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# Project SIMARINE-NATURA (LIFE10NAT/SI/141)

# Technical report on the telemetry of the Mediterranean Shags (*Phalacrocorax aristotelis desmarestii*) (Action A.2)

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# 1 Introduction

## 1.1 The Mediterranean Shag in the Slovenian sea

The Mediterranean Shag (*Phalacrocorax aristotelis desmarestii*) belongs to the cormorant family (Phalacrocoracidae). It is distributed solely in the Mediterranean and the Black Sea and is a distinct sea bird subspecies, breeding on rocky coasts and feeding at sea. Their entire breeding population is estimated at no more than 10,000 pairs, with about half of them breeding within the boundaries of the European Union. It is listed on Annex 1 of the Birds Directive (2009/147/EC).

The Mediterranean Shag does not breed in Slovenia, but merely visits the sea as a summer and autumn vagrant. Its breeding colonies closest to Slovenia are located at Brioni Islands, in the Kvarner region and on the Central Adriatic islands, where its breeding population is estimated at 1,500-2,000 pairs. In the Gulf of Trieste and elsewhere in the Northern Adriatic, Mediterranean Shags gather in the post-breeding period, from late spring onwards. In our country, more than 1,500 individuals are known to spend the summer, which is no less than 5 % of this subspecies' entire population. Each evening they gather at three large communal roost-sites on buoys of shellfish farms: at Sečovlje, Strunjan and Debeli rtič. In addition to these, there are several other small roost-sites along the Slovenian coast. In the morning, they head for the open sea, where they forage on fish.

## 1.2 Telemetry as data source for identification of marine IBAs

Marine IBA identification is based on a set of data sources on population numbers and distribution of seabirds in different stages of their life cycle, and different environmental data like bathymetry, sediments, chlorophyll, underwater habitat types, currents, etc. Ideally, the data should be obtained systematically and different data sources should prove that a particular site is important for conservation of one or more seabird populations. In recent years, telemetry has become one of the most important methods for systematic collection of data on movements and distribution of seabirds which are spending a lot of time away from easily accessible areas.

In the project SIMARINE-NATURA we used telemetry as one of two basic methods for collecting data on distribution of the Mediterranean Shags in the Slovenian sea (the other was the ESAS boat transects method), which was unknown before. Apart from the roosting population estimation there was no data about Mediterranean Shags in the Slovenian sea. Telemetry has been applied on Shags before (France, Greece), but this is the first time that Shags were trapped outside their breeding area and season which posed some technical challenges onto the team of researchers and technicians.

*Figure 1. A team of ornithologists putting a GPS logger on the first trapped individual, named Ari (4.10.2012). Figure 2. Šime, the second trapped Shag (5.10.2014) just before it was released. Photo: Urša Koce*

## 2 Methods and site description

### 2.1 Trapping method, location and season

The Shags were being trapped with modified clap-traps made by the field work team. The shape of traps was adapted so that they could be mounted on three different floating objects: vertical cylindrical buoys (r ≅ 1 m), cubic rafts (a = 1 m) and horizontal cylindrical buoys (r ≅ 0.4 m) (Figures 3 and 4). The trap was triggered remotely by the user when one or more Shags sat on the buoy or the raft.

*Figures 3 and 4. Round and square traps for the Mediterranean Shag set on vertical cylindrical buoy and a raft, respectively. Photos: Luka Novak and Urša Koce*

The traps were set at three sites by the Slovenian coast: (1) in the Viližan bay on the east side of the town of Izola and at two communal roost-sites of the Mediterranean Shags near Strunjan (2) and Sečovlje (3) (Figure 5). At the Izola trapping site the traps were mounted on four existing vertical cylindrical buoys, two at a time. At the Strunjan and Sečovlje trapping sites two cubic home-made rafts were tied among the existing buoys of the shellfish farms where the Shags usually rest, one at each site. Three additional traps were set on the existing surrounding horizontal cylindric buoys at the Strunjan trapping site.


*Figure 5. Trapping sites of the Mediterranean Shags by the Slovenian coast in years 2012–2014.*

The Shags were being trapped in autumn 2012 and in summers 2013–2014. The original time plan of the Telemetry action (A.2) was to trap Shags in summers 2012 and 2013 but unexpected technical problems with the GPS loggers which occurred in season 2013 prevented us to finish the field work within the original time plan. The action was thus extended till the end of the summer 2014 when the field work was successfully concluded.

## 2.2 Tracking devices

We used GPS-GSM loggers of Polish producer ECOTONE for tracking the Shags. In 2012 DUCK-3 model was used (3 units) (Figure 6) which was later replaced with a smaller SAKER model. This one was adapted for deep diving in series 2014 (filled with resin instead of polyurethane). The dimensions of the DUCK-3 model were nn X nn X nn mm, weight = 40 g, and those of the SAKER model were 45 X 25 X 18 mm, weight = 25 g. The devices were mounted on birds permanently, as backpacks with straps of teflon ribbon (Figures 6 and 7).

The devices are supplied with energy through solar panels, which can provide enough energy in good light conditions to fix a GPS position every half an hour. The data are transferred to server by SMSs after every 4 GPS fixes. They are accessible to the user by internet through a password protected web panel. Frequency and accuracy of GPS fixes, and operating hours of the loggers can be set remotely via the web panel. We tended to set the highest frequency of fixes during the day but sometimes it needed to be lowered due to energy savings. The loggers were switched off during high night hours.

The advantages of these devices are: relatively high frequency of GPS position fixes, extended period (from several months to well over a year) of activity due to solar source of energy, and remote data download. Especially the latter characteristic is crucial to track the Mediterranean Shags in their non-breeding areas, where recapture of the individual with the tracking device is practically impossible.

*Figure 6. GPS-GSM logger ECOTONE DUCK 3 with straps of teflon ribbon for backpack mounting on a bird. DUCK 3 series was wrapped in plastic to prevent watering in low depths. Photo: Urša Koce*

*Figure 7. Mounting a GPS logger on the Mediterranean Shag. Photo: Tomaž Mihelič*

### 2.3 Data analysis

The original dataset was cleared before it was used for the mIBA analysis. First, we omitted the GPS locations which were fixed:

- before the Shag was released,
- after the Shag died,
- with an obvious error (i.e. more than 100 m inland).

Tthe outcome dataset is referred to as 'clear dataset' in this report.

The locations in the 'clear dataset' were grouped by a date-individual grouping variable. They were categorized into three diurnal periods: 1] day, 2] twilight and 3] night, based on astronomical data about time of sunrise, sunset and beginning or end of nautical twilight in Ljubljana, Slovenia (http://www.timeanddate.com/sun/slovenia/ljubljana).

The 'clear dataset' was used to identify roost locations of the Shags. Locations of 5 Shags which were tracked for less than 3 days (Table 1) were excluded from the analysis at this point. One roost location per day was identified for each Shag. A roost location of individual Shag was defined as the first fixed location in a day (usually early in the morning before the Shags leave their roost sites).

