LIFE Project Number

# <LIFE13 NAT/IT/001061>

# PUBLIC Version of the FINAL Report

## Covering the project activities from 01/10/2014 to 31/3/2020

Reporting Date

# <31/8/2020>

LIFE+ PROJECT NAME or Acronym

# <Protection from Strike by Active cetacean detection and alarm issue to ships and FErries in pelagos sanctuary (WHALESAFE)>

Project Data

| | |
|---|---|
| **Project location** | Pelagos Sanctuary |
| **Project start date:** | <01/10/2014> |
| **Project end date:** | <31/3/2020> |
| **Total Project duration (in months)** | 65 months |
| **Total budget** | € 1,847,167.00 |
| **Total eligible budget** | € 1,847,167.00 |
| **EU contribution:** | € 923,214.00 |
| **(%) of total costs** | 50 |
| **(%) of eligible costs** | 50 |

Beneficiary Data

| | |
|---|---|
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# 1. List of contents

# 2. List of key-words and abbreviations

ADG - Acquario di Genova
CPSV - Capitaneria di Porto di Savona
DIFI - Dipartimento di Fisica (Physic Department)
DISTAV - Dipartimento di Scienze della Terra dell'Ambiente e della Vita
DMC - Dissemination Management Committee
MEPA - mercato elettronico Pubbliche amministrazioni
PCC - Project Coordination Committee
SCC - Scientific Coordination Committee
SOFTECO - ALGOWATT SPA (continuation of SOFTECO)
UNIGE - Università degli Studi di Genova

# 3. Executive Summary

The main objective of WHALESAFE is the improvement of the conservation status of the cetacean Sperm whale (Physeter macrocephalus), listed in the Annex IV of Habitat Directive as species in need of strict protection., being the species amongst Mediterranean cetaceans most exposed to threats due to human activity and resource exploitation.
The Mediterranean sub-population is assessed as endangered according to criteria C2,a of IUCN Redlist. The goal fulfils also the Italian National Priorities in particular the SAP 1.A and C as indicated by the Italian Ministero dell'Ambiente e della Tutela del Territorio e del Mare.
The threat addressed is the marine traffic that can lead to collisions and noise pollution, representing disturbance of feeding activity and causing potential changes in Sperm whale behaviour as well as injuries and, in the worst scenario, death of the animal
To accomplish this task we identified the following five specific achievements:

Objective 1: to prevent the decline of the number of individuals reducing risk of ship strikes in Pelagos Cetaceans' Sanctuary by an active collision avoidance system deployed in an area with strong presence of ship traffic.
Objective 2: to demonstrate the effectiveness of the tool and the threat mitigation measure to convince the local and national authorities to adopt the system in other areas in the EU.
Objective 3: to provide a whole set of information about the presence and sightings of these species in the area. This is required to acquire the assessed overview of the presence of the animals in the area, also identifying preferred sites, necessary to improve the present conservation regulations and, therefore, to reduce the risk of ship strikes.
Objective 4: to inform about the conservation status of Sperm whale (Physeter macrocephalus) in the Mediterranean Sea. Communication and dissemination about cetaceans' protection and safeguard is required to raise among the stakeholders the awareness about the necessity to adopt best practices.
Objective 5: to create an effective and long lasting collection of public data on Sperm whale presence and interferences with marine traffic, covering several years of observations, to provide the people directly involved in Sperm whale conservation and to researchers, with a set of data as large and updated as possible.
The output of the project is described in the deliverables produced by the actions planned as reported in this table

| Name of the Deliverable | Action | Date | Status |
|---|---|---|---|
| Project Action Plan | A.1 | 31/12/14 | ☑ |
| Communication Plan | A.2 | 31/03/15 | ☑ |
| Training Course Manual | A.4 | 30/10/18 | ☑ |
| *Protocol of Conduct* | A.5 | 31/12/17 | ☑ |
| Final Protocol of Conduct | A.5 | 30/11/19 | ☑ |
| Problem Perception Survey Report | A.6 | 31/03/15 | ☑ |
| Surveillance System Architecture description | C.1 | 31/03/15 | ☑ |
| Surveillance System Devices | C.2 | 31/06/15 | ☑ |
| Sea floor map | C.4 | 30/09/15 | ☑ |
| at least 7 acoustic samples | C.4 | 30/09/15 | ☑ |
| Data analysis and alarm generation centre | C.6 | 30/09/18 | ☑ |
| Final report on deep dives recordings | C.8 | 31/12/19 | ☑ |
| Recording of at least 4 deep dives | C.8 | 30/09/18 | ☑ |
| Final report on detection system operation | C.9 | 31/12/19 | ☑ |
| Final monitoring statistics | C.11 | 31/12/19 | ☑ |
| Report of warning and prevention activities | C.12 | 31/12/19 | ☒ |
| Guidelines and best practises for collision risk reduction | C.13 | 31/12/19 | ☑ |
| Impact risk evaluation and reduction risk assessment report | D.2 | 31/12/19 | ☒ |
| Protocol of conduct adoption and respect assessment | D.3 | 31/12/19 | ☒ |
| Report on the risk reduction achieved during the project | D.4 | 31/12/19 | ☒ |
| Socio-economic impact indicators selection and impact assessment | D.5 | 31/12/19 | ☒ |
| Quality of the area improvement assessment | D.6 | 31/12/19 | ☒ |
| Layman's report | E.1 | 31/12/19 | ☑ |
| 1 Workshop Proceedings | E.2 | 30/06/16 | ☑ |
| First Press Release | E.3 | 31/12/14 | ☑ |
| Final press release | E.3 | 31/12/19 | ☑ |
| 1 Video (short format) | E.4 | 30/09/19 | ☑ |
| 1 Video (long format) | E.4 | 30/09/19 | ☑ |
| WHALESAFE logo design and use guidelines | E.5 | 31/03/15 | ☑ |
| Initial leaflets | E.6 | 31/09/15 | ☑ |
| 1 Brochure and 1 Leaflets (5000 copies each) | E.6 | 30/06/19 | ☒ |
| 1 Final Workshop Proceedings | E.7 | 31/12/19 | ☒ |
| 1 Project Web-site | E.8 | 31/03/15 | ☑ |
| Dissemination material | E.10 | 31/12/15 | ☑ |
| System application guidelines and user manual | E.11 | 31/12/19 | ☑ |
| 2 Posters and 1 Paper for year | E.12 | 31/12/19 | ☑ |
| Lecture Proceedings | E.13 | 31/12/19 | ☑ |
| Quality Plan | F.3 | 31/12/14 | ☑ |
| After Life Conservation Plan | F.6 | 31/12/19 | ☑ |

Most of the deliverables have been provided and are discussed in this report together with the related action. Few deliverables have not produced and we explain the reasons in the corresponding actions (C.12, D.2, D.3, D.4, D.5, D.6, E.3, E.6 and E.7)

We can affirm that all objectives could have been achieved without the unexpected storm in October 2018, by means of the accomplishment of the concrete actions foreseen in the project. This result has been achieved notwithstanding the project suffered different problems that slowed down the foreseen activities delaying the completion of the project by two-year delay. All the occurred problems have been reported to the monitor and are listed in the Final Management Report.

We preceded the Concrete actions by a series of preparatory action designed to guarantee their success. We created among the beneficiaries good coordination and training, we defined and diffuse among the stakeholders a Protocol of Conduct aiming at reducing the risk for the target species. Particularly:

**Preparatory action 1**: we created a uniform and coordinated working group with tasks clearly distributed between the participants.
**Preparatory action 2**: we prepared the Communication Plan Report that includes the list of categories whose activities can represent a real or potential risk for dolphins and contact points, a time schedule and all information necessary to optimize the communication transfer.
**Preparatory action 3**: we created a network including the major representatives of the stakeholders interested to the project activity. All the representative of the stakeholders associations that operate in the project area signed the Protocol of Conduct (action A.6).
**Preparatory action 4**: we provided good training to the personnel involved in the project so they could manage the tools of their competence.
**Preparatory action 5**: we wrote a Protocol of Conduct for all cases considered. The representative of most of the stakeholders that operate in the project area signed it.
**Preparatory action 6**: we reached a good education of the stakeholders by means of dedicated meetings and a survey based on three thousand questionnaires administrated at the cruise terminal of Savona.
**Concrete action 1**: we created in the project area an interference avoidance system capable to detect and track Sperm whale, to identify the threats and to prevent collisions and other risks, by issuing warning messages in real time to ships in the area based on an automated detection and tracking system for Sperm whales and boats and an efficient communication system (Coast Guards messages, specific app for smartphones,) and ruled by a Protocol of Conduct specifically written and signed by the main stakeholders representatives (*Objective 1)*. We demonstrated that the system is capable to recognize the sounds produced by the Sperm whales. The system identified more than 5000 clicks of the Sperm whales in the area and recorded more than 3.500 hours of sounds together with environment parameters (*Objective 3*). The analysis of the data proved that the project area shows the seasonal presence of Sperm whales, however due to the impossibility to perform the year of application of the Protocol of Conduct we have not been able to verify if this presence has increased since the beginning of the project (*Objective 1*).
**Concrete action 2**: We demonstrated that the system could generate an alarm to forecast by means of Coast Guards messages, and by specific app for smartphones (*Objective 2*). Four sperm whales have been localized during the whole project and their presence in the project area has been verified a-posteriori with a visual campaign coordinated by WHALESAFE. None of these animals has been localized with alternatively methods, thus proving that the acoustic monitoring could be the real breakthrough in the reduction of risks for cetaceans.
**Concrete action 3**: We carried out an intense activity of dissemination aimed at raising among the stakeholders the awareness about the project. Costa Edutainement constantly organized events dedicated to the stakeholders and activities on board (*Objective 4*).
**Concrete action 4**: We implemented the basis for a database of sound recording and sightings (*Objective 5*). Unfortunately, due to the impossibility to maintain in operation the system the sample is limited to few animals. In this report after a preliminary description of the project objectives, in the Administrative part we present the four beneficiaries and their role in the project and we briefly summarize the project management process.
As reported in the AfterLife plan all the experience gained in WHALESAFE is being transferred to KM3NeT/ORCA located in France at the border of the PELAGOS Sanctuary. KM3NeT/ORCA has been designed to work for at least 15 years and it will be help to realize a long lasting environment safe for cetaceans.
In the Technical part, we discuss action by action the progress and the achievements of the project. All results are reported quantitatively.

# 4. Introduction

The Pelagos Sanctuary for Mediterranean Marine Mammals is a special marine protected area in the north-western Mediterranean Sea. It is located between Liguria, France and Sardinia and covers an area of around 90 000 $km^2$. The sanctuary is the most important breeding and feeding site for cetacean populations living in the Mediterranean Sea and thus crucial for their well-being. Distinct ecological and sea floor conditions in the sanctuary mean that primary production (the creation of organic compounds through photosynthesis or chemosynthesis) in the area is very high and supports a diversified food chain. The unique seabed features in the area, such as canyons, attract a large number of sperm whales that often emerge near the coast. Major commercial, tourist and industrial sites are also located in the area and marine traffic (e.g. passenger, cargo and fishing boats) increases particularly during the summer, when the presence of sperm whales is higher. Collisions and injured animals are consequently frequent and have a very high negative impact on the species, whose Mediterranean sub-population counts at just 2 500 mature individuals. The Life Project WHALESAFE implemented an interference avoidance system capable to detect and track sperm whales, to identify the threats and to prevent collisions and other risks by diffusing presence warning messages in real time to all categories involved. The project aims to accomplish the following specific objectives:

| | |
|---|---|
| Objective 1: | development of an interference avoidance system aimed at detecting and tracking sperm whales |
| Objective 2: | identification of threats to sperm whales |
| Objective 3: | prevention of collisions and other risks by issuing warning messages in real time to ships in the area; |
| Objective 4: | draft of a protocol for reducing the disturbance and impact risks in cooperation with the local coast guard and agreed by all stakeholders involved; |

The expected longer-term results were:

1) Implementation of an active conservation tool, suitable for replication in other areas of the Mediterranean Sea;
2) Reduction of ship collision risks and stress derived from noise pollution from marine traffic for sperm whales in the selected area;
3) Definition of specific regulations and strategies to prevent ship collisions;
4) An increase in public awareness concerning the threats affecting cetaceans in the Pelagos Sanctuary;
5) Implementation of a database of cetacean sightings that can be easily consulted and used for management, conservation and public dissemination purposes.

# 5. Technical part

## 6.1. Technical progress, per task

### Action A.1: Project start up and launch

Several meetings have been organized to coordinate the startup of the project and set the preliminary tasks for each action of the project. First of all, we met the expert Walter M. X. Zimmer to make a feasibility study of the project and to understand the limits and the opportunities of WHALESAFE.
We organized also the following meetings dedicated to individual actions:

- 2/10/2014 Kick-off of the project (Savona)
- 7/10/2014 Partner meeting (Savona)
- 22/10/2014 Meeting with Mr Deboni representative of AGEOTEC S.r.l. (DIFI)
- 24/11/2014 Participation at the Regional Consultative Commission (Savona)
- 25/11/2014 Visit to Bergeggi's Municipality to present the WHALESAFE Project (Bergeggi)
- 27-28/11/2014 Meeting with Pelagos
- 9/12/2014 Partner meeting (Savona)
- 9/12/2014 Meeting with prof. G.Pavan, University of Pavia (DIFI)
- 11/12/2014 Press Conference (UNIGE Balbi)
- 15/01/2015 Meeting with EdgeLab (DIFI)
- 27/02/2015 Partner meeting (Savona)
- 3/03/2015 Meeting with ship pilots (Savona)
- 22/04/2015 Partner meeting (Aquarium of Genoa)
- 7/05/2015 Meeting with Barracuda company (DIFI)

These meetings allowed us to create a uniform and coordinated working group with tasks clearly distributed between the participants.
Later we discussed with CPSV and dockers the best location of the buoys, an area was selected and the precise location fixed.
The WHALESAFE project was presented officially with a Press conference (11/12/2014) and with a visit to Bergeggi's Municipality (25/11/2014).

- Problems incurred – None
- Evaluation – Project start up actions completed.
- Completion – 100 %

### Action A.2: The Communication Plan

To produce the communication plan we identified the following objectives for our communication actions:

- Raise public awareness about the need to take concrete action for the conservation of cetaceans in the Pelagos Sanctuary
- Promote the adhesion of the various stakeholders, and in particular of the shipping companies, to the project and to the code of conduct
- Disseminate the results of the project and support the replicability
- Raise awareness though the stakeholders

The methodology used for the definition of the communication has followed these steps:

- Analysis of the context (setting appropriate action to be carried out);
- Identification of communication objectives;
- Identification of the target audiences and the stakeholders;
- Definition of common strategy that will be the bases of all activities and communications products of the project;
- Identification of actions and communication tools

Costa Edutainment has submitted a draft document, which was integrated, shared and discussed with the University of Genoa. The plan has been monitored during the whole project duration.
The objectives of the action have been achieved according to the original planning.

- Problems incurred – None
- Evaluation – Communication plan produced.
- Completion – 100 %

## Action A.3: Stakeholder network establishment

At the beginning of the work, the existing networks have been investigated. In particular, we have highlighted the main categories, which could support the technical and the communication activities. Through this process of selection, a list of various stakeholders has been elaborated, identified thanks to the contribution of all the partners.
The stakeholders have been divided in two categories according to the communication plan:

- primary, which includes the stakeholders directly involved in project development
- secondary, which includes the stakeholders who will be involved mainly in the dissemination activities.

The identified subjects were invited to attend the launch press conference and the fishermen were involved before the Regional Consultative Commission (24/11/2014).
The following events have been carried out to involve the stakeholders:

- during the first phase of the project, a meeting with the fishery commission have been organized
- on May 11th, 2015 a meeting with shipping companies has been organized in order to present the project.
- on July 4th, 2016 the stakeholders, in particular the shipping companies, have been invited at the Acquario di Genova, to present the protocol of conduct which was explained by the Port Authority of Savona. During the event Costa Crociere was the first shipping company to sign the protocol. Alessandro Bertorello, Head of Environment Carnival Maritime GmbH, signed the document. In Figure 2 the invitation card is reproduced.

A press release has been produced and several articles on newspaper and magazines have been published.


Figure 1: Signature of the Protocol of Conduct by Costa Crociere

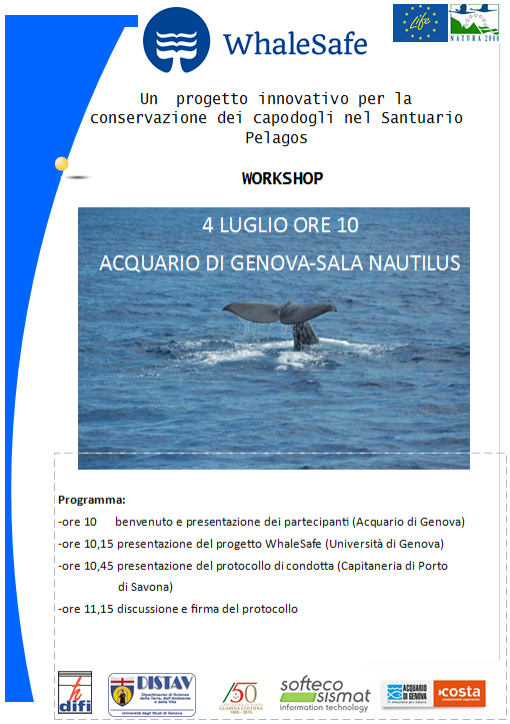


Figure 2: Invitation card

Beside Costa Crociere, which signed the protocol of conduct on 4/7/2016, the following new stakeholders have signed the document:

- Grandi lavori Fincosit (maritime works)
- Coldiretti (fishing association)
- Federcopesca (fishing association)
- Ilma sub (underwater works)
- Leganavale (Varazze) (recreational boating)
- Leganavale (Finale) (recreational boating)
- Ziggurmare (boating school)
- Liguria via mare (whale watching)

- Problems incurred – None
- Evaluation – Stakeholder network established including all the relevant companies.
- Completion – 100 %

## Action A.4: The Training Course on detection system operation and management

The beginning of the training course has been delayed due to the technical problems occurred in June 2016. This incident delayed the test phase of the project which provides fundamental information about the operating system that are very important for the training course.
Once the test phase has been concluded, the first training course has been attended by the UNIGE crew in September 2018.
Thanks to this course, the UNIGE crew has the ability to operate with the monitoring system, retrieve data, perform offline data analysis and restore the operativity of the detection system in case of failures. The course is based on the WHALESAFE manual which contains a description of the detector and the software of the system and the instruction to operate with the various tools.
The second course intended to train the personnel of the CPSV in the use of the alarms generated by the system, would have been started, if the system would have been restored after the incident of October 2018.

- Problems incurred – The training course has been delayed due to the incident occurred to the detector. The experience of the first summer campaign was essential, since it provided several inputs for the training course. As soon as the first summer campaign as been completed the training course for UNIGE personnel started.

- Evaluation – Training course material has been produced. Training course held for UNIGE personnel. CPSV personnel training was planned, but not held due to conclusion of the project.
- Completion – 80 %

## Action A.5: Definition of the Protocol of Conduct for disturbance and collision risk mitigation

In order to define mitigation measures, knowledge about collisions incidence, factors determining collisions and sperm whale behaviour are necessary. For these reasons, during the first six months of WHALESAFE project the biologists of DISTAV (Genoa University) conducted a study on these topics.

The review provides scientific knowledge useful to the CPSV for the definition of the mitigation measures. An increase of the incidence of collisions events equal to 2% in the last 20 years (from 6% to 8%) has been found. Ship size and speed seems to be the main factors responsible of collision. The severity of injuries to whales struck is strictly connected to these two factors. Incidence of ships damage was also reported in order to evaluate effects on navigation security. A detailed study of the behaviour of sperm whale is fundamental to define the protocol of conduct. Considering the "minutes of silence" of sperm whales (maximum time sperm whales spend without clicking) the warning alarm, indicating their presence at the surface, should be active for at least 20 minutes starting from the last detected click. Furthermore "a zone of respect", with no ships transit, of about 100 m around the whale at the surface would be appropriate in order to reduce disturbance and stress to sperm whales during breathing.

A first draft of the Protocol of Conduct foresaw three level of alert:

- Green: no sperm whales in the area
- Yellow: sperm whale diving in the area (immersion period)
- Red: sperm whale breathing at the surface, pass at low speed (< 6kt) inside 500 m from specimen or maneuvering the vessel. Transit is avoided inside 100 m from the breathing sperm whale.

The acoustic campaign allowed to improve knowledge about the behaviour of sperm whales. Particularly the distance travelled during breathing was investigated.

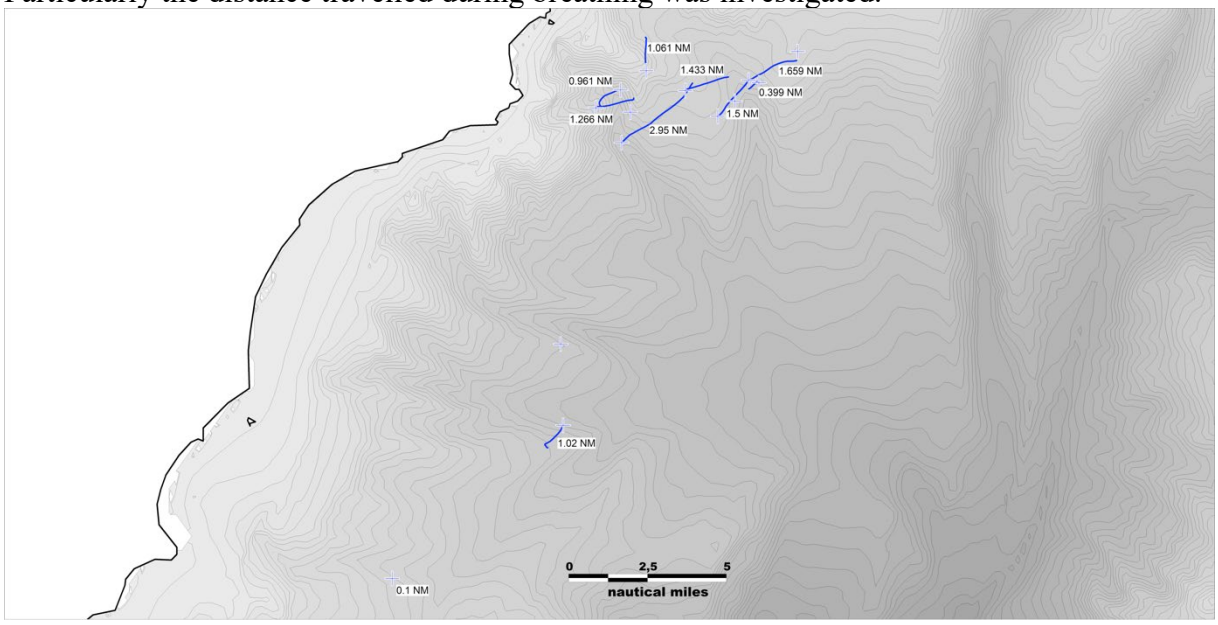



Figure 3: Blue lines are the sperm whales tracks during the sightings at the surface. Distance travelled are reported in the labels

| | |
|---|---|
| Average | 05:52 |
| Median | 06:00 |
| Standard deviation | 0.098484 |
| T max | 10:01 |
| T min | 01:29 |
| Mode | 0.25 |

Table 1 :Time spent by the sperm whales breathing at the surface

Maximum distance travelled results among 3 nautical miles, for this reason an area of among 3nm of diameter has been suggested as "alert zone" during red alarm. As suggested by the name, ships travelling in the alert zone have to keep particular attention by employing observers, transit in this area is forbidden at distance smaller than 100 m from the whale, and at distance lower than 500 m, the transit is allowed at speed lower than 6 kt. By considering the times that the sperm whales, sighted during the acoustic campaign, spent breathing at the surface (Table 1), the red alarm should last 15 minutes (the maximum times at the surface is 10 minutes, we suggest to add 5 minutes more to be sure that the whale is underwater). The protocol of conduct draft has been modified according to the results obtained by the analysis on the acoustic recorder data, and the meeting with stakeholders to share the Protocol of Conduct, in cooperation with the Savona Coast Guard.
The new version of the Protocol of Conduct has been defined in 2016. In synthesis it foresees three areas around the whale at the surface:

- No Transit Zone: 100 m around the whale
- Transit Zone at speed lower than 6 kt: 500m around the whale
- Alert Zone: 3nm around the whale. Ships travelling in the alert zone have to keep particular attention improving ship's lookout

The protocol of conduct foresees also four alarm levels:

- Green: no sperm whales in the area
- Yellow: sperm whale diving in the area (immersion period)
- Orange: sperm whale breathing at the surface, all ships are respecting the protocol of conduct
- Red: sperm whale breathing at the surface, one or more ship in route of collision with the whale.

The 11th May 2016 the protocol of conduct has been shared and discussed with stakeholders, in the Savona Coast Guard office (Figure 4). The aim of the meeting was to share the proposed protocol in order to define the final document with the stakeholders.

Figure 4: Dr. Alessi illustrating the protocol of conduct to Stakeholders

The 4th July 2016 the official Protocol of Conduct (attached as *Annex4-A5-Signed Protocol of Conduct*), as result of the previous meeting, was presented to the stakeholders and media, in the Sala Nautilus at the Genoa Aquarium (Figure 5).
The official document, as declaration of intent to respect the protocol, has been signed by Costa Crociere navigation company during the event (4th July 2016).

