Recent changes in the size of colonies of the Mediterranean Shag *Phalacrocorax aristotelis desmarestii* in Corsica, western Mediterranean

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INTRODUCTION

Relationships between the spatial distribution and the size of seabird breeding colonies suggest that seabird numbers may be limited by intraspecific competition for food around colonies during the breeding season, whether in tropical, temperate, or cold waters (Ashmole 1971, Furness & Birkhead 1984). Cormorant and Shag (Phalacrocoracidae) numbers can fluctuate over short periods of time, and both species change colony-sites regularly, often in close relation with the fluctuating numbers of some fish species (e.g. Cooper 1980). For these reasons, even a long-unattended breeding-site can rapidly become a large colony. For conservation, this underlines the importance of protecting and managing potential breeding-sites for future use. During the 1980s, the overall number of Mediterranean Shags *Phalacrocorax aristotelis desmarestii* was estimated at less than 10,000 pairs of which *ca.* 7,000 pairs were in the western Mediterranean islands, mainly in the Balearics and on Sardinia and Corsica (Guyot 1993). The aim of this paper is to present results of censuses of breeding Mediterranean Shags over a 17-year period in Corsica, and to show changes in distribution and colony size both for the overall population and five geographic areas.

METHODS

On the island of Corsica (42°N, 9°E), Mediterranean Shags breed on rocky islets surrounding the mainland and on cliffs along the west coast (Guyot 1985). Fig. 1 shows the location of the main colony-sites used by Shags between 1978 and 1994. All are isolated islets or archipelagoes, except on the west coast where Shags breed in isolated pairs or in small groups on inaccessible cliffs, and on only one island (Gargalo, = 6 on Fig. 1). Colony-sites have been grouped into five geographic areas: North (Finocchiarola I.), West (all coastal sites from Calvi to Cargèse), South-west (Lava I., Sanguinaires I., Piana I.), South (Bruzzi I., Tonnara I. and Lavezzi I.) and South-east (Cerbicale Is.). Guyot *et al.* (1985) have provided historical information about Shag surveys in Corsica, and the physical characteristics of islets surrounding Corsica are given in Guyot (1989).

To census, we landed on islet colony-sites; on the West coast, censusing was conducted from a boat. Isolated nests or groups of nests were mapped during each census. In the West area where most nests sites are inaccessible, we included all nests attended by adults or where young could be seen. For the other areas we included only active nests i.e. those with eggs or young. Studies elsewhere have shown that in some years even former breeders may refrain from breeding (Aebischer 1986, Aebischer & Wanless 1992), suggesting that in some cases nest counts may substantially underestimate the breeding population. In addition there are problems in using a single nest count to estimate population size for colonial breeders, since even the peak count usually underestimates the breeding population, especially when there is a large spread of laying dates and/or breeding success is poor (Harris & Forbes 1987, Green & Hirons 1988). The breeding season of the Mediterranean Shag varies from year to year in timing and duration, and laying can occur from November to May (Guyot 1985). In this paper we have used only censuses conducted in February, the month during which at least 90% of nests contain eggs or chicks (I. Guyot & J.-C.

