Settlement and population increase of the Mediterranean Gull *Larus melanocephalus*, breeding in the northwestern Adriatic coastal wetlands. A thirty-year study

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Abstract - This note aims to provide an analytical description of the colonization of the coastal areas in northeastern Italy by the Mediterranean Gull (*Larus melanocephalus*) and of the increase in its breeding population from 1995 to 2024, using both unpublished data and published information. After the first nesting of a single pair in 1996, the species nested occasionally until 2003, then increased to 5601 pairs in 2024. The wetlands of the northwestern Adriatic coast host significant numbers of breeding Mediterranean Gulls, probably one of the largest populations in Europe. Breeding occurred both on saltmarsh islets within lagoons regularly flooded by high tides and inside fish farms where water levels are strictly regulated. Recently, fish farms hosted 70-100% of the breeders, thus playing a key role in the species' conservation. Climate change, and in particular the increase of floods and storms during the breeding season, is expected to induce the disappearance of the colonies outside fish farms.

Key words: *Charadriiformes*, lagoon of Venice, Mediterranean Gull, Po Delta.

Riassunto - Insediamento ed espansione demografica del Gabbiano corallino (*Larus melanocephalus*), nidificante nelle zone umide costiere dell'Adriatico nord-occidentale. Uno studio trentennale.

La presente nota si propone di fornire una descrizione analitica dell'andamento temporale della colonizzazione delle aree costiere venete da parte del gabbiano corallino (*Larus melanocephalus*) e dell'incremento numerico della sua popolazione negli ultimi trent'anni, utilizzando sia dati inediti che informazioni pubblicate. Dopo il primo insediamento avvenuto nel 1996, la specie ha nidificato occasionalmente fino al 2023; successivamente è aumentata fino raggiungere circa 5601 coppie nel 2024. Il gabbiano corallino ha nidificato sia nella laguna aperta, su barene regolarmente sommerse dalle alte maree, che nelle valli da pesca e da caccia, dove il livello idrico è controllato dall'uomo. Le zone umide della costa adriatica nord-occidentale ospitano una ingente popolazione di gabbiano corallino, tra le più grandi d'Europa. Le valli da pesca e da caccia hanno ospitato recentemente il 70-100% della popolazione, svolgendo un ruolo chiave nella conservazione della specie. Gli effetti dell'instabilità meteo-climatica, in particolare l'aumento degli eventi di sommersione e delle tempeste durante la nidificazione, causerà probabilmente la scomparsa delle colonie dalle barene poste al di fuori delle valli da pesca e da caccia.

Parole chiave: *Charadriiformes*, Delta del Po, Gabbiano corallino, Laguna di Venezia.

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INTRODUCTION

The Mediterranean Gull (*Larus melanocephalus*) until the mid-20th century had a breeding range almost entirely restricted to southeastern Europe, with a core population located on the northern shores of the Black Sea (Ardamatskaya, 1999; BirdLife International, 2024). During the past decades, the species colonized several European countries, including the Netherlands, France, Italy, Greece, Turkey, England, Belgium, Germany, and Spain, as well as the coastal areas of the Caspian Sea (del Hoyo *et al*., 1996; Balmer, 2020). Its total population has been recently estimated at 236,000-656,000 mature individuals, with 118,000-328,000 breeding pairs in Europe (BirdLife International, 2024).

First breeding in Italy occurred in the 1970s by 25 pairs in the Comacchio wetland (Angle, 1978), followed by the colonization of Bertuzzi wetland in the early 1980s and then of the other wetlands bordering the Romagna coastline, reaching 2500-4000 pairs (Fasola, 1986; Volponi *et al.*, 1998; Brichetti & Foschi, 2006; Brichetti & Fracasso, 2018; Farioli, 2022).

The first nesting pair in Veneto was found in 1996, with a single pair occupying a multi-specific colony in the Lagoon of Venice (Scarton & Valle, 1997). The northern Po Delta was colonized in 2003 (Verza, 2014). Since then, the species has shown a strong population growth in the Veneto Region coastal wetlands, forming a population of thousands of pairs from 2014 onwards (Valle & Verza, 2020; Valle & Scarton, 2023). However, detailed descriptions of the temporal sequence of colonization and of the breeding habitat are still lacking.

This note provides an analytical account of both the temporal progression of the colonization of coastal areas of the Veneto Region (northeastern Italy) by the Mediterranean Gull, together with an investigation of the increase in its population numbers over the past thirty years, using both our unpublished data and published information. The distribution of colonies on different habitats (coastal lagoons and fish farms) is described. Finally, we analyze the trend of wintering Mediterranean Gulls using data collected during mid-January counts.

