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Agenda item 10 : Marine and Coastal Protected Areas, including in the open seas and deep seas

10.2. Regional Working Programme for the Coastal and Marine Protected Areas in the Mediterranean Sea including the High Sea

10.2.1. Activities for the identification and creation of SPAMIs in the open seas, including the deep seas

Sicily Channel/Tunisian Plateau: Satellite telemetry applied to fin whales in the Mediterranean Sea

UNEP/MAP
RAC/SPA - Tunis, 2015

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Background information

The Tethys Research Institute has conducted, between 2012 and 2014, a series of surveys with the aim of gaining insights on the fin whale (*Balaenoptera physalus*) fine scale habitat use as well as migration patterns and routes across the Region by means of satellite telemetry technology. These surveys commissioned by the Italian Ministry of the Environment, Land and Sea (MATTM), and as strongly suggested during the joint International Whaling Commission (IWC) and the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic area (ACCOBAMS) workshop organized in 2010, are essential to gather information the population structure of Mediterranean fin whales, important for the correct interpretation of the estimates of abundance and density and to evaluate possible trends is space and time.

While the first survey was carried out in September 2012 in the Ligurian Sea, north-western Mediterranean, the consecutive two surveys were carried out in the waters surrounding the Island of Lampedusa in the Sicily Channel (Central Mediterranean Sea) in March 2013 and 2014, respectively.

Considering that all the details on the project, such as the rationale behind the study, all the background information, a description of the study area and methodology as well as all the technical and specific details about the tags were provided in the previous report (N° of the contract(s) or the MoU: 09/RAC/SPA_2013 MedOpenSeas), with this document we present updates from the last campaign, carried out in the Sicily Channel in March 2015, describing and detailing only on the field work activities carried out during this last research expedition, as well as the preliminary analysis performed on the animal movements.

As stressed out in the previous report, it is critical to underline how the activities carried out so far, along with all the collected data, are particularly relevant to inform conservation and possibly put in place proper conservation and protection schemes where needed, but also for capacity building and education in light of the many collaborations established at the local, national and international level, and given the high profile of the innovative tools used. Due to these reasons we strongly believe that this project could contribute to the ongoing discussions within the international scientific community on this approach to cetacean research, and represent a leading example for the Mediterranean Region.

Data collection

Tagging tools and satellite transmission duty cycle

Low Impact Minimally Percutaneous External Electronic Tags (LIMPET), manufactured by Wildlife Computers (Seattle, USA), were selected for this field work, in light of the fact that they are thought to be minimally invasive. In these transmitters, the electronic components are external to the body, are relatively small in size and weight (~60-80 grams), and are anchored to the animal's tissue with two 70mm long darts, containing two sets of outwardly folded petals (Figure 1). Prior to implantation, the tip was covered with gentamicin sulphate cream to act both as antibiotic and lubricant. These devices were deployed on the dorsal fin with a 150lb crossbow (Vixen Excalibur II; Figure 2).

Fig. 1 – Low Impact Minimally Percutaneous External Electronic Tags (LIMPET) tag with anchor system and deployment arrow.

Fig. 2 – The Excalibur Vixen II crossbow with viewfinder.

These instruments were programmed to send 600 transmissions per day, over the following three temporal windows: 01-06, 12-17, 19-21, for a total of 12 hours per day. These time intervals have been selected in relation to the availability of the ARGOS satellites, setting latitude and longitude of the selected study area and a tentative period of transmission. Figure 3 presents the estimated satellite coverage obtained from the ARGOS web page.

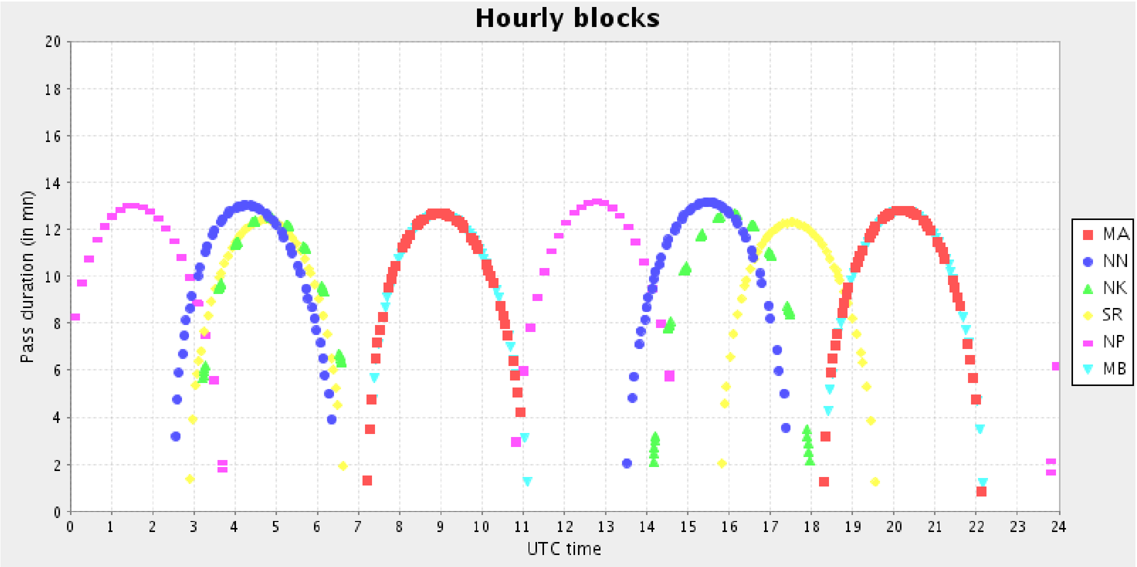

Fig. 3 – The predicted satellite coverage over 24 hours at the latitude and longitude of Lampedusa for March 2015.

Study area

As for the campaigns carried out in March 2013 and in March 2014, for the last campaign carried out in March 2015 the target study area were the waters surrounding the Island of Lampedusa, Sicily Channel, Central Mediterranean Sea (Figure 4). The knowledge on the presence of cetaceans in the area is limited, but it represents one of the few known winter feeding grounds for fin whales in the Mediterranean Sea so far reported. Furthermore, the Sicily Channel has been considered and proposed as a high priority area to be included in future conservation plans under the Convention on Biological Diversity (CBD) and the Specially Protected Areas and Biological Diversity Mediterranean (SPA/BD).

Fig. 5 – The study area in the Sicily Channel.

Research platform

For the aim of the study, daily expeditions at sea were carried out with a speed boat (Figure 6), as main navigation/observation and tagging platform.

Fig. 6 – Tagging platform used in the Sicily Channel.

Daily activities

Well aware of the weather instability and the intrinsic difficulties in forecasting large windows of weather conditions suitable for field work activities in the highly dynamic Sicily Channel area, we were expecting to spend two to three weeks on the Island of Lampedusa, standing-by and waiting for good weather conditions and take advantage of limited windows of positive conditions.

Communications from the local Marine Protected Area Isole Pelagie, informed us about first sightings of fin whales around the Island of Lampedusa by the end of February 2015. Due to the weather and marine forecast and actual conditions, characterized by strong winds, swells and often heavy rain and haze, conditions that are limiting for ield activities at sea (extracts of weather forcast for the area are provided in Figure 7, 8 and 9), we were able to reach the Island of Lampedusa on March 9th 2015. The working team was composed by three researchers, one dedicated to satellite telemetry activities (i.e. tag deployment), one to fin whales photo-identification and a third one to manoeuvring the speed-boat during close approaches to deploy the transmitters.

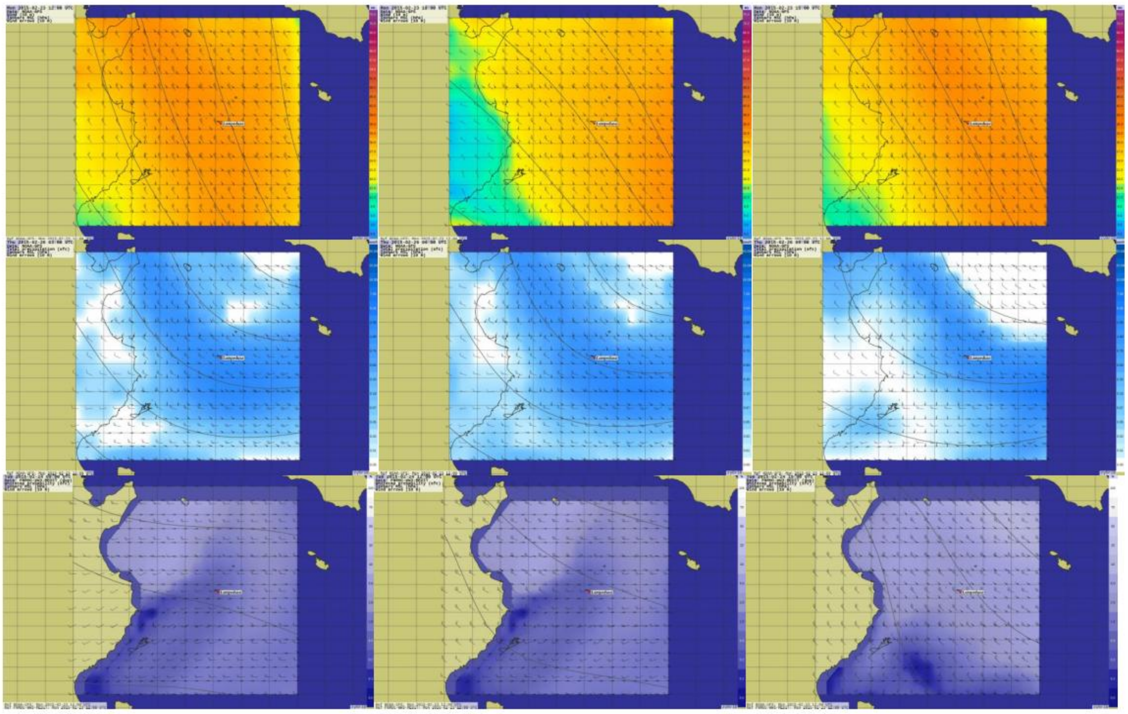

Fig. 7 – Extract of the weather forecast for the days before departure for field work. Top row: Wind and waves intensity and direction; Mid row: rain precipitation; Bottom row: whitecaps probability.