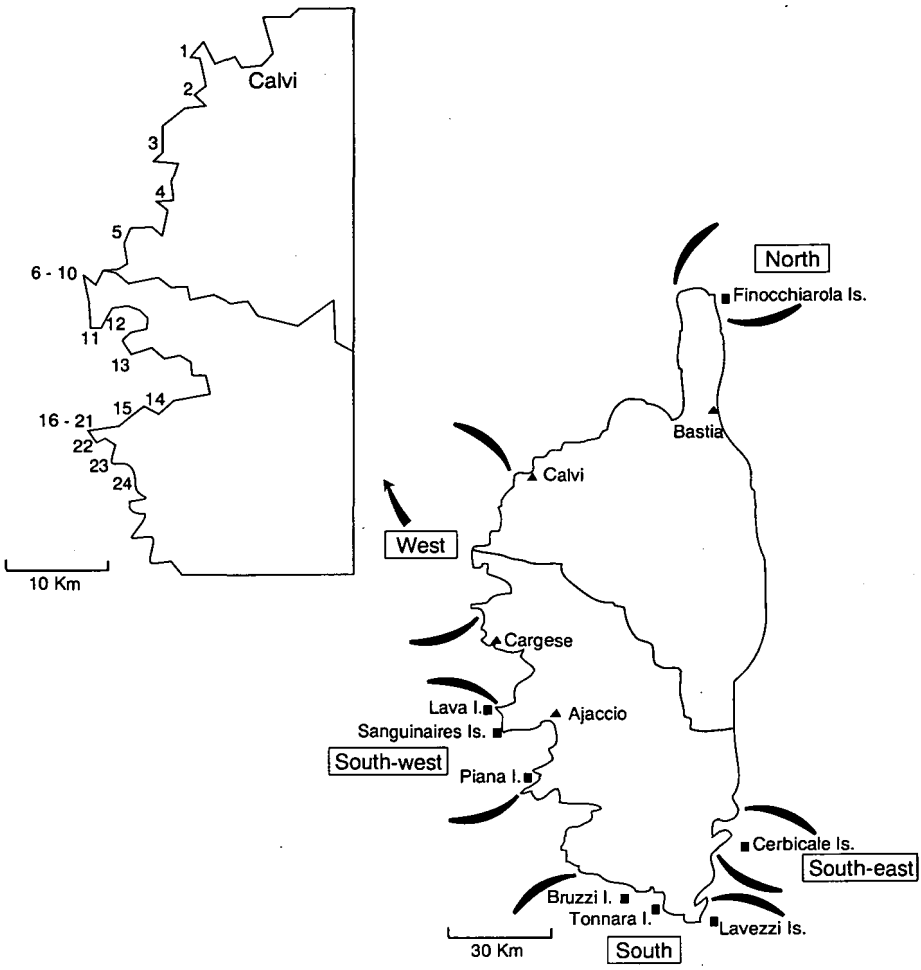

Figure 1. Areas and main Mediterranean Shag colony-sites on Corsica. Numbers indicate the different localities in the West area (see Appendix for identification).

Thibault unpubl. data). Between 1978 and 1994 censuses were obtained regularly for the West coast and Finocchiarola Is. (respectively 15 and 16 censuses for 17 years). Elsewhere censuses were less frequent, although some were obtained for all colony-sites from 1978 to 1985 and from 1993 to 1994.

We use throughout the terminology proposed by Kushlan (1986): "census" to count number of colony inhabitants, "colony-site" the site where Shags breed and "colony" the avian assemblage.

Because of the Shag's high survival rate and site fidelity (Potts 1969, Aebischer 1985), annual data from the same site are unlikely to be completely independent. We were cautious when interpreting levels of probability based on statistics that assume independence. Data on counts of

breeding pairs have been log-transformed. Linear regression was used to test significance of trend, Mann-Whitney U-test to compare data for colony-site between years, and Kendall's Coefficient of Concordance to compare variation between colony-sites over a period of several years.

RESULTS

Overall situation on Corsica

Censuses of all the colony-sites grouped in the five areas, from 1978 to 1994 are summarized in the Appendix. The overall number fluctuated from year to year, with an average annual decrease rate of 5% (although linear regression was not significant, r_4=-0.72). Fig. 2 shows trends in each of the five areas. With the exception of the North area which Shags colonized during this period,

