POPULATION STATUS AND DIET OF THE YELLOW-LEGGED GULL IN THE AZORES

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During 2004 a census of the Yellow-legged Gull (*Larus michahellis atlantis*) was conducted in the Azores to assess its present status in the archipelago. The census yielded an estimate of 4249 breeding pairs, an increase by almost 60% since the previous survey conducted in 1984. Gulls were detected on a total of 14 islets and/or sea stacks and are probably limiting the distribution of terns in the archipelago. Out of 37 gull breeding sites found during the 1984 and 2004 surveys, 24 were located within 1 km of tern colonies. All the gull colonies were coastal except Lagoa do Fogo on São Miguel Island. Pellet analysis indicated that gulls from all the colonies feed on refuse, but the percentage of pellets containing refuse on islands with small human populations was less than half than that of islands with more than 55000 inhabitants. Gulls have no direct competitors in the Azores and benefit from an increase in refuse production. The growing number and size of rubbish dumps over the last two decades has probably contributed to the large increase in the Azorean population.

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INTRODUCTION

Gulls act both as competitors and predators and are generally considered to significantly reduce the attractiveness of potential breeding sites for other birds (FINNEY et al. 2003). For example, FINNEY et al. (2003) recently showed that Puffins *Fratercula arctica* recruiting to the Isle of May avoided nesting in close proximity to gulls. And the abandonment, by terns, of traditional nesting areas in response to the encroachment of breeding gulls has also been demonstrated in a number of studies (WANLESS 1988; MORRIS et al. 1992; HOWES & MONTEVECCHI 1993). Gulls are notorious predators of tern eggs, chicks, and sometimes adults (SHEALER & BURGER 1992; YORIO & QUINTANA 1997; WHITTAM & LEONARD 1999; GUILLEMETTE & BROUSSEAU 2001; O'CONNEL & BECK 2003), and tern colonies at the leading edge of gull breeding range expansions may experience rapid increases in predation as gulls expand into new areas (BURGER & LESSER 1978; KIRKHAM & NETTLESHIP 1987; BURGER & GOCHFELD 1990). Gulls can also negatively impact on terns through kleptoparasitism (ORO 1996; RATCLIFFE et al. 1997; ARNOLD et al. 2004).

The Yellow-legged Gull *Larus michahellis* has been the subject of several predation studies and accounts. For example, this species has been shown to prey on eggs and chicks of Greater Flamingos (*Phoenicopterus ruber*, SALATHÉ 1983), eggs, chicks and adults of Audouin's Gulls (*Larus audouinii*, ORO & MARTINEZ-VILALTA 1994; GONZÁLEZ-SOLÍS et al. 1995) and chicks and adults of Storm Petrels (*Hydrobates pelagicus*, BORG et al. 1995; ORO et al. 2005), threatening some colonies with extinction (BORG et al. 1995). In the salines of the Rhône delta, France, Yellow-legged Gulls take over the best nesting sites to the detriment of terns and other charadriiforms (SADOUL et al. 1996) that are then forced to nest in poorer quality areas where their breeding success is insufficient for population renewal (SADOUL et al. 1996).

During the last decades the Yellow-legged Gull has increased in numbers throughout the western range of its distribution (SNOW & PERRINS 1998). In the Mediterranean, the increase has also been noticeable over the past few decades (VIDAL et al. 1998), mostly owing to the availability of abundant and predictable food sources from rubbish dumps and from commercial fisheries discards (ORO et al. 1995; ARCOS et al. 2001).

In the Azores, subtropical north-eastern Atlantic, Yellow-legged Gulls *L. m. atlantis* have no direct competitors and their numbers are also thought to be increasing in the archipelago (mainly due to refuse availability), raising conservation concerns such as possible displacement of Roseate Tern *Sterna dougallii* colonies and depredation of tern chicks as well as other seabird chicks and adults. The Roseate Tern is an endangered seabird in Europe for which the EU member states have a legal requirement to take conservation action (MITCHELL et al. 2004). The Azores is an important breeding locality for this species, holding more than 40% of the European population. Colonies of terns and gulls in the archipelago are normally separated for at least a few kilometres, but in some cases they either overlap or are in extreme proximity. Available data on gull numbers in the Azores are restricted to a census carried out in 1984, when 2705 breeding pairs were counted at 27 colonies (DUNN 1989). Recently gulls have been observed establishing at two of the main Roseate Tern colonies in the Azores: Ilhéu das Contendas, Terceira island and Ilhéu da Vila, Santa Maria island (V. Neves, pers. observ.), and on Ilhéu da Vila gulls have been observed taking tern chicks (J. M. Soares pers. com.). Two previous studies have described the diet of the Yellow-legged Gull in the Azores, reporting the presence of mesopelagic fish in their pellets (HAMER et al. 1994) and variations in the proportions of prey types between colonies (RAMOS et al. 1998).

