A Visual and Acoustic Survey for Marine Mammals in the Eastern Mediterranean Sea during Summer 2013

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Contents

Executive Summary

A research project was conducted by the *Song of the Whale* team and collaborators between 18 July and 2 September 2013 to undertake the first systematic broad-scale survey for sperm whales and harbour porpoises in the northern and central Aegean Sea and to survey parts of the eastern Mediterranean Sea that have previously received poor survey coverage. The Aegean Sea was surveyed both visually and acoustically for marine mammals at different spatial scales including: a broad-scale survey for sperm and beaked whales; and a fine-scale survey of the Thracian Sea (in the northern Aegean Sea) for harbour porpoises. Parts of the northern and central Levantine Sea were also surveyed between Rhodes, southern Turkey and Cyprus, as far south as the Eratosthenes Seamount. Unfortunately, it was not possible to obtain permission to survey within Egypt's EEZ (there was significant political unrest in Egypt during 2013).

The project had several aims: to fill the significant remaining systematic survey 'gaps' for sperm whales in the Mediterranean; investigate the waters of the northern reaches of the Aegean Sea for the presence of harbour porpoises and, to provide data to help identify risks posed by shipping to cetaceans such as noise pollution and ship-strikes. As such, background noise measurements were routinely collected using a calibrated hydrophone. Furthermore, Automatic Identification System (AIS) data were recorded to enable shipping traffic density estimations to be derived. Results are reported and a spatial analysis of the data presented. Notable findings include:

- Confirmation of the presence of harbour porpoises in the Thracian Sea (northern Aegean Sea): the first sightings of free-ranging porpoises in the Mediterranean for over 20 years. Groups of porpoises were sighted on two different dates in Saros Bay, Turkey, with one encounter including a calf. Acoustic detections of harbour porpoises were made in Greek Aegean waters north of Thasos Island and south of Alexandroupolis.
- Acoustic confirmation of the presence of beaked whales in the Aegean and Levantine Seas. A group of two beaked whales was acoustically detected in the Ikaria Basin (central Aegean Sea). Individual beaked whales were recorded on seven occasions over the Anaximander Seamounts to the south of Turkey.
- Sperm whales were recorded in three discrete locations during the survey: on two separate occasions in the Ikaria Basin; in the Rhodes Basin (east of Rhodes); and south of Cyprus. The latter detection is especially noteworthy as it occurred in an area where records of this species are rare, (a previous survey in 2007 did not detect any sperm whales in this block, but this may possibly reflect limited research effort). It is hoped that these detections will highlight the need for consideration of the presence of this species during oil and gas exploration which is gathering pace in the region.
- Rough-toothed dolphins, a species which is rarely encountered in the Mediterranean Sea, were encountered twice off Cyprus. The first sighting was of a mixed pod with Risso's dolphins. During

both encounters whistles were recorded with idiosyncratic jumps in frequency that may prove invaluable in recognising rough-toothed dolphins from acoustic surveys in the future.

- Risso's dolphins were sighted on four occasions. The Mediterranean sub-population of this species is categorized on the IUCN Red List as 'Data Deficient'. The sightings presented here provide additional evidence that the Anatolian Trough and Anaximander Mountains provide an important habitat for this species.
- A single monk seal was observed in offshore waters of the Levantine Sea, south of Cyprus. Documented records of the species distribution in Cyprus are limited; they are known to breed along the south coast of Turkey and most information comes from coastal whelping sites. Offshore sightings are particularly significant in terms of estimating the species range and identifying threats to seals belonging to increasingly fragmented populations.
- Calibrated measurements of ambient noise were made in the Eastern Mediterranean. High noise levels coincided with ship density (AIS data) and locations where sperm whales and beaked whales were detected. To the best of our knowledge, these are the first calibrated noise measurements recorded in the Eastern Mediterranean.
- Analysis of individual ship speeds using AIS data indicated a significant reduction in ship speeds, particularly container ships between 2007 and 2013. Reduced speed has favourable implications for cetaceans with regards risk from ship-strike and underwater noise. However speed reductions are probably linked to increased fuel prices rather than environmental policy. An opportunity thus exists to introduce policy to ensure that this trend is maintained, at least in critical habitats, in the event that economic factors allow ship speeds to increase in future.

1. Harbour porpoise survey of the northern Aegean Sea

1.1 INTRODUCTION

Harbour porpoises (*Phocoena phocoena*) were thought to be largely absent from the Mediterranean Sea. However, over the last two decades, 19 stranding records have been published of this species from Greek and Turkish coastlines (Frantzis *et al*., 2001; Frantzis *et al*., 2009; Tonay and Dede, 2013). Those harbour porpoises found stranded in the Aegean Sea (and in the Black and Marmara Seas) exhibit unique haplotypes, not found in the North Atlantic Ocean (Viaud-Martínez *et al.,* 2007). As such, they are thought to belong to the Black Sea harbour porpoise sub-species (*P. phocoena relicta*), an insular population listed as 'Endangered' on the IUCN Red List (Birkun and Frantzis, 2013). Crucially, the IUCN Red List does not include a listing for the Mediterranean harbour porpoise due to a lack of data from which to estimate key biological parameters (Birkun and Frantzis, 2013). Although they share the same haplotype as harbour porpoises in Ukrainian Black Sea waters, it remains possible that individuals encountered in the Aegean Sea comprise an insular and threatened population representing either a relict Mediterranean Sea or an isolated Black Sea sub-population (Frantzis *et al*., 2001; Viaud-Martínez *et al*., 2007; Tonay and Dede, 2013), or a combination of both.

In principle, harbour porpoises in Mediterranean waters are protected by both national legislation and international agreements including the EU Habitats Directive and the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area (ACCOBAMS). Their conservation status and distribution however in Europe generally have been subject to much discussion and concern within the conservation community and the Scientific Committee of the International Whaling Commission (IWC). In some parts of Europe the total bycatch of harbour porpoises has been well above a level deemed acceptable (Hammond *et al*., 2002; Vinther and Larsen, 2004). Harbour porpoises are listed as an Annex II species under the Habitats Directive, obliging EU member states to establish and maintain their favourable conservation status. However in some areas, there are insufficient data on presence, distribution and abundance to inform such measures. The Black and Aegean Seas are a case in point and one of the aims of the survey work presented here was to establish whether or not porpoises are present in the northern Aegean Sea (where most of the strandings have been recorded) using both acoustic and visual techniques during the first dedicated systematic survey of the area.

1.2 METHODOLOGY

1.2.1 Visual and acoustic survey of the most northern parts of the Aegean Sea

Marine Conservation Research (MCR) in conjunction with Pelagos Cetacean Research Institute conducted a visual and acoustic survey of the Aegean Sea to coincide with a planned aerial survey of cetaceans in the Black Sea. The survey was carried out from R/V *Song of the Whale* (SOTW) between 7 and 26 July 2013. SOTW is a 21 m auxiliary-powered cutter-rigged sailing research vessel operated by MCR Ltd. The survey was conducted under permits issued by the Cypriot, Greek and Turkish authorities by an international team including local scientists from NGOs and universities. Pre-determined track-lines were designed using Distance software (Thomas *et al.*, 2010) and the survey area was sub-divided into two survey blocks (Figure 1).

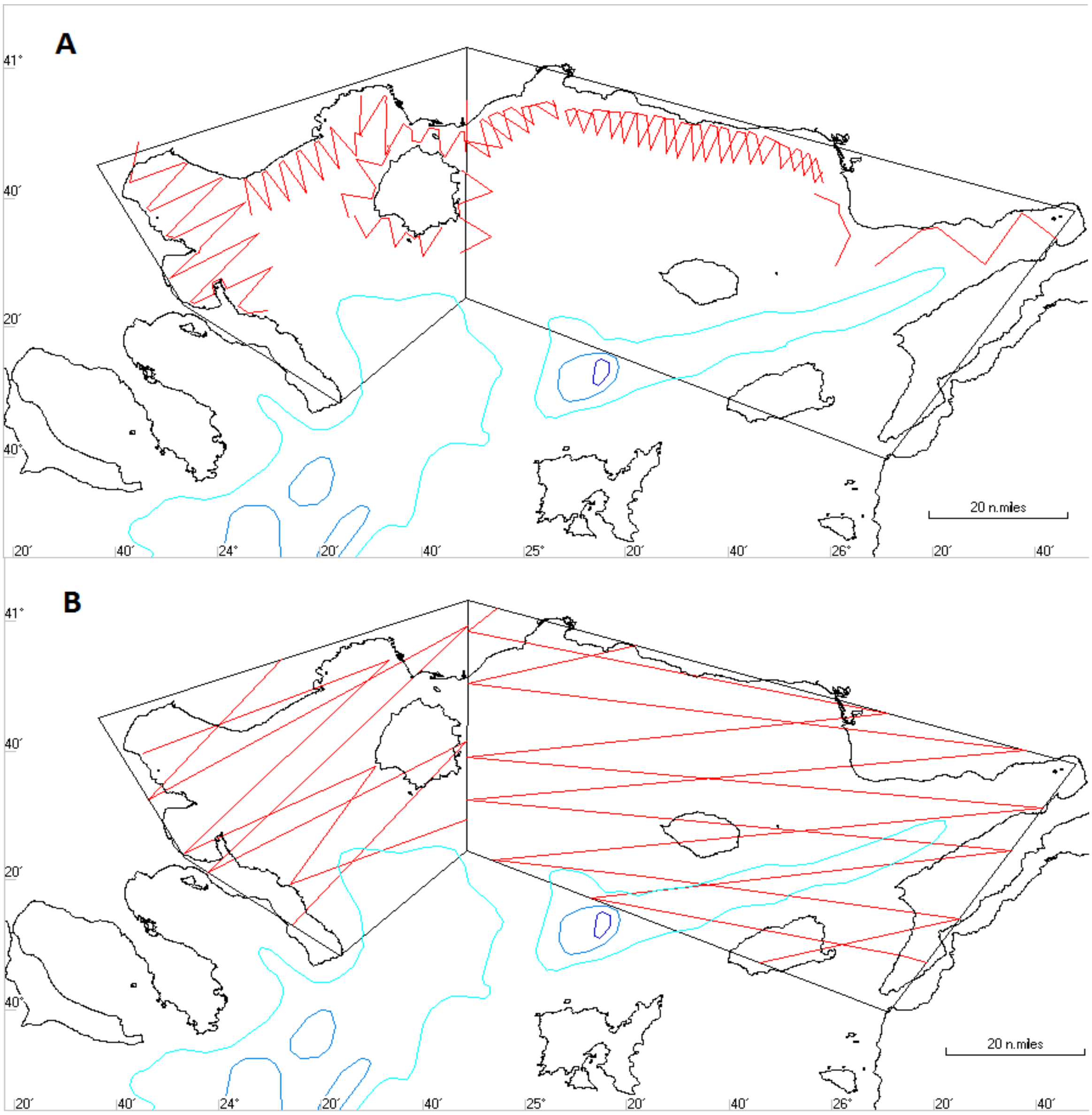

Figure 1. Survey areas showing the planned pre-determined track-lines in the Thracian Sea a) Coastal fine-scale survey; b) Offshore broad-scale survey.

Acoustic sampling for the harbour porpoise survey was conducted using two hydrophone arrays each containing a pair of broadband elements with 2 kHz to 200 kHz bandwidth, towed 200 m behind the vessel. Two two-channel 16-bit wav files were recorded continuously at a sample rate of 500 kHz using Pamguard (Gillespie *et al.*, 2009) and routine checks of the software (2 minutes every 15 minutes) were conducted to monitor for cetacean vocalisations and guarantee the equipment was working optimally. Signals were passed through bespoke buffer boxes to internal NI 6251 acquisition cards. The buffer boxes provided variable frequency responses; however, for the bandwidths of interest for harbour porpoises (115-160 kHz), the response was approximately flat.

Visual observations were carried out during daylight hours and in suitable sea states (sea state ≤ 3 for the harbour porpoise survey). For the harbour porpoise survey, a double platform method was employed following Hammond *et al.* (2002) whereby observers were positioned at two different heights above sea-level. Two observers on each of the two platforms maintained continuous visual effort but each of the four observers followed an hourly rotation with one to two hour breaks to reduce observer fatigue. Two "primary observers" were positioned on a foredeck platform (eye height of 3.5 m above sea level) and scanned the sea with the naked eye to a distance of 500 m in an arc from 0^o to 90^o either side of the vessel. These observers wore ear-plugs and were not prompted by other observers or acoustic information to ensure that an unbiased detection function could be derived. Upon sighting a marine mammal, the observer recorded the bearing using an angle board and the distance using a range-finding stick made for individual observers according to their eye height and arm length using the Heinemann (1981) formula.

From the A-frame situated on the aft deck (eye height of 5.5 m above sea level), two "trackers" scanned the sea ahead of the vessel using reticulated 7 x 50 binoculars. The binoculars were mounted on a monopod above a Panasonic HDCSD90 video camera set with a 3 second pre-record to allow Video Range Tracking (VRT) of animals. Upon sighting a marine mammal, the VRT camera was set to record, ensuring that both the target animal and the horizon were in frame. A running commentary was made by the observer stating the binocular reticular distance to the animal, direction of travel (*e.g.* right to left / left to right), relative angle of travel (in relation to the observer) and number of animals. This information was also documented using Logger (IFAW, 2010) software by a separate data collector. When a porpoise was being tracked, the second A-frame observer covered the whole area in front of the vessel, in order not to miss any additional animals. In order to obtain accurate distances to animals for each sighting, sequential images of each surfacing with the animal and the horizon in the image are extracted post-process. From observers' eye height on the A-frame and the distance to the horizon, an accurate distance can be calculated to the animal (Leaper and Gordon, 2001). Four downward facing open dome CCTV cameras with 3.6 mm lenses were mounted above the A-frame to capture images of the observers as they directed their binoculars towards a porpoise encounter. From perpendicular lines which run along the deck of the A-frame and a line running along the top of each pair of binoculars, accurate angles to the animal, relative to the vessel's heading, could be calculated (Figure 2). This circumvents issues associated with magnetic deviation that would otherwise arise if using compasses close to electronic devices and cabling.

Figure 2. Example of a CCTV image from the starboard camera 1

Environmental and GPS data were logged automatically to the Logger database continuously (every 10 s), including date, time, vessel position (latitude, longitude), true heading, sea surface temperature (°C), wind speed (knots) and direction. Records of estimated environmental variables (such as sea state, wave and swell height) and survey effort (numbers and positions of observers) were made hourly. Data on the distribution and densities of rubbish and discarded fishing gear were also collected throughout the survey (See 1.2.4).

1.2.2 Acoustic software

Pamguard software was used throughout all cetacean surveys with modules to automatically detect cetacean vocalisations including a click detector to log harbour porpoise, beaked whale, sperm whale and other odontocete click trains, and a whistle and moan detector to detect the tonal calls of both odontocetes and mysticetes. Two-minute listening stations were carried out at 15 minute intervals during which cetacean clicks or whistles were logged by an operator (to species level where possible). A subjective scale of zero (not heard) to five (nothing else audible) was used to qualify signal levels for both biological and anthropogenic signals.

1.2.3 Mid-frequency recording of cetaceans

In addition to the 500 kHz recordings made for porpoise and beaked whale detection, mid-frequency two-channel recordings at a sampling rate of 48 kHz were also collected via a RME *Fireface 800* sound card for other mid-frequency odontocetes, especially sperm whales.

1.2.4 Visual observations of floating debris

In order to estimate the density of rubbish, specifically floating debris, aft visual observers recorded the distance and bearing to each object observed along the track. These records were logged during daylight only.

Floating debris was classified into seven categories: fishing gear, food packaging, plastics, polystyrene, wood, balloons and other.

1.2.5 Post survey and statistical analysis

Post survey analysis was conducted using a Pamguard click detection module configured for harbour porpoise clicks and an analyst removed any false detections and selected detection trains. Clicks were classified as 'definite' harbour porpoise clicks if they met the following criteria: the click had a peak frequency between 100 and 160 kHz, the energy of the click was at least 8 dB above the background noise levels and less than 2 ms in duration, with a relatively flat structure revealed in a Wigner plot. All clicks were verified by a second analyst and only click trains with more than three clicks and which were listed as 'definite' were included in the results of this survey.

The variance in the number of harbour porpoise detections, *n*, and the detection rate *n*/100 km, were calculated using areas or transects as sampling units for the survey area and higher resolution survey zones respectively (Buckland *et al*., 2001, pp. 78-80). The variance in the number of detections for each block (Figure 1) was calculated as follows:

$$\hat{\mathrm{var}}(n) = L\sum_{i=1}^{k} l_i \left(\frac{n_i}{l_i} - \frac{n}{L} \right)^2 /(k-1)$$

where i is the transect number from 1 to k, l_i is the length of transect i and L is the sum of all transect lengths. The standard error (SE) was also calculated for the number of detections in each block.

1.3 RESULTS

1.3.1 Survey effort

In the Thracian Sea, a total of 3295 km of acoustic effort on transect were logged of which 757 km included single platform visual effort and 1001 km included double platform visual effort (Table 1 and Figure 3). The sea state was variable throughout the survey and double platform visual effort was only conducted in sea state three or below. Single observer visual effort was carried out in sea state four and acoustic effort continued throughout all sea states and at night.

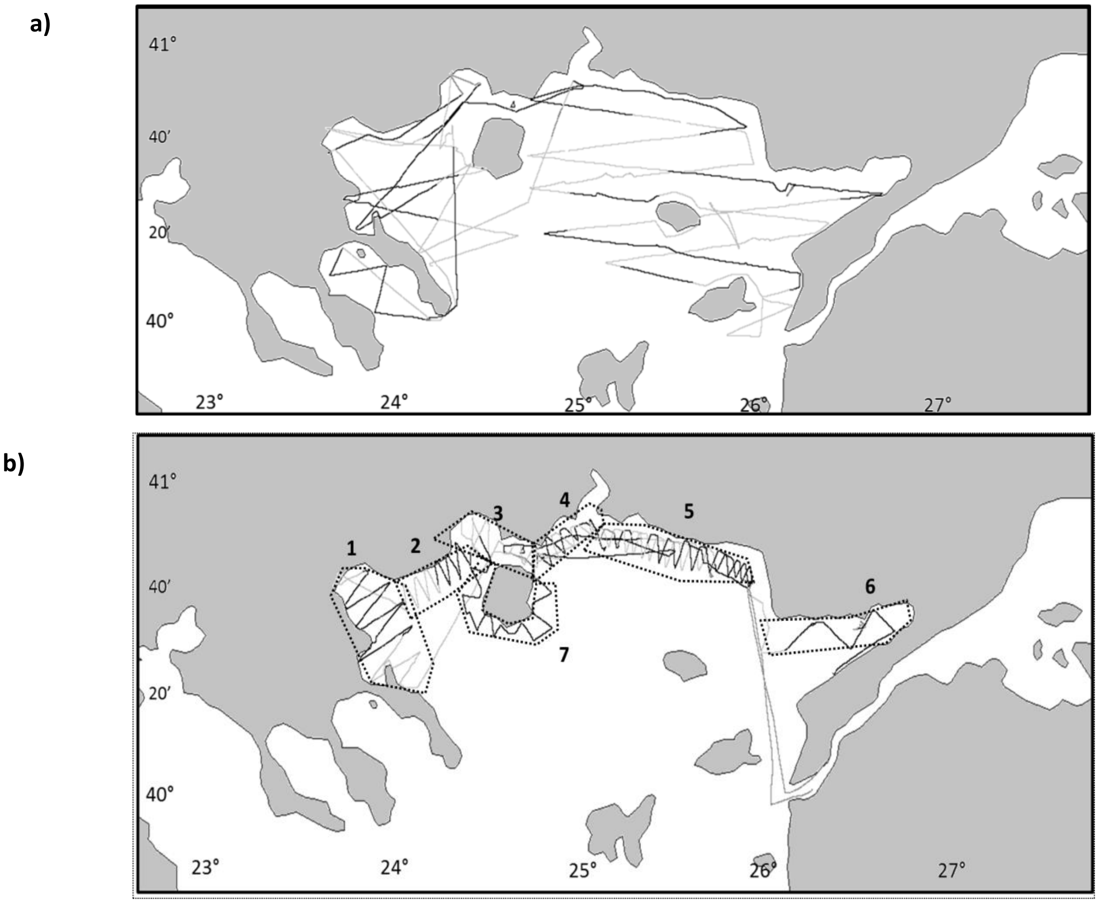

Figure 3. Survey tracks undertaken by SOTW in the northern Aegean (black lines represent survey with visual and acoustic effort and grey lines represent the survey with acoustic effort only: a) low resolution transects, b) higher resolution coastal blocks (marked 1-7, black dotted line) and coastal transects.

Table 1. Summary of dedicated (transect) and opportunistic (passage) survey effort during the harbour porpoise northern Aegean Sea survey.

