ECOLOGY AND CONSERVATION OF MEDITERRANEAN SEABIRDS

AND OTHER BIRD SPECIES UNDER THE BARCELONA CONVENTION

UPDATE & PROGRESS

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Proceedings of the

13th Medmaravis Pan-Mediterranean

Symposium

Editors

Pierre Yésou - Nicola Baccetti - Joe Sultana

2012

This volume is dedicated to the memory of our colleagues
Helmar Schenk (1941-2012) and Paolo Boldreghini (1945-2012)
pioneers of seabird monitoring in central Mediterranean and active members of Medmaravis

Editorial Note:
Since the 13th Medmaravis Pan-Mediterranean Symposium was held, the taxonomic status of the Cory's Shearwater complex has been reviewed. Now it would be appropriate to treat it as three full species, **Scopoli's Shearwater** *Calonectris diomedea,* **Cory's Shearwater** *Calonectris borealis*, and **Cape Verde Shearwater** *Calonectris edwardsii*. Therefore, in this publication all references to the Mediterranean form have been redirected to the Scopoli's Shearwater *Calonectris diomedea* except for Mia Derhe's paper which was based on an analysis of the global population (see footnote on page 29).

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Foreword

The 13th MEDMARAVIS Pan-Mediterranean Symposium was held on 14th-17th October 2011 in the charming Sardinian city of Alghero. It was co-organised with the Parco Naturale Regionale di Porto Conte, in association with Mediterranean Small Islands Initiative (PIM) of the Conservatoire du littoral, and with the support of the Presidenza del Consiglio della Regione Autonoma della Sardegna. The symposium was followed by a two-day workshop on Action Plans for Scopoli's/ Cory's and Yelkouan Shearwaters organised by BirdLife International.

This symposium celebrated the 25th anniversary of the foundation of MEDMARAVIS, which organised its first symposium also in the city of Alghero, way back in 1986. This signified the public presentation of MEDMARAVIS in the international scene and its widespread recognition by the scientific community.

The 2011 Symposium did not lag behind in significance. Most outstanding was the high level of attendance, including a new generation of seabird researchers who made important contributions and who showed that there are plenty of interesting scientific and conservation initiatives currently going on simultaneously in the Mediterranean region. This was most reassuring, especially as the General Assembly held during the symposium saw one of its founding members and most active promoter Xaver Monbailliu step down as Secretary-General. The Medmaravis Council and Executive Board, where he will continue to play an active role, were also renewed with the addition of several new members. It is now up to us to take up the baton and continue the extraordinary work led by the preceding Boards in the last 25 years, both at the regional and international level.

Challenging times lie ahead. MEDMARAVIS, as one of the member organizations of the World Seabird Union, participate in this partnership that aims to share research, knowledge, and ideas on a global level. The tools offered by the WSU will allow Mediterranean marine avifauna to be clearly visible on the world map. We expect to contribute data to the global picture from MEDMARAVIS members on breeding colonies, seabird distribution and movements. These are the strengths and opportunities for MEDMARAVIS in the future.

The organisation of a symposium and the preparation for the publication of the proceedings entail a lot of time and work. We are grateful to the Medmaravis board members, particularly Toni Torre (President) and Xaver Monbailliu (former Secretary-General) for all their efforts in organising the Symposium, and to Daniel Oro for compiling most of the scientific programme.

In conclusion I must mention with regrets and sympathy two significant members of the MEDMARAVIS family who have left us since the 13th MEDMARAVIS Symposium, Paolo Boldreghini, lecturer at the University of Bologna, a faithful companion of MEDMARAVIS, and Helmar Schenk, who involved himself in the study and conservation of the Sardinian wildlife. This volume is dedicated to their memory.

Carles Carboneras
Secretary-General
MEDMARAVIS

Message by the President of Parco di Porto Conte

25 years after Medmaravis' first seabird symposium in Alghero, the Porto Conte Natural Park joined forces in the organisation of the 13th Medmaravis symposium (the 8th seabirds symposium) in the same Sardinian City. Now it is with great satisfaction that we jointly present the symposium's scientific contributions. The Park authorities' motivation in sharing the duties of the organization of the conference and the proceedings' publication, at the invitation of Medmaravis, is due to the fact that this initiative fits perfectly within the aims of the Park and is in conformity with the undertakings of this coastal protected area.

The importance of Mare Nostrum for marine and coastal biodiversity has been widely acknowledged as one of the world's 25 biodiversity hotspots. We feel that the future of mankind is strictly tied to maintaining the conservation of these hotspots. By developing its Birds and Habitats Directives, the European Union has been moving in this direction and our Park follows the same approach. Sustaining biodiversity, however, is impossible without knowledge on species, habitats and their threats. In this regard, we have launched extensive surveys to update our knowledge on our local flora and fauna, on which a Management Plan will be based. The presence of several EU priority species obliges us to aim at monitoring and conserving their populations. In the last 50 years we have witnessed the loss of two key species, the Osprey and the Monk Seal in our territory, and we'll work hard to avoid similar misfortunes. One of our main aims targets the conservation of the breeding seabirds on the cliffs and islets of the Alghero coast.

Similar aims, across a larger area, will only be achieved by developing strong collaboration between governments, international organisations, protected areas' authorities and scientific NGOs in participating in projects focusing on the knowledge, management and sustainable use of our natural heritage. The geographical position of Sardinia, offers our region a good chance of acting as a link between the northern and southern shores as well as the western and eastern basins of this huge inland sea. Within this scenario, we already joined European projects to strengthen the relationships between North Sardinian parks and Corsican protected areas, with a specific activity on the Osprey. Under the stimulus of language sharing, Alghero has also developed strong links with the park network of Barcelona province. But we aspire to do more, as a research centre for Mediterranean Biodiversity – an old dream of Medmaravis – which is developing into our dream too. We could work together to make it happen at the Porto Conte Natural Park headquarters, with an educational role, a reference library and the organizaton of international meetings.

We are already working on this idea, which we hope to present at a new meeting on Mediterranean Biodiversity at Porto Conte. This will also serve as an occasion to update the 'Alghero Declaration on Marine and Coastal Biodiversity of the Mediterranean', produced during two previous symposia organized by MEDMARAVIS in 1995 and 1997 in collaboration with several Sardinian administrations, international institutions and NGOs from all Mediterranean and Black Sea countries.

Stefano Lubrano
Presidente del Parco di Porto Conte e Sindaco della Città di Alghero

Part 1: Population ecology and conservation of shearwaters

Assessing key conservation areas for Italian Scopoli's Shearwaters *Calonectris diomedea*

Jacopo G. Cecere,[1, 2] Giorgia Gaibani,[1] Carlo Catoni[1], Ivan Maggini[1] & Claudio Celada[1]

[1]Conservation Department of LIPU-BirdLife Italy, Via Trento 49, 43100 Parma, Italy.
[2]Istituto Superiore per la Protezione e la Ricerca Ambientale, via Ca' Fornacetta 9, 40064 Ozzano dell'Emilia (BO), Italy.

Summary: Seabirds are the most threatened of all bird groups and their status has deteriorated faster over the last decades. Through the Important Bird Areas (IBAs) programme, BirdLife International aims to identify key areas for the conservation of seabird species. LIPU-BirdLife Italy is working at the national level to identify the IBAs in the marine environment. In this context, tracking studies of Scopoli's Shearwater *Calonectris diomedea* were carried out during the 2008-2011 breeding seasons in three Italian colonies in the Mediterranean sea (Linosa island, Tremiti archipelago, Tuscan archipelago). Overall, 138 Scopoli's Shearwaters were tagged with GPS loggers. Notable differences emerged between colonies and between reproductive phases in the core areas used by Scopoli's Shearwater.

Key words: Scopoli's Shearwater, *Calonectris diomedea*, IBA, marine conservation areas, Italy.

Introduction

The Important Bird Areas (IBAs) programme of BirdLife International aims to identify, monitor and conserve priority sites for the long-term viability of bird populations by means of quantitative, standardised and globally agreed criteria (e.g. Heath & Evans 2000). Since the 1980s, a global network of IBAs has been implemented by the BirdLife Partnership in both terrestrial and freshwater environments. IBAs have been accepted worldwide as a powerful and effective conservation tool, and they have been recognized in the European Union as a scientific reference for the designation of Special Protection Areas (SPAs) establishing the Natura 2000 network under the Birds Directive (2009/147/EC, the codified version of Directive 79/409/EEC ; rulings of the European Court of Justice in Case C-3/96, Case C-202/01, Case C-240/00 and Italy Case C-378/01).

Although seabirds are the most threatened of all bird groups (Butchart 2004, Croxall *et al*. 2012),

the process of identifying IBAs in the marine environment is much more recent. This delay is mainly due to technological and logistic difficulties associated with obtaining distribution data of bird species at sea. Nevertheless, in the last decade BirdLife International has been developing a standard methodology to extend the IBA network into the marine environment (BirdLife International 2010a) and several BirdLife partners are currently collecting data in order to complete the IBA network at sea (BirdLife International 2010b). In this context, LIPU (Lega Italiana Protezione Uccelli, the BirdLife partner in Italy) is working at national level to identify the priority sites for the conservation of seabirds, including, among others, pelagic species such as the Scopoli's Shearwater *Calonectris diomedea*. Up to 2002, forty-one IBAs had been identified as seaward extensions of breeding colonies of seabirds (LIPU 2002). More recently, a further seven areas have been classified as candidate marine IBAs through a project funded by the Italian Ministry of Environment (LIPU 2009, BirdLife International 2010b). These candidate marine IBAs have been identified using vessel-based survey and tracking data, collected in compliance to the standard BirdLife International methodology. In particular, the GPS tracking of Scopoli's Shearwaters is a core activity that has been continued beyond the above-mentioned project until 2011, in three colonies of the Mediterranean Sea (Linosa island, Tremiti archipelago, Tuscan archipelago). In the present study we report the results of GPS tracking of Scopoli's Shearwaters showing the most frequented areas by tracked birds during the incubation and chick-rearing periods. These areas will be useful in identifying candidate marine IBAs.

Materials and methods

Tracking activities were carried out during the breeding seasons 2008-2011 in three Italian (group of) colonies: (1) Linosa island, located on the Tunisian marine Plateau in Gulf of Sidra region (35° 51'33" N; 12°51'34"E) between Sicily, Tunisia and Libya, which hosts one of the biggest colonies of Scopoli's Shearwater in the Mediterranean with an estimated 10,000 breeding pairs (Baccetti *et al.* 2009). On this island, field work was carried out during both the incubation (June 2008) and chick-rearing (July-August 2008 and 2009) periods. (2) Tremiti Archipelago (42°08'19"N; 15° 30'52"E), one of the biggest breeding colonies of the species in the Adriatic Sea, which comprises approximately 400 breeding pairs (Baccetti *et al.* 2009). There, field work was carried out on the islet of Capraia, during the incubation period only, in two seasons (June 2009 and 2010). (3) The islet of La Scola, located in the Tyrrhenian Sea, within the Tuscan Archipelago which hosts, on the whole, 200-400 pairs (Baccetti *et al.* 2009). There, field work was carried out during the chick-rearing period in two seasons (August 2010 and July 2011).

GPS logger deployment

We located shearwater nests by inspecting crevices and burrows. During incubation one pair partner is away foraging at sea while the other bird broods the single egg for several days. This makes it easy to catch the brooding bird by hand. After hatching of the chick, the adults spend the day foraging at sea and leave the chick alone in the nest, returning to the colony only at night. Consequently, during the chick-rearing period adults were caught at night just after they had fed their chick.

Birds were weighed and a mini-GPS logger was attached to the back feathers using 3-4 strips of Tesa® marine cloth tape (Tesa SE, Hamburg, Germany) (see Guilford *et al.* 2008). Birds

were sexed during handling by recognition of their sex-specific vocalizations or indirectly by sex determination of their partner. Total handling time was kept below 10 minutes and birds were returned to their nests immediately afterwards. We monitored all nests once every day. When a tracked bird eventually returned to the nest it was recaptured and the GPS logger removed by peeling away the tape from the feathers.

Three types of mini-GPS loggers were used: one by Earth & Ocean Technologies (Kiel, Germany), weighing 19.4 g (with a battery of 500 mA) and provided with an active antenna; and two different types by Technosmart (Guidonia, Italy) with chip antenna, weighing 11.9 and 9.8 g and provided with two different batteries (500 and 250 mA respectively). The deployment of lighter GPS loggers despite the drawback of their shorter life-span allowed us to track lighter birds. Device weight was always less than 3% of the bird's weight. All GPS loggers were configured to record both the position and the instantaneous speed of the bird every 10 minutes.

In order to assess whether handling and GPS deployment negatively affect the reproductive phase, we compared the hatching success of Linosa colony in 2008 from nests where at least one breeder was tagged to that one from nests where breeders were not manipulated. No significant difference resulted between the hatching success of the former group (63.3%) and that one of "control" birds (60.4%) ($\chi 2 = 0.066$; df = 1; n = 78; ns.).

Data analysis

In order to avoid replication inconveniences, we considered only one trip for each tracked bird. We considered the departure from the nest as the beginning of the trip and either the return to brood-guarding during incubation, or the first return to the colony during the chick-rearing period, as the end of the trip. Following previous experiences from BirdLife International partners (see Ramirez *et al.* 2008) we computed kernel analyses using only GPS positions with an instantaneous speed of less than 10 km/h. This threshold has been used by several authors (Pichegru *et al*. 2007, Guilford *et al.* 2008) to identify positions where seabirds were actually using the environment for either resting, searching for food, or diving, excluding positions where the bird was travelling. In the analysis of the data we computed the kernels separately for birds that performed long lasting trips (> 4 days) and those that performed short lasting trips (≤ 4 days) in order to identify important areas far from the colony where GPS positions were less dense which would have been lost if using all data in the same analysis. Then, the two kernels (from long and short trips) obtained from the same colony and in the same period were merged and cut in order to exclude islands and mainland. Fixed kernels were computed at the following probability level: 50%, 75% and 95%. Percentages of overlap were computed by dividing the overlapped area by the mean of the associated kernels and multiplying by 100. All spatial analyses have been performed using Esri ArcGIS 9.3.

Results

A total of 138 Scoploi's Shearwaters have been tagged with GPS loggers, but 29 devices did not contain any data after being recovered. In addition, two devices set to record positions continuously were excluded from analyses. The sample sizes for each colony in each field season are reported in Table 1. Figure 1 shows the kernels obtained by combining data from each colony recorded in different years but during the same reproductive phase. Table 1 reports the sizes of all kernels obtained for each field season. The percentages of overlap are shown in Table 2.

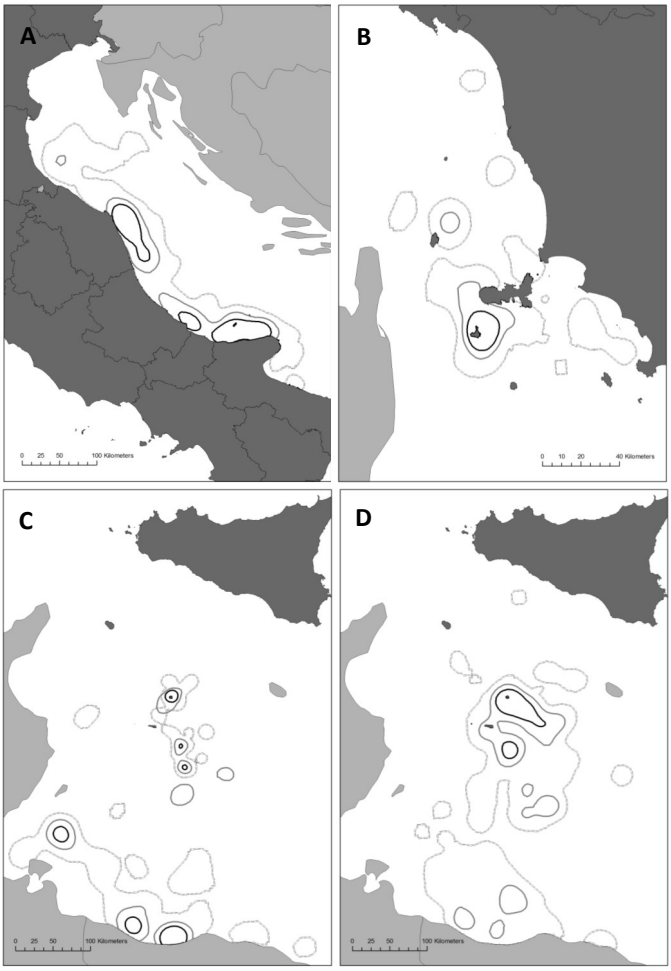

Figure. 1. Kernels obtained using GPS positions for Scopoli's Shearwaters with instantaneous speed < 10 km/h and combining data recorded at

(A) Tremiti Archipelago during incubation (2009-2010);

(B) Tuscan Archipelago (La Scola islet), during chick-rearing (2010-2011);

(C) Linosa island during incubation 2008;

(D) Linosa island during chick-rearing (2008-2009).

Black line = 50% prob; gray line = 75%; hatched line = 95%.

Discussion

In the last decade, the use of light GPS devices provided scientists with a large amount of information about bird movements, even on the open sea (see for a review: Wakefield *et al*. 2009). Despite this, only one paper (Dell'Ariccia et al. 2010) based on 17 tracked Scopoli's Shearwaters from an Italian colony was published. Using mini GPS loggers, we identified for the first time the main areas used by Scopoli's Shearwaters breeding in some of the biggest colonies of the central Mediterranean.

Comparing the sizes of the estimated kernels, marked differences can be noticed between colonies and between reproductive phases (Table 1). During incubation, despite the fact that birds from Linosa used mainly areas further away from the breeding site compared to Tremiti birds (Figure 1), the total size of core areas (50% fixed kernel) was slightly smaller than the size estimated for Tremiti birds in 2009 and considerably smaller than the size estimated for Tremiti birds in 2010. It is known that at large and meso-scales, seabirds are able to move directly from the breeding site to the most favoured and profitable foraging areas (Weimerskirch 2007). Thus, we can hypothesize

colony	period	year	birds	long lasting trips	position speed <10km/h	Kernel 50% (ha.)	Kernel 75% (ha.)	Kernel 95% (ha.)
Linosa Is.	incubation	2008	14	64.29%	8,916	173,049	637,986	2,551,582
	chick-rear.	2008	18	38.89%	9,021	200,249	1,213,556	4,205,731
	chick-rear.	2009	28	14.29%	8,111	681,798	1,825,973	4,720,180
	chick-rear.	2008-09	46	23.91%	17,132	296,814	976,992	4,642,604
Tremiti Arch.	incubation	2009	11	63.64%	5,919	247,257	516,611	1,134,799
	incubation	2010	15	66.67%	7,048	477,195	1,409,564	3,529,522
	incubation	2009-10	26	65.38%	12,967	409,662	857,501	2,525,286
Tuscan Arch.	chick-rear.	2010	10	30.00%	2,327	39,563	83,058	402,353
	chick-rear.	2011	11	9.09%	2,467	28,388	90,207	432,350
	chick-rear.	2010-11	21	19.05%	4,794	26,590	80,390	404,050

Table 1. Sample size, proportion of Scopoli's Shearwaters that performed long lasting trips (> 4 days) and kernel sizes obtained from each field season and combining data from different years recorded at the same colony and reproductive phase; only one trip for each bird was considered.

Colony	overlapped kernels	kernel 50%	kernel 75%	kernel 95%
Linosa island	incubation 2008 and chick-rearing 2008-2009	9%	25%	44%
	incubation 2008 and chick-rearing 2008	12%	25%	44%
	incubation 2008 and chick-rearing 2009	5%	22%	34%
	chick-rearing 2008 and chick-rearing 2009	30%	41%	56%
Tremiti Archipelago	incubation 2009 and incubation 2010	32%	50%	48%
Tuscan Archipelago	chick-rearing 2009 and chick-rearing 2010	45%	45%	43%

Table 2. Scopoli's Shearwaters: percentages of overlap computed by dividing the overlapped area by the mean of the associated kernels and multiplying by 100%.

that Linosa birds managed to reach known profitable areas travelling as far as the Libyan coast (> 300 Km) in order to use more restricted areas than those used by Tremiti birds.

During chick-rearing, birds from Linosa used larger areas than those used during incubation (Table 1).

In this reproductive phase, Scopoli's Shearwaters can alternate short trips for chick provisioning with longer trips for self-provisioning (Magalhaes *et al.* 2008). As a consequence of this behaviour, birds were constrained to use areas closer to the colony which could be less profitable and thus implying the use of larger areas for foraging. Birds from the Tuscan Archipelago used smaller areas closer to the colony than those used by Linosa birds during chick-rearing, suggesting the presence of profitable areas close to the breeding site (Figure 1).

The kernels at 50% and 75% identified during incubation and chick-rearing from Linosa had a very low (5-25%) degree of overlap, suggesting that, at least for this colony, it is essential to collect data during both periods in order to correctly identify key conservation areas for Scopoli's Shearwaters. Interestingly however, there was a relatively high overlap (30-56%) from year to year between kernels obtained from the same colony during the same reproductive phase.

Following the methodology proposed by BirdLife International (BirdLife International 2010a), all areas determined using the core areas can be considered as candidate marine IBAs. Nevertheless, as demonstrated in this study, medium to long term studies are needed to assess how the areas used change from year to year and which areas can be considered as marine IBAs.

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Body mass variation in Scopoli's Shearwaters *Calonectris diomedea* breeding at Linosa Island

Paolo Becciu[1], Bruno Massa[2] & Giacomo Dell'Omo[1]

[1] *Ornis italica*, Piazza Crati 15, 00199 Roma, Italy. pablob989@gmail.com
[2] Dipartimento DEMETRA, Laboratorio di Zoologia applicata, Università di Palermo, Viale delle Scienze 13, 90128 Palermo, Italy.

Summary: We investigated body mass variation during the reproductive season in male and female Scopoli's Shearwaters *Calonectris diomedea* breeding at Linosa Island, Sicily channel. Birds were weighed in three main periods: before and during egg-laying (mid-May - mid-June), around hatching (second half of July) and during the early stages of chick rearing (mid-July - mid-August). In addition, some measurements were taken during fledging (second half of October). When possible, the same individuals were weighed repeatedly. Overall, there was a marked difference in body mass between sexes; males weighing on average c.100g more than females. Body mass was higher in males before the engagement in breeding activities (just after the return from their winter migration) and decreased soon thereafter. Conversely, body mass was lower in females during laying and increased during the initial phase of incubation. No other significant variations on the time course of body mass emerged from the analyses. The difference between the sexes in body mass profile could be related to a differential effort during the early phases of the reproductive season.

Key Words: *Calonectris diomedea*, Scopoli's Shearwater, body mass, reproductive stress.

Introduction

The Scopoli's Shearwater *Calonectris diomedea* (Procellariidae) is a colonial bird characterized by a high reproductive investment (up to eight months), including a long incubation period (54 days) and a long phase of chick-rearing (90 days). The birds lay a single egg and the parental cares are equally shared between partners. The energetic demands might vary largely during the breeding season and can be different between females and males (Navarro et al. 2007). A reduction in body weight might be caused by reproductive stress. When breeding birds are engaged in an intense activity, the high energetic expenditure can produce an imbalance of physiological processes which might influence body mass (*reproductive stress hypothesis*, Moe *et al*. 2002). On the other hand, weight reduction could benefit the efficiency of foraging trips (*programmed anorexia hypothesis*, Navarro *et al*. 2007). An investigation on the variation of body mass of shearwaters breeding in Linosa Island provided the opportunity to test which of the two hypotheses was more likely supported.

Materials and methods

Body mass variation was recorded during 2007-2011 on breeding birds (about 150 pairs) in a colony characterized by nests in crevices in lava rocks at Linosa Island (Sicily Channel, Italy). Adult shearwaters of both sexes were ringed and captured repeatedly during the study period. Sex was assigned on the basis of morphology and vocalization (the male has a sharp pitch call, while the female has a heavy, lower-tone raucous call). Birds were weighed with Pesola® balance (accuracy 5g). Manipulation time was short; less than 3 minutes per bird.

Statistical analysis. We used the body mass data collected during the five years but we did not consider the Year factor. Data were pooled over two-week periods from mid-May until mid-October, therefore there were eight time periods (there were no data for September) which could be used to provide the time course of the body mass variation during the whole breeding period. However, the body mass measures were not repeated measures on same individuals, and the Time could not be treated as Repeated Measures but was treated as main Factor. Time and Sex and their interaction, were therefore analyzed using a Two-Way ANOVA, after having checked for the normal distribution of data.

Results

Body mass of the adult birds varied significantly depending on Sex ($F_{1,733}$=269.13, p<0.001) and Time period ($F_{7,733}$=7,36, p<0.001). Males were on average 104g heavier than females and the temporal profile of body mass (data of sexes pooled) was characterized by a higher mass in the first two weeks after engaging in the breeding followed by a relatively stable situation. The interaction between the two factors was also significant ($F_{7,733}$=8.21, p<0.001) and revealed between-sex differences during the laying and the initial phase of incubation (Figure1). In fact, around mid-May, at the start of incubation, males were at their highest mass (about 711 g) compared to that of the following periods (p<0.05 or less within sex comparisons) and in the second half of June they reached their lowest mass. On the contrary, the mass of females (corrected for egg mass), had a peak in the period just after egg-laying, when it increased to about 10% compared of the mean weight across the whole season (p<0.05 or less within sex comparisons).

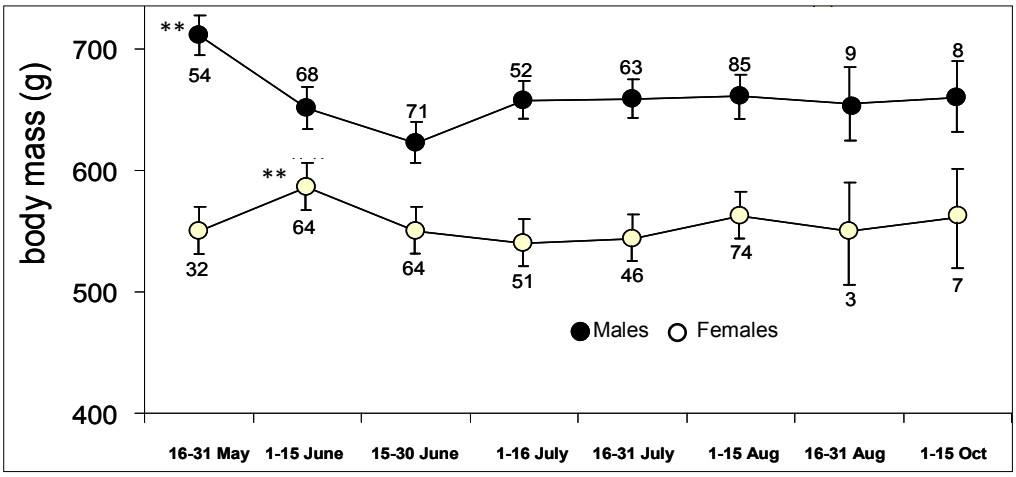

Figure 1. Body weight variation (means ± SE) in male and female Scopoli's Shearwaters during the breeding season at Linosa Island. The breeding season covers from mid-May to mid-October. Numbers indicate the sample size; ** p< 0.01 in within-sex comparisons.

Discussion

A previous study on weight variation during a single breeding season has been carried out at Linosa in 1982-1984 (Massa & Lo Valvo 1986), thirty years before our study. In this work it was also reported that weight fluctuated across the breeding season, but there were no between-sex

comparisons and data were based on a smaller sample size. Overall, our study shows that after three dacades, body mass of Scopoli's Shearwaters has remained the same and the fluctuations observed are within the range of those observed previously.

Usually, shearwaters undertake a pre-laying exodus that consists of extended foraging trips. These long trips are supposed to help the birds to store energy reserves in order to afford the high reproduction costs. These trips, last on average eight days in males and up to 19 days in females. It has been hypothesized that during these trips females store fats and proteins needed to produce the egg (Brooke 2004, Jouanin *et al.* 2001).

We observed that females were leaving the nest soon after having laid (often the day after), probably to recover from the effort of laying. Their first foraging trips were longer, often more than a week, and during this time females gained weight. Therefore, the males are committed to start the incubation with a first long period at the nest and consequently a long fast, resulting in a significant reduction in weight. As a consequence, in the central part of the incubation period (second half of June) male body mass reached the minimum value. This could be explained as the result of the more prolonged nest attendance for supporting the long recovery trips of the females. Later in the season nest attendance was balanced more equally between partners and body weight was stabilized. During the phase of chick-rearing a marked decrease in body weight of the parents was expected (Navarro *et al*. 2007), but contrary to expectations the time course was stable in both sexes. In conclusion, it seems that the sharing of the parental care resulted in a similar energetic expenditure in both parents during the whole breeding period, except for the period around the onset of the incubation. The marked decrease in body mass observed in males during this phase could be related to higher costs encountered, thus supporting the *hypothesis of reproductive stress*. Conversely, the *hypothesis of programmed anorexia* was not supported by our observations.

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Exploring marine habitats of two shearwater species breeding on French Mediterranean islands

Clara Péron[1], David Grémillet[1], Jean-Michel Culioli[2], Gilles Faggio[3], Pascal Gillet[4], Alain Mante[5] & Patrick Vidal[6]

[1]Centre d'Ecologie Fonctionnelle et Evolutive, CNRS UMR 5175, 1919 route de Mende, 34293 Montpellier, France. clara.peron@cefe.cnrs.fr ; david.gremillet@cefe.cnrs.fr
[2]Département Stratégies & Sciences de la mer, Office de l'Environnement de la Corse, "Parc Marin International des Bouches de Bonifacio", La Rondinara, 20169 Bonifacio, France.
[3]Conservatoire d'Espaces Naturels de Corse, Maison Andreani, Lieu-dit Revinco, 20290 Borgo, France.
[4]Parc National de Port-Cros, Allée du Castel Sainte Claire, 83406 Hyères cedex, France.
[5]Conservatoire d'Espaces Naturels de Provence-Alpes-Côte-d'Azur (CEN PACA), Réserve Naturelle Nationale de l'archipel de Riou, 166 Avenue de Hambourg, 13008 Marseille, France.
[6]Conservatoire d'Espaces Naturels Provence-Alpes-Côte-d'Azur (CEN-PACA), île du Frioul, 13 001 Marseille, France.

Summary: We used miniaturized electronic devices to investigate the movements at sea of two shearwater species breeding on six French Mediterranean islands. The aim of the study was to gain new insights in shearwaters' foraging and migratory strategies in order to provide key elements for the designation of coastal and offshore protected areas in the Mediterranean Sea. Yelkouan Shearwaters *Puffinus yelkouan* from Port Cros Island made *ca.*3 days foraging trips in coastal waters along the Gulf of Lion during the chick-rearing period. Scopoli's Shearwaters *Calonectris diomedea* tracked from 5 different islands (Porquerolles, Riou, Frioul, Giraglia and Lavezzi) foraged at sea for an average 1.25 days during the chick-rearing period. Cory's breeding in Marseille (Riou, Frioul) and Porquerolles islands shared similar foraging zones located on the continental shelf of the Gulf of Lion, whereas the two populations from Corsica foraged in distinct areas. Scopoli's from Lavezzi targeted mainly the strait of Bonifacio and the Gulf of Asinara in Sardinia, whereas those from Giraglia foraged close to the colony in local waters located north-east from Corsica. Regarding the inter-breeding movements, preliminary results for 4 Scopoli's shearwaters equipped with geolocators on the Lavezzi Island revealed long-distance migrations in three different Atlantic areas.

Key Words: distribution, foraging zones, tracking data, shearwaters, Mediterranean sea, French islands, Marine Protected Areas, conservation.

Introduction

The Mediterranean Sea is facing multiple human-induced threats, including oil spills, fisheries bycatch and over-fishing, that are impacting all levels of marine food webs. Whereas pelagic seabirds are important components of the Mediterranean ecosystem, few studies have been conducted on distribution at sea of birds from the French colonies compared to others breeding sites along the Mediterranean coast (Ristow *et al.* 2000, Louzao *et al.* 2009, Dell'Ariccia *et al.* 2010). The aim of our study was to fill this gap by investigating the foraging habitats of Yelkouan *Puffinus yelkouan* and Scopoli's Shearwaters *Calonectris diomedea* breeding in French Mediterranean islands. Both breeding and non-breeding seasons were investigated because marine environments experience

seasonal variations in physical and biological parameters, with consequences for seabird distributions and their exposure to threats at sea.

Foraging grounds of Yelkouan Shearwater during the breeding period

The Yelkouan Shearwater is a Procellariiform strictly endemic to the Mediterranean Basin, which has recently been uplisted to the Vulnerable IUCN extinction risk category (IUCN 2012). A recent demographic study conducted in Malta and Port-Cros (France) suggested that the greatest threat to the persistence of Yelkouan Shearwater colonies was likely to be human-induced mortality at sea (Oppel *et al.* 2011). However, the foraging ecology of Yelkouan Shearwater remained poorly known until recently because studying its movements at sea was technically challenging.

Yelkouan Shearwaters first return to their breeding sites in late October–early November, and egg-laying occurs from mid-March to early April. Hatching follows in May and chicks fledge in July-early August (Bourgeois *et al.* 2008). As most of the small and medium-sized petrel species, Yelkouan Shearwaters visit their nest at night and forage at sea by day.

Among the French Mediterranean islands, Yelkouan shearwaters breed almost exclusively in the Hyères archipelago (Porquerolles, Port Cros, Bagaud and Levant). Porquerolles and Port Cros hold a population estimated at *ca.*210-241 breeding pairs (Bourgeois & Vidal 2007). Our study was carried out at Port-Cros from 15 May to 15 June 2011, when birds were rearing a young chick. We equipped 7 breeding adults with 12g GPS loggers manufactured by Earth and Ocean Technology. Loggers' weight corresponded to *ca.*2.8% of bird body-weight, i.e. below the 3% limit recommended for flying birds (Phillips *et al.* 2003). GPS were fitted to back feathers using Tesa® tape. The GPS logger recorded the position of the birds every 3 minutes with an error estimated to be <100 m. One bird was tracked during two foraging trips, which resulted in eight tracks for the seven individuals fitted with GPS. Fixed kernel density maps were generated on the estimated locations to define the overall distribution of Yelkouan Shearwaters during the chick-rearing period.

Yelkouan shearwaters foraging trips lasted on average 2.86 (±1.33) days, travelling up to 263 km from their breeding colony at an average speed of 10 km/h (max=75 km/h). They mostly exploited coastal waters along the Gulf of Lion, from Marseille to Narbonne (Figure 1) and 95 % of the locations occurred on the continental shelf in waters > 200 m (Figure1). Birds used a narrow corridor to fly from Port Cros to the Gulf of Lion during both outward and inward journeys, flying close to Toulon.

Foraging grounds of Scopoli's Shearwater during the breeding period

Scopoli's Shearwater is the most widespread shearwater species breeding in the Mediterranean. The French population is estimated at *ca.*1200 breeding pairs distributed over *ca.*10 islands. Scopoli's Shearwaters first return to breeding sites in late February, egg-laying occurs in June, chick-hatching in late July and fledging in early October.

Birds were tracked simultaneously at five different breeding localities during the chick-rearing period (mid-July to mid-September 2011): Marseille islands (Riou and Frioul), Hyères archipelago (Porquerolles) and Corsica (Lavezzi and Giraglia islands). Scopoli's Shearwaters were fitted with 20g GPS (*c.*3.3% of bird body mass) that recorded birds position every three minutes with a

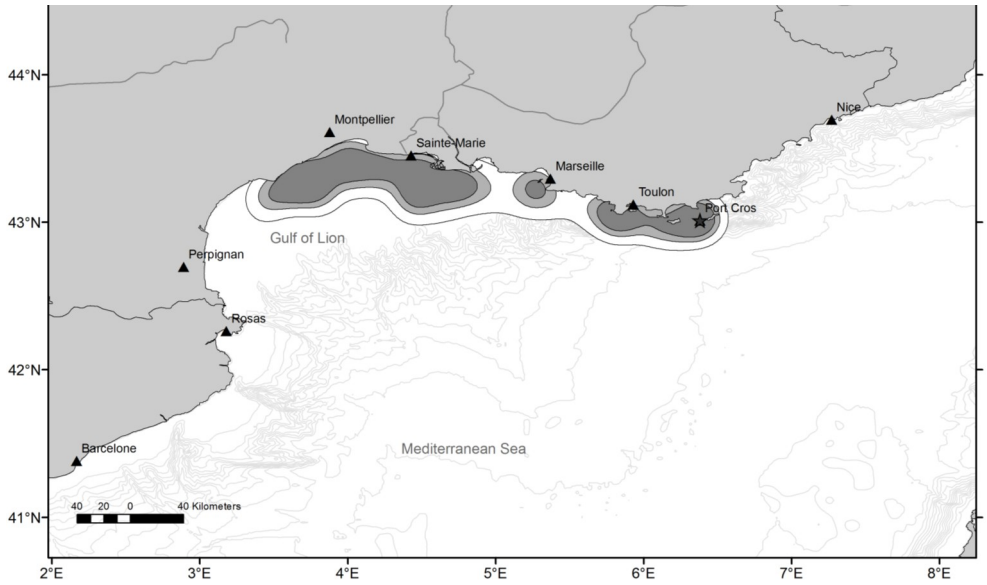

Figure 1. Summer distribution of 7 Yelkouan Shearwaters based on fixed kernel density analysis: 90, 70 and 50% kernel contours are displayed. Yelkouan shearwaters were tracked with GPS during the chick rearing period (May-June 2011), the star locates their breeding site.

high accuracy (error <100 m). GPS were fitted to the back feathers using Tesa® tape. The number of individuals fitted with GPS depended on population size (Figure 2). A total of 288 foraging trips were recorded on 120 successful breeders. Fixed kernel density maps were generated on the estimated locations to define the overall distribution of each breeding colony during the chick-rearing period. Foraging trips duration was 1.25 (± 1.03) days on average, with few birds spending more than 4 days at sea.

Total distance travelled and maximal range differed between breeding sites (Figure 2). There was substantial overlap between foraging grounds of Scopoli's Shearwaters breeding at Marseille islands and Porquerolles since they intensively exploited waters of the continental shelf and shelf-break of the Gulf of Lion (Figure 2). Few birds made longer trips reaching the Spanish coast in the Gulf of Rosas. In contrast, the two populations of Corsica foraged in distinct waters. Birds from Giraglia (north Corsica) targeted waters located in the north-east of the colony at an average range of 35 km, which was half that of birds from other colonies. At this site, low inter-individual variability indicated that Scopoli's Shearwaters rely on local, abundant and predictable resources. Shearwaters from Lavezzi foraged mainly in the strait of Bonifacio and Gulf of Asinara (Sardinia), at an average distance of 68 km from the colony. Few birds travelled along the coast of Corsica and one bird engaged in an exceptionally long trip, covering more than 2200 km in 8 days (Figure 2).

Foraging grounds of Scopoli's Shearwater during the non-breeding period

As seabirds may face different threats during the non-breeding period, we carried out a preliminary

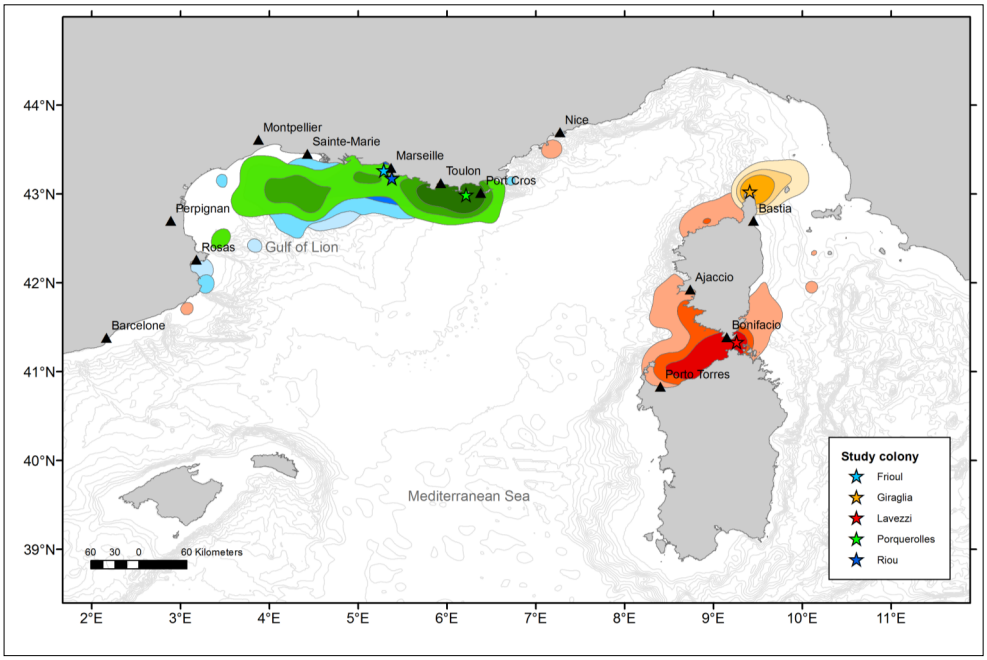

Figure 2. Summer distribution of 120 Scopoli's Shearwaters based on fixed kernel density analysis: 90, 70 and 50% kernel contours are displayed for each colony. Shearwaters were fitted with GPS on 5 different nesting sites (stars) during the chick-rearing period (mid-July to mid-Sep 2011).

study in 2009 to explore large-scale movements of Scopoli's Shearwaters during the non-breeding period (October to April). We used MK9 Global Location Sensing (GLS) loggers manufactured by the British Antarctic Survey (Cambridge) to track birds over long distances (Wilson *et al.* 1992). Four GLS were deployed on Scopoli's Shearwaters at Lavezzi in October 2009 and recovered in March 2010. Loggers, weighing 2.5g, were mounted on metal rings. Two positions per day can be inferred from light measurements with an average accuracy of 186 km (±114 km, Phillips *et al.* 2004). Fixed kernel density maps were generated on the estimated locations to define the wintering distribution of each individual bird.

This preliminary study revealed inter-individual variability in migratory behavior of Scopoli's Shearwaters breeding on the same colony. The four individuals that we tracked wintered in tropical and equatorial waters of the Atlantic Ocean in three distinct wintering grounds along a gradient of latitude ranging from 20°N to 35°S: one individual wintered in coastal waters of West Africa (from Mauritania to Guinea), two individuals wintered in the Gulf of Guinea and one individual travelled to the coast of Brazil (Figure3).

Discussion and perspectives

We have presented here the most comprehensive telemetric study carried out on the distribution at sea of shearwaters breeding on French Mediterranean islands. Our multi-site approach offers a synoptic view of shearwaters distribution during the breeding season. We identified five major

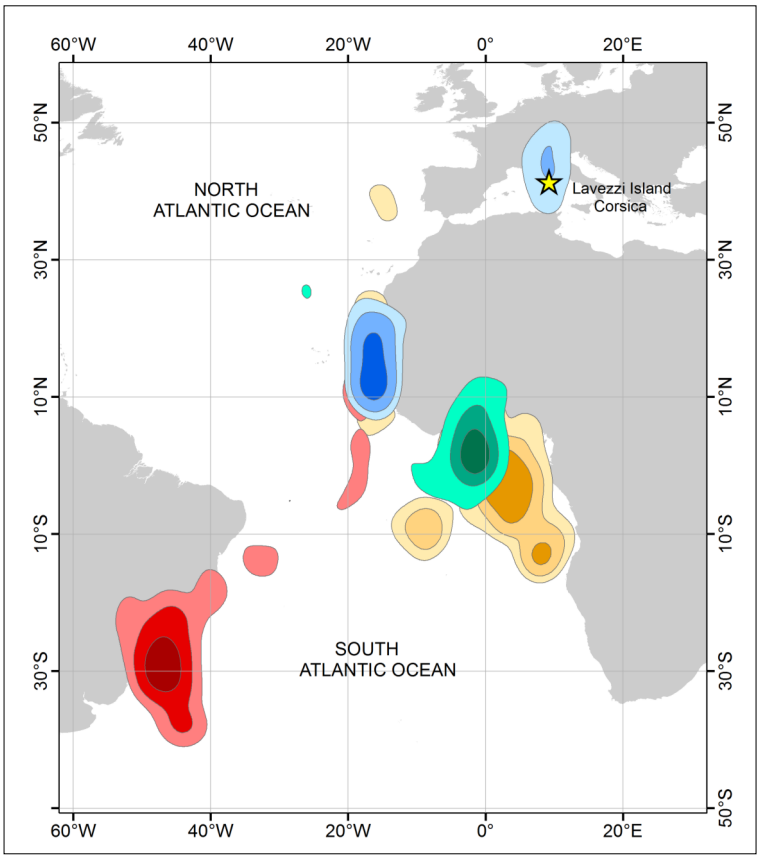

Figure 3. Winter distribution of 4 Scopoli's Shearwaters based on fixed kernel density analysis: 90, 70 and 50% kernel contours are displayed for each individual. The star locates their Mediterranean breeding site.

foraging grounds: the Gulf of Lion, the Spanish coast around Cape Creus and Rosas, the Gulf of Asinara, the Strait of Bonifacio and the zone located north-east of Corsica. Low inter-individual variability in summer foraging distribution at each breeding site, as well as high spatial overlap between three populations of Scopoli's and one population of Yelkouan Shearwaters, highlighted the importance of coastal and offshore waters of the continental shelf of the Gulf of Lion from May to September. Birds are likely to congregate off the Rhone delta in response to plumes of higher productivity associated with the spring–summer input of surface nutrients from the Rhone river (Cruzado & Velasquez 1990).

The Gulf of Lion supports high fishing pressures targeting small and large pelagic fish in spring and summer (Palomera *et al.* 2007). In this area shearwaters may interact with fishery activities either positively by feeding on fishing discards or negatively by competing for the same pelagic resources or by direct mortality through bycatch (Furness 2003). Oppel *et al.* (2011) suggested that fisheries bycatch could be the main cause of low adult survival probabilities of Yelkouan Shearwaters breeding in Port Cros, a fate similar to that of the closely related and endangered

Balearic Shearwater *Puffinus mauretanicus* (Oro *et al.* 2004). However, data on fishing effort remain unavailable in this region and there is no information on seabird bycatch rates from industrial fisheries. Yet, measures that reduce accidental bycatch at shearwaters foraging grounds would likely yield large conservation benefits. Moreover, the Gulf of Lion is exposed to chronic pollution from the Rhone river flow, with potential impact on marine ecosystem and particularly on apex predators such as seabirds that concentrate contaminants accumulated along the food web (Muir *et al.* 1999). Another potential threat to populations exploiting waters of the Gulf of Lion and Strait of Bonifacio is the risk of oil spills in these areas, which are highly frequented by oil tankers.

Preliminary results from GLS deployed on Scopoli's Shearwaters revealed inter-individual variability in migratory behavior of the four birds equipped at the same colony. These birds wintered along the west coast of Africa or east coast of Brazil, in productive coastal waters also visited by Scopoli's shearwaters breeding on Balearic Islands (González-Solís *et al.* 2007). In these upwelling ecosystems, shearwaters may also face fishing bycatch since fishing pressure is high throughout the year (Binet 1997).

This study provided a first step towards the identification of potential marine protected areas for the conservation of seabirds in the western Mediterranean Sea. A complementary study will be conducted in 2012 to assess inter-annual variability of the foraging grounds highlighted by this study. A second step will consist in coupling individual foraging trips and dynamic remote sensing oceanographic variables in a hierarchical mixed-effects model to characterize and compare habitat preferences at the population level. Predictions based on this modeling approach will provide key elements to assess the stability of shearwaters foraging grounds and thus help delineation of core marine protected areas. At a large spatial scale, our study complement others telemetric studies undertaken in Spain and Italy and should help the implementation of effective management and conservation strategies at the scale of the western and central Mediterranean basins.

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New assessment of the world's largest colony of Scopoli's Shearwater *Calonectris diomedea*

Pierre Defos du Rau[1], Karen Bourgeois[2], Lise Ruffino[3], Sylvain Dromzée[2], Ridha Ouni[4], Awatef Abiadh[5], Roger Estève[6], Jean-Patrick Durand[7], Lorraine Anselme[7], Gilles Faggio[8], Jaber Mohamed Yahya[9], Patrick Peters[10], Hamid Rguibi[11], Michel Renda[12], Bayrem Miladi[13], Hennabaal Hamrouni[14], Slim Alilech[14], Abdallah Ben Dhafer[4], Aymen Nefla[5], Wahbi Jaouadi[15], Sofiene Agrebi[15], Sébastien Renou[6]

[1]Office National de la Chasse et de la Faune Sauvage, Tour du Valat Le Sambuc 13200 Arles, France. pierre.defosdurau@oncfs.gouv.fr
[2]Percy Fitzpatrick Institute of African Ornithology, University of Cape Town & Royal Society for the Protection of Birds Gough Island, UK Overseas Territories.
[3]LT1, 243 Department of Biology Section of Ecolog, University of Turku, 20014 Turku, Finland.
[4]Bejaoua II, Sidi Thabet, BP. 23, 2020 Ariana, Tunisia.
[5]6, rue 6010 Omrane Supérieur, 1091 Tunis, Tunisia.
[6]Conservatoire du littoral, 3 rue Marcel Arnaud, 13100 Aix-en-Provence, France.
[7]CEN PACA, 166 Avenue de Hambourg, Immeuble Le Sud, 13008 Marseille, France.
[8]Maison Andreani, RN 193, 20290 Borgo, France.
[9]Environmental General Authority (EGA), P.O. Box 83618, Tripoli, Lybia.
[10]Natural Solution, 68 Rue Sainte, 13001 Marseille, France.
[11]Université Chouaib Doukkali, Faculté des Science, Département de Biologie, Laboratoire "Valorisation des Ressources Naturelles et Biodiversité", El Jadida, Morocco.
[12]Domaine des Cheminières, 11400 Castelnaudary, France.
[13]Association de Sauvegarde du Patrimoine Environnemental et Naturel du Cap Bon, ASPEN, Avenue Habib Bourguiba, El Haouaria 8045, Tunisia.
[14]Association les Amis des Oiseaux, Ariana Center, Bureau C 208/209, 2080 Ariana, Tunisia.
[15]2, rue Mohamed Rachid Ridha, Le Belvédère 1002, B.P. 280 2045 Cedex Tunis, Tunisia.

Summary. The largest population of Scopoli's Shearwater *Calonectris diomedea* was previously estimated on Zembra Island, Tunisia at 15,000-25,000 pairs. A distance-sampling survey conducted in 2009 and 2010 resulted in a new estimate of 141,780 breeding pairs (95 % CI: 113,720-176,750). This results in a re-estimation of the global population size, also supported by autumn counts of migrating Scopoli's Shearwaters at Gibraltar.

Key Words: Scopoli's Shearwater, *Calonectris diomedea*, Zembra, census, distance sampling, population estimate.

The Scopoli's Shearwater *Calonectris diomedea* is a Mediterranean endemic seabird. It is considered Vulnerable by IUCN due to recent declines in some populations. This species is threatened both at breeding sites and at sea, by introduced predators, egg exploitation, poaching of chicks, urban light-induced mortality and fishery bycatch. Assessment of impact of threats using population models requires estimates of population size. The latter necessitates an

adequate sampling design and an estimate of detectability, as well as important field survey efforts both in staff and skills. Until recently the Mediterranean population was estimated at 57,000-76,000 breeding pairs, with the largest population (15,000-25,000 pairs) breeding on Zembra Island, Tunisia (Zotier *et al*. 1999, Sultana & Borg, 2006). However, the estimate for this major breeding site dated back to the 1970-1980s and did not take detection and sampling imperfections into account. This population size estimate needed to be updated in order to better assess the status and vulnerability of this taxon in the Mediterranean.

The population of Scopoli's Shearwater breeding in Zembra was therefore censused during a two-year study using a suitable sampling design, taking in consideration the detection of imperfections. Indeed, bushy vegetation and rocky slopes of Zembra were likely sources of detection errors or imperfections, potential bias that needed to be addressed. A pilot survey was conducted in 2009 to decide upon survey method and desirable sample size. This test survey concluded that distance sampling line-transects and a minimum of 100 line-transects were the most adequate. In 2010, Scopoli's Shearwater nests were therefore counted throughout the entire Zembra Island (except the steepest cliffs) along 174 line-transects, following the distance-sampling methodology. This relatively strong sampling effort resulted in a new estimate of the Zembra breeding population of 141,780 breeding pairs (95 % confidence interval: 113,720-176,750). Modelling of distance data was clearly improved when nest occupancy status was taken into account, as occupied and empty nests were actually proved to be two different kinds of objects to search for in the field. Indeed the presence of the incubating adult often improved the detection process, including at some distance. However, no other observation, either related to nest habitat or to nest detection, improved model adequacy. In addition, observer skills were quantified individually in 2010 but did not prove influential either.

The main result of this study consists in a major re-estimation of the global population size of the Mediterranean Scopoli's Shearwater. A new breeding population estimate for the Mediterranean is now proposed from 57,000-76,000 to 179,000-193,000 breeding pairs. Results of two recent Scopoli's Shearwater counting schemes at both sides of the Strait of Gibraltar during autumn migration corroborate this major re-evaluation of the Mediterranean population size of the species. On the North side of the Strait, from 150,000 to 211,000 individuals were counted annually in October and November (from 2003 to 2008) migrating from the Mediterranean to the Atlantic (Programa MIGRES 2009). In the same months, more than 500,000 individuals were estimated to migrate annually (from 2005 to 2007) to the Atlantic off the South coast of the Strait (Navarrete 2008). These counts already suggested that the Mediterranean breeding population was largely underestimated and was probably above 130,000 pairs, based solely on counts from the southern side of the Strait. The Zembra breeding colony constitutes the largest population in the world for this species. Hence it is even more of major conservation concern at the global scale.

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Developing a population assessment for Scopoli's and Cory's Shearwaters *Calonectris diomedea/Calonectris borealis*

Mia Derhé[1]

[1]European Research and Conservation Officer, BirdLife International, Wellbrook Court, Girton Road, Cambridge, CB3 0NA, UK. m.derhe@lancaster.ac.uk

Summary

Despite being listed as Least Concern on the IUCN Red List, Cory's Shearwater *Calonectris diomedea* has been identified as having an unfavourable conservation status in Europe. This population assessment, prepared through extensive expert consultation and a review of the current literature, summarizes current data on the species' distribution, population size and trends, the threats to its survival, and identifies key knowledge gaps and research needed. The global population is estimated at 392,278-473,986 pairs/ 1,000,000-1,500,000 individuals, with the Atlantic population *C.d. borealis* comprising 251,100-251,300 pairs and the Mediterranean subspecies *C. d. diomedea,* comprising 142,478-222,886 pairs. By combining data for countries for which trend information is available, it is estimated that the global breeding population is stable or increasing. The main threats to both *C. d. diomedea* and *C. d. borealis* are from invasive, non-native predators and mortality from fishery bycatch. Research efforts should focus on censusing breeding colonies, monitoring the population at key breeding sites, assessing mortality rates from fishery bycatch and introduced predators, and studying the species' demographic parameters.

Key Words: *Calonectris diomedea*, Cory's Shearwater, Mediterranean, Azores, status assessment, bycatch, introduced predators, seabird conservation, rat eradication.

Introduction

Cory's Shearwater *Calonectris diomedea*(**) has been identified as having an unfavourable conservation status in Europe: it is listed in Annex I of the Birds Directive and reports indicate that mortality rates may have increased in recent years, particularly due to invasive, non-native predators and incidental fishing bycatch. A population assessment for this species is required before Action Plans are produced or updated, particularly as the current size and trend of many national populations are unclear. Cory's Shearwater breeds on islands and cliffs in the Mediterranean, with important outposts in the Atlantic in Spain (Canary Islands) and in Portugal (Azores; Madeira archipelago: Selvagens and Desertas; Berlengas Islands). There are two subspecies: the nominate form *Calonectris diomedea diomedea* in the Mediterranean and *Calonectris diomedea borealis* in the Atlantic. *C. d. diomedea* is known to breed in Algeria, Croatia, France, Greece, Italy, Malta,

(**) **When the assessment of *Calonectris diomedea,* which appears in this paper, was carried out and discussed at the 13th Medmaravis Pan-Mediterranean Symposium, the Cory's Shearwater *Calonectris diomedea* was considered as polytypic (2 races *C.d. diomedea* and *C.d borealis*). It should be noted that since then, the Taxonomic Sub-Committee of the British Ornithologists Union has recommended that these two races should be treated as two full species, Scopoli's Sheawater *Calonectris diomedea* and Cory's Shearwater *Calonectris borealis* (Taxonomic recommendations for British Birds: eight report. *Ibis* (2012) 154: 874-883).**

Spain (excluding the Canary Islands), Tunisia and Turkey. *C. d. borealis* breeds in Portugal (including the Azores, Madeira and Berlengas) and the Canary Islands.

Methods

The method of the assessment was: 1) to identify the range states and those holding significant populations at any stage of the life cycle; 2) to identify potential contributors and data providers; 3) to collect data (through an electronic questionnaire) on national breeding and non-breeding population sizes and trends, threats which likely affect the population at national and international level, and stakeholders and interests; 4) to collate the data and produce a draft assessment document (species status report); and 5) to organise an expert workshop, to (a) verify the data collected, clarify any inconsistencies and agree on national figures and trends; (b) elaborate a common expert assessment of the data (interpretation); (c) identify key knowledge gaps; and (d) identify and map key stakeholders and their interests in the species.

Results

Global breeding population size

Current data from known breeding sites gives a global population estimate of 392,278-473,986 pairs/ 1,000,000-1,500,000 individuals for Cory's Shearwater (including both subspecies). This correlates with counts of c. 600,000 individuals carried out at the strait of Gibraltar during autumn passage when the birds leave the Mediterranean basin (Navarrete 2008, J. M. Arcos pers. comm.). The Atlantic population *C.d. borealis* is estimated at 251,100-251,300 pairs. Previous estimates put the global population size of Cory's Shearwater at around 200,000 pairs (Brooke 2004), with the Mediterranean population *C. d. diomedea* estimated at around 80,000 pairs. A recent study using distance sampling of occupied nests on Zembra Island in Tunisia has estimated the population to be around 140,000 breeding pairs on this colony (Defos du Rau *et al.* for Initiative PIM, in prep., this volume pp.26-28). This apparent increase in population size from c.25,000 pairs (Isenmann & Moali 2000) is due to improved sampling methods rather than a genuine population increase. In order to accurately assess the population size of Cory's Shearwater, more breeding population censuses need to be conducted, particularly at major breeding sites such as the Azores and the Canary Islands, as well as in Algeria, for which there is little reliable recent data.

Breeding population trend

A lack of data on key sites combined with the absence of regular monitoring at the major breeding colonies (particularly the Azores, Tunisia and the Canary Islands) means that it is difficult to determine a global breeding population trend for the species. However, breeding population trend data is available for c.10% of the population (from Croatia, Greece, Malta, Madeira, Berlengas, and Spain) and the global breeding population trend has been estimated from this data. Assuming that the population is stable in those countries for which the population trend is unknown, it is predicted that, if the reported population trends remain constant in the future, the global breeding population is estimated to be increasing by c.30% over next 58 years, i.e. 3 generations, starting from 1980. At the current rate, the Mediterranean population (*C. d. diomedea*) is predicted to be declining by c.2% over 3 generations (from 1980), although this is based on data from only 6% of the subpopulation. The Atlantic population (*C. d. borealis*) is estimated to be increasing by c.100% over 3 generations (from 1980), due predominantly to a population recovery at Selvagem Grande

of an estimated 4.6% per year since 1980 (Granadeiro *et al.* 2006); however, this is based on data from only 13% of the subpopulation and on the assumption that the Azorean population is stable, which is unlikely to be the case. Determining the trend in the Azores is absolutely crucial in order to estimate the global trend for *C. d. borealis*, or indeed the species as a whole.

In any case, it is difficult to make firm conclusions on breeding population trends without data from the key colonies, particularly in the Azores and Tunisia. It is suspected that the population may be declining in the Azores, although this has not been confirmed, and reported rapid declines (43% decline during 1996-2001; Bolton 2001) are likely to be caused by inter-annual variations in colony attendance (Chastel *et al.* 1993, Jenouvrier *et al.* 2005) along with temporal behavioural differences between census years (Bolton 2001, Fontaine *et al.* 2011). The recent work conducted on Zembra Island in Tunisia has highlighted the importance of this site as the largest colony of Cory's Shearwater in the world (holding c.30% of the total global population and c.80% of *C. d. diomedea*). It is crucial that monitoring is conducted to determine the population trend and impact of threats on the Zembra colony. Until estimates of adult survival and breeding probabilities in Tunisia and on the main Azorean islands, as well as at other important locations (i.e. Madeira, Canary Islands and Italy), are available, any global population trend estimate for the species remains purely speculative.

Threats

Overall, breeding populations of Cory's Shearwater appear to be fluctuating, with the Mediterranean population possibly experiencing moderate declines. The main threats to both *C. d. diomedea* and *C. d. borealis* are from invasive, non-native predators (predominantly black rats *Rattus rattus* and domestic and feral cats *Felis catus* in the Azores), and mortality from fishery bycatch.

In long-lived species such as shearwaters, the impact of introduced predators is most severe when both adults and eggs are affected by predation (Warham 1990, Cuthbert *et al.* 2001). In addition to predation, other introduced mammals may adversely affect seabird populations through habitat degradation (e.g. Monteiro *et al.* 1996). Recent studies highlight the pressures imposed on breeding populations of Cory's Shearwaters by several introduced mammals (rats, cats, mice and rabbits; Rannisi *et al.* 2008, Zino *et al.* 2008, Baccetti *et al.* 2009, Henriques 2010) and colonies regularly show marked increases in breeding success during mammal control programmes (e.g. Igual *et al.* 2006, Zino *et al.* 2008, Pascal *et al.* 2008). The observed population decline of the species in Italy has been mainly attributed to alien predators, especially rats (Sultana & Borg 2006), which can heavily limit reproductive success by predation upon chicks and eggs (e.g. Thibault 1995, Martin *et al.* 2000, Igual *et al.* 2006, Baccetti *et al.* 2009, Towns *et al.* 2006, Jones *et al.* 2008, Ruffino *et al.* 2009).

Cory's Shearwaters are one of the most frequently represented seabirds in bycatch in the Mediterranean (Valeiras & Caminas 2003, García-Barcelona *et al*. 2010a, Laneri *et al.* 2010), with estimates of the numbers of individuals killed annually by Spanish fleets ranging from 200 (García-Barcelona *et al*. 2010) to 467-1867 (estimated 4-6% of the local breeding population; Belda & Sanchez 2001). There have been fewer assessments of the impacts of long-line other national fisheries on Cory's Shearwater, but results from a questionnaire suggest an annual bycatch of up to 1220 birds by Maltese fleets (8.5-10% of the breeding population; Dimech *et al.* unpubl.), although the authors emphasise that this is likely to represent an over-estimate skewed by high bycatch in a small number of vessels.

Additional important threats include high and increasing levels of light pollution, and disturbance to colonies resulting from tourist and residential development are affecting the species in several countries (Baccetti *et al.* 2005, Raine *et al.* 2007, Rodríguez & Rodríguez 2009, Rodríguez *et al.* 2011, Fontaine *et al.* 2011); competition with fisheries (I. Ramirez and J. Fric pers. comm.); oil spills (N. Baccetti and J. Fric pers. comm.); windfarms (N. Baccetti, J. Fric and C. Peron pers. comm.). Less prominent threats to some populations include intensive poaching of chicks in specific colonies in the Canary Islands (Lopez-Darias *et al.* 2011) and on Santa Maria Island, Azores (Fontaine *et al.* 2011), direct persecution/ vandalism at colonies (J. Bried pers. comm.), and geological events (Fontaine *et al*. 2011, Monteiro *et al*. unpublished data).

Stakeholders

Important stakeholders that have an interest in the species have been identified through literature review and consultation with species experts. These stakeholders fall roughly into 13 categories: National governments; regional and local governments; National Park/ Protected Area managers; BirdLife partners; other NGOs; research institutes, groups and individuals; industrial fisheries; local (artisanal) fishermen; tourist businesses (tourism companies, hoteliers, fish restaurants, tourists); wind energy community; island inhabitants; and oil companies.

Conclusions

The population assessment revealed that the population may be fluctuating or even increasing, but is still suffering from significant threats and so it is recommended that conservation actions are prioritised to address these threats. In particular, it is recommended that policymakers are encouraged to implement and enforce measures that reduce accidental bycatch of Cory's Shearwaters and other seabirds in commercial fishing operations in the Mediterranean. As a precaution, rats and feral cats should be controlled, or if possible eradicated, at breeding colonies, according to a preliminary threat assessment. The identification and implementation of measures to reduce/ mitigate the effects of light pollution on the species (see e.g. Raine *et al.* 2007) are also recommended. The assessment has also highlighted the paucity of available data for the species due to a lack of monitoring and research. Accurate and regular research and monitoring is needed in order to obtain reliable estimates of population size and trends and to assess the impact of threats on the species.

Priority research recommended

Population size

In order to accurately estimate the global population size, efforts should focus on conducting population censuses at breeding colonies for which there is currently little reliable and up-to-date data, particularly those in the Canary Islands and Algeria; surveying Azorean breeding colonies to determine breeding population size; conducting further studies on Zembra Island, Tunisia, to confirm the breeding population size; and conducting non-breeding/ migrating counts at bottleneck sites, e.g. at the strait of Gibraltar. In order to aid in the identification of marine Important Bird Areas for the species, all tracking data should be contributed to BirdLife International's seabird tracking database (http://www.seabirdtracking.org/).

It is important that census methodology is standardised so that population estimates

can be collated into a global estimate and are comparable both spatially and temporally. As such, recommendations and guidance on best-practice census methodology should be developed, including guidance on timing of 'non-breeding' counts (i.e. 'non-breeding' refers to moulting individuals in the non-breeding [moulting period] season). Simultaneous observation programmes should be promoted. Research is recommended to assess whether counts of at-sea rafts are a good proxy for breeding pairs.

Population trend

To accurately determine the long-term trend of the species, monitoring should be conducted at key breeding sites, particularly the Azores, Tunisia and Canary Islands; and population trends on Linosa Island, Sicily should be monitored.

In order to reliably assess the impact of threats on population trends, research should be conducted on the species' demographic parameters. In particular, the species' ecological requirements need to be understood and the impact of threats on breeding success and adult survival probabilities should be investigated in order to understand the relative importance of these parameters on population declines. Research on demographic parameters should also focus on determining the non-breeding proportion of the population.

Threats

Assessing mortality rates from accidental bycatch is a priority action. Research on the impact of introduced predators is needed to prioritise eradication and control efforts, investigating the long-term population dynamics and interactions between Cory's Shearwater and rats. Additional threats to the species should be researched and regularly monitored. In particular, threats to the Zembra Island and Selvagem Grande populations should be monitored.

