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Acoustic tracking methods in the Natural Marine Reserve of Miramare: monitoring the movements of target species inside a marine protected area, a case study

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Abstract - Here we describe the experimental set-up and outline the procedure for monitoring the movement of two target species, the European lobster (*Homarus gammmarus*) and the brown meagre (*Sciaena umbra*), by means of acoustic tracking systems. European lobsters are commercially important and actually over-exploited crustaceans; the brown meagre is a sonic fish, which has been protected since 1995 by the RAC-SPA Barcelona convention (UNEP annex 3 of RAC-SPA protocol). Both animals display a night activity and this characteristic makes their behaviour very difficult to study. We used two different acoustic tracking systems to check the short-term behaviour of individuals released inside the Miramare marine protected area in the summers of 2001 and 2002. In presenting our results, we discuss (1) the different methods of tagging animals with acoustic transmitter tags, (2) the benefits and disadvantages of the two tracking systems and (3) the relevance of the acoustic tracking method from the viewpoint of monitoring and restocking purposes.

1. Introduction

The Natural Marine Reserve of Miramare was created in 1986 and can be classified as a 'controlled natural reserve' according to the IUCN provisions. In 1996, the protected area was also recognised within the UNESCO 'Man and Biosphere' programme as a 'biosphere reserve'. The Reserve aims to maintain ecological processes and biological diversity, focusing on the

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development of scientific research and environmental monitoring as an important management objective (Man and the Biosphere - MAB Program; UNESCO, 1987).

Being a protected area, the Reserve's objective is to provide shelter, and thereby, protect a portion of the local reproductive population from fishing. However, this starts from the assumption that the adult individuals are relatively non-migratory in their behaviour. Therefore, local behaviour and habitat use are of extreme importance when undertaking enhancement and management programmes. The primary source of information on the behaviour of marine animals (as crustaceans or fish) comes from laboratory studies, which, however, entail certain limitations, particularly in large-sized species, and do not allow for an analysis of certain aspects such as habitat use, movement and biotic interactions. Telemetry is a step forward in the study of behaviour in the field. Telemetry means 'measuring from a distance' since direct interaction between operators and studied animals are limited to the tagging procedure: after an individual is fitted with an acoustic transmitter, it is followed for as long as possible from the research boat, estimating its position at regular intervals.

With this work, we aimed to develop a telemetry methodology, i.e. (1) to test different methods of tagging animals with acoustic transmitter tags, (2) to define the benefits and disadvantages of two different tracking systems, (3) to evaluate the relevance of the acoustic tracking method from the viewpoint of monitoring and restocking purposes.

2. Materials and methods

2.1. Description of the acoustic tracking systems at the project's disposal

We used two different types of acoustic tracking systems, i.e. the VR28 and the VR1 Tracking Systems (©Vemco Ldt., Halifax, Canada). The VR28 Tracking System consists of a four channel ultrasonic receiver, connected to a four element hydrophone array which has to be located under the research vessel. The quadritic hydrophone array provides 360 degrees of monitoring coverage. The VR28 Receiver is connected to a computer so that it monitors the signal strength on each of the receivers and uses this information to calculate the bearing to the transmitter. The bearing is shown graphically on the TRACK28's main tracking screen, with a bar graph of signal strength and background noise level on each hydrophone. Working with VR28, we used the continuous V8-2L-R256 transmitters (©Vemco Ldt., Halifax, Canada), that emit at the constant rate of 1 emission per second at 76.8 kHz. Each transmitter may last for about 6 months.

