# MOVEMENT PATTERNS OF BLACK AND RED SCORPION FISH ON ARTIFICIAL REEFS IN THE AEGEAN SEA, TURKEY

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## Abstract
This paper presents the results of an application of a new ultrasonic telemetry method for black scorpionfish (*Scorpaena porcus*) and red scorpionfish (*Scorpaena scrofa*) inhabiting an artificial reefs in the northern Aegean Sea, Turkey. The objective of the study was the use of Vemco Positioning System (VPS) methods to determine the residency and fine-scale movements of both species around artificial reefs. The results provided proof for a variety of aspects of the behavioural biology of both species, including strong site-fidelity and low levels of mobility around artificial reefs The results can be offer useful approach to decision makers in the field of sustainable fisheries in artificial reef sites.

*Keywords: Artificial reefs, Fish behaviour, Acoustics, Aegean Sea, Fisheries*

Artificial reefs have been widely implemented as tools for biodiversity conservation and fisheries management, amongst other goals. *S. porcus* and *S. scrofa* are associated with artificial habitats in the Mediterranean Sea [1, 2]. However, fine-scale movements and use of artificial reefs by both species is unclear. This paper, aims to report the residency and movements of these species around artificial reefs, using the VPS. The study was carried out between August 2013 and August 2014 in the Gulf of Edremit in the Northern Aegean Sea. The artificial reefs area was created by The Republic of Turkey Ministry of Food, Agriculture and Livestock between 2009 and 2012 which consist on ~7000 concrete blocks and approximately 3.7 km$^2$, it runs parallel to the coastline and has depths ranging between 12 and 32 m (Fig.1).

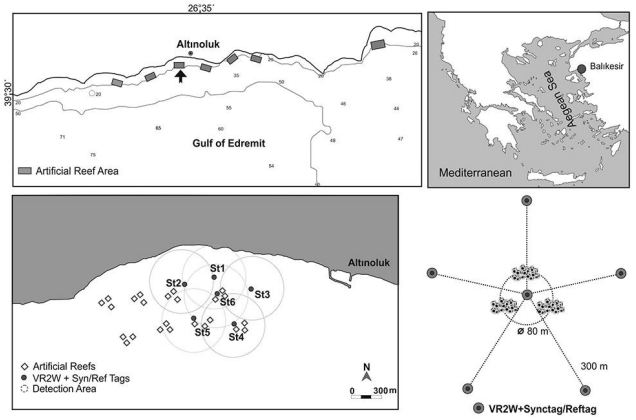


Fig. 1. Artificial Reef Area and VPS Design for Artificial Reefs

Movements of tagged fish within the artificial reef site were tracked using the VPS, which consists of receiver, synchronization tags and data processing [3]. In this study, six receivers (Vemco VR2W) were placed around the artificial reefs using a pentagonal design. Fourteen *S. porcus* (X = 23.3 cm TL) and seven *S. scrofa* (X = 32.1 cm TL) were caught with trammel nets and were surgically implanted with Vemco V8 and V9 tags. After surgery fish were released in artificial reefs with divers. To quantify the degree of site fidelity of tagged fish in the study area a residency index (RI) was calculated. In the present study, a total of 936867 detections were downloaded from the array of receivers and a total of 85442 positions were determined by the VPS system. The VPS system calculated the highest number of positions (45859) for fish coded T01 while no positions were calculated for T07 and T18. The tagged fish, the rates of detection and calculated positions are summarized in Table.1.

The tagged *S. porcus* and *S. scrofa* were found to have stayed in the artificial reef area for average 22.8 ± 4.4 days and 61.3 ± 10.1 days respectively. Average residency index (RI) values, defined in relation to the position of the acoustic array were 0.88 ± 0.10 for *S. porcus*, and 0.95 ± 0.00 for *S. scrofa*. These values show that both species have high interactions with artificial reefs. Fish size was not significantly correlated with residence index. However, there were significant correlations between fish size and total period of detection ($p<0.05$).