Based on clusters of roost locations (i.e. groups of at least 5 locations not further than 500 m from one another), roost-sites by the Slovenian coast were identified. (Roosting events in the Italian and Croatian territorial sea were excluded from the analysis.) A centre of each roost site was defined as the mean mid-point. Individual roost locations not belonging to any roost-site were omitted from further analysis.

In the next step a subset of locations which corresponded to date-individual values of the retained roost locations was extracted from the 'clear dataset' in order to create a set of locations belonging to those Shags which were roosting at the roost-sites identified in the previous step. This subset is referred to as 'reduced dataset' in this report.

In order to focus on the areas where the Shags have been most likely foraging and not only resting, more locations were omitted from the resulting dataset:

- locations in roost sites other than the one where the Shag actually roosted,
- daytime locations in the Shags' roosting sites,
- arbitrary locations at daytime resting places (i.e. locations next to the fish market where at least two tagged shags have been known to be fed by fish sellers; known daily resting spots, etc.),
- night and twilight locations outside roost sites.

We refer to the resulting dataset as 'end dataset' in this report.

The analysis for the identification of marine IBAs was done according to the Methods for identifying marine IBAs using seabird tracking data (BirdLife international 2013). The protocol consists of eight analytical steps: 1] creating data groups, 2] splitting dataset to trips, 3] calculating the scale of interaction with the environment (i.e. ars scale), 4] identifying the core use areas (i.e. kernels), 5] checking for significant site fidelity, 6] assessing representativeness of the dataset, 7] identifying the areas more intensively used by several individuals, and 8] applying threshold values to these areas (estimated as % of population that visits each area) and thus identifying the areas which represent mIBA candidates. (Steps 2–7 were applied to each data group.)

The data groups were created based on roost-sites of the Shags. We thus obtained 10 subsets of 'end dataset', one for each roost-site, and from hereon we describe the method for analysing individual subsets. Each subset was further split to trips. A trip was defined as a returning journey of individual Shag, starting and ending at the same roost site (corresponding to the concept of central place foraging). A set of locations was considered to represent a trip when the Shag moved at least a defined distance from the roost centre, stayed on its journey at least 1 hour, and returned back to the roost site (i.e. closer than a defined distance from the roost centre). The distances (referred to as inner and outer buffer) for each roost-site were defined according to the roost-site characteristics (Table 6). Furthermore, trips with less than six locations were automatically omitted from the dataset because they were below the threshold for identification of core use areas in step 4. The core use areas, where the Shags spent most of their time during their trips, were identified by fitting the kernels (kernel density analysis), whereby the scale of interaction with the environment (ars scale) calculated in step 3 was used. A variance test (step 5) was applied on the resulting set of kernels to check for significant site fidelity in each individual. In case the site fidelity of one or more individuals was significant, only one randomly chosen trip per individual was chosen for further analysis, to avoid bias due to pseudo replication. Assessing the representativeness of the dataset, using bootstrap method in step 6 provided a population threshold value to be used in step 7. If the dataset was not representative (bootstrap outcome < 70%), no mIBA candidates could be identified.

# 3 Results

In total 31 Shags were trapped between 3.10.2012 and 27.8.2014. Two of these were not equipped with GPS loggers because it was estimated that they were not fit enough to wear the loggers. They were released wearing only metal and colour rings.

In total 29 Shags were tagged with GPS loggers: 27 at the Izola trapping site and 2 at the Strunjan trapping site. There was no trapping success at the Sečovlje site. 2, 15, and 12 Shags were tagged in years 2012, 2013 and 2014, respectively (Table 1). In 2013, several devices stopped working soon after they were mounted on birds due to technical faultiness (see Preliminary technical report). The data from the devices which stopped working less than 3 days after they were mounted on birds (5 devices) were excluded from further analysis. Data from 24 birds were thus analysed for the purpose of marine IBA identification.

The tracking data used in the analysis was obtained between 3.10.2012 and 30.9.2014. Number of all tracking days in 'clear dataset' differed highly among Shags: from minimum of 0 to maximum of 447 days (average: 72) and so did the number of fixed GPS locations: from minimum of 0 to maximum of 8416 (average: 1428, n=29) (Table 1). The average number of tracking days in the 'end dataset' was 70, and the average number of locations was 608 (n=24) (Table 1).

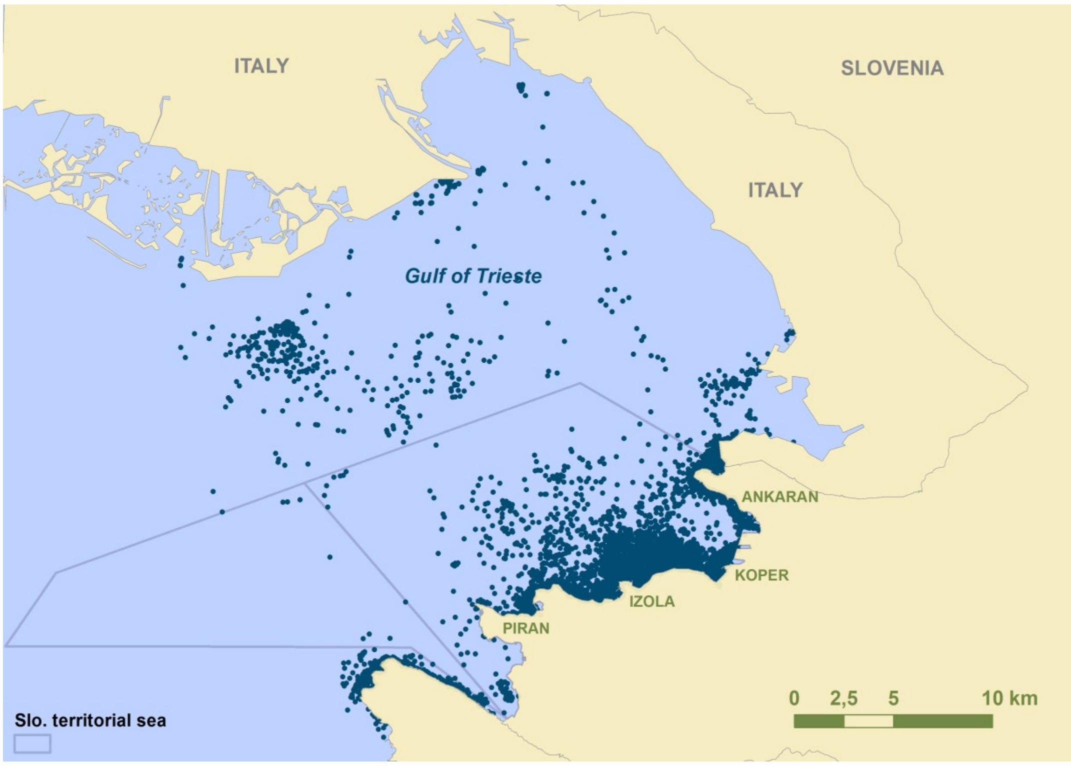



*Figure 8. GPS locations of 29 tracked Mediterranean Shags ('clear dataset'). Only the Gulf of Trieste is displayed. See Figure 15 for locations in Croatian waters.*

