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Regional Activity Centre For Specially Protected Areas



# ADRIATIC SEA: IMPORTANT AREAS FOR CONSERVATION OF CETACEANS, SEA TURTLES AND GIANT DEVIL RAYS



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support of the  
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# Contents

1. Context.....	5
2. The Adriatic Sea.....	7
3. Cetacean species in the Adriatic Sea.....	8
3.1. The common bottlenose dolphin ( <i>Tursiops truncatus</i> ).....	8
3.1.1. <i>Distribution and abundance</i> .....	8
3.1.1.1. Trends in distribution & abundance.....	11
3.1.2. <i>Population structure</i> .....	12
3.1.3. <i>Feeding ecology and behavior</i> .....	13
3.1.4. <i>Conservation status</i> .....	14
3.1.5. <i>Distribution and abundance</i> .....	16
3.1.6. <i>Population structure</i> .....	18
3.1.7. <i>Conservation status</i> .....	18
3.2. The Cuvier's beaked whale ( <i>Ziphius cavirostris</i> ).....	19
3.2.1. <i>Distribution and abundance</i> .....	19
3.2.2. <i>Population structure</i> .....	22
3.2.3. <i>Conservation status</i> .....	22
3.3. The Risso's dolphin ( <i>Grampus griseus</i> ).....	22
3.3.1. <i>Distribution and abundance</i> .....	22
3.3.2. <i>Population structure</i> .....	25
3.3.3. <i>Conservation status</i> .....	26
3.4. The fin whale ( <i>Balaenoptera physalus</i> ).....	26
3.4.1. <i>Distribution and abundance</i> .....	26
3.4.2. <i>Population structure</i> .....	27
3.4.3. <i>Conservation status</i> .....	27
3.5. Other non regular species.....	28
3.5.1. <i>The short-beaked common dolphin (Delphinus delphis)</i> .....	28
3.5.2. <i>The sperm whale (Physeter macrocephalus)</i> .....	29
3.5.3. <i>Visitor species</i> .....	29
4. Sea turtles species in the Adriatic Sea.....	30
4.1. The loggerhead turtle ( <i>Caretta caretta</i> ).....	30
4.2. Other species of sea turtles in the Adriatic Sea.....	33
5. The giant devil ray ( <i>Mobula mobular</i> ).....	34
5.1. Adriatic Sea.....	35
5.2. Population structure.....	36
6. Threats to species in the Adriatic Sea.....	37
6.1. Fishery.....	37
6.1.1. <i>Cetacean-fishery interactions</i> .....	38
6.1.2. <i>Sea turtle-fishery interactions</i> .....	40
6.1.3. <i>The giant devil ray-fishery interactions</i> .....	41
6.2. Gas and Oil exploitation.....	42
6.3. Maritime traffic.....	44
6.4. Tourism related issues.....	47
6.5. Pollution (including marine debris).....	48
7. Conservation status of considered species.....	48
8. Hotspots of megafauna vs hotspots of anthropogenic activities.....	48
9. Protected areas and other management actions for important habitats' protection.....	51
References.....	53

## List of Figures

Figure 1 Priority conservation areas in the Mediterranean (UNEP/MAP).....	6
Figure 2 Map of Adriatic Sea with bathymetry and protected areas.....	7
Figure 3 Map of sighting of common bottlenose dolphins during aerial surveys in 2010 and 2013..	9
Figure 4 Bottlenose dolphin distribution based on encounter rates (sightings/km) within cells of size 20x20km (Fortuna et al., 2013) .....	10
Figure 5 Common bottlenose dolphins, Central Adriatic. Photo: D.Holcer, BWI.....	12
Figure 6 Striped dolphins, Southern Adriatic. Photo: E.Filidei jr., ISPRA .....	16
Figure 7 Map of sighting of striped dolphins during aerial surveys in 2010 and 2013 .....	17
Figure 8 Striped dolphin distribution based on encounter rates (sightings/km) within cells of size 50x50km (ISPRA 2013).....	18
Figure 9 Cuvier's beaked whales, Southern Adriatic. Photo: C.M.Fortuna, ISPRA .....	18
Figure 10 Relative density of beaked whales predicted through habitat modelling of 1990-2010 data (Cañadas et al., 2011). (Authors marked that In the south-eastern region of the basin the lack of survey effort didn't allow making of predictions of presence/absence or relative density of this species). .....	20
Figure 11 Map of strandings and sighting of Cuvier's beaked whale during aerial surves in 2010 and 2013.....	21
Figure 12 Risso's dolphins, Southern Adriatic. Photo: BWI.....	23
Figure 13 Map of strandings and sighting of Risso's dolphins during aerial surveys in 2010 and 2013.....	24
Figure 14 Fin whale, Central Adriatic. Photo: C.M.Fortuna, ISPRA .....	27
Figure 15 Map of sighting of fin whales during aerial surveys in 2010 and 2013 .....	28
Figure 16 Loggerhead turtle, Central Adriatic. Photo: A.Žuljević, IOR.....	31
Figure 17 Map of sighting of (mostly) loggerhead turtles during aerial surves in 2010 and 2013...	33
Figure 18 Giant devil ray, Central Adriatic. Photo: D.Holcer, BWI .....	34
Figure 19 Map of literature records, opportunistic sightings and sighting of giant devil ray during aerial surveys in 2010 and 2013 .....	35
Figure 20 Map of cumulative anthropogenic impact on the Mediterranean and Black Sea (Micheli et al., 2013).....	37
Figure 21 Map of cumulative demersal fishing impact on the Mediterranean Sea (Author: GRID-Arendal, <a href="http://www.grida.no/">http://www.grida.no/</a> ) .....	38
Figure 22 Gas extraction platform in the Northern Adriatic Sea. Photo: D.Holcer, BWI.....	43
Figure 23 Map of recent seismic survey in the Adriatic Sea (Map: <a href="http://www.spectrumasa.com">http://www.spectrumasa.com</a> ) .	44
Figure 24 Map of maritime transportation routes in the Mediterranean Sea (Author: GRID-Arendal, <a href="http://www.grida.no/">http://www.grida.no/</a> ) .....	45
Figure 25 Maritime traffic and traffic separation scheme in the Adriatic sea (Policy Research Corporation, 2011) .....	46
Figure 26 Striped dolphins bowriding in front of the cargo ship, Southern Adriatic. Photo: D.Holcer, BWI.....	47
Figure 27 Yacht approaching group of common bottlenose dolphins, Central Adriatic. Photo: D.Holcer, BWI .....	47

Figure 28 Sightings of large marine vertebrates in the Adriatic Sea recorded during the aerial surveys in 2010 and 2013 .....	49
Figure 29 Areas of importance for megafauna in the Adriatic Sea: descriptive options based on ecological aspects of the selected species.....	50
Figure 30 Areas of importance for megafauna in the Adriatic Sea, protected areas and identified EBSA.....	51

## List of Tables

Table 1 List of neighboring countries for the priority areas addressed by the third phase of the “MedOpenSeas” project.....	5
Table 2 Minimum abundance estimates of bottlenose dolphins in the Adriatic Sea from the aerial survey 2010 .....	10
Table 3 Selected mark-recapture abundance estimates of bottlenose dolphins in the Adriatic Sea	11
Table 4 - Italian Initial Assessment (2012) on the bottlenose dolphin status under the MSFD (based on ISPRA 2013).....	15
Table 5 Abundance estimates of striped dolphins in the Adriatic Sea (aerial survey 2010) .....	17
Table 6 Existing numbers on historical killings of dolphins in the Adriatic Sea .....	39
Table 7 Annual estimates of bycatch of cetaceans in the Adriatic Sea.....	39
Table 8 Report from italian national stranding network ( <a href="http://mammiferimarini.unipv.it">http://mammiferimarini.unipv.it</a> ) .....	40
Table 9 Annual estimates of bycatch of loggerhead turtles in the Adriatic Sea.....	41



# 1. Context

Since 2008, the Regional Activity Centre for Specially Protected Areas (RAC-SPA) under the framework of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP) has been implementing the “MedOpenSeas” project to identify and establish Marine Protected Areas (MPAs) in the open seas, including the deep seas. The primary objective of this project is to promote the establishment of a representative ecological network of MPAs in the Mediterranean within the framework of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) on the establishment of Specially Protected Areas of Mediterranean Importance (SPAMIs). This project is financially supported by the European Commission, and is now in its third phase.

The first phase of the project, completed in late 2009, led to the identification of twelve priority conservation areas in the open seas, including the deep seas. These priority areas could become candidates for SPAMI listing and/or be recommended for inclusion in other frameworks, such as Ecologically or Biologically Significant Areas (EBSAs) developed under the Convention on Biological Diversity (CBD).

The aim of the project’s second phase, completed in early 2012, was to support neighboring Parties of the above-mentioned priority areas in evaluating and potentially presenting these sites as candidate(s) for inclusion in the SPAMI List, in accordance with the provisions of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean. The RAC/SPA in Tunis has been facilitating this preparatory work, including oceanographic surveys and stakeholder negotiations. The programme of work of the second phase included the establishment of ad hoc working groups, composed of representatives from the countries bordering the Alboran Sea (Algeria, Morocco, Spain) and Gulf of Lions (France, Spain) priority areas.

*Table 1 List of neighboring countries for the priority areas addressed by the third phase of the “MedOpenSeas” project*

<b>Priority areas addressed during 3rd phase</b>	<b>Neighbouring countries</b>
Adriatic Sea	Albania, Bosnia-Herzegovina, Croatia, Italy, Montenegro and Slovenia
Alboran Sea	Algeria, Morocco and Spain
Sicily Channel/Tunisian Plateau	Italy, Libya, Malta and Tunisia

The current third phase focuses on the spatial planning and evaluation of three priority areas (see Table 1 and Figure 1): Adriatic Sea, Alboran Sea and the Sicily Channel/Tunisian Plateau areas. The two adjacent sites within the Sicily Channel/Tunisian plateau will be dealt with in joint meetings and working groups to maximize the effectiveness in the broader area. The process in the Alboran

Sea benefits from initial preparatory work and a stakeholder meeting in 2011 conducted during the second project phase. The RAC/SPA is currently starting to prepare meetings with the representatives of the neighboring countries to these three sites, in order to present the proposed process and to discuss the feasibility of setting up multilateral working groups.

A wealth of biological and environmental data is available for the above-mentioned areas, based on long-term research and exploration efforts made by several countries. Ongoing programmes, for example on sea birds and marine mammals, continue to improve our understanding of the biodiversity in these regions.

Much of these data are however scattered across different national research institutes and are not necessarily formally published. A summary report and review of our current understanding of the biodiversity for each of the four priority areas will be essential to develop MPAs in these key open sea regions. Therefore expertise will be recruited i) to compile and review available data on the ecology for each of the priority areas and ii) to produce a report illustrating the state of ecological knowledge for the respective areas. Ultimately these outputs will provide the foundation for assessing the suitability of each of the sites for SPAMI listing.

In parallel to the preparation of an overall marine ecology report, there will be an initial and a follow-up project meeting for each priority area. This will assist stakeholder communication throughout the process, as well as the collection of data for the overall marine ecology report.

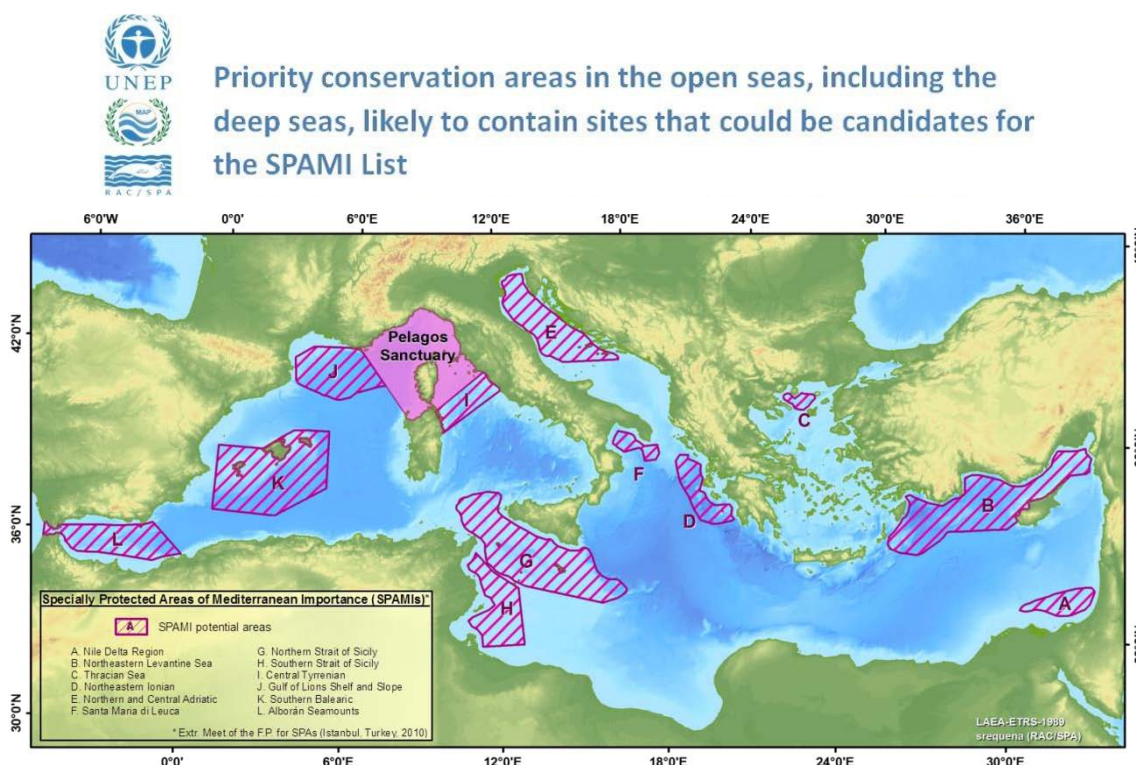
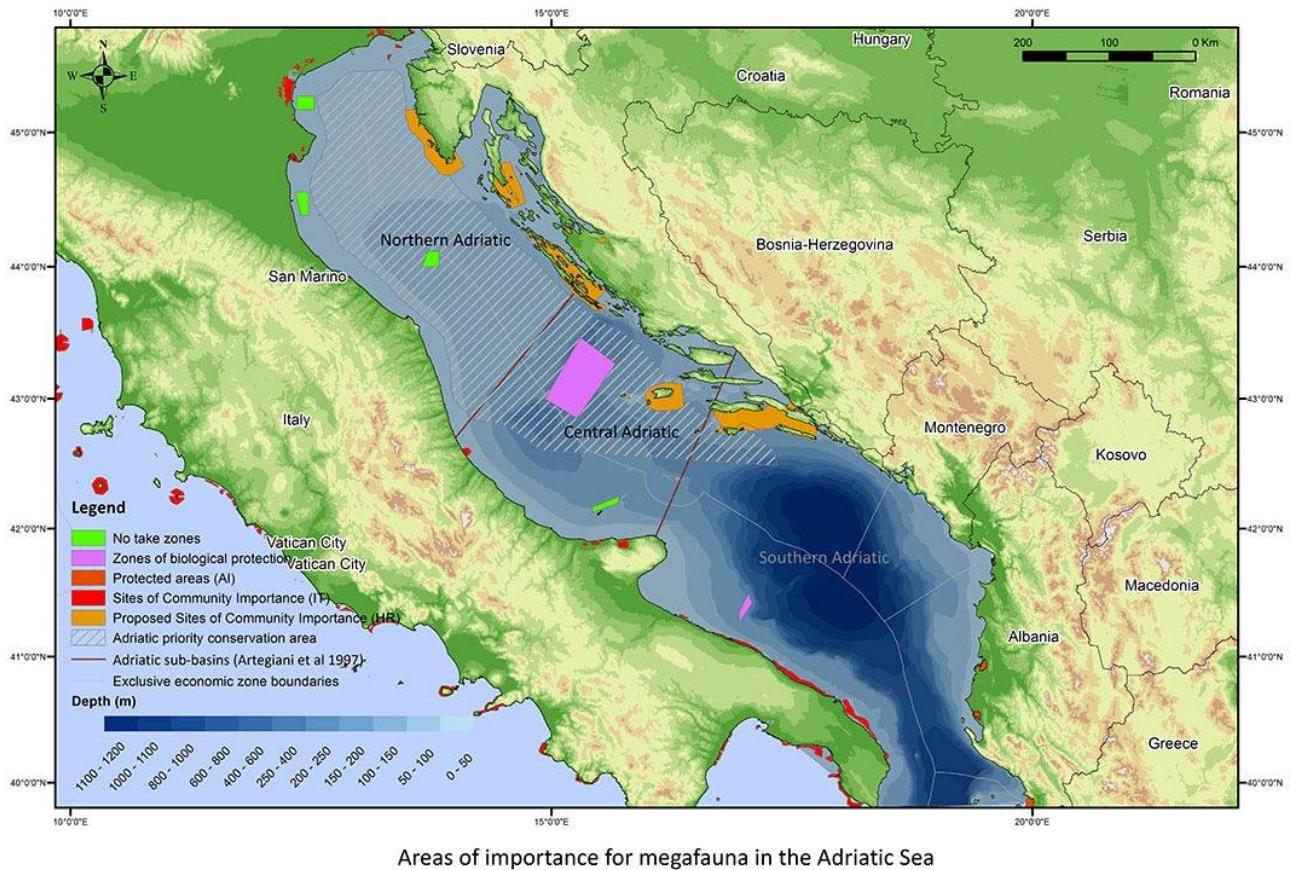


Figure 1 Priority conservation areas in the Mediterranean (UNEP/MAP)



## 2. The Adriatic Sea

The Adriatic Sea is the northernmost arm of the Mediterranean basin. It is a semi-enclosed sea with a surface area of around 138,000 km<sup>2</sup>, connected to the Mediterranean through the narrow (72 km wide) but deep (780 m) Strait of Otranto (Cushman-Rosin et al., 2001). The bathymetry of the Adriatic Sea is characterized by strong latitudinal and longitudinal asymmetries (Figure 2).



*Figure 2 Map of Adriatic Sea with bathymetry and protected areas*

The northern sub-basin is shallow, with an average depth of 35 m and is strongly influenced by the Po river plumes, with low salinity, low water temperature and high productivity. The 100 m bathymetric contour line roughly separates the northern basin from the central Adriatic (Artegiani et al., 1997).

The central Adriatic is a transition zone with some open sea characteristics and the 270 m deep Jabuka (Pomo) pit (Russo and Artegiani, 1996) influenced by the inflow of Levantine Intermediate Water (LIW).

Finally, the 170 m deep Palagruža (Pelagosa) sill separates the central sub-basin from the much deeper southern Adriatic. This sub-basin, with steep slopes, higher salinity and maximum depth of 1200 m, consists of around 55% of the surface area but about 80% of the total volume of the Adriatic Sea (Cushman-Rosin et al., 2001) and as such it can be considered as a pelagic oceanic habitat (Fonda-Umani, 1996).

These three sub-regions have also noticeable differences in sea current gyres (Artegiani et al., 1997).

### 3. Cetacean species in the Adriatic Sea

Eleven Cetacean species are present with regular populations in the Mediterranean Sea and contiguous area (Notarbartolo di Sciara and Birkun, 2010). Three of this species have limited range; killer whale (*Orcinus orca*) is present in the Strait of Gibraltar, rough-toothed dolphin (*Steno bredanensis*) in the Levantine basin and harbour porpoises (*Phocoena phocoena relicta*) in the Aegean Sea (Notarbartolo di Sciara and Birkun, 2010). Other eight species are present throughout the Mediterranean and are recorded in the Adriatic Sea with different densities. These include the common bottlenose dolphin, *Tursiops truncatus*, the short-beaked common dolphin, *Delphinus delphis*, the striped dolphin, *Stenella coeruleoalba*, the fin whale (*Balaenoptera physalus*), the sperm whale (*Physeter macrocephalus*), the long-finned pilot whale (*Globicephala melas*), the Risso's dolphin (*Grampus griseus*) and the Cuvier's beaked whale (*Ziphius cavirostris*) (Holcer, 1994; Holcer et al., 2002). Additionally, two more species (considered visitors to the Mediterranean Sea), the false killer whale (*Pseudorca crassidens*) and the humpback whale (*Megaptera novaeangliae*), have been recorded with solitary individuals in the Adriatic Sea (Holcer et al., 2002; Genov et al., 2009a).