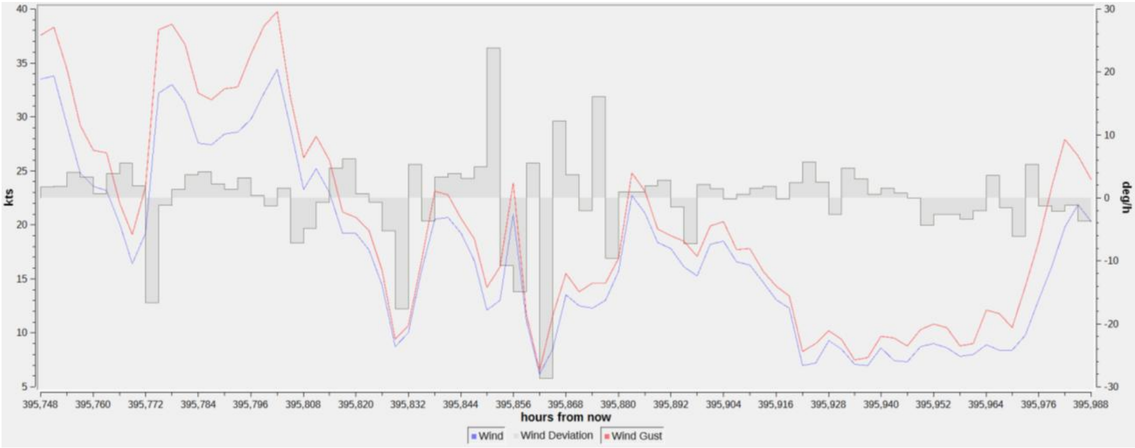

Fig. 8 – Plot of the wind and wind gusts intensity and direction for 10 days before departure for field work.

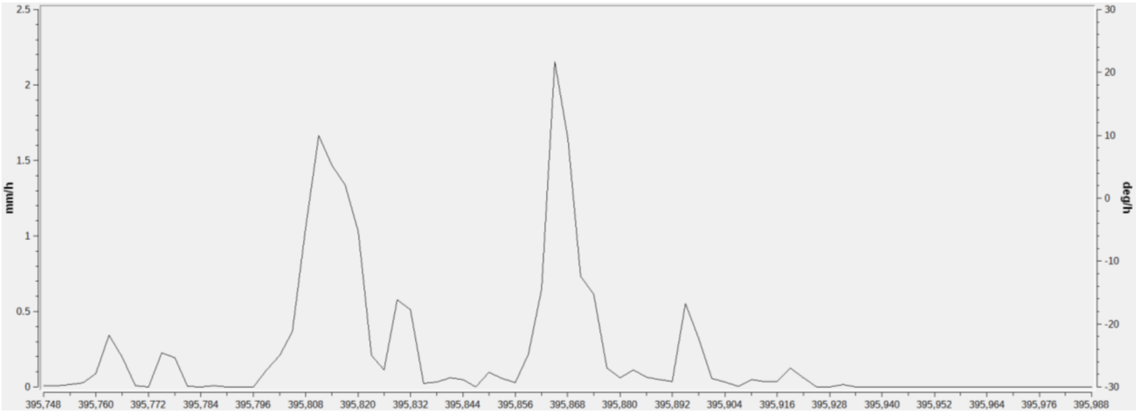

Fig. 9 – Plot of the rain precipitation for 10 days before departure for field work.

Overall, field work in March 2015 lasted 17 days, from the 9th till the 25th, with 7 days totally spent out at sea looking for fin whales and other cetaceans. In total, we spent 53:45 hours at sea, totalling 838 km of navigation searching effort. 14 cetacean sightings were recorded, with 9 fin whales and several common bottlenose dolphins sighted. A summary of sightings is presented in Table 1, while a map with the total effort and sightings is presented in Figure 10.

Species	**No of sightings**	**%**
Fin whale	7	50
Bottlenose dolphin	7	50
Total	14	100

Tab. 1 – Summary of the recorded sightings by species.

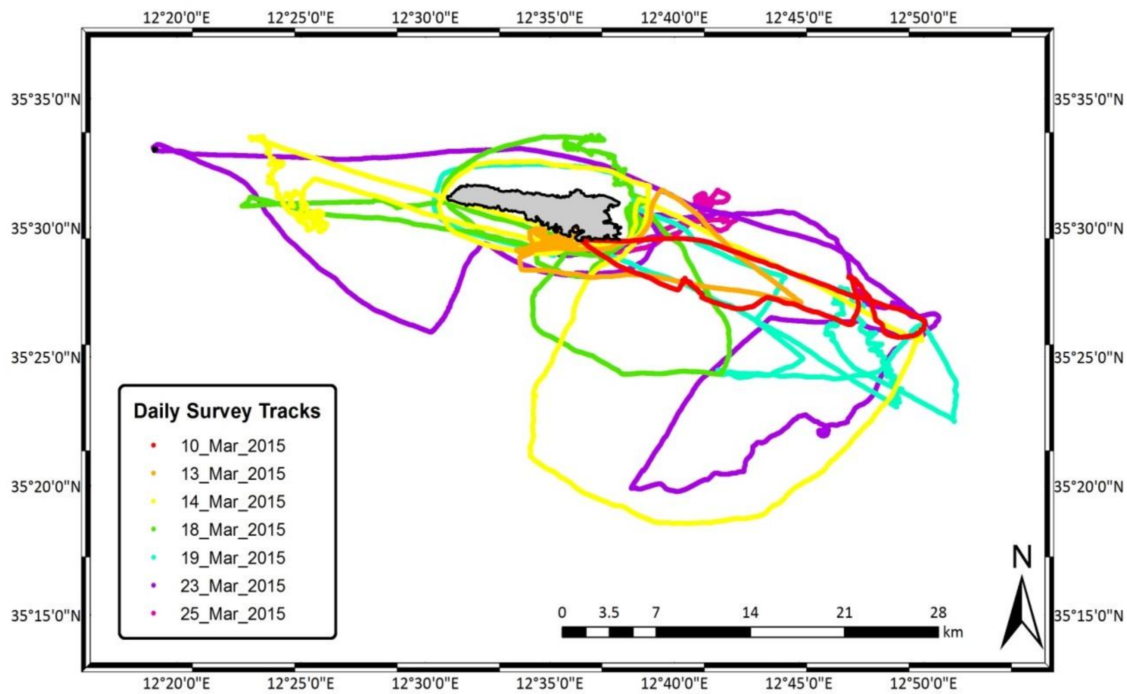

Fig. 10 – Plot of the navigation and recorded sightings.

A detailed description of daily activities follows:

Day 1 – 10 March 2015

The effort of the day spent at sea is presented in Figure 11. One fin whale was sighted approximately 10 nautical miles south of the Island of Lampedusa. During the sighting we observed very little surface feeding activities. A few minutes after sighting the whale, before trying a close approach to deploy the satellite transmitter, the whale dived and was not seen again.

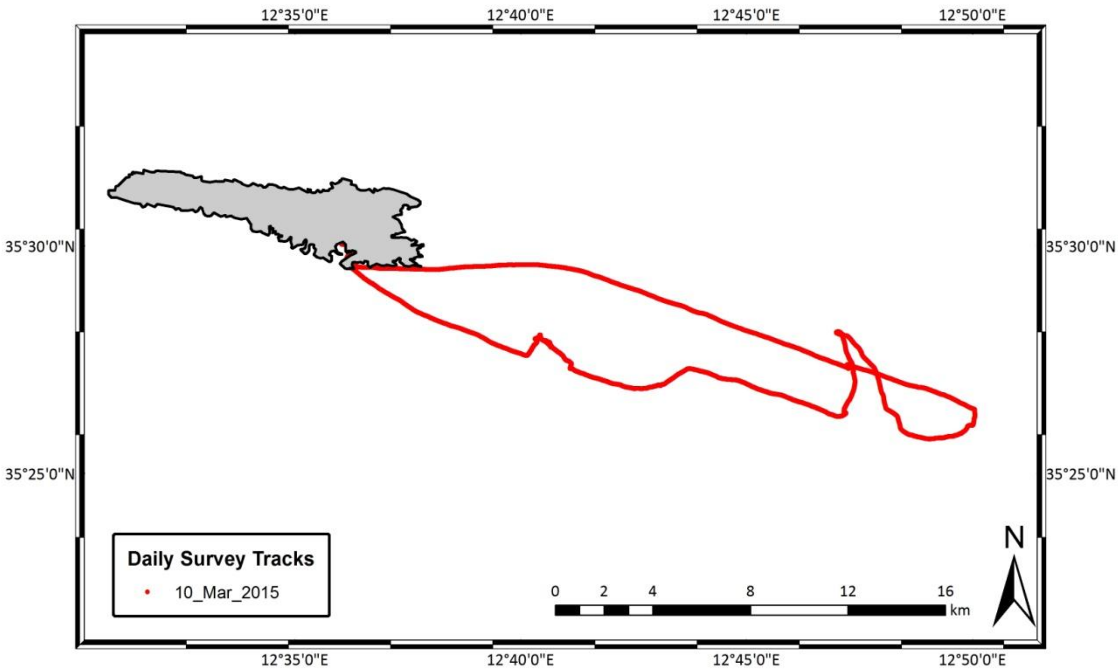

Fig. 11 – Track of the navigation.

<u>Day 2 – 13 March 2015</u>

The tracks of the day are shown in Figure 12. One fin whale sighted very close to the southern coast of Lampedusa, off the port. The whale engaged in several surface feeding activities, as seen in Figure 7. During two consecutive feeding events it is very hard to predict the location of the whale at the surface due to the highly convoluted movements typically associated with feeding and the sudden and common changes of direction. Once at the surface, the whale never surfaced completely taking the dorsal fin under the water, thus precluding the possibility to deploy a satellite transmitter. After a few hours and several attempts to deploy the transmitters, the lack of light and the consequent difficulties in spotting the whale and follow its movements under the water during close approaches forced us to close the survey and go back to the harbour.