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N.B. See Table pages 37-38

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Table 1. Cory's Shearwater *Calonectris diomedea* breeding and non-breeding population size estimate and breeding population trend by country

Country	Breeding population in 2004 (pairs)	Current breeding population (pairs)	Year(s)	Current breeding population reference	Current non-breeding population (individuals)	Year(s)	Current non-breeding population reference	Recent breeding population trend	Year(s)	Reference
Algeria*	-	1,070	2000	1	-	-	-	-	-	-
Croatia*	800-1,000	1,000-1,500	2004-2011	2	-	-	-	10-40% decrease	2004-2011	2
France*	970-1200	1,044-1,293	1996-2001	3	-	-	-	Possibly increasing	-	26
Greece*	5,000-5,000	5,200-8,300	1995-2011	4	50-200	2009-2011	5	Stable	2007-2011	5
Italy*	15,000-18,000	13,344-21,873	2000-2008	6	0	1980-2011	7	Unknown	2000-2009	6,27
Malta*	6,090-7,130	4,100	2011	8	5,000-7,000	1983-2011	9	5-10% de-creasing	1980s-2011	28, 29, 30, 31, 32
Portugal+										
Azores+	188,000	188,000	1996	10, 11	120-2,000	2005	10, 12	Possibly decreasing	2002-2008	33
Madeira+	16,500-25,000	31,000-32,000	2000-2010	13, 14, 15, 16	-	-	-	3-41% in-creasing	1996-2010	13
Berlengas+	300-450	1,000-1,100	2005; 2010-2011	17, 18	-	-	-	165-233% increasing	2002-2005	18, 34
Spain – Med.*	2,500-10,000	3,000-8,000	1991-2011	19, 20, 21	-	-	-	5-15% de-creasing	2000-2010	35, 36, 37
Spain – Atlantic+ *(Canary Islands)*	30,000-30,000	30,000	1987-1991	22, 23	-	-	-	Decreasing	2000-2010	38

Table continued overleaf

Country	Breeding population in 2004 (pairs)	Current breeding population (pairs)	Year(s)	Current breeding population reference	Current non-breeding population (individuals)	Year(s)	Current non-breeding population reference	Recent breeding population trend	Year(s)	Reference
Tunisia*	-	113,720-176,750	2010	[24]	-	-	-	Unknown	-	-
Turkey*	0-200	0-?	2011	[25]	-	-	-	Unknown	-	-
Mediterranean Total		142,478-222,886								
Atlantic Total		250,800-251,100								
Global Total		**392,278-473,986**								

* Mediterranean population *C. d. diomedea*

\+ Atlantic population *C. d. borealis*

1 - Isenmann and Moali 2000; 2 - Budinski *et al.* 2010; 3- Cadiou *et al.* 2004; 4 - Hellenic Ornithological Society 2009; 5 - Hellenic Ornithological Society 2011; 6 - Bacetti *et al.* 2009; 7 - Brichetti and Fricasso 2003; 8 - Sultana *et al.* 2011; 9 - J. J. Borg pers. comm.; 10 - Monteiro *et al.* 1996; 11 - BirdLife International 2004; 12 - Bried, J., Crochet, P.-A., Didner E. and Pedro P. *in litt.*; 13 - Catry *et al.* 2010; 14 - Granadeiro *et al.* 2006; 15 - Oliveira and Menezes 2004; 16 - Geraldes 2000; 17 - Lecoq *et al.* unpub.; 18 - Lecoq 2010; 19 - Aguilar 1991; 20 - Carboneras 2003; 21 - Arcos *et al.* 2009; 22 - Delgado *et al.* 1987; 23 - Martin and Lorenzo, 2001; 24 – P. Defos du Rau *in litt.*; 25 - J. P. Tavares pers. comm.; 26 - Cadiou *et al.* 2011; 27 - Baccetti *et al.* 2008; 28 - Borg and Mallia 1995; 29 - Borg & Sultana 1990-91; 30 - Borg and Sultana 2002; 31 - Sultana and Borg 2006; 32 - UNEP - MAP - RAC/SPA 2006; 33 - Fontaine *et al.* 2011; 34 – Lecoq 2003; 35 - Sanz-Aguilar *et al.* 2011; 36 - Igual *et al.* 2009; 37 - J. M. Arcos pers. comm.; 38 - Rodríguez *et al.* 2011.

Movements and 'moving' population estimates of Yelkouan Shearwater *Puffinus yelkouan* at Tavolara, Sardinia

Marco Zenatello[1], Giovanna Spano[2], Carla Zucca[3], Augusto Navone[2], Massimo Putzu[2], Caterina Azara[4], Egidio Trainito[5], Mirko Ugo[6] & Nicola Baccetti[1]

[1]ISPRA, via Ca' Fornacetta 9, 40064 Ozzano Emilia BO, Italy. marco.zenatello@isprambiente.it

[2]AMP Tavolara-Molara-Capo Coda Cavallo, Olbia, Italy. educazione@amptavolara.it

[3]Anthus snc, Cagliari, Italy. corymbosa@hotmail.com

[4]Loc. La Punga 734, Arzachena OT, Italy. lapunga@tiscali.it

[5]Villaggio i Fari, Porto San Paolo OT, Italy. et@egidiotrainito.it

[6]Parco Nazionale dell'Arcipelago di La Maddalena, La Maddalena OT, Italy. m.ugo@lamaddalenapark.org

Summary. An ongoing monitoring programme allowed the re-assessment of the population size of Yelkouan Shearwater Puffinus yelkouan breeding at Tavolara (Sardinia, Italy), the largest world colony of this species. Results point at 9,991-13,424 breeding pairs, obtained by afternoon counts from land of birds approaching the colony and confirmed by the census of ground plots. Feeding areas of breeding adults, investigated with GPS loggers, stretch for some hundred kilometres and are mostly located at coastal gulfs of N and W Sardinia and SW Corsica, between Oristano, Ajaccio and the Maddalena archipelago. Counts from land suggest that the Orosei Gulf, in E Sardinia, might also be used.

Key Words: Yelkouan Shearwater, Puffinus yelkouan, population size, Tavolara, GPS loggers, Italy

Introduction: continuous fluctuations of Sardinian population estimates

Sardinia (24,000 km^2) is the second largest island in the Mediterranean Sea. An update of the national breeding figures for Scopoli' s Shearwater *Calonectris diomedea* and Yelkouan Shearwater *Puffinus yelkouan* highlighted the outstanding importance of this area for the conservation of both species (Baccetti *et al.* 2009). Concerning the latter species, the most recent estimates (Bourgeois & Vidal 2008, Baccetti *et al.* 2009) were suggesting that at least 18% (and possibly up to 61%) of its world population breed at 12 colonies located on Sardinia's sheer cliffs and satellite islands. The large degree of uncertainty comes from the fluctuating estimates proposed so far for the largest breeding site, Tavolara island. Indeed, estimates for this crucial area were repeatedly changed since the late 1970s, although re-assessments were not always based on updated field data. Consequently, not all changes of national (and global) estimates for this species were

associated to genuine improvements in knowledge. The first estimates for Tavolara date back from 1978-79 (6,000-9,000 pairs for the whole archipelago, i.e. Tavolara, Molara and Figarolo islands) and were based on counts of huge rafts that at that time were usually seen offshore (Schenk & Torre 1986). These figures were used as such for the following 15 years, until Brunner *et al.* (2002) dropped them to 1,000-2,000 pairs. In 2006, counts from land of shearwaters moving towards their colonies (Zenatello *et al.* 2006) increased again the population estimate. The values which were proposed for Tavolara since 2006 on (500-5,000 pairs: Bourgeois & Vidal 2008, then 1,200-7,800 pairs: Baccetti *et al.* 2009) were based on steadily improving estimates obtained through the latter method.

This situation prompted us to set up a monitoring programme aimed at (i) producing more reliable estimates of breeding numbers; (ii) recording the breeding success and main limiting factors; and (iii) investigating the foraging range and routes to/from the colony, in order to identify areas important for this population. Ongoing studies on this species, not accounted for in the present paper, also addressed year-round changes of distribution and at sea activity patterns through leg-mounted geolocator-immersion loggers.

Study area

The core breeding range of Yelkouan Shearwater in Sardinia is concentrated on Tavolara island (40°54'N 09°42'E), where 1,200-7,800 pairs were estimated by Baccetti *et al.* (2009). Two nearby islands (Figarolo: 40°59'N 09°39'E and Molara: 40°52'N 09°44'E) host 310-700 additional pairs, bringing the total for the whole area to 1510-8500 pairs. The main breeding site, Tavolara, is a large limestone island (*ca.*600 ha) reaching 566 m at sea level, with its SE slope largely occupied by almost vertical cliffs. About half of its surface is covered by a tall *Juniperus phoenicea* scrub; the other portion is mostly bare rock, with clumps of low termo-xerophilous scrub and a few plots hosting scattered trees, mainly *Olea europaea* var. *sylvestris* and *Acer monspessulanum*. Eggs and chicks of Yelkouan Shearwaters are diffusely predated by black rats Rattus rattus; feral cats are present on Tavolara, but their impact on shearwaters is unknown. In 2008, an eradication project led to a temporary removal of black rats from the nearby island of Molara (Sposimo *et al.* this volume).

Methods

Traditionally, estimates of breeding shearwaters relied on evening counts of rafts in the vicinity of the main colony site (Tavolara island). Despite large rafts were present, and occasionally counted, until the turn of the 20th century, this method did not prove to be useful in recent years, as visual searches from the island were strongly limited due to difficult accessibility and large territory and rugged morphology. It was also difficult to use a boat or a helicopter to locate any important evening rafts.

Census of occupied burrows.
On Tavolara island, 10 ground plots (total area: 3.99 Ha, average size: 0.44 Ha ± 0.31 s.d.) were geo-referenced by GPS and entirely searched for nests between late April and mid-May 2008-

2010, by teams of 3-6 people advancing on a front. Burrows encountered by the observers were visually checked, using a hand torch and, when necessary, a RIDGID Seesnake inspection camera). The contents and occupation status of each burrow were checked and assigned to one of the following categories: (a) occupied; (b) not occupied but apparently suitable for nesting; and (c) unknown (complete visual inspection not possible). Plots were made in areas suitable for breeding, i.e. along slopes and valleys covered by loose bush/tree vegetation and rocks. Areas where previous explorations had never revealed active nests (NW slope of the island and surfaces covered by dense *Juniperus* scrub) were excluded from sampling at this stage. The area considered here as suitable for nesting covers roughly half of the (flat) surface of the island (317 ha "suitable" and 283 ha "unsuitable") (Figure 1).

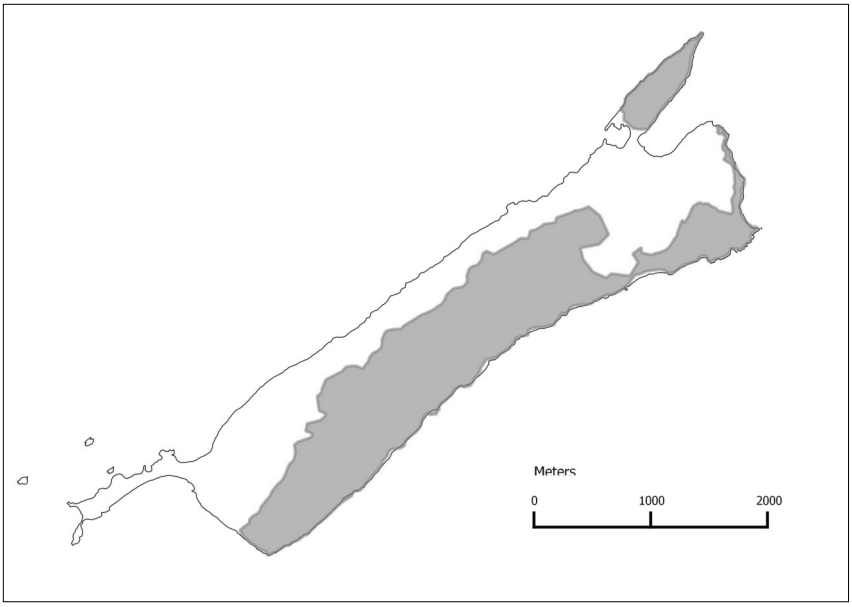

Figure 1. Map of Tavolara showing areas 'suitable' (shaded) and 'unsuitable' (white) for breeding Yelkouan Shearwater (see text for definitions).

Counts from land.

A pilot count of both shearwater species from coastal observation points all around Sardinia (Zenatello *et al.* 2006) had indicated that flocks of Yelkouan Shearwater were showing strongly oriented coastal movements, with afternoon flights heading towards the main known colonies even from distances of some hundreds of kilometres. In 2007 and 2008 similar counts were made only in NE Sardinia, in order to focus on the Tavolara breeding population of Yelkouan Shearwater. Counts were carried out from vantage points at promontories or bottlenecks, far enough from the colony to count birds in active flight and avoid the circling birds near the evening rafts. Four suitable sites were identified and used, three to the north and one to the south of Tavolara (Figure 2). Two to four census points were visited weekly during most of the breeding season (January-June), in days close to the last moon quarter. On these days, the moonless hours are concentrated soon after sunset, so that most birds are expected to adjust their flight schedule for

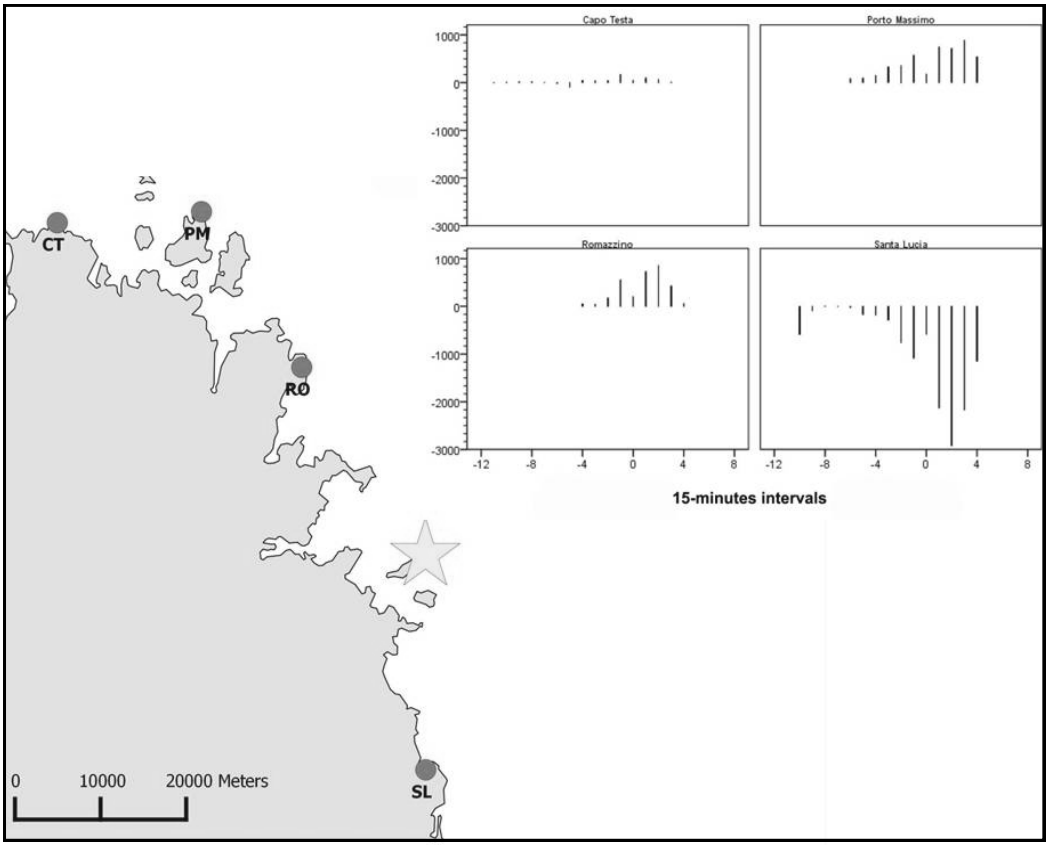

Figure 2. Map of the coastal census points around Tavolara (star): CT=Capo Testa, PM=Porto Massimo, RO=Romazzino, SL=Santa Lucia. Histograms give an example of the results at each one of these sites (count of 29 February 2008, see Table 2 for totals at each site). Time of day on the x-axis is expressed as 15-minutes periods before/after sunset time (0); on the y-axis, the number of birds is expressed by positive numbers for birds approaching the colony, and by negative numbers for birds travelling in the opposite direction.

an early arrival to the colony (Bourgeois *et al*. 2008). The number of birds and their flight direction (towards left/right of the observer) were recorded at 5 minutes intervals from early afternoon to dawn, by teams of two-three persons equipped with 20-60x telescopes and binoculars. Sessions ended when darkness prevented the identification and counting of birds, although their flow sometimes continued. Since foraging trips of adult medium-sized shearwaters can take more than one day (see Brooke 1990 for *P. puffinus*, Aguilar *et al.* 2003 for *P. mauretanicus*, and Results), we assumed that (i) only an (unknown) fraction of breeders visits the colony in any one night and that (ii) only a fraction of the latter was detected during counts from land. Hence, monthly maxima (instead of average values) were used as an index of population size. The number of birds which were counted was attributed to breeding individuals (before egg-laying: January-February) or

pairs (during incubation and rearing: from March onwards): egg-laying occurs between late February and early March at Tavolara (pers. data).

Movements of local breeders.
Since 2011, short-term movements have been investigated with back-mounted GPS-loggers (Gypsy-2 and Gypsy-4 by Technosmart and I-gotU GT120 by Mobile Action Technology), attached to mantle feathers of breeding adults with adhesive TESA tape (total weight: 13-20g according to battery size). The weight of GPS-loggers was 3.1%-4.7% the average mass of adults (424.5g ± 28.6g s.d., N=29, pers. data). Deployment sessions were carried out in 2011 (fourteen Gypsy-2 loggers) and 2012 (five Gypsy-4 and eight I-gotU loggers), during incubation (April) and chick-rearing (June).

Results

Burrows occupancy rate and density.
The occupancy status could be verified in about 75% of the 574 inspected burrows. A total of 157 cavities were classified as occupied (fresh faeces or bird seen/heard) and 271 were empty but apparently suitable for nesting. The density of occupied burrows fluctuated widely among census plots, averaging 43.3±34.4 s.d. burrows/ha (range: 5.7-95.0, Table 1). This average density would produce an estimate of 13,726 nests for the whole suitable area of Tavolara.

	Burrow density	**Estimated number of breeding pairs**
	mean/ha (range)	mean (range)
Occupied burrows	43.3 (5.7-95)	13,726 (1,806-30,105)
Empty suitable burrows	103.3 (17.6-223.6)	32,746 (5,582-70,881)

Table 1. Density of burrows occupied by/suitable for Yelkouan Shearwater on Tavolara island sample plots.

Counts from land.
With the exception of some data collected at Capo Testa, the westernmost site, afternoon movements observed from land were highly directional towards Tavolara at all census points. Inter-annual differences were large, and so were the differences of counts performed in consecutive weeks. The foraging areas were located both north and south of the colony, as shown by the movements of incoming flocks at the census points (Table 2). Within the narrow period of the lunar cycle when birds were counted, no clear relationship between bird totals and moon phase was apparent. Possible confounding factors (e.g. height of waves and visibility) were not quantified, hence their effect on count accuracy could not be evaluated. Both investigated years gave extremely fluctuating figures, even in similar dates.

Foraging trips.
Counts around Sardinia in 2006 (Zenatello *et al.* 2006) had suggested a foraging range stretching between the Stintino peninsula and the Orosei Gulf, i.e. *ca.* 200 km West and 100 km South of the colony site. Loggers used in 2011 and 2012 gave some preliminary insights on the foraging movements of local breeders. Overall, six Gypsy and seven I-gotU loggers, retrieved 3-8 days

	2007									2008			
	13-Jan	19-Jan	10-Feb	17-Feb	12-Mar	18-Mar	13-Apr	10-May	12-Jun	30-Jan	29-Feb	28-Mar	26-Apr
Capo Testa (N)					X	91		683		X	X	X	X
Porto Massimo (N)							X			1215	653	5186	
Romazzino (N)	524	X	X	-40		X	X		649	X	X		6343
S.Lucia/ C.Comino (S)	7304	X	X	6919	X	5095	X	4731	1162	1516	12150	4805	7081
Total	7825			6879		5186		5414	1811	2731	12803	9991	13424
Days to new moon	6	0	7	0	7	1	4	6	3	8	7	9	9

Table 2. Variability of afternoon counts of Yelkouan Shearwater flying to the Tavolara-Molara archipelago. Census points to the north and south of the colony are identified by (N) and (S), respectively. Their geographical location is shown in Figure 1. Values are the highest totals for each month, calculated as the difference between positive (birds flying towards the colony) and negative (birds flying away from the colony) counts. On dates when counts were below the monthly maximum, an "x" shows the census points that were used.

after deployment, contained useful GPS fixes. Partial tracks were due to the rather frequent failure of data recording by one of the two GPS modules. Two partial tracks, obtained in 2011, recorded large movements between Tavolara and feeding areas at the mouth of the Oristano Gulf (W Sardinian coast, more than 300 Km from Tavolara). In both cases the GPS stopped their recording after 5 days, when the birds were still in that feeding area. The other tracks pointed at some other less distant feeding areas, such as SW Corsica, the area between Capo Testa and Castelsardo, the Maddalena archipelago, and the Gulf of Olbia (Figure 3). The mean duration of foraging trips, calculated on the available sample of complete tracks, was 2.38±1.76 days (range: 1-7 days, N=13). April trips (during incubation) were shorter (1-2 days, N=6) than those performed during chick-rearing (first half of June: 2-7 days, N=7).

Discussion

Despite their large variability, counts of birds on afternoon flights offered the best method so far to evaluate the size of this colony. This method invariably gives minimum absolute counts (not estimates) of birds, which must then be assigned to "breeding individuals" or "breeding pairs" according to the breeding phenology. Maximum counts obtained during a given phase of the breeding season can be used to approximate the minimum size of the breeding population. In this respect, confounding environmental factors (e.g. wind, rain), and variable schedules of daily colony attendance by breeders (related to moon phase which also affects the timing and duration

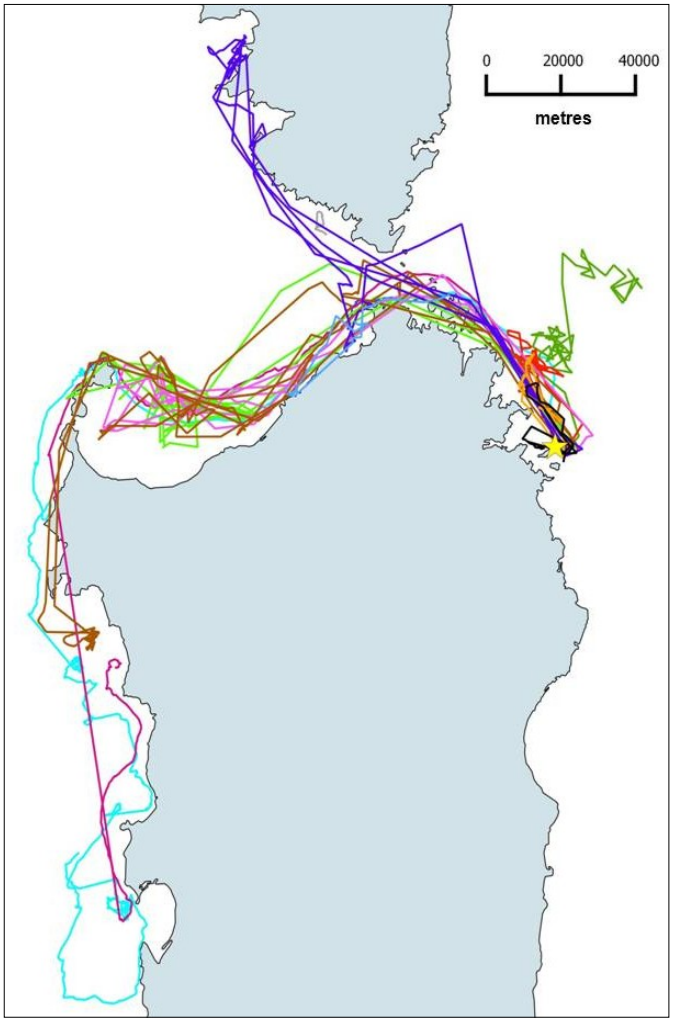

Figure 3. Foraging tracks of Tavolara breeding Yelkouan Shearwaters equipped in 2011 and 2012 with GPS loggers. Each colour identifies a feeding trip. The colony site is shown by a yellow star.

of dark nights, see Bourgeois *et al. 2008)* can probably cause an underestimation of the investigated population, hence supporting the use of maxima values. Indeed, if no dramatic environmental changes (e.g. massive invasions of predators or their eradication, food shortages) take place within a short time lapse (1-2 years), the species' high philopatry and low productivity (a common feature to most Procellariiformes, Warham 1990) suggest that top values from consecutive years could also be pooled in order to estimate the local breeding population. In counts obtained at the start of the breeding season (during pair formation, nest occupation and before the peak of egg-laying, i.e. until early March), both partners are likely counted among the flocks (but see Guilford *et al.* 2012 for detailed schedules of colony attendance by partners in pre-laying dates). Such counts must, hence, be prudently attributed to breeding individuals. Counts during incubation (March - late April) are invariably missing at least one member of each breeding pair, the other one sitting in the nest.

Maximum counts before egg-laying (12,803 on 29 February 2008) suggested a population estimate of no less than 6,401 breeding pairs, while figures obtained during incubation (March - April 2008) pointed at 9,991-13,424 pairs, which we propose here as a new estimated range for the local population breeding in the Tavolara-Molara archipelago. The large variability of counts from land showed that, besides seasonal variations, local weather conditions and distribution of prey might play an important role, affecting daytime distribution, flight paths, detectability, and possibly also the return rate of individuals; some of these factors are known to affect the nocturnal activity patterns at the colony (Bourgeois *et al.* 2008).

Estimates from nest density plots are still very preliminary as they are based on a small portion of the island. They are likely to change in the next future following an increase of the sampled area and a more precise identification of the island portions suitable/unsuitable for nesting. Nevertheless, 13,726 estimated occupied burrows would nicely fall within the range of values obtained from counts of birds moving to the colony. Nest density estimates were not adjusted to take the presence of multiple cavities into account (burrows occupied by more than one pair), hence representing an underestimation of the Yelkouan Shearwater population size. Burrows hosting (or potentially suitable to host) more than one pair were occasionally found during the ground survey (in about 5% of occupied burrows and in less than 1% of suitable non-occupied ones). Sites hosting several pairs each are definitely much more represented along the SE shoreline of Tavolara, which is entirely occupied by vertical cliffs with large and often inaccessible karstic caverns. The density of breeding birds (number of pairs/ha) calculated from nest density plots is nearly 6 times lower than that found by Bourgeois & Vidal (2007) at the Hyères archipelago, which was already considered as a very low value among *Puffinus* species. On the other hand, the occupancy rate of burrows at Tavolara is similar (c. 29% vs. 33%) to that found by Bourgeois & Vidal (2007), suggesting that the availability of suitable breeding sites is not a limiting factor for Yelkouan Shearwater.

GPS tracks, albeit still few in number, showed that Yelkouan Shearwaters from Tavolara passed at close range from several Sardinian promontories and confirmed the suitability of our coastal watch points. Distances covered, larger than the *ca.*200 km inferred from coastal counts (Zenatello *et al.* 2006), lead to inshore waters such as bays and gulfs of northern and western Sardinia and southern Corsica, often near river mouths, notably the Tyrsus, the main Sardinian river, flowing into the Gulf of Oristano. Only land-based counts, however, suggested that the largest gulf of the East coast (Gulf of Orosei) has to be also considered as a foraging area for the Tavolara breeders.

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The Yelkouan Shearwater *Puffinus yelkouan* at l-Irdum tal-Madonna, Malta

John J. Borg[1] & Joe Sultana[2]

[1]National Museum of Natural History, Malta. john.j.borg@gov.mt
[2]Dar ta' Gajdoru/3, Gajdoru Street, Xagħra, Gozo XRA 2503, Malta. joesultana@maltanet.net

Summary.The early contributions to Maltese ornithology mentioned that the Yelkouan Shearwater *Puffinus yelkouan* bred in the Maltese Islands, but they hardly gave any other information. Since the setting up of the Ringing Scheme within the Malta Ornithological Society (now BirdLife Malta) in 1965, seabird studies have been carried out in various ways (e.g. Sultana & Gauci 1970, Borg & Sultana 2002, Borg *et al.* 2010). The largest colony of the Yelkouan Shearwater was discovered at l-iRdum tal-Madonna in 1969, and was visited irregularly throughout the breeding season for several years. In the early 1980s, special attention was given to the breeding biology of Procellariiformes, several studies where initiated, and visits to seabird colonies increased. When the Yelkouan Shearwater was separated from the Manx Shearwater *Puffinus puffinus* and was given species status, more international attention was focused on this Mediterranean endemic. In Malta it has always been difficult to carry out ornithological research due to the prevailing hostile environment to birds. Apart from intensive bird shooting, the accessible nesting sites of shearwaters have been under continuous disturbance, and adult birds, eggs and young have always been regularly taken from nests. The colony at l-iRdum tal-Madonna also faced the problem of predation by rats, weasels and rabbit hunters' ferrets. These issues were addressed by an EU LIFE project carried out from 2006 to 2010 (Borg *et al.* 2010). The breeding colony at l-iRdum tal-Madonna and the birds' movements at sea were also investigated. This paper presents the studies carried out on the feeding and wintering areas, as well as the main aspects of the Yelkouan Shearwater breeding biology.

Key Words: Yelkouan Shearwater, *Puffinus yelkouan*, Maltese Islands, breeding biology, post-breeding dispersal.

Introduction

The Yelkouan Shearwater *Puffinus yelkouan* is endemic to the Mediterranean. It is a breeding visitor to the Maltese Islands from October to late July-early August. Schembri (1843) was the first to mention the presence of this species in Malta. He wrote that it was a resident and as common as the Scopoli's Shearwater *Calonectris diomedea* and that it was found more commonly on Comino and Gozo than in Malta. Wright (1864) narrated that he found several nets stretched on canes on Filfla Island, placed to catch shearwaters. Dead as well as live Yelkouan Shearwaters were entangled in the nets, left there by the fishermen until they were needed. In a letter dated 26 August 1907, addressed to F.C.R. Jourdain, John H. Stenhouse wrote that Yelkouan eggs used to be collected by the local people and sold as hen's eggs (ms. At Alexander Library, EGI, Oxford). In 1969, a large colony was discovered on the north-east coast of Malta (Sultana & Gauci 1970) and since then this colony has provided the main source of information on the Yelkouan Shearwater in Malta. Following years of decline, when adults, chicks and eggs were regularly taken primarily by humans and rats, an EU Life project was initiated in 2006. The four year-long project

addressed problems related to the conservation of the Yelkouan Shearwater and its breeding colony at l-iRdum tal-Madonna. It included the use of telemetry techniques to discover the birds movements during and after the breeding season.

Methodology

Visits to the colony.

The colony at l-iRdum tal-Madonna (35°59'28.76"N, 14°22'15.02"E) lies on the north-eastern coast of mainland Malta. The geological formations are composed entirely of Upper Coralline Limestone cliffs, which are honey-combed with caves, crevices and fissures as well as an extensive boulder scree. This provides ideal breeding habitat for the shearwaters. This colony has been visited annually since 1969. On average three visits were carried out annually to ring and control adult birds. From 1983 to 2000 visits increased considerably with an average of ten annually. However from 2001 there was a decline in the number of visits and it was only in 2006, when the EU Life project was initiated that the colony was visited regularly (2-3 times per week) up to 2010. Visits to the colony start in late October and gradually increases when they peak in June and then slowly decline towards the end of July. A total of 213 night visits to the colony were carried out during the Life project (2007-2010) and the month with the most intense number of visits was June, coinciding with telemetry work on breeding adults.

Ringing.

Ringing activities, with a few exceptions, are carried out after nightfall. The majority of incubating birds breed in deep crevices. Adult birds are mostly caught as they arrive at the colonies. Nets are stretched in front of the crevices and as soon as birds are caught, they are removed and processed. Access to the breeding ledges is by means of scaling rock faces and in one area by means of a boat. Ringing at l-iRdum tal-Madonna is mainly carried out at two sites. Three other sites are visited sporadically. One site under study since 1969 was no longer surveyed from 1996 when the cliff face became unstable. During the Life project, one of the sites, a large cave, was visited on a number of occasions with very satisfactory results, hence the increase in new adults and chicks ringed (Table 1). The low numbers in 1989-1998 was due to an increase in the rat population at l-iRdum tal-Madonna.

Number ringed as:	1969-1978	1979-1988	1989-1998	1999-2008	2009-2011
adult	210	186	85	158	110
chick	40	28	4	57	45

Table 1. Number Yelkouan Shearwater ringed at l-iRdum tal-Madonna.

Telemetry.

Towards the end of two breeding seasons, 10 young Yelkouan Shearwater (2 in 2008 and 8 in 2009), were fitted with Northstar Solar 'Platform Terminal Transmitter' (PTT) satellite tags between 19 June and 7 July before fledging . A thin, flexible plastic platform was attached to the birds' back feathers with strips of duct tape. PTT tags were then mounted onto the platform using UV-

resistant cable ties. Each tag weighed approximately 13 gm, with another 1 gm for the base, glue and ties. This equaled to approximately 3.5% of the average body weight, well within the limit recommended for tracking studies (Kenward 2001). Doppler-derived location data were downloaded directly from the Argos web site, and were assigned to one of seven quality classes as specified by Argos, depending on the number of satellites the fix has received. Fixes with a quality of 1, 2 or 3 have an estimated error of less than 1,500 m, less than 500 m and less than 250 m respectively. Fixes assigned to class 0 are less reliable, with an estimated error of greater than 1,500 m, while fixes assigned to A, B or Z are the least reliable (in that order) with no accuracy estimation available (Raine *et al*. 2010 and 2011).

Status

The current population estimate for the Maltese Islands was presented by Sultana *et al*. (2011) with an estimate of 1,190 - 1,680 breeding pairs. These numbers are based on seasonal counts of rafting birds during the courting season and repeated estimates at the colonies. The species has breeding colonies on Malta, Gozo, Kemmuna and Kemmunett, and probably also on Fungus Rock (Borg & Sultana 2002). The species is presently absent from Filfla islet where it was still breeding in the late 1970s. Nine of the eleven IBAs in the Maltese Islands have been designated for this species.

Arrival at colonies and breeding behavior

The first adult birds return to the breeding colonies in the second week of October, soon after they complete their moult (Borg *et al*. 2002). Visits gradually increase and by the second week of December all the mature adults would have made their first landfall and spend most of the night occupying their nesting holes. Some birds remain inside the nest during daytime. Courting is at its peak in mid-February and the earliest birds lay their single egg before the end of the month. All birds lay their egg by the end of March. The male takes the first spell which may last up to 11 days (average 8 days) after which he is replaced by the female. These changeovers continue for a period of around 52 days. Chicks hatch from mid-April to early May. The young chick is taken care of by one of the adults for the first 4-6 days when it is visited for feeding only at night. Some of the adults feed the young every night while others visit the nest every other night. This is very evident in the various stages of growth in young birds which hatch at the same time, but weigh 80-100 gm more than others. Chicks that are fed every night grow faster than those fed on alternate nights. The average feed weighs *ca*. 30 gm per adult bird, but meals of up to 60 gm were also regularly recorded. Young birds venture out of the nest hole to exercise their wings about 10 days before they fledge. Fledging starts in mid-June and the colonies are deserted by the end of July (the last birds to leave were recorded on 29 July). The desertion period is very short, with parents visiting their young up to a day or two before fledging.

Longevity and age of first returns

Out of 993 birds ringed, 306 have been recaptured in subsequent years. The majority of these birds were controlled in the first two years after ringing. The oldest bird which was ringed as an adult on 19 May 1976 was last re-trapped on 21 December 1994, 18 years 7 months later. A total

of 168 chicks and 36 juveniles have been ringed, the majority of these from 2007 to 2009. Seven chicks were re-trapped in their natal colony (see Table 2). The last three birds are exceptional, since most young shearwaters do not make their first landfall before they are two years old (Warham 1990).

RING No	Ringing date	First Retrap date	Interim
EE00727	02.06. 2005	08.06.2008	3 years 6 days
EE01129	22.06.2007	19.05.2009	1 year 11 months
EE01136	28.06.2007	14.05.2008	11 months
EE01143	20.07.2007	30.05.2009	1 year 10 months
EE01144	20.07.2007	01.03.2009	1 year 8 months
EE01154	18.06.2008	23.06.2009	1 year
EE01172	25.06. 2008	14.03.2009	9 months

Table 2. Date of first return to the colony ("first landfall") for Yelkouan Shearwater ringed as chicks at l-iRdum tal-Madonna.

Movements

Ringing has yielded very little information on post-fledging movements. The limited ringing data show that some first-year birds from Maltese colonies move to the Aegean and Black Seas after fledging. To date there are only four foreign recoveries of birds ringed at L-iRdum tal-Madonna. Two of these were ringed as chicks and were recovered in the Black Sea (Borg & Sultana 2002).

On the other hand, telemetry has provided valuable information on post-breeding movements of adults and fledglings. A total of 166 fixes were received from the ten tagged birds over the course of the study. Of these, 52 (31.3%) were of a 'good' quality (Argos class 0–3) while the remainder were of 'low' quality (Argos classes A, B or Z). It was decided to use only fixes within the good quality classes, as well as those from the low quality class A. Transmission periods averaged 20.4 + 18.5 days, with three birds transmitting for over three weeks and one of these (80875) transmitted for a total of 68 days. After transmissions ended from each bird, it was assumed that the tags had fallen off. The majority of fixes came from the central and eastern Mediterranean, the Aegean Sea and off the North African coast. One bird flew towards Sicilian waters when transmission stopped after six days. Another bird provided insufficient data for consideration. All the other birds left Maltese waters within a few days from fledging. One bird travelled south-west towards the Tunisian coast before moving in a north-westerly direction to the central Mediterranean where its tag ceased to transmit. The other seven birds all moved eastwards immediately after fledging with five (71%) entering Greek waters. Three of the birds were ultimately tracked to waters around islands off the west coast of Greece (Lefkada, Kefallonia and Ithaki), while one passed on into the Aegean

Sea where it remained for the duration of tag transmission. Another bird was tracked to the western coast of Greece before a final transmission in the South Adriatic Basin off the coast of Croatia. The remaining two birds travelled into the eastern Mediterranean (with one first entering the southern Aegean) and then down to the North African coast where they moved westwards again along the Egyptian and Libyan coastlines. Tracking has also shown that individual birds do not follow set routes in subsequent years. One bird spent much of the post-breeding season in the Central Mediterranean in one year and less time in the Black Sea while in the following year it spent more time in the Black Sea. Another bird spent almost equal time between the Aegean and the Black Seas but at different times of the post-breeding season.

During the post-breeding season (July-August) birds disperse into the Ionian, Aegean and Black Seas while a smaller number frequent the Gulf of Gabes and the Central Mediterranean. In September and October the majority of birds were found to visit the Black Sea but as soon as the breeding season approached, all adult birds were found to be in the Central Mediterranean.

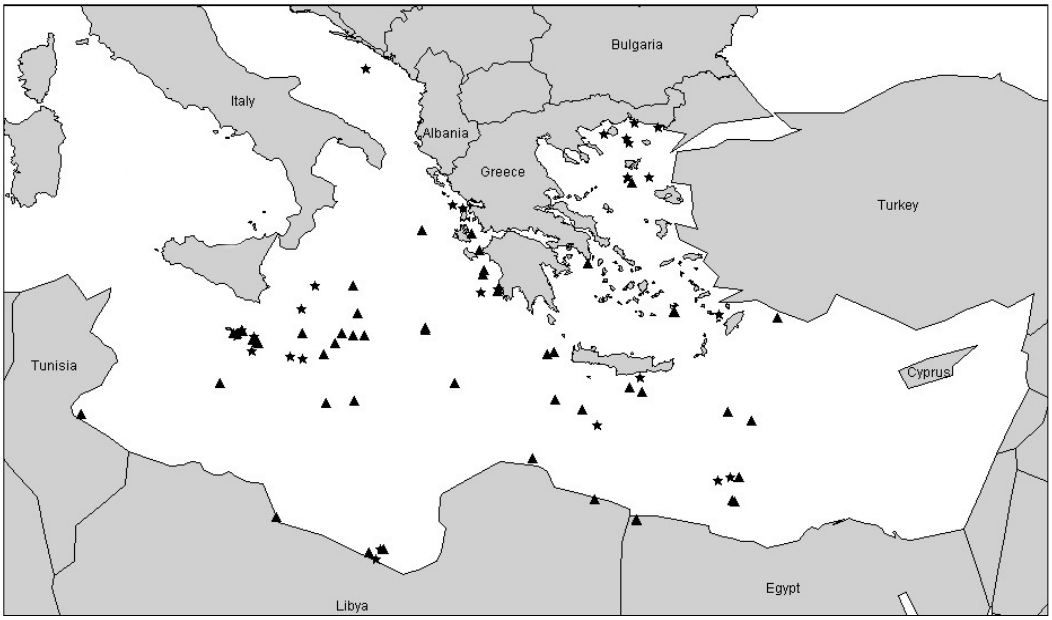

Figure 1. Location of satellite tag fixes for ten juveniles Yelkouan Shearwater during the post-fledging dispersal. Triangle denote good quality fixes (Argos Classes 0-3), and stars are poor quality fixes in Argos class 'A' (after Raine *et al* 2011).

Conservation issues

Like most other birds, shearwaters suffer from human activities. During the study period various threats were identified. These varied from direct human persecution on land and at sea to light and sound disturbance at the colonies. Predation by rats *Rattus rattus*, weasels *Mustela nivalis* and rabbit hunters' ferrets *Mustela putorius furo* was found to be also significant (Borg *et al*. 2010). Rat predation was identified as one of the main threats to both nestlings and adults (Sultana & Gauci 1982).

A rat eradication project was therefore initiated in December 2006, with intensive baiting commencing in January 2007. After the initial two weeks of intensive baiting of the site, evidence of rats declined dramatically. These results indicated that the rat eradication program was successful in the cliff areas of l-iRdum tal-Madonna and minimized the return of rats on the top of the cliffs. This was further confirmed by the complete lack of any rat signs on the study ledges as well as the regeneration of plant life on the same ledges.

In 2012, a new EU Life+ project will be initiated in Malta. The aim of this project is to identify important bird areas at sea. This project will continue to build on the previous Life project (Borg *et al.* 2010) and apart from Yelkouan Shearwater, the movements of both Cory's Shearwater *Calonetris diomedea* and European Storm-petrel *Hydrobates pelagicus* will be studied through telemetry and boat-based observations at sea.

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Presence and behaviour of Yelkouan Shearwaters *Puffinus yelkouan* at the Bosphorus

Dilek Şahin[1], Ergün Bacak[1,2], Sercan Bilgin[3], Canan Atay[3,4], Kerem Ali Boyla[3,5] & Jose Tavares[6]

[1]Istanbul University, Institute of Life Science, 34134 İstanbul, Turkey. dileks@ymail.com
[2]ergunbacak@gmail.com
[3]Susam street 8/2 Cihangir Beyoğlu, 34433 İstanbul, Turkey.sercanb@yahoo.com
[4]ataycanan@gmail.com
[5]kerem.boyla@gmail.com
[6]The Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK. jose.tavares@rspb.org.uk

Summary. This study aims at determining the population size and migratory movements of Yelkouan Shearwaters *Puffinus yelkouan* through the Bosphorus (Istanbul,Turkey). The study was carried out between 16 March 2010 and 4 April 2011. The counts were done on a daily basis from the morning to midday once every 15 days. A total of 33 count-days were organized; on each survey day a total of 4 hours was spent in the field. The survey results indicate the passage of a maximum of 55.682 individuals through the Bosphorus in one morning. During September and October, very few individuals were observed. Numbers increased in November and reached their maximum on January and February. From May to October, the numbers decreased. This study sets the basis of knowledge on the Yelkouan Shearwater's occurrence in Turkey. With this study, we are able to establish important information about the migration dynamics of this species through the Bosphorus.

Key Words: Yelkouan Shearwater, *Puffinus yelkouan*, Bosphorus, migration.

Introduction

The Yelkouan Shearwater *Puffinus yelkouan* is endemic to the Mediterranean Basin. The species' breeding sites are known to be limited and the global population has been estimated at 39,000 – 99,000 individuals (BirdLife International 2004), which could have been an overestimate (Zotier 1992, Bourgeois & Vidal 2008). In the present state of knowledge, the population is estimated at. 46,000 – 92,000 individuals (Mia Derhé, this volume). Yelkouan Shearwaters use the 33 km long Bosphorus throughout the year (Kirwan *et al*. 2008). Nankinov (2001) had emphasized that the behaviour and the abundance of prey food items affect Yelkouan Shearwaters' movements to the Black Sea through the Bosphorus. As stated by current tracking studies in the central Mediterranean (Borg *et al.* 2010; Borg & Sultana this volume), outside the breeding season Yelkouan Shearwaters range out to the Adriatic, Aegean and Black Seas for feeding. After leaving the nests, the young spend some months at the coasts of Greece and Turkey, and many individuals then go north to the Black Sea through the Turkish straits (Dardanelles and Bosphorus) and the interior Sea of Marmara. The Bosphorus is the only connection between the Sea of Marmara and the

Black Sea and thus it is an important bottleneck on the species' migration route. Monitoring of the type of movements and the numbers in this region is valuable to provide data on migration behaviour and population numbers of Yelkouan Shearwaters. In this project we aimed at collecting detailed information on seasonal presence of Yelkouan Shearwaters and compared those findings with what was known about this species in the Istanbul area of the Bosporus.

Material and Methods

The study area is located in the middle of the Bosphorus. Censuses were done at Rumeli Hisarı which is the narrowest part of the Bosphorus (680m width between Europe and Asia). During the study, direct count method was used in the study area. In order to count the birds, binoculars (10x40 and 8x40) were used. Censuses were done periodically two times a month and started at 8:30 a.m. during the winter months (October-April), and at 7:30 a.m. during the summer months (May-September). Total numbers were noted every half an hour together with weather conditions, wind strength and direction, visibility and sea conditions. Three observers were always present: one counting the groups passing south-north direction, a second person counting those passing north-south, and the third one taking notes of the counts and following up if there was any missed flocks. Birds were counted in doubles or fives (Bibby *et al.* 2000). Consecutive day counts were carried out after 25 November to determine whether the species' daily migration in the Bosphorus is regular or not. The same count methodology was applied in the second day. Censuses were performed by the same people to avoid bias in count (Bibby *et al.* 2000). The possibility that counts at the Bosphorus mid-point were biased by birds turning around several times within the strait was also taken in consideration: a three point count was organized once (8 January 2011), with observers stationed at the south entrance of the Bosphorus, at the usual mid-point monitoring place, and at the north entrance of the strait.

Results

According to our counts, between 16 March 2010 and 4 March 2011 the most intense passages of Yelkouan Shearwaters through the Bosphorus were registered in January and February. The highest total number of birds counted in both directions was 55,682 on 3 February 2011. In September, October and November, numbers were greatly reduced and the minimum total dropped to 452 in one morning. Towards the end of December numbers gradually began to increase again (Figure 1). During most counts, the vast majority of birds were seen passing in a north to south direction (i.e. from Black Sea to the Sea of Marmara), except in the autumn when the reverse was true, but daily totals were much smaller. The consecutive day data showed little consistency, indicating that there is considerable variation between consecutive day counts.

Discussion

The Yelkouan Shearwater is a species of global conservation importance and is one of the most data deficient species of regular occurrence in Turkey. With this survey, we aimed at increasing our limited knowledge on the movements of this species through the Bosphorus. Yelkouan Shearwaters had been observed in the Bosphorus throughout the year in the past (e.g. Nankinov 2001, Kirwan *et al.* 2008, Bourgeois & Vidal 2008) but their exact phenology had not been

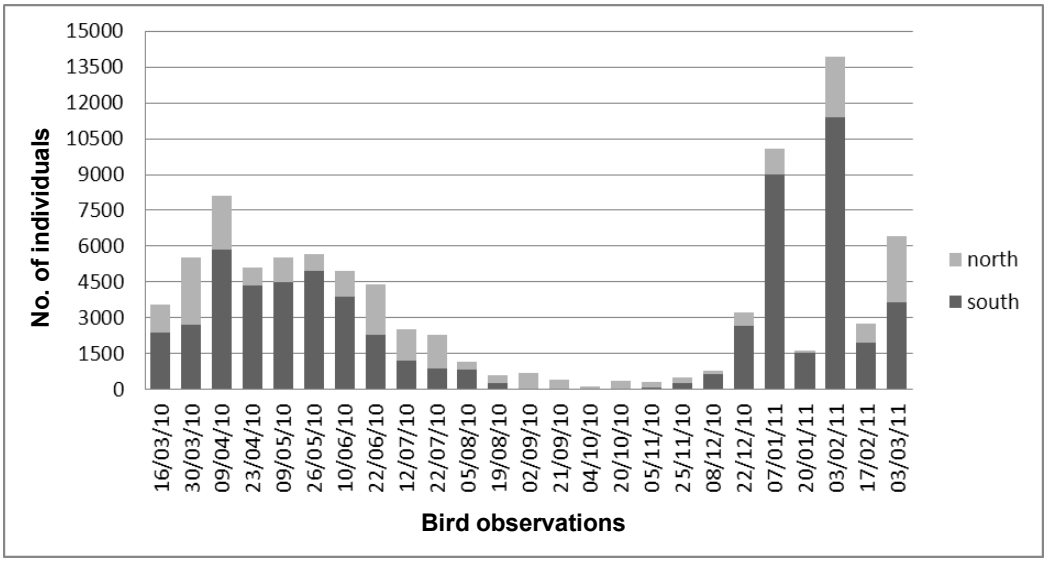

Figure 1. Numbers of Yelkouan Shearwater passing the Bosphorus in a north-south direction (south) and a south-north direction (north) in a year-long period.

established before the present study: passage is very intense during winter and spring, and decreases during summer and autumn.

Nankinov (2001) suggested that Yelkouan Shearwater movements at the Bosphorus decreased from January to the beginning of April, then reached their maximum during April and May: for these months he gave an estimate of 5,000 – 6,000 individuals per hour moving to the north and 800 – 1,000 individuals to the south. During our census, figures regularly exceeded Nankinov's estimates, and migration reached its maximum during January and February, just before the egg laying period. The intense movements from the Bosphorus in a southbound direction during this period may indicate the possible presence of yet undiscovered breeding colonies in the Marmara Sea. The maximum number of Yelkouan Shearwaters observed passing through the Bosphorus in one morning was 55,682 individuals, in February. Previously recorded maximum numbers were 25,000 individuals in one day between February and October (Bourgeois & Vidal 2008), and 6,800 individuals per hour in April (Kirwan *et al.* 2008). Our study shows that number of birds passing through the Bosphorus is much greater than estimated by the previous studies and includes a significant proportion of the world population.

Nankinov (2001) suggested that the life-cycle and dynamics of fish species were explaining the abundance of Yelkouan Shearwayters in the Black Sea, hence the timing of their passage through the Bosphorus. However, nothing is known of the relationships between the shearwaters and the fish they are preying upon during their presence within the Bosphorus. Further research will be needed to better characterize this.

Lastly, numbers counted on 8 January 2011 in the middle of the Bosphorus and at each end of the strait were very similar, suggesting a real passage rather than circulation. However, this needs

to be confirmed by more counts at different times of the year. Also, in order to refine the present results future census should take place from more points during different periods of the day. Continuation of such monitoring is being planned.

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Rat eradication at Yelkouan Shearwater *Puffinus yelkouan* colonies on NE Sardinian islets: success followed by unexplained re-appearance

Paolo Sposimo[1], Giovanna Spano[2], Augusto Navone[2], Sara Fratini[3], Lapo Ragionieri[4], Massimo Putzu[2], Dario Capizzi[4] , Nicola Baccetti[5] & Barbara Lastrucci[1]

[1]NEMO S.r.l., P.za M. D'Azeglio 11, I-50133 Firenze (FI), Italy. sposimo@nemoambiente.com
[2]Consorzio di Gestione Area Marina Protetta Tavolara Punta Coda Cavallo, Via Dante 1, I-07026 Olbia (OT), Italy.
[3]Dipartimento Biologia Evoluzionistica, Università degli Studi di Firenze, Via Romana 17, I-50125 Firenze (FI), Italy.
[4]Regione Lazio, Agenzia Regionale Parchi, Via del Pescaccio 96, I-00166 Roma (RM), Italy.
[5]ISPRA, via Ca Fornacetta 9, I-40064 Ozzano Emilia (BO), Italy.

Summary: The Tavolara archipelago (NE Sardinia, Italy), which possibly holds over 50 % of the world population of breeding Yelkouan Shearwaters *Puffinus yelkouan*, was infested by black rats *Rattus rattus*. An action plan was developed in order to decrease the impact of rats. In October 2008, rat eradication of Molara Island has been achieved by aerial distribution of poisoned baits while ground-based eradication was carried out on three islets. Post eradication monitoring has shown that the operations were successful. However rats were found again on Molara Island 21 months after eradication. Genetic analysis showed that they were from the mainland population. Thus, most probably they have been intentionally introduced by man.

Key Words: seabird conservation, rodent eradication, Yelkouan Shearwater, *Puffinus yelkouan, Rattus*, Italy.

Introduction

The eradication of rodents on islands, aimed at the conservation of seabird populations and other components of insular ecosystems, is becoming a common management practice. To restore island ecosystems, rodents (mainly rats *Rattus* sp. and house mouse *Mus musculus*) are removed according to standardized methods, including the spreading of poisoned baits by helicopter, which enables access to large (up to more than 12,000 ha) or difficult-to-reach islands (Howald *et al*. 2007, Veitch *et al*. 2011). In recent years eradication projects have been carried out on small to medium-sized islands in the Mediterranean Sea (Genovesi & Carnevali 2011). The largest Mediterranean islands where success has been confirmed are Lavezzi (73 ha) (Pascal *et al*. 2008), Zannone (103 ha) (Francescato *et al*. 2010) and Giannutri (240 ha) (Sposimo *et al*. 2008). They were all treated by networks of bait stations placed on the ground. High predation rates by black rats *Rattus rattus* on the largest concentration of colonies of Yelkouan shearwater *Puffinus yelkouan*, potentially hosting more than 50 % of the species' global population (Baccetti *et al*. 2009, Zenatello *et al*. this volume), suggested the urgent adoption of conservation measures in the Tavolara archipelago which lies within the Tavolara – Punta Coda Cavallo Marine Protected Area (NE Sardinia, Italy). An action plan for an overall decrease of the rat impact was produced

and operational strategies were evaluated for all different islands and islets of this area. Here we report on the first actions that were put into practice, namely eradication of black rat from Molara island (360 ha), achieved by aerial distribution (see Veitch 2002) in October 2008, and ground-based black rat eradication on three islets.

Study area

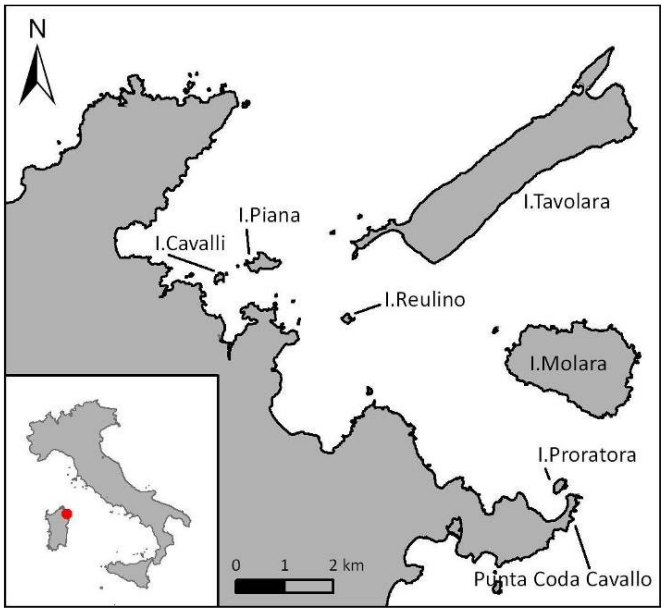

Figure 1.Situation of Molara and surrounding islands.

Tavolara's group (Figure 1) is composed of 2 main islands, Tavolara and Molara (600 and 340 ha, and 1900 and 1600 m from the nearest point of the Sardinia's coast, respectively) and some islets, 4 of which have a surface between 2.2 and 13.6 ha and lie in an intermediate position between the coast and the main islands. The only wild mammals inhabiting Molara and the smaller islands were the black rat (absent only from one islet) and the house mouse (absent only from Molara). Feral cats were present on Tavolara, cows on Molara and goats on both islands.

Materials and methods

Prelimary trapping

In March and September 2008 we performed two four-night trapping sessions (19-22 March; 2-5 September) on Molara, in order to estimate the relative abundance of rats.

Livestock protection

To avoid poisoning free-ranging livestock, two enclosures were built (total enclosures area: 1 ha) and *ca.* 50% of the goats and 80% of cattle were herded in.

Rat eradication on Molara

Bait was chosen according to the results of palatability and longevity tests. The selected product was Brocum® (with 0.005% brodifacoum as the active ingredient). The formulation was 2g cereal pellets. A spreader bucket for the aerial broadcast of pellet baits was purchased from HeliOtago, New Zealand and a helicopter (Eurocopter Ecureil AS 350 - B2) was hired for the operation. The pilot had no previous experience of similar works. Distribution trials for instrumental calibration and pilot training have been conducted using non-toxic baits. Trials showed that, from a height of 50m, in absence of wind, pellets were distributed on a radius of 45m, i.e. on 90m wide

transects. A transect map was drawn with GIS software and transferred on the helicopter's GPS. Distribution transects were spaced 50 m from each other, for a total transects length of 53 km (Figure 2). In October 2008 two aerial distributions of bait were performed, spreading 12.3 kg of bait/ha on 1st October and 11.6 kg/ha on 21st October. The pilot's assistant manually switched the spread on and off. The two enclosures were excluded from aerial distribution. In these areas bait was placed inside tamper-resistant bait stations, as a buffer area surrounding the enclosures. A 20 m wide belt running all along the sea coast, larger in two areas (Figure 2), was baited by hand. To assess the success of the rat eradication we placed and monitored 29 monitoring stations, containing gnawing sticks, toxic and non-toxic wax blocks, six of which were located at most likely landing places.

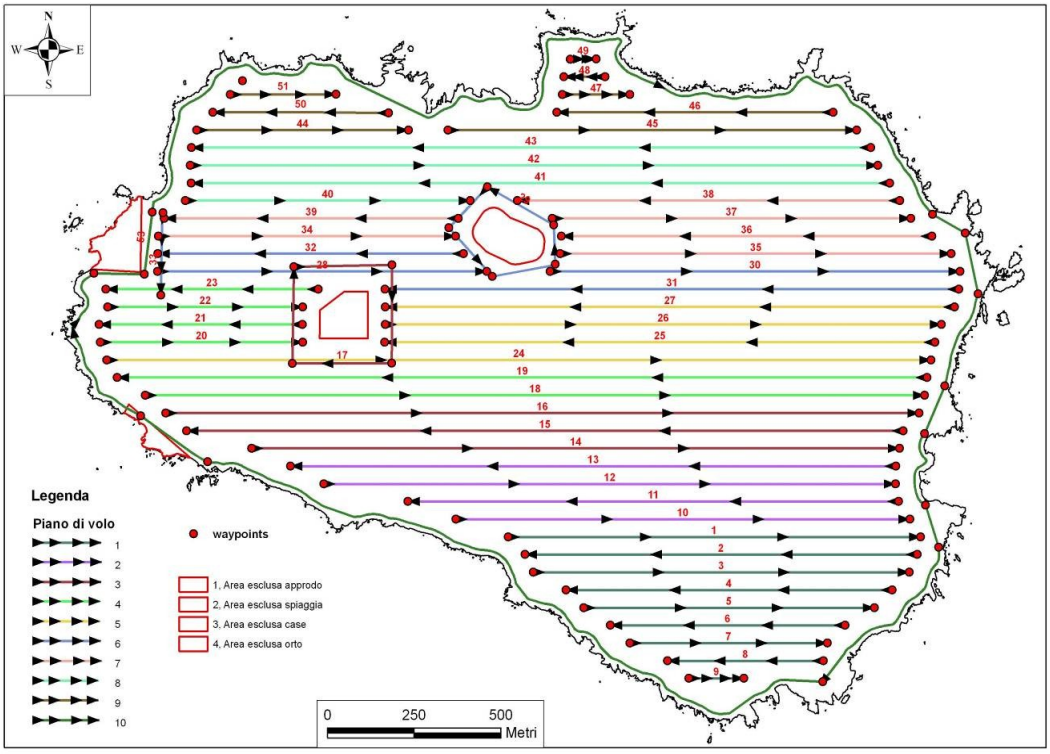

Figure 2. Flight route as planned over Molara island.

Rat eradication and control on other islands

Ground-based rodent eradication was performed on the three islets in winter 2009-2010. To determine eradication units for future operations (also on Tavolara) and evaluate the risk of rat reinvasion of Molara, rat specimens were trapped and collected for genetic analyses, in order to test possible genetic flow between rat populations in the archipelago and on the adjacent Sardinian coast. Genetic analysis was performed by genotyping 8 microsatellite loci (see Abdelkrim *et al*. 2005 and 2009) in four black rat populations (Tavolara Is., N = 30; Molara Is., N = 30; Piana Is., N = 30, Sardinian mainland - Capo Coda Cavallo, N = 24). DNA was isolated from rat tail tissues using the Puregene Kit (Gentra System), re-suspended in TE buffer and then

preserved at -20°C. Each individual was genotyped for 8 microsatellite loci already used on *Rattus rattus* (see Abdelkrim *et al.* 2005 and 2009).

Results

Molara rat eradication

The relative abundance of rats on Molara was higher in late winter (0.75 ind/trap/night in March) and much lower in late summer (0.38 ind/trap/night in September), suggesting that summer was a critical period for rat survival. This evidence allowed us to identify the latter season as the best period to carry out the rat eradication on Molara. A total of 7.4 tons of rodenticide bait was scattered on the island. Several technical problems occurred during the operation. The most serious of which was the malfunctioning of the spinner engine on both distributing sessions, so most transects were covered by vertical dropping (see Micol & Jouventin 2002 for a similar episode). Pellet distribution on the ground was found to be in 10 m wide stripes, alternating to *ca.*40m wide empty stripes. The comparison of the helicopter tracks recorded by GPS and the original planned transects showed marked discrepancies (up to 35m in some cases). Nevertheless, in the first distribution only six areas, all smaller than 1 ha, were at distances greater than 40m from the nearest treated point. Considering both distrubutions together, no areas were left with a distance of more than 30m from the nearest treated point.

Starting two days after the first delivery, several rain showers were recorded, which steadily degraded most fallen pellets. After 21 days, on the date of the second delivery, most previous pellets already seemed considerably degraded. On the day following the second delivery, a heavy and unpredicted rainfall (33 mm recorded by the nearest weather station) almost completely degraded the newest pellets. If any rat had survived the first delivery, therefore, pellets from the second one were available to them in adequate conditions only for a single night.

Carried out in a season when very few gulls (Laridae) are locally present, poisoning affected few non target species. Corpses of two Barn Owls *Tyto alba* and two Ravens *Corvus corax* were

Islands	Rat	Breeding success	n	Year/remarks
Molara (Sardinia)	Y	0	18	2006
	Y	0	7	2007
	C	0,67	3	2008
	E	0,71	7	2009
	E/R	0,86	7	2010
Tavolara (Sardinia)	Y	0	22	2007; top of the island and in caverns with rats
	N	0.78	9	2007; inside caverns inaccessible to rats
	C	0,73	15	2009; in caverns with rats and local control

Table 1. Breeding success (number of fledged chick per pair; n=number of sampled nests) of Yelkouan Shearwater according to the presence/absence of black rat (N= absent, Y= present; C= controlled; E=eradicated; R=reinvaded); G. Spano & M. Putzu, unpubl. data.

found, both presumably dead after secondary poisoning. Livestock that could not be herded into the enclosures was affected for an estimated one third of the goats while none of the 6-7 free ranging cows died or showed any problems.

Despite these difficulties, the control of monitoring stations gave no sign of rat presence over the next 21 months, and thus the rat eradication was considered to have been successfully completed. Yelkouan shearwater breeding success greatly increased after rat eradication on Molara, from total failure before rat eradication to values reaching 0.71-0.86 fledglings per pair in 2009 and 2010 (Table 1).

After 21 months of an apparent absence of rats, signs of their presence were discovered in July 2010 along 1 km of the Molara coast facing the Sardinian mainland, 1600m far. These signs of rats followed the appearance of several domestic rabbits (quickly captured and removed) in the previous winter. We did not investigate who may have brought the rabbits to Molara and why.

Rat eradication from islets

Rats were easily eradicated from all three islets, but success was short lived. After 6 months they were found again on the islet nearest to the mainland (Proratora, 4.6ha, 170m offshore), and also at Cavalli (2.2ha, 300m offshore) after two years, although not yet present on adjacent Piana (13.6 ha, 660m far from land and 530m from Cavalli).

Population	Na	Ho	He	P
Piana Is.	2.36	0.352	0.355	P < 0.001
Tavolara Is.	4.22	0.510	0.554	P < 0.001
Molara Is.	4.42	0.488	0.545	P = 0.28
Capo Coda Cavallo	6.67	0.715	0.724	P = 0.03

Table 2. Genetics of black rat *Rattus rattus* from Molara and surrounding places (E. Sardinia, Italy): mean allelic richness per locus (Na), observed heterozygosity (Ho), expected unbiased heterozygosity (He) and the P- value of departure from the Hardy-Weinberg equilibrium (P).

Genetic analyses

All the analyzed loci are polymorphic, with a mean number of alleles equal to 10. The highest values of genetic variability have been recorded for the Capo Coda Cavallo population, while the lowest one is for the population of Piana (Table 2). Molara and Tavolara populations have similar value of allelic richness, number of alleles and heterozygosity values. Piana and Tavolara populations show evidence of heterozygosity excess. All four populations are characterized by a high number of private alleles, a clear evidence of inter-population differentiation. Statistically, this is confirmed by AMOVA that shows low levels of gene flow among our populations (Fst = 0.33, P < 0.001), as well as by SAMOVA showing that the number of population groups that maximised the distribution of genetic variation was k = 4. Moreover, the cluster analysis conducted with the program STRUCTURE recorded the presence of four groups of populations (K = 4), each corresponding to one of the four analysed populations. Finally, STRUCTURE indicates that the genotypes of two specimens of *R. rattus* collected on Molara during the post-eradication monitoring

cluster within the mainland population and not with the pre-eradication Molara population.

Discussion

Aerial bait distribution proved an efficient way to eradicate rats on Mediterranean mid-sized islands, where a ground-based action could not be possible for technical and/or economic reasons. The Molara operation represented the first case in the Mediterranean and Europe of using the helicopter and bucket method. Problems with instruments (at least partially due to inexperienced staff in their utilization) and the lack of a trained pilot made sticking to strict protocol (Cromartry *et al*. 2002, McClelland 2011) impossible. On the other hand, failure of the spinner engine had also occurred during the successful eradication of an island larger than Molara (Saint-Paul Island, 800 ha, Micol & Jouventin 2002), which prompted us not to suspend the flight. The experience gained on Molara has thereafter helped two eradication projects carried out with the same bucket, on Sa Dragonera (Balearic Is., Mayol *et al*. 2012) and on Montecristo (Italy, P. Sposimo *et al.* un-pub.), where all instruments worked without noticeable problems.

The fact that the two rats collected during post-eradication monitoring on Molara Island clearly clustered with the Sardinian mainland population and not with the pre-eradication Molara population strongly suggests that (1) a new population is present; (2) the eradication efforts had been successful despite the combined effects of inexperienced staff, heavy rains and engine malfunctioning; and (3) the potential source for rat recolonization is the Sardinia mainland population. Assessing whether re-colonization occurred spontaneously (which would entail the largest sea crossing recorded for the species, 500 m being the maximum known; e.g. Russell *et al*. 2005 & 2008; Russell & Clout 2005) or following intentional introduction is unfortunately impossible to discern. Unintentional transportation is also possible, but we consider this as the most unlikely option. The concurrent, and definitely intentional, introduction of rabbits represents an additional evidence of the intentional introduction option. However, the rapid reinvasion of the islet nearest to the mainland (130 m), followed by that of the second nearest, shows that re-colonization by swimming rats is a frequent phenomenon and confirms that a careful evaluation of the risks of re-colonization is a fundamental measure before a rat eradication project is carried out (see e.g. Capizzi *et al*. 2010).