Current knowledge of the status of the Cetacean species in the Adriatic Sea indicates that only common bottlenose dolphin is regularly present in the entire Adriatic Sea. Striped dolphin, Risso's dolphin and the Cuvier's beaked whale are present in different densities only in the Southern Adriatic, while sperm whales occasionally visit the area. Fin whales are present seasonally in Central and Southern Adriatic. Long-finned pilot whale, false killer whale and humpback whale present rare visitors to the Adriatic Sea. Finally, the short-beaked common dolphin, once present in the entire Adriatic Sea should be considered regionally extinct, as it is present only through either remnant or strayed animals.

#### 3.1. The common bottlenose dolphin (*Tursiops truncatus*)

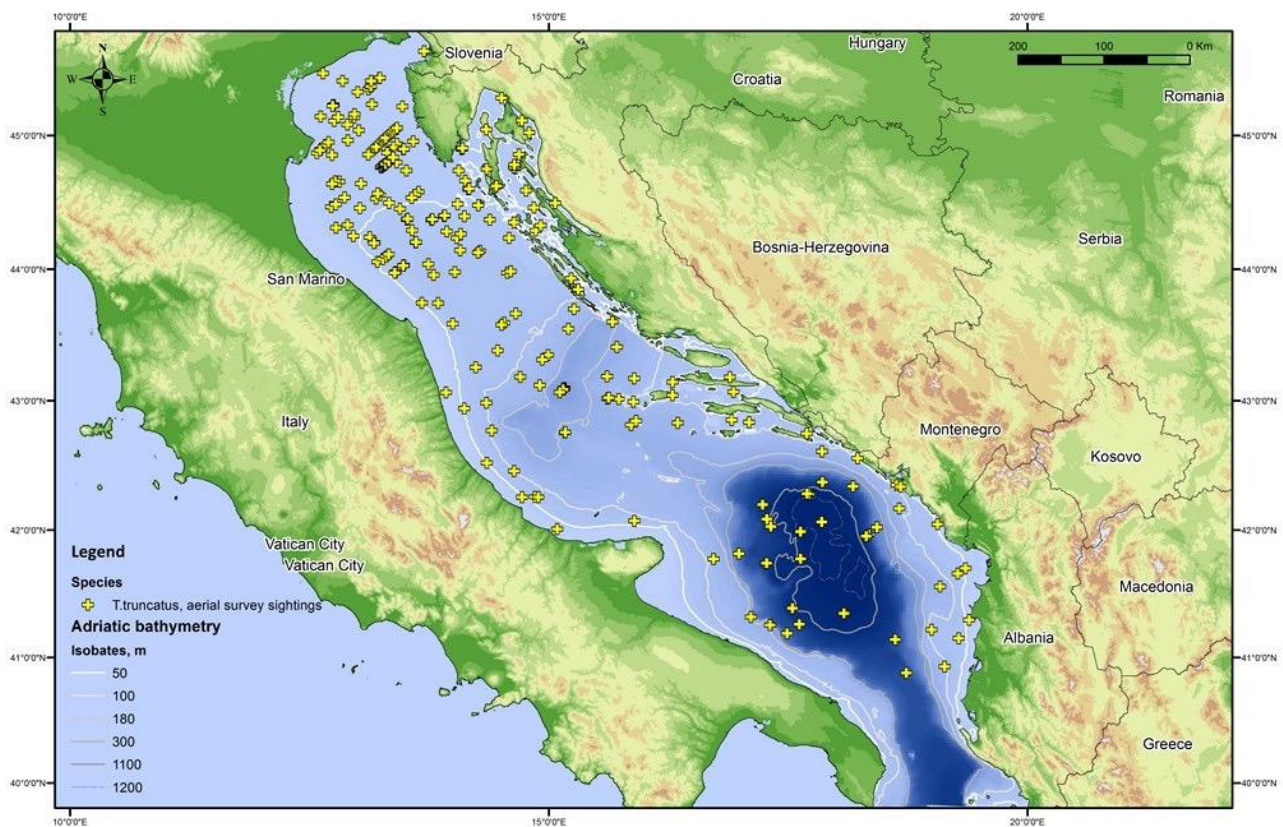
##### 3.1.1. Distribution and abundance

The common bottlenose dolphin (*Tursiops truncatus*) is one of the most widely distributed species in the Mediterranean (Bearzi et al., 2008b). This species is believed to be most abundant in regions where neritic waters are predominant (e.g. the northern Adriatic Sea) or important (Notarbartolo Di Sciara et al., 1993). Nevertheless bottlenose dolphins are found in a wide variety of other habitats, ranging from lagoons and river deltas to the oceanic waters (see Bearzi et al. (2008b) for a review).

Prior to the 2010 aerial survey (Fortuna *et al.* 2011), anecdotal accounts of bottlenose dolphins were reported from many corners of the Adriatic basin, although reliable systematic data were limited to few research studies. Since late 80s a long-term project on ecology of bottlenose dolphins has been operating in the Losinj-Cres archipelago and its adjacent areas (Notarbartolo Di Sciara et al., 1993; Bearzi and Notarbartolo di Sciara, 1995a; Bearzi et al., 1997; Bearzi et al.,

1999; Bearzi et al., 2008b; Bearzi et al., 2009). This study uses the photo-identification as main tool for looking at many aspects of the ecology of this population. It has been the first one to provide quantitative information on population dynamics of the local population of bottlenose dolphins (Bearzi et al., 1997; Fortuna et al., 2000; Fortuna, 2006; Pleslić et al., 2014). Other long-term studies started in Slovenia (Genov et al., 2008; Genov et al., 2009b) and central Croatia in 2002 (Impetuoso et al., 2003), and south Croatia in 2007 (Holcer et al., 2008c; Holcer et al., 2009; Holcer, 2012). Additional data from short and medium-term projects on distribution, relative abundance and social structure was collected from Italian and Croatian waters (Bearzi et al., 2008a; Kammigan et al., 2008; Triossi et al., 2013).

Bearzi et al. (2008a) using data collected during oceanographic cruises in the north-western part of the northern Adriatic observed that bottlenose dolphins' distribution changed depending on seasonal forcing. Given that their study area was relatively uniform in terms of bottom topography, they also concluded that habitat use by the animals seems to depend on complex interactions among hydrological variables, caused primarily by seasonal change and likely to determine shifts in prey distribution.



Sightings of common bottlenose dolphin the Adriatic Sea (2010 & 2013)

*Figure 3 Map of sighting of common bottlenose dolphins during aerial surveys in 2010 and 2013*

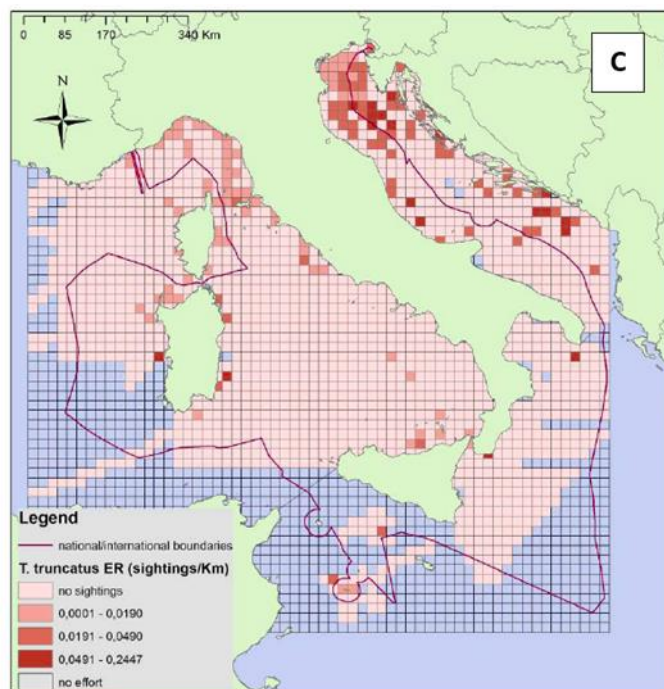
In 2010 and 2013 two aerial surveys were carried out providing a snapshot of the summer distribution and abundance of bottlenose dolphins in the entire Adriatic Sea. Figure 3 shows the bottlenose dolphins distribution recorded during these surveys. These surveys confirmed that the bottlenose dolphin is the only cetacean species regularly observed in the Adriatic Sea

(Notarbartolo Di Sciara et al., 1993; Bearzi and Notarbartolo di Sciara, 1995b; Bearzi et al., 2008b). In terms of distribution it is clear that this species prefers (five more times) the neritic province (<200m) to the oceanic one (see also Table 2), with a higher prevalence for areas with depths <100m.

*Table 2 Minimum abundance estimates of bottlenose dolphins in the Adriatic Sea from the aerial survey 2010*

Stratum	Sample size	Model	Group density per km <sup>2</sup> (CV)	Animal density per km <sup>2</sup> (CV)	Uncorrected estimate (CV; 95% CIs)	Estimated mean group size (CV)
All Adriatic (survey transect spacing: 20 km; area: about 133,400 km <sup>2</sup> )	61	Half-normal/Cosine	0.014 (21.6%)	0.043 (25.7%)	5,772 (25.7%; 3,467-9,444)	3.87 (20.7%)
North Adriatic only (survey transect spacing: 20 km)	35	Uniform/Cosine	0.025 (26.0%)	0.074 (30.2%)	3,608 (30.2%; 1,971-6,604)	2.80 (14.9%)
Central and south Adriatic only (survey transect spacing: 20 km; area: about 73,900 km <sup>2</sup> )	23	Uniform/Cosine	0.010 (28.9%)	0.024 (34.8%)	1,786 (34.8%; 903-3,534)	2.87 (18.5%)

In the past the Adriatic bottlenose dolphins was described as mostly scattered into relatively small inshore 'local populations'. After two aerial surveys it seems that this determination must have been largely affected by a perception bias connected to existing studies that were mainly coastal. A biased view-point gained working in relatively small study areas (100-3,000 km<sup>2</sup>). Wider surveys have revealed a different overall picture both in terms of general extension of this species distribution and its total numbers.



*Figure 4 Bottlenose dolphin distribution based on encounter rates (sightings/km) within cells of size 20x20km (Fortuna et al., 2013)*

For the Initial Assessment (IA) of this species under the Marine Strategy Framework Directive (MSFD), Italy provided an overview on the sub-region “Adriatic Sea” (ISPRA 2013). This was based on most of the above mentioned data (including the 2010 aerial survey). Figure 4 shows the bottlenose dolphin distribution obtained in this IA based on their encounter rates (sightings/km) obtained pooling all data available between 1986 and 2010. The cell size was 400km<sup>2</sup> (20x20) (Fortuna et al., 2013).

For what concerns the information on abundance of bottlenose dolphins, preliminary estimates obtained for the entire Adriatic Sea from the 2010 aerial survey (not corrected for perception nor availability bias) are shown in Table 2 (Fortuna et al., 2011b).

Densities are not particularly high, however, they are comparable to those of other areas of the Mediterranean Sea (i.e. Alboran Sea, Balearic Islands, see Bearzi et al. (2008b)). Both, densities and abundance estimates, when corrected for availability bias (diving behaviour) increased of over 20%; whereas when accounting for the group size they increased of about 50%. New abundance estimates accounting for availability and perception bias are due in 2014 (ISPRA & BWI, *unpublished data*).

Data on abundance obtained with mark-recapture methods in local studies is summarised in Table 3.

*Table 3 Selected mark-recapture abundance estimates of bottlenose dolphins in the Adriatic Sea*

Location (Sampling year)	Model	Total estimate (CV; 95% CIs)	Source
North-western Adriatic sea, Slovenia & Croatia (2005)	M <sub>th</sub> of Chao estimator	68 (0.18; 62-81)	Genov <i>et al.</i> (2008)
North-western Adriatic sea, Slovenia & Croatia (2008)	M <sub>t</sub>	69 (0.08; 68-70)	
Losinj-Cres archipelago, Croatia (1995)	M <sub>th</sub> of Chao estimator	168 (0.14; 132-229)	Fortuna (2006)
Losinj-Cres archipelago, Croatia (1998)	M <sub>th</sub> of Chao estimator	130 (0.11; 108-152)	Fortuna (2006)
Losinj-Cres archipelago, Croatia (2001)	M <sub>th</sub> of Chao estimator	105 (0.20; 76-160)	Fortuna (2006)
Losinj-Cres archipelago, Croatia (2004)	M <sub>th</sub> of Chao estimator	197 (0.16; 162-272)	Pleslic <i>et al.</i> 2013
Losinj-Cres archipelago, Croatia (2007)	M <sub>th</sub> of Chao estimator	200 (0.13; 172-252)	Pleslic <i>et al.</i> 2013
Losinj-Cres archipelago, Croatia (2010)	M <sub>th</sub> of Chao estimator	186 (0.11; 164-230)	Pleslic <i>et al.</i> 2013
Vis-Lastovo arcipelago, Croatia (2008)	M <sub>h</sub> jackknife	396 (0.09; 350-456)	Holcer (2012)
Vis-Lastovo arcipelago, Croatia (2010)	M <sub>th</sub> of Chao estimator	474 (0.22; 352-638)	Holcer (2012)

### 3.1.1.1. Trends in distribution & abundance

There is not quantitative historical information that can be used to infer population trends in the Adriatic Sea. However, local experts believe that bottlenose dolphin numbers probably declined by at least 50% in the second half of the 20th century, largely as a consequence of deliberate killing

initially (see paragraph 5.1.1.1), possibly followed by habitat degradation and overfishing of prey species (Bearzi et al., 2004; Bearzi and Fortuna, 2006; Bearzi et al., 2008b). Aerial survey data collected in 2010 and 2013 will allow the first quantitative comparison for the entire basin and for its sub-regions.

### **3.1.2. Population structure**

In the context of looking at the population structure of bottlenose dolphins in the Adriatic Sea, the meta-population concept is a useful one. A '*meta-population*' comprises '*local populations*' that are discrete or relatively discrete entities in space, which interact via migration and gene flow (Hanski and Gaggiotti, 2004). The concept of meta-population also implies that the processes of 'geographical extinction' and 'recolonisation' occur 'regularly'. In ecology, it is widely accepted that fragmentation of the landscape represents the most visible anthropogenic threat to the survival of natural populations (e.g. (Hanski, 2005)). Such fragmentation can occur within the range of a local population, particularly for highly mobile species. In extreme cases, this might ultimately lead to both genetic and geographical isolation (Freedman et al., 2003; Hanski and Gaggiotti, 2004). In the marine ecosystem the landscape fragmentation is difficult to detect and explain, but there are increasing evidence that both oceanographic and anthropogenic factors can actually induce a fragmented genetic landscape in cetaceans too (e.g. Natoli et al. (2005) [ENREF 205](#)).



*Figure 5 Common bottlenose dolphins, Central Adriatic. Photo: D.Holcer, BWI*

Based on mitochondrial (mtDNA) and nuclear DNA from skin samples of 63 Adriatic bottlenose dolphins, Gaspari et al. (2013) found that the Adriatic population cannot be considered as a single 'unit-to-serve'. In particular Adriatic bottlenose dolphins revealed a fine-scale genetic structure showing a differentiation between north and central-south sub-basins (mtDNA), as well as between the western and eastern coasts (nuclear DNA). This subdivision seems to reflect the existing physiographic differences along both latitudinal and longitudinal axes of the Basin. In this fine-scale genetic structure females appear to be the principal gene flow mediators. The assessment of recent migration rates also indicates a relatively high level of gene flow from the North Adriatic towards adjacent areas. Finally, the mtDNA and nuclear DNA revealed diverse levels of genetic differentiation between the Adriatic putative local populations and those from the Tyrrhenian Sea and the Aegean Sea. This reinforces the MSFD sub-region 'Adriatic Sea' as an ecologically meaningful overall management area for this species. According to these results (Gaspari et al., 2013), despite potential sample size limitations, it seems sensible to address conservation issues of the bottlenose dolphin in the Adriatic Sea at the 'sub-regional' if not the 'local' population level, rather than focussing on the entire basin. Potential threats should be evaluated accordingly.

Photo-identification data have also suggested that bottlenose dolphins of the Adriatic Sea are structured in putative local populations (Fortuna, 2006; Genov et al., 2008; Genov et al., 2009b; Holcer, 2012; Pleslić et al., 2013). Social characteristics can also play an important role in structuring a meta-population and should be investigated to inform managers on *inter alia* average populations' ranging distances (home ranges).

### **3.1.3. Feeding ecology and behavior**

As in other parts of the world, bottlenose dolphins in the Adriatic Sea appear to have highly adaptive feeding habits (Stewart, 2004) with a possible preference for demersal prey (Mioković et al., 1999), Fortuna, unpublished data). Results of the analysis of stomach contents of bottlenose dolphins in the Kvarnerić region (Northern Adriatic) indicates that prey species are very diverse and include large number of species of bony fish and cephalopods.

In the Cres-Lošinj area (Croatia) Mioković et al. (1999) suggested the existence of some qualitative overlap between local fisheries species and dolphin prey. They found that commercially important species, such as the European hake (*Merluccius merluccius*) and conger eel (*Conger conger*) were a significant component of the diet of this species (N=1). Stewart (2004) found that *Sparidae* made up to 45% of stomach content of bottlenose dolphins (n=3), horse mackerel (*Trachurus* sp.) 25%, hake only 2% and European conger 1%.

Sprčić (2011) analysed four stomach contents of four bottlenose dolphins found later in the same area (2006-2007). Horse mackerel represented the 8.5% of the identified fish species, European hake 11%, Sparidae 16%, Gobidae 7,7%, Octopoda 10,3% and Teuthoidea 7.7%. Interestingly, no remains of small pelagic fish were found in any of the stomach contents analysed and, the percentage of mullets (*Mullus* sp) was quite small (1-2%). These results are in contrast with observations of dolphins regularly following both bottom trawlers (Fortuna et al., 1996; Bearzi et al., 1999; Casale and Giovanardi, 2001; Stewart, 2004; Prihoda, 2005; Fortuna, 2006) and mid-

water trawlers (Fortuna et al., 2010c; Holcer, 2012) for feeding purposes and fishermen claim substantial damage to caught red mullet (*Mullus barbatus*).

Results from stable isotopes analyses (C, N) on samples from bottlenose dolphins biopsied in the Central Adriatic Sea show a partially different story (Holcer, 2012). For these dolphins there is a seasonal shift in prey species. At the end of the winter over the 87% of biopsied dolphins feed almost exclusively on small pelagic fish, mostly sardines. These findings could indicate that other fish species are either less available or pelagic fish is very abundant. According to a number of authors, the end of winter is time when sardines migrate from the open sea towards the coastal areas for spawning and is present in the Central Adriatic with large biomass. In spring red mullet become available in large quantities along the eastern Adriatic coast. This is the period when, according to interviews with local fisherman, most dolphin-fisheries interactions occur. Biopsy samples taken in spring and summer show prey species similar to those found in the north-eastern stomach contents. In addition, individual diet differences were also recorded either indicating individual preferences and/or different prey availability.

Bearzi et al. (1999) looked at the diurnal behaviour of a bottlenose dolphin community in the north-eastern Adriatic. The behavioural budget showed a predominance (about 80%) of activities characterized by long dives (>30 sec), which these Authors considered to be largely related to prey search or feeding. Foraging near the surface was observed rarely. The frequent following of trawlers (accounting for 4.5% of the behavioural budget) was indicative of the presence of alternative strategies for finding food and overlaps between dolphins distribution and fishing activities, confirmed also in other studies (Prihoda, 2005; Fortuna, 2006).

Triossi et al. (2013) analysed the behaviour of bottlenose dolphins around and within offshore gas fields off Ravenna (Italy). Their analyses showed that dolphin density was approximately 80% higher within 750m of gas platforms (compare to densities >750 m from platforms). In addition they noticed that slightly higher frequencies of feeding and milling behaviour were observed closer to gas platforms, whereas dolphins observed further away exhibited higher frequencies of socialising and travelling. As gas platforms are known to provide habitat for demersal fishes and act as aggregation points for pelagic fishes, they concluded that bottlenose dolphins may utilise gas platforms opportunistically as feeding sites. It should be noticed that under the Italian law, it is forbidden to anchor, fish or navigate within 500 m from these 130 platforms scattered over the Adriatic Sea. Oil and gas platforms in this region are essentially acting as highly dense network of small marine protected areas.