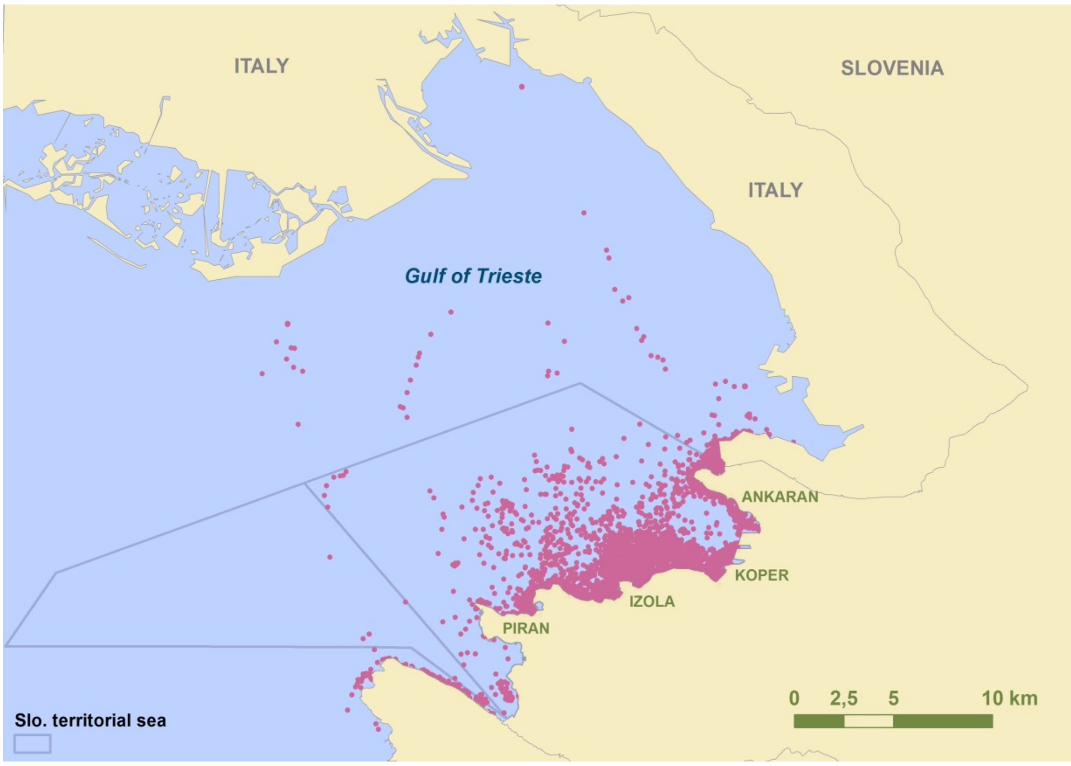



*Figure 9. GPS locations of 29 tracked Mediterranean Shags ('reduced dataset')*

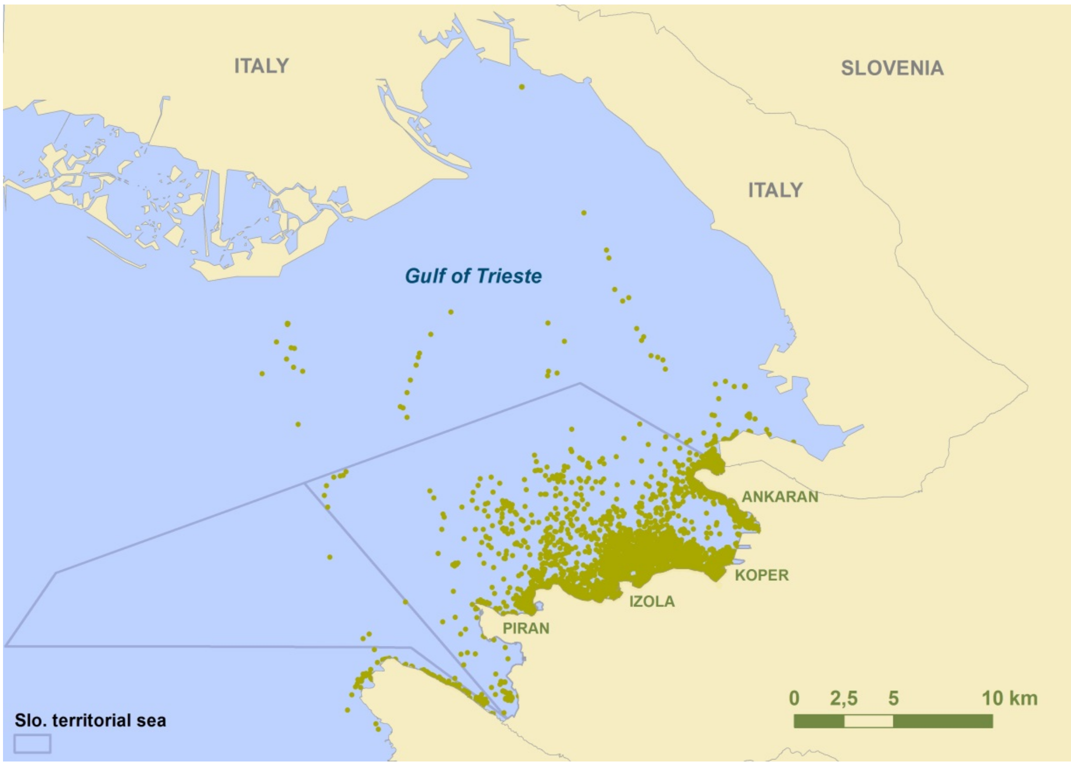



*Figure 10. GPS locations of 29 tracked Mediterranean Shags ('end dataset')*

*Table 1. List of Mediterranean Shags which were tagged with GPS loggers within the scope of the project SIMARINE-NATURA (LIFE10NAT/SI/141) in Slovenia in years 2012–2014. The Shags which were tracked less than 3 days are marked green, and those which were tracked for more than 100 days are marked orange (we refer to the 'clear dataset' summary column). Note that Ugo was trapped twice and that its damaged logger was replaced.*