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Developing a population assessment for Yelkouan Shearwater *Puffinus yelkouan*

Mia Derhé[1]

[1]European Research and Conservation Officer, BirdLife International, Wellbrook Court, Girton Road, Cambridge, CB3 0NA, UK. m.derhe@lancaster.ac.uk

Summary

Yelkouan Shearwater *Puffinus yelkouan* was uplisted from Least Concern to Near Threatened on the IUCN Red List in 2008 and has been identified as having an unfavourable conservation status in Europe. However, the species is poorly monitored and studied, particularly in its non-breeding range. This population assessment, prepared through extensive expert consultation and a review of the current literature, summarizes current data on the species' distribution, population size and trends, the threats to its survival, and identifies key knowledge gaps and research needed. The global population is estimated at 15,337-30,519 pairs/ 46,000-92,000 individuals. However, very high non-breeding season numbers reported in the Bosporus suggest that there is likely to be a large percentage of non-breeding birds in the population and estimates of breeding numbers at colonies may be underestimated. By combining data for countries for which trend information is available, it is predicted that the global breeding population is suffering a rapid decline of c.50% over three generations (54 years) – a considerably higher rate of decline than was previously predicted. As such, the species' global Red List status has now been revised to Vulnerable based on the findings of this assessment. The main threats to the species are mortality from incidental fishing bycatch and predation by invasive predators. Research efforts should focus on searching for new breeding colonies and censusing known breeding colonies, monitoring the population at key breeding and bottleneck sites, assessing mortality rates from fishery bycatch and introduced predators and studying the species' demographic parameters.

Key Words: *Puffinus yelkouan*, Yelkouan Shearwater, seabird conservation, status assessment, population decline, bycatch, introduced predators, rat eradication.

Introduction

Yelkouan Shearwater *Puffinus yelkouan* has been identified as having an unfavourable conservation status in Europe as it is listed in Annex I of the Birds Directive, is classified as Near Threatened on the IUCN Red List as a result of recent declines, and reports indicate that mortality rates may have increased in recent years. A population assessment for this species is required before any Action Plans are produced or updated, particularly as the current size and trend of many national populations is unclear. Yelkouan Shearwater is endemic to the Mediterranean basin with outposts in the Black Sea, but its precise distribution is not well known and numbers are disputed (Bourgeois & Vidal 2008). The species is known to breed in France, Italy, Malta, Greece, Croatia, Tunisia, Algeria, Albania and Bulgaria. Breeding is assumed in Turkey on offshore islands or mainland cliffs in the Aegean and Mediterranean, but there is very little data on this. A small population may also breed on the eastern Balearic Islands in Spain, although the existence of the species here is somewhat controversial, given the taxonomic uncertainty of the birds breeding in Menorca. The species spends time as a non-breeder season in Bulgaria, Turkey, Greece,

France, Croatia, Spain, Tunisia, Italy, Malta, Ukraine, Romania, Slovenia, Russia, Montenegro, Cyprus, Georgia, Egypt, Libya, Algeria and possibly Bosnia.

Methods

The method of the assessment was (1) to identify the range states and those holding significant populations at any stage of the life cycle; (2) to identify potential contributors and data providers; (3) to collect data (through an electronic questionnaire) on national breeding and non-breeding population sizes and trends, threats which likely affect the population at national and international level, and stakeholders and interests; (4) to collate the data and produce a draft assessment document (species status report); and 5) to organise an expert workshop, to a. verify the data collected, clarify any inconsistencies and agree on national figures and trends; b. elaborate a common expert assessment of the data (interpretation); c. identify key knowledge gaps; and d. identify and map key stakeholders and their interests in the species.

Results

Global breeding population size

The current data from known breeding sites gives a global population estimate of 15,337-30,519 pairs/ 46,000-92,000 individuals. This figure roughly corresponds with preliminary counts conducted during the non-breeding season at the Black Sea in which up to 75,000 individuals have been sighted migrating through the Bosporus (J. Tavares and D. Şahin. *in litt.* 2012). Due to the lack of breeding confirmation for some sites, lack of surveys at definite breeding locations, lack of regular monitoring, and potential overestimation due to survey methods during some counts (e.g. at-sea counts of rafts), it is possible that the global population of Yelkouan Shearwater could be at the lower end of this estimate. However, the high non-breeding season numbers reported in the Bosporus suggest that there is likely to be a large percentage of non-breeding birds in the population and estimates of breeding numbers at colonies may actually be underestimated. In addition, it is possible that there may be large numbers of birds at sites that have not yet been surveyed. The global breeding population was previously estimated at 10,815-53,574 pairs (BirdLife International 2011), although figures pointed more to a total of 14,700-52,000 pairs (Tucker and Heath 1994) or 100,000 individuals. Bourgeois & Vidal (2008) suggested that the global breeding population may be smaller, ranging from 5,899–9,409 to 11,355-54,524 breeding pairs.

Breeding Population trend

A lack of data on key sites combined with the absence of long-term regular monitoring at the major breeding colonies (in Italy, Greece and Turkey) means that it is difficult to determine a global population trend for the species. However, there is evidence of both recent and historical colony extinctions, with nine colonies (comprising around 300-400 breeding pairs) having been reported extinct in the last 60 years (Bourgeois & Vidal 2008). Since 2009, one breeding colony off the south-west corner of Sardinia (San Pietro Island) has been reported as absent, possibly extinct (N. Baccetti pers. comm.; originally recorded at 500 pairs by Schenk & Torre 1986). Breeding population declines and low breeding success has also been reported in the main breeding sites, including Tuscany (Sposimo & Tellini 1995), Sardinia (Baccetti *et al.* 2009) and Malta (Bourgeois

& Vidal 2008, J. Borg pers. comm.). The trends of populations in Albania, Algeria, Bulgaria, Cyprus, Turkey and Tunisia are currently unknown, but it is suspected that populations in Croatia (I. Budinski pers. comm.) and Greece (J. Fric pers. comm.) could be declining. It has been reported that the Italian, French and Maltese colonies (which represent 73% of the global population) are declining. By combining data for the three countries for which trend information is available, it is predicted that, if the species continues to decline at the current reported rate, the global breeding population will decrease by c.50% over 54 years, i.e. three generations, from 1995 onwards, assuming that the populations in all other countries remain stable (which is the best-case scenario). The global population trend has been projected from 1995 since this is the earliest date for which we have trend data. Due to the findings of this assessment, the species's global Red List status has now been uplisted from Near-Threatened to Vulnerable under criterion A3bcde as it is projected to be suffering a rapid population reduction of 30-49% over three generations.

Threats

Yelkouan Shearwater populations are known to be declining, with the main drivers being mortality from incidental fishing bycatch and predation by invasive predators (predominantly black rats *Rattus rattus* and feral cats *Felis catus*).

Despite mortality in long-lines and fishing nets having been identified as one of the main causes of seabird mortality at a global level (Gilman 2001, Cooper *et al.* 2003), data on Yelkouan Shearwater bycatch and fishing effort in the Mediterranean is limited. However, a recent study in France and Malta (Oppel *et al.* 2011) implicated fishing bycatch as a critical cause of mortality for the species. Recently, shearwater deaths by long-lines have also been reported in the Gulf of Lion, in the Straits of Bonifacio, in Italian waters and around Malta (Bourgeois & Vidal 2008). The impact of incidental bycatch on Yelkouan Shearwater has also been detected in Spain in more recent years (J. M. Arcos pers. comm.). Demersal long-liners in particular affect the species (Arcos *et al.* 2008, Louzao *et al.* 2011), often on an irregular basis, but can impact fairly large numbers at a time (ICES 2008).

Yelkouan Shearwaters have been shown to suffer substantial predation pressure by introduced mammalian predators on breeding grounds (Bourgeois *et al.* 2008, Bonnaud *et al.* 2009). The black rat is present on all islands with Yelkouan Shearwater colonies (Martin *et al.* 2000). Predation by rats has been identified in the assessment as a high threat in Italy, Greece, Malta, France and Croatia (Capizzi *et al.* 2010, Raine *et al.* 2009, Borg *et al.* 2010, HOS unpublished, C. Peron and I. Budinski pers. comm.). Predation by feral cats has also been identified as a high threat, but only in the Hyères archipelago (France: Bourgeois and Vidal 2008, Bonnaud *et al.* 2009, Ruffino *et al.* 2009). However, Oppel *et al.* (2011) found that annual survival of breeders only slightly increases after removal of feral cats from colonies and remains below what is needed to maintain a stable population.

Additional important threats include high and increasing levels of light pollution and disturbance to colonies resulting from tourist and residential development (Raine *et al.* 2007, 2009, 2010 and 2011, Borg *et al.* 2010, Oppel *et al.* 2011), competition with fisheries (Oro *et al.* 1996, Oro 1999, Arcos *et al.* 2008), oil spills (Raine *et al.* 2009, Borg *et al.* 2010, Oppel *et al.* 2011), wind farms

(Raine *et al.* 2010, N. Baccetti, J. Fric, M. Sammut and J. M. Arcos pers. comm.), and illegal hunting (predominantly in Malta: Raine 2007, Raine & Temuge 2009, Borg *et al.* 2010). Low impact threats identified in the assessment include environmental events such as geological erosion, mainly in Malta (J. Borg pers. comm.), and toxic algae blooms (Gutiérrez 2007).

Stakeholders

Important stakeholders that have an interest in the species have been identified through literature review and consultation with species experts. These stakeholders fall roughly into 13 categories: National governments; regional and local governments; National Park/ Protected Area managers; BirdLife partners; Other NGOs; Research institutes, groups and individuals; Industrial fisheries; Local (artisanal) fishermen; Tourist businesses (tourism companies, hoteliers, fish restaurants, tourists); Wind energy community; Island inhabitants; and Oil companies.

Conclusions

The population assessment revealed a worryingly rapid population decline driven by high adult mortality rates and low breeding success. The major drivers of this decline have been identified in the assessment and it is recommended that conservation actions are prioritised to address these threats. In particular it is recommended that policymakers are encouraged to implement and enforce measures that reduce accidental bycatch of Yelkouan Shearwaters and other seabirds in commercial fishing operations in the Mediterranean and Black seas. As a precaution, rats and feral cats should be controlled, or if possible eradicated, at breeding colonies, according to a priority analysis and at sites with evidence of predation. The identification and implementation of measures to reduce/ mitigate the effects of light pollution on the species (e.g. see Raine *et al.* 2007) are also recommended. The assessment has also highlighted the paucity of available data for the species due to a lack of monitoring and research. Accurate and regular research and monitoring is needed in order to obtain reliable estimates of population size and trends and to assess the impact of threats on the species.

The global population trend estimated here at 52% over 54 years, qualifies the species' Red List status to be uplisted. To explore the impact of uncertainty on the overall trend and category, a number of alternative scenarios were also explored, which all resulted in the species meeting the criteria for uplisting, except only the most optimistic (and unlikely) scenario. Based on the findings of this assessment, the species' global Red List status has now been revised to Vulnerable under criterion A3bcde as it is projected to be suffering a rapid population reduction (30-49% decline over three generations).

Priority research recommended

Population size

In order to accurately estimate the global population size, efforts should focus on determining whether the species breeds in Turkey; searching for new colonies; conducting population censuses at breeding colonies for which there is currently little reliable, up-to-date data; continuing breeding and non-breeding period counts at the Bosporus and other bottleneck sites. Existing geolocator

data and data from boat-based surveys should be utilised to conduct a long-term population assessment of at-sea populations to identify distribution and 'hotspots' at sea, and to conduct an assessment in the Adriatic of wintering or non-breeding birds. In order to aid in the identification of marine Important Bird Areas for the species, all tracking data should be contributed to BirdLife International's seabird tracking database (http://www.seabirdtracking.org/).

It is important that census methodology is standardised so that population estimates can be collated into a global estimate and are comparable both spatially and temporally. As such, recommendations and guidance on best-practice census methodology should be developed, including guidance on timing of 'non-breeding' counts (i.e. 'non-breeding' refers to moulting individuals in the non-breeding [moulting period] season)

Population trend

To accurately determine the long-term trend of the species, monitoring should be conducted at key breeding sites in Greece, Croatia and Tunisia (and Turkey, if colonies are found), and geolocator data should be utilised to complement non-breeding counts conducted in the Bosporus.

In order to reliably assess the impact of threats on population trends, research should be conducted on the species' demographic parameters. In particular, the species' ecological requirements need to be understood and the impact of threats on breeding success and adult survival probabilities should be investigated in order to understand the relative importance of these parameters on population declines.

Threats

Assessing mortality rates from accidental bycatch is a priority action. More specifically, oceanographic and fisheries data (identification of prey, distribution of prey, which fish species are being fished, etc.) from across the Mediterranean can be related to seabird distribution data to identify bycatch 'hotspots'. Research should also be conducted on the scale of Mediterranean and Black Sea fisheries in order to assess correlation between species population trends and trends in fishing effort.

Research on the impact of introduced predators is needed to prioritise eradication and control efforts, investigating the long-term population dynamics and interactions between Yelkouan Shearwater and rats; determining the impact of predator control/ eradication programmes on annual survival and breeding success at different sites; and conducting genetic analysis on rat colonies to evaluate success of eradication and control. Additional threats to the species should be regularly monitored.

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This assessment of *Puffinus yelkouan* was initiated in the course of a workshop organized during the 13th Medmaravis Pan-Mediterranean Symposium. It thereafter provided the basis for the evaluation of the species' status carried out by BirdLife International on behalf of IUCN. This led to the Yelkouan Shearwater being upgraded from Near Threatened to Vulnerable on the IUCN 2012 Red List.

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Table 1 Breeding and non-breeding population size estimate and breeding population trend by country

Country	*Breeding population in 2008 (pairs)*	*Current breeding population (pairs)*	*Breeding population year*	*Breeding population reference*	*Current non-breeding population size (individuals)*	*Non-breeding population year*	*Non-breeding population reference*	*Recent breeding population trend*	*Year(s)*	*Reference*
Albania	1-10	**1-10**	2004	-	-	-		-	-	-
Algeria	8-10	**8-10**	1992	-	-	-		-	-	-
Bulgaria	0-10	**0-10**	2004-2005	1	2,000-12,000	2003-2006	2	Unknown	-	-
Croatia	250-300	**300-500**	2006-2011	3	1,000-2,000	1955-2011	4	Unknown	2006-2011	-
Cyprus	-	**-**	-	-	10-200	1994-2011	5	-	-	-
France	1,045-1,636	**662-1,109**	2004-2007	6, 7	10,000	2004	8	6% per year Decreasing	2004-2010	23
Greece	4,000-7,000	**4,000-7,000**	1995-2011	9, 10	29,000-46,000*	2004-2011	9, 10	Unknown	2007-2011	-
Italy	7,000-14,000	**9,000-20,000**	1995-2008	11, 12, 13	-	-	-	10-50% Decreasing	1995-2008	-
Malta	1,400-1,560	**1,190-1,680**	2010-2011	14	5,000-7,000	1983-2011	15	0-15% Decreasing	2002-2011	14, 24 25
Spain+	0	**0**	-	16	5,000-15,000	2003-2011	17, 18, 19	-	-	-
Tunisia	?	**176-200**	2011	20	-	-	-	-	-	-
Turkey	0-10,000 or 1,000-30,000	**0-?**	2010-2011	21	1,000-14,000	2010-2011	22	Unknown	2002-2011	-
Global Total	11,355-54,524	**15,337-30,519**	-		**52,000-102,200 individuals**	-				

1 - Iankov 2007; 2 - Nikolov et al. 2006; 3 - Budinski et al. 2010; 4 - Rucner 1998; 5 - Martin Hellicar & Michael Miltiadou pers. comm.; 6 - *Bourgeois and Vidal 2009; 7 - Cadiou et al. 2011; 8 - Bourgeois and Heurtebise 2006; 9 - Hellenic Ornithological Society 2009; 10 Hellenic Ornithological Society 2011; 11- Corso et al. 2009; 12 - Baccetti et al. 2009; 13 - N. Baccetti pers. comm.; 14 - Sultana et al. 2011.; 15 - J. Sultana pers. comm.; 16 - J. M. Arcos pers. comm.; 17 - Arcos 2001; 18 - Arcos et al. 2009; 19 - Bécares et al. 2011; 20 - Ouni et al. 2011; 21 - J. M. Tavares and D. Sahin pers. comm; 22 - D. Sahin pers. comm; 23 - Oppel et al. 2011; 24 – Raine et al. 2009; 25 - Borg and Sultana 2002*.

Recent insights in the distribution and abundance of Balearic Shearwater *Puffinus mauretanicus* off Brittany, western France

Pierre Yésou[1], Laurent Thébault[2], Yann Février[3], Matthieu Fortin[4], Armel Deniau[5], Jean-Luc Dourin[6] & Sébastien Mauvieux[7]

[1]ONCFS, CS 42355, 44323 Nantes cedex 3, France. pierre.yesou@oncfs.gouv.fr
[2]Groupe d'Etudes Ornithologiques des Côtes d'Armor, Couign ar fao, Kerlaudy, 29420 Plouénan, France.
[3]Groupe d'Etudes Ornithologiques des Côtes d'Armor, 10 Boulevard Sévigné, 22000 Saint-Brieuc, France.
[4]Bretagne Vivante (BV-SEPNB), Réserve naturelle nationale des Marais de Séné, Brouël Kerbihan, 56860 Séné, France.
[5]Réserve naturelle des Sept-Îles, L'île Grande, 22560 Pleumeur-Bodou, France.
[6]Groupe des Naturalistes de Loire-Atlantique (GNLA), 9 rue de Nantes, 44830 Bouaye, France.
[7]Groupe Ornithologique Breton (GOB), 7 Fuzoret, 29260 Ploudaniel, France.

Summary: During its post-breeding summer exodus to the Atlantic, the Balearic Shearwater *Puffinus mauretanicus* is occurring in increasing numbers near the coast of Brittany, France. Recent records included an unprecedented 5780 birds in the western Channel, northern Brittany, in July 2010, then 5000 in Mor Braz on the Atlantic coast of Brittany in September 2011, a record number for the area. Some birds linger up to mid-winter in increasing number too.

Key Words: Balearic Shearwater, *Puffinus mauretanicus*, Brittany, France.

Introduction

The summer presence of non-breeding Balearic Shearwaters *Puffinus mauretanicus* in coastal waters off the Atlantic coast of France has been known since the end of the 19th century. In the early 20th century the species was mostly reported from an area known as *Mor Braz* in southern Brittany (Mayaud 1936, Figure 1). That Balearic Shearwaters were gathering by the thousands became obvious in the early 1980s off Vendée, central Biscay (Yésou 1986). At this time, the species was regular but rarely numerous off northern Brittany, i.e. in the western Channel where it became more abundant from the 1990s while it simultaneously decreased off Vendée (Liéron 2000, Yésou 2003). At the same time increasing abundance was recorded near the northern limits of the species non-breeding range, particularly off south-west England and less markedly in the North Sea (Wynn & Yésou 2007, Wynn 2009). It has been hypothesized that these recent changes in Balearic Shearwater non-breeding dispersal are linked to increasing sea-surface temperature and the effects it induces on the food web (Wynn *et al.* 2007), a proposal strongly supported by further analyses of oceanographic parameters (Luczack *et al.* 2011). Here we document the recent status of Balearic Shearwater off Brittany, showing new record numbers both in Mor Braz and in the southern part of the Channel. We also briefly present other information arising from the ongoing surveys.

The surveys

Sea-watchers have been active for years at various sites in northern Brittany and in Mor Braz.

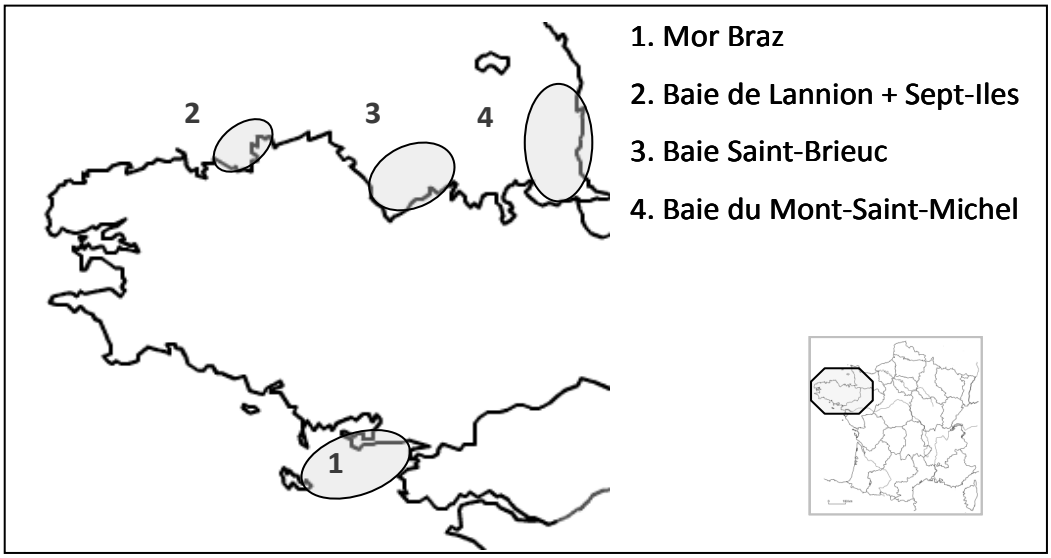

Figure 1. Main areas where large numbers of Balearic Shearwaters have occurred in Brittany from 2009 to 2011.

A few observers have been active at sea, and regional bird watching societies (mostly GOB and GEOCA) were collecting the more casual data. However, no organized survey was aiming at documenting the changing status of Balearic Shearwater in the area. In 2009, two of the present authors (P.Y. & L.T.) set up such a survey with the assistance of the local and regional bird watching and conservation societies, in order to precisely document on a yearly basis the regional status of the species. The geographical scope was extended outside administrative boundaries of Brittany in order to include the eastern part of Baie du Mont-Saint-Michel (which lays in Normandy) and the southern part of Mor Braz (in Pays-de-la-Loire, the neighbouring administrative region). Since 2010 this regional survey is benefiting from increasing efforts developed under the framework of the EU sponsored FAME project (*Future of Atlantic Marine Environment*) which runs until 2012. By October 2011, we had collected 267 data for 2009 and *ca*.270 for 2010 (data gathering still in progress), accounting for *ca*.18.000 and *ca*.65.000 birds respectively, including repeated counts of the same groups on more than one day. Most of the available information for 2011 has been collected up to early September.

Selected results

High numbers

In 2009 no particularly high numbers were recorded in northern Brittany (highest count *ca*.400 in early July), but more than 1000 birds have been recorded from mid-September to early October in Mor Braz with peak counts of 1500 to 2000 on 20 September and 1750 on 3 October. The 2010 season has been a record one, with 5780 birds close to the coast of Côtes-d'Armor, northern Brittany, in the last week of July, including 4630 together in Baie de Lannion on 30 July (Thébault *et al*. 2010, Février *et al*. 2011, Figure 2) while 788 were counted in Mor Braz on 27 July. Although not strictly simultaneous counts, these figures suggest that an unprecedented 6600 birds were in

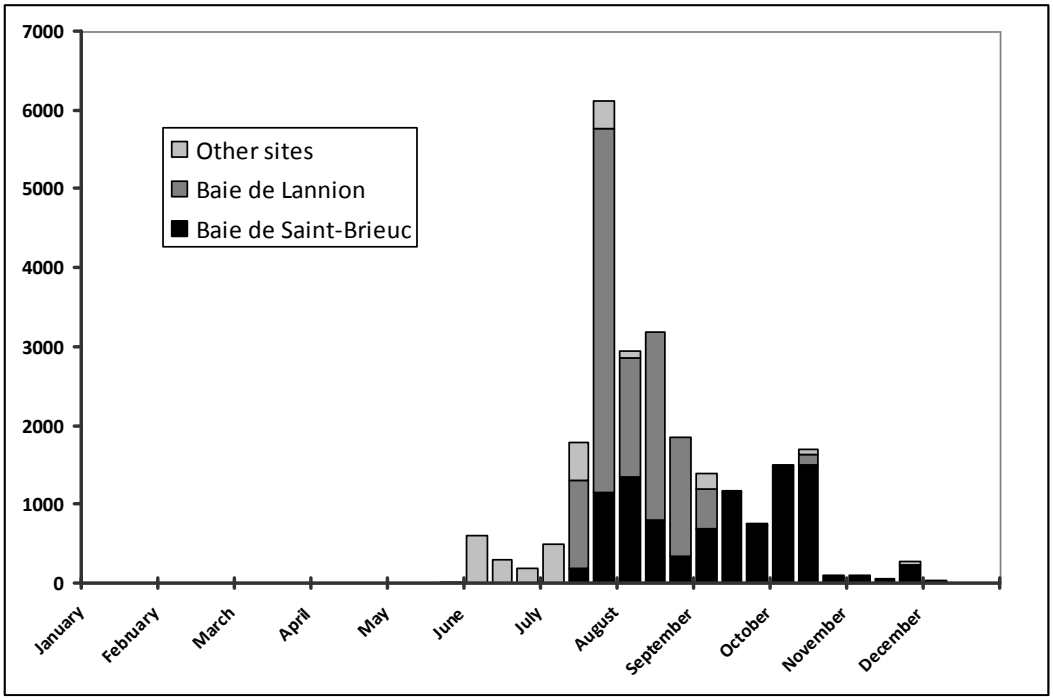

Figure 2. Seasonal variation in Balearic Shearwater abundance off Côtes-d'Armor, northern Brittany, in 2010 (after Février *et al*. 2011). The peak at 5780 individuals in late July included 4630 birds in Baie de Lannion.

Brittany inshore waters at that time. Numbers remained high in Brittany later on with up to 2550 birds in Mor Braz on 20 September (*ca*.1500 remaining until the end of October); 1150 on 14 September and 1500 on 9 and 10 October in Baie de Saint-Brieuc; and 1420 in the Normandy part of Baie du Mont-Saint-Michel on 29 September. Saint-Brieuc and Mont-Saint-Michel being *ca*.430 km and *ca*.500 km to the north of Mor Braz respectively, these figures suggest that at least 5000 birds were still present around Brittany in late September 2010. In late summer 2011, *ca*.4250 birds were counted in Mor Braz on 3 September, a record number for the area (previously up to 4000, although no such number had been recorded since the 1980s, Yésou 2003).

Winter records

The species occurs regularly in winter, mostly in December-January, usually in small parties of up to a few tens. Record numbers occurred during winter 2007-2008 in Baie de Saint-Brieuc with at least 750 birds in January (Plestan *et al*. 2009). No such winter influx has been recorded since 2008, but groups larger than usual have been observed recently, e.g. 38 on 4 January 2009 in Baie de Saint-Brieuc, 60 on 25 December 2009 in Baie de Douarnenez (at the tip of Brittany), and 55 on 12 December 2010 in Baie du Mont-Saint-Michel.

Bycatch by recreational fisheries

From 2009 to 2011 we have been informed of 3 cases where Balearic Shearwaters have been hooked by leisure anglers, who consider that feeding shearwaters are indicators of fish of potential interest and thus can locate their fishing activity close to groups of feeding birds. Taking in

consideration the low level of contacts between anglers and birdwatchers, the fact that three cases arose might suggest a more widespread phenomenon (Thébault 2011).

Odd individuals and shearwater identification

The numerous, repeated observations of Balearic Shearwaters have led to encounters with the odd whitish bird (Yésou & Bentz 2007), and more recently to the intriguing observation of "dwarf" individuals (Brosse & Yésou 2010, Laurent Thébault unpublished). Such records will help in the ongoing refinement of the field identification of Balearic Shearwater and related taxa (Russell Wynn and coll., work in progress).

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Balearic Shearwaters *Puffinus mauretanicus* in northeast Atlantic waters: an update on their distribution and behaviour based on geolocator tracking and visual monitoring data

Russell B. Wynn[1] and Tim Guilford[2]

[1]National Oceanography Centre, Southampton, European Way, Southampton, SO14 3ZH, UK. rbw1@noc.ac.uk
[2]Department of Zoology, University of Oxford, Oxford, OX1 3PS, UK.

Summary: A combination of tracking studies and visual monitoring are providing new insights into the at-sea distribution and behaviour of Balearic Shearwaters *Puffinus mauretanicus* in northeast Atlantic waters. Geolocator tracking has revealed that Mallorcan breeding birds spend the inter-breeding period in seasonally productive waters off northwest Portugal and southwest Brittany. Visual monitoring has also discovered large concentrations further north, with up to 25% of the World population aggregating off northwest Brittany and southwest UK in summer and autumn. These more northerly aggregations are thought to be dominantly composed of non-breeding birds, which may be shifting their distribution northwards in response to recent changes in prey fish availability and distribution. Other at-sea threats include low frequency, high-impact events such as oil spills, which need to be taken into account during future conservation planning.

Key Words: Balearic Shearwaters, *Puffinus mauretanicus*, northeast Atlantic, geolocator tracking, distribution shifts.

Introduction

The Balearic Shearwater *Puffinus mauretanicus* is Europe's only Critically Endangered seabird, with an estimated population of 3,200 breeding pairs or 25,000 individuals (Arcos 2011). The species has consequently been a focus for intensive research in and around its Mediterranean breeding grounds over the last decade (Arcos & Oro 2002, Aguilar *et a*l. 2003, Oro *et al*. 2004, Ruiz & Martí 2004, Genovart *et al*. 2003, 2005 and 2007, Louzao *et al*. 2006a,b, 2009, 2011 and 2012, Yésou 2006, Garcia 2009, Navarro *et al*. 2009, Wynn *et al*. 2010, Arcos 2011, Arcos *et al*. 2012, Oppel *et al*. 2012). Visual monitoring has revealed that Balearic Shearwaters also occur in northeast Atlantic coastal waters during summer and autumn, as part of post-breeding migration. Estimated counts of up to 10,000 individuals have been reported from French Biscay coasts since the early 1980s (Le Mao & Yésou 1993, Yésou 2003), with large numbers also reported off Portugal and Spain (Mouriño *et al*. 2003, Poot 2005). However, the absolute numbers and provenance of these migrants is poorly constrained, and there are also indications for northwards distribution shifts of post-breeding concentrations in Atlantic waters (Yésou 2003). The need for more detailed information on the Atlantic distribution, particularly to inform spatial conservation measures (Arcos 2011), has triggered a number of recent studies in this region. Here, we review recent geolocator tracking and visual monitoring studies in order to provide an update on the at-sea distribution and

migratory behaviour of the Balearic Shearwater in northeast Atlantic waters, and discuss the conservation implications of these new data.

Geolocator tracking

A total of 34 breeding birds at the largest known cave colony (Sa Cella on Mallorca, Figure 1) were tagged with archival light-logging geolocators in spring 2010, with 28 devices recovered in spring 2011 yielding 26 complete datasets (Guilford *et al.* 2012). All birds moved into northeast Atlantic waters after breeding (median date 27 June 2010; range 31 May – 11 July), with the Atlantic exodus lasting about three months (median duration 88 days; range 66-137 days). All birds subsequently returned to Mediterranean waters in the autumn (median date 23 Sept.. 2010; range 8 Sept. – 3 Nov.).

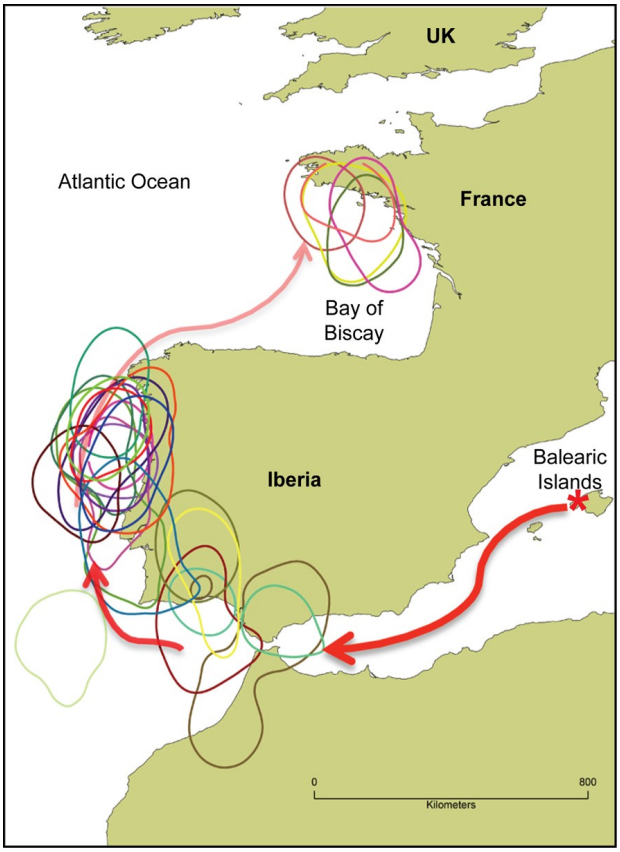

Figure 1. Map showing the 50% occupancy kernels for 26 individual Balearic Shearwaters tracked with geolocators during the inter-breeding period (modified from Guilford *et al.* 2012). Kernels only represent the inter-breeding period when birds are present in northeast Atlantic waters, i.e. west of the Straits of Gibraltar. The red asterisk marks the position of the breeding colony at Sa Cella cave on Mallorca. Most birds migrated to northwest Portugal, with five (all females) moving further north to south-west Brittany.

Analysis of the 50% occupancy kernels during the Atlantic migration period identifies two key locations, centred on seasonally productive shelf waters off northwest Portugal and southwest Brittany (Figure 1). It is notable that the five birds that visited Brittany were all females, raising the possibility of sexual variation in migratory behaviour (Guilford *et al.* 2012). Birds from other breeding colonies on Menorca and Ibiza have also recently been tracked with geolocators, and the results of these ongoing studies will aid assessment of inter-colony differences in migration strategy. The work on Ibiza has been undertaken as part of the EU-funded Future of Atlantic Margin Environments (FAME) project; this project also included Platform Terminal Transmitter (PTT) tracking of six birds from Ibiza in late spring 2011, which revealed that one suspected non-breeding bird also visited west Portuguese waters (Louzao *et al.* 2012).

Visual monitoring

Analysis of (non-effort-corrected) sightings data from northwest European (Atlantic) coastlines was undertaken for the period from 1980 to 2003 (Wynn & Yésou 2007, Wynn 2009). This study revealed a dramatic upsurge in records north of the Bay of Biscay since the mid-1990s (Figure 2), with concentrations noted off northwest France (up to 2250 birds, or 10% of the estimated World population) and southwest UK (up to 250 birds, or 1% of the estimated World population) between July and October. Lower numbers were reported further north and east during this period, with day counts at individual sites not exceeding 100 birds. There is also evidence for a concurrent decline, or at the very least a higher degree of inter-annual variability, in numbers present at traditional post-breeding sites in the Bay of Biscay and off west Iberia since the mid-1990s (Wynn & Yésou 2007).

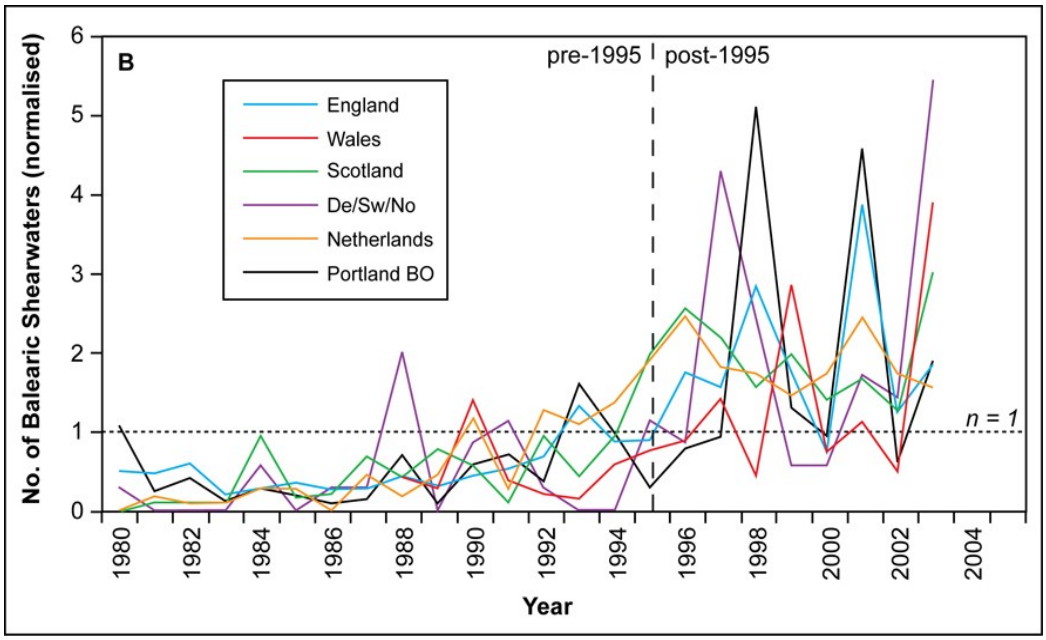

Figure 2. Time series showing numbers of Balearic Shearwaters in northwest European waters from 1980-2003 (modified from Wynn *et al.* 2007); note the consistent increase in numbers in the mid-1990s (vertical dashed line). Individual annual totals have been normalised relative to 1980-2003 average values; a value of 1.0 (represented by dotted line) is therefore equal to the long-term average, a value of 0.5 is half the long-term average, and a value of 2.0 is double the long-term average. Values for Denmark (De), Sweden (Sw) and Norway (No) have been combined.

More recently, counts from southwest UK and northwest France from 2004 onwards have revealed a continuation of the upward trend in numbers in this region. In autumn 2011 there were record counts from several sites off southwest England (Darlaston & Wynn 2012), with an estimated 600 birds concentrated in Lyme Bay (equivalent to 2.5% of the World population). Off northwest France an unprecedented aggregation of about 6,000 birds was present in July 2010, equivalent

to 25% of the World population (Thébault *et al*. 2010, Février *et al*. 2011, Yésou *et al*. 2012). Interestingly, none of the tracked breeding birds from Mallorca penetrated this far north in summer 2010, raising the possibility of age-partitioning of the population; birds that penetrate further north may therefore comprise the non-breeding component of the population, or may represent birds from different breeding colonies (Guilford *et al*. 2012).

The increase in numbers of Balearic Shearwaters reported from northwest European coasts during the inter-breeding period since the mid-1990s has been attributed to a northwards distribution shift (Wynn *et al*. 2007). This northwards shift has been hypothesised as resulting from climate-driven changes to prey availability, which may also be driving the unprecedented numbers of birds lingering into the winter off southwest UK and northwest France over the last decade, e.g. 750 off northwest Brittany in January 2008 (Plestan *et al*. 2009, Wynn 2009). Observed and modelled changes to zooplankton and fish assemblages in the studied region appear to support this hypothesis (Luczak *et al*. 2011). However, it is also important to take account of the influence of changes to discard availability and the changing taxonomic status of the species during the review period (Votier *et al*. 2008).

Conservation implications

The studies reviewed above have provided important new insights into the at-sea distribution and migratory behaviour of Balearic Shearwaters in northeast Atlantic waters. Tracking studies are beginning to highlight important areas for Mallorcan breeding birds off northwest Portugal and southwest Brittany (Guilford *et al*. 2012); these areas are now targets for spatial conservation planning, e.g. Important Bird Areas. In addition, aggregations of up to 6,000 inferred non-breeding birds, equivalent to 25% of the World population, have recently been concentrated into a relatively small region of northwest France during the inter-breeding period (Thébault *et al*. 2010, Février *et al*. 2011). This concentration makes them potentially vulnerable to low frequency, high-impact events such as oil spills, and this threat is accentuated by the possibility of age-related and sexual partitioning of the population (Guilford *et al*. 2012). Bycatch in commercial fishing gear has been identified as a threat in Mediterranean and Portuguese waters (Laneri *et al*. 2010, Arcos 2011), but as yet there is no evidence for this threat having an impact along northwest European coasts (although birds are occasionally foul-hooked by leisure anglers, e.g. Thébault 2011). Finally, changes to prey fish availability and distribution are apparently driving a northwards distribution shift of the Balearic Shearwater (Wynn *et al*. 2007, Luczak *et al*. 2011), which needs to be taken into account during future conservation planning.

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New estimates at sea suggest a larger global population of the Balearic Shearwater *Puffinus mauretanicus*

José Manuel Arcos[1], Gonzalo M. Arroyo[2,3], Juan Bécares[1], María Mateos-Rodríguez[2], Beneharo Rodríguez[1], Antonio R. Muñoz[3], Asunción Ruiz[1], Andrés de la Cruz[3], David Cuenca [4], Alejandro Onrubia[3] & Daniel Oro[5]

[1]SEO-BirdLife, C/ Múrcia 2-8, local 13, 08026 Barcelona, Spain. jmarcos@seo.org
[2]Biology Department, Faculty of Marine and Environmental Sciences, University of Cadiz, P.O. Box 40, 11510, Puerto Real, Cadiz, Spain.
[3]Fundación Migres, Complejo Huerta Grande, Ctra. N 340 Km. 96.7, 11390 Pelayo, Algeciras, Cadiz, Spain.
[4]GOES, Ornithological Group of the Strait of Gibraltar. P. O. Box 351, 11300. La Línea de la Concepción, Cádiz, Spain.
[5]Institut Mediterrani d'Estudis Avançats IMEDEA (CSIC-UIB). C/ Miquel Marquès 21, 07190 Esporles, Mallorca, Spain.

Summary: The Balearic Shearwater *Puffinus mauretanicus* is considered the most threatened seabird in Europe, based on a prediction of extinction within 3 generations. Such prediction was computed in 2004, based on a population estimate of 2,000 breeding pairs at that time. However, the breeding population has been recently updated to 3,193 pairs. Furthermore, figures for the global population, merely inferred from the breeding population, were thought to be within the range of 8,000-15,000 individuals at most. New estimates of the global population are presented here, from two different approaches: boat-based surveys at sea and coastal counts of migrating birds. Boat-based surveys consisted in transect counts that covered systematically the Iberian Mediterranean shelf in November-December 2003-2005, i.e. during the pre-breeding period, when the bulk of the global population is present there. Bootstrap procedures were used to infer a global estimate of Balearic Shearwaters from the observed densities at sea. Coastal counts were performed from Tarifa (Strait of Gibraltar) from mid-May to mid-July 2007-2010, covering the peak of the post-breeding outflow to the Atlantic. Coverage varied among years from 37% to 67% of the daylight time and estimates for the whole period were inferred using GAM models. Both methodological approaches provided similar figures, which were also consistent between years, with conservative estimates of about 25,000 birds. These figures could not be easily explained with the currently estimated breeding population, according to a basic model that incorporated conceivable demographic parameters to link breeding and total populations. It is crucial to clarify the species' population size and its demographic structure by reinforcing census and monitoring effort in the breeding grounds, as well as keeping the census efforts at sea, since they provide key information to assess the extinction time of a species while misestimating could result in ineffective conservation strategies.

Key Words: census, conservation, demography, Mediterranean, migration, seabird

Introduction

The Balearic Shearwater *Puffinus mauretanicus* is considered the most threatened seabird at European level, following its listing as Critically Endangered in 2004 according to the IUCN criteria (BirdLife International 2004). This categorization was based on the prediction that the species could become extinct in an average 40 years (less than 3 generations) according to the combination

of an extremely rapid population decline (-7.4% per year) and a small population size (estimated then in *ca*. 2,000 breeding pairs), which is restricted to the Baleairc Islands (Oro *et al*. 2004). However, information of both population trends and figures is subject to considerable uncertainty. It is therefore crucial to improve these estimates and properly assess the status of the species. Here we focus on the issue of population estimates.

Estimates for the breeding population of the Balearic Shearwater have ranged between *ca*. 1,750 and 4,500 breeding pairs during the last 20 years (Aguilar 1991, Ruiz & Martí 2004), with the last update being 3,193 pairs, although differences between those figures appear to be primarily related to different methodological approaches rather than to actual changes in numbers (Arcos 2011). Indeed it is extremely difficult to properly assess the numbers of a seabird breeding in caves, burrows and crevices of sea cliffs and islets, and any population estimate needs to rely on indirect methods at least for the most inaccessible colonies, thus being subject to biases (Gregory *et al.* 2004, Mitchell *et al*. 2004). As for the global population, no systematic counts are available, but different sources have considered it to range between 8,000 and 15,000 birds at most, mainly based on inferences from the breeding population estimates and partial information from counts at sea (Gutiérrez & Figuerola 1995, Mayol *et al*. 2000, Arcos & Oro 2002, Ruiz & Martí 2004, BirdLife International 2004). Here we consider two alternative approaches to assess the population of the Balearic Shearwater, both based on counts at sea of the global population outside the breeding grounds: (1) boat-based transect counts at sea; and (2) coastal counts from a strategic migratory point, the Strait of Gibraltar. We also elaborate a simple model to infer which would be the global population departing from different breeding figures, compare these results with those estimated from the counts at sea, and discuss the discrepancies.

Methods

Boat-based transect counts. Systematic seabird counts were conducted by SEO-BirdLife over the Mediterranean Iberian shelf (Figure 1) in November-December 2003, 2004 and 2005, taking advantage of the annual ECOMED cruise onboard R/V *Cornide de Saavedra* (Spanish Institute of Oceanography, IEO). This cruise was designed to assess the abundance of small pelagic fish by acoustical means in the study area, providing ideal conditions for the census of seabirds. Indeed, the vessel conducted systematic transects over the continental shelf (as delimited by the 200 m isobath) and uppermost shelf slope, perpendicular to the coastline and spaced either 4 or 8 nautical miles apart, depending on the width of the shelf, from NE to SW. The bulk of the Balearic Shearwater global population is expected to be within the study area at this time of year, prior to the breeding season, after their return from the post-breeding outflow to the Atlantic (Gutiérrez & Figuerola 1995, Ruiz & Martí 2004, Arcos *et al*. 2012, Guilford *et al*. 2012).

Seabirds were counted within a 300 m strip transect band, at one or two sides ahead of the vessel depending on census conditions, and snap-shot counts were used to count flying birds (Tasker *et al*. 1984). Seabird observations were summed up into 10 minute survey units, for which species density values were estimated (birds/km^2). On each cruise between 1,300 and 1,900 km of line transects were surveyed, totaling ca. 500 count bins per year (see details in Arcos *et al*. 2009).

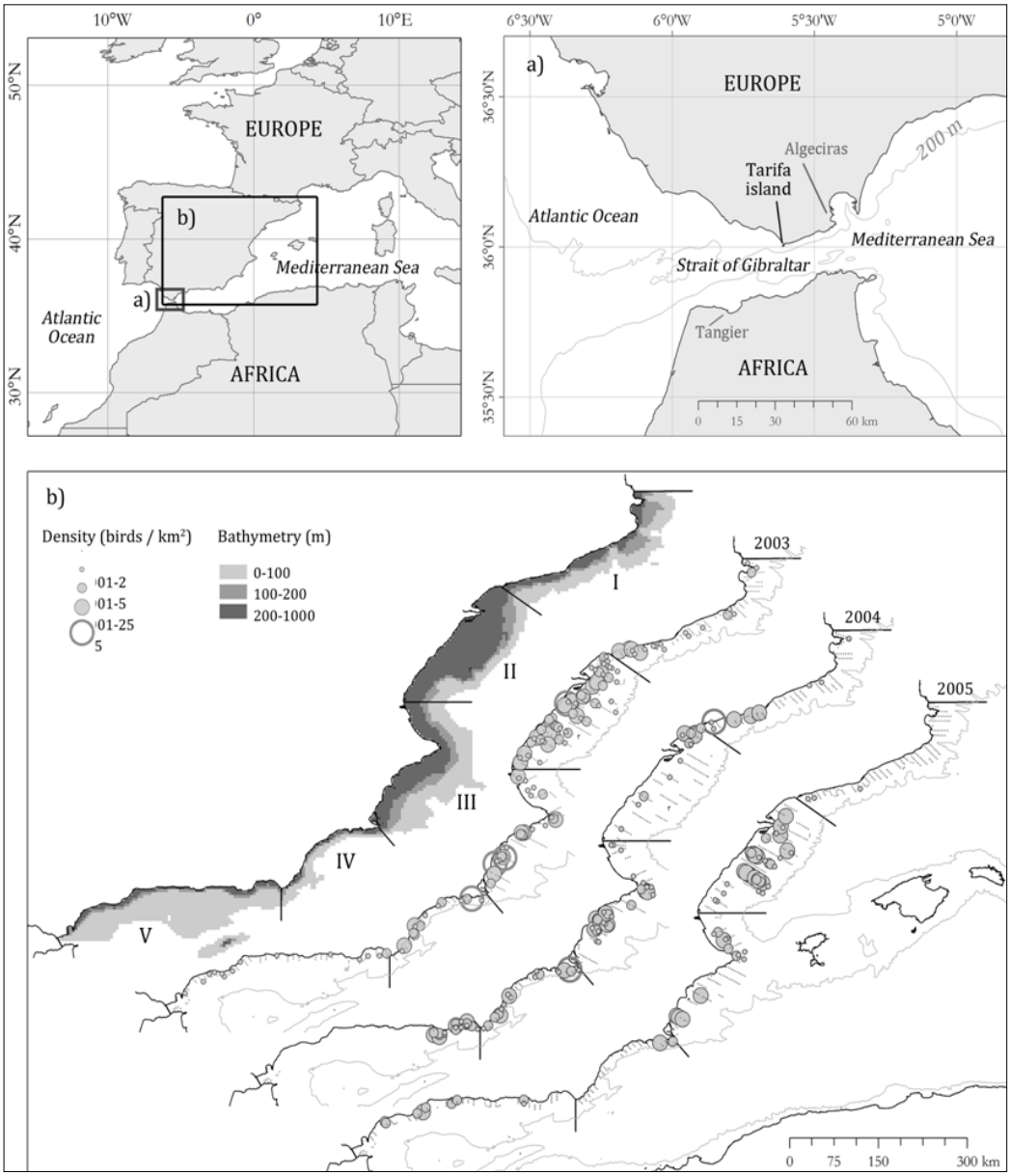

Figure 1. Study areas for the land based coastal counts (a) and the boat-based transect counts (b). Figure 1a shows the Strait of Gibraltar with details of the African and Spanish coastline and Tarifa Island, the coastal survey point. Figure 1b shows the Mediterranean Iberian shelf, with the five geographical sectors (I-V) and the bathymetric categories considered (0-100, 100.200 and 201-1000 m). For each year of survey, the transect locations and the shearwater densities are also shown (each 10 min transect bin is represented by a small dot if shearwaters were not observed, and by a circle proportional to the density if shearwaters were observed).

The study area was divided in three bathymetric categories (0-100, 100-200 and 200-1000 m) and then in five geographical regions according to their topographic and hydrographic features (Salat 1996, Millot & Taupier-Letage 2005) (Figure 1). For each region and bathymetric category the number of shearwaters was inferred by extrapolating density values to its total surface. Since density data were highly variable between transect bins and did not fit a normal distribution, 95% confidence intervals were estimated using bootstrapping (Efron & Tibshirani 1991).

Coastal counts. Systematic counts of Balearic Shearwaters were carried out from Tarifa Island, the southernmost point of the north coast of the Strait of Gibraltar (Figure 1), in the context of the *Migres* programme. The Strait of Gibraltar, with only 14.4 Km at the nearest point between European and African coasts, represents a migratory bottleneck for pelagic seabirds and it concentrates the totality of the Balearic Shearwaters post-breeding migration moving out the Mediterranean in late spring and early summer (Programa Migres 2009, Arcos *et al*. 2009, de la Cruz *et al*. 2011). Moreover, previous studies have demonstrated that Balearic Shearwaters passing across the northern sector of the Strait (where the post-breeding migration of the species is most notorious) tend to concentrate closer to the coast than randomly expected (Mateos-Rodríguez *et al*. 2010, Mateos-Rodríguez & Arroyo 2011), making them particularly detectable from particular vantage points such as Tarifa Island.

Daily censuses were conducted from mid-May to mid-July in 2007-2010. Counts were carried out by two experienced seabird ornithologists, occasionally assisted by trained volunteers, during daylight hours (details in Programa Migres 2009, de la Cruz *et al*. 2011). Despite a high census effort (see below), gaps in counts occurred due to resting breaks or missed days. To estimate the numbers of birds passing during those gaps, we modelled the counts using Generalized Additive Models (GAM), following the method described by Mateos-Rodríguez *et al*. (2012).

Relationship between breeding population and global population. To understand the relationship between breeding birds and global population, we inferred an estimate for the global population based on available breeding figures and considering the following demographic parameters: breeding success (*BS*), survival (*S*; age-dependent), recruitment (*R*; age-dependent), and rate of sabbaticals (*Sb*) (Figure 2). We defined 3 scenarios encompassing the conceivable variability of values in demographic parameters (Oro *et al*. 2004, Louzao *et al*. 2006), to get a reasonable range of values for the total population (Table 1). On one hand, scenario A considered low breeding success and low survival rates, high recruitment and high rate of sabbaticals, thus resulting in a small total vs. breeding population ratio; on the other hand, scenario C considered relatively high breeding success and survival rates, low recruitment and high rate of sabbaticals, thus making highest the ratio of total vs. breeding populations; scenario B used intermediate values for these parameters. We also considered three different values of breeding population size as departing point, considering the range of published estimates: 2,000 (figure used to assess the population viability analysis, Oro *et al.* 2004), 3,200 (current estimate), and 4,400 pairs (maximum estimate in the last 20 years, see Ruiz & Martí 2004, Arcos 2011).

Results

Boat-based transect counts. Balearic Shearwaters were common throughout the Iberian Mediterranean shelf during the pre-breeding period, mostly in shallow waters (0-100 m) (Figure 1).

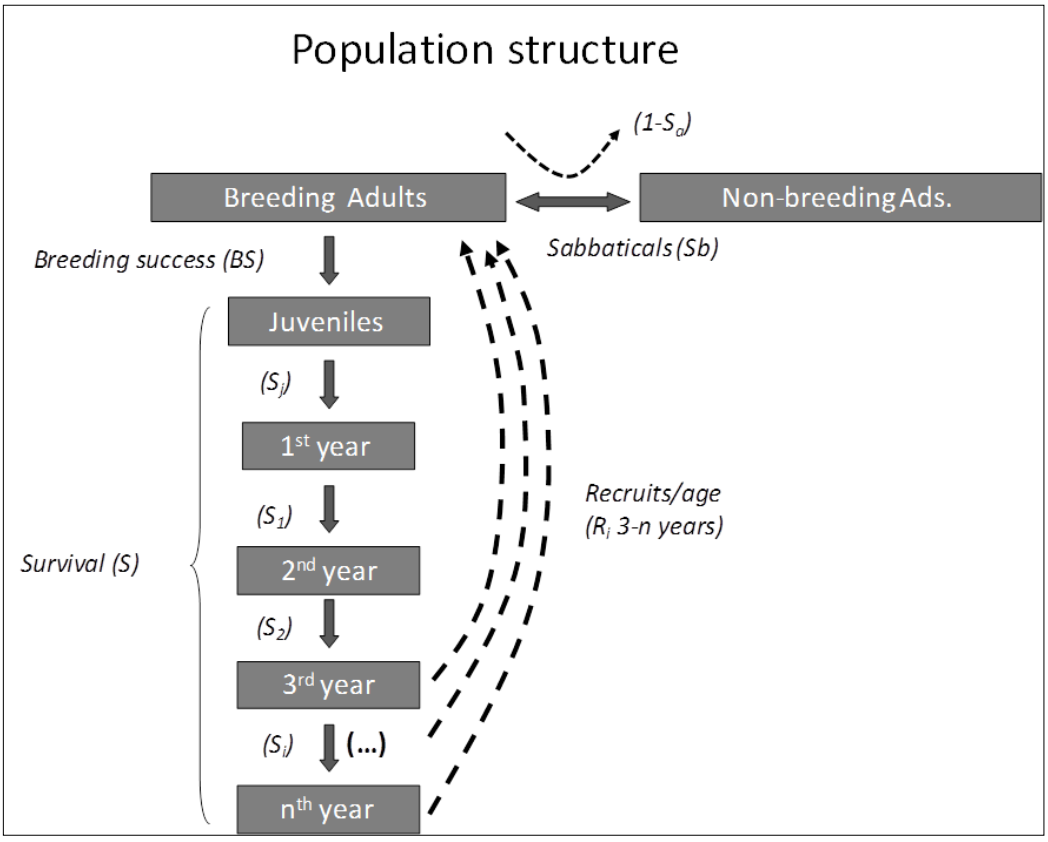

Figure 2. Outline of the model used to relate the breeding and the total populations of Balearic Shearwater. The model builds up on the number of breeding adults, and from this figure it estimates the number of non-breeding mature adults (birds on sabbatical), juveniles and sub-adults of different age classes (here a bird is considered as sub-adult if it has not bred yet, irrespective of its age). Demographic parameters used to link these figures are breeding success (*BS*), survival (*S*; age-dependent), recruitment (*R*; age-dependent); and rate of sabbaticals (*Sb*). The model is "static", as it does not contemplate changes in the population of breeding adults, and should be taken as a mere approximation.

The bulk of the population concentrated in the eastern coast between S Catalonia and N Murcia, although there were slight differences in the distribution patterns between years. In any case, total estimates were quite consistent, although confidence intervals based on bootstrapping were wide (Table 2). Average estimates ranged from 23,148 birds in 2005 to 36,108 in 2004 (Table 2).

Coastal counts. Raw counts of Balearic Shearwaters flying westwards ranged from 12,835 in 324 hours in 2010 to 17,874 in 477 hours in 2009 (Table 3). A markedly lower number of Balearic Shearwaters were registered flying east, from 585 in 2007 to 267 in 2008. Annual variations were principally due to the different coverage in observation time, from 37.5% of the daylight time in 2007 to 67.3% in 2008. Once the gaps were filled using GAM, we inferred a net westwards passage across the Strait ranging from 23,780 birds in 2008 to 26,535 in 2009. These estimates

Parameter		Scenario A	Scenario B	Scenario C
Breeding success (BS)		0.50	0.59	0.75
Survival (S)	S_j	0.60	0.70	0.70
	S_1	0.65	0.74	0.75
	S_2	0.70	0.78	0.80
	S_3	0.75	0.78	0.85
	S_{ad}	0.78	0.78	0.90
Recruitment (R)	R_3	0.30	0.30	0.05
	R_4	0.50	0.40	0.10
	R_5	0.75	0.50	0.15
	R_6	0.90	0.60	0.20
	R_7	1.00	0.70	0.25
	R_8	-	0.80	0.25
	R_9	-	0.90	0.25
	R_{10}	-	1.00	0.25
	R_{11}.R_{21}	-	-	0.25
Sabbaticals (Sb)		0.12	0.26	0.35

Table 1. Demographic parameters used to infer the global population of Balearic Shearwater from the breeding figures. Three scenarios were considered, allowing using a conceivable range of demographic values. Scenario A would provide the most conservative ratio of total to breeding populations, whereas scenario C would result in the largest ratio. Scenario B would be in between, and would be the most realistic according to currently published information.

were robust (with standard deviations lower than 7% in all the cases) and consistent throughout the years (Table 3).

Relationship between breeding population and global population. Departing from the most recent estimate of almost 3,200 breeding pairs, the expected global population would range between *ca.* 10,800 and 17,500 individuals according to our modeled scenarios (Table 4). Only when considering a figure of 4,400 breeding pairs the inferred estimates for the global population (range ca. 14,800-24,000) approached the figures obtained from the two survey methods described in this paper, though only marginally.

	Depth			Total (average)	95% CI
	0-100 m	100-200 m	200-1000 m		
2003	29,572	870	2,184	32,627	14,787 - 58,855
2004	29,474	5,780	855	36,108	10,066 - 75,940
2005	20,282	323	2,543	23,148	10,586 - 40,394

Table 2. Balearic Shearwater estimated numbers (average ± 95% confidence intervals, CI) inferred from the boat-based transect counts at sea, in the three years of study. Results are presented separately for each bathymetric stratum, and for the whole study area.

			Shearwaters counted			Shearwaters estimated				
Year	Period	Effort (days)	W	E	Time (h)	W	E	Net flux	SD	Time (h)
2007	23 May-9 July	42	12,858	585	238	25,626	1,283	24,343	1,634	634
2008	15 May-9 July	56	17,805	267	490	24,246	466	23,780	655	728
2009	15 May-14 July	61	17,874	271	477	26,867	332	26,535	834	793
2010	17 May-4 July	49	12,835	376	324	26,653	521	26,132	1,485	637

Table 3. Extreme dates of census (period), observation effort (number of days; also actual and inferred number of hours: Time) and total numbers of Balearic Shearwater (separated according to flight direction) per year off Tarifa, 2007-2010. The table also shows the inferred estimates of total westwards flow of shearwaters (Net flux, average ± standard deviation, SD) after the census gaps were filled using GAM calculation.

Breeding population	2,000 bp	3,200 bp	4,400 bp
Scenario A	6,748	10,797	14,845
Scenario B	8,232	13,172	18,111
Scenario C	10,919	17,470	24,021

Table 4. Inferred global population of Balearic Shearwater according to the three demographic scenarios described in Table 1 (A, B & C) and three potential figures for the breeding population (number of breeding pairs, bp).

Discussion

Results presented here show that the global population of the Balearic Shearwater is considerably larger than the 8,000-15,000 birds previously thought. This is so even when only the raw data from Gibraltar are considered (up to 17,397 birds in net flow in 2009), but the difference is more obvious once inferred data are calculated to represent either the whole study period (post-breeding migration at Gibraltar) or study area (counts at sea). According to these approaches, we propose a conservative estimate of *ca*. 25,000 birds for this species. The fact that two complementary at sea methodological approaches provided similar figures, which were also consistent between years, reinforces our statement. A further reinforcement came recently from the observation of 16,421 birds in only 2 hours off Cullera (Valencia, NE Spain) during a coastal census in December 2009 (Aleixos-Alapont, *in press*).

Reliability of the new estimates. Seabird estimates at sea are subject to various potential biases,

which deserve consideration here. The consistency of our complementary approaches suggests that such biases were minimized; nevertheless they cannot be excluded. For transect counts at sea, density values should only be considered as indicative (Haney 1985) and therefore the derived estimates could be biased, but Tasker *et al.* (1984) methodology was developed to minimize such biases. The main potential bias for these counts would be related to the lack of detection of some birds, as no related corrections have been applied (Distance Sampling, Buckland *et al.* 2001). Such corrections, if relevant, would however give an even larger estimate than the one presented here. Another point is that due to the species' gregariousness, the estimates could be inflated by the inclusion of large rafts of shearwaters in transects. However the observed distribution is considerably scattered, with only a few large rafts observed in very coastal waters, which were predominantly outside the census band and therefore did not contribute significantly to the density estimates. It might also be thought that the bird flow between different areas would have entailed repeating individuals between counts. However, the counts were conducted during the return passage of the shearwaters into the Mediterranean (main flow from SW to NE) and the cruise took the opposite direction, thus reducing the possibility of repeating individuals. Finally, the possible effect of the boat as attractor, inflating the estimates, is reduced as fishing operations were only performed at night during the cruise.

Concerning coastal counts at Gibraltar, the reliability of land-based counts for quantifying seabirds at sea is constrained by the distance at which birds can be detected, being unrealistic to assume coverage of the whole Strait of Gibraltar width. However, Balearic Shearwaters passing along the north part of the Strait tend to concentrate near the coast, with the great majority of birds flying closer than 3km according to radar studies (Mateos-Rodríguez *et al.* 2010 and Mateos-Rodríguez & Arroyo 2011). Moreover, ship-transects across the Strait of Gibraltar have confirmed that movements of Balearic Shearwaters are very rare across both the central and the southern part of the Strait (see appendix in Mateos-Rodríguez & Arroyo 2011). Thus, the number of Balearic Shearwaters undetected by observers should be negligible, and in such case this bias would indicate a slight underestimation. There are not evidences of the occurrence of neither reverse migration or nocturnal migratory movements of the species based on the above sources of information (see also Guilford *et al.* 2012).

A final point to consider is that both approaches presented here conservatively assumed that the whole population of Balearic Shearwaters is constrained to the corresponding study area and period. For the boat-based counts, the bulk of the Balearic Shearwater population seems indeed concentrated in Mediterranean Iberia during the sampling period (Ruiz & Martí 2004, Guilford *et al.* 2012), but there is increasing evidence that some birds remain in European Atlantic waters during the autumn-winter (Mouriño *et al.* 2003, Poot 2005, Wynn & Yésou 2007), and birds also visit other areas within the Mediterranean (Rebassa *et al.* 1988, Guilford *et al.* 2012), suggesting that the global population could be even greater than proposed here. The same occurs for the Strait of Gibraltar counts, as the bulk of the migration takes place between mid May and mid July, but some birds pass through the area either earlier or later (Programa Migres 2009), or just remain in the Mediterranean or the Atlantic the whole period.

How to explain the discrepancies? Assuming that the figures provided in this paper for the total

population of Balearic Shearwater are correct, it seems unlikely to explain them with the currently estimated figure of 3,200 breeding pairs, according to the simple modeling approach developed here. Indeed, taking into account a wide range of conceivable values, the estimates of the global population inferred from those of the breeding population were always below the figures obtained from counts at sea, even when considering the most optimistic estimates for the breeding population (i.e. 4,400 breeding pairs). The modeling approach was however simplistic, assuming a "static" population, and was used as a tentative guess. There are still many gaps regarding the population structure of the species, and therefore this inference should be taken with care.

Tentatively, the alternative must be considered that the breeding population is really underestimated and might be closer to 5,000 breeding pairs or even more. Whatever unlikely this might seem at first glance, it is important to bear in mind that the Balearic Shearwater often breeds in inaccessible and discrete sites, which require indirect census methods potentially subject to strong biases (e.g. Gregory *et al*. 2004, Mitchell *et al.* 2004). Thus, the number of breeding pairs could be underestimated in known colonies, and/or new colonies might still to be discovered, especially in the rugged NW coast of Mallorca. It could also be proposed that colonies are to be found outside the Balearic archipelago, for example on the Algerian coast, but there is no firm evidence, or even suggestion, to that.

Implications for conservation. The estimates reported in this study could be good news for the Balearic Shearwater, although they should be taken with extreme caution. First of all, it is necessary to clarify the actual breeding and total population size. Second, it is necessary to update the data on demographic parameters and properly assess the current population trend, taking into account data from a representative selection of colonies. Although the population figures now appear to be larger than previously expected, it is also likely that the alarming decline described by Oro *et al.* (2004) actually is even sharper, as it was based on data from colonies free of introduced predators. This threat is particularly serious in the case of carnivores, which prey on adults and thus influence negatively on survival rates, with about one third of the known breeding population exposed to them (Arcos 2011). Ultimately, the species faces serious threats both on land (predation, disturbance) and at sea (fishing bycatch, pollution, fish prey overexploitation and others; see review in Arcos 2011), and its declining trend seems beyond any doubt. A larger population than previously assumed, if confirmed, might "buy years to extinction", but the declining trend deserves urgent conservation action to allow the safeguarding of the species in the long term (Louzao *et al*. 2006).

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Part 2: Ecology and Conservation of Mediterranean Storm-petrel and Mediterranean Shag

The Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* in Malta.

Joe Sultana[1] & John J. Borg[2]

[1]Dar Ta' Gajdoru/3, Gajdoru Str., Xagħra, Gozo XRA 2503, Malta. joesultana@maltanet.net

[2]National Museum of Natural History, Mdina, Malta. diomedea@onvol.net

Summary: The Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* is a localised, breeding visitor to Malta, nesting mainly at Filfla, an islet about 4.5km off the southern coast. The current population is estimated at 5,000–8,000 pairs at Filfla, and over 25 pairs at Ta' Ċenċ. The Mediterranean Storm-petrel is asynchronous in its breeding behaviour: the egg-laying period spans four months (April to July) and courtship is still at its peak in mid-May. In the 1950s it was reported that only two breeding pairs were found. A series of visits to Filfla were initiated in 1968 to monitor the seabird populations. The islet was being used for target practices by foreign military forces, which were stopped in 1970. The loose rubble and boulder scree, remnants of bombing activities, and the difficulty in approaching the island with the least swell, have all made it difficult to carry out any extensive studies. Nevertheless, after 40 years of fieldwork, the accumulation of data is providing several interesting aspects of the species' biology. Some of the studies cover longevity, movements, moult strategies and breeding biology. The colony at Filfla faces some major threats: the increasing colony of Yellow-legged Gulls *Larus cachinnans* and the loss of nesting areas below the cliffs due to heavy erosion.

Key Words: Mediterranean Storm-petrel, *Hydrobates pelagicus melitensis*, population, breeding behaviour, Filfla, Malta.