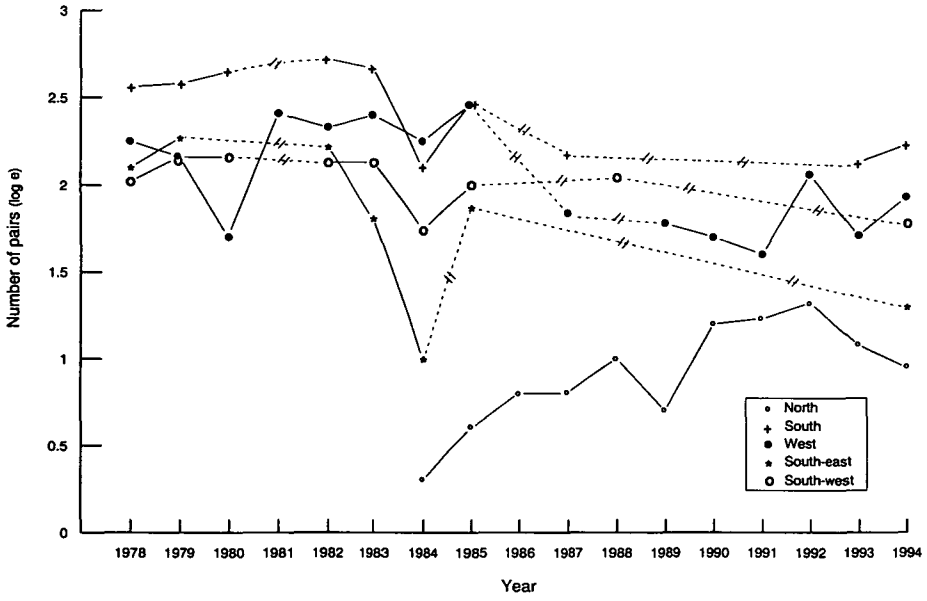

Figure 2. Changes in numbers of breeding Shag pairs in five areas on Corsica from 1978 to 1994 (Small open circle: North area, cross: South area, dot: West area, star: South-east area, open dot: South-west, double bar with broken line: number unknown).

numbers for all areas decreased at an average annual rate of respectively 10% (South-east), 4.5% (South), 5% (West) and 3% (South-west). The rank orders of annual counts over years were not significantly correlated either for all five areas (Kendall's coefficient of concordance, $\tau = 0.25$, n = 6, n.s.), or excluding the North area ($\tau = 0.54$, n = 6, n.s.).

Although Shag numbers decreased between 1978-81 and 1990-94 in the four main areas (South-east, South, West and South west), this was not associated with a reduction in the number of occupied colony-sites during these periods (Table I). Nevertheless, in the West area there is a significant relationship between the number of pairs and the number of sites occupied ($r_{12} = 0.69$, $p<0.01$), but such a relationship does not exist among the other areas (Fig. 3), excepted South-west which included no more than three colony-sites.

TABLE I. NUMBERS OF COLONY-SITES OCCUPIED BY MEDITERRRANEAN SHAGS IN CORSICA IN 1978-81 AND 1990-94

	1978-81	*1990-94*
North	0	1
West	21	20
South-west	1-2	3
South	8	9
South-east	6	5
Total	36-37	38

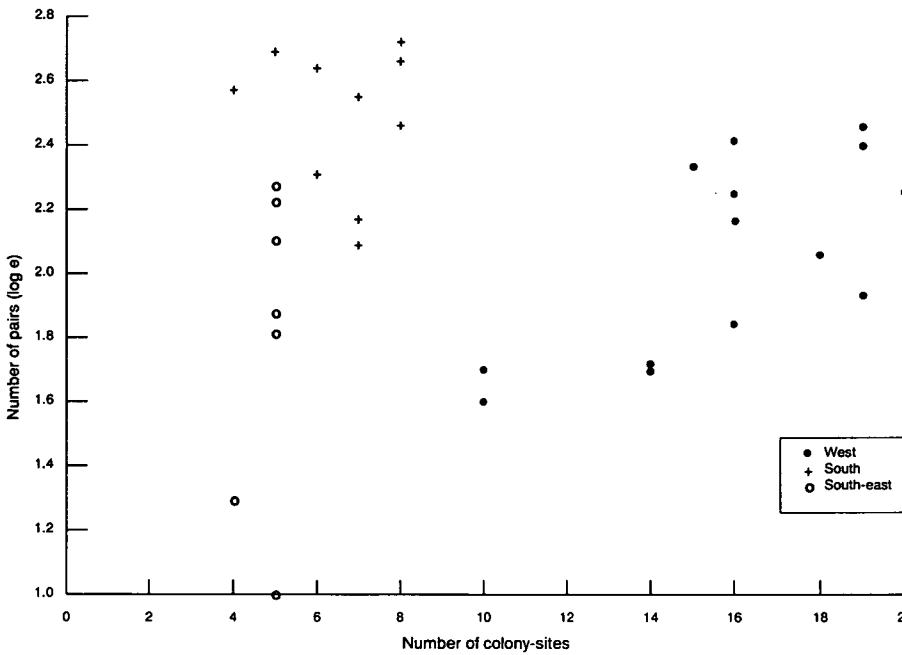

Figure 3. Relationship between number of breeding pairs (log transformed) and number of occupied colony-sites.

Detailed situation in the five areas

North area

Shags were first recorded breeding on Finocchiarola Is. (1 colony-site) in 1984 (Appendix). Since then, they have bred regularly, although numbers are low and fluctuate from year to year. The overall increase is significant (r_9= 0.77, $p<0.01$) with an average annual rate of 16%.