This study examines changes in distribution and numbers of Yellow-legged Gulls in the Azores archipelago over the last 20 years. Additionally, diets were also studied in some of the main colonies. The main aim of this study was to document current population sizes of the Yellow-legged Gull in the Azores to determine if the expected population increases have actually occurred. Data on gull diet were also collected on six of the nine islands of the archipelago. We examined the relationship between number of inhabitants and percentage of refuse in the gull pellets, predicting that gulls breeding on islands with larger human populations should consume larger amounts of refuse. We also examined the relationship between island area and the area/coastline ratio and the percentages of marine and terrestrial items in the pellets. At one of the colonies, Capelinhos – Faial Island, pellets were collected throughout the breeding cycle to evaluate seasonal changes.

MATERIAL AND METHODS

Population survey

Gulls were surveyed in summer 2004 using transect counts and counts from vantage points as described by WALSH et al. (1995). Gull breeding sites are mostly located in inaccessible cliffs and sea stacks and therefore we could only do transect counts on nine out of the 32 colonies monitored, i.e. Lagoa do Fogo - São Miguel island, Ilhéu de Baixo - Graciosa island, Ilhéu do Topo - São Jorge island, Mistério da Prainha - Pico island, Capelinhos & Costa da Nau - Faial island and Ilhéu Maria Vaz, Ilhéu do Cartário and Ilhéu Álvaro Rodrigues - all on Flores island. Only the colonies in São Jorge and Flores could be monitored by transect counts alone. We attempted to survey all the colonies discovered during the 1984 census (DUNN 1989). Additionally, boats were used to monitor colonies that could not be seen from land and to detect new colonies formed since 1984. For Santa Maria, Terceira, Faial and Flores, the whole perimeter of the coastline was covered, but for the remaining islands only smaller sections were covered. Fieldwork was conducted between 23 April and 6 June. The census unit was Apparently Occupied Nest (AON), i.e. a well-constructed nest, attended by an adult and capable of holding eggs (WALSH et al. 1995). Due to weather constraints we could not monitor three small colonies detected in 1984

(Fajã do Nortezinho and Fajã do Cardoso on São Jorge Island, and Ponta do Marco on Corvo Island).

Diet studies

Diet was studied using pellets collected in six different colonies: Capelinhos (Faial), Mistério da Prainha (Pico), Ilhéu do Topo (São Jorge), Lagoa do Fogo (São Miguel), Ilhéu de Baixo (Graciosa), and Ilhéu das Cabras (Terceira). Pellets were collected during the incubation and early hatching stages, while conducting the census. Faial colony was monitored over a larger period, and sampling included both incubation and chick-rearing. Diet on Faial was also studied through samples obtained from adults and chicks that regurgitated when handled and measured. Pellets were collected in individual plastic bags, labelled with the date of collection and colony and identified later at the laboratory. Food items were classified into the following categories: vegetable matter (grass and other), refuse (paper, glass, plastic, aluminium foil, poultry remains and others), goose barnacle (*Lepas anatifera*), gastropod molluscs (mainly *Janthina janthina*), fish, squid, bird, insect, mammal, and unidentified. Sagittal otoliths were identified using the reference collections of the Dept. of Oceanography and Fisheries (University of the Azores) and of the Belgian Royal Museum of Natural History (with the help of Dr. Dirk Nolf) and reference books (NOLF 1985; COHEN et al. 1990; SMALE et al. 1995; QUERÓ et al. 2003; VEEN & HOEDMAKERS 2005). Other prey items such as fur, bones, fish vertebrae, scales and bird feathers were identified with the help of reference material, literature (ZARIQUIEY 1968, WHITEHEAD et al. 1986), museum collections, and specialists (birds by RWF and insects by Geoff Hancock).

Frequencies of occurrence were calculated as the number of samples with a given prey type (e.g. fish, refuse, etc.) expressed as a percentage of the total number of pellets. Differences in the proportion of prey types between colonies and between the incubation and chick-rearing periods (for Capelinhos colony only) were tested following ZAR (1996) using Chi-square analysis.