	Miles	Km	Hours:mins
Total Track	2184	4046	344:21
Passage + Acoustic	305	565	35:21
Passage + Acoustic + Visual	101	187	14:49
Transect + Acoustic	830	1537	138:25
Transect + Visual	0	0	00:00
Transect + Acoustic + Visual	408	756	67:30
Transect + Acoustic + Double Visual	540	1001	88:00

1.3.2 Harbour porpoise sightings

Harbour porpoises were seen on nine occasions over two separate days within Saros Bay in Turkish Aegean waters. On 12 July 2013, four sightings of porpoises were recorded; one of a group of four animals, two sightings of two animals and a further sighting of a single individual. Several re-sightings were made both from the primary platform and whilst tracking the animals. After completing the remaining low resolution transects, SOTW returned to Saros Bay two weeks later, as part of the higher resolution survey (Figure 3). On 26 July, SOTW encountered harbour porpoises on five separate occasions, clustered in to three groups of two animals and two single individuals. One of the pairs sighted included a calf swimming alongside another animal, presumably the mother. Several re-sightings were made as the vessel broke track to approach the animals in order to take photographs. Photographs were taken during all encounters in order to confirm species identification (Figure 4). During both days when porpoises were seen in Saros Bay, sighting conditions were excellent: sea state 0 to 1.

Figure 4. A photograph of a harbour porpoise encounter with two individuals in Saros Bay, Thracian Sea (26/07/2013 10:34 UTC).

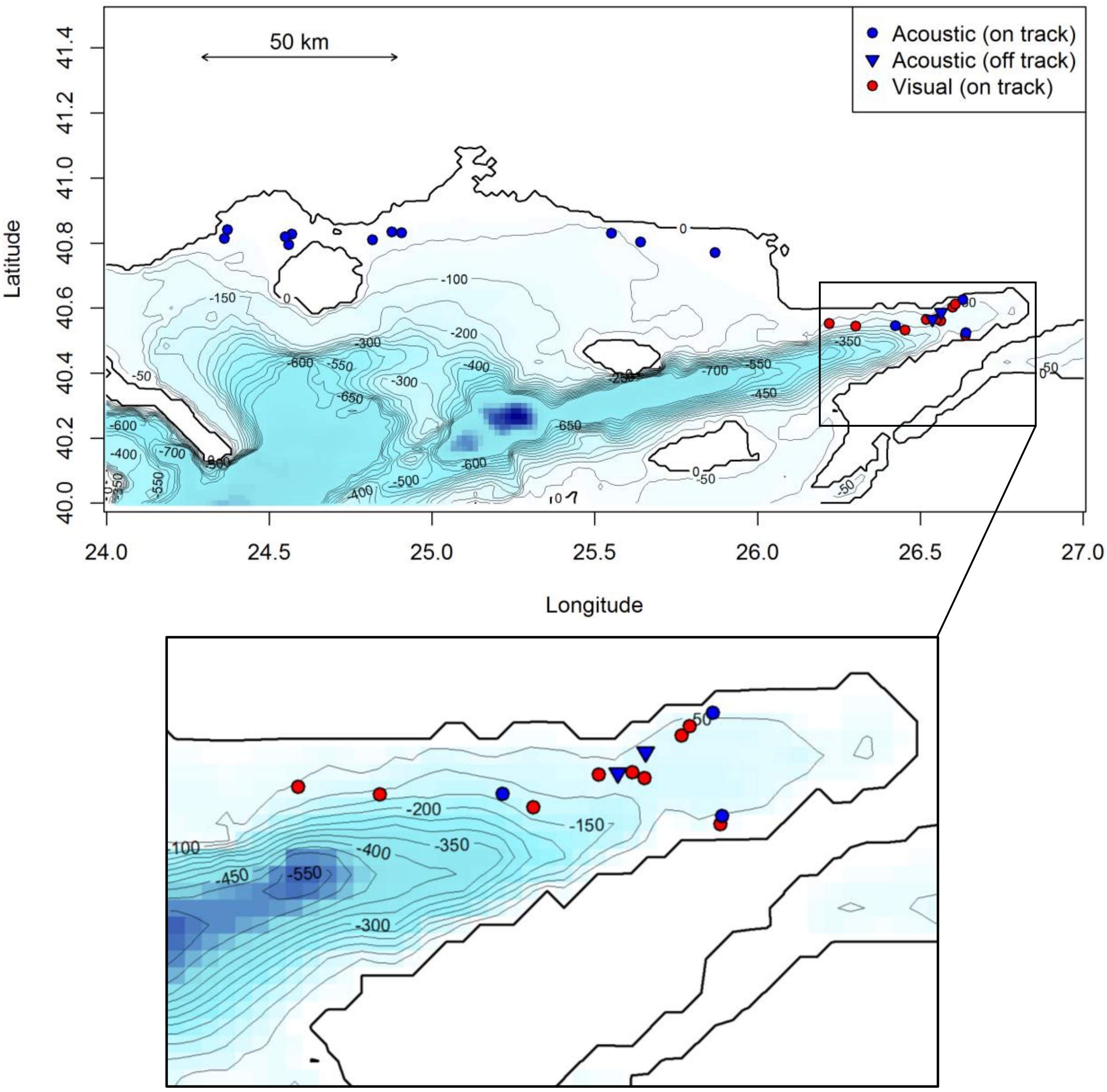

Figure 5. Map showing the locations of harbour porpoise detections (n = 16) and sightings (n = 9) in the Thracian Sea, including an enlarged map of Saros Bay, Turkey, showing on-track and off-track detections from two separate visits to the area (12 and 26 July 2013). For survey effort and track, see Figure 3.

1.3.3 Acoustic Detections of harbour porpoises

Acoustic detections of porpoises (*n* = 16; of which 14 were 'on track') were made in various locations during the survey in Greek and Turkish waters, four of which were accompanied by visual encounters (Figure 5). The detections occurred to the north of the Greek island of Thasos, west of the Greek city of Alexandroupolis, and in Saros Bay (Figure 5). Each of the reported acoustic detections was separated by at least 12 minutes and is therefore deemed to be from different porpoise groups considering the average speed of SOTW was 6 knots and the porpoises were only observed swimming slowly (maximum swimming speed of harbour porpoises is 8.3 knots (Otani *et al*., 2000).

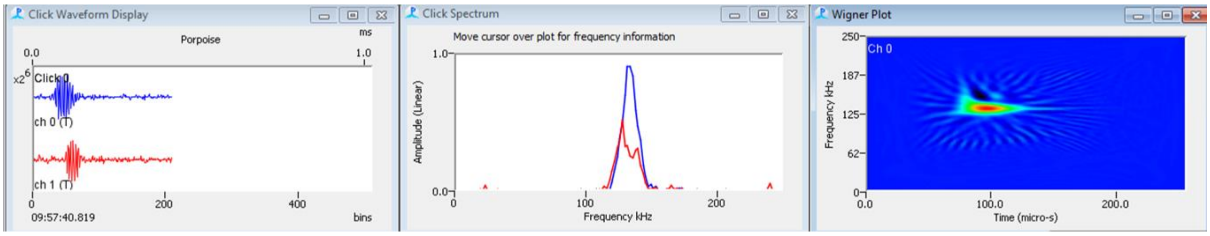

Figure 6. A typical porpoise click recorded in the Aegean Sea (peak frequencies of approximately 134 kHz). The figure shows the two channels (red and blue lines), their waveforms, click spectrum and Wigner plot as displayed in a Pamguard click detector (Gillespie, 2009). This click displays the characteristic sinusoidal waveform, narrowband ultrasonic peak frequency

Relative 'on track' acoustic encounter rates (*n*/100 km surveyed) were calculated for the survey as a whole, including both the high and low resolution survey blocks (Table 2). The high resolution coastal transects of the Saros Bay survey area resulted in the highest acoustic encounter rate.

Table 2. Harbour porpoise acoustic detections per 100 km acoustically surveyed. The number of sightings is also listed from the low-resolution survey (high-resolution survey sightings in parentheses).

On-track acoustic detections *n* / 100 km (*SE* of *n*/100 km)	No. of sightings
Combined high and low resolution survey results: 0.35 (<0.01)	9
High resolution coastline survey results (Areas shown in Figure 1):	
Area 1 – 0 (0)	0 (0)
Area 2 – 0.7 (0.02)	0 (0)
Area 3 – 2.3 (0.05)	0 (0)
Area 4 – 0.8 (0.03)	0 (0)
Area 5 (Alexandroupolis)– 0.9 (0.02)	0 (0)
Area 6 (Saros Bay) – 3.6 (0.04)	5 (4)
Area 7 (South of Thasos)– 0 (0)	0 (0)

1.3.4 Other species acoustically and visually detected during the harbour porpoise survey

Four cetacean species were sighted while surveying the Thracian Sea (Table 3), three of which, the common bottlenose (*Tursiops truncatus*), short-beaked common (*Delphinus delphis*) and striped (*Stenella coeruleoalba*) dolphin were seen repeatedly. Risso's dolphins (*Grampus griseus)* were seen just once by the Aktè Peninsula, Greece (Figure 11). The most frequently encountered species recorded in the northern Aegean Sea (*i.e.* during dedicated harbour porpoise survey) was the common bottlenose dolphin (*Tursiops truncatus*) which was largely confined to coastal waters (Figure 7, Table 3). The largest group size was estimated at 45 individuals. By contrast, the second most abundant cetacean species in the northern Aegean Sea, striped dolphin (*Stenella coeruleoalba*), was mostly confined to deeper waters further offshore (Figure 7). Striped dolphins were recorded in similar relative abundances to bottlenose dolphins, albeit with a smaller mean group size (Table 3). Turtles were seen on six occasions, three of which were identified as loggerhead turtles (*Caretta caretta*), in addition to one shark (species unknown).

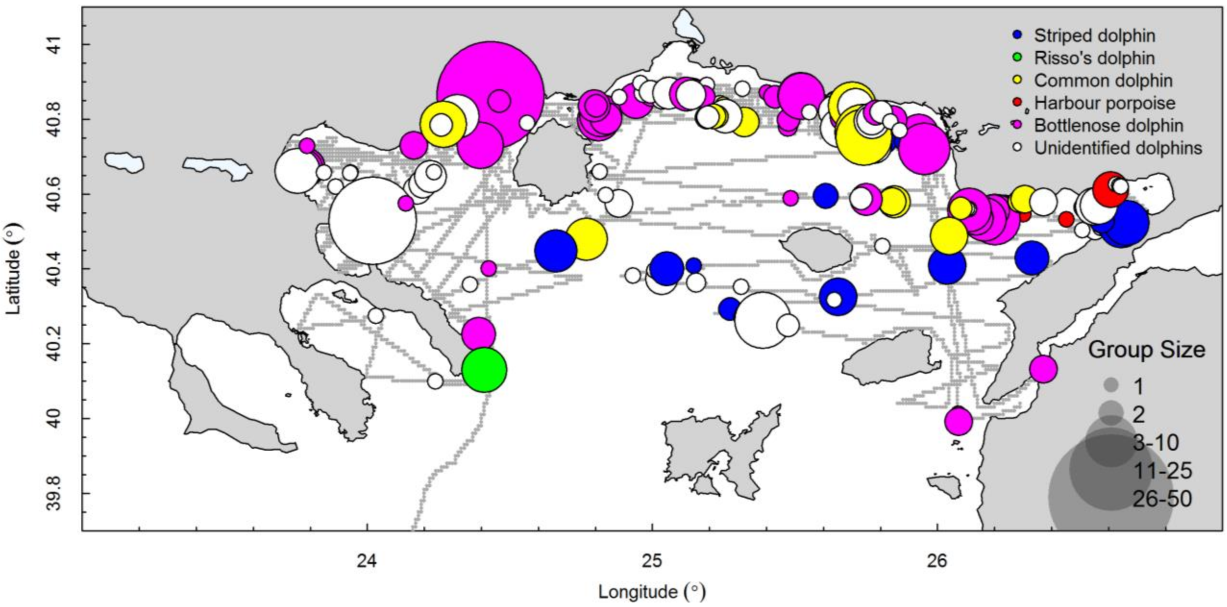

Figure 7 Sightings of marine mammals during the Thracian Sea survey. The radius of each symbol, and hence the symbol size, is proportionate to mean estimated group size. NB: Some areas were more intensively surveyed than others, and the sightings presented here are not corrected for effort. The track of SOTW is shown as a grey line.

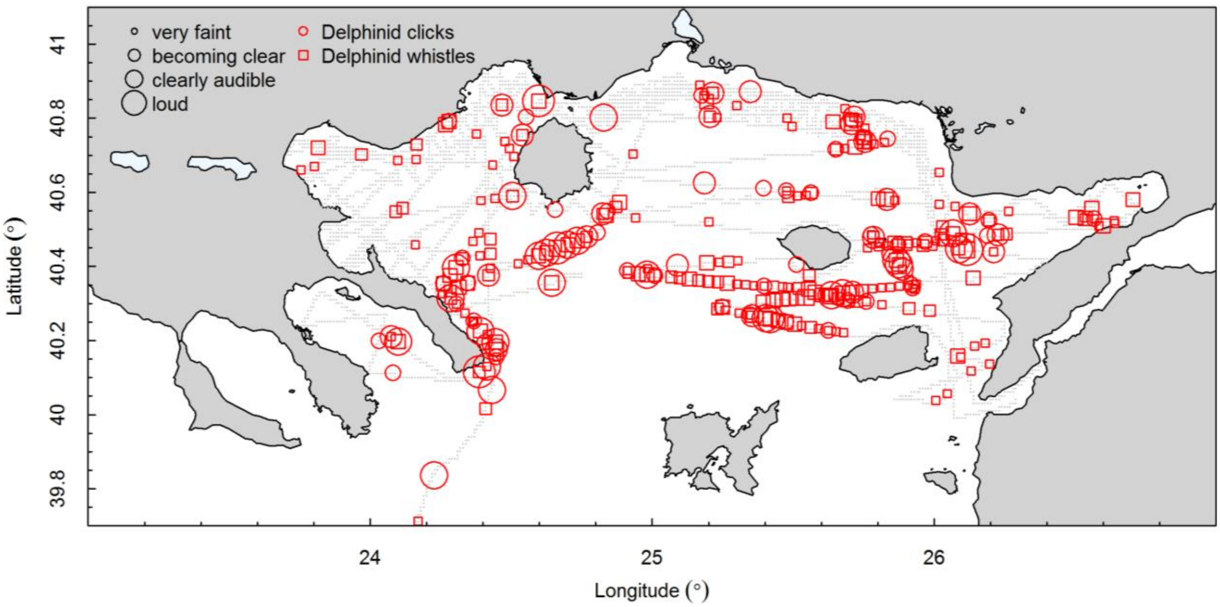

Figure 8. The locations of delphinid clicks and whistles heard during 2 min listening stations (every 15 min) during the northern Aegean Sea harbour porpoise survey. The vessel track is shown as a grey line.

Table 3. Summary of the cetacean sightings recorded during surveys throughout the northern Aegean Sea (included one mixed species sighting with common dolphins and one with striped dolphins).These data have not been corrected for being on-track or in sighting conditions under sea state three.*

Thracian Sea

Species	Groups (*n*)	Group size range	Mean estimated group size	Groups hr^{-1}	Groups 100 km^{-1}
Bottlenose dolphin	45*	1-50	4.2	0.264	0.023
Common dolphin	16	1-15	3.8	0.094	0.008
Risso's dolphin	1	6-10	8	0.006	<0.001
Striped dolphin	20	1-20	4.1	0.117	0.010
Unidentified dolphin	31	1-10	2.1	0.182	0.016
Total	**113**	**0**	**14.3**	**0.663**	**0.058**
Loggerhead turtle	3	1	1	0.018	0.002
Unidentified turtle	3	1	1	0.018	0.002
Unidentified shark	1	1	1	0.006	<0.001

1.4 DISCUSSION

1.4.1 Harbour porpoise survey

This was the first dedicated survey for harbour porpoises in the Mediterranean Sea and confirms the presence of free-ranging harbour porpoises in Greek and Turkish waters of the northern Aegean Sea for the first time in twenty years. There were a total of 21 unique acoustic or visual detections of harbour porpoises throughout the survey (visual *n* = 9; acoustic *n* = 16 of which four were of sighted groups) clustered in three different areas: north of the Greek Island of Thasos; southwest of Alexandroupolis; and Saros Bay. The highest encounter rate (acoustic and/or visual) was recorded in Saros Bay. All sightings and detections were in locations with a depth of < 150 m. Although no previous systematic survey for harbour porpoises had been conducted in the study area, parts of this area had previously been surveyed for cetaceans. During visual surveys of the Turkish waters of the Aegean Sea between 2005 and 2008, including Saros Bay, no harbour porpoises were observed (Dede and Öztürk, 2007; Öztürk, 2009; Altuğ *et al.,* 2011). The small size and cryptic surfacing behaviour of harbour porpoises compromises the probability of seeing individuals in sea states below two (Teilmann, 2003) and significantly reduces probability of detection above sea state three (Palka, 2006). Due to these challenges, harbour porpoises are difficult to observe in all but ideal sea conditions. Although the mode sea state during this survey was two, during many parts of the survey the sea state exceeded three, reducing the probability of sightings; this highlights the particular merit of passive acoustic detection techniques when conducting surveys for harbour porpoise (or indeed other cryptic/deep diving) species.

Prior to this study, strandings data indicated the presence of porpoises in the Aegean Sea was largely confined to the northern Thracian Sea coast with several strandings northwest of Thasos Island and close to

Alexandroupolis (Birkun and Frantzis, 2008). However these patterns do not take into account any possibility of carcass drifting. The known distribution of harbour porpoises presented here is largely consistent with that from stranding records (Birkun and Frantzis, 2008). However this survey indicates that Saros Bay may be a potentially important porpoise habitat; a finding not apparent from stranding records where just one stranding of two individuals has been documented (Tonay *et al*., 2009; Tonay *et al.,* 2012).

Harbour porpoises in the Aegean Sea are thought to either be remnant of a distinct Mediterranean population or part of the critically endangered Black Sea population (Frantzis *et al*., 2001) which have passed through the Istanbul and Çanakkale Straits (Tonay *et al*., 2012). As incursions of cool and less saline Black Sea water enter the Northern Aegean Sea, Rosel *et al.,* (2003) suggested that this region might provide suitable habitat for harbour porpoises exiting the Black Sea. Although this cool water influence in the northern basin may provide habitable conditions for harbour porpoises, the effects are likely counter-balanced by the warm and very saline waters of Levantine origin in the southern basin (Skliris *et al*., 2011). In this study harbour porpoises were found in the northern Aegean Sea during July, remaining within the same bay while surface water temperatures increased from 19 to 25°C in two weeks. The upper temperature is above the "limiting thermocline" described previously for this species (Tolley and Rosel, 2006) and may be the warmest sea surface temperatures in which harbour porpoises have been observed.

Harbour porpoises within the Black and Aegean Seas are facing many threats including pollution, climate change, fisheries bycatch and habitat degradation (Notarbartolo di Sciara, 2002). For example one fishery survey from 1999 reported 996 licensed fishing vessels with 964 set nets and long-lines, 29 purse seines, two trawls, and one beach seine operating in Turkish waters of the northern Aegean Sea alone (Kara and Gurbet, 1999). Furthermore, 39% of total production in this region was provided by set nets and long-lines (Kara and Gurbet, 1999). Since this study was published the number of registered fishing vessels has increased (A. A. Öztürk, 2013 pers. comm.). Information is currently lacking on the level of harbour porpoise bycatch in fisheries in the Aegean Sea. Monitoring and reporting of marine mammal bycatch in fisheries in the northern Aegean is urgently required to provide baseline data to allow assessment of this well documented threat. More information on the seasonality and distribution of harbour porpoises in the northern Aegean is required to this end, especially via the Turkish Straits (Dardanelles and Bosphorus).

Zones for marine protected area (MPA) designation have already been suggested in the Aegean high seas (Öztürk, 2009). Due to high biodiversity, Saros Bay was declared a MPA in January 2011 setting limitations on large-scale trawling, purse-seining and bivalve dredging. While this is a welcome conservation action there are currently no measures limiting the use of gillnets, which have been described as "the single most important threat to porpoises" in other parts of their range (Jefferson and Curry, 1994). In certain areas, such as the coastline off Alexandroupolis and north of Thasos Island, the need for MPAs has already been noted and the information presented here strengthens the case for designation of marine Natura 2000 sites.

Multiple sightings and the presence of a calf indicate that harbour porpoises in the Northern Aegean are part of a breeding population. The Black Sea harbour porpoise population is estimated to be 10% of its previous size (Fontaine *et al*., 2010). Considering the unknown status of harbour porpoises in the Mediterranean Sea, the presence of porpoises and signs of a possible breeding group in the Aegean Sea warrants further research and policy measures to maintain favourable conservation status, as required for Annex II species by the EU Habitats Directive.

