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Pelagic seabirds in coastal waters of the Western Ligurian Sea: occurrence and seasonality

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ABSTRACT

Seabirds are a heterogeneous group of birds that, due to their behaviour and at-sea distribution, remain difficult to study when compared to other avian species. In the Liguro-Provençal basin (Mediterranean Sea), the fragmentary information of presence and number of individuals available fails to capture the variability of occurrence of these species year-round and at smaller regional scales. This study aimed to fill this gap of knowledge in seabirds' presence and phenology for the coastal Western Ligurian Sea. Data were collected opportunistically at sea, year-round, from June 2018 to May 2022. Two hundred and seventy-four surveys were conducted, totalling 1,522.91 hours of observation year-round, during which 12 species of seabirds, excluding seagulls, cormorants, shags, and landbirds, were identified. Observations of species and group size were collected to estimate cumulative seasonal encounter rates (ER) for all species and seasonal ERs (only for the most common taxa). Spring and autumn had the highest ER cumulative for all species, as these are migratory periods for several species. These are also periods of the highest presence of the most sighted species - Yelkouan *Puffinus yelkouan* and Scopoli's Shearwaters *Calonectris diomedea* - at French breeding colonies. Species also observed in large numbers were the Northern Gannet *Morus bassanus* and the Sandwich Tern *Thalasseus sandvicensis*, whose sightings matched their migratory phenology. Other northern breeding species, such as the Atlantic Puffin *Fratercula arctica*, and more rare species like skua spp. were also recorded.

The year-round presence of migratory species indicates the region is an important foraging ground also for individuals that are not taking part in the pre-breeding migration and for shearwaters breeding in the Tyrrhenian Sea. This study highlights the importance of the Western Ligurian Sea for pelagic seabird species, emphasizing the need for specific conservation actions to enhance their protection.

Keywords: Coastal waters, Gannets, Mediterranean Sea, Seabirds, Shearwater.

INTRODUCTION

Seabirds are species adapted to marine environment, spending the majority of their life in offshore areas. Their wide-ranging distribution and often elusive behaviour make them difficult to monitor and, as a result, less studied than many other bird groups. Historically, a vast number of research on seabirds has been conducted at their breeding colonies (Brichetti 1980; Baccetti et al. 2009), and migrating individuals have been recorded either from land (Şahin et al. 2011; Elmberg et al. 2016) or from opportunistic platforms at sea (e.g. Martín et al. 2020). Although ringing has been performed on several colonies, allowing researchers to monitor birds during reproduction, information on the at-sea ecology and year-round movements of these species have only been obtained by using miniaturised GPS trackers (Bridge et al. 2011; Péron & Grémillet 2013; Bernard et al. 2021; De Pascalis et al. 2022).

The Mediterranean basin, recognised as a biodiversity hotspot (Coll et al. 2010), hosts multiple endemic species of seabirds, and is used as wintering ground (Carboneras 1988) by various species nesting in northern Europe, such as auks and gannets (Balestrieri et al. 2023, Borgo et al. 2024). The Liguro-Provençal Basin, located in the North-Western portion of the Mediterranean Basin, supports vast breeding colonies of shearwaters (Péron et al. 2012). Two endemic species of Procellariformes can be found regularly in this area (Spina & Volponi 2008; BirdLife International 2021a, b, d): the Least Concerned (BirdLife International 2021a) Scopoli's Shearwater *Calonectris diomedea* (Scopoli, 1769) - presenting important colonies in the Gulf of Lion, Tuscany, Sardinia, Corsica and Strait of Sicily (Baccetti et al. 2009; Péron & Grémillet 2013) - and the Vulnerable (BirdLife International 2021d) Yelkouan Shearwater *Puffinus yelkouan* (Acerbi, 1827) - breeding along the Mediterranean French coast (Péron et al. 2012) but with a main breeding colony at Tavolara island (Sardinia) (Zenatello et al. 2012). The other species of Procellariformes present in the area is the Least Concerned (BirdLife International 2021b) European Storm Petrel *Hydrobates pelagicus* (Linnaeus, 1758) largely unstudied in this basin (Baghino et al. 2012; Lago et al. 2019). Within the Mediterranean basin the subspecies Mediterranean Storm

Petrel *Hydrobates pelagicus melitensis* (Schembri, 1843) is also present. The Least Concerned (BirdLife International 2021c) Northern Gannet *Morus bassanus* (Linnaeus (1758)) is also found in the area, particularly during the winter (Spina & Volponi 2008; Baghino et al. 2012), with individuals migrating primarily from British and French colonies (Kubetzki et al. 2009; Fort et al. 2012). Regular and occasional species of skuas and terns are present, with some appearing in smaller numbers year-round or at specified seasons. Atlantic Puffin *Fratercula arctica* (Linnaeus (1758)) and Razorbill *Alca torda* (Linnaeus (1758)) have also been observed to winter in the Ligurian basin (Spina & Volponi 2008; Ballardini et al. 2005; Balestrieri et al. 2023).