RESULTS

Population survey

The census yielded 4,249 pairs of Yellow-legged Gulls (Table 1). We found a total of 32 colonies (locations given on figures 1-3). During both surveys, a total of 37 colonies were found, out of which 24 were situated no more than one km from a tern colony (Table 2). Direct nest counts accounted for 42% of the total number of breeding pairs detected and the rest was derived from counts of birds and apparently occupied nests. During the 1984 census all the colonies were monitored using only counts from vantage points. For the colonies where transect counts were made in 2004 there has been an increase by 104% (897 pairs) since 1984 and on the remaining colonies there has been an increase by 35% (647 pairs).

Table 1
Number of breeding pairs in 1984 and in 2004 and percentage of change between the two surveys. Number of colonies shown in brackets

Island	1984*	2004	Percentage increase
Santa Maria	90 (1)	96 (2)	7
São Miguel	650 (6)	820 (7)	26
Terceira	430 (3)	904 (7)	110
Graciosa	260 (1)	320 (1)	23
São Jorge	560 (5)	980 (2)	75
Pico	250 (3)	483 (3)	93
Faial	270 (3)	480 (5)	78
Flores	105 (4)	166 (5)	58
Corvo	90 (1)	-	-
TOTAL	**2,705 (27)**	**4,249 (32)**	**57**

* Source: DUNN 1989

Anecdotal observations were carried out at six rubbish dumps, on Faial, São Miguel, Terceira, Graciosa, São Jorge and Flores. While in the former three islands hundreds of gulls were present, only a few dozens were observed in the others. The refuse dump that serves the main city of the archipelago, Ponta Delgada (65,854 inhabitants in 2001) is located less than 15 km from the main gull colony on São Miguel, Lagoa do Fogo, with 605 pairs. We visited the refuse dump on 24 April and observed an estimated 600 gulls foraging in the area.

Table 2
Details of surveys in 1984 and in 2004.

Colony►	Island	Site	Habitat description	Estimated pairs 1984	Estimated pairs 2004	On or whithin 1km of tern colonies
1	Santa Maria	Lagoinhas	Sea stack	90	95	√
2		Ilhéu da Vila°	Islet	0	1	√
3	São Miguel⊗	Mosteiros*	Islet & sea stacks	-	115	√
4		Ponta do Escalvado	Cliff	-	40	√
5		North of Ponta da Ferraria	Cliff	-	60	√
6		Ladeira da Velha (Miradouro de Santa Iria)	Cliff	-	1	
7		Praia dos Moinhos	Cliff & sea stack	-	2	
8		Lagoa do Fogo•	Inland lake	-	600	
9		Porto da Caloura	Cliff	-	2	
10	Terceira	Quatro Ribeiras	Cliff	0	10	√
11		Ponta do Raminho	Cliff	30	36	
12		Ponta da Serreta	Cliff	0	3	√
13		Ponta Rubra (south Serreta)	Cliff and cliff base	0	65	
14		Monte Brasil	Cliff	0	50	√
15		Ilhéu das Cabras W	Islet	150	350	√
16		Ilhéu das Cabras E	Islet	250	390	√
17	Graciosa	Ilhéu de Baixo•	Islet	260	320	√
18	São Jorge	Ilhéu do Topo°	Islet	300	730	√
19		Ponta dos Rosais**	Cliff & sea stacks	150	250	√
		Morro do Lemos	Cliff	45	0	
		Fajã do Cardoso	Cliff base	35	n.s.	√
		Fajã do Nortezinho	Cliff base	30	n.s.	
20	Pico	Ponta do Espigão	Cliff	100	50	
21		Mistério da Prainha•	Lava edge	100	380	
22		Ilhéus da Madalena***	Sea stacks	50	53	√
23	Faial	Costa dos Espalhafatos	Cliff base	0	25	
24		Costa da Nau (N Capelinhos)•	Cliff	0	125	√
25		Vulcão dos Capelinhos•	Cliff and volcano slopes	100	160	√
26		Baía do Varadouro	Cliff	150+	150	
27		Morro de Castelo Branco	Cliff	20	20	√
		Mte. da Guia	Cliff	≈	0	√
28	Flores	Ilhéu Maria Vaz°	Islet	40	86	√
29		Ilhéu do Cartário°	Islet	10	32	√
30		Ilhéu Álvaro Rodrigues°	Islet	50	42	√
31		Ilhéu da Muda°	Islet	5	5	√
32		Ponta Furada°	Cliff	0	1	√
	Corvo	Ponta do Marco	Cliff	90	n.s.	