1.4.2 Sightings and acoustic detections of other cetacean species in the northern Aegean Sea

The most frequently encountered species recorded in the northern Aegean Sea (*i.e.* during dedicated harbour porpoise survey) was the common bottlenose dolphin (*Tursiops truncatus*), followed by striped and common dolphin. These results support the assessments by Bearzi *et al.* (2003) and Frantzis *et al.* (2003) that the northern Aegean, specifically the Thracian Sea, may be disproportionately important for common dolphins compared to adjacent waters. Although relative encounter rates were low compared to other dolphin species, nonetheless the area appears to be an isolated and important habitat for this species which is in drastic decline in the Mediterranean Sea. A single Risso's dolphin encounter is an important record as this species is only known from nine previously published sighting records (Frantzis *et al.* 2003). Notably, two of these previous records were within ~30 km of our latest sighting, on the northern side of the Anatolian Trough suggesting that this could be an important area for Risso's dolphins. Further targeted survey effort will be required to determine this. Acoustic detections of delphinids shows a general concordance with sightings in the survey region, although acoustic detections far outnumbered visual detections given that PAM was operational during day and night (Figure 7, Figure 8).

2. Cetacean distribution in relation to underwater noise, shipping and litter in the eastern Mediterranean Sea

2.1 INTRODUCTION

A recent review of the threats and status of species in the Mediterranean Sea identified ship strikes (namely direct impact with the hull, propeller or associated underwater structure of a vessel) and entanglements in drift nets as primary threats to large whales (Notarbartolo di Sciara and Birkun Jr., 2010). Anthropogenic sound is also of major concern for certain species in the region (*e.g.* Cuvier's beaked whales; Aguilar Soto *et al*., 2006; Pirotta *et al*., 2012). Given the intensity of shipping between the Mediterranean and Black Seas *via* the Aegean Sea, both ship strike and noise have been identified as posing potential threats to individuals and populations of whales (Notarbartolo di Sciara and Birkun Jr., 2010). Chemical and debris pollution, entanglements and disturbance are also serious threats to small cetaceans (*e.g.* Bearzi *et al.,* 2009). Over the past fifty years the marine environment has been increasingly contaminated by synthetic, non-biodegradable materials such as plastics (Gregory, 2009). Plastic debris is now considered a major threat to marine biodiversity (Sutherland *et al.*, 2010). Floating plastic debris is particularly harmful to the marine environment and fauna (Derraik, 2002) with over 250 species having been reported to be impacted by entanglement (Laist, 1997). Ingestion of litter is an increasingly prevalent welfare and conservation issue which has been documented in 48 cetacean species to date (Baulch and Perry, 2014; Beck and Barros, 1991; Tomás *et al.*, 2002). Associated impacts include the absorption of persistent organochlorine contaminants from ingested plastics (Ryan *et al.*, 1988) and debris rafts as vectors of invasive species (Barnes, 2002).

Towards achieving goals set out by the Marine Strategy Framework Directive (MSFD), the European Commission and the EU member states are developing criteria and methodological standards for defining good environmental status in relation to several descriptors including marine litter (Descriptor 11) and underwater noise (Descriptor 10). The MSFD has identified that shipping noise should be mitigated to achieve the good environmental status of European waters. One of the criteria under development requires member states to monitor shipping noise levels and ensure they will not increase. The measurements of ship noise in the region will hopefully encourage governments in complying with their international obligations under the International Maritime Organisation (IMO) and EU, and assist in identifying the types of vessels which will benefit most from ship quieting technology.

Sperm whales in the Mediterranean Sea are distributed from the Straits of Gibraltar to the Levantine Basin, and formerly were thought to be common in certain areas. However, the Mediterranean subpopulation, which is genetically distinct, now contains fewer than 2,500 mature individuals and potentially as few as the mid hundreds (Notarbartolo di Sciara *et al.,* 2012). Surveys undertaken previously indicate that sperm whale numbers are highest in the western basin and the Hellenic Trench (Lewis *et al*., 2007; Frantzis *et al*., 2011);

surveys of other parts of the Mediterranean have not revealed the existence of very high concentrations of sperm whales (Notarbartolo di Sciara *et al.*, 2012). In the absence of effective management to mitigate ongoing threats to sperm whales from bycatch (entanglement in fishing gear) and ship strikes, the population decline is continuing. Previous surveys by IFAW and the SOTW team in 2003, 2004 and 2007 were aimed at filling significant 'gaps' in survey coverage for sperm whales and demonstrating acoustic survey techniques (Lewis *et al.*, 2007). The project in 2013 aimed to provide survey coverage of the northern Aegean Sea, Egyptian waters and some other parts of the Levantine Basin which had previously received little effort. Unfortunately due to political unrest in Egypt during the summer 2013, it was not possible to obtain diplomatic clearance to undertake the planned survey off Egypt.

2.2 METHODOLOGY

The main survey regions in the northern, central Aegean Sea and Levantine Basin shown in Figure 8 were sub-divided according to suitable cetacean habitat and survey priorities (Table 4).

Table 4. Survey structure according to habitat type and survey priorities.

Region	Timeframe	Aims	Survey speed	Survey design
Northern and central Aegean Sea	26 Jul –8 Aug	1. Sperm whale distribution and abundance 2. Cetacean distribution in relation to shipping lanes 3. Describe background noise levels 4. Record floating debris (ancillary aim)	6 – 8 kn	Fig. 7
Levantine Sea	9 Aug –2 Sep	1. Cetacean distribution in relation to shipping lanes 2. Describe background noise levels 3. Record floating debris (ancillary aim)	6 – 8 kn	Fig. 7

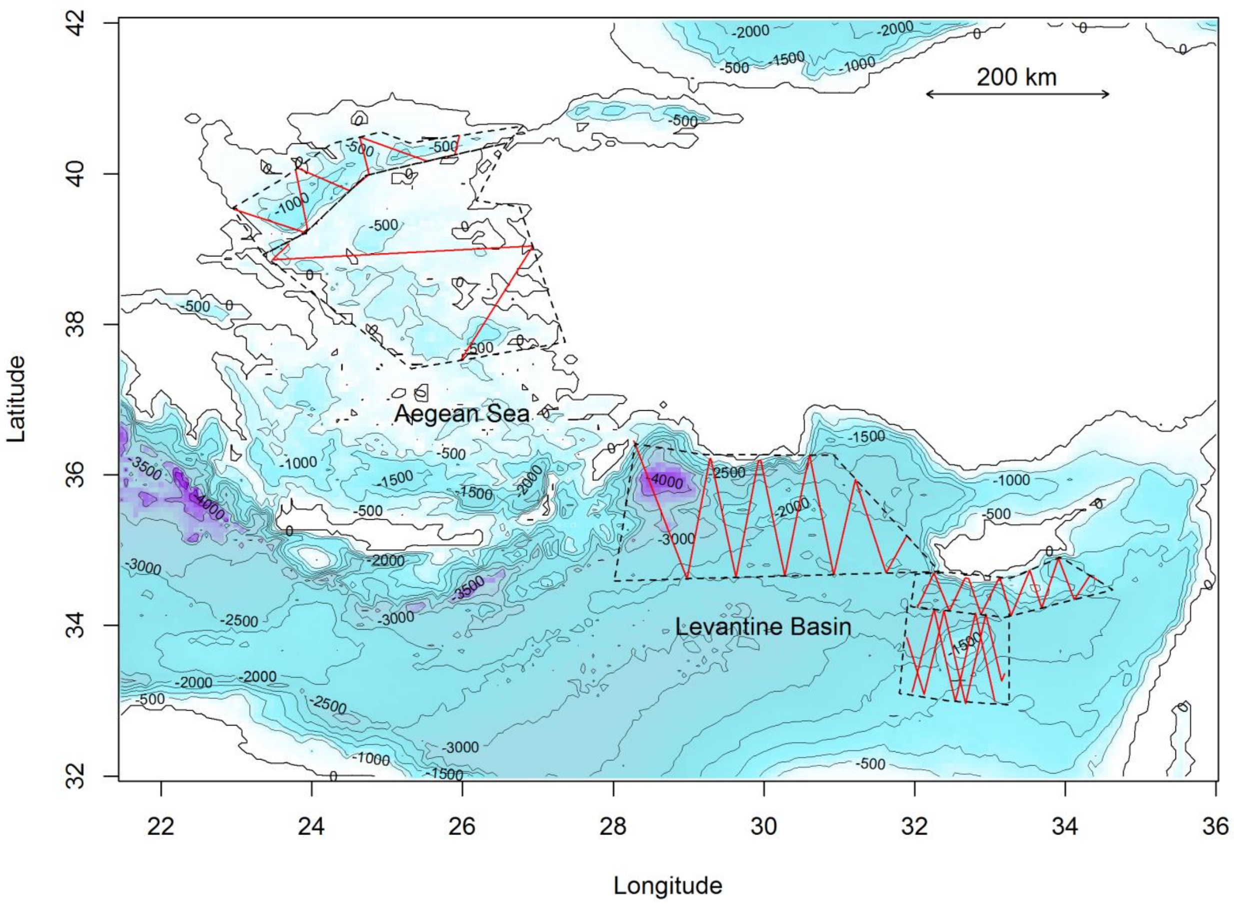

Figure 9. Survey areas showing the planned pre-determined track-lines in the Aegean Sea and Levantine Basin. For additional survey track-lines in the northern Aegean Sea, see figure 1 in section 1.2.

2.2.1 Cetacean surveys of the Aegean and Levantine Seas

For the general cetacean survey, a two-channel 400 m single towed array was used for making mid-frequency recordings of sperm whales and delphinids at a sampling rate of 48 kHz (two channel recordings via a RME *Fireface 800* sound card). In addition, higher frequency recordings were made at a sampling rate of 192 kHz to detect beaked whales (via a bespoke buffer boxes with internal NI 6251 acquisition card). The entire system was capable of detecting signals from 10 Hz to 200 kHz. For the bandwidths of interest for both sperm whale (2 to 24 kHz) and beaked whale clicks (25 to 50 kHz) the response of the system was approximately flat. For these surveys, visual observations were conducted from a single platform only, *i.e.* A-frame observations as described in section 1.2.1 above.

2.2.2 Acoustic software See section 1.2.2.

2.2.3 Mid-frequency recording of cetaceans See section 1.2.3.

2.2.4 Visual observations of floating debris See section 1.2.4.

2.2.5 Ambient noise measurements

Point samples of calibrated ambient noise recordings were made on the survey track using an omni-directional RESON TC4032 hydrophone with a frequency response of ±2.5 dB between 10 Hz and 80 kHz. During recording the hydrophone was housed in a protective weighted cage deployed from the aft davits of SOTW to a depth of 30 m. This point sampling was carried out throughout the survey area twice a day at 07:00 and 19:00 local time with simultaneous CTD casts to circumvent biases associated with strong sea surface warming during daylight hours. Recordings of 30 second duration were made while SOTW was stationary, with the engine, echo-sounder and generator powered off. During subsequent analysis, voltages measured from the calibrated hydrophone were converted to broadband sound pressure levels (SPL) from 10 to 24,000 Hz for each 30 second recording with SpectraPLUS (Pioneer Hill Software) using the system's gain, soundcard scaling and knowledge of the hydrophone's calibration values. In addition, power spectrum density levels (PSDL) were measured for three 1/3 octave bands (centred at 63, 125 and 1000 Hz) for each 30 second recording to examine frequency-specific variation in ambient noise. The first two bands were chosen following recommendations by the Technical Subgroup on Underwater Noise for the European Marine Strategy Framework Directive (2008/56/EC, Descriptor 11 on underwater noise and other forms of energy). Towards the goal of achieving 'Good Environmental Status', the technical working group recommends monitoring underwater anthropogenic noise around these frequency bands in order to standardise noise measurements (Van der Graaf *et al.* 2012). Frequency bands (63 and 125 Hz) are deemed to be most appropriate by the Technical Subgroup following Knudsen's sea-state zero values (Knudsen *et al.*, 1948; Van der Graaf *et al.* 2012).

2.2.6 Recording vessel density

The Automatic Identification System (AIS) was developed for vessels by the IMO (International Maritime Organisation) to complement the use of radar in order to aid navigation at sea. Every commercial vessel with a gross tonnage of greater than 300 t and all passenger ferries transmit AIS signals which can be monitored using a transceiver. This presents a convenient means by which to record locations of individual vessels in order to investigate the distribution of shipping traffic and assess ship density levels and hence identify high risk zones for cetacean ship-strikes (Leaper and Danbolt, 2008). The navigation system on board SOTW (*dKart Navigator,* Morintech Navigation) recorded the following data approximately once every 10 s for each vessel within AIS range: MMSI (maritime mobile service identity) number; latitude; longitude; course over ground; speed over ground and destination. The data were concatenated using an Excel macro and the minimum distance from SOTW to each unique vessel-per-day was plotted using R (R Team, 2005).

2.2.7 Conductivity, temperature, depth (CTD) casts

CTD profiles were taken at each point sampling station (twice a day as in section 2.2.1) using a *SBE 19plus SeaCAT Profiler* (Sea-Bird Electronics Inc.). Casts were made to a depth of 100 m, or 20 m above the seabed in depths of <100 m, at each sampling station. The CTD instruments sampled at a rate of 4 Hz while the profile was taken at a speed of 1 ms^{-2}. Only the ascending casts were used for analysis. The instrument sensors were rinsed with deionised water between each profile. Data were downloaded to a computer directly from the instrument and were converted, filtered, aligned and plotted using *SEASOFT-Win32* software. The thermo- and halocline were defined as the depth at which temperature and salinity differential were greatest.

2.3 RESULTS

2.3.1 Survey effort and sightings

A total of 644 hours (26.9 days) of acoustic data were collected along pre-determined randomly designed track lines in the Mediterranean Sea. Some additional 226 hours (9.4 days) of acoustic recordings were made during passages in the region (*Table 5*). A total of 35 sightings of an estimated 196 individual cetaceans were made including six species of odontocete (Table 6). Of these, four groups could not be identified to species level, usually where the groups were too distant to observe diagnostic features. No baleen whales were recorded in the region. A single monk seal (*Monachus monachus*) was observed south of Cyprus. Sightings of other marine megafauna included 11 individual turtles, seven of which were identified as loggerhead (*Caretta caretta*) (Table 6).

Table 5. Summary of dedicated (transect) and opportunistic (passage) survey effort in the eastern Mediterranean and Aegean Seas.

	Aegean Sea		**Levantine Basin**	
Survey mode	km	hh:mm	km	hh:mm
Passage+acoustic	416.6	40:28	709.4	62:01
Passage+visual	67.1	6:03	22.2	2:37
Passage+acoustic+visual	73.8	6:30	426.7	37:10
Transect+acoustic	536.7	46:23	1859.9	157:22
Transect+visual	45.6	3:40	12.1	1:02
Transect+acoustic+visual	359.6	28:55	1479.2	124:49
Point Sampling	na	39:50	na	105:10
Grand Total	1621	151:30	5230.4	492:55

Table 6. Summary of the cetacean sightings recorded during surveys in the Aegean Sea and eastern Mediterranean Sea. Sightings of turtles and monk seal are also summarised.

Aegean Sea

Species	groups (*n*)	group size range	mean estimated group size	groups hr^{-1}	groups 100 km^{-1}
Bottlenose dolphin	6	1-9	23	0.077	0.011
Common dolphin	2	2	2	0.026	0.004
Unidentified dolphin	3	1-2	4	0.038	0.006
Striped dolphin	10	2--18	63	0.128	0.019
Total	**21**	**0**	**112**	**0.282**	**0.041**
Loggerhead turtle	2	1	2	0.026	0.004
Unidentified turtle	1	1	1	0.013	0.002

Levantine Sea

Species	groups (*n*)	group size range	mean estimated group size	groups hr^{-1}	groups 100 km^{-1}
Bottlenose dolphin	1	4-5	5	0.006	<0.001
False killer whale	1	3-4	4	0.006	<0.001
Risso's dolphin	3	2-15	7	0.018	0.002
Rough-toothed dolphin	2	3-9	12	0.012	0.001
Striped dolphin	6	2-18	42	0.037	0.003
Unidentified dolphin	1	1	1	0.006	<0.001
Total	**14**	**1**	**84**	**0.086**	**0.008**
Monk Seal	1	1	1	0.006	<0.001
Unidentified turtle	1	1	1	0.006	<0.001

There was a single record of common bottlenose dolphin in the Levantine Sea: off southern Turkey (Figure 10 and Figure 11). Striped dolphins (*Stenella coeruleoalba*) were mostly observed in waters further from shore (Figure 10 and Figure 11), whereas short-beaked common dolphins (*Delphinus delphis*) were observed in both coastal and offshore waters of the Aegean Sea (Figure 10), but were not documented from the Levantine Sea, albeit based on much lower survey effort (Figure 11). Risso's dolphins (*Grampus griseus*) were seen on three occasions in the Levantine Basin: between Rhodes and Cyprus, and to the south of Cyprus (Figure 11). On the latter occasion, two Risso's dolphins were associating with rough-toothed dolphins (*Steno bredanensis*). All two sightings of rough-toothed dolphins were recorded in waters to the south of Cyprus. A single group of false killer whales (*Pseudorca crassidens*) was observed offshore to the southwest of Cyprus (Figure 11).

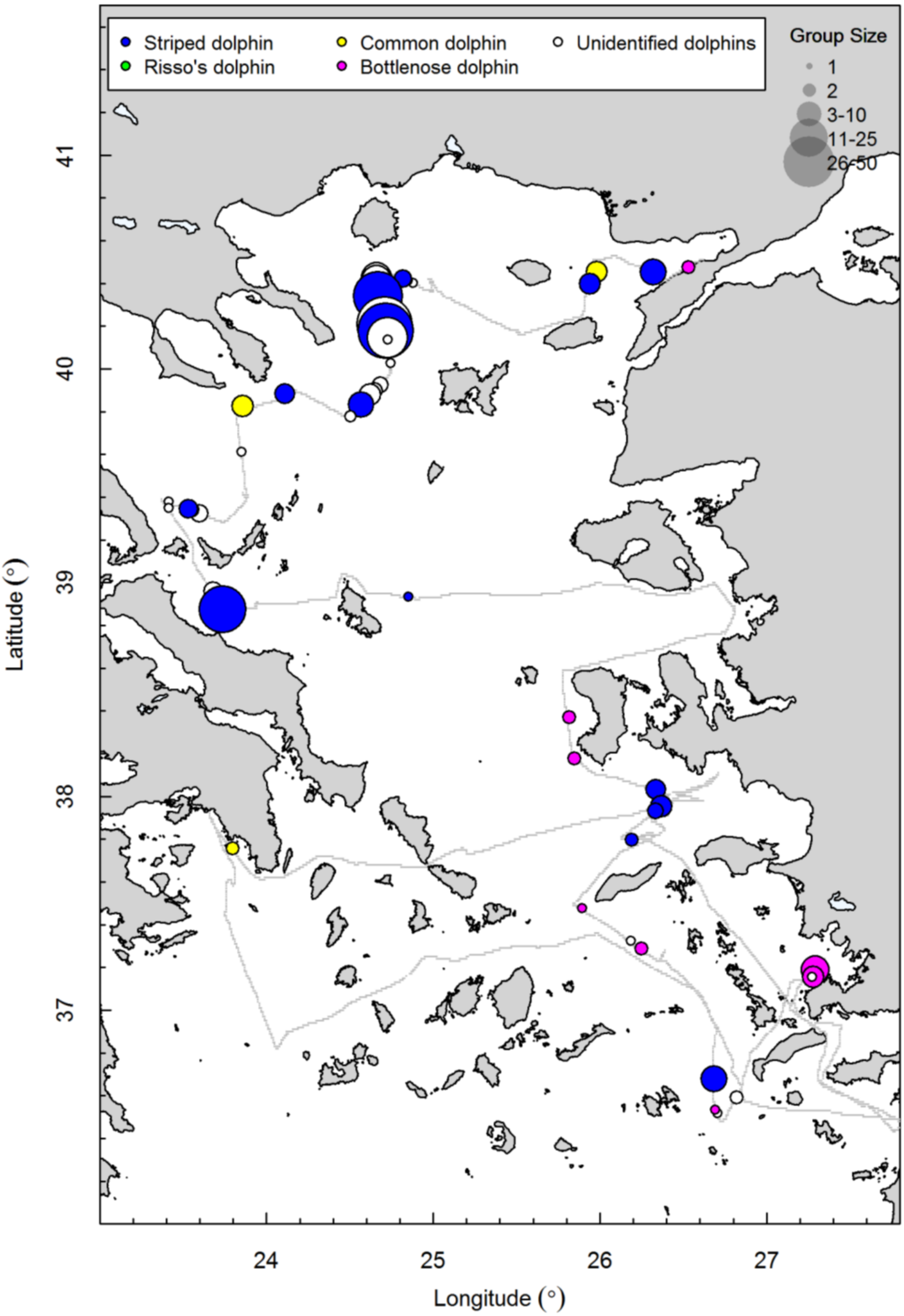

Figure 10. Distribution of cetacean sightings during the Aegean Sea survey. The radius of each symbol, and hence the symbol size, is proportionate to mean estimated group size. NB: Some areas were more intensively surveyed than others, and the sightings presented here are not corrected for effort. The track of SOTW is shown as a grey line.