Various studies have identified the Liguro-Provençal basin as highly frequented by seabirds, but only limited information on their year-round presence has been obtained over several years (Rufray et al. 2014; Lambert et al. 2017). The Western Ligurian Sea (Central part of the Liguro-Provençal basin), in particular, has not been extensively monitored (Bourgeois & Vidal 2008). This area differs from the adjacent regions – such as the Gulf of Lion and the Eastern Ligurian Sea (Cattaneo-Vietti et al. 2010; Prieur et al. 2020) – due to its narrow continental shelf and the presence of several underwater canyons. According to David and Di-Méglio (2012), these undersea structures provide diverse habitats that support numerous species of cetaceans and seabirds. Despite its ecological significance, comprehensive information on seabird communities in the area remains limited.

This study aims to describe the seasonal occurrence of pelagic seabirds in coastal waters of the Western Ligurian Sea over a period of four years. By building upon existing knowledge, it seeks to contribute to a foundational understanding of the area's importance for seabird ecology and to inform future research and conservation efforts.

MATERIALS & METHODS

Study Area

The study area is located within the Liguro-Provençal Basin, more exactly in the Western Ligurian Sea (Western Mediterranean Sea) (Fig. 1).

It covers approximately 812 km^2 of the coastal area from the Italo-French border (43°47'06"N, 7°31'44"E) to the west and Capo Noli (44°11'53"N, 8°25'30"E) to the east, from the shoreline to the 500 m bathymetric line. The maximum distance from shore ranges from less than 4 km to up to 11 km, encompassing the shallow continental platform (up to 200 m) and the continental slope. This area is characterised by a narrow continental platform that makes space for the continental slope relatively close to the shore. Moreover, there are 11 underwater canyons that cut through the continental platform (Migeon et al. 2011) allowing for steep changes in depth, reaching up to 800 m within the study area.

The area is included in the "Pelagos Sanctuary", established in 1999 for the

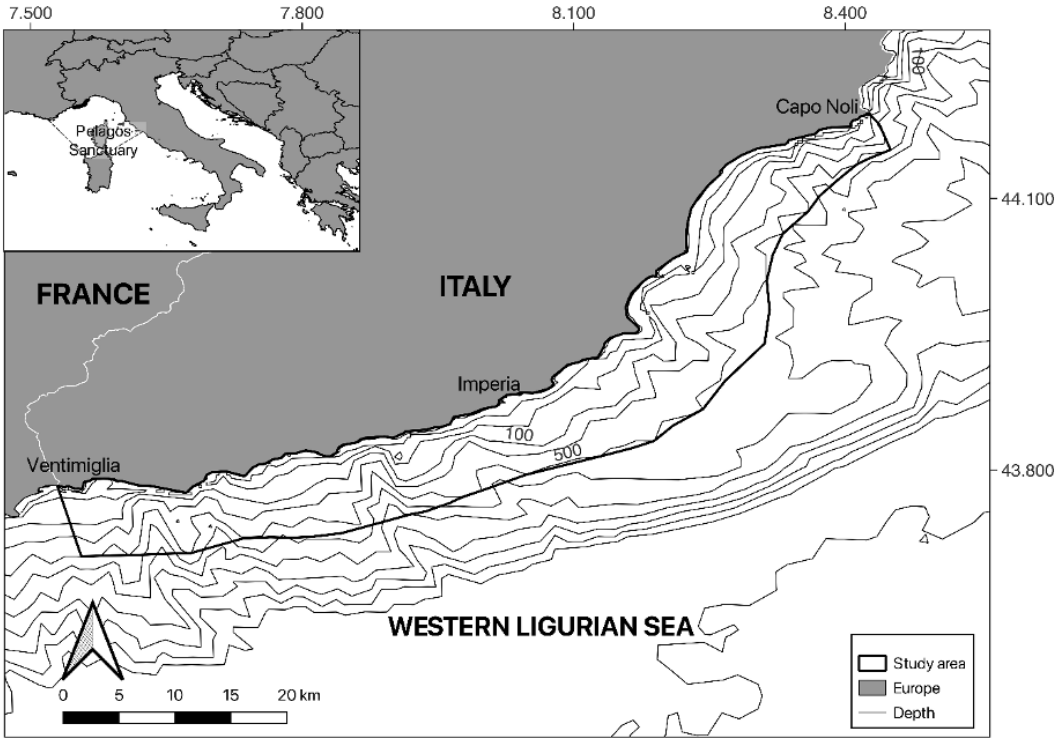

Figure 1. Study area showing bathymetric contour lines, with the 100 m and 500 m isobath highlighted.

protection of marine mammals and listed in 2001 as a Specially Protected Areas of Mediterranean Importance (SPAMIs) (Notarbartolo di Sciara et al. 2008).