| ID | Shag name | Age | Mass [g] | Wing length [mm] | EURING code | Colour ring code | GPS | Trapping location | Tagging date | No. tracking days (clear dataset) | No. fixed locations (clear dataset) | No. tracking days (reduced dataset) | No. tracking locations (reduced dataset) | No. tracking days (end dataset) | No. tracking locations (end dataset) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ari | 1Y | NA | NA | 01VK_LJ_SLO | 01A | XSLO03 | Izola | 4.10.2012 | 15 | 405 | 6 | 162 | 6 | 88 |
| 2 | Šime | AD | NA | NA | 02VK_LJ_SLO | 02A | XSLO02 | Izola | 5.10.2012 | 160 | 1377 | 72 | 886 | 72 | 622 |
| 3 | Janez | AD | 1765 | 267 | 11VK_LJ_SLO | 11A | XSLO05a | Izola | 15.6.2013 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Ugo | AD | 1967 | 270 | 12VK_LJ_SLO | 12A | XSLO06a<br>XSLO07b | Izola<br>Izola | 15.6.2013<br>17.7.2013 | 152 | 3053 | 97 | 2652 | 97 | 1416 |
| 5 | Bruno | subAD | 1743 | 262 | 13VK_LJ_SLO | 13A | XSLO03 | Izola | 15.6.2013 | 7 | 230 | 6 | 210 | 6 | 83 |
| 6 | Srečko | 1Y | 1348 | 250 | 14VK_LJ_SLO | 14A | XSLO01 | Izola | 15.6.2013 | 57 | 2358 | 53 | 2264 | 53 | 627 |
| 7 | Štefko | 1Y | 1487 | 265 | 15VK_LJ_SLO | 15A | XSLO08a | Izola | 16.6.2013 | 1 | 20 | 0 | 0 | 0 | 0 |
| 8 | Štelio | 1Y | 1653 | 263 | 16VK_LJ_SLO | 16A | XSLO09a | Izola | 16.6.2013 | 17 | 473 | 16 | 439 | 16 | 183 |
| 9 | Nace | AD | 1878 | 265 | 17VK_LJ_SLO | 17A | XSLO11b | Izola | 5.7.2013 | 91 | 2997 | 84 | 2852 | 84 | 1526 |
| 10 | Momo | 1Y | 1692 | 258 | 18VK_LJ_SLO | 18A | XSLO12b | Izola | 5.7.2013 | 6 | 198 | 5 | 168 | 5 | 68 |
| 11 | Mihi | 1Y | 1678 | 259 | 20VK_LJ_SLO | 20A | XSLO04b | Izola | 6.7.2013 | 440 | 6489 | 429 | 6404 | 406 | 2771 |
| 12 | Jakomo | 1Y | 1560 | 270 | 22VK_LJ_SLO | 22A | XSLO13b | Izola | 10.7.2013 | 447 | 8416 | 444 | 8376 | 437 | 3449 |
| 13 | Vilko | AD | 1343 | 252 | 23VK_LJ_SLO | 23A | XSLO06b | Izola | 10.7.2013 | 1 | 11 | 0 | 0 | 0 | 0 |
| 14 | Karlo | AD | 1541 | 256 | 24VK_LJ_SLO | 24A | XSLO14b | Izola | 11.7.2013 | 74 | 1951 | 61 | 1854 | 61 | 729 |
| 15 | Pino | AD | 1480 | 256 | 25VK_LJ_SLO | 25A | XSLO16b | Izola | 17.7.2013 | 65 | 2168 | 25 | 797 | 24 | 384 |
| 16 | Dino | AD | 1453 | 254 | 26VK_LJ_SLO | 26A | XSLO05b | Izola | 17.7.2013 | 2 | 25 | 0 | 0 | 0 | 0 |
| 17 | Andro | AD | 1546 | 250 | 27VK_LJ_SLO | 27A | XSLO08b | Izola | 17.7.2013 | 2 | 41 | 0 | 0 | 0 | 0 |
| 18 | Nikola | 1Y | 1618 | 273 | 28VK_LJ_SLO | 28A | XSLO05c | Strunjan | 18.6.2014 | 96 | 2462 | 89 | 2427 | 89 | 752 |

| ID | Shag name | Age | Mass [g] | Wing length [mm] | EURING code | Colour ring code | GPS | Trapping location | Tagging date | No. tracking days (clear dataset) | No. fixed locations (clear dataset) | No. tracking days (reduced dataset) | No. tracking locations (reduced dataset) | No. tracking days (end dataset) | No. tracking locations (end dataset) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Tartini | 2Y | 1780 | 252 | 29VK_LJ_SLO | 29A | XSLO06c | Strunjan | 19.6.2014 | 17 | 382 | 16 | 366 | 16 | 158 |
| 20 | Bepo | 2Y | 1568 | 245 | 30VK_LJ_SLO | 30A | XSLO07c | Izola | 14.7.2014 | 62 | 1071 | 60 | 1063 | 59 | 380 |
| 21 | Tonin | AD | 1907 | 266 | 31VK_LJ_SLO | 31A | XSLO08c | Izola | 15.7.2014 | 16 | 285 | 9 | 252 | 8 | 67 |
| 22 | Ante | AD | 1889 | 273 | TA_15034 | P74 | XSLO10c | Izola | 16.7.2014 | 78 | 1656 | 76 | 1623 | 75 | 264 |
| 23 | Ilija | 1-2Y | 1766 | 256 | 32VK_LJ_SLO | 32A | XSLO12c | Izola | 18.7.2014 | 52 | 1323 | 7 | 212 | 7 | 107 |
| 24 | Ivek | AD | 1849 | 264 | 33VK_LJ_SLO | 33A | XSLO17c | Izola | 23.7.2014 | 36 | 774 | 28 | 727 | 28 | 199 |
| 25 | Oto | 3Y | 1527 | 247 | 34VK_LJ_SLO | 34A | XSLO18c | Izola | 29.7.2014 | 29 | 532 | 26 | 490 | 26 | 117 |
| 26 | Ogi | 3Y | 1831 | 260 | 35VK_LJ_SLO | 35A | XSLO19c | Izola | 29.7.2014 | 26 | 733 | 13 | 385 | 13 | 196 |
| 27 | Dado | 1-2Y | 1336 | 257 | 37VK_LJ_SLO | 37A | XSLO15c | Izola | 1.8.2014 | 62 | 928 | 60 | 915 | 46 | 122 |
| 28 | Jura | 1-2Y | 1585 | 262 | 38VK_LJ_SLO | 38A | XSLO09b | Izola | 1.8.2014 | 38 | 648 | 37 | 645 | 23 | 210 |
| 29 | Roko | 3Y | 1698 | 262 | 39VK_LJ_SLO | 39A | XSLO20b | Izola | 27.8.2014 | 36 | 416 | 34 | 385 | 30 | 77 |

*Table 2. Destiny of Mediterranean Shags and of the GPS loggers they were tagged with. The table was updated on 26.2.2015. The Shags with working loggers at that time are marked green.*