#### **3.1.4. Conservation status**

The Mediterranean subpopulation of the bottlenose dolphin is listed as "Vulnerable" under IUCN (World Conservation Union) criterion A2dce (Bearzi and Fortuna, 2006, 2012).

In its Marine Strategy Framework Directive (MSFD) report to the European Commission (Fortuna et al., 2013) Italy also provided an initial assessment (IA) for this species considering all waters (not only the Italian territorial waters), arguing that any assessment at the sub-region level - of both cetacean species and potential threats to these species - can be meaningful only if carried out



cooperatively with all bordering countries (not only the European Member States (EU MS)). Given the lack of time for setting up an effective cooperation on this matter even within EU MS for the first run of the MSFD reporting, the Italian IA for bottlenose dolphin in the Adriatic sub-region is presented in Table 4.

According to UNEP (2011) Cres-Lošinj Archipelago (Kvarnerić area) represents the habitat of the resident population that has been researched since 1987. Based on this research this area was proclaimed as the part of National Ecological Network and potential NATURA 2000 site, as well as proposed marine reserve.

The Cres-Lošinj Special Marine Reserve (CLSMR) was designated in 2006 with the specific aim to conserve a local dolphin population and sustainably manage the use of the natural resources of the Cres-Lošinj archipelago. The archipelago is a nationally important region for tourism. Between July 2006 and July 2009 the CLSMR was the largest marine protected area (MPA) in the Adriatic Sea (about 500 km<sup>2</sup>).

*Table 4 - Italian Initial Assessment (2012) on the bottlenose dolphin status under the MSFD (based on ISPRA 2013)*

MSFD topic	Criterion	Evaluation	Reliability of data
Initial Assessment	Distribution (1.1.)	Within the norm for the entire Adriatic Sea (see Figure 4)	High
	Abundance (1.2.1)	Minimum estimate for the entire Adriatic Sea: over 5000 specimens	High
	Genetic population structure (1.3.2)	At least two general subdivisions (north and central-south Adriatic) and an additional differentiation east/west for males*.	High
Potential threats	Fishery accidental captures (bycatch)	Unknown cumulative impact of all fisheries. Bycatch rate in Italian mid-water trawlers (GSA 17) = 0.001 animal/haul, for a total of 19 specimens (CV=59%; 95%CI 10-29) per year in this fishery alone (Fortuna & Filidei 2012).	High
	Chemical pollution	Unknown	Medium
	Overfishing of demersal resources	Unknown	Low
<p><b>Key:</b> MSFD=Marine Strategy Framework Directive; High=based on reanalyses of robust data collected of the subregion; Medium=based on published data collected from some part of the region; Low=based on expert opinion; *conclusions revised after Gaspari <i>et al.</i> 2013.</p>			

The CLSMR represented Croatian commitments to many of the international environmental agreements signed by the government. However local development commitments made were in conflict with the objectives of the MPA. As a result, support for the concept was affected and the imbalance between local development commitments and international ones led to a proposed downgrading of the MPA and subsequent degazettement (Mackelworth and Holcer, 2011; Mackelworth *et al.*, 2013a).

## The striped dolphin (*Stenella coeruleoalba*)

### **3.1.5. Distribution and abundance**

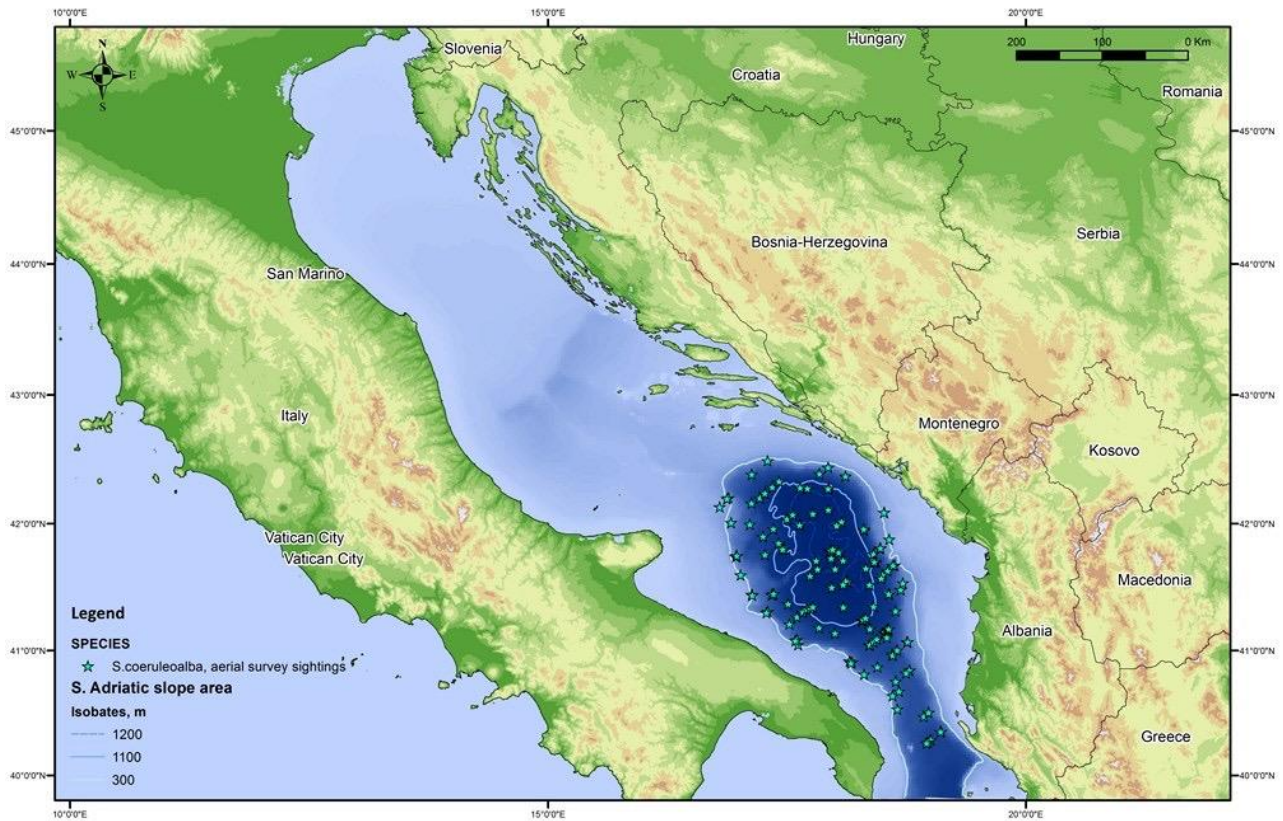
The striped dolphin (*Stenella coeruleoalba*) is considered the most abundant cetacean species in the Mediterranean Sea (Aguilar, 2000). This seems to be the case in the Adriatic Sea too (Fortuna et al., 2011b), although its presence is regular only in the southern part of the basin (Figure 7). This distribution reflects the oceanographic characteristics of the sub-basins (Notarbartolo Di Sciara et al., 1993; Fortuna et al., 2011b). Striped dolphin tends to occur in sea depths greater than 600 m, where it feeds mostly on cephalopods, epipelagic fish (Aguilar, 2000). Only exceptionally it is found in areas less than 200 m (Notarbartolo Di Sciara et al., 1993; Fortuna et al., 2007). This happens in the Adriatic with solitary dolphins and stray small groups in the northern portion of the basin (Bearzi et al., 1998; Francese et al., 2007; Rako et al., 2009; Nimak-Wood et al., 2011).

The striped dolphin is a gregarious species found in the south Adriatic Sea in large herds of some hundreds of individuals (Fortuna et al., 2011b) whereas in the northern Adriatic the group size range from one to three specimens (Bearzi et al., 1998; Francese et al., 2007; Rako et al., 2009; Nimak-Wood et al., 2011).



*Figure 6 Striped dolphins, Southern Adriatic. Photo: E.Filidei jr., ISPRA*

Some authors argued that these more frequent reports of striped dolphins along the northern Adriatic coastline possibly suggest an expansion of this species distribution range as it has been reported for other Mediterranean areas (Bearzi et al., 1998). Others suggest that an increased interest and easy to document cetacean sightings may explain this increased number of reports even on single individuals (Francese et al., 2007; Rako et al., 2009).



Sightings of striped dolphin in the Adriatic Sea (2010 & 2013)

Figure 7 Map of sighting of striped dolphins during aerial surves in 2010 and 2013

Data on the abundance of this species in the Adriatic Sea is summarised in Table 5. Please note that this is to be considered as minimum estimate (uncorrected for availability and perception bias).

Table 5 Abundance estimates of striped dolphins in the Adriatic Sea (aerial survey 2010)

Location (Sampling year)	Total estimate (CV; 95% CIs)	Source
Central-south Adriatic sea (2010)	15,343 (0.28; 8,545-27,550)	Fortuna <i>et al.</i> (2011)

### 3.1.6. Population structure

Little is known on the genetic population structure of the striped dolphin in the Adriatic Sea. However, from a very preliminary study (n=15) it seems that specimens using the Adriatic Sea are not strongly differentiated by those of other parts of the Mediterranean Sea (Galov et al., 2009).

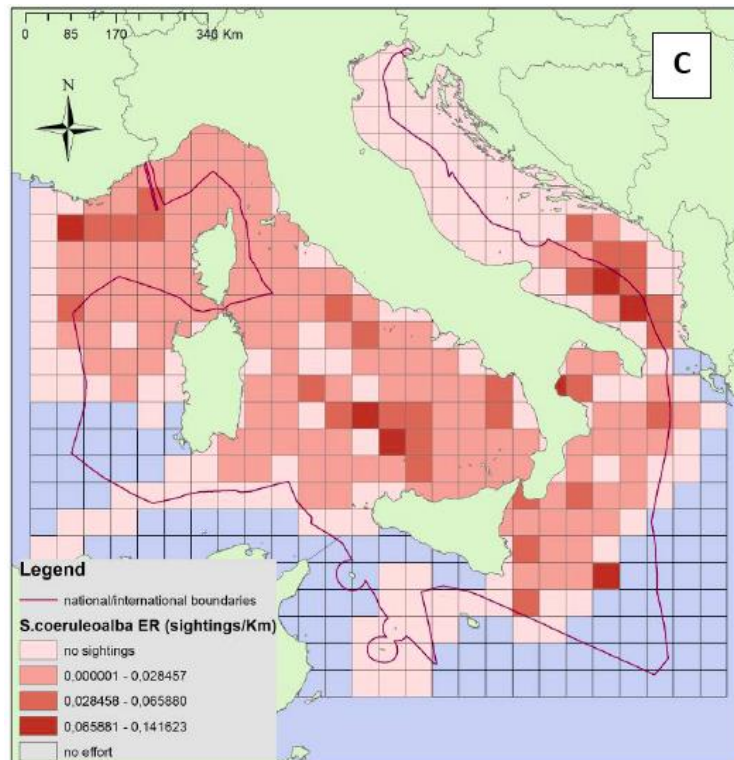


Figure 8 Striped dolphin distribution based on encounter rates (sightings/km) within cells of size 50x50km (ISPRA 2013)

### 3.1.7. Conservation status

The Mediterranean subpopulation of the striped dolphin is listed as "Vulnerable" under IUCN (World Conservation Union) criterion A2bcde (Aguilar and Gaspari, 2012).

## 3.2. The Cuvier's beaked whale (*Ziphius cavirostris*)

### 3.2.1. Distribution and abundance

Cuvier's beaked whale (Figure 9) is a mid-sized Cetacean with adults reaching between 5,5 and 7m in length (MacLeod, 2006). Of all the beaked whales it has the widest distribution range. Its distribution is global while it is absent only from polar waters (Heyning, 1989).

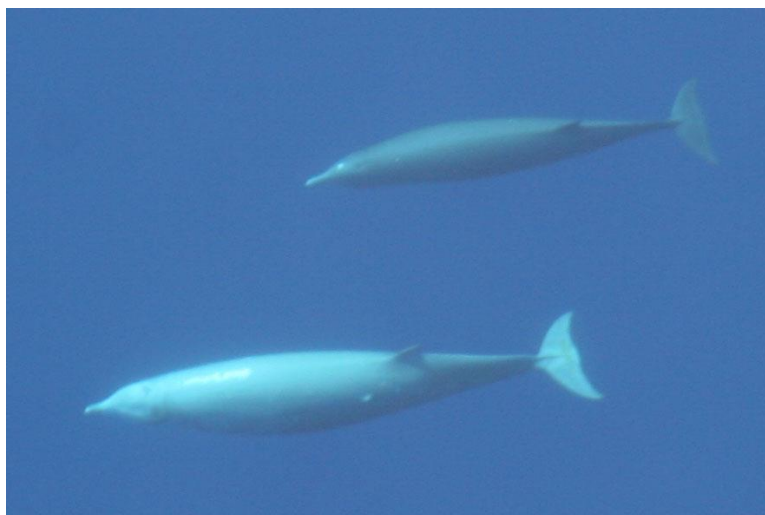


Figure 9 Cuvier's beaked whales, Southern Adriatic. Photo: C.M.Fortuna, ISPRA

Within the beaked whale family, Cuvier's beaked whale is the only species known to regularly occur throughout the entire Mediterranean Sea, with no notable difference in distribution between the western and the eastern basins (Notarbartolo di Sciara & Demma 1997, Notarbartolo di Sciara 2002). Research of the species in the Mediterranean Sea revealed relatively higher abundance in the areas of Alboran Sea (Cañadas, 2011), along the Hellenic trench, from Rhodos to NW Corfu (Frantzis et al., 2003) and in the Ligurian Sea where a long-term site fidelity is established through photo-identification (Revelli et al., 2008; Rosso et al., 2011). Population size estimates exist only for areas of the Alboran Sea & Gulf of Vera (Cañadas, 2011) where availability bias corrected estimate of abundance for 2008-2009 was 1994 (CV=39,7%) and the northern Ligurian Sea where mark-recapture analysis in the period of 2004-2005 yielded total estimate of 85 (CV=0,24)/ 94 (CV=0,21) animals (left/right side) (Rosso et al., 2007).

Species has been recorded through sightings and strandings in a number of other locations in the Mediterranean (D'Amico et al., 2003; Frantzis et al., 2003; Podestà et al., 2006; Holcer et al., 2007; Gannier and Epinat, 2008; Notarbartolo di Sciara and Birkun, 2010; Gannier, 2011).

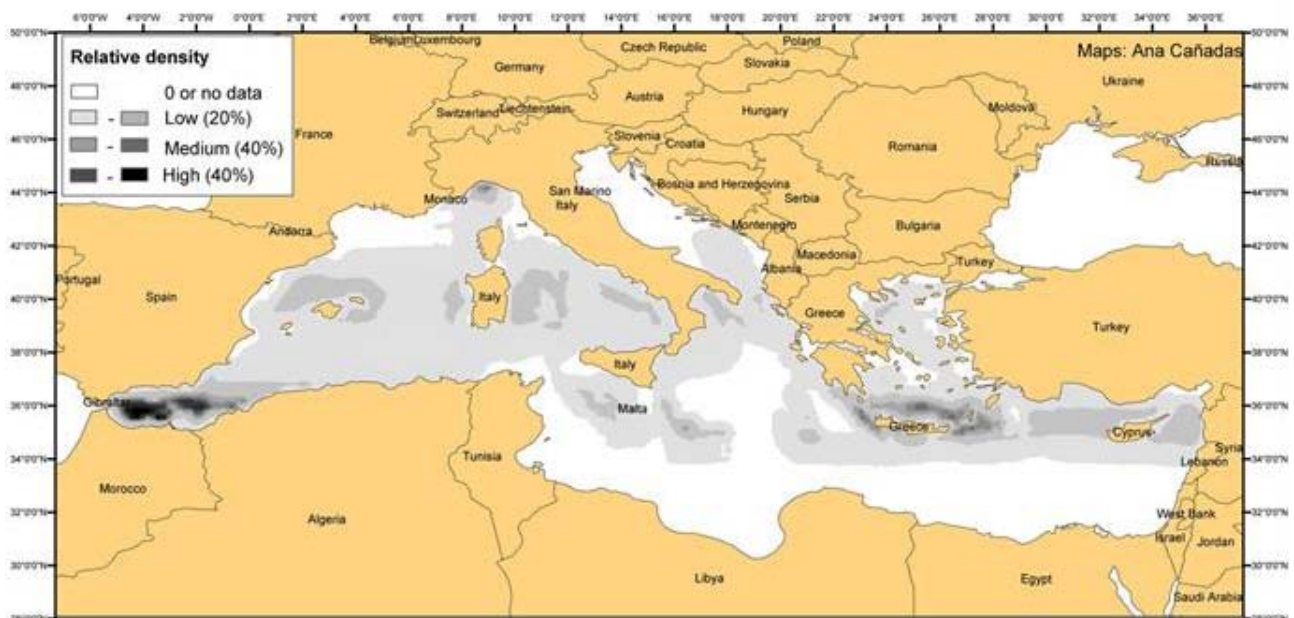
Cuvier's beaked whale is often associated with deep slope habitat and a preference for submarine canyons, steep slopes, scarps or submarine mounts (D'Amico et al., 2003; MacLeod, 2005; Gannier and Epinat, 2008). In the area of Pelagos Sanctuary Moulins et al. (2007) found out that sightings of Cuvier's beaked whales were most often where the depth was between 756 and 1389 m (and slope was steeper) but the encounter rate was higher between depths of 1389 and 2021 m

(where slope was more flat). In Greece animals were observed above depths from 500 – 1500 m along slopes (Frantzis et al., 2003).

Based on the data collected by different organisations in the period of 1990 to 2010, habitat modelling of Cuvier's beaked whales in the Mediterranean (Figure 10) identified previously mentioned areas of the Alboran Sea, the central Ligurian Sea, the Hellenic Trench and the south Aegean Sea (north Cretan Sea) as the areas of highest predicted density and the areas of the Tyrrhenian Sea, the southern Adriatic Sea and some areas to the north of the Balearic islands and south of Sicily had relatively high predicted densities compared to the rest of the Mediterranean (Cañadas et al., 2011). The modelling exercise did not include all of the records from the Adriatic Sea presented here.

Cuvier's beaked whale is mainly teuthophagic although fish may also be an important component of their diet (MacLeod, 2005). The most common prey in the Mediterranean are oceanic and pelagic (meso- or bathy-) cephalopods of the families Histioteuthidae, Cranchiidae and/or Octopoteuthidae (Podestà and Motti, 1991; Carlini et al., 1992; Lekaditou and Pouloupoulos, 1998; Blanco and Raga, 2000; MacLeod, 2005).

Special concern over species status and impact of anthropogenic sound has been expressed due to several atypical mass strandings coinciding with use of naval mid-frequency sonars (Frantzis, 1998; Arbelo et al., 2008; ACCOBAMS SC, 2012). Additionally, seismic surveys mostly for hydrocarbons and general increase of sea ambient noise and its cumulative effects present additional cause for concern (Gordon et al., 2003).