MATERIALS AND METHODS

The fieldwork was conducted during the 1995-2024 breeding seasons, in the complex of wetlands along the northwestern Adriatic coastline between the mouth of the Sile River (45°28'N; 12°35'E) and the Po di Goro River (44°49'N; 12°17'E). This includes the Lagoon of Venice (55,000 ha) and the portion of the Po Delta (61,000 ha) within the Veneto Region, which will hereafter be referred to as the "northern Po Delta". The area is characterized by several shallow lagoons, ranging from a few hundred meters to several kilometres wide (~850 km^2 overall), hosting hundreds of natural saltmarsh islets (about 3600 ha overall) and more than one hundred artificial dredge islands, i.e., intertidal islands built with sediments coming from channel dredging (Scarton *et al*., 2013). The lagoons are separated from the sea by 30 barrier islands and are bordered by 50 privately owned fishing and hunting farms, where water levels are artificially regulated. Some barrier islands, saltmarsh islets, dredge islands, and dikes are used each year by single- or multi-species colonies of gulls and terns. The community of seabirds that breeds in our study area is one of the largest within the Mediterranean, with ~20,000 pairs. Nine species of breeding gulls and terns have been recorded: Slender-billed Gull *Larus genei*, Black-headed Gull *Larus ridibundus*, Mediterranean Gull, Yellow-legged Gull *Larus michahellis*, Gull-billed Tern *Gelochelidon nilotica*, Lesser-Crested Tern *Thalasseus bengalensis*, Sandwich Tern *Thalasseus sandvicensis*, Common Tern *Sterna hirundo*, and Little Tern *Sternula albifrons* (Scarton & Valle, 2015; Valle & Verza, 2020).

Data were collected within a project aimed at monitoring the breeding of all waterbirds, conducted continuously since 1989 throughout the coastal lagoons in the Veneto region (Scarton & Valle, 2015; Verza *et al*., 2024). Following the discovery of the first breeding pair of Mediterranean Gull in 1996, the entire area was searched for colonies by boat, during each breeding season from 1996 to 2024. Only in the Lagoon of Venice, fish farms could not be surveyed every year; thus, it is possible that some colonies remained unnoticed. The colonies were visited at least twice during the peak breeding season, May-July, avoiding days with unusually high tides, strong winds, and rain, and the middle hours of the day. Active nests, i.e., containing eggs and/or chicks, were counted, and the peak number of nests was retained as colony size. The number of Mediterranean Gull breeding pairs was assumed to be the same as the number of active nests, an assumption that may not always be valid (Frederick *et al*., 2006). Nevertheless, gulls and terns lay their eggs synchronously, particularly Mediterranean Gulls, which are very synchronous, at least within the same colony (Cramp, 1985; Fasola, 1986). Therefore, except for replacement clutches, any underestimation should be modest. The colony location was plotted on a 1:10,000 scale map and recently recorded using portable GPS. In this paper, a "breeding site" is considered a spatially well-defined place (a salt marsh islet, a dredge island) used at least once by at least one breeding pair. Since 2017, we have also used drones to count nesting pairs at colonies (Valle & Scarton, 2023). To minimize disturbance to birds, nests were mapped from drone flying at elevations above ground higher than the agitation distance of the species (Valle & Scarton, 2018). Since 2017, incubating birds were semi-automatically counted on drone images using the freeware ImageJ (https://imagej.net/ij/), according to previously validated protocols for the species (Corregidor-Castro & Valle, 2022).

Furthermore, we reported here the findings of the regular monitoring of tagged individuals, which has been conducted in the Lagoon of Venice since 2011. Since the end of the last century, marking projects with colored rings on Mediterranean Gulls began in various European countries, in order to collect more data on the migratory movements of this species. In the northern Po Delta, this activity began in 2003 (Basso, 2008) and in the Lagoon of Venice in 2011 (Basso & Panzarin, 2014). Regular monitoring of tagged individuals has been carried out in the Lagoon since 2011, resulting in records for >250 individuals.

Data about counts made in mid-January between 1993-2024 (Lagoon of Venice) or 1997-2024 (northern Po Delta) are presented and discussed; these data come from unpublished yearly reports, freely available at www.faunistiveneti.it for the Lagoon of Venice or from www.birdingveneto.eu for the northern Po Delta.