| ID | Shag name | Tagging date | Last GPS location date | Migration date | Date of death | Certainty of death | Cause of death | Comments |
|---|---|---|---|---|---|---|---|---|
| 1 | Ari | 4.10.2012 | 17.10.2012 | | 15.10.2013 | confirmed | injury | logger was retreived and reused |
| 2 | Šime | 5.10.2012 | 22.3.2013 | 16.12.2012 | | | | logger stopped working in Croatia |
| 3 | Janez | 15.6.2013 | none | | | | | logger stopped working |
| 4 | Ugo | 15.6.2013 | 15.6.2013 | | | | | logger was damaged and replaced |
| | | 17.7.2013 | 14.12.2013 | 22.10.2013 | | | | logger stopped working in Croatia |
| 5 | Bruno | 15.6.2013 | 21.6.2013 | | 2.1.2015 | confirmed | predation | logger stopped working; fresh eaten carcass found |
| 6 | Srečko | 15.6.2013 | 10.8.2013 | | | | | logger stopped working |
| 7 | Štefko | 16.6.2013 | 16.6.2013 | | | | | logger stopped working, the Shag later observed several times |
| 8 | Štelio | 16.6.2013 | 2.7.2013 | | | | | logger stopped working |
| 9 | Nace | 5.7.2013 | 10.10.2013 | | 2.10.2013 | suppositional | unknown | logger found in nearby vineyard, straps apparently cut-off, logger still working; no traces of Shag's presence or predation |
| 10 | Momo | 5.7.2013 | 10.7.2013 | | | | | logger stopped working |
| 11 | Mihi | 6.7.2013 | 15.2.2015 | 13.2.2014, 12.12.2014 | | | | logger stopped working in Croatia |
| 12 | Jakomo | 10.7.2013 | | 5.2.2015, 25.2.2015 | | | | logger still working |
| 13 | Vilko | 10.7.2013 | 10.7.2013 | | | | | logger stopped working |
| 14 | Karlo | 11.7.2013 | 12.10.2013 | | between 18.9. in 4.10.2013 | suppositional | unknown | logger stopped working, staying in one place btw. 4.-12.10.2013 |

| ID | Shag name | Tagging date | Last GPS location date | Migration date | Date of death | Certainty of death | Cause of death | Comments |
|---|---|---|---|---|---|---|---|---|
| 15 | Pino | 17.7.2013 | 23.9.2013 | | 20.9.2013 | suppositional | unknown | logger stopped working, flown by sea current |
| 16 | Dino | 17.7.2013 | 18.7.2013 | | | | | logger stopped working |
| 17 | Andro | 17.7.2013 | 18.7.2013 | | between 18.7. in 26.8.2013 | confirmed | unknown | decaying carcass with broken logger found on 26.8.2013 |
| 18 | Nikola | 18.6.2014 | 21.9.2014 | | | | | logger stopped working |
| 19 | Tartini | 19.6.2014 | 5.7.2014 | | | | | logger stopped working |
| 20 | Bepo | 14.7.2014 | 13.9.2014 | | | | | logger stopped working |
| 21 | Tonin | 15.7.2014 | 30.7.2014 | | | | | logger stopped working |
| 22 | Ante | 16.7.2014 | 4.11.2014 | 18.10.2014 | | | | logger stopped working |
| 23 | Ilija | 18.7.2014 | 7.9.2014 | | 3.9.2014 | suppositional | unknown | logger stopped working |
| 24 | Ivek | 23.7.2014 | 2.10.2014 | | 22.8.2014 | suppositional | unknown | logger stopped working, staying in one place btw. 3.-7.9.2014 |
| 25 | Oto | 29.7.2014 | 26.8.2014 | | | | | logger stopped working, staying in one place btw. 22.8.-18.9.2014 |
| 26 | Ogi | 15.7.2014 | 23.8.2014 | | | | | logger stopped working |
| 27 | Dado | 1.8.2014 | logger still working | | | | | logger still working |
| 28 | Jura | 1.8.2014 | 12.9.2014 | | | | | logger stopped working |
| 29 | Roko | 27.8.2014 | logger still working | 18.12.2014 | | | | logger still working |

5.573 trips of 21 Shags were identified from the 'end dataset' GPS locations in the first step of the mIBA identification analysis (Table 3). Sets of GPS locations of 3 Shags (Andro, Dino and Roko) did not meet the methodological criteria for trips to be identified, because either they didn't leave the roost-site or didn't return to it, or the number of locations was too few (less than six) for fitting the kernels in the subsequent steps of the analysis.

Number of trips differed among Shags, ranging from 2 (Tonin) to 1.125 (Jakomo), and so did they among roost sites (Table 3). The distances from roost sites travelled by Shags on their daily trips varied strongly among individuals. The four most stationary Shags travelled on average less than 2 km from their roost sites, while the most wandering Shag (Ilija) travelled on average almost 13 km from its roost site (Table 4). Moreover, the Shags differed according to their site fidelity. Some were faithful to their roosting and foraging sites, while others were not. Individuals were using 1 to 5 different roost sites. 12 (57 %) Shags were using only one roost site (Table 3).

*Table 3. Number of trips of individual Mediterranean Shags per roost site derived from the 'end dataset'. Note that no trips were identified for 3 Shags (Andro, Dino and Roko). Roost-sites which contributed to identification of candidate sites for marine IBAs, are coloured blue.*

| **Shag name** | **Roost-site** | | | | | | | | | | | **No. of used roost-sites** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **all** | |
| Ante | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 1 |
| Ari | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 21 | 1 |
| Bepo | 0 | 0 | 208 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 208 | 1 |
| Dado | 0 | 0 | 0 | 14 | 67 | 0 | 0 | 0 | 0 | 0 | 81 | 2 |
| Ilija | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 0 | 61 | 1 |
| Ivek | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 1 |
| Jakomo | 0 | 0 | 13 | 0 | 591 | 0 | 0 | 483 | 38 | 0 | 1125 | 4 |
| Karlo | 361 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 378 | 2 |
| Mihi | 14 | 0 | 396 | 0 | 182 | 0 | 0 | 141 | 0 | 0 | 733 | 4 |
| Momo | 0 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 | 1 |
| Nace | 565 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 565 | 1 |
| Nikola | 44 | 0 | 334 | 0 | 0 | 0 | 0 | 155 | 0 | 0 | 533 | 3 |
| Ogi | 138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 138 | 1 |
| Oto | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1 |
| Pino | 0 | 0 | 0 | 0 | 41 | 0 | 0 | 36 | 0 | 130 | 207 | 3 |
| Srečko | 0 | 0 | 0 | 47 | 11 | 67 | 116 | 0 | 0 | 0 | 241 | 4 |
| Šime | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 1 |
| Štelio | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 85 | 0 | 0 | 85 | 1 |
| Tartini | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 133 | 0 | 0 | 133 | 1 |
| Tonin | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 29 | 2 |
| Ugo | 162 | 19 | 691 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 872 | 3 |
| **Total** | 1408 | 19 | 1698 | 61 | 930 | 67 | 116 | 1045 | 99 | 130 | 5573 | |
| **No. of ind.** | 9 | 1 | 7 | 2 | 7 | 1 | 1 | 8 | 2 | 1 | | |