Since 2023, it has also been included in the North Western Mediterranean Sea Particularly Sensitive Sea Area (NW Med PSSA) (IMO). Moreover, the study area is close to multiple IBAs (BirdLife, 2023) on the southern coast of France, around Corsica Island and the Tuscan Archipelago.

The Liguro-Provençal Basin is important for cetaceans' conservation and for different seabird species listed within the SPA/BD Protocol (UNEP-MAP-RAC/SPA 2010).

This basin presents a cyclonic circulation with the Liguro-Provençal-Catalan system being its main feature (Casella et al. 2014). This system presents currents of different densities that allow the formation of waterfronts and eddies responsible for vertical mixing (Picco et al. 2010) and upwelling phenomena (Poulain et al. 2010; Casella et al. 2014), features that have been linked to the presence of foraging seabirds such as shearwaters and Northern Gannets (Paiva et al. 2010; Sabarros et al. 2014; Scale et al. 2014). This circulation is strongly driven by wind action, mainly the mistral wind regime

(Poulain et al. 2010) and, together with the underwater topography, is responsible for the high biological productivity (Estrada 1996) and biodiversity of the area (Cattaneo-Vietti et al. 2010; Coll et al. 2010). This productivity, together with the heterogeneous morphology found in coastal waters, makes this region important not only for resident, but also for migratory species (Paiva et al. 2010; Péron & Grémillet 2013; Pollonara et al. 2015).

Data collection

Data were collected opportunistically during boat-based surveys from June 2018 to May 2022 with a primary focus on the population of bottlenose dolphins (*Tursiops truncatus*) (Ascheri et al. 2022).

Surveys were conducted onboard a 5.2 metre long zodiac equipped with a 40HP outboard engine and took place year-round, during daylight and with favourable weather and sea conditions (wind speed of Beaufort scale ≤ 3 and sea state of Douglas ≤ 2). The duration of the survey varied from 6 to 9 hours, depending on weather conditions and cetacean sightings. The surveys followed random tracks and depended on the weather conditions as described in Ascheri et al. (2022). Each track consisted of two linear routes parallel to the shore, 2 nautical miles apart, to avoid double counting of cetaceans and seabirds present in the same area.

The study area was monitored as equally and as homogeneously as possible in each season, although the surveying effort could vary according to the weather conditions and cetaceans' sightings. During the survey, the position of the zodiac was automatically recorded every 2 minutes using a portable GPS (Garmin ETrex 32x), with the starting and ending point being the port of Imperia. A constant speed of less than 7 knots (13 km/hr) was maintained throughout. A team of at least two experienced observers with comparable visual skills was onboard, visually scanning the sea with and/or without binoculars (7x50), covering a full 360° around the boat to detect the presence of both cetaceans and seabirds (Ascheri et al. 2022; Fontanesi et al. 2024).

Environmental data including wind and sea conditions, visibility and cloud coverage, were collected at regular intervals as described in Ascheri et al. (2022), to ensure comparable surveying effort and data collection. If the envirnomental conditions were not favourable (see above) the effort was suspended and data were not collected.

In this study, observers were considered "on effort" when actively scanning the area with and/or without binoculars, under favourable conditions, aiming to identify seabird species to the lowest possible taxonomic level. If cetaceans were sighted, the effort was switched off to allow for the collection of cetacean data as described in Ascheri et al., (2022). The effort and seabird observation was later resumed when the cetacean sighting was concluded. When an individual or group of birds were sighted, the GPS position of

the zodiac, the species and the number of individuals were recorded. To minimise the risk of double counting, observers recorded birds only when they were perpendicular to the boat, following a method similar to the transect sampling (Camphuysen et al. 2004). For foraging flocks, two experienced observers estimated the number of individuals grouping them by species (Spear et al. 2004). To prevent overestimation of individuals, the visual survey was temporarily suspended until the area was clear. However, underestimation is expected for smaller species, such as storm petrels, and less conspicuous individuals, such as stationary birds on the water (Tasker 1984).

The protocol developed for the seabird data collection excluded from the monitoring landbirds and few species of seabirds. The choice of excluding from the data collection seagulls, cormorants and shags was supported by the need to record information on species that are not easily sighted from land. Moreover, for these bird species, census-monitoring activities at breeding colonies are normally conducted (Walsh et al. 1995) and their accounting during boat-based monitoring, due to the large number of Yellow-legged Gull *Larus michahellis* (Naumann, 1840) and Black-headed Gull *Chroicocephalus ridibundus* (Linnaeus, 1766) in the area, might hinder data collection on other, less common species. During the study, 12 species from the families Procellariidae, Hydrobatidae, Sulidae, Stercorariidae, Alcidae as well as individuals of the subfamily Sterninae were recorded in the field and further analysed. If a bird could not be identified to the species level, it was recorded as an unidentified individual of a specific family (e.g. unidentified tern). For the family Stercorariidae the species was always confirmed through photographs. Data were not collected if the family could not be determined.