Statistical analyses were performed using TRIM, version 3.5 (Pannekoek & Van Strien, 2005). Categorical data are presented as percentages, and continuous data as mean ± standard deviation. All tests are two-tailed, and a value of $p<0.05$ was considered significant.

RESULTS

The first nesting Mediterranean Gull in the study area occurred in 1996 in the Lagoon of Venice, where a single pair was found within a colony of Sandwich Terns in a saltmarsh island in the southern open Lagoon of Venice (Tab. 1 and Fig. 1). Not until 1999 a second occurrence of breeding was recorded in the Lagoon of Venice. Then, in 2012, a colony of 350 pairs settled in the same saltmarsh island where the two previous nesting had occurred, again in association with Sandwich Terns (Fig. 2). Thereafter, the occupancy has been very irregular, with a mean population of 157±721 pairs, but a wide range, with a peak of 2512 pairs in 2016 in the open Lagoon of Venice, and no pair in four breeding seasons of the study period. In the same years, the species colonized the fish farms of the northern Lagoon of Venice, since 2003, with a small population of 23 pairs, which showed a peak of 1764 pairs in 2021, with a mean population of 1145±1670 pairs over 22 years. The fish farm population of the Lagoon of Venice further increased with the colonization of the southern Lagoon in 2023, with a population of a hundred pairs, abruptly increased to 2314 pairs in 2024. Mediterranean Gulls showed a different colonization pattern in the northern Po Delta, where they bred exclusively within fish farms (Figs. 3 and 4), arguably due to the absence of suitable saltmarsh islands in the open lagoons. Here too, an increase occurred from a few dozen pairs to several thousands, with an increasing trend, though with marked fluctuations (Tab. 1 and Fig. 1).

Over the study period and the whole study area, TRIM classified the trend until 2015 as "uncertain" given the high inter-annual variability; since 2016, the trend was "strong increase" ($p<0.01$), with an annual increase rate of 28.7%.

When comparing the distribution of birds between the two different parts of the study area, the absolute preference for fish farms in the northern Po Delta is evident, no nesting attempt being found in the open lagoons. On the contrary, in the Lagoon of Venice, the Mediterranean Gull nested on several occasions in the open lagoon, using different habitat types, albeit on only four sites out of hundreds available. Birds used two saltmarsh islands, 800 m distant from each other; one dredge island, with a few pairs: one and 26 in 2022 and 2023, respectively, and even a minuscule islet (0.01 ha) formed by remnants of an old building.

Regarding the wintering population, International Waterbirds Census counts for the study area (Fig. 5) show that the vast majority of individuals (97-100% in each year) were recorded in the Lagoon of Venice, with a mean number for the 32 years of 2924±1819 birds, of which 87% were in the southern open lagoon and only a minority in the northern open lagoon or along the littoral strip; the fish farms accounted only for 1%. The northern Po Delta had a very low number of birds, with a mean of just 27.8±74.2 birds; in 13 winters out of 28, no bird was observed. No clear trend