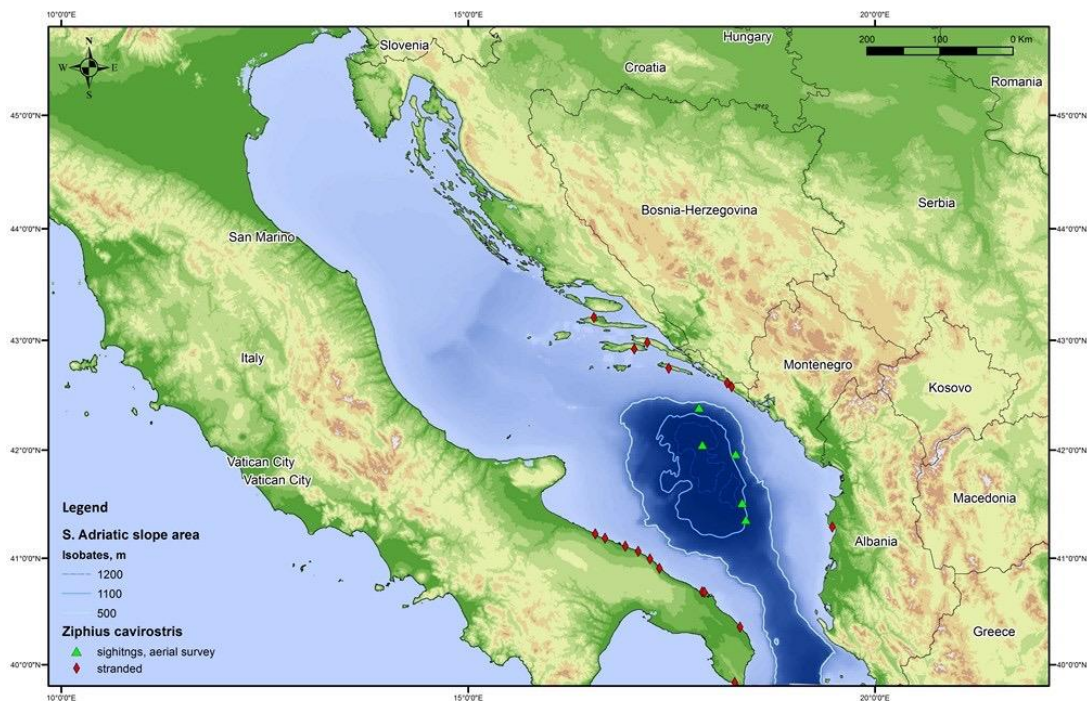


*Figure 10 Relative density of beaked whales predicted through habitat modelling of 1990-2010 data (Cañadas et al., 2011). (Authors marked that in the south-eastern region of the basin the lack of survey effort didn't allow making of predictions of presence/absence or relative density of this species).*

### 3.2.1.1. Adriatic Sea

Historic information regarding the species' distribution and occurrence in the Adriatic Sea is scarce and species was considered occasional in the deeper southern basin, where stranded specimens have been found (Lamani et al., 1976; Centro Studi Cetacei, 1987; Notarbartolo di Sciara et al., 1994; Centro Studi Cetacei, 1995; Storelli et al., 1999; Holcer et al., 2002; Holcer et al., 2003; Gomerčić et al., 2006a; Podestà et al., 2006). In the review paper by Holcer et al. (2007), the authors presented detailed overview on the occurrence of the species in the Adriatic concluding based on the relative number of strandings that southern Adriatic Sea could be important habitat for Cuvier's beaked whale. In total eleven stranded specimens of Cuvier's beaked whales have been documented in the Adriatic Sea until 2004 (Holcer et al., 2007). Five of these were recorded along the Apulian coast in Italy, one recorded in Albania and the remaining five strandings have occurred along the Croatian Adriatic shores (Figure 11). Additionally, in 2008 a newborn Cuvier's beaked whale has been found in Trstenica bay on Pelješac in Croatia (Kovačić et al., 2010). Previously unreported two stranded animals in the Brindisi area were reported by Pino d'Astore et al. (2008). Finally, two additional stranded animals were reported by Museo Civico in Gallipoli and Dept. of pathology University of Bari to the Italian stranding database (mammiferimarini.unipv.it).

Map of strandings of Cuvier's beaked whale in the Adriatic show that stranded animals have been found around entire southern Adriatic basin. Also, it has never been found in the Northern Adriatic Sea and the occurrence in the Central Adriatic is marginal (as stranded specimens were most probably taken by the sea currents to the stranding locations). Considering that Cuvier's beaked whale is a deep diving animal with most notable preference for deep slope habitats, the lack of occurrence in the rather shallow continental shelf of the Northern Adriatic should not be surprising.



Sightings and strandings of Cuvier's beaked whale in the Adriatic Sea (1939 - 2013)

**Figure 11** Map of strandings and sighting of Cuvier's beaked whale during aerial surveys in 2010 and 2013

The analysis of stomach content of the Cuvier's beaked whale from the Adriatic Sea revealed similar type of pray like in the stranded specimens in the Mediterranean. Pray included species of Histoteuthidae (34,7%), Octopoteuthidae (39,1%; not found in the Adriatic), Chiroteuthidae (17,7%), Cranchiidae (8,2%%; not found in the Adriatic) and Sepiolidae (0,2%) (Kovačić et al., 2010) occurring in the deep Southern Adriatic. Furthermore, some of the pray species found in the analysed stomach content were not recorded in the Adriatic Sea indicating either some form of migration between Adriatic and Mediterranean or lack of knowledge of the deep living cephalopods of the Adriatic Sea.

Additionally to the strandings, presence of Cuvier's beaked whales in the Adriatic Sea has been confirmed through aerial surveys of cetacean abundance in 2010 and 2013 (Figure 11). In total, five sightings of Cuvier's beaked whales were made in 2010 and 2013. Sightings occurred at depths between 700 -1200m in the areas of steep bathymetry. It is notable that sightings are grouped along the northern and eastern part of the south Adriatic basin where there is almost direct drop to the depth of 1000m. Within the sighing areas known pray species are found. Sightings included females with juvenile animals indicating southern Adriatic as nursery area.

### **3.2.2. Population structure**

No information exists on population structure of *Ziphius* throughout its Mediterranean range. Mean group size ranges in the Mediterranean is between 2.2 to 2.3 individuals (Canadas et al., 2005; Moulins et al., 2007; Gannier, 2011). Indication of group size based on five sightings during aerial surveys in the Adriatic is 2,6 (authors data).

Analysis of genetic diversity between 87 samples obtained worldwide (10 Mediterranean, 2 Adriatic) found that mtDNA haplotypes from the Mediterranean sea were not found anywhere else and were highly distinct from the neighbouring Eastern North Atlantic (Dalebout et al., 2005). Low diversity could indicate low level of exchange between two basins. Of the two found haplotypes (T3 and T4) only one (T3) was found on two specimens stranded on the Croatian coast (Dalebout et al., 2005).

### **3.2.3. Conservation status**

The Mediterranean subpopulation of the beaked whale is listed as "Data Deficient" (Cañadas, 2012).

## **3.3. The Risso's dolphin (*Grampus griseus*)**

### **3.3.1. Distribution and abundance**

Risso's dolphins (Figure 12) are relatively large dolphins measuring up to 4m in length (Kruse et al., 1999). Most distinctive is blunt head without beak and dark coloration dominated by whitish scars which Risso's dolphins accumulate throughout life, making older animals appear almost

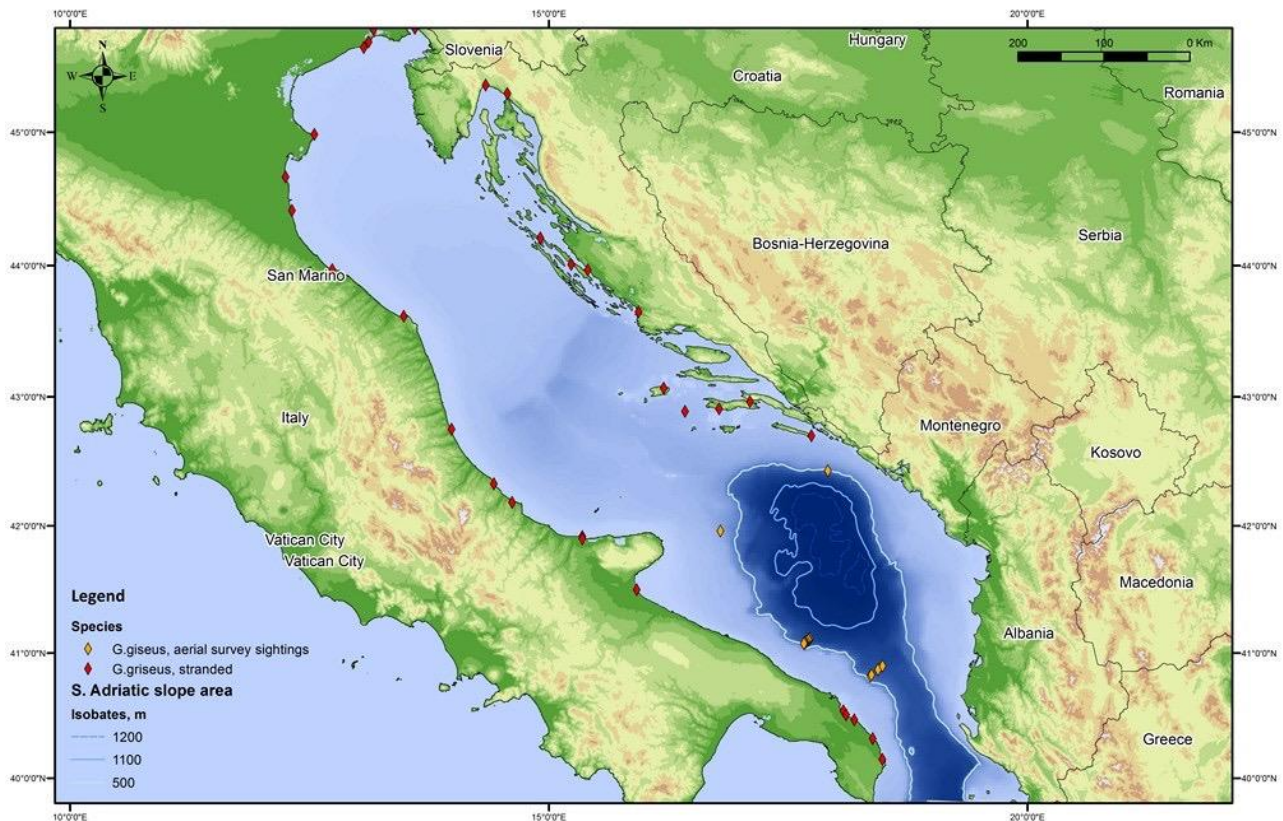


white. Risso's dolphin is distributed worldwide in tropical and temperate seas with preference for deep offshore waters and coastal areas with narrow continental shelves (Letherwood *et al.*/1980).



*Figure 12 Risso's dolphins, Southern Adriatic. Photo: BWI*

Risso's dolphin is present in the entire Mediterranean and is considered a regular inhabitant although abundance is unknown (Notarbartolo di Sciara and Birkun, 2010). In the Mediterranean Risso's dolphin is mostly encountered in deep pelagic waters, in particular over steep shelf slopes and submarine canyons (Gaspari, 2004; Azzellino *et al.*, 2008; Gómez de Segura *et al.*, 2008). Furthermore, Gaspari (2004) found out that distribution of Risso's dolphin is not a function of depth but rather of the habitat. She showed that Risso's dolphins have preferences for areas with higher depth and slope gradient where the continental slope was deeper and steeper suggesting a feeding specialization. Analysis of stomach contents of stranded Risso's dolphins indicate that species is feeding mostly with cephalopods inhabiting oceanic waters over the steep continental slope (Podestà and Meotti, 1991; Wurtz *et al.*, 1992). Analysis of Blanco *et al.* (2006) show that Risso's dolphins feed on cephalopods on the middle slope (600-800m depth).



Sightings and strandings of Risso's dolphin in the Adriatic Sea (1905 - 2013)

*Figure 13 Map of strandings and sighting of Risso's dolphins during aerial surveys in 2010 and 2013*

Within the Mediterranean Risso's dolphins are known through regular observations and/or strandings from most areas of the Mediterranean (Bearzi et al., 2011b) although no data exists for most of southern Mediterranean (Notarbartolo di Sciara and Birkun, 2010). Within the Mediterranean, Ligurian-Corso-Provençal basin is identified as an area of greater importance for Risso's dolphins.

Basin wide data on the distribution and abundance is lacking. Abundance estimates exist for few areas like the Spanish central Mediterranean, where aerial surveys from 2001–2003 resulted in an uncorrected estimate of 493 Risso's Dolphins (95% C.I. 162–1,498) in an area of 32,270 km<sup>2</sup> (Gómez de Segura et al., 2006). Other aerial and ship based surveys carried out within the western Mediterranean did not yield sufficient number of observations to obtain abundance estimate (Fortuna et al., 2007; Panigada et al., 2011). In the Ligurian basin densities have been low i.e. 0,035 individuals/km<sup>2</sup> during winter and 0,011 individuals/km<sup>2</sup> during summer (Laran et al., 2010).

### 3.3.1.1. Adriatic Sea

Risso's dolphins have been recorded on numerous occasions in the Adriatic Sea (Figure 13). First records originate from 19<sup>th</sup> century (Giglioli, 1880; Faber, 1883b; Brusina, 1889; Kolombatović, 1894). Most records originate from stranded animals found along Italian (Trois, 1894; Valle, 1900;

Francesca et al., 1999; Storelli et al., 1999; Zucca et al., 2005) and Croatian coasts (Hirtz, 1938; Notarbartolo di Sciara et al., 1994; Holcer et al., 2002; Gomerčić et al., 2006b; Bilandžić et al., 2012), while according to the available information animals were not observed or found on the coasts of Slovenia, Montenegro and Albania. Stranded animals have been found along the entire Adriatic Sea basin and including even the shallow areas of the Northern Adriatic (Figure 13). In a number of occasions animals stranded live and consecutively, some animals died while some have been returned to the sea (Zucca et al., 2005). In most occasions records relate to single animals, while only in two cases more animals were observed; three animals were observed near the Gulf of Trieste (Francesca et al., 1999) and two animals were found stranded together on Island of Molat (Gomerčić et al., 2006b). Regardless of the relatively high numbers of strandings and their presence throughout the Adriatic basin, most authors concluded that Risso's dolphin is only occasionally present in the Adriatic Sea (Bearzi et al., 2004).

Dedicated and opportunistic surveys with relatively high effort carried out in the Northern Adriatic Sea in the period of 1988 to 2013 (Bearzi et al., 1997; Fortuna, 2006; Bearzi et al., 2008a; Bearzi et al., 2009; Fortuna et al., 2010b; Pleslić et al., 2013) did not record any sightings of Risso's dolphin confirming that species is not present in that part of the basin. Localised surveys in the Central Adriatic (Holcer et al., 2008a; Holcer et al., 2008b; Holcer et al., 2008c; Holcer et al., 2010; Holcer and Fortuna, 2011; Holcer, 2012) also did not find any sighting of the Risso's dolphins. It is worth noting that all of this research effort was in the areas which would not present suitable habitat for Risso's dolphin and thus presence of the Risso's dolphins should not be expected.

Results of two aerial surveys of Cetacean abundance carried out on the basin-wide scale confirm such conclusion (Fortuna et al., 2011b; Lauriano et al., 2011) as Risso's dolphins were observed only in the Southern Adriatic along the steep slope areas with depths between 600-900m (Figure 13). Several additional observations in the Southern Adriatic basin were made from the ferries running through Southern Adriatic Sea (Giovagnoli, 2013). Such results are in line with known habitat preferences and feeding specialisation of Risso's dolphins that prefer deep slope habitats between depths 500-1000 (Azzellino et al., 2008) present in the Southern Adriatic. A preliminary abundance estimate was obtained in 2010 (510 individuals; CV=78.1%; 95% Cis=124-2,089), indicating that the southern Adriatic could host few hundreds of Risso's dolphins (Fortuna et al., 2011a).

As deep diving cetaceans may be prone to mortality due to the impact of anthropogenic sound a concern over impact on the species has been expressed by several international panels.

### **3.3.2. Population structure**

The overview of the current details on the status and ecology of Risso's dolphin in the Mediterranean are given by Bearzi et al. (2011b) and Gaspari and Natoli (2012). Generally, little is known of the social structure and behaviour of Risso's dolphins.

Group size in the Ligurian basin ranges from 2 to 70 individual with average size of 14,5 animals

and most frequent groups of four and five animals as found by Gaspari (2004) an average group size of 9,8 during summer and 11,3 during winter as found by Laran et al. (2010). In the area of Alboran Sea average group size was 12,5 (Canadas et al., 2005) and off south-eastern coast of Spain 21,7 (Gómez de Segura et al., 2008). Group sizes observed in the Adriatic Sea during aerial surveys ranged from 1 to 12 animals with most frequent group size of four and six animals (authors data).

Groups of Risso's dolphins in the Ligurian Sea presented mostly weak inter-individual associations but also some consistent longer term relationships between individuals over periods of even years (Gaspari, 2004).

Available data based on the microsatellite and mitochondrial DNA analysis show that Mediterranean Risso's dolphins are genetically differentiated from the nearest eastern Atlantic population and the gene flow is limited (Gaspari et al., 2007). No data on DNA analysis on Adriatic samples exist, although research of Gaspari et al. (2007) indicate potential Mediterranean regional population structuring.

Research in the Ligurian basin based on the photo identification indicate that animals show site fidelity (Airoldi et al., 2005), but seasonal (summer/winter) difference in density (Laran et al., 2010) indicate possible seasonal migration within the Mediterranean.

### **3.3.3. Conservation status**

The Mediterranean subpopulation of the Risso's dolphin is listed as "Data Deficient" (Gaspari and Natoli, 2012)

## **3.4. The fin whale (*Balaenoptera physalus*)**

### **3.4.1. Distribution and abundance**

Fin whales (Figure 14) in the Mediterranean are most common in deep waters (400 to 2,500 m), but they can occur in slope and shelf waters as well, depending on the distribution of their prey (e.g. Canese et al. (2006)). They favour upwelling and frontal zones (Notarbartolo-Di-Sciara et al., 2003) and coastal areas (Canese et al., 2006) with high zooplankton concentrations their main prey in the region.

Within the Adriatic Sea most of the records on this species rely on stranding and sightings of stray individuals scattered all around the northern and central Adriatic (Lipej et al., 2004; BWI unpublished data) and some regular sighting in the central Adriatic likely related to the seasonal presence of prey (Holcer, unpublished data, (Fortuna et al., 2011b)).



*Figure 14 Fin whale, Central Adriatic. Photo: C.M.Fortuna, ISPRA*

Recent research indicates that fin whales regularly enter the southern and central Adriatic Sea and their abundance depends probably on the abundance of krill. Large biomass of krill has been recorded in the Central Adriatic, particularly area of Jabuka pit but the seasonality of presence and abundance is yet unknown. However, observation of fin whales feeding in the vicinity of Vis island and collected faeces indicate that there is a causal connection between fin whales and krill and that the area might have some seasonal importance for fin whales (Holcer, unpublished data).

There are not abundance estimates for the fin whale in the Adriatic Sea nor for the eastern Mediterranean.

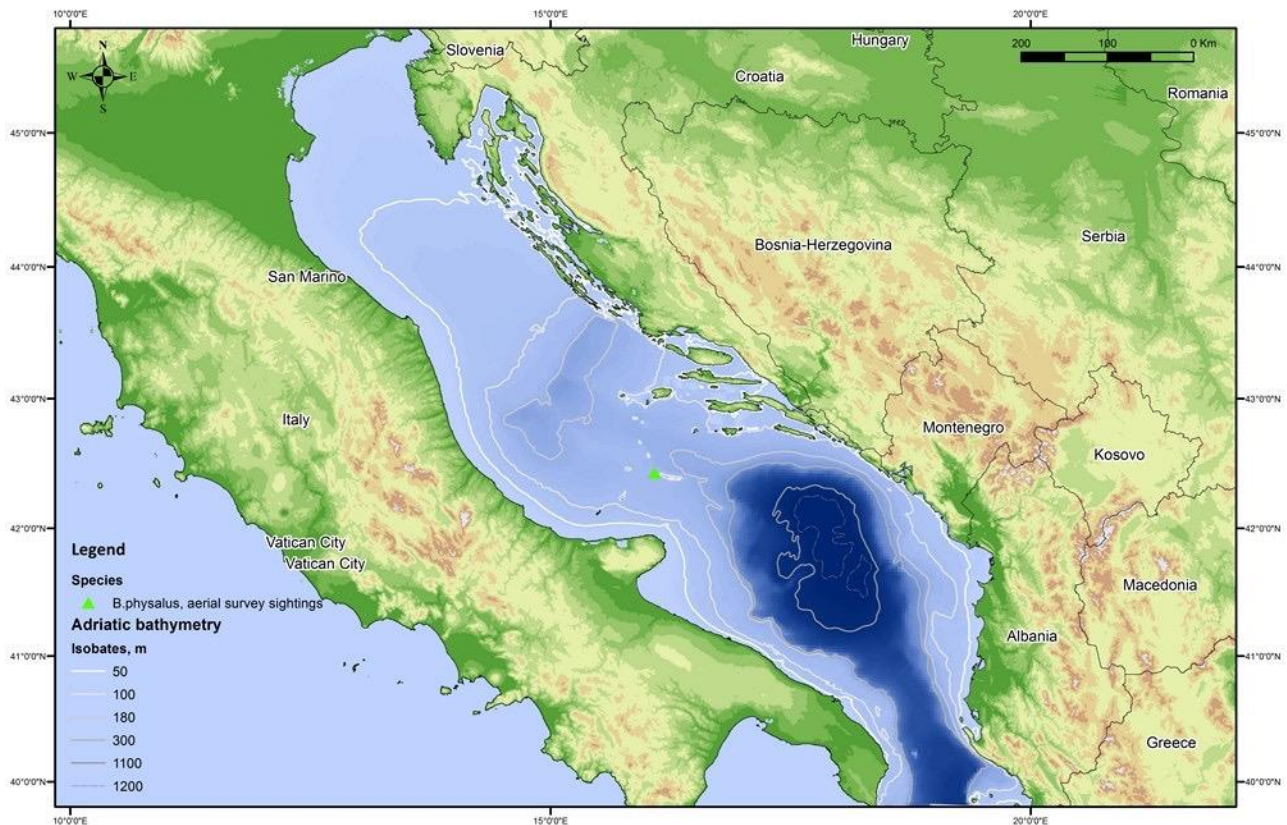
#### **3.4.2. Population structure**

Genetic analyses are indicating that the Mediterranean fin whales is largely resident in the basin, although limited but recurrent gene flow was detected in the samples (Palsboll et al., 2004). According to the IUCN definition for subpopulation (i.e., less than about one migrant/year), the Mediterranean fin whale can certainly be considered as sub-population (Palsboll et al., 2004).