Data analysis

Four seasons were considered: winter (December -February), spring (March - May), summer (June - August) and autumn (September - November). In annual analyses, data were grouped by sampling period (I-II-III-IV): period I from June 2018 to May 2019 included, period II from June 2019 to May 2020 included, period III from June 2020 to May 2021 included, period IV from June 2021 to May 2022 included.

The total surveying effort (hour) was extrapolated from the GPS tracks, considering only “on effort” intervals. The encounter rate (ER) was obtained as the number of sightings - within a specific period (e.g. across the study, season or sampling period) and of a specific species and/or across species - per hour on effort (sig h^{-1}) in said period. The presence/absence of a species in a season, and in a sampling period, was recorded. Moreover, the total number of species sighted in a season, and in a sampling period, was obtained.

The cumulative number of individuals and sightings was calculated for the entire study period and for each season.

The seasonal ER – cumulative of all species – was calculated. For each species, the total ER, across the study period, was computed. Additional analyses were performed for species presenting a number of individuals across the study period higher than 100 and for the storm petrel, species presenting relatively large numbers.

For each species with more than 100 individuals recorded (Scopoli's and Yelkouan Shearwaters, Northern Gannet, and Sandwich Tern) the following qualitative and quantitative analyses were performed. A qualitative analysis of the monthly occurrence of the species across years was performed through visual representation. For quantitative analyses the seasonal ERs were obtained and compared using a non-parametric Kruskal-Wallis test, followed, when significant, by a post-hoc Dunn-test to identify significantly different comparisons. Moreover, the seasonal average group size was also calculated and compared using a non-parametric Kruskal-Wallis test, followed by a post-hoc Dunn-test to recognise seasons with significant differences.

For storm petrels only the comparison between seasonal ERs across the study period was performed. The smaller sample size did not allow an effective qualitative analysis of monthly occurrence nor to compare between seasonal average group sizes.

All statistical analyses were performed using the R Software (R Core Team 2022) and statistical significance set at p-value <0.05.

RESULTS

Surveying Effort and Species Occurrence

From June 2018 to May 2022 a total of 274 surveys were conducted across all seasons, totalling 1,522.91 hours on-effort (Tab. 1). A total of 4361 sightings of seabirds were collected, amounting to 18,301 individual seabirds belonging to 12 confirmed species (Tab. 2).

The highest seasonal ER - cumulative of all species - was recorded in spring (4.576), followed by autumn (2.354), summer (2.170) and winter (1.805). Except for the Arctic Skua (*Stercorarius parasiticus* (Linnaeus, 1758)), all identified species were sighted during summer. Four species were sighted in winter, five in autumn and seven in spring (ESM1). The sampling period during which more species were identified was period IV (June 2021 - May 2022), with nine species recorded. This was followed by periods II (June 2019 - May 2020) and III (June 2020 - May 2021), with seven species each, and period I with six species (June 2018 - May 2019) (ESM1).

Table 1. Summary of the number of surveys performed by season relative hourly effort (h)

	Number of surveys	Hourly effort
Winter	26	119.65
Spring	75	428.33
Summer	104	597.23
Autumn	69	377.70

Table 2. Summary table on the species sighted with the number of sightings and individuals recorded, and total ER for the study. The species have been divided based on their taxonomy

Common name	Scientific name	Sightings	Individuals	ER
Northern storm petrels				
European Storm Petrel	*Hydrobates pelagicus*	72	75	0.047
Procellariids				
Yelkouan Shearwater	*Puffinus yelkouan*	2428	14 573	1.595
Scopoli's Shearwater	*Calonectris diomedea*	1265	2837	0.831
Sulids				
Northern Gannet	*Morus bassanus*	421	512	0.277
Terns				
Gull-billed Tern	*Gelochelidon nilotica*	1	1	0.001
Sandwich Tern	*Thalasseus sandvicensis*	145	257	0.095
Common Tern	*Sterna hirundo*	6	14	0.004
Unidentified Tern	-	8	13	
Skuas				
Great Skua	*Stercorarius skua*	1	1	0.001
Pomarine Skua	*Stercorarius pomarinus*	2	4	0.001
Arctic Skua	*Stercorarius parasiticus*	1	1	0.001
Long-tailed Skua	*Stercorarius longicaudus*	1	1	0.001
Unidentified Skua	-	6	6	
Alcids				
Atlantic Puffin	*Fratercula arctica*	4	6	0.003
Total		**4361**	**18 301**	

Procellariformes

Scopoli's Shearwater and Yelkouan Shearwater were the species with the most recorded sightings, accounting cumulatively for 17,412 individuals (95.1% of all sightings): 2,839 individuals (15.5%) and 14,573 individuals (79.6%) respectively.

Scopoli's Shearwater

This species was present in the area for the majority of the year but was not recorded during winter. Of the total 2,839 Scopoli's Shearwater observed, 52.9% were sighted in spring. Notably, 1,375 individuals were recorded in May alone,

accounting for 48.4% of all Scopoli's Shearwater's sightings. The record of this species seemed to follow a bimodal distribution with a main peak in May/June and a smaller one in September (Fig. 2A).