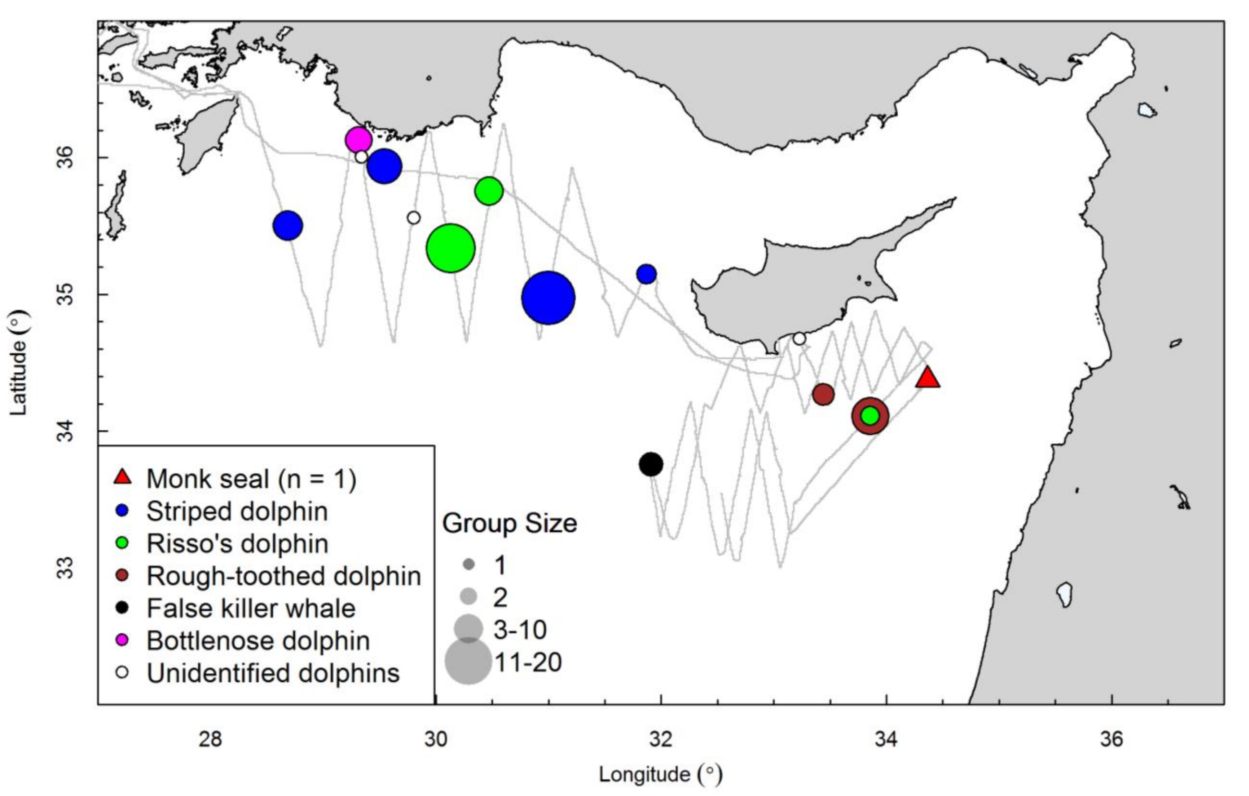

Figure 11. Distribution of cetacean sightings during the eastern Mediterranean survey (Levantine Basin). The radius of each symbol, and hence the symbol size, is proportionate to mean estimated group size. NB: Some areas were more intensively surveyed than others, and the sightings presented here are not corrected for effort. The track of SOTW is shown as a grey line.

2.3.2 Acoustic detections

The hydrophone was monitored every 15 minutes by a researcher with headphones in order to log and classify the presence of cetacean vocalisations. Dolphin clicks and whistles were heard throughout the study area (Figure 12). Detections were frequent in the northern Aegean Sea (Figure 12). Sperm whale clicks were confined to three areas: the Ikaria Basin (Figure 14), a deep area north of Ikaria Island in western Turkey; the Rhodes Basin 40 nm south-east of Rhodes (Figure 15); and to the south of Cyprus (Figure 15). On two separate occasions (30 July and 8 August 2013) groups of vocalising sperm whales were tracked acoustically in the Ikaria Basin (Figure 14). Although sperm whales were not encountered at the surface, it was possible to count the number of individuals acoustically. On the both occasions, a minimum of three individuals was tracked. Similarly, a group of three sperm whales was tracked in the Rhodes Basin (10 August 2013; Figure 15). A more detailed post-survey analysis of the 192 kHz recordings revealed a beaked whale detection in the Ikaria Basin (Figure 14), the route of which was plotted using; target-motion analysis. Dispersed detections were also made of individual (n = 7) beaked whales between Rhodes and Cyprus (Figure 15); insufficient numbers of clicks precluded target-motion analysis in these instances.

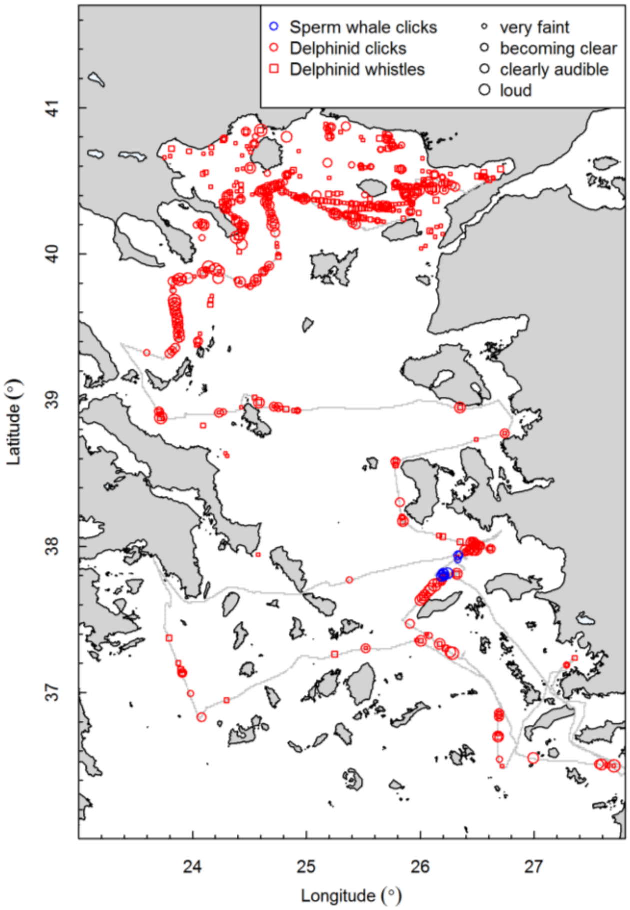

Figure 12. Distribution of delphinid clicks and whistles heard during 2 min listening stations (every 15 min) from the Aegean Sea broad-scale survey. The track of SOTW is shown as a grey line.

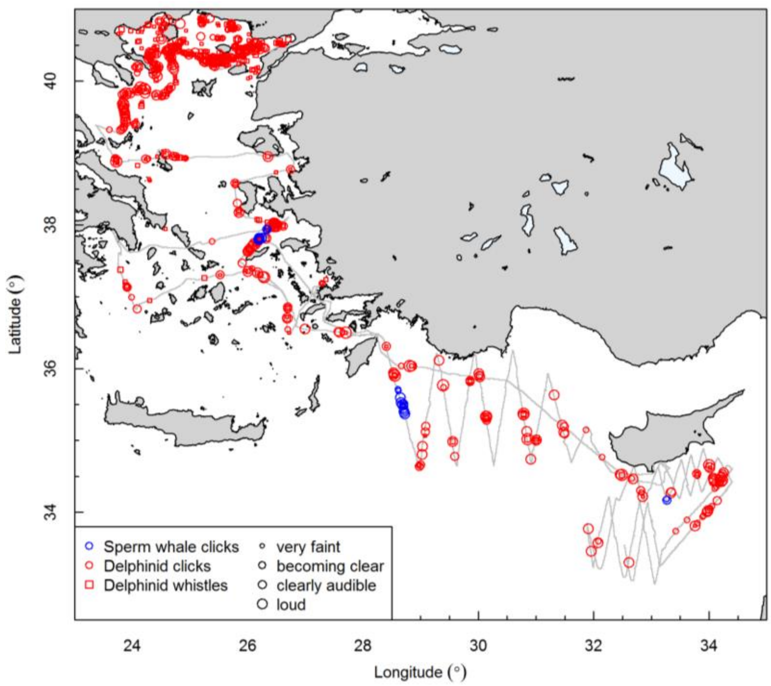

Figure 13. Distribution delphinid clicks and whistles heard during 2 min listening stations (every 15 min) from the Aegean Sea and Levantine Sea surveys. The track of SOTW is shown as a grey line.

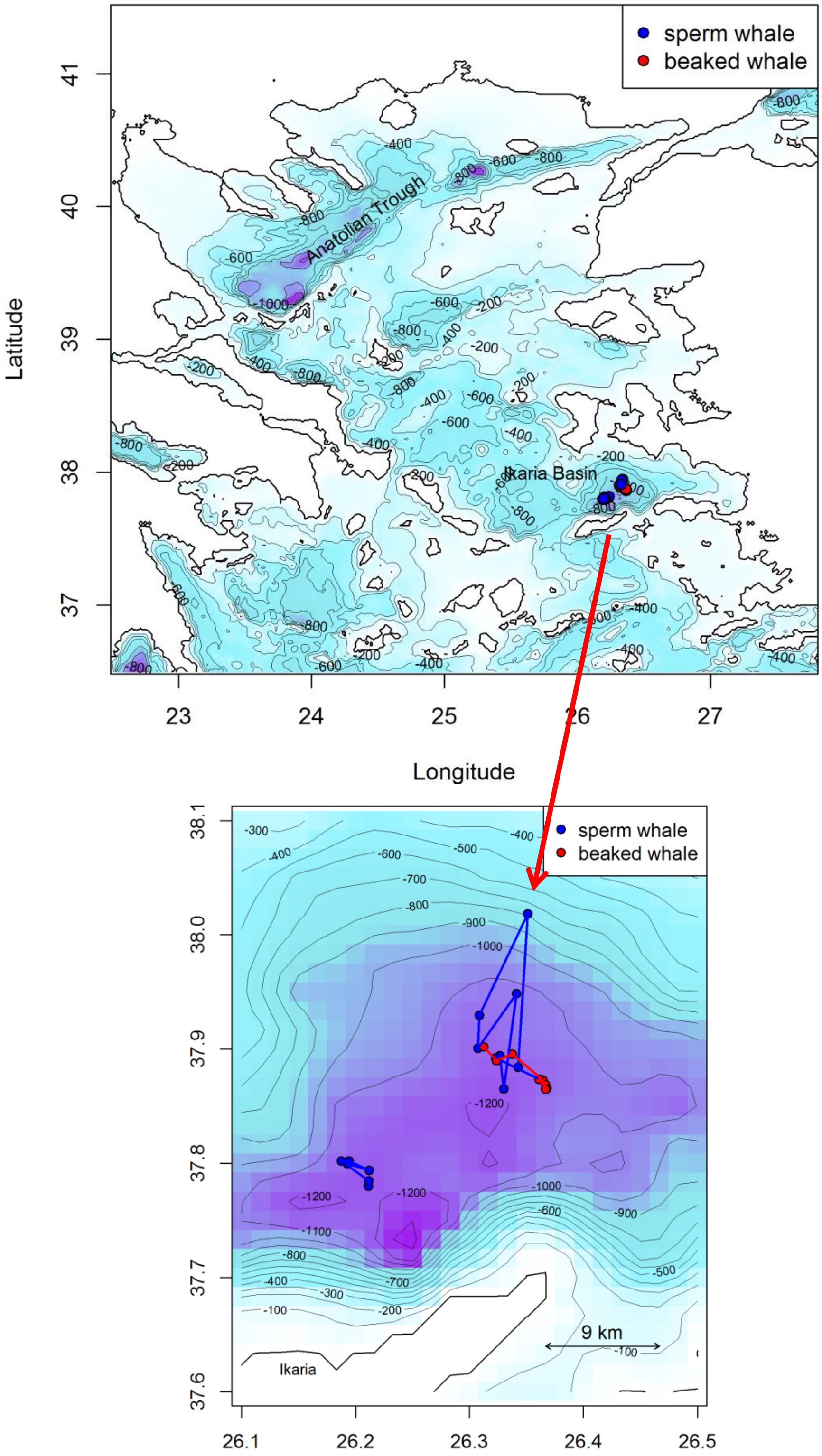

Figure 14. Acoustic detections of sperm whales (2 min listening stations every 15 min) and beaked whales. The beaked whale detections were determined using a click detector module in PAMGUARD, and analysed later by two independent analysts to exclude false-detections. Below: close-up of the Ikaria Basin showing where target-motion analysis tracks of two separate groups of sperm whales (both n = 3) and a single beaked whale sp (n =1).

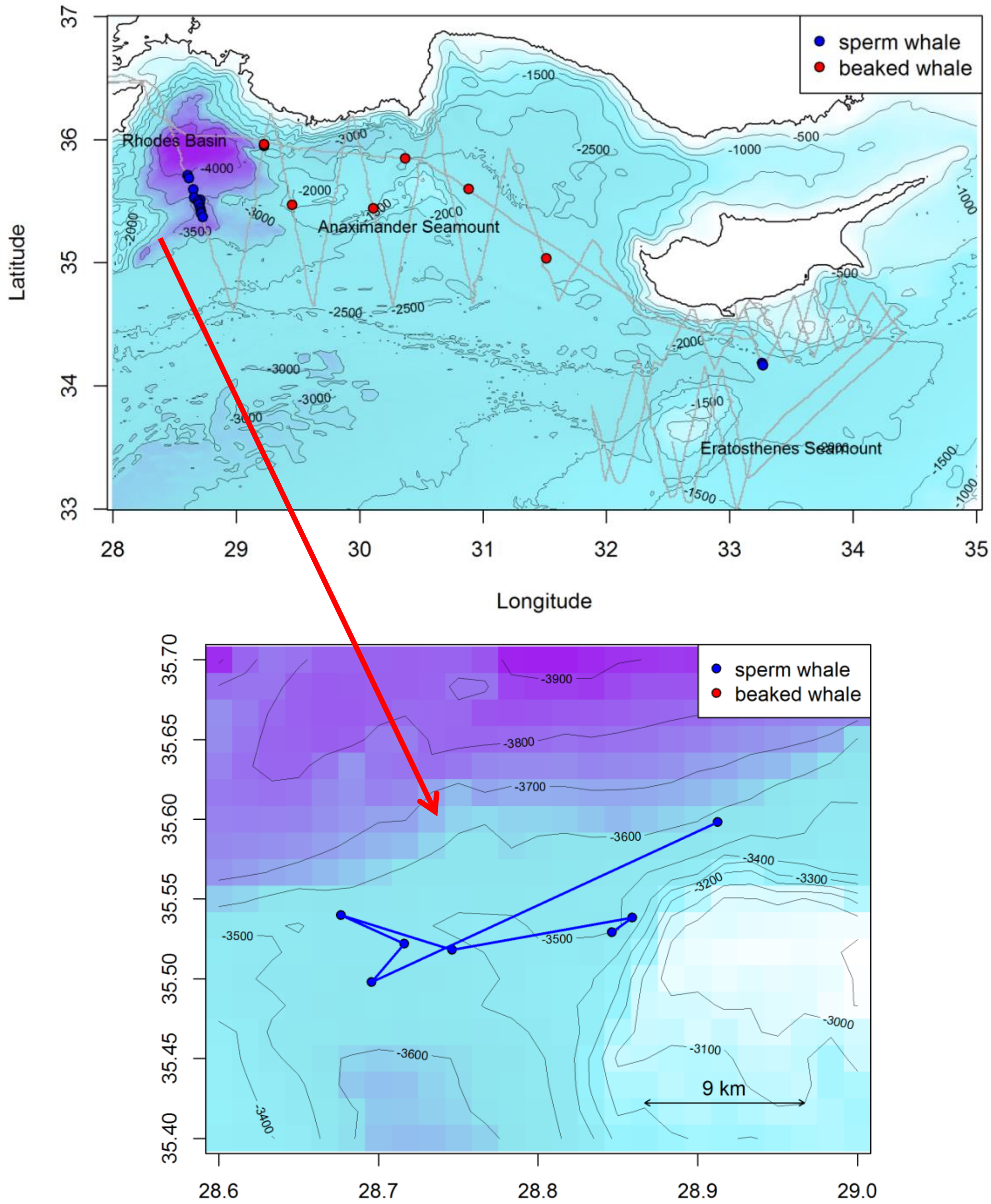

Figure 15. Acoustic detections of a single group of sperm whales (n = 3) and beaked whales (all n = 1). The beaked whale detections were determined using a click detector module in PAMGUARD, and analysed later by two independent analysts to exclude false-detections.

2.3.3 Calibrated noise measurements and CTD casts

Simultaneous calibrated hydrophone recordings and CTD casts were made at 44 stations along the survey track. CTD data were used to calculate the thermocline and halocline depth at different sampling areas (Figure 16). Calibrated recordings taken at the stations were used to characterise background noise levels in the region by interpolating between stations for three frequency bands: infrasonic (63 Hz), low (125 Hz) and mid (1000 Hz) frequency. Power spectrum density levels (PSDLs) exhibited strong gradients for infrasonic and low frequency bands, but were comparatively uniform for mid-frequencies (Figure 17). Subsequent interpolations made using the entire bandwidth of the recordings showed apparent concordance with the shipping densities recorded using AIS data; *i.e.* higher sound pressure levels corresponded well with areas of high density ship traffic (Figure 21).

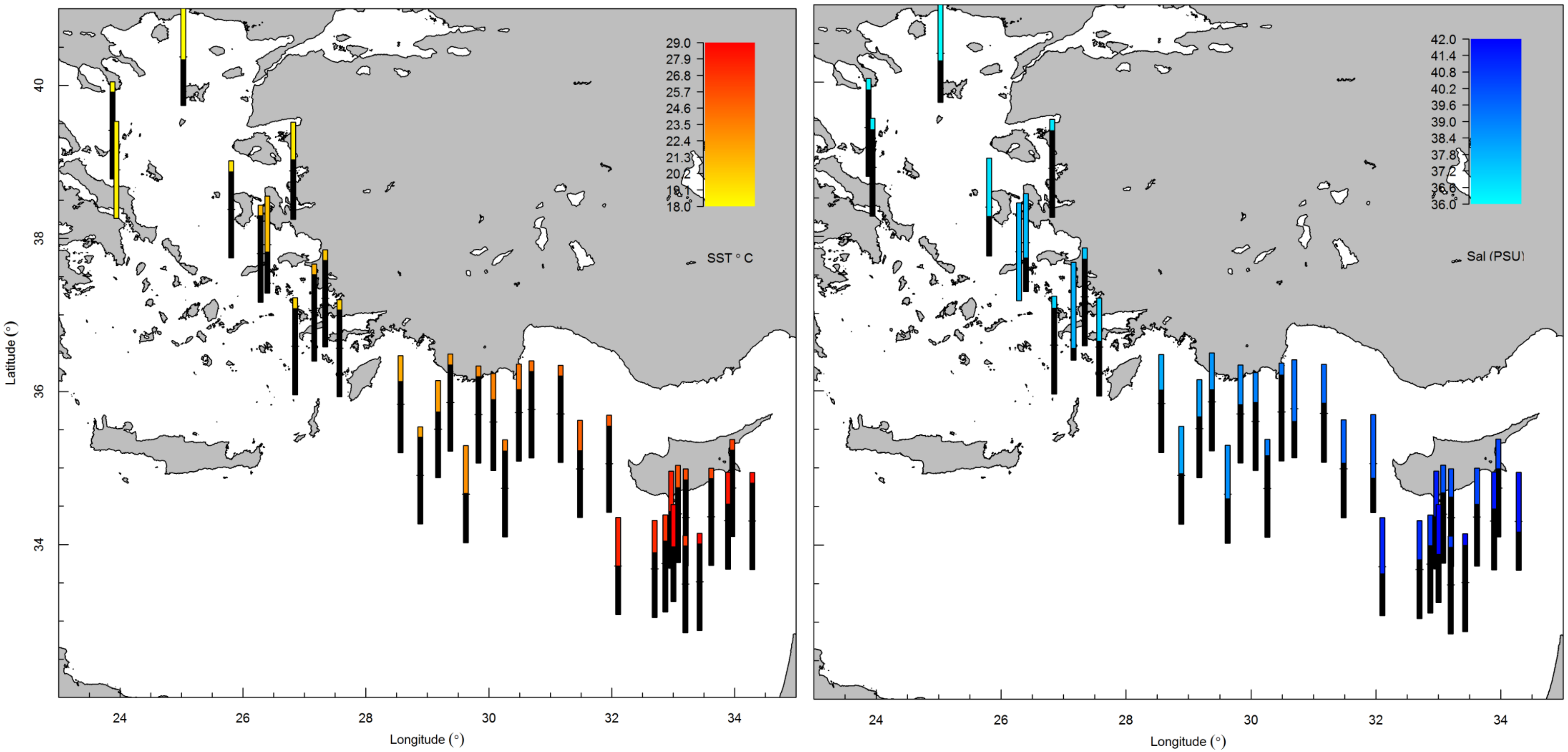

Figure 16. The depth of the thermocline and halocline at sampling stations (n = 40) throughout the Aegean and north-western Levantine Seas, where each bar represents the upper 50 m of the water column. The temperature and salinity at the thermocline and halocline are presented as shades of yellow-red and light-dark blue respectively. The plots show that the water column was uniformly stratified throughout the Levantine Sea, but that the Aegean Sea and parts of the Eratosthenes Seamount were more dynamic and variable with respect to both thermo- and haloclines.