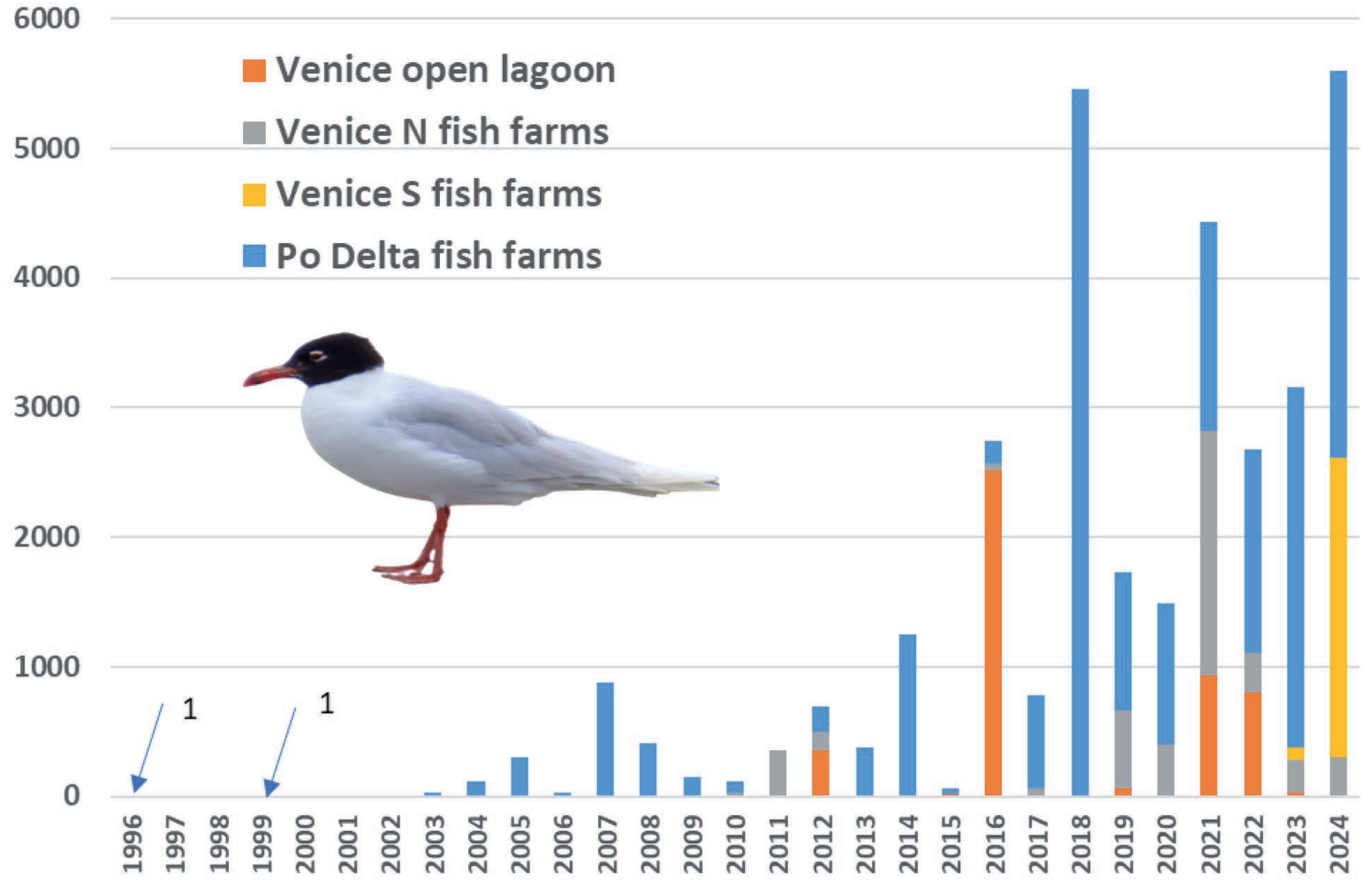

Fig. 1 – Numbers of Mediterranean Gull breeding in the complex of coastal wetlands of the Lagoon of Venice and the northern Po Delta (northwestern Adriatic coastline) over the whole study period. / Andamento della popolazione di Gabbiano corallino nidificante nel complesso di zone umide costiere della Laguna di Venezia e del Delta del Po nel periodo di studio.

Tab. 1 – Numbers of Mediterranean Gull in the Lagoon of Venice and Po Delta (northwestern Adriatic coastline) over the whole study period. / Popolazione di Gabbiano corallino nidificante nella Laguna di Venezia e nel Delta del Po durante il periodo di studio.

Year	Open lagoon	Lagoon of Venice Northern fish farms	Southern fish farms	Northern Po Delta Fish farms	Total Open lagoon + fish farms
1995	0	0	0	0	
1996	1	0	0	0	1
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	1	0	0	0	1
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	0	0	23	23
2004	0	0	0	110	110
2005	0	0	0	303	303
2006	0	0	0	25	25
2007	0	0	0	875	875
2008	0	0	0	412	412
2009	0	0	0	145	145
2010	0	30	0	86	116

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Year	Open lagoon	Lagoon of Venice Northern fish farms	Southern fish farms	Northern Po Delta Fish farms	Total Open lagoon + fish farms
2011	0	350	0	0	350
2012	350	150	0	194	694
2013	8	Not assessed	0	364	372
2014	2	Not assessed	0	1250	1252
2015	19	Not assessed	0	40	59
2016	2512	60	0	165	2737
2017	0	60	0	723	783
2018	0	?	0	5456	5456
2019	57	600	0	1069	1726
2020	0	400	0	1090	1490
2021	928	1894	0	1611	4433
2022	803	300	0	1577	2680
2023	26	250	100	2776	3152
2024	0	300	2314	2987	5601

emerged from the counts across the 1993-2024 years for the whole study area; bird numbers fluctuated widely around the mean value, with peaks observed in 2020 and 2022.