Introduction

In a mid-eighteenth century manuscript there is an interesting episode about a French Knight, Etienne François Turgot, who visited Gozo to search for rare plants and birds (Agius de Soldanis 1746). In July 1746 Turgot collected eight specimens of a small unknown seabird from Ta' Ċenċ Cliffs. Agius de Soldanis, who saw the birds in and out of the nest, described the seabirds as strange, black, and foul-smelling, having the size of a thrush, with a black beak similar to a pigeon, with the eyes somewhat nearer to the upper-part of the head, and with webbed feet. He wrote that these small seabirds nest in caves below Ta' Ċenċ, staying in fissures during the day and fly out

at night in search of food at sea, and wherever they stay, they leave behind them a strong stinking smell. He was assured by several fishermen that these birds were not found breeding in any other caves. This was the first description of the Storm-petrel from the Maltese Islands, and probably the first documented collection of specimens of the Storm-petrel from the Mediterranean (Sultana *et al.* 2011). A small colony has been rediscovered in 1994 in one of the caves below Ta' Ċenċ cliffs (Borg & Sultana 1992-1994), showing the resilience and faithfulness of this small pelagic bird to its breeding colonies.

However the first proper scientific description of the European Storm-petrel *Hydrobates pelagicus* from the Mediterranean was given by Antonio Schembri from specimens collected from Filfla. Authors describing specimens from the British Isles had not mentioned the white base of the tail feathers, which Schembri noticed on the Filfla specimens. Therefore he thought that he had discovered a new species and named it *Thalassidroma melitensis* (Schembri 1843). However, a year later, specimens obtained from Malta were found to be identical with the *Thalassidroma pelagica* = *Hydrobates pelagicus* of the British seas (Strickland 1844). While no one, since then, has claimed that this population of the Storm-petrel belongs to a distinct species, in recent years it has been confirmed that the population which breeds in the Mediterranean belongs to a different subspecies *Hydrobates pelagicus melitensis* (Hemery & d'Elbée 1985, Cagnon *et al.* 2004).

Status & breeding behaviour

The status of the Mediterranean Storm-petrel in Malta was not known properly before the late 1960s. Roberts (1954) stated that it had formerly been a common resident, but that it was depleted in number. He recorded only two pairs at Filfla in June 1952.

Since 1968, regular annual visits to Filfla have been organised to monitor the seabird populations. During the first few years, the colony was estimated to consist of about 10,000 pairs (Sultana & Gauci 1970 and 1982). However, due to loss of suitable nesting sites by storms washing away parts of the scree below the cliffs, as well as the increasing colony of the Yellow-legged Gull *Larus michahellis* at Filfla, the numbers were noted to decline (Massa & Sultana 1993). Presently the number of breeding pairs at Filfla is estimated between 5,000-8,000 pairs, while the small cave colony at Ta' Ċenċ holds over 25 pairs (Borg & Sultana 2004, Sultana *et al.* 2011).

The Mediterranean Storm-petrel is asynchronous in its breeding behaviour. The earliest birds visit the colony from late February. While courtship of several birds is still ongoing in mid-May, the first eggs are laid in mid-April. The latest eggs are laid in mid-July, but a few young birds are still hatching in early August whereas some others start fledging by mid-August. The latest birds fledge by mid-October. There seems to be two separate groups of breeders; an early larger group which start laying from mid-April and a smaller group, probably first time breeders or failed breeders, laying by mid-July (Figure 1). In fact the number of adult birds present in the colony in May and June is much higher than in August and September. Figure 2 gives an indication of the frequency and number of birds visiting the colony throughout the breeding season. The sharp drop in the number of birds mist-netted throughout August and September reflects the lower portion of breeding birds laying by mid-July, which are probably first time breeders or failed breeders.

Months	20 Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	20 Oct	
Days	10	31	30	31	30	31	31	30	20	**= 244**
			Group A				**Group B**			

Figure 1. The entire breeding season of Mediterranean Storm-petrel takes about 244 days from the earliest arrivals to last departure. The egg-laying of the first group takes place around mid-April and that of the second group around mid-July (Borg & Sultana 2010; Sultana *et al*. 2011).

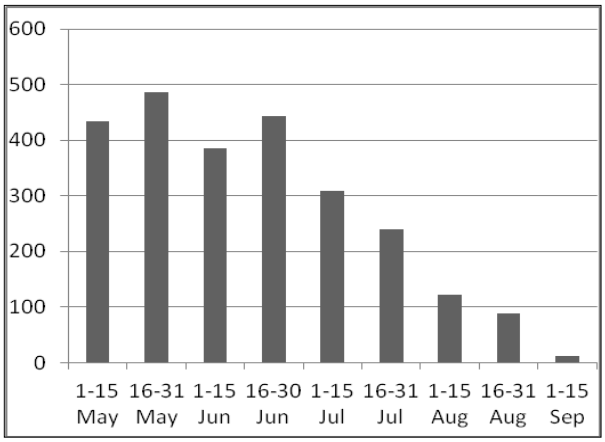

Figure 2. Average no. of adult Mediterranean Storm-petrels caught per visit at Filfla every half-month period from 1968-2011 (updated from Sultana *et al.* 2011).

Longevity

About 21,300 birds have been ringed at Filfla from 1968 up to 2011, and over 2,400 of these have been retrapped at least once. Most of the birds have been retrapped in the first 10 years after ringing, with the highest number of retraps occurring during the first two years. Furthermore, 368 birds which have all been ringed as adults, were retrapped more than 9 years after ringing. The oldest bird retrapped (at least 27 years old) had been ringed on 16th August 1974 and retrapped on 31st May 2001. The second oldest (at least 26 years old) was a bird ringed as an adult on 20th June 1981 and found dead in a Yellow-legged Gull pellet on 12th June 2007 (Figure 3). Another adult bird, which was ringed in May 1986, was controlled in May 2012, 26 years later.

Site tenacity

The colony at Filfla is spread out along the whole surrounding scree area below the cliffs. During the nesting period birds seem to fly directly from the sea towards their nesting area. Ringed birds

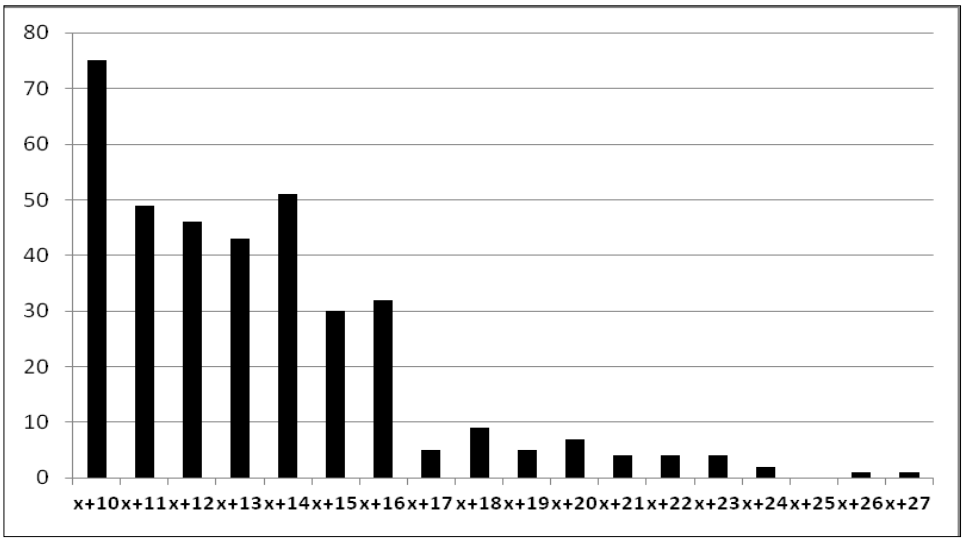

Figure 3. Mediterranean Storm-petrels re-trapped at least once more than 9 years after ringing at Filfla. X = year of ringing (updated from Sultana *et al.* 2011)

are normally retrapped in the following years at the same site, or in close proximity of the site where they were originally ringed: 93.66% of 221 birds retrapped in the years 2004-2011 had been ringed in the same site on the islet.

Movements

Despite the fact that about 21,300 birds have been ringed at Filfla from 1968 up to 2011, only 12 adult birds have been recovered away from the Maltese islands (Table 1). The waters off the Syracuse

Ring No.	Age	Ringed on	Recovered	Recovery Site
BC74767	2	29.06.1968	(28.12.1969)	Techine: 33°29';10°00'E Matmata, Gabes, Tunisia
697989	2	12.06.1971	25.09.1971	off Ash Shabbah 35°08'N;12°11'E Tunisia
S4121	4	24.05.1986	20.02.1990	Côte Sauvage, La Tremblade: 45°46' N; 01°08' W France
697638	2	13.06.1970	29.07.1976	S.Ionian Sea: 37°04'N;15°17' E (Sr), Sicily
2114915	2	27.05.1972	20.08.1972	Itala Marina: 38°03N; 15°26'E (Me), Sicily
2120540	4	27.05.1972	27.04.1975	Lago di Siracusa: 37°04'N; 15°16'E Sicily
2148091	4	28.06.1973	24.07.1973	Pachino: 36°43'N; 15°06'E (Sr), Sicily
2148353	4	28.06.1973	15.04.1975	Ionian Sea: 38°30'N; 17°00'E (Sr), Sicily
2126117	4	06.08.1973	15.04.1975	25km off Syracuse: 36°55'N; 15°25'E Sicily
2206646	2	01.07.1978	07.04.1979	off Syracuse: 57°04N';15°18'E Sicily
S7347	4	15.06.1991	14.07.1996	Marettimo I.: 37°58N';12°04'E Sicily
2114213	4	10.07.1971	15.09.1989	Ameland: 53°25'N; 04°45'E Strand, Netherlands

Table 1. Recoveries of Mediterranean Storm-petrels ringed at Filfla.
Age code: 1=pullus; 2=fully grown (year of hatching unknown); 4= hatched before current calendar year but exact year unknown. The recovery date in brackets is the date of the reporting letter.

Ring No.	Age	Ringed at Marettimo Is.	Recovered at Filfla Is.
KN03195	4	02.07.1994	02.07.1998
K46821	1	16.07.1987	15.07.1989
KN16489	1	19.07.2003	10.08.2009
KN23928	I	23.08.2011	30.06.2012

Table 2. Recoveries of Mediterranean Storm-petrels ringed at Marettimo Island, Sicily and recovered at Filfla. Age code: 1=pullus; 2=fully grown (year of hatching unknown); 4= hatched before current calendar year but exact year unknown (updated from Borg & Sultana 2009).

coast in eastern Sicily, where seven birds have been recovered, appear to be attractive to Maltese Storm-petrels. Another bird was controlled at a breeding colony at Marettimo Island, off the west coast of Sicily. Hashmi & Fliege (1994) stated that there is no hint of migration of the Mediterranean population through the Straits of Gibraltar. However two adult birds ringed at Filfla during the breeding season were found dead outside the Mediterranean Sea, although the origin of these two birds is unknown. One ringed on 24th May 1986 was found long dead on the French Atlantic coast of La Tremblade on 20th February 1990. The second bird ringed at Filfla on 10th July 1971 was washed ashore after a storm on Ameland Beach in the Netherlands on 15th September 1989. Marettimo Island, off the west coast of Sicily, holds a colony of over 1,000 pairs of Mediterranean Storm-petrels and since 1973 this colony has been visited by Sicilian ornithologists almost every year to ring the birds. Contrary to Filfla, the majority of birds ringed at Marettimo are young birds. Four of the Marettimo-ringed birds have been recovered at Filfla (Table 2). These results, apart from showing movements of various distances, also highlight the fact that the gene-flow of the Mediterranean Storm-petrel may not be very low as previously believed (Massa & Sultana 1990-1991).

Moult

The onset of moult in adult birds starts with the primary flight feathers, dropping the innermost primary feather, and progressing slowly outwards towards the wing-tip (descendant moult). The

	July							August
	5th	8th	11th	13th	16th	18th	26th	5th
Sample no.	88	138	111	143	189	143	133	106
Average primary moult score	5(0-18)	3(0-15)	4(0-20)	5(0-18)	6(0-24)	5(0-21)	10(0-22)	19(3-36)
Birds with no active pr. moult	17%	21%	13.5%	10.5%	10%	9%	2.2%	0%

Table 3. Average primary score in moulting Mediterranean Storm-petrels and percentage of birds not in active primary moult. Score criteria for feathers: 0 = old; 1 = missing or totally in pin; 2 = one-third grown; 3 = two-thirds grown; 4 = nearly full grown; 5 full grown. The Storm-petrel has 11 primaries, with the outer one (the 11th) minute. The latter is not taken in consideration in the primary score.

earliest birds commence moult in the latter half of June and, by early August, all adult birds are in active primary moult. The primary moult is regular, while the moult of the secondaries and tail is slower and irregular. Birds usually start moulting their secondaries from three loci, but not simultaneously, and by mid-September most birds are also in active secondary and tail moult. Primary moult scores are given in Table 3 and Figures 4-5.

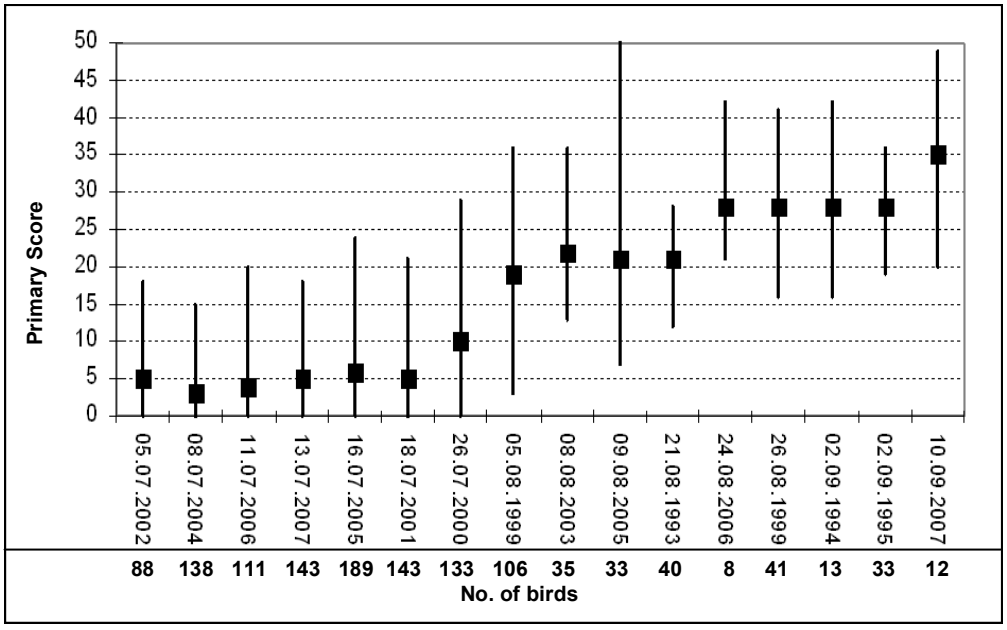

Figure 4. Average and ranges of moult score of 1,267 Mediterranean Storm-petrels from Filfla. For criteria of moult score see Table 3.

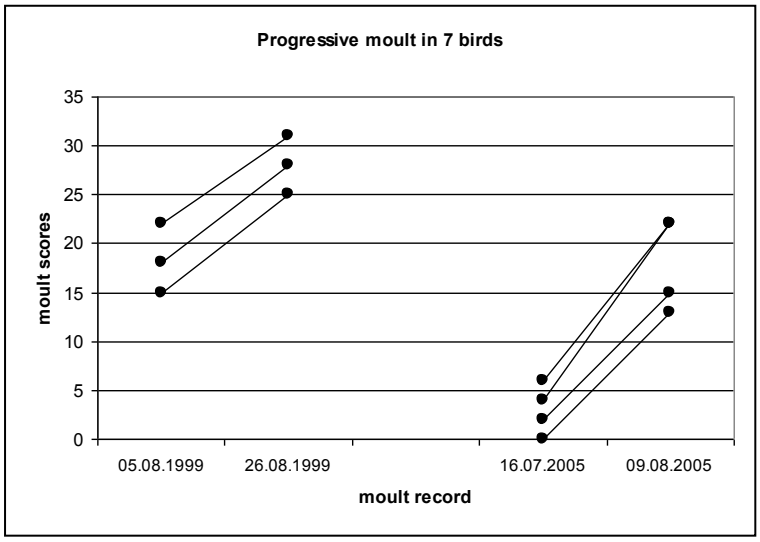

Figure 5. Progressive primary moult of seven Mediterranean Storm-petrels caught twice in the same year while moulting.

Threats to Mediterranean Storm-petrels at Filfla

Fortunately Filfla islet is rat free. However, the increasing population of the Yellow-legged Gull on the islet is becoming detrimental to the Storm-petrels. This gull frequently takes Storm-petrels in substantial numbers as they alight on the ground during moonlit nights. The regurgitated pellets of Yellow-legged Gulls collected from Filfla always contain a significant amount of Storm-petrel remains. The species is mostly preyed upon during the gulls chick-rearing stage, particularly by those pairs that have their nests close to the Storm-petrels' nesting sites. An analysis of 48 regurgitated pellets of Yellow-legged Gulls, collected from an area of 20 m² below the cliffs at Filfla, contained the remains of 32 petrels (Borg *et al.* 1992-1994). Between 1984 and 2007, 394 pellets containing avian remains were collected from Filfla: 191 (54%) of these were found to contain Storm-petrel remains (Sultana *et al.* 2011).

Storm-petrels are also at times disorientated by light at night. Adults as well as fledged young are occasionally attracted to lights. Three recently fledged young were found together on 3rd September 2005 close to the Delimara lighthouse following adverse weather conditions; three single birds were picked up at Għar Lapsi (27th August 1987, 11th August 2005 and 5th September 2005 respectively); one juvenile fell in the middle of Żurrieq village square during the village festa on 30th August 2000; and one was picked up at Marsalforn Bay in Gozo on 24th July 2000. Adult Storm-petrels are also frequently attracted to lights while fishermen are fishing for squid. This happens especially off the southern coast of Malta.

Erosion and weathering are also causing dramatic changes to the topography of Filfla Islet and is resulting in a substantial loss of suitable nesting sites. Conservation measures should address these problems. Efforts should continue to keep the islet rat free and to monitor regularly the Storm-petrel colony. However, the main difficulty lies in controlling and curbing the erosion of the nesting habitat.

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Conservation of the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* at Benidorm Island (Spain)

Ana Sanz-Aguilar[1], Emmy Libois[1], Eduardo Minguez[2], Daniel Oro[3], Roger Pradel[1] & Olivier Gimenez[1]

[1]Biometry and Population Biology Group, Centre d'Ecologie Fonctionelle et Evolutive (CEFE-CNRS) UMR 5175, 1919 Route de Mende, F-34293 Montpellier, France. ana.sanzaguilar@cefe.cnrs.fr
[2]Planification and Conservation Department, Ardilla-ConnectingLife, Agustín Betancourt 21, 28003 Madrid, Spain.
[3]Population Ecology Group, Instituto Mediterráneo de Estudios Avanzados, IMEDEA (CSIC-UIB), Miquel Marqués 21, 07190 Esporles, Mallorca, Spain.

Summary: The effectiveness of the management actions developed at Benidorm Island (western Mediterranean) for the conservation of the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* are revised. Plastic nest-boxes were installed inside two caves where Storm-petrels bred in 1996 and individuals of Yellow-legged Gulls (a predator of Storm-petrels) have been selectively culled in 2004, 2005, 2006, 2010 and 2011. Conservation actions implemented at Benidorm Island have been highly effective at increasing Storm-petrel breeding success, survival and breeding numbers.

Key Words: Mediterranean Storm-petrel, *Hydrobates pelagicus melitensis*, conservation action, nest-box, breeding success, survival.

Introduction

The European Storm-petrel *Hydrobates pelagicus* is one of the smallest long-lived procellariiform seabirds (average body mass 28g, Warham 1990). There is no particular concern for the status of the species worldwide, but the Mediterranean subspecies *H. p. melitensis* is considered vulnerable. Populations of this subspecies are confined to sites free of invasive rats (De Leon *et al*. 2006), which remain scarce among Mediterranean islands (Ruffino *et al*. 2009). Storm-petrels lay a single egg in natural borrows, under boulders or in crevices. Incubation last about 40 days and chick rearing takes about 63-70 days (Warham 1990, Mínguez 1996 and 1998). They are pelagic and return to land at night only to breed or to prospect potential breeding colonies (Warham 1990). Their behaviour and nesting habitat make its populations very difficult to monitor (Mitchell & Newton 2000, Sanz-Aguilar *et al*. 2010) and insights in their population dynamics are usually achieved through the analysis of life-histories of individually marked birds (Tavecchia *et al*. 2008, Sanz-Aguilar *et al*. 2008, 2009a-b and 2010). Major threats of Mediterranean Storm-petrels in their current breeding colonies are predation by sintopic bird species as gulls or raptors (Oro *et al*. 2005, Sanz-Aguilar *et al*. 2009a) and habitat deterioration (Cadiou *et al*. 2010). Monitoring of Mediterranean Storm-petrels, habitat management (installation of artificial nest boxes) and

selective culling of predatory Yellow-legged Gulls *Larus michahellis* have been carried out in recent years at Benidorm Island, a 6.5ha Special Protection Area off the Mediterranean coast of Spain (38º 30'N, 0º 08'E) (De León & Minguez 2003, Sanz-Aguilar *et al*. 2009a). Here we review the actual knowledge on the effectiveness of the management actions performed, in terms of predatory pressure, Storm-petrel survival, breeding success and evolution of breeding numbers.

Methods

Study area. At Benidorm Island, Mediterranean Storm-petrels breed under boulders and in crevices on cliffs but concentrate in two caves where they nest at high densities: Cave 1 contains over 200 breeding pairs, whereas Cave 2 is home to approximately 100 breeding pairs (Mínguez 1994). Previous studies have provided evidence that young individuals are highly philopatric and return to the cave they were born in; and that there are high levels of nesting-site fidelity in breeders; individuals start breeding at three years of age and reproduce annually, being rarely sabbaticals (Sanz-Aguilar *et al*. 2008 & 2009b). An average of 535 pairs of Yellow-legged Gulls (median = 515, range = 300-750) have bred annually at Benidorm during the study, with a mean population growth rate of 6% during 1993-2007 (95%CI = 1.04-1.09) (Sanz-Aguilar *et al*. 2009a). Gulls nest mostly on open ground but a few pairs breed in close proximity to the two major petrel colonies.

Storm-petrel monitoring. Breeding birds (n=1252) and chicks (n=1527) have been captured and recaptured (>4000 recaptures) at their nest sites since 1993 to 2011 and marked with stainless steel rings with a unique alphanumeric code. Each year, breeding birds were caught only once, during the incubation period. These individual data have been used to estimate survival and recruitment probabilities by means of capture-recapture models (Tavecchia *et al*. 2008, Oro *et al*. 2005, Sanz-Aguilar *et al*. 2008, 2009a,b and 2010, Libois *et al.* 2012). During the 19 years of the study, 435 different natural nests have been recorded, i.e. nests where reproduction (= egg laying) occurred at least in one breeding season. Each nest (both natural nests and nest boxes, see below) is inspected at least four times during the whole breeding period annually, to record occupancy, laying dates, hatching success, fledging success and breeding success. Chicks are considered to have fledged if they are at least 35 days when visited for the last time. Since 2008, the monitoring effort was reduced by removing 193 nests from the monitored sample. Data on Storm-petrel breeding success at Benidorm colonies has been analyzed using Generalized Linear Models (GLM, GLMM) (Tavecchia *et al*. 2008, Sanz-Aguilar *et al*. 2008 and 2009a,b, Libois *et al.* 2012).

Figure 1. Artificial nest-boxes for Mediterranean Storm-petrels placed in Cave 2, at Benidorm Island.

Nest boxes. In November 1996, 86 artificial nest boxes were installed in the Storm-petrel colonies (45 in Cave 1 and 42 in Cave 2) to increase the availability of suitable breeding sites (Figure 1, De León & Minguez 2003). The design of the artificial nest-boxes is straightforward, inexpensive

and endurable. It consists of a rectangular nesting chamber (25 x12 cm) accessed via a short tunnel (*c.*10cm). Nest-boxes were manufactured from plastic PVC containers. Each box was perforated to allow drainage as well as transpiration and body heat dissipation from its potential occupants. The entrance tunnel prevents predation of adults, eggs or chicks by gulls. Sand from the surroundings of the colonies was inserted into the boxes to provide an adequate substratum. In 2004, 22 nest boxes were removed from Cave 1 and moved to a neighboring island.

Year	Colony: Cave 1	Colony: Cave 2
2004	4	4
2005	2	1
2006	10	2
2010	3	0
2011	1	0

Table 1. Number of Yellow-legged Gulls removed from the vicinity of Mediterranean Storm-petrel colonies at Benidorm Island from 2004 to 2011.

Evaluation of predatory pressure and culling of specialist gulls. Mediterranean Storm-petrel predation by Yellow-legged Gull is assessed by the inspection of indigestible food items in pellets collected near gull nests around the Mediterranean Storm-petrel colonies, Cave 1 and Cave 2, since 2002 (see details in Oro *et al*. 2005). The minimum number of Mediterranean Storm-petrels killed by gulls is estimated as half the number of pellets containing petrel remains found, because gulls produce two pellets for every Storm-petrel eaten (Oro *et al*. 2005). 'Specialist' gulls are identified as those individuals in which territory (three meters around gull nests) more than one pellet with Storm-petrel remains is found (Oro *et al*. 2005). From 2004 to 2005 a total of 8 gulls breeding in territories identified as belonging to 'specialist' pairs were captured by means of nest traps placed on the nests (Table 1). All individuals were killed by an authorized wildlife agent through the injection of an excess sedative in jugular vein. In 2006, 2010 and 2011, 16 additional individuals were trapped on nests located close to the breeding colonies as a precautionary measure.

Results

Nest boxes: occupancy, breeding success and survival. Occupancy rate of nest boxes placed in Cave 1 has been very low. In Cave 2, occupancy rate increased gradually until 2005 and remained relatively stable until the end of the study period (Figure 2). A recent study has shown that mean breeding success and survival of birds breeding in natural nests at Cave 2 (0.53 and 0.82, respectively) was lower than in artificial nest boxes (0.78 and 0.89, respectively; Libois *et al.* 2012).

Culling of specialist gulls: predatory pressure, breeding success and survival. The number of pellets containing petrel remains found after the removal of specialist gulls in 2004-2005 was lower than in previous years at both colonies (Figure 3). In 2006 a group of juvenile gulls spent the night and preyed upon Mediterranean Storm-petrels in both colonies (direct observation, Figure 3). Some gull territories in Cave 1 from which adults were removed were reoccupied by other gulls during 2007 when culling was stopped. There was an apparent increase in predation rates following the reoccupation of gull territories during 2008-2009, but after removal of 4 gulls in 2010-2011 the number of preyed Storm-petrels decreased again (Figure 3). In Cave 2, with the exception of 2006, the predatory pressure has been relatively low (Figure 3). The selective removal of a few gulls in Cave 1 led to a reduction of *ca*. 65% in the number of Mediterranean

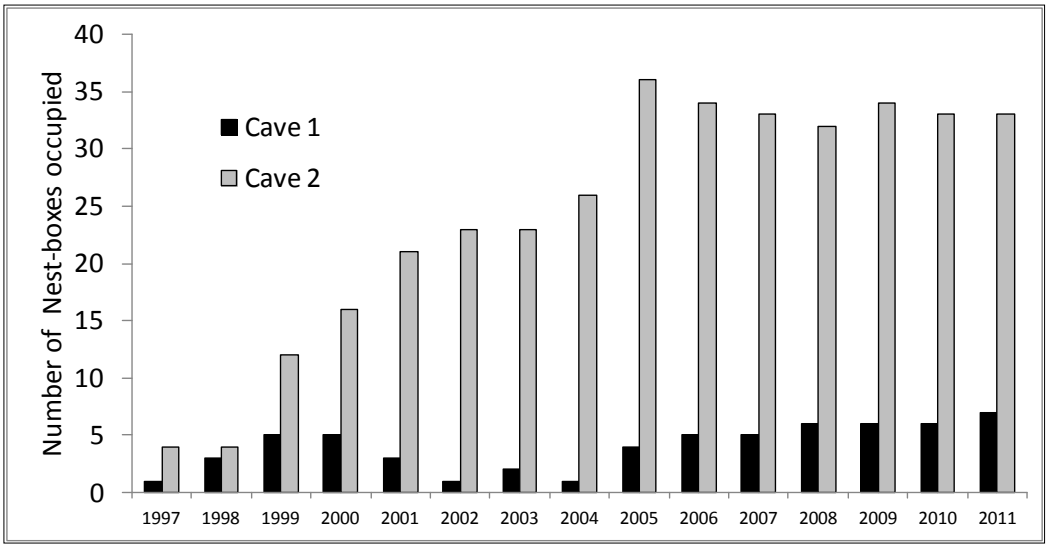

Figure 2. Annual number of artificial nest boxes occupied by breeding Mediterranean Storm-petrels in Caves 1 and 2, at Benidorm Island.

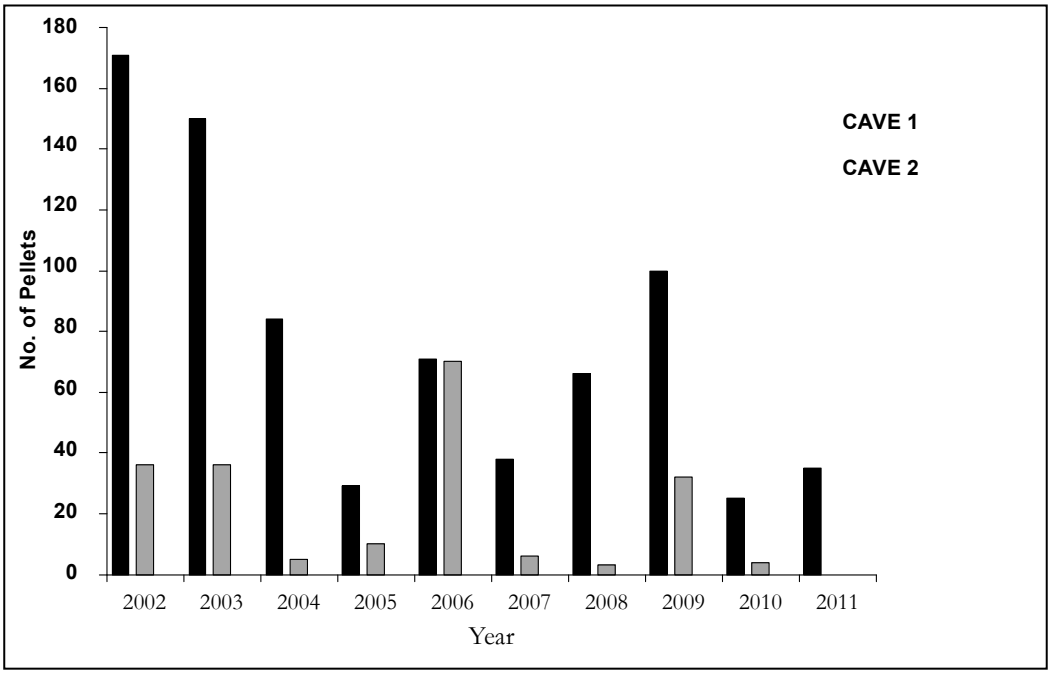

Figure 3. Annual number of Yellow-legged Gull pellets containing remains of Mediterranean Storm-petrels collected in Caves 1 and 2, at Benidorm Island.

Storm-petrels killed, and to a relative increase in their survival and breeding success probabilities, 16% and 23% respectively (Sanz-Aguilar *et al*. 2009a).

Evolution of observed breeding numbers. The number of observed breeding pairs decreased in both colonies during the first years of monitoring (Figures 4-5). In Cave 1, the number of breeding pairs began to increase following the culling of specialist gulls (Figure 4) but without reaching the 1993 level. In Cave 2, breeding numbers greatly increased after the installation of artificial nest-boxes and the culling of specialist gulls (Figure 4). During the last years, when monitoring effort has been reduced, breeding numbers remain relatively stable at both colonies (Figures 4-5).

Discussion

Conservation actions developed to recover Procellariiform populations are usually carried out on breeding grounds and include the eradication of predators (especially alien carnivores and rats) and the improvement of nesting habitat (De León & Mínguez 2003, Bried *et al*. 2009, Sanz-Aguilar *et al*. 2009a). The fact is that conservation actions are easier to implement on breeding grounds and less expensive than at sea (Wilcox & Donlands 2007), and can be highly effective for small species that are not at risk from fisheries bycatch (Baker *et al*. 2002, Igual *et al*. 2009, Sanz-Aguilar *et al*. 2009a). Accordingly, conservation actions implemented at Benidorm island have been highly effective at increasing Mediterranean Storm-petrel breeding success, survival and breeding numbers when the populations were declining.

Nest-boxes used at Benidorm are inexpensive and very endurable. Breeding success of Mediterranean Storm-petrels breeding in nest-boxes is higher than in natural nests, probably as a consequence of thermal conditions inside boxes, a reduction in egg damage caused by small stones on the nest floor puncturing the egg shell, and a reduction of intra- and inter-specific interferences (egg breakage due to trampling by the adults, adult-chick attacks, infanticides, gull predation, etc.; Warham 1990, De León *et al*. 2003, Bolton *et al*. 2004). In Cave 2, where most nest-boxes were occupied, high proportions of natural nests were exposed and vulnerable to predators. Probably, the lack of adequate breeding cavities in this cave limited breeding numbers before the installation of nest-boxes and was the determinant of the high proportions of nest-boxes occupation (De León *et al*. 2003). On the contrary, in Cave 1, there were high numbers of empty natural cavities suitable for nesting and occupancy rates of nest-boxes were low. As artificial nest-boxes protect breeding individuals from gull predation during incubation, survival of birds breeding in nest-boxes was higher than that of individuals breeding in natural nests. Monitoring of birds breeding in nest boxes is easier; however the extrapolation of parameters (survival and breeding success) estimated by the monitoring of nest boxes to the whole breeding population may be biased.

The selective removal of low numbers of gulls led to substantial reductions in the number of Mediterranean Storm-petrels killed, and to an increase in the survival and breeding success probabilities of individuals breeding in Cave 1. We have evidenced that only a few specialized predators (Oro *et al*. 2005) were responsible for the bulk of the impact on the Storm-petrel population and that the removal of those specialized individuals is an effective and efficient way to improve demographic parameters of Mediterranean Storm-petrels and recover their breeding

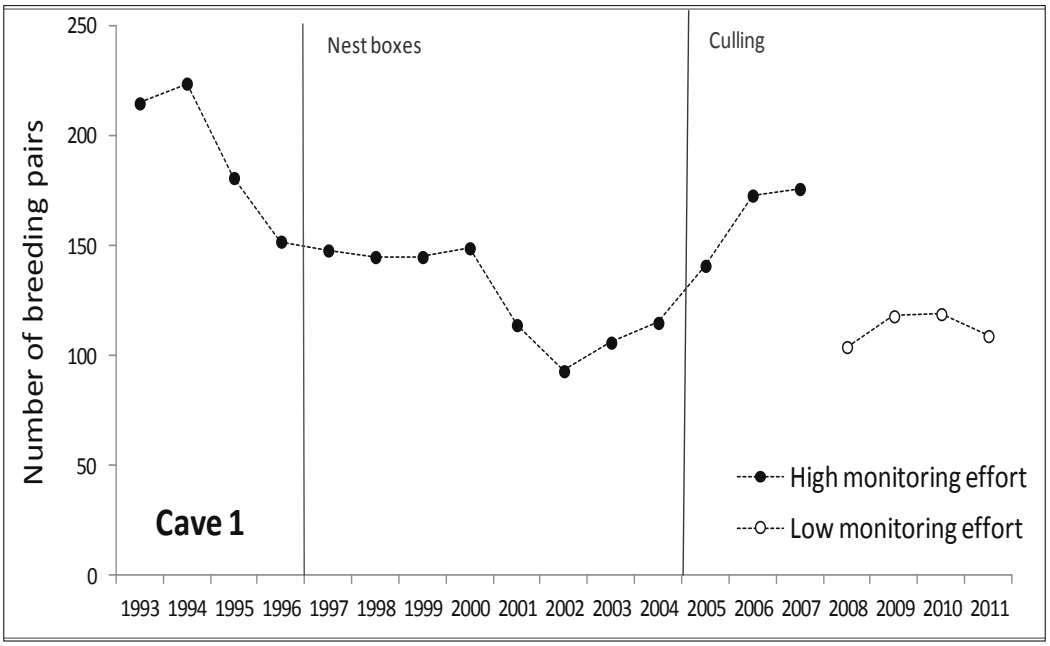

Figure 4. Number of breeding pairs of Mediterranean Storm-petrels observed annually in Cave 1 at Benidorm Island.

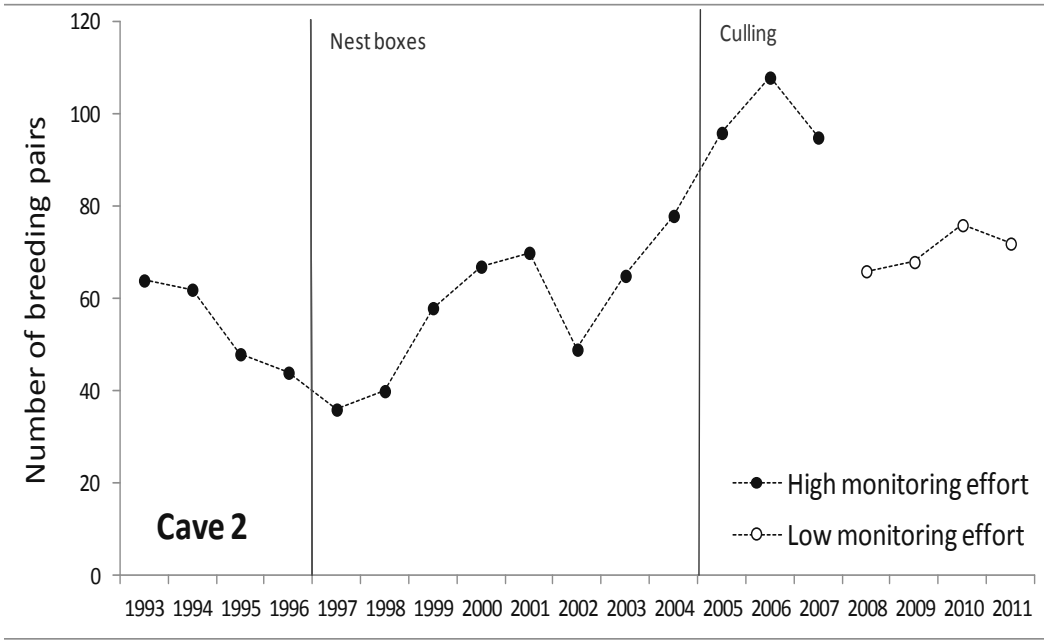

Figure 5. Number of breeding pairs of Mediterranean Storm-petrels observed annually in Cave 2 at Benidorm Island.

numbers. At Benidorm Island the high spatial concentration of breeding Mediterranean Storm-petrels in two caves facilitated the identification of specialized predators. Nevertheless, stochastic predation by juvenile gulls remains a problem to be solved.

In conclusion, management actions based on previous evidences developed at Benidorm island are easy to implement, inexpensive and highly effective for guaranteeing the conservation of Storm-petrels. We recommend that both the management actions (annual removal of predators and maintenance of nest boxes) and the evaluation of their efficacy should continue in the future.

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The importance of diet specialization for the feeding ecology of the Mediterranean Shag *Phalacrocorax aristotelis desmarestii* in the upper Adriatic Sea

Mauro Cosolo[1], Nicoletta Privileggi[1], Barbara Cimador[1] & Stefano Sponza[1]

[1]Department of Life Sciences, University of Trieste, via Giorgieri 9, 34127 Trieste, Italy.

Summary: In order to illustrate the reasons of Mediterranean Shag *Phalacrocorax aristotelis desmarestii* post-breeding movements in the northern Adriatic Sea, we update the knowledge on this species diet during both the breeding season in Croatia and the post-breeding period in the Gulf of Trieste. The analysis of 611 regurgitated pellets allowed identifying important differences between the two areas. In the Gulf of Trieste, Mediterranean Shags specialized on demersal fishes, whereas in Croatia Shags foraged on bentho-pelagic mobile prey. The diet analysis validated our previous results obtained by the application of behavioural models on Mediterranean Shag diving strategies and foraging performance. The lack of a feeding specialization in Croatia is affected by the overfishing of benthic fishes forcing Mediterranean Shags to move after nesting towards more profitable areas such as the Gulf of Trieste.

Keywords: Adriatic Sea, diet specialization, Mediterranean Shag, *Phalacrocorax aristotelis desmarestii.*

Introduction

The European Shag *Phalacrocorax aristotelis* is a foot-propelled diving seabird. Its diet has been used to assess the recruitment and abundance of fish populations (Barrett *et al*. 1990). The Atlantic subspecies *P. a. aristotelis* feeds on a wide range of benthic, demersal and schooling pelagic fish, so Shags are considered as opportunistic predators (Barrett 1991, Velando & Freire 1999). However, sandeels (*Ammodytes* spp.) dominate the diet of the species both in summer (e.g. Furness & Tasker 2000) and in other seasons (e.g. Harris & Wanless 1991). In the north Adriatic Sea, the Mediterranean subspecies *P. a. desmarestii* has become a regular summer visitor in the Gulf of Trieste, with increasing numbers. This population comes mainly from the Croatian breeding colonies (Sponza *et al*. 2010). On the basis of a previous study, obtained by the application of behavioural models on Mediterranean Shag diving strategies and foraging performance (Sponza *et al*. 2010) and by the comparison of the diet of the species between breeding and post-breeding seasons (Cosolo *et al*. 2011), we highlight reasons why Mediterranean Shags, after breeding in Croatia, move to the Gulf of Trieste.

Methods

Mediterranean Shag diet was characterised by pellet analysis (Cosolo *et al*. 2011). In order to minimise the effects of digestive processes, all the identified otoliths have been accurately compared with a reference collection of diagnostic bones (Privileggi 2003), which helped to evaluate

the otoliths' original size. The importance of each prey type in the diet was estimated as numerical frequency. Contingency tables tested by chi-square test (χ^2) were used to compare the numerical frequency of different prey types between the two study areas. We also evaluated the total length and mass of each prey by means of both original (Privileggi 2003) and published (e.g. Veldkamp 1995) equations that relate otoliths length to the body size and then to the mass of fish. In order to identify the diet during the 2005 post-breeding season (May-October) in the Gulf of Trieste (45° 44'N, 13°39'E), we analysed a total of 486 pellets, collected on monthly intervals at each of the three roosts used by Mediterranean Shags. Conversely, to identify the diet during the 2006 breeding season (January-April) in Croatia, we collected a total of 125 pellets at Oruda island in Lošinj archipelago (44°33'N, 14°30'E), one of the most important Croatian colonies in the upper Adriatic Sea. During monthly visits all around the island to collect pellets, we observed only adult birds in breeding plumage.

The analysis of the diving behaviour of Mediterranean Shags was carried out at both areas by means of video-recordings of a total of 317 single-foraging birds (3,081 dives of which 3,010 were analysed; Sponza *et al.* 2010). A total of 130 Mediterranean Shags were recorded in this way in the Gulf of Trieste (period 2002-2006), while in Croatia (Lošinj archipelago) we collected data from 187 individuals during the 2005 and 2006 breeding seasons: 116 Mediterranean Shags were video-recorded in shallow depths (<25 m) and 71 within higher depths (>25 m).

Results

The analysis of 611 pellets revealed 23,988 identified items. In the Gulf of Trieste, Gobiidae were the focal prey (81.5%). Second by importance (11.9%) were Atherinidae (i.e. *Atherina boyeri*). Conversely, in Croatia Atherinidae were the most important prey (28.4%), followed by Gobiidae (18.1%), Serranidae (i.e. *Serranus hepatus*, 16.1%), Labridae (i.e. *Crenilabrus tinca*, 12.0%) and Sparidae (12.6%) (Figure 1). The diet composition was significantly different between the two areas ($\chi^2 = 8894.5$, df = 8, $\alpha < 0.0001$).

In order to assess a relationship between frequency and biomass values we correlated the overall data for the two study areas. We found a significant correlation in the Gulf of Trieste only (Spearman's rank correlation: $N_{\text{Gulf of Trieste}} = 9$, $r_s = 0.88$, $\alpha < 0.01$; $N_{\text{Croatia}} = 9$, $r_s = 0.35$, $\alpha = 0.36$). However, at both sites we found two atypical points relative to the two more abundant taxa, which were Gobiidae and Atherinidae. In Croatia, they showed high frequency but low biomass values. In the Gulf of Trieste this trend was confirmed for Atherinidae, while a high frequency of Gobiidae corresponded to high biomass values. When these exceptions were removed, the regressions became similar and overlapping (Spearman's rank correlation: $N_{\text{Gulf of Trieste}} = 7$, $r_s = 0.96$, $\alpha < 0.001$; $N_{\text{Croatia}} = 9$, $r_s = 0.86$, $\alpha < 0.02$).

The estimated mean (±SD) prey length was similar between the breeding (Croatia, 7.5 ± 3.6 cm) and the post breeding seasons (Gulf of Trieste, 7.6 ± 3.0 cm). In the Gulf of Trieste, the larger prey sizes were recorded in May and June, without difference between these two months. Moreover, in this area prey lengths decreased within the post-breeding season (Spearman's rank correlation: $N = 6$, $r_s = -0.83$, $\alpha < 0.05$).

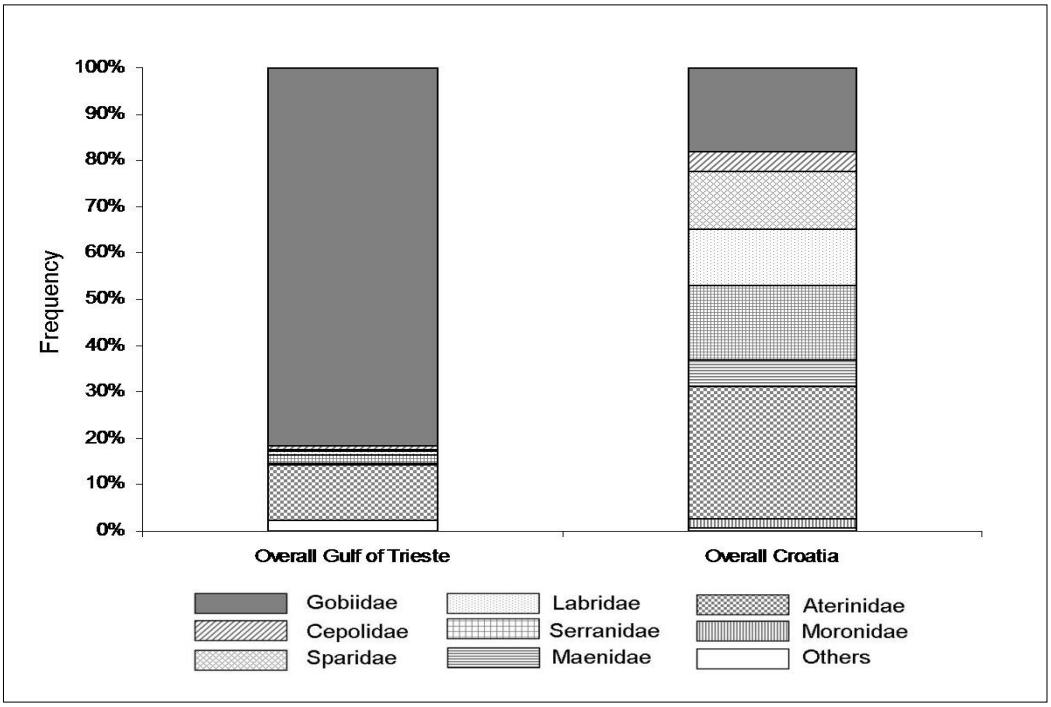

Figure 1. Numerical frequency of prey of Mediterranean Shags in the Gulf of Trieste and at Oruda breeding colony. Within the histograms, per cent values of each family follow the legend's order.

Regarding the Mediterranean Shag diving behaviour, we observed that in Croatian waters less than 25 m deep, the mean dive duration was significantly shorter than in the Gulf of Trieste, while mean time spent on the surface was higher (Figure 2).

Discussion

The most important aspect of our results is the dietary diversity during the breeding season. The prey spectrum is particularly wide in Croatia, where we recorded the prevailing importance of 5 families (Sparidae, Gobiidae, Serranidae, Labridae, Maenidae). This evidence clashes with most Atlantic studies, which suggest that the Atlantic Shag mostly relies on sandeels during the chick rearing period (e.g. Harris & Wanless 1993, Velando & Freire,1999). Conversely, a feeding specialization was recorded during the post-breeding period. In the Gulf of Trieste, Mediterranean Shags indeed focalise on demersal Gobiidae in terms of frequency (81.5%), but also in terms of biomass (87.1%). The most captured species was the Black Goby (*Gobius niger*, 70.8%).

These results are better appreciated when we consider that from May to October the Gulf of Trieste is one of the most important areas in the Adriatic for the abundance of pelagic species like Anchovy *Engraulis encrasicolus*, Sardine *Sardina pilchardus* and Mackerel *Scomber scomber*. In late spring, these species leave the Central Adriatic areas and reach the Gulf of Trieste's shallow waters for spawning (Skrivanic & Zavodnik 1973, Orel & Zamboni 2004). While they represent

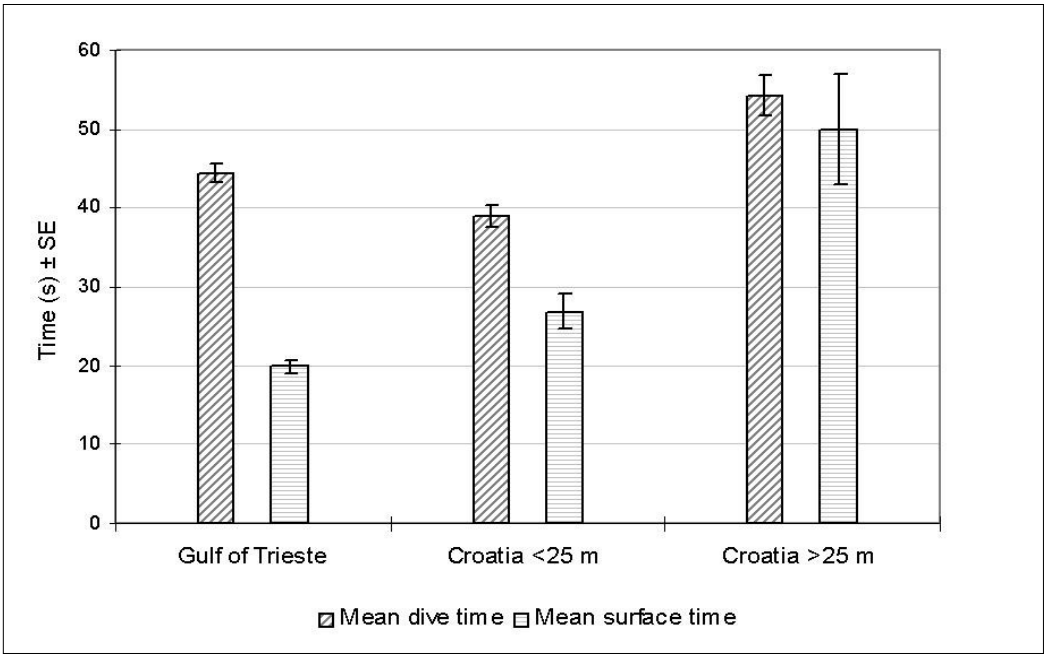

Figure 2. Mean (±SE) dive duration and time spent at the surface for the Mediterranean Shag: (a) In Gulf of Trieste (*N* = 30, dive duration = 44.3 ± 1.2 s, time at surface = 19.8 ± 0.8 s); (b) In Croatian waters less than 25 m deep (*N* = 116, dive duration = 39.1 ± 1.4 s, time at surface = 26.9 ± 2.1 s); (c) In Croatian waters more than 25 m deep (*N* = 71, dive duration = 54.3 ± 2.4 s, time at surface = 49.9 ± 6.9 s). Modified from Sponza *et al.* 2010.

74% of the north Adriatic fish landings (Prestamburgo *et al*. 2005), these fishes correspond to less than 1% and 0.5% of Mediterranean Shag diet in the Gulf of Trieste and in Croatia, respectively.

The importance of Gobiidae in the north Adriatic diet of Mediterranean Shag can also be inferred from the analysis of the frequency/biomass ratio, which highlights how these prey are a discriminating factor at both study areas. If we remove Gobiidae values, the diet indeed tends to a similar frequency/biomass ratio in the two areas. On the contrary, we record a positive effect of Gobiidae in the Gulf of Trieste only. This is due to the larger size of gobies in the Gulf of Trieste than to Croatia.

During the breeding season in Croatia, the prey lengths are slightly shorter than that of preys of Shags breeding in Scotland (9.7 cm; Wanless *et al*. 1993) and Spain (9.8 cm; Velando & Freire 1999). Interesting too is the trend of the monthly mean size of prey: our results suggest an increase in the prey length at the end of the breeding season (April), probably linked to chick-rearing. Conversely, larger preys in May and June in the Gulf of Trieste are likely necessary in order to recover from the energetic costs of breeding. Thereafter, the prey size decreases with the ongoing season.

Considering the ecology of prey, Gobiidae are demersal fishes which are characterised by a very

low mobility (Whitehead *et al*. 1986). Conversely, the most important prey in Croatia (*Atherina boyeri, Serranus hepatus, Crenilabrus tinca, Pagellus erythrinus*) are bentho-pelagic fishes which are characterised by a higher mobility (Whitehead *et al*. 1986). We retain that the ecology and behaviour of prey play a fundamental role for the foraging ecology of Mediterranean Shags. In particular, the different behaviour of fish species affects the accessibility to prey and leads to substantial differences in the facility of prey capture. This interpretation is supported by the observations on Mediterranean Shag diving behaviour. Indeed, we showed that in Croatian shallow waters the mean dive time was significantly shorter than in the Gulf of Trieste, while the time spent at the surface was longer. From a physiological point of view, the necessity to extend surface pause durations, even if mean dive times were shorter, indicates a higher oxygen use at similar depths. We suggest this higher oxygen consumption to be linked with a higher costs of foraging on bentho-pelagic mobile prey. Moreover, in waters more than 25 m deep, both dive and surface durations increased further as a consequence of the higher dive costs.

Perspectives

Compared to Croatia, the Gulf of Trieste is characterised by a shallower bathymetry and Mediterranean Shags can specialize on strictly benthic and low mobile preys. This leads to lower physiological costs of foraging and a high predictability of dives (Sponza *et al*. 2010). Thus the Gulf of Trieste seems to be an optimal foraging area, but conversely, it does not offer undisturbed sites suitable for breeding. Croatia is the exact opposite. The lack of dietary specialization in Croatia is a likely response to local prey abundance, and this could result from over-fishing of demersal species around the breeding locations (Mannini *et al*. 2005). It is suggested that after breeding Mediterranean Shags move to the Gulf of Trieste because demersal species are likely to be more abundant there (Cosolo *et al*. 2011). We consider that such differences are the basis for the post breeding movements (Sponza *et al*. 2010).

Given the extreme importance of the Gulf of Trieste for Mediterranean Shag, it should be of key importance to delimit an Important Bird Area in the northern Adriatic Sea. This was already proposed in the implementation of a preliminary study for the identification of marine IBAs in Italy (see LIPU 2009). Moreover, in the light of the results presented here it should be of key importance to identify and characterize the foraging areas of Mediterranean Shags, to verify whether the birds select their prey or sample the fish community near the seabed, and finally to identify the possible role of the energetic value of prey.

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Important post-breeding roosting area of Mediterranean Shag *Phalacrocorax aristotelis desmarestii* in Gulf of Trieste (N Adriatic)

Iztok Škornik[1], Paolo Utmar[2], Kajetan Kravos[3], Silvano Candotto[3] & Robert Crnković[4]

[1]Sečovlje Salina Nature Park, , SOLINE Pridelava soli d.o.o., Seča 115, SL-6320 Portorož, Slovenia. iztok.skornik@kpss.si
[2]Area Marina protetta di Miramare, Viale Miramare, 349, I-34014 Grignano, Italy. paolo.utmar@libero.it
[3]Riserva Naturale Regionale "Foce dell'Isonzo", "SBIC - Stazione Biologica Isola della Cona", c/o Isola della Cona, I-34079 - Staranzano, Italy. kkajetan@tin.it
[4]21220 Trogir, Balančane 18, Croatia. tragos.crni@gmail.com,

Summary: From the 1980s onwards, Mediterranean Shags *Phalacrocorax aristotelis desmarestii* have become regular summer visitors in the Gulf of Trieste, as post-breeding movements from Croatian breeding colonies. A large aggregation of Mediterranean Shags forages in the area in late summer and autumn with a counted number of 2,000–4,000 birds which is more than half the entire breeding population in the Adriatic. The Italian and Slovenian parts of the Gulf of Trieste together fulfil the criteria for the fourth marine IBA type as a foraging area for an important part of the global population of the Mediterranean subspecies of the European Shag *Phalacrocorax aristotelis*.

Key words: *Phalacrocorax aristotelis desmaresti*, Mediterranean Shag, roost, Gulf of Trieste

Introduction

In the Mediterranean, including the Gulf of Trieste, a general consensus has been accepted for the conservation of this relatively sensitive and heavily influenced sea region. According to Appendix II of the Barcelona Convention, an action plan has been prepared for 15 threatened marine bird species (UNEP MAP RAC/SPA 2003); 14 species from this list have been recorded in the North Adriatic. Among them, seven species have been regularly frequenting the North Adriatic coast in recent years: Yelkouan Shearwater *Puffinus yelkouan*, Mediterranean Shag *Phalacrocorax aristotelis desmarestii*, Pygmy Cormorant *Phalacrocorax pygmeus*, Osprey *Pandion haliaetus*, Lesser Crested Tern *Sterna bengalensis*, Sandwich Tern *Sterna sandvicensis* and Little Tern *Sternula albifrons*.

An analysis of population size estimates was conducted in terms of the proportion of birds of the respective global populations breeding, wintering or foraging rather regularly in the Gulf of Trieste. The proportion of their global population was high (>1%) for the Yelkouan Shearwater (up to 1.5%) and Mediterranean Shag (up to 11.4% of the endemic Mediterranean subspecies *Ph. a. desmarestii*). Both Yelkouan Shearwater and Mediterranean Shag exhibited dense summer aggregations in foraging areas of the relatively shallow and rich Gulf of Trieste (Vrezec 2006).

Results and discussion

The largest colonies of Mediterranean Shag were found in the Kvarner and Brijuni Archipelagos, with the main colony on Silbanski Grebeni near Zadar. Only at five locations Mediterranean Shags nest in large numbers, forming colonies. These are Rovinj Islands (70 pairs), Brijuni Islands (232 pairs), Oruda - Palacol (197 pairs), Morovnik (39 pairs), and Silbanski Grebeni (254 pairs). Often, nests occur sporadically in rock crevices. It is estimated that the number of breeding pairs of Mediterranean Shags along the North and Central Adriatic does not exceed 900 pairs (Pavoković 2010). Breeding colonies are also present in the South Adriatic with up to 100 breeding pairs on Lastovo Island.

From 1910 to 2010, 773 Shags were ringed in the Adriatic area, most of them with colour rings from 2005 to 2010. A total of 460 colour ringed birds were observed (J. Kralj, pers. comm. 2011). Between 2006 and 2011, we recorded more than 150 colour-ring readings in the Gulf of Trieste and over 50 in Venezia Lagoons. Of all registered observations, 61% came from Brijuni Islands, 13% from Silbanski Grebeni, 10% from the Kvarner Archipelago and 16% from others places (Figure 1).

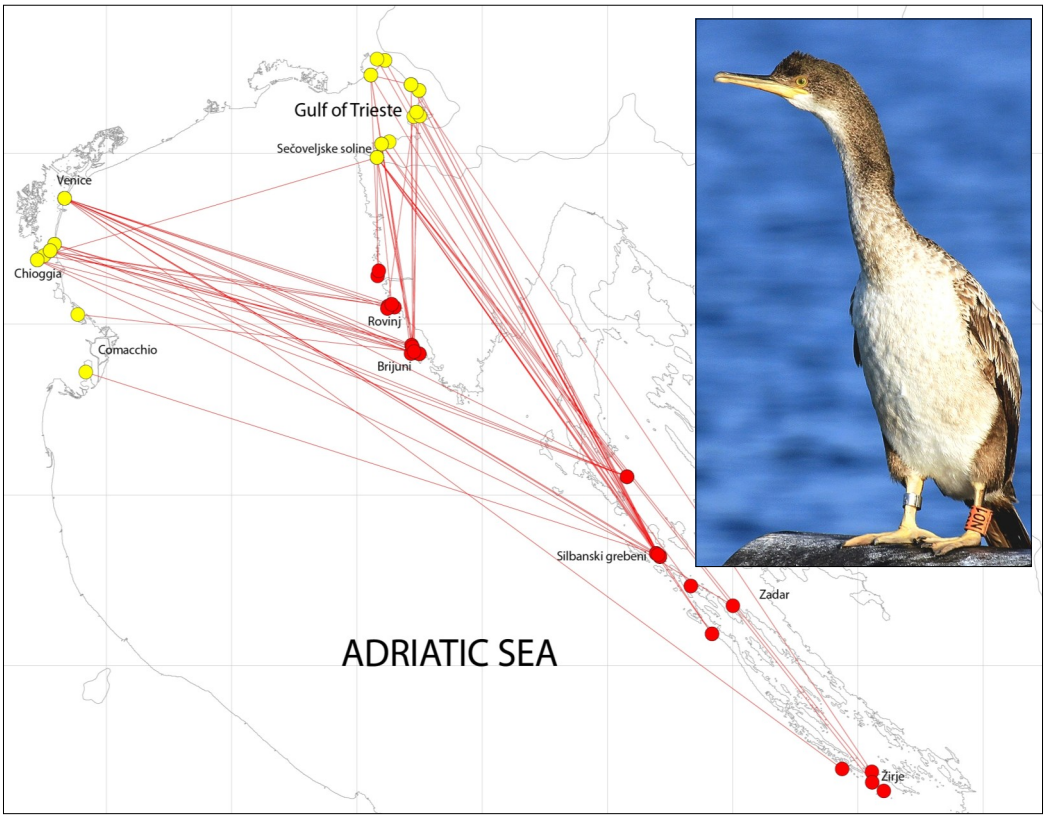

Figure 1. Nesting sites (red) and post-breeding roosts (yellow) of Mediterranean Shag. Inset: Mediterranean Shag with ring code N01 was ringed at nest on the island Kosmerka near Šibenik (Croatia) on 30 March 2011. On 9 September 2011 it has been observed in a shellfish farm in front of the Sečovlje Salina, Slovenia. (Photo: I. Škornik).

Observations on roosting areas have shown that Mediterranean Shags use to stay in the same places for a long period of time during post-breeding dispersal, while some are still being observed in the winter period. In successive seasons, Mediterranean Shags tend to return to the same sites where they have been observed before. There also are some cases where Mediterranean Shags have roosted at different locations.

Since the 1980s, Mediterranean Shags have become regular summer visitors in the Gulf of Trieste (Figure 2), as post-breeding movements from Croatian breeding colonies show (Benussi 2005, Škornik 2012). A large aggregation of Mediterranean Shags also forages in the area during late summer-autumn with counts of 2,000–4,000 birds, which is more than half the entire breeding population in the Adriatic Sea (estimated at 1,600 – 2,000 pairs by J. Kralj).

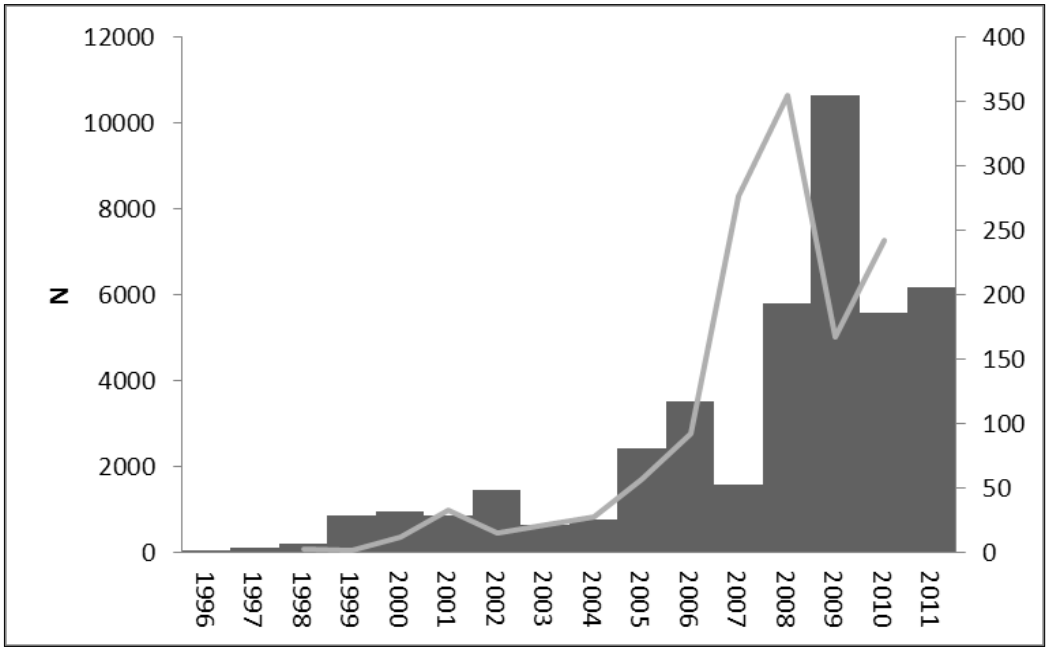

Figure 2. Abundance of the Mediterranean Shag in Gulf of Trieste from 1996-2011. The histogram shows the total number of individuals per year. The grey line depicts the consistent increase in the winter censuses of the International Waterfowl Census (IWC) since 1997.

To characterize this recent summer occurrence and to explore diving optimality models, ornithologists from Trieste University (Italy) have investigated foraging strategies and diving patterns at different depths, during breeding and post-breeding seasons. Behavioural data were cross-checked with the species' diet. The birds foraged on and close to the seabed, with a prevalent anticipatory breathing strategy. In the Gulf of Trieste, the shallow depths and low mobility of prey allowed the birds to use just the oxygen of the respiratory tract, thus reducing the physiological stress for diving. In Croatia, diving stress increased with depth and prey mobility, resulting in a higher oxygen expenditure that also involved respiratory storage. Such ecological and physiological aspects

characterize the Gulf of Trieste as an optimal area for feeding and restoring from the costs of breeding incurred in Croatia. This could be the cause of these post-breeding movements (Sponza *et al*. 2010). Given these data, the Italian and Slovenian parts of the Gulf of Trieste areas together fulfil the criteria for the fourth marine IBA type as a foraging area for an important part of the global population of the Mediterranean Shag.

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Part 3: Ecology and Conservation of Gulls and Terns

Results from the 1990-1994 colour-ringing programme of Italian Mediterranean Gulls *Larus melanocephalus*

Riccardo Santolini[1], Federico Morelli[1] , Paolo Boldreghini[**], Fabio Pruscini[1] & Michele Gili[1]

[1]Università degli Studi di Urbino, Campus Scientifico E. Mattei, 61029 Urbino (PU), Italy. riccardo.santolini@uniurb.it

Summary: 274 Mediterranean Gulls *Larus melanocephalus* were colour-ringed in the Comacchio area, Italy, from 1990 to 1994. A total of 2,764 subsequent observations of these birds were recorded over 21 years. These controls show the importance of wintering and stop-over sites during the species pre- and post-breeding movements. This population, the first to be colour-ringed in Europe, migrates in two preferred directions, to the Mediterranean and to the North Sea, with a high proportion of birds continuing to the Atlantic. This highlights the flexibility of the species which, from Morocco to England, must adapt to varying environmental conditions. Some individuals lived for more than 17 years.

