area" unless it is permissible to include (a) a wide area to incorporate temporal and spatial variability and (b) to consider the nature of threats (and their mitigation) at an early stage. This rule has been legitimately used by some Member State to justify the lack of Natura 2000 sites for bottlenose dolphins and loggerhead turtles in their waters, especially when the robust information on "criteria B" (see below) is lacking not only nationally, but at the Mediterranean level. Our data and other studies (e.g., Lazar et al., 2004b; Casale et al., 2007, 2012) suggest that for loggerhead turtles a single site encompassing Cc. 1–3 feeding and wintering grounds could be proposed (**Figure 2**). Concerning the bottlenose dolphin, due to the fact that they do not have specific areas where they feed, mate or reproduce (Bearzi et al., 1997, 1999; Genov et al., 2008; Holcer, 2012; Pleslić et al., 2013; Triossi et al., 2013), the variability of their distribution is greater. Yet, higher density areas (**Figure 1**) and their annual variability (**Figure 3**) consistently suggest that at least the entire northern half of the north Adriatic could be proposed for protection. However, fine-tuning strict boundaries around these higher density areas for both these species it is challenging.

On one hand, the general legal requirements of the HD (and possibility of sanctions in case of non-compliance), may incentivize Member States to establish marine N2k sites in locations where studies have been carried out, rather than actual important habitats, or based on just "expert opinion." This may lack true understanding of the actual distribution of the species, the estimated proportion of the management/population unit that will benefit from such designation and the biological significance of proposed areas (as characterized under criteria B.a-B.d (Annex III of HD).

Important additional complications come from the wording in those four criteria.

(1) "Size and density of the population of the species present on the site in relation to the populations present within a national territory" (B.a). As illustrated in **Table 2**, the relevance of using the baseline of the size and density present "within a national territory" can be rather dubious in terms of biological significance considering the relevant biological population or management unit. In addition (e.g.,

TABLE 3 | Key areas for bottlenose dolphins in the Adriatic Sea based upon the combined 2010 and 2013 datasets (see **Figure 1**).

	Description	Relevance to existing Natura 2000 sites
Tt. 1	North Adriatic offshore waters (includes areas from H-HHD to MAXD)	–
Tt. 2	North-eastern Adriatic (includes areas from H-HHD to MAXD)	Overlapping sites HR5000032, HR3000161 and HR3000419 and adjacent to HR4000001
Tt. 3	North/north-western coastal waters off the Po delta and offshore waters off Veneto and Emilia-Romagna (Italy) (includes areas from L-MD to M-HD)	Overlapping sites IT3250047 and IT3250048, and adjacent to IT3320037; also overlaps or is adjacent to IT4060005, IT4060003, IT4060005, which do not list the bottlenose dolphin
Tt. 4	Pelagic habitat around Jabuka/Pomo island, including waters over 12 nm (includes areas with H-HHD)	Adjacent to site HR3000469
Tt. 5	Southern Adriatic, offshore waters off the of Dubrovnik, Croatia and Montenegro (includes areas with H-HHD)	Adjacent to site HR3000426

TABLE 4 | Proposed key areas for loggerhead turtles in the Adriatic Sea based upon the combined 2010, and 2013 datasets (see **Figure 2**).

	Description	Details
Cc. 1	Coastal waters of the north-eastern Adriatic (Istrian peninsula, Croatian waters and outside the Croatian archipelagos (includes areas from L-MD to MAXD)	Overlapping Natura 2000 site HR5000032 and adjacent to HR3000161, HR3000419 and HR4000001, none of which lists the loggerhead turtle
Cc. 2	Offshore waters off the Istrian peninsula, Croatia, outside the Croatian archipelagos (Cres-Lošinj, Premuda-Molat, Dugi Otok-Kornati) and off the Italian Regions of Veneto and Emilia Romagna (includes areas from H-HHD to MAXD)	–
Cc. 3	Coastal waters of the north and north-western Italian Adriatic (area between the Marano Lagoon, Friuli, and Sacca di Goro, Emilia Romagna) (includes areas from L-MD to MAXD)	Overlapping Natura 2000 site IT4060005, IT4060003, IT4060005 IT3250047, IT3250048, IT3320037 and IT3330008, and adjacent to IT3330005
Cc. 4	Offshore waters in the southern Adriatic (between the Italian Region of Puglia, Montenegro and Albania) (includes areas with L-MD)	

see **Figure 3**), the abundance and density can vary widely from year-to-year.