DISCUSSION AND CONCLUSIONS

Our work yielded four principal findings. Firstly, our results show that the Mediterranean Gull has successfully established a breeding population in the coastal wetlands of the northwestern Adriatic Sea. This is in line with the observed range expansion and population growth of this species observed in other European regions (Balmer, 2020; Jankowiak *et al*., 2024). For the northwestern Adriatic wetlands, there were no records of nesting along the northern Adriatic coastline, north of the Po di Goro River, in historical times, before the first breeding in 1970 (Naccari, 1823; Contarini, 1843; Ninni, 1879; Dal Fiume, 1896; Ninni, 1938; Fasola, 1986).

A second outcome of the present study is that the Lagoon of Venice-northern Po Delta complex represents an area of considerable importance for the Mediterranean Gull breeding in Italy, with an average of 3471±1422 pairs observed from 2020 to 2024. Compared to the most recent estimates of the Italian breeding population of 2500-4000 pairs (Farioli, 2022), the northwestern Adriatic contingent represents the majority of the national population, and it is close to 8% of the EU28 total (EIONET, 2021). Within Europe, only France and the Netherlands host populations of Mediterranean Gulls larger than our study area.

Fig. 2 – Colony of Mediterranean Gull placed on a saltmarsh islet of the Lagoon of Venice (May 2021). Severe damage to halophilous vegetation by massive bird trampling is clearly visible. / Fig. 2 - Colonia di Gabbiano corallino su una barena della Laguna di Venezia (maggio 2021). Sono chiaramente visibili i gravi danni alla vegetazione alofila causati dal continuo calpestio degli uccelli.

Fig. 3 – The largest colony of Mediterranean Gull (4618 pairs), found during the whole study period (1995-2024), located on two parallel levees in a fish farm of the northern Po Delta (June 2018). / La più grande colonia di Gabbiano corallino (4618 coppie) del periodo di studio (1995-2024), situata in una valle da pesca del Delta del Po settentrionale (giugno 2018).

The third finding of our work is that the nesting in the Lagoon of Venice-northern Po Delta complex showed an impressive growth, from sporadic pairs to thousands. The analysis of the temporal dynamics shows that after a first period of settlement and moderate growth the Mediterranean Gulls reached the level of one thousand pairs at the beginning of the century, then entered a phase of relative stability, except for periodic abrupt fluctuations, such as in 2015, when the species almost disappeared from the study area. It is possible that the Mediterranean Gulls may have bred in those years, in the Romagna wetlands, which are known to host the species (Fasola, 1986), as was the case in 2015, when the Cervia salt pans hosted 3250 pairs (Nardelli *et al*., 2018). However, the Valli di Comacchio, which were previously identified as the core breeding site for the species in Italy (Fasola, 1986), did not host the species in recent years (Volponi, 2018). Unfortunately, no conclusion can be drawn since data are scarce for the other wetlands of Romagna in the recent literature, to the best of our knowledge.

Breeding Mediterranean Gulls showed a clear preference for fish farms, which hosted the largest proportion of breeders (on average 89% from 2020 to 2024, and 100% in two of the years) in accordance with previous findings (Fasola, 1986). Breeding in fish farms guarantees better reproductive success (Valle & Scarton, 2021 and *pers. obs*.) in comparison to the open lagoons, where massive egg losses result from frequent tidal flooding during spring storms (Valle & Scarton, 2023). Clutch loss due to tidal surges assumed catastrophic proportions in 2016, when all the 2512 clutches were washed away in the colonies located in the open Lagoon of Venice. The frequency of tides higher than 0.8 m asl (i.e., higher than saltmarshes) in the Venice Lagoon has been rapidly increasing over the last 20 years, due to climate change that caused sea level rise and increased storminess (Ferrarin *et al*., 2022; Baldan *et al*., 2023). Between 1996 and 2022, the sea level increased by about 10 cm (www.comunedivenezia.it). The occurrence of high tides in late spring, when they once were rare, is already having a heavy impact on waterbirds nesting in the saltmarshes, and soon these habitats will no longer be suitable as nesting sites. Only dredge islands, which have a slightly higher elevation than natural saltmarshes, could still be suitable.

Within the fish farms, Mediterranean Gulls often select small levees, which are higher above the water level than saltmarsh islets (pers. obs.), as reported for other breeding areas (Fasola & Canova, 1991), thus providing safety from flooding. Moreover, Yellow-legged Gulls, the main avian predator of chicks and eggs of Mediterranean Gulls, are virtually absent from most of the fish farms (Valle & Verza, 2020). Although Mediterranean Gulls are known to be only marginally affected by predation (Fasola & Canova, 1991), catastrophic losses are reported (Girard & Fouquet, 2012). Another factor for the preference of fish farms could be the very low anthropic disturbance, thanks to severely restricted public access. However, disturbance is negligible in the open Lagoon of Venice as well, where human presence is limited to a few fishermen.

