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Underwater Acoustics and Whales in the Mediterranean Sea

by Walter M.X. Zimmer[1]

Summary: The presence of whales in the Mediterranean Sea is well documented and eight species of cetaceans can be found on a regular basis. As a result of this presence and because of a perceived threat to Mediterranean marine mammals by anthropogenic factors, Italy, France and Monaco created a cetacean sanctuary in the Ligurian Sea in 1999. In 1998, the NATO SACLANT Undersea Research Centre adopted a marine mammal risk mitigation policy to minimize the impact of the Centre's underwater research activities on marine mammals. At the same time the Centre initiated a multi-disciplinary research project to understand the presence and absence of cetaceans in the oceanographic context and to improve the knowledge of the affect of active sonar on cetaceans. To this goal a Sperm Whale *(Physeter macrocephalus)* was tagged in 2001 with a self-recording device and exposed to moderate sonar signals. Preliminary analysis indicates that no disruption of behaviour was observed during sonar exposure up to 120 dB re μPa@ 1 m received level. The result of this experiment and future research plans are discussed.

INTRODUCTION

In the Mediterranean Sea we find on a regular basis eight species of cetaceans and one species of pinniped (Tab. 1, DI SCIARA & DEMMA 1957). In the summer months an increased concentration of cetaceans has been observed in the north-western part of the Mediterranean Sea.

Zipius cavirostris	Cuvier's Beaked Whale	Cuvier-Schnabelwal	rare
Balenoptera physalus	Fin Whale	Finnwal	3500+
Physeter macrocephalus	Sperm Whale	Pottwal	rare
Globicephala melas	Long Finned Pilot Whale	Gewöhnlicher Grindwal	rare
Grampus griseus	Risso's Dolphin	Rundkopf-Delphin	frequent
Tursiops truncates	Bottlenosed Dolphin	Großer Tümmler	frequent
Delphinus delphis	Short-beaked Common Dolphin	Gemeiner Delphin	rare
Stenella coeruleoalba	Striped Dolphin	Blau-weißer Delphin	200,000
Monachus monachus	Mediterranean Monk Seal	Mittelmeer-Mönchsrobbe	very rare

Tab. 1: Presence of marine mammals in the Mediterranean Sea.

As a result of this presence and by "considering the threats encountered by Mediterranean marine mammals and in particular to their habitats" (http://www.oceanlaw.net/texts/ sanctuary.htm), Italy, France and Monaco created in 1999 a marine mammal sanctuary in the Ligurian Sea. However, there is only little information on the abundance of marine mammals (Tab. 1). We have inadequate knowledge of where cetaceans go in the winter, if the different species are migrating in and out of the Mediterranean Sea and when, and in particular, if there are areas devoid of cetaceans.

ACOUSTIC RISK MITIGATION

In 1998, the NATO SACLANT Undersea Research Centre (SACLANTCEN) responded to concerns about the impact of underwater sound on marine mammals by implementing an acoustic risk mitigation policy and by establishing a research project to overcome the lack of scientific knowledge relevant to marine mammal acoustic risk mitigation.The acoustic risk mitigation policy applies to all SACLANTCEN experiments with underwater sound emission and is characterized by three requirements:

- An Environmental Scoping Study is carried out to find areas of no or low cetacean presence.
- Tracks are planned taking into account acoustic propagation and predefined thresholds for sound exposure.
- Special effort is required to ensure a mammal-free zone, by visual and acoustic observation and by ramping up the sound exposure immediately prior to an experiment. The appropriate procedures depend on species, sound frequency and signal type.

SOLMAR PROJECT

Parallel to the implementation of an acoustic risk mitigation policy, SACLANTCEN initiated a research project, designated Sound Oceanography and Living Marine Resources (SOLMAR) to overcome the known shortfalls in meeting it's goals for acoustic risk mitigation. This project is multidisciplinary and supported by scientists from Italy, USA, UK and other NATO Nations. The area of interest is initially restricted to the Ligurian Sea, but may be extended to other areas of interest to SACLANTCEN.