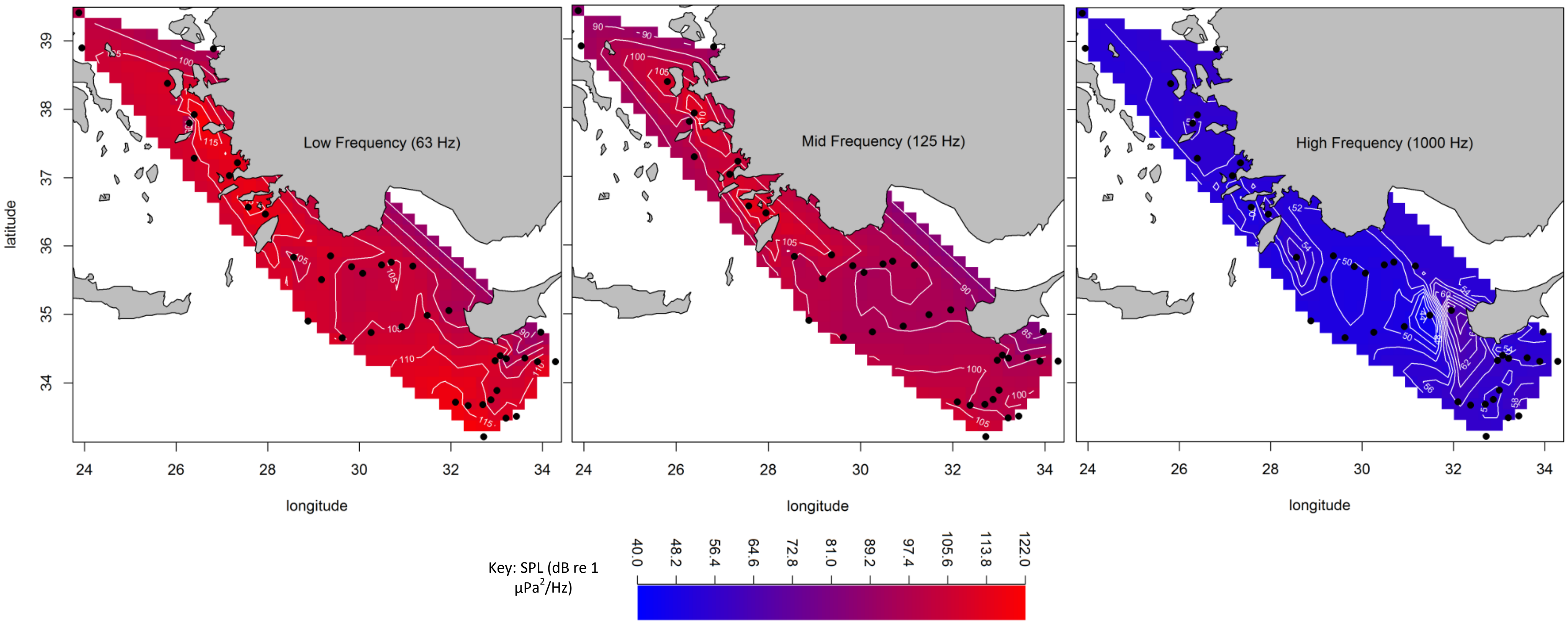

Figure 17. Ambient noise measurements recorded at stations (black dots; n = 41) in the Aegean and north-western Levantine Seas. Power spectrum density levels (PSDLs) were interpolated for the region using linear splines. White contours show areas of equal PSDL measured in dB re 1 µPa^2/Hz, plotted at the same scale for low, mid and high frequencies.

2.3.4 Ship traffic and AIS analysis

As the reporting interval of AIS transmissions depends on the speed and course changes of a given vessel, the raw AIS data received are unlikely to be homogenous. Therefore, for the analysis of AIS data, only single observations per vessel per day were considered at an arbitrary point from which to make comparisons. This arbitrary point was chosen to be the closest point of approach to SOTW. A total of 3402 such vessel records (unique vessels per day at their closest point of approach to SOTW) were recorded throughout the project. These data are useful in identifying areas of high shipping density for primarily large vessels including shipping lanes (Figure 18). Patterns in the AIS data demonstrated three main thoroughfares for vessels in the Levantine Sea: from the Suez Canal towards the western Mediterranean; from the Suez Canal towards the Black Sea; and east-west along the south coast of Turkey. In the Aegean Sea, the main thoroughfares were from the Dardanelles Straits towards: Athens; The Suez Canal (via the Dodecanese Archipelago); and Turkey/Cyprus via Rhodes (Figure 18). Most of the vessel traffic in the Thracian Sea centred around the port cities of Kavala and Alexandropoulos. High-speed craft (passenger ferries) in the southern part of the Aegean Sea are clearly seen as red lines, travelling between 30 – 40 knots (Figure 16).

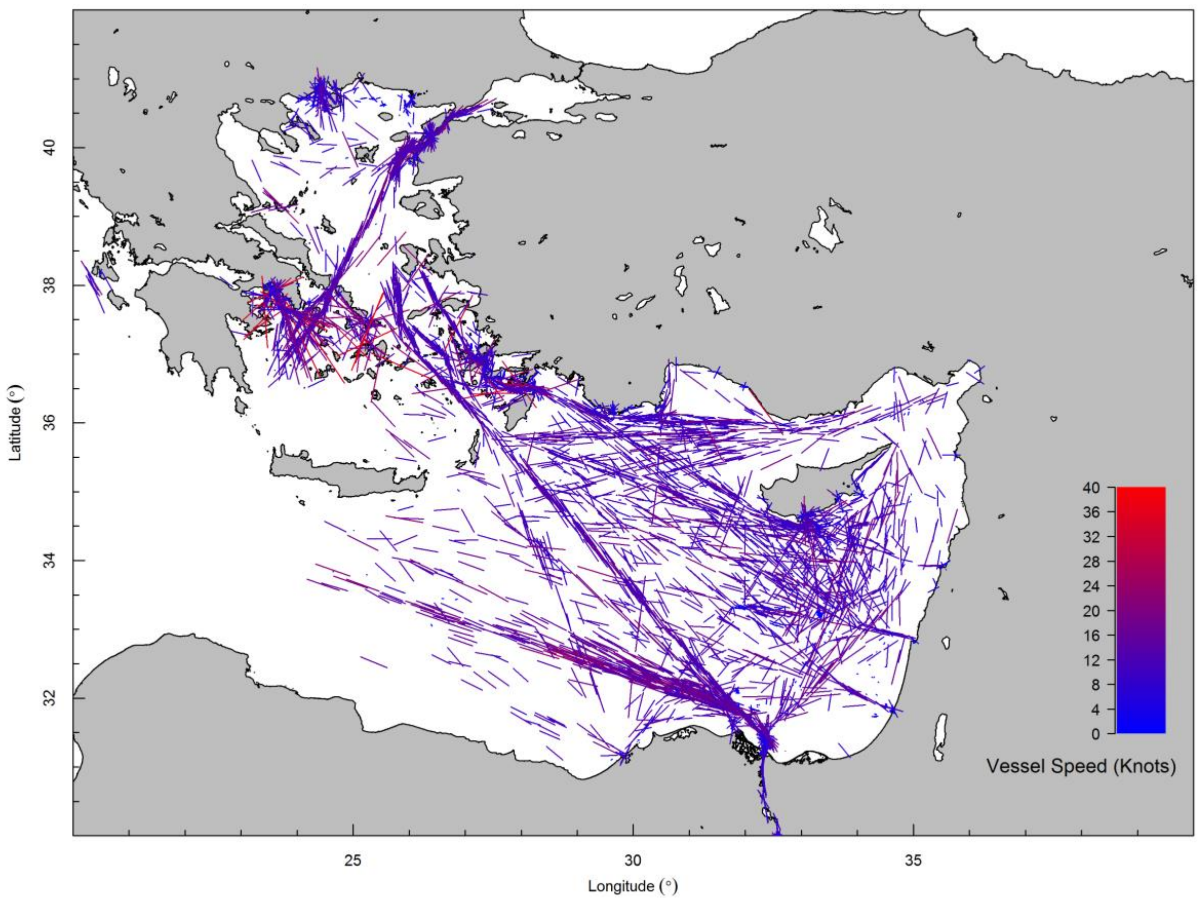

Figure 18. Vectors showing the speed and heading of vessels obtained from AIS during the 2013. The data presented here are unique vessels per day at their closest point of approach to R/V Song of the Whale. Fast ferries can be seen in the southern Aegean Islands (>30 knots).

During 2007, a similar survey of the Levantine Basin was conducted by the SOTW team in order to determine the density of sperm whales (Lewis *et al*., in prep.). AIS data were collected in the same way during both the 2007 and 2013 surveys allowing changes in vessel speeds to be investigated in the Levantine Basin over a six year interval. Only the speed over ground for each unique vessel (using MMSI numbers) at the closest point of approach to SOTW was considered. These data selection criteria were applied on a per day basis, resulting in speeds for unique vessels per day at the closest point of approach to SOTW. Statistical analyses were carried out to test for whether differences in ship speeds between 2007 and 2013 were significant (Figure 19). Variance within the speed over ground data was found to be homogeneous (Bartlett's $K^2 = 0.17$; df = 1; $p = 0.68$). The mean speed during 2013 was 11.74 kn; which is significantly less ($t = 23.29$; df = 5280; $p < 0.001$) than that recorded during the same season in 2007 (14.38 kn). To investigate whether this significant reduction in mean ship speed was biased by certain vessels, the AIS data were queried such that only vessels that were recorded during *both* 2007 and 2013 were considered ($n = 192$ vessels), using their MMSI number as a unique identifier. Furthermore, only AIS observations within a 1^o x 1^o region corresponding with the main Suez Canal – Black Sea thoroughfare (N 34^o, W 30^o) were considered for this subset of vessels (Figure 18). Again, vessel speed over ground for was significantly greater ($t = 33.51$; df = 786; $p < 0.001$) for observations from 2007 (15.17 kn) compared to 2013 (12.20 kn).

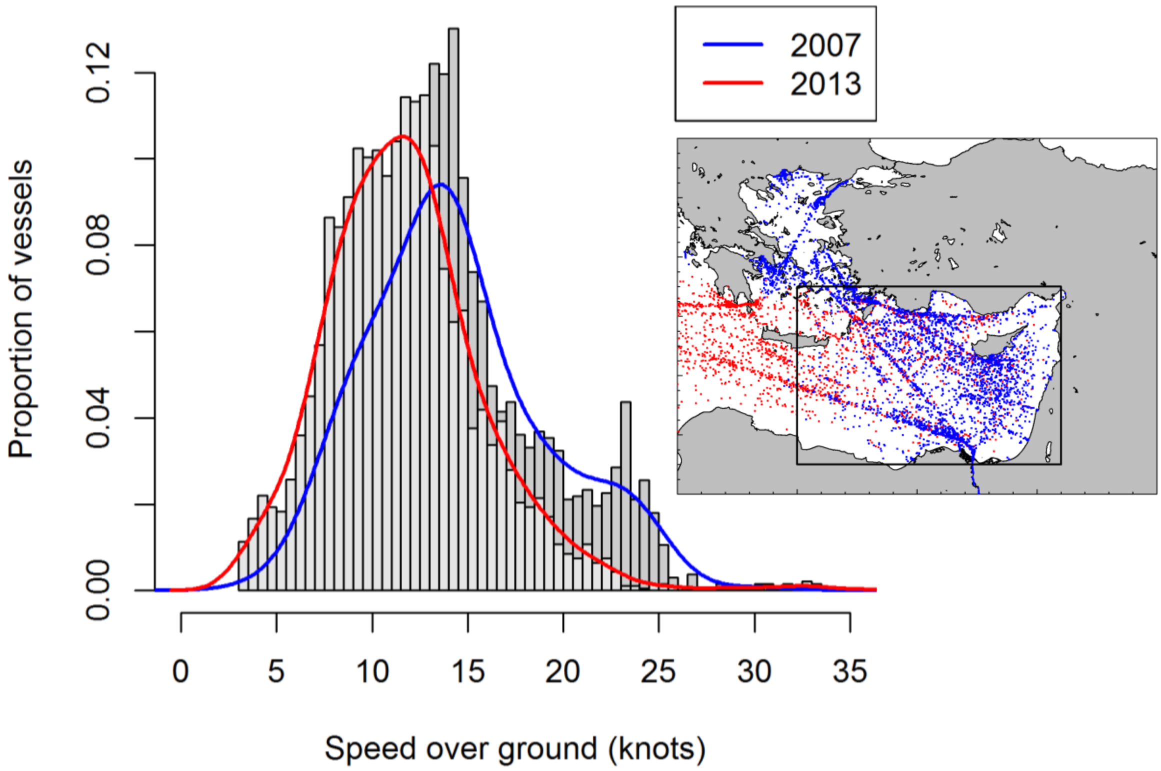

Figure 19. AIS vessel speeds, showing the reduction between summer 2007 (May-Sep) and 2013 (Jun-Sep) in the area demarcated in the inset map. Speed over ground was significantly greater in 2007 (15.17 kn) than 2013 (12.20 kn ($36^o – 25^o$ N, $37^o – 31^o$ E).

In order to further explore this stark change in vessel speeds, vessel class was considered as a factor. It is clear from figure 18 that greatest speed reductions along the Suez Canal – Sicilian Channel thoroughfare are accounted for by container ships, which are the fastest of the vessel classes (Leaper *et al.,* 2014). Such changes in vessel speeds, and the reasons for them, are critical to inform management initiatives that aim to assess risk and to mitigate for cetacean ship-strikes.

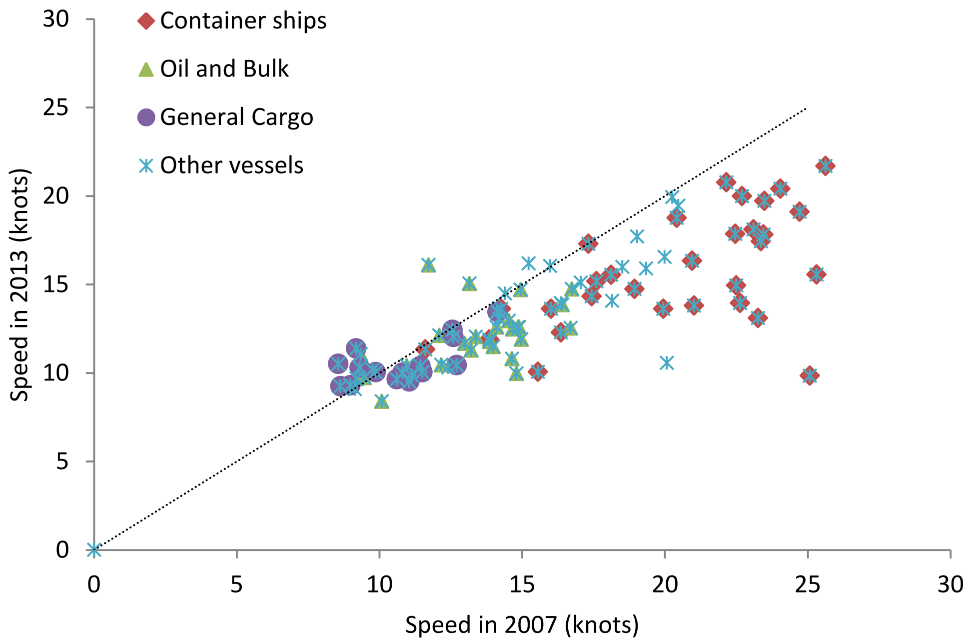

Figure 20. Comparison of vessel speeds for vessels observed in both 2007 and 2013 along the Sicilian Channel - Suez Canal thoroughfare, from AIS data. Dotted line = parity. [Figure reproduced from Leaper et al., 2014)

Finally, the density of shipping traffic was plotted using one million AIS locations selected randomly from the 2013 dataset. Kernel density estimates and the proportion of vessels at a given location highlighted five areas of high shipping density: Dardanelles; Athens / Cyclades; Rhodes / Dodecanese; Cyprus and Port Said / Alexandria (Figure 21). Linking these high density areas are discrete thoroughfares between the Black Sea and the Suez Canal and eastern Mediterranean ports via the Aegean Sea (Figure 22). In the Aegean Sea, these thoroughfares are narrow as they are channelled by numerous islands. With the exception of traffic to and from the Suez Canal, ships in the Levantine Sea tended to exhibit a more widespread distribution by comparison with the Aegean Sea (Figure 22).

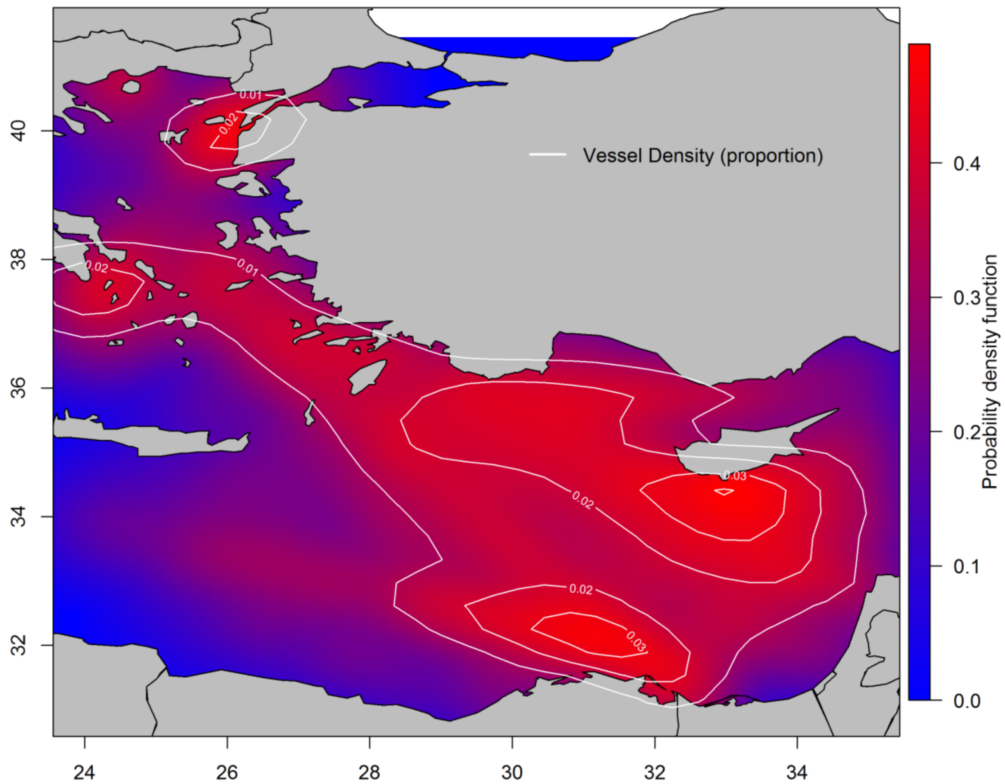

Figure 21. Density of maritime traffic (vessels > 300 t travelling >10 knots) in the Aegean and Levantine Seas, estimated using kernel density smoothing (standard bivariate normal) denoted by colours. The proportion of vessels at a given location in relation to the whole region is indicated by white contours. All data were recorded from SOTW between 27 July and 2 September 2013.