*Table 4. Trip distances statistics by individual Mediterranean Shags. Note that no trips were identified for 3 Shags (Andro, Dino and Roko). SD – standard deviation*

| Shag name | Average trip distance [km] | SD [km] | Median trip distance [km] |
|---|---|---|---|
| Ilija | 12,7 | 7,0 | 10,8 |
| Ogi | 5,9 | 4,8 | 5,7 |
| Karlo | 5,6 | 2,6 | 6,3 |
| Bepo | 4,6 | 2,7 | 5,2 |
| Nikola | 4,0 | 2,6 | 4,0 |
| Oto | 3,6 | 3,1 | 3,3 |
| Štelio | 3,6 | 2,9 | 3,5 |
| Mihi | 3,4 | 2,3 | 3,4 |
| Pino | 3,0 | 2,1 | 2,4 |
| Momo | 3,0 | 2,2 | 2,2 |
| Tartini | 2,9 | 1,7 | 2,9 |
| Jakomo | 2,9 | 2,3 | 3,2 |
| Šime | 2,7 | 2,1 | 1,6 |
| Nace | 2,6 | 1,3 | 3,1 |
| Ugo | 2,4 | 1,9 | 1,5 |
| Ante | 1,9 | 0,9 | 2,4 |
| Srečko | 1,9 | 1,3 | 1,7 |
| Ari | 1,5 | 0,9 | 1,5 |
| Tonin | 1,4 | 0,7 | 1,4 |
| Ivek | 1,4 | 0,5 | 1,5 |
| Dado | 0,8 | 0,4 | 0,7 |

*Table 5. Trip distances statistics by roost sites for 21 Mediterranean Shags. Note that no trips were identified for Andro, Dino and Roko.*

| Roost-site | Average trip distance [km] | SD [km] | Median trip distance [km] |
|---|---|---|---|
| 9 | 10,2 | 6,5 | 7,7 |
| 1 | 4,2 | 2,8 | 3,9 |
| 8 | 4,0 | 2,3 | 4,6 |
| 10 | 3,9 | 2,0 | 4,7 |
| 3 | 2,9 | 2,1 | 2,4 |
| 2 | 2,4 | 0,7 | 2,8 |
| 7 | 2,4 | 1,4 | 2,5 |
| 6 | 1,8 | 1,1 | 2,1 |
| 5 | 1,5 | 1,6 | 0,8 |
| 4 | 1,0 | 0,7 | 1,0 |

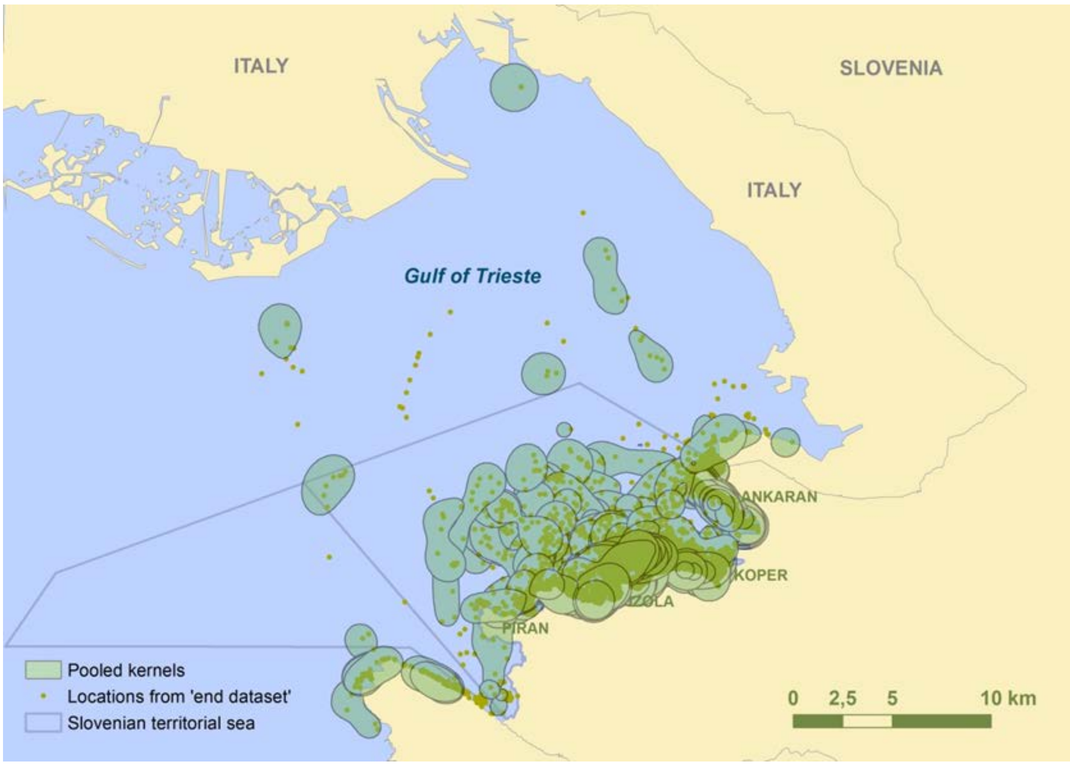



*Figure 11. Core use areas (kernels) of 21 tracked Mediterranean Shags derived from the 'end dataset'.*

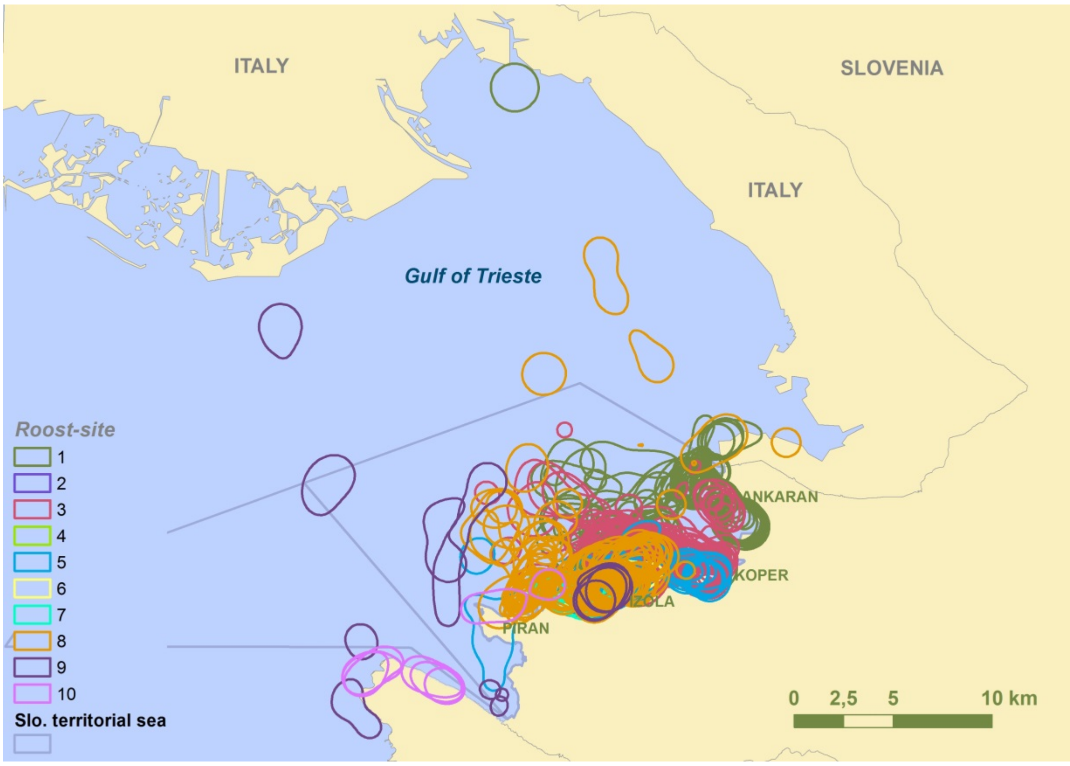



*Figure 12. Core use areas (kernels) of 21 tracked Mediterranean Shags on their round trips, starting and ending at their roost-sites (derived from the 'end dataset').*