The VR1 Receiver, on the other side, is a submersible, single-channel receiver capable of identifying coded transmitters. It consists of a hydrophone, receiver, ID detector, data logging memory and battery, all housed in a submersible case (205 mm length, 60 mm diameter). The case may be easily moored underwater. The VR1 Receiver records automatically the identification number and time stamp, for a maximum of six months, from acoustic transmitters as the animal being studied travels within receiver range. Four VR1 receivers were located inside the Natural Marine Reserve of Miramare, in proximity to the rocky reefs present in the area. The range of detection of the receivers is about 300 meters at the most, however it strongly depends on the bottom topography. Working with VR28, we used the coded V8-1L transmitters (©Vemco Ldt., Halifax, Canada), that emit a train of six pings to identify themselves each 40-60 seconds at a 69-kHz frequency. Each train contains a sync period, identification periods, and verification periods. Each transmitter may last for about 6 months.

2.2. The target-species

We applied the acoustic tracking technique to two different species: a crustacean, i.e. the European lobster (*Homarus gammarus L.*) and a teleost fish, i.e. the brown meagre (*Sciaena umbra L.*). European lobsters are large, mobile, commercially important crustaceans. The small size of the marketed *H. gammarus* throughout the Mediterranean Sea suggests a species over-exploited (Relini et al., 1999). The brown meagre, on the other side, is a sonic fish which has been protected since 1995 by the RAC-SPA Barcelona convention (UNEP annex 3 of RAC-SPA protocol, i.e. the list of fish species whose exploitation has to be regulated). Both target species are actually under strong fishing pressure and therefore need an effort towards conservation. Being both nocturnal species, they are extremely difficult to study with conventional visual techniques.

Both species are naturally present at the Natural Marine Reserve of Miramare. The animals released were caught close to Pirano (Slovenia) and then traslocated to the Reserve. In fact, if transplanted animals do not leave the release-area, the marine reserve may play a crucial role in restocking depleted species under overfishing pressure.

3. Results

3.1. Tagging procedures

In decapod crustaceans, as the lobster, the presence of an exoskeleton offers an evident advantage for attaching external tags. The tagging procedure was relatively easy: the transmitter was attached to the dorsal surface of the cephalothorax with quick-setting epoxy resin, after drying the carapace with alcohol (Van der Meeren, 1997). The procedure lasted 2 minutes. On the other hand, the tagging procedure of teleosts is one of the most frequently addressed problems in animal telemetry. Therefore, external and internal tagging procedures on anaesthetised brown meagres were tested during this study. We tagged six brown meagres externally, i.e. securing the transmitter onto a side of the fish with nylon wires inserted through the dorsal musculature (Lewis and Muntz, 1984). Two brown meagres were tagged by forced insertion of the transmitter into the stomach (Mellas and Haynes, 1985) and two brown meagres were tagged by surgical intraperitoneal implanction (Adams et al., 1998). Six of the externally tagged fish shaded their pingers within 24 hours and the other two kept pingers for more than 5 days; all brown meagres showed wounds and infections. The transmitters located in the stomach were regurgitated by the fish within 48 hours, whereas the transmitters implanted in the peritoneal cavity were retained more than 20 days and the brown meagres recovered within 24 hours from the operation, showing normal feeding and swimming behaviours. We concluded that intraperitoneal implantation is the best tagging procedure considering both the retention of the transmitter and the health of the animal.

3.2. Tracking at sea: lobsters' movements

On 16 May 2001 and 13 July 2001 two tagged lobsters were released in different locations of the Reserve at about midday at a depth of about 8 meters, and were then monitored by means of the VR28 Tracking System. In both cases, even if shelters were present at the site, the animals departed from the releasing point and moved continuously for 10 hours before settling inside the Reserve, at 150 m from the releasing point, and for 5 hours before settling outside the Reserve, at 1100 m from the releasing point, respectively. The lobsters stopped at 3- and 17- meter depth respectively, in locations were beach rocks were present. The max recorded speed of the animals was 200-300 m/hour. The animals were followed for 26 hours and 72 hours of continuous tracking before the signal of the transmitters was definitely lost. A total of 130 and 150 hours of active search was carried out after the last signal received before stopping the session.