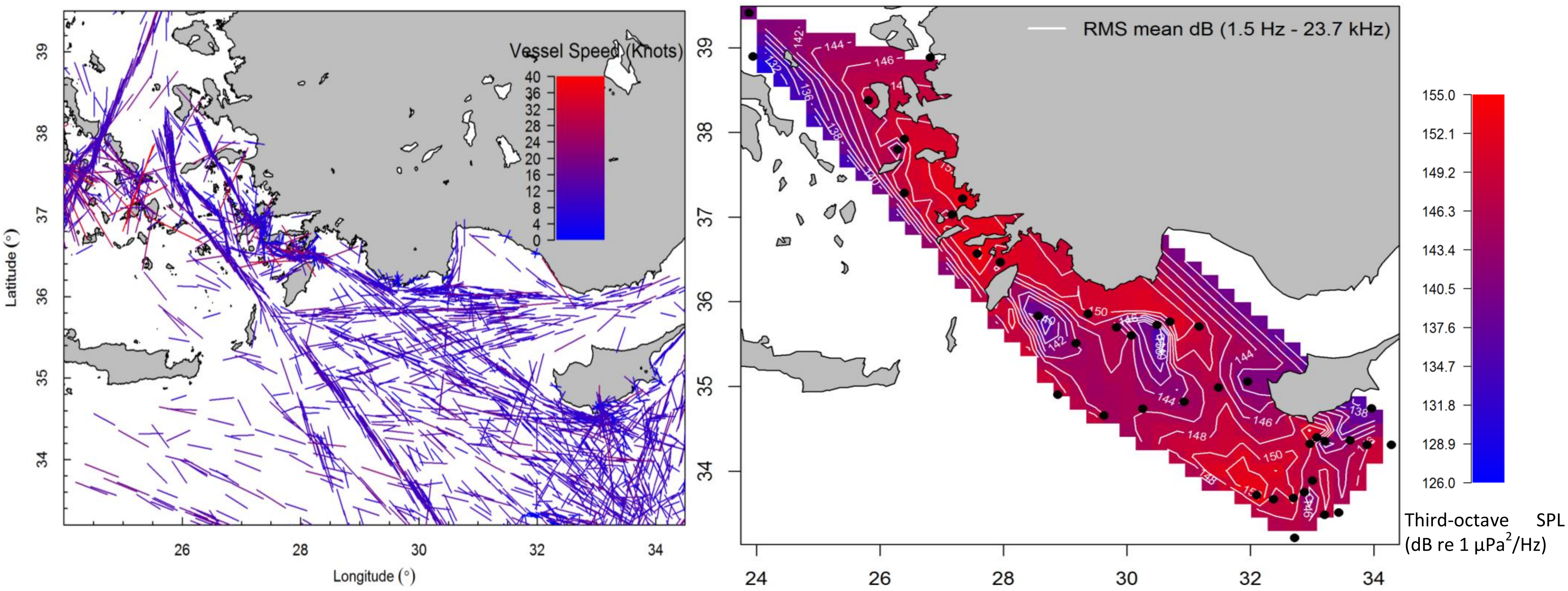

Figure 22. Showing that ambient noise (RIGHT) is generally highest in shipping thoroughfares (LEFT). Ship traffic was traced using vectors of individual vessels from AIS data where each line is a vector whose length and colour are proportionate to the speed of a given vessel. A consistent pattern is evident for sound pressure levels at all recorded frequencies (route mean square of sound pressure levels measured in dB re 1 µPa from 1.5 Hz to 23.7 kHz) from 41 calibrated ambient noise measurements in the Aegean and Levantine Seas. SPL values have been interpolated using linear splines, within the convex hull of the ambient noise recording locations (black dots).

2.3.5 Presence and distribution of rubbish and plastic debris

During 'on track' visual survey effort (in sea states of ≤ 3), a total of 610 items of floating debris was recorded in the Thracian, Aegean and Eastern Mediterranean Seas. Plastic debris (*n* = 552) was distributed widely both inshore and offshore (Figure 23). A caveat of visually recording floating debris is that less conspicuous items such as plastic sheeting and bags will be under-recorded, compared with more buoyant items such as polystyrene or balloons. The highest relative abundance of litter encountered during the surveys was in the Thracian Sea, where the encounter rate of debris and plastic was over three times that of the rest of the Aegean Sea and Cyprus, and almost twice that of southern Turkey (Table 7).

Table 7. Summary of survey effort and encounter rate of floating marine debris (plastics only in parentheses) in four regions

Region	Km surveyed ('on track' ≤ sea-state 3)	Debris encounter rate (100 km^{-1})
Thracian Sea	1256.2	48.6 (43.9)
Central and southern Aegean	438.3	16.4 (14.6)
South of Turkey	687.7	26.2 (23.4)
South of Cyprus	739.3	10.9 (10.3)

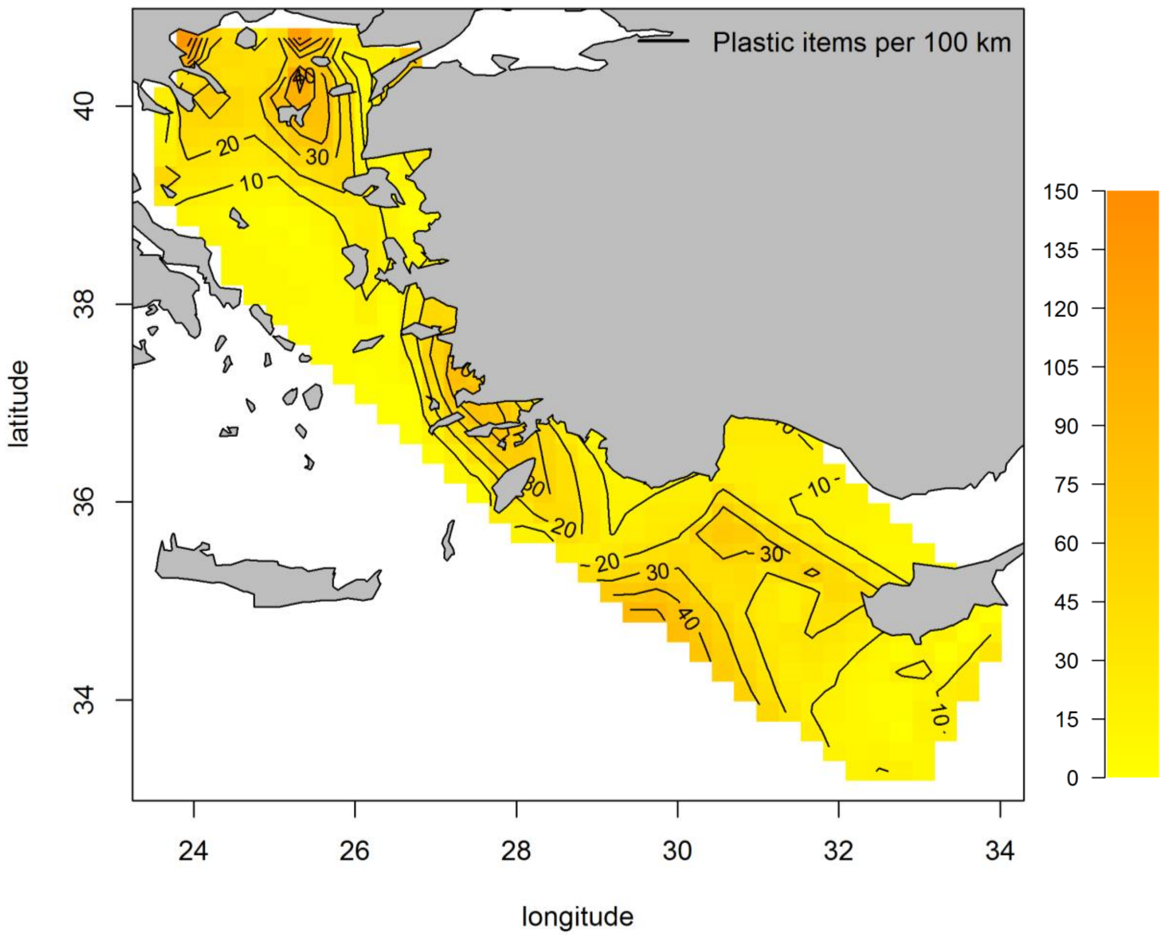

Figure 23. Effort-corrected encounter rates (100 km^{-1}) of floating plastic items observed during cetacean visual surveys (in sea state ≤ 3 during daylight). Standard bivariate kernel density smoothing was used to interpolate encounter rates from the start of each transect line (n = 68). Transect lengths differed ($\bar{x}$ = 26.3 km; SD = 25.3). NB: Some areas were more intensively surveyed than others and extrapolations beyond sampled areas must be interpreted with caution.

2.4 DISCUSSION

2.4.1 Marine mammal distribution and relative abundance in the Aegean and Levantine Seas

A higher relative abundance of cetaceans, measured as encounters (*i.e.* groups) per 100 km, was found in the Aegean Sea by comparison with the Levantine Sea. Furthermore, the diversity of species observed was greatest in the Aegean Sea. However the Levantine Sea is home to several species of marine mammals that are poorly known in the Mediterranean Sea and some species that have not been reported from the western basin *e.g.* rough-toothed dolphin. Despite the lower relative abundances, the region is perhaps disproportionately important considering the relatively unique assemblage of species including monk seal, rough-toothed dolphin, Risso's dolphin, and false killer whale. Sperm whales were recorded at three discrete locations exclusively in deep-water troughs (600 – 3600 m). Beaked whales were spatially associated with sperm whales in the Ikaria Basin only. The distribution of beaked whales in the Levantine Sea was apparently mutually exclusive with that of sperm whales. Whether this pattern is an artefact of a small sample size (n = 6 beaked whale detection events) or due to some underlying ecological process remains unknown. In the North Atlantic Ocean for example, beaked and sperm whales are known to exhibit fine-scale habitat preference influenced by oceanography (Waring *et al*., 2001), possibly as a result of their very similar trophic niches which may put them in competition for resources (Ostrom *et al.*, 1993; Pauly *et al.*, 1998). However this hypothesis requires further investigation in the Mediterranean Sea where niche partitioning might be different from that in the Atlantic for the species concerned.

The concept of geographically defined protected areas as a management tool for the conservation of cetaceans is usually fraught with difficulties, given that cetaceans tend to be migratory or range over vast areas (Argady *et al.,* 2011). However two discrete areas appear to be particularly important for cetaceans in this study: Saros Bay and the Ikaria Basin. In Saros Bay the water is shallow but the depth drops steeply to 550 m at the entrance. Here, cetacean species richness was higher than any other area of comparable size in the region surveyed. Four species of cetacean were recorded including harbor porpoise, bottlenose dolphin (both listed under Annex II of the EU Habitats Directive), common dolphin and striped dolphin. Whether this species richness is influenced by the restriction on certain fisheries including trawling remains to be determined (Saros Bay is a 'Special Environmental Protected Area'), but certainly warrants investigation. The second location of interest is the Ikaria Basin, which is a semi-enclosed trough of deep water (up to 1500 m deep), isolated by shallower waters on all sides. In this small basin, *ca.* 35 km in diameter, both sperm whales and beaked whales were detected acoustically on more than one occasion, and striped dolphins were sighted. Although the effectiveness of small and isolated marine protected areas for the conservation of highly mobile cetacean species has been questioned, Saros Bay and the Ikaria Basin may warrant further investigation in terms of suitability and appropriateness as candidates for protection, given the indications presented herein. Further surveys ought to be conducted at these sites to provide seasonal coverage, and a more detailed investigation of surrounding areas. This may help to determine whether targeted changes to human activities could be an effective approach to improving the protecting of cetaceans in the Aegean Sea.

2.4.2 Sperm whale

Sperm whales were detected at three discrete locations in deep-water troughs (600 to 3600 m deep). The results from this study build on previous surveys that found sperm whales in the eastern Mediterranean were concentrated within the Hellenic oceanic trench and its easterly extension (Lewis *et al.,* in prep). In the surveys conducted by the *Song of the Whale* team in 2007, sperm whales were detected in the north Rhodes Basin as in this study. Similarly, the Rhodes Basin has been recognised as an important region for sperm whales in a recent review (Öztürk *et al*., 2013) and has been proposed as a High Sea Marine Protected Area in part due to its importance for sperm whales (Öztürk, 2009). Findings presented here lend credence to the notion that the Rhodes Basin is ecologically important for sperm whales, perhaps linked to the concentration of nutrients by the quasi-permanent Rhodes Gyre, making it the most productive area of the eastern basin with the largest phytoplankton biomass (Bosc *et al.,* 2004). Sperm whales were also detected on two separate occasions in the Ikaria Basin, a region where sperm whales have been documented on at least four other occasions between October 2004 and November 2012 (Öztürk *et al*., 2013). Further research effort is required to establish seasonal use of this region as all documented sightings have occurred between July and November, yet it remains unclear if this due to a bias in effort.

During previous surveys conducted from *Song of the Whale* in 2007, sperm whales were not encountered in the waters around Cyprus. Although the IUCN Red List describes sperm whales as native to Cyprus, there are no reliable records of free-swimming individuals in Cypriot waters apart from a group of 10 individuals encountered within 20 km of Cyprus in 1997 (Kerem *et al*., 2012). A recent review of cetaceans in the Mediterranean listed sperm whales as rare or absent from Cypriot waters (Notarbartolo di Sciara & Birkun, 2010). However there is an unpublished record of a single dead calf from the northwest of Cyprus in December 2004 (Savvas Michaelides, pers. comm. 1 March 2014). The acoustic detections reported in this study represent only the second documented live sperm whales from this area. As known sperm whale distribution in the eastern Mediterranean basin is patchy and based very few records, further research effort in Cypriot waters would be useful, considering the lack of research effort to date. Sperm whales were not detected in the Anatolian Trough, an area previously noted for sperm whale presence (Frantzis *et al.,* 2003; Öztürk *et al.,* 2013). It is possible sperm whales use this trough only intermittently or seasonally when crossing shallower regions as they transit from one area of steep underwater relief to another (Frantzis *et al.,* 2003).

2.4.3 Beaked whales

All eight beaked whale detections were made in waters greater than 1000 m, inside the Ikaria Basin or over the Anaximander Seamounts. On one occasion, it was possible to track a single beaked whale (unidentified beaked whale species) for two hours using acoustic tomography. The individual remained in the deepest waters of the Ikaria Basin. Beaked whales were detected by acoustic means but not sighted, which is not surprising given their inconspicuous nature at the surface and propensity for long dives of up to two hours. Results demonstrate the value of passive acoustic monitoring during cetacean surveys in the Mediterranean Sea in order to effectively detect all cetacean species. Although species identification using click characteristics is being advanced (Baumann-Pickering *et al.*, 2013), it has not been possible to determine species due to a lack of species-specific information on beaked whale clicks from the Mediterranean Sea. Given that the Mediterranean Sea has a low diversity of beaked whale species, it is most likely that these were Cuvier's beaked whale. However, Sowerby's beaked whale is a remote possibility, as this species has been recorded twice in the Mediterranean Sea and once in the Aegean Sea (Frantzis *et al.*, 2003; Bittau *et al.*, 2013).

2.4.4 Rough-toothed dolphin

Rough-toothed dolphins were encountered twice during the survey, both times in the Levantine Basin. Although occasionally represented in the stranding records throughout the Mediterranean Sea (see Reeves & Notarbartolo di Sciara, 2006 and Kerem *et al*., 2012 for reviews), sightings of live animals in the Mediterranean Sea are extremely rare (Watkins *et al*., 1987; Boisseau *et al.,* 2010; Kerem *et al*., 2012) with only eight sightings of live individuals having been recorded to date (Kerem *et al*., 2012). The encounters reported here are noteworthy considering the Mediterranean sub-population of this species is now tentatively proposed as 'regular' in the Eastern Mediterranean but retains the status of 'visitor' in the Western Mediterranean. The status of this species in the Mediterranean Sea is currently being assessed, and the records presented here from 2013 contribute further valuable data to inform the on-going review of the range and status of rough-toothed dolphin in the Mediterranean Sea. As this species appears to be absent from the northern reaches of the Red Sea, it seems likely that individuals encountered in the Levantine Basin are year-round residents and not Lessepsian migrants (*i.e.* from the Red Sea via Suez Canal). They tend to favour deeper offshore waters with occasional forays in to coastal waters. Photographs taken in this and previous surveys from *Song of the Whale* could contribute to a photo-identification catalogue of *Steno* in the Mediterranean to allow the tracking of individuals and estimation of population size. As in previous Mediterranean surveys conducted from *Song of the Whale*, the whistles of this species showed idiosyncratic stepped jumps in frequency that may prove to be a useful characteristic to recognise and distinguish rough-toothed dolphins from acoustic surveys alone. Funding is needed to describe these findings in order that automated detection algorithms can be developed. This would facilitate a rapid re-analysis of previous acoustic surveys, enabling this poorly studied species to be identified from archived datasets.

2.4.5 Risso's dolphin

Four sightings of Risso's dolphin were recorded during the entire survey (one from the northern Aegean Sea, and three in the Levantine Basin). These records are useful as the Mediterranean sub-population of this species is categorised on the IUCN Red List as 'Data Deficient' (Taylor *et al*., 2012). Although considered a regular inhabitant of the Mediterranean Sea, Risso's dolphins appear scarcer in the eastern basin, with perhaps as few as 12 documented sightings of live animals in the Levantine Basin (Dede *et al.,* 2012; Kerem *et al*., 2012). However, this may be due to a paucity of regional surveys as the three encounters documented in this study alone elevate the number of known sightings by 25%. Evidence is accumulating in support of proposals for the Anaximander ridge to receive protection as part of a south Aegean Sea Peace Park (CIESM, 2011) or the M1 High-Seas Marine Protected Area (Öztürk, 2009): Risso's dolphins were recorded over the Anaxaminder Mountains in 2013 (Figure 13); 2012 (Dede *et al.,* 2012) and 2007 (Boisseau *et al.,* 2010).

2.4.6 Striped dolphin

The striped dolphin is believed to be the most abundant cetacean in the Mediterranean (Forcada *et al*., 1994) with abundance decreasing towards the eastern basin, presumably due to a decreasing gradient of productivity (Notarbartolo di Sciara & Birkun, 2010). Almost 50% of the encounters in this study were of striped dolphins with sightings concentrated in the North Aegean Basin. This is reflected in the acoustic data too as delphinid acoustic detection rates were also relatively high in this area. Data gathered during these surveys show an apparent preference for offshore waters in this species in the northern Aegean Sea. There were however several sightings of striped dolphins in more coastal waters of the Aegean Sea, and occasionally in association with common dolphins. Although once considered absent from waters east of 30°E (Marchessaux, 1980), striped dolphins were encountered in this study between Rhodes and Cyprus. In keeping with other studies (Boisseau *et al*., 2010; Kerem *et al*., 2012), it seems striped dolphins may range throughout the eastern basin and a perceived absence may merely reflect a lack of survey effort.

2.4.7 Common bottlenose dolphin

The distribution of bottlenose dolphins was restricted to coastal waters (<15 km from land) less than 400 m deep. The species was recorded with higher relative abundance in the northern Aegean Sea and along the west and southwest coast of Turkey where it was the second most frequently encountered cetacean species, after striped dolphin. One notable sighting was a bottlenose dolphin with no dorsal fin in Saros Bay, Turkey, an injury consistent with fisheries interaction. A crude comparison between relative abundance from other surveys indicates that groups of bottlenose dolphins were encountered at a much lower rate in the Thracian (0.023 groups 100 km^{-1}), Aegean (0.011 groups 100 km^{-1}) and Levantine Seas (<0.001 groups 100 km^{-1}) compared to other regions in the Mediterranean: *e.g.* the Adriatic (1.4 groups 100 km^{-1}) and Ionian Seas (0.6 groups 100 km^{-1}; Bearzi *et al.,* 2008) and the Sicilian Channel (0.1 groups 100 km-1; Boisseau *et al*., 2010). However caution is warranted in over-interpreting these comparisons because differences in survey design, platform height and vessel type may be confounding. As in previous surveys from *Song of the Whale*, bottlenose dolphins were not encountered east of 30° of longitude, however they have been encountered further east along the Turkish coastline (Dede *et al*., 2012) and lack of understanding of this species' distribution in the eastern basin likely relates to patchy survey effort (*e.g.* in Egyptian waters). There is evidence of some geographical differentiation within the Mediterranean Sea; however, current genetic evidence suggests bottlenose dolphins inhabiting Israeli waters are more similar to animals from the contiguous Atlantic region than the Aegean or Black Seas (Natoli *et al*., 2005; Viaud-Martinez *et al.*, 2008).

