Journal of the Marine Biological Association of the United Kingdom, 2018, 98(5), 1011–1028.
doi:10.1017/S0025315417000339

Cetacean stranding and diet analyses in the North Aegean Sea (Greece)

C.B. MILANI[1,2], A. VELLA[1], P. VIDORIS[2], A. CHRISTIDIS[2], E. KOUTRAKIS[2], A. FRANTZIS[3], A. MILIOU[4] AND A. KALLIANIOTIS[2]

[1]Conservation Biology Research Group, University of Malta, Msida MSD 2080, Malta, [2]Fisheries Research Institute of Kavala, 64007 Nea Peramos, Kavala, Greece, [3]Pelagos Cetacean Research Institute, Athens, Greece, [4]Archipelagos Institute of Marine Conservation, Samos-Athens, Greece

Cetacean stranding reports in the North Aegean Sea were recorded since 1998 from Strimonikos Gulf in Chalkidiki up to Alexandroupoli on the Turkish border and in a few northern Aegean islands. On site, the specimens were examined to identify species, gender, approximate age and, when possible, cause for stranding. A total of 26 filled stomachs of five cetacean species collected since 2002 were analysed: bottlenose dolphins Tursiops truncatus *(N = 8), common dolphins* Delphinus delphis *(N = 8), harbour porpoises* Phocoena phocoena *(N = 5), striped dolphins* Stenella coeruleoalba *(N = 4) and Risso's dolphins* Grampus griseus *(N = 1). From the analysed stomachs it was found that the bottlenose dolphins fed mainly on snake blenny* Ophidion barbatum *(34%), bogue* Boops boops *(22%) and round sardinella* Sardinella aurita *(13%); common dolphins on round sardinella (17%), picarels* Spicara *spp. (10%) and Cocco's lantern fish* Lobianchia gemellaris *(9%); harbour porpoises on Gobidae (four-spotted goby* Deltentosteus quadrimaculatus *41% and black goby* Gobius niger *37%) and round sardinella (7%); striped dolphins on Myctophydae (Madeira lantern fish* Ceratoscopelus maderensis *51%), and on Pfeffer's enople squid* Abraliopsis morisii *(10%) and bogue (8%); and Risso's dolphin exclusively on Teuthidae (31%), the umbrella squid* Histioteuthis bonellii *(30%) and the reverse jewel squid* H. reversa *(14%). The present work represents the first attempt to investigate the diet up to species level for several cetaceans in Greek waters and for harbour porpoises stranded in the Mediterranean Sea.*

Keywords: Cetacean strandings, *Delphinus delphis*, diet analysis, *Grampus griseus*, North Aegean Sea, *Phocoena phocoena*, *Stenella coeruleoalba*, stomach contents, *Tursiops truncatus*

Submitted 2 March 2016; accepted 20 February 2017; first published online 3 April 2017

INTRODUCTION

Although occasional records of cetacean stranding in Greece have appeared since the 1980s, the establishment of a national sighting and stranding network started in September 1991 (Frantzis, 1997) to December 2008 (Frantzis *et al.*, 2003; Frantzis, 2009; Kapiris *et al.*, 2015). Between 1991 and 2008, a total of 1392 strandings were reported in all Greek waters. Bottlenose dolphins was the most common species among strandings (45% of the total), followed by striped dolphins (31%), common dolphins (12%), Cuvier's beaked whale *Ziphius cavirostris* (5.5%), Risso's dolphins (2.2%) and harbour porpoises (1.5%) (Frantzis, 2009). The percentage of unidentified specimens was very high. Of the 15 total stranding of harbour porpoises, 13 occurred in the North Aegean Sea (Frantzis, 2009; present research). According to the national network, no mass stranding has been recorded in the Thracian Sea (Frantzis *et al.*, 2003; Milani *et al.*, 2011).

The diet composition of cetacean species has been described in several parts of the world and in the Mediterranean Sea. Despite the quite abundant bibliography recorded for the Atlantic European waters (Hassani *et al.*, 1997; De Pierrepont *et al.*, 2005; Spitz *et al.*, 2006a, b, 2010; Brophy *et al.*, 2009; Fernández *et al.*, 2009; Haelters *et al.*, 2011; Jansen *et al.*, 2013; Santos *et al.*, 2013; Hernandez-Milian *et al.*, 2015a, b; Leopold, 2015) in general dietary studies on Mediterranean cetaceans using stomach content analysis are not very numerous, they regard mainly the Western Mediterranean Sea and most of them are quite old (Carlini *et al.*, 1992; Würtz *et al.*, 1992; Würtz & Marrale, 1993; Blanco *et al.*, 1995, 2001, 2006; Boutiba & Abdelghani, 1995; Oztürk *et al.*, 2007; Violani *et al.*, 2012).

In the present research, focusing on cetaceans stranded in the Thracian Sea, stomachs of five cetaceans species have been analysed: eight stomachs from bottlenose dolphins, eight from common dolphins, five from harbour porpoises, four from striped dolphins and one from Risso's dolphin. For all these species, no published information is available from the Greek Aegean Sea, where diet composition analysis had never been conducted before the present research (Milani *et al.*, 2011, 2012). In addition, prior to this study, no diet composition analyses had been performed on harbour porpoises in the Mediterranean Sea.

The aim of this research is to assess the efficacy of the stranding network and analyse the diet of cetaceans found stranded in the study area. The objectives to reach this aim are:

(1) Evaluate the local stranding network operating in the Thracian Sea.

Corresponding author:
C.B. Milani
Email: crismilani13@hotmail.com

(2) Determine, when possible, the cause of death in relation to human activities.
(3) Analyse the stomach contents of the cetacean specimens stranded on the Thracian coasts up to the lowest possible taxonomic level.
(4) List the prey of the stranded specimens divided by species in terms of per cent of total number of prey, per cent of extrapolated biomass and frequence of occurrence in the diet.
(5) Determine the trophic level of each species.

MATERIALS AND METHODS

Stranding network and identification of the stranding

Records on stranding data were collected from the Thracian Sea, extending from Strimonikos Gulf (40°31′45″N 23°55′49″E) up to the Evros River, at the Turkish border (40°43′43″N 26°02′13″E – Figure 1). A local stranding network was established since 1998 with the main port authorities of the study area (Ierissos, Nea Peramos, Kavala, Keramoti, Thassos and Alexandroupoli). During spring 2013, the collaboration with two Greek NGO (Pelagos and Archipelagos) provided seven additional stomachs for content analysis.

Once on site, each animal was examined to identify the species, gender and approximate age from body size measurements for young animals and from tooth condition for old specimens. Since the quality of information decreased if the dolphin was decomposed, tissue samples were collected only from fresh or slightly decomposed cetaceans (Duignan, 2000; Pugliares *et al.*, 2007). From 1998, morphometric data on stranded animals and samples of several different tissue have been collected by the authors for further analyses, whenever the animal was found in good condition (Duignan, 2000; Geraci & Lounsbury, 2005; Pugliares *et al.*, 2007). Stomachs and other parts of the digestive system (such as oesophagus) were collected from January 2002 to August 2013 from cetaceans. Four to six teeth from specimens were collected for age determination. Sex was determined anatomically by the analysis of reproductive organs morphology and if the stranded individual was a female, it was also determined if she was lactating or pregnant.

When possible, cause of death was determined either on site or later in the laboratory, after a necropsy examination, when the animal could be collected. An external examination was carried out looking for traumatic injuries, parasites or any irregularities on the body surface. The presence of parasitic cysts, lesions or oedema was investigated; samples of tissues and organs (skin, blubber, muscle, heart, lung, liver, spleen and kidney) were taken for other analyses, not included in the present research.

Particular attention was given to evaluating if signs revealed direct human interactions such as signs of propeller

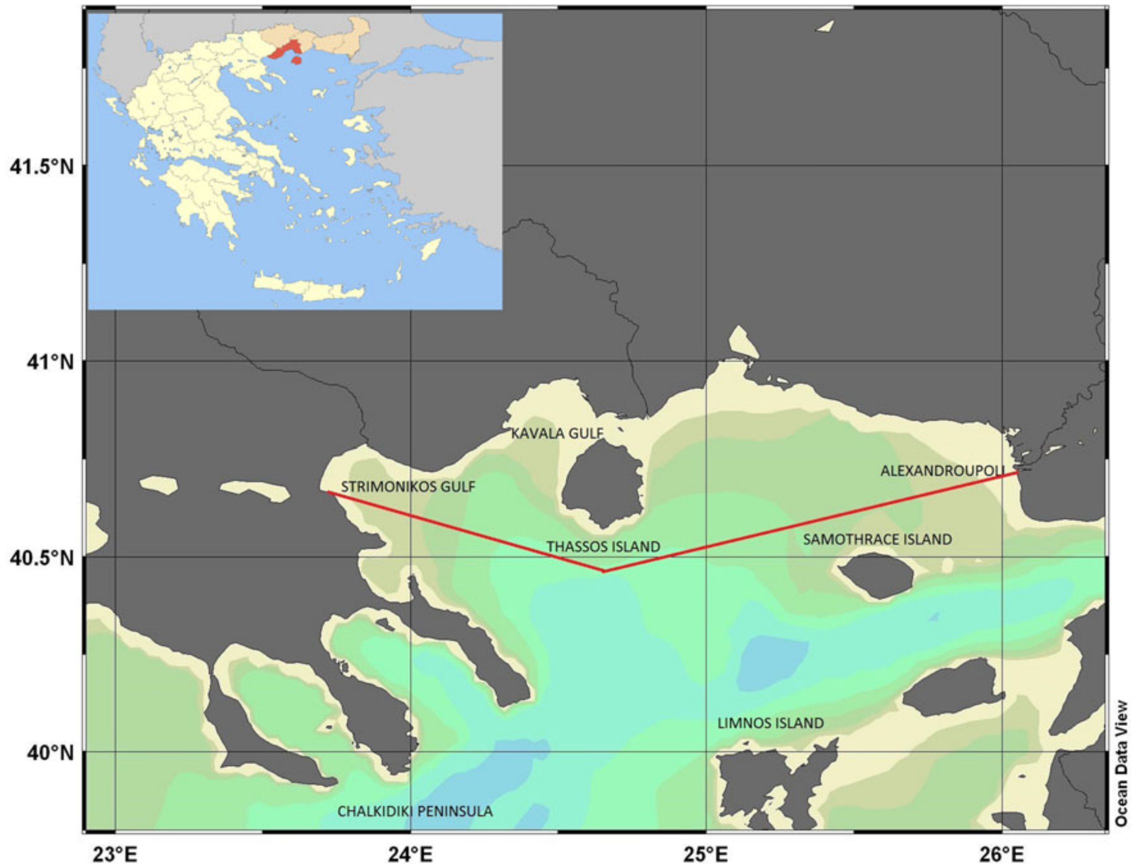

Fig. 1. Map of local strandings network from Strimonikos Gulf at the beginning of Chalcidice Peninsula up to Alexandroupoli, close to the Turkish border on the mainland; the island of Thassos was included in the stranding network. Bathymetry is indicated as a scale from yellow to darker greens, representing the depths of 25, 50, 100 and 200 m, respectively.

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

strikes or portions of net or signs testifying the entanglement, were present on the specimens. The Necropsy Protocol for Cetaceans was used and a specific form was filled in for each stranding record (NOAA, 1993; Geraci & Lounsbury, 2005).

Assessing Human Interactions (HI), guidelines that suggest conservative evaluations have been followed. The likelihood that the observed human interaction contributed to the stranding event was indicated on a scale of 0–3 (0 = Uncertain, 1 = Improbable, 2 = Suspect, 3 = Probable) (Moore & Barco, 2013). If evidence of human interaction was found, then the objective finding is YES (Pugliares *et al.*, 2007). Moreover, a distinction was made between ante-mortem, pre-mortem and post-mortem injury, where the first is normally an old injury which is not related to the time of death, pre-mortem injury is an injury or lesion that occurs immediately before death and could be the cause of it and post-mortem injury occurs after the animal's death and is not related with it (Merriam-Webster, 2012).

HI caused by fishing gears, entanglement in fishing nets or in other gears and gear ingestion, were considered; in absence of fishing gears, encircling lesions, impressions, lacerations and abrasions left on the carcass by fishing gears were considered (Moore & Barco, 2013). Again, a distinction between ante-mortem, pre-mortem and post-mortem injury was investigated. Predation and scavenger damage caused by other organisms post-mortem, were evaluated (Moore & Barco, 2013).

Diet composition analyses

Odontocetes' diet was determined through contents analyses of parts of the digestive system (mainly stomachs and oesophagi) of the stranded dolphins and porpoises found in the study area. Stomachs were collected from stranded cetaceans since spring 2002, whenever the stranded specimen was still in relatively good conditions. The stomachs and the other tissue samples were kept in a freezer at −20°C until further analysis. Then stomachs and oesophagi were defrosted, opened and the content was examined following standard protocols (Duignan, 2000; Pugliares *et al.*, 2007). The prey items were carefully emptied and rinsed in a metal tray and then sieved through a 0.5 mm mesh size sieve. The different sorted components, such as fish partially digested, were conserved in formalin 4%. Otoliths and dentary bones were conserved in dry plastic Eppendorf and in ethanol 70%. Cephalopods beaks, part of undigested cephalopods and crustaceans were conserved in ethanol 70% (Geraci & Lounsbury, 2005).

All prey remains were identified to the lowest possible taxonomic level. A binocular stereoscope Nikon SMZ1500 was used to examine the fish sagittal otoliths, while partially digested fish and beaks of cephalopods were normally examined with the naked eye (Lefkaditou, 2006).