During the periods 13-29 May and 23-28 May 2002, two other lobsters were released in succession at exactly the same location (at the rocky reef of Miramare) and their presence was detected by means of the VR1 Tracking System. A total of 7038 signals were detected by the four hydrophones (5407 and 1646 signals from each lobster, respectively) before the animals exited definitely from the range of detection of the four VR1 receivers located in the Reserve. It is interesting to note that the number of detections increased dramatically after the release of the second lobster. In two cases, we observed that a large number of signals originating from both lobsters were detected simultaneously by the same VR1 receiver. It is very likely that the lobsters interacted among themselves after being released.

3.3. Tracking at sea: brown meagre movements

On 31 July 2002, a brown meagre was released at about midday at the rocky reef of Miramare at a depth of about 8 meters. The animal was monitored by means of the VR28 Tracking System. The animal hid in the rocky shelters present at the site for the first 10 hours (up to 22.20 p.m.); at night the animal moved away from the reef, leaving the protected area at about 23 p.m. The animal swam along the coast in a north-oriented direction up to 24 p.m., when the monitoring was stopped due to bad weather conditions. The fish was no longer identifiable in the area (2500 meters from the realising point) after the beginning of a new monitoring session, at 5 a.m. the following day. After the last signal received, a total of 30 hours of active search was carried out before stopping the search. The max recorded speed of the animals was 1.5 km/h.

Another brown meagre was released at the rocky reef of Miramare and its presence was detected by means of the VR1 Tracking System during the period 31 July - 30 December 2002. A total of 2997 signals were detected by the four hydrophones. The presence of the animal was sporadic during time; the last signal was recorded on 7 November 2002. 638 signals were received almost simultaneously from different receivers (inter-pulses delay < 11 sec.), allowing a refined positioning of the animal by triangulation.

4. Discussion and conclusions

Our results, both on lobsters and brown meagres, demonstrate that locating a transplanted animal in a suitable area does not imply the colonisation of the area itself. To the contrary, all the animals traslocated to the Reserve moved away from the releasing site. Considering the characteristics of the Reserve, the departure of the animals can reasonably be not related to the lack of food, nor to the lack of shelters, but rather it is likely linked to social interactions between conspecifics, due to the high population density usually defined as part of the 'Reserve Effect' (Ciriaco et al., 1998).

The acoustic tracking systems have proven to be an effective way of monitoring movements and activity of individual animals without the need for directed observations. The active tracking system (VR28) was not ideal for tracking lobsters because the varied bottom structure and the shelter-seeking behaviour of this species, did not allow the hydrophones to identify the signals originated by the pingers. Moreover, in this study active tracking on brown meagres was strictly limited by time and weather constraints. We conclude that this technology is ideal for short-term studies, that need accurate positioning.

The automating monitoring system (VR1) was suitable for our kind of research: it provided continuous recorded monitoring of many individuals simultaneously, it does not suffer from time or weather constrains and it is still active at that moment. The use of four VR1 hydrophones did not complete coverage of the protected area of Miramare, however allowed the monitoring of the two local rocky reefs (where most of the animals are usually located) with a degree of overlapping between range of the the four hydrophones that permitted a rough triangulation. In fact, the spatial resolution obtained by the VR1 system is not amenable to analysis of fine-scale movements. However, dial activity and site affinity pattern may be easily studied by VR1-data, provided that the animals stay within the range of the receivers. We consider that VR1 mode is ideal for applications such as site residency studies or for long-term monitoring of animal movements in an MPA or in hot-spots (i.e. to evaluate the colonisation of an area by transplanted animals).

Concluding, we would like to underline the potential of the telemetry technique as a tool for managing a marine protected area. Possible fields of application are:

1. monitoring - telemetry as tool for detecting the home range of the animals;
2. conservation - telemetry as a tool for designing a network of protected area;

3. scientific purpose - telemetry as tool for describing variables in animal movements;
4. restocking - telemetry as tool for understanding animal behaviour and recognising the best way for restocking.

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