The only information about genetics for fin whales frequenting in the Adriatic Sea comes from the analysis of a single specimen that showed an alotype typical from the Ligurian Sea (Caputo and Giovannotti, 2009).

#### **3.4.3. Conservation status**

The Mediterranean subpopulation of the fin whale is listed as "Vulnerable" under IUCN (World Conservation Union) criterion C2a(ii) (Panigada and Notarbartolo di Sciara, 2012).



Sightings of fin whale in the Adriatic Sea (2010 & 2013)

Figure 15 Map of sighting of fin whales during aerial surveys in 2010 and 2013

### 3.5. Other non regular species

#### 3.5.1. The short-beaked common dolphin (*Delphinus delphis*)

The short-beaked common dolphin is a small cetacean species with a world-wide distribution. It was distributed in the whole Mediterranean and was considered the most abundant Cetacean species. Currently the abundance is in steep decline throughout the central and eastern Mediterranean (Bearzi et al., 2003) with more notable population remaining only in the Alboran Sea (Canadas and Hammond, 2008). Overview of species status and ecology is reviewed in Bearzi et al. (2003).

Mediterranean common dolphins can be found in pelagic and neritic habitat (Notarbartolo di Sciara and Birkun, 2010) where they feed mostly with epipelagic and mesopelagic shoaling fish and cephalopods (Bearzi et al., 2003).

Short-beaked common dolphin has been well present in the Adriatic Sea until mid-19<sup>th</sup> century. Numerous records by respected researchers of the time noted the species as the most common in the Adriatic Sea (Faber, 1883b; Brusina, 1889; Trois, 1894). During the late 1970s a decrease in the numbers and group sizes of common dolphins in the Adriatic was noted (Pilleri and Gahr, 1977). During the following years researchers have been following the disappearance of the species throughout the northern Adriatic (Bearzi, 1989; Notarbartolo di Sciara and Bearzi, 1992; Bearzi and

Notarbartolo di Sciara, 1995b; Bearzi et al., 2000) with documented presence of only solitary individuals or small groups since late 1990s (Bearzi, 2000; Rako et al., 2009; Boisseau et al., 2010; Genov et al., 2012; Lazar et al., 2012). The role of overfishing, organised culling and habitat degradation as main reasons for the decline and disappearance of short-beaked common dolphins from the Adriatic Sea has been reviewed by Bearzi et al. (2004). Due to the lack of information from the Central and Southern Adriatic the species has been listed as data deficient in the Croatian red list, although it was indicated that species could be critically endangered (Holcer, 2006).

Recent aerial surveys of the entire Adriatic Sea in 2001 and 2013 (Fortuna et al., 2011b) and *ISPRA and BWI unpublished data*) did not yield any sightings of the short-beaked common dolphin leading to a conclusion that species is regionally extinct in the Adriatic Sea.

The Mediterranean subpopulation of the short-beaked common dolphin is listed as "Endangered" under IUCN (World Conservation Union) criterion A2abc (Bearzi, 2003).

### **3.5.2. The sperm whale (*Physeter macrocephalus*)**

Sperm whale is the largest Odontocete inhabiting Mediterranean. The population of the Mediterranean is genetically distinct (Drouot et al., 2004). No estimate of population size exists for the region. Preferred habitat in the Mediterranean are areas of deep continental slope waters where mesopelagic cephalopods are abundant (Azzellino et al., 2008; Praca and Gannier, 2008).

Occasional occurrence of sperm whales in the Adriatic Sea including 36 strandings has been documented in a number of occasions from as early as 1555 (Bearzi et al., 2011a). Furthermore, this is the only Cetacean species that had mass strandings on the Adriatic Sea coast with the latest occurring in December 2009 when a pod of seven male sperm whales stranded on northern side of Gargano promontory (Mazzariol et al., 2011). As deep diving Cetaceans, sperm whales do not have suitable habitat in the Central and Northern Adriatic. Southern Adriatic, although deeper, may host vagrant animals coming from the Ionian Sea or animals arriving during seasonal migration but given its physiography and size most probably it is not of greater importance for Mediterranean sperm whales.

Further, such conclusion is confirmed through the results of the aerial surveys of cetacean abundance in the Adriatic sea in 2001 and 2013 that did not produce any sightings of sperm whales (Fortuna et al., 2011b) and *ISPRA and BWI unpublished data*)

### **3.5.3. Visitor species**

#### **3.5.3.1. Long-finned pilot whale (*Globicephala melas*)**

The only occurrence of long-finned pilot whale in the Adriatic Sea was reported in 1922 when two individuals were caught in a tuna trap on the island of Rab (Hirtz, 1922). Larger of the two animals managed to escape, while other was killed by local fishermen. Animal that was caught was a male approximately 5.5 m long that was well described by Hirtz (1922).

### 3.5.3.2. The false killer whale (*Pseudorca crassidens*)

A well described instance of capture of the false killer whale in central Adriatic on the island of Korčula was recorded by Hirtz (1938). Three individuals from a pod of 30-40 false killer whales were reportedly captured in northern Adriatic waters off Ravenna, Italy, in a fishing episode occurred between 1959 and 1961 (Stanzani and Piermarocchi, 1992).

### 3.5.3.3. The humpback whale (*Megaptera novaeangliae*)

Occurrences of humpback whales are rare in the Mediterranean (Notarbartolo di Sciara and Birkun, 2010), and on two occasions they have been reported in the Adriatic Sea. First occurrence was of a 10 m long humpback whale was reported off Senigallia, Italy, in August 2002 (Affronte et al., 2003). Approximately two weeks before one individual was spotted in the Ionian sea so there was a possibility it was the same animal (Frantzis et al., 2003). Second sighting occurred in the Piran bay in 2009 (Genov et al., 2009a) where it stayed for almost three months.

## 4. Sea turtles species in the Adriatic Sea

### 4.1. The loggerhead turtle (*Caretta caretta*)

Loggerhead turtle is the most abundant sea turtle in the Mediterranean (Broderick et al., 2002). Reproductive isolation from the Atlantic populations and reproductive habitat philopatry of the animals lead to genetic divergence of the Mediterranean turtles into several distinct populations (Laurent et al., 1998; Carreras et al., 2007) and forming of reproductive subpopulations (Schroth et al., 1996; Carreras et al., 2007). The main nesting places of the loggerhead turtles are in the eastern Mediterranean in Greece, Turkey, Cyprus and in Libya (Margaritoulis et al., 2003). Smaller reproductive populations exist in Israel, Lebanon and Tunisia while occasional nesting events have been documented in Italy, Spain, France and Albania (Lazar, 2010). Total abundance of the loggerhead turtles in the Mediterranean is yet unknown particularly due to the lack of information on the actual size of the Libyan population that has been estimated based on partial survey of the coastline (Laurent et al., 1999). Without considering Libya, it is estimated that there is around 5000 nests along the Mediterranean coasts and the entire Mediterranean breeding population consist of 2280-2787 nesting females with average re-migration period of two years (Broderick et al., 2002).





*Figure 16 Loggerhead turtle, Central Adriatic. Photo: A.Žuljević, IOR*

Before reaching sexual maturity sea turtles inhabit different habitats in the oceans going through ontogenetic developmental shift between habitats. Pelagic habitats for loggerhead turtles are present in the parts of eastern and western Mediterranean and waters of Ionian and southern Adriatic Sea (Margaritoulis et al., 2003; Casale et al., 2005; Casale et al., 2007a). Neritic habitats are mostly limited to eastern Mediterranean where Gulf of Gabès and Central and Northern Adriatic present two of the largest neritic areas of the Mediterranean (Lazar and Tvrtkovic, 2003; Margaritoulis et al., 2003). The importance is further confirmed through numbers of recoveries of tagged individuals (Margaritoulis, 1988; Margaritoulis et al., 2003; Lazar et al., 2004b) and high numbers of incidental catch in the bottom trawling nets (Lazar and Tvrtković, 1995; Casale et al., 2004; Jribi et al., 2007).

Loggerhead turtles of the Mediterranean express high level of philopatry for nesting places (Carreras et al., 2007) and for marine habitats (Lazar et al., 2004b; Broderick et al., 2007; Casale et al., 2007a; Revelles et al., 2008). Although neritic habitats are shared by animals from several reproductive populations (Lazar et al., 2004b; Maffucci et al., 2006; Casale et al., 2008), after recruitment of particular neritic habitat there is only a small probability that animals will change that habitat during lifetime (Casale et al., 2007a).

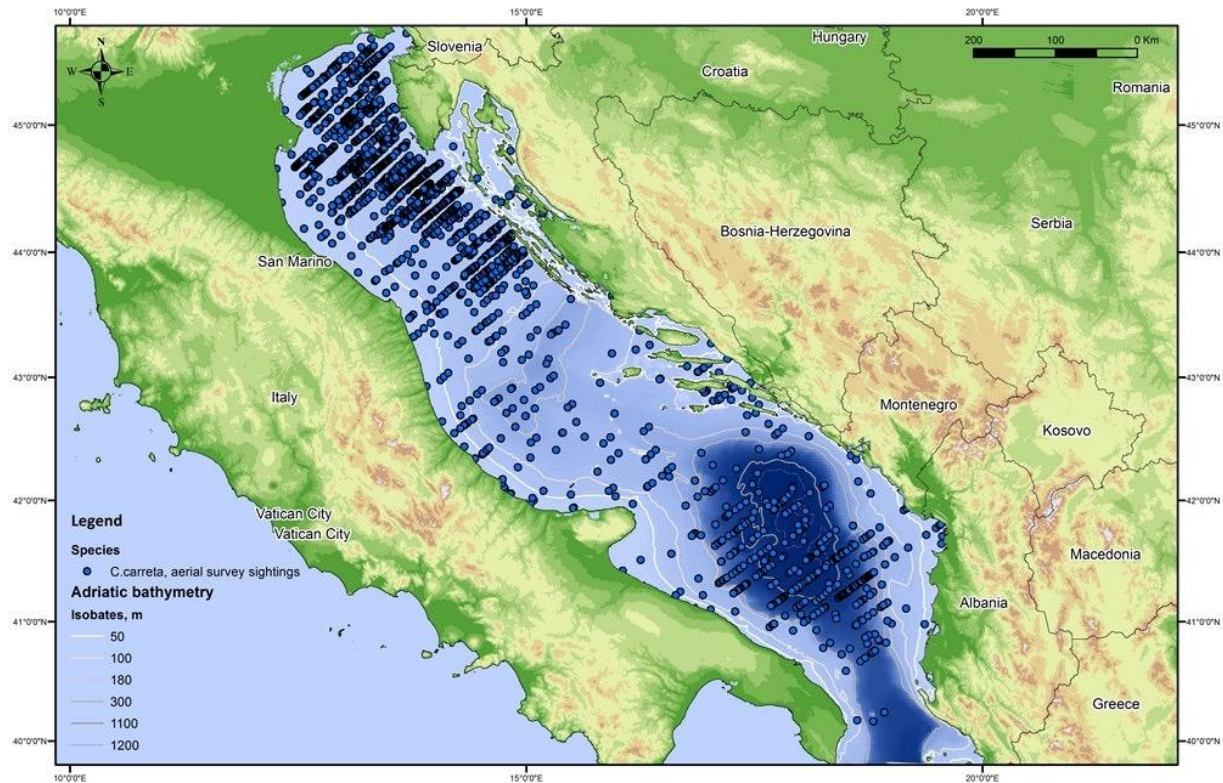
Data on the demography of the loggerhead turtles in the Mediterranean are scarce. Estimated average survival rate of the animals with 22-88 cm CCL is 0,73 (98% CV 0,67 – 0,78, (Casale et al., 2007b)) with age of maturity at 16 to 28 years (Casale et al., 2009). Loggerhead turtles are under heavy pressure of anthropogenic activities (Margaritoulis et al., 2003). Most of the nesting beaches in the Mediterranean are currently under some form of protection (Margaritoulis et al., 2003). Presently, incidental capture estimated between 152723 to 209717 captures per year is the most dangerous human activity for sea turtles (Casale, 2008). Focal areas for by-catch on pelagic longlines are developmental habitats in the pelagic areas of western Mediterranean and Ionian Sea with estimated 60000-80000 by-catch incidents per year (Lewison et al., 2004). Neritic

habitats of the Adriatic Sea (Lazar and Tvrtković, 1995; Lazar and Tvrtković, 2002; Casale et al., 2004; Lazar et al., 2006), Tunisia (Jribi et al., 2007) and Egypt (Nada and Casale, 2008) are focal areas of trawling and trammel net bycatch. Estimated yearly impact of bottom trawlers in the Mediterranean is between 36700 – 90300 captures with direct mortality of 0,6 to 12,5% (Lazar et al., 2003; Casale, 2008) and total mortality up to 34% (Casale et al., 2004).

#### **4.1.1. Adriatic Sea**

A study carried out on 264 loggerhead turtles from northern Adriatic between 1995 – 2007 confirmed northern and central Adriatic as a neritic habitat of loggerhead turtles. The area is shared by juvenile and adult animals originating from Greece (75,3%) and Turkey (19,5%) and to lesser extent Cyprus, Israel and Libya (Lazar, 2010). Recruitment of small juvenile animals (CCL 25-30 cm) into northern Adriatic indicates ontogenetic habitat shift from oceanic to neritic stage and primarily benthic feeding. Of particular importance is gillnet mortality of 74% and bottom trawling by-catch with direct mortality of 7,5% and potential mortality of 26,9% (Lazar, 2010).

Preliminary abundance estimate based on the aerial survey results from 2010 yielded total estimate of 25.692 (CV 21,6%) loggerhead turtles in the entire Adriatic sea and 18.008 (CV 15,1%) loggerhead turtles in the northern Adriatic (Fortuna et al., 2010a). This numbers grow dramatically when corrected for dive time (73.406 and 51.451 loggerhead turtles in whole and northern Adriatic) (Fortuna et al., 2010a). Estimated numbers have some limitations as for example smaller turtles could not be seen from the air. Therefore, estimated numbers are only indication of the scale of loggerhead turtle abundance in the Adriatic Sea.



Sightings of loggerhead turtle in the Adriatic Sea (2010 & 2013)

Figure 17 Map of sighting of (mostly) loggerhead turtles during aerial surves in 2010 and 2013

Due to such large number of loggerhead turtles, interaction with human activities is substantial. Estimated number of only incidental capture by bottom trawlers is over 11.000 (Casale, 2011). Such large impact has overall implications on the entire population.

#### 4.2. Other species of sea turtles in the Adriatic Sea

Two other sea turtle species are present in the Mediterranean Sea, the leatherback turtle (*Dermochelys coriacea*) and the green turtle (*Chelonia mydas*). The leatherback turtle is the only species that is regularly present in the Mediterranean but does not nest in the area. Their immigration from the Atlantic is connected with feeding (Casale et al., 2003). Their presence in the Mediterranean is year round while their appearance in the Adriatic indicates seasonality with higher number of records during the summer (Lazar et al., 2008a).

Mediterranean population of the green turtle is one of the smallest and most endangered populations of this species in the world and is a remnant of once thriving population whose decline was caused by anthropogenic influence (Sella, 1995). Most nesting is concentrated on few beaches in Turkey, Syria and Cyprus while small number of animals nests also in Lebanon, Israel and Egypt (Kasperek et al., 2001; Rees et al., 2008). Estimated number of nesting females is only between 339-360 females with triennial re-migration period (Broderick et al., 2002). Main neritic habitats of the species are along the coasts of northern Africa (Broderick et al., 2007) while developmental habitats of juvenile individuals are present in the Ionian and southern Adriatic Sea (Margaritoulis and Teneketzis, 2001; Lazar et al., 2004a)

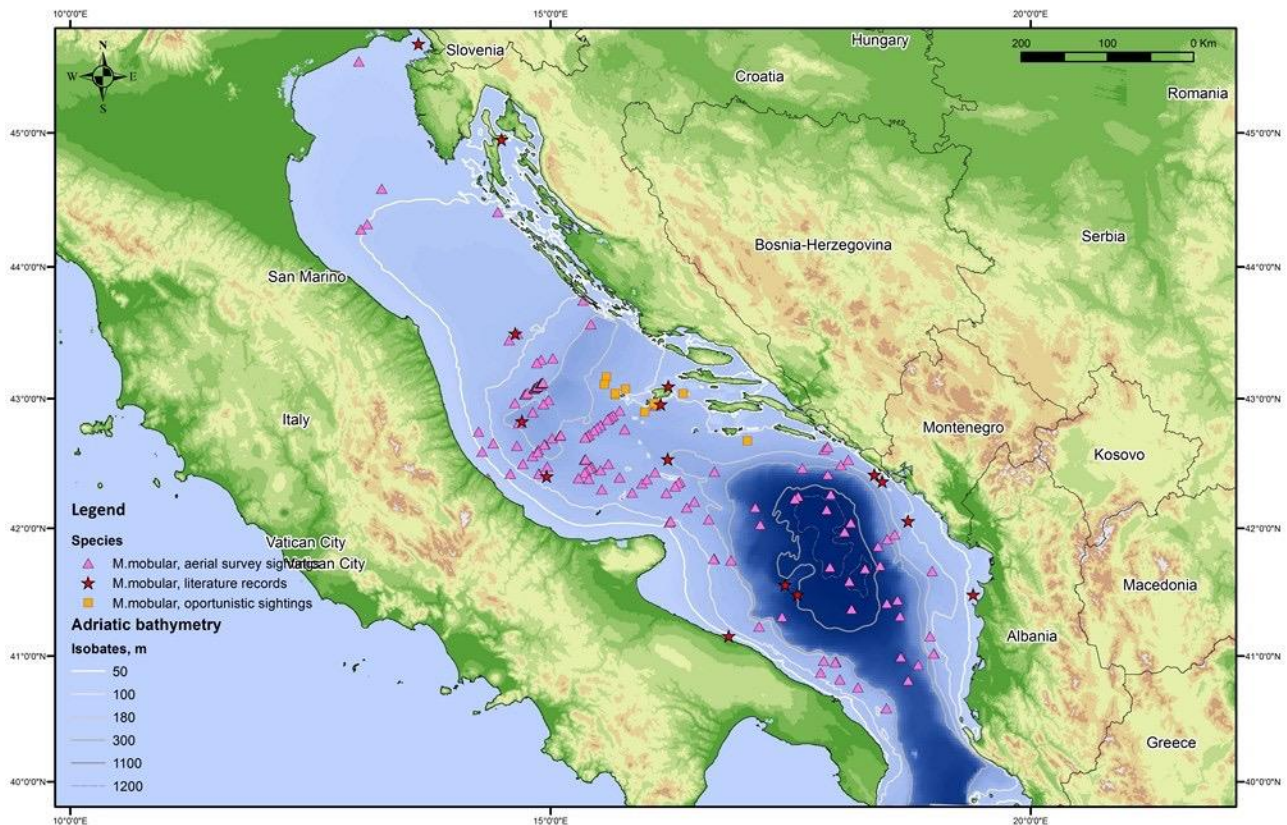
## 5. The giant devil ray (*Mobula mobular*)



Figure 18 Giant devil ray, Central Adriatic. Photo: D.Holcer, BWI

The giant devil ray (Figure 18) is a large marine vertebrate and can reach up to 5.2 m in disc width (DW), although specimens of about 3 m DW are most common (Serena, 2005). This large epipelagic batoid fish inhabits the entire Mediterranean and possibly the adjacent Atlantic waters (Serena, 2005). Due to its geographic distribution and rare records outside the Mediterranean it is considered as an endemic elasmobranch in the region (Notarbartolo di Sciara and Bianchi, 1998). The giant devil ray has been recorded in a number of Mediterranean countries including Albania (Rakaj, 1995), Algeria (Hemida et al., 2002) Croatia (Šoljan, 1948; Jardas, 1996), France (Capapé et al., 1990; Capapé et al., 2006), Greece (Bearzi et al., 2006), Italy (Notarbartolo di Sciara and Bianchi, 1998), Israel (Golani and Levy, 2005), Malta (Schembri et al., 2003; Burgess et al., 2010), Tunisia (Bradai and Capapé, 2001) and Turkey (Akyol et al., 2005), demonstrating its basin-wide distribution. Information on the biology of the giant devil ray is scarce (Couturier et al. 2012). The limited data have largely been obtained from opportunistic measurements of a few specimens caught in various locations in the last century (Couturier et al., 2012). It mostly inhabits deep pelagic waters where it feeds on plankton, predominantly krill and small schooling fish (Notarbartolo di Sciara, 2005) but there are also occasional records from the shallow waters of the northern Adriatic Sea, the Gulf of Gabès and the south-western coastal part of Sardinia (Bradai and Capape, 2001; Storai et al., 2011; Holcer et al., 2013). Throughout its range the giant devil ray is believed to live in low numbers although population estimates are unavailable (Notarbartolo di Sciara et al., 2006).