(2) "Degree of conservation of the features of the habitat which are important for the species concerned and restoration possibilities" (B.b). In many cases, identifying the important "physical and biological features" of the habitat for highly mobile species is difficult (and thus so is the concept of "restoration"). For example, whilst nesting sites of loggerhead turtles are easily identified and site protection designation is an effective conservation tool, only sporadic nesting activity has been recorded in the western Adriatic (Mingozzi et al., 2007) so the overall contribution to conservation of the RMUs of such site(s) may be minimal or even irrelevant. However, applying criterion B.b to their other important habitats—such as a feeding and wintering neritic habitat—is more difficult and is yet to be applied.

(3) "Degree of isolation of the population present on the site in relation to the natural range of the species" (B.c); and (4) "Global assessment of the value of the site for conservation of the species concerned" (B.d). The difficulty with both of these items lies in their use of phrases, such as "natural range of the species" and "global assessment [...] of the species" implying that the species is the suitable baseline. For widespread species, such as the bottlenose dolphin and the loggerhead turtle this would make the Adriatic Sea almost inevitably a "less important" area. This is clearly not an advisable baseline for conservation efforts that should focus on smaller "management units," such as biological or demographically isolated populations or sub-populations.

CONCLUSIONS

This paper does not propose any new protected areas for these species despite highlighting areas of relatively high density within the region. Rather it shows how data and modeling can be used to inform the designation process. In addition, it shows that there are weaknesses within the N2k designation process for marine wide-ranging species and proposes changes to the use of the Habitats Directive with regards to the use of Annex III. Utilizing biological data alone will have limited effect for conservation. Combining socio-economic data and stakeholder use patterns will enable conservation measures to be tailored to the regulatory context (Gissi et al., 2018). This is in line with other EU instruments that apply within this region, such as the Marine Strategy Framework Directive (2008/56/EC) (MSFD), the Marine Spatial Planning Directive (2014/89/EU) (MSP), the Environmental Impact Assessment Directive (2014/52/EU) (EIA), the European Common Fisheries Policy (CFP) and the EU Strategy for the Adriatic Ionian Region (EUSAIR).

Scientific Basis for Natura 2000 Sites

The experience from the Adriatic has shown the value of systematic large-scale aerial survey data for identifying abundance, density and broad-scale distribution of many large marine species, such as cetaceans and turtles (e.g., Pollock et al., 2006; Rowat et al., 2009; Lauriano et al., 2011; Panigada et al., 2011; Fortuna C. M. et al., 2014). However, such surveys can only produce a "snapshot" for time the survey is carried out. There are

natural variations in density and distribution, as illustrated by the differences between the summer 2010 and 2013 surveys, which may complicate the definition of conservation goals. There are also often seasonal differences as witnessed in the Mediterranean by Panigada et al. (2011). For these reasons, especially for the species considered in this study but not only, the identification of site-based conservation measures must:

(1) be based upon several (we would suggest at least three) years of good quality broad-scale surveys to capture natural variability;
(2) incorporate effort in different seasons;
(3) take into account any methodological issues (e.g., missing smaller turtles <30 cm in carapace length, Fortuna C. M. et al., 2014) incorporating the uncertainty;
(4) take into account relevant small-scale studies (e.g., photo-identification for bottlenose dolphins, telemetry studies, data on bycatch from independent observers' schemes);
(5) undertake regular surveys after boundaries have been established to validate their suitability; and, in parallel,
(6) be based upon good knowledge of stock structure.

These "golden rules" are all "*sine qua non.*" Applying only some of these rules undermines the final objective of designating effective site-based conservation measures. At present, in the usual marine N2k context, these are not applied consistently nor fully.