The ER for this species during the entire study period was 0.831. It reached a maximum seasonal average of 1.186 during spring and a minimum of 0 during winter. Its ER in summer was 0.980 and in autumn 0.455. The ER differed significantly between seasons (Kruskal-Wallis test: $H(3) = 10.007$, $p = 0.02$). A post-hoc Dunn-test revealed the winter ER to be significantly lower than both spring ($Z = 2.843$, $p < 0.01$) and summer ($Z = 2.618$, $p < 0.01$).

The average group size across the study was 2.2 individuals (±SD = 5.8, min-max = 1-100). The largest groups were recorded during spring (mean number of individuals ± SD: 3.0 ± 7.5), although most sightings were of single individuals. Group size differed significantly across seasons (Kruskal-Wallis test: $H(2) = 32.651$, $p < 0.001$), with summer and autumn groups being significantly smaller than spring (post-hoc Dunn-test: Summer: $Z = 5.702$, $p < 0.001$; Autumn: $Z = 2.446$, $p = 0.007$).

Yelkouan Shearwater

The Yelkouan Shearwater was observed year-round, although with varying encounter rates across seasons. The highest count was recorded in spring, totalling 10,077 individuals (69.1% of all Yelkouan Shearwaters), with May accounting for the highest number of monthly records with 6,582 individuals (45.2%). In contrast, winter had the lowest numbers of individuals recorded, with only 257 individuals observed (1.8%). The monthly counts of individuals appeared to follow a bimodal distribution, with a first peak in May and a second one in October (Fig. 2B).

The overall ER for this species across the study period was 1.594. The highest seasonal average ER was observed in spring (2.951) and the lowest occurred in winter (0.476). The ER values for summer and autumn were 0.829 and 1.620 respectively. The ER differed significantly between seasons (Kruskal-Wallis test: $H(3) = 9.640$, $p = 0.02$). Spring ER was found to be significantly higher from summer (post-hoc Dunn test: $Z = 2.302$, $p = 0.01$) and winter (post-hoc Dunn-test: $Z = 2.748$, $p = 0.003$).

Group size comprised, on average, 6.0 individuals (±SD = 11.7, min-max = 1-200). The largest groups were found in spring, (mean number of individuals ± SD = 7.9 ± 14.5), but single individuals made up most sightings. The group size differed significantly between seasons (Kruskal-Wallis test: $H(3) = 139.453$, $p < 0.001$) with spring having significantly larger groups than all other seasons (post-hoc Dunn test: Autumn: $Z = 7.814$, $p < 0.001$; Summer: $Z = 10.613$, $p < 0.001$; Winter: $Z = 3.475$, $p < 0.001$). Summer and autumn median group size were also significantly different with larger groups in autumn (post-hoc Dunn test: $Z = 2.944$ $p = 0.002$).

European Storm Petrel

The European storm petrel was the only species of the Hydrobatidae family record-