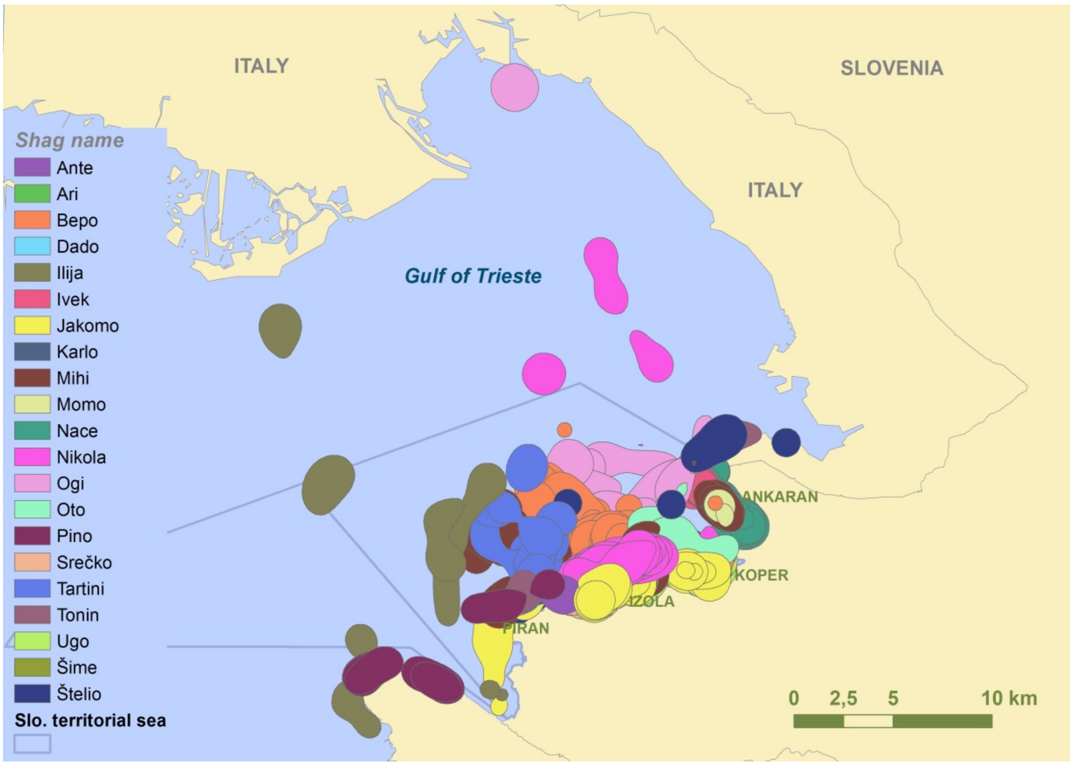



*Figure 13. Core use areas (kernels) of 21 tracked Mediterranean Shags on their round trips, starting and ending at their roost-sites (derived from the 'end dataset').*

Eight candidate sites for the marine IBAs were identified in total, based on Shags from roost-sites 1, 3 and 5. No sites were identified based on trips from other roost sites. It was estimated, that the maximum numbers of Shags which were visiting individual areas, ranged between 7 and 220 individuals (Table 8).

*Table 6. Parameters and outcomes of the mIBA identification analysis according to the according to the Methods for identifying marine IBAs using seabird tracking data (BirdLife international 2013) (see 2.3).*

| Roost-site | Inner buffer [km] | Outer buffer [km] | Ars scale | Site fidelity | Sample representa-tiveness | Comments |
|---|---|---|---|---|---|---|
| 1 | 0,7 | 0,7 | 0,732 | not significant | 97,42 | mIBAs 1A-B |
| 2 | 0,3 | 0,3 | | / | | sample too small |
| 3 | 0,35 | 0,35 | 0,675 | significant | 79,8 | mIBAs 3A-D |
| 4 | 0,4 | 0,4 | 0,7 | / | | sample too small |
| 5 | 0,3 | 0,5 | 0,545 | not significant | 99,31 | mIBAs 5A-B |
| 6 | 0,2 | 0,2 | 0,600 | / | | sample too small |
| 7 | 0,2 | 0,2 | 0,629 | / | | sample too small |
| 8 | 0,4 | 0,4 | 0,829 | significant | 56,07 | sample not representative |
| 9 | 0,6 | 0,6 | 1,471 | / | | sample too small |
| 10 | 0,3 | 0,3 | 1,067 | / | | sample too small |

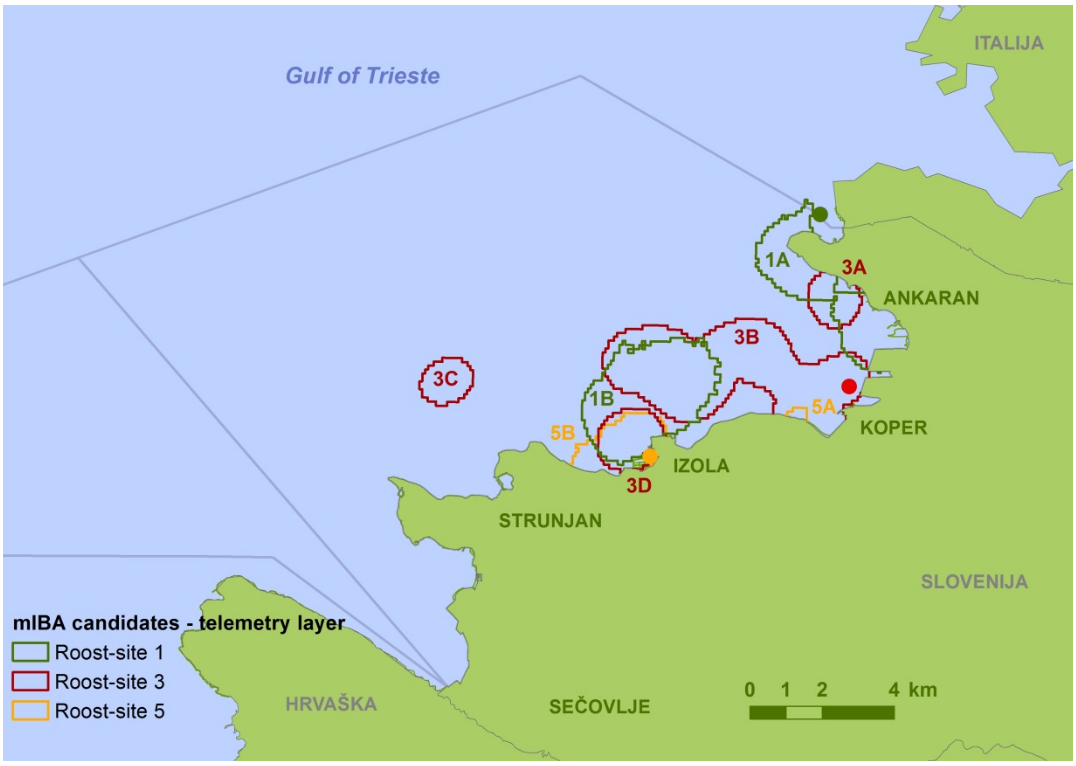



*Figure 14. Marine IBA candidates as identified by the analysis of the telemetry data of Mediterranean Shags. No IBAs was indetified from data groups from roost sites 2-7 and 9-10.*