Improved Conservation Approaches for These Species

This review has identified a number of features of the N2k process in relation to wide-ranging and/or migratory marine species, such as cetaceans and sea turtles, which require attention:

(1) the scientific basis for any sites must be robust, including identification of management units at supranational level (possibly through one of the exists coordinating bodies, such as the EUSAIR or Barcelona Convention);
(2) the nature of threats should be incorporated from the start of the process (e.g., in identifying potential SCIs and establishing their likely effectiveness at the supranational management unit level);
(3) Member States should collaborate with each other (and with non-EU range states) in developing SCIs and SACs that will actually improve conservation at the supranational management unit level rather than a perceived national level; and
(4) recognition should be given to the fact that to be effective, marine N2k sites may have to be extremely large in comparison to others for species with smaller ranges or well-identifiable critical habitats (e.g., feeding and breeding grounds).

Our study clearly shows that site protection measures alone are unlikely to have a significant conservation effect in protecting a sufficient proportion of the bottlenose dolphins or loggerhead turtles found in the Adriatic waters under EU jurisdiction, unless vast areas are designated as SCIs. Without implementing high priority wide-scale conservation measures to mitigate specific threats to these species, MPAs may in fact provide a sense of false security in terms of meeting their conservation objectives (Agardi et al., 2011).

While small MPAs have a direct conservation role where habitats are static, such as Posidonia beds, reef systems or shipwrecks, they have a limited direct conservation effect on wide ranging species. Conversely, MPAs may have multiple secondary effects on conservation, such as raising public awareness about a species, threat or issue, applying political pressure on decision makers or generally improving behavior and responsibility on the sea, which has previously been considered as open access and therefore the responsibility on none.

The objective of the EU Habitats Directive is improved conservation of species within their natural range; hence, implementing this overarching objective should be seen as primary focus, rather than focusing on only on the implementation of one of the available tools (i.e., site-based protection) in order to appear to be meeting HD legal requirements.

For wide-ranging and migratory species, HD Article 4.1 should be applied rigorously. Member States and European authorities in charge of the protection of these wide-ranging species should engage in cost-benefit analyses of all alternative conservation tools, before selecting a costly site-based solution, such as the designation of N2k sites. They should give the highest priority to the full implementation of Articles 11 and 12—two other HD conservation pillars. Particularly MS should (a) "*undertake surveillance of the conservation status of the natural habitats and species*," (b) "*establish a system to monitor the incidental capture and killing*," and (c) "*take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned*."

In practice, all suggested actions or refinements to the HD are in line with the principle of creating an assessment framework for species and anthropogenic threats, with priority given to the evaluation and mitigation of incidental captures in fisheries and any other direct or indirect mortality caused by, for example, seismic surveys and ship strikes. This approach is fully in line with other European directives and policies, including the MSFD, MSP Directive, CFP and EIA Directive. It is worth noting that a draft Regulation related to the new EU Common Fisheries Policy on technical measures on the conservation of fishery resources and the protection of marine ecosystems, is currently being discussed (Anonymous, 2016). This proposed Regulation contains new potentially important provisions on gears, fishing techniques and gears' modification (e.g., gear length, mesh size, soaking/towing time, seasonal closures, excluder devices, pingers, etc.) to be used to mitigate the impact of bycatch on sea turtles and cetaceans. These technical measures, if fully developed and implemented by EU MSs, would be key legislative tools and they would have a more promising impact on the protection of these charismatic species than the designation of an area either as SCI or MPA.

While this paper focuses specifically on the HD in relation to other EU legislations, it has implications for the other policies relevant to this region including the Barcelona Convention and the Convention for Biological Diversity (Rio, 1992) which lists three areas within the Adriatic as EBSAs (dec-COP-12-DEC-22).

The regional seas agreement could provide a platform that can be used to improve coordinated conservation of species and habitats at international level (Bastari et al., 2016). However, it is down to the relevant national authorities to focus on streamlining and fully implementing all the relevant management and mitigation tools established under these policies to be applied at supranational level.

AUTHOR CONTRIBUTIONS

CF conceived the manuscript. All authors contributed to the writing and revisions of the manuscript. AC analyzed all data. DH edited all figures. CF, GD, and PM edited the final manuscript.

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