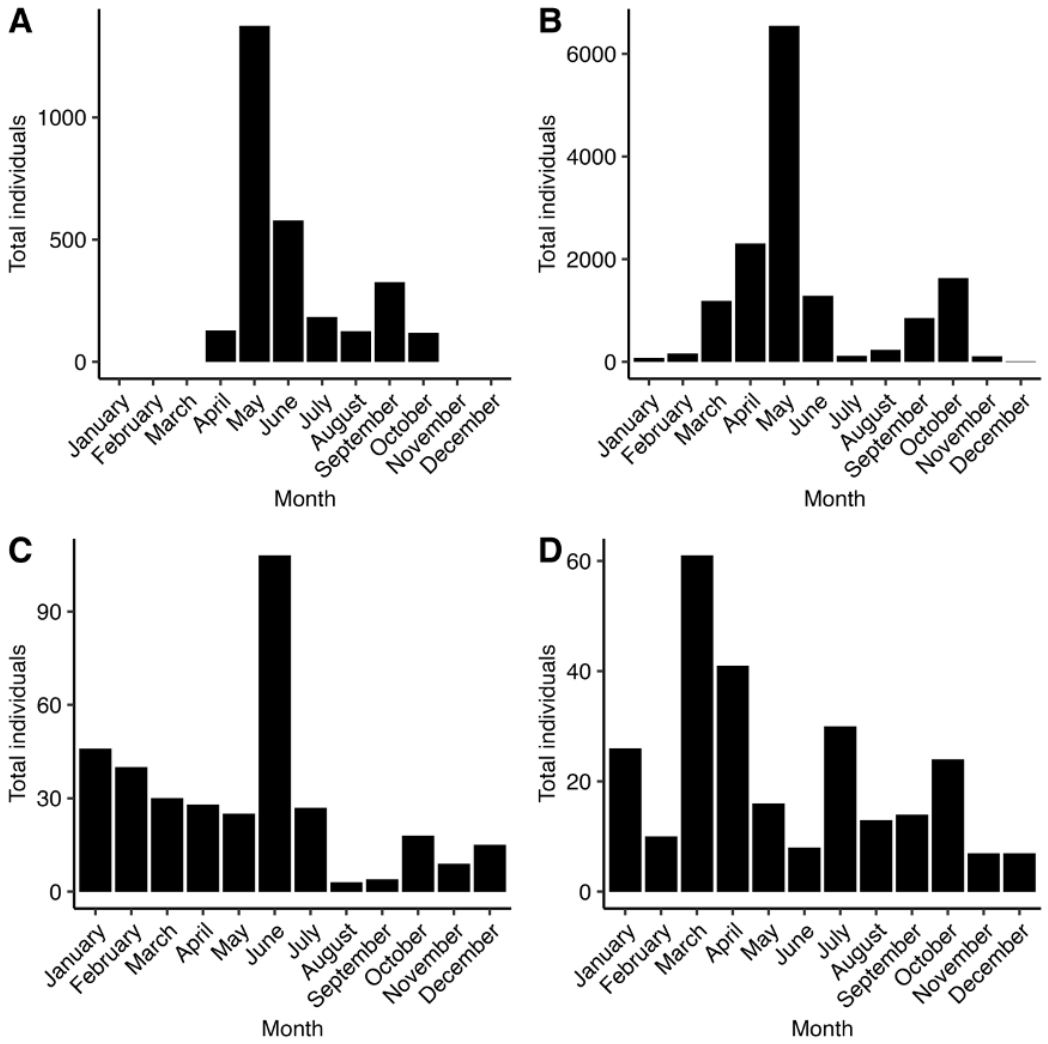

Figure 2. Total individual sighted during each month across the entire study period for the species: A) Scopoli's Shearwater, B) Yelkouan Shearwater, C) Northern Gannet and D) Sandwich Tern.

ed and the small number of individuals recorded did not allow for an analysis of group size between seasons. Presence was recorded from March to September, with a peak of 22 individuals in May, followed by July and August with 15 and 14 individuals respectively. The total ER for the species across the study period was 0.046. The highest seasonal average ER was recorded in spring (0.072), followed by summer (0.066) and autumn (0.003); no individuals were sighted in winter. The ER did not differ significantly between seasons (Kruskal-Wallis test: $H(3) = 6.830$, $p = 0.078$).

Sulids

Northern Gannets

The Northern Gannet represents the third most frequently observed species with 512 individuals recorded, accounting for 2.8% of all seabirds sighted. Sightings of Northern Gannets were spread across the year with the highest number of sightings in summer, for a total of 177 individuals (34.6%) and peaking in June with 137 individuals (26.7%). This was followed by 142 individuals (27.7%) in winter, 100 individuals (19.5%) in spring and 93 individuals (18.2%) in autumn. No clear distribution in the monthly counts of individuals (Fig. 2C) seemed to emerge.

The ER for this species across the study period was 0.276. The highest seasonal ER was in winter (1.00) while the minimum was recorded in spring (0.198). The ER was 0.228 in summer and 0.212 in autumn. The ER did not differ significantly between seasons (Kruskal-Wallis test: $H(3) = 4.125$, $p = 0.248$), although winter presented a high variability (mean ER ± SD = 0.868±0.476). The average group size was 1.2 (±SD = 0.7, min-max = 1-10) across the entire study period with no seasonal difference (Kruskal-Wallis test: $H(3) = 3.428$, $p = 0.334$). Single individuals made up the majority of sightings, 85.2% of groups.

Terns

Among Sterninae species, only the Sandwich Tern was sighted in larger numbers, with 257 individuals (1.4% of all individuals sighted) with an ER of 0.095 (Fig. 2D). This species had the highest seasonal ER in winter (0.318), followed by spring (0.133). The ER in autumn and summer were lower, 0.061 and 0.045 respectively. The ER did not differ significantly between seasons (Kruskal-Wallis test: $H(3) = 5.934$, $p = 0.115$), although winter presented a high variability (mean ER ± SD = 0.279±0.159). The average group size was 1.8 (±SD = 1.9, min-max = 1-20) across the entire study period and presented significant seasonal differences (Kruskal-Wallis test: $H(3) = 14.674$, $p = 0.002$). Significant differences between winter and the other seasons were found (post-hoc Dunn test: Autumn: $Z = 2.110$, $p = 0.017$; Summer: $Z = 3.441$, $p < 0.001$; Spring: $Z = 3.160$, $p < 0.001$).

Fourteen individuals of Common Tern (*Sterna hirundo* (Linnaeus, 1758)) (ER = 0.004) and one of Gull-billed Tern (*Gelochelidon nilotica* (Gmelin, 1789)) (ER = 0.001) were recorded. For 13 individuals, the species could not be ascertained.