For partly digested cephalopods and fish species identifications, FAO (Fisher *et al.*, 1987a, b) and UNESCO (Whitehead *et al.*, 1984, 1986a, b) manuals were used.

For fish otolith and bone identification, a large collection of identified otoliths and bones, gathered by the team of the Fisheries Research Institute (FRI) from sampling campaigns during the programmes MEDITS and DISCARDS, was used. For the species not present in the collection, identification guides (Schmidt, 1968; Tuset *et al.*, 2008), related works (Kallianiotis, 1992; Lefkaditis, 2009) and the online database AFORO from the Mediterranean Centre for Marine and Environmental Research CMIMA (http://www.cmima.csic.es/aforo/) were also used (Lombarte *et al.*, 2006). Cephalopod beaks were identified through training, references and an *ad hoc* collection created from samples for identifications by Dr Eugenia Lefkaditou (Lefkaditou, 2006).

The total number of prey individuals per stomach was recorded. Sagittal otoliths were identified as right or left and the total number of eaten fish was estimated by the largest number of otoliths of either side. When this was not possible, the minimum total number of fish was estimated by halving the number of otoliths (Fitch & Brownell, 1968; Ambrose, 2010). Cephalopod beaks were sorted into upper and lower and the largest count of either provided the estimate of specimens ingested. Indices of importance for individual prey taxa was used to characterize the overall diet as (1) per cent of total number of prey; (2) per cent of extrapolated biomass of prey; (3) frequence of occurrence of each prey species in cetacean diet.

Otoliths, dentary bones and beaks were measured using a stereoscope with a graduated scale or an electronic digital caliper, according to their size. In order to calculate the prey biomass, several equations relating the otolith, bone and beak measurements to the prey length and weight have been used. These equations are generally the type $y = a + bx$ for fish length and $y = ax^{b}$ for fish weight or $\ln y = a + \ln x$ for cephalopod weight and were found in the literature. When the equation for a species was not available, the equation for the closest species of the same genus or family was used. When this option was also not available, the relation between otolith length and fish length (OL/TL) was used (Härkönen, 1986) and the relation between fish length and fish weight was found on *FishBase* (www.fishbase.org). When possible, comparison with samples collected during FRI campaigns was made. A detailed table with the equations used in this work is presented in Appendix 1.

Trophic levels of cetaceans

The fractional trophic level (TROPH) of a species (i) was defined according to Pauly & Christensen (2000):

$$\mathrm{TROPH}i = 1 + \sum_{j=1}^{G} DCij \times \mathrm{TROPH}j$$

where TROPHj is the fractional trophic level of prey (j), $DCij$ is the fraction of j in the diet of i and G is the total number of prey species.

Despite the low number of strandings, dietary information on cetaceans in the study area came from the stomach content analyses of the stranded specimens. The acquired information was used to calculate their trophic levels (TROPHs) and standard errors (SE). The trophic levels of their prey have been extracted from published sources (Pauly *et al.*, 1998; Stergiou & Karpouzi, 2002; Kaschner *et al.*, 2004). In particular, TROPHs of fish prey have been extracted from *FishBase* (www.fishbase.org) while TROPHs of cephalopods were extracted from *SeaLifeBase* (www.sealifebase.fisheries.ubs.ca) where available. Default TrophLab values were used for fish and cephalopod prey reported at taxonomic levels higher than genus as well as for all remaining prey taxa (Stergiou & Karpouzi, 2002).

TROPHs of the cetacean species were calculated as the mean of all the TROPHs values estimated for all the specimens of all the different species, according to Pauly & Christensen (2000).

RESULTS

Stranding network and identification of the stranding

IDENTIFICATION AND CAUSE FOR STRANDINGS

A total of 58 individuals of six different species were stranded dead from Strimonikos to Alexandroupoli since 1998 up to summer 2013 (Figure 2). The animals belonged to the following species: bottlenose dolphins (11 specimens), common dolphins (17), striped dolphins (15), Risso's dolphins (2), fin whale *Balenoptera physalus* (2) and harbour porpoises (7), as shown in Appendix 2. A particular record regards the seven specimens of harbour porpoises, which were found from their original distribution in Evros and Alexandrupoli on the Turkish border, up to the Strimonikos Gulf in Thessaloniki (Figure 2).

From the 58stranded specimens, eight showed signs of negative interaction with human activities and died due to them; among them six specimens were found entangled in nets or with part of a net in their digestive system. Table 1 shows details on the levels of interaction (Code HI) and on the timing of the injury, if pre-mortem or post-mortem (PRM/PSM).

Diet composition analyses

From the 39 stranded cetaceans found, 12 were in extremely bad condition and no samples were collected (representing 31% of the total stranding since stomach collection took place), seven of them presented with an empty stomach at the on-site necropsy. A total of 24 stomachs were collected and brought to the laboratory for analysis. Three of them were empty and the remaining 21 were analysed. Another five non-empty stomachs, coming from the specimens given by the two NGOs, were added to the sample. From the 26 stomachs collected and analysed eight belonged to bottlenose dolphins, eight to common dolphins, five to harbour porpoises, four to striped dolphins and one to Risso's dolphins. The wet weight of stomach contents and main prey phyla are shown in Table 2.

The percentage of prey pooled at family level was evaluated for each species. For bottlenose dolphins, common dolphins and striped dolphins, due to the high number of prey families, only the families with a value higher than 2% are represented.

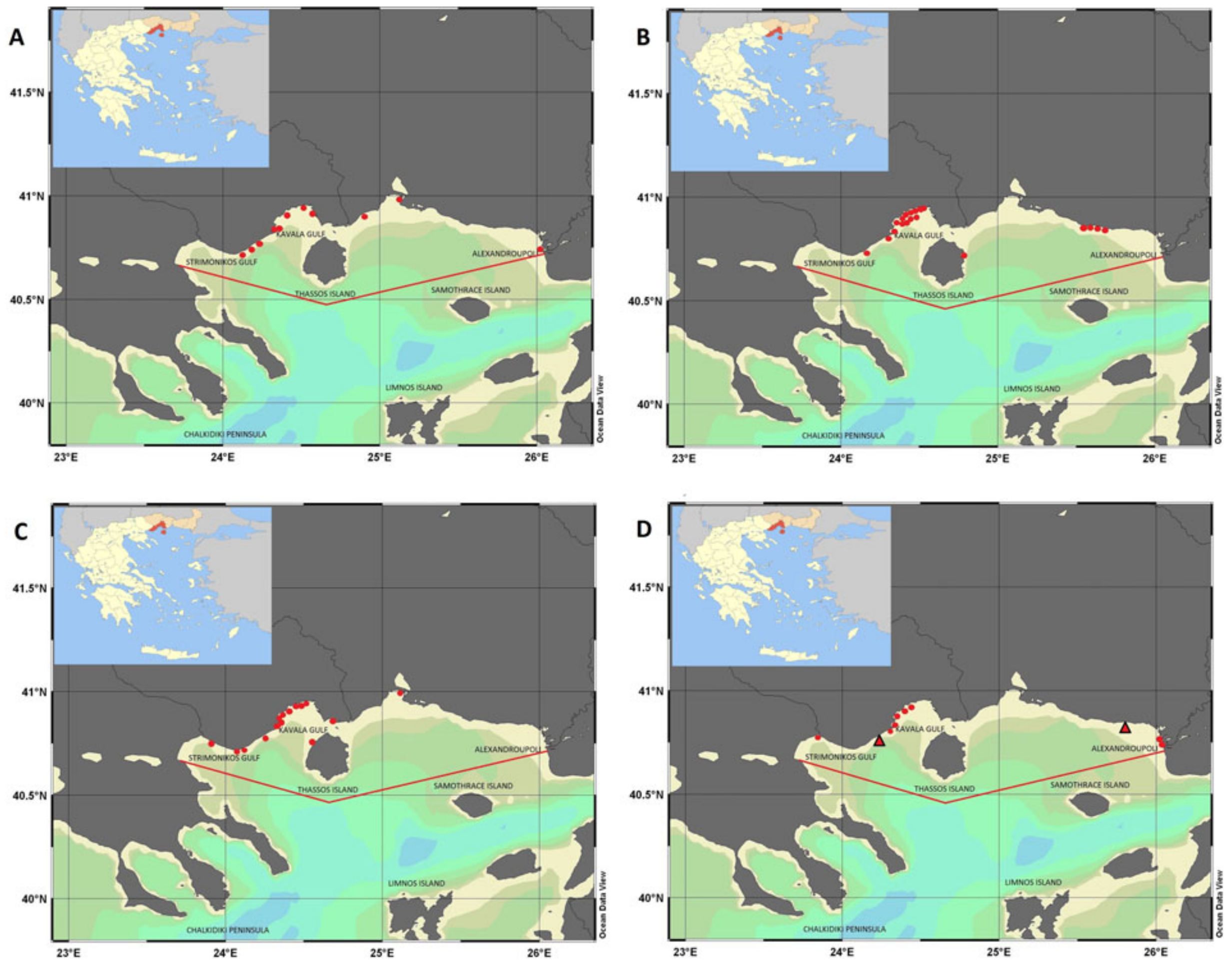

Fig. 2. Map of strandings data collected by this study from the stranding network during the period 1998–2013. (A) *Tursiops truncatus* (N = 10); (B) *Delphinus delphis* (N = 18); (C) *Stenella coeruleoalba* (N = 15); (D) *Phocoena phocoena* (N = 7) indicated with dots and *Grampus griseus* (N = 2) indicated with triangles.

Table 1. Stranded cetaceans whose cause of death was shown to be due to human interactions.

Species	Date	Gender	Age Cl	Tot L	Site	Notes	Code HI	PRM/PSM
Phocoena phocoena	11/2/2000	M	AD	128	Evros Delta	Propeller	2	PRM?
Stenella coeruleoalba	29/5/2001	M	AD	193	Keramoti	Shot	2	PRM?
Delphinus delphis	18/11/2002	M	YO	174	Kavala (Sfaghia)	Entangled	3	NI
Tursiops truncatus	8/5/2005	F	OL	285	Kavala	Net in the stomach	YES	PRM
Phocoena phocoena	22/12/2006	F			Palio (Kavala)	Entangled	YES	PRM
Tursiops truncatus	8/2/2008	F	AD	252	Nea Peramos	Net in oesophagus	YES	PRM
Stenella coeruleoalba	26/10/2010	M	YO	214	Prinos-Thassos	Entangled	3	NI
Phocoena phocoena	22/8/2013	F	YO/AD	132	Kavala (Sfaghia)	Entangled	YES	PRM

M, male; F, female; AD, adult; YO, young; OL, old; Tot L, total length in cm.
Code HI = code used to classify the Human Interaction (HI); from 0–3 (0 = Uncertain, 1 = Improbable, 2 = Suspect, 3 = Probable); YES = certain HI; PRM = pre-mortem; PSM = post-mortem; NI = not identified.

For the species harbour porpoises and Risso's dolphins all the prey families are represented in the graphs, because of the high selectivity in their diet. The values of percentage of prey pooled at family level for each cetacean species are shown in Figure 3. The detailed diet composition, as revealed from the stomach contents, for each specimen analysed is shown in Tables 3–7. The diet of the specimens collected could be summarized as follows.

BOTTLENOSE DOLPHINS

In the present work the species most relevant for the diet of the sampled specimens were *Boops boops, Sardinella aurita* and *Ophidion barbatum* (Table 3). At family level Ophiidae and Sparidae occupy about 60% in numbers of the diet of the specimens. *Trachurus* sp. was also present but with a smaller percentage. While *B. boops* was generally present in all the stomachs, except the ones belonging to the two specimens entangled in fishing nets, *O. barbatum* was present only in two specimens in high number of individuals. *Sardinella aurita* was also found in the stranded specimens in quite high number. The bottlenose dolphins that presented interaction with fishery had very few prey in the stomach and normally species not found in the other specimens (*Sepia officinalis* in one case and *Lithognatus mormyrus* in the other) which are the target species and a secondary species of the nets where the dolphins were entangled, suggesting a direct predation on the nets.

COMMON DOLPHINS

In the present research the prey found with a higher percentage in the diet were *Sardinella aurita, Lobianchia gemellaris, Spicara* spp. and *Trachurus mediterraneus* (Table 4). At family level the preys with higher encounters were Clupeidae, Myctophydae, Centracanthidae and Sparidae that

Table 2. Twenty-six specimens of stranded cetaceans of five different species collected from 2002 up to 2013 where stomach samples were collected.