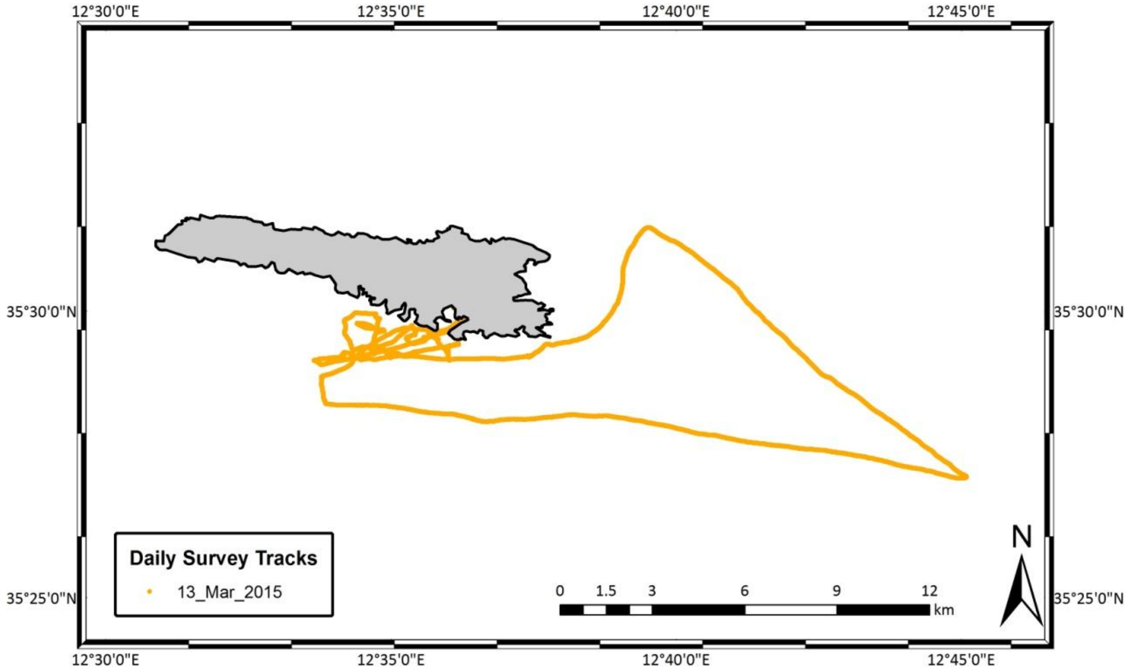

Fig. 12 – Track of the navigation.

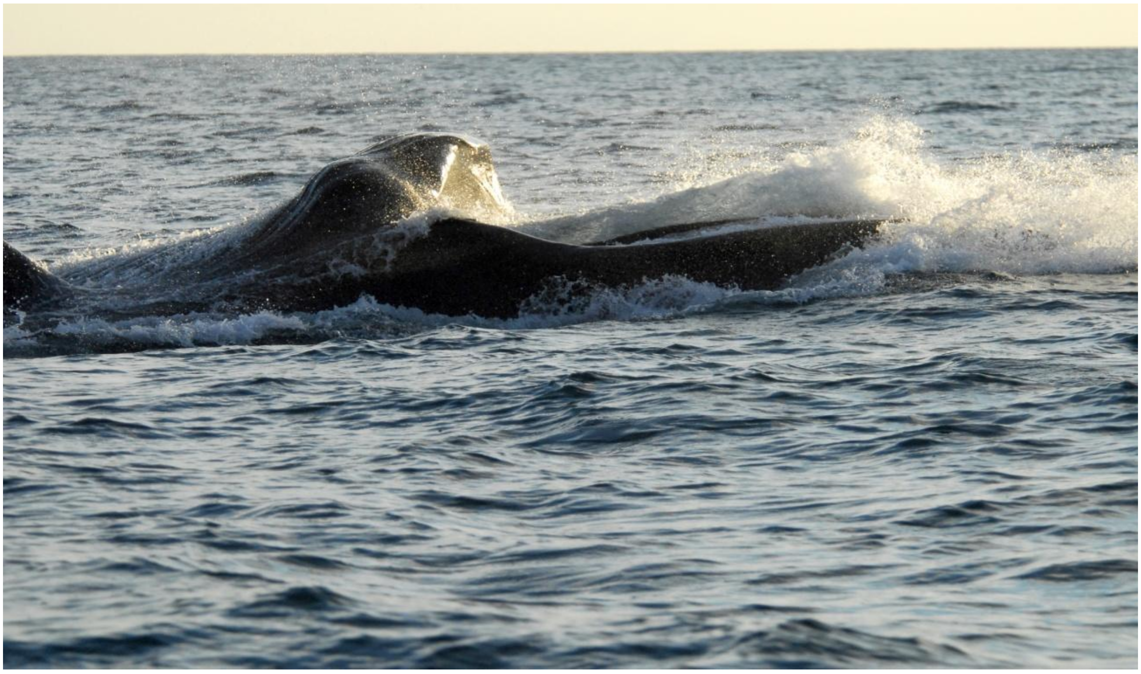

Fig. 13a – One examples of surface feeding events.

Fig. 13b – Another examples of surface feeding events.

Day 3 – 14 March 2015

The whole day was spent out at sea looking for whales (Figure 14). In the afternoon we observed a pair of whales, between the islands of Lampedusa and Lampione. We followed the whales at slow pace to assess their behaviour and to select the best way to closely approach them for satellite transmitters deployment. After a few hours, two successful close approaches allowed us to deploy two satellite transmitters. One transmitter has been attached to the left side of the dorsal fin, PTT-id 87780 (Figure 9). No reaction was shown by the marked whale. A second transmitter, PTT-id 87776, has been attached to the right side of the dorsal fin (Figure 10), with a startle reaction of the whale (tail slap) right after deployment. The increase of the wind and the lack of light forced us back to the harbour and prevented further follow up on the behaviour of the two animals as well on the status of the satellite transmitters on the body of the whales.

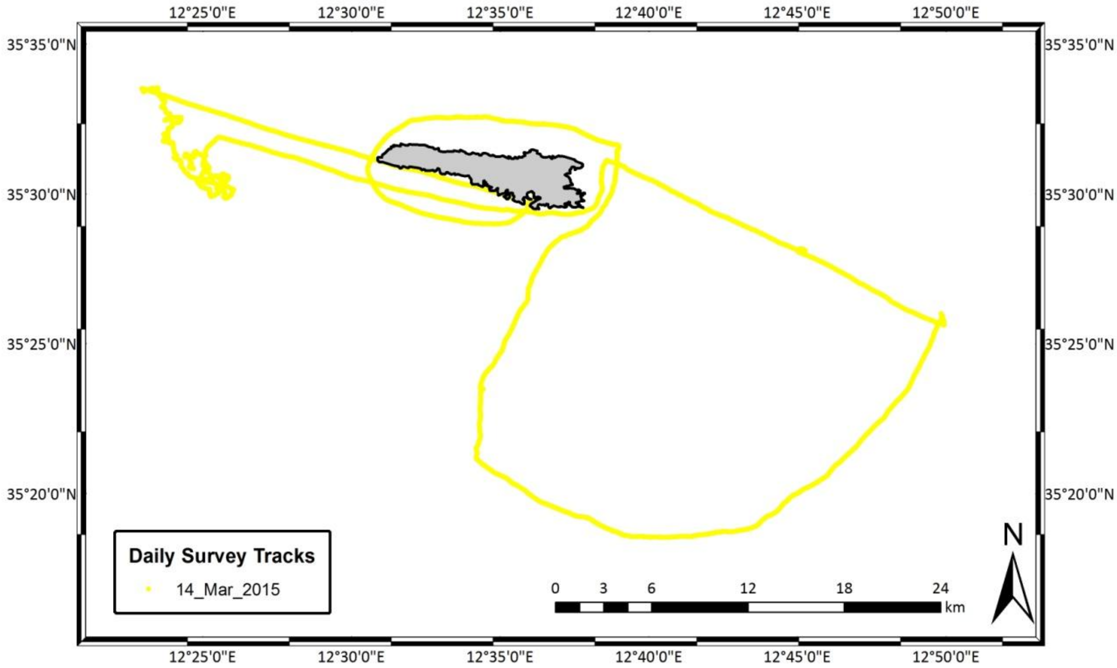

Fig. 14 – Track of the navigation.

Fig. 15 - PTT-id 87780 on the left side of the dorsal fin of the whale.

Fig. 16 - PTT-id 87776 on the right side of the dorsal fin of the whale.

Day 4 – 18 March 2015

One fin whale sighted soon after departure from the harbour of Lampedusa, very close to shore, off Cala Pisana. High waves and low visibility rendered difficult to follow the whale. We tried several close approaches to deploy the satellite transmitter, but the whale dived every time before we were at the proper distance of less than 10 meters, perpendicular to the dorsal fin. After two and a half hours we decided to abandon this whale and we kept looking for other whales. No more sightings were reported before it became dark and we went back to port. The tracks of the day are shown in Figure 17.

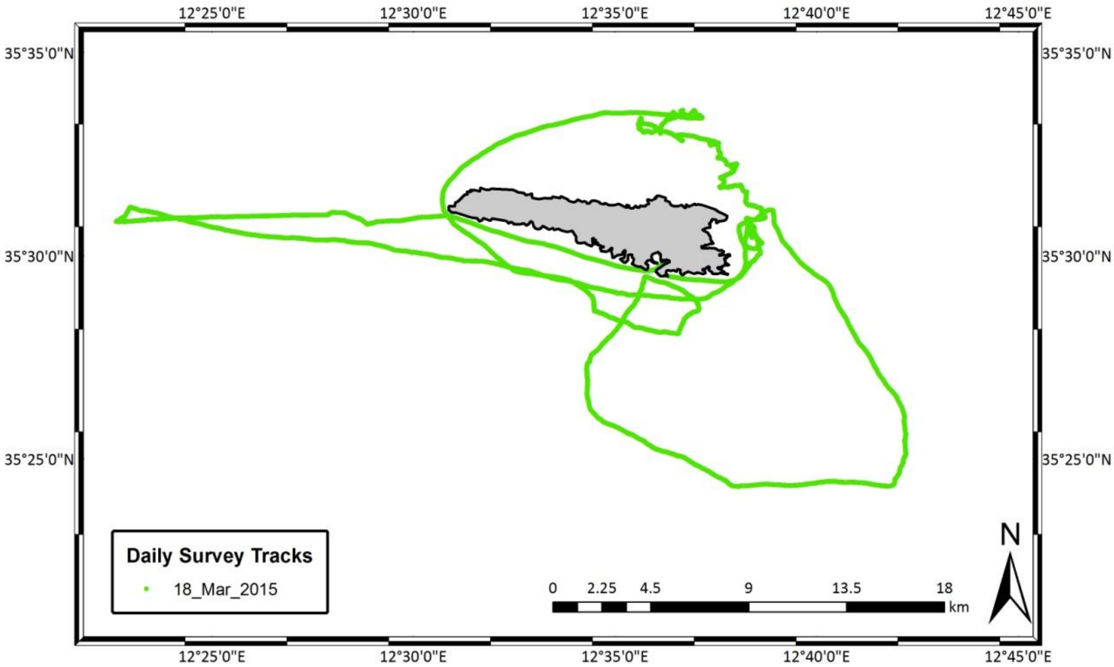

Fig. 17 – Track of the navigation.