Skuas

Species of the family Stercorariidae were sighted 12 times. The Long-tailed Skua (*Stercorarius longicaudus* (Vieillot, 1819)), the Great Skua (*Stercorarius skua* (Brünnich, 1764)) and the Arctic Skua were recorded once - in August 2020 (Carta et al. 2021), June 2021 and April 2022, respectively - each with an ER of 0.001. Four Pomarine Skuas (*Stercorarius pomarinus* (Temminck, 1815)) were observed on two occasions, with a total ER of 0.001. In the remaining seven sight-

ings, species identification was not possible, and these individuals were classified as unidentified skuas.

Alcids

The only species of the Alcidae family recorded was the Atlantic Puffin with an ER of 0.003 across the entire study period. Single birds were sighted in July 2019 and August 2020, 2 individuals were sighted together in January 2022 and 2 together in March 2022.

DISCUSSION

Information on seabird presence and occurrence in the Ligurian Sea is limited and outdated. Atlases on birds wintering in the region rely on data collected from land during the 20th century (Spanò et al. 1998), whereas checklists only report species' occurrence and phenology over larger areas (Baghino et al. 2012). Moreover, there is a lack of studies specifically on the coastal distribution of seabirds in the Western Ligurian Sea. The current study is an attempt to address these gaps by characterising and describing the seabird species found in the coastal area of the Western Ligurian Sea. To our knowledge, the dataset presented in this paper is the largest yet analysed with 12 species considered for this marine area.

In terms of species occurrence, while spring had the highest ER, summer had the most species sighted. This can be explained by the increased surveying effort, which improved the likelihood of sightings of rarer species of skuas and Common and Gull-billed Terns. The highest ER reported in spring, on the other hand, can be explained by the high primary productivity found in springtime (Estrada 1996; Bosc et al. 2004; Casella et al. 2014; Mayot et al. 2017) which can influence shearwaters distribution, the most frequently sighted species.

Overall, throughout the study period, the seabird community comprised several species observed year-round, and during all sampling periods, such as Northern Gannets, shearwaters and Sandwich Terns. In addition to these, other species were occasionally recorded, according to the migratory behaviour, contributing to the community diversity and stressing the ecological importance of the Western Ligurian Sea.

Procellariformes

Shearwaters made up most sightings, with Yelkouan Shearwaters vastly outnumbering Scopoli's Shearwaters (5:1 ratio). This was expected as in the Western Mediterranean Basin major nesting colonies of both species of shearwaters can be found (Baccetti et al. 2009; Péron & Grémillet 2013). Shearwaters presented more numerous groups than other species, with significantly larger flocks recorded in spring. As shown for the Gulf of Lion – region close to the study area - bigger flocks have been linked to an enhanced productivity (Meier et al. 2015; Mayot et al. 2017) for both foraging Scopoli's Shearwater (Péron et al. 2018; Martín

et al. 2019) and for Yelkouan Shearwater feeding at low trophic levels (Bourgeois et al. 2011; Martín et al. 2019). The high primary productivity in the Ligurian basin consequently drives the presence of these species in the study area during spring (Mayot et al. 2017).

For shearwaters the ERs recorded well suit their known migratory behaviours with significant seasonal differences found in both species. Scopoli's Shearwaters were absent from the study area in winter. This result is in accordance with main research on its post-breeding migratory routes (Grémillet et al. 2015; Campioni et al. 2022; Muñoz Arroyo & Mateos-Rodríguez 2022), but it differs from what was previously reported in the Ligurian region (Baghino et al. 2012), therefore highlighting the need for further monitoring in this season. The large number of individuals in spring and early summer relates to the arrival of this species to main breeding sites on Italian and French coasts. From these colonies they depart for their foraging trips towards our study area (Péron & Grémillet 2013; Pollonara et al. 2015). The slight increase in numbers in autumn coincides with the pre-migratory movement, preceding the start of their migration outside of the Mediterranean Basin (Péron & Grémillet 2013; Grémillet et al. 2015).

Similarly to Scopoli's Shearwaters, Yelkouan Shearwaters increase in their numbers from March to May, likely in relation to foraging trips towards the Ligurian Sea (Pezzo et al. 2021). This increase leads to a significantly different seasonal ER from both summer and winter. The low summer ER coincides with the inter-breeding migration to the Eastern Mediterranean Basin performed by part of the population (Militão et al. 2013; Raine et al. 2013). The slightly higher ER in autumn coincides with the return of breeding individuals to the French nesting colonies in preparation for the next breeding season (Brichetti & Fracasso 2003; Péron et al. 2013), while the number of individuals remains low also in winter, a period of low productivity of the Ligurian waters.

A good number of European Storm Petrels were recorded in this study. This species, normally found in more offshore and pelagic areas (Brichetti & Fracasso 2003), is in fact listed as an irregular migrant (Baghino et al. 2012) in the Ligurian region. The higher ERs during spring (0.069) and summer (0.063) corresponds to previous findings on the distribution of this species obtained through aerial surveys (Pettex et al. 2017) and observations in the Gulf of Lion (Rufray et al. 2014).