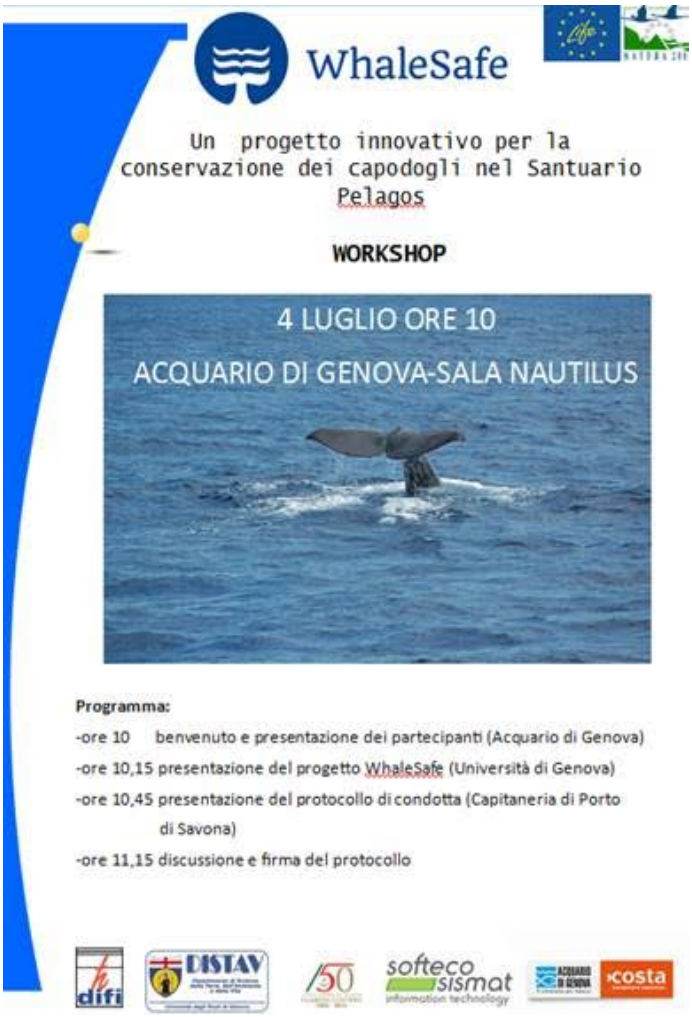


Figure 5: Flyer of the meeting with stakeholders

In 2018 the description of setup has been slightly modified according to the modification of the apparatus described in Action C.9. Particularly the final document shows the configuration with a single buoy with the hydrophones suspende below it, and includes limitations in the navigation close to the buoy.

- Problems incurred – None
- Evaluation – The protocol of conduct has been defined.
- Completion – 100 %

## Action A.6: Stakeholders Problem Perception Survey

The aim of this action is to investigate the awareness of the stakeholders (in particular ferries' passengers) in relation to the collision problem targeted by the project; a questionnaire was developed in collaboration with an expert of the Department of Science Education of the University of Genoa. The questionnaire is composed by three types of questions:

- a set of questions to investigate the degree of knowledge of the passengers about the Pelagos sanctuary and about the presence of a large number of cetaceans in the area.
- some questions related to the perception of the problems that can affect the cetaceans
- a question to test the willingness of passengers to choose a shipping company that adheres to the conduct code agreement to avoid collisions with sperm whales.

Three thousand questionnaires have been administered at the cruise terminal of Savona, where thousands of passenger transit and spend time just before the departure to various destinations. The questionnaire has been produced also in English.
This action has been slightly delayed compared to the original planning, due to the long time required to obtain authorization by Costa Cruises for the administration of the questionnaires.
The data analysis highlights that there is awareness about the need to protect the cetaceans, although very few people know the Pelagos sanctuary and are aware where it is. All respondents answered that it would be important and useful if the shipping companies adhere to a protocol to avoid possible collisions between whales and ships.

- Problems incurred – None
- Evaluation – The awareness of the stakeholders has been investigated. The action has been completed.
- Completion – 100 %

## Action C.1: Design of Detection System

This action foresees the development of the detection system, defining the detailed design of the acoustic data acquisition and analysis system to be installed in the target areas. It addressed the following topics:

- selection of the specific sensors;
- selection of the integrated acquisition devices including sensor, digitization, transmission device, power supply, marine container and buoy;
- specification and selection of the link devices for data transmission from the buoys to the receiving station;
- design of data processing electronic boards (beamforming, data processing and data transmission);
- development of the local processing software for cetacean detection
- specification of the buoy requirements.

The nominated company for the construction of the buoy has been EDGELAB that have long term experience with NATO Undersea Research Centre on scientific buoys system. The first buoy design is shown in Figure 6.

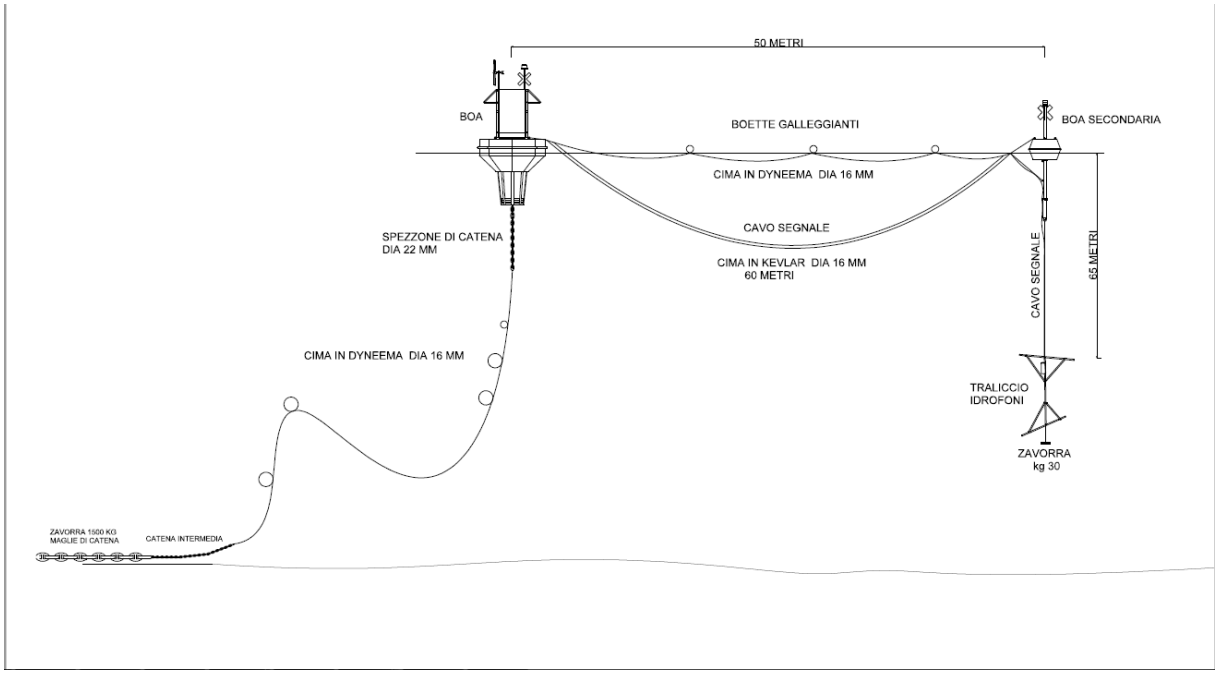


Figure 6: WHALESAFE detector design (two buouy configuration)

The system was initially designed as two stations positioned on the previously selected location offshore Bergeggi. Each station is formed by two floating bodies, one is the primary buoy which hosts all electronic instrumentation for acquisition processes, data transmission and for power supply. The main buoy has an octagonal shape (height 5.70 m, diameter 2.50 m).
The buoy has a flat surface where is housed a mechanical structure, called castle.
This structure is a support for the solar panels and the wind rotor that provides the power by means of a charge regulator. Furthermore, the castle directly bolted to the plane of the buoy contains a sealed box where the electronics is housed.
The buoy is ballasted in the underlying part with 650 kg (2.5 m below the centre of the buoy) in order to obtain a low centre of gravity and make it much more stable, even in presence of stormy sea. This object is anchored at a depth of 370 m, where the seabed presents a steep slope which would have complicated the mooring operation. In order to overcome this issue, we used a 1500 kg anchor chain (composed of 15 ring) that guaranteed a good grip on the sea floor.
The mooring line is a kevlar cable (diameter 16 mm) with a resistance to breakage of 2 tonnes. The mooring line is connected to the anchor and the buoy through a Crosby swivel hoist ring capable of withstanding up to 3-4 tonnes.
The secondary buoy is a smaller object (height 3.0 m, diameter 1.0 m, weight 90 kg). The underwater passive acoustic system is deployed below the secondary buoy (50 m aside the principal buoy, depth 75 m) to avoid mechanical stress and interference due to the wave motion.
The two buoys are connected though two cables: a mechanical cable constituted by a synthetic cable slightly below the sea level (maintained close to surface by 8 floats) and a signal cable below the surface between the two floating objects as can be seen in Figure 6.
The first cable secures the two buoys and handles the mechanical stresses due to the sea state and the wind, the second cable transfers the ethernet signals and the power to the electronic components below the secondary buoy. This cable is coupled with another kevlar cable that ensures resistance to the mechanical stress due to the relative motion of the two buoys.
The detection system is an improved version of the LIFE09 NAT/П7000190 ARION detection unit. Four hydrophones are located at the vertex of a tetrahedron at a depth of 70 meters. Hydrophones will be sensitive up to 150 kHz. We opted for the hydrophones GP0289-M produced by COLMAR,

the same used in ARION. These are optimal for our purpose, with high sensibility, low noise and wide bandwidth.
The distance between each couple of hydrophones is 4 meters and the vertical spacing is 4 meters. The orientation of underwater acoustic structure is measured by means of a high-resolution compass PNI Corp. TCM5XB with the nominal precision of 0.1 degree. This device is able to compensate the magnetic deviation due to presence of iron near the acoustic station.
The acquisition system is based on the National Instruments technology PC NI9081 cRIO (http://www.ni.com/compactrio/). This is a very reliable industrial control system (we had no failures during ARION project).
Signals are digitized using a 4-ch ADC converter NI9223 capable of up to 1000 KSample/s and elaborated on board to detect events. Time delays between the hydrophones is used to compute the position of the sound source.
Two serial port interface modules (for RS232 and RS422 communication protocols) guarantee communication with the compass, the tiltmeter, the power control board and other environmental parameters.
Data have been sent to shore thanks to a long-range omni directional Wi-Fi bridge. The receiving antenna has been placed in the Bergeggi city hall according to an agreement with the Municipality which hosted the antenna and the computer of the shore station.
This action includes the milestone Overall system design ready that has been accomplished on March 31, 2015 in time with respect to schedule.
The incident of June 2016 leaded us to the definition of a new detection system with only one couple of buoys and the incident of September 2017 leaded us to the definition of the final design with a single buoy (Figure 30). These modifications were considered part of "Detection system operation and maintenance", so they are be discussed in Action C.9.

- Problems incurred – The detector has been redesigned in order to avoid further incidents due to human misbehaviours.
- Evaluation – The detector design has been completed.
- Completion – 100 %

## Action C.2: Detection System Procurement

The public tenders concerning the procurement of the buoys and the hydrophones have been awarded according to the Italian regulation. The public tenders took into consideration both legal and technical aspects: the participating companies must meet technical requirements for their devices and must demonstrate their administrative correctness. Legal procedures were not the same for the different purchases, but they depended on the economic amount.
The public tenders have been done through MePA, the web portal for purchases of the Public Administration. Since only registered companies can participate in tenders, this method accelerated the procedures for the purchases.
We purchased all the electronic devices and components, fundamentals items for the elaboration of the acoustic signals.
The main components for each single buoys are:

- National Instruments Ethernet RIO (NI 9149) and Simultaneous Analog Input module (BNC, NI 9223) for the acoustic signals processing
- Data acquisition systems cRIO (NI 9403) for the data elaboration
- Onboard PC NI9081 cRIO +I/O modules
- 4 ch 1MS/ s 16bit A/D Converter (NI9223 ADC)
- S.E.A. GPS + 3G modules for data transfer and remote access.
- 4 floating bodies: two buoys main and two secondary buoys (Edgelab)
- The mooring line (Edgelab)
- The mechanical cable for connection between the two buoys (Edgelab)
- The mechanical structure where hydrophones were housed (Edgelab)

- The power supply system (Edgelab)
- 4 Hydrophones GP2080M supplied by C.ol.Mar s.r.l (omnidirectional hydrophones with a passband between 3kHz to 90 kHz and a sensitivity of -169 dB re 1V/uPa, equipped with preamplifier able to gain 36dB on a differential output.
- 500m cable (4x2x24 AWG F/UTP category 6 2x18 AWPE/PUR 600V BS 160kg 2 x 18 AWG tinned coupled conductor 19 x 0.25mm) for signal transmission from underwater box to surface.
- 2 POD: cylindrical boxes located 100 m below sea level (height 660 mm, diameter 248 mm) that will accommodate the electronics.
- 2 watertight box: two containers for the electronics housed on the main buoy at the surface.
- Compass TCM5XB by PNI Corp accuracy 0,1 degrees
- 2 iron naval chains with spring lines (diameter 97 mm, length 7.5 m each)
- 2 iron naval chains with spring lines (diameter 97 mm, length 7.5 m each)
- 1 monitor UMHT2EE.909
- 3 transmitters RM5-T1
- 3 antennas AMO-5G-13

These devices have been chosen according to our experience in the ARION project (LIFE 09 NAT/IT/000190) and they worked without major problems during the whole WHALESAFE project. Some new components have been bought after the incident of September 2017, these purchases have been considered as part of Action C.9 (Detection system operation and maintenance).
In details, the required expenses have been:

- Modification of the mooring line
- New Zero-twist cable
- Buoy deployment operations

- Problems incurred – None
- Evaluation – All the mechanical buoys system and every electronic device have been purchased.
- Completion – 100 %

## Action C.3: Detection System Deployment Planning

First a suitable area for the installation of the acoustic detection system has been identified. Several requirements have been considered for the identification of the area:

- the size of the marine area to monitor,
- the information about habits of sperm whales' population,
- the presence of morphological structure that could affect the sound propagation in the project area.

The depth of the hydrophone location has been also optimized considering interference of the system with local nautical activities.
The knowledge of the definitive design of the buoys allows us to request to different specialized companies for a quotation for the deployment of the marine infrastructures.
An underwater survey was carried out in order to identify the correct depth and surface of the sea bottom near the two buoys' spots. The steepness of the sea bottom required the design of a special mooring line by EdgeLab.
The permission for the deployment of the two acoustic units was issued by Italian Ministry for Infrastructures and Transports and Liguria Regional Agency (conservation of the regional coastal ecosystem). Moreover, the locations of the deployment were selected in agreement with the professional fishermen operating in the area in order to avoid possible interference with their activities (Figure 7).

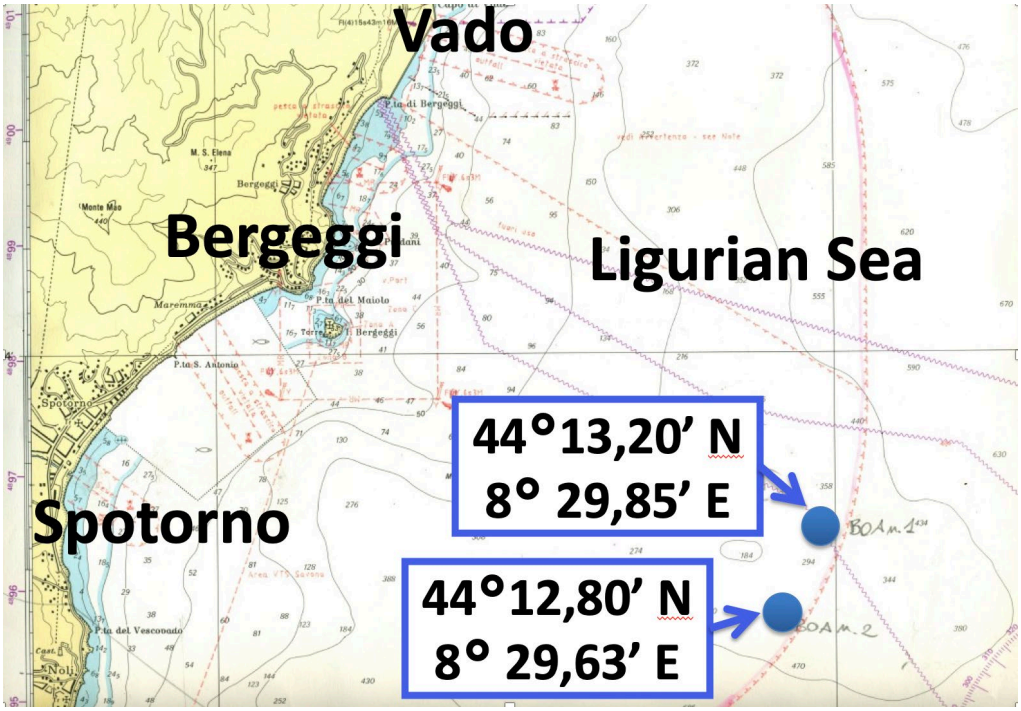


Figure 7: Location of the WHALESAFE detection units

Finally, the technical office Marifari La Spezia gave the indication for the signals and the surface light of the buoys.

- Problems incurred – The detector design has been modified as shown in Action C.9, however this new configuration has not implied major modification to the deployment plan.
- Evaluation – The deployment plan has been defined and applied successfully.
- Completion – 100 %

## Action C.4: Preliminary area survey and acoustic campaign

The Action C.4 consists of two main activities: the area survey and the acoustic campaign. Regarding the first, we conducted a preliminary cartographic study in order to select two locations for the positioning of the WHALESAFE buoys.

The bathymetric profiles of various points were analysed using the Geographic Information System MAPINFO Software in order to identify locations with small slope. We used a harmonised EMODnet Digital Terrain Model (DTM) with resolution of a grid size of 1/8 * 1/8 minutes.

Given the steep slope of the seabed, the success of the system installation is strictly connected to this survey. For this reason, we decided to employ a multibeam, a much more accurate tool. UNIGE does not have its own multibeam, so we conducted a tender between specialized companies that has been awarded to the company UBICA, according to the administrative rules of the University. We requested to map the area where the two buoys have been placed, this area has been divided in two subareas with centre corresponding to the geographic positions identified for the buoy installation and a radius of 300 m.

The mapping campaign has been performed on 8$^{th}$ September 2015, in good sea state, through Multi Beam R2 Sonic 2024. The result of the area survey was received in September 22$^{th}$, it includes:

- a report;
- the acquired data by the multi-beam
- various 2d and 3d maps obtained though the analysis of the data.

The survey provided the geomorphological structure of the two areas of interest and the surrounding areas. The location A is at a depth of 345 m and the corresponding area of interest at depths between 280 m and 390 m. Close to the location B the measured depth is 370 m and the corresponding area

of interest is between 270 m and 400 m. The survey data were provided in ASCII format. We created a grid of 3D xyz points projected in the UTM32 mapping system (Figure 8, Figure 9, Figure 10).

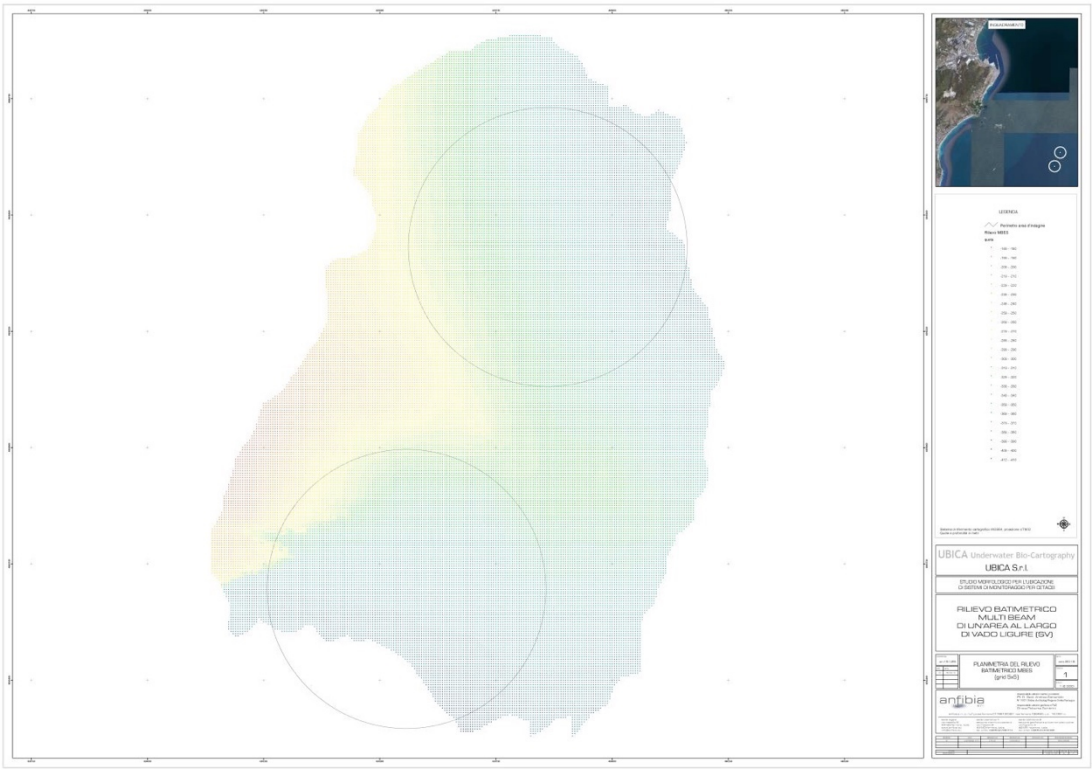



Figure 8: Multi beam echo-sounder grid

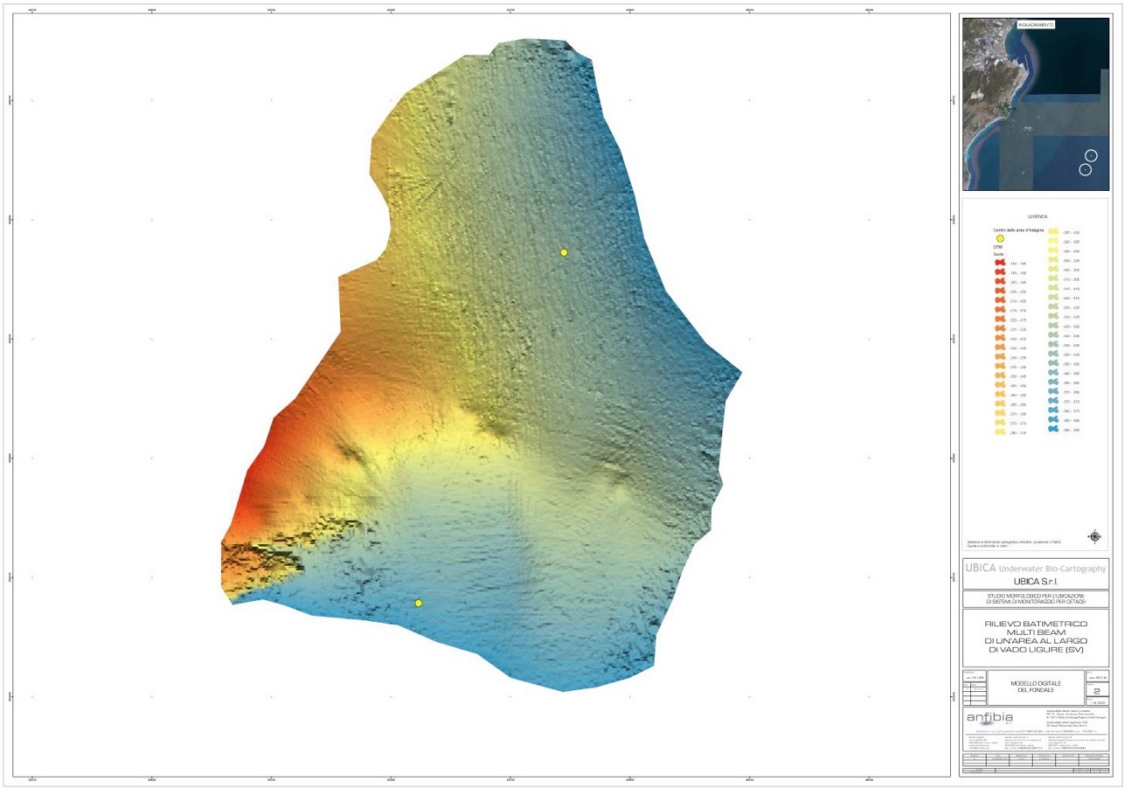



Figure 9: Digital Terrain Model

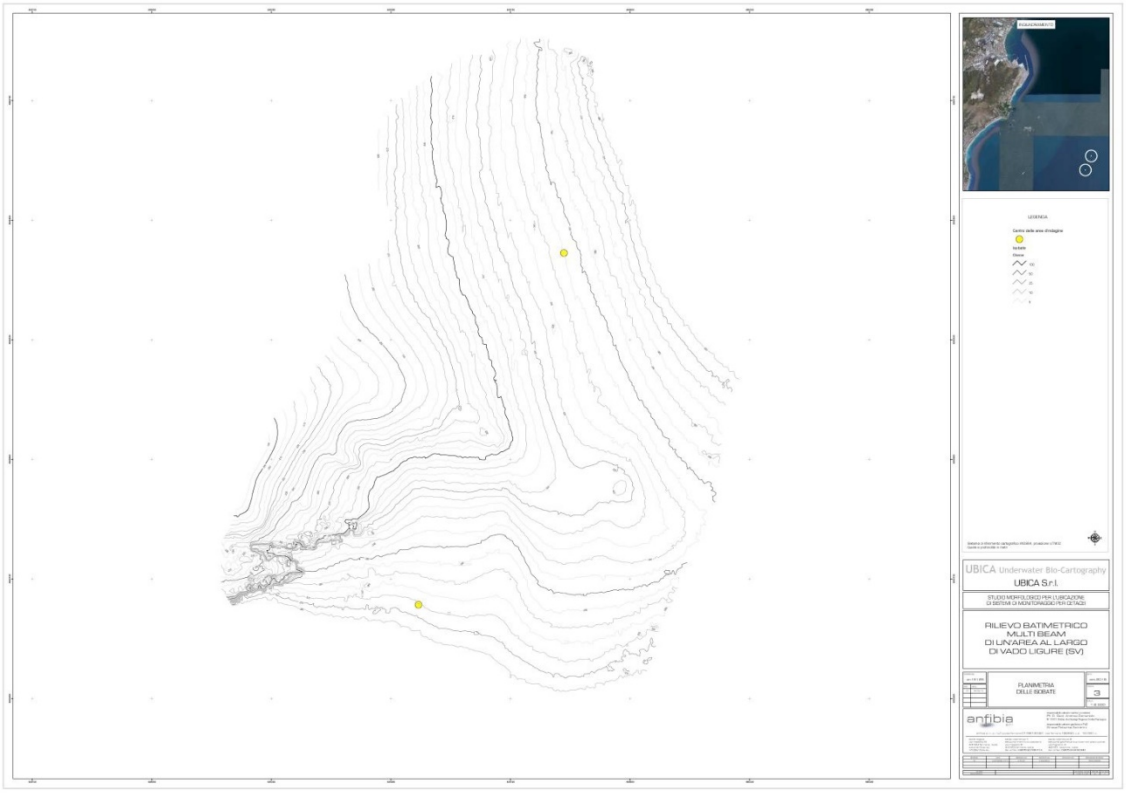



Figure 10: Bathymetric map

Regarding the acoustic campaign activity, first we defined the sampling protocol and design (attached as Annex 3). We opened a tender for the rental of a boat with the following characteristics:

- A boat with propulsion engine of at least 150 hp
- Moored in the project area, in order to sample more frequently the area
- Requirement of a raised area of at least 2 meters from the sea surface, able to accommodate at least two observers, in order to increase visibility of observers and increase the likelihood of sperm whale sightings.