Tab. 1. Characteristics of tagged *S. porcus* and *S. scrofa* (TL: Total length; TP: period between the release date and the last detection; DD: total number of days detected; RI: residence index).

| Fish ID | Species | TL (mm) | Weight (g) | Tag | Detections | Positions | TP (d) | DD (d) | RI |
|---|---|---|---|---|---|---|---|---|---|
| T01 | *S.scrofa* | 445 | 1347.6 | V9-2H | 262559 | 45859 | 102 | 99 | 0.97 |
| T02 | *S.porcus* | 271 | 359.4 | V9-2H | 158398 | 21098 | 48 | 48 | 1.00 |
| T03 | *S.scrofa* | 364 | 852.2 | V9-2H | 35954 | 5788 | 48 | 48 | 1.00 |
| T04 | *S.porcus* | 211 | 162.8 | V8-4H | 16071 | 408 | 34 | 34 | 1.00 |
| T05 | *S.porcus* | 195 | 121.4 | V8-4H | 7197 | 145 | 25 | 25 | 1.00 |
| T06 | *S.porcus* | 182 | 109.4 | V8-4H | 32117 | 1874 | 24 | 24 | 1.00 |
| T07 | *S.porcus* | 196 | 123.5 | V8-4H | 101 | 0 | 1 | 1 | 1.00 |
| T08 | *S.porcus* | 238 | 275.3 | V8-4L | 2421 | 16 | 7 | 6 | 0.86 |
| T09 | *S.porcus* | 206 | 170.5 | V8-4L | 1256 | 16 | 15 | 6 | 0.40 |
| T10 | *S.scrofa* | 275 | 341.3 | V9-2H | 10158 | 65 | 57 | 57 | 1.00 |
| T11 | *S.scrofa* | 275 | 224.3 | V9-2H | 94146 | 776 | 91 | 91 | 1.00 |
| T12 | *S.porcus* | 277 | 395.0 | V9-2H | 12626 | 527 | 23 | 23 | 1.00 |
| T13 | *S.porcus* | 253 | 288.0 | V9-2H | 171737 | 3021 | 59 | 59 | 1.00 |
| T14 | *S.porcus* | 240 | 287.3 | V9-2H | 47921 | 3278 | 15 | 15 | 1.00 |
| T15 | *S.porcus* | 245 | 238.5 | V8-4H | 309 | 2 | 25 | 8 | 0.32 |
| T16 | *S.porcus* | 223 | 181.9 | V8-4L | 7890 | 13 | 30 | 28 | 0.93 |
| T17 | *S.porcus* | 269 | 370.0 | V8-4L | 5099 | 43 | 12 | 10 | 0.83 |
| T18 | *S.scrofa* | 259 | 271.2 | V8-4L | 4225 | 0 | 23 | 22 | 0.96 |
| T19 | *S.scrofa* | 376 | 1008.1 | V9-2H | 32559 | 1892 | 54 | 38 | 0.70 |
| T20 | *S.scrofa* | 252 | 236.1 | V9-2H | 33751 | 590 | 54 | 54 | 1.00 |
| T21 | *S.porcus* | 259 | 305.1 | V9-2H | 372 | 31 | 1 | 1 | 1.00 |

Acoustic telemetry can be an extremely useful tool to understand the behavior and movement models of the fish type in artificial reefs. This study has contributed new information on black and red scorpion fish movements at artificial reefs and is the first to focus on movements and habitat use of these species using VPS. Acoustical data indicate that artificial reefs and nearby areas provided suitable habitat for *S. porcus* and *S. scrofa* for ecologic reasons [4]. Both species fish showed that clear homing behavior and strong site fidelity. In future studies, should be increased the number of tagged fish and monitoring time to understand fish behaviors in artificial reef area. This will provide us with better understanding of the relationship between fish and artificial reefs and fish and fishermen.

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