Sulids

Northern Gannet was the third species for individuals sighted. The few tracking studies performed in the Mediterranean (Kubetzki et al. 2009; Fort et al. 2012; Rodríguez et al. 2013), together with ringing activity, support the idea that the individuals found in the Western Basin come from breeding colonies in the British Isles (Spina & Volponi 2008). As supported by the Ligurian checklist (Baghino et al. 2012), this species appears to be a regular

migrant, both wintering and summering in our study area, with no significant seasonal differences in ERs. The highest ER was found in winter, similarly to other wintering areas in Western Iberian waters (Araújo et al. 2022) and in the Gulf of Lion (Rufray et al. 2014). Interestingly, more than a quarter of all individuals recorded were sighted in the single month of June. This finding is consistent with what has been described in the Gulf of Lion area, presenting a peak in numbers in the same month, although of lower magnitude (Rufray et al. 2014). Overall, this presence at the beginning of summer in the study area has not been investigated thus far, and hypotheses to explain this occurrence have not been put forward.

The presence of Northern Gannet year-round suggests the importance of the study area for foraging not only during winter, but also in summer for individuals not partaking in reproductive activities. This is linked to the presence in the area of waterfronts (Picco et al. 2010; Casella et al. 2014) that support an increased Chl-a, proxy of productivity, in turn linked to the foraging probability of this species (Grémillet et al. 2008; Sabarros et al. 2014; Scale et al. 2014).

Sandwich terns

Sandwich Tern was the fourth most abundant species recorded. It is a regular wintering migrant in the Ligurian region (Baghino et al. 2012), as confirmed also by our results. Regardless of its migratory and breeding habits on the Eastern coasts of Italy (Brichetti 1980; Spina & Volponi 2008; Scarton et al. 2018; Valle & Scarton 2022), the species is present year-round in the study area (Fasola & Bogliani 1990). Spring and summer had the lowest ERs, aligning with its breeding season (Spina & Volponi 2008).

All other species

All the other species analysed in this study were spotted in smaller numbers. The Common and Gull-billed Tern, were sighted in summer and have been described as regular migrants in the region (Baghino et al. 2012). The sightings of skuas throughout the study period contribute significantly to the knowledge of the occurrence of these rare species in the area. This is particularly true for the Pomarine skua listed as Vagrant for the Ligurian region with only 6 individuals recorded until 2011 (Baghino et al. 2012), but registered, in this study alone, for a total of 4 individuals. Only 6 individuals of Atlantic Puffin were recorded, even though this species is described as a regular migrant (Baghino et al. 2012) with multiple sightings in Liguria (Carboneras 1988; Ballardini et al. 2005). The few sightings can be linked to a more offshore distribution or a higher use of the Gulf of Lion area (Rufray et al. 2014).

Methodological considerations

Opportunistic surveys of seabirds offer the chance to collect information on species that are otherwise difficult to study,

increasing our knowledge in their occurrences and behavioural patterns (Balance 2008; Viola et al. 2024).

In our study the opportunistic nature of the data collection enabled us to compile a large dataset on the occurrence of various seabird species in a coastal area. However, the lack of a standardised number of surveys per season, together with the need for favourable environmental conditions for comparable monitoring, led to a variation in surveying effort. This uneven effort likely contributed, at least partially, for the higher number of species recorded in summer. Althought these differences did not hinder analyses of the most sighted species, they underscored the need for an increased monitoring effort during other seasons.

In order to avoid hindering the data collection on cetacean species, which was the main focus of these coastal surveys (Ascheri et al. 2022), a selection of the species to record was made. All landbirds sighted migrating in the area were omitted from data collection, as were seagull species, cormorants and shags. This allowed recording data only on species not easily sighted from land. For cormorants and shags, in particular, main monitoring studies are conducted on land, along the coast of their breeding areas. Similarly, counts of seagulls are highly efficient when performed at breeding colonies from land (Walsh et al. 1995). Moreover, for seagulls, the strong presence of Yellow-legged Gull as well as Black-headed Gull in our area of investigation, would have strongly impacted the data collection on other species both of cetaceans but also seabirds. This species selection, while preventing a complete description of the seabird community, allows us to provide important information on species less easily sighted from land, contributing to their study.

Conclusions

The findings of this study provide a valuable baseline for the seasonal occurrence of seabirds in this area, offer significant information about species presence, and underscore the potential ecological role of the Western Ligurian Sea for seabird populations. These results emphasise the crucial need to establish year-round, long-term monitoring programmes to gather essential information for the conservation of these species. This especially in light of the ongoing debate over the development of offshore wind farms in the Western Mediterranean Sea, which may cause significant impacts (Bray et al. 2016).

Future studies can assess the abundance and density of these species in the area, allowing for the revision of atlases of seabirds and helping to identify potential areas of conservation interest for the protection of the most vulnerable species. Moreover, long-term studies on seabird distribution in the area will help recognise possible spatial and temporal changes in occurrence in relation to environmental variables, therefore providing important information for their conservation.

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