The no profit organization "MENKAB: il respiro del mare" won the tender.
Due to administrative delays in the tender, we started the acoustic campaign in September 2015.
We encountered many days of bad sea state, the survey protocol required a sea state less than or equal to 3 according to the Beaufort Scale. From 11$^{th}$ September to 19$^{th}$ November 2015 we conducted 10 day of survey (Figure 11) covering about 680 nautical miles, where we detected cetacean clicks in 102 locations (Figure 12, Table 2). The acoustic campaign globally counted 31 sightings (Figure 13):

- 9 sperm whale;
- 14 striped dolphin;
- 8 Cuvier's beaked whale sightings.

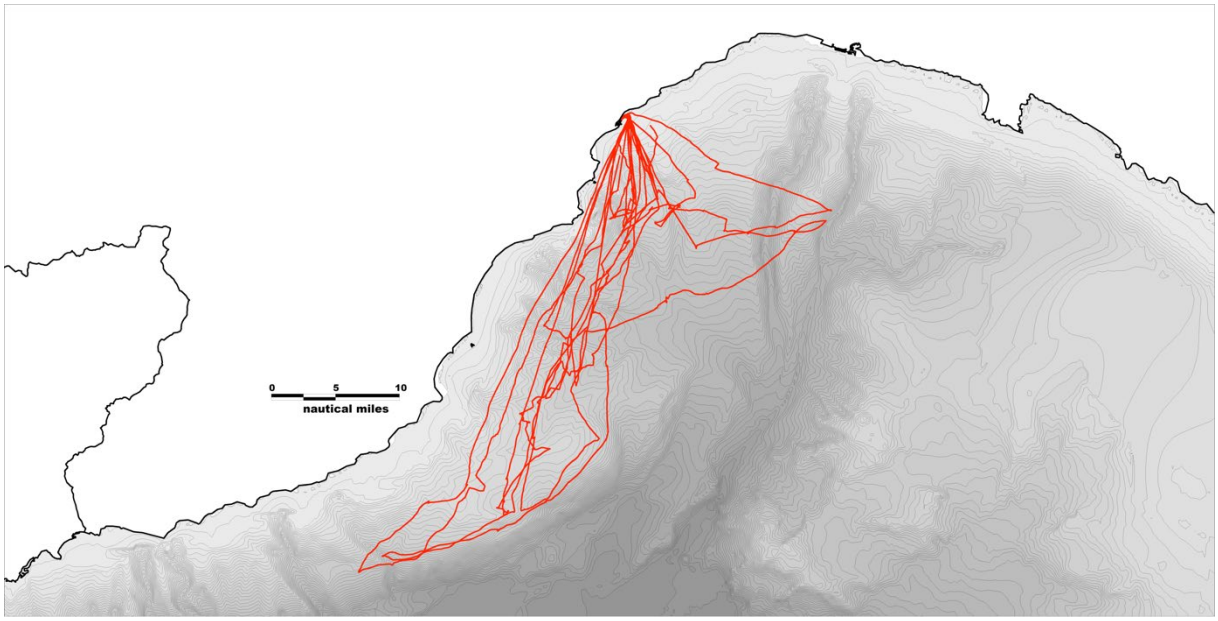


Figure 11: Routes followed for the acoustic campaign

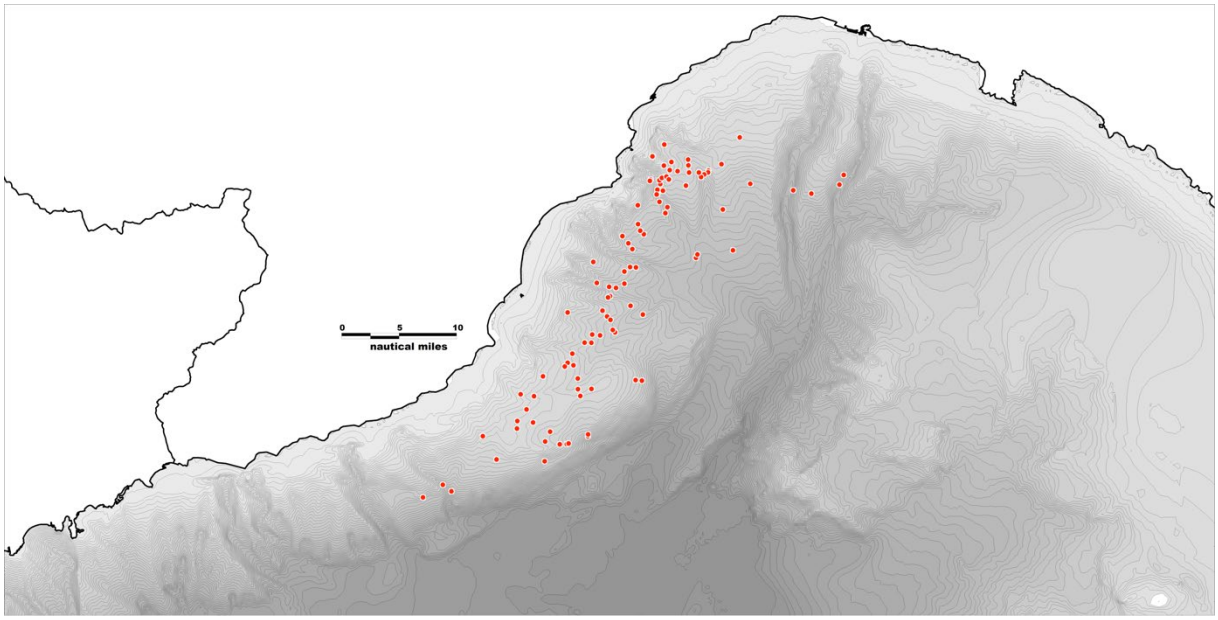


Figure 12: Acoustic stations (red dots)

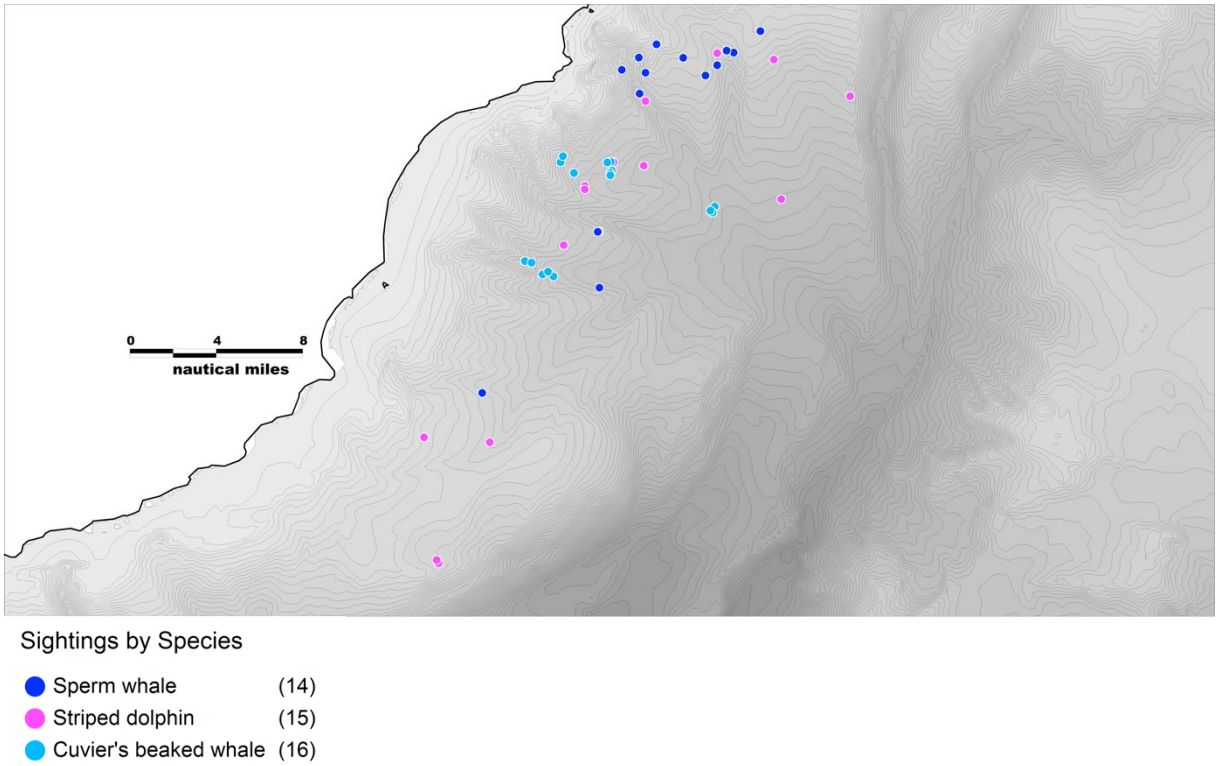



Figure 13: Cetaceans sighted

| **Date** | **N° Listening point** |
|---|---|
| 11092015 | 2 |
| 2509020 15 | 5 |
| 11102015 | 15 |
| 18102015 | 15 |
| 6112015 | 14 |
| 7112015 | 13 |
| 11112015 | 6 |
| 12112015 | 11 |
| 13112015 | 10 |
| 19112015 | 11 |
| **TOTAL** | **102** |

Table 2: Number of listening points during each daily survey

The acoustic sample results are summarized in Table 3. The total number of recording is 23, 4 are background noises and 19 are sperm whale vocalizations. The global time of the measurements is 11 hours and 17 minutes: 53 minutes of background noise and around 10 hours and 23 minutes of sperm whale vocalizations.

| Date | Acoustic Sample N° | Background Noise | Sperm Whale vocalization |
|---|---|---|---|
| 11092015 | 1 | 00:06:23 | |
| 11092015 | 2 | 00:12:17 | |
| 25092015 | 3 | 00:10:38 | |
| 11102015 | 4 | | 00:14:15 |
| 11102015 | 5 | | 00:02:20 |
| 11102015 | 6 | | 00:33:20 |
| 11102015 | 7 | | 00:22:53 |
| 18102015 | 8 | | 00:07:13 |
| 18102015 | 9 | | 00:14:54 |
| 6112015 | 10 | | 01:00:06 |
| 6112015 | 11 | | 00:05:18 |
| 6112015 | 12 | | 00:03:15 |
| 7112015 | 13 | | 01:31:41 |
| 7112015 | 14 | | 00:45:08 |
| 7112015 | 15 | | 00:47:57 |
| 7112015 | 16 | | 00:41:47 |
| 11112015 | 17 | | 00:45:52 |
| 11112015 | 18 | | 00:13:27 |
| 11112015 | 19 | | 00:13:05 |
| 11112015 | 20 | | 02:23:16 |
| 12112015 | 21 | 00:11:04 | |
| 12112015 | 22 | | 00:17:30 |
| 13112015 | 23 | 00:13:29 | |
| **TOTAL** | **23** | **0:53:51** | **10:23:17** |

Table 3: Details of the collected recordings

In the maps below we show the location in which sperm whales vocalization were detected (green dot) (Figure 14) and the position of the sperm whale sightings (blue dots) (Figure 15).

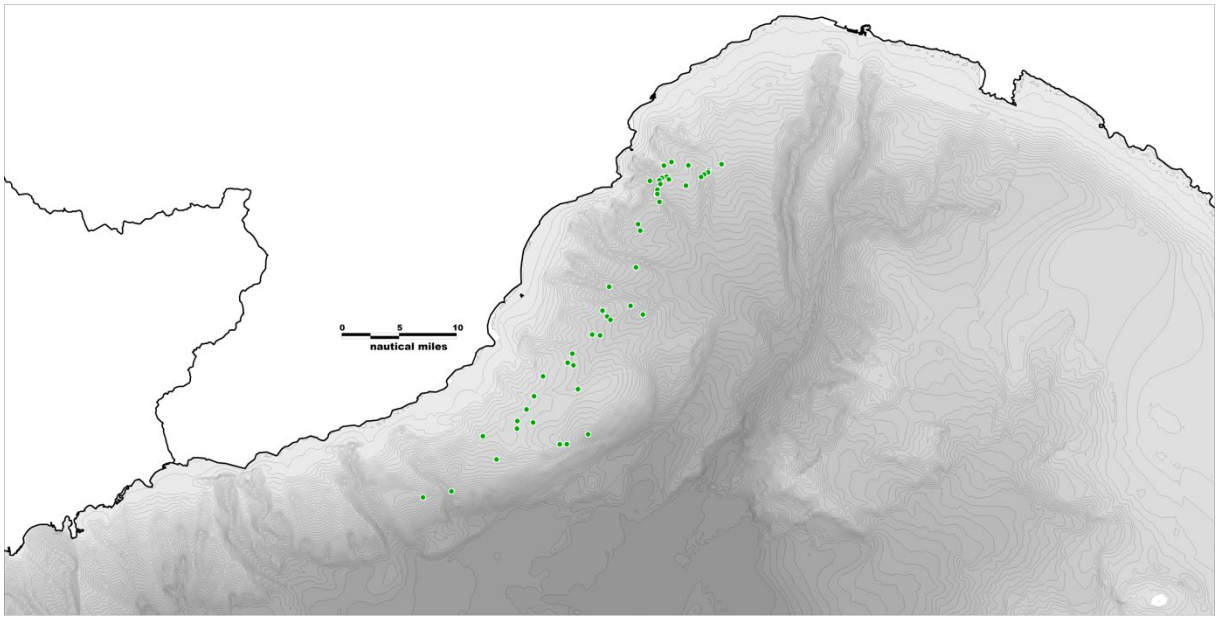



Figure 14: Acoustic stations in which sperm whales were detected (green dots)

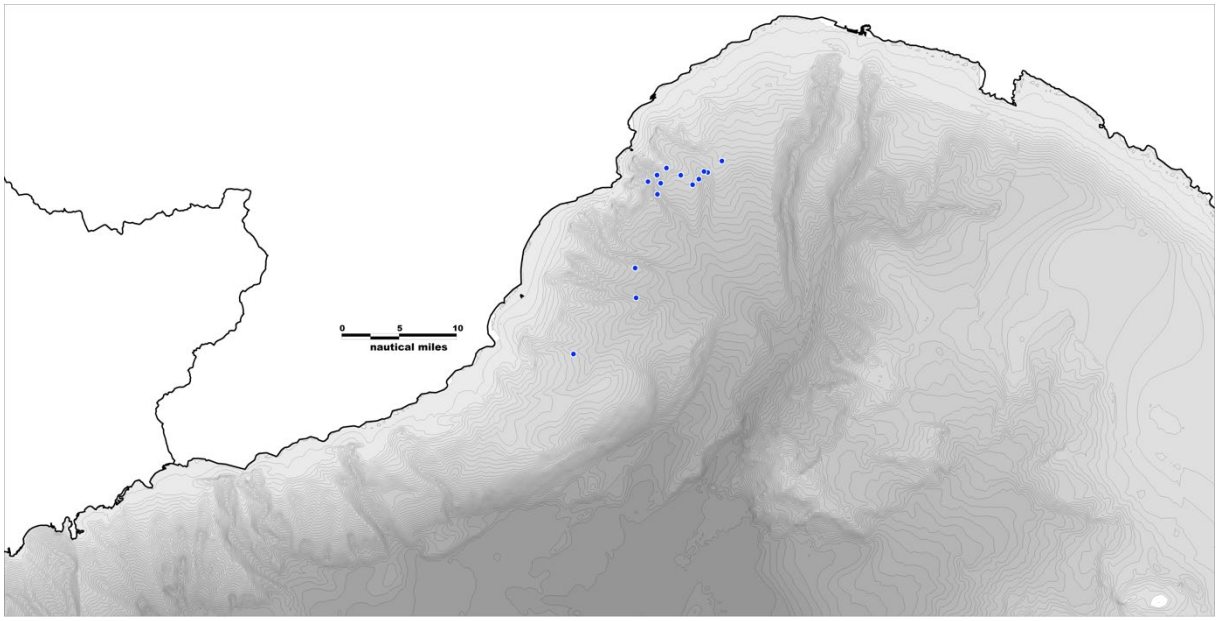


Figure 15: Sightings points of sperm whale (blue dots)

- Problems incurred: – The budget required to realize the Action C8 was greater than expected. We employed the remaining 10 days boat rent (Action C4, already appointed to the Menkab Association) for the tagging campaign (see action Action C8 for further details). This solution was the most convenient considering that the expected results of the acoustic campaign (C4) had been already reached and the collected clicks were sufficient to realize the detection algorithm as well as to study the underwater behaviour of the sperm whale.
- Evaluation – The preliminary area survey and acoustic campaign has been completed.
- Completion – 100 %

## Action C.5: Installation of Detection System

The detector installation has been performed smoothly during spring 2016.
In particular the primary buoys have been installed on 21st April 2016. The pictures below show the principal operations.


Figure 16: Primary buoy transportation to the WHALESAFE site

Figure 17: Detail of a main buoy with Life, WHALESAFE and Natura 2000 logos


Figure 18: Deployment of a main buoy

The secondary buoys have been installed and linked to the main buoys on 18th May 2016. Some pictures of the operations.

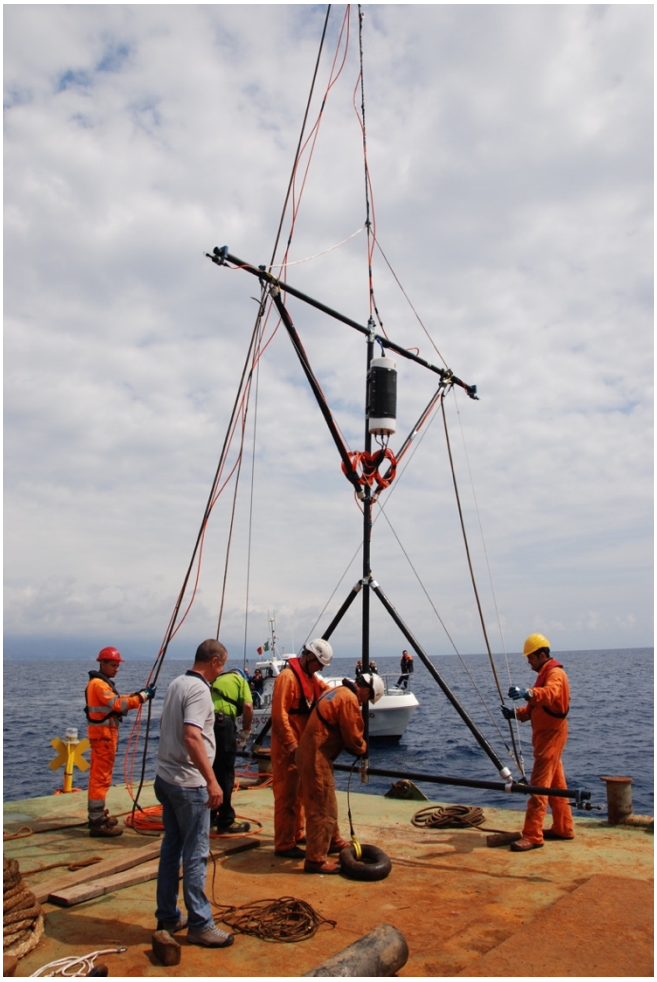


Figure 19: A detail of the support structure with the four hydrophones

Figure 20: The operators link a secondary buoy with its primary

The detector installation has been completed on 18th May 2016. The action was completed.

The new installations performed after the incidents described in the Action C.9 are considered part of Action C.9 “Detection system operation and maintenance”.

- Problems incurred – None
- Evaluation – The detector has been installed successfully
- Completion – 100 %

## Action C.6: Monitoring and alarm generation centre development and set up

The alarm generation centre and data centre software main features were

- A database that stored detection data coming from the on-site detection software, data regarding user accounts and support data for the monitoring of the data centre
- An HTTP site that allowed upload of audio, image or other large volume data if necessary.
- A web services layer that allowed communication with external software (on-site detection software and future mobile clients)
- A Web Portal User Interface http://monitor.whalesafe.eu/ , username unige, password Wh@l3safe2015) application that allowed consortium users (CPSV and University) to access both real-time information about detections and historical reports of past detections. It allows the visualisation of the map with the latest sightings and a list of latest sightings.

The system has been operative since September 2017 (Figure 21).

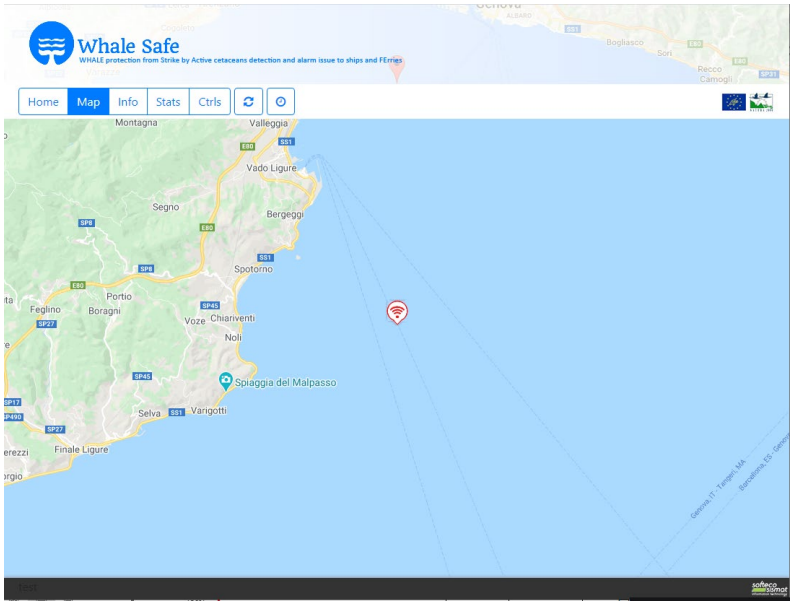



Figure 21: Screenshot of the portal

The portal was set in operation recording data during the interval in which the buoy was active. The following screenshots illustrate the data collected in the summer of 2018 (Figure 22).

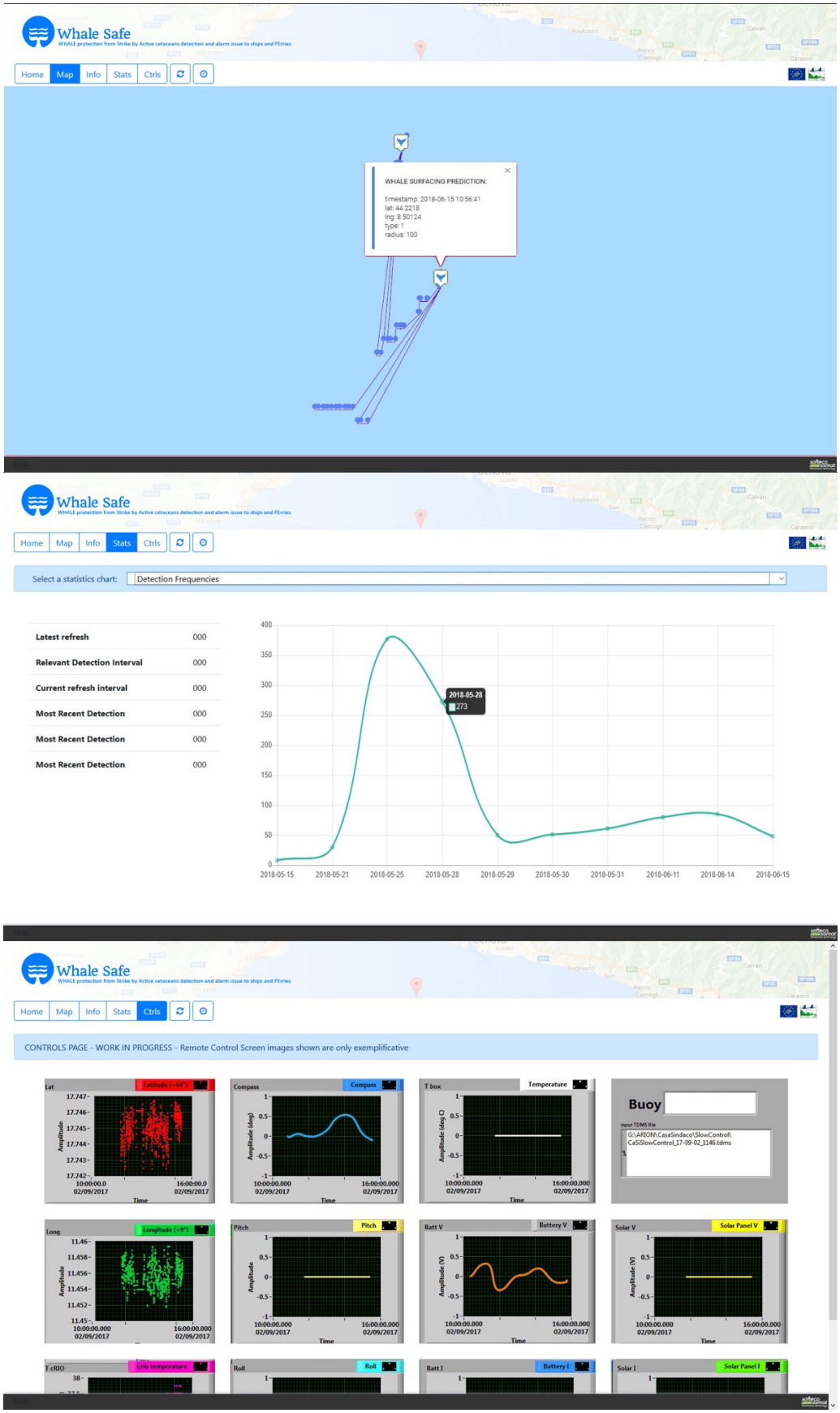



Figure 22: Screenshots of portal (data collected in summer 2018)

The setup of the portal and datacentre infrastructure is completed but, due to the accident described in Action C.9, we have not implemented the monitoring system in the control room of the CPSV. The monitoring system in the control room of the CPVS foresees a screen reproducing the portal and an

acousting alarm to be activated when the presence of a sperm whale is confirmed by the detection system. In this way the Coast Guard personnel can be promptly informed of the presence of the Cetaceans on the project area and can react accordingly.