Key Words: Mediterranean Gull, *Larus melanocephalus*, colour ring-reading, age, migration

Introduction

The Mediterranean Gull *Larus melanocephalus* is a relatively recent breeding species in Central and Western Europe. Since the 1950s and 1960s, it has been expanding its range to the west and the northwest, including the Mediterranean area through colonization of the Camargue (France) in 1962, Valli di Comacchio (Italy) in 1978 and Ebro Delta (Spain) in 1987 (Cramp & Simmons 1983, Del Hoyo *et al*. 1996). This westward extension of the breeding range led to a new context of migration movements, with new sites adopted as stop over or wintering areas (Cramp & Simmons 1983). In order to better understand the new situation and expand the knowledge of this yet poorly known species, a colour ringing scheme has been developed in the Comacchio area. The ringing activities took place as part of a study project for the conservation of wetlands of the Po River Delta (Comacchio area) coordinated by Paolo Boldreghini (University of Bologna) and Riccardo

*** * The Editors regret to announce the death of their colleague Paolo Boldreghini, a long-time supporter of Medmaravis, which occurred since the last Medmaravis Symposium was held in Alghero. Sincere condolences to his relatives and friends.**

Santolini (University of Urbino), it was the first colour-ringing scheme concerning the Mediterranean Gull in Europe and anticipated the development of an European ringing scheme for this species (Boldreghini et al.1992, Meninger 1998). This paper is based on observations of 664 individual Mediterranean Gull which had been marked with colour rings between 1990 and 1994 in the Comacchio area. The high number of ringed individuals provided the opportunity to collect observations over a period of 21 years. This enabled us to understand the importance of wintering and stop over sites during the species pre- and post-breeding movements. This also made it possible to investigate the population dynamics, to identify new dispersal directions and to discover that different populations are subject to interact.

Methods

The population of Mediterranean Gull in the Comacchio area increased from 25-27 pairs in 1978 to about 200 pairs in 1982 and 1986; then reaching *ca.* 900 pairs in 1989. During the ringing period (1990-1994), the population was no fewer than 800 pairs, with a maximum of 1,900 pairs in 1993, except for 1992 (only 23-25 pairs - Brichetti & Fracasso 2006). Up to 1992 the Mediterranean Gull nested in Italy only in the Comacchio area. In 1993 it began to colonize other sites and in 1999 the population reached a maximum of *ca.*2,300 pairs following a Life project (in

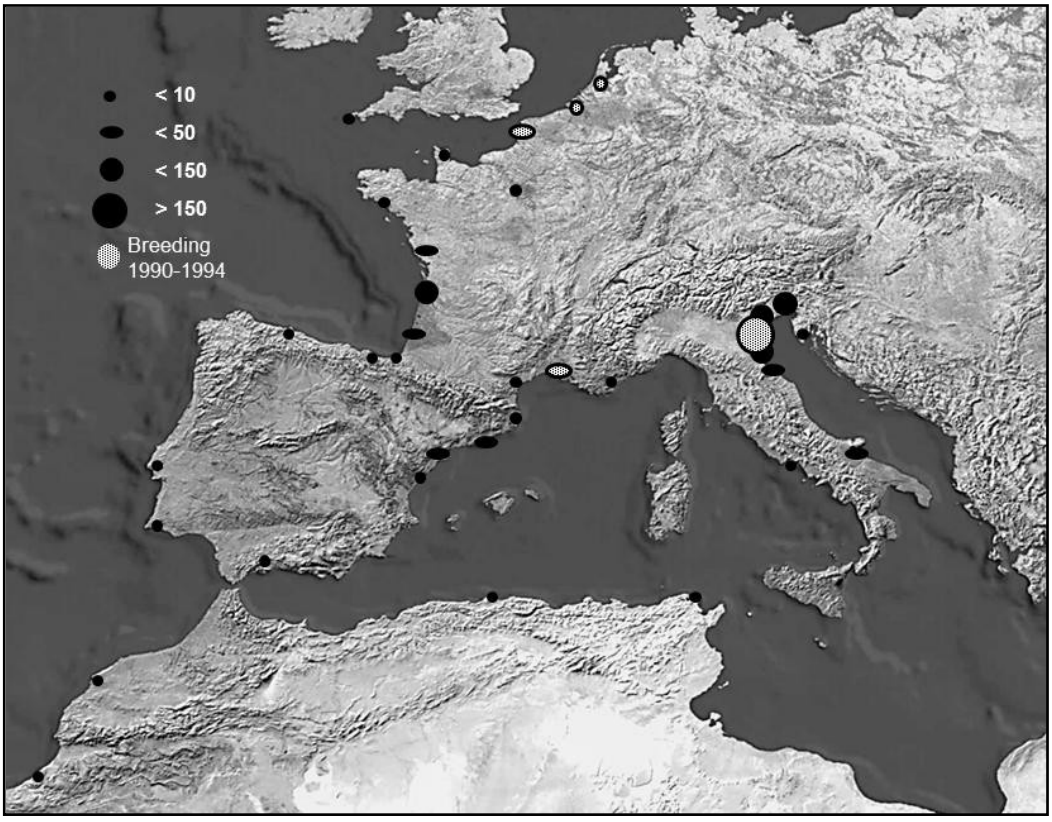

Figure 1. Sightings (black dots) of Mediterranean Gulls ringed as chick in the Comacchio area (open circle).

1998-1999) which enabled the reconstruction of 10 artificial sandbanks in Pialassa of Ravenna (Comacchio area), which were colonized by 1,990 pairs (Santolini *et al*. 1999, Santolini & Boldreghini 2000). During five years, 664 chicks were ringed in the Comacchio area: 568 chicks in Bertuzzi lagoon (1990-1994) and 96 chicks in the Comacchio lagoon (in 1991 only). The ringed birds were fitted with blue plastic rings. The present analysis is based mainly on data from the archives of ISPRA. The records have been organized in a database which contains the life history of different individuals observed repeatedly.

Results

Since 1990 we recorded a total of 2,794 observations. An examination of the sightings gives the opportunity to make some observations on the following topics: (a) presence of particular direction of population movements; (b) consolidation of stop over and wintering sites related to age of individuals; and (c) individual longevity.

Direction of movements, stop over areas and wintering sites. The distribution of sightings (Figure 1) has unequivocally demonstrated the presence of trends towards two particular directions: a Mediterranean dispersal along the Italian, French, Spanish and North African coasts up to Morocco; and movements towards the North Sea, both overland in Central Europe and along West Atlantic coast.

*The Mediterranean direction***.** The analysis of sightings has clearly pointed to short-distance movements from the Po Delta towards the Scardovari and Venice lagoons which are important post-breeding (late August-September) sites. This situation was known prior to our study, when

Sites	J	F	M	A	M	J	J	A	S	O	N	D
Tarragona (Spain)	3	2	9							1	1	
Malaga (Spain)	1											1
Girona (Spain)			1									
Castellon de la Plana (Spain)		1										
Barcelona (Spain)	3	2	1	2			3	2	9	6	1	2
Hérault (France)	1	1						1				1
Gard, Salines d'Aigues-Mortes (France)				2		2	6					
Bouches-du-Rhône (France)		1		1	2	2	1	1				
Alpes-Maritimes (France)				1							1	
Algiers (Algeria)	1											
Zarzunah (Tunisia)			1									
Totals	**9**	**7**	**12**	**6**	**2**	**4**	**10**	**4**	**9**	**7**	**3**	**4**

Table 1. Monthly distribution of Mediterranean Gulls ringed as chicks in the Comacchio on their main stop-over sites in the Mediterranean.

autumn recoveries were suggesting some overland passage across the Balkans (Cramp & Simmons 1983). These North Adriatic wetlands are abandoned by mid-October or early November at the latest (Basso 2008). From these pre-migratory crossroad areas Mediterranean Gulls move southward along the Italian Adriatic coast (late September-October) and the Tyrrhenian Sea, also crossing overland over the Apennines range, to reach wintering quarters which extend up to Sicily and Tunisia to the south and Spain and northwest Africa to the west. Along this route there are several important sites (Table 1): the Llobregat river delta near Barcelona in Spain; and the Rhône delta (the Camargue) and coast of Gard in France, which are stop-over and wintering sites. In North Africa, the Algerian coast is more likely a wintering area, while Tunisia seems to be a stop-over area during the pre-breeding migration. Mediterranean sightings largely concern birds over one year old (Figure 2): the age class <1 year appears significantly only in December and January.

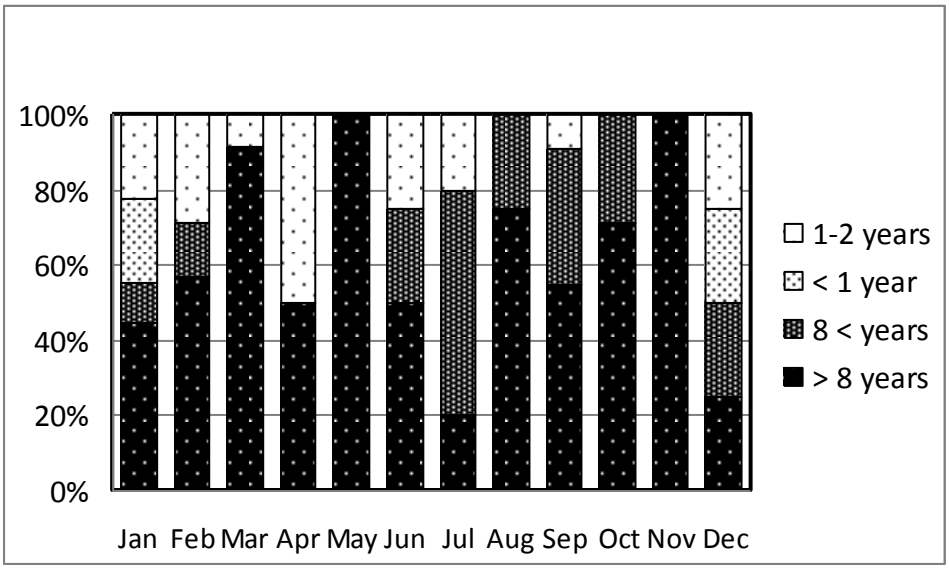

Figure 2. Monthly variation in age classes of Mediterranean Gulls, ringed as chicks in the Comacchio, and observed on Mediterranean coasts.

The North Sea and Atlantic directions. This shows unequivocally the existence of movements oriented to the west and northwest, that lead some individuals to cross Central Europe from Italy to the Netherlands. This was also mentioned for a few individuals only by Meininger & Flamant (1998). Such movements have developed considerably over the years to become a stable, preferred direction with numerous sightings from April to October, peaking June to August, on the North Sea coast of France, Belgium and The Netherlands. Sightings of birds ringed in Comacchio area are also distributed along the French Atlantic coast (Table 2) during summer and autumn (July-October), then decreasing up to December. The most important sighting areas vary according to season: Charente-Maritime mainly during post-breeding migration, Landes in winter (January-March) and Vendée in spring. The Mediterranean gulls controlled on the Atlantic and North Sea coasts (Figures 3 and 4) mostly are adult birds (95%), whereas younger birds (< 1 year: 6%; 1-2 years: 13%) occur in proportions similar to what is seen in north Adriatic.

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Cornwall (UK)								1					1
Normandie (France)		1											1
Bretagne (France)							1						1
Vendée (France)			28	18	1		2	8		1			58
Charente Maritime (France)	1	10	7				25	35	29	17	9	7	140
Hossegor, Landes (France)	22	19	2								3	4	50
Pyréneés-Atlantiques (France)	3	1										1	5
Txinguidi (Spain)	1												1
Gijon (Spain)	2											2	4
Lisboa (Portugal)	2												2
Algarve (Portugal)												1	1
Sidi Moussa (Morocco)												1	1
Tan tan (Morocco)					1								1
Total	**31**	**31**	**37**	**18**	**2**		**28**	**44**	**29**	**18**	**12**	**16**	**266**

Table 2 Monthly distribution of Mediterranean Gulls, ringed as chicks in the Comacchio, on their main stop-over sites on the Atlantic coast.

Link between breeding areas. The *curriculum vitae* of individuals born in the Comacchio area indicate a preference to return to their natal site. However, some Italian born Mediterranean Gulls stay to breed near the North Sea. This behaviour somewhat illustrates a sort of union between the two main migration routes, the Mediterranean and the Atlantic ones, but an unidirectional genetic exchange as Belgian and Dutch individuals do not seem to breed in Italian colonies, although they can be found wintering in northern Adriatic.

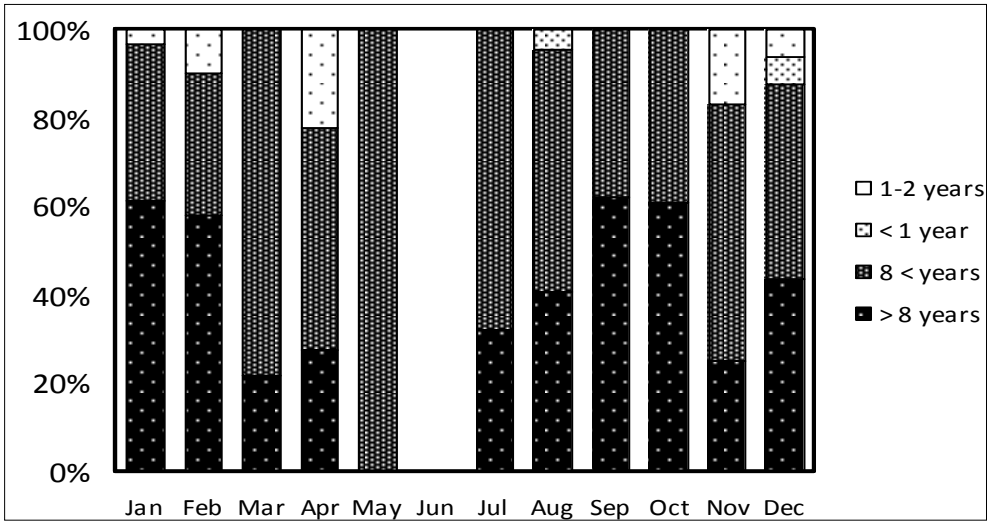

Figure 3. Monthly variation in age classes of Mediterranean Gulls, ringed as chick in the Comacchio, and observed on the Atlantic coast.

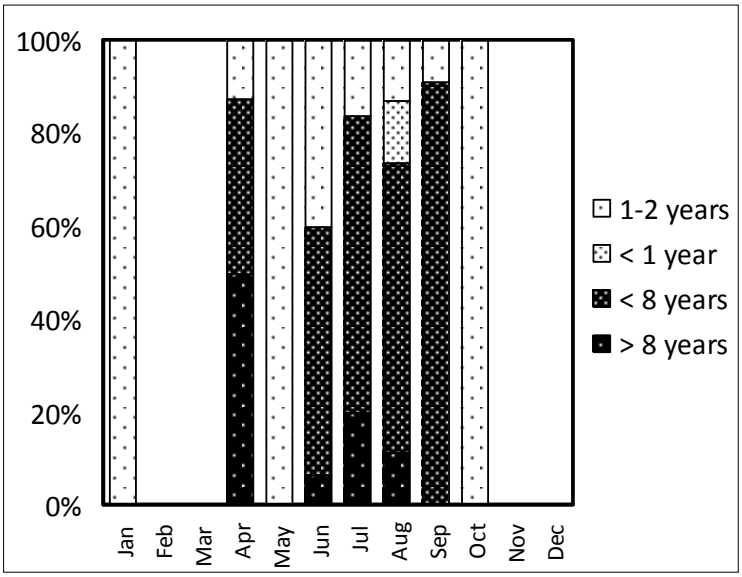

Figure 4. Monthly variation in age classes of Mediterranean Gulls, ringed as chick in the Comacchio, and observed in the North Sea.

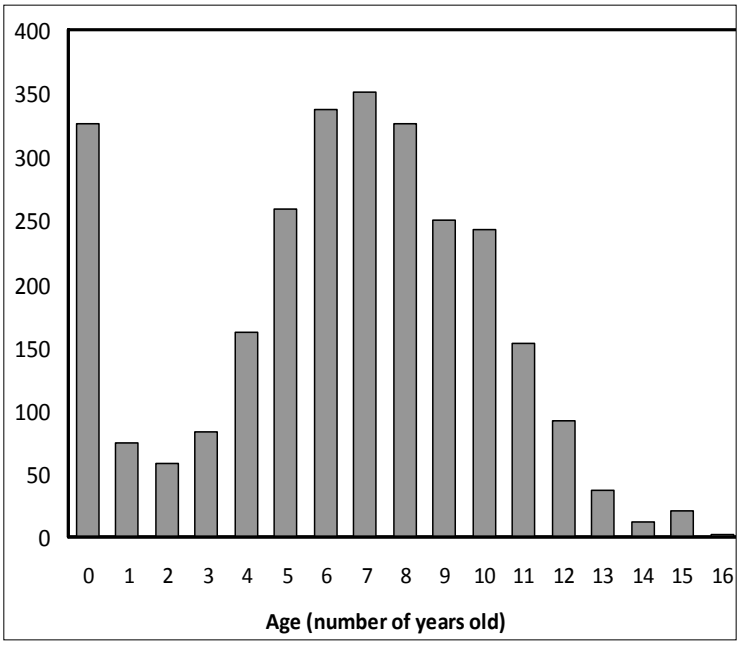

Figure 5. Distribution of age classes at the time of observation, for Mediterranean Gulls ringed as chick in the Comacchio (N= 2,795 records).

Age structure. The ages of the birds at the time of sighting (Figure 5) are normally distributed, suggesting either a dispersal outside the studied area or a higher mortality in the first year. Thereafter, birds can live longer, with birds seen when they were 15 and 16 years old. The older birds have all been seen in northern Mediterranean (i.e. Spain, southern France, Italy).

Conclusions

The 2,794 colour-ringed controls of Mediterranean Gulls obtained in over 21 years indicate that (a) post-breeding movements from the Comacchio area occur in preferred directions, being both coastal along the Mediterranean and Atlantic coastlines, and overland following the continental large hydrographic network;
(b) there is a link between breeding areas, with an exchange of individuals which seem to have a preferred north-west direction; and (c) such a dispersal pattern suggests a great ecological flexibility, supported by a long life expectancy.

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Demography of Mediterranean Gulls *Larus melanocephalus* during winter and migration: Results from colour-ring studies

Carles Carboneras[1]

[1]Universitat de Barcelona, Departament de Biologia Animal, Avda. Diagonal 645, 08028-Barcelona, Spain. carles@gavines.org

Summary: Colour-ring data of Mediterranean gull *Larus melanocephalus* obtained at several traditional wintering grounds allowed to study the species' population structure, wintering site fidelity and migration strategy. Wintering patches tend to aggregate the same individuals over time and constitute important sites for the conservation of the species.

Key Words: winter season, site-fidelity, survival, migration strategy, conservation, Mediterranean Gull, *Larus melanocephalus*

Introduction

Migratory birds from different origins gather regularly at traditional wintering grounds but the demographic characteristics of these temporal populations often are poorly known. The Mediterranean Gull *Larus melanocephalus* is a European near-endemic species with a patchy distribution. In recent decades, it expanded its breeding range to western Europe, although wintering has been maintained in traditional patches, most notably around the Mediterranean Sea. The species has been the focus of several colour-ringing programmes for over 20 years (e.g. Santolini *et al.*, this volume), with over 19,000 individuals marked in 18 countries.

Questions and Methods

I explored: (a) if winter congregations of this species have a population structure that can be modelled and predicted; (b) what determines the population composition at any one site; and (c) the migration strategy of the species. To answer these questions, I collected re-sightings of individually marked gulls during five consecutive winter seasons (September to February, 2005-2010) in a 350 km long coastal area in NE Spain. The data base consisted of ca. 4000 re-sightings of 647 individuals ringed in 13 countries, and their life histories. Subsets of data were analysed with capture-recapture methods using software MARK to estimate apparent survival, site-fidelity, population composition and migratory movements to the study area. Additionally, I compared lists of individual rings recorded at 7 localities around the Iberian Peninsula during 4 seasons (2005-2009) using hierarchical cluster analysis to study differences in population composition between those sites; similarities between pairs of sites were tested against the physical

distance between them. I also examined arrival and departure dates of birds that stayed over winter and tested for differences between age classes.

Results

Capture-recapture analysis gave an estimate of apparent adult survival probability of 0.81 (SE = 0.02). Fidelity to the wintering grounds after hatching-year was high, and comparable to breeding site-fidelity. For first-year birds, I related the probability of survival in the first months to the ringing effort. Thus, it was possible to deduce the relative probability that an individual reached the study area in NE Spain and to infer the population composition. The probability of arrival of first-year birds to the study area differed greatly and was related to the origin of the birds. Colony distance was the main predictor of population composition, in an inverse logarithmic function. As expected, the closest colonies contributed the most first-year birds, but the contribution of colonies further away would depend on the migration route followed by the gulls. Data suggested that birds did not follow a direct route but adopted a mixed strategy migrating via rivers and coastal routes in an optimal combination of minimal distance along favourable topography.

Comparison between wintering areas in the Iberian Peninsula revealed a gradient of 'Atlantic' (i.e., born in Atlantic or North Sea colonies) vs. 'Mediterranean' birds (i.e., born in Mediterranean or Black Sea colonies). Atlantic birds predominated in Galicia and Portugal and became rarer into the Mediterranean and towards Catalonia (where most birds were from Mediterranean or Black Sea origin) (Carboneras *et al*. 2010). The wintering population in Malaga showed intermediate characteristics, being more similar to the population wintering in SW Portugal, despite being on the Mediterranean coast. Near (<500 km) sites shared 6-24% of individuals but distant (500-2500 km) ones had <0.02 % of their birds in common.

Arrival/departure date analysis showed significant differences between age classes, in line with age-specific breeding commitments. First-year birds were the first to arrive to the study area and also stayed the longest. Birds 5-11 years old arrived much later and were also the first to depart for the breeding colonies, possibly reflecting competition pressure and stronger reproductive commitments. Birds 1-4 years old were intermediate in arrival/departure dates. Birds older than 12 years behaved similarly to non-breeding first-year olds, suggesting a relaxation of their breeding commitments. Despite being significant (KW test = 31.87, $P < 0.001$, n = 703; KW test= 49.30, $P < 0.001$, n = 507), these results need to be interpreted with caution because the probability of detection remained below 0.5, so many birds could have been present at the study area for some time before being detected.

Conclusions

The study of individually-marked Mediterranean gulls at the wintering areas can provide important data to help understand demographic processes taking place during the winter months. In the Mediterranean Gull, wintering populations are more structured that initially thought, as revealed by the spatial composition of populations, relative to their breeding origin, and the strong site-fidelity of birds from their first year onwards. Thus, wintering patches would tend to aggregate the same

individuals over time and, therefore, constitute important sites for the conservation of the species. There is little exchange of individuals between wintering areas, indicating that each population is regulated by its own combination of breeding output and survival. Therefore, a site-specific approach to the management of winter sites is recommended, in coordination with breeding and migration sites. The model linking distance and probability of arrival can be applied to predict the winter population origin and composition throughout the species' distribution range.

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Meditarranean Gull *Larus melanocephalus* migration atlas in Apulia (SE Italy)

Giuseppe La Gioia[1]

[1]Associazione Or.Me. c/o Giuseppe La Gioia, via M. Saponaro 7, I-73100 Lecce, Italy ormepuglia@gmail.com

Summary: Mediterranean Gulls *Larus melanocephalus*, both young birds born in Apulia and older birds present in June-July, leave the area early. From August, birds ringed in Apulia are controlled in distant localities within their wintering area, mostly in northern Adriatic, but also on the Atlantic coast of France. Birds ringed in Apulia are never controlled in Apulia outside the following breeding seasons, but young birds born in Ukrania, Greece and Hungaria are observed in Apulia from August to January.

Key Words. Mediterranean Gull, *Larus melanocephalus,* migration, Apulia.

Introduction

Bird migration atlases have been published recently for Italy and Apulia (a south-eastern Italian region). The Italian Atlas (Spina & Volponi 2008) has been updated up to 2003 but does not take into account reports of birds sporting visual marks, while the Apulian Atlas, updated to 2008, is a local publication which includes the analysis of colour ring sightings databases (La Gioia & Scebba 2009). Results presented here refer to the Mediterranean Gull *Larus melanocephalus* in Apulia, a region where this species migrates, winters and breeds (La Gioia *et al.* 2009). The most important wintering areas in Apulia are Lake of Varano and Manfredonia Gulf (breeding also occurs at this site), both in the Foggia province, and, particularly in the last few years, localities on the south-west coast of Apulia near Ugento, with an Apulian wintering population ranging from 6000 to 10,000 birds in 2007-2011.

Methods

In order to identify Mediterranean Gull migration routes in Apulia, we analyzed the ISPRA and SOA databases of colour ring sightings, as well as the “Gruppo Inanellamento Limicoli” (G.I.L., Napoli) database which includes a smaller number of data of birds recovered through various identification ways. We thus compiled 1889 records (Table 1), including recoveries of birds ringed

Type of recapture	Number	"direct" recaptures during	
		autumn migration	spring migration
At the ringing site	94		
Apulia-Apulia	6		
Apulia-Italy	782	56	
Apulia-abroad	374	27	
Italy-Apulia	77		
Outside Apulia, but concerning specimen with recapture Italy-Apulia	346	28	2
Abroad-Apulia	146	48	
Outside Apulia, but concerning specimen with recapture abroad-Apulia	64	14	
TOTAL	**1889**	**173**	**2**

Table 1. Composition of recapture database for Mediterranean Gull in Apulia.

in Apulia and recaptured either in other Italian regions (782 records) or abroad (374 records). There are 133 "direct" recoveries, between the capture and recovery sites without any intermediate control, all bar two referring to movements from breeding sites.

Results

Young Mediterranean Gulls ringed in Apulia leave the region very soon, from August onwards, in conformity with the Italian situation (Brichetti & Fracasso 2006, Spina & Volponi 2009). Early recaptures are from the more remote parts of the Apulian population wintering areas, mainly in northern Adriatic, but also on the Atlantic coast of France (Figure 1a). None of these birds have ever been found in Apulia outside the following breeding seasons, even though Apulia hosts a large number of migrating and wintering Mediterranean Gulls coming from other areas (Figure 2). Mediterranean Gulls wintering in Apulia exclusively are from eastern populations (Figure 1b), but not from the northern Adriatic where Apulian Mediterranean Gulls winter.

The "direct" recoveries of young birds ringed outside Apulia concern specimens born in Ukraine, Greece and Hungary (Figure 1b-c), which move to more western wintering areas than those born in Apulia. These birds are present in Apulia from August to January, their controls decrease in February as noted by Spina & Volponi (2008) for the whole of Italy.

There are no "direct" recovery in Apulia of juveniles born in either northern Adriatic or Atlantic coasts. On the other hand, specimens from most areas within the Mediterranean Gull range are recaptured in Apulia throughout the year, either during migration, wintering or breeding periods, including long displacements with a maximum of 3 200 km (Figure 2).

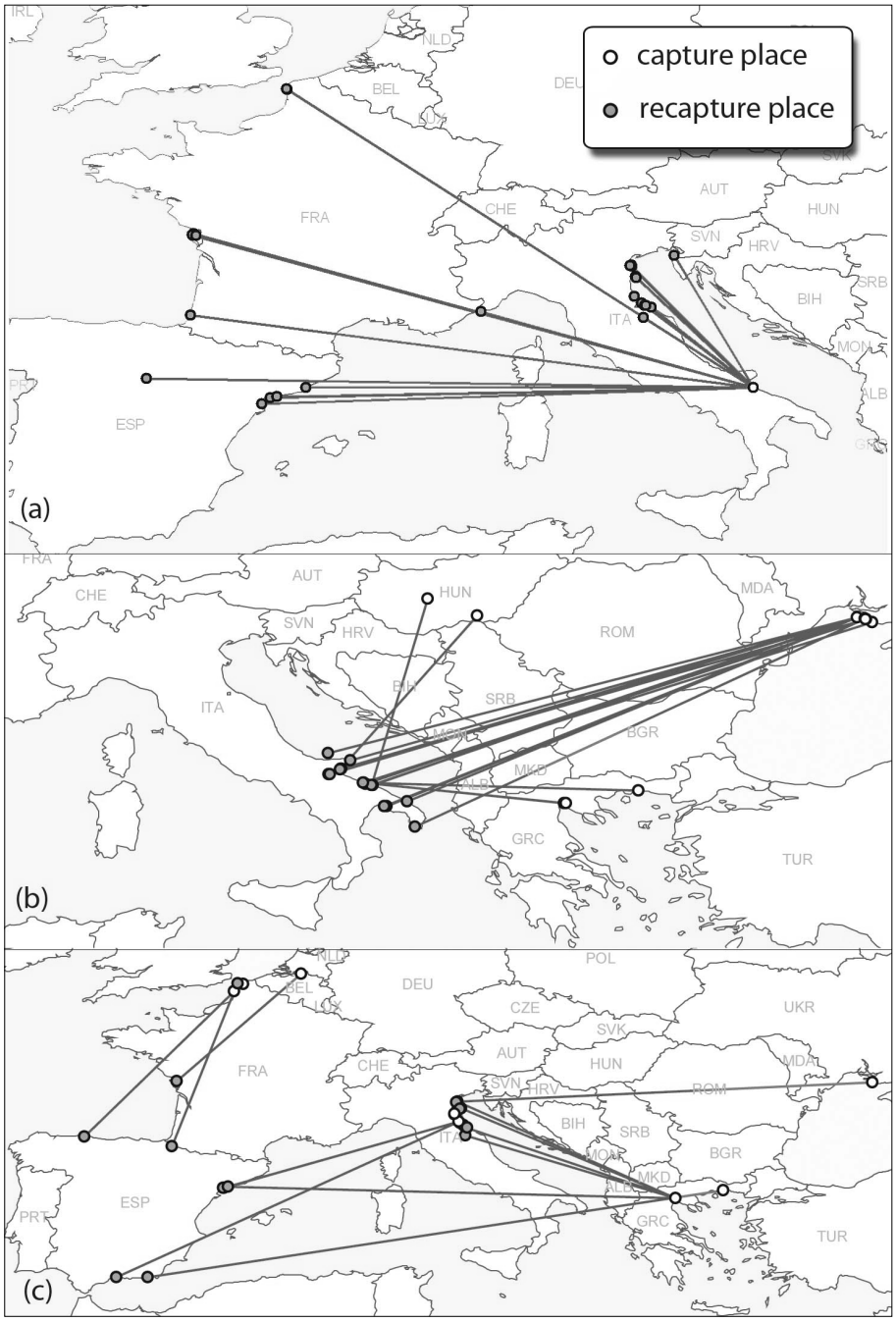

Figure 1. Migration of Mediterranean Gull in Apulia. (a) Dispersal of birds born in Apulia ("direct" recoveries). (b) Winter records in Apulia of birds of eastern origin ("direct" recoveries). (c) Long distance movements, outside Apulia, of birds which have been controlled in Apulia in another part of their life

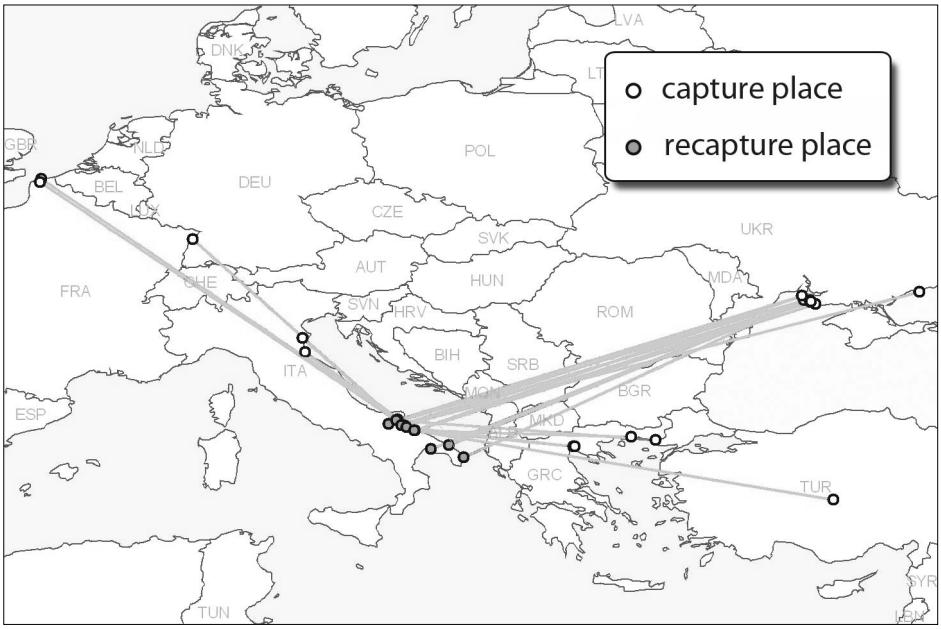

Figure 2. Long distance movements of Mediterranean Gull controlled in Apulia

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The breeding population of Audouin's Gull *Larus audouinii* in Greece

Victoria Saravia Mullin[1,2], Danae Portolou[1,3], Angelos Evangelidis[1,4], Kostas Gaganis[1,5], Aris Manolopoulos[1,6] & Jakob Fric[1,7]

[1]Hellenic Ornithological Society, 80 Themistokleous str., GR 10681, Athens, Greece.
[2] vsaravia@ornithologiki.gr
[3]dportolou@ornithologiki.gr
[4]evangelidis@ornithologiki.gr
[5]kgaganis@ornithologiki.gr
[6]amanolopoulos@ornithologiki.gr
[7]jakobfric@ornithologiki.gr

Summary: The Greek islands of the Agean Sea are home for a breeding population of Audouin's Gull *Larus audouiniii*, which dropped from 700-900 breeding pairs in 1995 to 350 - 500 pairs in 2010. Thanks to UE LIFE projects, the species has been better monitored both at breeding sites and at sea in order to improve conservation measures, particularly the identification of Marine Important Bird Areas.

Key Words: Audouin's Gull, *Larus audouinii*, Greece

Introduction

In comparison to the large colonies in the western Mediterranean, the Audouin's Gull *Larus audouinii* population in Greece has always been relatively small. The species breeds on uninhabited islets, thus habitat availability is considered high, however predation and food availability seem to limit its population size. The Hellenic Ornithological Society (BirdLife Greece) has been monitoring Audouin's Gulls in the Greek insular area since 1995 through two major LIFE Nature projects as well as through the HOS project "Survey and Conservation of Seabirds in Greece" which was implemented during 2007-10. The first LIFE project (B4-3200/96/498 'The conservation of *Larus audouinii* in Greece') ran during 1997-1999, while the second (LIFE 07 NAT/GR/00285 'Concrete Conservation Actions for the Mediterranean Shag and Audouin's Gull in Greece, including the Inventory of Relevant Marine IBAs') is currently underway (2009-2012) (Portolou *et al*. 2009). Apart from coastal surveys, colony monitoring, and chick-ringing, radio telemetry has also recently provided information on the ecology and breeding performance of the species population in the Aegean Sea.

Methods

In most sites, data collection has focused on (a) estimation of breeding population, (b) colony monitoring, and (c) foraging and at-sea distribution. However, monitoring effort has varied between years and colonies.

Parameter	Census 1998 - 1999	Census 2010	1995 - 2011
Number of islets	24 (30%)	16 (19.5%)	84
Islet area (ha)	108	25	66
Number of breeding regions	21	15	33
Number of breeding pairs	610 (590-630)	320	
Average pairs / colony	26	20	30
Range (pairs / colony)	3-86	1-67	1-86

Table 1. General characteristics of the breeding population of Audouin's Gull in Greece.

Estimation of breeding pairs has been undertaken in April - early May through coastal censuses using project vessels and hired boats, covering the coastline of most important breeding areas, and following visits to breeding colonies. Colony size has been determined either by direct counts of occupied nests (mid-May), counts of incubating adults or, in cases where nest counts were not possible, by recording the maximum number of adults observed (then applying the ratio number of pairs= number of adults * 0.75).

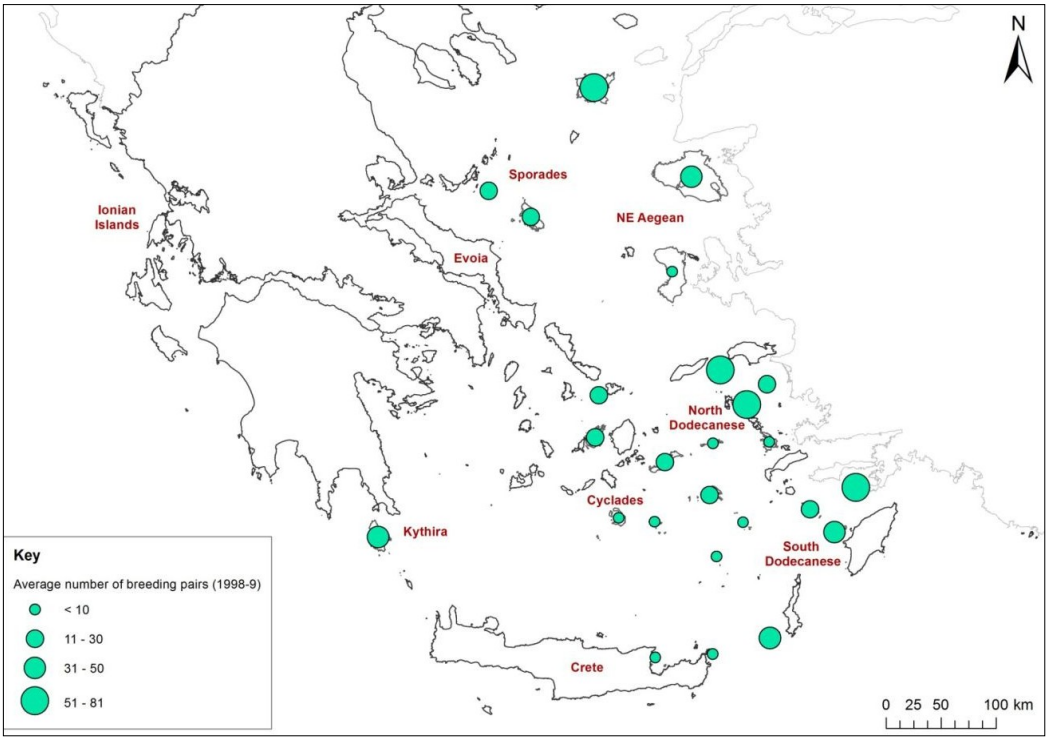

Figure 1. Distribution of Audouin's Gull colonies in Greece during the first national population census (1998-1999).

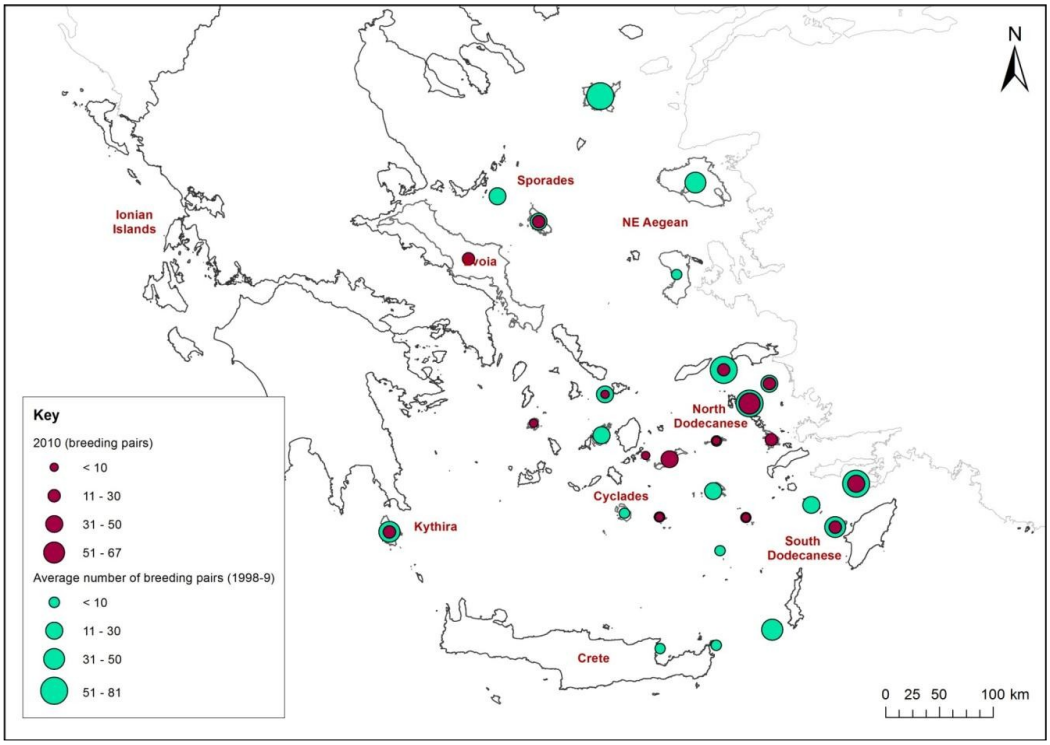

Figure 2. Distribution of Audouin's Gull colonies in Greece during the second national population census (2010).

Colony-monitoring was carried out from May to early June during visits to mark nests and checking the contents of nests at selected colonies. Productivity was estimated as the maximum number of fledglings per used nest during the last monitoring visit (mostly in mid-June) and in certain cases during the chick-ringing visit (mid-June to early-July).

The species foraging and at-sea distribution was established using data from the main foraging grounds and from areas used by the species in the wider marine area and coastal zone. Specifically, data were collected through coastal line transects (May), European Seabirds at Sea (ESAS) counts from project vessels and ferry boats (all year round, since 2009) and telemetry (May-June, since 2009).

Results

The descriptive parameters of the Audouin's Gull breeding population in Greece are summarized in Table 1. In general, the species breeds on small uninhabited islets (it also had bred twice on inaccessible peninsulas of large inhabited islands), while colonies frequently shift breeding islets from one year to the next. Overall, 84 uninhabited islets in 33 breeding regions have been used for nesting, ranging in size from 0.26 to 1,400 ha. Colonies are relatively small, ranging from 1 to 86 breeding pairs.

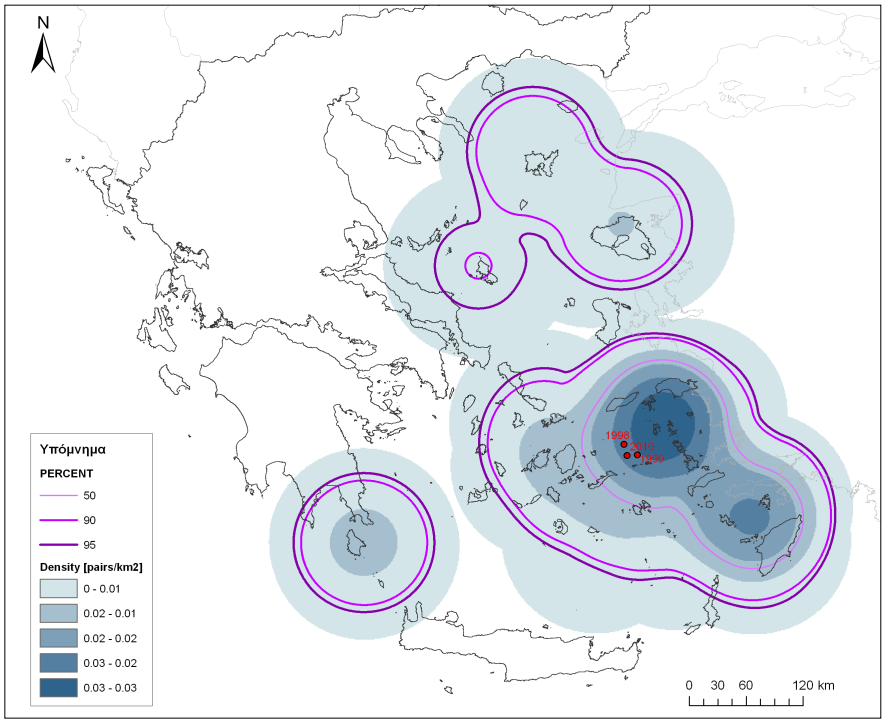

Figure3. Kernel density calculation for Audouin's Gull colonies in Greece in 1998.

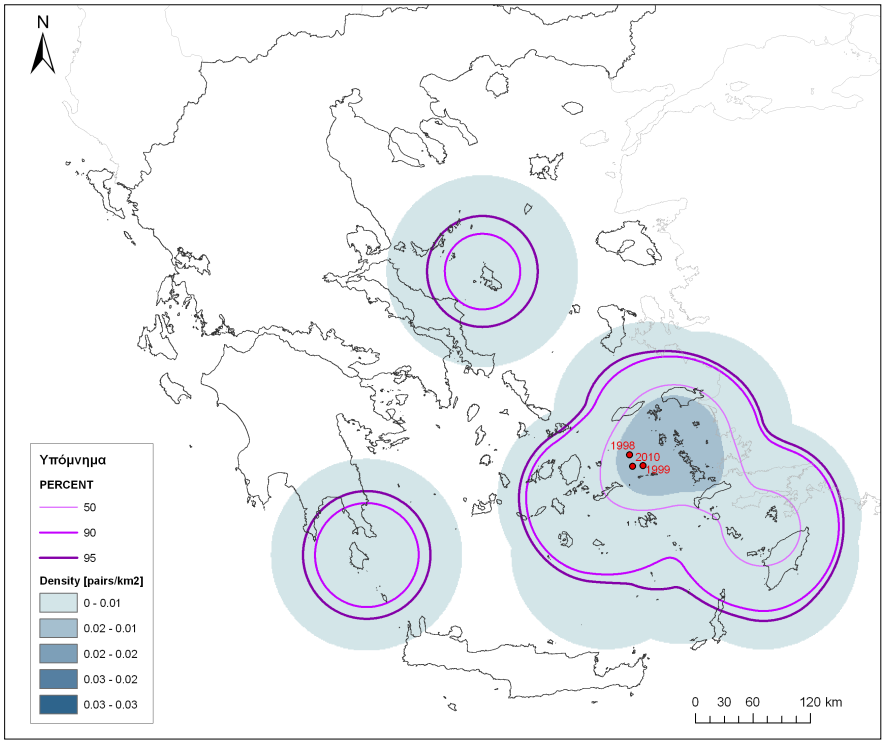

Figure 4.

Kernel density calculation for Audouin's Gull colonies in Greece in 2010.

Population Census. Since 1995, two national population surveys have been implemented, in 1998 and 2010. The first national population estimate was 700-900 breeding pairs (Portolou *et al* 2006). The main colonies (> 30 pairs) were located on islets in Limnos, Lesvos, Fournoi, Leipsoi, Symi, Tilos, Chalki, Kasos, Amorgos and Kythira regions (Figure 1). The second national population survey covered 90% of the known breeding distribution and produced an estimate of 350 - 500 pairs, *i.e.* an apparent decline of approximately 28-33%. Most important colonies were located in Leipsoi, Symi and Amorgos; while three new small colonies were confirmed, six previous large colonies were present. The stronghold of the breeding distribution of the species is still located in the historical breeding sites (North Dodecanese, eastern Cyclades), while it is possible that some colonies have been abandoned (Figures 3 & 4). Kernel Density analysis shows that the geometric mean of the colonies presents minimal shift (< 20 km).

Colony monitoring. Overall, 55 colonies have been monitored to a different extent during 1997-2011. Analyses of parameters were performed between the two periods 1997-1999 and 2009-2011, during which monitoring efforts have been more consistent. Mean colony size remained small, while population estimates showed a decline between the two periods in all regions and significantly so in the Cyclades and North Dodecanese (Figure 5; n = 48, mean = 30 nests, std = 20.6 range: 1-86 breeding pairs). No correlation was found between colony size and productivity, or between clutch size and productivity for data from all colonies and all years.

Clutch size has been found to be similar to that recorded in small island colonies in the rest of the Mediterranean (n = 48, mean = 2.25 eggs per nest, std = 0.39, range: 1-2.75). Mean clutch size and mean productivity did not differ significantly between the two periods or between regions. Mean productivity in 1997 was significantly higher than from 1999 onwards (Figure 6; n=35, $p<0.05$).

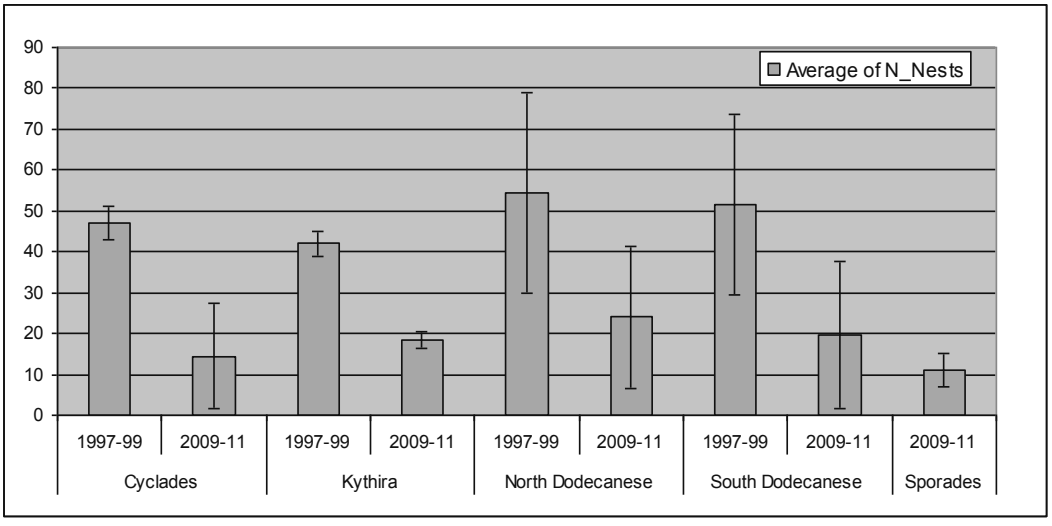

Figure 5. Mean colony size of Audouin's Gull in Greece.

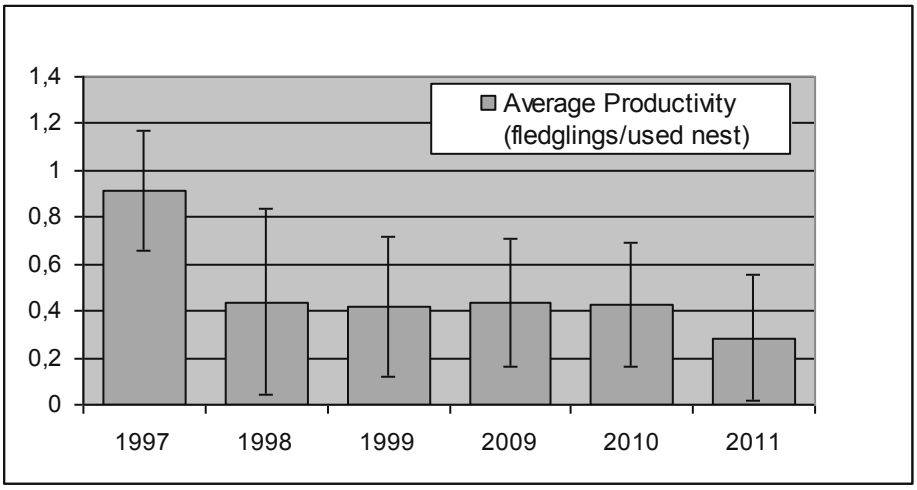

Figure 6. Mean productivity of Audouin's Gull in Greece.

Dispersal. Ringing of fledglings began in 1997, mostly in the North Dodecanese and Cyclades regions. Overall, 604 fledglings and 16 adult birds have been ringed, 434 of which were also fitted with a red Darvic ring. Fifteen recoveries have been reported (2.4%) from all around the Mediterranean, the largest distance being from the eastern coast of Spain (Valencia, 2,350 km).

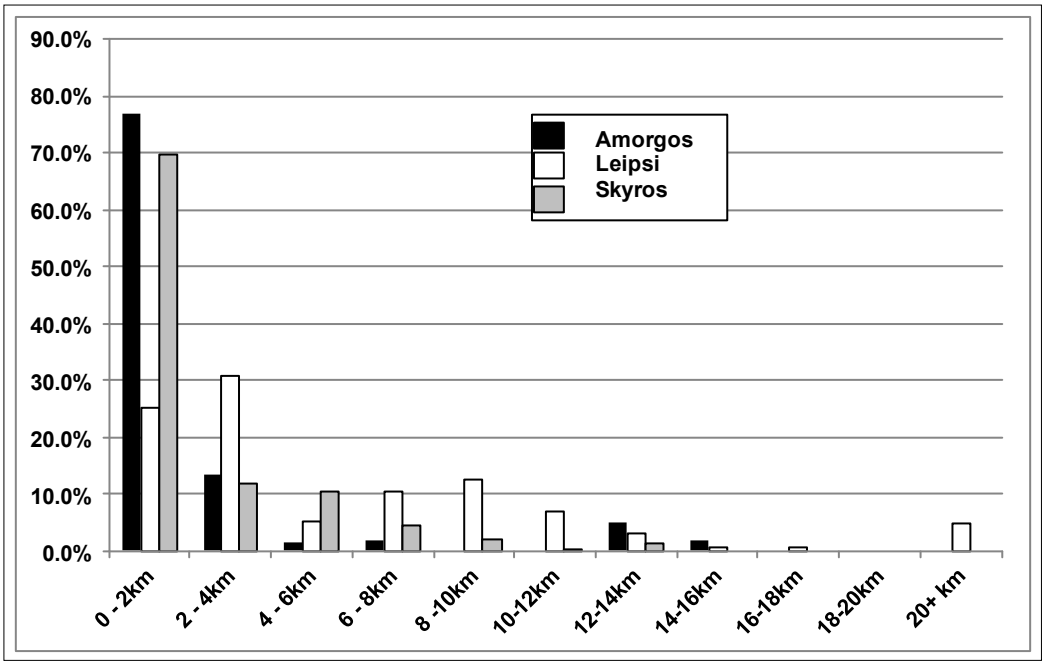

Figure 7. Seabird foraging distribution deduced from telemetry data: % locations according to distance from the colony for breeding Audouin's Gull in Greece.

The northern coast of Africa (Libya, Tunisia) and the Maltese area are thought to be important wintering grounds for the Greek population, although recovery data is still quite limited to certify this.

At-sea distribution. Overall, 5,162 nautical miles (nm) were covered through coastal surveys and 13,756nm through the ESAS method. In total 1,843 Audouin's Gulls were recorded. In addition to the above, at-sea distribution and activities of the Audouin's Gulls were also recorded through telemetry in the islands of Skyros, Amorgos and North Dodecanese. Specifically, 53 foraging tracks were obtained after the placement of 7 GPS data-loggers, 5 geolocators, 12 radio-transmitters and 1 GPS BlueTooth transmitter. Data suggested that in Greece the species seems to forage in the coastal zone and close to their colonies (approx. 10-12km; Figure 7), although analysis is not yet complete. Telemetry data will be used to identify foraging marine areas in the northern Dodecanese, Amorgos and Skyros, and other insular regions of the project and provide directions towards the delineation of marine IBAs.

Conclusion

There is evidence that the national breeding population of Audouin's Gull has declined during the last decade from 700-900 to 350-500 pairs. Although breeding regions and sites have remained the same, colony size has declined, while colony fragmentation has been recorded. Productivity has declined and is considered low. The exact reasons for this remain unknown. However, threats have been identified (Table 2) and it is expected that colonies will become more vulnerable to predation and disturbance in the near future, further reducing breeding success. Particularly, low prey availability is expected to intensify competition with Yellow-legged Gulls *Larus michahellis* for limited resources, while also increasing probability of predation events by the same species and of accidental bycatch in fishing gear as adult birds are forced to feed behind coastal long-line

Identified threats	Evaluation of impact
Depletion of fish stocks	General phenomenon throughout Greece identified by fishermen but no concrete data available - Threat level unknown, potentially high.
Predation (rats, gulls, raptors)	Significant variation between years and sites. Rats are predating up to 14% (potentially up to 23%) of eggs and chicks. Gulls are predating up to 9% of eggs and chicks. Raptors can locally predate up to 100% chicks and even adult birds.
Competition for prey (gulls)	Competition for food with Yellow-legged Gull intensified - Threat level unknown
Bycatch in fishing gear	Bycatch in demersal longlines - Locally at least 2.5% of breeding population annually.
Human disturbance during spring/summer	Generally low although locally may be high if visits prolonged and at incubation period - Impact unknown.

Table 2. Threats identified for Audouin's Gull in Greece.

fisheries. In order to address these threats, rat eradication and Yellow-legged Gull population control actions have been implemented on specific islets where predation has been recorded in the past, as well as promotion of bycatch mitigation measures. At the end of 2012, with the closure of the running LIFE-Nature project, HOS will produce its first marine IBA inventory based to a great extent on all the data collected through the aforementioned projects. IBA designation will hopefully ensure the protection of the most critical marine areas for seabirds in Greece.

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Evolution of the population of Audouin's Gull *Larus audouinii* in Valencian Region: the Action Plan.

Blanca Sarzo[1], Concha Torres[2], Marcos Ferrández[1] & Juan Jiménez[1]

[1]Conselleria de Infraestructuras, Territorio y Medio Ambiente, Generalitat Valenciana, Servicio de Espacios Naturales y Biodiversidad, Francisco Cubells 7, 46011 Valencia, Spain. blancasarzo@gmail.com
[2]Parque natural de las Lagunas de La Mata-Torrevieja. Generalitat Valenciana, Consellería D´Infraestructures, Territori i Medi Ambient. Carretera N-332 Km 64,5, 03188 Antigua Casa Forestal, Torrelamata, Torrevieja, Alicante, Spain.

Summary: In 1998 the Valencian Region had a single Audouin's Gull *Larus audouinii* colony established in the Columbretes Islands (Castellon), showing a steady decline and very low breeding success. From 1999, a series of conservation projects focusing on this species have been carried out by the Valencian Government, co-funded by the European Union (Life projects). The Valencian Government finally approved a Seabirds Action Plan that have allowed the expansion of this species in the area. The main conservation actions carried out within the Seabirds Action Plan, which concerns five different seabird species, are presented. The results obtained until 2011 have been favorable to most species, indicating the importance of implementing this kind of management plans.

Key Words. Audouin's Gull, *Larus audouinii*, Valencian Region, Seabirds Action Plan, management plans..

Introduction

The conservation of Audouin´s Gull in Valencian region is part of the Seabirds Action Plan of Valencian Region (Jiménez *et al*. 2009). This Action Plan, which includes five of the six seabird species breeding in Valencian Region (Scopoli's Shearwater *Calonectris diomedea*, Mediterranean Shag *Phalacrocorax aristotelis desmarestii*, Mediterranean Storm-Petrel *Hydrobates pelagicus melitensis*, Slender-billed Gull *Larus genei* and Audouin`s Gull *L. audouinii*), is resulting from two previous Life projects: SPAs Islands Conservation in Valencian Region (1998-2001) and *Larus audouinii* Conservation in Valencian Region (2002-2006).

From 1998 to 2002, a single Audouin's Gull *Larus audouinii* colony was established in the Valencian Region, in the Columbretes Islands (Castellon). From 2003 this species began to colonize new areas within this region. In 2003, a breeding attempt occurred in l'Albufera Natural Park. In 2004, another attempt was noted at Torrevieja Natural Park. Between 2005 and 2008, these two breeding attempts (l'Albufera and Torrevieja) were consolidated with established colonies, and another breeding attempt occurred in 2008 at Benidorm Island (Serra Gelada Natural Park), related to the local hatchling release program. In 2009, there were three established

colonies, and another breeding attempt occurred at Almenara lagoon. The situation remained the same in 2010, but for another breeding attempt at Benidorm Island. In 2011, there were four established colonies in the Valencian Region (with a new one in Castellon port) and another breeding attempt at Benidorm Island. The regional population was 4500 pairs.

Conservation Actions

The main conservation actions carried out with regards to Audouin's Gull are the following.

Protection of nesting and feeding areas. In Valencian Region, all the colonies (except the most recent one in Castellon port) are protected in one way or another: Columbretes Archipelago is a Natural Park and Marine Reserve; Almenara lagoon is a Special Protected Area; and l'Albufera, Benidorm Island and Torrevieja are Natural Parks. There is also a Marine Reserve at the Cape San Antonio, which is a very important feeding area.

Vegetation Management. This action has been taking place at Columbretes Islands, Benidorm Island and Albufera Natural Park.

Hatching release program. This technique is based on the species' philopatry. The gulls often return to breed in the area from where they fledged. Audouin`s Gull chicks were collected at first from the Ebro Delta colony, and later from Torrevieja colony. The age of these chicks was around three weeks. They were moved to the Rescue Centre of El Saler, and remained there for about 2 weeks. Then they were moved to the hacking cage on either Columbretes Islands or Benidorm Island, and remained there for two more weeks. After this time the chicks were released.

Control of Yellow-legged Gull Larus michahellis. This action took place for some years at Benidorm Island and at Torrevieja Natural Park. A culling programme (elimination of eggs, nests, adults and chicks) together with mitigation measures (petards**,** globes**,** nylon) has been developed at Benidorm. At Torrevieja Natural Park, the elimination of eggs and nests of Yellow-legged Gulls has been carried out since 2009 in Audouin´s Gull breeding area.

Population monitoring. In all the colonies and at sites where breeding attempts have occurred, an effort has been made in undertaking censuses, ringing chicks, reading coded plastic rings, and estimating breeding success (number of fledglings per pair).

Main results

Vegetation Management. In the 1990s, clearing of some *Lavatera arborea* was conducted on Isla Grossa, the largest island within the Columbretes Archipelago. This action was positive for the Audouin's Gull during the first years, but the pairs thereafter left this breeding area to establish themselves on the smaller islands. At Benidorm Island, *Opuntia maxima* control was carried out from 1999 to 2001, removing 200 tons from the island. This action was negative for the Yellow-legged Gull colony established in the island. In the same years 1999-2001, paths were laid out on the island, which on the other hand were positive for the Yellow-legged Gull as less people were trampling all over the island, leading to quieter breeding (Martínez-Abraín *et al.* 2004). As a result, the

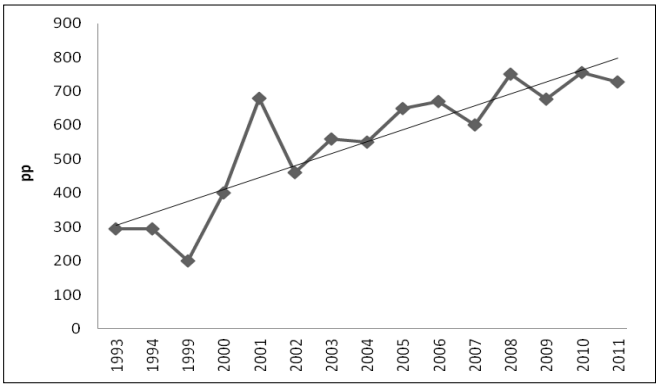

Figure 1. Yellow-legged Gull population growth on Benidorm Island.

Figure 2. Management in l'Albufera N.P.: a sandbar step has been removed (circle) to protect the island were a colony of Audouin's Gull is established (star).

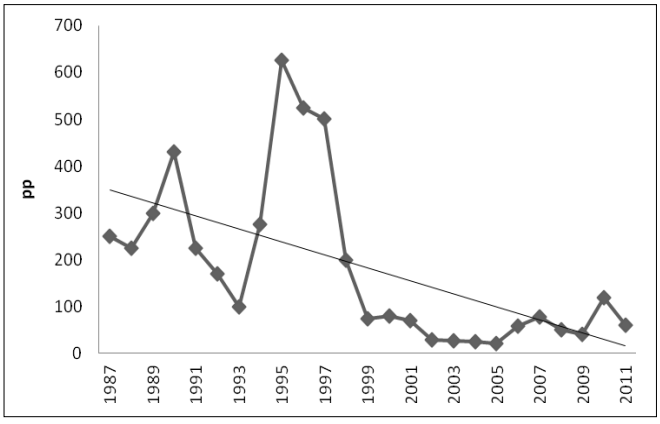

Figure 3. Breeding pairs of Audouin's Gull on Columbretes Islands.

colony grew up to 700 pairs (Figure 1), posing an increasing predation threat on Audouin's Gull. At l'Albufera Natural Park, a sandbank was removed in 2007 to prevent the entry of dogs and people to the islands (Figure 2). In this colony too, a selective clearing of the island vegetation was performed in 2010 (1600 m^2 cleared and 14 m^3 of *Carpobrotus edulis* removed) to facilitate the breeding of Audouin's Gull. Following this action the population increased threefold (from 275 to 646 pairs).

Hatchling release program. The numbers of chicks released were 254 at Benidorm (from 1999 to 2006) and 173 at Columbretes Islands (from 2003 to 2010). The hatchling release program has not been totally successful since no colony was thereafter established at Benidorm, while the colony of Columbretes continued to decline**.** However, there have been breeding attempts by chicks released at both sites (Martínez-Abraín *et al*. 2002). Also, data from Benidorm showed that released gulls have an ability to long-distance migration (5.4% of the chicks released were reported from traditional wintering head-quarters in Africa) and their survival was similar to that of wild chicks (Oro *et al*. 2010). The hatchling program has not been successful mainly for five reasons: (a) the influence of

nearby colonies: released birds have been attracted to nearby larger colonies like Torrevieja, Isla Grosa in Murcia, and Albufera; (b) the presence of syntopic predators: the ratio *Larus michahellis/ Larus audouinii* at both sites is highly in favour of the Yellow-legged Gull (600 pairs at Columbretes and 700 at Benidorm); (c) the lack of sufficient conspecific attraction: gulls will prefer to return to breed in an area where conspecifics are located; (d) the sex-ratio of the chicks released was biased toward the females: males showed a stronger tendency to philopatry than females (the chicks were sexed from blood samples); (e) the two islands were not very attractive for the Audouin`s Gull; in Spain this species shows preference for salt marshes and saltpans.

Evolution of population. On Columbretes Islands the population of Audouin's Gull has been declining since the early 1990s (Figure 3; Sarzo *et al*. 2004), despite an increase in 1996 due to the presence of predators in the Ebro Delta colony, which forced gulls to migrate to nearby colonies. The breeding success is worse in smaller islets (Table 1). As mentioned above, the abundance of Yellow-legged Gulls is negative for Audouin`s Gull (100 pairs versus 600 pairs of Yellow-legged Gull). The Columbretes Archipelago does not seem to be a high quality site for the species.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Location	Foradada	Bauza	Ferrera	Grossa	Grossa	Grossa	Bauza	Bauza	Foradada	Ferrera
Breeding success	0	0	0	**0,9**	**0,59**	**0,66**	0	0,09	0,29	0,33

Table 1. Location and breeding success of the Audouin`s Gull colony within the Columbretes Archipelago, 2002-2011.

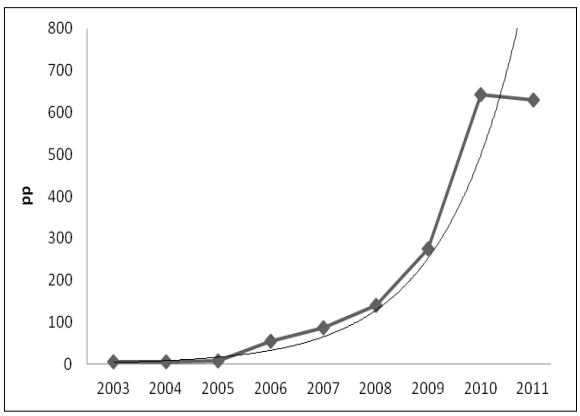

Figure 4. Breeding pairs of Audouin's Gull at l'Albufera N.P.

Year	2004	2005	2006	2007	2008	2009	2010	2011
B.S.	3	1	0,75	1,08	0,18	0,72	1,87	1,58

Table 2. Breeding success of the Audouin`s Gull colony at l'Albufera N.P.