Species	Date	Place	General notes	Wet W.
Tursiops truncatus	9/5/2002	Almira (Egnatia)	FISH	212
Delphinus delphis	18/11/2002	Kavala	FISH	48
Phocoena phocoena	17/1/2003	Amolofi (Nea Peramos)	FISH	12
Stenella coeruleoalba	2/4/2003	Nea Karvali	FISH, CEPH	15
Grampus griseus	9/1/2004	Alkioni (Maronia)	CEPHALOPODS	47
Delphinus delphis	16/4/2004	Amolofi (Nea Peramos)	FISH	201
Delphinus delphis	19/4/2004	Kavala	FISH	449
Tursiops truncatus	14/2/2005	Ag. Christophoros Egnatia	FISH	616
Tursiops truncatus	8/5/2005	Kavala	FISH, CEPH	15
Phocoena phocoena	22/12/2006	Palio (Kavala)	FISH	280
Tursiops truncatus	8/2/2008	Nea Peramos	FISH, CEPH	32
Tursiops truncatus	10/10/2008	Nea Peramos	FISH, CEPH, CRUS	18
Phocoena phocoena	13/11/2008	Nea Peramos	FISH	32
Stenella coeruleoalba	5/2/2009	Nea Iraklitsa	FISH, CEPH	43
Delphinus delphis	18/9/2009	Egnatia	FISH, CEPH	5
Delphinus delphis	14/2/2010	Kalyves Gerakini Chalkidiki	FISH	0.2
Tursiops truncatus	11/5/2011	Porto Lagos	FISH	6
Tursiops truncatus	11/7/2011	Nea Karvali	FISH	98
Stenella coeruleoalba	4/2/2012	Palio Glastres	FISH, CEPH.	5
Stenella coeruleoalba	19/9/2012	Paralia Ofriniou	CEPHALOPODS	12
Tursiops truncatus	19/9/2012	Vathi North Samos	FISH, CRUS	300
Delphinus delphis	22/2/2013	Kavala (port)	FISH	6
Phocoena phocoena	13/3/2013	Makris Panoramatos Alexand	FISH	4
Delphinus delphis	26/3/2013	Potokaki Beach Samos	FISH	560
Delphinus delphis	14/5/2013	North Samos	FISH	0.2
Phocoena phocoena	22/8/2013	Sfaghia	FISH	24

Wet W., wet weight of content in grams.

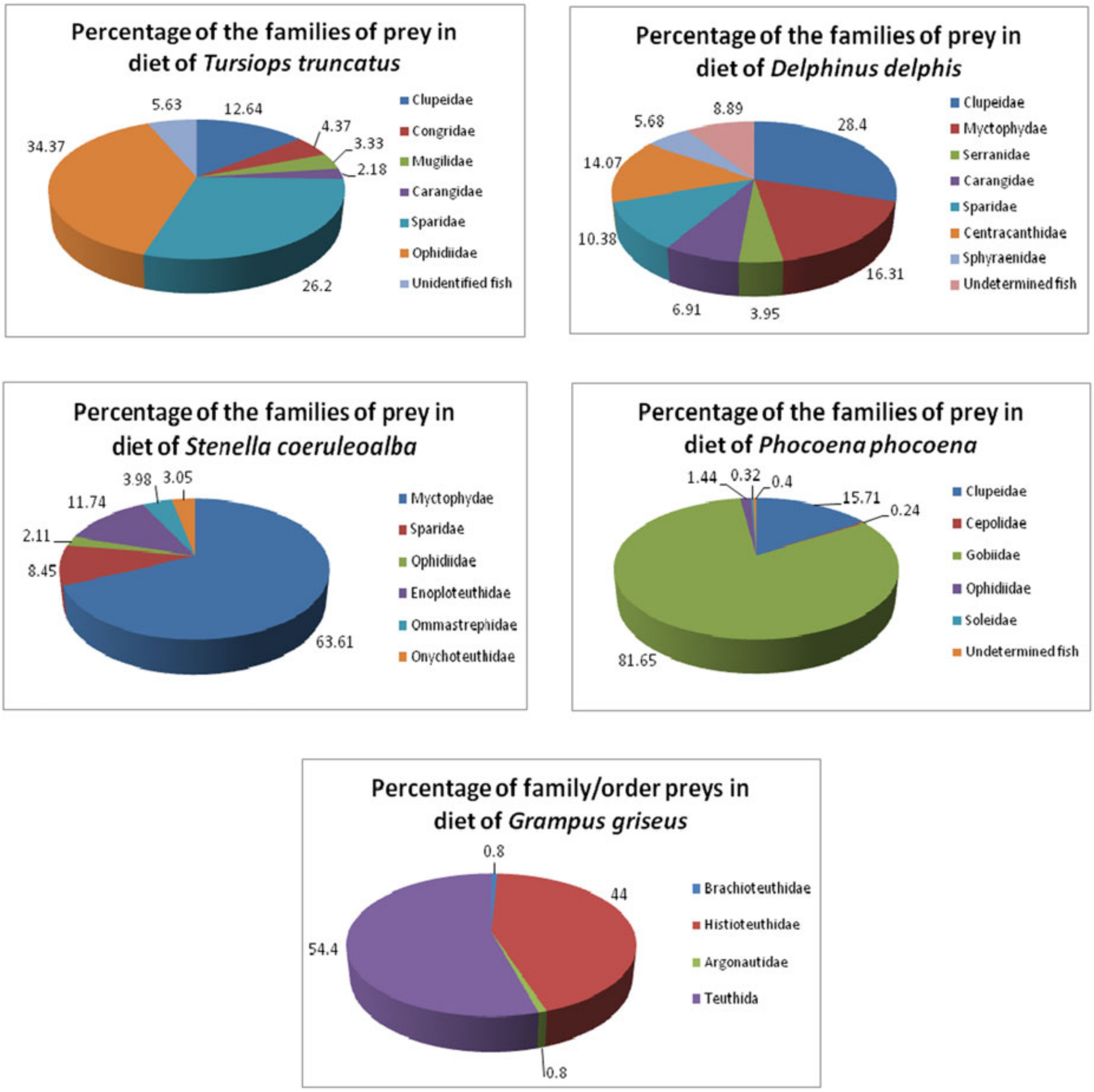

Fig. 3. Percentage of prey pooled at family level in the stomach content of: *Tursiops truncatus* (N = 8); *Delphinus delphis* (N = 8); *Stenella coeruleoalba* (N = 4); *Phocoena phocoena* (N = 5); *Grampus griseus* (N = 1). For the first three species, only the families represented at a value higher than 2% are included.

represent 70% in numbers of the diet of the sampled specimens. As for the Mediterranean studies the family of Myctophydae is very important in the diet, eaching 16% of the prey, while the Clupeidae amounted to 28% of the total prey.

STRIPED DOLPHINS

In the present study the species most abundant in the diet were the Myctophid *Ceratoscopelus maderensis*, the Sparidae *Boops boops* and the cephalopod *Abraliopsis morisii* (Table 5). The family of Myctophydae represent the most important prey of the sampled striped dolphins reaching 64% of the total diet of the sampled specimens. In one case the family represented almost all of the prey. Two of the four specimens presented a diet based primarily on cephalopods, especially the species *Abraliopsis morisii* and *Todarodes sagittatus* for one specimen and *Pyroteuthis margaritifera* and *Heteroteuthis dispar* for the other specimen, in accordance with other studies in the Mediterranean.

HARBOUR PORPOISE

In the present work the prey found in maximum percentage in the stomach content of the species were *Deltentosteus quadrimaculatus, Gobius niger* and *Engraulis encrasicolus* (Table 6). At family level 82% in number of the total prey were represented by the family of *Gobiidae*, while another 16% was occupied by *Clupeidae*, these two families therefore representing almost 100% of the diet of the sampled specimens. Among the five sampled specimens three of them fed almost exclusively on species belonging to the *Gobiidae* family, while the two specimens entangled in static fishing nets presented almost exclusively prey belonging to the *Clupeidae* family in their stomachs.

RISSO´S DOLPHIN

In the present research a single stomach of Risso's dolphin was analysed. Almost 100% of the prey of the single sampled specimen were represented by Teuthidae of the species *Histioteuthis bonnellii and H. reversa*, showing a very high diet specialization of the stranded animal (Table 7).

Trophic levels of cetaceans

Mean estimated TROPHs of North Aegean Sea cetacean species show quite high values, ranging from 4.20 for harbour porpoises to 4.70 for Risso's dolphins (Table 8). As expected, all the cetaceans investigated in the North Aegean Sea appear to be top level predators with high values of trophic level (all higher than 4.00).

DISCUSSION

Stranding network and identification of the stranding

Even if a percentage of samples were lost due to the weakness of the network presented in the Materials and methods, it was however possible to obtain values of strandings higher than the ones obtained during previous years at national scale. In the North Aegean local network presented in this work, a total of 60 reported stranding in 15 years in a coastal perimeter of about 500 km (corresponding to 0.80 cetaceans per 100 km of coastline per year) were reported. This has to be considered an improvement compared with the data obtained by Frantzis through the stranding network in 1991–2001 (Frantzis *et al.*, 2003), where 715 stranded specimens were recorded along the Greek coastline of about 14,000 km (Minakakis, 2009) in 10 years (corresponding to 0.51 cetacean per 100 km of coastline per year). Compared with other situations in the Mediterranean Sea, our stranding network was less efficient than the Italian one, which reported an average of 1.58 stranded cetaceans per 100 km of coastline per year (http://mammiferimarini.unipv.it/spiaggiamenti_pub.php?lang=it). A higher rate of stranding cetaceans per km was also obtained by the Spanish Stranding Network operating in the Alboran Sea among the years 1991–2008, where an average of 8 cetaceans per 100 km of coast per year was recorded (Rojo–Nieto *et al.*, 2011). This difference in strandings recording among the different areas, is both due to the higher concentration of cetaceans in the Western Mediterranean Sea, thanks to the bathymetric and physicochemical characteristics of the Atlantic waters that enter it (Cañadas, 2006) and, last but not least, thanks to the financial support given to cetacean research in Italy and Spain, which is not comparable to the situation of the small North Aegean local network.

Compared with other areas outside the Mediterranean, the number of sightings, reported strandings and extremely high number of records are common among the coasts of the East Atlantic and North Sea (Silva, 1999; De Pierrepont *et al.*, 2005; Haelters *et al.*, 2011; Read *et al.*, 2014). These dramatic increases in reported strandings both mean a higher impact on cetaceans due to human activities, and a possible greater abundance of cetaceans in these areas (Tregenza *et al.*, 1997; Dans *et al.*, 2003).

Diet composition analyses

The present work gave the first data on the diet of five cetacean species in the area and for three species, the first data on diet for Greece. Though the results obtained from a limited sample size are to be considered with caution (Pierce *et al.*, 2004), cetacean diet has been reported to vary among populations and sometimes among groups of the same population in different regions, maximizing the use of resources available seasonally. The study therefore also took into consideration possible causes of error in such circumstances. According to the authors, when dealing with stomach contents, one needs to consider (1) if prey components, such as fish otoliths and cephalopod beaks, remain in the stomach for the same period of time, (2) the type of measurement unit used in the analysis (wet weight, volume, numbers, frequency of occurrence, etc.), (3) whether the stomach contents of stranded animals represent the diet of local healthy populations and (4) the small-scale regional and seasonal variation in the diet composition of marine mammal species.

However, in spite of the biases due to the nature of the sampling, stomach contents analysis still remains the most widely used technique for evaluating cetacean diet (Pierce *et al.*, 2004; Birkun & Frantzis, 2006; Tonay *et al.*, 2007; Violani *et al.*, 2012).

Compared with other areas of the Mediterranean and the close Atlantic Ocean the diet of the species investigated in the present work is analysed species by species and reported as follows.

DIET OF BOTTLENOSE DOLPHINS

In the literature, the bottlenose dolphin is extremely flexible and adaptable, therefore big differences in the diet have been found within each geographic area, due to the difference in prey availability and distribution; the species has a wide range of foraging strategies, which depend on the prey availability and their seasonal abundance and distribution (Kovacic & Bogdanovic, 2006). In general this species is ichthyophagous, but specimens of cephalopods, even some crustaceans, were found to form part of its diet. In the Western Mediterranean and North Atlantic the main prey items include *Gadus* sp., *Engraulis encrasicolus, Sardina pilchardus, Trachurus* spp., *Clupea* spp., *Mugil* spp. (Blanco *et al.*, 2001). In Galician waters the most important prey were *Micromesistus potassou* and *Merluccius merluccius* while the most frequently recorded cephalopods were squid of the family Ommastrephidae (Santos *et al.*, 2007) and in the Bay of Biscay large specimens of demersal fish (91% by mass) and cephalopods were found (Spitz *et al.*, 2006b). In a study on stranded and bycaught common dolphins in Western Ireland the most important prey were *M. merluccius, Molva molva, Trachurus trachurus* and *Conger conger* (Hernandez-Milian *et al.*, 2015a, b).

In general, from the samples collected during the present research, the bottlenose dolphin shows a very wide prey range, varying from neritic prey, such as round sardinella and squids of the genus *Loligo*, to semi-pelagic prey, such as bogue and Sparidae, up to benthic species, such as European hake and conger, snake blenny among fish and common octopus and cuttlefish among cephalopods. The species also presents in its diet the bathyal octopus species *P. tetracirrhus*, showing a very wide use of the feeding habitat, from the ones close to the coast in shallow water, to the ones in deeper waters

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

Table 3. Prey found in stomach contents of eight bottlenose dolphins from North Aegean Sea among 2002–2013.