- Problems incurred – The system was ready for installation at the CPSV control room, the only missing step for the completion of the action would have been the placement of a dedicated monitor in the control room. The action has not been completed because of the impossibility to refurbish the detector after the last incident.
- Evaluation – Setup of the portal and datacenter infrastructure completed. During the last Monitor visit, the monitoring and alarm generation system has been activated simulating a real time streaming of data.
- Completion – 90 %

## Action C.7: Overall System Test

After being installed in the target areas, in the first year of operation the monitoring system has been tested for a period of two months to discover optimal settings and to analyse the acoustic background for improving Cetaceans detection performance. Despite the first accident that limited the time dedicated to the test, we recorded several signals.
The detector has continuously recorded data from 18th May 2016 to 13rd July 2016. A typical spectrum of a recorded cetacean signal is shown in Figure 23.

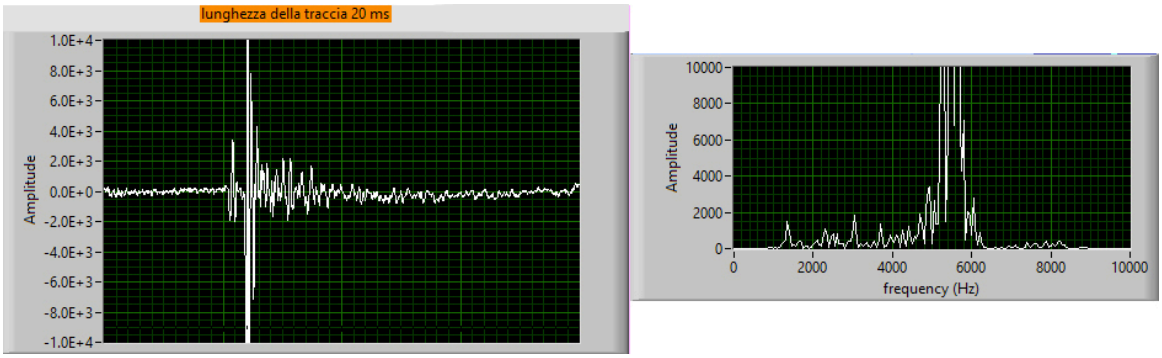



Figure 23: A typical cetacean signal

In order to test the performance of the system two different track reconstruction algorithms have been developed. The first combine the information of the two systems of hydrophones, the latter exploit the reflection of sound waves on the sea surface to reconstruct the cetacean location using only one buoy system. The two algorithms are described in detail in *Annex33-C7-Overall system test overview*.
The results of the two algorithms are quite compatible, the difference on the average reconstructed geographical position of the cetacean is 0.0008°= 2,5" which corresponds roughly to 50 m.
Also, the predicted depth of the cetacean is quite similar during most of the period considered in this analysis, for more than 75% of the time the difference of the estimated depth between the two algorithms is below 20 m.
The results of the two algorithms are robust. This shows that the detector can achieve the foreseen scientific results even with only one buoy system operating.
The tests on this data sample leaded to a small modification of the click recognition algorithm optimizing the length time window of each potential event.

*Uncertainty due to sea state*
The effect of buoy position uncertainty due to the sea waves has been also evaluated. Several sperm whale distances have been investigated, for each one the distribution of the reconstructed distances is reported in Figure 24.
It is clear that as the distance of the sperm whale decreases, the accuracy of the reconstructed distance increases, as an example at a distance of 2 km the accuracy is better than 100 m, while at a distance

of 5 km the accuracy reduces to 1 km and becomes worse at larger distances. However, the reconstruction precision improves by averaging the results of the reconstruction of the several clicks that the sperm whales emit in short period of time.

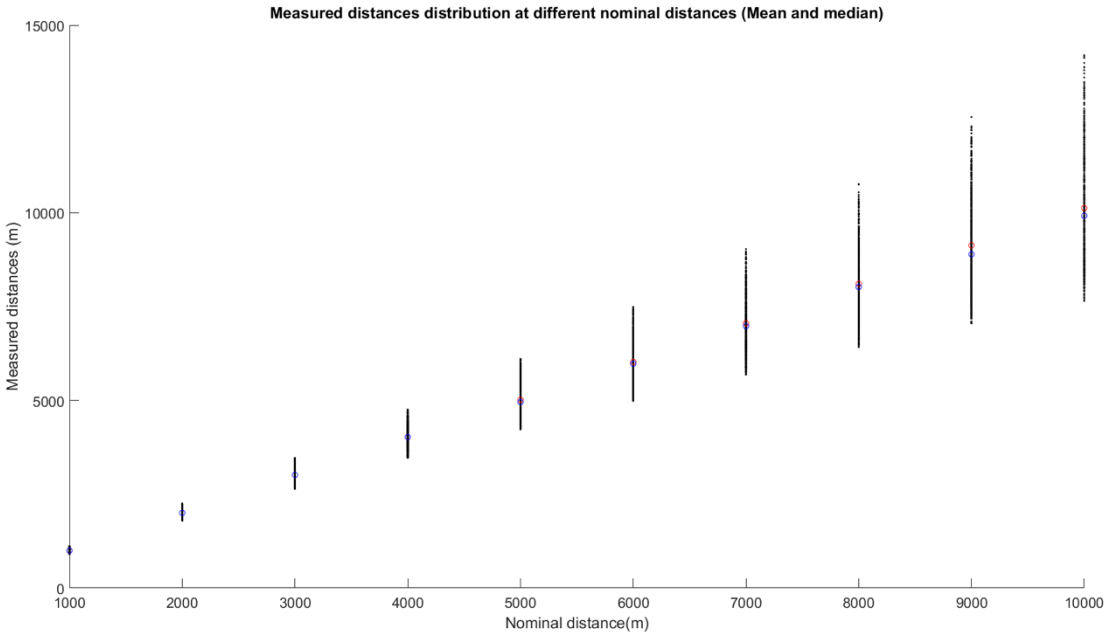



Figure 24: Reconstructed distance as a function of the sperm whale distance (sperm whale depth 500 m, sea wave height 0.5 m) The red dot indicates the mean, the blue one the median and the length of the vertical line the accuracy.

*Uncertainty due to the sound velocity profile*

Another important source of uncertainty is the lack of knowledge of the sound velocity profile (SVP) with the depth. Sound speed depends on several factors: pressure, temperature and salinity. In Mediterranean Sea, sound speed profile is strongly influenced by the seasons (Figure 25). In colder seasons the effect is much smaller, and the speed depends almost exclusively on pressure (and therefore varies almost linearly with depth). In summer, however, there are different effects.

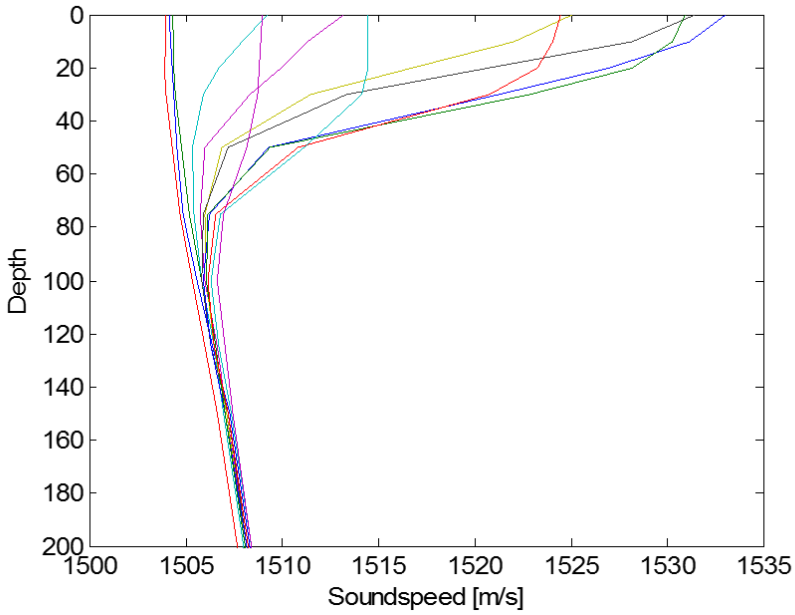



Figure 25: Monthly average of the sound velocity profile offshore in front of Savona

We developed a simulation that calculates the reflected wave angle and the delay time assuming different velocity profiles and different direct wave angles.
In particular, the cetacean signal recorded on 26 May 2016 has been analysed: this detection allowed us to test how the thermocline influences our prediction of the cetacean position. Figure 26 shows the reconstructed distance of the cetacean assuming a winter (red) or a summer (black) thermocline.

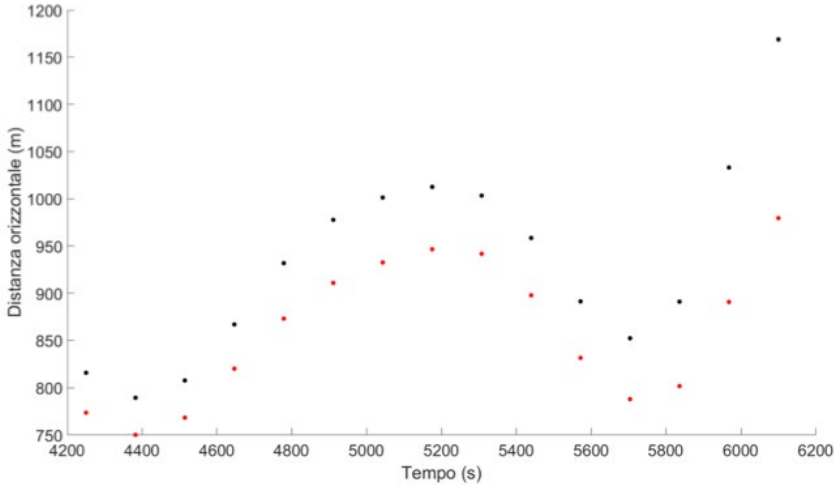



Figure 26: Reconstructed distance of the cetacean assuming a winter (red) or a summer (black) thermocline.

The difference between the two predictions is rather small (around 50-100 m), so our system is not relevantly affected by the assumption of the thermocline.
The performance of the detector highlighted with this analysis are expected also with the new system configuration (with one single detection unit) since the detection principle is exactly the same.

*Acoustic calibration of the detector*
An attempt to calibrate the system with an acoustic beacon failed because the intensity of the sound emitted by the beacon was not high enough to test the system at large distances, therefore after the last deployment, the behaviour of the detection system has been checked tracking boats moving in the project area. The absolute calibration of the hydrophone orientation was done tracking the Coast Guard boat moving along fixed routes and tracking the ships leaving the Savona harbour. The route of ships up to a distance of 8 km from the detection system have been correctly reconstructed.

*Tests with data of 2018 summer campaign*
The analysis of the data recorded during summer 2018 has been used to further test the performances of the detector.
In particular the cetacean signals recorded on 12$^{th}$-13$^{th}$ July 2018 has been analysed as described in Action D.1. This detection allowed us to test how the thermocline influences our prediction of the cetacean position**.**
It resulted that including the summer profiles, the computation using two different approaches predicts the same cetacean depth.
Another test performed during the 2018 summer campaign is the study of the detector rotation, which could be an issue in the new configuration of the detector since the hydrophones and the main buoy are not anymore decoupled.
Figure 27 shows the variation of the detector orientation during the period with large presence of the sperm whales.
The compass value is stable showing that the orientation of the detector does not dramatically change in time.

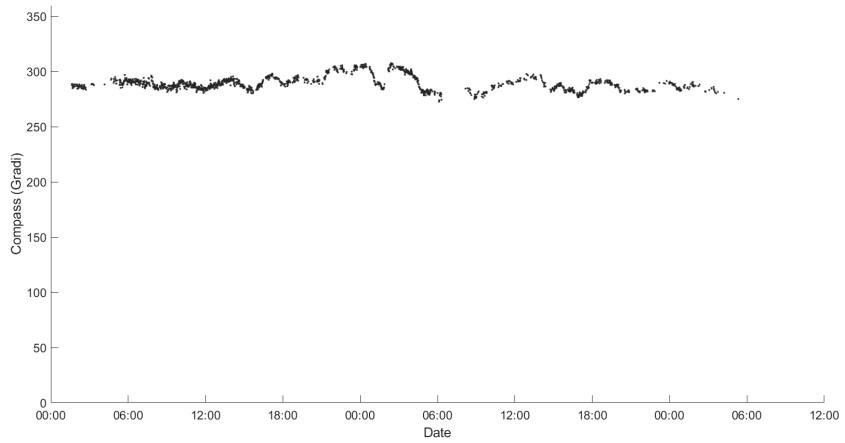


Figure 27: Variation of the detector orientation during the period with large presence of the sperm whales.

*Visual search in real time*

The most important operation test of the system has been the sea campaign of 13th July. DISTAV partners were on a boat in the project area in contact with the DIFI staff, which was monitoring the detector. The indication of sperm whale presence provided by the WHALESAFE detector allowed the DISTAV staff to reach the location of emersion of a couple of cetaceans. The GPS track of the DISTAV boat compared with the location of the sperm whale emersions are provided in Action D.1.

- Problems incurred – Delay due to the technical problems described in Action C.9
- Evaluation – According to the results of all this tests, we can conclude that we have found the ideal configuration of the detector, which allows to reconstruct the routes of cetaceans in real time with the required accuracy and at the same time minimize the risk of accident due to ship strike or illegal fishing activity. The WHALESAFE detector has been continuously maintained in operation in the foreseen site for the whole 2018 summer season without any problem of data collection, processing or transmission or any damage. The system is perfectly under control by the DIFI crew and it does not require any further hardware or software modification.
- Completion – 100 %

## Action C.8: Tagging Campaign

The tagging campaign is meant to test onsite the performance of the WHALESAFE system. The original plan for this action foresaw the usage of animal-attached acoustic recording data loggers (DTAG) that provides the location of the tagged sperm whales; this data could be compared to the positions reconstructed by the system.

DTAG provides the position of the sperm whale during the dive and also the geographic position during the emersion. Comparing these data with the positions reconstructed by the system we could optimize trajectory estimation algorithms.

In order to perform the tagging campaign two conditions are necessary:

- Sperm whale presence in the area (summer season)
- The WHALESAFE system has to be installed and working.
- Good sea state (Beaufort ≤ 3)

Being the two conditions unpredictable and beyond the control of researchers, we have developed a contingency plan for the worst-case scenario: sperm whale in the area, but the sea state is not good or vice-versa.

If the worst scenario would have occurred, we foresaw two backup option:

- Visual verification of the predicted emersion location from a sampling boat
- Obtain data on underwater behaviour of sperm whale applying tags to sperm whale outside the project area

As the project was progressing, we realized that this action, as was concealed, had a rather high failure risk because we observed that, especially during 2016, the presence of cetacean in the area was reduced with long period of complete absence. In addition, the costs resulted much higher than estimated.
As reported in *Amendment 1*, the tag with the visual localization of the cetacean in the project area performed by means of periodic patrolling of the area has been selected as best option for the fulfilment of this action.
The campaign has been planned to use a dedicated boat equipped for whale watching activity. The available vessel can reach the emersion site in 30 minutes, in time for a visual identification of the animal.
This plan has been applied during the 2018 campaign when two sperm whales have been visually identified thanks to the emersion location provided real time by the WHALESAFE detector. The presence of cetaceans has been recognized by WHALESAFE on 12th July and the next day the DISTAV crew was ready in the Savona harbour for the campaign as foreseen in our plan. The available vessel was able to reach the emersion site in 30 minutes, in time for a visual identification of the animal after the alarm generated by the system. In this way the DISTAV crew was able to

Figure 28: two moments of the presence of the sperm whale observed by DISTAV during the 13th July excursion

record three sightings and all cases the position of the emerging sperm whale was within few hundred meters the position estimated by WHALESAFE. Details of the analysis is reported in this report in Action D.1
Unfortunately, no other sperm whale signal has been detected in the 2018 Summer season, so no further tagging campaigns have been performed.

- Problem incurred – We realized that the action had a rather high failure risk because we observed that the presence of cetacean in the area was reduced with long period of complete absence. The action had been modified in order to reduce the cost and increase the probability of success. The new plan allowed a successful tagging campaign.
- Evaluation – The action can be considered almost completed. We have recorded and visually identified 2 sperm whales using the emersion location predicted by the WHALESAFE detector. During the two days with high sperm whale presence in the area around 30 cetacean tracks have reconstructed.
- Completion – 80%

## Action C.9: Detection system operation and maintenance

The detector installation has been completed on 18th May 2016 (see Action C.5).
In the first weeks of operation the detector tuning has been performed.
The maintenance of the detector has been smooth, the only operation required has been the substitution of some fuse. In particular several maintenance visits have been performed on 27/5/16, 6-7/6/16 and 24/6/16.
In the first weeks of operation also the data transmission has been optimized.

On 13th July 2016 the signals of the two buoys have been lost.
After investigation of the port authorities, we discovered that one of the two main buoys and the two secondary buoys have been loosened from anchorage.
On the evening of 17/7 the buoy has been retrieved and brought back to Vado port, we found that the secondary buoy (heavily damaged) and the hydrophones were still connected.
The other secondary buoy and the related electronics and hydrophones have never been found; it probably sank.
The damage was compatible with a collision with a medium-size boat.
After the incident of 13/7/16 the system needed a refurbishment and the WHALESAFE system with a single detection unit has been proposed.
The new system exploits the reflection of the sounds as shown in the picture below to reconstruct the whale routes.

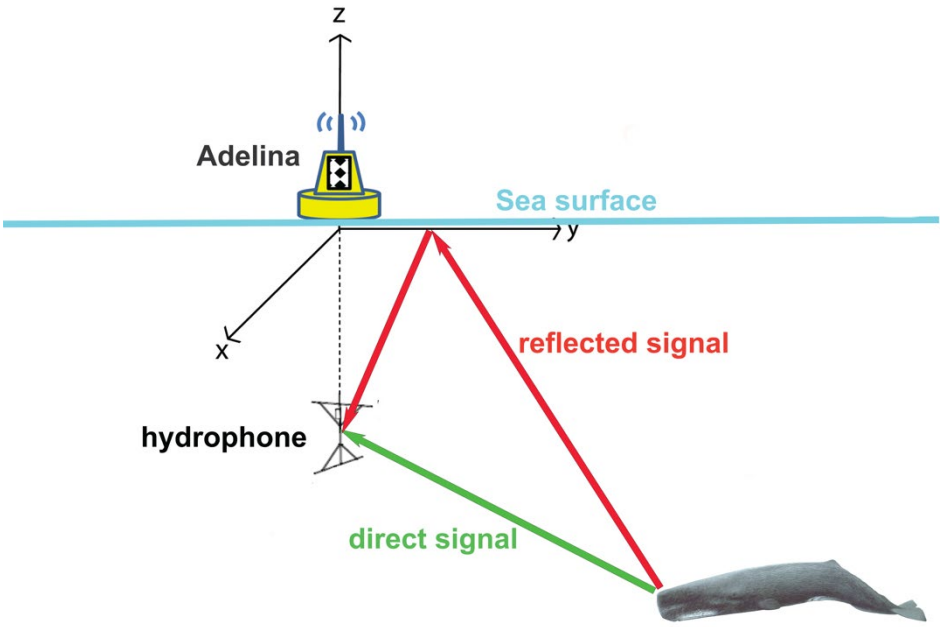



Figure 29: New WHALESAFE detection strategy using only one set of hydrophones

When the cetacean is below the hydrophones level, two different sound signals are expected: the direct signal and the reflected signal. The measurement of the two signals allows a proper reconstruction of the position and the depth of the sperm whale.
The analysis of a cetacean signal detected on 28th June 2016, when both sets of hydrophones were operating, tested the performance of the reconstruction strategy that exploit the sound reflection (see Action D.1).
After the July 2016 incident we decided to install AIS locator on the main buoy, in this way we had real time monitoring of the buoy position and moreover large vessels with AIS system could see the position of the WHALESAFE buoy on their navigation tools.
In the morning of 20th September 2017 the main buoy has been deployed, unfortunately due to adverse sea conditions in the afternoon, the secondary buoy deployment has been postponed to 22nd September 2017.
On 28th September 2017 the data cable connecting secondary and main buoy has been damaged. After Coast Guard investigation it has been discovered that several line with hooks for tuna fishing have torn the data cable. This activity is severely forbidden in the protected marine area of Bergeggi, so it is classified as illegal fishing. For this reason, we could have not expected this kind of risk and

moreover tuna fishing lines are typically really long, so probably the ship that damaged the data cable was quite far away from the detector, out of the range of our monitoring tools.
In any case we used our monitoring tools to try an identification of the ship that damaged the detector. We used the AIS system to verify if a vessel has entered the 100 m interdicted navigation range around the buoy.
The closest vessel passed 200 m away from the buoy, so it is not likely to be responsible of the damage. Moreover, it is not likely that a large vessel (AIS is installed only on ships with 300 or more gross tonnage) is dedicated to tuna illegal fishing.
The maintenance of the detector has restarted right after the deployment of the detection unit (6/6/18). The detector operated smoothly for the whole summer campaign.
This unpredictable poaching activity leaded to the unfeasibility of the system with two buoys, so a new detector design has been proposed.

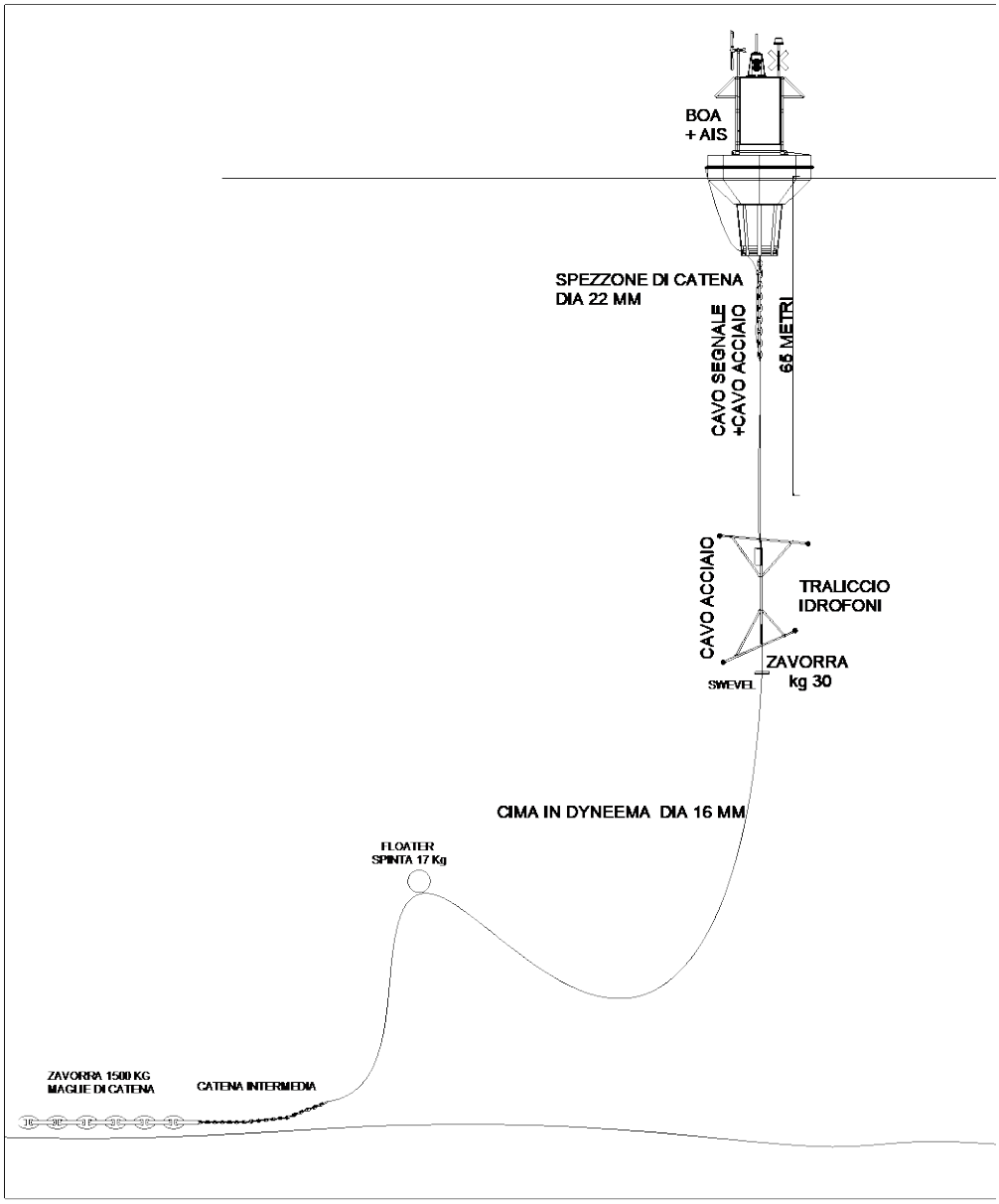



Figure 30: Final WHALWSAFE detector design

The hydrophones have been installed directly on the main (and unique) buoy and the rotation of the hydrophones with respect to the buoy has been avoided thanks to a zero-twist stainless steel cable. Avoiding the rotation of hydrophones is essential for a proper operation of the detector.
The zero-twist cable is connected through a swivel to the mooring line. For an additional security, the hydrophones are connected to the buoy also with a dyneema cable.
We evaluated that we would considerably reduce the risk of fishing line damages with this new design, since there are not anymore horizontal cables in the system. Moreover, a single main buoy has been left at the deployment site for a year without any damage, probing the reduction of risk with this new proposed design.
This solution was not considered at the beginning of the project because the two buoys configuration has the advantage of the fixed position of hydrophones, while with the one buoy design the position and the heading of the system will change continuously. However, the data recorded during Summer 2017 showed that the position and inclination of the hydrophones can be measured with high precision and the orientation of the detector can be live-time corrected in order to reconstruct properly the cetacean route.
The reconstruction strategy described above and used with the previous configuration of the system has been perfectly adapted to the new proposed detector. Using the information provided by the reflected sounds, we expect a satisfying reconstruction accuracy (~ 50 m for the coordinate of the cetacean, ~ 20 m for the depth).
The deployment of the new system has been completed on 6$^{th}$ June 2018. The picture shows the buoy at the end of the deployment. It is clearly visible the AIS solar panels on the top of the buoy, the Wi-fi antenna(top-left) and the webcam (top-right) pointing at the boat.