At l'Albufera the first breeding attempt occurred in 2003, possibly in connection with the hatchling release program. From 1999 to 2010 there has been a continuous presence of chicks in the Rescue Centre located near of the island where the first pairs were established. This colony experienced an almost exponential growth (Figure 4). The area (artificial island without predators) is suitable for the species from the point of view of breeding and feeding. The breeding success is good (Table 2); the lower value in 2008 resulted from heavy rain in May and June during the pre-breeding and chick -rearing periods. In this colony an effort has been made in ringing. Until 2011, 444 birds have been ringed, and an effort has been made also in reading

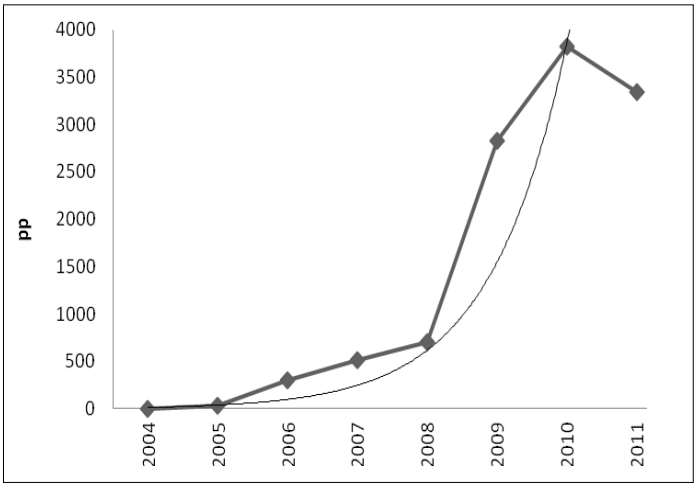

Figure 5. Population Breeding pairs of Audouin's Gull at Torrevieja Natural Park.

Year	2004	2005	2006	2007	2008	2009	2010	2011
B.S.	0	0,7	0,66	0,58	0,85	0,85	0,39	1,05

Table 3. Breeding success of Torrevieja Audouin`s Gull colony.

plastic rings (mostly from Ebro Delta).

The colony at Torrevieja is presently the second largest colony in Spain. It occupies a wide area of salt pans and the pairs are distributed into sub-colonies. The colony had a rapid growth (Figure 5). There are only about 60 pairs of Yellow-legged Gulls, and the breeding success of Audouin's Gull is good (Table 3). The low success in 2010 was due to a trawling moratorium in June, which coincided with the chick-rearing period. An effort has also been made to ring the birds in this colony. Up to 2011, 1762 birds have been ringed with coded plastic rings.

The colony at Castellon Port was established in 2011, in a wide plain area (when construction works were stopped). The colony was visited somewhat late in the reproductive period (late june, when chicks were already fully grown). The census results was of 303 pairs. We don`t have data of the breeding success, but it is presumed that next year the colony would be larger, due to conditions of the area. In addition, the port is very near the colony, and there are continuous presence of the species in the area (importance of conspecifics for the establishment of new colonies).

Benidorm Island seems to be a low quality site for two main resons: (a) the high density of vegetation (especially *Opuntia*), and (b) the high number of Yellow-legged Gull (around 700 pairs). Five breeding attempts occurred there since 2005, but only twice chicks succeeded to fledge; one in 2007 and two in 2010.

Another breeding attempt occurred at Almenara (Castellon), a restored lagoon with artificial sand islands. Habitat restoration was carried out in 2008. Two pairs of Audouin's Gull were present in the following year, but breeding was not successful, probably due to hunting and fishing poachers. In 2010 the small colony moved to another island in the same lagoon, but the vegetation was dense and, although more pairs settled there, they all eventually left the colony.

Conclusion

The species status is very positive in Valencian Region, where the population has increased from

200 pairs in 1998 to 4500 in 2011, mainly due to arrivals from Ebro Delta. The hatching release programme has not been successful, but it helped to increase our knowledge on the species biology. Most probably it facilitated the establishment of a new colony (Albufera). Conservation efforts for seabirds species through the Action Plan should be continued. The Audouin's Gull, which has a high colonization and dispersal ability, will attempt to breed If habitat is available. Thus the conservation and the creation of breeding and feeding areas are crucial for the species.

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Wintering of Audouin's Gulls *Larus audouinii* in Castellón (Spain)

José-Luis Greño[1], Pablo Vera[2] & Blanca Sarzo[3]

[1] Pº Morella 80 6E, Castellón PB.12004, Spain. jogreru@gmail.com
[2] SEO – BirdLife-Spain
[3] Equipo de Seguimiento de Fauna Catalogada CITMA

Summary: This work aims to determine the time limits of the wintering period for the population of Audouin's Gulls *Larus audouinii* wintering in the Castellón harbour during the winter of 2010-2011, and to describe its age-structure and the origin of the birds. The wintering period was identified as lasting from 10 November to 27 February. All observed birds originated from the Ebro Delta and Columbretes Islands colonies, Spain. One bird was in its third winter, whilst all the others were older.

Key Words: Audouin's Gull, *Larus audouinii*, wintering, origin, age, Mediterranean

Audouin's gull *Larus audouinii* winters mainly on the coast of West and North Africa, although some individuals remain on the eastern and western Mediterranean coast. During the 1990s, this species was studied in the breeding colony of Columbretes Islands (Castellón, north-eastern Spain), in order to determine the age and origin of the birds wintering in the locality. It was found that most individuals present in the islands in winter were adult birds born in the Ebro Delta (eastern Spain) and Columbretes colonies (Jiménez & Cardá 1997). The aim of the present work is to update these data by determining the time limits of the wintering period and describing the age and origin of the population of Audouin's Gulls in the Castellón harbour during the winter of 2010-2011.

Data were obtained between 1st September 2010 and 29th March 2011 in Castellón harbour (39º58'N 0º01'E). Sampling sessions (2 hours long) were grouped into 21 periods of 10 days (1 to 5 sampling sessions per period, mean 2.9). During each session the whole accessible area was surveyed with a telescope Kowa TSN-883, and as many individuals with colour rings as possible were identified. A total of 663 sightings (362 individuals) were collected during the study.

The wintering period was defined by means of a cluster analysis (Ward's method and squared Euclidean distances) based on a 21*362 matrix. The matrix reported whether each different bird was identified (1) or not (0) during each period of ten days. Through this analysis we obtained a hierarchical cluster dendrogram where the 21 periods were grouped according to the number of individuals recorded in common. It was expected that the wintering period consisted of closely grouped periods (due to individual birds present all along these periods, thus being considered as 'local' individuals), whilst differences would be higher for other periods because of the shorter presence of migrant birds.

Through this analysis (Figure 1), we determined the wintering period as lasting from period 8 (10 November 2010) to period 18 (27 February 2011) During this time, 87 different marked individuals

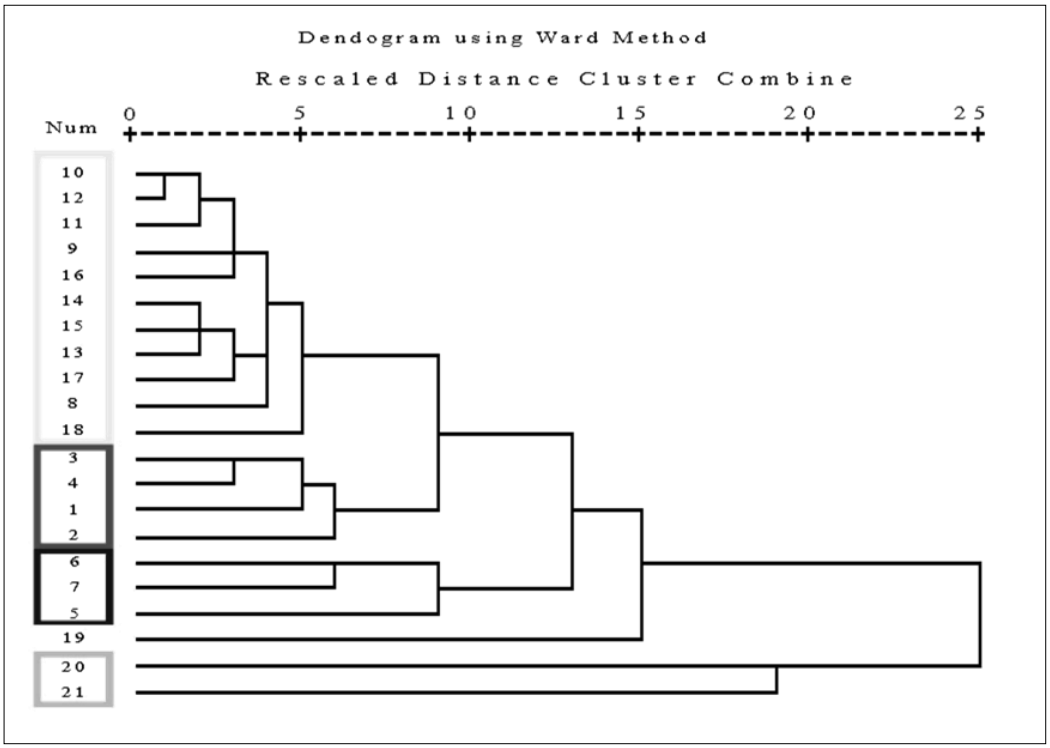

Figure 1. Hierarchical Cluster Dendrogram of the 21 sampling periods for Audouin's Gulls wintering in the Castellón harbour (2010-2011). Five different stages of the birds' local life cycle can be identified (cluster from top to bottom): wintering period (10 November to 27 February), early post-breeding migration (1 September to 10 October), late post-breeding migration (11 October to 9 November), early pre-breeding migration (28 February to 9 March), late pre-breeding migration (10 March to 29 March).

were identified (173 observations). All birds originated from the Ebro Delta and Columbretes Islands colonies, although one cannot excluded a minor presence of unringed birds from other colonies. Regarding their age, one bird was in its third winter and the other ones were older. Table 1 shows the proportion of observed birds according to the total number of observed birds ringed for each age class and colony. Age classes are those suggested by Oro & Pradel (2000). In this analysis, only birds of known age (i.e. ringed as chicks) were used (81 individuals).

Our results about age and origin correspond to previous findings in this area. Regarding 3-year old birds, their low frequency might be linked to the low number of chicks reared in the Ebro Delta colony in 2008 (Oro *et al*. 2008), thus a year effect may be misinforming on the average proportion of birds of this age wintering in the area. Sampling in several winters is necessary to elucidate this.

Describing the wintering populations in the western Mediterranean is important since it allows to carry out further studies dealing with questions such as why some birds apparently do not need to

	Ebro Delta		Columbretes islands	
Age classes (c.y.)	Obs	Proportion	Obs	Proportion
2	0	0	0	0
3	0	0	1	0,0450
4-5	12	0,0038	0	0
≥6	60	0,0034	7	0,0040

Table 1. Proportion of Audouin's Gulls wintering in the Castellón harbour (2010-2011) according to age classes (calendar years) and colony of birth: total number of observed individuals, and proportion of these observed birds according to total number of birds ringed per age class for each colony.

migrate, and which benefits (reproduction and or survival success) are expected to result from such behaviour. This species could be considered as being partially migratory, as it has been suggested for Mediterranean Yellow-legged Gulls *Larus michahellis* (Galarza *et al*. 2012). It would be expected that non-migrant gulls arriving first in the nearest breeding colonies may acquire the best breeding places. Contrarily, the over-winter survival probabilities could be reduced in the case of suboptimal temperature and food availability in western Mediterranean compared to those in the North-West African winter quarters. Thus, long-term studies would be needed for determining the trade-off involved in the decision to migrate or not, as was recently done in another partial migrant species, the Greater Flamingo *Phoenicopterus roseus* (Sanz-Aguilar *et al*. 2012).

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Results from ringing chicks of Audouin's Gulls *Larus audouinii* at Aspretto colony (Corsica) and controls in Corsica of chicks ringed in Italy

Bernard Recorbed[1], Arnaud Le Dru[2], Ségolène Travichon[3], Cécile Jolin[4], Gilles Faggio[4], Nicola Baccetti[5] & Aurélien Besnard[6]

[1]Ministère de l'Ecologie/DREAL Corse, BP334, F-20080 Ajaccio cedex , France.
bernard.recorbet@developpement-durable.gouv.fr
[2]12 rue Jacquard, F-69740 Saint-Genis-Laval, France. portableledru@free.fr
[3]LPO, BP 90363, F-17305 Rochevort, France. segolene.travichon@lpo.fr
[4]Conservatoire d'espaces naturels de Corse, Maison Andreani, RN 193, F-20290 Borgo.
gilles.faggio@espaces-naturels.fr & cecile.jolin@espaces-naturels.fr
[5]Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), via Ca' Fornacetta 9, I-40064 Ozzano Emilia, Bologna, Italy. nicola.baccetti@isprambiente.it
[6]CEFE-CNRS, UMR 5175, 1919 route de Mende, F-34293 Montpellier Cedex ,France,
aurelien.bernard@cefe.cnrs.fr

Key Words: *Larus audouinii*, Corsica, dispersal, survival, Audouin's Gull

The Audouin's Gull *Larus audouinii* breeds in the gulf of Ajaccio (Corsica, France ; 41°55' N, 08° 47' E) in a Natura 2000 area (SPA FR9412001, FR9410096), with 38 to 59 pairs. The ringing of young birds with alphabetical colour rings began in 2000 and 293 birds have been ringed in 9 years. Many birds have been controlled and these controls allow to map their dispersal and to estimate their survival and degree of philopatry. Furthermore, the controls in Ajaccio of birds ringed outside Corsica show exchanges between colonies. We have also estimated the age of first reproduction, the breeding success according to age and the sex-ratio in relation to the origin of birds.

The majority of Corsican Audouin'gulls are in Morocco in autumn and winter (Figures 1 & 2) and a first winter bird has been seen as south as Senegambia). In spring, a number of Corsican-born birds stay in Italy and Spain.

Most of the foreign birds seen at Aspretto are coming from Italian islands, above all Sardinian islands and Tuscany, also from Apulia (Figure 3). Despite the high number of birds ringed in the Ebro delta, Spain, only two Spanish Audouin's Gulls were seen at Aspretto. Six chicks ringed in Italy settled to breed on the study colony.

Corsican birds do not return to the colony in their first-year (Figure 4). First breeding occurs in the third or fourth year. Reproductive success is very low (Figure 5).

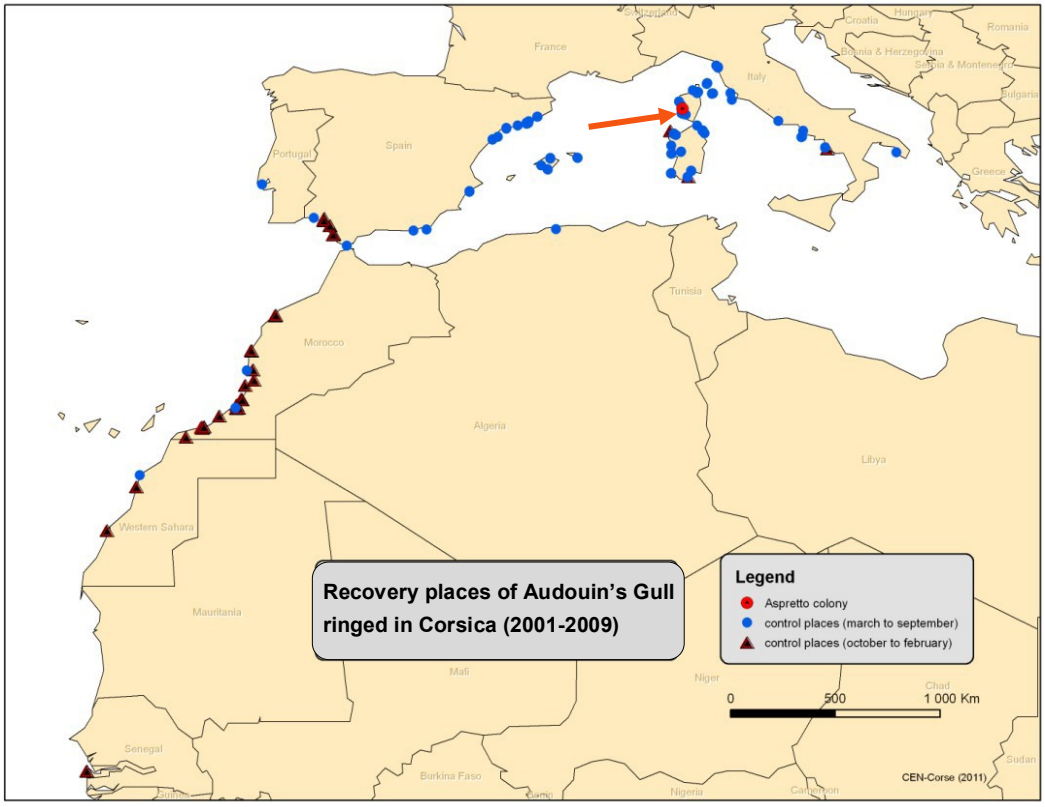

Figure 1. Map showing observations of Audouin's Gulls ringed as chicks at Aspretto colony (Corsica: red spot).

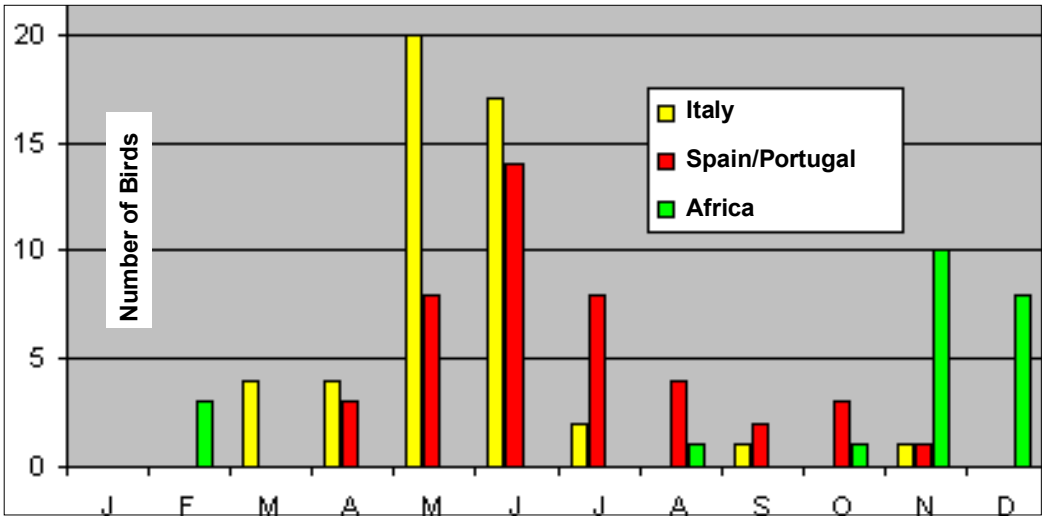

Figure 2. Number of Audouin's Gulls ringed as chicks at Aspretto colony (Corsica) observed by month in Italy (yellow) , Spain/Portugal (red) and Africa (green) .

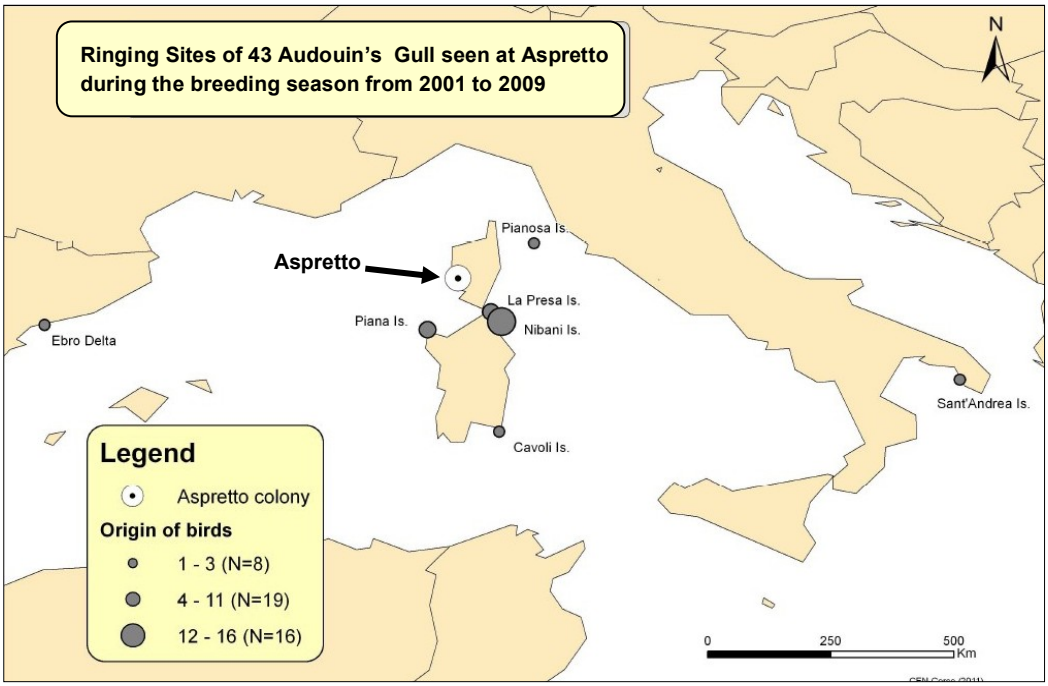

Figure 3. Sites in Italy and Spain where Audouin's Gulls were ringed and observed at Aspretto (Corsica).

Age class	Rate of global recapture	Rate of local recapture
First year	7 %	0 %
Second year	26 %	between 0% et 84%
Third year and more	64 %	64 %

Table 1. Recapture rate for Audouin's Gulls *Larus audouinii* ringed at Aspretto, Corsica, as calculated with M-Surge software (Lebreton *et al*. 1992, Choquet *et al*. 2004).

Age class	Global survival	Confidence interval	Local survival	Confidence interval
First year	0.64	0,52 – 0,74	0,46	0,36 – 0,56
Second year and more	0.87	0,81 – 0,92	0,9	0,83 – 0,95

Table 2. Global survival of Audouin's Gulls ringed at Aspretto, Corsica.

The probality of control of Audouin's gulls ringed as chicks at Aspretto increases with age (Table 1).The calculated survival for first-year Corsican birds (0,64, Table 2) seems to be lower than that calculated in the Ebro delta (0,79 according to Oro 1998), but this value might be underestimated. For second-year and older birds, no comparison is possible with Ebro delta since the used age-class

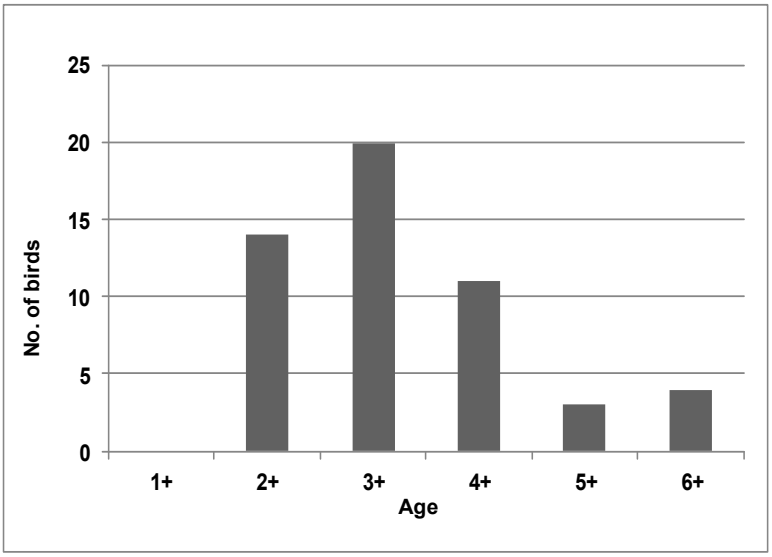

Figure 4. Age of the first return to the colony of Audouin's Gulls (N= 60),

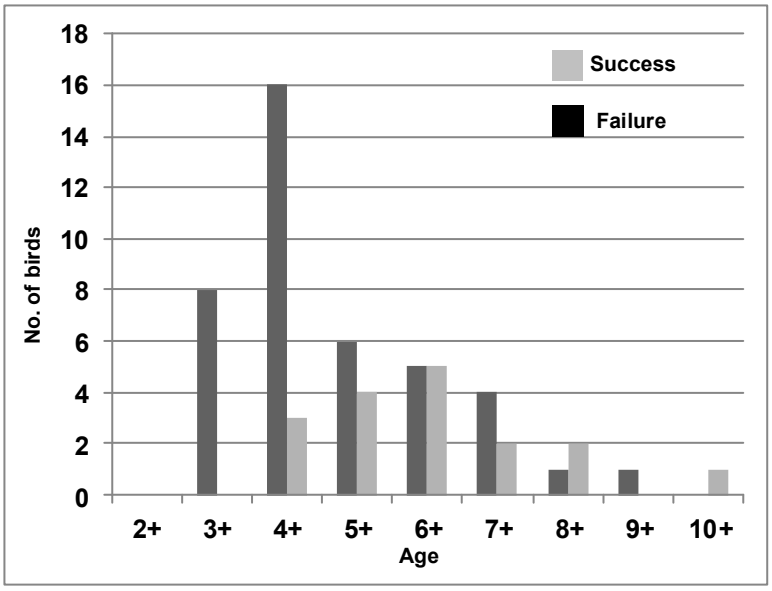

Figure 5. Breeding success of Audouin's Gulls ringed at Aspretto or in Italy in relation to age.

system differs. In any case, our sample size needs to increase in order to obtain more precise results, particularly through smaller confidence indexes.

Figure 5 shows that 84.7% of the ringed chicks at Aspretto and controlled at this colony were males. The recruitment of females from Italian colonies indicates exchange between colonies

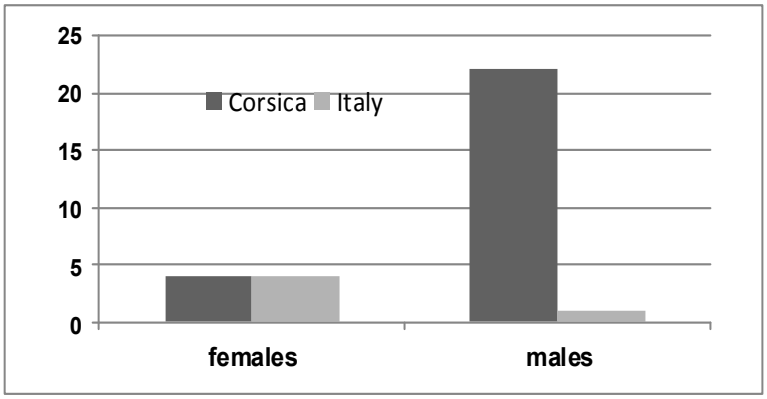

Figure 6. Sex-ratio of ringed Audouin's Gulls breeding at Aspretto, Corsica (N=31: 22 males and 4 females ringed in Corsica and 1 male and 4 females ringed in Italy).

around Corsica, Sardinian and Tuscan archipelagos. We expect that the continuation of the ringing programme and more intensive reading of coded rings at breeding colonies (both in Corsica and in Italy) will improve the estimate of survival rates. It will also allow to compare the local survival of males and females, which might help to understand the apparent sex-biased philopatry. Overall, a better knowledge of reproduction failures and exchanges between colonies should help us to understand the mechanism of desertion of colonies.

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Estimating the breeding success of Audouin's Gull *Larus audouinii* at the main Italian colony (Laguna di Nora, Sardinia)

Sergio Nissardi[1], Carla Zucca[1], Nicola Baccetti[2] & Marco Zenatello[2]

[1]Anthus sn.c., Via Luigi Canepa 22, 09129 Cagliari, Italy. anthus@anthus.info
[2]ISPRA, via Ca' Fornacetta 9, 40064 Ozzano Emilia, BO, Italy. nicola.baccetti@isprambiente.it; marco.zenatello@isprambiente.it

Summary: Reproductive parameters obtained in 2009-2011 at the main Italian colony of Audouin's Gull *Larus audouinii* (Laguna di Nora, south Sardinia, *ca.* 30 % of the Italian population) are presented. Resightings of colour-ringed juveniles and census of dead chicks allowed annual productivity to be calculated with two mark-recapture methods. A large and steady decrease of this crucial breeding parameter, not related to colony size, was observed. More than 0.7 chick/pair were fledged in 2009, but only *ca*. 0.2 chick/pair in 2011. Bad weather after hatching and food shortage are the likely causes of this particularly poor breeding performance at Nora colony in two out of three investigated seasons.

Key Words. Audouin's Gull, *Larus audouinii*, breeding success, Lincoln method, Sardinia

Introduction

Audouin's Gull *Larus audouinii* is a species of conservation concern, with a world distribution confined to the Mediterranean basin. It is currently classified as Near Threatened at the global level (BirdLife International 2012), following the population increase which has taken place in the western Mediterranean basin during the last 30 years, and as Lower Risk/Near Threatened at the national level (Peronace *et al*. 2012). After Spain, Italy is the second important country for this species (Oro *et al*. 2000). Size and distribution of the Italian breeding colonies are regularly assessed; annual totals do not show any clear trend, with large fluctuations in some years (Serra *et al*. 2001, ISPRA unpublished). Information on breeding success and on factors that affect it are scanty. Estimating annual productivity requires counts of fledged birds (see e.g. Craik 2000 and Martinez-Abrain *et al*. 2003 for examples referring to gull species). As a general rule, counts of newly-fledged individuals may be relatively easy when colonies are located on small islands, where juveniles gather on coastal rocks soon after fledging. It can be more problematic, however, in coastal salt-marsh habitats due to dense vegetation which may hide an important part of juveniles. In this context, the aim of this work is to provide data on breeding success obtained through two different survey protocols based on the simplest mark-recapture method (the Lincoln method: Bibby *et al*. 1992).

Figure 1. Nora Lagoon. Colony (rectangle) and roosting site (circle) of Audouin's Gulls.

Study area and methods

The breeding colony at the Laguna di Nora (38°59'N 09°00'E) was chosen to investigate the main breeding parameters in the three years 2009-2011. This site accounts for about 30% of the Italian population (ISPRA unpublished). It is a 55 Ha coastal lagoon located along the southern coast of Sardinia, separated from the sea by a dam created in 1957 for fish farming (Figure 1). During the 1980s, 11 artificial islets (with an approximate total surface of 1.7 Ha) were built to act as winter shelters for fish. They are now abandoned and totally overgrown by salt scrub vegetation (*Halimione portulacoides* and *Arthrocnemum* sp.). These islets constitute an area protected from terrestrial predators and external disturbance. The colony of Audouin's gull likely settled there in the mid 1990s (G. Ollano pers. comm.); it has been monitored regularly only since 2003. Observers can easily approach the breeding site, but counts of nests or chicks from the outside is not possible, as most are hidden by scrubby vegetation. After fledging, part of juveniles first gather in a resting area close to the colony, where ring-reading is possible, but they quickly disperse along a wider coastal area. Hence, counts of fledged individuals invariably refer to an unknown portion of juveniles and cannot be used to calculate annual productivity.

The colony was monitored as follows:

(a) a complete count of nests and their contents performed around mid-incubation period (15-16 May) by three teams of two people each, to minimize the time spent in the colony;

(b) a second visit to the colony carried out one month later, to mark all visible chicks with darvic and metal rings within a time of 30-45 minutes; during this visit all dead chicks are counted and removed;
(c) one or more telescope sessions carried out in the days following fledging, to read rings and assess the frequency of marked juveniles in flocks of known size roosting close to the colony;
(d) a third visit to the colony after all fledglings have left, to count chicks that had died after the ringing session.

The number of fledged juveniles (P) was then estimated as:

Method 1 ("live juveniles"): frequency of marked birds among fledged juveniles: P = (A/B) × (I-IM) where A = total number of juveniles checked for rings during the telescope session; B = number of ringed juveniles; I = total number of ringed chicks; IM = number of ringed chicks that had died before fledging.

Method 2 ("dead chicks"): frequency of marked birds among dead fledglings: P = I × M/IM where I = total number of ringed chicks; M = number of chicks that had died after ringing and before fledging; IM = number of ringed chicks that died before fledging.

	2009	2010	2011
Estimated start of laying	10-20 Apr	15-20 Apr	7-18 Apr
Number of nests	550	605	493
Number of laid eggs	1176	1464	1070
Mean clutch size ± sd (range)	2.1±1 (0-4)	2.4±0.9 (0-4)	2.1±1 (0-5)
% nests with eggs	90.0%	92.7%	88.4%
% nests without egg	10.0%	7.3%	11.6%
% nests with 1 egg	14.7%	6.7%	12.9%
% nests with 2 eggs	33.6%	25.1%	34.4%
% nests with 3 eggs	41.3%	60.7%	40.7%
% nests with 4 eggs	0.4%	0.2%	0.2%
% nests with 5 eggs	0.0%	0.0%	0.2%
Number of ringed chicks	77	94	66
Number of fledglings (method "live juveniles")	408	204-230	81-84
Mean number of fledglings/pair (method "live juveniles")	0.74	0.34-0.38	0.16-0.17
Number of fledglings (method "dead chicks")	394	226	116-125
Mean number of fledglings/pair (method "dead chicks")	0.72	0.37	0.23-0.25

Table 1. Reproductive parameters of Audouin's Gull at Laguna di Nora, Sardinia, in 2009-2011

Start of egg-laying was estimated from the age of hatched broods during the count of nests, and an incubation period of 26-33 days (Cramp and Simmons 1983). During nest counts, eggs outside nest cups were also counted and are included in the "Number of laid eggs" value. However, mean clutch size was calculated using eggs inside nests only.

Results and discussion

The results obtained in the 2009 to 2011 breeding seasons are summarized in Table 1. Annual counts ranged between 493 (2011) and 605 pairs (2010). The average clutch size and the percentage of nests without eggs showed small differences among the three investigated seasons (2.06-2.40 eggs/pair and 7.28-11.60 % respectively), whereas productivity showed much larger between-years fluctuations (0.16-0.74 using ring readings on juveniles, 0.23-0.72 using dead chicks).

The 2010 breeding season had the highest number of breeding pairs and the highest proportion of large clutches (three or more eggs, ca. 61%). Both 2009 and 2011 had a much lower frequency of large clutches (slightly higher than 40%), and a higher proportion of small ones (1-2 eggs). Reproductive success showed a steady decrease over the three years, with values which roughly halved each year and reached a very low level in the last investigated season. As a result, 2010 and 2011 were featured by a very poor breeding outcome. Indeed, the number of fledged birds was dramatically affected by limiting factors acting during the rearing period. These limiting factors, still to be fully identified, likely include food shortage, but also adverse weather after hatching.

The two methods used to estimate the annual productivity gave similar results, with differences of less than 5% in two of the investigated seasons (2009 and 2010); differences were much larger in 2011 (>30%). The poor correspondence between the two methods in 2011 is likely to be attributed to an inadequate sampling of fledged birds. In 2011 only one successful telescope session could be performed on a reduced sample of juveniles, since soon after fledging the usual roosting area was flooded and birds no longer used it. We suggest that both methods allow reliable estimates of the number of fledged young in Audouin's Gull colonies. Values obtained with the two methods are similar, provided that a sufficient sample of fledged birds are checked before they leave their natal colony (Method 1) or that all dead chicks are counted before and after fledging (Method 2).

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Abundance and predictability of local waste food may keep juveniles Yellow-legged Gull *Larus michahellis* in their natal areas

Alessio Franceschi[1], Paolo Dall'Antonia[1], Andrea Galardini[1] & Nicola Maggi[1]

[1]Centro Ornitologico Toscano, C.P.le 470, 57100 Livorno. alfranceschi@alice.it

Summary: We analysed recoveries of juvenile Yellow-legged Gulls *Larus michahellis* ringed in the coastal city of Livorno, Italy. We assessed whether the availability of food resources affect the movements of juvenile gulls raised in the urban area. Results showed that juveniles tend to remain close to their natal area, limiting or delaying their movements towards northern wintering quarter.

Key Words: *Larus michahellis*, Yellow-legged Gull, juvenile, dispersal, recoveries, food availability

Introduction

In the Mediterranean basin most juvenile Yellow-legged Gulls *Larus michahellis*, once fledged, show a tendency to move towards richer North-European feeding areas and then return to natal areas after three or four years (Isenmann 1973, Yésou 1985, Snow & Perrins 1998, Brichetti & Fracasso 2006). On one hand, these dispersive movements seem to confirm the tendency of the species to avoid competition between age classes and to explore new environments (Soldatini *et al*. 2005). On the other hand, these gulls are opportunistic feeders, exploiting a wide variety of food (Snow & Perrins 1998). In urban and coastal areas, dumped refuse and fishing discards are highly predictable, daily renewed and locally abundant resources (e.g. Chace & Walsh,2006), presumably allowing the gulls to minimize time and energies spent foraging.

Aim and Methods

The aim of our study was to assess whether juvenile gulls born in an urban area where anthropogenic food resources are available, accessible and abundant, tend to remain in their natal area after fledging or disperse towards North-European quarters. Since 2001 in the coastal city of Livorno, Italy (43°33'6"N, 10°18'2"E), we have been monitoring an urban population of Yellow-legged Gull (Arcamone & Leone 2001, Arcamone & Franceschi 2006), and from 2009 we started to trap adult breeders and their nestlings in order to band them with coloured rings. A total of 31 chicks were banded in Livorno during the breeding seasons 2009 and 2010. The low number of chicks caught is mainly due to the complexity in capturing gulls in urban environment where most breed on rooftops (tile roofs): the reduced sample depends on the lack of suitable and safe places that ensure the safety both of the researchers and of the gulls, still unable to fly. The chicks were ringed at 15-20 days old, with both metal and engraved colour PVC rings allowing each chick to be individually recognized. Sighting data were actively collected, checking every fifteen days all

year round from July 2009 to June 2011 in all known foraging areas around the city of Livorno, while reports from other ornithologists or birders were also collected.

Results

A total of 32 sightings of 14 individuals were collected, i.e. about 45 % of the ringed chicks. Seven immature gulls were observed as age 3 in late summer or early autumn and then re-sighted five years after their birth (Table 1). We also collected two sightings from abroad: the first was a juvenile ringed on 25 May 2009 thereafter observed on 18 November 2009 at Pasajes, Guipúzcoa, Spain (43°19'20"N, 01°56'01"W) on the Atlantic coast of the Bay of Biscay (age 3; distance 988 km; direction from ringing site: 272,68 °), while the other one ringed on 12 May 2010 has been observed on 12 May 2011 at Zeebrugge, Belgium (51° 20' N, 03° 11'; age 5; distance: 1017,5 km; direction from ringing site: 330,82 °).

Ringing data	Metal ring	Coloured ring	Place	Number of Recoveries		
				Aug-Oct	Nov-Mar	Apr-Jul
20/05/2009	CC 9771	IVAH	Livorno – ITALY	0	2	2
26/05/2009	CC 9782	IVBB	Livorno – ITALY	0	1	2
05/05/2009	CC 9785	IVBF	Livorno – ITALY	0	1	0
07/05/2010	CH 1201	IVCA	Livorno – ITALY	2	1	2
07/05/2010	CH 1202	IVCB	Livorno – ITALY	0	0	1
07/05/2010	CH 1203	IVCL	Livorno – ITALY	0	0	1
28/05/2010	CH 1210	IVCN	Livorno – ITALY	0	3	1

Table 1: Recoveries of Yellow-legged Gulls ringed in Livorno and observed as 2cy (age 5) near the natal colony.

Discussion

Most (88%) of the observations took place at the Porto Mediceo of Livorno, where gulls feed daily on discards arising from fishing vessels activities. Recoveries were made all year round suggesting that some of the juveniles reared in the urban area tended to remain close to their natal area or delayed the departure towards North-European wintering areas. Immature gulls probably find plenty of food available during the winter and thus limit their movements.

Information on the dynamics of urban population of gulls remains scarce and needs more attention, particularly when their management is required. Our data suggest that an available and abundant source of food provided throughout the year, may hold juvenile Yellow-legged gulls in their natal area, or reduce to some extent their dispersal movements. These preliminary results need further investigations and experimental studies involving more marked individuals.

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The breeding status of Slender-billed Gull *Larus genei* in the Valencian Region (E Spain): 20 years of survey and management.

Marcos Ferrández[1], J. Ignacio Dies[3], Concha Torres[2] & Blanca Sarzo[1]

[1]Generalitat Valenciana, Consellería D´Infraestructures, Territori i Medi Ambient, Servicio de Biodiversidad. Francisco Cubells 7, 46011 Valencia, Spain. fsmarcos@wanadoo.es; centre_santafaz@gva.es
[2]Parque natural de las Lagunas de La Mata-Torrevieja. Generalitat Valenciana, Consellería D´Infraestructures, Territori i Medi Ambient. Carretera N-332 Km 64,5, 03188 Antigua Casa Forestal, Torrelamata, Torrevieja, Alicante, Spain.
[3]Brigada de Calidad Ambiental de Zonas Húmedas, Servicio Devesa-Albufera. Ayuntamiento de Valencia. Ctra. CV-500 km 8,5, 46012 Valencia, Spain.

Summary: Up to 2010, the Slender-billed Gull *Larus genei* has bred at three coastal locations in the Valencian Region (E Spain) since first breeding was recorded in this region in 1991. Changes in colony size at each location (Salinas de Santa Pola, Lagunas de La Mata-Torrevieja and l'Albufera de Valencia) are described as well as threats recorded and management efforts made to preserve the colonies. Despite unstable numbers of pairs at each site, the regional total increased up to 500 breeding pairs after 2006. Conservation issues were: availability of nesting site; competition with the Yellow-legged Gull *L. michahellis*; and exposure to organophosphate pesticides used at colony surroundings.

Key-words. Slender-billed Gull, *Larus genei*, survey, management, Valencian Region, threats.

Introduction

The Slender-billed Gull *Larus genei* is a species associated to coastal salt marshes. It breeds in mixed colonies with other species of gulls, terns and waders, mostly on islands and sandy margins with vegetation. It feeds on fish and invertebrates in shallow waters in coastal lagoons, marine bays, salt pans and fish-farm ponds (Del Hoyo *et al*. 1996). This species shows a high dispersal rate, both natal and reproductive. Distance ring reading data of individuals from the Spanish colonies enabled us to show how the western Mediterranean populations are connected as a metapopulation (Oro 2003).

Here we summarize the fate of the three breeding colonies of Slender-billed Gull that exist in the Valencian Region (Comunitat Valenciana, Mediterranean coast of Spain). Two are located in the wetlands of southern Alicante province (Salinas de Santa Pola and Lagunas de La Mata-Torrevieja). The third colony is located in l'Albufera de Valencia in Valencia province. The species was first observed at Salinas de Santa Pola in the mid-1980s and the first colony subsequently was established in 1991. At Lagunas de La Mata-Torrevieja the species started breeding in 1995 (with individuals coming from Salinas de Santa Pola after colony desertion). At l'Albufera de Valencia the first breeding took place in 1994.

Surveys

The major wetlands in the Valencian Region are of importance for waterbird conservation and a long series of censuses were carried out. These censuses were coordinated locally by SEO/ BirdLife until 2002 as a result of agreements with the local administration (Generalitat Valenciana). Since 2002, the administration itself has been in charge of coordinating the censuses, which are performed both by its own staff and SEO/BirdLife observers. Methods used to estimate the size of the Slender-billed Gull breeding population included: (a) direct counts of nests and incubating adults, and (b) breeding pairs estimates based on the number of adults observed at the colony. Censuses were carried out from the beginning of March to late July. The number of visits and dates were established for each site by the local groups, based on local knowledge and previous experience (Gómez, 2006).

Variations in number per breeding site

Figure 1 illustrates the evolution of the number of breeding Slender-billed Gull in the Valencian Region, as presented below.

At Salinas de Santa Pola the species performed well until 2004, when the number of breeding pairs began to decrease, with no reproduction on some years. One of the main causes for this desertion was the competition with the Yellow-legged Gull *Larus michahellis* for breeding sites, and predation by Yellow-legged Gulls. Most breeding pairs then moved to Lagunas de La Mata-Torrevieja. In 2011 the species bred again successfully (325 pairs) in Salinas de Santa Pola, in an area that had been restored in 2007 and where other gulls (except the Yellow-legged Gull), terns and waders were breeding.

At Lagunas de La Mata-Torrevieja the species first bred in 1995, establishing a colony on the artificial island at La Mata lagoon. This island was destroyed by a storm and re-built together with

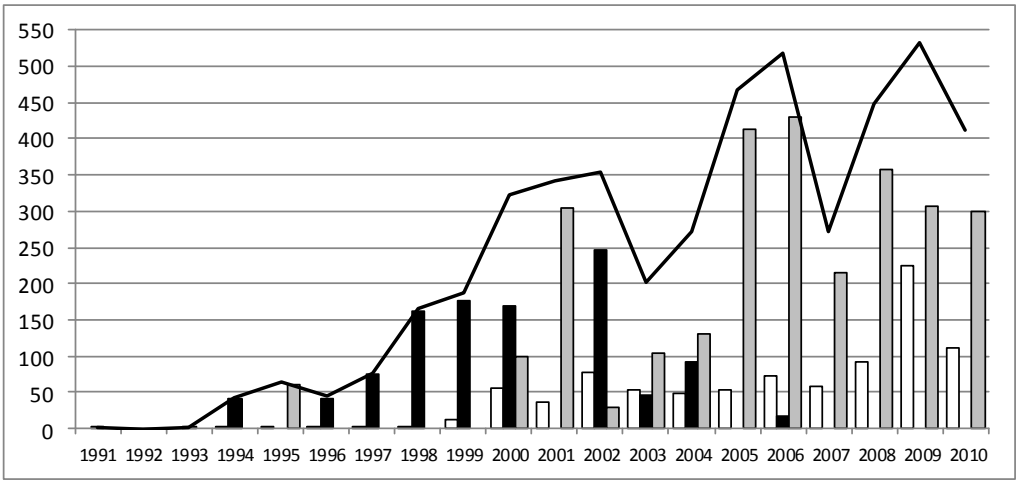

Figure 1. Number of breeding pairs of Slender-billed Gull in the Valencian Region (E Spain): l'Albufera de Valencia (empty bar), salinas de Santa Pola (solid bar), lagunas de La Mata-Torrevieja (grey bar), and regional total (line).

a new one in 2003. The first one was re-used by the Slender-billed Gulls for a few years until predation by Yellow-legged Gull forced them to move to the other island. The first breeding season at this new site was very successful but in the following year (2011) the colony was again heavily predated by Yellow-legged Gull non-breeders. In 2004 the species bred at Torrevieja lagoon (131 pairs) on a dike within the salt exploitation area, together with various species of waders and terns.

The colony in l'Albufera de Valencia was established in 1994 and showed a positive evolution reaching a maximum of 224 pairs in 2009. This colony has always occupied the islands and beaches of the Racó de l'Olla reserve area. This 64ha reserve is a salt marsh integrated in a beach barrier. It has been restored in 1993 with the purpose of creating an optimal breeding habitat for gulls, terns and waders. The Slender-billed Gull has bred successfully almost every year. Cases of predation by foxes and rats have been registered although rarely. Death of adults and chicks can occur due to exposure to organophosphate pesticides used at the nearby rice fields, where the adults feed.

Conclusion

Conservation problems for the Slender-billed Gull in the Valencian Region vary from one breeding site to the other. In Alicante, they are related to the quality and availability of breeding sites and the competition with the Yellow-legged Gull. In l'Albufera de Valencia the main conservation problem seems to be related to pesticides used at nearby rice fields where the gulls feed.

The breeding performance of the colonies fluctuated during the studied period, but the total number of pairs did increase. The existence of alternative breeding sites in the vicinity of the colonies seems important for the species. The breeding sites should also be attractive to waders (such as the Pied Avocet *Recurvirostra avosetta* and the Black-winged Stilt *Himantopus himantopus*) and terns because these species actively defend their colonies from Yellow-legged Gulls and other predators, a behaviour which would be beneficial to the less aggressive Slender-billed Gulls.

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New important wintering sites for the Black-headed Gull *Chroicocephalus ridibundus* in Apulia, SE Italy

Cristiano Liuzzi[1], Giuseppe La Gioia[1] & Fabio Mastropasqua[1]

[1]Ornitologia Mediterranea c/o Giuseppe La Gioia, via M. Saponaro 7, I-73100 Lecce, Italy.
ormepuglia@gmail.com

Summary: The distribution and abundance of Black-headed Gull *Chroicocephalus ridibundus* in Apulia are better known thanks to the data collected from 2003 to 2011 for the International Waterbird Census project by the Or. Me. ("Ornitologia Mediterranea") Nature Association. The species was dominant at regional level with an average of 55,623 individuals. A new site of international importance for the species was found (code BA0200, corresponding to the coast around Trani in Bari province) where an average of 23,157 individuals were counted (min. 5,611 in 2003, max. 58,622 in 2006, SD 17,133).

Key-words: *Chroicocephalus ridibundus*, Black-headed Gull, Apulia, Italy

Introduction

In Apulia, the International Waterfowl Census (IWC) project brought about a widespread and almost complete coverage of the region since 2003, after a trial year in 2002. Fieldwork was carried out by the Ornitologia Mediterranea Association. Until then, only the most important inland waters for birds had been counted (i.e. the wetlands of Foggia province and the Salento), thus ignoring many areas that have proved particularly suitable for marine birds. This note reports the distribution and abundance of Black-headed Gull *Chroicocephalus ridibundus* in Apulia from 2003 to 2011.

The species overwinters regularly in Italy. During the period 1996-2000, on average, 208,247 birds were counted in 322 zones, making it the most abundant and widespread gull species (Baccetti *et al.* 2002). Apulia is one of the areas where the greatest concentrations are observed (Brichetti & Fracasso 2006). The Apulian wetlands were divided by Italian National Wildlife Institute INFS (now known as ISPRA) into 47 "macrozones", i.e. functional ecological units, made up of one or more zones (Baccetti & Serra 1994, and subsequent changes and additions: http://www.infs-acquatici.it). Two further zones were added which, although on the borders of Apulia, were encoded as being in neighbouring regions.

Methods

The complete census method (Overton 1971), used for counting wintering waterfowl, was adopted. The birds were observed using suitable optical devices, such as 10x42 binoculars and a 20-60x72 telescope. Species-level identification was carried out using Svensson *et al.* (1999) and Olsen & Larsson (2003). As far as possible, we followed the directions provided by Cranswick (1998) and implemented in the counts of wintering waterfowl regularly carried out in conjunction with INFS. In order to standardize the censuses, a map was created for each zone based on IGM (Istituto Geografico Militare) maps, showing the path to follow during the census and stop-off points for observation: this made it possible to follow the same route and benefit from optimum views. Field

observations were entered into a database for data analysis, while the maps were created using the ArcGIS 9.2 software.

Results

At regional level, over the nine years of surveys, the species was found in 98 zones, with a maximum of 64 in 2004 and a minimum of 50 in 2010 (Figure 1). On average, 55,623 Black-headed Gulls were counted (min. 29,246 in 2003, max. 94,421 in 2007, SD 23,189). Of particular interest is a new site of international importance for the Black- headed Gull (code BA0200, corresponding to the coast around Trani in Bari province). An average of 23,157 Black-headed Gulls were counted: (min. 5,611 in 2003, max. 58,622 in 2006, SD 17,133).

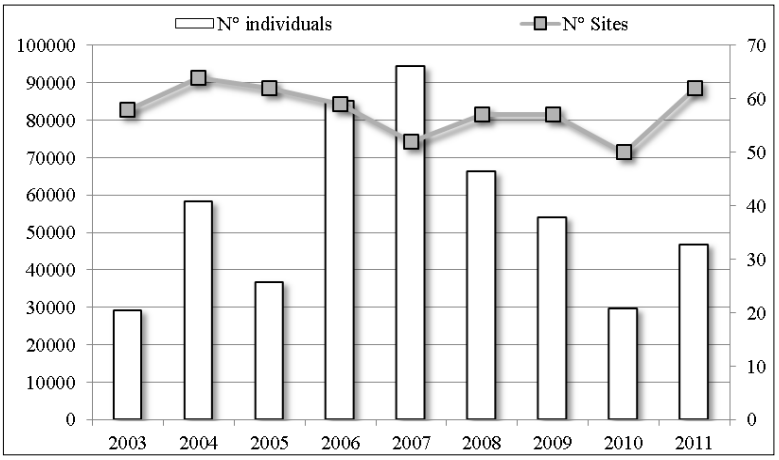

Figure 1. Number of sites and individuals of Black-headed Gulls in Apulia, 2003-2011.

Zone Code	BA 0200*	TA 0800	BA 0600	BA 0400	FG 1000	BA 0100	FG 0300	FG 0500	BA 0500	TA 0200	BR 0700	BR 0400	BR 0300
Mean	23157	6613	6233	3905	3689	2654	2650	2610	2422	1334	1295	752	652
%	39.1	11.2	10.5	6.6	6.2	4.5	4.5	4.4	4.1	2.3	2.2	1.3	1.1

Table 1. Important regional sites (*Important international site) for Black-headed Gull in Apulia, with average numbers and proportion of each site in the regional grand total. Zone Codes: according to the INFS wetland list.

Discussion and Conclusions

In Apulia Black-headed Gulls were mostly concentrated in the coastline between Gargano and Bari, but discreet concentrations were recorded near Taranto and Brindisi city (Figure 2), close to the major harbour areas, particularly along the regional Adriatic coast. Numbers were rather low in southern Apulia, probably due to the absence of large fishing fleets. From this work emerges the importance of macrozone BA0200 (Table 1) corresponding to the coastal stretch between Barletta, Trani and Bisceglie, which should be classified as a Site of International Importance under the Ramsar Convention (criterion 5), as it exceeds the value of the presence of 20,000 birds.

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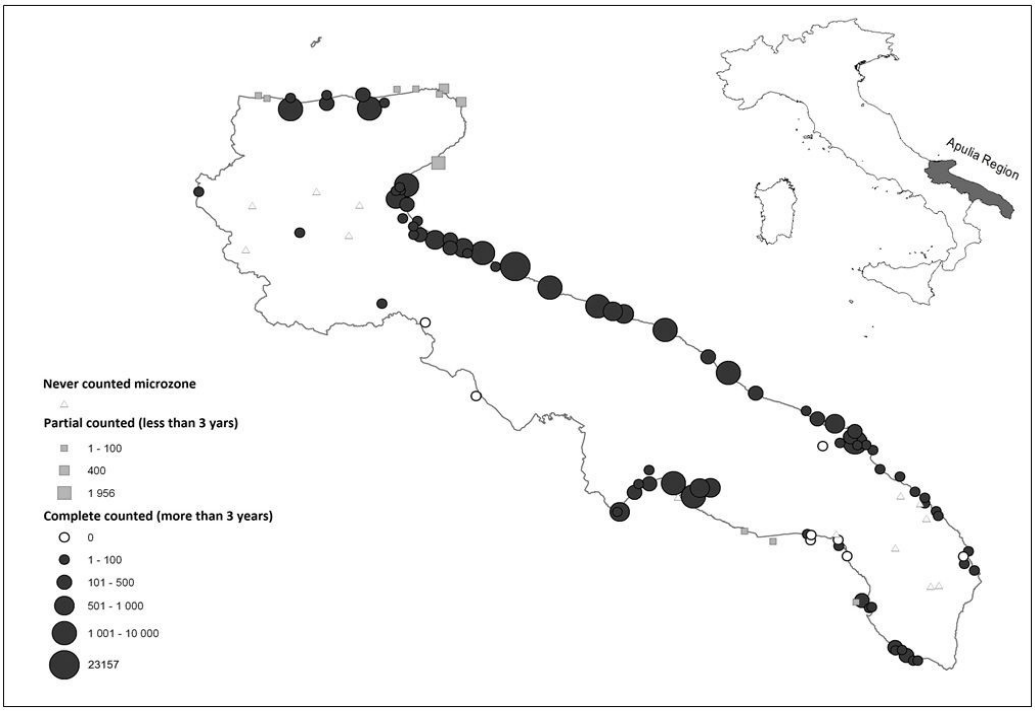

Figure 2. Distribution of Black-headed Gull in Apulia, 2003-2011.

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State of knowledge and population trends of the Lesser Crested Tern *Sterna bengalensis emigrata* in the Mediterranean: threats identified and proposed actions for small islands in the Mediterranean

Abdulmaula Hamza[1], Hichem Azafzaf[2] & Jaber Yahia[3]

[1]Environment General Authority (Libya), Nature Conservation Department. Tripoli, Libya (current address: IECS, University of Hull, HU67RX, England). abdhamza@gmail.com
[2]11 Rue Abou El Alla el Maari, 2080 Ariana, Tunisia. azafzaf@gnet.tn
[3]Environment General Authority (Libya), Nature Conservation Department. Al Bayda, Libya.
jaber.yahia@gmail.com

Summary: Information on the Mediterranean breeding population of the Lesser Crested Tern has increased steadily during the last five years, as a result of a regular monitoring and ringing program initiation by the Libyan authorities at the species breeding sites off the Libyan coast. As a priority species of the Mediterranean Seabirds Action Plan (coordinated by RAC/SPA) and the Mediterranean Small Island Initiative (PIM), updated and available information has been compiled in a form of a species monograph, dealing with both breeding and stop-over sites. A new breeding site was added. Sightings of Mediterranean-ringed birds were obtained along the north-west African migration route and at wintering areas in West Africa. Basic information on the ecology and biology of the species (nest shape, nesting habitat description, feeding behaviour and diet information) was included. Population trends and conservation status were assessed for the Mediterranean population, with emphasis on proposed conservation actions required to maintain the stability of the population size at the small islands in Libya.

Key Words : Lesser Crested Tern, *Sterna bengalensi emigrata,* Mediterranean Sea, population, conservation

Introduction

The Lesser Crested Tern *Sterna bengalensis*, or *Thalasseus bengalensis* (Bridge *et al.* 2005), is not a globally endangered species, as its world population is estimated at 225,000 pairs, of which 50,000-60,000 pairs are found in the Middle East (Gochfeld 1996). However, the number of breeding pairs of the Mediterranean subspecies *S. b. emigrata* in Libya (and the Mediterranean region as a whole), does not exceed 2,400 pairs (Hamza *et al.* 2007). A further 5000 breeding individuals are located in the Egyptian Red Sea area (Goodman & Meininger 1989) and are given as transitional between Mediterranean *emigrata* and the nominate *bengalensis* (Cramp 1985).

The population that breeds in Libya – the only area regularly occupied in the Mediterranean – completely depends on 3-4 unprotected sites along the eastern Libyan coast. This extreme localization determines its particular conservation status at the Mediterranean regional level, as an endangered taxon under the Mediterranean Seabirds Action Plan (UNEP-MAP-RAC/SPA 2003).

A colony of Lesser Crested Terns was first found in Libya at Garah island, mis-identified as Caspian Terns *Sterna caspia* (Bini 1935). Two years later, in August 1937, the presence of a large colony was confirmed by Moltoni (1938) who estimated the colony to hold more than 2000 birds including both adults and nestlings. No further information was available until July 1993 when Meininger estimated a total of 1700 pairs at Garah island and 40 pairs at a new nesting site further east, at Al Ulbah island (Meininger *et al.* 1994). In mid-June 2004 there seems to have been a breeding colony of over 50 pairs on an islet in one of Benghazi's lagoons (Gaskell 2005). In 2006, both Garah and Ulbah were still hosting breeding populations of Lesser Crested Terns (Azafzaf *et al*. 2006), in an almost stable condition when compared to that reported by Meininger *et al.* (1994). The species was also recorded in 2006 in Benghazi, without confirmation of breeding; this was confirmed in August 2007 on the only islet of Sabkhat Julyanah, or Benghazi Western Lake (Hamza *et al*. 2007). Finally, a small colony was found in 2010 at Ftiha island within the Gulf of Bumbah, believed to be part of Ulbah colony which had moved to Ftiha due to human disturbance (Yahia, pers. obs.).

The aim of this paper is to update information on the Mediterranean population of Lesser Crested Tern by presenting the species monograph recently produced (Hamza & Azafzaf 2012) for the Mediterranean small islands initiative (Petites Iles de Méditerranée, PIM).

Study area

Colonies were monitored at the following sites in Libya (Figure 1):

Garah island (alternative names: Jazīrat Garah, Gezeret Garah, Le Garagh island, Gezerit Legarah, Gezerit Lahberi, Bird Island, Isola degli Uccelli): the main breeding site for the species in the Mediterranean, located within the Gulf of Sirt, about 12 km off the coast (30°48'N 19°54'E). Low sandstone cliffs or gentle slopes surrounding low hills with scattered rocks to the north, east and western sides, the southern side with small beach. The top plain has low halophytic plants and shrubs. The island is situated within the concessions of Zuwaytinah Oil Terminal, thus it is vulnerable to oil pollution, although it seems that it did not experience any major oil spills in recent times, and the general environmental status is acceptable.

Al Ulbah island (alternative names: Jazīrat al Ulbah, Jazīrat al Alba, Gezeret Ain al Ghazalah, Gezerit Um Elmaracheb, Gezerit el Elmarakeb, El Maracheb Island, Isola el Maràcheb). Larger low lying island situated in front of the Gulf of Bumbah (32°14'N 23°17'E), at about 2 km from the mouth of Ayn al Ghazalah bay. Halophytes are dominant, with few low shrubs. About 50% is bare area.

Julyanah islet (islet inside Sabkhat Julyanah): A very small low laying islet of ca. 30m^2 (32°05'N 20°03'E) made of stone pieces, with mud and litter accumulations, in the middle of the northern

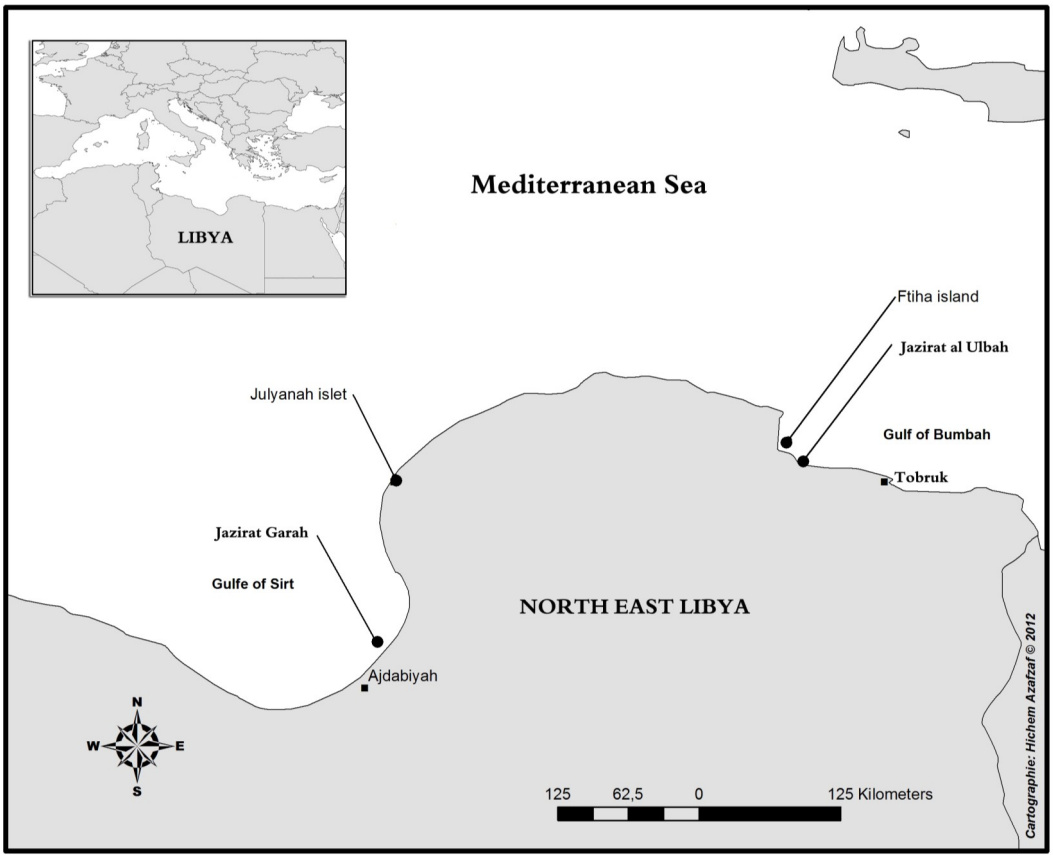

Figure 1. Breeding colonies of Mediterranean Lesser Crested Tern *emigrata* (filled circles) in Libya.

part of a lagoon which is permanently flooded. The islet is used in winter by Cormorants *Phalacrocorax carbo* as a roosting site.

Ftiha island (alternative names: Jazirah Al Watyah, Gezira el-Uàtia, Jazirat Ftiha). A flat islet in the Gulf of Bumbah (32°23'N 23°09'E), elongated in shape, *ca*. 6 ha large, with a flooded wetland and salt marsh inside. In 2010, 16 pairs from Ulbah colony bred here (Hamza, unpubl. data). The colony was deserted following poaching and disturbance by local people.

Methods

Activities were carried out following the guidelines for working in tern colonies on small islands, elaborated for the Red Sea region (PERSGA/GEF 2003) and the UK (Walsh 1995), in addition to the recent guidelines of the management plan for coastal and marine important areas to birds and/or marine and coastal protected areas (UNEP-MAP-RAC/SPA 2007). The following schedule was implemented: (a) Preparation of fieldwork trips, by obtaining information about marine conditions and weather and arranging logistics for boat transfers to breeding sites in islands: (b)Development of a specific protocol for fieldwork, including safe approaching at sensitive breeding

habitat of an endangered species and fast counting techniques for birds and nests; and (c) Ringing operations were carried out after herding the crèche of young terns (or a part of it) into enclosures, according to previous experiences by Italian and French team members, each participant being assigned of a fixed, specific task so that all chicks could be released within 30-40 minutes from capture.

Results

Population size. The numbers of breeding pairs varied from one year to the other, peaking at 2264 pairs in 2009 (Table 1).

Sites	1937 (a)	1978 (b)	1993 (c)	2005 (d)	2006 (e)	2007 (e)	2008 (e)	2009 (f)	2010 (f)
Garah	1000		1700		1920	1800	2000	2100	2000
Ulbah					29	24	14	24	16
Julyanah		164		50	200	125	120	140	70
Ftiha									12
Totals	1000	164	1700	50	2149	1949	2134	2264	2098

Table 1. Documented breeding population size (number of pairs) of Lesser Crested Terns in Libya. After (a) Moltoni (1937); (b) Baker (1984); (c) Meininger *et al.* (1994); (d) Gaskell (2005); (e) EGA and RAC/SPA surveys; (f) A. Hamza (unpublished data).

Nesting ecology. Eggs are laid on open bare soil, ridges, or on soil surrounded by low vegetation; the nest is a shallow scrape but edges may be occasionally fortified by adult droppings (at Ulbah; Hamza, pers. obs.). Some nests contain few sea shells and debris. Colonies are usually near island shores, possibly to give juveniles an escape way to water, or may occur at the centre of islands, near salt marshes connected to the sea (Ulbah colony). In Libya the nesting sites are moving from year to year (e.g. at Garah, colony site rotated anticlockwise from 2006-2010 breeding seasons); at Ulbah colony, about half of the parent birds moved to a nearby island (Ftiha) in 2010 season, as a possible response to disturbance. Colony size varies from small groups of a few couples (Ulbah) to thousands (Garah). Clutch size is commonly of one egg, with a small percentage of 2-egg nests. Replacement clutches, which are common in the Gulf region (for *Sterna bengalensis torresii*), were not noticed in the Mediterranean population.

Behaviour and diet. Fish are caught in both shallow and deep waters by plunge-diving. It takes surface fishes like sardines or flying fish or juvenile fish of other species. Feeds individually, or in groups of 10 to >70 individuals. Some birds can carry 1-4 fish at a time (Hamza, pers. obs.). Information is scarce on the feeding areas for the Mediterranean breeding population, however field observations at Libyan colonies indicates feeding areas up to about 10 nautical miles from the colony site. Techniques such as light-weight GPS tracking and intensive boat-based monitoring at sea can help in identifying the main feeding areas. These would help to draw precise maps of feeding sites, to be included in buffer zones for marine protected areas, which should be established for the conservation of the species (priority action).

Distribution of the Mediterranean population. The Mediterranean subspecies *emigrata* mainly winters in West Africa (Sierra Leone, Guinea Bissau, Senegal, Gambia, and possibly Ghana), with some individuals in Morocco and Mauritania. There is a series of winter records in Libya (Meininger *et al*. 1994), which suggests regular occurrence of isolated individuals in the winter months (Brehme 2003). Three to seven individuals were reported in the course of winter censues of waterbirds of Libya between 2007 and 2010 (EGA - RAC/SPA waterbird census team 2012).