n.s. not surveyed
► Only the colonies where gulls were found breeding in 2004 are numbered
° Transect count
• Transect count plus vantage point
⊗ Dunn (1989) refer to six colonies totalling 650 pairs but numbers for individual colonies are not given.
* The islet had 105 breeding pairs. Additionally there are three sea stacks. The two furthest north had one and nine breeding pairs, respectively.
** This colony is scattered along the north coast from Ponta dos Rosais to Fajã Fernando Afonso. The colony also includes two sea stacks (Torrão de Açúcar and Caralhete) with two and one breeding pairs respectively.
*** This colony includes two sea stacks; the smaller one (Ilhéu em Pé) had only 3 pairs.
≈ small colony, not counted

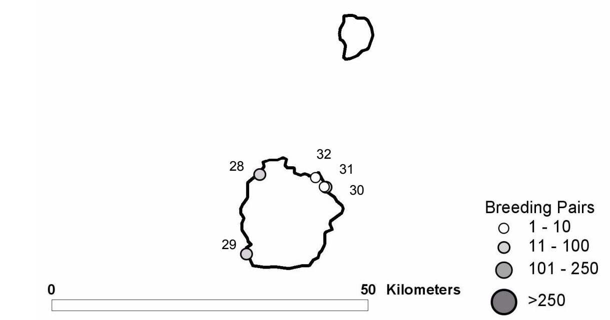

Fig. 1. Distribution and estimated colony sizes of Yellow-legged Gull in the western group. Colony numbers as in table 2.

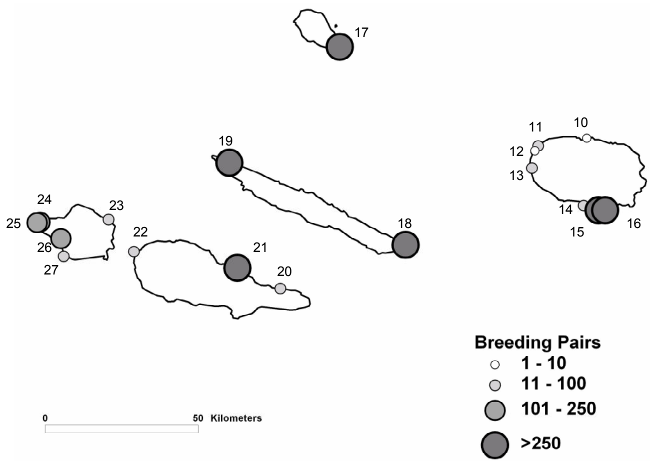

Fig. 2. Distribution and estimated colony sizes of Yellow-legged Gull in the central group. Colony numbers as in table 2.

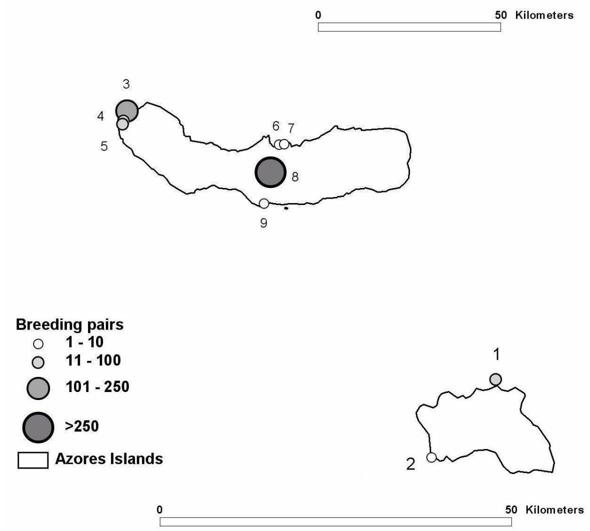

Fig. 3. Distribution and estimated colony sizes of Yellow-legged Gull in the eastern group. Colony numbers as in table 2.

On Faial, DUNN (1989) mention the existence of a small gull colony at Porto Pim, Monte da Guia, but in 2004 only terns were found breeding at this site. A new colony (25 pairs) was found at Costa dos Espalhafatos on a landfall formed after the 1998 earthquake. The main gull colony, Capelinhos, is located less than 5 km from the refuse dump where we observed 400-450 individuals foraging.