Day 5 – 19 March 2015

One fin whale observed close to Secca di Levante; initially quite, with short dives and slow swim speed. The first approach was not at the right distance to deploy the transmitter and the whale was not perpendicular to the tagger. Several other approaches were tried, but the whale reacted to the inflatable and dived after one or two surfaces, as soon as the inflatable was closer. Increasing wind from East and growing waves made it impossible to reach short distances between the inflatable and the fin whale and with the decreasing of the light we decided to go back to port. Overall, 138 km were travelled during the day, as shown in Figure 18.

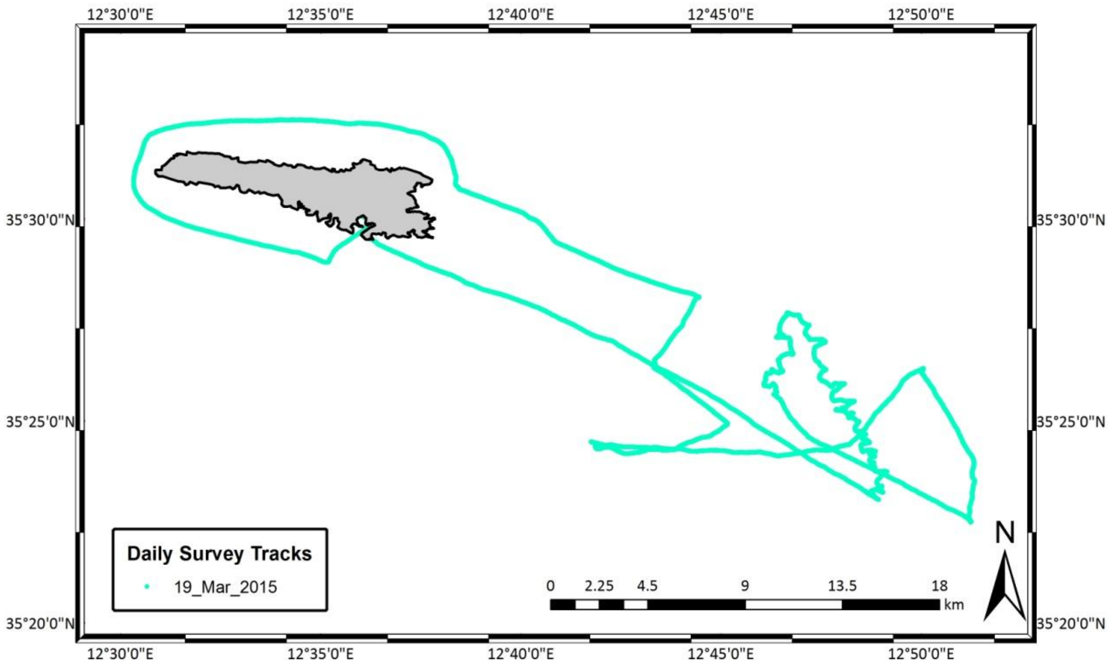

Fig. 18 – Track of the navigation.

Day 6 – 23 March 2015

One whale sighted very close to a trawling fishing boat, with slow swim speed and inconspicuous surfacing events. High waves rendered it hard to follow the whale that after just a few sightings disappears and is not sighted again. Several more hours were spent around the island of Lampedusa, towards the Island of Lampione and back to Lampedusa before dawn but no other sightings were recorded. Figure 19 presents the daily effort.

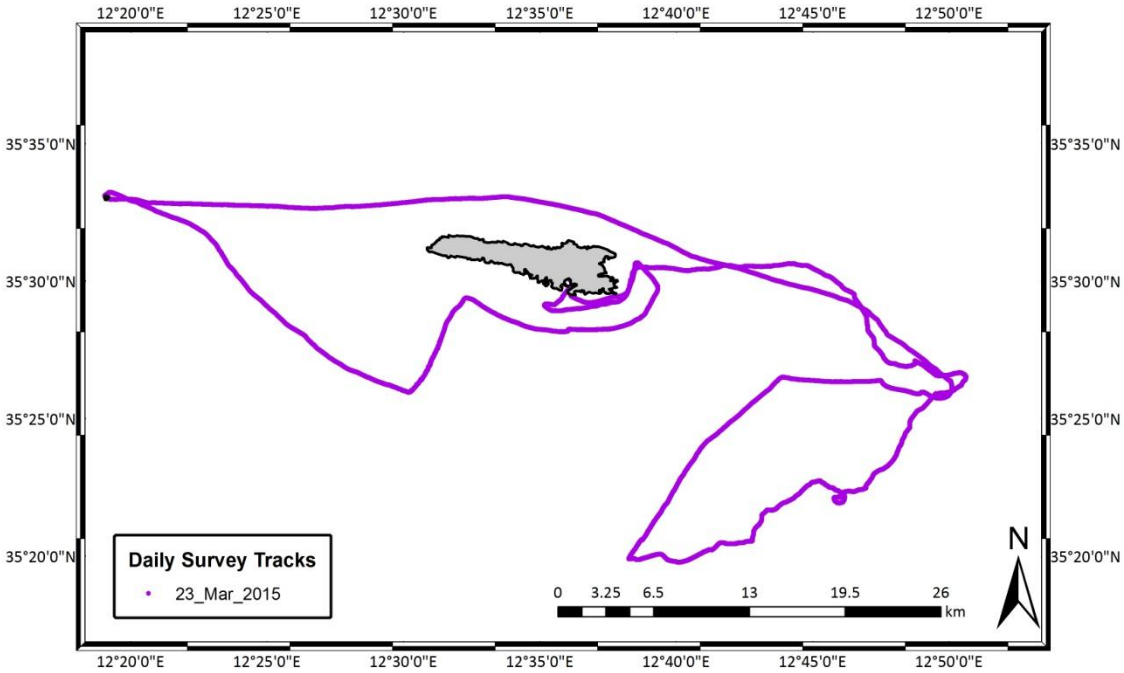

Fig. 19 – Track of the navigation.

Day 7 – 25 March 2015

A fin whale has been observed soon after leaving the harbour of Lampedusa. Very high waves of more than 3 meters, plus unforeseen wind form SE made it very difficult to follow the whale and to attempt the deployment of satellite tags. After a few approaches we decided that the very rough marine conditions were unsuitable for approaching any other whale and unsafe for working at sea, hence we headed back to the harbour. The track of daily effort is presented In Figure 20.

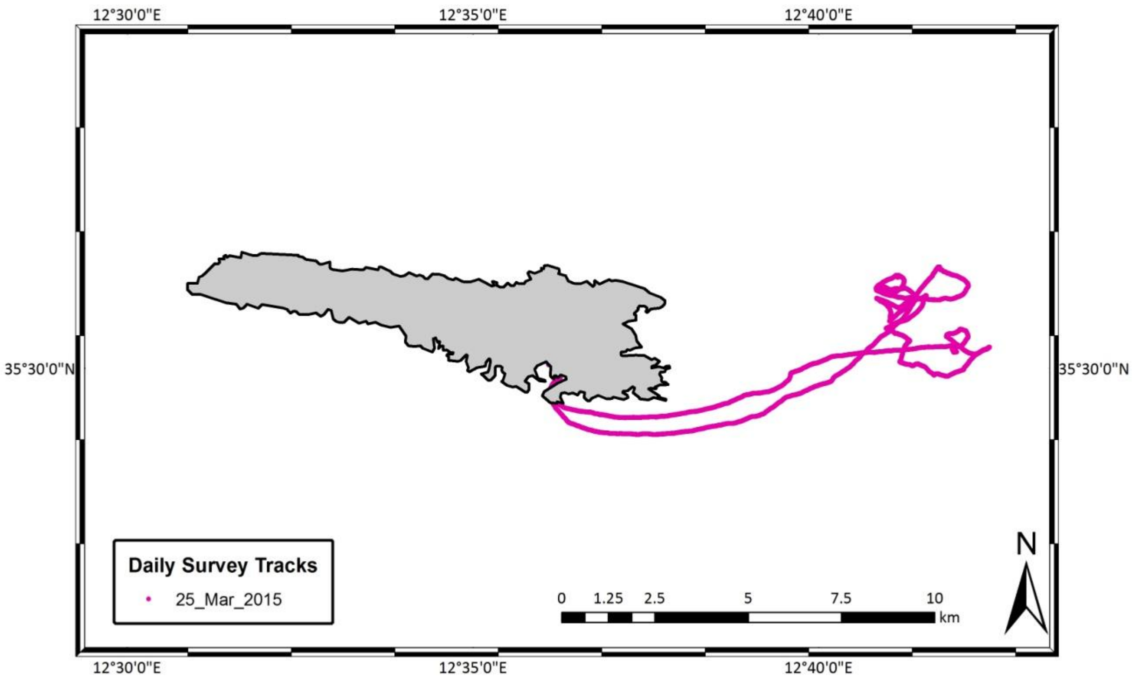

Fig. 20 – Track of the navigation.

This was the last day of field work. The weather forecast for the next 6 days depicted an unsuitable general situation for working at sea with very limited time windows of good weather. Given the forecast and the general instable meteorological conditions throughout the western Mediterranean Sea we decided to consider finished the 2015 Lampedusa campaign.