West area

Detailed data for the 24 colony-sites are presented in the Appendix. Variations in numbers between 1978 and 1994 (15 counts) are significantly related among the six main colony-sites [1, 4,

6-12, 14-22, 23, 24 (grouped owing to close geographical distribution); $\tau = 0.54$, $p<0.001$]. There was a significant decrease in the overall number for this area between 1978 and 1994 ($r_{13}= -0.51$, $p<0.05$); three distinct periods may be discerned: 1978-80 (decrease), 1981-85 (maximum number), 1987-94 (marked decrease, followed by stabilization at a low level). Most colony-sites decreased in size between 1981-85 and 1987-94. The three largest showed significant decreases between periods: Capo rosso area (= 14-23) (U=2, $n_1=5$, $n_2=7$, $p<0.05$, Mann-Whitney U-test), Ciuttone (U=2, $n_1=5$, $n_2=7$, $p<0.05$) and Gargalu (U=0, $n_1=5$, $n_2=7$, $p<0.05$). Three colony-sites nearly disappeared (Cavallu, Orchinu and Castel-Arone). But several other smaller sites present different patterns: one did not present any trend (Elpa nera, $r= -0.03$, ns), two were colonized (since 1985 for Senino and 1987 for Revellata).

South-west area

Numbers on the Sanguinaires Is. (1 colony-site) decreased significantly between 1978 and 1994 ($r_7= -0.69$, $p<0.05$) at an average annual rate of 6%. On Piana I. (1 colony-site) only three censuses were conducted, no Shags were recorded in 1980, small numbers were present in 1988 and 1994. On Lava (1 colony-site), Shags were discovered in 1989, and counted only in 1992 and 1994.

South area

Numbers of Shag nests were not significantly correlated between the colony-sites of Bruzzi, Tonnara and Lavezzi Is. ($\tau = -0.25$, n=10, n.s.), nor among the 8 colony-sites of Lavezzi Is. ($\tau = -0.19$, n=7, n.s.) over the period 1978-94.

The decrease on Lavezzi Is. (8 colony-sites) between 1978 and 1994 (average annual rate: 7%) was significant ($r_{10}= -0.78$, $p<0.01$). Between 1978 and 1980, the main colony-sites (islets A and B) were apparently full up, and Shags colonized several parts of the main island of Lavezzi (Lavezzi 1 and 2, Appendix). After 1986, numbers seemed to remain low, although censuses were not conducted on all islets every year. However since then, the number of main sites (islets A and B) has been very low, and number declines on the main island are resulting in desertion.

The situation was different on other isolated islets of the archipelago of Lavezzi: (i) Ratino and Porraggia showed no significant trend (respectively $r_7= -0.50$, n.s. and $r_{10}= -0.21$, n.s.), (ii) Piana, where Shags were absent from 1978 to 1983, constituted the main colony-site in 1993-94.

On Bruzzi I. (1 colony-site) numbers fluctuated annually, sometimes dramatically, with 1 pair in 1978 and 40 two years later (Appendix). There was no significant trend between 1980 and 1994 ($r_9=0.17$, n.s.). Tonnara I. (1 colony-site) was colonized by Shags after 1985 (Appendix).

South-east area

Variation in numbers on Cerbicale Is. between 1978 and 1994 were not significantly related to variations among colony-sites ($\tau = 0.19$, n=6, n.s.). Decrease between 1978 and 1994 is significant ($r_4= -0.85$, $p<0.05$). Between 1978 and 1982, high numbers were noted on one site (Pietricaggiosa, see Appendix). Subsequently there was a general decline in all the colony-sites.

DISCUSSION

While there was no major change in either the distribution or the number of colony-sites of Mediterranean shags in Corsica between 1981-82 and 1993-94, there was a marked decline in the number of nests with the total population decreasing by 55% during the study (Fig. 4). Thus while seven colony-sites held over 100 nests in 1981-82, by 1993-94 only two contained more than 50 nests (Appendix).