Banding activities. During 2006-2010, 1140 nestlings were ringed at the three main breeding sites in Libya (Table 2). The majority were at Garah (86.4%). Recoveries (usually sightings) of the juveniles were obtained from Spain (4, all from sites adjacent to Morocco), Senegal (2), Sierra Leone, Morocco and Libya (one bird each), making a recovery percentage of 0.79% of the total ringed nestlings. No birds from Ulbah colony were reported, either because of low number of banded chicks and high mortality in the first few years, or possibly because they could follow a different migration route (heading east instead of west, to join Red Sea birds). Tracking studies and field observations at the Egyptian Mediterranean coastline are necessary to test this hypothesis.

Ringing Sites	2006	2007	2008	2009	2010	Totals	Recovered
Garah	61*	425*	204	48	247***	985	8
Ulbah	9*	25	18	25	8**	85	0
Julyanah	0	0	66	4	0	70	1
Totals	70	450	288	77	255	**1140**	9

Table 2. Results of the ringing program of Lesser Crested Terns in Libya (2006-2010); * all birds ringed with metal rings only, ** one bird ringed with metal ring only, * 31 birds ringed with metal rings only; all the other birds were fitted with metal and engraved darvic rings.**

Conservation

A number of conservation problems were recorded during the study, all connected to the general issue of the lack of legal protection for the species and its breeding and foraging areas in Libya. Illegal waterfowl hunting in the easternmost part of the country is causing severe disturbance to the Ulbah colony. Habitat alteration by urban development, without taking national guidelines of Environmental Impact Assessment in consideration was a problem at Benghazi, where Sabkhat Julyanah was drained in 2010, causing the loss of more than 70 nests due to stray dog predation. Illegal blast fishing in the vicinity of breeding sites was recorded around both Garah and Ulbah islands. Some limited conservation action implemented to date has taken place on Garah, where a protective fence was erected at the top of the cliff, to prevent chicks from falling down the cliff (especially in case of human disturbance).

Parameters of interest in conservation biology (population size, capture-recapture data and fledging success) suggest an apparent stability of the population. However, being a continuous production

of about a thousand juvenile terns every season at Garah alone, some increase in population size could be theoretically expected. This not being the case at present, significant mortality rates at wintering sites should be assumed and need further studies and protection efforts.

A simplified action plan for the species was presented in the PIM monograph (Hamza & Azafzaf 2012), which identified threats (Table 3) as well as specific actions proposed on local, national and regional levels. On the local level, identified actions are education, public awareness and participation of local communities, site protection and management. On the national level, the action plan stresses the importance of species protection, education, public and government awareness, as well as activities to protect the species during breeding season. Finally, on the regional level, several actions were proposed, starting from a better implementation of the Action Plan on marine birds listed in the SPA protocol, and strengthening information sharing between countries on breeding, passage and wintering areas, with the organization of scientific meetings and symposia.

	Site	Habitat alteration	Climate change	Over-fishing	Pollution	Invasive or introduced species
Libya	Garah island	X	X	X	X	
	Ulbah and Ftiha islands		X	X	X	X
	Julyanah islet	X	X	X	X	X
NW and W Africa	Migration and wintering areas	X		X	X	X

Table 3. Main threats identified for Mediterranean Lesser Crested Tern.

As a future achievement, ongoing studies have to be mentioned on the phylogeny of the species in Libya, and its relationship to the breeding population of the Red Sea (Hamza *et al.* 2009) and the Gulf region (Bahrain). Results are suggesting some independency of the Mediterranean population, offering additional reasons for improving its conservation status. Furthermore, a detailed study on feeding biology of the species is underway, to inventory all diet components used by the species at its confined breeding sites in Libya.

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Part 4: Ecology and Conservation of other bird species of concern under the Barcelona Convention

The Eleonora's Falcon *Falco eleonorae* in Morocco: breeding ecology, threats and proposed actions

Hamid Rguibi Idrissi[1], Abdeljebbar Qninba[2], Abelaziz Benhoussa[3], Vicente Urios Moliner[4] & Frederic Jiguet[5]

[1]Moroccan Wildlife Association, Laboratoire "Valorisation des Ressources Naturelles et Biodiversité", Université Chouaib Doukkali, Faculté des Sciences, El Jadida, Morocco. hrguibi@hotmail.com
[2]Institut Scientifique, Agdal-Rabat, Morocco.
[3]Moroccan Wildlife Association, Univ. Mohammed V, Fac. Sci, Rabat, Morocco.
[4]Centro Iberoamericano de la Biodiversidad, Universidad de Alicante, Alicante, España.
[5]Centre de Recherche sur la Biologie des Populations d'Oiseaux, 55 rue Buffon, 75005 Paris, France.

Summary: The Eleonora's Falcon *Falco eleonorae* is a raptor of conservation concern in the Mediterranean region. The first study of the species' breeding ecology in Morocco has been conducted on two breeding sites at Essaouira (Mogador) in 2010 and 2011. A population increase has been observed at one of the two sites only. A number of conservation actions are proposed.

Key Words: Eleonora's Falcon, *Falco eleonorae*, breeding population, conservation, threats, Essaouira, Morocco

Introduction

Eleonora's Falcon *Falco eleonorae* is a colonial, diurnal raptor whose distribution ranges from the Mediterranean region to the eastern coast of Morocco and the Canary Islands, where the westernmost and southernmost breeding colonies are found (Cramp & Simmons 1980, De León *et al*. 2007, Aghnaj *et al*. 2002). Its breeding season begins much later (in July), compared to other Palearctic birds. Consequently, it can include in its diet the plethora of southbound migratory bird species that overfly the Mediterranean basin during the end of summer (Walter 1970, Wink & Wink 1989): the species breeding period is adapted to coincide with the postnuptial migration of small passerines.

The migration route of Eleonora's Falcon has largely been a mystery until recently. The most widely accepted hypothesis on its migration suggested a coastal route through the Mediterranean Sea eastwards, crossing the Suez Canal, and proceeding southwards through the Red Sea following

the East coast of Africa to the wintering grounds in Madagascar and the Mascarene islands (Lopez-Lopez *et al*. 2009). Satellite telemetry has been recently used to map its migratory routes and to identify the main wintering habitats in Madagascar (Gschweng *et al*. 2008, López-López *et al*. 2009 and 2010, Mellone *et al*. 2011 and 2012, Kassara *et al*. in press). These researches highlighted that the species migrate on a broad front during both seasons, crossing the African continent and adjusting its behaviour according to the landscape; for example migrating during the night especially when crossing the Sahara desert and showing slower speeds in the more hospitable regions of the Sahel (Lopez-Lopez *et al*. 2010). Moreover, the species shows a high degree of flexibility in relation to weather conditions, when crossing the Indian Ocean (Mellone *et al*. 2011).

Since the patterns of variation in avian reproduction are both ultimately adapted to and ultimately generated by variations in food supply (Dijkstra *et al.*1988), knowledge on diet composition is crucial to understand properly many other aspects of the species ecology, such as habitat, phenology, and populations dynamics. Such information may help to understand the species' requirements, hopefully contributing to the recovery of the Moroccan population of this globally endangered species. In line with these recommendations, two aims are pursued in this paper: (a) to update census data of the breeding population of Eleonora's Falcon in the archipelago of Essaouira (previously known as Mogador); and (b) to evaluate the population tendency of Eleonora's Falcon in the archipelago of Essaouira by using data from previous studies.

Numbers and distribution in Morocco

The Moroccan population, which breeds at two sites, was approximately 100 breeding pairs in 1996, i.e. larger than the 1970-1980 population estimates (Figure 1). At Sidi Moussa cliffs, the

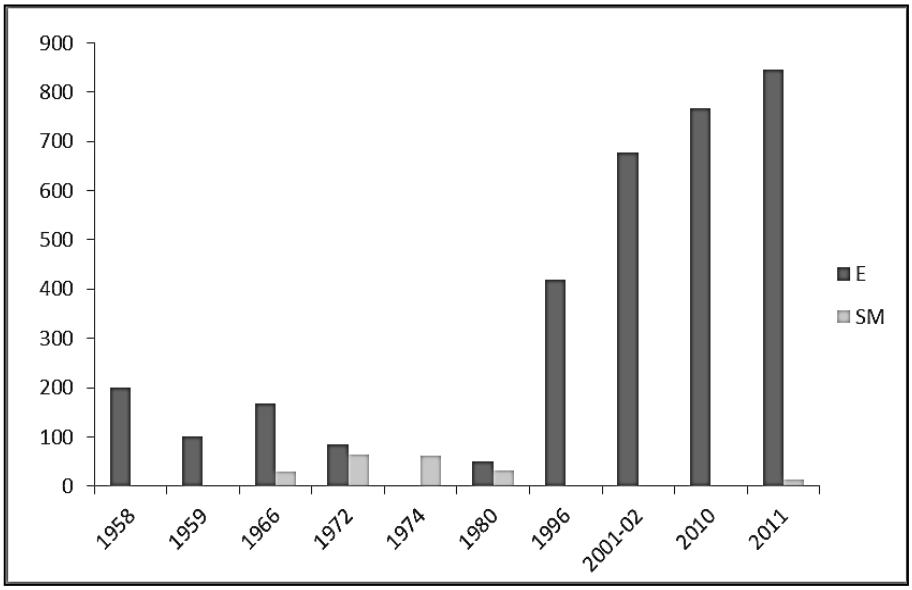

Figure 1. Total number of breeding pairs of the Eleonora's Falcon in the archipelago of Essaouira (E) and Sidi Moussa cliffs (SM).

populations had increased by 30 breeding pairs (35%). No change was found for all sites in the archipelago of Essaouira, where a considerable increase was not expected due to limited availability of favourable breeding sites. The population trend was positive over the last 40 years, but more substantially from late 1996s onwards.

'FalEleo' Program in Morocco

'FalEleo' program was launched in 2010 in partnership with the *Haut commissariat aux Eaux et Forêts et à la Lutte contre la désertification* and the PIM (Small Islands Initiative) in order to develop an action plan for the conservation of this species in Morocco, and as part of a wider project across the Mediterranean (Qninba *et al.* 2010, Rguibi *et al.* 2012). The program continues with the development of other studies which are part of the species' conservation plans (e.g., study of diet and feeding areas).

The definition of a national action plan for conservation of the species in Morocco included the creation of a working group. The aims of the "FalEleo" working group are:

- To estimate the number of breeding pairs in Morocco;
- To define the migration pattern of this falcon;
- To determine the relative importance of each site;
- To determine the food resources of both breeding sites.

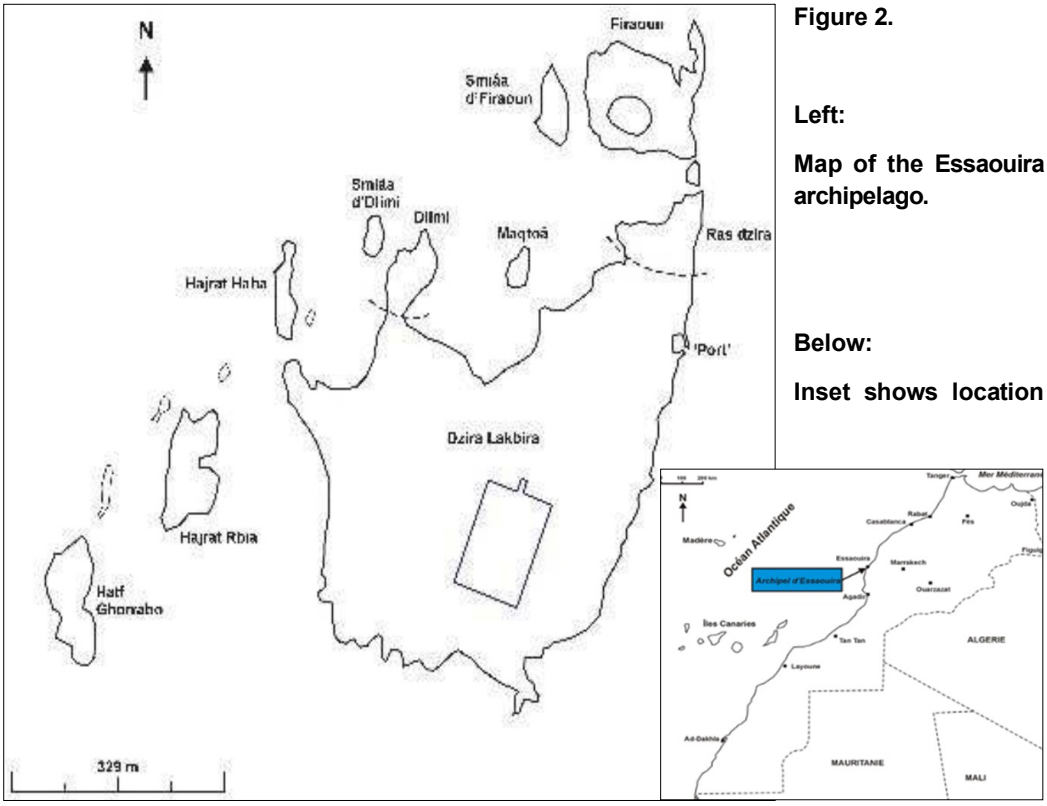

Figure 2.

Left:

Map of the Essaouira archipelago.

Below:

Inset shows location

Materials and methods

The archipelago of Essaouira (Mogador) is situated along the Moroccan Atlantic coast about 700 km south of the Strait of Gibraltar and consists of eight islets and rocks (Figure 2): Dzira Lakbira (Big Island or Main Island), 22.7ha, up to 29m high; Firaoun (Pharaoh Island), 2.1ha, 26m high with a pit (kind of crater) in the middle; Smia of Firaoun, a tower-shaped rock ("minaret") reaching 18m , on the west side of Firaoun island; Maqtoâ, an isolated rock on the north side of the main island and about 7m above sea level; Smia of Dlimi, another tower-shaped rock, also 18m high and located at the north-west of the main island; Haha Hajrat, a fairly narrow and elongated island covering 1ha and about 11m high; Hajrat Rbia, a relatively large island with an area of 1ha and a maximum altitude of 10m; and Hatf Ghorrabo (or Hatf Oughorrabo), the westernmost island of the archipelago, which covers about three-quarters of an acre and has an altitude of 13m.

The census was focused on those sites where breeding had previously been confirmed. Data were collected on three days every week from 1st July until 30th October during the years 2010 and 2011. In Dzira Lakbira and Smia of Feraoun, we prospected all accessible areas and visited active nests to record the geographical coordinates using a hand-held GPS navigator.

First results

Reproductive success. Egg-laying began during the first week of July in both years. The peak of hatching occurred during the last week of July, again in both years. The clutch size varied from 1 to 5 eggs, with a modal size of 3 eggs. A comparison of the distribution of clutch size in the two years showed no significant difference ($\chi 2 = 7.24$, $P = 0.29$). The maximum reproductive success (chicks per pair) was 1.25 in 2010, 2 in 2011. There were no significant differences between the reproductive success in two years ($H1,723=0.65$, $P = 0.72$, Table 1).

Models	N	AICc	WAICc
Number of pairs	1	-5,27	0,41
specific composition+number of pairs	2	-4,83	0,328
phenology+number of pairs	2	-3,21	0,146
Specific composition+phenology+number of pairs	2	-2,72	0,114
phenology	1	19,67	0,000001
specific composition	1	13,43	0,00003
phenology+specific composition	2	15,47	0,00001

Table 1. Models representing the relationships between reproductive success of Eleonora's Falcon *Falco eleonorae* and various parameters (N = number of variables).

Factors determining the reproductive success. The effect of factors specific to the colony and environmental variables on reproductive success was tested by generalized linear models (GLM). Selection of the best model was made from the rank of the Akaike Information Criterion (AIC) of each model; models used are those where the difference with the AIC of the best model is less than 2 (Burnham & Anderson 2002). There is a similarity of reproductive success for the colonies

in the two years of study (see above). The ratio between the number of colonies and the number of variable was 27.75. The average model was used and only the variable “Number of pairs" was used. The increased reproductive success with colony size is then explained by a combination of factors:

- The absence of predators (no rats or dogs);
- The phenology of reproduction of colonies does not appear to influence the reproductive success, which does not differ between early and late colonies;
- The availability of food in the feeding area is constant during the breeding season and allows young birds to eat;
- The isolation of nesting site and the absence of human activities (buildings, houses) is a major factor in the success of reproduction and has a significant effect on the falcon population in Essaouira.

Falco eleonorae vs passerines migrants. Preliminary analyses provided a better understanding of the influence of environmental factors on the population dynamics of Eleonora's Falcon, particularly in relation to their migratory behavior. Indeed, the results showed a correlation between the intensity of migration of passerines rich in energy reserves and survival of juveniles. It has been estimated at about one and a half million migrating passerines were consumed by the falcon colony during feeding of young (Figure 3). This aspect is potentially important to better integrate this dimension in the design and support programs to monitor the population on the island of Mogador.

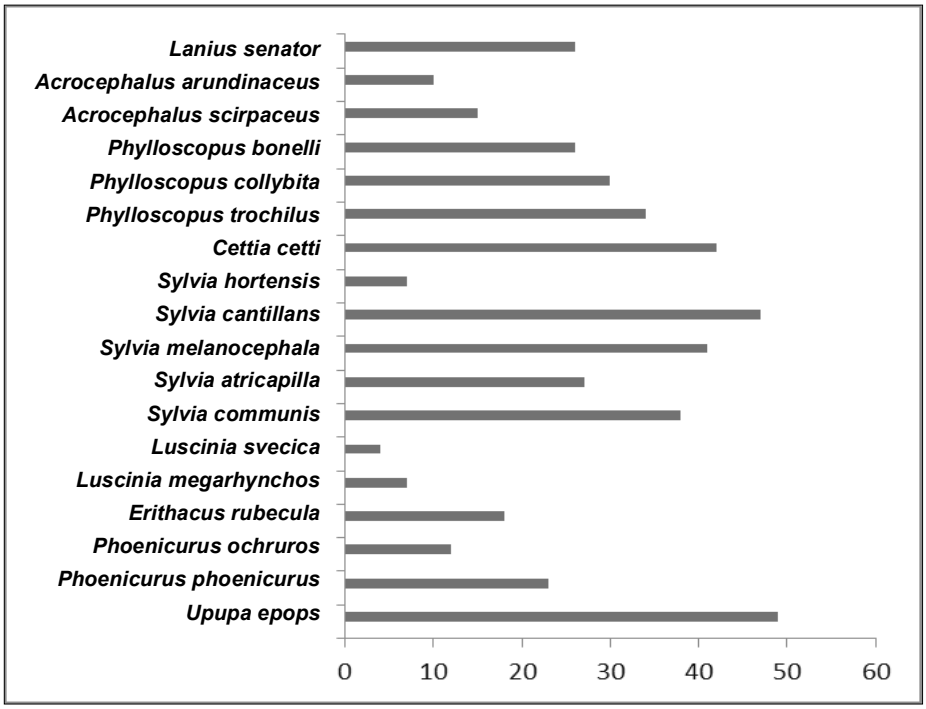

Figure 3. Numbers of birds by species taken by Eleonora’s Falcons in the breeding season at the Archipelago of Essaouira.

Migration routes. Two adult Eleonora's Falcons were trapped in Essaouira Island (*ca.* 1km of Essaouira, Morocco, 31.49° N, 9.78° W) on the 20 September 2011, when chicks were 15-20 days old. Birds were equipped with 9.5-gram Argos solar-powered satellite transmitters (Mellone *et al.*, unpublished).

Conservation challenges and actions undertaken on the small islands

Conservation actions implemented so far over the species' range include (a) the declaration of Eleonora's Falcon as a protected species, either specifically or among the birds of prey as a group, in all the countries where the species breeds; (b) the declaration of Eleonora's Falcon as a vulnerable or rare species on the Red Lists elaborated in some countries; and (c) the registration of most nesting sites (islands and small islands) as IBAs (Important Bird Areas), Protected areas, Specially Protected areas or Hunting Preserves. In Morocco, conservation challenges for Eleonora's Falcon focus on improving the breeding success by (a) reducing human disturbance; (b) combating ground predators and invasive species; (c) opposing the destruction and vandalism of nests and chicks in some colonies; and (d) measuring the concentration of pollution in sensible areas.

Management actions. The following actions have been proposed to be carried out: (a) preventing the invasion of domestic carnivores on islands with falcon colonies; (b) promoting pilot projects for developing sustainable tourism in most sensitive coastal habitats (e.g. cliffs of Sidi Moussa, where breeding number have decreased from *c.*80 pairs to 14 pairs, mostly because of increasing tourism projects along the cliffs); (c) posting, if necessary, a guard on breeding colonies to avoid all problems or vandalism; (d) defining areas (at nesting sites) where access should be forbidden from 1st July to 1st November; (e) promoting habitat protection in wintering areas and along falcon migration routes; (f) promoting the exchange of information and experiences on monitoring and management of nesting sites between experts and conservation organizations; and (g) raising public awareness to protection needs of the species and its habitats.

Research. The working group suggests that the following monitoring and research programs are developed: (a) estimating the total breeding population of Eleonora's Falcon through the establishment of a standard census protocol; (b) annual monitoring of breeding success; (c) monitoring human activities and land use on islands where colonies occur; (d) monitoring socio-economic development at the vicinity of colonies; (e) carrying out research on the impact of predators; (f) identifying routes and migration patterns; and (g) locating the wintering areas, define the ecological requirements and identify threats in these areas. Also, it is proposed to prepare a management guide recommending management measures favorable to the species on two sites in Morocco. This however requires prior knowledge on diet and habitat use by the falcons.

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Identification of flight behaviour and land use of Eleonora's Falcon *Falco eleonorae* in Skyros island, Greece: case study for a wind farm project

Ortaç Onmuş[1]

[1]Department of Biology Faculty of Sciences, Natural History Museum, Research and Application Centre, Ege University, Izmir, Turkey. ortac.onmus@ege.edu.tr

Summary: Skyros Island, in the central part of the Aegean Sea, is holding significantly important populations of Eleonora's Falcon *Falco eleonorae* (approximately 785 breeding pairs) and breeding seabirds. Due to its outstanding value in biodiversity, it is protected under a number of status. We aim to identify the flight behaviour and land use of Eleonora's Falcon in order to explore the possible impact of a very large wind farm project planned to be built on Kochilas Mountain in Skyros. The island and surrounding islets were divided into 1x1km UTM grids for the field survey and visited between 22 August and 20 September 2010. Line transect method was applied from land and sea. A total of 18 different line transects were applied in 18 different observation days and 138 different UTM squares were surveyed. With GIS, the mean and maximum number of soaring and flying birds, the observed flight directions and flight behaviours in each UTM square were calculated and compared with the topographical character of the mountain, wind speed, wind direction and current breeding locations of Eleonora's Falcons. The observations revealed that the falcons are using the survey site for soaring and for transect flights. However, they are not using it for searching flights when hunting. The results indicate that Eleonora's Falcons are using almost the entire Kochilas Mountain and its surroundings. They use the topographical traits of the mountain for transect flights and use the vertical winds as well as the updrafts provided by the mountain for soaring. The mountain enables the falcons to travel for off-shore hunting, lowers their energy consumption during these transport flights and maximizes the energy gain from hunting. Therefore Kochilas Mountain contributes to the healthiness and stability of the entire Eleonora's Falcon population in Skyros. As the falcons use the mountain for soaring and gliding flights, the construction of wind turbines on the mountain would clearly have a negative impact on their population.

Key Words: Flight behaviour, land use, Eleonora's Falcon *Falco eleonorae*, Skyros Island, Greece, wind farm project

Introduction

Eleonora's Falcon *Falco eleonorae* breeds on islands and islets in the Mediterranean Sea and off the North African coast in the east Atlantic (Walter 1978, Cramp and Simmons 1980). The breeding season is finely adapted to coincide with the peak of autumn bird migration (mainly passerine) since falcons feed their young with small and medium-sized birds on passage migration between Eurasia and African winter quarters (Hustler et al. 1990, Ristow and Wink 1995, Clark 1999, Gschweng *et al.* 2004). Recently there has been a plan to build a large wind farm on Kochilas Mountain in Skyros, a Greek island hosting several colonies of this sensitive species. An investigation on the land use of Eleonora's Falcon was required to explore the possible impact of

the farm on the breeding population of these colonies. The aim of this research was to identify the flight behaviour and land use of Eleonora's Falcon at and around Kochilas Mountain in Skyros.

Study Area

Skyros Island is located in the central part of the Aegean Sea and lies about 19 nautical miles to the northeast of Evvoia Island (Figure 1). It is the largest island of the Northern Sporades, with a total area of 20,693ha and its 38 surrounding islets of 0.1 – 433ha in size. The climate is typical Mediterranean with a mean annual rainfall of 500mm (max). The topography differs much between the north and the south parts of the island. The north-western part of Skyros is covered by Aleppo Pine (*Pinus halepensis*) forests and lush maquis vegetation. The southeast part, however, is the complete opposite, with Mount Kochylas (792m) sloping steeply to the sea in the northern and eastern parts and forming high cliffs. The island of Skyros is important for breeding seabirds, raptors and species associated with maquis vegetation. The most important bird species of the area, which have been used as qualifying species for the SPA Natura sites are *Falco eleonorae*, *Emberiza cineracea* and *Emberiza caesia* for the Kochilas site and *Larus audouinii*, *Phalacrocorax aristotelis desmarestii*, and *Puffinus yelkouan* for the surrounding islets site. Specifically, it hosts 8.5% of the national breeding population of *Falco eleonorae*, 3.75% of the national breeding population of *Larus audouinii* and 5-6% of the national breeding population or 0.9% of the EU population of *Phalacrocorax aristotelis desmarestii.* Due to its unique and outstanding value in biodiversity, Skyros Island has several protected areas according to both international and national legislations: Specially Protected Area (SPA), Site of Community Importance (pSCI), three different Wildlife Refuges and Important Bird Area (IBAs - International Designation Code IN06).

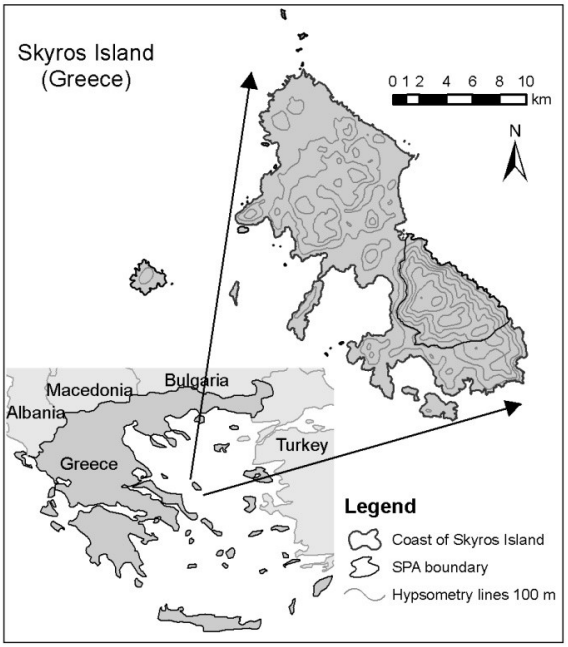

Figure 1. Study area location and main geographical features.

Materials and Methods

Eleonora's Falcons *Falco eleonorae* in Skyros Island were studied from 22 August to 20 September 2010. Field measurements of flight behaviour and land use were conducted through line transects (= survey tracks). The survey tracks were recorded using a GPS (Garmin) and the observations were carried out by using a 8X40 binocular (porroprism Nikon Monarch) and a 20–60X zoom fieldscope (Optolyth), a magnetic compass, an optical range finder (Newcon optic 7.5x30mm, with a maximum measurement range and accuracy of 1,200m ± 1%).

All the island and surrounding islets were divided into 322 1x1 km UTM squares (= grids) and the field observations were made according to these UTM grids. Most of the field observations and measurements were focused on and around the Kochilas Mountain which is located in the southern part of the island, where the wind power turbines are planned to be constructed. The GPS tracks that were recorded during the survey were transferred into a portable computer and all the tracks were converted as separate ArcGIS shapefiles using various softwares (Garmin MapSource 6.15.11, EasyGPS, and ExpertGPS).

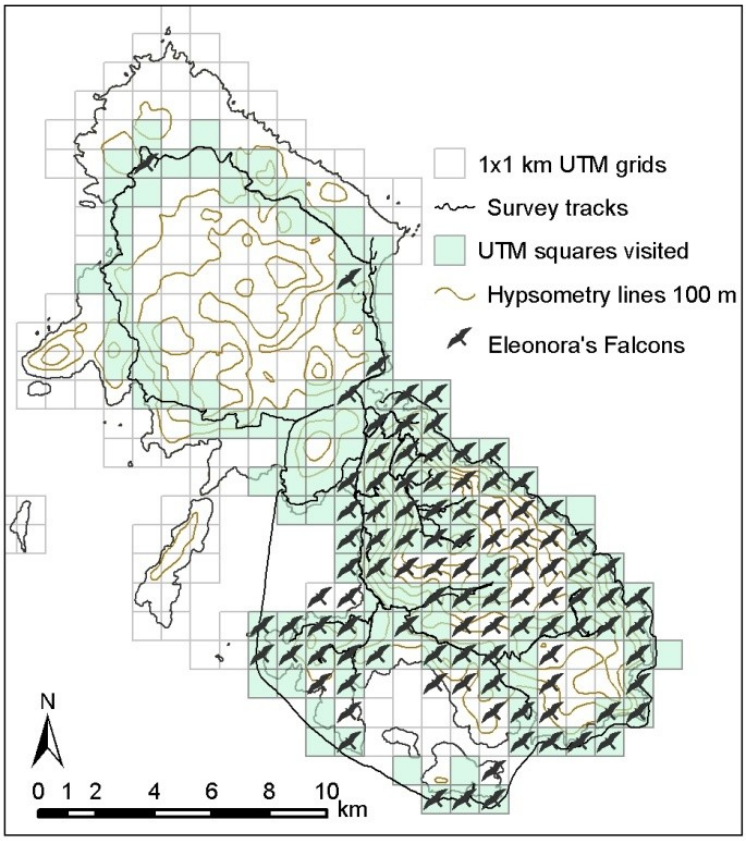

Figure 2. Details of the UTM grids used, the survey tracks (on land and on sea), the number of surveyed UTM squares, and Eleonora's Falcon observation localities on Skyros island.

The field observations started between 0830hrs and 0900hrs and ended between 1330hrs and 1400hrs. Observation durations were typically set at 30 minutes per UTM grid. During the observations, the number of birds seen (Eleonora's Falcons as well as other birds) were registered with their positions (i.e. in which UTM squares they were observed), the time of observation, their flight direction (FD, only for soaring birds) and flight behaviour (FB).

Field observations of FD were measured using a traditional scientific compass. To simplify the presentation of the results, the flight directions were classified according to their clockwise angle from the north, into 20 degree-intervals. FD for falcons flying over or near the observer was measured directly by compass, while FD for falcons flying at far distances from the observer, measurements were done by using the "best judgement" method. This method includes using a scientific compass, a range finder (to estimate the distance between the observer and the bird for calculating the GPS position of the bird), a GPS (to measure either the location of the observer or the possible location of the bird) and a map.

The observed behaviour of falcons was mainly classified using the terminology of Hedenstrom *et al.*(1999) and Rosen & Hedenstrom (2002), based on the characteristics of their flights: When they were soaring, flying, and/or searching for prey, they were .recorded as "Soaring birds", "Transect Flights (birds in active flights)", and "Searching Flights", respectively. A breeding pair survey had been carried out by HOS in 2005 and those results are used here for reference and comparison with the data collected in the present study.

Meteorological data (wind speed, wind direction, pressure, rain, cloud cover, and visibility) measured at 0900hrs and 1500hrs by the Meteorology Station of the Skyros Airport (Skyros Airport 2010) were obtained and used for the analyses. Two different data sets (two periods) were downloaded for each day of the field study. Each data set was called a "period" for convenience.

All the data collected during the field survey were entered into a computer spreadsheet (MS Excel and converted into MS Access). Statistical analyses were done by using SPSS (SPSS 15.0) program, GIS analyses were done by using ArcInfo module (ArcGIS 9.3) and all the graphs were produced using SigmaPLOT (SigmaPLOT 10.0). Mean (= total number of birds observed/total number of observation days) and maximum number of soaring and flying birds observed in each UTM square were calculated by using the raw data. Then these results were classified according to the method of Natural Breaks (Jenks) classification and presented based on ArcGIS 9.3 Software.

The observed flight directions of Eleonora's Falcons in each UTM square were first presented as raw data to provide general information. Then mean numbers of flying birds in each flight direction of each UTM square were calculated separately. Subsequently, density (= mean number of birds) dependent flight direction distributions were also presented to reveal the main flight patterns of Eleonora's Falcons in the study area and provide a more specific insight into their preferences.

Results

A total of 18 different line transects (survey tracks) were carried out in 18 different days during the study. Among them, 15 survey tracks were in the southern part, whereas 2 survey tracks were in

the northern part of the island. Besides these tracks, another line transect was applied at sea by a boat along the south and southeast coast of the island where the main Eleonora's Falcons breeding colonies are. During these survey tracks, a total of 138 different UTM squares were surveyed among which 98 were conducted only from land, 36 only from the sea and four were both from land and sea. Out of 138 UTM squares visited, birds were recorded in 114 different squares, among them Eleonora's Falcons were observed in 103 squares. The details of the UTM grids used, the survey tracks (on land and on sea), the number of surveyed UTM squares, and Eleonora's Falcon observation localities are shown in Figure1b.

Among all the wind data (n=59 periods) collected during the study, there were five (8.5%) periods with no wind and three (5%) with missing data. The three dominant wind directions during the survey were North (N: 0,0°) winds (n=22, 37.3%), North-North-East (NNE: 22,5°) winds (n=15, 25.4%) and North-East (NE: 45°) winds (n=4, 6.8%). Their mean wind strengths were 20.28 km/h, 17.79km/h, and 13.90 km/h, respectively.

Maximum number of birds showing transect flights, soaring and searching flights, their observed flying directions per UTM square are presented in Figure 3 (a-f). The main breeding colonies of Eleonora's Falcon are situated along a 27.7 km stretch of the south and the southeast coast of the main island and 7.3 km on the south and east coast of Sarakino islet, holding approximately 785 pairs of Eleonora's Falcons. The coast consists of almost vertical cliffs, facing east to northwest and ranging in height from 20 to 200 m. The number of breeding pairs and their locations are presented for reference and comparisons in Figure 3.

Discussion and Conclusion

The data presented in Figure 3 (a-f) clearly indicate that Eleonora's Falcons are using almost the entire Kochilas Mountain and its surroundings. The number of falcons presented in this report are based on observations with about 30-minute duration per UTM square, therefore the actual daily number of birds using the mountain is much higher than the numbers given here. The observations reveal that the falcons are using the survey site for soaring and for transect flights. However, they are not using it for searching flights for hunting. The total number of UTM squares in which they show searching flights is only two and within these squares there are water tanks which possibly concentrate some of the migrating passerines. Therefore, there should be a reason why falcons are significantly using the entire mountain although they are nesting on the cliffs of the main island and/or surrounding islets. A likely explanation is hypothesized below.During our observations falcons showed mainly four distinct flight patterns and Figure 3f indicates where these are used preferentially. These are:

Flights at low altitudes: Birds in this flight mode cover distances up to several hundred metres in a straight line and longer distances (within the range of a few km) by a combination of several such flights with a similar direction. This type of flight behaviour is very distinctive and can frequently be observed at the north-east side of the Kochilas Mountain (near Flea and Achili). Almost all falcons show this, and when reaching the hill near Achili, they start soaring there and gaining altitude togo possibly for offshore hunting. An obvious second reason to do that is probably to carry prey to the nestlings.

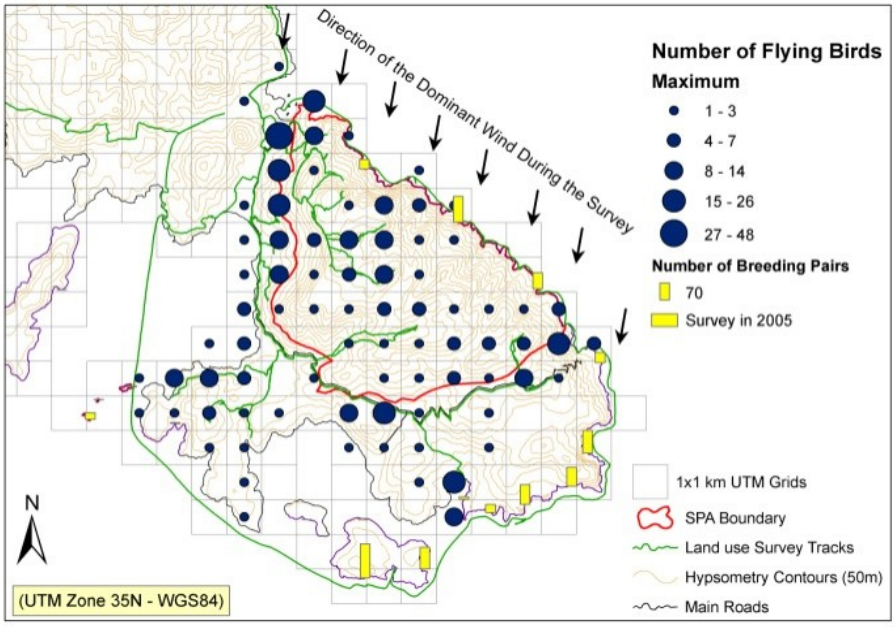

Figure 3a. Observed max. no. of flying Eleonora's Falcons and their locations on Skyros Island.

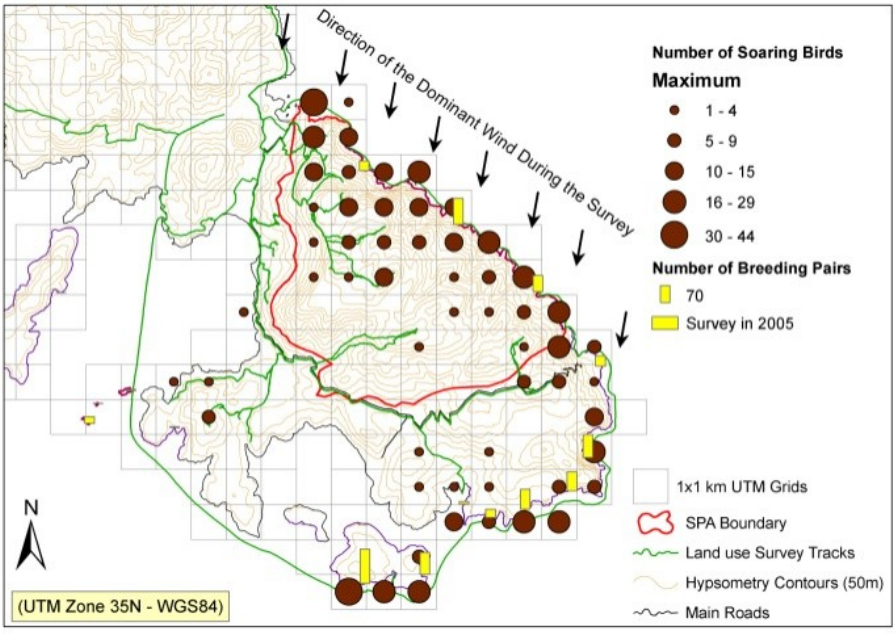

Figure 3b. Observed maximum number of soaring Eleonora's Falcons and their locations (the number of breeding pairs of Eleonora's Falcons and their breeding locations are also shown as yellow coloured columns for reference).

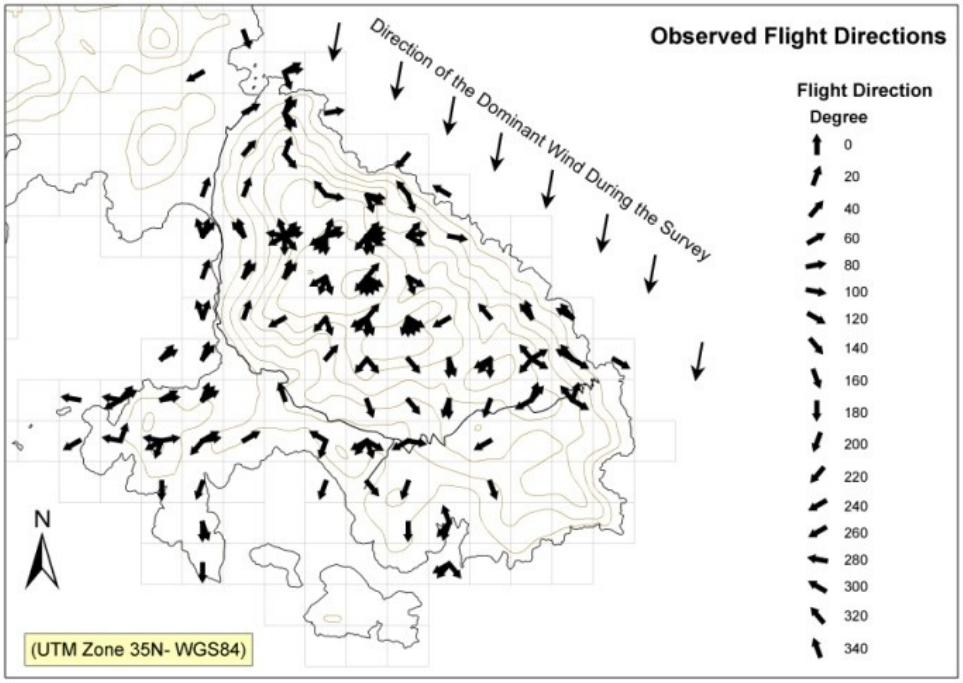

Figure 3c Observed flight directions of Eleonora's Falcons recorded and classified into 20 degree intervals.

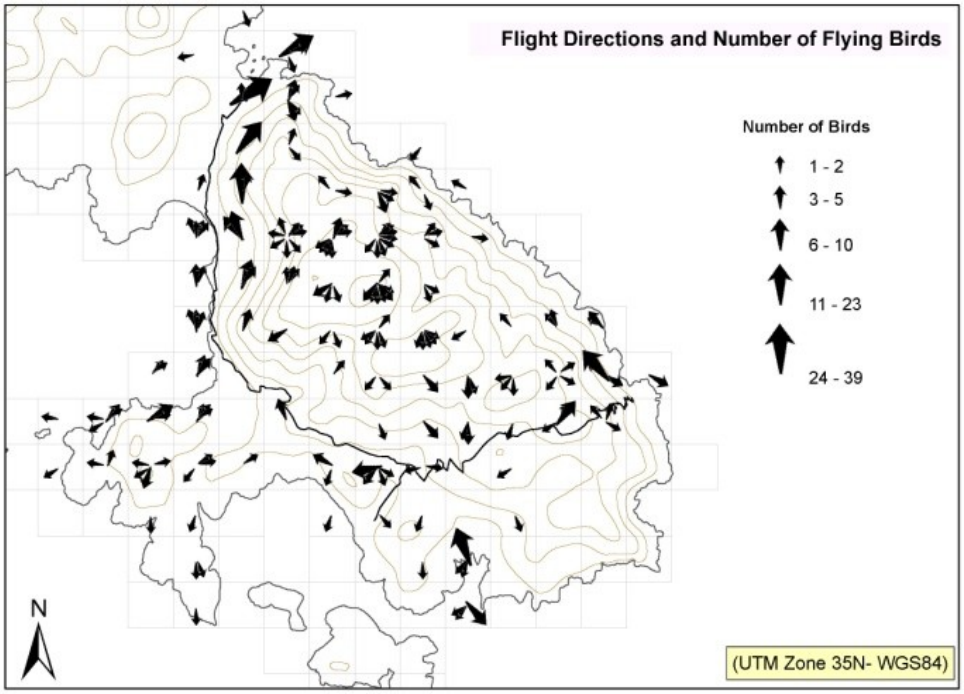

Figure 3d. Eleonora's Falcons' frequency of flight directions.

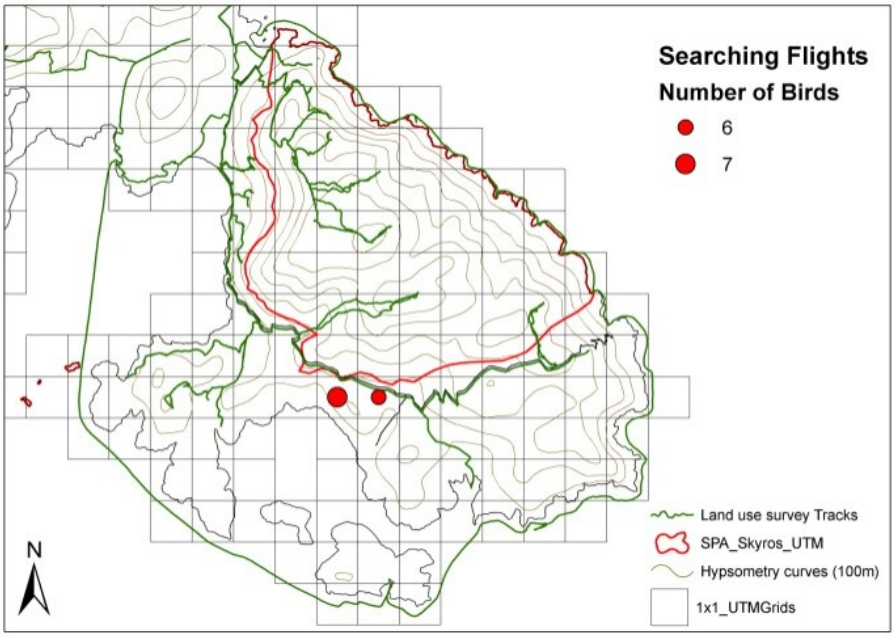

Figure 3e. observed number of searching flights of Eleonora's Falcons and their locations.

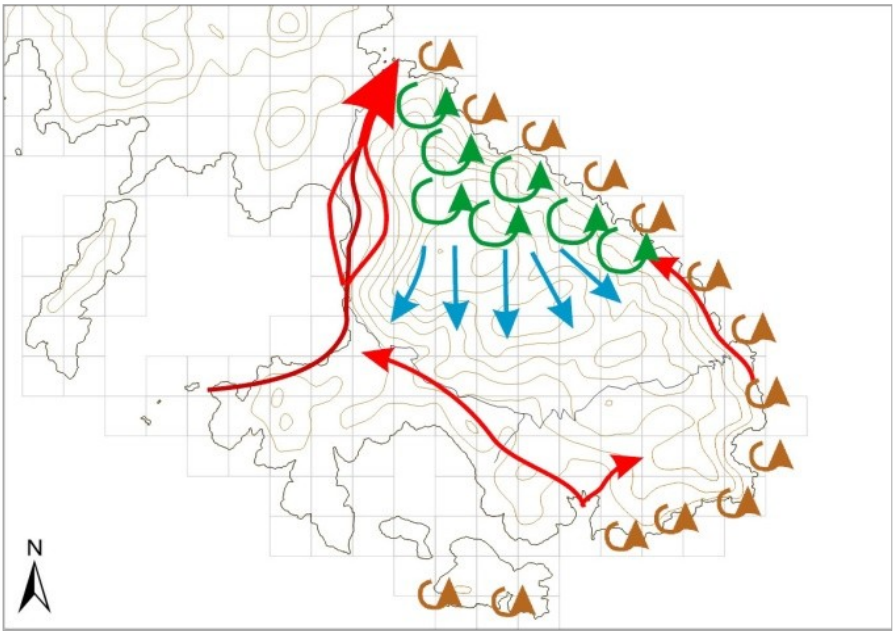

Figure 3f. Simplified scheme of the main flight patterns of Eleonora's Falcon: red coloured lines represent low altitude flight patterns and locations, green lines represent main soaring flight patterns and locations, blue coloured lines represent high altitude flight patterns and locations, and brown coloured lines represent soaring flight above breeding cliffs.

Soaring flights for gaining altitude: These occur at the north and top of Kochilas Mountain. The North and North-East facing slopes of Kochilas Mountain provide excellent places for soaring (see below).

Flights at high altitude: These occur at the top and south of Kochilas Mountain. Almost all birds observed above the southern slopes and ridges of Kochilas Mountain show flight directions towards the south, southeast or southwest.

Soaring flights to preserve altitude: This flight mode is common above the breeding sites to observe nests.

The soaring and flight behaviour of Eleonora's Falcons and how they use Kochilas Mountain can be explained by the falcon's demand of minimal energy consumption. Because energy demands of clutch and parents are high, the falcons have to commute several times per day between the breeding colony and off-shore hunting areas. To lower the energy expenditure during these transport flights and maximize the energy gain from hunting, falcons should use rising air when available, because gliding flight is energetically cheaper than powered flight. Also, soaring is an advantage for parent birds in order to maximize the rate of energy delivered to the young (Hedenstrom *et al.* 1999, Rosen & Hedenstrom 2002). Once a falcon reaches the top of the mountain it can easily set off for off-shore hunting or go on to its breeding location. Flight performance of Eleonora's Falcons were well studied and described by Hedenstrom *et al.* (1999) and Rosen & Hedenstrom (2002). These authors found that when Eleonora's Falcons perform a straight gliding flight without any external wind effect and without flapping ("level flight"), they have a mean flight speed of 10.46±3.5m/s and a sink rate (altitude loss per second) of -0.22 m/s (minus sign indicates downward movement). Therefore, theoretically, if such a falcon starts its journey at about 800m altitude from the top of Kochilas Mountain with the mean dominant north wind blowing at 20.3km/h (5.6m/s) and glides southward until it loses all of its initial altitude, it can glide up to a minimum of 25.3km and a maximum of 71.2km without spending effort. It should be noted that the wind speed used in this estimate relies on measurements at sea level, therefore the actual wind speed is much higher above the Kochilas Mountain due to the wind gradient effect. Thus, with this stronger tail wind, the falcons can glide even farther. As gliding flight is energetically cheaper than powered flight, the lift provided by the mountain enables the falcons to travel for off-shore hunting, lowers their energy consumption during these transport flights and maximizes the energy gain from hunting.

This study shows that Eleonora's Falcons use the topographical character of the mountain for transect flights and they use the vertical winds as well as the updrafts provided by the mountain for soaring. In conclusion Kochilas Mountain is necessary to lower the cost of transport and maximize the energy gain, and contributes to the health and stability of the entire Eleonora's Falcon population in Skyros. As the falcons use the mountain for soaring and gliding flights, the construction of wind turbines on the mountain would clearly have a negative impact on their population.

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State of knowledge and population trends of the Osprey *Pandion haliaetus* in the Mediterranean basin.

Flavio Monti[1]

[1]Maremma Regional Park, via del Bersagliere 7/9, I-58010 Alberese GR, Italy cheb.rep@tiscali.it

Summary: With less than 100 breeding pairs distributed within Corsica, the Balearics, Morocco and Algeria, the Osprey *Pandion haliaetus* shows traits of weakness and instability within a long time span in the Mediterranean. During the last century, persecution by man and habitat alterations determined local extinctions which resulted in a reduction of its distribution range. Direct management actions (e.g. creation of nature reserves, environmental improvements and strict conservation laws) have allowed a partial recovery of this raptor species in Corsica and the Balearics, but the present population still represents about only one third of the number of individuals living during the first half of the 20th century. In Morocco and Algeria, some surveys have been carried out to count breeding pairs, but data are still scarce. One of the most crucial stages for Osprey conservation is its recovery at historical breeding areas (e.g. Spain, Italy), for a sound conservation strategy at the Mediterranean scale. A state of knowledge on Osprey is reported here, as a part of a monograph written in the framework of the Mediterranean Small Island Initiative (PIM), co-ordinated by the French *Conservatoire du Littoral*. This paper includes a review of basic information on biology, ecology and geographical distribution of this species, on the basis of previous published studies. Data are reported on trends of the populations and their conservation status. The main threats, at the Mediterranean scale, are identified and discussed. Data on biology and spatial ecology of Ospreys in the Mediterranean are far from being comprehensive and future research should be addressed to fill the gaps. In particular, collecting information about movement patterns and dispersal strategies of the Mediterranean Ospreys represents a primary condition for conservation purposes. In this way, it will be possible to detect key conservation-related measures that should be applied in order to progress into an effective management of the species.

Key Words: Osprey, *Pandion haliaetus*, conservation, Mediterranean population, trends.

Introduction

Distributed worldwide, the Osprey presents a good conservation status at the global scale (*Least Concern*; IUCN, 2011). In spite of this, during the last decades most of the areas belonging to the ancient range of distribution have been lost, and local populations have disappeared in many parts of the Mediterranean area because of the strong direct persecution (e.g. Italy, Brichetti & Fracasso 2003; Portugal, Palma 2001; Greece, Cramp & Simmons 1980; Turkey, Cramp & Simmons 1980 ; continental part of Spain, Urios *et al.* 1991). As a result, the Mediterranean Osprey population is nowadays scattered and threatened, confined in few islands and stretches of coast. With less than 100 breeding pairs distributed between Corsica, the Balearics, Morocco and Algeria, the species is, hence, considered as endangered at this regional level and deserves sound conservation measures (Table1; Figure 1).

Geographic Area	Location	Breeding pairs (90)	References
Balearic Islands	Mallorca	12	Triay & Siverio 2008; (Triay unpubl., 2011)
	Menorca	5	
	Cabrera	2	
Spain	Marismas del Odiel (Huelva)	1	Muriel et al. 2010
	Embalse del Guadalcacin (Cadiz)	1	
Chafarinas Islands	Isla de Congreso	1	Triay & Siverio 2008
Italy	Maremma Regional Park (Tuscany)	1	Monti et al. 2011
Morocco	National Park of Al Hoceima	18	Orueta & Cherckaoui 2010
Algeria	West coast (Oran) + East coast (El-Kala)	15+2	Orueta & Cherckaoui 2010; Abdelaziz Telailia com. pers.
Corsica	West coast (Scandola MPA)	32	Dominici 2008; LPO Mission Rapaces 2011

Table 1 Geographical distribution and population size of the Osprey *Pandion haliaetus* in the Mediterranean.

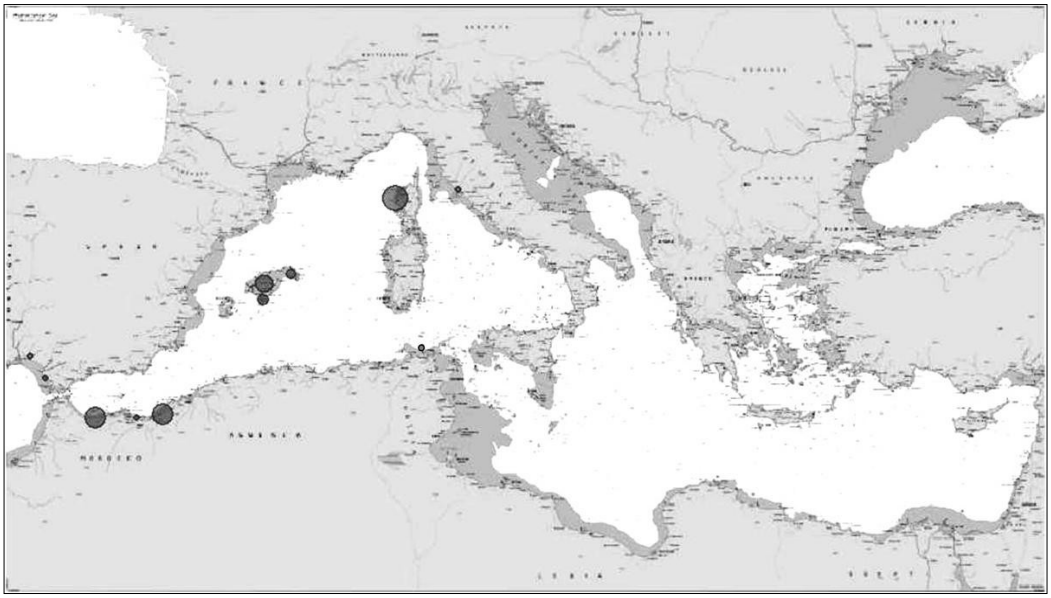

Figure 1. Geographical distribution of the Osprey *Pandion haliaetus* breeding populations in the Mediterranean. Breeding areas are shown by circles proportional to the population size (see Table 1).

Although the Osprey is almost exclusively a tree-nester in freshwater ecosystems of northern Europe, it chooses rocky cliffs for nesting and marine environments for fishing in the Mediterranean area (Cramp & Simmons 1980). The diet is principally represented by euryaline species of

medium-sized fish caught near the sea surface, such as *Liza spp.*, *Diplodus sargus*, *Dicentrarchus labrax*, etc. (Thibault & Patrimonio 1992). In Corsica, the diet of breeding Ospreys has been studied by identifying fish remains at nests: prey mainly belonged to mullets, e.g. *Liza ramada* and *Mugil cephalus*, and breams, e.g. *Diplodus sargus* (Francour & Thibault 1996). At Mediterranean latitudes, no significant variation in the timing of the breeding season has been reported among different locations. The breeding season begins between February and April, when pairs gradually return to occupy their nests (Thibault & Patrimonio 1991). Laying mainly occurs in March and April, while fledging takes place between June and July, generally after about 50 days from the hatching date (Bretagnolle & Thibault 1993). For the Corsican population, first flights were mainly recorded during the first week of July (Thibault & Patrimonio 1991). The Mediterranean population is thought not to migrate outside the Mediterranean Sea (Thibault & Patrimonio 1992; Thibault *et al.* 1996). Some individuals were actually observed in their breeding sites also during the winter (Thibault *et al.* 2001). Data from ringing recoveries, along sea coasts and wetlands in the Mediterranean (including North Africa), only suggest reduced movements within the basin (Thibault & Patrimonio 1989; Thibault *et al.* 1996; but see also Triay 2002). Nevertheless, movements, dispersal and migratory schedules are not yet studied in a detailed manner (e.g. by means of satellite telemetry; but see Triay 2002). Thus, basic information on spatial ecology of Osprey is still lacking at this scale of resolution and should be better investigated (Monti 2012).

Geographical distribution and population dynamics

Corsica. At the beginning of the 20th century a swinging number of 40-100 breeding pairs occupied the majority of Corsican rocky coasts (Thibault *et al.* 2001). In 1974, due to intense direct persecution, only three pairs remained. In 1975, the Nature Reserve of Scandola, located along the north-western coast of Corsica, was created. Thanks to this and other important direct management actions, Osprey population gradually recovered. A first period of rapid increase in population size (between 1974 and 1990) was followed by a second period of relative stability with fluctuations in population size likely due to the increasing density dependence (Bretagnolle *et al.* 2008). Due to the high philopatry of the species and local shortage of available nest sites, mature birds returned to breed in a relatively small area. Consequently, the mean distances between breeding territories decreased drastically and the competition for nest sites became intense (Bretagnolle *et al.* 2008). As a result, important changes in demography were observed: in particular, a reduction in hatching and fledging success were recorded (Bretagnolle *et al.* 2008). Nowadays, Corsican population is made of more than 30 breeding pairs, but it is still considered threatened.

The Balearics. During the 20th century, about 35-40 pairs inhabited all the main islands of the archipelago, before disappearing from Ibiza and Formentera in the 1970s (Terrasse & Terrasse 1977; Mayol 1978). Due to intense direct persecution, only 8 pairs remained in the 1980s (Triay & Siverio 2008). Thereafter the population gradually recovered, reaching a total of 16-18 breeding pairs in 1999 (Triay & Siverio 2008). Nevertheless, a decrease phase occurred between 2001 and 2007, when the population decreased to only 13 pairs. In 2008, 15 territorial pairs were present (Triay & Siverio 2008). The species presently occupies the rocky coasts of Menorca, Mallorca and Cabrera (Figure 1).

Morocco and Chafarinas Island. The first exhaustive survey of the coast of Morocco was carried out in 1983 (Berthon & Berthon 1984). The Osprey population was then estimated at 10-15 pairs scattered along the rocky coast from Cabo Negro to Al Hoceima (Thibault *et al.* 1996). More recent data showed little variation in numbers: 19-21 pairs in 1993 (Thibault *et al.* 1996) and 15-20 pairs mentioned by Franchimont (1998). Recent surveys assessed the population at 14-18 pairs, within the territory included in the National Park of Al Hoceima (Orueta & Cherckaoui 2010). In the Chafarinas Islands, belonging to the Spanish territory, the Osprey was present with two breeding pairs since the 1950s (Terrasse & Terrasse 1997). Since 1994, only one pair inhabits the archipelago, breeding on Congreso island (GENA 2004-2007; Triay & Siverio 2008).

Algeria. Past data are very scarce. A survey conducted in 1978 identified two breeding areas, the first located west of Oran and the second near El-Kala, as reported by Jacob *et al*. (1980) and later confirmed by Boukhalfa (1990) and Thibault *et al.* (1996). During the period 1989-1993 the population was estimated at 9-15 pairs (Thibault *et al.* 1996), similar to the previous estimate by Jacob *et al*. (1980). Repeated surveys carried out in the framework of the Mediterranean Small Island Initiative (PIM), co-ordinated by the French "Conservatoire du Littoral", confirmed the presence of the species between 2004 and 2006 in the Habibas islands (Mouret 2008). Both in 2007 and 2008, a breeding pair was found in the island of Grande Île (nest located in the Baie de la Morte), but in 2011 no breeding pair was observed. New data are needed for the whole country.

Main identified threats

Within the Mediterranean basin, as in other parts of the world, the main threats affecting Osprey populations are closely linked to human activities. During the first decades of the 20th century human disturbance, mainly consisting of trapping and egg-collecting, together with shooting both on the nesting grounds and on migration, represented a major threat for Osprey populations (Poole 1989, Thibault *et al.* 1996). Thanks to the legal protection enforced since 50 years ago, direct persecution has nowadays significantly decreased, even though illegal killings still occur in some places. Moreover, other kinds of indirect human activities can be considered as potential factors of disturbance and can be limiting the expansion of populations. In Corsica, for instance, Bretagnolle & Thibault (1993) recorded the negative effects on breeding individuals caused by boat passages in the neighbourhood of nest sites. This fact highlights the need of regulation of nautical tourist traffic even within protected areas. In other cases, electrocution due to presence of power lines running close to sea shores was identified as a major cause of adult mortality (e.g. in Corsica, Thibault *et al.* 2001, and in the Balearics, Triay & Siverio 2008). Losses can be reduced by structural modifications to the pylons, and existing structures can be replaced by others with a less dangerous design (Nadal & Tariel 2008). Finally, in many Mediterranean areas, intense habitat modifications, largely due to tourism and recreation, have forced the species to move away from historical sites along the seashore. The recolonization of some stretches of coasts occupied during the 19th and 20th centuries seems to be difficult because of the scarcity of suitable nesting sites. Finally, other factors can be considered as a potential threat. The over-exploitation of natural resources by man can influence the availability of prey, particularly in the case of dynamite-fishing activities along the rocky coasts of North Africa that can reduce the presence of fish shoals in the bays and, thus, deplete a key resource for the Osprey year-round

(Orueta & Cherckaoui 2010). In the long term, all this can strongly influence the fate of the small populations, such as those found in the Mediterranean.

Conservation actions

In the Mediterranean, the Osprey requires accurate management actions for achieving effective conservation. One of the most crucial strategies of conservation appeared to be the recovery of the historical breeding sites. In this context, two reintroduction projects are currently being run in the Mediterranean area. Thanks to them, the species has returned to breed in mainland Spain and Italy in 2009 and 2011, respectively.

In mainland Spain the Osprey had completely been extirpated in 1981 (Triay & Siverio 2008; Muriel *et al.* 2010). The last pair bred in the province of Alicante (Urios *et al.* 1991). A reintroduction program was started in 2003 in Andalusia to re-establish a breeding population in the Iberian Peninsula (Casado & Ferrer 2005). Between 2003 and 2009, 129 young Ospreys were released by means of the hacking technique in two different locations (Muriel *et al*. 2006 and 2010). The translocated nestlings were taken from wild nests in Germany (65.1%), Scotland (20.2%) and Finland (14.7%) (Muriel *et al*. 2010). The first breeding attempts occurred between 2005 and 2006, but only in 2009 a successful case of breeding was recorded. Two pairs are presently breeding in this area (Muriel *et al.* 2010).

In Italy, the Osprey became extinct as a breeding bird by the end of the 1960s (Bulgarini *et al.* 1998; Brichetti & Fracasso 2003). The last breeding sites for the species were located in Tuscany (Montecristo Island), Apulia (Frugis & Frugis 1963), Sicily and Sardinia (Thibault & Patrimonio 1992; Brichetti & Fracasso 2003). A reintroduction program for Osprey (carried out jointly by the Parc Naturel Régional de Corse and the Maremma Regional Park) was launched in coastal Central Italy in 2006, aiming at re-establishing a breeding population connected to the closest and vulnerable Corsican small breeding population (Sforzi *et al*. 2007). Between 2006 and 2010, 33 juvenile Ospreys were translocated from Corsica to Tuscany and were released by means of the hacking technique. In 2011, for the first time after about 40 years from its extinction, the Osprey bred in Italy again. One pair, consisting of a Corsican male translocated in 2006 and a wild female, successfully raised two chicks (Monti *et al.* 2011).

Conclusions

Although migratory strategies and movement patterns of the larger populations of northern Europe are well known (Hake *et al.* 2001), the dispersal dynamics and areas used during winter were not yet investigated in a detailed manner in the Mediterranean basin. Few banding recoveries were collected in the last decades (Thibault & Patrimonio1989) and only three Ospreys from the Balearics were equipped with satellite tags (Triay 2002). Northern African populations have not yet been investigated in any way. As a result, information on spatial ecology of the Osprey in the Mediterranean basin is still lacking, especially out of the breeding season. A long-term monitoring of ringed birds, together with satellite tracking and genetic analyses will allow gathering more information about spatial ecology and, at the same time, help understanding the foraging areas

used by breeding adults. In conclusion, a better understanding of the factors affecting Osprey population dynamics in the Mediterranean is a key prerequisite for conservation purposes and will consequently allow planning appropriate management actions.

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Effects of salinas reconversion on the Greater Flamingo *Phoenicopterus roseus* in the Camargue.

Anne-Sophie Deville[1,2], David Gremillet[2,3], Michel Gauthier-Clerc[1] & Arnaud Béchet[1]

[1]Centre de recherche de la Tour du Valat, Le Sambuc, 13200 Arles, France. deville@tourduvalat.org; gauthier-clerc@tourduvalat.org , bechet@tourduvalat.org
[2]Centre d'Ecologie Fonctionnelle et Evolutive (CNRS), 1919 route de Mende, 34090 Montpellier, France. david.gremillet@cefe.cnrs.fr
[3]FitzPatrick Institute, DST/NRF Centre of Excellence, University of Cape Town, Rondebosch 7701, South Africa.

Summary: The expected changes of salinas management in the Camargue could lead to modifications in the foraging area of many waterbirds, including the emblematic Greater Flamingos *Phoenicopterus roseus*. Here, we use mechanistic and individual-based models, combining physiological, behavioural and environmental characteristics to predict species' range in order to quantify the consequences linked with habitat changes. Two complementary models are used: NicheMapper^{TM} (Porter & Mitchell 2006) to assess the effects of variables on energetic expenditure and MORPH (Stillman 2008) to predict the effect of environmental changes on the distribution of Flamingos and their survival as a function of energetic needs and resources availability. This research started in 2010, so only methods and some preliminary results can be presented here.