2.4.8 Short-beaked common dolphin

Common dolphins were found in low relative abundance in the Thracian (0.008 groups 100 km^{-1}) and Aegean Seas (0.004 groups 100 km^{-1}), but were not encountered in the Levantine Sea. Common dolphin populations have been in serious decline in the Mediterranean Sea since the 1960s and poor survey coverage has precluded thorough assessment of their conservation status in the eastern basin (Bearzi *et al.*, 2003). Abundance estimates are only available for the Alborán Sea in the western Mediterranean where population decline has been linked to aquaculture (Cañadas and Hammond, 2008). Our study supports the assessment by Bearzi *et al.,* (2003) that a small and potentially isolated population of common dolphins exists in the northern Aegean Sea, but they are occasionally seen in the rest of the Aegean Sea. Subject to funding, it is hoped that the data herein will be used to derive abundance estimates for common, bottlenose and striped dolphins in the Aegean Sea; this is of particular importance as the Mediterranean sub-population of *Delphinus delphis* is currently listed as 'threatened' under the IUCN Red List. Although there have been an increasing number of sightings of common dolphins in Israeli waters since 2003 including calves (Kerem *et al*., 2012), the lack of sightings in the intervening waters between the Aegean Sea and Israel (including surveys conducted in 2007; Boisseau *et al.*, 2010) suggest there may be some geographic isolation, notwithstanding a sighting of two individuals to the west of Cyprus in 2008 (Dede *et al*., 2012). Genetic corroboration is currently lacking.

2.4.9 Monk seal

A single monk seal was sighted 70 km south of Cape Greco, Cyprus (only 20 km from the Lebanese EEZ); this is significant given that very little is known about the offshore distribution of this critically endangered species in the Mediterranean Sea. It is most likely that this individual belongs to the Greece-Turkey sub-population (part of which whelps at sites along the south and north coasts of Cyprus), in which case this single record extends the current known range of this population (Coll *et al*., 2010, Gucu *et al*., 2004). As fewer than 500 individuals are thought to exist worldwide, offshore sightings away from the refuge of land caves are particularly significant in terms of estimating the home ranges of seals belonging to increasingly fragmented populations.

2.5 Ambient noise and ship traffic density

Our results show a clear concordance between shipping density and sound pressure levels, particularly for low frequency but also for broadband measurements. This finding reaffirms that shipping was the main source of noise pollution in the Aegean and eastern Mediterranean Sea during our study. Two areas where sperm and beaked whales were recorded, Rhodes and Ikaria Basins, were subject to relatively high levels of low frequency noise: 110-115 dB re 1 $\mu Pa^2/Hz$ for the 63 Hz band. These values compare with 53 dB re 1 $\mu Pa^2/Hz$ for the same frequency band in perfectly quiet (*i.e.* no shipping noise) conditions, albeit in a different ocean: the North Atlantic (Reeder *et al.*, 2011). These high values were measured in these areas despite the fact that they are both very deep (4000 m and 1400 m respectively), where one would expect to find a greater dissipation of sound energy due to spherical spreading. These are areas where alterations to shipping lanes coupled with a reduction in vessel speeds might greatly benefit these highly threatened species which rely on such isolated deep-water habitats. Greater survey effort in these important areas is necessary to advise specific policy changes that will have measureable benefits for the conservation of these species. As underwater noise is explicitly considered a descriptor of Good Environmental Status under the Marines Strategy Framework Directive (van der Graaf *et al*., 2012), Member States must ensure that the "introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment".

Shipping density was found to be heterogeneous in this study, with clear traffic thoroughfares apparent. Although no large-scale Traffic Separation Schemes exist in the eastern Mediterranean, the bulk of traffic encountered coincides with the shortest travel distances between key corridors such as the Suez Canal and the

Sicilian Channel. Faster vessels were often encountered in the Aegean Sea and represent local fast-ferry routes. A comparison of speed over ground with a comparable dataset collected by the *Song of the Whale* team in 2007 showed a significant decrease in vessel speed over this six year interval. Decreases were most evident for faster vessels, chiefly container ships. It has been suggested that this reduction in net speed is in response to fuel prices (Leaper *et al.*, 2014) and possibly a growing awareness in the shipping industry about climate change emissions. New regulations aimed at improving the energy efficiency of international shipping entered into force on 1 January 2013 (Hughes, 2013) following amendments to the International Convention for the Prevention of Pollution from Ship (MARPOL) adopted in July 2011 (Bazari & Longva, 2011). The regulations apply to all ships of 400 gross tonnage and above with some exemptions for new ships.

Reduced ship speeds are likely to be beneficial for marine mammals in the Mediterranean and globally, as higher speeds are associated with increased mortality risks from ship-strikes (Gende *et al.,* 2011; Vanderlaan & Taggart, 2007; Wiley *et al.,* 2011). This is of particular relevance to the larger species, such as fin and sperm whales, for which ship-strike may present a significant mortality risk (Jensen *et* al., 2004; Panigada *et al*., 2006). Mitigation efforts to reduce the anthropogenic impact on marine mammals are often based upon known 'hotspots' or key habitats; however, as so little is known of marine mammal distribution in the eastern basin of the Mediterranean, a precautionary approach to reduce ship speeds is likely to be more appropriate. AIS data presented here have been used to model ship noise using an acoustic foot-print approach (Leaper *et al.,* 2014). It is hoped that this framework could be used to make recommendations on ship-noise where empirical noise measurements are lacking, although verifying the accuracy of this approach using noise measurements from the field would be greatly advantageous. Efforts should be made to capitalise on the recent net decrease in ship speed to facilitate conservation measures in the region. It is not known what, if any, effect that the change in vessel speeds has had on the rate of ship-strikes, given the current lack of available data in the region. Research into ship-strikes should be a priority given that the risk is poorly quantified as whales that have been struck by ships are continuing to be reported in the region. A fatal ship-strike of a sperm whale was recently documented near a small island to the north-west of Rhodes, ~10 km from the main Suez-Black Sea shipping thoroughfare (Figure 24).

Figure 24. A 10 m long sperm whale stranded (dead) at Astipalea, Aegean Sea, Greece on 17 Feb 2014 showing severe trauma (deep parallel wounds) consistent with propeller strike from a large vessel. © Filiatranet

2.6 Floating plastic debris

Marine waste, particularly synthetic organic polymers, have a very considerable half-life and are therefore persistent in the environment. Although some waste may provide artificial habitats for marine invertebrates and fish (Aliani & Molcard, 2003) these limited benefits are outweighed by deleterious effects including transport of alien species, habitat damage, entanglement, ingestion and bio-accumulation of micro plastics (see Derraik, 2002 for review). Globally, the use of plastics is increasing and plastics presently comprise 90% of marine debris. The incidence of debris-related fatal ingestion and entanglement of marine animals has increased by 40% in the last decade (CBD, 2012). In the Mediterranean Sea, the situation is particularly serious as the mean sea surface plastic concentration (116,000 pieces km^{-2}; Collignon *et al*., 2012) is rivalled only in the western and eastern North Pacific (174,000 and 334,271 pieces km^{-2} respectively, Yamashita & Tanimura, 2007; Moore *et al*., 2001) in a region known as the ‘‘Great Pacific Garbage Patch’’.

Marine debris has been recorded in the Mediterranean Sea through beach surveys, analysis of stomach contents (Tomás *et al.*, 2002), sea floor surveys (Stafatos *et al.*, 1999; Katsanevakis & Katsarou, 2004) and a small number of boat based floating marine debris surveys in the Ligurian Sea (Aliani & Molcard, 2003) and north-western Mediterranean Sea (Galgani *et al.*, 1995). Although collection of marine debris was a secondary aim of this project, the results from this survey represent one of the first systematic boat based surveys for marine litter covering the whole Aegean Sea and a large part of the Eastern Mediterranean. The results herein provide an overview of the density of floating marine debris in the Mediterranean Sea. Furthermore, this survey demonstrates a practical system for collecting data on the presence and abundance of floating debris from vessel-based surveys, which could potentially be included as ancillary data collection in the standard protocols for cetacean and sea bird surveys (such as SCANS, NASS, ESAS) to fill large data gaps.

In total, 90% of the marine debris recorded during this survey was plastic. Plastics are of particular concern because of their longevity. Although they may fragment, they will not biodegrade and are estimated to persist in the marine environment for hundreds to thousands of years (Derraik, 2002). The highest concentration of floating marine debris in the survey area was found near the northern Aegean coastline in the Thracian Sea. This finding is most likely due to geography and the surface currents of the Aegean Sea (Figure 25), which concentrate the marine debris within the northern reaches. The large amount of marine debris in the Thracian Sea is of great concern, as it is just one of the many anthropogenic pressures on the marine fauna in this area. In areas such as this, where debris re-circulates, although the danger of "invasive" organisms spreading is low, there needs to be greater effort to reduce the amount of marine debris entering the sea. Until proactive measures are taken, debris will accumulate presenting severe problem for marine wildlife. This is particularly problematic in light of the high density of gillnets (Kara and Gurbet, 1999) and the presence of harbour porpoises in the region as discussed in Section 1. Plastic debris has had unforeseen cumulative effects with other threats to cetaceans. In the north-western Black Sea, for example, the bycatch rate of harbour porpoises was found to be almost twice as high in gillnets contaminated with plastic debris compared with litter-free nets (Birkun, 2009). Birkun (2009) suggests that netted litter may be attractive to some fish, thereby providing a concentration of harbour porpoise prey, albeit with an inherent risk of both entanglement and ingestion of plastic.

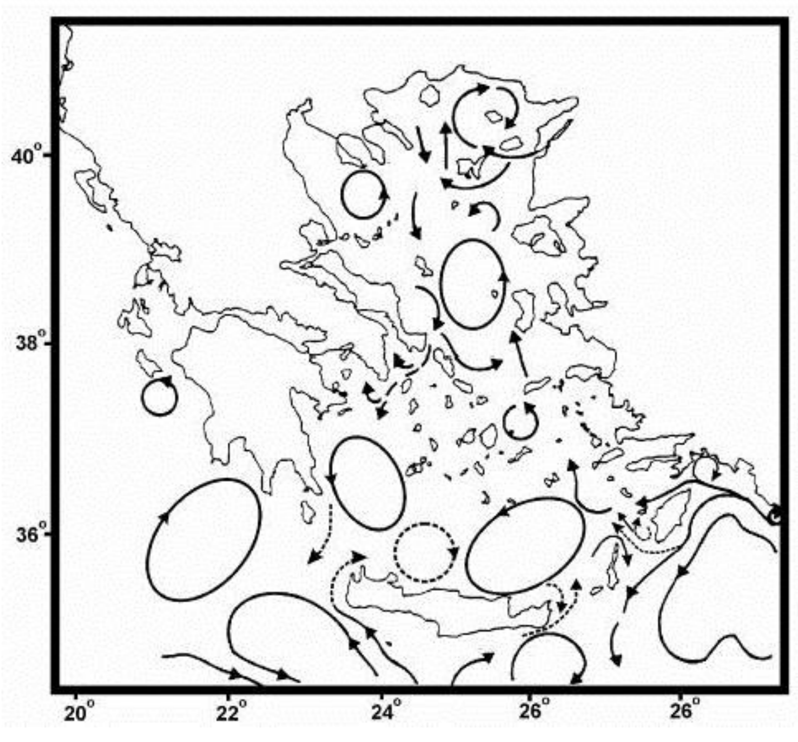

Figure 25. Schematic of the major upper layer circulation in the Aegean Sea (Lykousis et al., 2002)

A peak in sea surface plastic concentration over the Anaximander Seamounts is also of concern as this deep water habitat seems important for teuthophagous species, such as Risso's dolphin and sperm whales in the nearby Rhodes Gyre, which are known to ingest large quantities of plastic, presumably due to perceived similarities with their favoured prey species (Walker & Coe, 1990; Fernandez *et al.,* 2009). The threat of ingesting plastic marine debris for already threatened species is both a conservation and welfare concern that warrants further assessment in this region. In 2012, a sperm whale stranded dead in the Mediterranean having died from the ingestion of plastic sheeting, thought to be from the greenhouse agriculture industry (de Stephanis *et al.*, 2013). Sperm whales were detected in the Ikaria Basin, Rhodes Basin and South of Cyprus and therefore we would suggest that particular efforts should be made to assess and address the problem of floating marine debris in these areas. A recent Conference of Parties of the Barcelona Convention for the Protection of the Mediterranean adopted a regional plan to manage marine litter (European Commission memo/13/1110 on 06/12/2013). The adoption provides a common framework for Mediterranean countries to tackle the problem of marine litter and may help EU Member States meet their obligation to achieve 'good environmental status' by 2020 under the MSDF (Descriptor 10: marine litter). The information presented in this study helps address one of the goals of this regional plan by increasing knowledge and baseline data of the problem.

The estimated encounter rate for marine debris in the Aegean Sea and Eastern Mediterranean are likely to be conservative and should be considered a minimum estimate. Very small debris items may be under-recorded, especially as distance increases. No correction was used to allow for this in the relative encounter rates presented here, although this may be possible in future analyses of these data. Furthermore, in areas with high cetacean sighting rates, collection of debris data was given secondary priority so as not to compromise the cetacean survey. As such, the debris survey was a pilot to determine if it can be conducted concurrently with marine mammal surveys. More detailed analysis of the data from the sighting survey, and further consideration of the caveats (including suggestions for sampling standardisation and the considerations in the collection of comparable and quantifiable data) will be outlined.

3. Conclusions and Recommendations

- Harbour porpoises (including a calf) were present in the Thracian Sea, northern Aegean Sea, in July 2013. Further research on seasonal presence and distribution of harbour porpoises would be helpful to inform conservation activities, but based on these findings, immediate international collaboration to introduce protective measures in areas where porpoises are known to be present is required to reduce risks from bycatch and disturbance to these geographically isolated porpoises.
- Ambient noise levels in the Aegean Sea are highest where shipping thoroughfares are geographically constrained by the complex network of islands. Some of the nosiest areas happen to correspond with isolated sperm whale and beaked whale habitats. In cases where vulnerable species occupying discrete habitats, there is an opportunity to focus conservation policy such as regulating vessel speeds and relocating shipping lanes to reduce risk to whales.
- Between 2007 and 2013 there was a documented reduction in the speed of individually identified vessels (monitored in both years) in the eastern Mediterranean Sea. This is likely due to the economic downturn and increased fuel costs, rather than policy changes aimed at reducing ship noise or ship-strikes. While this incidental speed and associated noise reduction is beneficial to cetaceans, it is still a priority to continue implementation of quieting measures for ships. Indeed, the current trend of commercially constrained shipping speeds provides an ideal opportunity to implement policies to prevent future increases. Such measures are less likely to face opposition at present, compared with *e.g.* 2007 when the financial incentive for increasing vessel speeds was greater.
- Marine debris potentially poses a serious threat to marine fauna in the Thracian Sea, and in combination with gill-net fisheries, may present a cumulative threat to harbour porpoises. The presence of visible floating debris is indicative of a greater issue which is difficult to address: micro-plastics and debris beneath the surface. Floating marine debris was found at high densities in the Thracian Sea; it is hoped that the pilot study currently under analysis will provide recommendation as to how best to gather systematic, quantitative sighting data on floating debris as an ancillary exercise during cetacean and/or seabird visual surveys.
- The Aegean Sea is home to a diverse assemblage of cetacean species including: striped, bottlenose, common and Risso's dolphins, harbour porpoise, sperm whales and beaked whales (likely Cuvier's). Additional (ideally internationally coordinated) cetacean surveys of the Aegean Sea are needed to monitor these species, most of which are known to be in decline.
- The surveyed areas of the Levantine Sea were characterized by a lower relative abundance of marine mammals, albeit with a unique assemblage of species: while no common dolphins or harbour porpoises were detected, rough-toothed dolphins, sperm whales, beaked whales (likely Cuvier's) and false-killer whales were present. A single monk seal was observed in offshore waters, outside the current known range for this species.

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5. Literature Cited

Aguilar Soto N., Johnson M., Madsen P. T., Tyack P. L., Bocconcelli A. & Borsani J. F. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science* 22(3): 690-699.

Agardy, T., Di Sciara, G. N. & Christie, P. 2011. Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy* 35(2): 226-232.

Aliani, S. & Molcard, A. 2003. Hitch-hiking on floating marine debris: macrobenthic species in the Western Mediterranean Sea. *Hydrobiologia* 503: 59–67.

Altuğ, G., Aktan, Y., Oral, M., Topaloğlu, B., Dede, A., Keskin, Ç. & Çiftçi, P. S. 2011. Biodiversity of the northern Aegean Sea and southern part of the Sea of Marmara, Turkey. *Marine Biodiversity Records*, 4(1): 65.

Barnes, D.K.A., 2002. Biodiversity: Invasions by marine life on plastic debris. *Nature* 416: 808-809.

Baulch, S., & Perry, C. 2014. Evaluating the impacts of marine debris on cetaceans. *Marine pollution bulletin*, *80*(1): 210-221.

Bazari, Z., & Longva, T. 2011. Assessment of IMO mandated energy efficiency measures for international shipping. *Estimated CO_2 Emissions Reduction from Introduction of Mandatory Technical and Operational Energy Efficiency Measures for Ships, Project Final Report*, *31*.

Bearzi, G., Reeves, R. R., Notarbartolo di Sciara, G., Politi, E., Canadas, A., Frantzis, A., & Mussi, B. 2003. Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mammal Review* 33(4): 224-252.

Bearzi, G., Agazzi, S., Bonizzoni, S., Costa, M. & Azzellino, A. 2008. Dolphins in a bottle: abundance, residency patterns and conservation of bottlenose dolphins *Tursiops truncatus* in the semi-closed eutrophic Amvrakikos Gulf, Greece. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *18*(2): 130-146.

Bearzi, G., Fortuna, C. & Reeves, R. R. 2009. Ecology and conservation of common bottlenose dolphins Tursiops truncatus in the Mediterranean Sea. *Mammal Review* 39(2): 92-123.

Beck, C. A. & Barros, N. B. 1991. The impact of debris on the Florida Manatee. *Marine Pollution Bulletin* 22: 508–510.

Birkun, Jr.A. 20009. Plastic waste cause fishing nets to kill more Black Sea marine mammals. *Fins* 4(2): 17-18.

Birkun A.A. Jr. & Frantzis, A., 2013. *Phocoena phocoena relicta*. IUCN Red List Threat. Species Version 2013.1.

Bittau, L., Mattia Leone, V.G., Costa, G. & Manconi, R. 2013. First Mediterranean record of a free-ranging Sowerby's beaked whale (*Mesoplodon bidens*) in a mixed species group with Cuvier's beaked whales (*Ziphius cavirostris*). Poster Presentation to the 27th Annual Confernce of the European Cetacean Society, 8-10 April, Sétubal, Portugal.

Boisseau, O., Lacey, C., Lewis, T., Moscrop, A., Danbolt, M.& McLanaghan, R. 2010. Encounter rates of cetaceans in the Mediterranean Sea and contiguous Atlantic area. *Journal of the Marine Biological Association of the United Kingdom*, *90*(8): 1589-1599.

Bosc, E., Bricaud, A. & Antoine, D. 2004. Seasonal and interannual variability in algal biomass and primary production in the Mediterranean Sea, as derived from 4 years of SeaWiFS observations. *Global Biogeochemical Cycles* 18: 1-17.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers & D.L., Thomas, L. 2001. Introduction to Distance Sampling. University Press, Oxford.

Cañadas, A., & Hammond, P. S. 2008. Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. *Endangered Species Research* 4(3): 309-331.

CBD (Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel) 2012. *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions*. CBD Technical Series No. 67, 61 pp.

CIESM. 2011. *Marine peace parks in the Mediterranean – A CIESM proposal*. CIESM Workshop Monographs (edited by F. Briand) 41: 128 pp.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F. B. R., Aguzzi, J. & Voultsiadou, E. 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PloS one* 5(8): e11842.

Collignon A., Hecq J-H., Glagani F., Voisin P., Collard F. & Goffat, A. 2012. Neustonic microplastic and zooplankton in the North Western Mediterranean Sea. *Marine Pollution Bulletin* 64: 861–864.

Dede, A., & Öztürk, B. 2007. Cetacean observations in the Marmara and Aegean Sea in spring season 2005. *Rapport du Congress de la CIESM* 38: 455.

Dede, A., Saad, A., Fakhri, M. & Öztürk, A. 2012. Cetacean sightings in the Eastern Mediterranean Sea during the cruise in summer 2008. *Journal of the Black Sea/Mediterranean Environment* 18: 49-57.

Derraik, J. G.B. 2002. The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin* 44(9): 842-852.

Fernandez, R., Santos, M.B., Carrillo, M., Tejedor. M. & Pierce, P. 2009. Stomach contents of cetaceans stranded in the Canary Islands 1996-2006. *Journal of the Marine Biological Association of the UK* 89: 873-883.

Fontaine, M.C., Tolley, K.A., Michaux, J.R., Birkun, A.Jr., Ferreira, M., Jauniaux, T., Llavona, A., Öztürk, B., Öztürk, A. A., Ridoux, V., Rogan, E., Sequeria, M., Bouquegneau, J-M. & Baird, S.J.E. 2010. Genetic and historic evidence for climate-driven population fragmentation in a top Cetacean predator: the harbour porpoises in European Waters. *Proceedings of the Royal Society* 227: 2829-2837.

Forcada J., Aguilar A., Hammond P.S., Pastor X. & Aguilar R. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. *Marine Mammal Science* 10: 137–150.