Most colony-sites were affected by a sharp decrease, but no information collected allows us to know if birds permanently left Corsica. We did not witness a massive shift between colony-sites, although several examples of colonization of new sites do suggest that shifts occurred on a smaller scale: (i) in the West area, on Revellata after 1985 (corresponding to decrease in numbers on

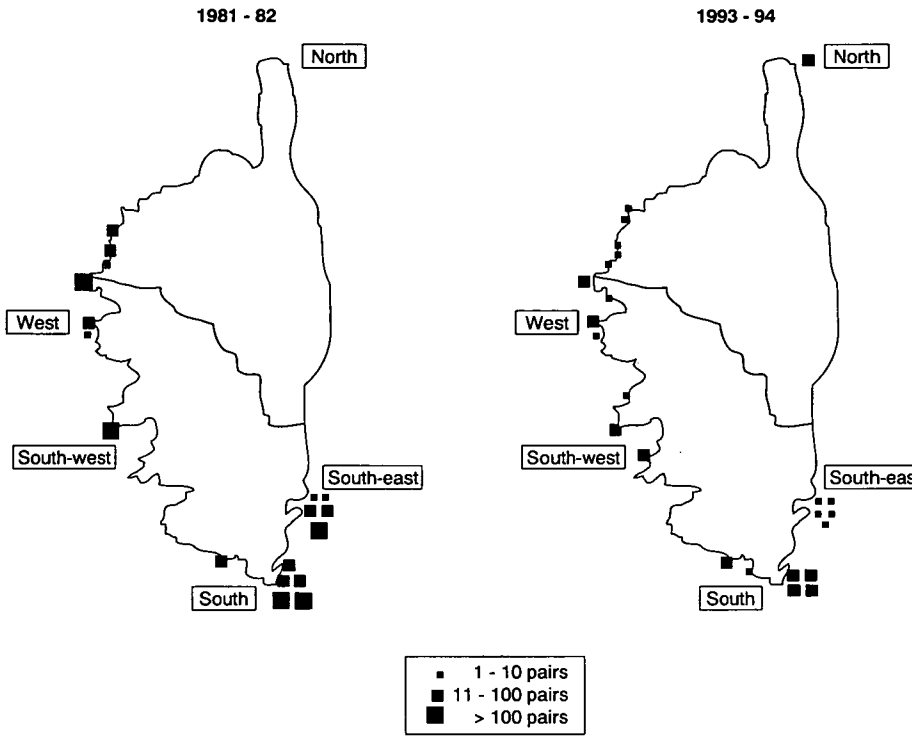

Figure 4. Changes in distribution and size of colonies of Mediterranean Shag on Corsica, between 1981-82 and 1993-94.

Cavallu) and Seninu after 1984 (Appendix), (ii) on Tonnara I., colonized after 1985 by at least some birds from Lavezzi Is., as indicated by observations of several Shags with colour rings (distance between the two colony-sites: 18 km., I. Guyot unpubl. data), (iii) Piana I. became the main colony-site in the Lavezzi archipelago, and (iv) colonization of isolated islets, such as Bruzzi I. after 1978, Piana I. (South-west area) after 1980 and Finocchiarola I. after 1983. Colonization of new but small sites, suggests that wider distribution has compensated for a decrease in number.

What therefore are the reasons for this rapid decrease? Adult mortality is apparently not a cause, as revealed by ringing studies, nor are pesticides, heavy metal poisoning or oil contamination to blame (I. Guyot & J.-C. Thibault unpubl. data). The Shag is moreover a protected species and poaching is rare. Nearly all colony-sites in Corsica are protected (natural reserve or other protection) and birds are not especially disturbed during breeding. As for competition with other species, another fish feeding species, the Yellow-legged Gull *Larus cachinnans*, increased in number during the 1980's with an average annual growth rate of 7% (I. Guyot & J.-C. Thibault unpubl. data). However it should be noted that during this period in the West area, the distribution of Yellow-legged Gulls was limited, and increases were restricted to a few sites. In contrast Mediterranean Shag numbers decreased on most colony-sites, and shags have colonized islets (Piana of Lavezzi, Tonnara) where gull numbers were very high. We therefore suggest that

changes in Shag feeding conditions have caused the observed population changes.