Key Words: *Artemia*, Camargue, conservation, energy expenditure, feeding ecology, feeding functional response, mechanistic models, *Phoenicopterus roseus,* salinas, wetlands

Introduction

The Camargue salinas, in the south of France, are used by many waterbird species, including flagship ones such as the Greater Flamingo *Phoenicopterus roseus* (hereafter Flamingo). Flamingos are filter feeders (Jenkin 1957) using their unique bill structure to harvest a diversified diet including aquatic invertebrates and seeds (Johnson & Cézilly 2007). Biannual counts show that up to one third of the local Flamingo population can be found in salinas (Béchet, unpubl.), indicating how important these areas are for this species in the Camargue. These areas have a double role for Flamingos. Firstly, they are important areas for invertebrate production, especially during the Flamingo breeding period, with an important production of brine shrimps *Artemia sp. pl.* (hereafter *Artemia*) (Gabrion *et al.* 1982). Secondly, for historical reasons, the breeding area of Flamingos is located in Salin-de-Giraud salinas with an average of 10 000 pairs each year (Johnson & Cézilly 2007). Being independent from neighbouring marshes which undergo natural hydrological variations, the salinas are artificial pans representing predictably available wetlands, always filled with water at the same period year after year (Masero 2003). Béchet *et al.* (2009) showed that during dry years, with low water levels in natural wetlands, the proportion of breeding flamingos using salinas was twice as high as during a normal year, salinas acting as a refuge.

Flamingos can also forage in alternative habitats including freshwater marshes and natural brackish lagoons. In spring, they can forage in freshly sown rice fields causing important crop damage (Fasola & Ruiz 1996; Tourenq *et al.* 2001). The use of these agricultural areas by Flamingos could increase with further decline of natural wetlands and commercial salinas (Czech & Parsons 2002). Since the salt industry is presently declining in Europe, many salinas have been abandoned or transformed. In the Camargue, the area used for salt production has been reduced, some parts have been sold and a project is currently under study to start using some for the production of micro algae. All these modifications represent potential changes in the foraging areas for Flamingos. The goal of this study is to understand how these environmental changes will affect foraging decisions and spatial distribution of Flamingos. This should help in quantifying the effects of salinas reconversion on concerned bird population size, as well as the surface areas of salinas (or equivalent habitats) that are necessary to maintain the present Flamingo population size in the Camargue.

Methods

To assess the consequences of salinas reconversion, we use mechanistic and individual based models, increasingly used in conservation. They consist in combining physiological/behavioural traits and environmental characteristics to predict species' ranges. Here, we use MORPH (Stillman 2008), which needs numerous data on Flamingo foraging ecology and environmental parameters. MORPH requires three key parameters. (i) the functional response, i.e. the intake rate or the bird ingestion efficiency as a function of prey density, (ii) the energetic requirements in function of environmental variables, for which another mechanistic model, NicheMapper^{TM} (Porter & Mitchell 2006), will be used, and (iii) prey distribution in the Camargue. The two latter parameters will not be dealt with in the present paper.

Functional responses quantifying changes in predators intake rate relative to prey density (Solomon 1949) are key elements for understanding habitat selection, food resource preferences (Mysterud & Ims 1998), food webs and hence general predator-prey interactions (Dale *et al.* 1994; Barnhisel & Kerfoot 2004). Functional response measurements provide two parameters: the attack rate (instantaneous rate of food discovery) and the handling time, i.e. time required to extract and ingest food (Holling 1959). The value of these parameters can differ according to food item (Badii *et al.* 2004) and/or substrate types (Kuhlmann & Hines 2005). Functional responses typically inform about (a) the foraging effort necessary to balance the energy budget of a predator feeding on a given resource, (b) the threshold prey density below which sustainable foraging is compromised (Enstipp *et al.* 2007), and (c) foraging efficiency depending on prey type.

Holling (1959) described three main types of functional responses. First, a predator has a Type I response when it presents a negligible handling time and keeps up with increasing prey densities by eating them in direct proportion to their abundance in the environment. Its intake rate therefore increases linearly with increasing food density. Nevertheless, this linear increase ceases at a maximum food density beyond which the intake rate becomes constant (Begon *et al.* 1990). This Type I functional response is defined by the following equation: Intake rat e= a*D where D is for density. When consumers require a non negligible handling time to ingest their prey, the intake

rate initially rises quickly as the density of prey increases, but then decelerates asymptotically towards a plateau. Such consumers present a Type II functional response, which is the most commonly found (Jeschke *et al.* 2004), following the equation: Intake rate = a*Density/ (1 + a*h*D). Finally, the Holling's Type III functional response is similar to Type II, but differs in that the intake rate is depressed at low prey density. Such a response is found if the predation rate increases with increasing prey density and results in a per prey capture rate that initially increases, and then decreases, with prey density. Type III should follow equation: Intake rate = 1/(1+exp(-a*D). According to theory, Type I response is exclusive to filter feeders (Holling 1965) as they are theoretically not limited by food processing. This is explained by their ability to capture several food items simultaneously and the relative small size and immobility of their food compared to those of non-filter feeders (Jeschke *et al.* 2004).

Our objective is to evaluate Holling's predictions in Flamingos, a vertebrate filter feeder, for different food items in order to better assess how habitat changes might affect its foraging performance, and hence, its population dynamics across the Mediterranean. Here we tested functional response on *Artemia* and rice seeds. The study was conducted at Basle Zoo (Switzerland) in February and March 2011. Eleven birds, randomly selected from a flock of 112 Flamingos, were kept in a 15 m² indoor aviary. Foraging trials were done by putting different densities of preys in a 28x28cm tray, 13.5cm deep. In order to attempt to get only one individual per trial, we used a second tray as a way to scatter the birds in the aviary. The night before each trial, birds were deprived of food and trials were performed in the morning. The order in which the different food densities were offered was randomized. A video-camera recorded the bird behaviour during each trial. One trial started when the first bird put its bill in the tray. Rings permitted individual recognition. Trial duration was not too long in order to avoid a potential bias linked to food depletion (Royama 1971, Fritz *et al.* 2001). Since Flamingos forage mainly by filter-feeding, it was not possible to assess peck rate and bite size, both of which are generally measured in functional response studies. Rather, we directly measured the mass of *Artemia* or the number of rice seeds taken per second of filtering, as in Pettifor *et al.* (2000). We offered 1, 2.5, 5, 15, 30, 50, 90, 150 and 200g of live *Artemia* per tray, representing a range from 130 to 26,000 *Artemia* and 50, 100, 300, 600, 1000, 2000, 3000 or 4000 rice seeds per tray, representing a range from 0.5kg to 40kg m^{-2} of dry rice (in order to simulate natural conditions, seeds were spread on a 4cm sand layer). As the intake rate was still increasing from 3000 to 4000 rice seeds, we added three trials of 6000 seeds in order to search for a possible asymptotic intake rate. Then, intake rate for each food item was calculated by taking the density of food remaining and relating this value to the foraging time as determined from the video footage. In cases where it was not possible to calculate individual intake rate because several individuals ate in the experimental tray, we calculate an average intake rate for the set of birds encountered. The data set thus consisted of 43 experimental trials for *Artemia* and 51 experimental trials for rice.

Statistical analyses. We used linear and non linear models to assess variations in intake rates with increasing resource densities. Type I functional responses were assessed by fitting a linear relationship between intake rate and food density. Type II and Type III functional responses were fitted with package 'nlme' in R (R Development Core Team 2012), using the equation Intake rate~a*D / (1 + a*h*D) (where D, a and h are as defined previously) to test a Type II and IR~1/

(1+exp(-a*D)) to test a type III. Model selection was based on the Akaike Information Criterion with adjustment for small sample sizes (AICc, Burnham & Anderson 2002).

Holling Model Type	Description	Equation	AICc	∆ AICc	K	Deviance	AICc weights (%)
Type II	Intake rate varies asymptotically with food density	IR~a*D/(1+a*h*D)	566.49	0	6	553.11	1
Type I	Linear relationship between intake rate and food density	IR~a*D	589.74	23.25	4	581.11	0.00
Type III complete sigmoid	Intake rate remains low at low prey densities and then accelerates as a Type II (sigmoid shape)	IR~1/(1+exp(-a*D))	718.03	151.54	3	711.66	0.00

Table 1. Model selection for Types I, II and III functional responses of Greater Flamingos feeding on *Artemia* (130 to 26000 *Artemia* per tray). The best model is indicated in bold. K corresponds to the number of parameters, IR designs intake rate, D is the food density, a the attack rate (in number of *Artemia* per second) and h the handling time (in seconds).

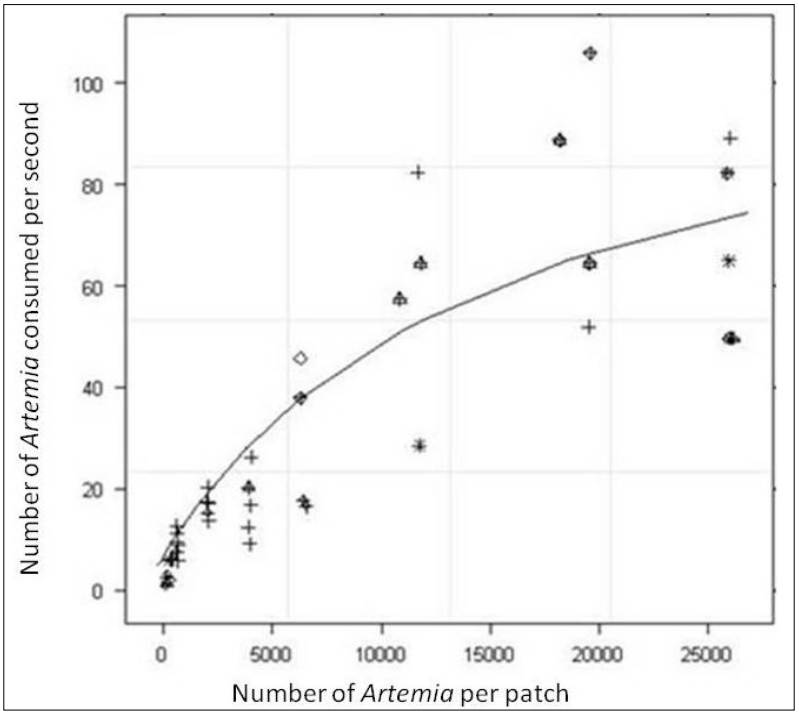

Figure 1. Intake rate (number of *Artemia* consumed per second) of Greater Flamingos as a function of *Artemia* density (number of *Artemia* per patch).

Results

Intake rate on *Artemia* varied asymptotically with food density, thus presenting a type II functional response (∆ AICc >2; Table 1). The mean instantaneous quantity of *Artemia* searched during the entire foraging trial (in number of *Artemia* per time unit, *i.e.* the attack rate) was 0.0081±0.0015 *Artemia* second^{-1} ($p<0.001$). The average time spent on processing *Artemia* (*i.e.* the handling time) was 0.0088±0.0013 seconds ($p<0.001$). The fitted model was thus Intake rate= (0.0081 * Density)/ (1+0.0081 * Density * 0.0088). We calculated the asymptotic intake rate corresponding to ratio 1/h. The plateau was around 113 *Artemia* per second (Figure 1).

Rice intake rate also increased asymptotically with food density until a plateau (Type II, ∆ AIC>2, Table 2). The mean instantaneous seeds searched during the entire foraging trial (in number of seeds rice per time unit, *i.e.* the attack rate) was 0.020±0.0057 seeds per second ($p<0.001$). The average time spent on processing seeds rice (*i.e.* the handling time) was 0.22±0.013 seconds ($p<0.001$). The fitted model was thus Intake rate = (0.020*Density)/ (1+0.020*Density*0.22). Asymptotic intake rate was 1/0.22 rice seeds per second, thus corresponding to approximately 5 rice seeds per second (Figure 2).

Holling Model Type	Description	Equation	AICc	∆ AICc	K	Deviance	AICc weights (%)
Type II	Intake rate varies asymptotically with food density	IR~a*D/(1+a*h*D)	426.46	0	6	413.65	1
Type I	Linear relationship between intake rate and food density	IR~a*D	475.79	49.33	4	467.41	0
Type III	Intake rate remains low at low prey densities and then accelerates as a Type II (sigmoid shape)	IR~1/(1+exp(-a*D))	565.15	138.69	3	558.93	0

Table 2. Model selection for types I, II and III functional responses of Greater Flamingos feeding on rice seeds (50 to 6000 rice seeds per tray). The best model is indicated in bold. K corresponds to the number of parameters, IR designs intake rate, D is the food density, a the attack rate (in number of seeds per second) and h the handling time (in seconds).

Discussion

In this study, we analyzed Flamingos' functional responses for *Artemia* and rice seeds. Holling (1959) predicted that filter-feeders should show a Type I functional response because they have negligible handling time, allowing them to ingest many items simultaneously. Nevertheless, a non-linear Type II functional response adequately described our data in both cases (Figures 1 and 2). Thus, contrary to theoretical predictions for filter feeders (Holling 1965), Flamingos were not able to ingest food items in direct proportion to their abundance. This rather surprising result

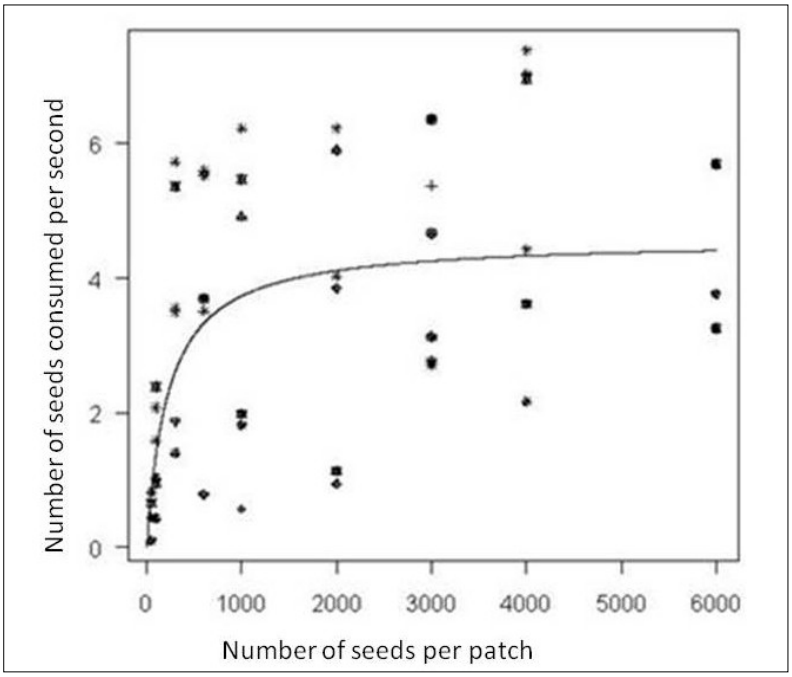

Figure 2. Rice intake rate (seeds consumed/ second) of Greater Flamingos as a function of rice density (seeds per patch).

might be due to the structural limit set upon intake rates by the maximum volume of water which can be filtered through the Flamingo's bill per unit of time, or a possible clogging of the lamellae (Guillemain *et al.* 1999).

This result has major implications for the conservation and management of Flamingos. For instance, knowing the food density in a wetland and Flamingo's energetic requirements, we can predict what the energetic gains per hour are and the time required for the species to be satiated. Furthermore, under natural conditions food densities required for Flamingos to reach asymptotic intake rates are rarely met for any of the food items presented in this study (Britton & Johnson 1987), stressing the negative effect of a potential decrease in prey density for Flamingo foraging. The majority of Mediterranean Flamingos forage in commercial salt pans, which harbour high invertebrate biomass, especially *Artemia*. However, >50% of such habitats have been abandoned over the last 50 years (López *et al.* 2010) resulting in a lower profitability for Flamingos highly dependent on salt pans (Béchet & Johnson 2008) and to the development of competing land uses, such as tourism or industry (Weber *et al.* 1999, Masero 2003, Ortega *et al.* 2004). In this context, functional relationships such as those determined in our study are key input for mechanistic models required to predict individual energy budgets (Kearney & Porter 2004, Fort *et al.* 2009). This information can then be amplified within individual-based models such as MORPH (Stillman 2008), to predict population responses to potential habitat changes such as those faced by Flamingos across the Mediterranean (Fargione *et al.* 2008).

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Greater Flamingo *Phoenicopterus roseus* breeding in Sardinia: numbers and management issues

Sergio Nissardi[1], Carla Zucca[1], Pier Francesco Murgia[2] & Alessia Atzeni[3]

[1]Anthus s.n.c., Via Luigi Canepa 22, 09129 Cagliari, Italy. anthus@anthus.info
[2]Fraz. S. Isidoro, Mela Murgia, Quartucciu CA, Italy. murgia@hotmail.it
[3]Parco Naturale Regionale Molentargius Saline, Edificio Sali Scelti, 09100 Cagliari, Italy. alessia.atzeni@molentargius.net

Summary: The Greater Flamingo *Phoenicopterus roseus* was possibly breeding in Sardinia in historic times. After some breeding attempts in the 1970s, colonies were regularly recorded from 1993 in the immediate surroundings of the city of Cagliari, initially on Stagno di Molentargius, then also at Macchiareddu salinas. The local breeding success was affected by several limiting factors, usually connected to the high level of human activities in this area. Nevertheless, if not for a few instances of total colony failure, usually due to stray dogs, the breeding success has been relatively high, in the range of 61-94%. Colour marking of chicks started in 1997 and showed a broad juvenile dispersion to North Africa, France and Spain. According to ring readings, the Cagliari breeders rely for feeding on many wetlands within a radius of 100 km from the colony.

Key words: Greater Flamingo, *Phoenicopterus roseus*, breeding success, limiting factors, conservation management

Introduction

Sardinian wetlands have been known for a long time as important stop-over and wintering grounds of the Greater Flamingo *Phoenicopterus roseus*. Some unconfirmed information about local breeding was reported in the 19th century and early 20th century (Cara 1842; Giglioli 1886; Bittanti 1911). Since then, breeding evidence has been lacking until a few failed attempts were recorded in Molentargius in 1975, 1980 and 1992 (Schenk 1976; Mocci Demartis & Pinna 1980; pers. data) and in Saline di Macchiareddu in 1979, 1981 and 1982 (Brichetti *et al*. 1992). Regular breeding started in Molentargius in 1993 (Schenk *et al.* 1995; Johnson & Cézilly 2007 and references therein). A considerable increase of the number of breeding pairs was recorded thereafter, colonies being located initially at Molentargius and later on in the nearby Saline di Macchiareddu. Several recent breeding attempts outside the Cagliari wetlands were recorded too, but these always failed, due to probable disturbance and predation by people, dogs or foxes. In 1997, the international Greater Flamingo ringing program was extended to Sardinia and continued till 2011 with some discontinuities, usually due to lack of funds. In this paper we present an overview on population size at the breeding colonies, breeding success, limiting factors and dispersion of flamingos ringed at Sardinian colonies over a period of 15 years.

Methods

The number of breeding pairs has been estimated either on distance counts of the brooding birds and/or on nest counts after the breeding season. The numbers of fledglings have been estimated by distance counts of the crèche and in four cases counts were made on pictures taken from helicopter. The breeding success has been estimated as the ratio number of fledglings / number of pairs (minimum values)´ 100. In Macchiareddu the breeding success estimate has been improved in 2004-2009 by the additional count of dead chicks and lost or abandoned eggs near the breeding colony.

Year	Molentargius			Saline di Macchiareddu			Total	
	Pairs (min. value)	fledglings	breeding success	pairs	fledglings	breeding success	pairs	fledglings
1993	1,300	940	72%				1,300	940
1994	860	710	83%				860	710
1995	750	635	85%				750	635
1996	950	850	89%				950	850
1997	2,400	1,800	75%				2,400	1,800
1998	4,400	4,120	94%				4,400	4,120
1999	*unsuccessful breeding attempt*			800	600	75%	800	600
2000	2,700	2,500	93%	700	0	0%	3,400	2,500
2001	2,392	0	0%				2,392	0
2002	3,100	2,840	92%				3,100	2,840
2003	4,600	4,000	87%	1,400	850	61%	6,000	4,850
2004	1,500	1,200	80%	6,500	5,600	86%	8,000	6,800
2005				7,600	6,900	91%	7,600	6,900
2006				7,400	5,800	78%	7,400	5,800
2007				14,000	12,000	86%	14,000	12,000
2008				2,310	850	37%	2,310	850
2009				8,685	5,912	68%	8,685	5,912
2010	*late season breeding attempt*			500	0	0%	500	0
2011	6,963	6,039	87%				6,963	6,057
Total	**32,615**	**25,652**	**79%**	**49,395**	**38,512**	**78%**	**82,010**	**64,164**

Table 1. Numbers of Greater Flamingos breeding at Molentagius and Macchiareddu (Cagliari, Sardinia), 1993-2011.

Results

Until 1998, only Molentargius has been occupied by breeding flamingos, with a fluctuating number of pairs. Macchiareddu has been colonized in 1999, and since 2004 this site is the most important one, hosting increasing numbers. The breeding success has always been high, between 61% and 94%, except in two years when the colony was totally abandoned and no further breeding attempts were made (Table 1). Away from Cagliari, some failed breeding attempts were recorded in the following localities and years: Sulcis wetlands (SW Sardinia) in 2000 and 2001 (Grussu 2000 and 2001); Stagno di Cabras (north of Oristano) in 2001; and Stagno di S'Ena Arrubia (south of Oristano) in 2001 and 2003 (Nissardi and Zucca unpubl.).

The two cases of complete abandonment in Molentargius resulted from the presence of stray dogs. These caused the desertion of the colony during the courtship phase in 1999 (the colony then moved to Macchiareddu), and in 2001 a total abandonment of the eggs at the end of the incubation period. No successful breeding attempts followed in that year. Cases of total desertion of the colony were recorded also at Macchiareddu in 2000 (caused by human-induced disturbance), 2010 (for unknown reasons) and again 2011. In the latter year a stray dog caused the total desertion of the colony, but part of the flamingos made a successful breeding attempt late in the season at Molentargius.

Further limiting factors also affect the breeding success, though generally with a moderate impact. In 1993, at Molentargius, high interest by the media for the first Sardinian breeding episode attracted amateur photographers and film-makers during the occupation phase of the colony, causing the abandonment of the nests closest to their hide. Some disturbance by photographers has been recorded more recently in Macchiareddu, especially in 2009, when incubating birds were frequently forced to move and many eggs fell from nests. In some cases, hydraulic works affected the vicinities of the breeding site. As a consequence, birds had to delay site occupancy or move to other breeding sites. The presence of power lines across wetlands (now removed from Molentargius, but still present at Macchiareddu) caused a mortality in both adult and young individuals. In 1997, around 8% of the locally ringed chicks died after crashing into power lines just after fledging.

Predation by Yellow-legged Gull *Larus michahellis*, a species that heavily depends on resources made available by man, is low in Molentargius, where only about 10-20 pairs breed. It seems, however, to be an important cause of egg and chick losses in Macchiareddu, where the breeding population of the gulls is more than 200 pairs. A further problem that has occurred in Molentargius is the loss and erosion of dykes., as these are not being managed after the interruption of salt production. There is now a scarcity of suitable dykes and islets, resulting in strong competition for breeding sites that affected mainly other bird colonies, such as Slender billed Gull *Larus genei*, which flamingos force to select sub-optimal sites.

Discussion

The conservation of the Sardinian breeding population strictly depends on the management of the two sites in which the Greater Flamingo has successfully bred until now: the active salt-pans of Macchiareddu and the disused salt-pans of Molentargius, presently a Regional Park. Moreover,

re-sightings of ringed birds during the breeding period suggest that the survival of the breeding population strongly depends also on the management of several other Sardinian wetlands within a radius of 100 km from Cagliari, which are used for feeding. Availability of food resources across such a large area and a low incidence of limiting factors are the reasons for a high productivity which have been recorded so far at the Sardinian colonies. An increase of re-sighting effort on feeding areas during the breeding period is one of the monitoring priorities of the flamingo project in Sardinia.

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Part 5 : Surveys and Conservation at national and regional level

State of knowledge of the populations of vulnerable raptor and seabird species in the Mediterranean: threats identified and action proposals

Mathieu Thévenet[1]

[1]Project Albatros / PIM initiative, 3 rue Marcel Arnaud, 13100 Aix-en-Provence, France.
m.thevenet@conservatoire-du- littoral.fr

Summary: In the framework of the « Albatros project » part of the "Mediterranean Small Islands Initiative" coordinated by the French Coastal Agency, in collaboration with more than 30 people from 10 different countries, a state of knowledge was elaborated in 2011 and 2012 concerning 7 target species of Mediterranean raptors and seabirds. In order to get a general picture of the conservation status of these species, a monograph has been prepared for each species, including information about biology, ecology, threats in the small islands and proposals of conservation actions specific for Mediterranean small islands. As a first step, censuses and monitoring data were collected from managers, researchers and institutions. The monographs were written by a number of experts in management and ornithology. A review of the monographs was carried out in spring 2012. All these activities are aimed at pooling and sharing of data among all the actors of bird conservation in the Mediterranean.

Key Words: Mediterranean Shag, *Phalacrocorax aristotelis desmarestii*, Mediterranean Storm-petrel, *Hydrobates pelagicus melitensis*, Yelkouan Shearwater, *Puffinus yelkouan*, distribution, status, threats, Mediterranean

In the framework of the project *Albatross* coordinated by the French Coastal Agency (*Conservatoire du littoral*) and with the technical support of the CEN PACA (regional nature conservancy for south-eastern France), a state of knowledge was completed concerning seven vulnerable bird species inhabiting small islands. A monograph has been elaborated for each of them, gathering information from research programs, publications and the managers of protected areas.

The species concerned are the Osprey *Pandion haliaetus* (by Flavio Monti, University of Ferrara);

the Eleonora's Falcon *Falco eleonorae* (by Hamid Rguibi - University of Chouaib Doukkali of Al Jedida, and Abdeljebbar Qninba - University Mohamed V of Rabat); the Lesser-crested Tern *Sterna bengalensis emigrata* (by Abdulmaula Hamza - Hull University, and Hichem Azafzaf - Association des Amis des Oiseaux); the Yelkouan Shearwater *Puffinus yelkouan* (by Karen Bourgeois - A dos d'île); and the Mediterranean Shag *Phalacrocorax aristotelis desmarestii*, the Mediterranean Storm Petrel *Hydrobates pelagicus melitensis* and the Cory's Shearwater *Calonectris diomedea diomedea* **(*)** (by the members of the CEN PACA - managers of the Islands of Marseille, Nature Reserve)

The elaboration of these documents was a one year process running from 2011 to 2012, following a decision taken in 2009. In October, the "PIM initiative" (initiative for the small Mediterranean islands, acronym PIM for *Petites Îles de Méditerranée*) organized the first "Albatross" workshop in Marseille. During this meeting it has been decided to focus the efforts on 10 target species identified by one or more of the following criteria: nesting on small islands, vulnerable, gaps in knowledge, necessity of setting up long-term monitoring, and availability of technical and logistic means for such monitoring.

Monitoring data concerning these species are spread between different Mediterranean actors, including managers (from administrations or from NGOs) and scientists involved in research programs. Access to these data is not always an easy task, at least not immediately available, particularly for entities which are not part of research programs. Therefore, this work responded to the needs for the centralization and update of the information on the geographical distribution of breeding populations for each species, as well as the identification of specific threats having an impact of these populations at Mediterranean islands. Concerning this last concern, the

Contents of each Monograph	**Aims**
Species' Description	Get a general presentation of the species
Ecology & Behaviour	Compile the most recent knowledge concerning the biology and behaviour (points useful for good monitoring)
Geographical distribution of breeding populations	Get a general view of the situation in the Mediterranean
	Identifying main colonies
	Identify gaps in knowledge
Threats identified on small islands	Identify the main challenges
Action proposals	Get a working base for the implementation of conservation actions on small islands

Table 1. Project Albatross for Mediterranean small islands: contents of species monographs.

(*) Editorial Note: It should be noted that recently the Taxonomic Sub-Committee of the British Ornithologists Union has recommended that the Cory's Shearwater complex is best treated as three full species, which should be listed in the following sequence: Cory's Shearwater *Calonectris borealis* (monotypic); Scopoli's Shearwater *Calonectris diomedea* (monotypic); and Cape Verde Shearwater *Calonectris edwardsii* (monotypic) (Taxonomic recommendations for British Birds: eight report. *Ibis* (2012) 154: 874-883).

monographs include suggestions for action that should be implemented at local, national and regional (Mediterranean) level to improve the state of conservation of these species. Table 1 presents the different components of the monographs with the corresponding aims responding to the needs mentioned above. Authors of monographs were selected on their level of knowledge and experience in study or management of these species. The first phase of elaboration of the documents was carried out by the author themselves. The monographs were written simultaneously after gathering the data necessary during summer 2011, and a draft version was presented to the Medmaravis symposium in October 2011.

Following this first step, the documents were reviewed during the rest of the year. A total of 15 reviewers were mobilized (researchers, members of NGOs and various institutions) in order to cross-check the information and data contained in the seven monographs. These monographs are the product of a joint effort by 32 persons (authors, data providers and reviewers) from 10 different Mediterranean countries. The documents have now been published on the PIM Initiative website: http://www.initiative-pim.org/ . All the information found in these seven monographs cannot be fully outlined in the present proceedings, but it has been decided to present maps with an updated geographical distribution of the breeding population for the seven species (Figures 1-7). The monographs will be used as a working base for the implementation of future conservation actions validated and prioritized by the working group currently in elaboration. This process of data centralization should be considered also as a platform for updating regularly the knowledge on these species as well as to assist in pooling and sharing information on their status and conservation among stakeholders involved in bird research and conservation. By supporting actions of monitoring (e.g Zembra Island in Tunisia, Essaouira archipelago in Morocco), the PIM initiative is involved in producing data for the improvement of knowledge concerning these species.

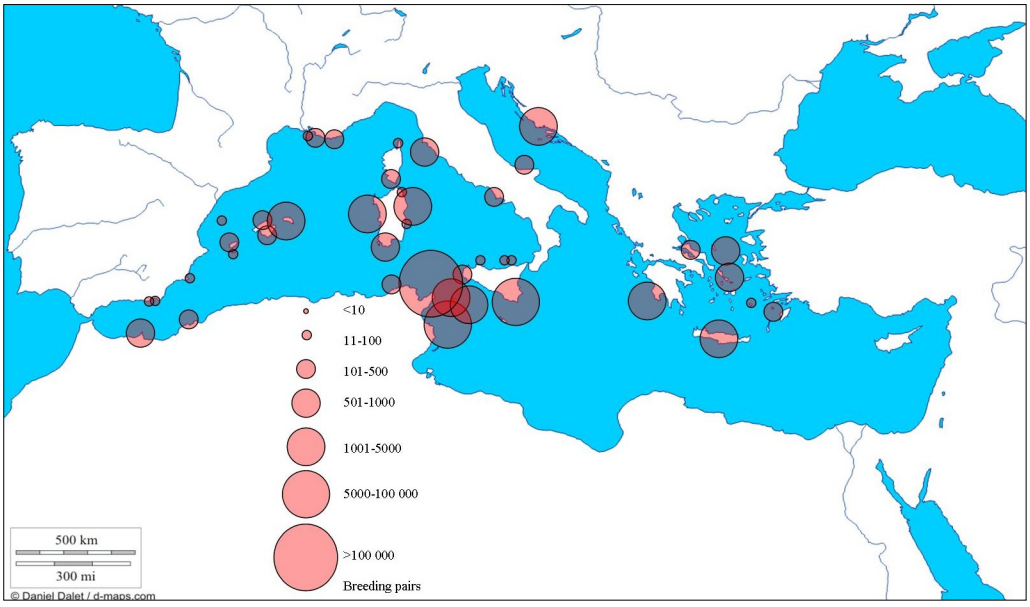

Figure 1. Breeding population of Scopoli's Shearwater *Calonectris diomedea.*

Figure 2. Breeding population of Mediterranean Storm-petrel *Hydrobates pelagicus melitensis.*

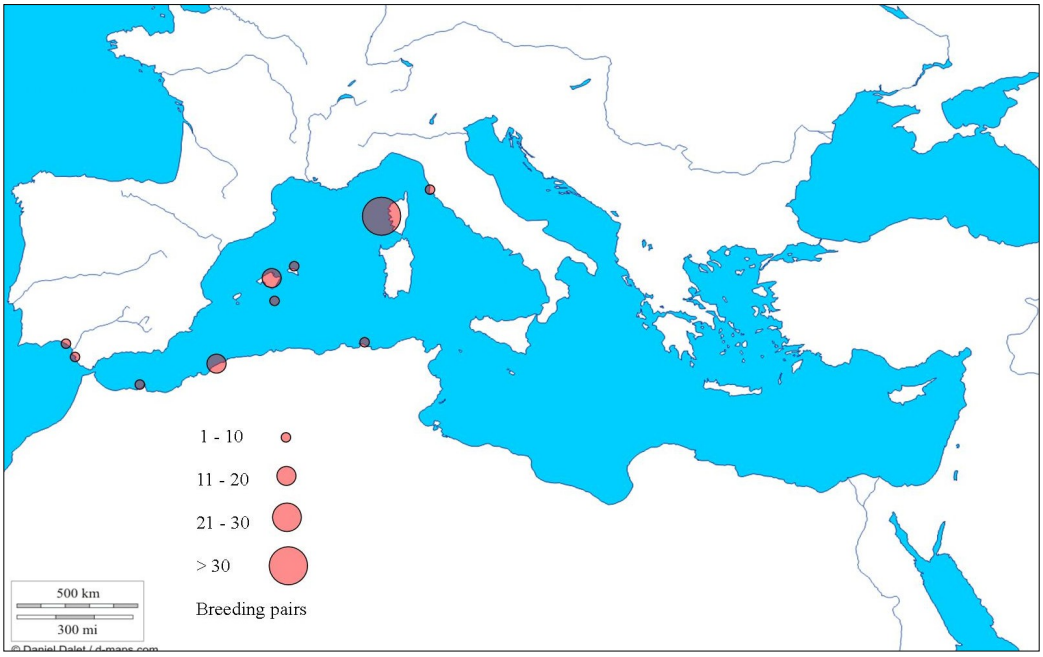

Figure 3. Breeding population of Osprey *Pandion haliaetus* in the Mediterranean.

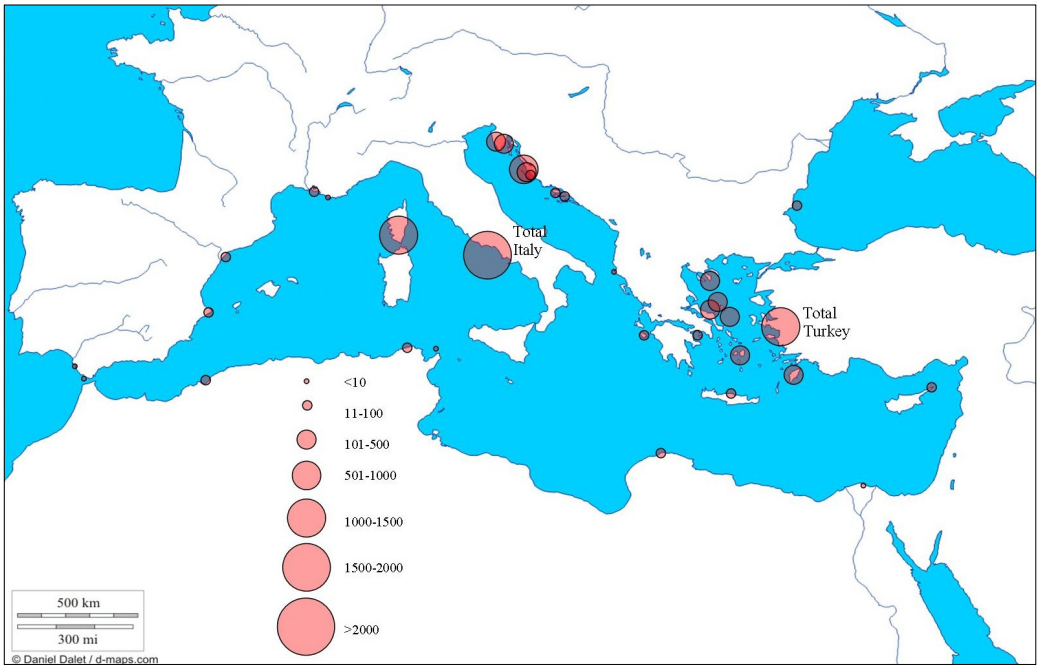

Figure 4. Breeding population of Mediterranean Shag *Phalacrocorax aristotelis desmarestii*.

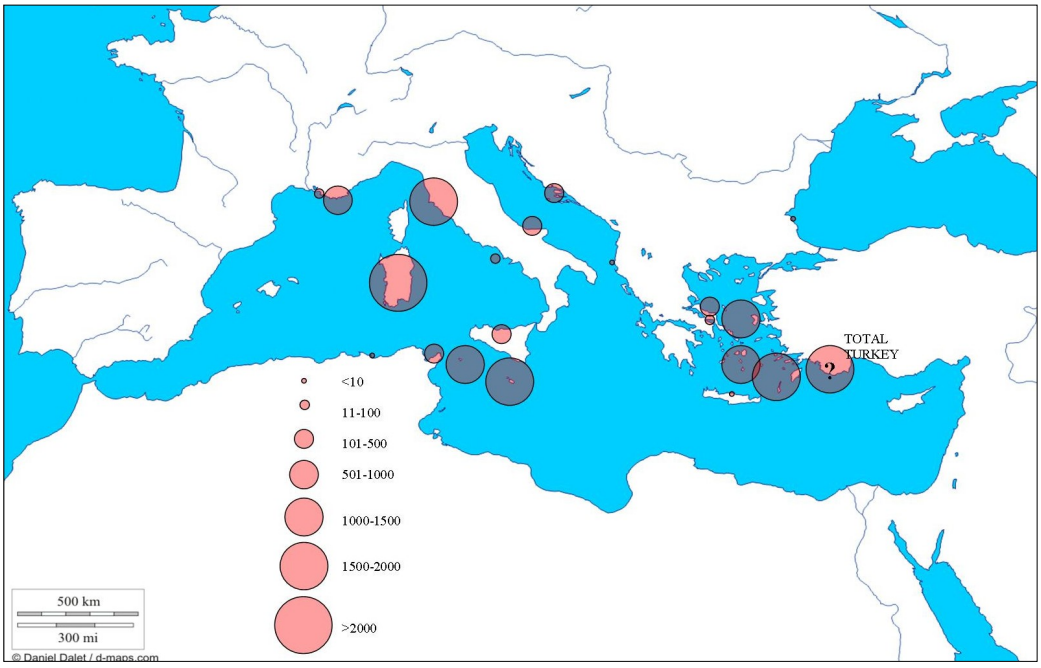

Figure 5. Breeding population of Yelkouan Shearwater *Puffinus yelkouan*.

Figure 6. Breeding population of Mediterranean Lesser Crested Tern *Sterna bengalensis emigrata*.

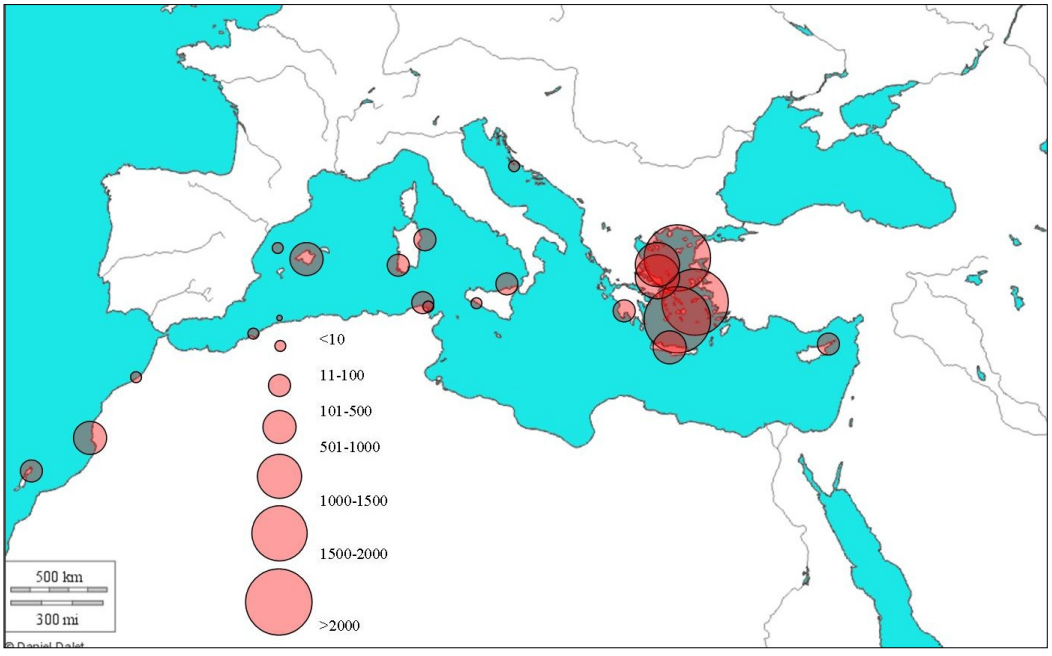

Figure 7. Breeding population of Eleonora's Falcon *Falco eleonorae*.

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Present situation of the population of seabirds (*Calonectris diomedea, Puffinus yelkouan, Phalacrocorax aristotelis desmarestii, Larus audouinii, Larus michahellis and Sterna hirundo*) breeding in Lastovsko otočje nature park, Croatia

Robert Crnković[1]

[1]Croatian Ornithological Society, Draškovićeva 54, 10000 Zagreb, Croatia.

Summary: This note informs on seabird populations breeding within the Nature Park ″Lastovo Archipelago″ on the Adriatic coast of Croatia.

Key words: Lastovo Archipelago, protected area, breeding seabird.

Introduction

In the spring of 1999, the Croatian Ornithological Society was informed by the local people that some shearwaters were breeding on one particular islet near Lastovo island. Investigations, research and bird ringing started there in summer 2004. From then to 2011, various data about shearwaters and other seabirds have been gathered. The Lastovo archipelago (Figure 1) comprises about 40 islets, besides the major island Lastovo. Almost all islets, except the smallest rocks and the principal island, are inhabitated by sea birds, not just the particular one mentioned by the locals. Species recorded and counted are Scopoli's Shearwater *Calonectris diomedea*, Yelkouan Shearwater *Puffinus yelkouan*, Mediterranean Shag *Phalacrocorax aristotelis desmarestii*, Audouin´s Gull *Larus audouinii*, Yellow-legged Gull *Larus michahellis* and Common Tern *Sterna hirundo*. On 29 September 2006, the Croatian Parliament proclaimed the Nature Park ″Lastovo Archipelago″ as a protected area, which makes it the eleventh Nature Park in Croatia. This Nature Park includes 46 islands, islets and rocks, a total area of 196 km^2, and covering a land area of 53 km^2 and sea area of 143 km^2, with the lighthouses Sušac, Tajan, Glavat and Struga as its borders.

Population size

The Scopoli's Shearwater breeds almost on all the islets and the total breeding population is presently estimated at 200-350 pairs. The Yelkouan Shearwater is less widely distributed and less numerous. Its total breeding population is estimated at 150-200 pairs. The Mediterranean Shag population is 50-80 breeding pairs. The Audouin´s Gull breeding population is more difficult to estimate, because these birds change their breeding site almost every year and their number vary. A rough estimate is between 20 and 60 pairs. The Yellow-legged Gull has increased markedly, as everywhere in the Mediterranean. Its breeding population is estimated at 800-1200 pairs. The Common Tern is very scarce and only 1-3 pairs are known to breed.

These figures are the result of counts and monitoring which has been carried out from summer 2004 up to the end of spring 2011. It is hoped that research will carry on, so that the knowledge on seabirds in Lastovo Archipelago Nature Park will improve and the population figures continue to be updated.

CITATION: The editors recommend that for references to this work the following citation should be used: **Crnković, R.** 2012. Present situation of population of seabirds (*Calonectris diomedea, Puffinus yelkouan, Phalacrocorax aristotelis desmarestii, Larus audouinii, Larus michahellis and Sterna hirundo*) breeding in Lastovsko otočje nature park, Croatia. (Pp.221-222). **In Yésou, P., Baccetti, N. & Sultana, J.** (Eds.), *Ecology and Conservation of Mediterranean Seabirds and other bird species under the Barcelona Convention* - Proceedings of the 13th Medmaravis Pan-Mediterranean Symposium. Alghero (Sardinia) 14-17 Oct. 2011. Medmaravis, Alghero.

Figure 1. A view at Lastovo Archipelago Nature Park (inset young Yelkouan Shearwater).

Conservation actions for the Mediterranean Shag *Phalacrocorax aristotelis desmarestii* and Audouin's Gull *Larus audouinii* in Greece, including the inventory of relevant marine IBAs

Jakob Fric[1], Roula Trigou[1], Panagiotis Dendrinos[2], Georgios Karris[3], Panagiota Peristeraki[4], Panagiotis Kasapidis[4], Ivan Ramirez[5] & Tasos Dimalexis[1]

[1]Hellenic Ornithological Society, 24 Vas. Herakliou, GR 10682 Athens, Greece. jakobfric@ornithologiki.gr
[2]Society for the Study and Protection of the Monk Seal, 18 Solomou Street, GR 10682 Athens , Greece.
[3]Technical Educational Institution of Ionian Islands, 2 Kalvos Square, GR 29100 Zakynthos, Greece.
[4]Hellenic Centre for Marine Research, PO Box 2214, GR 71003 Herakleion, Greece.
[5]Portuguese Society for the Study of Birds, 105 2E Avenida da Liberdade, 1250-140 Lisbon, Portugal.

Summary: Since 2009, the LIFE Nature project entitled "Conservation actions for the Mediterranean Shag and Audouin's Gull in Greece, including the inventory of relevant marine IBAs" (LIFE07 NAT/GR/00285) is being implemented in 17 Special Protection Areas in an attempt to improve the knowledge and the conservation status of seabird target species in Greece. Seabird distribution at sea is being assessed with standardized survey methods such as that proposed for European Seabirds at Sea, coastal counts and telemetry, in order to delineate marine Important Bird Areas for the Mediterranean Shag *Phalacrocorax aristotelis desmarestii* and the Audouin's Gull *Larus audouinii*. Conservation actions, including rat eradications and pilot gull control operations, aim to improve directly the breeding performance of target seabirds at selected colony sites. Additionally, seabird bycatch is being assessed from on-board surveys and questionnaires. The data collected from more than 10,000 nautical miles at-sea surveys, telemetry and coastal counts, have enabled the preliminary delineation of marine IBAs at all 17 project sites. Additionally, rat eradication operations and control of Yellow-legged Gulls *Larus michahellis* have been successfully implemented. On 5 islet complexes (total surface area 133ha) hosting colonies of the target seabird species, rats have been removed and the monitoring of benefits of rat removal is in progress. The assessment of seabird bycatch during 166 fishing days of surveys on board pelagic and coastal fisheries and by more than 241 questionnaires providing information by fishermen have revealed types of fishing gear and patterns of seabird bycatch which lead to seabird mortality.

Key Words: Mediterranean Shag, *Phalacrocorax aristotelis desmarestii*, Audouin's Gull, *Larus audouinii*, conservation action, marine IBAs, rat eradication, gull population control, Greece.

Introduction

The Audouin's Gull *Larus audouinii* and the Mediterranean Shag *Phalacrocorax aristotelis desmarestii* are two species of high conservation concern in Greece. The Mediterranean Shag breeds on islands and uninhabited islets in both the Aegean and Ionian Seas, while the Audouin's Gull breeds only in the Aegean Sea. The national breeding populations were estimated at 1,000-

1,200 pairs and 350-500 pairs respectively (BirdLife International 2004, Portolou *et. al* 2010) (since then, the Shag population has been re-evaluated at 1300-1450 pairs, Fric *et al*. 2012). A four-year LIFE Nature project "Conservation actions for the Mediterranean Shag and Audouin's Gull in Greece, including the inventory of relevant marine IBAs" (LIFE07 NAT/GR/00285) is being implemented since 2009 with the objective of improving the knowledge and the conservation status of these two seabird target species in Greece. The project actions are implemented at colony sites and the wider marine areas of 17 Special Protection Areas (SPAs) in the Aegean and the Ionian Seas; these SPAs are hosting 89% of the national population of the Mediterranean Shag and 73% of the national population of the Audouin's Gull. The project aims to address several of the major threats for these target species in Greece, namely the lack of protection of important marine areas, seabird bycatch in fishing gear, rat predation, Yellow-legged Gull *Larus michahellis* predation and competition, as well as a low level of public awareness on the conservation issues.

Methods

Data related to at-sea distribution and behaviour of seabirds is being collected by ship-based line transect surveys, *i.e.* European Seabirds at Sea (ESAS) method and line transects along the coastline, as well as coastal counts and telemetry using radio transmitters, GPS data loggers, geolocators and GPS-Bluetooth transmitters. The acquired data are used to produce density and distribution maps. The dispersal of individuals within Greece and in the Mediterranean is additionally being assessed through ringing and ring recoveries. Seabird diet samples are being collected at nesting sites and analyzed using conventional methods *i.e.* otolith analysis, as well as molecular methods, in order to determine prey composition of the target seabird species. Complementary to direct observations of seabird distribution, maximum entropy habitat predictive modeling, using a series of static and dynamic oceanographic variables (e.g. Phillips *et al.* 2006, Louzao *et al.* 2009, Thaxter *et al.* 2011, Pittman & Brown 2011), has been applied to further assess seabird at-sea distribution. Based on these results and following the application of IBA criteria, preliminary boundaries of marine IBAs have been delineated and a preliminary inventory of the marine IBAs for the Mediterranean Shag and the Audouin's Gull in Greece has been created.

Data on seabird bycatch is being collected by observations on board drifting longline fisheries and coastal fisheries in the Aegean and Ionian Seas, in addition to questionnaires which have been distributed to fishermen at major fishing ports. Bycatch data has also been collected through non-systematic seabird bycatch records as well as records of bycatch incidents found during surveys at seabird colonies or at sea.

A series of rat eradications have been carried out on uninhabited islets hosting colonies of the Audouin's Gull and the Mediterranean Shag in the Aegean Sea in order to improve their breeding success and the quality of their breeding habitats. The islets or islet complexes where rat eradication was implemented were selected among those with the highest priority for rat eradication, as deduced by a relevant cost-ecological benefit analysis. Custom made bait stations have been used for rat eradication as well as post eradication monitoring. During the eradication process, bait station have been loaded with a predefined number of Brodifacoum-based bait pellets, the numbers of which are monitored daily. Baiting is carried out until all rat activity come to an end

and the pellets are replaced with permanent bait and parathion blocks which are used as a quarantine measure and post eradication monitoring, respectively (Fric *et al.* 2006, see also *e.g.* Thomas & Taylor 2002, Spurr *et al.* 2007). Rat tissue samples were collected using snap traps prior to the eradication process and genotyped at 15 microsatellite loci in order to detect genetic variations among rat populations which were planned to be eradicated, and rat populations on neighbouring islands which could be the source future recolonization of rat-free islands. Based on these results, quarantine measures have been applied after eradication in order to prevent rat reinvasions.

Pilot Yellow-legged Gull population control operations have been implemented in order to assess suitability and effectiveness of Yellow-legged gull population control with the aim to reduce their competition and predation pressure on other seabirds species (Fric 2010). Two methods have been applied to reduce the breeding success of the Yellow-legged Gull, namely egg oiling and egg removal.

A series of communication, dissemination and environmental education activities are taking place to increase the knowledge and the appreciation of seabirds, their insular and marine environment and the environmental issues these are facing, as well as to promote the nature protection actions implemented in the framework of the project. These include production of leaflets and posters, public events, press releases and articles in local, regional and national newspapers, as well as production and pilot implementation of an environmental education kit on the Mediterranean Shag and the Audouin's Gull.

Preliminary results

Identification of IBAs. In total more than 10,000 nautical miles of at-sea line transect surveys have been carried out in the marine areas of the Aegean and Ionian Seas during which 1,390 Audouin's Gulls and 7,826 Mediterranean Shags have been recorded (Gaganis *et al.* 2010, Portolou *et al.* 2010, Zakkak *et al.* 2010). In total 25 and 12 tracking devices have been mounted on Audouin's Gulls and Mediterranean Shags, resulting in 53 and 25 foraging tracks respectively. These data, in association with more than 210 hours of coastal counts, revealed that in Greece both species forage mainly within a 10-15km radius from their colonies, with foraging ranges varying among sites and regions. Additionally, both species proved to be foraging primarily in shallow, coastal waters. These results were further supported by the composition of their diet, which consists almost exclusively of coastal fish species, and by the maximum-entropy based predictive habitat models which produce comparable results. Additionally, a total of 62 and 161 colour rings were placed on Mediterranean Shags and Audouin's Gulls respectively (Portolou *et al.* 2010). Ring recoveries revealed that in their main breeding area in the northern Aegean Sea, Mediterranean Shags are remaining within the area of their breeding sites, congregating into large groups which can consists of more than 1,000 individuals. Conversely, Audouin's Gulls are dispersing during winter throughout the entire Mediterranean Basin from Spain in the west to Lebanon on the east. Based on these results, a preliminary marine IBAs inventory for the Mediterranean Shags and Audouin's Gulls in Greece has been produced. Almost all marine IBAs identified for these two species are extensions of their breeding colonies. Foraging characteristics of the two species

allowed the application of foraging range approach for the delineation of marine IBA boundaries (BirdLife International 2010). The preliminary marine IBAs inventory consists of 34 marine sites for the Mediterranean Shag and 27 sites for the Audouin's Gull.

Fisheries bycatch. Although no seabird bycatch has been recorded during 166 days of survey on board fishing vessels in the Aegean and Ionian Seas, 241 questionnaires filled in by fishermen indicated significant bycatch rates of seabirds in fishing gear. The most often mentioned victims were Scopoli's Shearwater *Calonectris diomedea* and Yelkouan Shearwater *Puffinus yelkouan* which were caught primarily in longlines, although there were also occasional incidents of large numbers of Yelkouan Shearwaters being caught in fishing nets. Similarly the main fishing gear affecting Audouin's Gulls were longlines. Mediterranean Shag, on its side, got caught primarily in nets. These results were further supported by non-systematic records, occasional reports by fishermen, and evidence collected at colony sites. Apart from the Mediterranean Shag where the threat of bycatch is considered low, with only exceptional cases of high mortality, the bycatch threat to other seabird species is considered medium. In the case of the Audouin's Gull, where birds may adapt to local fishing activities, the threat may be locally high. The level of bycatch of shearwaters reaches a peak during spring and summer months and may become high, depending on the local abundance of shearwaters and their seasonal behaviour. In general fishermen do not consider seabirds to create significant damage or financial losses. In order to avoid the losses of bait and financial costs associated with seabird bycatch, several fishermen already apply mitigation measures, such as night setting and hauling of longlines, heavier weights for longlines, avoiding large concentration of birds and distraction of seabirds by noise and colourful strips of cloth (Karris *et al.* 2010, Kalfopoulou *et al.* 2011).

Rat eradication. A total of 83 islet complexes have been included in the cost-benefit analysis for the prioritization of islets for potential rat eradications. Based on the resulting priority list of islet complexes, rat eradications have been carried out on 8 islets within 5 islet complexes in four regions, namely Skyros, Thasos, Fourni and Kythera, thereby improving the breeding success of the Audouin's Gull and the Mediterranean Shag, which have been estimated to experience up to 9% losses of eggs and chicks due to rat predation. The total surface area of the islets where rats were eradicated is 133 hectares. Post eradication monitoring using chew sticks, snap traps and surveys for direct signs of rat presence confirmed that rats were successfully removed from all islets treated. It is estimated that these operations have benefited to 11.2-14.7% and 10.0-40.4% of the national populations of the Mediterranean Shag and Audouin's Gull, respectively. Genetic analysis of the connectivity of rat populations which have been eradicated with those on neighbouring islands are still in progress, therefore quarantine measures consisting of regular monitoring of rat presence and loaded bait stations are still in progress until the isolation of eradicated populations is confirmed.

Yellow-legged Gull population control. A total of 144 colonies were assessed and prioritized for the potential Yellow-legged Gull population control. Pilot gull control operation consisting of egg oiling and egg removal were applied on a pilot basis at three Yellow-legged Gull colonies. As a result, 98% of eggs treated with oil failed to hatch. In a particular section of a target Yellow-legged Gull colony all eggs were systematically removed during the entire breeding season. In the case

of large gull colonies consisting of several hundred pairs, the aforementioned methods seemed to discourage gulls from nesting at treated sites during the following years.

Future action

The final inventory of the marine IBA for the Audouin's Gull and the Mediterranean Shag in Greece will be produced by the end of the project at the end of 2012. A campaign to promote bycatch mitigation will be carried out based on the results of the assessment of seabird bycatch. Rat eradications and Yellow-legged gull population operations as well as associated monitoring of target species colonies will continue in order to increase the project's overall impact on the conservation of the Mediterranean Shag and the Audouin's Gull.

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Progress towards the establishment of the World Seabird Union

The Medmaravis Secretariat presented a poster with the title "*Towards the Foundation of the World Seabird Union*" at the 13th Medmaravis Pan-Mediterranean Seabird Symposium. This paper summarises it and presents an update of its contents.

Background - Mission

At the 1st World Seabird Conference (SSC1) held in 2010 at Victoria, Canada, it was decided that a transition team be set up to explore the possibilities of establishing a World Seabird Union (WSU) with the mission to place seabird research, management, and conservation into a worldwide perspective. The WSU vision is to aid in creating global partnerships that will continue into the future by sharing research, knowledge, and ideas on a global level.

Relevant regional seabird groups, including MEDMARAVIS, were invited to take part in this process. The WSU Transition Team is currently made of 20 organisations (full list at http://www.seabirds.net/member-organisations.html). It meets quarterly since 2011 and the minutes of such meetings are available on the seabirds.net website. The organisation has been registered as non-profit in the US and an Executive Board made of regional representatives is to take effect as of 1 January 2013.

WSU Main Projects

Seabird Information Network

The Seabird Information Network is a network of databases which contain important information about the status of seabirds worldwide. These databases represent a substantial step towards the sharing of information around the world, which will have direct benefits towards the study and conservation of seabirds. As of October 2012, the Seabird Information Network comprises the following databases:

Global Seabird Colony Register, an interactive map that displays seabird colony, population, and diet records throughout the world.

Waterbird Population Estimates (WPE), an online database with current and historic estimates, trends and 1% thresholds for over 800 waterbird species and 2300 biogeographic populations worldwide. Developed by Wetlands International with the support of Environment Canada and the Ramsar Convention on Wetlands.

Seabird Tracking Database - Tracking Ocean Wanderers database, the largest collection of seabird tracking data in existence. It serves as a central store for seabird tracking data from around the world and aims to help further seabird conservation work and support the tracking community *OBIS-SEAMAP* (Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations), a spatially referenced online database, aggregating marine mammal, seabird and sea turtle observation data from across the globe.

Global Metadata Portal, an interactive map that displays current seabird study efforts throughout the world.

Circumpolar Seabird Data Portal, an interactive map that displays seabird colony, population, and diet records throughout the circumpolar north.
European Seabirds at Sea (ESAS) database, a collaborative partnership between the Joint Nature Conservation Committee (JNCC) and seabird researchers in north-west Europe.
eBird, launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society, provides rich data sources for basic information on bird abundance and distribution at a variety of spatial and temporal scales.

Global Biodiversity Information Facility (GBIF), an international initiative dedicated to the mobilization, online publication and use of species occurrence records from around the world.

North Pacific Seabird Data Portal, an interactive map that displays seabird colony, population, and diet records throughout the North Pacific coastlines.

Pacific Seabird Monitoring Database (PSMD), with more than 20,000 observations, provides data from seabird monitoring programs conducted in the North Pacific Ocean. Parameters include population indices, overall productivity, breeding chronology, adult survival, and prey indices.

North Pacific Pelagic Seabird Database (NPPSD), with data collected 1972-2003 by researchers in Canada, Russia, and the U.S.

Seabird Monitoring Programme (SMP) collects and collates abundance and breeding success data collected at seabird colonies throughout the United Kingdom and the Republic of Ireland. Parameters included abundance (whole colonies and plots) and breeding success.

Tagging of Pacific Predators (TOPP), started in 2000 as one of 17 projects of the Census of Marine Life, an ambitious 10-year, 80-nation endeavour to assess and explain the diversity and abundance of life in the oceans, and where that life has lived, is living, and will live

PETREL

PETREL (PErsonnel TRacker and E-List) is a directory of seabird professionals and students that will allow users to search for others studying similar subjects, or species. This system will increase the presence of individual seabird researchers, allowing individual research to be highlighted. Users will also be able to upload photos and their own published articles that will be searchable.

Seabirds.net

Fully operational since August 2012, seabirds.net offers a variety of services to the seabird community: professionals, students and enthusiasts. The website is dedicated to the facilitation of communication and data sharing between seabird scientists around the world. Besides the *Seabird Information Network* and the *PETREL* directory of seabird researchers, it offers a *Discussion forum* for discussions revolving around seabird science. In the near future, it is planned to offer *Seabird News*, a series of updates as News Articles pertaining to the World Seabird Union, the World Seabird Conference, and various other seabird related

Opportunities for MEDMARAVIS

The establishment of the World Seabird Union offers Mediterranean seabird professionals, students and enthusiasts a direct connection with similar studies and initiatives in other parts of the world. It also opens the possibility to make our work widely known with little effort. Finally, it increases the opportunities for collaborative research with other institutions

Carles Carboneras & Xaver Monbailliu

List of Participants at MEDMARAVIS Symposium

Croatia
Crnković, Robert

France
Bernard, Fabrice
Debize, Elodie
Defos Du Rau, Pierre
Deville, Anne-Sophie
Faggio, Gilles
Mante , Alain
Monbailliu, Xaver
Sanz Aguilar, Ana
Peron, Clara
Thevenet, Mathieu
Yésou, Pierre

Greece
Fric, Jakob
Karris, Georgios
Portolou, Danae

Italy
Albores-Barajas, Yuri V.
Baccetti, Nicola
Bambini, Giulia
Bassu, Lara
Becciu, Paolo
Bonginelli, Paolo
Brau, Bernardo
Cadoni, Venanzio
Denegri, Paolo
Campus, Erica
Carta, Patrizia
Carta, Antonio
Cecere, Jacopo G.
Contini, Ponziano
Cosolo, Mauro
Dell'Omo, Giacomo
Fasciolo, Antonio
Fiesoli, Cristina
Fiori, Raffaele
Fozzi, Alberto
Franceschi, Alessio
Fresi, Carmen
Gaibani, Giorgia
Gazale, Vittorio
Ghiani, Marco
Giannini, Francesca
Liuzzi, Cristiano
Lorrai, Alberto
Luchetti, Sara
Manca, Francesco
Massa, Bruno
Meloni, Sebastiano
Molinu, Antonio
Montanari, Federico
Monti, Flavio
Mura, Giampiero
Muzzeddu, Marco
Navone, Augusto
Nissardi, Sergio
Pinna, Erica
Pisu, Danilo
Planeta, Fabio
Pola, Luciano
Porcu , Maurizio
Pudda,Flavia
Riva, Elena
Santolini, Riccardo
Serra, Mauro
Serusi, Simona
Soldatini, Cecilia
Spano, Giovanna
Sponza, Stefano
Sposimo, Paolo
Teti, Pierpaolo
Torre, Antonio
Vacca, Giovanni
Zucca, Carla

Libya
Hamza, Abdulmaula

Malta
Borg, John J.
Sultana, Joe

Morocco
Idrissi, Hamid Rguibi

Portugal
Carvalho Magalhães, Maria
Ramirez, Ivan

Slovenia
Skornik, Iztok

Spain
Amengual, José
Arcos, Pep
Carboneras, Carles
De la Cruz Muñoz, Andres
Eguía Martínez, Sergio
Gomez Martinez, Sandra
Gonzalez Barbera, Gonzalo
Greño Ruiz, Jose-Luis
Louzao, Maite
Muñoz Arroyo, Gonzalo
Sarzo, Blanca

Tunisia
Azafzaf, Hichem
Sami, Ben Haj

Turkey
Onmuş, Ortaç
Samsa , Sebnem
Şahin, Dilek
Tavares, José

United Kingdom
Derhe, Mia
Guilford, Tim
Meier, Rhiannon
Wynn, Russel

The following persons participated only at the BirdLife International Workshop:
Budinski, Ivan (Croatia)
Sammut, Michael (Malta)

Previous MEDMARAVIS Symposia and Proceedings

Pan-Mediterranean Seabirds symposia:

- **Alghero, Sardinia, Italy:** March 26-30, 1986. Organizers: MEDMARAVIS, Regione Sardegna.

Proceedings: MEDMARAVIS & Monbailliu, X. (eds), 1986 – *Mediterranean Marine Avifauna.* NATO ASI Series G12. Springer-Verlag, Berlin-Heidelberg, 535 pp. Italian translation of the volume also published (Studio delle popolazioni e conservazione dell'avifauna marina del Mediterraneo, Edizioni del Sole, Alghero, 493 pp).

- **Calvià**, **Mallorca, Spain:** March 21-26, 1989. Organizers: MEDMARAVIS, SEO/BirdLife.

Proceedings: Aguilar, J.S., Monbailliu, X. & Paterson, A.M. (eds), 1993 – Status and Conservation of Seabirds. SEO/BirdLife, Madrid, 386 pp.

- **Chios , Greece:** September 15-20, 1992. Organizers: MEDMARAVIS, WWF Greece.

Proceedings: Fasola, M (ed), 1992 – *Avocetta* 16 (2): 126 pp.

- **Hammamet, Tunisia.** April 11-16, 1995. Organizers: MEDMARAVIS, Association "Les Amis des Oiseaux".

Proceedings: Walmsley, J.G., Goutner, V., El Hili, A. & Sultana, J. (eds), 1998 – Ecologie des oiseaux marins et gestion intégrée du littoral en Méditerranée. Arcs Editions, Tunis, 304 pp.

- **Gozo, Malta:** September 29 – October 3, 1998. Organizers: MEDMARAVIS, BirdLife Malta.

Proceedings: Yésou, P. & Sultana, J. (eds), 2000. *Monitoring and Conservations of Birds, Mammals and Sea Turtles of the Mediterranean and Black Seas.* Environment Protection Department, Malta, 315 pp.

- **Benidorm, Alicante, Spain:** October 11-15, 2000. Organizers: MEDMARAVIS, IMEDEA, SEO.

Proceedings: Mínguez, E., Oro, D., De Juana, E. & Martínez-Abraín, A. (eds), 2003. *Mediterranean seabirds and their conservation. Scientia Marina* 67 (2), Barcelona, 153 pp.

- **Vilanova i la Geltrú, Spain:** November 17-19, 2006. Organizers: MEDMARAVIS, SEO.

Proceedings: Aransay N. (ed), 2006. Proceedings of the first symposium on the mediterranean action plan for the conservation of marine and coastal birds. Vilanova i la Geltrú, (Spain), 17-19 November 2005, RAC/SPA publ., Tunis : 103 pp. (downloadable from http://www.rac-spa.org/sites/default/files/doc_birds/sympo.pdf).

Other symposia and conferences:

- **Alghero, Sardinia, Italy:** January 19-22, 1995. Organizers: MEDMARAVIS, Alghero City Council.

Proceedings: Monbailliu, X. & Torre, A. (eds), 1996. *First Forum on Coastal and Marine Biodiversity in the Mediterranean.* Edizioni del Sole, Alghero, 208 pp.

- **Porto Torres, Sardinia, Italy:** April 17-19, 1997. Organizers: MEDMARAVIS, Porto Torres City Council. Management of Protected Islands in the Mediterranean. A pan-Mediterranean conference for local authorities managing island ecosystems.

- **Alghero, Sardinia, Italy:** October 9-12, 1997. 9th Italian Congress of Ornithology. Organizers: CISO, MEDMARAVIS.

Proceedings: Bogliani, G., Galeotti, P. & Torre, A. (eds), 1997. Atti del IX Convegno Italiano di Ornitologia. *Avocetta* 21, 153 pp.

- **Alghero, Sardinia, Italy:** November 27-29, 1997. Organizers: MEDMARAVIS, Alghero City Council. Second Forum on Coastal and Marine Biodiversity in the Mediterranean.

- **Porto Torres (Sardinia, Italy),** October 17-20, 2002. Conference on oil pollution. Organizers: IFAW, MEDMARAVIS, Asinara National Park.

Proceedings: Walmsley, J. (ed), 2002. *Oil pollution and conservation of biodiversity*. 203 pp. (downloadable from http://www.medmaravis.org/).