Family	Species	TOT	%Number	%Biomass	%FO
Fish		**831**	**95.52**	**84.10**	**100**
Clupeidae	*Sardinella aurita*	110	12.64	8.43	25
Congridae	*Conger conger*	38	4.37	14.85	12.5
Mugilidae	*Liza ramada*	29	3.33	5.87	12.5
Belonidae	*Belone belone*	2	0.23	0.17	12.5
Melucciidae	*Merluccius merluccius*	17	1.95	8.17	12.5
Serranidae	*Serranus cabrilla*	5	0.57	1.15	25
Carangidae	*Trachurus mediterraneus*	19	2.18	3.81	25
Sparidae	*Boops boops*	190	21.84	20.92	62.5
Sparidae	*Diplodus* sp.	2	0.23	0.17	12.5
Sparidae	*Lithognatus mormyrus*	6	0.69	1.66	12.5
Sparidae	*Oblada melanura*	3	0.34	0.53	12.5
Sparidae	*Pagellus acarne*	12	1.38	2.71	25
Sparidae	*Pagellus erythrinus*	10	1.15	3.07	25
Sparidae	*Pagrus pagrus*	2	0.23	0.53	12.5
Sparidae	*Spondilosoma cantharus*	2	0.23	0.53	12.5
Sparidae		3	0.34	–	12.5
Centracanthidae	*Centracanthus cirrus*	6	0.69	1.11	12.5
Centracanthidae	*Spicara smaris*	3	0.34	0.23	12.5
Labridae	*Symphodus* sp.	4	0.46	0.21	12.5
Scombridae	*Scomber scombrus*	2	0.23	0.25	12.5
Gobidae	*Gobius niger*	8	0.92	0.15	37.5
Gobidae	*Lesueurigobius frisei*	8	0.92	0.06	12.5
Gobidae	*Lesueurigobius* sp.	1	0.11	0.01	12.5
Ophidiidae	*Ophidion barbatum*	299	34.37	9.58	25
Sphyraenidae	*Sphyraena sphyraena*	1	0.11	0.92	12.5
Citharidae	*Citharus linguatula*	1	0.11	0.03	12.5
	Unidentified fish	49	5.63	–	62.5
Cephalopods		**35**	**4.02**	**15.91**	**37.5**
Sepiidae	*Sepia officinalis*	4	0.46	3.51	12.5
Loliginidae	*Loligo forbesi*	5	0.57	2.21	12.5
Loliginidae	*Loligo vulgaris*	11	1.26	5.17	25
Theutidae	Theutidae type E	9	1.03	–	12.5
Octopodidae	*Octopus vulgaris*	1	0.11	2.01	12.5
Octopodidae	*Pteroctopus tetracirrhus*	5	0.57	3.01	12.5
Crustacea		**4**	**0.46**		**25**

TOT – total number. %Number – Per cent of relative abundance in terms of number of prey. %Biomass – Per cent of relative abundance in terms of estimated biomass of prey; %FO – Per cent values of frequency of occurrence of each species on the total samples.

and in open sea. Moreover, two of the stranded bottlenose dolphins showed evidence of net depredation, due to the presence of parts of the nets in the digestive system and to the presence of some prey in the stomach content belonging to the main target species of the net in which the specimens were entangled.

Diet of common dolphins

In the literature, the common dolphin also shows differences in the diet within the geographic areas where the species is distributed, due to the difference in prey availability and distribution (Silva, 1999; Santos *et al.*, 2004). Common dolphins have a wide range of foraging strategies, which depend on prey availability and their seasonal abundance and distribution (Evans, 1994; Ohizumi *et al.*, 1998; Santos, 1998; Santos *et al.*, 2013). In the literature, the common dolphin is known to feed abundantly on small pelagic fish, for example Clupeidae (Fernández *et al.*, 2009; Santos *et al.*, 2013), Myctophidae (Spitz *et al.*, 2010) and small Gadidae (De Pierrepont *et al.*, 2005; Brophy *et al.*, 2009). In the North Atlantic the main prey items include Scombridae (mackerel), *Sprattus* spp. (sprat) and Ammodytidae (sand eel), other mesopelagic species for the oceanic dolphins (Ohizumi *et al.*, 1998) and cephalopods such as *Enoplotheuthis* sp. and Ommastrephidae (Fernandez *et al.*, 2009), while the Mediterranean Sea common dolphins feed mainly on epipelagic and mesopelagic fish and squids (Orsi Relini & Relini, 1993; Cañadas & Sagarminaga, 1996; Agazzi *et al.*, 2004), with prevalence of myctophid fish (Pusineri *et al.*, 2007). In the Black Sea the species mostly feeds on *Trachurus* spp., *Engraulis encrasicolus, Sprattus* spp. and *Mugil* spp. (Tonay *et al.*, 2007).

In general, from the samples collected during the present research, the common dolphin also shows a very wide prey range, varying from neritic prey, such as round sardinella and several Myctophydae to benthopelagic species, such as European barracuda, *Pagellus* spp. and *Spicara* spp., typical of the continental shelf. Prey is distributed in a similar percentage to several fish families, while the presence of cephalopods in the diet of common dolphins stranded and analysed in the area, is very poor.

Diet of striped dolphins

In the literature, striped dolphins also have a wide range of foraging strategies, which depend on prey availability and

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

Table 4. Prey found in stomach contents of eight common dolphins from the North Aegean Sea among 2002–2013.

Family	Species	TOT	%Number	%Biomass	%FO
Fish		**401**	**99.01**	**99.15**	**100**
Engraulidae	*Engraulis encrasicholus*	17	4.2	1.28	25
Clupeidae	*Sardina pilchardus*	30	7.41	5.13	25
Clupeidae	*Sardinella aurita*	68	16.79	18.68	37.5
Synodontidae	*Synodus saurus*	1	0.25	0.29	12.5
Myctophydae	*Ceratoscopelus maderensis*	1	0.25	0.05	12.5
Myctophydae	*Lobianchia gemellaris*	36	8.89	0.87	12.5
Myctophydae	*Myctophum punctatum*	1	0.25	0.07	12.5
Myctophydae	*Notoscopelus bolini*	8	1.98	0.05	12.5
Myctophydae	*Symbolophorus veranyi*	20	4.94	1.17	12.5
Nettœstomaidae	*Nettastoma melanurum*	1	0.25	1.63	12.5
Congridae	*Conger conger*	2	0.49	1.99	12.5
Melucciidae	*Merluccius merluccius*	2	0.49	3.03	12.5
Serranidae	*Serranus hepatus*	16	3.95	7.46	12.5
Carangidae	*Trachurus mediterraneus*	28	6.91	9.85	37.5
Sparidae	*Boops boops*	1	0.25	0.68	12.5
Sparidae	*Dentex macrophthalmus*	1	0.25	1.56	12.5
Sparidae	*Diplodus vulgaris*	2	0.49	1.14	12.5
Sparidae	*Pagellus acarne*	6	1.48	4.34	12.5
Sparidae	*Pagellus bogaraveo*	1	0.25	1.33	12.5
Sparidae	*Pagellus erythrinus*	8	1.98	5.65	12.5
Sparidae	*Pagellus* sp.	8	1.98	5.65	12.5
Sparidae	*Sparidae*	15	3.7	–	12.5
Centracanthidae	*Spicara maena*	12	2.96	2.03	12.5
Centracanthidae	*Spicara smaris*	2	0.49	0.36	12.5
Centracanthidae	*Spicara* sp.	42	10.37	7.77	12.5
Centracanthidae	*Centracanthidae*	3	0.74	–	12.5
Pomacentridae	*Chromis chromis*	6	1.48	1.17	12.5
Gobidae	*Deltentosteus quadromaculatus*	1	0.25	0.05	12.5
Gobidae	*Lesuerigobius friesii*	1	0.25	0.04	12.5
Sphyraenidae	*Sphyraena sphyraena*	23	5.68	17.24	25
Atherinidae	*Atherina boyeri*	1	0.25	0.08	12.5
Triglidae	*Trigla lucerna*	1	0.25	0.40	12.5
Citharidae	*Citharus linguatula*	2	0.49	0.08	12.5
	Unidentified fish	36	8.89	–	37.5
Cephalopods		**4**	**0.99**	**0.85**	**25**
Ommastrephidae	*Illex coindetii*	2	1.98	0.85	12.5
	Unidentified cephalopods	2	1.98	–	25

TOT – total number. %Number – Per cent of relative abundance in terms of number of prey. %Biomass – Per cent of relative abundance in terms of estimated biomass of prey; %FO – Per cent values of frequency of occurrence of each species on the total samples.

their seasonal abundance and distribution. The diet of the species normally includes cephalopods, fish and macro-plankton crustaceans. The main prey items include Myctophid and Sternoptychid such as lanternfish *Notoscopelus kroeyeri* and *Lobianchia gemellarii*; oceanic histioteuthid, gonatid and brachiteuthid such as *Teuthowenia megalops* and *Histioteuthis* spp., *Chiroteuthis veranyi, Mastigoteuthis* spp. and *Octopoteuthis* spp.; pelagic shrimps *Sergastes arcticus* and deep sea crab *Pasiphaea multidentata*; neritic fish including gadoids (such as cods and whitings) and anchovy and even coastal fish such as atherinid (Clua & Grosvalet, 2001; Ringelstein *et al*., 2006; Spitz *et al*., 2006a; Fernandez *et al*., 2009; Hernandez-Milian *et al*., 2015a, b). In the Mediterranean Sea striped dolphins feed mainly on cephalopods, among them *Todarodes sagittatus* seems to be the preferred species, but specimens belonging to the genus *Histioteuthis, Heteroteuthis, Brachioteuthis, Illex, Todaropsis, Loligo, Abralia* and others are also present (Pulcini *et al*., 1992; Würtz & Marrale, 1993; Blanco *et al*., 1995; Öztürk *et al*., 2007); fish are less numerous in the stomachs and among them the most common are *Micromessistius potassou*, small pelagics and several species of Myctophid (Würtz & Marrale, 1993). Bycaught striped dolphins from the eastern Mediterranean Sea off the Turkish coast presented in their stomachs a large number of fish of the Myctophydae family, mainly *Diaphus* spp. and *Ceratoscopelus maderensis* and several cephalopod species, among them *Onychoteuthis banksii*, which was the only cephalopod species found in all the stomachs analysed (Dede *et al*., 2016).

In general, from the samples collected during the present work, the striped dolphin shows a narrower prey range compared with the previous two species. The majority of prey belongs to the neritic and oceanic waters, such as round sardinella and several Myctophydae, while benthopelagic and benthic species are much reduced in number and biomass. The presence of cephalopods in the diet of striped dolphins stranded and analysed in the area is common and reaches almost 50% of biomass. Among the cephalopod prey, the mesopelagic species, especially *A. morisii* and the European flying squid, but also other bathypelagic species belonging to

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

Table 5. Prey found in stomach contents of four striped dolphins from North Aegean Sea among 2002–2013.

Family	Species	TOT	%N	%Biomass	%FO
Fish	**Fish**	**333**	**78.17**	**50.34**	**75**
Clupeidae	*Sardinella aurita*	6	1.41	3.76	25
Myctophydae	*Ceratoscopelus maderensis*	218	51.17	12.60	25
Myctophydae	*Diaphus metopoclampus*	3	0.7	0.22	25
Myctophydae	*Lampanyctus crocodilus*	3	0.7	0.27	25
Myctophydae	*Stomias boa*	19	4.46	1.79	25
Myctophydae	*Myctophydae*	31	7.28	–	25
Sparidae	*Boops boops*	36	8.45	27.80	25
Gobidae	*Gobius niger*	1	0.23	0.11	25
Ophidiidae	*Ophidion barbatum*	9	2.11	2.15	25
Soleidae	*Microchirus variegatus*	1	0.23	0.81	25
Soleidae	*Monochirus hispidus*	1	0.23	0.83	25
	Unidentified fish	5	1.17	–	50
Cephalopods	**Cephalopods**	**93**	**21.83**	**49.67**	**100**
Sepiolidae	*Heteroteuthis dispar*	8	1.88	1.97	50
Brachioteuthidae	*Brachioteutis riisei*	2	0.47	0.45	25
Loliginidae	*Loligo vulgaris*	1	0.23	1.57	25
Loliginidae	*Loligo* sp.	1	0.23	2.96	25
Chiroteuthidae	*Chiroteuthis veranyi*	3	0.7	1.57	25
Enoploteuthidae	*Abralia veranyi*	6	1.41	5.91	25
Enoploteuthidae	*Abraliopsis morisii*	44	10.33	4.07	25
Ommastrephidae	*Illex coindeti*	1	0.23	19.25	50
Ommastrephidae	*Todarodes sagittatus*	13	3.05	0.81	25
Ommastrephidae	*Todaropsis eblanae*	3	0.7	5.95	50
Onychoteuthidae	*Ancistroteuthis lichtensteini*	11	2.58	0.99	25
Onychoteuthidae	*Onychoteuthis banksii*	2	0.47	2.60	25
Pyroteuthidae	*Pyroteuthis margaritifera*	9	2.11	2.60	25
	Unidentified cephalopods	6	1.41	–	25

TOT – total number. %Number – Per cent of relative abundance in terms of number of prey. %Biomass – Per cent of relative abundance in terms of estimated biomass of prey; %FO – Per cent values of frequency of occurrence of each species on the total samples.

Table 6. Prey found in stomach contents of five harbour porpoises from North Aegean Sea among 2002–2013.

Family	Species	TOT	%N	%Biomass	%FO
Fish	**Fish**	**1254**	**100**	**100.00**	**100**
Engraulidae	*Engraulis encrasicholus*	76	6.06	4.87	16.7
Clupeidae	*Sardina pilchardus*	30	2.39	4.32	33.3
Clupeidae	*Sardinella aurita*	85	6.78	19.51	33.3
Clupeidae	*Clupeidae*	6	0.48	–	16.7
Cepolidae	*Cepola macrophthalma*	3	0.24	0.60	33.3
Gobiidae	*Deltentosteus quadrimaculatus*	509	40.59	34.71	50
Gobiidae	*Gobius niger*	460	36.68	33.15	50
Gobidae	*Lesueurigobius frisei*	32	2.55	0.32	16.7
Gobidae	*Lesueurigobius sueri*	22	1.75	0.22	16.7
Gobidae	*Pomatochistus* sp.	1	0.08	0.04	16.7
Gobidae	*Gobidae*	3	0.24	–	16.7
Ophidiidae	*Ophidion barbatum*	18	1.44	1.81	16.7
Soleidae	*Solea kleinii*	4	0.32	0.45	16.7
	Unidentified	5	0.4	–	33.3

TOT – total number. %Number – Per cent of relative abundance in terms of number of prey. %Biomass – Per cent of relative abundance in terms of estimated biomass of prey; %FO – Per cent values of frequency of occurrence of each species on the total samples.

the order Teuthida, are present. The diet of the striped dolphins analysed in the area, reflects a habitat mainly mesopelagic and bathypelagic, farther from the continental shelf and more typical of open waters.