In particular we wanted to know where and where not we might encounter cetaceans. For this we implemented a database for historic standings and sightings and carry out on a yearly basis cetacean surveys, called SIRENA, with state of the art visual and acoustic tools. During these surveys we

[1] NATO SACLANT Undersea Research Centre, Viale S. Bartolomeo 400, 19138 La Spezia, Italy; <walter@saclantc.nato.int>

measure additional oceanographic and biological parameters, which may be useful for cetacean habitat descriptions.

We continuously improve our techniques to detect cetaceans by visual and acoustical means in varying weather conditions.

Finally we would like to know what the expected behaviour change is as a function of the underwater sound. To this end we carry out experiments in which selected species are exposed in a controlled way to sonar.

Sperm Whales and oceanography

A major objective of the SOLMAR project is to describe the actual cetacean habitat by oceanographical and biological parameters. It is known for example, that Sperm Whales are usually found close to the 1000 m contour line, in areas of ocean upwelling and downwelling (JAQUET 1996). During our first sea trial in 1999, we expected to find Sperm Whales along the 1000 m contour line, but had no success. In 2000 and 2001 we found Sperm Whales in the middle of the Corsica-Ligurian-Provencal Basin.

Figure 1 shows the Sperm Whale sightings of SIRENA 2001 overlaid on a representation of the 13.8 isotherm surface. We can see clearly that most Sperm Whales were found in the vicinity of a dome of cold water.

Driven by cyclonic currents and westerly winds this dome is probably generated by ocean upwelling. The number of measurements (year to year, season to season) is not large enough to establish a general correlation and to obtain a prediction capability.

Passive Sonar

The use of sonar is one of the major expertises of SACLANTCEN. Our quiet research vessel, NRV Alliance, allows continuous passive acoustic surveys and a long horizontal line array (128 hydrophones) gives us the spatial and spectral resolution required to detect and/or track and count acoustic sources.

Figure 2 shows a typical snapshot of the passive sonar display. On the left we see the clicks of a nearby Sperm Whale and on the right we see the associated spectrum. In the middle of both sides (about -14 s) we can recognize a sequence of weak and fast clicks, called creaks, which are attributed to foraging events (GORDON 1987). In addition to this Sperm Whale, we detect other Sperm Whales in different directions and the fast clicks of a single dolphin.

Tagging

In addition to the SACLANTCEN sonar facilities, the SOLMAR project uses digital tags (DTAG) developed by Mark Johnson and Peter Tyack from Woods Hole Oceanographic Institution (WHOI). This DTAG is attached to the animal by means of suction cups and has been successfully attached by the WHOI team on Sperm Whales, Right Whales and Pilot Whales (JOHNSON & TYAK 2003). Key elements of this tag are the built-in hydrophone, the 3-axis accelerometer and 3-axis magnetometers.

The first interesting result is the reconstruction of the underwater track of the animal (Fig. 3). We see the horizontal component of the animal track (in green). The blue dots are the