While the giant devil ray is not considered to have been subjected to a directed fishery, 'incidental' catches in the otherwise highly selective Sicilian swordfish harpoon fishery were reported until the late 1990s (Bauchot, 1987; Celona, 2004); despite the absence of abundance data, the level of exploitation was considered 'low' by Bauchot (1987).



Sightings and records of the giant devil ray in the Adriatic Sea (1883 - 2013)

Figure 19 Map of literature records, opportunistic sightings and sighting of giant devil ray during aerial surveys in 2010 and 2013

With respect to incidental catches, there have been numerous reports for purse-seines, longlines, trammel nets, mid-water/pelagic trawls and traditional tuna traps in addition to IUU (Illegal, Unregulated and Unreported) driftnet fisheries (Marano et al., 1983; Notarbartolo di Sciara and Serena, 1988; Bradai and Capape, 2001; Akyol et al., 2005; Scacco et al., 2009; Storai et al., 2011) and most recently unregulated fishery along the coast of the Gaza Strip (Palestine) taking advantage of winter aggregations (Couturier et al., 2013). Bycatch from the large pelagic driftnet fishery was reported up until two decades ago (Di Natale et al., 1995; Di Natale, 1998a).

Due to its limited range, inferred low densities and presumed unsustainable interactions with fisheries, the giant devil ray is listed as Endangered (EN A4d) on the IUCN Red list (Notarbartolo di Sciara et al., 2006).

## 5.1. Adriatic Sea

The presence of the giant devil ray in the Adriatic was relatively unknown until recently and the species was considered as rare (Jardas, 1985, 1996; Jardas et al., 2008). The literature review from 19<sup>th</sup> century onward on the giant devil ray indicates that it is a species known to occur in the Adriatic (Bello et al., 2012; Holcer et al., 2013) (Figure 19). The first known records originate from the end of 19<sup>th</sup> century when the species was listed as *Dicerobates giornae*, Lac. (Stossich, 1880),

and a specimen was caught in the Gulf of Trieste and noted under same synonym by Faber (1883a) (Figure 19).

The seasonal distribution of records, with a peak in the summer suggests the existence of a temporal pattern of occurrence (Holcer et al., 2013), similar to some other large pelagic vertebrates, such as leatherback sea turtle, *Dermochelys coriacea* (Lazar et al., 2008b). The giant devil ray is generally considered to be a plankton feeder, feeding on pelagic crustaceans and small schooling fish (Celona, 2004; Serena, 2005). The earliest seasonal observations of the giant devil ray in the Adriatic are from the area of open waters in the central Adriatic in April and May while the majority of opportunistic sightings, however, are made in the areas closer to the coast late in the spring and throughout the summer (Holcer et al., 2013). This distribution coincides with appearance of large quantities of sardines and anchovies (Skrivanić and Zavodnik, 1973; Benović et al., 1984; Regner, 1996). The increase in the number of sightings closer to the central Adriatic islands and along the western coast is likely to be connected with the migration of sardines along the eastern coast (Skrivanić and Zavodnik, 1973) and anchovies on the western coast of the Adriatic Sea (Regner, 1996).

If the spatial distribution of records is considered, most findings originate from the southern and the central Adriatic sub-basins (Figure 19). This conforms with the proposed local geographic range of this species (Notarbartolo di Sciara et al., 2006). The giant devil ray is an epipelagic species which spends most of its time (81.5%) in surface waters between 0 and 50 m, although it is capable of deep dives to 700 m (Canese et al., 2011). Spatial distribution of the giant devil ray in the Adriatic coincides with the distribution of other oceanic species, such as the Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*) and the leatherback turtle (Holcer et al., 2007; Lazar et al., 2008b; Bearzi et al., 2011a).

Aerial surveys of megafauna distribution and abundance in the Adriatic sea carried out in 2010 and 2013 provide the first overview of the summer distribution and abundance of the giant devil ray in the Adriatic Sea (Fortuna et al., 2011b; Fortuna et al., in press). The results of the survey between 31 July and 16 August 2010 with applied availability correction factor (0.49; SD=0.25) to the uncorrected estimate (N=1,595; CV=0.23) for confirmed adult giant devil rays, yielded the estimate of abundance to 3,255 individuals (CV=0.56) (Fortuna et al., in press).

Data from the aerial surveys in 2010 and 2013 survey (Figure 19) generally confirm information from earlier opportunistic data and inferred distribution, with more encounters in the central and southern parts of the Adriatic (Notarbartolo di Sciara et al., 2006; Fortuna et al., 2011b; Holcer et al., 2013; Fortuna et al., in press).

## 5.2. Population structure

No information exists on population structure of *Mobula mobular* throughout its range. Most sightings in the Adriatic Sea are of solitary animals. During aerial survey in the Adriatic sea in 2010 the mean group size was 1,2 animals (SD=0.6; range=1-4) (Fortuna et al., in press)

## 6. Threats to species in the Adriatic Sea

Cumulative model of 22 anthropogenic drivers categorised as climate (i.e. the combined cumulative impact of temperature and UV increase, and acidification), fishing, sea-based drivers (commercial shipping, invasive species, oil spills and oil rigs) and land-based drivers (nutrient input, organic pollution, urban runoff, risk of hypoxia and coastal population density) show that Adriatic Sea is one of the areas with highest anthropogenic impacts (Micheli et al., 2013) (Figure 20). When climatic drivers (that cannot be directly controlled or managed) are not included, demersal fishing, hypoxia and pollution from land-based activities are major contributors to high cumulative impacts to the Adriatic (Micheli et al., 2013). At the same time, within the Adriatic Sea it is visible that there is very high difference in the overall impact between eastern and western coast, later being more impacted (Figure 20).

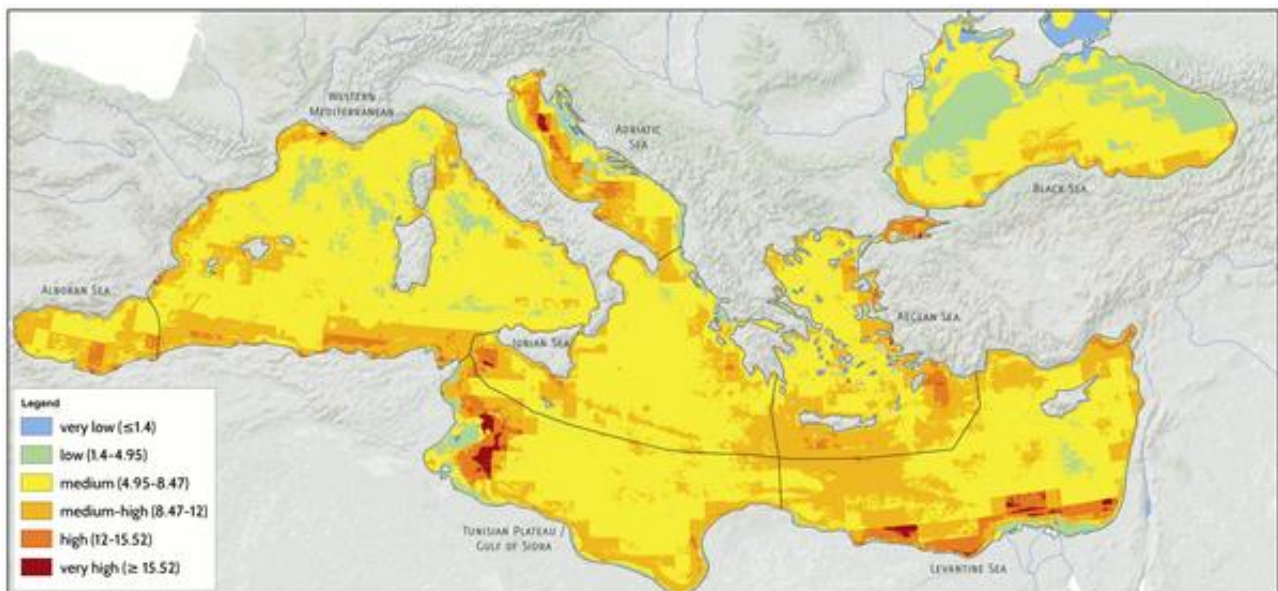


Figure 20 Map of cumulative anthropogenic impact on the Mediterranean and Black Sea (Micheli et al., 2013)

### 6.1. Fishery

As one of two largest areas of continental shelf in the Mediterranean, Adriatic Sea (and Gulf of Gabès) is the most heavily bottom trawled area in the Mediterranean (Figure 21) presenting great value for fishing (Mannini and Massa, 2000). Bottom trawling together with purse-seining and pelagic pair-trawling has the largest impact on the Adriatic ecosystem (Mannini et al., 2005). Additionally, bottom and pelagic long-lines, trammel nets and other forms of artisanal fisheries reduce the overall fish biomass (Matic-Skoko et al., 2011).

Impact of reduced prey availability due to overfishing, habitat degradation and by catch are the main sources of concern for large marine vertebrates including Cetaceans, marine turtles and cartilaginous fish.

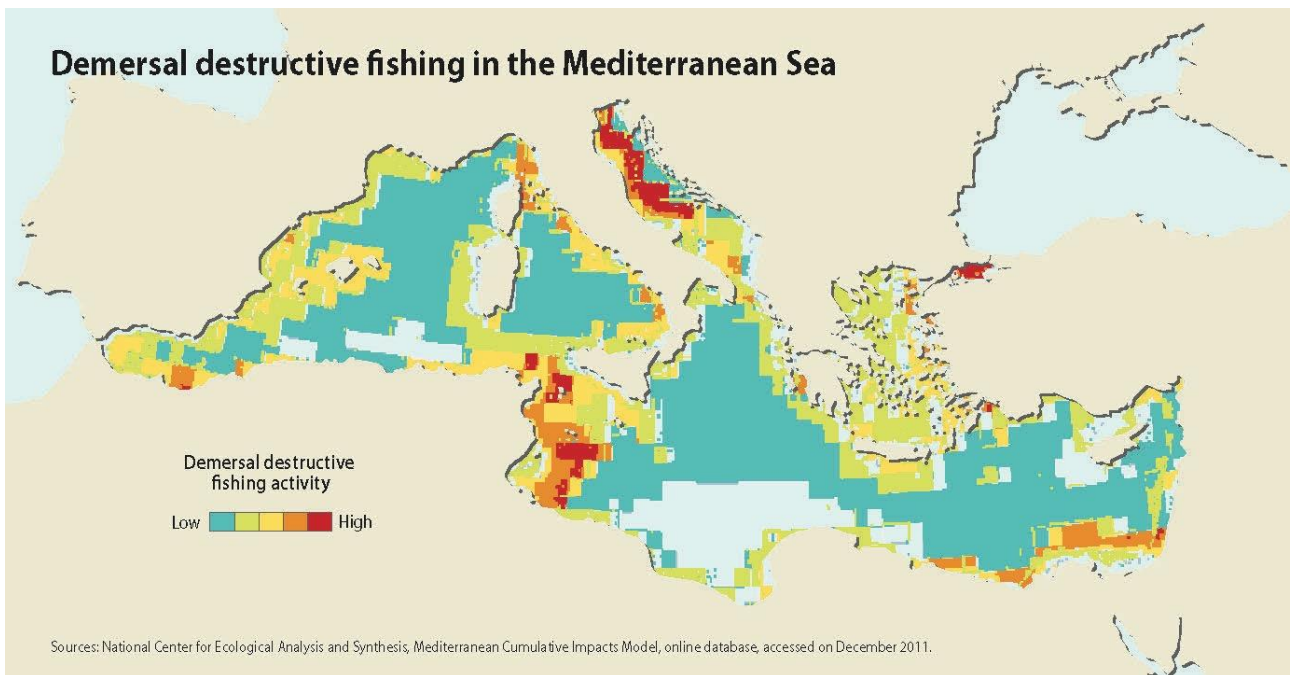


Figure 21 Map of cumulative demersal fishing impact on the Mediterranean (Author: GRID-Arendal, <http://www.grida.no/>)

### 6.1.1. Cetacean-fishery interactions

Historically, interaction between dolphins and fishery in the Adriatic was acute as fisheries report great loss in catch due to depredation by dolphins. That led to a number of culling campaigns organised in the 19<sup>th</sup> and 20<sup>th</sup> centuries by Adriatic states (Italy, Austria, Yugoslavia) where bounties were paid for each animal landed.

Further, net depredation has been reported as serious issue along the west coast of Istrian peninsula and in the northern Dalmatian archipelagos (Holcer, unpublished data). Such interactions lead to cases of net entanglement and intentional killing (BWI, unpublished data) and mortality caused by strangulation (Gomercic et al., 2009).

In some shelf areas following of the trawler boats is relatively regular activity (Fortuna et al., 1996; Bearzi and Notarbartolo di Sciarra, 1997; Casale and Giovanardi, 2001; Holcer, 2012) causing potentially drowning in the net for dolphins and loss of catch. Pelagic pair trawlers have also been documented to cause dolphin bycatch (Fortuna et al., 2010c).

#### 6.1.1.1. Past culling campaigns

Historically, direct killing of *Tursiops truncatus* has been a significant threat to the Adriatic populations. From early 30s till late 60s the Italian and Yugoslavian governments campaigned for the elimination of Adriatic dolphins, offering fishers rewards per dolphin killed (Table 6). The exact numbers of dolphins killed during and after this campaign were largely undocumented, but experts considered these numbers substantial (Bearzi et al., 2004). Despite the existing data failing to specify the dolphin species killed, past literature implies that the two main species were the common dolphin (*Delphinus delphis*) and *Tursiops truncatus* (Bearzi et al., 2004).



Table 6 Existing numbers on historical killings of dolphins in the Adriatic Sea

Period	Number of killed dolphins	Area	Source
1929	Unknown (funding sufficient for 250-500 specimens)	Italian coasts (not only Adriatic Sea)	Italian Ministerial Decree (28 december 1928)
1933-35	at least 335 dolphins	Croatian coast	Crnkovic 1958
1955-60	788 dolphins	Croatian coast	Crnkovic 1958; Marelic 1961
1956-57	239 dolphins	Croatian coast	Crnkovic 1958

An unknown number of dolphins were also caught in the northern Adriatic between 1964-78 for live display in captive facilities (Duguay et al., 1983; Greenwood and Taylor, 1987).

#### 6.1.1.2. Accidental fishery-related mortality (cetacean bycatch)

Little quantitative data exist on past or current cetacean bycatch totals or rates for the Adriatic Sea (see Table 7). Additional descriptive and quantitative data can be found in (Fortuna, 2009; Fortuna and Filidei Jr, 2010; Fortuna et al., 2010c; Fortuna and Filidei Jr, 2011, 2012, 2013).

Table 7 Annual estimates of bycatch of cetaceans in the Adriatic Sea

Fishing gear	GFCM Fishing area	Species	Period	Total number (N, CV)	Source
Mid-water pair trawlers	GSA 17	<i>Tursiops truncatus</i> ( <i>Tursiops</i> )	2006-2012	31 (0.41) average on a 7-years period	Fortuna & Filidei (2013)
	Northern Adriatic (only fishing boats registered in Veneto & Emilia-Romagna)			30 (0.35) average on a 7-years period	

Additional information on likely interactions with fisheries can be found in data collected in Italy (1986-2013) by the national stranding network ([http://mammiferimarini.unipv.it/advsearch\\_db.php](http://mammiferimarini.unipv.it/advsearch_db.php)). All details on these accounts for the Adriatic Sea only are presented in Table 8.

Table 8 Report from Italian national stranding network (<http://mammiferimarini.unipv.it>)

1986-2013	North					Central				South				Total
	Firearm	By catch	Presence of hooks	Presence of nets	Fishing gear marks	Firearm	By catch	Presence of nets	Fishing gear marks	By catch	Presence of hooks	Presence of nets	Fishing gear marks	
<i>Tursiops truncatus</i>	3	13		7	1		12	10	2	11	2	4		65
<i>Stenella coeruleoalba</i>						3	3			21	1	6	3	37
<i>Grampus griseus</i>		1	1							2	1	1		6
Undetermined							2	1	1	6		1		11
TOTAL	3	14	1	7	1	3	17	11	3	40	4	12	3	119

#### 6.1.1.3. Competition for resources

One recent analysis of ecosystem structure and fishing impacts in the Adriatic Sea suggested that the role of dolphins is minor in terms of competition for resources and that the greatest pressure comes from fisheries (Coll et al., 2007).

#### 6.1.2. Sea turtle-fishery interactions

Interaction with fisheries is one of the main threats for sea turtles world-wide (Casale, 2010, 2011) and the Adriatic is not an exception (Lazar and Tvrković, 1995; Casale et al., 2004; Lazar, 2010; Casale, 2011).

The higher number of bycatch events was recorded in bottom trawlers (Lazar and Tvrković, 1995; Casale et al., 2004; Lazar, 2010; Casale, 2011), followed by mid-water/pelagic trawlers (Casale et al., 2004; Fortuna et al., 2010c). There are not reliable data for gill-net or longlines, however experts believe that mortality in these fishing gear is also high (Casale et al., 2004; Lazar, 2010; Casale, 2011).

Existing estimates of loggerhead turtles total bycatch in the Adriatic Sea are provided in Table 9.

Table 9 Annual estimates of bycatch of loggerhead turtles in the Adriatic Sea

Fishing gear	GFCM Fishing area	Species	Period	Total number (N, CV)	Source
Mid-water pair trawlers	GSA 17	Tartaruga comune ( <i>Caretta caretta</i> )	2009	994 (0.02)	Fortuna & Filidei (2010)
			2010	714 (0.05)	Fortuna & Filidei (2011)
			2011	358 (0.29)	Fortuna & Filidei (2012)
			2012	747 (0.14)	Fortuna & Filidei (2013)
	1999-2000		161 (-)	Casale <i>et al.</i> (2004)	
	2009		561 (0.02)	Fortuna & Filidei (2010)	
	2010		421 (0.21)	Fortuna & Filidei (2011)	
	2011		268 (0.30)	Fortuna & Filidei (2012)	
	2012		481 (0.17)	Fortuna & Filidei (2013)	
	Bottom trawlers		Northern Adriatic (only fishing boats registered in Veneto & Emilia-Romagna)	1995	2,500 (ND)
1999-2000		4,273 (ND)		Casale <i>et al.</i> (2004)	

### 6.1.3. The giant devil ray-fishery interactions

Although interactions of *M. mobular* with fisheries in the Adriatic have been documented for swordfish drifting longlines (Marano et al., 1983; Bello, 1999), pelagic pair trawlers (Scacco et al., 2009), bottom longlines and trammel nets (Table 1 and references therein), no precautionary measures are in place to mitigate human-induced mortality. Moreover, in the Mediterranean the giant devil ray has also been by-caught in purse seiners (di Natale, 1998b; Notarbartolo di Sciarra et al., 2006), a fishery responsible for the majority of fish caught in the Adriatic Sea. The importance of purse-seiners, in terms of their possible impact on the giant devil ray in the Adriatic, is further stressed when considering that 89% of the total Croatian pelagic fish catch for 2009 was using this gear (IOR, 2011). In addition purse seiners constitute about 30% of the total Italian pelagic catch, operating off Abruzzo and Apulia regions (IREPA, 2009). This fishery in the southern and the central sub-basins is potentially the most detrimental for giant devil rays in the Adriatic Sea due to their feeding habits and epipelagic behaviour (Canese et al., 2011).