Audio Recordings

During visual observation of fin whales, when possible and only when data sampling wouldn't interfere with the tagging activities, real time audio recording were collected using a calibrated hydrophone with a sensitivity of –205.6 dB re1V/l μPa ± 4.0 dB and a frequency range between 0.1 Hz to 80 kHz (Model 8104, Bruel and Kjer, Nærum, Denmark). The instruments were made available by the Bioacoustics Lab, IAMC Capo Granitola, Italian National Research Council. The full technical specifications of the hydrophone are summarised in Table 2

Voltage Sensitivity with cable at 20	56 uV/Pa ± 15 uV C
Charge Sensitivity	0.44 pC/Pa pC/Pa
Capacitance with integral cable	7800 pF pF
Frequency Range re 250 Hz	0.1Hz to 10 kHz (±1.5 dB) / 0.1Hz to 120 kHz (+4/−12.0 dB) dB
Operating Temperature Range Short-term Continuous	-30 to +80 C
Max Operating Static Pressure	252 dB = 4 × 10^6 Pa dB
Dimensions	120 mm (4.73 inch) Inch
Weight Including Integral Cable	1.6 kg (3.5 lb) kg
Integral Cable	10 m waterblocked low-noise shielded cable to MIL-C-915 with BNC plug

Tab. 2 – The hydrophone specifications.

The hydrophone was connected to a preamplifier and then to an external ultrasound recording interface with a balanced analog input, trigger button, acoustic monitoring output, rugged aluminium housing connected to a laptop via a USB 2.0 interface. Figure 21a and Figure 21b show the front and rear panels of the UltraSoundGate 116H (Avisoft Bioacoustics, Germany) while Table 3 summarises the relevant information about the audio-board technical specifications.

Fig. 21a - UltraSoundGate 116H front view.


Fig. 21b - UltraSoundGate 116H, back view.

Number of channels	1
ADC type	Delta-Sigma architecture with integrated adaptive anti-aliasing filter
Resolution	16 bit or 8 bit
Sample rates [kHz]	1000, 750, 666.6, 500, 400, 375, 333.3, 300, 250, 214, 200, 187.5, 166.6, 150, 125, 100, 75, 62.5, 50
Frequency response (-3dB, external input without mic)	20 Hz - 460 kHz
Acoustic monitor output	yes (adjustable 2 to 30-fold undersampling), adjustable volume
Overload indicator (red LED)	yes
Peak level meter (4 LEDs)	no
Input sensitivity (max trim)	-43.2dBV = -41 dBu = 6.9 mVrms
Input sensitivity (min trim)	-3.2dBV = -1 dBu = 0.69 Vrms
Input sensitivity (max trim) step gain option	-28.4 dBV = -26.2 dBu = 38.0 mVrms
Input sensitivity (min trim) step gain option	1.6 dBV = 3.8 dBu = 1.2 Vrms
Gain adjustment potentiometer	40 dB continuous range (standard) or 30 dB range with 3 dB increments (optional)
Input impedance	50 kOhm
Analog input connector	female XLR-5 socket
Other inputs	external trigger input/output (TTL-compatible), one digital input (TTL-compatible), SYNC in/out
Computer interface	USB 2.0, isochronous high-speed mode
Physical USB connection	standard B-type USB socket
Maximum power supply current (drawn from the USB)	250 mA
Housing	compact aluminum enclosure
Physical dimensions (W/H/D) in mm	80 x 42 x 130
Weight	320 g
System requirements	PC with at least an Intel Atom at 1 GHz, running Windows Vista, 7 or 8

Tab. 3 – The external ultrasound recording interface UltraSoundGate 116H specifications.

Audio recordings were finally made through the sound recording and analysis software Avisoft-SASLab Pro (Avisoft, Germany, http://www.avisoft.com/soundanalysis.htm) setting the sampling frequency at 50 kHz and 16-bit resolution.

Totally 6 single recordings where collected between the 9th and the 19th of March, with an average duration of about 16 minutes per audio file (min= 10 minutes; max= 22 minutes), totallying 96 minutes of recordings. Through visual and aural inspection, on all the recordings, after proper editing, the typical 20Hz fin whale calls where identified. Figure 22 shows a sequence of the above mentioned calls of about 6 minutes (370 seconds) of duration and a particular of one single call.

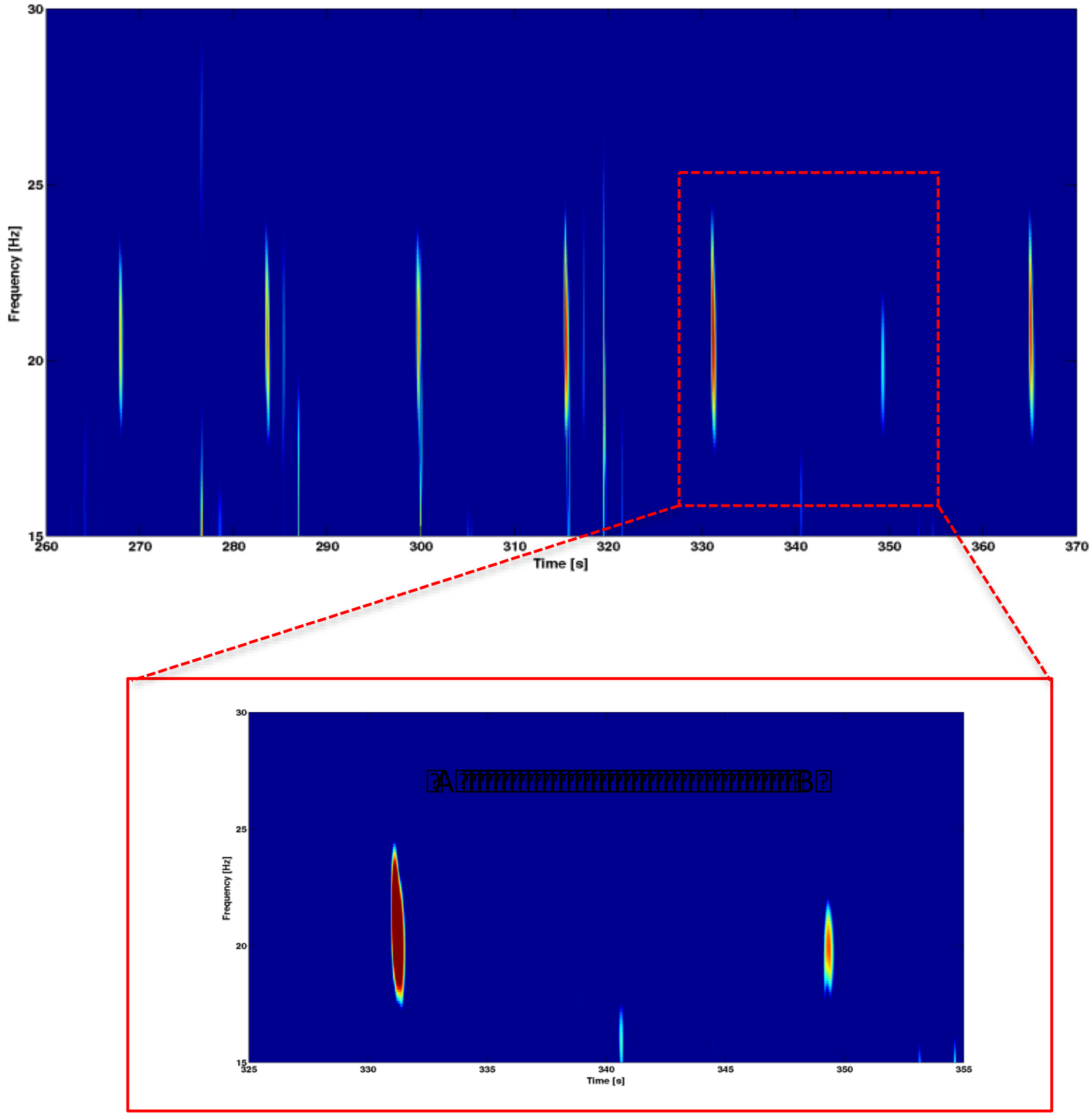

Fig. 22 – An example of the spectrogram (day 10.03.2015- h 18:10) in the frequency band between 15 and 30 Hz, with fin whale pulses recorded in the Lampedusa on the 10th of March 2015 at approximately 6:00 pm.

Results

Despite the adverse weather conditions that regularly affect the strait of Sicily and the Island of Lampedusa, particularly severe this winter, during the field work campaign we were able to successfully deploy two satellite transmitters on the dorsal fin of two fin whales (Figs 15, 16).

Platform 87776 was deployed on 14-Mar-2015 at 17:42:53 (UTC); the last transmission was received on 13-Apr-2015 at 15:59:52 (UTC), with a total duration of 29d 22h 16m. Overall, 591 messages were received from the satellites. The tracks of the fin whale are presented in Figure 23.

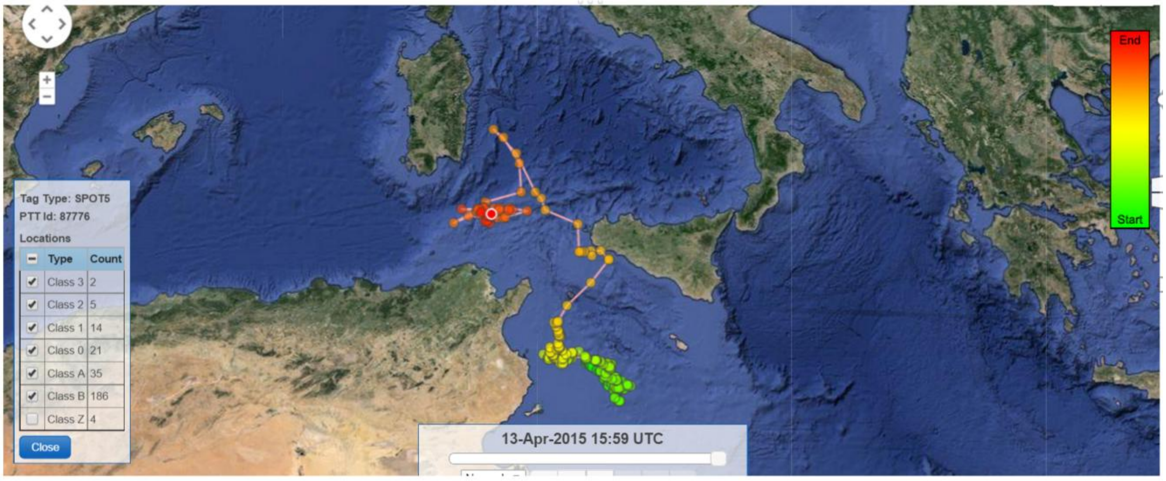

Fig. 23 – The total tracks of whale equipped with platform 87776.