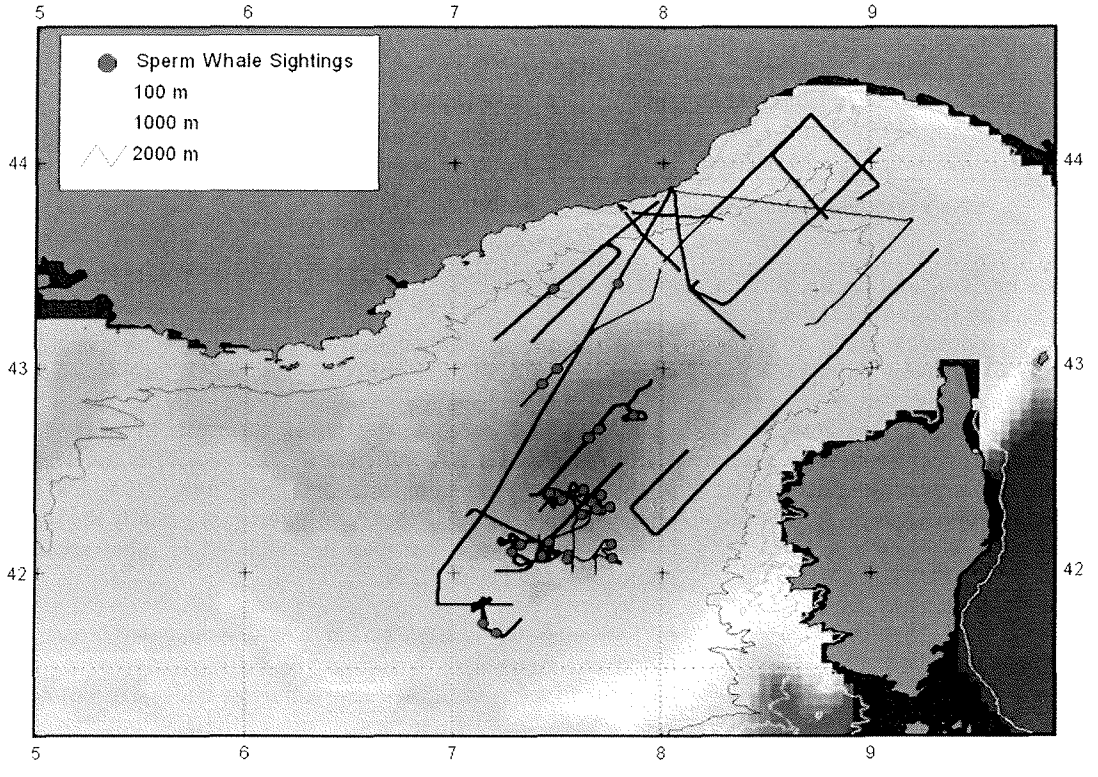

Fig. 1: Sperm Whale sightings during SIRENA 2001 overlaid on a representation of the 13.8 isotherm surface; red = deep, blue = shallow.