However, with the exception of the Italian pelagic/mid-water trawlers operating in the northern and central sub-basins, (Fortuna et al., 2010c), to our knowledge no other fishery by-catch monitoring scheme exists in the Adriatic Sea. Hence the extent of fishery – giant devil ray interaction is beyond our knowledge for this region. Furthermore, the Adriatic Sea is primarily frequented by large individuals with DW ranging between 2 and 3 m (Table 1). In a K-selected species with life

history similar to giant devil rays these size classes are the most sensitive to anthropogenic perturbations (Heppell et al., 2000; Heppell et al., 2005). Given the protected status and the estimated population decline (Notarbartolo di Sciara et al., 2007) an assessment of the impact of fisheries at Adriatic level, coupled with further research on the distribution and abundance, should be underlined as a priority for the elaboration of an effective conservation and management strategy for giant devil rays in the region.

## 6.2. Gas and Oil exploitation

The exploitation of offshore fields in the Adriatic Sea started in the 1960's with the Ravenna Mare and Porto Corsini fields. Currently, there are more than 130 different gas and oil extraction installations in the Adriatic (Figure 22), some of which have been abandoned as hydrocarbon reserves were exhausted. Still, the Adriatic Sea, continues to be in the focus of interest of oil and gas industry that continue search for gas and oil and building of new off-shore rigs.

The largest numbers of platforms are positioned along the western coast of the Adriatic Sea, along the Italian coast. In Croatia, small numbers of platforms are positioned in the northern Adriatic where commercial production of gas started in 1999. Additional seven platforms were added to the operations until 2006. Along with gas production, there are several known oil-fields (along western coast) where oil production is under way or planned<sup>1</sup>.

The economic crisis and high prices of oil products further stimulated additional research in hydrocarbon deposits in the Adriatic Sea. In Croatia, the entire national waters and economic zone has been recently (7<sup>th</sup> Sep 2013 - 21<sup>st</sup> Jan 2014) surveyed with 2D seismic technique<sup>2</sup> (Figure 23) and Government of Croatia plans to hold extraction licensing round in for potential investors during 2014<sup>3</sup>. The survey was carried out without any environmental impact study. Further, no monitoring scheme apart from survey operator marine mammal observation was in place. The survey was carried out within the known areas of importance for Cetaceans and sea turtles. Further, until the end of February 2014 the first bid for awarding concessions for oil and gas exploitation and production activities in the offshore of Montenegro is underway.

Such intensive extraction pressure to already heavily impacted and semi-closed basin like Adriatic Sea present a serious threat to large marine vertebrates, particularly Cetaceans.

The most notable direct impact comes from seismic activities aimed at understanding the geology and hydrocarbon beds on the sea bottom. Further, testing and wells drilling, rigs construction and their operation, additional drilling during operational lifetime in order to stop decline in the oil production are additional sources of significant noise pollution. Depending on the extracting methodology, particularly during secondary and tertiary recovery, a number of different chemical

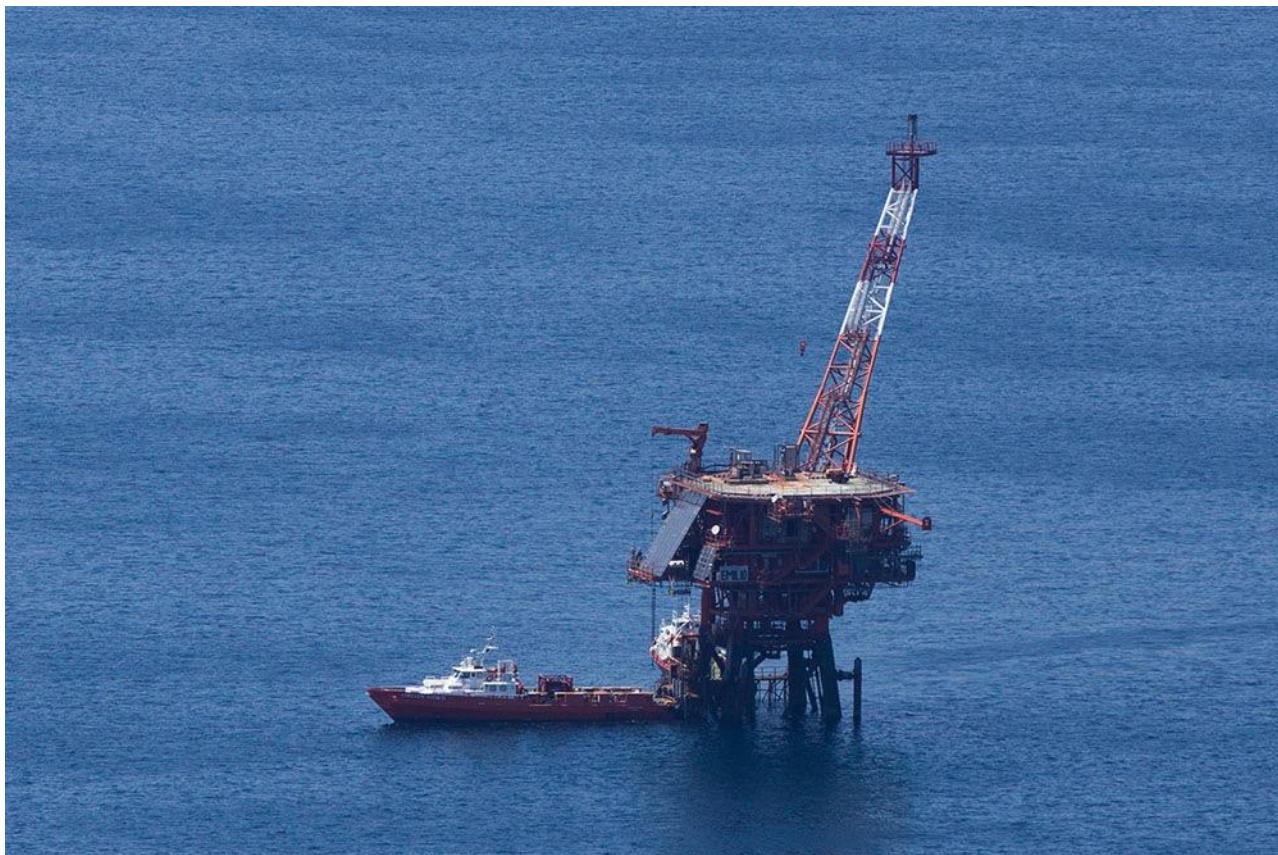
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<sup>1</sup> [http://unmig.sviluppoeconomico.gov.it/unmig/monitoraggio/mare/webgis/ge\\_mare.asp](http://unmig.sviluppoeconomico.gov.it/unmig/monitoraggio/mare/webgis/ge_mare.asp)

<sup>2</sup> <http://www.spectrumasa.com/technical-paper/croatia-a-new-oil-province-at-the-heart-of-europe>

<sup>3</sup> <http://www.mingo.hr/default.aspx?id=4996>

compounds used for extraction together with hydrocarbons could end up in the environment. Finally, recent catastrophe in the Gulf of Mexico with Deep Water Horizon platform oil spill further stress the potential negative impact of oil and gas extraction from the sea bed.

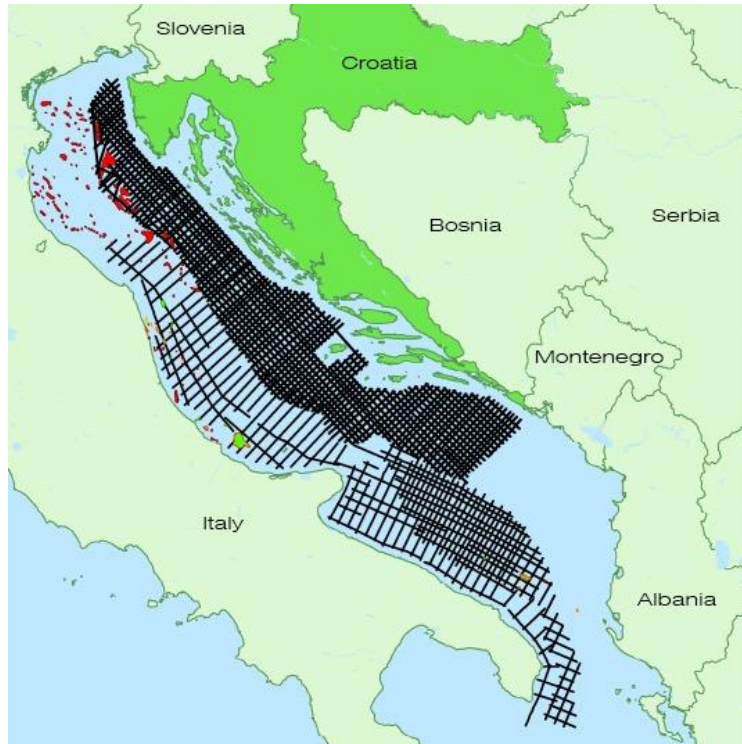


*Figure 22 Gas extraction platform in the Northern Adriatic Sea. Photo: D.Holcer, BWI*

Seismic surveying with airguns and additional high-intensity noise during drilling, additional surveying during exploitation of the gas/oil fields and similar present serious threat to Cetaceans. The range of impact is from direct mortality to short and long term injuries (most notably to auditory system), displacement and disturbance (Gordon et al., 2003). Furthermore, cumulative impact of different types of activities on Cetaceans could be detrimental and therefore precautionary principle and applying of the activities aiming at minimising the uncertainty of the impact should be used. Such activities include environmental impact assessment, mitigation measures, monitoring (pre-, during and post-exposure) and where needed additional research.

Additionally, a liquid natural gas (LNG) offshore terminal located in the northern Adriatic 9 miles (14 km) offshore of Porto Viro, in Porto Levante, near Rovigo, Italy has been in operation since 2009. Additionally an offshore terminal is proposed in the Gulf of Trieste in Italy and in Croatia there are plans to build LNG terminal on Krk Island in Kvarner region.

The impact of these terminals on the environment (except those connected with shipping and possible accidents) are not well known but again, a number of potentially toxic chemical compounds could end up in the environment. Currently there are some questions about Rovigo LNG terminal as there is constant foam of unknown origin present on the sea surface around it.



*Figure 23 Map of recent seismic survey in the Adriatic Sea (Map: <http://www.spectrumasa.com>)*

Long term impact of operating gas and oil rigs on marine communities are relatively unknown. Studies show that after initial damage to benthic communities during construction and drilling they recover with impact visible in a limited zone (Daan and Mulder, 1996; Gates and Jones, 2012). Further, levels of hydrocarbons in the area where oil-based drilling muds were disposed were higher than elsewhere even eight years after drilling while species diversity was lowered (Daan and Mulder, 1996). Waste produced during drilling with high levels of hydrocarbons also have largely negative impact on the environment including acute and chronic toxicity (Holdway, 2002). Research carried out in the offshore gas field off Ravenna between 2001 – 2005 provided the first information on the bottlenose dolphin behaviour near gas platforms in the Adriatic Sea. The results showed that dolphin density was higher within 750 m of gas platforms than further and that dolphins were spending more time feeding and milling closer to the gas platforms (Triossi et al., 2013). As one of the reason for such behaviour authors indicated possibility that gas platforms aggregate larger number of prey. Nevertheless, if we consider possibility of negative effects of chronic exposure to toxicants in different concentrations, such behaviour of bottlenose dolphins might have a long-term negative impact on the population.

### **6.3. Maritime traffic**

The Mediterranean is among the busiest shipping area accounting for 15% of global shipping. The major shipping route that accounts for about 90% of traffic connects Gibraltar (Atlantic) with Sues (Red sea) and Bosphorus (Black sea) (Figure 24). Passenger ships and dry cargo ships makes most of the traffic between Mediterranean ports.

Compared to the Mediterranean, relatively moderate traffic branch goes towards the northern Adriatic ports of Venice, Trieste, Koper and Rijeka. Lesser traffic goes to other Adriatic ports of Zadar, Split, Ploče, Dubrovnik (Hr), Bar (Mn), Bari, Ancona, Brindisi (It) and Durres and Vlorë (Al).



Figure 24 Map of maritime transportation routes in the Mediterranean (Author: GRID-Arendal, <http://www.grida.no/>)

Adriatic countries plan to increase traffic through their ports in the future. Due to the sensitivity of the area it has been proposed as Particularly Sensitive Sea Area (Vidas, 2005). If designated it would require special protection through action by the International Maritime Organisation (IMO) to reduce the risk associated with shipping<sup>4</sup>.

Maritime traffic in the Adriatic (Figure 25) includes transport routes for tankers with crude oil to northern Adriatic ports, liquefied gas transport to Rovigo LNG terminal, dry cargo and container ships, chemical tankers and passenger ships. Maritime traffic further constitutes of fishing vessels, yachts, recreational boats, military and other official boats and research vessels.

Such large shipping produces a number of negative effects on the marine environment. Of particular environmental concern are ballast waters, pollution and oil spill, collision, noise and habitat degradation.

One of the main anthropogenic causes of death for large cetaceans like fin whale and sperm whale in the Mediterranean is boat collision (Weinrich et al., 2005). A report by Panigada et al. (2006) reports that 16% of stranded fin whales in the Mediterranean have died because of collision with ships. Further, boats involved in a collision are ferries, cargo and fast ferries (catamarans). Boat collision with Cetaceans in the Adriatic is seldom.

<sup>4</sup> <http://www.imo.org/OurWork/Environment/PollutionPrevention/PSSAs/Pages/Default.aspx>

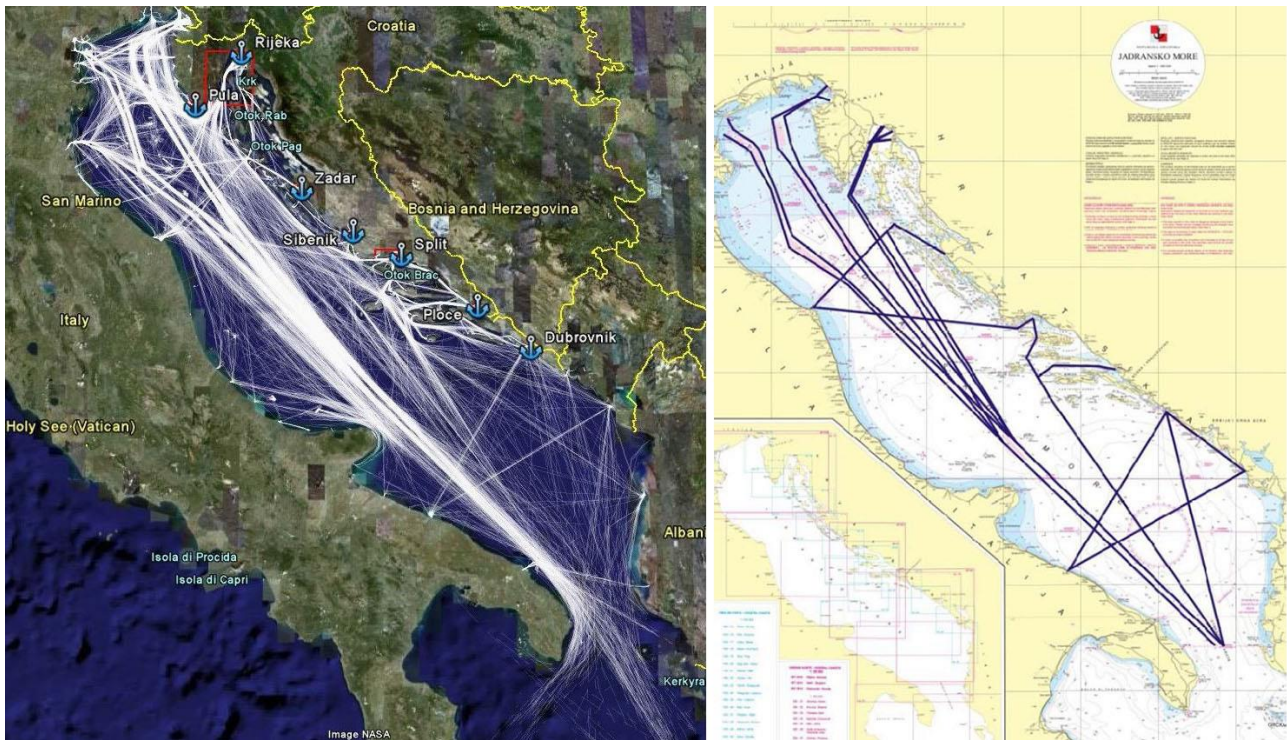
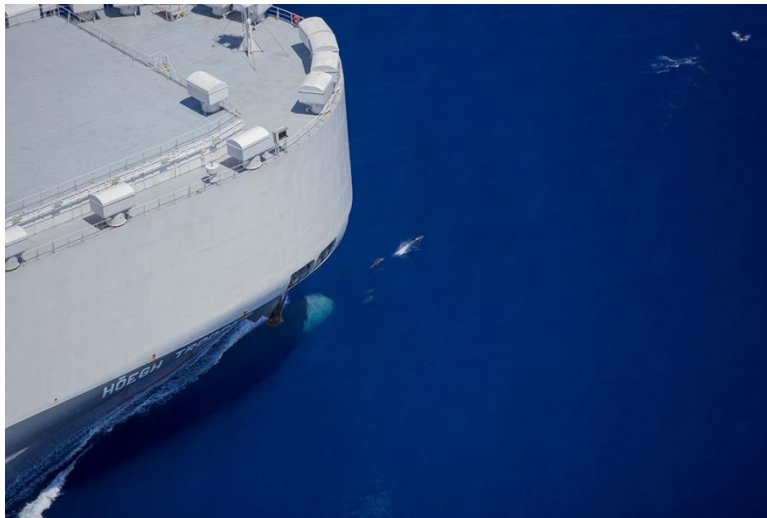


Figure 25 Maritime traffic and traffic separation scheme in the Adriatic sea (Policy Research Corporation, 2011)

As species appearing in the Adriatic are smaller and more agile, collision with larger vessels is highly unlikely (Figure 26). The source of potential concern could be dramatic increase of leisure boat traffic during summer months particularly in the coastal areas (Figure 27). Nevertheless, in over 20 years of regular surveys of coastal communities of bottlenose dolphins on a single occasion an animal with healed wounds potentially inflicted by propeller has been encountered (*authors' data*). Further, on one occasion a body of Cuvier's beaked whale with cut-off caudal part of the body was washed on the beach in near Giancole in 2003 indicating potential collision with larger vessel (Pino d'Astore et al., 2008). Still, it was not possible to conclude whether animal was alive or dead at the time of collision.

Similarly, collision with vessels, particularly fast going, is of concern for sea turtles (Demetropoulos, 2000). In a number of areas with high intensity of fast traffic number of turtles injured through collision is increasing (Camiñas and de Málaga, 2004). That is of particular importance in areas with higher abundance of sea turtles like in the areas of nesting beaches in the period of mating and nesting (Demetropoulos, 2000). Boat collision in the Adriatic Sea is most notable along north and western part (Casale et al., 2010).





*Figure 26 Striped dolphins bowriding in front of the cargo ship, Southern Adriatic. Photo: D.Holcer, BWI*

On the contrary, turtle stranding network along eastern coast rarely report turtles injured with boat collision (authors data). The reason for such result probably is a fact that sea turtles do not enter channels along the Croatian coast in larger numbers where most of the recreational traffic occurs. At the same time, they are present in high densities in the open waters of the northern Adriatic so they get injured by speedboats exiting Italian harbours.

#### **6.4. Tourism related issues**

Tourism is a major economic activity in the region. The seasonal nature of tourism makes its impact even more obvious (Figure 27). While collisions between boats and cetaceans are believed to be rare in this region, both physical and acoustic disturbance is believed to play a significant role in displacing populations in the summer season (Rako, et al., 2012). Work undertaken in the eastern archipelago of Cres-Lošinj suggests that the increasing in sea ambient noise, related to the exponential increasing in leisure boating in the summer months, acts as a trigger to displace the local population of bottlenose dolphins in the region (Rako, et al., 2013).