Frantzis, A., Gordon, J., Hassidis, G. & Komnenou, A. 2001. The enigma of harbor porpoise presence in the Mediterranean Sea. *Marine Mammal Science* 17: 937–944.

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

Frantzis A. 2009. Cetaceans in Greece: Present status of knowledge. Initiative for the Conservation of Cetaceans in Greece, Athens, Greece, 94 pp.

Frantzis, A., Airoldi, S., Notarbartolo-di-Sciara, G., Johnson, C. & Mazzariol, S. 2011. Inter-basin movements of the north-western Mediterranean sperm whales provide insight into their population structure and conservation. *Deep-Sea Research part I* 58: 454-459.

Galgani, F., Jaunet, S., Campillo, A., Guenegen, X., & His, E. 1995. Distribution and abundance of debris on the continental shelf of the north-western Mediterranean Sea. *Marine Pollution Bulletin*, *30*(11): 713-717.

Gende, S. M., Hendrix, A. N., Harris, K. R., Eichenlaub, B., Nielsen, J. & Pyare, S. 2011. A Bayesian approach for understanding the role of ship speed in whale-ship encounters. *Ecological Applications* 21(6): 2232-2240.

Gillespie D., Mellinger D.K., Gordon J., McLaren D., Redmond P., McHugh R., Trinder P., Deng X-Y. & Thode A., 2009. PAMGUARD: Semi-automated, open source software for real-time acoustic detection and localisation of cetaceans. *Journal of the Acoustical Society of America* 125(4): 2547-2547.

Gregory, M.R. 2009. Environmental implications of plastic debris in marine settings – entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical Transections of the Royal Society of Biological Sciences* 364 (1526): 2013-2025.

Gucu, A. C., Gucu, G. & Orek, H. 2004. Habitat use and preliminary demographic evaluation of the critically endangered Mediterranean monk seal (*Monachus monachus*) in the Cilician Basin (Eastern Mediterranean). *Biological Conservation* 116(3): 417-431.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. & Øien, N. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology* 39: 361–376.

Heinemann, D. 1981. A range finder for pelagic bird censusing. *Journal of Wildlife Management* 45(2): 489 – 493.

Hughes, E. 2013. A new chapter for MARPOL Annex VI – requirements for technical and operational measures to improve the energy efficiency of international shipping. Press releases accessed 06/01/13: http://www.imo.org/KnowledgeCentre/PapersAndArticlesByIMOStaff/Documents/A%20new%20chapter%20for%20MARPOL%20Annex%20VI%20-%20E%20Hughes.pdf

Jefferson, T. A., & Curry, B. E. 1994. A global review of porpoise (Cetacea: Phocoenidae) mortality in gillnets. *Biological Conservation* 67(2): 167-183.

Jensen, A. S., Silber, G. K. & Calambokidis, J. 2004. *Large whale ship strike database*. NOAA Technical Memorandum NMFS-OPR, January 2004. US Department of Commerce, National Oceanic and Atmospheric Administration. 39 pp.

Kara, O.F. & R. Gurbet 1999. *Investigation on industrial fishery of the Aegean Sea*. The Republic of Turkey, Ministry of Agriculture and Rural Affairs, No: 5, 135 pp., Bodrum. [In Turkish].

Katsanevakis, S., & Katsarou, A. 2004. Influences on the distribution of marine debris on the seafloor of shallow coastal areas in Greece (Eastern Mediterranean). *Water, air, and soil pollution*, *159*(1): 325-337.

Kerem, D., Hadar, N., Goffman, O., Scheinin, Katsnevakis, S. & Katsarou, A., Kent, R., Boisseau, O., & Schattner, U. 2012. Update on the cetacean fauna of the Eastern Mediterranean Levantine Basin. *Open Marine Biology Journal* 6: 6—27.

Knudsen, V.O., Brainard, R.E. & Emling, J.W. 1948. Underwater ambient noise. *Journal of Marine Research* 7:410-429.

Laist, D. W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: *Marine debris, sources, impacts, and solutions* (*eds* J. M. Coe & D. B. Rogers), pp. 99–139. New York, NY: Springer-Verlag.

Leaper, R. & Gordon, J. 2001. Application of photogrammetric methods for locating and tracking cetacean movements at sea. *Journal of Cetacean Research and Management* 3(2): 131–41.

Leaper, R. & Danbolt, M. 2008. Use of Automatic Identification Systems (AIS) data to estimate patterns of shipping density for use in modelling collision risk with whales. International Whaling Commission Meeting Santiago Chile SC/60/BC3, 8 pp.

Leaper, R., Renilson, M. & Ryan, C. 2014. Reducing underwater noise from large commercial ships: current status and future directions. *Journal of Ocean Technology* 9(1): 64-83.

Lewis, T., Gillespie, D., Lacey, C., Matthews, J., Danbolt, M., Leaper, R., McLanaghan, R. & Moscrop, A. 2007. Sperm whale abundance estimates from acoustic surveys of the Ionian Sea and Straits of Sicily in 2003. *Journal of the Marine Biological Association of the United Kingdom* 87(1): 353-357.

Lewis, T., Matthews, J. N., Boisseau, O., Danbolt, M., Gillespie, D., Lacey, C., Leaper, L., McLanaghan, R. & Moscrop, A. In prep. Abundance estimates for sperm whales in the south western and eastern Mediterranean Sea from acoustic line-transect surveys.

Lykousis, V., G. Chronis, A. Tselepidis, N. B. Price, A. Theocharis, I. Sikou-Frangou, F. Van Wambeke, R. Danovaro, S. Stavrakakis, G. Duineveld, D. Georgopoulos, L. Ignatiades, A. Souvermezoglou & Voutsinou-Taliadouri, F. 2002. Major outputs of the recent multidisciplinary biogeochemical researches undertaken in the Aegean Sea. *Journal of Marine Systems* 34: 313-334.

Marchessaux, D. 1980. A review of the current knowledge of the cetaceans in the Eastern Mediterranean Sea. *Vie Mar* 2: 59-66.

Moore C. J., Moore S.L., Leecaster M. K. & Weisberg S. B. 2001. A comparison of plastic and plankton in the North Pacific central gyre. *Marine Pollution Bulletin* 42: 1297–1300.

Natoli A., Birkun A., Aguilar A., Lopez A. & Hoelzel A. R. 2005. Habitat structure and the dispersal of male and female bottlenose dolphins (*Tursiops truncatus*). *Proceedings of the Royal Society, Biological Sciences* 272: 1217-26.

Notarbartolo di Sciara, G. 2002. Introduction. In: G. Notarbartolo di Sciara (Ed.), Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies. A report to the ACCOBAMS Secretariat, Monaco, February 2002. Section 2, 3 pp.

Notarbartolo di Sciara, G. & Birkun Jr., A. 2010. Conserving whales, dolphins and porpoises in the Mediterranean and Black Seas: an ACCOBAMS status report, 2010, Monaco, 212 p.

Notarbartolo di Sciara, G., Frantzis, A., Bearzi, G. & Reeves, R. 2012. *Physeter macrocephalus* (Mediterranean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 11 November 2013.

Ostrom, P.H., Lien, J. & Macko, S.A. 1993. Evaluation of the diet of Sowerby's beaked whale, *Mesoplodon bidens*, based on isotopic comparisons among northwestern Atlantic cetaceans. *Canadian Journal of Zoology* 71.4: 858-861.

Otani, S., Naito, Y., Kato, A., & Kawamura, A. 2000. Diving behaviour and swimming speed of a free- ranging harbour porpoise, *Phocoena Phocoena*. *Marine mammal science*, *16*(4): 811-814.

Öztürk, B. 2009. Marine protected areas in the high seas of the Aegean and Eastern Mediterranean Seas, some proposals. *Journal of Black Sea / Mediterranean Environment* 15: 69-82.

Öztürk, A. A., Tonay, A. M. & Dede, A. 2013. Sperm whale (*Physeter macrocephalus*) sightings in the Aegean and Mediterranean part of Turkish waters. *Journal of Black Sea / Mediterranean Environment* 19(2): 168-176.

Palka, D. 1996. Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. *Report to the International Whaling Commission* 46: 575-582.

Panigada, S., Pesante, G., Zanardelli, M., Capoulade, F., Gannier, A. & Weinrich, M. T. 2006. Mediterranean fin whales at risk from fatal ship strikes. *Marine Pollution Bulletin* 52(10): 1287-1298.

Pauly, D., Trites, A. W., Capuli, E., & Christensen, V. 1998. Diet composition and trophic levels of marine mammals. *ICES Journal of Marine Science: Journal du Conseil 55*(3): 467-481.

Pirotta E., Milor R., Quick N., Moretti D., Di Marzio N., Tyack P., Boyd I. & Hastie G., 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. *PLoS One* 7(8): e42535.

R development Core Team 2005. R: A language and environment for statistical computing. ISBN 3-900051-07-0. R Foundation for Statistical Computing. Vienna, Austria, 2013. url: http://www. R-project. org.

Reeder, D.B., Sheffield, E. & Mack, S.M. 2011. Wind-generated ambient noise in a topographically isolated basin: A pre-industrial era proxy. *Journal of the Acoustical Society of America* 129: 64-73.

Reeves, R. & Notarbartolo di Sciara, G. (eds) 2006. The status and distribution of cetaceans in the Black Sea and Mediterranean Sea. IUCN Centre for Mediterranean Cooperation, Malaga, Spain. 137pp.

Rosel, P. E., Frantzis, A., Lockyer, C., & Komnenou, A. 2003. Source of Aegean Sea harbour porpoises. *Marine Ecology Progress Series* 247: 257-261.

Ryan, P.G., Connel, A.D. & Gardner, B.D. 1988. Plastic ingestion and PCBs in seabirds: is there a relationship? *Marine Pollution Bulletin* 19: 174–176.

Skliris, N., Sofianos, S. S., Gkanasos, A., Axaopoulos, P., Mantziafou, A., & Vervatis, V. 2011. Long-term sea surface temperature variability in the Aegean Sea. *Advances in oceanography and limnology* 2(2): 125-139.

Stefatos, A., Charalampakis, M., Papatheodorou, G. & Ferenitinos, G. 1999. Marine Debris on the Seafloor of the Mediterranean Sea: Examples from Two Enclosed Gulfs in Western Greece. *Marine Pollution Bulletin* 38(5): 389-393.

de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Expisito, C. & Cañadas, A. 2013. As a main meal for sperm whales: Plastic debris. *Marine Pollution Bulletin* 69.1: 206-214.

Sutherland, W.J., Clout, M., Côté, I.M., Daszak, P., Depledge, M.H., Fellman, L., Fleishman, E., Garthwaite, R., Gibbons, D.W., De Lurio, J., Impey, A.J., Lickorish, F., Lindenmayer,D., Madgwick, J., Margerison, C., Maynard, T., Peck, L.S., Pretty, J., Prior, S., Redford, K.H., Scharlemenn, J.P.W., Spalding, M. & Watkinson, A.R. 2010. A horizon scan of global conservation issues for 2010. *Trends in Ecology and Evolution* 25(1): 1-7.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J.K.B., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2012. *Grampus griseus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1

Teilmann, J. 2003. Influence of sea state on density estimates of harbour porpoises (*Phocoena phocoena*). *Journal of Cetacean Research and Management* 5(1): 85-92.

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R., Marques, T.A. & Burnham, K.P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5–14.

Tolley, K. A., & Rosel, P. E. 2006. Population structure and historical demography of eastern North Atlantic harbour porpoises inferred through mtDNA sequences. *Marine Ecology Progress Series* 327: 297-308.

Tomás J., Guitart, R., Mateo, R. & Raga, J.A. 2002. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the western Mediterranean. *Marine Pollution Bulletin* 44: 211-216.

Tonay, A.M., Dede, A., Öztürk, A. & Öztürk, B. 2009. Cetacean strandings in the Turkish Straits System (TSS) and the Northern Aegean Sea coast of Turkey during 1999-2008. Poster presented at the 23rd Annual Conference of the European Cetacean Society, 2009 Istanbul, Turkey.

Tonay, A. M., Dede, A., Maracı, Ö., & Bilgin, R. 2012. A preliminary genetic study on the harbour porpoise (*Phocoena phocoena*) in the Turkish Seas. *Journal of the Black Sea / Mediterranean Environment* 18: 83-89.

Tonay, A.M. & Dede, A. 2013. First stranding record of a harbour porpoise (*Phocoena phocoena*) in the Southern Aegean Sea. *Journal of the Black Sea / Mediterranean Environment* 19(1): 132-137.

Van der Graaf, A.J., Ainslie, M.A., André, M., Brensing, K., Dalen, J., Dekeling, R.P.A., Robinson, S., Tasker, M.L., Thomsen, F. & Werner, S. 2012. European Marine Strategy Framework Directive - Good

Environmental Status (MSFD GES): Report of the Technical Subgroup on Underwater noise and other forms of energy. 75 pp.

Vanderlaan, A. S. M. & Taggart, C. T. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science* 23(1): 144-156.

Viaud-Martinez K. A., Brownell R. L. Jr, Komnenou A. & Bohonak A. J. 2008. Genetic isolation and morphological divergence of Black Sea bottlenose dolphins. *Biological Conservation* 141: 1600-1611.

Viaud-Martínez, K.A., Vergara, M.M., Gol'din, P.E., Ridoux, V., Öztürk, A.A., Öztürk, B., Rosel, P.E., Frantzis, A., Komnenou, A. & Bohonak, A.J. 2007. Morphological and genetic differentiation of the Black Sea harbour porpoise *Phocoena phocoena*. *Marine Ecology Progress Series* 338: 281–294.

Vinther, M. & Larsen, F. 2004. Updated estimates of harbour porpoise (*Phocoena phocoena*) bycatch in the Danish North Sea bottom-set gillnet fishery. *Journal of Cetacean Research and Management* 6: 19–24.

Walker , W.A. & Coe, J.M. 1990. *Survey of marine debris ingestion by odontocete cetaceans*. In: R.S. Shomura and M.L. Godfrey (eds) Proceedings of the Second International Conference on Marine Debris , 2-7 April 1989, Honolulu, Hawaii. Volume 1. US Dept. of Commere. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-154. 747-774 pp.

Watkins, W. A., Tyack, P., Moore, K. E. & Notarbartolo di Sciara, G. 1987. *Steno bredanensis* in the Mediterranean Sea. *Marine Mammal Sci*ence 3: 78-82.

Waring, G. T., Hamazaki, T., Sheehan, D., Wood, G. & Baker, S. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast US. *Marine Mammal Science*, *17*(4): 703-717

Wiley, D. N., Thompson, M., Pace III, R. M. & Levenson, J. 2011. Modelling speed restrictions to mitigate lethal collisions between ships and whales in the Stellwagen Bank National Marine Sanctuary, USA. *Biological Conservation* 144(9): 2377-2381.

Yamashita R. & Tanimura A. 2007. Floating plastic in the Kuroshio current area, western North Pacific Ocean. *Marine Pollution Bulletin* 54: 485–488.

6. Appendix

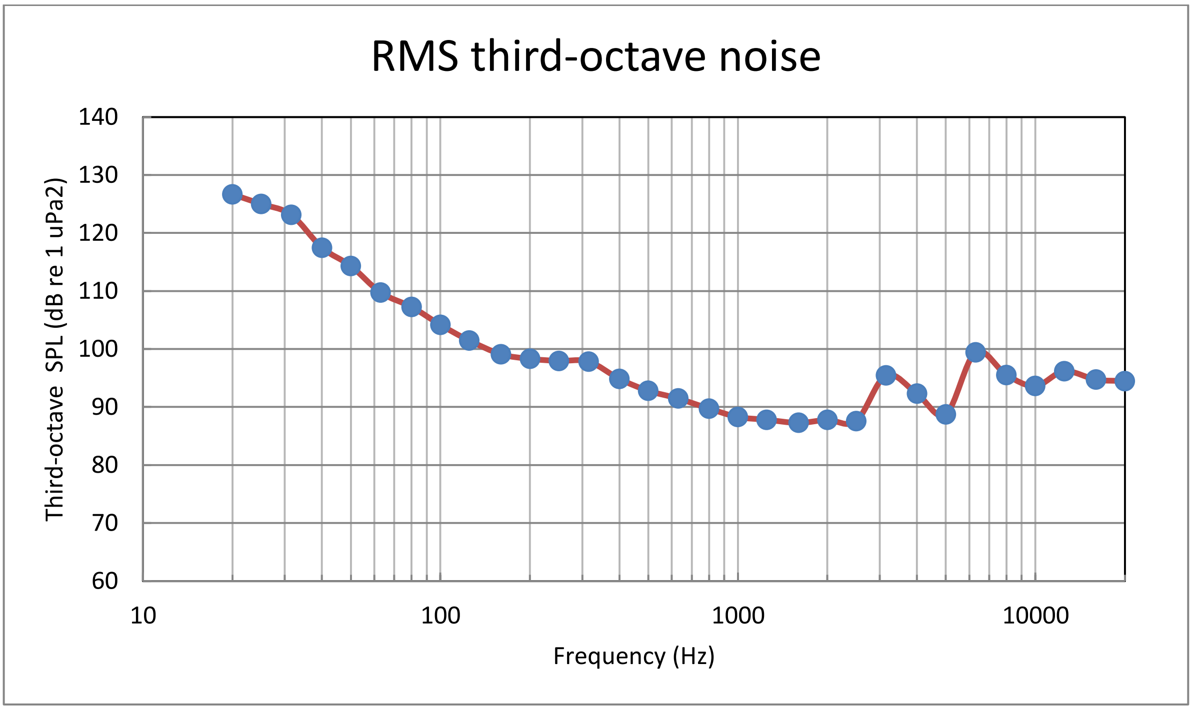

Figure A1. Ambient noise levels (route mean square values of third octave noise) for recordings taken at 41 stations in the Aegean and Levantine Seas between 27 July and 30 August 2013 (See Figure 17 for sampling locations).

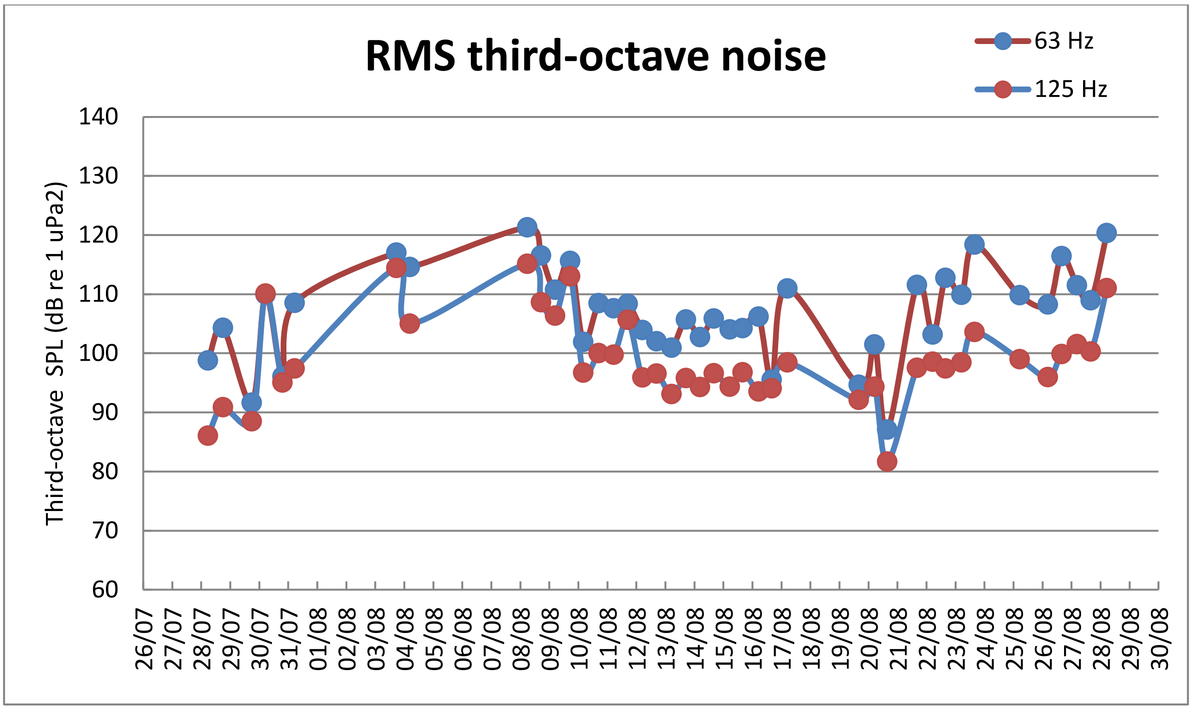

Figure A2. Route mean square values of third octave bands centred at 63 and 125 Hz for calibrated recordings taken at 41 stations in the Aegean and Levantine Seas between 27 July and 30 August 2013 (See Figure 17 for sampling locations).