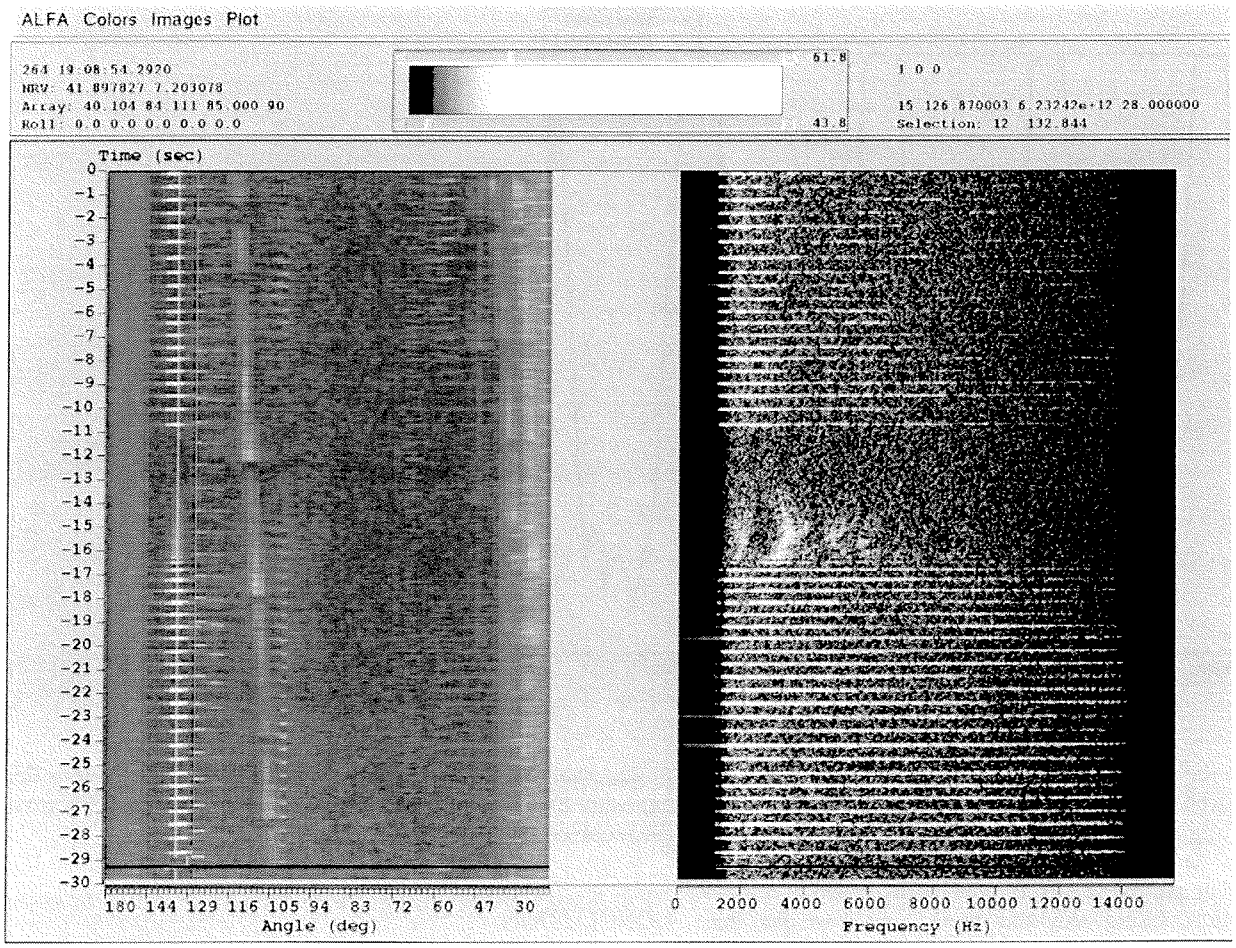

Fig. 2: Passive sonar display.

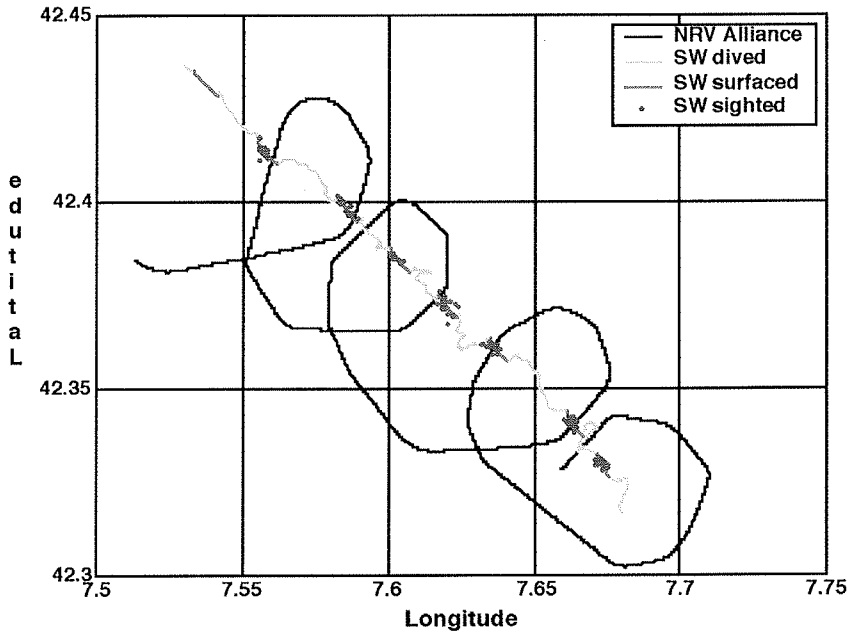

Fig. 3: Reconstruction of Sperm Whale (SW) track; NRV *Alliance*, the research vessel.