DIET OF HARBOUR PORPOISES

Several differences in the diet of harbour porpoises have been found within its geographic areas, due to the difference in prey availability and distribution. Harbour porpoises feed mostly on small fish, especially *Clupea* spp., *Mallotus* spp., *Sprattus* spp. and small schooling fish living close to the seafloor, but occasionally also on squids and crustaceans (Spitz *et al.*, 2006b). Some authors recorded in the diet of the species in Galician waters the prevalence of the species *Trisopterus* spp., *Micromesistus potassou* and *Trachurus* spp., while in Scotland the prevalence of the prey *Merlangius merlangus*

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

Table 7. Prey found in stomach contents of one Risso's dolphin from North Aegean Sea among 2002–2013. Theuthidae type B and C are probably the upper beaks of *H. bonellii* and *H. reversa*, respectively.

Family	Species	TOT	%Number	%Biomass	%FO
Cephalopods	**Cephalopods**	**125**	**100**	**100**	**100**
Brachioteuthidae	*Brachioteutis frisei*	1	0.8	2.05	100
Histioteuthidae	*Histioteuthis bonnellii**	37	29.6	61.45	100
Histioteuthidae	*Histioteuthis reversa*	18	14.4	33.52	100
Argonautidae	*Argonauta argo*	1	0.8	2.98	100
Teuthida	Theutidae type A	5	4	–	100
Teuthida	Theutidae type B*	39	31.2	–	100
Teuthida	Theutidae type Ĉ	15	12	–	100
Teuthida	Theutidae type D	9	7.2	–	100

TOT – total number. %Number – Per cent of relative abundance in terms of number of prey. %Biomass – Per cent of relative abundance in terms of estimated biomass of prey; %FO – Per cent values of frequency of occurrence of each species on the total samples.

Table 8. Trophic level (mean, range, standard deviance, SE and number of specimens) estimated for each of the five cetacean species found and analysed in the North Aegean Sea, using the per cent of biomass of the prey in the diet.

Family	Species	Trophic level	Range	SD	SE	N
Delphinidae	*Tursiops truncatus*	4.42	3.42–4.80	0.44	0.16	8
Delphinidae	*Delphinus delphis*	4.44	4.10–4.75	0.22	0.08	8
Delphinidae	*Stenella coeruleoalba*	4.64	4.22–4.89	0.31	0.16	4
Delphinidae	*Grampus griseus*	4.70	/	/	/	1
Phocoenidae	*Phocoena phocoena*	4.20	4.11–4.37	0.09	0.04	6

SD, – standard deviation; SE, – standard error; N, – number of specimens.

and Ammodytidae was recorded (Read *et al*., 2014). Stomach contents analysis on harbour porpoises stranded along the Dutch coast, indicated that the species fed mainly on gobies, whiting, lesser sandeel, herring, cod, sprat and Clupeidae (Jansen *et al*., 2013; Leopold, 2015), similarly to the specimens stranded along the Belgian coast, where gobies, sandeels (Ammodytidae) and gadoids (Gadidae) were mainly found (Haelters *et al*., 2011). In the Black Sea and Marmara Sea harbour porpoises are recorded as having a typical ichthyophagous diet, where the most common prey were *Sprattus* spp., *Merlangius merlangus* and *Trachurus trachurus* (Tonay *et al*., 2007). Much work has been done on harbour porpoise diet, mainly in the North-east Atlantic and in the Black Sea and from the literature it appears that harbour porpoises mainly feed on both pelagic schooling fish (herring, capelin, whiting, blue whiting, sardine, anchovy), and demersal or benthic fish (hake, small cod, sandeels, gobies) (Santos & Pierce, 2003). Data on the feeding behaviour of this species in the Mediterranean Sea are poorly available and the present work could give a first glance on several aspects of the species in the Mediterranean.

In general, from the samples collected during the present work, the harbour porpoise shows a more restricted diet range in which the single specimens are shown to be very selective. Several specimens not affected by bycatch in fishing gears fed exclusively on benthic species, such as Gobidae in very high numbers and biomass and secondly on Ophidiidae. Other specimens, represented by the two harbour porpoises entangled in static fishing nets, fed only on Clupeidae, such as European anchovy and pilchard and round sardinella, inhabiting the neritic zone and that were not target or discard species of the fishing nets in which they were entangled. This feeding pattern was very interesting and difficult to explain but suggests that the entanglements were due to accidents rather than to predation on the nets.

DIET OF RISSO´S DOLPHINS

The diet of Risso's dolphin is based almost exclusively on squid where the most abundant species are *Ancistroteuthis lichtensteini, Histioteuthis bonnellii, H. reversa* and *Todarodes sagittatus* and the sepiolid *Heteroteuthis dispar* (Carlini *et al*., 1992; Würtz *et al*., 1992; Kruse *et al*., 1999). In the Western Mediterranean the main prey species were oceanic cephalopods, especially *Argonauta argo*, and secondarily species belonging to the families Ommastrephidae, Histioteuthidae and Onychoteuthidae, mainly present between 600 and 800 m depth (Blanco *et al*., 2006). In Greece only few stomach contents have been analysed and not to the species level: in two stomachs several unidentified squids and squid remains were found, and in one of these stomachs the entire skeleton of the beltfish *Trichiurus lepturus* was recorded. In a third stomach of a sick specimen, observed for several days before it died and stranded, only one unidentified squid beak was found (Frantzis, 2009).

In the present research almost the totality of the prey were represented by cephalopods of the Teuthidae order and particularly of the species *Histioteuthis bonnellii* and *H. reversa*. This confirms the results found by the other mentioned authors and shows a very high specialization in the diet of the stranded indivual. Risso's dolphin is typical of the oceanic habitat and it is often associated with the continental shelf and slope, therefore its diet reflects a habitat mainly mesopelagic and bathypelagic, more typical of open waters. One prey species deserves a mention, the greater argonaut *Argonauta argo*, which was present as one specimen in the Risso's dolphin's stomach. The species has never been fished

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

in the North Aegean Sea, even if some evidence of its presence has been found in the Thracian Sea (some paper-thin eggcases produced by females have been found during experimental sampling), according to Lefkaditou (2008). The present work represents the first attempt to investigate the diet of *Grampus griseus* in Greek waters at species level, despite the fact that only one stomach of the species was evaluated.

Trophic levels of cetaceans

In recent years, some authors have demonstrated the phenomenon termed 'fishing down marine food webs' by comparing two global maps of trophic level (TL) changes from the early 1950s to the present (Pauly & Watson, 2005). Calculating trophic level is a necessary first step to quantifying and understanding trophic interactions between marine mammals and other species in marine ecosystems (Trites, 2001). In the present research, as seen from the results, the trophic levels of the studied cetacean species are high to very high, indicating that all the species are at the top level of the trophic system (Stergiou & Karpouzi, 2002). The values range from 4.20 for harbour porpoises to 4.70 for Risso's dolphins. Estimated trophic levels for species were similar to average Mediterranean TROPHs as computed by Kaschner *et al.* (2004) and to global TROPHs (Pauly *et al.*, 1998). In comparison to the Mediterranean values estimated by Kaschner *et al.* (2004), the values obtained for this study area are slightly lower for bottlenose dolphin, common dolphin and harbour porpoise and slightly higher for striped dolphin and Risso's dolphin. These higher values for species that present a high or total presence of cephalopods in the diet could be explained by the fact that most cephalopods were non-commercial species, for which there was no available TROPH value. So a default value, that considers a default TROPH of fish as 3.2 and default TROPH of cephalopods as 3.7, was used. This could have produced a bias in the values. The other lower values are similar to the global values of Pauly *et al.* (1998), since the Mediterranean values calculated by Kaschner *et al.* (2004), were higher than the global ones. Small differences in TROPH values are, however, expected since each species' diet is affected by the availability of prey that could be different for the different regions or even in the same region but in different seasons or years.

In any case, comparing the TROPHs estimated in this research with those of Mediterranean fish species (Stergiou & Karpouzi, 2002) and cephalopods (Pauly *et al.*, 1998), it is evident that cetaceans tend to be positioned higher in the food web than most fish and cephalopod species in the region. The estimated average for Mediterranean fish TROPHs was 3.2, ranging from a value of 2 to 4.5 and average cephalopod TROPHs was 3.7, ranging from 3.4 to 4.6 and, according to their estimation, Mediterranean marine mammals TROPHs had an average value of 4.3, ranging from 3.4 to 4.5.

In the present study, the average TROPHs for the five species of cetacean in the region (bottlenose dolphin, common dolphin, striped dolphin, Risso's dolphin and harbour porpoise) is 4.48, ranging from 4.20 to 4.70. It is important to note that the area investigated in this study has, in general, shallow waters and the presence of deep-water species is extremely occasional, while the study of Kaschner takes into consideration the whole Mediterranean Sea and all the 12 species present in it (the five species of this study and *Balaenoptera physalus, Monachus monachus, Ziphius cavirostris, Globicephala melas, Hyperodon ampullatus, Physater macrocephalus* and *Orcinus orca*). In this research area, apart from one stranding of fin whale (*B. physalus*) where it was impossible to collect the stomach content and a sighting of Mediterranean monk seal (*M. monachus*), where again it was impossible to obtain any feeding information, the other Mediterranean species have never been observed. Only Cuvier's beaked whale (*Z. cavirostris*) have been recorded by Frantzis *et al.* (2003) both by sighting and by stranding north of Limnos Island and off the Chalkidiki Peninsula, in areas where the sea depth is at least 500 m, but never in this present study area, where the greatest depth reaches just 120 m south of Thassos.

The TROPHs values of species with a higher percentage of cephalopods in the diet, such as striped dolphin and especially Risso's dolphin, tend to be higher than the values of species that feed exclusively on fish, such as harbour porpoise. The TROPHs of bottlenose dolphin and common dolphin, which feed primarily on fish and for a smaller percentage on cephalopods, have intermediate values, as expected.

The data on trophic level could be affected by biases due to two main causes. First, the nature of stomach content analysis itself, as we have already discussed; second, the lack in the literature of the trophic level of several prey, especially non-commercial cephalopods and the impossibility of determining the trophic level of prey identified only at family level. In those cases, to overcome this problem, it was necessary to make use of some default TROPHs, found in the literature (Pauly *et al.*, 1998).

The present research, in spite of the limited number of stomachs for each species, gives the first representation of the diet of at least three species in Greece (striped dolphins, Risso's dolphins and harbour porpoises) and paves the way for further detailed dietary studies in the country. Since the North Aegean area is one of the 22 areas of importance for cetaceans defined by ACCOBAMS (2010), the present work has to be seen as a contribution to gaining essential knowledge for the conservation of these species in the region.

ACKNOWLEDGEMENTS

We would like to thank the port authorities of the area for providing stranding records, measurements and photos and the volunteers and friends who periodically took part in the data and sampling collection. Special thanks go to Dr Eugenia Lefkaditou, who has created a collection from the different beaks found during sampling, providing training and assistance for cephalopod beaks identification. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

REFERENCES

ACCOBAMS (2010) *Rapport de la quatrieme reunion des parties contractantes a l' ACCOBAMS*, Monaco, 9–12 November 2010, 399 pp.

Agazzi S., Bearzi G. and Politi E. (2004) Common dolphin prey species in the eastern Ionian Sea: insight from fish scales sampled during surface foraging. *European Research on Cetaceans* 15, 351–353.

Ambrose S.T. (2010) *Feeding ecology and diet shift of long-beaked Common dolphin* Delphinus capensis *(Gray, 1828) incidentally* *caught in anti-shark nets off Kwazulu-Natal, South Africa*. MSc thesis. Rhodes University, 127 pp.

Birkun A. Jr and Frantzis A. (2006) Harbour porpoise *Phocoena phocoena* relicta (Black Sea subspecies). In Reeves R. and Notarbartolo di Sciara G. (compilers and eds) *The status and distribution of cetaceans in the Black Sea and Mediterranean Sea*. Malaga: IUCN Centre for Mediterranean Cooperation, pp. 39–47, 137.

Blanco C., Aznar J. and Raga J.A. (1995) Cephalopods in the diet of the striped dolphin *Stenella coeruleoalba* from the western Mediterranean during an epizootic in 1990. *Journal of Zoology* 237, 151–158.

Blanco C., Raduan M.A. and Raga J.A. (2006) Diet of Risso's dolphin (*Grampus griseus)* in the western Mediterranean. *Scientia Marina* 70, 407–411.

Blanco C., Salomón O. and Raga J.A. (2001) Diet of the bottlenose dolphin (*Tursiops truncatus*) in the western Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 81, 1053–1058.

Boutiba Z. and Abdelghani F. (1995) Food of the common dolphin (*Delphinus delphis*, L.) in Algerian waters. *European Research on Cetaceans* 9, 182.