As an aside, we mention that from the "history life" by several European ringing schemes, we can state that birds from colonies in Hungary, Serbia, Slovenia, Czech Republic, Poland, Belgium, France, Germany, The Netherlands, Ukraine and Greece transit through the Lagoon of Venice (Fig. 6). Many of the individuals identifiable by the ring seem to maintain a constant period of passage (at a month decade level) in the Lagoon over the years.

The distribution of wintering birds, almost restricted to the Lagoon of Venice, even if the northern Po Delta has remarkably similar ecological characteristics, is not easily explained. The species is known to prefer habitats

Fig. 4 – Colony of Mediterranean Gull on a vegetated mound in a fish farm of the Po Delta (July 2021). Photo: Lorenzo Zanella / Colonia di Gabbiano corallino su un dosso artificiale interamente vegetato in ambente vallivo nel Delta del Po (luglio 2021). Foto: Lorenzo Zanella.

Fig. 5 – Numbers of Mediterranean Gull wintering in the coastal wetlands of the Lagoon of Venice and the northern Po Delta (northeastern Adriatic coastline) between 1993 and 2024. In 2021, no census was done at the Lagoon of Venice. Census in the Po Delta began in 1998. / Andamento della popolazione di Gabbiano corallino svernante nelle zone umide costiere della Laguna di Venezia e del Delta del Po settentrionale (costa adriatica occidentale) tra il 1993 e il 2024. Nel 2021 non sono stati effettuati censimenti nella Laguna di Venezia. Il censimento nel Delta del Po è iniziato nel 1998.

characterized by extensive beaches, high marine productivity, and proximity to agricultural areas. These conditions are met in regions such as the Ebro and Rhone deltas (Carboneras, 2009), but the northern Po Delta would also satisfy these requirements. Social factors are also known to influence the winter distribution of this species (Carboneras, 2009; Carboneras *et al*., 2010). The large occurrence of Mediterranean Gulls in the southern Lagoon of Venice in winter (2380 birds on average from 1993 to 2020 with peaks of 7242 in 2020) could be related to the occurrence of the fishing port of Chioggia, the largest in the northern Adriatic (Monti *et al*., 2014), since fish discards are one of the most important components of the Mediterranean Gull diet (Cama *et al*., 2011). An assessment of the importance of the population wintering in the study area on a national scale is hindered by the lack of recent information. A comparison with data for the period 1996-2010 provided by Brichetti & Fracasso (2018) indicates that our study area hosted between 12% and 30% of the Italian total. In January 2018, 10,614 birds were counted in Italy (Zenatello *et al*., 2018), which suggests that approximately 20% of the total occurred in the northern Po Delta - Lagoon of Venice. The same authors also indicate a moderate decline in Italy between 2009-2018, while in our study area, numbers fluctuated with an "uncertain" trend in the same period. Moreover, a comparison with the EU28 population size indicates that about 5% of it occurs in the study area (EIONET, 2021).

Our work confirms previous observations (Brichetti & Fracasso, 2006) on post-reproductive movements in the Lagoon of Venice from August to mid-November, with juvenile dispersions from mid-July and spring movements from mid-February to May, though we observed significant migration flows, including adult birds, as early as mid-July. In addition, the tendency of individuals born in Veneto to overwinter mainly on the coast of southwestern Europe (Spain, Portugal, and France) is also confirmed.

Our work has some limitations. It reports a single estimate of each colony per breeding season and therefore may lack accuracy. In addition, inferences on the relationship between habitat selection and reproductive success at fish farms lack an analytical approach and must therefore be taken with caution. Finally, the lack of available recent data for the other nesting areas of the species limits our understanding of the reasons for the variations in the size of the Mediterranean Gulls population in the study area, reduced to zero in some breeding seasons.

In conclusion, the wetlands of the northwestern Adriatic coast host a significant population of the Mediterranean Gull and one of the largest populations in Europe. Fish farms host the largest part of the population, and nowadays they play a key role in the conservation of the species in the study area.

Fig. 6 – Mediterranean Gull with Hungarian ring. Lagoon of Venice (July 25th, 2024). Photo: Alessandro Sartori. / Gabbiano corallino con anello ungherese. Laguna di Venezia (25 luglio 2024). Foto: Alessandro Sartori.

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