In Shags and Cormorants, reduced food availability before and during breeding is believed to cause decline in numbers, as documented for the Shag on the Isle of May (Aebischer 1986, Aebischer & Wanless 1992). Shags have a small capacity for foraging far from their colony-site (Schreiber & Clapp 1987), and a decline in feeding resources cannot be offset by longer travel; either birds simply do not breed or they move to a nearby colony-site for better food availability. No data exist on distance in feeding travel for breeding Mediterranean Shag, but in the North Sea, radio-tracking techniques indicate a mean foraging range of 7 km (Wanless *et al.* 1991). Analysis of pellets and regurgitation from chicks during the 1980's in Corsica, when Shag numbers were high, has shown that sandeels (Ammodytidae) were the predominant prey item, whereas outside the breeding season birds were dispersed largely along the coasts of Corsica and Northern Sardinia (I. Guyot unpubl. data), and fed mainly on *Posidonia* grass fishes (Guyot 1985). In the Mediterranean, sandeels show high inter-annual fluctuations (Tortonèse 1975), in contrast with *Posidonia* grass fishes which show less annual variation, although they are less abundant than the former during the Shag breeding season (Francour 1994). Seasonal abundance of sandeels provides food for a large number of Shags, but the lower production of *Posidonia* grass fishes constrains birds to breed in smaller numbers, well spread out along the coast. Several declining populations may be explained by the disappearance of seabirds from important feeding areas (Gargalo I. and Foccolara shoal: distance 5 km, Lavezzi A and B and Tour de Lavezzi shoal: <2km), suggesting that fish have vanished locally.

Consequently, we suggest that year-to-year fluctuations on all colony-sites, changes in colony size and shift between colony-sites may reflect modifications in food availability, such as a decrease in sandeels. Due to the lack of data on fluctuation of sandeels in this part of the Mediterranean, it is unknown whether their number decrease corresponds to a change in their biological cycle or to a long-term decline.

ACKNOWLEDGEMENTS

Many people helped with the fieldwork but particular thanks are due to the staff of Corsican Nature Reserves (François Arrighi, Charles-Henri Bianconi, Alain Camoin, Jean-Michel Culioli, Jean-Marie Dominici, Franck Finelli, Roger Miniconi, Jean-Pierre Panzani, Paul Peschet and Félix Santarelli). Nicolas Aebischer, Vincent Bretagnolle, and the Editor Sarah Wanless improved the manuscript with their comments and advice. Patricia Howlett improved the English. Gratitude is expressed here to all.

SUMMARY

Censuses of Shag colony-sites were conducted in Corsica from 1978 to 1994. No significant change was noticed in the overall distribution, but between 1981-82 and 1993-94, the decrease was 52 to 80% according to areas, whereas decrease of the overall population was 55%. Several new colony-sites were colonized during this period. It is suggested that year-to-year fluctuations on all colony-sites, changes in colony size and shift between colony-sites reflect modifications in food availability.

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APPENDIX. CENSUSES OF MEDITERRANEAN SHAG NESTS ON CORSICA BETWEEN 1978 AND 1994. THE LOCATION OF THE FIVE AREAS AND THE COLONY-SITES ARE SHOWN IN FIGURE 1.

Area / *Colony-site*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*
North																	
Finocchiarola Is.	?	0	0	0	0	0	2	2-6	6	6	10	5	16	17	21	12	9
West																	
Revellata (1)	?	0	0	?	0	?	0	0		3		4-6	3	?	10	7	6
Nichiaretu (2)	?	?	?	?	?	?	?	?		?		1-3	?	?	3	2	3
Cavallu (3)	5	?	4	c.40	8-15	8-12	>1	20-30		5		7-9	0	0	4	3	1
Ciuttone (4)	15-23	19	16	35-36	>23	33-37	>35	14-17		2		7-10	18	4-7	18	14	6
Elpa nera (5)	3-5	9	3	8-9	0	5	>10	4-7		1		4	3	>3	12	3	6
Punta palazzu (6)	2-3	8	3	5-6	>6	>7-8	?	3-4		2		6	3	4	2	0	2
Cala di l'oru (7)	3	2	0	6	7-8	9	1	2-3		0		0	?	0	1	1	1
Gargalu I. (8)	40-60	37-42	15	100-110	>100	>95	55-85	c.165		26		17	>17	>7	14	3	22
A sulana (9)	5	4	3	4	3-4	5	3-7	1		0		2	0	2	1	1	1
Gattaghia (10)	6-7	10	7	19-20	10-12	5-6	8-9	7-13		0		2-3	2	1	2	2	2
Punta scandola (11)	4-5	3	1	1	1	1?	3	3		1		2	?	1	0	0	3
Ficaja (12)	4	14	4	10	>9	15-18	c.6	5		2		0	0	0	1	0	1
Seninu (13)	0	0	1	0	0	?	0	4-5		1		3?	5	4-5	14	5	3
Punta piana (14)	0	0	0	2	6-8	>4	5-8	2		4		‡	‡	‡	1	0	2
Guardiola (15)	6-7	16	1	4	5-11	14-15	7-13	8-13		2		‡	‡	‡	2	2	1
Éboulis de Piana (16)	22-25	3	1	2	7-14	>10-14	>4	4-8		1		‡	‡	‡	14	10	5
Turghio-San Pelegrino (17)	3	0	1	5	5-8	>4-5	c.10	10-12		3		?	>5	3-7	5	1	12
Passage (18)	7	4	0	0	c.7	2	3-4	2-4		1		‡	‡	‡	1	0	1
Sbiro (19)	6	1	0	0	0	1	0	0		0		‡	‡	‡	0	0	0
Terre face 39 (20)	7	5	0	0	0	0	0	0		0		‡	‡	‡	0	0	0
Ilot pointu (21)	1	0	0	0	0	0	0	0		0		‡	‡	‡	0	0	0
Cala genovese (22)	5	3	1	?	3-4	1-2	3-5	2-3		0		‡	‡	‡	0	0	0
Castel-Arone (23)	9	4	0	5-6	?	5-6	0	1?		1		?	0	0	0	0	1
Orchinu (24)	1	0	?	9	?	11-13	3-6	11-15		5		?	0	0	0	1	?
Total	160-200	140-150	c.50	255-270	200-230	235-260	160-200	270-310	?	c.70	?	c.60	c.50	30-50	105	c.52	c.80