Figure 31: Deployment of the final version of the WHALESAFE system

During the 2018 summer campaign, we had a consistent presence of sperm whales in the project area between 12$^{th}$ and 13$^{th}$ July 2018. After the detection of the first clear cetacean signals on 12$^{th}$ July, a sea campaign has been scheduled for the next day allowing the visual identification of the sperm whales and the validation of the estimated emersion location with on-site verification. Details of the

analysis of the 12th-13th July data sample are included in Action C.8. No other cetaceans have been observed after this date.
Confident on the effectiveness of the new design, we presented an Amendment request to prolong the project duration until the end of 2019 in order to complete the project activities as foreseen in the original proposal. The amendment was submitted in 28th September 2018.
After the summer campaign, the system has been placed in the Savona-Vado harbour in order to preserve it for the 2019 summer campaign. However, on 29th October 2018 an exceptional storm hit most of the cost of Liguria, destroying several harbours. Also Savona-Vado harbour suffered of huge damages destroying and sinking all the vessel in the port. The WHALESAFE buoy was on the main pier of the harbour and it has been thrown in the sea and it sank. The buoy has been recovered one month later during the operation of restoration of the harbour. The buoy was completely destroyed, some pictures are here below.

Figure 32: The support structure of the hydrophones

Figure 33: The upper part of the buoy from below. It lost completely all the buoyancy structure.

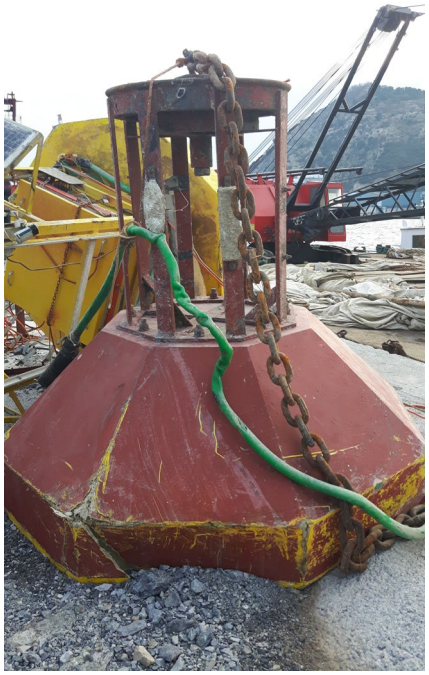


Figure 34: The bottom part of the buoy which allows the buoyancy and the anchor line.

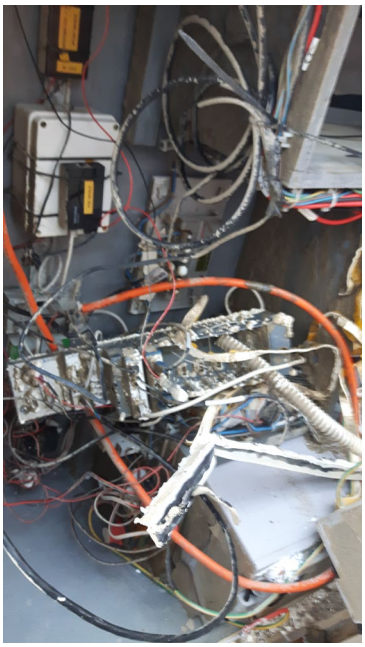


Figure 35: Also the main box has been damaged (left), water damaged all the components inside (middle). Detail of the cRIO module (right)

Figure 36: The hydrophones

After the incident of October 2018 the system required a full restoration. As soon as we have been informed in January 2019 of the approved prolongation of the project, we started to contact all the original providers (hydrophones, cables, buoy, etc.) and we promptly received all price quotations expect for the buoy repair. We contacted several shipyards in the Genova and Savona area, but the repair of all leisure boats damaged by the same storm that destroyed the buoy already overcommitted all companies we contacted, no one guaranteed the refurbishment in time for 2019 summer campaign. The cost of the buoy refurbishment would have been around 10000 €.
The companies that provided us all the instrumentation have been contacted for an evaluation of the refurbishment costs of the damaged electronics. According to the offers we received, the cost of the new hydrophones and connectors would be around 12000 €, the cost of the data/power cable and its connectors would be 2500 €, the cost of the mooring system 7000 € and the cost of the deployment 10000 € (based on previous experience).
Considering that:

- the project after the second amendment was scheduled to end at the beginning of 2020,
- the expected amount of money necessary to restore the system was more than 40000 €,
- the time necessary to refurbish the system was too long to have the system in operation in summer 2019,
- we lost the two biologists expert in Cetaceans (A.Mandich retired in autumn 2019 and J.Alessi contract ended at the beginning of 2019 and cannot be renewed);

regretfully we evaluated not feasible the completion of the project even in case of an additional extension of the project duration. This decision in our opinion appears the best one also considering the explosion of the covid-19 pandemy that could have stopped the 2020 project activities.

- Problem incurred – The incidents have been caused by unpredictable forbidden human activities and exceptional meteorological conditions. According to the 2018 storm accident, we evaluated that we would have retired the detector after each summer campaign in order to preserve it for the following campaigns. The final refurbishment of the detector has not been completed since no company guaranteed the completion of the works in time for the final summer campaign.
- Evaluation – The system operation and detector maintenance has been smooth during the all the summer campaigns
- Completion – 100 %

## Action C.10: Integration of Acquired Data

The data recorded during the various campaigns by the detector have been analysed. The structure and the relationship of the specific tables in the WHALESAFE support database have been defined.

In the first phase, waiting for the buoys signal, the system has been tested with simulated signals. In any case the portal and database software have been arranged in order to not be dramatically revised in case of data format changes.

- Problem incurred – None
- Evaluation – All WHALESAFE data has been integrated, the system does not require any further improvement.
- Completion – 100 %

## Action C.11: Alarm Generation

This action comprises the operation of the data processing and alarm generation centre for the whole project duration, after the initial preparation. It includes software upgrade, maintenance as needed, hosting of the applications accessible through the web and support to all users.
A short video and its description shows in detail how the alarm is generated in the Coast Guard Control Room.

- Problem incurred – None
- Evaluation – The maintenance and operation of the data centre has been operational during the whole WHALESAFE project. It could have promptly restarted in case of a new deployment of the system.
- Completion – 100%

## Action C.12: Notification to Ferries and Sailors

The Coast Guard defined the different messages to communicate to the Ferries and Sailors according to the alarm level.
The presence of sperm whale in the project area is reported in the WHALESAFE portal on a screen located in the Control Room of the Savona VTS. As soon the presence of a cetacean is detected by the WHALESAFE system an acoustic alarm is generated in the Control Room, thus activeting the personnel of the Coast Guard who can follow the movement of the animals, check the presence of boats and deliver the warning messages according to the Protocol of Conduct.

- Problem incurred – The preparation phase has been completed, but the notification of the alerts to ferries and sailors foreseen after the commissioning of the system has not started because of the incident in 2018.
- Evaluation – All the systems for the alert notification has been already tested by UNIGE and SOFTECO, the WHALESAFE data acquisition system is already integrated with the SOFTECO notification software which could send the alert to the Port Authority (CPSV) in Savona. CPSV has defined a protocol for the notification of alert to ferries and sailors in the area.
- Completion – 70 %

## Action C.13: Issue of Guidelines and Best Practices for Collision risk reduction

The action has been postponed by one year according to Amendment 2. Unfortunately we were not able to have a second summer campaign in 2020 to collect data for a detailed definition of Guideline and Best Practice. However WHALESAFE achieved the fundamental results that only with an acoustic passive monitoring in real time it is possible to have the certitude of the presence of sperm whale in the area. Therefore we strongly suggest that any system dedicated to the protection of this species should include the acoustic monitoring. For this reason we intend to replicate the system in the Toulon area in France as described in the After Life plan.

- Problems incurred – This action has not been fully implemented since the system has not been refurbished in time for the last summer campaign when the Protocol of Conduct would have been implemented (as described in Action C.9) nevertheless the experience gained allowed to produce the deliverable
- Completion – 80 %

## Action D.1: Detection Event Monitoring

This monitoring action was intended to monitor the effectiveness of the acoustic detection system, which is at the basis of the project impact on Cetacean preservation.
The first monitoring activities have been performed during 2016 Summer campaign.
On the 28th June 2016 between 1 P.M and 2 P.M. both Adelina and Guendalina buoys detected a distinct signal of a cetacean.
The two reconstruction algorithms described in Action C.7 have been used to reconstruct the cetacean track.
The reconstructed tracks according to the "two buoys algorithm" and the "single buoy algorithm" are shown in Figure 37. The position of the cetacean is expressed as a function of the distance from Adelina buoy.

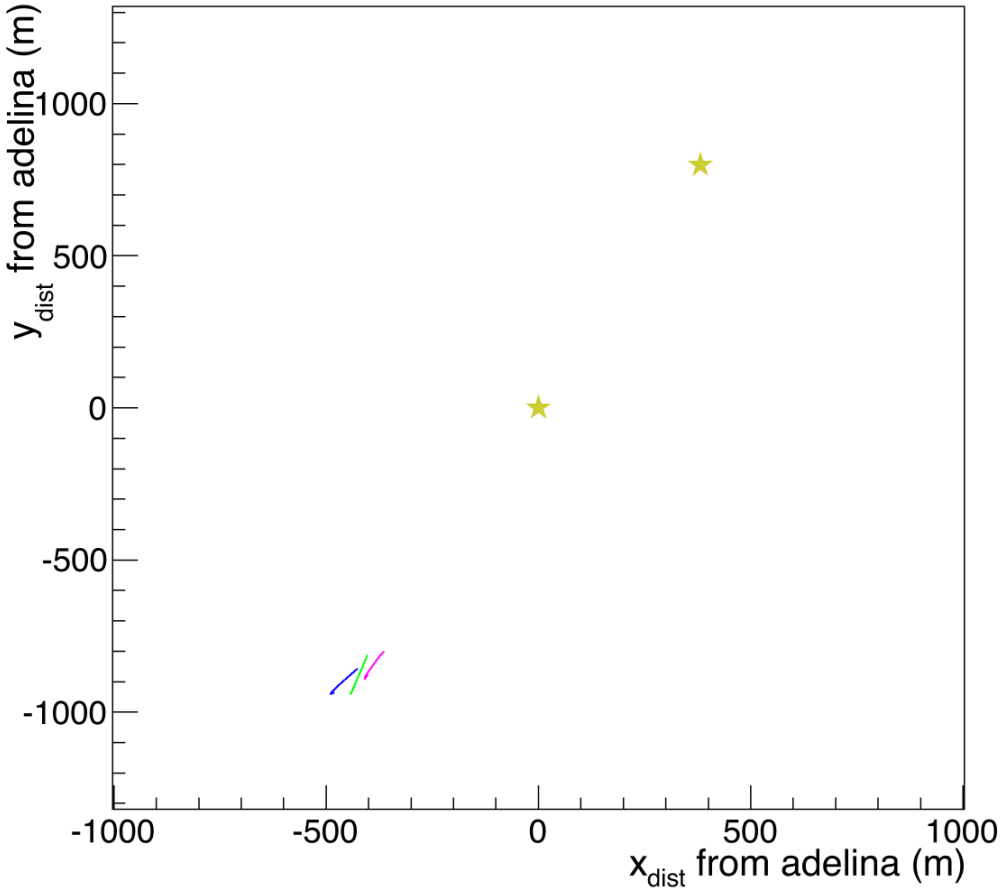



Figure 37: Reconstructed track of the cetacean according to the "two units algorithm" (green) and according to the "single unit algorithm" using only Adelina unit (blue) or Guendalina unit (magenta), xdist and ydist are the distance of the reconstructed track from the Adelina buoy in the direction West-Est and North-South respectively. The two stars represent the position of the Adelina and Guendalina buoys.

The results of the two algorithms are quite compatible (Figure 38), the difference on the average reconstructed geographical position of the cetacean is 0.0008°= 2,5" which corresponds roughly to 50 m.
Also, the predicted depth of the cetacean is quite similar during most of the period considered in this analysis, for more than 75% of the time the difference of the estimated depth between the two algorithms is below 20 m.
The results of the two algorithms analysing a genuine signal of a cetacean are quite compatible, so we could use even only one buoy system to fulfil the project requirements.

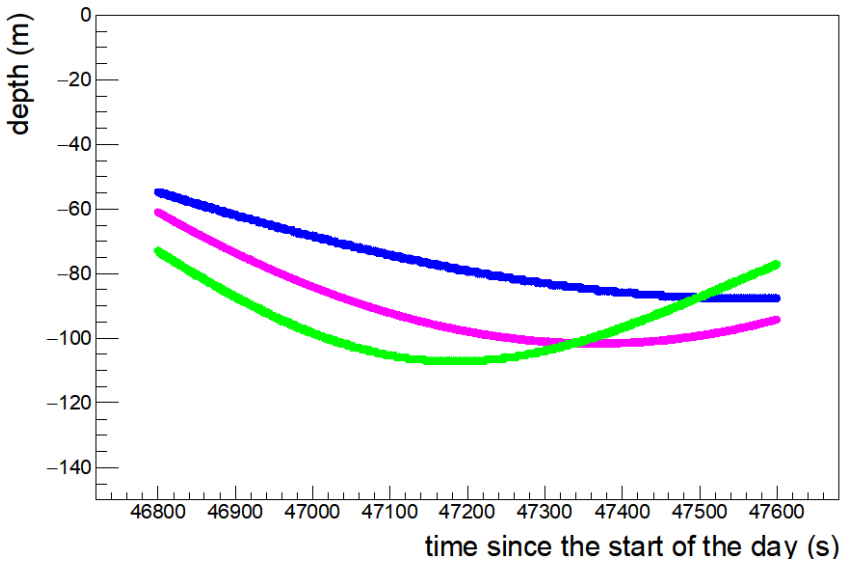



Figure 38: Reconstructed depth of the cetacean according to the "two units algorithm" (green) and according to the "single unit algorithm" using only Adelina unit (blue) or Guendalina unit (magenta).

This option has been implemented after the incident of July 2016, when a system with a single detection unit has been proposed. We analysed also a cetacean signal recorded on 26 May 2016.
We would like to emphasize again that the performances obtained in this analysis, using a single detection unit, fulfilled the sensitivity requirement for the operation of the detector.

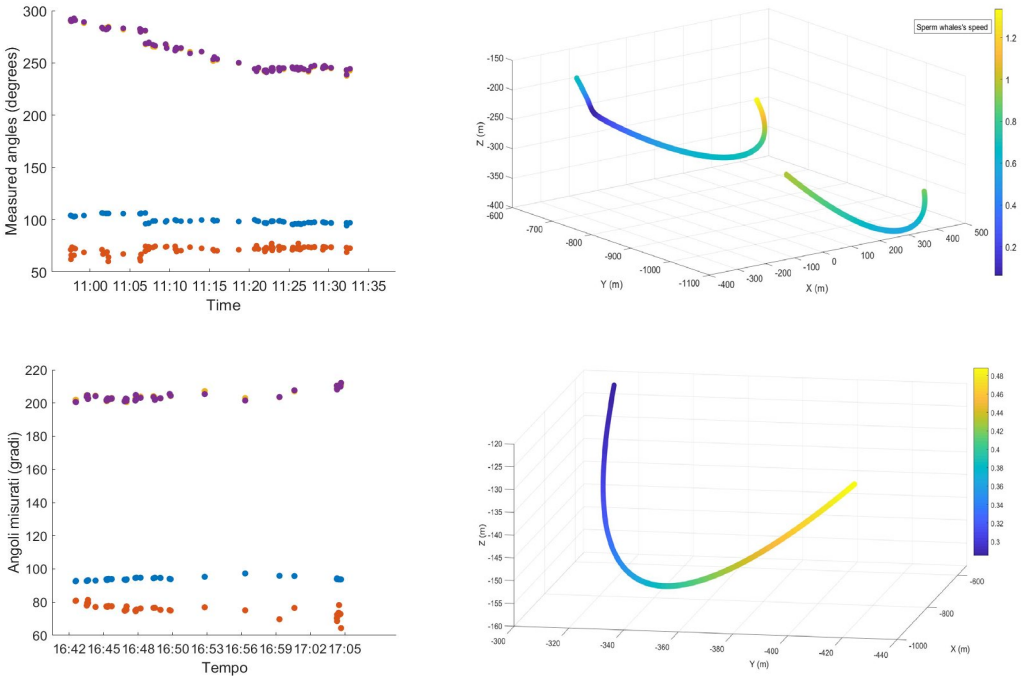



Figure 39: Zenith direct signal (blue) and reflected signal (red), azimuth direct signal (yellow) and reflected signal (purple) (top left), the circles indicate signals attributed to different sperm whales; reconstructed 3D track (bottom right) where the color indicates the flow of time (from blue to yellow).

Finally, the system has been tested during the 2018 summer campaign, when a continuous presence of cetaceans has been found on 12th and 13th July 2018, when 1308 sperm whale clicks has been recognized.
One of the most remarkable time intervals is shown in Figure 39, where we can see several reconstructed sperm whale clicks (left panels) and the corresponding reconstructed paths (right panels), in one case with two animals in the region at the same time.
The accuracy of the detection system is confirmed by the fact that in the plot the azimuthal angles (heading) of the direct and reflected sounds overlap.
We compared the reconstructed tracks of the sperm whales with the visual identification of the cetacean made by the DISTAV team on a boat in the area.
The DIFI team, during the afternoon of 13th July 2018, followed the movement of the cetaceans according to the reconstruction performed by the WHALESAFE system: the position of the sperm whales, reconstructed by the system, was notified by M. Brunoldi at UNIGE, by mobile phone, to the crew on the boat, which was able to follow the path of the animal in real time and to verify the predicted emersion location.
Figure 40 shows the GPS route of the boat and the three location of visual identification of the sperm whales. The two orange dots correspond to a first observation on surface of the whale and his immersion, the green dot corresponds to the immersion of a second whale.

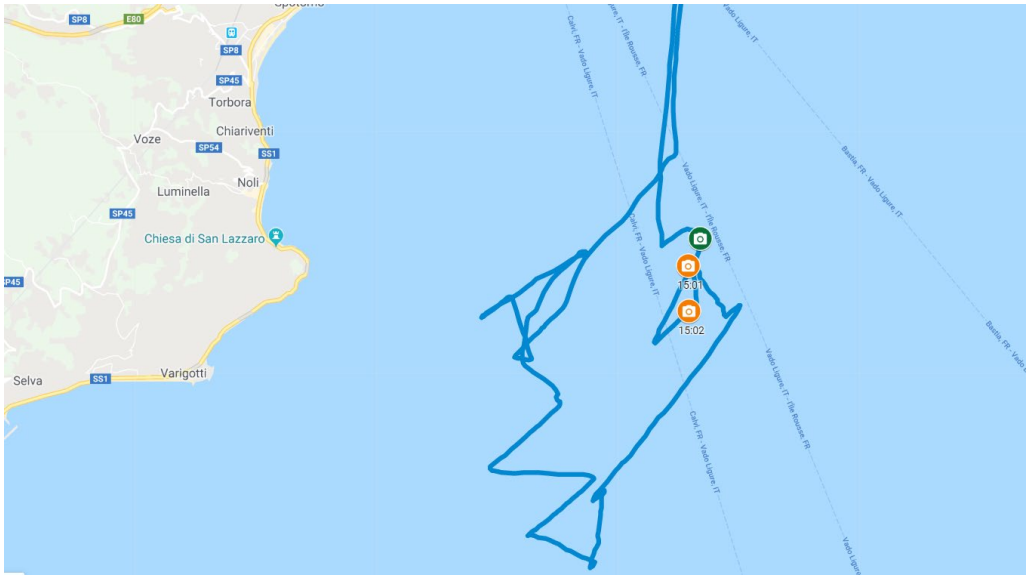


Figure 40: GPS route of the DISTAV boat and the three location of visual identification of the sperm whales.

Comparing the time of the three observations with the sequence of detected clicks it is possible to associate the visual sightings with the reconstructed tracks: as shown in Figure 41, the first two sperm whale sightings (reported as vertical blue lines) are in coincidence with the set of clicks numbered with ② and the third sighting (reported as a vertical orange line) with the set numbered with ④.

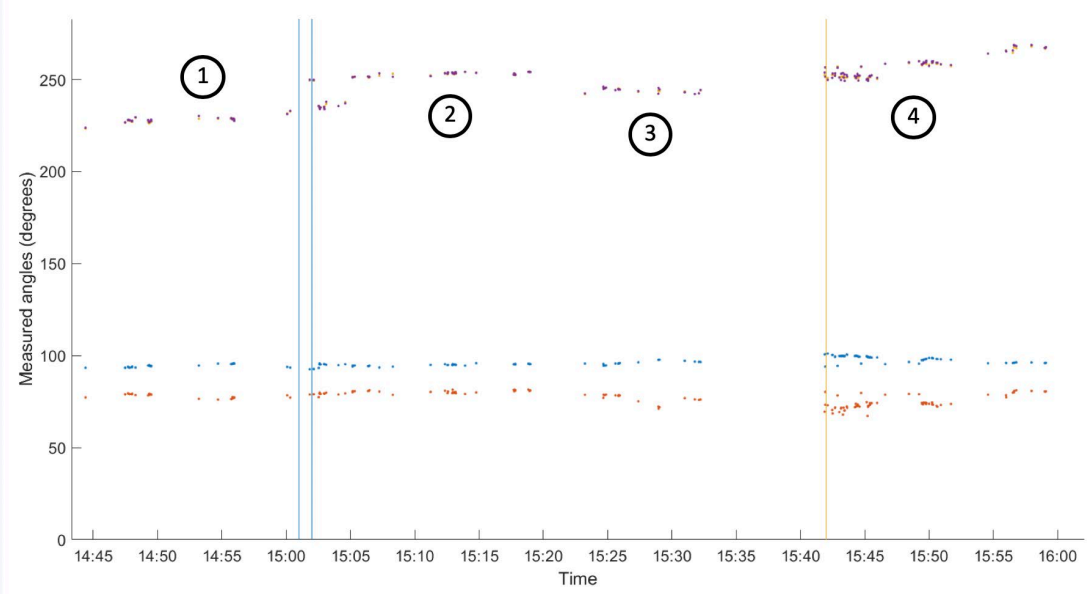



Figure 41: Zenith direct signal (blue) and reflected signal (red), azimuth direct signal (yellow) and reflected signal (purple). The two blue vertical lines represent a visual identification of a sperm whale emersion and immersion respectively, while the orange line is a visual identification of a sperm whale immersion.

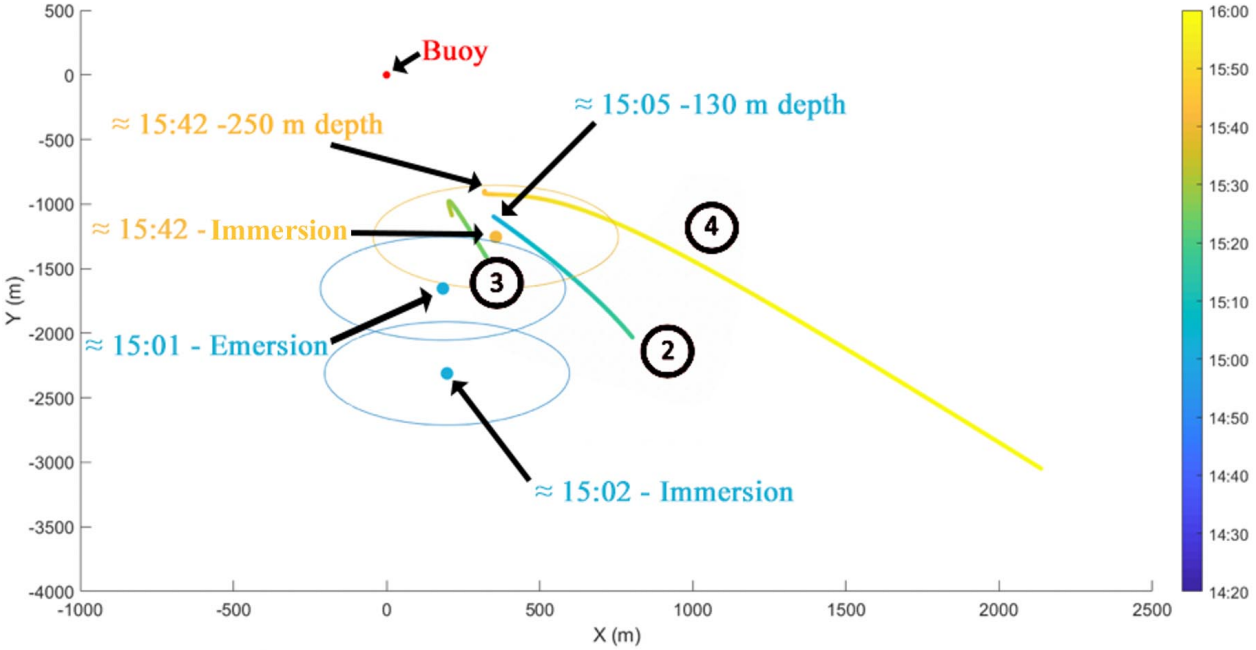



Figure 42: The three selected tracks and the GPS location of the boat at the moment of the sighting, the circle (400 m radius) indicates the uncertainty on the position of the sperm whale that cannot be measured directly.

Having defined the time sequence of the events it is now possible to compare the reconstructed route of the cetacean with the position of the visual identification.
As shown in Figure 42, taking into account the uncertainties in the position of the visual identification estimated in 400 m, there is a clear spatial correlation between the sightings and the reconstructed sperm whale routes, which confirms the previous hypotheses about immersion and emersion of the animals.