Brophy J.T., Murphy S. and Rogan E. (2009) *The diet and feeding ecology of the short-beaked common dolphin* (Delphinus delphis) *in the north-east Atlantic*. International Whaling Commission Scientific Committee paper SC/61/SM 14.

Brown E.G. and Pierce G.J. (1998) Monthly variation in the diet of harbour seals in inshore waters along the southeast Shetland (UK) coastline. *Marine Ecology Progress Series* 167, 275–289.

Campillo A. (1992) *Les pêcheries françaises de Méditeranée: synthèse des connaissances*. Issy-les-Moulineaux: Institut Francais de Recherche pour l'Exploitation de la Mer, 206 pp.

Cañadas A. (2006) *Towards conservation of dolphins in the Alboran Sea*. PhD thesis – European Doctorate. Universidad Autonoma de Madrid, 329 pp.

Cañadas A. and Sagarminaga R. (1996) A long-term survey of distribution and dynamics of cetaceans along the south-eastern coast of Spain: fourth year of research 1992–1995. *European Research on Cetaceans* 10, 125–129.

Carlini R., Pulcini M. and Würtz M. (1992) Cephalopods from the stomach of a Risso's dolphins (*Grampus griseus*, Cuvier 1812) stranded along the central Tyrrhenian coast. *European Research on Cetaceans* 6, 196–198.

Cicek E., Avsar D., Yeldan H. and Ozutok M. (2006) Length-weight relationships for 31 teleost fishes caught by bottom trawl net in the Babadillimani Bight (northeastern Mediterranean). *Journal of Applied Ichthyology* 22, 290–292.

Clarke M.R. (ed.) (1986) *A handbook for the identification of cephalopod beaks*. Oxford: Clarendon Press, 273 pp.

Clua E. and Grosvalet F. (2001) Mixed species feeding aggregation of dolphins, large tunas and seabirds in the Azores. *Aquatic Living Resources* 14, 11–18.

Dans S.L., Alonso M.K., Pedraza S.N. and Crespo E.A. (2003) Incidental catch of dolphins in trawling fisheries off Patagonia, Argentina: can populations persist? *Ecological Applications* 13, 754–762.

Dede A., Salman A. and Tonay A.M. (2016) Stomach contents of by-caught striped dolphins (*Stenella coeruleoalba*) in the eastern Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 96, 869–875.

De Pierrepont J.F., Dubois B., Desormonts S., Santos M.B. and Robin J.P. (2005) Stomach contents of English Channel cetaceans stranded on the coast of Normandy. *Journal of the Marine Biological Association of the United Kingdom* 85, 1539–1546.

Duignan P.J. (2000) Marine mammal autopsy techniques and sample collection. In *Marine Wildlife: The Fabian Fay Course for Veterinarians (Proceedings 335)*. Gold Coast, Australia: Post graduate Foundation in Veterinary Science, Sea World, pp. 387–428.

Evans W.E. (1994) Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. In Ridgway S.H. and Harrison R.J. (eds) *Handbook of marine mammals*, Volume 5. London: Academic Press, pp. 191–224.

Fernández R., Santos B.M., Carrillo M., Tejedor M. and Pierce G.J. (2009) Stomach contents of cetaceans stranded in the Canary Islands 1996–2006. *Journal of the Marine Biological Association of the United Kingdom* 89, 873–883.

Filiz H. and Bilge G. (2004) Length-weight relationships of 24 fish species from the North Aegean Sea, Turkey. *Journal of Applied Ichthyology* 20, 431–432.

Fisher W., Bauchot M.L. and Schneider M. (rédacteurs) (1987a) *Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Volume I. Végétaux et Invertébrés*. Rome: FAO, 760 pp.

Fisher W., Bauchot M.L. and Schneider M. (rédacteurs) (1987b) *Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Volume II. Vertèbres*. Rome: FAO, pp. 761–1530.

Fitch J.E. and Brownell R.L. (1968) Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. *Journal of the Fisheries Research Board of Canada* 25, 2561–2574.

Frantzis A. (1997) Cetaceans and cetology in the Hellenic Seas. *European Research on Cetaceans* 10, 114–118.

Frantzis A. (2009) *Cetaceans in Greece: present status of knowledge*. Athens: Initiative for the Conservation of Cetaceans in Greece, 94 pp.

Frantzis A., Alexiadou P., Paximadis G., Politi E., Gannier A. and Corsini-Foka M. (2003) Current knowledge of the cetacean fauna of the Greek Seas. *Journal of Cetacean Research and Management* 5, 219–232.

Geraci J.R. and Lounsbury V.J. (2005) *Marine mammals ashore: a field guide for strandings*. 2nd edition. Baltimore, MD: National Aquarium of Baltimore, 372 pp.

Gurkan S., Bayhan B., Can Akcinar S. and Taskavak E. (2010) Length-weight relationship of fish from shallow waters of Cadarli Bay (North Aegean Sea, Turkey). *Pakistan Journal of Zoology* 42, 495–498.

Haelters J., Kerckhof F., Toussaint E., Jauniaux T. and Degraer S. (2011) *The diet of harbour porpoises bycaught or washed ashore in Belgium, and relationship with relevant data from the strandings database*, Volume 2. Brussels: Royal Belgian Institute of Natural Sciences, 46 pp.

Härkönen T. (1986) *Guide to the otoliths of the bony fishes of the Northeast Atlantic*. Hellerup: Danbiu ApS.

Hassani S., Antoine L. and Ridoux V. (1997) Diets of albacore, *Thunnus alalunga*, and dolphins, *Delphinus delphis* and *Stenella coerulaeoalba*, caught in the Northeast Atlantic albacore drift-net fishery: a progress report. *Journal of Northwest Atlantic Fishery Science* 22, 119–123.

Hernandez-Milian G., Berrow S., Santos M.B., Ried D. and Rogan E. (2015a) Insights into the trophic ecology of bottlenose dolphins (*Tursiops truncatus*) in Irish waters. *Aquatic Mammals* 41, 226–239.

Hernandez-Milian G., Ried D.G. and Rogan E. (2015b) Foraging strategies of an offshore predator: the striped dolphin (*Stenella* *coeruleoalba*). In *Proceedings of the 29th Conference of the European Cetacean Society. St. Julian, Malta, 23rd–25th March 2015*.

Jansen O.E., Michel L., Lepoint G., Das K., Couperus A.S. and Reijnders P.J.H. (2013) Diet of harbor porpoises along the Dutch coast: a combined stable isotope and stomach contents approach. *Marine Mammal Science* 29, 295–311.

Kallianiotis A. (1992) *Biology and structure of Bogue populations [*Boops boops *(L.)], in the coastal area of island of Crete*. Doctorate thesis. University of Crete, 233 pp.

Kallianiotis A., Mazzola S., Petrakis G., Argyri A., Vidoris P., Basilone W., Patti D., Chilari A. and Tsamis E. (2002) The purse seine landing composition in Eastern and Central Mediterranean. *Final Report NAGREF-Fisheries Research Institute Nea Peramos*, Kavala, Greece, 251 pp.

Kapiris K., Karkani M., Borbar L., Corsini-Foka M., Peristeraki N., Komnenou A., Drougas A., Koutrakis E., Christidis A. and Paximadis G. (2015) Strandings of marine mammals and reptiles in the Greek coasts in the period 2010–2013. In *Proceedings of the 11th Hellenic Conference on Oceanography and Fisheries, Mitilene, 13th–17th May 2015*, pp. 217–220. [In Greek]

Karakulak F.S., Erk H. and Bilgin B. (2006) Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *Journal of Applied Ichthyology* 22, 274–278.

Kaschner K., Stergiou K.I., Weingartner G. and Kumagai S. (2004) Trophic levels of marine mammals and overlap in resource utilization between marine mammals and fisheries in the Mediterranean Sea. In *Investigating the Roles of Cetaceans in Marine Ecosystems. CIESM Workshop Venice, 28–31 January 2004*, pp. 51–58.

Koutrakis E.T. and Sinis A.I. (1994) Growth analysis of gray mullets (Pisces, Mugilidae) as related to age and site. *Israel Journal of Zoology* 40, 37–53.

Koutrakis E.T. and Tsikliras A.C. (2003) Length-weight relationships of fishes from three northern Aegean estuarine systems (Greece). *Journal of Applied Ichthyology* 19, 258–260.

Kovacic I. and Bogdanovic I. (2006) *Diet of the bottlenose dolphin (Tursiops truncatus,* Montague 1821) in the Adriatic Sea. Gdynia: Act of the European Cetacean Society.

Kruse S., Caldwell D.K. and Caldwell M.C. (1999) Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In Ridgway S.H. and Harrison R. (eds) *Handbook of marine mammals Volume 6: the second book of dolphins and the porpoises*. London: Academic Press, pp. 183–212, i-xix+ pp. 486.

Lamprakis M.K., Kallianiotis A.A., Moutopoulos D.K. and Stergiou K.I. (2003) Weight-length relationships of fishes discarded by trawlers in the North Aegean Sea. *Acta Ichthyologica et Piscatoria* 33, 145–152.

Lefkaditis D. (2009) *Intelligent visual otolith classification for bony fish species recognition*. PhD thesis, School of Engineering, University of Brighton (in collaboration with the Fisheries Research Institute in Kavala, Greece), 184 pp.

Lefkaditou E. (2006) *Taxonomy and biology of cephalopods in the North Aegean Sea*. PhD thesis, University of Patras, Patras, Hellas, 298 pp + Annexes. [In Greek, English abstract]

Lefkaditou E. (2008) Τα Κεφαλόποδα Των Ελληνικόν Θαλασσόν. Προκαταρτική Εκδόση. (Cephalopods of the Greek Seas. Preliminary version). HCMR Publ., Athens, 78 pp. [In Greek]

Leopold M.F. (2015) *Eat and be eaten. Porpoise diet studies*. PhD thesis, Wageningen University, November 2015, 239 pp.

Lombarte A., Chic O., Parisi-Baradad V., Olivella R., Piera J. and Garcia-Ladona E. (2006) A web-based environment for shape analysis of fish otoliths. The AFORO database. *Scientia Marina* 70, 147–152.

Lu C.C. and Ickeringill R. (2002) Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes. *Museum Victoria Science Reports*6, 65 pp.

Madureira L.S.P. and Rossi-Wongtschowski C.L.D.B. (2005) Prospecção de recursos pesqueiros pelágicos na Zona Econômica Exclusiva da Região Sudeste-Sul do Brasil: hidroacústica e biomassas. *Série documentos Revizee: Score Sul, Instituto Oceanográfico*. São Paulo: USP, 144 pp. [In Portuguese]

Merella P., Quetglas A., Alemany F. and Carbonell A. (1997) Length-weight relationship of fishes and cephalopods from the Balearic Islands (western Mediterranean). *Naga, the ICLARM Quarterly* 20, 66–68.

Merriam-Webster (2012) *MedlinePlus medical dictionary*. http://www.merriam-webster.com/medlineplus.

Milani C., Vella A., Vidoris P., Christidis A. and Kallianiotis A. (2011) Diet of five cetacean species in the North Aegean Sea (Greece). In *Proceedings of the 25th Conference of the European Cetacean Society, Cadiz, 21–23 March 2011*.

Milani C., Vella A., Vidoris P., Christidis A. and Kallianiotis A. (2012) Dolphin species' diet, fisheries association and net damage in coastal fisheries of the North Aegean Sea (Greece). In *Proceedings of the 26th Conference of the European Cetacean Society, Galway, 26–28 March 2012*.

Minakakis B. (2009) *Geography and geopolitics of Greece, Volume 1. World illustrated atlas*. Athens: Sky Book Publications, 189 pp. [In Greek]

Moore K.T. and Barco S.G. (2013) *Handbook for recognizing, evaluating, and documenting human interaction in stranded cetaceans and pinnipeds*. Washington, DC: U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-510, 102 pp.

Moutopoulos D.K. and Stergiou K.I. (2002) Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology* 18, 200–203.

NOAA (1993) *Marine mammals ashore: a field guide for strandings*. National Marine Fisheries Service Office of Protected Resources. Galvestone, TX: Texas A&M Sea Grant Publications, 118 pp.

Ohizumi H., Yoshioka M., Mori K. and Miyazaki N. (1998) Stomach contents of common dolphins (*Delphinus delphis*) in the pelagic western North Pacific. *Marine Mammal Science* 14, 835–844.

Orsi Relini L. and Relini M. (1993) The stomach content of some bottlenose dolphins (*Delphinus delphis* L.) from the Ligurian Sea. *European Research on Cetaceans* 7, 99–102.

Öztürk A.A., Tonay A.M. and Öztürk B. (2012) *Review on small cetaceans of the Turkish part of the Eastern Mediterranean Sea*. International Whaling Commission, SC/65b/SM15Rev., 7 pp.

Öztürk B., Salman A., Öztürk A.A. and Tonay A. (2007) Cephalopod remains in the diet of striped dolphins (*Stenella coeruleoalba*) and Risso's dolphins (*Grampus griseus*) in the eastern Mediterranean Sea. *Vie et Milieu* 57, 57–63.

Pauly D. and Christensen V. (2000) Trophic levels of fishes. In Froese R. and Pauly D. (eds) *FishBase 2000: concepts, design and data sources*. Los Baños Laguna, Philippines: ICLARM, p. 181.

Pauly D., Christensen V., Dalsgaard J., Froese R. and Torres F. Jr (1998) Fishing down marine food webs. *Science* 279, 860–863.

Pauly D. and Watson R. (2005) Background and interpretation of the 'Marine Trophic Index' as a measure of biodiversity. *Philosphical Transactions of the Royal Society B* 360, 415–423.