South-west																	
Lava I.	?	?	?	?	?	?	?	?	?	?	?	x	?	?	8	x	4-5
Sanguinaires Is.	80-130	130-160	130-160	?	120-150	120-150	c.55	c.100	?	?	80-110	?	?	?	?	?	33-50
Piana I.	?	?	0	?	?	?	?	?	?	?	12-16	?	?	?	?	?	20
Total	80-130	130-160	130-160	?	120-150	120-150	c.55	c.100	?	?	92-126	?	?	?	?	?	57-75
South																	
Bruzzi I.	1	?	40	c.60	c.25	c.15	c.25	25	?	60	?	?	?	?	?	34	55
Tonnara I.	0	0	0	0	0	0	0	0	?	30	?	17	?	?	?	10-13	5-10
Lavezzi 1 (Lavezzi Is.)	2-3	?	2-5	c.25	c.50	c.30	c.25	25	25-30	21	27	11	3	3	0	3	1
Lavezzi 2 "	0	0	0	<10	c.60	c.10	?	c.35	?	1	?	♂	0	2	♂	0	0
Islet A "	c.150	c.150	c.150	c.150	>150	<150	<50	>50	?	25	?	<10	♂	♂	♂	♂	5
Islet B "	c.190	c.190	c.190	?	>180	<180	<50	>45	?	?	?	<10	♂	♂	♂	♂	10
Ratino "	8-12	?	15	?	25	c.8	5	c.30	25-30	?	?	?	?	?	?	33	22-27
Porraggia "	25-30	25-30	c.50	c.50	c.50	c.20	1-2	c.30	50-65	30-32	?	?	?	?	?	19	16-22
Sperduto "	1-3	1-3	1-3	c.10	c.10	c.10	>5	5	c.10	8	?	?	?	?	?	?	?
Piana "	0	0	0	0	0	?	?	?	>5	?	?	?	?	?	?	20-50	56-65
Total	c.380	c.380	c.450	?	c.550	<420	<160	>245	?	c.175	?	?	?	?	?	129-174	170-195
South-east (Cerbicale Is.)																	
Forana "	?	6	?	?	4-10	6	?	?	35	?	?	?	?	?	?	?	2-5
Piana "	10-20	50	?	?	<5	c.15	?	?	10-15	?	?	?	?	?	?	?	6-10
Pietricaggiosa "	65-85	c.100	?	?	c.125	30-35	1	?	13	?	?	?	?	?	?	?	5-7
Vacca "	10-15	5-6	?	?	c.20	1	0	?	8	?	?	?	?	?	?	?	0
Toro "	5-10	30	?	?	?	?	<10	?	1	?	?	?	?	?	1-3	?	1-3
Total	90-130	c.190	?	?	>160	50-80	c.10	?	70-80	?	?	?	?	?	?	?	14-25
Total count	710-840	840-880	?	?	c.1,000	825-910	385-425	?	?	?	?	?	?	?	?	?	320-375

Note

Numbers in brackets correspond to those shown on Fig. 1.

c. = estimated mean number, ? = presence and number unknown, x = present, but number unknown, ‡ = grouped data, < = maximum number, > = minimum number.

Range indicates effective count and estimated number.