We have been able to superimpose the sperm whale movements to the seafloor batimetry, the whale routes follow the profile of the canyon as shown in Figure 43. This is a typical sperm whale behaviour as reported in literature.

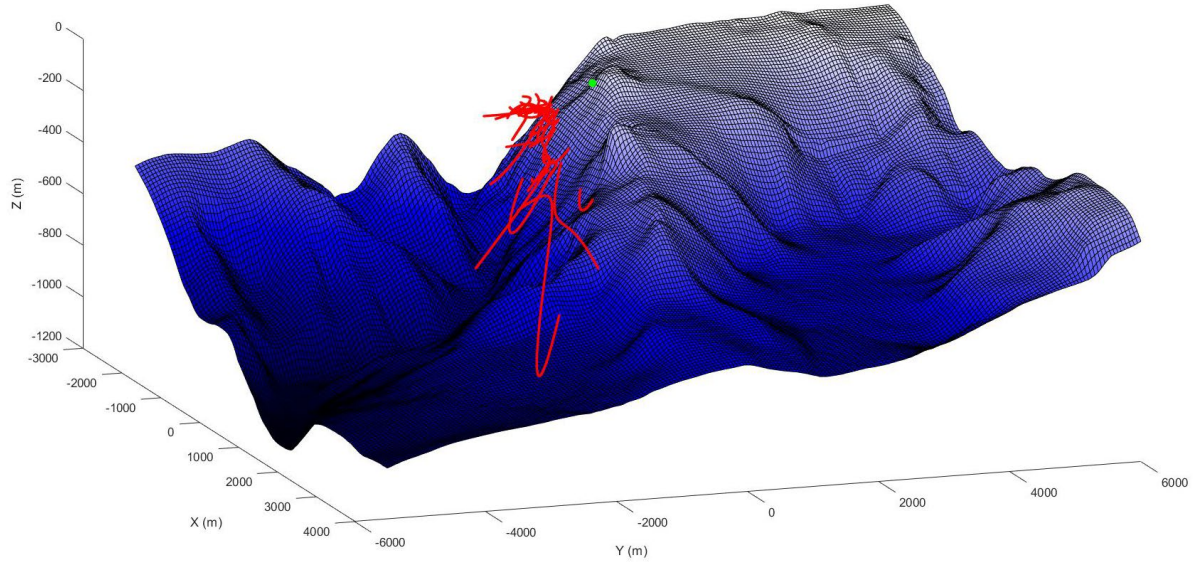



Figure 43: All the reconstructed sperm whale routes recorded in the 12th'-13th July data sample compared with the batimetry of the area. The location of the buoy is indicated with a green dot.

This is an additional confirmation of the effectiveness of the WHALESAFE monitoring system.
In summary, the results of the campaign confirm that the present configuration of the detector can satisfy the requested accuracy foreseen by the project. The data acquisition, elaboration and transmission are sufficiently fast to deliver prompt alert to vessel in the area, in order to provide sufficient time to take actions as foreseen by the Protocol of Conduct.

- Problems incurred – None
- Evaluation – Several genuine signal of sperm whales has been analysed to test the detector performance. The global performance of the detector exceeded our expectation, so we do not foresaw any technical modification to the structure of the detector or the software that process the acquired data. This action includes the sperm whale tracking, the transmission to SOFTECO and finally to the CPSV control room, it has been completed in the first two parts.
- Completion – 100 %

## Action D.2: Impact Risk Reduction Estimation

Because of the technical problems described in Action C.9, the alerts have not been delivered to ferries and sailors. According to the Amendment n.2 the action was postponed to 2019. However, since the refurbishment of the detector has not been possible, this action cannot be implemented. We can only present qualitative argument in favour of the effectiveness of the proposed system

- Problems incurred –The UNIGE team lost the two biologists expert in marine mammals during 2019. Furthermore, with only one summer campaign when the notification system could have been in operation, the risk reduction estimation would have been quite difficult since it will be based on a single campaign. It was even possible that the presence of sperm whales would be limited to few days further reducing the available data for the estimation of impact risk reduction. Since the refurbishment of the detector has not been possible in 2019, this action has not been implemented.
- Completion – 0%

### Action D.3: Monitoring Protocol of Conduct

Because of the technical problems described in Action C.9, the alerts have not been delivered to ferries and sailors. According to the Amendment n.2 the action was postponed to 2019. However, since the refurbishment of the detector has not been possible, this action has not been implemented.

- Problems incurred –Since the refurbishment of the detector has not been possible in 2019, we lost the summer campaign when the notification system would be in operation, therefore this action has not been implemented.
- Completion – 0 %

### Action D.4: Monitoring Risk Mitigation

Because of the technical problems described in Action C.9, the alerts have not been delivered to ferries and sailors. According to the Amendment n.2 the action has been postponed to 2019. However, since the refurbishment of the detector has not been possible, this action has not been implemented.

- Problems incurred – Since the refurbishment of the detector has not been possible in 2019, we lost the summer campaign when the notification system would be in operation, therefore this action has not been implemented.
- Completion – 0 %

### Action D.5: Socio-economic Impact

- Problems incurred – J. Alessi, one of the cetacean experts that was part of the project, has left UNIGE, so we lost her pluriannual experience of interaction with whale watching companies and other stakeholders. Moreover the refurbishment of the detector has not been possible in 2019, and we lost the summer campaign when the notification system would be in operation, therefore this action has not been implemented.
- Completion – 0 %

### Action D.6: Ecosystem Restoration

We analysed the sound recording of June and July 2018, when the presence of sperm whale in the area has been confirm. A clear correlation between the measured noise and the weather conditions has been observed, on the contrary no clear impact of the anthropic activity has been observed. In general the background noise level is low and the main contributions come from natural sources.

- Evaluation –The data acquisition system has been developed in order to allow the recording of all the acoustic sounds 24 hours a day. Then we can study the trend of the acoustic noise during the day and we can correlate the sounds with the route of ships using Marine Traffic.
- Completion – 50 %

## 6.2 Dissemination actions

### Action E.1: Layman's report

The Layman's report has been prepared. It includes various sections regarding the sperm whales, the project area, the WHALESAFE system, the Protocol of Conduct, the monitoring system, the dissemination activities and the results.

- Problems incurred – None
- Completion – 100 %

### Action E.2: Workshop after first year

The workshop has been organized at the Acquario di Genova (ADG) after the first year of operation, in order to present the projects and its preliminary results (in particular the analysis of the preliminary survey carried out in the action A6), to collect advices and suggestions, to improve the future work and to enlarge the stakeholders network.

On June 8th in occasion of the International Ocean day, at the Auditorium of Acquario di Genova, a workshop addressed to stakeholders and large public was organized (Figure 44). The aim of the event was to make people aware about the first project results and to increase the consciousness about the threats affecting the cetaceans in the Pelagos Sanctuary.
The program was the following:

- Introduction and presentation by Bruna Valettini (Acquario di Genova)
- Short speech by the Admiral Giovanni Pettorino (Port Authority) and presentation of a video about a sperm whale rescue.
- Alberta Mandich (Università di Genova-DISTAV) - Cetaceans of the Sanctuary: information about sperm whales, their conservation and sounds emissions
- Mauro Taiuti (Università di Genova-DIFI)- The project WHALESAFE
- Roberto Cerruti (Porth Authority of Savona) - The role of the Porth Authority in the project

At the end of the workshop, a refreshment was offered to the participants. 200 persons attended the workshop.

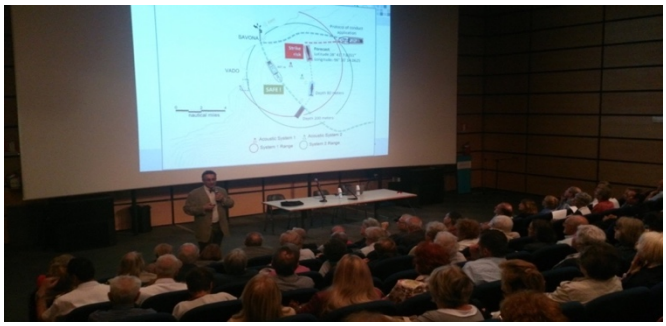



Figure 44: Some pictures of the workshop

- Problems incurred – None
- Evaluation – On June 8th in occasion of the International Ocean day, at the Auditorium of Acquario di Genova, a workshop addressed to stakeholders and large public was organized. The action is completed.
- Completion – 100 %

## Action E.3: Media Communication

On December 11, 2014 a press conference to launch the project was organized. The following press agencies attended it: Ansa, Secolo XIX, Mentelocale, Rai.
Seven press releases have been produced and diffused to the media channels:

- Launch event
- Educational activity at the Acquario di Genova
- Launch of educational activities in collaboration with Costa Crociere cruise shipping
- Positioning of buoys
- Presentation of the protocol of conduct
- Educational laboratories at the Festival della Scienza
- Information speeches in front of the dolphin tank @ Acquario di Genova

On 27 October a press release has been produced in collaboration with the press office of Costa Crociere in order to communicate the collaboration between Costa Edutainment and Costa Crociere about the WhaleSafe project and the joint communication activities carried out.
On the occasion of the buoys positioning, journalists were invited on board of the Coast Guard's vessel; they filmed the event and they realized two TV emissions.
A TV emission has been dedicated by a regional broadcaster to the activity of the CPSV. M. Sanguineti has been interviewed and he described the project.
The total number of journal article regarding the project is 76:

- 33 on printed journals
- 43 on online journals

We estimate a total number of 4 million readers reached.
The total number of tv/radio emissions regarding the project is 16:

- 5 tv emission
- 11 news report
    - 4 national tv newscast (TG1, TG2, Ra1 Linea Blu, Rai News)
    - 1 national radio newscast (Rai Isoradio)
    - 6 regional newscast (3 TG Regione Rai, 2 Primocanale, 1 Telecity)

We estimate a total number of 4,5 million viewers reached.

- Problems occurred – None
- Evaluation – Media communications and press releases have been done during the whole duration of the project, following all the milestone of WHALESAFE.
- Completion – 100 %

## Action E.4: Video Production

Within the end of the project two videos have been produced: the first one, with an expected legth of 2-3 minutes, has been realized at the beginning of the project; the second one, with an expected legth of 15-20 minutes, summarizes the project results.
The videos has been carried out in collaboration between Costa Edutainment, which elaborated the storyboard and dealt with the production and the University of Genoa, which provided the images. It has been decided to purchase the necessary equipment for shooting in the sea, in order to avoid having to resort to external professional staff, which would have not allowed to stay within the budget.
The first short video has been realized in computer graphic in order to get it more appealing for the large public (Figure 45). The video is addressed to all the targets, but especially to the large public. It has been produced in Italian and English version and it has been broadcasted on board of the Costa Crociere cruise boats through the on board TV, reaching thousands of passengers.
It has also been loaded on Costa Edutainment you tube Channel:
https://www.youtube.com/watch?v=0lWRUviPfG4

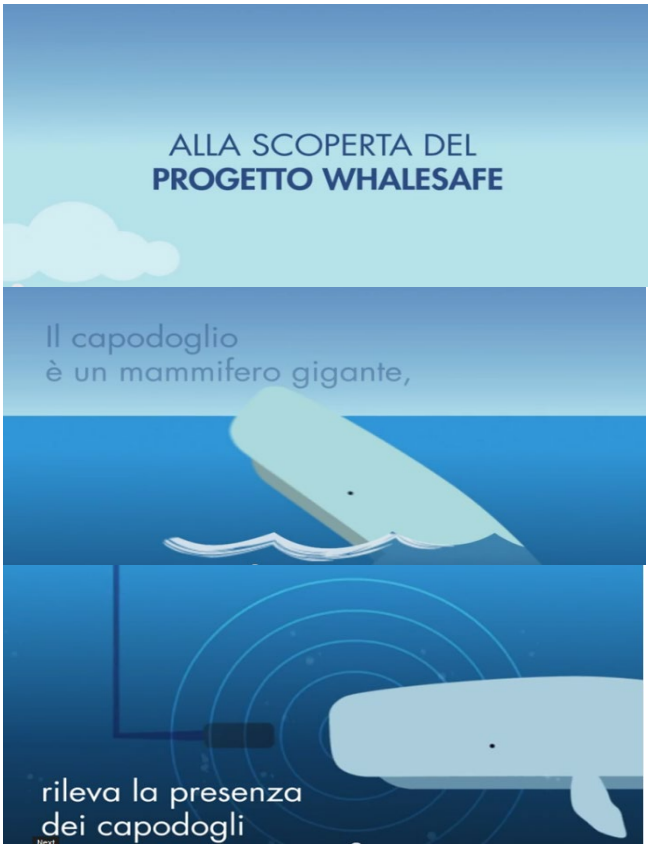


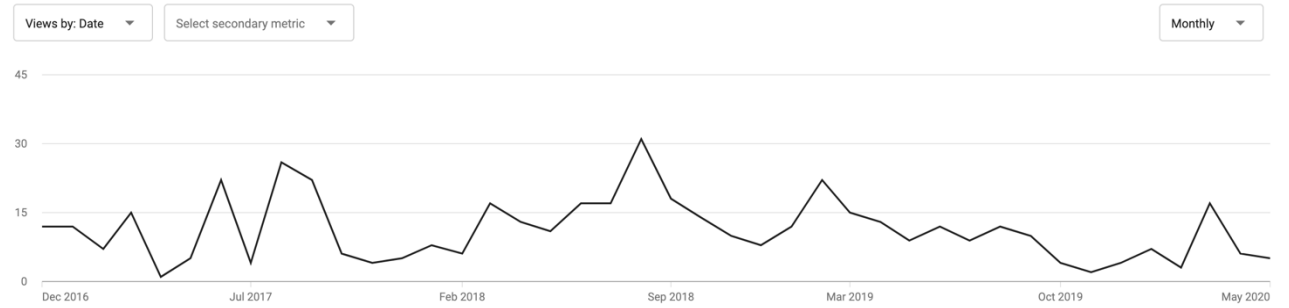
Figure 45: Some video screenshots

The video shows the logos of WHALESAFE, Natura2000, Life and the partners at the end of the video. The video has been upload on the WHALESAFE YouTube channel, https://www.youtube.com/channel/UC2jwhEclZpfb8atwrrBY27g/ which include other 12 videos recorded during the project.
The statistics of the YouTube WHALESAFE channel are reported below

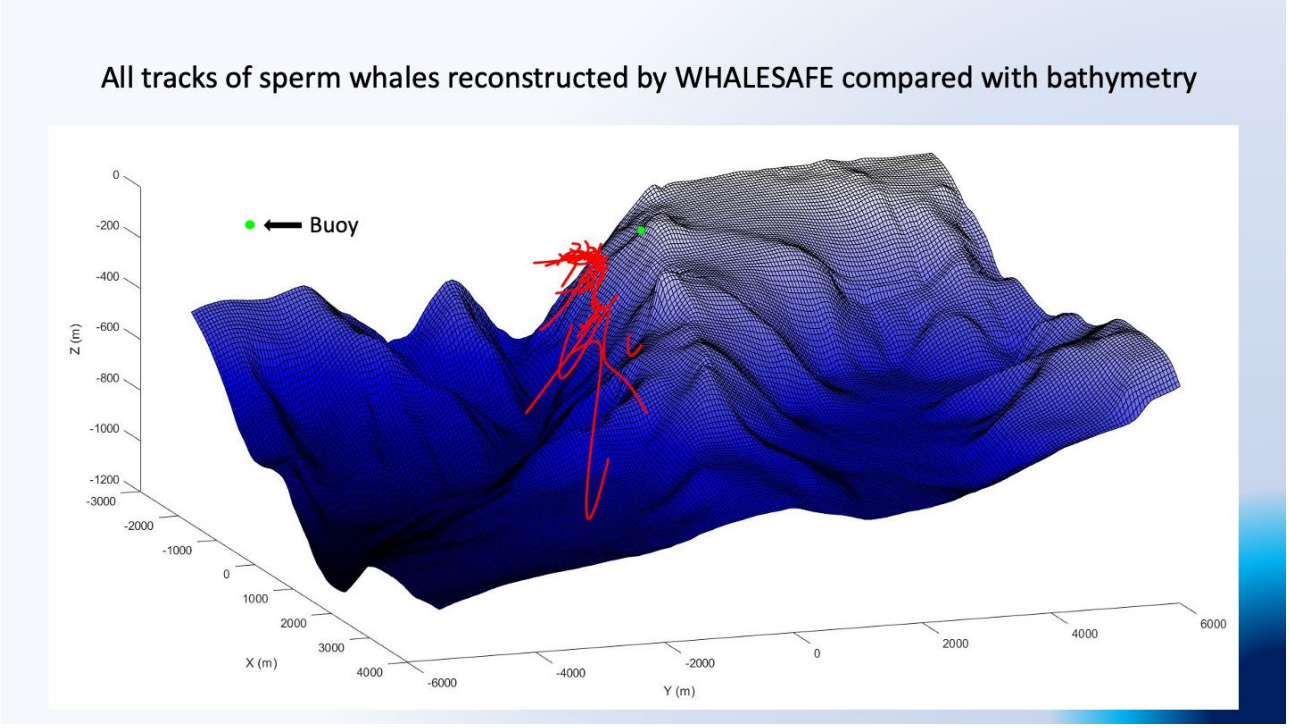
| Video | Views | Watch time (hours) | Average view duration | Impressions | Impressions click-through rate |
|---|---|---|---|---|---|
| **Total** | **473** | **6.3** | **0:47** | **3,974** | **5.7%** |
| Installazione boe WHALESAFE - WHALESAFE buoy deployment 1... | 120 25.4% | 0.7 11.7% | 0:22 | 698 | 9.6% |
| Installazione Boe WHALESAFE | 108 22.8% | 2.2 35.8% | 1:14 | 1,014 | 7.2% |
| Installazione boe WHALESAFE - WHALESAFE buoy deployment 2... | 53 11.2% | 0.3 5.3% | 0:22 | 394 | 6.8% |
| Presentazione WHALESAFE - WHALESAFE introduction | 39 8.3% | 0.6 9.9% | 0:57 | 45 | 15.6% |
| Documentario su WHALESAFE - WHALESAFE documentary - 22/8... | 36 7.6% | 1.2 18.9% | 1:58 | 362 | 5.0% |
| Monitoraggio delle navi con il sistema WHALESAFE - Ship monito... | 26 5.5% | 0.2 2.7% | 0:23 | 305 | 3.0% |
| Installazione Boe WHALESAFE | 25 5.3% | 0.2 2.9% | 0:25 | 189 | 5.8% |
| WHALESAFE @ Festival della Scienza - 28/10/2016 RaiNews24 | 23 4.9% | 0.3 4.2% | 0:40 | 237 | 1.7% |
| A volte il mare non è nostro amico - Sometimes sea is not our frie... | 13 2.8% | 0.0 0.6% | 0:11 | 79 | 5.1% |
| Installazione boe WHALESAFE - WHALESAFE buoy deployment 1... | 12 2.5% | 0.2 2.6% | 0:48 | 100 | 2.0% |
| Presentazione protocollo WHALESAFE - WHALESAFE ... | 7 1.5% | 0.1 2.1% | 1:08 | 56 | 5.4% |
| Presentazione protocollo WHALESAFE - WHALESAFE protocol pre... | 6 1.3% | 0.1 1.7% | 1:05 | 364 | 0.3% |
| Presentazione protocollo WHALESAFE - WHALESAFE protocol pre... | 5 1.1% | 0.1 1.7% | 1:15 | 131 | 0% |

| Geography | Views | Watch time (hours) | Average view duration |
|---|---|---|---|
| **Total** | **473** | **6.3** | **0:47** |
| Italy | 29 6.1% | 0.6 10% | 1:18 |

| Device type | Views | Watch time (hours) | Average view duration |
|---|---|---|---|
| **Total** | **473** | **6.3** | **0:47** |
| Computer | 204 43.1% | 3.2 50.5% | 0:55 |
| Mobile phone | 200 42.3% | 2.1 34.1% | 0:38 |
| Tablet | 58 12.3% | 0.7 11.2% | 0:43 |
| TV | 10 2.1% | 0.3 4.1% | 1:32 |
| Game console | 1 0.2% | 0.0 0.2% | 0:35 |




The final video containing an overview of the project and the main results has been produced and uploaded on the WHALESAFE YouTube channel.
A couple of screenshots of the video are reported below:




- Problems occurred – None
- Evaluation – The two foreseen videos have been produced.
- Completion – 100 %

## Action E.5: Logo Design

The logo of the project has been created and it has been inserted in all the communication materials (Figure 46).
The basic concepts of the narrative are "Tail" and "Waves".
The tail is a form of visual metonymy, a part for the whole: an element that, even biologically, identifies the sperm whale. The waves are the link between two worlds: they represent both a physical data (wave propagation), and a natural one (the waves).

Whale Safe

Figure 46: The WHALESAFE logo

- Problems occurred – None
- Evaluation – The WHALESAFE logo has been designed and is being used in all public events as well as a tag on all equipment.
- Completion – 100%

## Action E.6: Leaflet and brochure

It has been decided to create a leaflet that is not just a presentation of the project, but also a tool for the dissemination to the large public, optimizing the resources. The leaflet contained a text related to the project, a text on the Pelagos sanctuary and a board showing the main species of cetaceans that inhabit the sanctuary.

The leaflets have been distributed during the communication activities carried out on board of the cruise ships, at the Acquario di Genova, on board of the whale watching boats and at conferences and seminars.
We point out that there was an error in the technical description as it mentions the production of a leaflet and a brochure both at the beginning and at the end of the project, but it would not have been effective to produce a brochure at the beginning, when there were not results yet or another leaflet when the project is finished. Therefore, only the leaflet used to make people aware about the project has been produced at the beginning of the project (Figure 46).


Figure 47: The WHALESAFE leaflet

The leaflet has been produced in Italian and English version and it has been printed in 3000 copies. Table 4 shows the leaflets distribution in detail:

| EVENT | N° |
|---|---|
| During whale watching activities | 2000 |
| During educational events | 650 |
| Seminars and conferences | 350 |
| tot | 3000 |

Table 4: Distribution of the leaflet

- Problems occurred – The final brochure has not been produced since the collision avoidance system has never been implemented in real time, as described in Action C.9.
- Evaluation – The leaflet has been produced and distributed at several dissemination events
- Completion – 80 %

## Action E.7: Final Workshop for Project Results Dissemination

- Activities – None
- Problems incurred – The Final Workshop can not be held because of the SARS COVID-19 outbreak.
- Completion – 0 %

## Action E.8: Website Development, Upgrade and Promotion

The website is active, running on Softeco's servers and reachable at the URL:
**http://www.whalesafe.eu/.**
The web site contains sections for project overview, consortium member descriptions, news and events, and a link to the partner restricted area.
A dissemination video illustrating the project and its objective have been produced by the consortium (Action E.4) and a link to it has been inserted in the project site's home page.
No specific problems have been encountered in the maintenance of the website.
The web site have been developed based on CMS technology which will allow, besides dynamic enrichment and update of its contents, also future integration with data produced by the project.
This action includes the milestone "Start-up communication and dissemination including website" that has been accomplished on 30/1/2015 in advance with respect to schedule.
In Figure 48 some statistics about the WHALESAFE website visits are shown for different time periods.

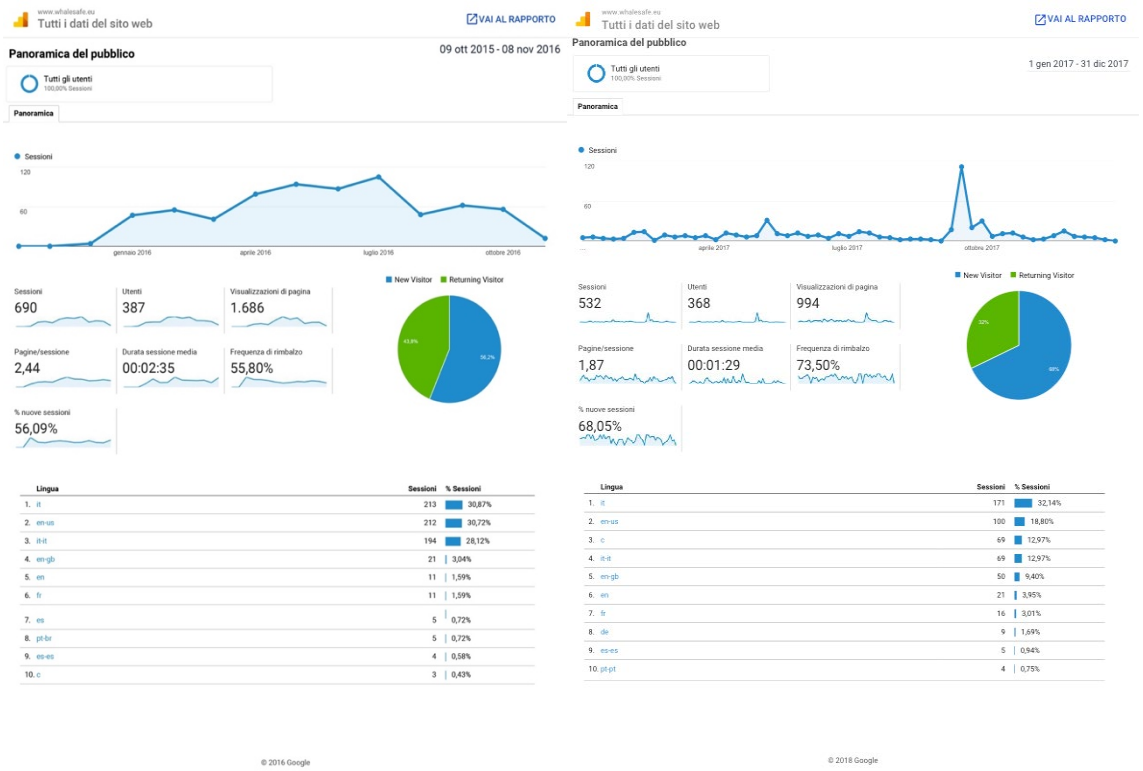



Figure 48: Statistics about the WHALESAFE website visits (9/10/15-8/11/16 and 1/1/17-31/12/17)

With respect to the initial version the web site graphical aspect has been redesigned (Figure 49). Following are some screenshots of the final web site graphical aspect. The final report of accesses to the web site shows that there is an international interest in the project with accesses from France, USA and China.