Platform 87780 was deployed on 14-Mar-2015 at 16:42:28 (UTC) and it is currently transmitting as this report is being prepared. Total duration of the transmitter as on 15-Apr-2015 is 31d 12h 40m. Overall, 983 messages have been received from the satellites. The tracks of the fin whale are presented in Figure 24.

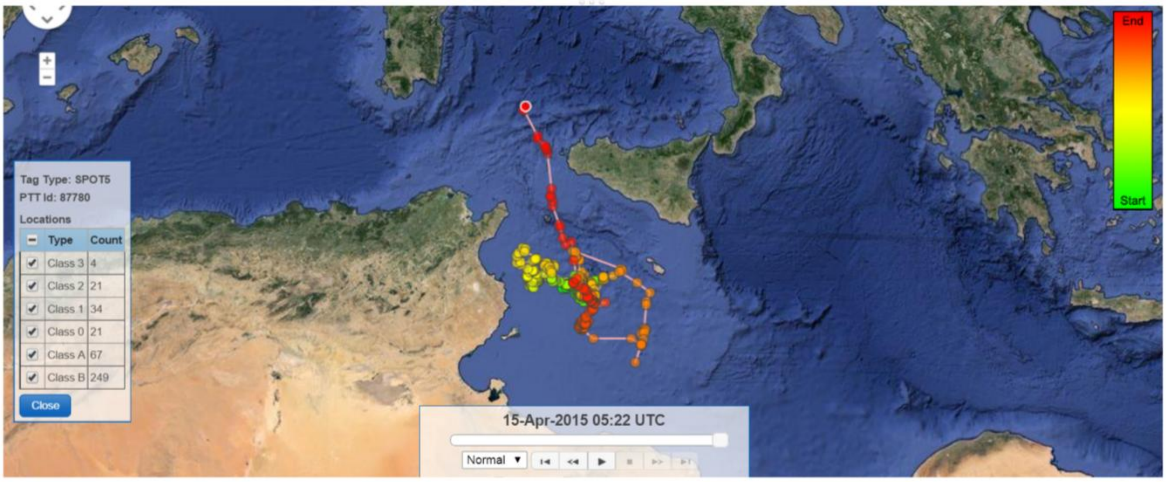

Fig. 24 – The total tracks of whale equipped with platform 87780.

Identification of fin whales feeding areas

To identify the potential feeding areas for fin whales, based on tagging locations, Minimum Convex Polygon (MCP), Kernel Density Analysis (KDE) and Percentage Volume Contours (PVS or Isopleths) were calculated using a series of Geographic Information System (GIS) tools, specifically the software ArcGis 10.1 as well as third party software interfacing with ArcGis 10.1 and the free software environment for statistical computing and graphics R, specifically the Geospatial Modelling Environment (GME) Tool.

In particular, the MCP in the form of a Convex Hull (CH) was calculated through the GME Tool as the total space used by an animal. It represents a polygon around every single feeding location point in the data set. Despite the identified area might contain some sectors never used by the animals, at this stage of the analysis, considering that at least one satellite transmitter is still transmitting positions, it can be hypothesized that fin whales might move back and forth to use previously acquired knowledge on the presence of aggregations of preys within the same identified area.

The KDE analysis was performed through the KDE tool within the Spatial Analysis Tool of ArcGis 10.1. This tool calculates the density of feeding locations in a neighborhood around those same locations, and uses this density to estimate the probability that an individual will use neighboring cells. It, therefore, provides an estimate of which areas an individual uses most frequently.

Finally, based on the results of the KDE analysis, Isopleths or PVC were calculated to identify those areas where an individual is likely to occur for a certain amount (percentage) of the time. The 95% PVC corresponds to the area in which the probability to find the animal is equal to 0.95, and is often taken as a measure of the total range. The 50% PVC is the area with a 0.50 relocation probability and is usually referred to as the core range.

The following figures (25-31) present the results of this analytical exercise.

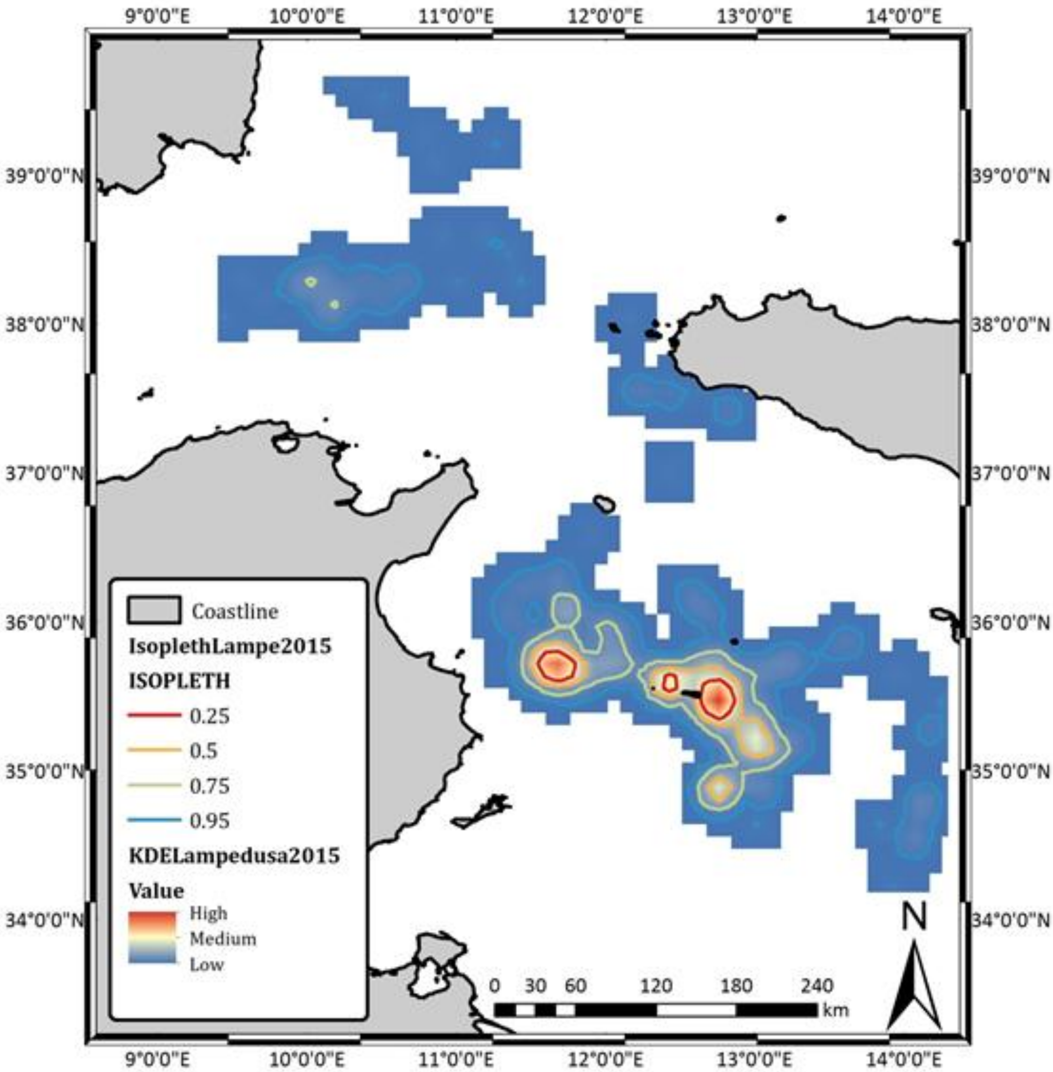

Fig. 25 – Kernel Density Estimation (KDE) and isopleths (Percentage Volume Contours) for feeding locations recorded for the two whales. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