On Santa Maria, only one colony was found in 2004, at Ilhéu das Lagoinhas (95 pairs) on the northern coast. In 2003 a gull nest had also been found on a smaller sea stack nearby Ilhéu das Lagoinhas but the gulls did not use this site in 2004. This stack has been used by both Common and Roseate Terns in the past. Also on Santa Maria and in 2004, a single nest (3 eggs) was detected at Ilhéu da Vila, a Special Protected Area that holds important populations of Roseate Terns and other seabirds. Gulls have been observed breeding at Ilhéu da Vila since 2002.

On Pico, the colony at Mistério da Prainha is overall very accessible but some areas have large stones and a dense cover of scrub vegetation, mainly *Erica azorica* that make them very difficult to survey. On the accessible area we counted 327 nests and we estimated an additional 60 nests on the remaining area. The colony at Ponta do Espigão was one of the few that showed a decrease in numbers from 1984. Sea conditions prevented us from surveying the colony by boat so numbers were estimated by land from Baía do Canto, and are probably an underestimate.

On São Jorge, DUNN (1989) mention the existence of a small gull colony at Morro Grande, but during 2004 no gulls were found breeding at this site. Ilhéu do Topo is used to raise cattle and in 2004 it had six cows and more than 50 sheep. Nevertheless gull nests were found everywhere in the islet. Both Roseate and Common Terns *S. hirundo* bred on this islet in the past but in 2004 only 37 pairs of Common Terns were breeding. There are two refuse dumps on the island, the one located 11 km from Ponta dos Rosais colony and the other located 23 km from Ilhéu do Topo colony. The refuse is regularly covered in both places and gulls are present in smaller numbers; we counted 75 individuals in the dump near Ponta dos Rosais and 70 individuals in the dump near Topo.

On Terceira, a gull nest was detected at Ilhéu das Contendas in 2003, an important colony for both Common and Roseate Terns, but in 2004 no gulls were breeding there. Terceira has a large refuse dump that receives refuse from the whole island; during our visit (8 June, 12:00-12:30), we counted 950-1000 individuals foraging in the area.

On Flores, access to the islets proved to be extremely difficult due to the high and almost vertical cliffs. At the time of our visit most eggs had hatched but the nests were still recent and easy to count. We counted a total of 165 nests on the islets and a total of 350-380 individuals. Additionally a nest with 2 chicks was detected at Ponta Furada when monitoring tern colonies on 28 May. This site held a colony of 91 pairs of Common Terns and three pairs of Roseate Terns and we found the remains of at least 10 predated eggs. When we approached the colony six gulls were flying over the colony but only one nest was found.

We visited Corvo Island between 28 May and 1 June but bad weather prevented us from surveying the island by boat as planned. On 1 June we did attempt to survey the island by boat; we counted 30 individuals at Pão de Açúcar, but we could not reach Ponta do Marco, where a colony of 90 pairs was found in 1984. The individuals observed at Pão de Açúcar were not breeding.

Diet

Pellets

A total of 1950 pellets were collected in six colonies of the Azores (Table 3). A single pellet contained up to 5 types of prey, with only a few pellets being a discrete prey type (mostly fish, goose barnacle or bird). Fish was not very abundant in the samples and contributed to a maximum frequency of occurrence of 37.1% (during chick-rearing at Graciosa); nevertheless the fish prey was highly diverse with a total of 35 different species identified through otoliths and vertebrae (Table 4).

In the Faial colony, the proportion of prey types during the incubation period was significantly different from the proportion of prey

Table 3

Frequency of occurrence (%) of different prey types in pellets of Yellow-legged Gull. SMG = São Miguel, TER = Terceira, GRW = Graciosa, FAI = Faial, PIX = Pico and SJZ = São Jorge