*Figure 27 Yacht approaching group of common bottlenose dolphins, Central Adriatic. Photo: D.Holcer, BWI*

There have been reports of collisions between sea turtles resting on the surface, or just below, and leisure boats in the region. While numbers are not considered to be high, compared to the bycatch of trawlers and other fishing vessels in the region, it is an aspect that should be considered in the future with increasing numbers of fast moving leisure boats in the region. Of particular concern is impact of tourism on sea turtles causing habitat degradation on turtles nesting sites. Activities related to tourism causing negative impact are recreational activities, beach traffic, lights, noise, development, beach pollution, vegetation planting, boat strikes, fishing and coastal erosion (Demetropoulos, 2000)

## **6.5. Pollution (including marine debris)**

Polychlorobiphenyls (PCBs) are among the most common and the most toxic chlorinated hydrocarbons; their presence in marine environments, including in sea turtles and cetacean tissues of the Adriatic Sea, is well documented (Corsolini et al., 1995; Marsili and Focardi, 1997; Corsolini et al., 2000; Lazar et al., 2011b; Lazar et al., 2012) Herceg Romanic et al., unpublished). Marine debris are proven to have a widespread negative impact on marine wildlife (Derraik, 2002), including sea turtles and cetaceans inhabiting the Adriatic Sea. Pribanić et al. (1999) found in a stomach of a striped dolphin stranded in the northern Adriatic that the entire stomach volume was occluded by different kinds of plastic material (approximately 1.5 litre), including plastic and garbage bags, a rubber glove and cellophane wrapping. Lazar et al. (2011a) examined the occurrence of marine debris in the gastrointestinal tract of 54 loggerhead sea turtles (*Caretta caretta*) found stranded or incidentally captured by fisheries in the Adriatic Sea. Marine debris was present in 35.2% of turtles and included soft plastic (68.4% of cases), ropes (42.1%), Styrofoam (15.8%) and monofilament lines (5.3%). Considering the relatively high occurrence of debris intake and possible sub-lethal effects of even small quantities of marine debris, Lazar et al. (2011a) concluded that this can be an additional factor of concern for loggerheads in the Adriatic Sea.

## **7. Conservation status of considered species**

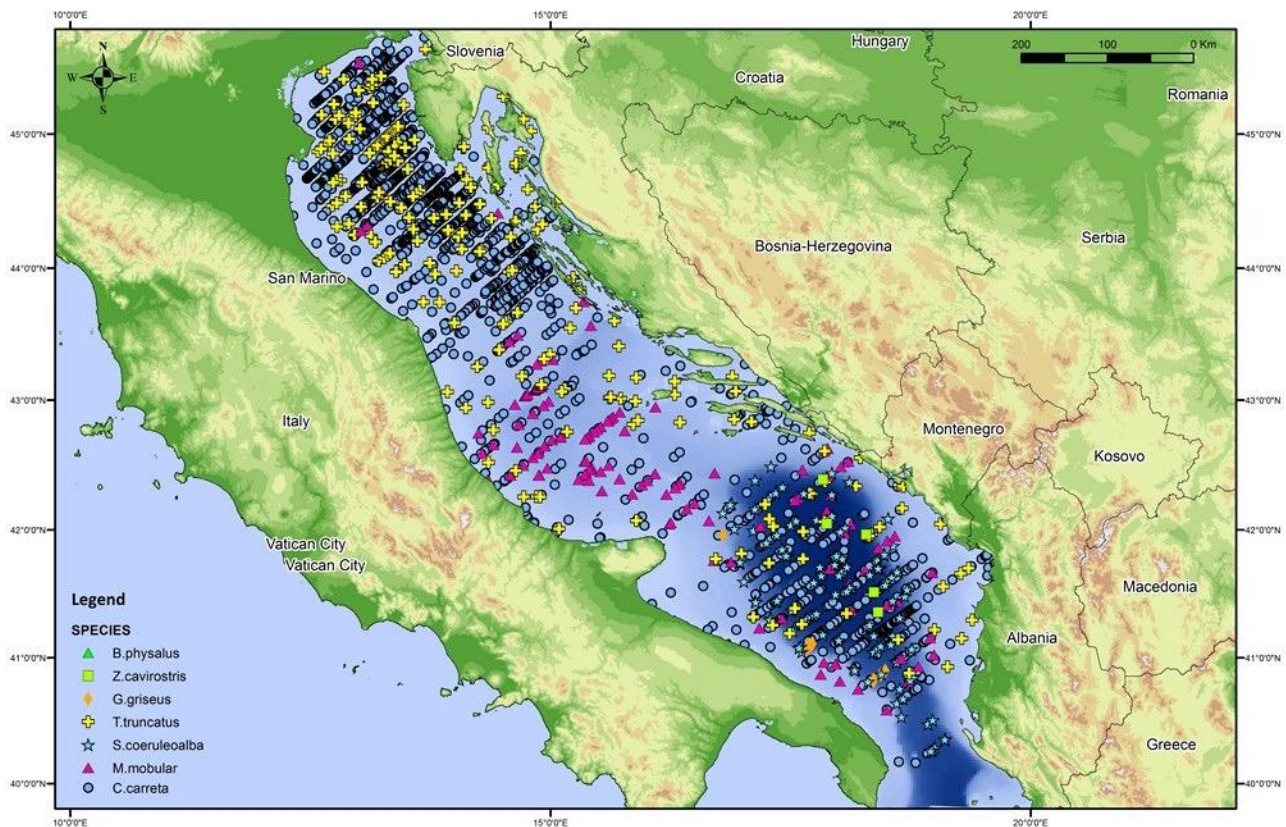
While cetaceans, sea turtles and elasmobranchs are all listed under the IUCN Red books for the countries in the region, the absence of basin wide data, prior to this survey has meant that all of the species listed here were listed as data-deficient. In order to build upon the preliminary data presented here there is a need to continue basin-wide monitoring of these species. Due to the clearly defined geographical nature of the region a series of aerial surveys, with coordinated boat based surveys, in different seasons could provide vital data to define the conservation status of these species.

## **8. Hotspots of megafauna vs hotspots of anthropogenic activities**

Given the nature of the Adriatic Sea - a very complex area in terms of oceanography, presence of biodiversity and economic use - when identifying hotspots for biodiversity we should probably apply the approach of defining vulnerable marine areas (VMAs; as defined by Zacharias & Gregr

2005). Such approach requires that after the identification of valued ecological features (VEFs) - i.e. biological or physical features and processes deemed by humans to have environmental, social, cultural or economic significance (Zacharias & Gregr 2005) - VMAs can be defined and prioritised through the use of predictive models.

In Figure 28 all sightings of large marine vertebrates in the Adriatic Sea recorded during the aerial surveys in 2010 and 2013 (cetacean species, sea turtles and giant devil rays) are shown. These would be our priority biological features on which to base the identification of vulnerable marine areas.



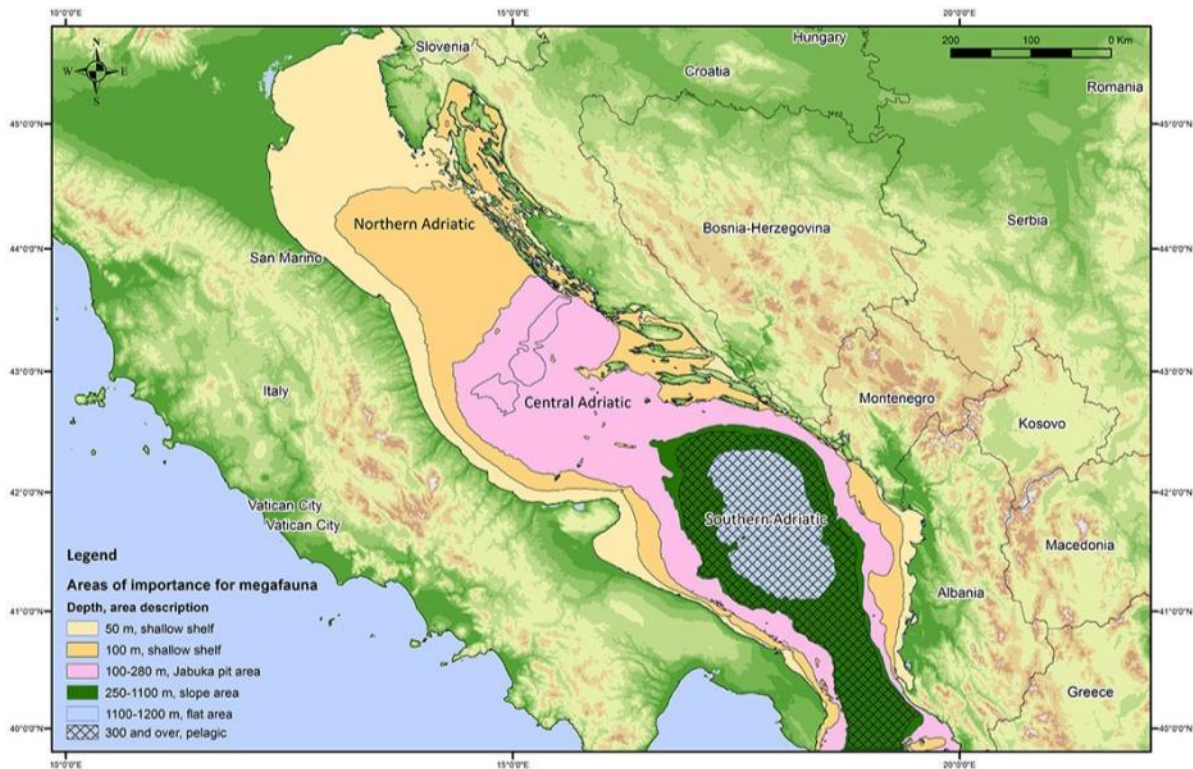
Sightings of large marine vertebrates in the Adriatic Sea during aerial surveys 2010 & 2013

*Figure 28 Sightings of large marine vertebrates in the Adriatic Sea recorded during the aerial surveys in 2010 and 2013*

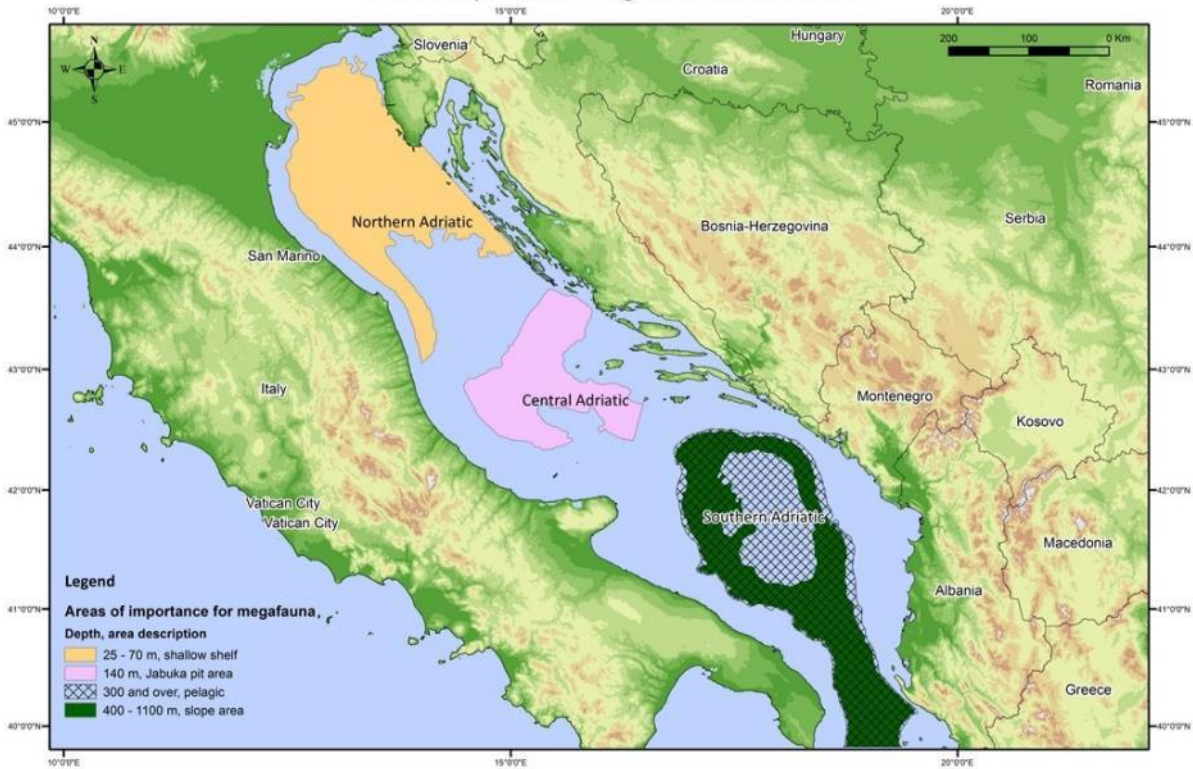
Figure 29 shows two descriptive options of areas of importance for megafauna in the Adriatic Sea, based on ecological aspects of the selected species (biological features). Based on the knowledge of the region, including aspects related to anthropogenic pressures (e.g. bycatch, human disturbance, habitat loss/degradation, alien invasive species, overexploitation, pollution), we believe that in order to identify vulnerable marine areas that need stricter protection and/or management, the following features should be considered in a predictive model:

- areas with encounter densities higher than a given % of the total for “species X”
- areas with encounter densities higher than a given % of the total for “species Y”
- areas with encounter densities higher than a given % of the total for “species Z”
- areas with monthly or annual traffic intensity higher than a given % of the total
- areas with monthly or annual effort of bottom fishing activities higher than of the a given % of the total

Reference points for species density and activities intensity and the right combination of species to be considered, should be object of a thorough scientific and technical discussion. Identifying vulnerable marine areas will ultimately help defining areas that need specific protection and/or management of human uses.



Areas of importance for megafauna in the Adriatic Sea

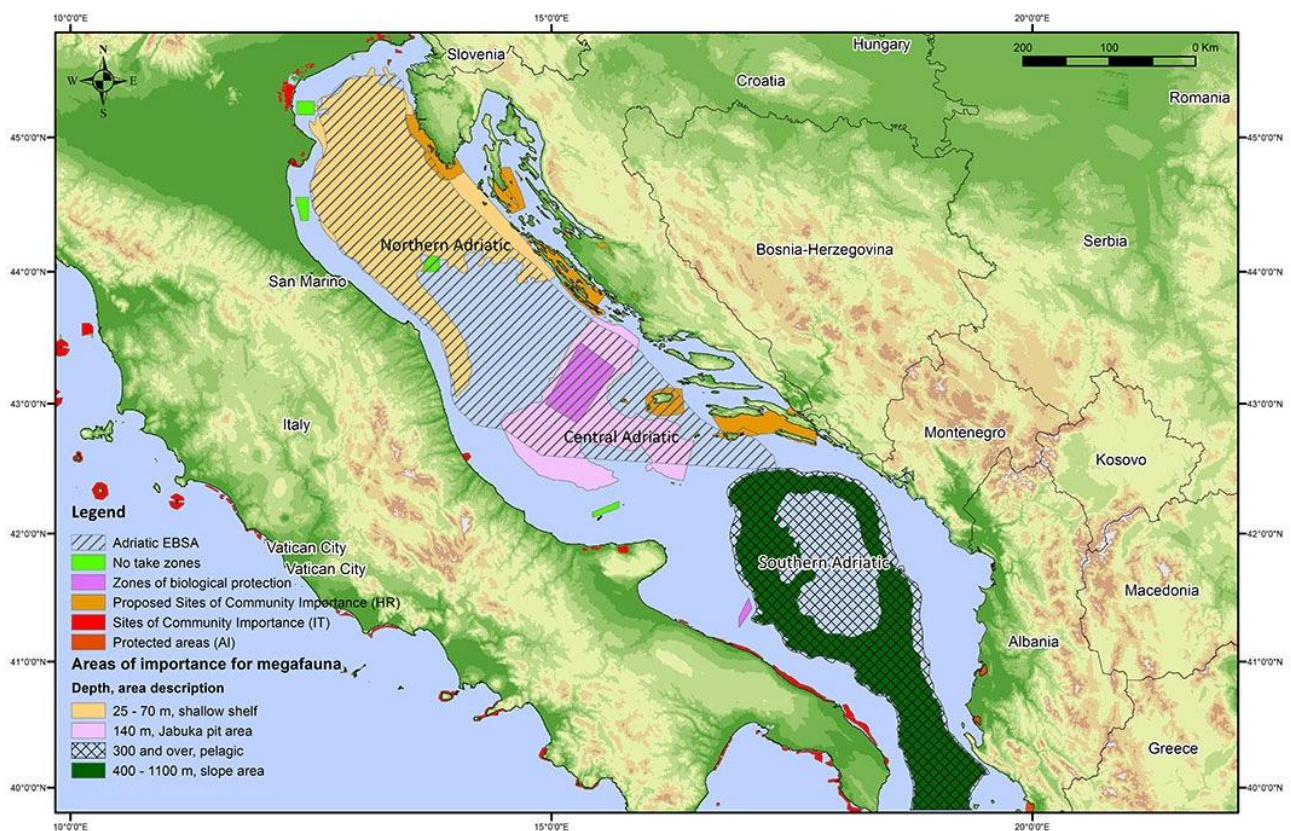


Areas of importance for megafauna in the Adriatic Sea

Figure 29 Areas of importance for megafauna in the Adriatic Sea: descriptive options based on ecological aspects of the selected species

## 9. Protected areas and other management actions for important habitats' protection

The Adriatic has been recognized as an important habitat for many protected species. While there is no Adriatic agreement on protection of biodiversity in the basin there are multiple initiatives, such as the Adriatic-Ionian (established in May 2000) as a platform for cross-border/international between Albania, Croatia, Greece, Italy, Montenegro, and Slovenia. Within the European Union strategy, the Adriatic Sea is a sub-region of the Marine Strategy Framework Directive (MSFD) (Council Directive 2008/56/EC) underlining its importance as a region for conservation and management of sea use. The region presented as Adriatic EBSA in Figure 30 had been identified based on expert opinions for areas important for marine turtles, nursery areas for elasmobranchs, suitable areas for small pelagics, and deep-sea coral reefs (Notarbartolo Di Sciara, 2011). Finally, the Adriatic was discussed at the meeting “Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Areas (EBSAs)” in April 2014, organized jointly by the UNEP/MAP and the Convention on Biological Diversity (CBD). The outcome of the workshop was 17 EBSAs defined in the Mediterranean. The Contracting Parties meeting of CBD in October 2014 adopted 16 of these. The Adriatic EBSA was changed from what is presented in Figure 30 and it was split into two areas, one in the north and one central, with an additional one in the south entering also the Ionian Sea. These EBSAs will be a useful tool also for the Convention for the Protection of the Marine Environmental and Coastal Region of the Mediterranean (Barcelona, 1976, 1995) in its work to select candidate sites to be listed as a Specially Protected Area of Mediterranean Importance (SPAMI).



Areas of importance for megafauna in the Adriatic Sea

Figure 30 Areas of importance for megafauna in the Adriatic Sea, protected areas and identified EBSA

All of the species listed in this report are migratory to an extent that they move between borders of the adjacent states. As such the Convention on Migratory Species (Bonn, 1979) should play a strong role in the region. The CMS fulfills its obligations in two manners, under appendix I, species identified as being in danger of extinction are protected directly by imposition of strict conservation objectives on party States. However, the primary role of CMS is to foster regional agreements convened under the convention for species that have an unfavorable conservation status or would benefit from international cooperation, under appendix II. In the case of the Mediterranean the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean and contiguous Atlantic Area (ACCOBAMS) (Monaco, 1996) is the primary agreement for the conservation of migratory cetaceans.

There are over 30 MPAs registered in the region, the majority being located on the Italian coast, however there are increasing numbers of initiatives being promoted (Mackelworth et al., 2013b) (Mackelworth et al., 2013a,b). On the eastern coast, with the inclusion of Croatia into the EU there has been a push to designate sites under the Natura 2000 network of the Habitats Directive (Council Directive 92/43/EEC), many of these areas have the potential to be important habitats for the species listed in this report. In those regions still outside the EU, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979) provides the option for the creation of the Emerald Network.

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