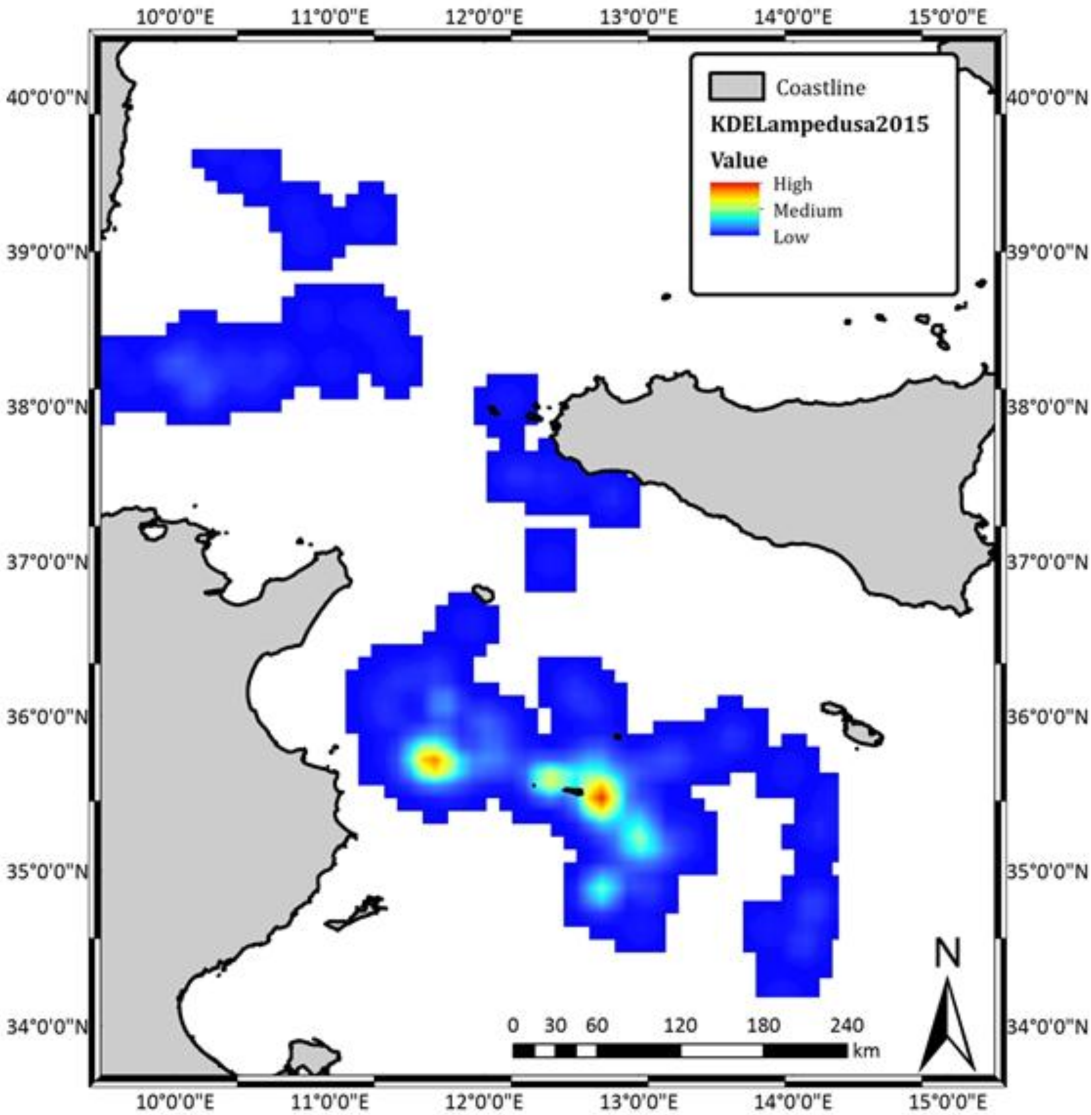

Fig. 26 – Kernel Density Estimation for feeding locations recorded for the two whales. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

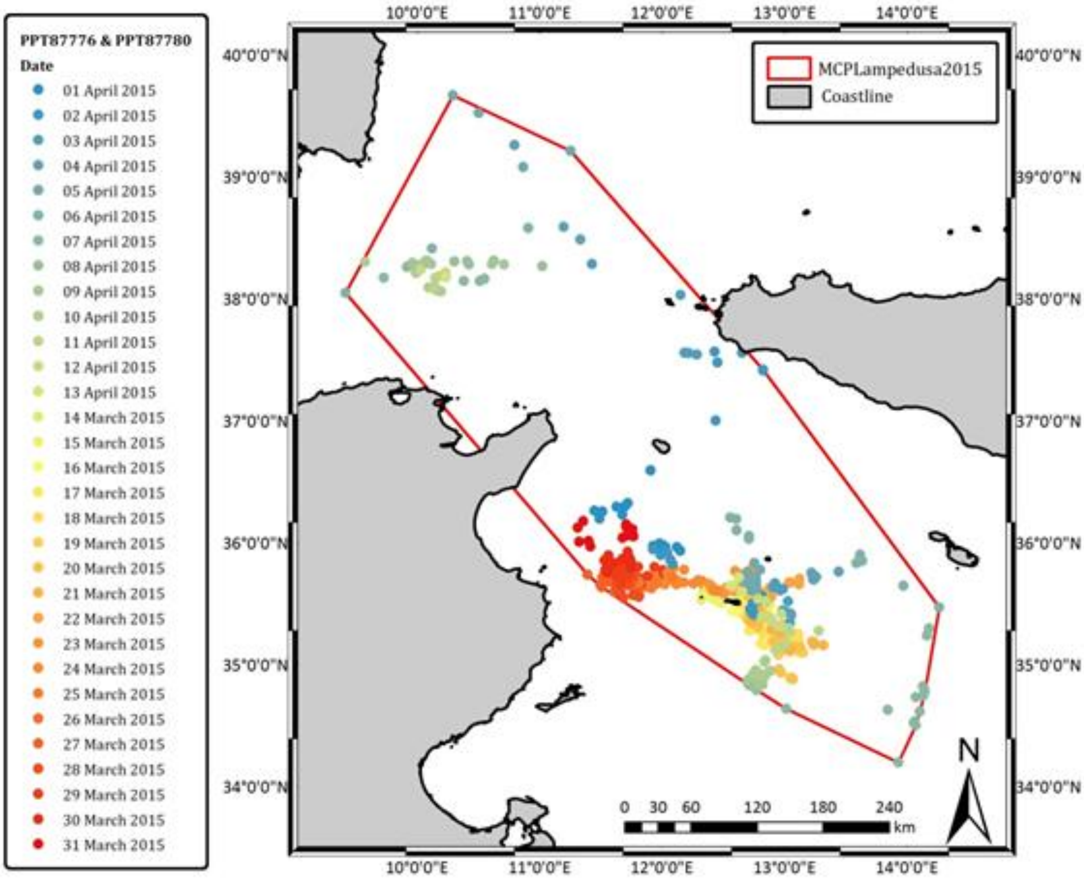

Fig. 27 – Minimum Convex Polygon (MCP) and feeding locations recorded for the two whales. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

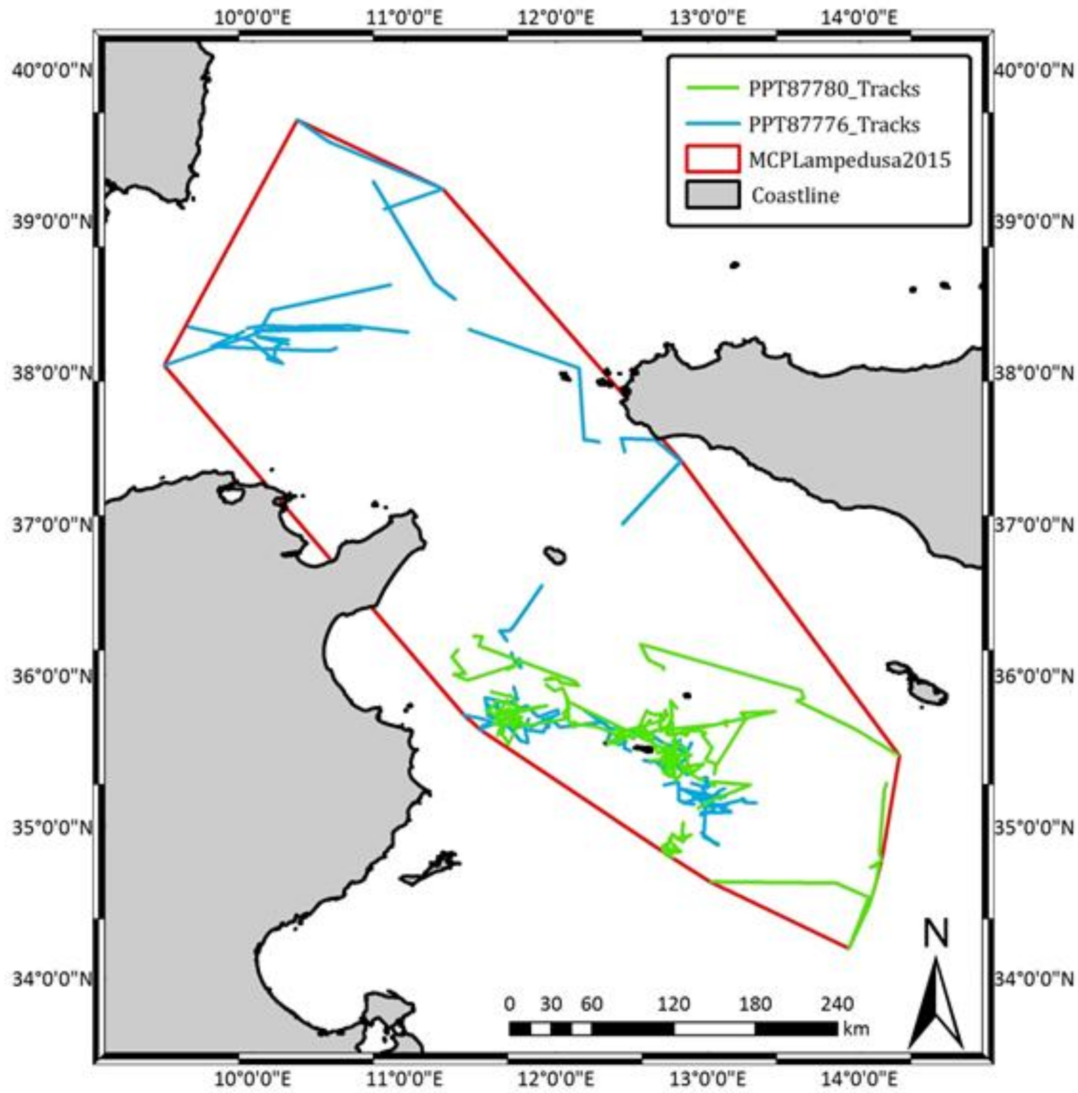

Fig. 28 – Minimum Convex Polygon (MCP) and whale tracks based on the feeding locations recorded for the two whales. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