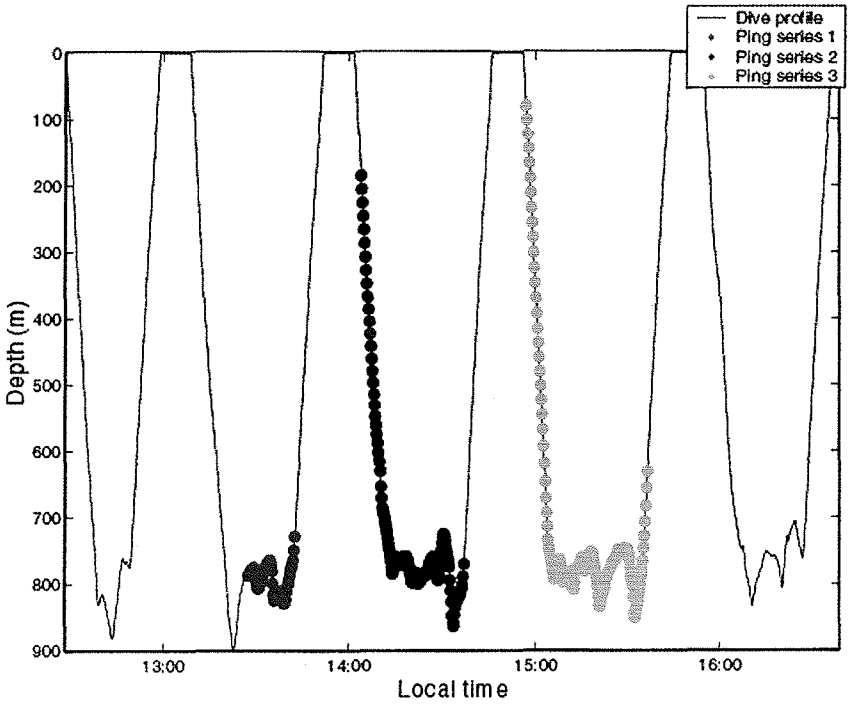

Fig. 4: Vertical Sperm Whale dive profile.

positions from the visual sightings. During the whole experiment, the research ship (black line) was able to stay with the animal by circling around it. This was only possible due to the Target Motion Analysis (TMA) capabilities of the passive sonar system. The animal seems to move undisturbed in northwesterly direction. Using only the depth sensor we get the time-depth plot known also from other tag types. The animal is diving consistently to a depth of 700 to 900 m (Fig. 4) where it stays for about 20 minutes before it comes up again to the surface. This is consistent with independent observations (WATKINS et al. 1993). Remarkably, the water depth is 2600 m and therefore the animal does not feed close to the bottom but above mid-water, a fact that may be related with the upwelling observed in the oceanography.

The first dive is shorter than the other dives, which is probably due to the tagging event. The dots indicate sonar transmissions carried out by our research vessel. During the 2nd, 3rd and 4th dive we transmitted a sequence of short sweeps every 15 seconds (0.1 s FM sweeps with 200 Hz bandwidth around 2.6, 3.8, 8 and 15 kHz). No dramatic reaction can be seen in the dive pattern. Analysis of the acoustic data on the tag hydrophone revealed 120 dB re 1 μPa as maximum received level for our sonar signal. Taking into account the above figures (horizontal track and dive profile) we can say that, for our sonar signal, a received level of 120 dB was not sufficient to generate dramatic avoidance reactions. In future controlled exposure experiments, however, we will try to slowly increase the received level above 120 dB.

CONCLUSION

The NATO SACLANT Undersea Research Centre addressed the marine-mammal noise issue by establishing a risk mitigation policy and by initiating a research programme to improve this policy by acquiring as much scientific knowledge as possible on marine mammal distribution, behaviour and response.

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