Pierce G.J., Santos B.M., Learmonth J.A., Mente E. and Stowasser G. (2004) Methods for dietary studies on marine mammals. In *Investigating the Roles of Cetaceans in Marine Ecosystems. CIESM Workshop, Venice, 28–31 January 2004*, pp. 29–38.

Pugliares K.R., Bogomolni A., Touhey K.M., Herzig S.M., Harry C.T. and Moore M.J. (2007) Marine mammal necropsy: an introductory guide for stranding responders and field biologists. Technical Report, The Cape Cod Stranding Network. doi: 10.1575/1912/1823.

Pulcini M., Carlini R. and Würtz M. (1992) Stomach contents of striped dolphin *Stenella coeruleoalba* (Meyen, 1833) from the South-Central Tyrrenian coast. *European Research on Cetaceans* 6, 194–195.

Pusineri C., Magnin V., Meynier L., Spitz J., Hassani S. and Ridoux V. (2007) Food and feeding ecology of the common dolphin (*Delphinus delphis*) in the Oceanic Northeast Atlantic and comparison with its diet in neritic areas. *Marine Mammal Science* 23, 30–47.

Read F., Learmonth J., Santos M.B., Thomsen I., González A., López A., Ferreira M., Murphy S., Brownlow A. and Pierce G.J. (2014) Harbour porpoise life history, diet and fisheries interactions in two regions of the Northeast Atlantic: Scotland (UK) and the north-west Iberian Peninsula. In *28th Conference of the European Cetacean Society, Liege, Belgium, 5th–9th April 2014*, p. 52.

Ringelstein J., Pusineri C., Hassani S., Meynier L., Nicolas R. and Ridoux V. (2006) Food and feeding ecology of the striped dolphin *Stenella coeruleoalba*, in the oceanic waters of the north-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom* 86, 909–918.

Rojo-Nieto E., Álvarez-Díaz P. D., Morote E., Burgos-Martín M., Montoto-Martínez T., Sáez-Jiménez J. and Toledano F. (2011) Strandings of cetaceans and sea turtles in the Alboran Sea and Strait of Gibraltar: a long-term glimpse at the north coast (Spain) and the south coast (Morocco). *Animal Biodiversity and Conservation* 34, 151–163.

Romeo T., Battaglia P., Pedà C., Perzia P., Consoli P., Esposito V. and Andaloro F. (2012) Pelagic cephalopods of the central Mediterranean Sea determined by the analysis of the stomach content of large fish predators. *Helgoland Marine Research* 66, 295–306.

Santos M.B. (1998) *Feeding ecology of harbour porpoises, common and bottlenose dolphins and sperm whales in the Northeast Atlantic.* PhD thesis, University of Aberdeen, Aberdeen, Scotland.

Santos M.B., Fernández R., López A., Martínez J.A. and Pierce G.J. (2007) Variability in the diet of bottlenose dolphin, *Tursiops truncatus* (Montagu), in Galician waters, NW Spain, 1990–2005. *Journal of the Marine Biological Association of the United Kingdom* 87, 231–242.

Santos M.B., German I., Correia D., Read F.L., Martinez-Cedeira J., Caldas M., López A., Velasco F. and Pierce G.J. (2013) Long-term variation in common dolphin diet in relation to prey abundance. *Marine Ecology Progress Series* 481, 249–268.

Santos M.B. and Pierce G.J. (2003) Diet of harbour porpoise (*Phocoena phocoena*) in the Northeast Atlantic. *Oceanography and Marine Biology* 41, 355–390.

Santos M.B., Pierce G.J., López A., Martínez J.A., Fernández M.T., Ieno E., Mente E., Porteiro C., Carrera P. and Meixide M. (2004) *Variability in the diet of common dolphins (Delphinus delphis)* in Galician waters 1991–2003 and relationships with prey abundance. Copenhagen: ICES CM, pp. 21.

Schmidt W. (1968) Vergleichend morphologische Studie uber die Otolithen mariner Knochenfische. *Arch. Fischeriwiss* Volume 19 Beiheft 1, 1–96. Berlin. [In German]

Silva M.A. (1999) Diet of common dolphins (*Delphinus delphis*) off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom* 79, 531–540.

Sobrino I. and Gil J. (2001) Studies on age determination and growth pattern of the red (Blackspot) seabream [*Pagellus bogaraveo* (Brünnich, 1768)] from the Strait of Gibraltar (ICES 9a/SW Spain): application to the species migratory pattern. *Science Council Research Document* NAFO SCR Doc. 01/87. Serial no. N4474, 5 pp.

Spitz J., Richard E., Meynier L., Pusineri C. and Ridoux V. (2006a) Dietary plasticity of the oceanic striped dolphin, *Stenella coeruleoalba*, in the neritic waters of the Bay of Biscay. *Journal of Sea Research* 55, 309–320.

Spitz J., Mourocq Y., Leauté J.P., Quéro J.C. and Ridoux V. (2010) Prey selection by the common dolphin: fulfilling high energy requirements with high quality food. *Journal of Experimental Marine Biology and Ecology* 390, 73–77.

Spitz J., Rousseau Y. and Ridoux V. (2006b) Diet overlap between harbour porpoise and bottlenose dolphin: an argument in favour of interference competition for food? *Estuarine, Coastal and Shelf Science* 70, 259–270.

Stergiou K.I., Bobori D.C., Ekmekçi F.G., Gökoğlu M., Karachle P.K., Minos G., Özvarol Y., Salvarina I., Tarkan A.S. and Vilizzi L. (2014) New fisheries-related data from the Mediterranean Sea (April 2014). *Mediterranean Marine Science* 15, 213–224.

Stergiou K.I. and Karpouzi V.S. (2002) Feeding habits and trophic level of Mediterranean fish. *Reviews in Fish Biology and Fisheries* 11, 217–254.

Stergiou K.I. and Moutopoulos D.K. (2001) A review of length-weight relationships of fishes from Greek marine waters. *Naga, the ICLARM Quarterly* 24, 23–39.

Stergiou K.I. and Politou C.-Y. (1995) Biological parameters, body length-weight and length-height relationships for various species in Greek waters. *Naga, the ICLARM Quarterly* 18, 42–45.

Tonay A.M., Dede A., Öztürk A.A. and Öztürk B. (2007) Stomach content of harbour porpoise (*Phocoena phocoena*) from the Turkish western Black Sea in spring and early summer. *Rapport Commissione Internationale Mer Méditerranée* 38, 616.

Torres M.A., Ramos F. and Sobrino I. (2012) Length-weight relationships of 76 fish species from the Gulf of Cadiz (SW Spain). *Fisheries Research* 127–128, 171–175.

Tregenza N.J.C., Berrow S.D., Hammond P.S. and Leaper R. (1997) Common dolphin, *Delphinus delphis* L., by-catch in bottom set gillnets in the Celtic Sea. *Report of the International Whaling Commission* 47, 835–839.

Trites A.W. (2001) Marine mammals trophic levels and interactions. In Steele J., Thorpe S. and Turekain K. (eds) *Encyclopedia of ocean science.* London: Academic Press, pp. 1628–1633.

Tuset V.M., Lombarte A. and Assis C.A. (2008) Otolith atlas for the western Mediterranean, north and central eastern Atlantic. *Scientia Marina* 72(S1), 7–198.

Veiga P., Machado D., Almeida C., Bentes L., Monteiro P., Oliveira F., Ruano M., Erzini K. and Gonçalves J.M.S. (2009) Weight-length relationships for 54 species of the Arade estuary, southern Portugal. *Journal of Applied Ichthyology* 25, 493–496.

Violani A., Mancusi C., Padà C., Romeo T., Scuderi A. and Targusi M. (2012) Analisi del contenuto stomacale degli esemplari di *Stenella coeruleoalba* (Montagu, 1821) spiaggiati lungo le coste toscane. *Sez. Scientifica* 29, 240–246. [In Italian]

Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen and Tortonese E. (eds) (1984) *Fishes of the North-eastern Atlantic and the Mediterranean*, Volume I. Bungay: Printed by Richard Clay Ltd, 516 pp.

Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen and Tortonese E. (eds) (1986a) *Fishes of the North-eastern Atlantic and the Mediterranean*, Volume II. Bungay: Printed by Richard Clay Ltd, pp. 517–1014.

Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen and Tortonese E. (eds) (1986b) *Fishes of the North-eastern Atlantic and the*

Mediterranean, Volume III. Bungay: Printed by Richard Clay Ltd, pp. 1015–1473.

Würtz M. and Marrale D. (1993) Food of striped dolphin, *Stenella coeruleoalba*, in the Ligurian Sea. *Journal of the Marine Biological Association of the United Kingdom* 73, 571–578.

and

Würtz M., Poggi R. and Clarke M.R. (1992) Cephalopods from the stomach of a Risso's dolphin, *Grampus griseus*, from the Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* 72, 861–867.

Correspondence should be addressed to:
C.B. Milani
Conservation Biology Research Group, University of Malta, Msida MSD 2080, Malta
email: crismilani13@hotmail.com

APPENDIX

Table A1. Regression equations used to estimate fish and cephalopods sizes and biomass.

Family	Species	Estimated prey length (mm)	Source	Estimated prey weight (g)	Source
Clupeidae	*Engraulis encrasicholus*	TL = 9.14 + 0.26*OL	Ka & (02)	*W* = 0.0128*TL^2.7828	K & T (03)
	Sardina pilchardus	TL = 788 + 16.66*OL	Ka & (02)	*W* = 0.016*TL^2.868	K & T (03)
	Sardinella aurita	See note 1 & 2		*W* = 0.0087*TL^2.95	K & T (03)
Synodontidae	*Synodus saurus*	See note 1		*W* = 0.02*TL^2.715	S & M (01)
Myctophydae	*Ceratoscopelus maderensis*	See note 3		See note 4	
	Diaphus metopoclampus	See note 3		See note 4	
	Lampanyctus crocodilus	See note 3		*W* = 0.0051*TL^2.98	Me & (97)
	Lobianchia gemellarii	See note 3		See note 4	
	Myctophum punctatum	See note 3		*W* = 0.01504*TL^3	Pa & (98)
	Notoscopelus bolini	See note 3		See note 4	
	Symbolophorus veranyi	See note 3		*W* = 0.0156*TL^2.912	M & R (05)
	Stomias boa	See note 3		See note 4	
Nettastomidae	*Nettastoma melanurum*	See note 5		See note 5	
Congridae	*Conger conger*	See note 1 & 2		*W* = 0.00054*TL^3.225	S & M (01)
Mugilidae	*Liza ramada*	See note 1		*W* = 0.011*TL^2.955	K & T (03)
Belonidae	*Belone belone*	OL/FL = 1:110–170	Hä (86)	*W* = 0.009*TL^3.04	K & T (03)
Melucciidae	*Merluccius merluccius*	TL = −0.63 + 23.88*OL	Hä (86)	*W* = 0.016*TL^2.77	St & (14)
Serranidae	*Serranus cabrilla*	See note 6		*W* = 0.0144*TL^2.935	K & S (08)
	Serranus hepatus	TL = −0.4354 + 0.9196*VL	Pi & (11)	*W* = 0.0121*TL^3.122	La & (03)
Cepolidae	*Cepola macrophthalma*	See note 7		*W* = 0.0863*TL^1.543	La & (03)
Carangidae	*Trachurus mediterraneus*	TL = −27.02 + 34.939*OL	B & P (98)	*W* = 0.00339*TL^3.273	S & M (01)
Sparidae	*Boops boops*	See note 7		*W* = 0.01467*TL^2.877	M & S (02)
	Dentex macrophthalmus	See note 7		See note 8	
	Oblada melanura	See note 7		*W* = 0.02185*TL^2.831	S & M (01)
	Diplodus vulgaris	See note 7		*W* = 0.0119*TL^3.125	K & S (08)
	Diplodus spp.	See note 9		*W* = 0.0365*TL^2.695	M & S (02)
	Lithognathus mormyrus	See note 7		*W* = 0.0094*TL^3.115	K & T (03)
	Pagellus acarne	TL = −1.443 + 2.2698*OL	Pi & (11)	*W* = 0.01501*TL^2.933	M & S (02)
	Pagellus bogaraveo	TL = 24.25 + 1.12*OL	S & G (01)	*W* = 0.007*TL^3.209	Ca (92)
	Pagellus erythrinus	TL = −2.3896 + 2.5229*OL	Pi & (11)	*W* = 0.0231*TL^2.778	M & S (02)
	Pagrus pagrus	See note 7		*W* = 0.152*TL^3.005	M & S (02)
	Spondilosoma cantharus	See note 7		*W* = 0.01772*TL^2.951	M & S (02)
Centracanthidae	*Centracanthus cirrus*	See note 10		*W* = 0.0081*TL^3.039	Ci & (06)
	Spicara maena	TL = 6.436 + 1.858*OF	Pi & (11)	*W* = 0.0356*TL^2.627	M & S (02)
	Spicara spp.	See note 10		See note 10	
Pomacentridae	*Chromis chromis*	See note 7		*W* = 0.09959*TL^2.415	S & M (01)
Labridae	*Symphodus* spp.	See note 11		*W* = 0.01439*TL^3.012	S & M (01)
Scombridae	*Scomber colias*	See note 12		*W* = 0.0051*TL^3.131	To & (12)
	Scomber scombrus	TL = −20.41 + 87.59*OL	Hä (86)	*W* = 0.00446*TL^3.348	S & M (01)
Gobiidae	*Deltentosteus quadrimaculatus*	See note 13		*W* = 0.0074*TL^3.05	Me & (97)
	Gobius niger	TL = −0.4332 + 3.5852*OL	Pi & (11)	*W* = 0.03045*TL^2.89	S & P (95)
	Lesueurigobius friesii	See note 13		*W* = 0.0392*TL^2.13	F & B (04)
	Lesueurigobius suerii	See note 13		*W* = 0.0155*TL^2.561	La & (03)
	Pomatochistus spp.	TL = −23.36 + 56.94*OW (See note 14)	Hä (86)	*W* = 0.0037*TL^3.289	Gu & (10)
Ophidiidae	*Ophidion barbatum*	See note 7		*W* = 0.0762*TL^2.081	Ka & (06)
Sphyraenidae	*Sphyraena sphyraena*	See note 7		*W* = 0.06477*TL^2.32	S & M (01)
Atherinidae	*Atherina boyeri*	See note 7		*W* = 0.0075*TL^3.023	K & T (03)
Triglidae	*Trigla lucerna*	TL = 16.7 + 71.92*OL (See note 15)	Hä (86)	*W* = 0.00985*TL^3.011	S & M (01)
Citharidae	*Citharus linguatula*	See note 7		*W* = 0.00074*TL^3.447	S & M (01)