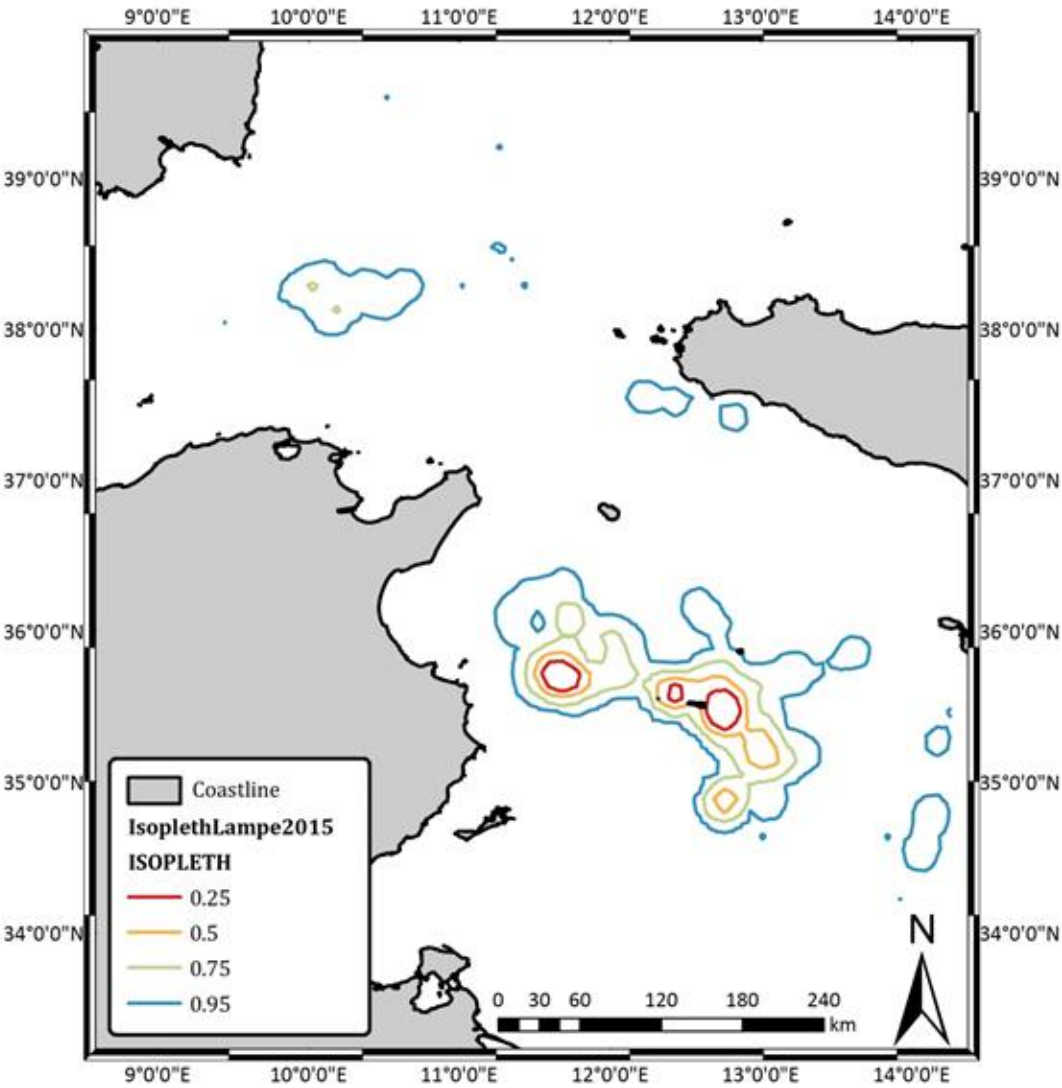

Fig. 29 – Isopleths (Percentage Volume Contours) for feeding locations recorded for the two whales. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

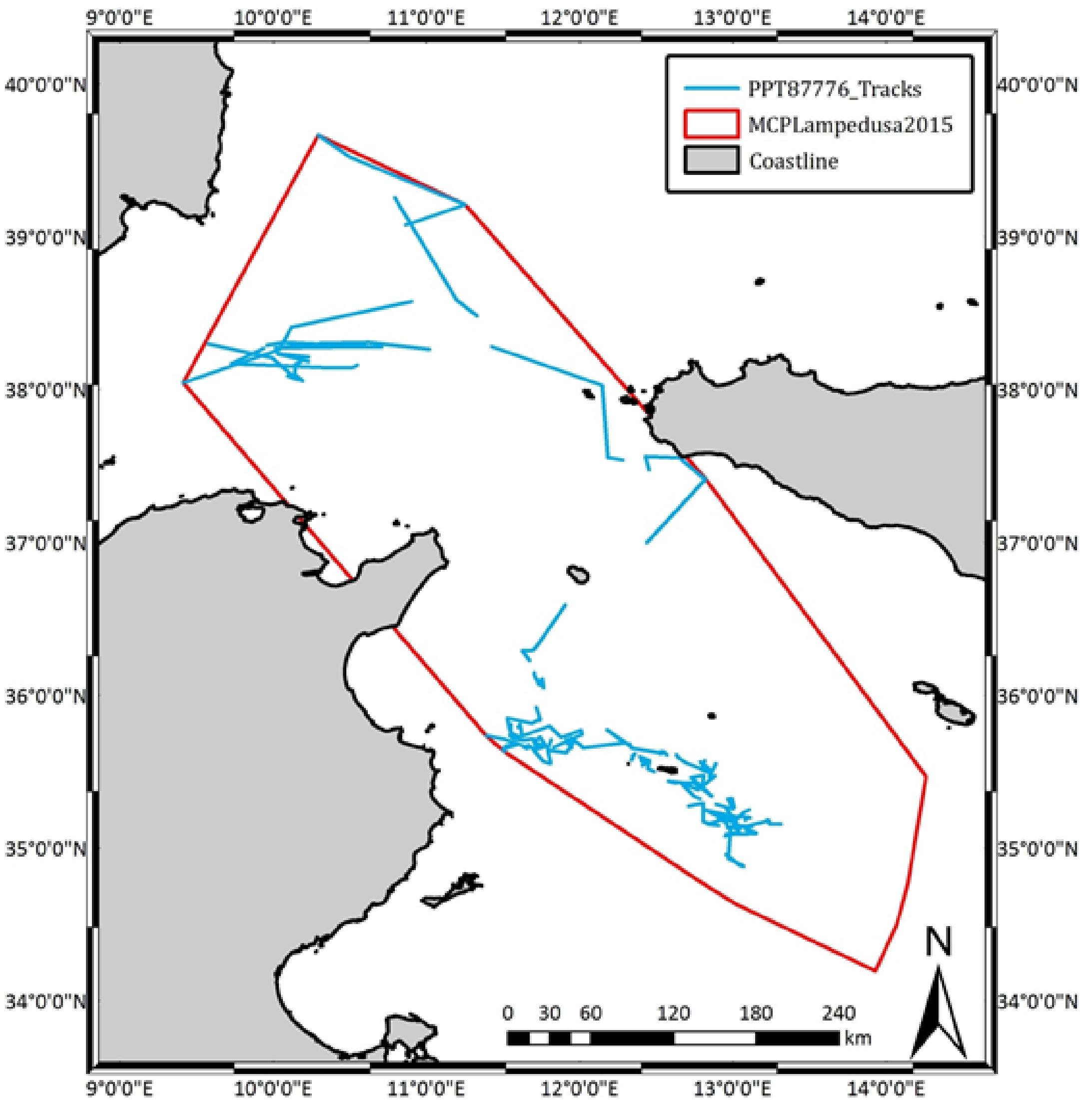

Fig. 30 – Minimum Convex Polygon (MCP) and whale tracked with satellite tag identified by PPT number 87776. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

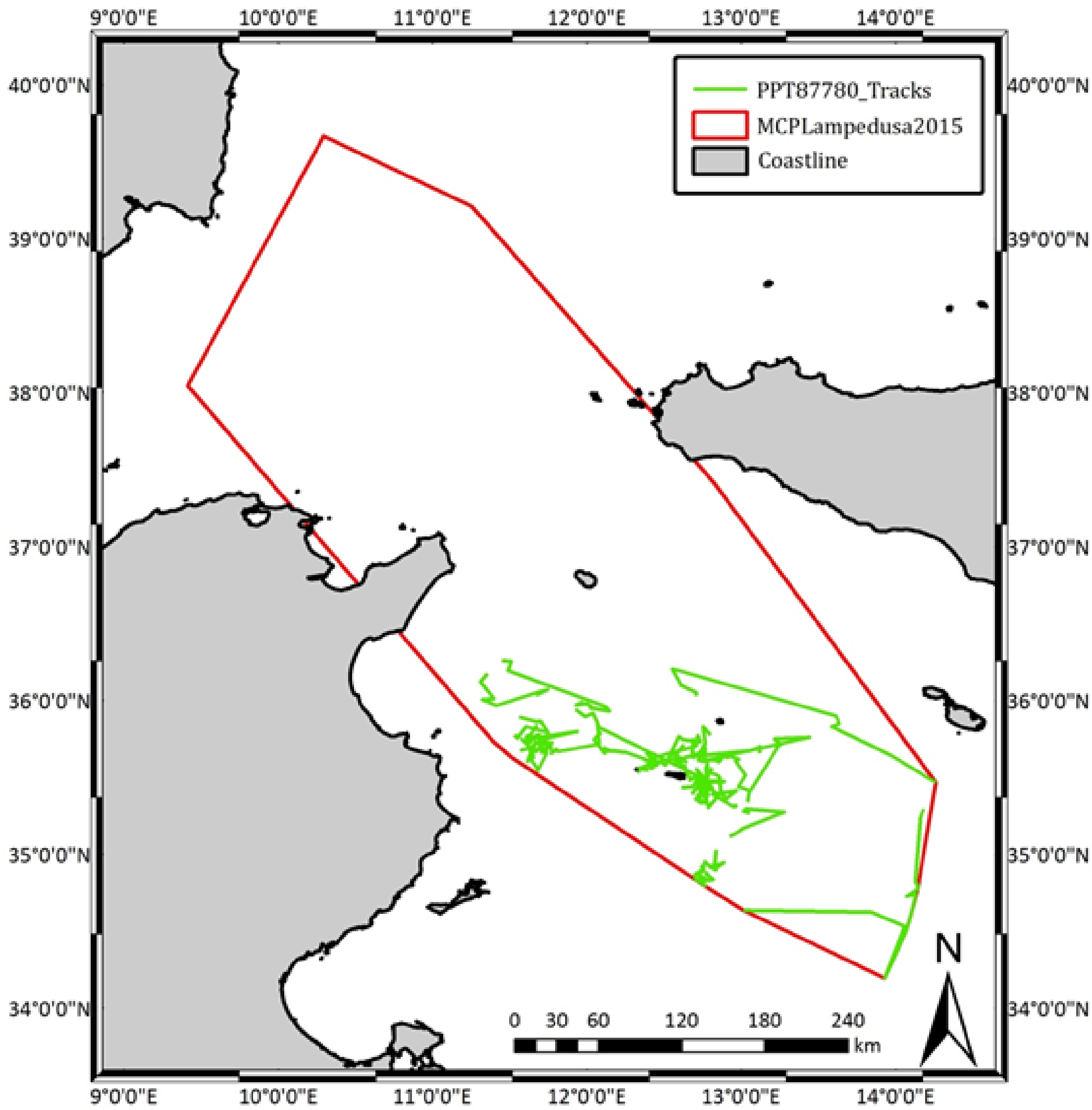

Fig. 31 – Minimum Convex Polygon (MCP) and whale tracked with satellite tag identified by PPT number 87780. Calculations are based on locations obtained between the 14th and of March and the 13th of April 2015.

Main scientific literature and references

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