## The Project

### BACKGROUND

The Pelagos Sanctuary for Mediterranean Marine Mammals is a special marine protected area in the north-western Mediterranean Sea. It is located between Liguria, France and Sardinia and covers an area of around 90 000 km2. The sanctuary is the most important breeding and feeding site for cetacean populations living in the Mediterranean Sea and thus crucial for their well-being. Distinct ecological and sea floor conditions in the sanctuary mean that primary production (the creation of organic compounds through photosynthesis or chemosynthesis) in the area is very high and supports a diversified food chain.

The unique seabed features in the area, such as canyons, attract a large number of sperm whales that often emerge near the coast. Major commercial, tourist and industrial sites are also located in the area and marine traffic (e.g. passenger, cargo and fishing boats) increases particularly during the summer, when the presence of sperm whales is higher. Collisions and injured animals are consequently frequent and have a very high negative impact on the species, whose Mediterranean sub-population counts at just 2 500 mature individuals.

### OBJECTIVES

### LINKS

*WhaleSafe was born with the financial contribution of the European Union programme Life+*

Whalesafe Youtube Channel

### WHALESAFE VIDEO


### CONTACTS

Contact person: Mauro Taiuti
Tel: 393471652214




## The Partners

### UNIVERSITÀ DEGLI STUDI DI GENOVA (COORDINATOR)

The "Università degli Studi di Genova" is a public teaching and research body participating to the project with two departments: the Department of Physics, specialised in remote detecting systems in the marine environment, and the Department of Earth, Environment and Life Sciences (DISTAV), with a well documented research on cetaceans and teaching history.

### SOFTECO SISMAT SRL

Established in 1979, Softeco Sismat S.p.A. is a leading Company in the Information and Communication Technology market. Thanks to its specific applicative and technological competence, Softeco Sismat is present on the market as a supplier of innovative solutions allowing its customers to exploit the potential offered by Information Technology and Internet.

Softeco Sismat carries out important IT and industrial projects by integrating systems, networks, products and technologies, supplementing its offer with the supply of technical and management consulting, as well as specialized services and training.

### COSTA EDUTAINMENT SPA

Costa Edutainment S.p.A. is a service company dealing with management of public aquariums and museums. The overall goal of its activity is to answer the growing demand for a high quality use of leisure time, in which cultural and educational experiences

### LINKS

*WhaleSafe was born with the financial contribution of the European Union programme Life+*

Whalesafe Youtube Channel

### CONTACTS

Contact person: Mauro Taiuti
Tel: 393471652214
Email: Mauro.Taiuti@ge.infn.it


Figure 49: New design of the WHALESAFE website

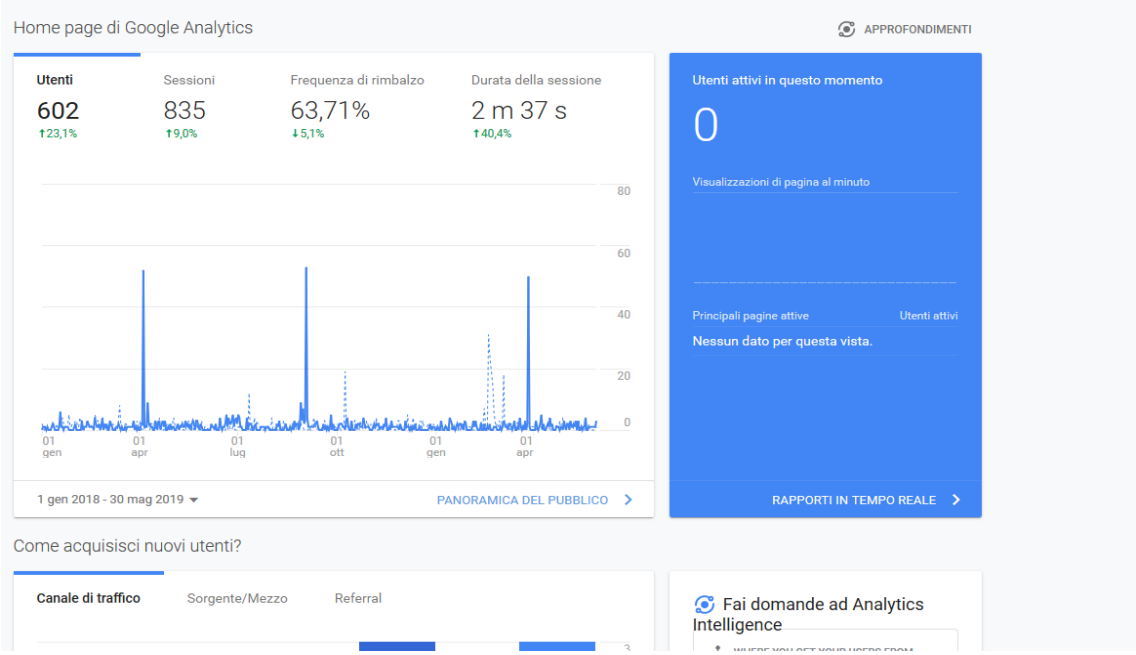



Figure 50: Statistics about the WHALESAFE website visits (1/1/2018-30/5/2019)

- Problems occurred – None
- Evaluation – The website has been maintained and update during the whole project
- Completion – 100 %

## Action E9: Divulgation and dissemination on board passengers

A collaboration agreement has been signed between Costa Crociere (a cruise shipping company) and Costa Edutainment, in order to disseminate the projects communication materials to the cruise passengers.

A didactic game about Cetaceans has been produced and distributed to the staff of the “Squok club”. The game is addressed to the young passengers (3-6 and 7-11 years) who are involved in animation

activities aiming to learn how to detect the Cetacean that live in the Pelagos Sanctuary. A biologist of the Acquario di Genova has carried out the staff training on board.

Figure 51: Staff training

Figure 52: Activities on board


Figure 54: Explication phase


Figure 53: Young passengers playing WHALESAFE game

The game was used on board of three Costa cruise ships which leave from Savona port terminal: Magica, Diadema, Fascinosa and Mediterranea.
The game is carried out weekly for both mini and maxi clubs, in two versions: one for younger children 3/6 years and another for older children/teens.
It is estimated that since the beginning of the project around 5200 children/teens played the game.
The game consists of a series of cards showing sperm whale tales and dolphins tales pictures; the players must detect the pictures relate to any single individual observing the different shape and the signs that characterize each animal.
Some cards of the game have been added with the sperm whale tails and cards on the project and the sperm whale have been distributed to all animators. During the game the staff explains the WHALESAFE project and its aims.
In January 2018, other 6 game kits were produced for the Diadema ship.
Before starting their cruises and once landed at the cruise terminal of Savona, cruise passengers can visit an exhibition dedicated to cetaceans of the Pelagos Sanctuary (Figure 54). Here, they have the opportunity to have information about the Whalesafe project and about the Cetacenans leaving in the Pelagos Sanctuary. The exhibition has been open from August 2015 until mid 2019 and it is estimated that more than 1 million visitors have seen it since very year one million of passengers transit at the cruise terminal.


Figure 55: Panels at the cruise terminal

- Problems incurred – None
- Evaluation – Several dissemination activities have been performed at Savona port terminal and on cruise ships.
- Completion – 90 %

## Action E.10: Dissemination

An exhibit has been realized and placed at the cruise terminal in Savona. The location has been decided according to the huge number of passing visitors, in order to make the communication as much effective as possible.

The leaflets have been distributed during 20 whale watching cruises which leave from the dock in front of the Acquario di Genova. During the cruise biologists on board explain the WHALESAFE project and its aims.
On 15,16,17 June 2016 special guided tours have been carried out along the Cetacean's pavilion path at the Acquario di Genova (Figure 56). A biologist explained the project, the environmental problem addressed and the cetaceans, which inhabit the Pelagos sanctuary, with a special focus about sperm whales. About 360 persons attended the event.

Figure 56: Guided tour at Acquario di Genova


Figure 57: News on social network

During the international Science festival fair (www.festivalscienza.it) which is organized every year in Genoa, from 27 October to 6 November 2016, a didactic laboratory has been organized (Figure 58). During the laboratory, addressed to young people (6-14), the participants have been invited to listen different cetaceans sounds in order to learn how they use and produce the sounds and how WHALESAFE buoys system is able to detect the sperm whales transiting in the identified area. Moreover, they have played the same identification game diffused to passengers on board of the cruise ships (Figure 59).

The number of people which have attended the didactic laboratory is 846.

Figure 58: Festival della Scienza program


Figure 59: Educational laboratory during Festival dell Scienza

On 27th May 2017 the WHALESAFE project has been presented during the event "Messina incontra la biodiversità" ("Messina meets the bio-diversity") at the Messina city hall (Figure 60). Two hundred students of primary and secondary schools attended the event (Figure 61). During the event the leaflet of the project have been distributed.


Figure 60: Poster of the event

Figure 61: A couple of pictures of the event

Figure 62: A couple of pictures of the event

During the international fair "Slow Fish" held every two years in Genoa, the project was presented at the Liguria Region stand on May 20th (Figure 62).
Two or three days every week, along the visitor path, a short speech is made in front of the dolphin tank of Acquario di Genova (Figure 63). Visitors can listen different cetaceans' sounds and learn information about the Whalesafe project. Since September 2017, 20 short speeches attended by around 1200 people, have been carried out.

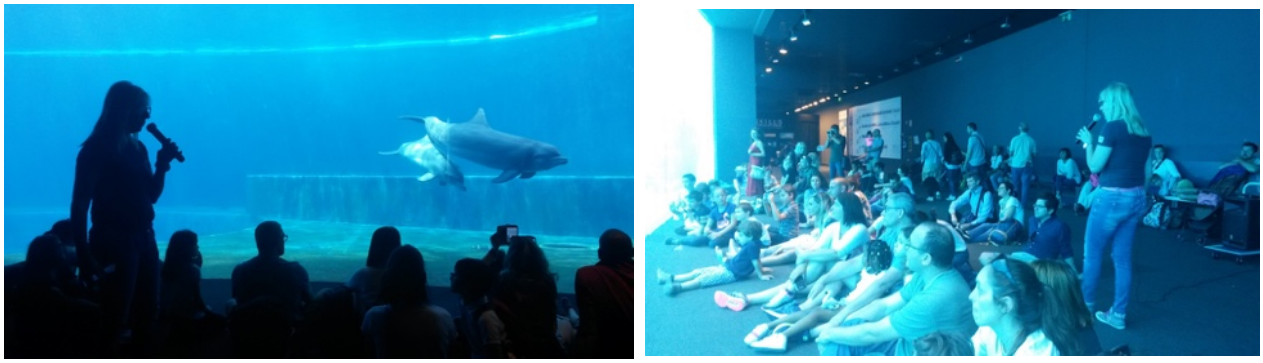


Figure 63: A couple of pictures of the speeches

On 24/6/2017 within the event "Festival del Tigullio" an educational laboratory for children has been carried out.
On 21th January 2019 the WHALESAFE project has been presented by M. Sanguineti at the Nautical Technical Institute (secondary school/college 14-19 years) in Camogli (GE) (Figure 64). The conference has been followed by around 60 students. Some photos of the event are reported below.



Figure 64: Pictures of the seminar at Camogli Nautical Institute

- Problems occurred – None.

- Evaluation – Several dissemination activities have been performed in festivals, schools and at the Genova Aquarium.
- Completion – 100 %

### Action E.11: Guidelines and user manual

The user manual, which contains a description of the setup architecture and the maintenance/operation of the detector, has been completed.

- Problems occurred – The data analysis of the risk assessment has not been possible since the alarm generation phase has never started due to the problem of refurbishment described in Action C.9.
- Evaluation – The user manual has been produced
- Completion – 90 %

### Action E.12: Poster and publications

The WHALESAFE project has been presented at the following scientific meetings

- **101° Congresso della Società Nazionale di Fisica, Rome 21-25 September 2015.** The Congress of the National Society of Physics, held in Rome in September 2015, was a very important opportunity to present WHALESAFE, at national level, to an audience of some hundreds of researchers. This work was focused on the procedure followed for the development of the detector system to obtain the best accuracy for sperm whale tracking in order to prevent collisions with boats and ships.
  Alessi J, Bianchi C.N., Bozzini G., Brunoldi M., Cappanera V., Casale A., Cavalleri O., Corvisiero P., Fanciulli G., Falzoi N., Grosso D., Magnoli N., Mandich A.,Melchiorre C., Morri C., Pesce A., Povero P., Stasi N., Taiuti M., Viano G., Wurtz M (2015). First steps into WhaleSafe project. **Design of a detector for sperm whale clicks in acoustic signals.** *Oral presentation, 101° Congresso Nazionale della Società Nazionale di Fisica, Roma 21-25 September 2015.*

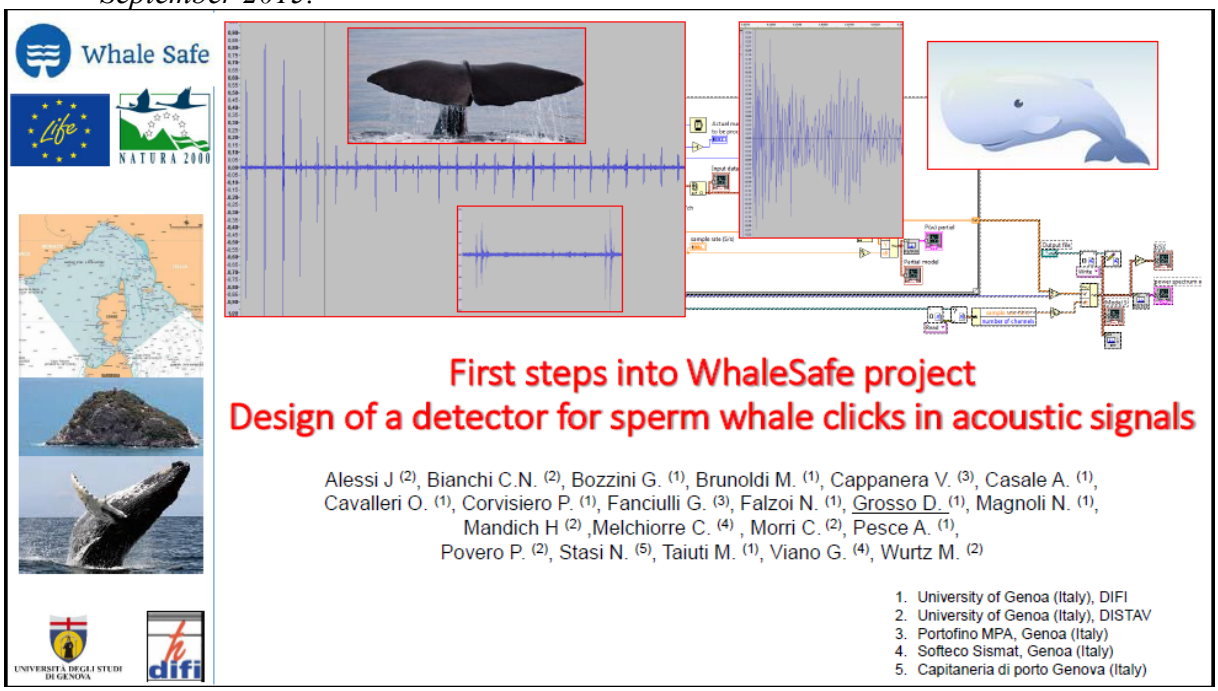


Figure 65: First slide of WHALESAFE talk at 101° Congresso della Società Nazionale di Fisica, Rome (21-25 September 2015)

- **30th Conference of the European Cetacean Society at Funchal, Madeira, 14 - 16 March 2016.**

The European Cetacean Society (ECS) aims to promote and advance the scientific studies and conservation efforts of marine mammals and to gather and disseminate information about cetaceans to members of the Society (senior and young researchers, and students). ECS membership fluctuates between 350-750 persons from more than 25 European countries and several countries outside Europe. For this reason, ECS was selected for the presentation of WHALESAFE project.
The theme of the 30th Conference, *Into the Deep: Research and Conservation on Oceanic Marine Mammals*, was particularly in line with the objectives pursued by WHALESAFE. At this Conference, we presented some technical aspects of the interference avoidance system capable to detect and track acoustically sperm whales, to identify the threats and to prevent risks by issuing warning messages in real time to vessels in the area. The technical design and differences of the system that would be in use in WHALESAFE are compared to the system already in use in the project ARION-LIFE+09 NAT/IT/190.
J. Alessi, A. Mandich, P. Vassallo, G. Bozzini, M. Brunoldi, A. Casale, N. Falzoi, D. Grosso, M. Petrillo, C. N. Bianchi, C. Morri, A. Pesce, Or. Cavalleri, G. Gnone, B. Valettini, C. Gili, V. Cappanera, G. Fanciulli, Ch. Melchiorre, G. Viano, N. Stasi, D. Buffelli, V. Vitale, M. Wurtz, M. Taiuti. **Fixed acoustic stations for sperm whale and bottlenose dolphins real time monitoring. The case studies of the Life projects WHALESAFE and ARION.** *Poster presentation*, *30th Conference of the European Cetacean Society at Funchal, Madeira, 14-16 March 2016.*

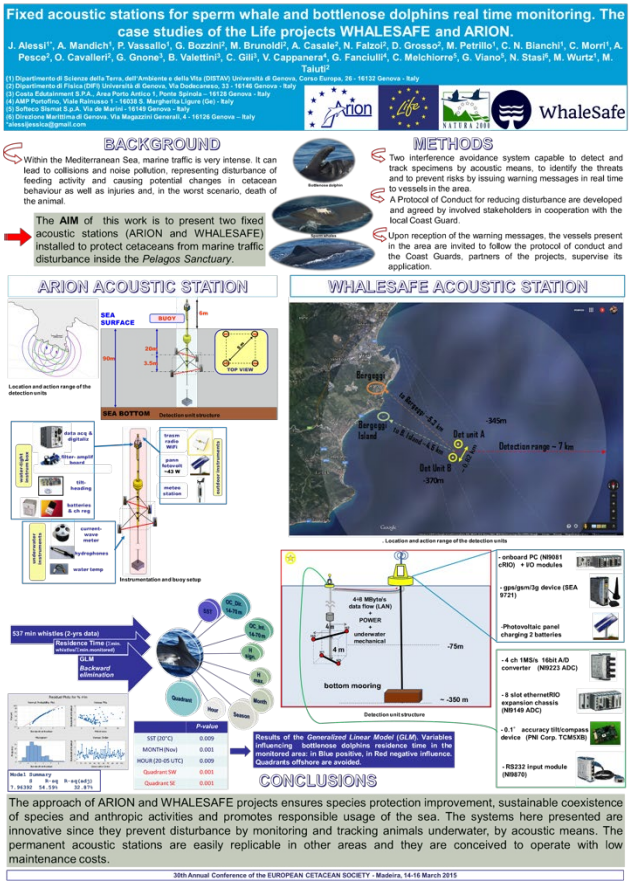


Figure 66: WHALESAFE poster at 30th Conference of the European Cetacean Society at Funchal, Madeira (14 - 16 March 2016)

- **47° Congresso della Società Italiana di Biologia Marina Torino, 13-17 June 2016**
  The Società Italiana di Biologia Marina (S.I.B.M.) aims to promote studies into the life of the sea, to encourage contacts between researchers, spreading all the theoretical and practical knowledge derived from modern advances. As part of the six working groups currently active within the S.I.B.M., the Cetacean Group organizes each year a one-day workshop. In 2016,

the workshop has been entitled "Cetaceans and research in Italy: focus on methods, results and future perspectives". In this Meeting, the project and the technical details of the permanent acoustic station created to reduce the risk of strike between ships and cetaceans in the Controlled Area in front of Savona-Vado harbour, have been presented and discussed. The work highlighted the innovative aspects of WHALESAFE regarding the improvement of sperm whale protection, the sustainable coexistence of the species with anthropic activities and the responsible usage of the sea. Moreover, the easy replicability of the acoustic station in other areas and its possibility to operate with low maintenance costs, have been underlined.
J. Alessi, A. Mandich, N. Falzoi, P. Vassallo, M. Petrillo, M. Brunoldi, D. Grosso, A. Pesce, O. Cavalleri, G. Gnone, B. Valettini, CH. Melchiorre, G. Viano, M. Taiuti. **The project Life + Whalesafe: development of a permanent acoustic station for the protection of sperm whale (Physeter macrocephalus) from collisions in the Ligurian Sea.** *Oral presentation, accepted for the 47° Congresso della Società Italiana di Biologia Marina Torino, 13-17 giugno 2016.*

*47° Congresso della Società Italiana di Biologia Marina*
*Torino, 13-17 giugno 2016*

JESSICA ALESSI[1*], ALBERTA MANDICH[1], NICOLÒ FALZOI[2], PAOLO VASSALLO[1], MARIO PETRILLO[1], MARCO BRUNOLDI[2], DANIELE GROSSO[2], ALESSANDRA PESCE[2], ORNELLA CAVALLERI[2], GUIDO GNONE[3], BRUNA VALETTINI[3], CHRISTIAN MELCHIORRE[4], GIANNI VIANO[4], MAURO TAIUTI[2]

(1) Dipartimento di Scienze della Terra, dell'Ambiente e della Vita (DISTAV) Università degli Studi di Genova, Corso Europa, 26 - 16132 Genova - Italy
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(4) Softeco Sismat S.p.A. Via de Marini - 16149 Genova - Italy
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IL PROGETTO LIFE+ WHALESAFE: SVILUPPO DI UNA STAZIONE ACUSTICA PERMANENTE PER LA PROTEZIONE DEL CAPODOGLIO (*PHYSETER MACROCEPHALUS*) DALLE COLLISIONI IN MAR LIGURE

*THE PROJECT LIFE + WHALESAFE: DEVELOPMENT OF A PERMANENT ACOUSTIC STATION FOR THE PROTECTION OF SPERM WHALE* (PHYSETER MACROCEPHALUS) *FROM COLLISIONS IN THE LIGURIAN SEA*

***Abstract*** *– Sperm whale (*Physeter macrocephalus*) is an endangered cetacean species, particularly sensitive to noise pollution and highly vulnerable to ship strikes. In the framework of the Life+ Nature WHALESAFE it was realized an interference avoidance system capable to detect and track sperm whale, to identify the threats and to prevent collisions and other risks by issuing warning messages in real time to ships. The permanent acoustic station is able to detect sperm whale in a range of about 7 km.*
***Key-words:*** *passive acoustic monitoring, collision,* Physeter macrocephalus*, Ligurian Sea.*

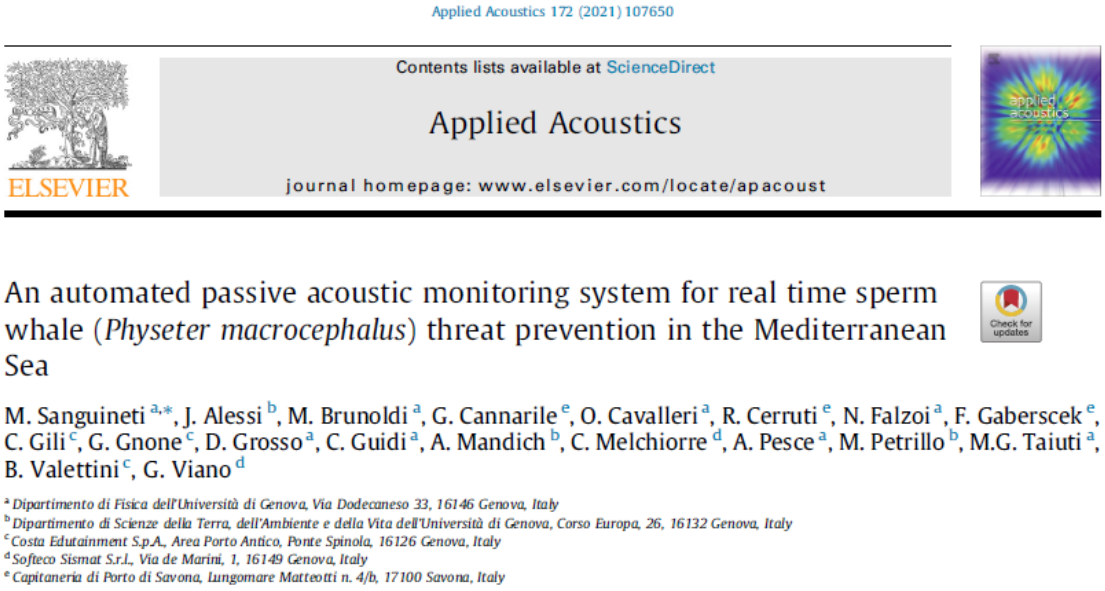
Figure 67: WHALESAFE at 47° Congresso della Società Italiana di Biologia Marina Torino (13-17 June 2016)

- **45th Annual symposium of the European Cetacean Society at Funchal, Genova, 8 - 11 March 2017**
  M. Sanguineti, J. Alessi, M. Brunoldi, A. Mandich, D. Grosso, G. Gnone, B. Valettini, C. Gili, C. Melchiorre, G. Viano, P. Vassallo, M. Petrillo, , A. Pesce, O. Cavalleri, G. Gnone, M. Taiuti. **Use of underwater sound to prevent collision between ship and sperm whale (Physeter macrocephalus) the case study of the project Life+ WHALESAFE.** *45th*

*Annual symposium of the European Cetacean Society at Funchal, Genova, 8 - 11 March 2017*

- **32th Conference of the European Cetacean Society at La Spezia, 6 - 10 April 2018** Miclaus Andreea Ioana, Mandich Alberta, Vassallo Paolo, Petrillo Mario, Burlando Marco, Sanguineti Matteo, Grosso Daniele, Pesce Alessandra, Cavalleri Ornella, Gnone Guido, Valettini Bruna, Melchiorre Christian, Viano Gianni, Taiuti Mauro Gino, Alessi Jessica. **Measuring the size of Mediterranean sperm whales through the inter-pulse interval: comparative study of the total body length formulas.** *Poster presentation*, *32th Conference of the European Cetacean Society at La Spezia, 6-10 April 2018*

A paper with the title "An automated passive acoustic monitoring system for real time sperm whale (Physeter macrocephalus) threat prevention in the Mediterranean Sea" has been submitted to "Journal of A pplied Acoustic" on 30th April 2019. The article has been published in Applied Acoustics 172 (2021) 107650 (Figure 68).