*Table 7. Candidate mIBA sites identified based on the telemetry data of the Mediterranean Shags in the Slovenian sea.*

| Roost-site | SiteID | Site area [ha] | Roosting population | max. % of roosting population | max. mIBA site population |
|---|---|---|---|---|---|
| 1 | A | 776 | 530-610* | 24,37 | 129-149 |
| | B | 892 | | 36,13 | 191-220 |
| 3 | A | 179 | ~100** | 14,29 | 14 |
| | B | 1592 | | 57,14 | 57 |
| | C | 147 | | 14,29 | 14 |
| | D | 256 | | 14,29 | 14 |
| 5 | A | 48 | ~50** | 12,9 | 7 |
| | B | 395 | | 78,49 | 39 |

*Roost-site monitoring yearly maxima in 2012 and 2013
**Estimated based on land observations.

In addition to movements across the Slovenian sea, four Shags were tracked on their migration to Croatian waters (Figure 15). One of them, a young Mihi, only made a one week trip into the surrounding of Poreč, and then returned back to its foraging site near Izola, Slovenia. Three of them, Ante, Ugo and Šime, all adults, were probably returning to their breeding sites, where they were tracked for some time during the breeding season, before the loggers stopped working. Ante was the only individual among "our" tracked Shags which had been colour-ringed before we trapped it in Izola. It was marked as a nestling on the Oruda island near Lošinj, where it returned in autumn 2014, which indicates that Shags can be faithful to the breeding sites where they've been hatched, too.

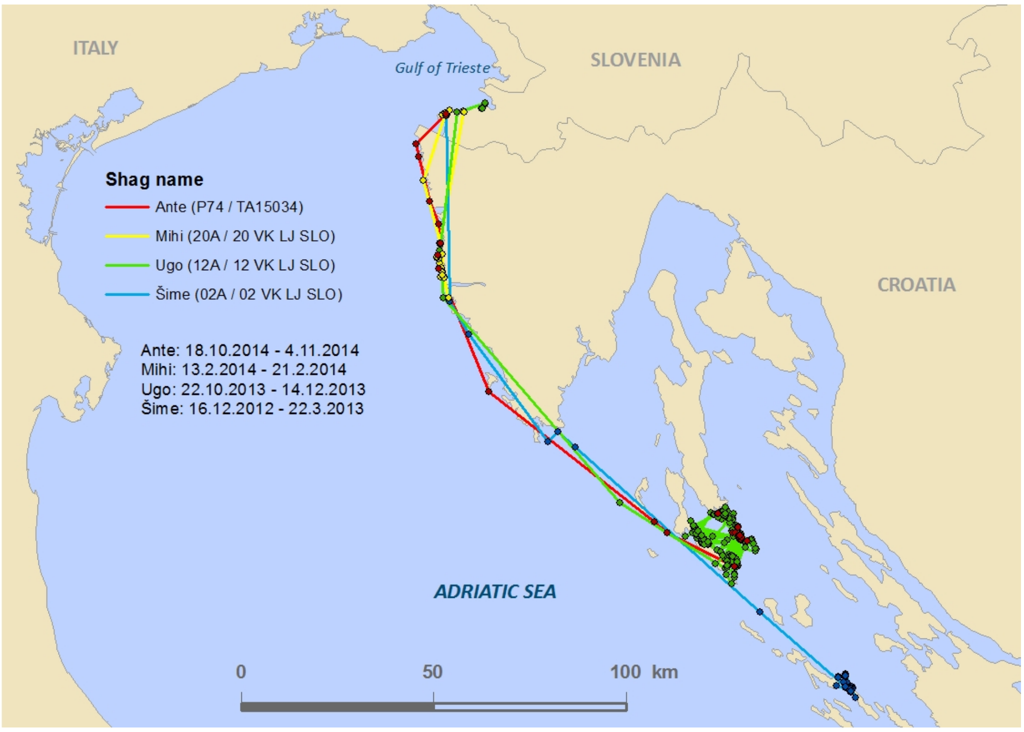
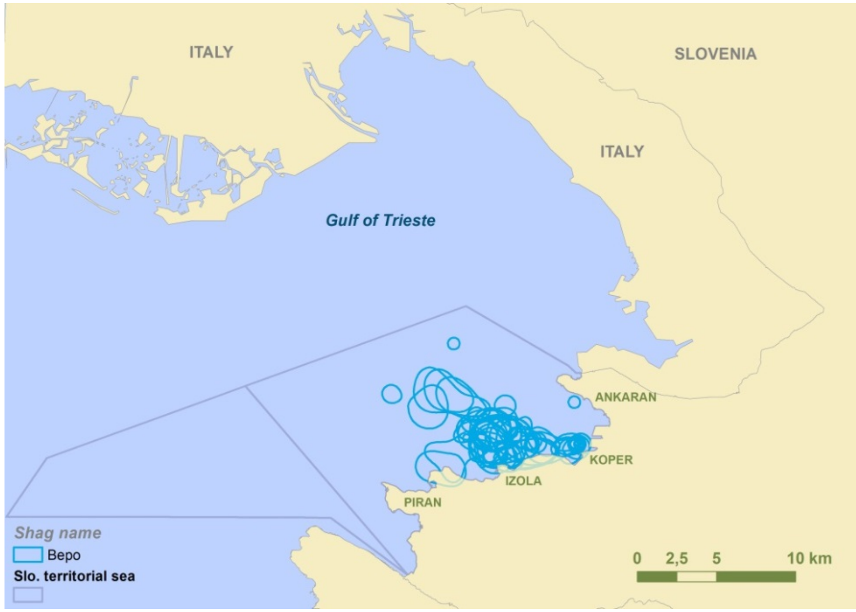



*Figure 15. Migration routes of three Mediterranean Shags which were tracked on their autumn (pre-breeding) migration from the Slovenian sea to Croatian breeding areas, and one individual (Mihi, 2Y) who visited Croatian waters for a week during winter. Ante, Ugo and Šime, all adults, most probably migrated to their breeding sites.*

*Annex: Maps of core use areas (kernels) of individual Shags in the Slovenian sea (same data as in Figure 13 but split into individual maps).*



*Annex: Maps of core use areas (kernels) of individual Shags in the Slovenian sea (same data as in Figure 13 but split into individual maps).*

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