Continued

Table A1. Continued

Family	Species	Estimated prey length (mm)	Source	Estimated prey weight (g)	Source
Soleidae	*Microchirus variegatus*	See note 7		$W = 0.0137$*TL^3.027	Ka & (06)
	Monochirus hispidus	See note 7		$W = 0.01439$*TL^3.16	Ve & (09)
	Solea kleinii	See note 7		$W = 0.0075$*TL^3.04	K & T (03)
Sepiolidae	*Heteroteuthis dispar*	ML = 17.474*LRL1.924	Wü &(92)	$W = 3.201$*LRL 3.081	Wü &(92)
Sepiidae	*Sepia officinalis*	ML = −2.14 + 21.89*LHL	Sa & (07)	$W = 0.123687$*LRL^4.06	Sa & (07)
Loliginidae	*Loligo forbesi*	ML = −42.22 + 84.274*LRL	Sa & (07)	$W = 6.19536$*LRL^3.242	Sa &(07)
	Loligo vulgaris	ML = −42.22 + 84.274*LRL	Sa & (07)	$W = 14.913$*LRL^2.8798	Le (Unp)
	Loligo spp.	ML = −42.22 + 84.274*LRL	Sa & (07)	$W = 6.19536$*LRL^3.242	Sa & (07)
Brachioteuthidae	*Brachioteutis riisei*	ML = 6.25 + 8.13*LRF	L & I (02)	ln$W$ = 0.55 + 1.41*ln LRL	Cl (86)
Chiroteuthidae	*Chiroteuthis veranyi*			lnW = −0.241 + 2.7*ln LRL	Cl (86)
Enoploteuthidae	*Abralia veranyi*	ML = −2.103 + 24.257*LRL	Öz & (07)	lnW = 0.979 + 2.304*lnLRL	Ro & (12)
	Abraliopsis morisii	ML = −6.6187 + 27.747*URL	Le (Unp)	lnW = −3.25 + 3.09*lnLRF (See note 16)	L & I (02)
Histioteuthidae	*Histioteuthis bonnellii*	ML = −2.36 + 5.36*LRF	L & I (02)	lnW = −2.69 + 3.04*lnLRF	L & I (02)
	Histioteuthis reversa	ML = −1.97 + 7.75*LRF	L & I (02)	lnW = −2.49 + 2.99*lnLRF	L & I (02)
Argonautidae	*Argonauta argo*	ML = −46.7764 + 18.2608*LCL	Ro & (12)	lnW = −0.545 + 3.26*lnLHL	Ro & (12)
Ommastrephidae	*Illex coindetii*			$W = 5.3059$ LRL^2.5038	Le (Unp)
	Todarodes sagittatus			$W = 7.6139$ LRL^2.218	Le (Unp)
	Todaropsis eblanae	ML = −35.56 + 31.63*LHL	L & I (02)	lnW = −0.19 + 3.00*lnLHL	L & I (02)
Onychoteuthidae	*Ancistroteuthis lichtensteini*	ML = 33*LRL^0.983	Wü &(92)	$W = 2.296$xLRL^2.207	Wü &(92)
	Onychoteuthis banksii	ML = 7.73 + 38.45*LHL	L & I (02)	lnW = 0.80 + 2.46*lnLHL	L & I (02)
Pyroteuthidae	*Pyroteuthis margaritifera*	ML = 5.48 + 21.54*LHL	L & I (02)	lnW = 0.41 + 2.78*lnLHL	L & I (02)
Octopodidae	*Octopus vulgaris*	See notes 1 & 2		$W = 6.17186$*LRL^3.03	Cl (86)
	Pteroctopus tetracirrhus	ML = 17.98378*LHL^1.3371	Le (Unp)	$W = 1.0771$*LHL^4.3455	Le (Unp)

TL, total length for fish; ML, dorsal mantel length for cephalopods; W, total weight; lnW, natural logarithm of weight; OL, otolith length; OW, otolith width; OF, outer fork length (from symphysis to the outer fork of the dentary); VL, ventral length (from symphysis to the tip of the ventral limb of the dentary); LRF, lower rostral tip to lateral wall free corner length; LHL, lower hood length; LRL, lower rostral length; UCL, upper crest length. Sources are as follows: B & P (98), Brown & Pierce (1998); Ca (92), Campillo (1992); Ci & (06), Cicek *et al.* (2006); Cl (86), Clarke (1986); F & B (04), Filiz & Bilge (2004); Gu & (10), Gurkan *et al.* (2010); Hä (86), Härkönen (1986); Ka & (02), Kallianiotis *et al.* (2002); Ka & (06), Karakulak *et al.* (2006); K & S (94), Koutrakis & Sinis (1994); K & T (03), Koutrakis & Tsikliras (2003); La & (03), Lamprakis *et al.* (2003); Le (Unp), Lefkaditou (Unpublished); L & I (02), Lu & Ickeringill (2002); M & R (05), Madureira & Rossi-Wongtschowski (2005); Me & (97), Merella *et al.* (1997); M & S (02), Moutopoulos & Stergiou (2002); Öz & (12), Özturk *et al.* (2012); Pa & (98), Pauly *et al.* (1998); Pi *&* (11), Pierce *et al.* (2011); Ro & (12), Romeo *et al.* (2012); Sa & (07), Santos *et al.* (2007); S & G (01), Sobrino & Gil (2001); St & (14), Stergiou *et al.* (2014); S & M (01), Stergiou & Moutopoulos (2001); S & P (95), Stergiou & Politou (1995); To & (12), Torres *et al.* (2012); Ve & (09), Veiga *et al.* (2009); Wü & (92), Würtz *et al.* (1992).

Notes:

(1) No regression was available for this species and length was estimated in comparison with reference material.
(2) Intact animals were found and measured.
(3) No regression was available for this species/genus and the regression for *Benthosema glaciale* was used.
(4) No regression was available for this species/genus and the regression for *Lampanyctus crocodilus* was used.
(5) No regression was available for this species/genus and the regression for *Conger conger* was used.
(6) No regression was available for this species and the regression for *Serranus hepatus* was used.
(7) Length was estimated in comparison with Tuset *et al.* (2008).
(8) No regression was available for this species/genus and the regression for *Pagrus pagrus* was used.
(9) We used the regression for *D. anularis*, the most common *Diplodus* in the area.
(10) We used the regression for *Spicara maena*, the most common *Centracanthidae* in the area.
(11) We used the regression for *S. mediterraneus*, one of the most common *Symphodus* in the area.
(12) No regression was available for this species and the regression for *S. scombrus* was used.
(13) No regression was available for this species/genus and the regression for *Gobius niger* was used.
(14) We used the regression for *P. minutus*, the most common *Pomatoschistus* in the area.
(15) No regression was available for this species/genus and the regression for *Eutrigla gurnardus* was used.
(16) No regression was available for this species and the regression for *Abraliopsis gilchristi* was used.

https://doi.org/10.1017/S0025315417000339 Published online by Cambridge University Press

Table A2. Sixty specimens belonging to six different species of cetaceans, stranded from Strimonikos to Alexandroupoli, during the years 1998–2013.

Species	Date	Gen.	Age Cl	Tot. length	Site	Notes
Balaenoptera physalus	26/12/1998	F	YO	1250	Nea Iraklitsa	
Grampus griseus	1/6/1999	M	YO	240	Eleftheres (Egnatia)	
Phocoena phocoena	11/2/2000	M	AD	128	Evros Delta	**Propeller**
Tursiops truncatus	21/3/2000	M	AD	294	Erasmiou (Xanti)	
Delphinus delphis	22/3/2000			195	Maronia	
Delphinus delphis	22/3/2000			240	Maronia	
Delphinus delphis	22/3/2000			215	Maronia	
Delphinus delphis	23/3/2000	M	AD	195	Manaritsa (Maronia)	
Delphinus delphis	18/1/2001	F	AD	223	Kavala	
Tursiops truncatus	3/2/2001	F	AD	275	Vasova	
Tursiops truncatus	30/4/2001	M	YO	193	Alexandroupoli	
Stenella coeruleoalba	29/5/2001	M	AD	193	Keramoti	**Shot**
Stenella coeruleoalba	10/10/2001	M	AD	222	Pr. Ilias (Maronia)	
Stenella coeruleoalba	14/12/2001	M	OL	225	Nea Iraklitsa	
Tursiops truncatus	22/1/2002	F	AD	267	Pirgo (Egnatia)	
Stenella coeruleoalba	28/3/2002	F	YO	139	Porto Lagos	
Stenella coeruleoalba	22/4/2002	F	AD	201	Almira (Egnatia)	
Tursiops truncatus	9/5/2002				Almira (Egnatia)	
Delphinus delphis	18/11/2002	M	YO	174	Sfaghia (Kavala)	**Entangled**
Phocoena phocoena	17/1/2003				Amolofi (Nea Peramos)	
Phocoena phocoena	25/3/2003	F	AD	135	Strimona	
Stenella coeruleoalba	2/4/2003	M	AD	193	Nea Karvali	
Grampus griseus	9/1/2004	M	YO	273	Alkioni (Maronia)	
Delphinus delphis	16/4/2004	M	AD	215	Amolofi (Nea Peramos)	
Delphinus delphis	19/4/2004	M	AD	238	Kavala	
Baby *Delphinus* or *Stenella*	26/1/2005	M	CA	43	Nea Karvali	
Tursiops truncatus	14/2/2005	M	AD	260	S. Christophoros Egnatia	
Tursiops truncatus	8/5/2005	F	OL	285	Kavala	**Net in stomach**
Phocoena phocoena	20/7/2005	M	YO	124	Nea Iraklitsa	
Delphinus delphis	28/12/2005				Nea Karvali	
Delphinus delphis	3/1/2006				Potamia (Thassos)	Alive, released
Delphinus delphis	5/2/2006				Kavala	
Delphinus delphis	20/11/2006	F	YO	106	Peramos	
Phocoena phocoena	22/12/2006	F	AD	138	Palio (Kavala)	**Entangled**
Undetermined	24/12/2006				Kalamitsa (Kavala)	
Phocoena phocoena	11/5/2007	F	YO	110	Alexandroupoli	
Stenella coeruleoalba	9/1/2008	F	YO	200	Pirgo (Egnatia)	
Tursiops truncatus	8/2/2008	F	AD	252	Nea Peramos	**Net in oesophagus**
Stenella coeruleoalba	18/3/2008	F	AD	215	Nea Iraklitsa	Alive, released
Stenella coeruleoalba	21/3/2008	M	YO	177	Nea Karvali	
Tursiops truncatus	10/10/2008	F	OL	288	Nea Peramos	
Phocoena phocoena	13/11/2008	F	YO	103	Nea Peramos	
Stenella coeruleoalba	5/2/2009	M	YO	153	Nea Iraklitsa	
Delphinus delphis	21/3/2009	M		191	Kavala	
Delphinus delphis	18/9/2009	M	YO	213	Egnatia	
Delphinus delphis	28/9/2009	M	AD	224	Spathis Kavalas	
Delphinus delphis	3/10/2009	F	AD	204	Nea Karvali	
Undetermined	6/11/2009				Nea Karvali	
Delphinus delphis	7/11/2009	M	AD	190	Palio (Kavala)	
Delphinus delphis	19/4/2010		AD	220	Kavala	
Balaenoptera physalus	20/4/2010				Keramoti	
Stenella coeruleoalba	21/5/2010			214	Nea Peramos	
Stenella coeruleoalba	26/10/2010	M	YO	214	Prinos (Thassos)	**Entangled**
Tursiops truncatus	11/5/2011				Porto Lagos	
Tursiops truncatus	11/7/2011				Nea Karvali	
Stenella coeruleoalba	2/4/2012			210	Palio Glastres	**very bad condition**
Stenella coeruleoalba	19/9/2012	M	YO	196	Paralia Ofriniou	**very bad condition**
Stenella coeruleoalba	23/10/2012	M	YO	197	Kavala (cementry)	**stomach empty**
Delphinus delphis	22/2/2013	M	YO	205	Kavala (port)	**very bad condition**
Phocoena phocoena	22/8/2013	F	YO/AD	132	Kavala (Sfaghia)	**Entangled**

Gen, gender; Age Cl, age class; YO, young; AD, adult; OL, old; CA, calf; Total length in cm.