Applied Acoustics 172 (2021) 107650

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

An automated passive acoustic monitoring system for real time sperm whale (*Physeter macrocephalus*) threat prevention in the Mediterranean Sea

M. Sanguineti [a,*], J. Alessi [b], M. Brunoldi [a], G. Cannarile [e], O. Cavalleri [a], R. Cerruti [e], N. Falzoi [a], F. Gaberscek [e], C. Gili [c], G. Gnone [c], D. Grosso [a], C. Guidi [a], A. Mandich [b], C. Melchiorre [d], A. Pesce [a], M. Petrillo [b], M.G. Taiuti [a], B. Valettini [c], G. Viano [d]

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[e] Capitaneria di Porto di Savona, Lungomare Matteotti n. 4/b, 17100 Savona, Italy

Figure 68: Front page of the WHALESAFE paper

- Problems occurred – None
- Evaluation – The WHALESAFE project has been presented at five international conferences and a paper has been submitted to a top ranked (Q1) journal.
- Completion – 80 %

## Action E.13: Lectures and Seminars

In the following lecture or seminars the WHALESAFE project have been presented:

- 9/6/2016 Prof. Alberta Mandich presented the project WHALESAFE during a seminar in Savona dedicated to the whale watching operators, organized by CIMA Foundation


Figure 69: First Slide of the WHALESAFE presentation at Savona

**BOZZA DI PROGRAMMA**

GIORNATA INFROMATIVA 'WHALE-WATCHING IN LIGURIA'

| | |
|---|---|
| 11:00 - 11:15 | **Registrazione** |
| 11:15 - 11:30 | Saluti |
| 11:30 - 11:45 | 12 anni di whale-watching in Liguria in collaborazione con Fondazione CIMA |
| 11:45 - 12:00 | Presentazione del codice di condotta per l'avvicinamento |
| 12:00 - 12:15 | Presentazione del label di ACCOBAMS/PELAGOS |
| 12:15 - 12:30 | **Discussione** |
| 12:30 - 13:30 | Pranzo |
| | **Sessione - Contributi del whale-watching** |
| 13:30 - 13:45 | Educazione ambientale |
| 13:45 - 14:00 | Monitoraggio dell'ambiente |
| | **Sessione - Esperienza di Whale-watching** |
| 14:00 - 14:15 | Il whale-watching in Francia |
| 14:15 - 14:30 | Il whale-watching nel mondo |
| | **Sessione - Progetti di ricerca in Liguria** |
| 14:30 - 14:45 | Il progetto Grampo - Finanziato da Pelagos Int. |
| 14:45 - 15:00 | Il progetto Noise - Finanziato da Pelagos Int. |
| 15:00 - 15:15 | I progetti AIRION - WhaleSafe |
| 15:15 - 15:30 | Il progetto Delfini Metropolitani |
| 15:30 - 16:00 | **Discussione** |

Figure 70: Program of the seminar at Savona

- 27/4/2016 Dr. Jessica Alessi illustrated the project during lectures on the *Acoustic System in Cetacean*, in the framework of the course on *Biology and Monitoring Techniques of Cetacean* (Master Degree in Biological Monitoring) at the Genoa University.
- 9/11/2016 Dr. Jessica Alessi during a seminar about *Cetacean Conservation in the Mediterranean Sea* illustrated the project with details about the impact of human activity on sperm whales, the project objectives and the system functioning, held at the Tuscia University in the framework of the course *Protection of the marine environment* (Master Degree in Marine Biology and Ecology).
- 20/06/2017, J. Alessi, Slowfish @ Genoa. Title: "The sperm whale"

- 8/6/2017, J. Alessi, World Oceans Day @ Museo Doderlin of University of Palermo. Title: "How cetaceans will save the planet, if we save them."
- 19/6/2017, A. Mandich @ Meeting with sea-coast Municipality of Liguria organized by the Ministry of Environment and Safeguard of the Territory and the Sea, "Sala 7 Maggio" Direzione Marittima Genova, Title: "Acoustic detection system for the safeguard of cetaceans: the LIFE+ ARION and WHALESAFE projects"
- 15/9/2017, J. Alessi, CAMINETTO @ Rotary club Agrigento. Title: "Dolphins and whales: an underwater journey discovering the giant of the sea"
- 17/9/2017 WHALESAFE project had been presented at a seminar dedicated to whale watchers and during the course on Biology and Monitoring Techniques of Cetacean (Master Degree in Biological Monitoring) at the Genoa University
- 26/9/2017, M.Taiuti, Lecture @ University's Europa Point Campus, Gibraltar, Title: "Novel approaches to the conservation of dolphins and other cetaceans in the Mediterranean"
- 23/10/2017 C. Gili @ EUAC (European Aquarium Curators) project has been presented at the annual conference
- 23/05/2018 C. Gili @ EAZA (European Zoo and Aquarium association)-project has been presented at the Conservation forum

- Problems occurred – None
- Evaluation – The WHALESAFE project has been presented in 11 seminars with expert auditorium.
- Completion – 80 %

### Action E.14: Dissemination among Fisherman and Boaters

The different options in terms of available technologies for the development of a mobile application running on all the major mobile platforms (mobile web applications, native mobile applications, multiplatform applications) have been considered.
The required infrastructure to support the functionality of the app has been prepared as a tier of web services (HTTP/JSON) for the access of the portal data.
A mobile application implemented as a mobile web site and the required infrastructure to support its functionality is available (Figure 71).The web site is accessible without password at the link http://mobile.whalesafe.eu/ .

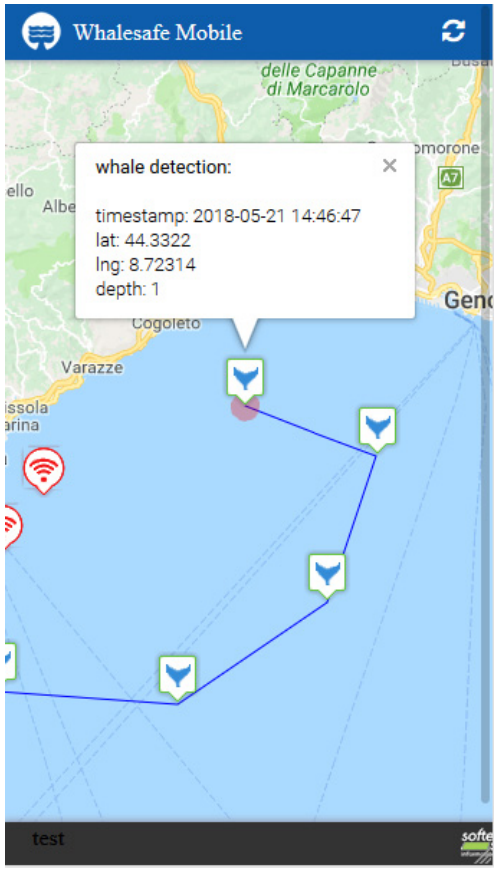

Figure 71: A screenshot of the mobile app

- Evaluation – The web site is ready for use and it has been tested with simulated and real data. However, due to the end of the project, the advertising of the web site was not possible.
- Completion – 80 %

## Action F.1: Overall Project Administration

The administrative project management activity is coordinated by UNIGE. Dr. N.S. Falzoi has been appointed as Project Manager and Dr. Valeria Betti, chief of the administrative office of the Department of Physics, is responsible for keeping track of all expenditure and documentation.
Three committee, as foreseen in the proposal, has been formed:

- Project Coordination Committee (PCC): M.Taiuti (Unige), G.Viano (Softeco), V.Vitale (CPSV), B.Valettini (ADG)
- Technical Coordination Committee (TCC): M.Taiuti (Unige), G.Viano (Softeco), D.Buffelli (CPSV), N.S.Falzoi (Unige)
- Dissemination Management Committee (DMC): B.Valettini (ADG), J.Alessi Unige), C.Melchiorre (Softeco)

This action includes the milestone Project Kickoff Meeting that has been accomplished on October 2, 2014 in advance with respect to schedule.
Since June 2016, Dr. Matteo Sanguineti has been appointed as new Project Manager and D. Buffelli has been replaced by R. Cerruti at the Capitaneria di Porto di Savona.
Three new composizion of the committees is

- Project Coordination Committee (PCC): M. Taiuti (Unige), G. Viano (Softeco), V. Vitale (CPSV), B. Valettini (ADG)
- Technical Coordination Committee (TCC): M. Taiuti (Unige), G. Viano (Softeco), G.Cannarile (CPSV), M. Sanguineti (Unige)
- Dissemination Management Committee (DMC): B. Valettini (ADG), J. Alessi Unige), C. Melchiorre (Softeco)

A merger by incorporation of Softeco Sismat S.r.L. into the parent company TerniEnergia S.p.A. (currently owning 100% of Softeco Sismat S.r.L.'s share capital) has been carried out and is effective since March 1st, 2020. Since March 2nd, 2020, TerniEnergia S.p.A. has adopted the name "AlgoWatt S.p.A.", with registered office in Milan. As a result of this, starting from March 1st, 2020, the Partnership Agreement with Softeco Sismat S.r.L. for implementing the Project "LIFE13 NAT IT 1061– WHALESAFE" , will continue to be implemented by AlgoWatt S.p.A., with no change in the amount of resources/MM as agreed by Softeco Sismat S.r.L. as well as in MM rates for resources.
AlgoWatt S.p.A. will inherit all assets and liabilities (rights and obligations) of Softeco Sismat S.r.L., including intangible assets representing, but not limited to, experience in the field, acquired as a result of the works executed and/or received by Softeco Sismat S.r.L., including the Project implementation team, as well as any licenses, certificates and authorizations, operating authorizations and other authorizations, or other IPR held by the company.
The documentation relative to this merger is attached to this Report as Annex39-F1-Softeco Merging in ALGOWATT
In the financial report "SOFTECO" is replaced by "ALGOWATT SPA (continuation of SOFTECO)"

- Problems occurred – None
- Evaluation – The administration of the project has been smooth for the whole duration of the project.
- Completion – 100 %

## Action F.2: Scientific and Technical Project Coordination

Prof. M. Taiuti (Unige) has been appointed as Project Coordinator and Prof. A.Mandich (Unige) has been appointed as Scientific Coordinator. Prof. Taiuti followed also the technical direction of the project. The technical Coordination Committee met regularly mostly at the Capitaneria di Porto di Savona (in average one meeting every two months). M.Taiuti maintained regular contact with the other members by mail exchange.

- Problems occurred – None
- Evaluation – The administration of the project has been smooth for the whole duration of the project.
- Completion – 100 %

## Action F.3: Quality Assurance and Project Document Management

A first version of the QAP has been issued and uploaded on the project internal repository (see below) in the first year of the project.
A restricted area of the web site has been set up to act as internal repository to store project assets and ease communication and teamwork among partners.
The repository is reachable by the link
http://srvweb02.softeco.it/cgi-bin/dinApp16.cgi?project=WHALESAFE
and from a "Restricted Area" menu item on the project's web site.
Accounts to restricted area for project partners have been generated and distributed among partners.

- Problems occurred – None
- Evaluation – The quality assurance has been performed regularly. A repository for all the documentation has been created.
- Completion – 100 %

## Action F.4: Monitoring of the project progress

The Monitoring of the Project is executed month by month controlling the progress of any action. In this way, the delays and problems encountered are followed individually and all traces of the events taken. The costs are updated regularly.

We have encountered some difficulties due to technical problems during the work (see Action C.9). These problems have been analysed and a solution proposed that permits the continuation of the project without change in the expected results.

- Problems occurred – Technical problems discussed in Action C.9
- Evaluation – The progress of the project has been monitored regularly.
- Completion – 100 %

## Action F.5: External audit

- Problems occurred – none
- Evaluation – The auditor accessed the whole documentation of the project and produced the report
- Completion – 100 %

## Action F.6: After LIFE plan

Even if it will not be possibile to maintain WHALESAFE in the Savona area, all concrete preservation action are being transferred to the infrastructure KM3NeT-ORCA presently under construction close to Toulon. It started the operation in the last years and is operative since 17th May 2019 and it is expected to be completed in 2021. Mauro Taiuti, the coordinator of WHALESAFE is presently also the coordinator of KM3NeT-ORCA and together with Matteo Sanguineti and Carlo Guidi, they are implementing in KM3NeT-ORCA the detection algorithms and the alarm generation system. KM3NeT-ORCA is a neutrino telescope and is located in France at the beginning of the PELAGOS Sanctuary and has been designed to work for at least 15 years. All KM3NeT detection units are instrumented with hydrophones which are normally used to reconstruct the instantaneous shape of each detector component. The same company that produces the hydrophone used by WHALESAFE provides those adopted in KM3NeT.
When KM3NeT will be completed there will be an array of more than 100 hydrophones located at a depth of 2500 m. We expect that this infrastructure will be able to detect and tracks not only sperm whale but also others cetaceans in the area.
The full WHALESAFE alarm generation system can be easily implemented without additional costs in KM3NeT/ORCA, thus providing the basis to reproduce the WHALESAFE system.
The area is crossed by the routes of commercial ships directed to the Toulon and Marseille harbours therefore with a level of risk of collisions comparable, if not higher, with that in the Savona-Vado area.
The UNIGE and SOFTECO groups are beneficiaries of the recently submitted LIFE proposal LIFE20-NAT_IT_001330 FERA'S LIFE.
The main purpose of FERA'S LIFE is the reduction of the impacts between marine traffic and bottlenose dolphins in particular to reduce:
The risk of collision,
The alteration of dolphins behavior;
The masking of dolphin’s communication and echolocation sounds;
The dolphins area avoidance.
These will be achieved through a reduction of negative interactions between dolphin and boating in 3 Italian MPAs (Pelagie islands, Plemmirio and Capo Milazzo), by means of a new real-time passive acoustic monitoring (PAM) system aimed at the detection of dolphins, other occasional cetaceans species and boats transiting in the monitored areas, and by diffusing a code of conduct to be applied in presence of dolphins. The PAM system will be an evolution of the acoustic system implemented by the ARION (LIFE09 NAT/IT/000190 ARION) and WHALESAFE Projects.

- Problems occurred – none
- Evaluation – We consider that transferring the After life activities to KM3NeT-ORCA is an unique opportunity to guarantee the WHALESAFE After life plan. The UNIGE personnel is

presently leading the project and this guarantees the implementation of the plan. The costs can be easily included in the budget of KM3NeT and the position of KM3NeT is as strategic as WHALESAFE, being located in an area with heavy maritime traffic and therefore high collission risks.

- Completion – 100 %

### Action F.7: Network Setup

This action foreseaw the setup of a network bringing together institutions and organizations with previous experience on sperm whale acoustic or ship strike prevention. The main project contacted was REPCET (repcet.com) a collaborative system depending on the on-board surveillance in the Pelagos Sanctuary: when a crew member spots a cetacean, he enters the animal's position relative to the ship into the software; the software automatically calculates the position of the ship and so the animal. Then the information is transmitted in real time to all other subscribers and they can see the animal's position on the map). REPCET and WHALESAFE are complementary in the sense that REPCET can cover a large sea area thanks to the movements of ships but relies on the capabilities of whachers to visually detect the whales while WHALESAFE worked in a specific area of the Pelagos Sanctuary but with a much higher detection efficiency because can listen to the clicks produced during the long immersion period the whole day. This collaboration will be maintained in the after life activity because KM3NeT/ORCA is inside the Pelagos Sanctuary and therefore inside the area covered by REPCET.

Moreover, the WHALESAFE Consortium is very well available to coordinate with other projects on similar topics funded under this or other calls.

Some institutions and organizations have been identified as potential partners of the network: Thetis, CNR of Capo Granitola and Oceanomare Delphis Onlus (cetacean monitoring institutions). The potential partners have been found at the workshop "Anthropic noise in the sea and its impact on cetaceans" by Mauro Taiuti (who was presenting ARION-LIFE project) (http://bellia.lns.infn.it/workshop-acustica/).

A very fruitful synergy has been started with the KM3NeT collaboration, which will duplicate the WHALESAFE detection system offshore Toulon (close to Pelagos Sanctuary). The details are described in the After Life Plan document.

The WHALESAFE project has been contacted by Regione Liguria to enter in the SICOMAR network (http://interreg-maritime.eu/web/sicomarplus). SICOMAR is project financed by the Interreg Italia-Francia "Marittimo" program, with a duration of three years (2018-2021) that will comprise several detection systems in the Ligurian Sea to improve the safety for the navigation. WHALESAFE did not participated only because the project did not restart after the last incident.

The progress of this action has been affected by the final incident**.**

- Evaluation – The WHALESAFE project aroused interest in the scientific community, beside the project has not fulfilled the final goal of the implementation of a collision avoidance system. The WHALESAFE sperm whale detection system is going to be implemented in the framework of the KM3NeT project.
- Completion – 80% %

## 6.3 Evaluation of Project Implementation

| Task | Foreseen in the revised proposal | Achieved | Evaluation |
|---|---|---|---|
| **Objective 1)** development of an interference avoidance | **Action C.1. Design of Detection System.** | The design of the detection system has been completed and | All the preliminary actions for the deployment of the detector have been completed on schedule |

| | | | |
|---|---|---|---|
| system aimed at detecting and tracking sperm whales | **Action C.2. Detection System Procurement**<br><br>**Action C.3. Detection System Deployment Planning**<br><br>**Action C.4. Preliminary area survey and acoustic campaign**<br><br>**Action C.5. Installation of Detection System in the Planned Sites**<br><br>**Action C.6. Monitoring and alarm generation centre development and set up** | all the principal detection systems have been procured.<br>The detection system deployment planning, the preliminary area survey and the acoustic campaign have been performed in 2015.<br>The detector has been deployed on 21st April 2016.<br>The setup of the portal and datacentre infrastructure has been completed. | without any significant issue.<br>The deployment of the detector has been really smooth.<br>Because of the incidents that seriously damaged the system, several new deployments of the system have been performed, this activities are considered as part of detector maintenance (Action C.9) |
| **Objective 2)** identification of threats to sperm whales | **Action D.1. Detection event monitoring and Assessment**<br><br>**Action D.2. Impact risk reduction estimation and assessment** | The first cetacean event has been detected on 28th June 2016. The event has been reconstructed using both detection units and also using only one detection unit (exploiting sound reflection | The performance of the one detection unit method demonstrates the capability of the system to perform the foreseen objectives even if only one detection unit is available.<br>Because of the two man-made incidents that seriously damaged the system (July 2016 and September 2017), an accurate evaluation of the |

| | | | |
|---|---|---|---|
| | | on the sea surface).<br>Several other sperm whale routes have been reconstructed in the following summer campaigns. In particular 29 sperm whales routes have been reconstructed on 12-13 July 21018 | threats to sperm whales is not available.<br>However, these incidents prove the high vessel traffic in the WHALESAFE site: a collision between a vessel and our system happened even if the buoys were clearly signalled.<br>This demonstrates a significant collision risk also for sperm whales.<br>Due to the failure to refurbish the system in time for final summer campaign where the avoidance system would have been implemented, we can not estimate the impact risk reduction. |
| **Objective 3)** prevention of collisions and other risks by issuing warning messages in real time to ships in the area | **Action D.3. Monitoring Protocol of Conduct**<br><br>**Action D.4. Monitoring risk mitigation** | The system for the issuing of warning messages in real time is ready, but it will not be implemented because was not possible to refurbish the system in time for the final summer campaign | Because of the incident of October 2018, the system has been completely destroyed and the refurbishment in time for the 2019 summer campaign was not possible as described in in Action C.9. The alerts have not been delivered to ferries and sailors, so we can not evaluate the number of collision prevented. |
| **Objective 4)** draft of a protocol for reducing the disturbance and impact risks in cooperation with the local coast guard and agreed by all stakeholders involved | **Action A.3. Stakeholder network establishment**<br><br>**Action A.5. Definition of the Protocol of Conduct for disturbance and collision risk mitigation**<br><br>**Action A.6.** | The stakeholder network has been established and a questionnaire has been proposed to ferries' passengers in order to investigate their awareness of the sperm whale problems. | The definition of the protocol of conduct has been a great synergy between Coast Guard, University of Genoa, Costa Edutainment, the cruise companies and other stakeholders.<br>The process has been smooth and no major oppositions have been encountered.<br>The Protocol of Conduct has been only slightly modified when we |

| | | | |
|---|---|---|---|
| | **EX ante stakeholders problem perception survey** | The protocol of conduct has been defined. The 4th July 2016 the official Protocol of Conduct was presented to the stakeholders and media. The official document has been signed by several companies: 1 cruise company, 2 maritime work companies, 2 fishing associations, 2 recreational boating companies, 1 boating school and 1 whale watching company. | updated the configuration of the detector. |

## 6.4 Analysis of long-term benefits

1. Environmental benefits

   Since the project has been concluded before the final sea campaign when the collision avoidance would have been implemented, we ca not evaluate the environmental benefits of the project.

2. Economical and social benefits.

   The main durable result already achieved by the project is the definition of the protocol of conduct. The protocol definition process has been shared with all the stakeholders creating a long-lasting collaboration with the local ferries, the sailors, the fishermen, the whale-watcher companies and all other stakeholders.
   Another durable result is the increased awareness of the sperm whale threats achieved with all the dissemination action performed during the project: workshops, media communications, leaflet distributed on whale watching boats, dissemination on cruise ship, publications and participation to international conferences.
   We have not been able to evaluate the economical benefits. We can list two possibile benefits: a) takeholders participating to the application of the Protocol of Conduct can

attract investors sensible to the environment and cruise company could offer service on board (as already did during the project); b) whalewatchers company when knowing the position of the sperm whales could effectively organize sighing cruise reducing navigation costs.

3. Replicability, transferability, cooperation:

We created an acoustic detection system that could be easily adopted in other sites.
The system has worked continuously between the major incident described in Action C.9, demonstrating that the detection system does not show any major issue.
The first incident leaded us to consider the possibility to reconstruct the position of the cetacean using only one detection unit. The results presented in Action D.1 show that the foreseen objectives can be achieved even if only one detection unit is working. This means that the system could be replicated using only one buoy system almost halving the cost of the equipment and its maintenance.
The rules defined in the Protocol of Conduct could be easily adapted for a local, national or European regulation of the prevention of the marine mammals. The Protocol of Conduct defines clear limits of velocity and distance of vessels in presence of whales in the area. These rules can be straightforwardly implemented by the control bodies and they can effectively adopt countermeasures.
A very fruitful synergy has been started with the KM3NeT collaboration, which will duplicate the WHALESAFE detection system offshore Toulon (close to Pelagos Sanctuary). The UNIGE and SOFTECO groups are also beneficiaries of the recently submitted LIFE proposal LIFE20-NAT_IT_001330 FERA'S LIFE whose concrete actions are largely inspired by WHALESAFE.
The details are described in the After Life Plan document (*Annex30-F6-After Life Conservation Plan*).

4. Best Practice lessons

a) We underestimated the difficulties due to the vessel traffic in the WHALESAFE project site. Even if the buoys were correctly signalled to all the vessels, two incidents occurred. For this reason, we decided to set up a video-surveillance system to monitor the passage of vessels in proximity of the buoys and individuate eventual responsible of further damages. This issue was not expected because the previous LIFE project ARION never encountered problems due to interference with vessels, even if the Portofino area has a quite high marine traffic.
b) After the second incident we redesigned the system using a single-boy configuration, in order to avoid horizontal cables below the sea level. This modification consitly reduced the probability of damages due to vessel routing close to the WHALESAFE system.
c) Due to the climate change, the occurrence in the Mediterranean Sea of extreme natural events has increased. During the fall of 2018 we assisted to a storm whose intensity was higher than that of the “storm of the century”. This means that the future equipments should be designed taking in account greater safety margin.
d) A huge improvement would be the deployment of the monitoring system at larger depth and connected to the on-shore station by means of a submarine cable. This solution is more effective but also much more expensive than that used in this project.

A possibility is to used already exisiting infrastructure like KM3NeT/ORCA where we will implement the WHALESAFE protocol as described in the After Life program (*Annex30-F6-After Life Conservation Plan*)

e) During the first year of the project, we improved the detection system using the information carried by the sound reflected by the sea surface. This permits to reduce the number of detection units and therefore the cost of the project
f) Even if we did not succeed to complete the project we verified the importance of monitoring the presence of the sperm whale by means of passive acoustive systems rather than the most common technique of visual localization, as discussed in the technical part of this report.

5. Innovation and demonstration value:

The WHALESAFE project has several innovative aspects:

- it is the first time that a permanent monitoring station has been designed to work 24 hours per day for the preservation of sperm whales
- all technologies used are well established but this is the first time that they are adopted for this purpose
- it is the first time, at least in Italy, that the Coast Guard is directly involved in sperm whale preservation
- it is the first time that an acoustic interference system has been demonstrated to be able to recognize the sound wave profile.
- the route of most of the sperm whales recorded during the final sea campaign follow the underwater canyon as expected in literature. This result probes the accuracy of the system.
- for the first time a system has been able to predict timely the emersion location of the sperm whale in order to allow a visual identification

6. Policy implication:

WHALESAFE aimed at introducing the acoustic monitoring as a mean to localize sperm whale and evaluate the level of risk. This program is in the frame of other succesful project as REPCET where the visual localization is used to create a map of the presence of sperm whale in PELAGOS so that ships can adjust their routes accordingly in order to reduce the risk of collisions. We proved that acoustic monitoring has a great advanted compared to the visual localization because the former can be performed for the whole duration of the divings, while the latter is effective only when the animal is already on surface (i.e. for a rather short period of time). In addition we verified that acoustic monitoring is by far more effective than visual because the echolocalization sounds can be detected also a very large distances: for all detected sperm whales in WHALESAFE there were no alert generated by visual sighting!
The implementation of acoustic monitoring system together with the support of the National Coast Guard can drastically reduce the risk of impact for sperm whale.

# 6. Key Project-level Indicators

To assess the good functioning of the proposed management plan for WHALESAFE project we will use the follow indicators, considering that in the After Life plan we indicate KM3NeT/ORCA and FERA'S LIFE as the next applications of WHALESAFE

1) **Number of detected sperm whales tracks inside the project area**
   300/yr
2) **Number of sperm whales detection per month of operation**
   2.5
3) **Number of boat in the area/alarm**
   2
4) **Number of monitored cetacean species**
   3
5) **Functioning rate**
   90% (300 days/yr)
6) **Number of communications to the general public**
   2/yr
7) **Number of communications to specialized audience**
   2/yr
8) **Number of accesses to the web site**
   1000/yr