	Incubation				**Chick rearing (Includes incubation and early chick rearing)**			
Prey type	Lagoa do Fogo (SMG) 25 April n = 86	Ilhéu das Cabras (TER) 9 May n = 34	Ilhéu de Baixo (GRW) 10 May n = 34	Capelinhos (FAI) 3-13 May n = 576	Ilhéu de Baixo (GRW) 29 June n = 62	Capelinhos (FAI) 16 May – 8 June n = 402	Mistério Prainha (PIX) 17 & 24 May n = 587	Ilhéu do Topo (SJZ) 18 May n = 169
Fish (otoliths)	8.1 (1.2)	0	20.6 (2.9)	13.7 (5.7)	37.1 (17.7)	24.88 (9.5)	28.3 (12.4)	3.6 (0)
Gastropod molluscs [1]	0	0	17.7	3.7	3.2	10.5	10.1	23.7
Goose barnacle	5.8	3.2	32.4	22.7	46.8	35.8	16.2	32.5
Squid	0	0	2.9	0.2	0	0	0	0
Vegetable matter	1.2	3.2	14.7	63.2	22.6	39.8	70.0	61.0
Refuse [2]	91.9	96.8	20.6	46.2	21.0	35.3	30.2	13.1
Bird [3]	0	3.2	23.5	0.5	14.5	1.7	6.0	5.9
Eggshells	0	0	8.8	5.4	0	3.2	5.1	3.0
Insect [4]	0	9.7	11.8	3.9	11.3	1.5	6.3	31.4
Mammal [5]	2.3	6.5	26.5	18.1	14.5	12.9	22.0	10.1
Unidentified	0	3.2	0	3.7	4.8	2.7	5.8	0

[1] Mainly *Janthina janthina*.

[2] Plastic, glass, paper, aluminium foil, cigarette filters, kitchen scraps, strings, etc.. Pellets from SMG and TER contained large percentages of bones and feathers of chicken, 91.4% and 76.7%, respectively.

[3] Cory's shearwater *Calonectris diomedea*, Madeiran storm-petrel *Oceanodroma castro*, buzzard *Buteo buteo*, serinus *Serinus canarius*, European starling *Sturnus vulgaris* and other passerines.

[4] Scarabaeid beetles subfamily Coprinae: *Onthopagus* sp.; Cicindelidae: *Cicindela* sp.; Curculionidae: *Otiorhyncus* sp.; Elateridae and unidentified.

[5] Mainly rats *Rattus norvegicus*, *R. rattus* and rabbits *Oryctolagus cuniculus*.

Table 4
List of identified fish prey species, percentage of occurrence of otoliths (number of otoliths in brackets) and respectively habitat and depth ranges

Order	Family		Species	Percentage of occurrence of otoliths (n=203)	Habitat and depth range***
Anguiliformes	**Congridae**			**2.0 (4)**	
		£	*Conger conger**	-	Demersal; 0-500m
			Gnatophis mystax	1.5 (3)	Demersal; 80-800m
			Paraconger macrops	0.5 (1)	Demersal; 30-100m
Myctophiformes	**Myctophidae**			**38.9 (79)**	
			Unidentified	1.5 (3)	
			Ceratoscopelus warmingii	0.5 (1)	Bathypelagic; 25-1500m
			Diaphus effulgens	0.5 (1)	Bathypelagic; 40-700m
			D. rafinesquii	1.5 (3)	Bathypelagic; 40-1080m
			Electrona rissoi	29.6 (60)	Bathypelagic; 90-820m
			Hygophum hygomii	0.5 (1)	Bathypelagic; 0-800m
			Lampanyctus crocodilus	0.5 (1)	Bathypelagic; 45-1000m
			L. photonotus	0.5 (1)	Bathypelagic; 40-1100m
			Lobianchia dofleini	0.5 (1)	Bathypelagic; 20-750m
			L. gemellarii	3.0 (6)	Bathypelagic; 25-800m
			Myctophum punctatum	0.5 (1)	Bathypelagic; 0-1000m
Gadiformes				**12.3 (25)**	
	Macrouridae			10.3 (21)	
			Unidentified	0.5 (1)	
			Caelorinchus caelorinchus	4.9 (10)	Benthopelagic; 140-2000m
			C. labiatus	0.5 (1)	Bathydemersal; 460-2220m
			Gadomus longifilis	1.0 (2)	Bathypelagic; 630-2165m
			Malacocephalus laevis	0.5 (1)	Bathydemersal; 200-1000m
			Odontomacrurus murrayi	3.0 (6)	Bathypelagic; 0-2500m
	Phycidae	£	*Phycis phycis*	1.5 (3)	Benthopelagic; 13-614m
	Gadidae		*Gadiculus argenteus*	0.5 (1)	Pelagic; 100-1000m
Beloniformes	Belonidae		*Belone belone**	-	Epipelagic; 2-4m
Beryciformes				**13.8 (28)**	
	Diretmidae		*Diretmus argenteus*	10.3 (21)	Mesopelagic; 500-700m
	Trachichthyidae		*Hoplostethus mediterraneum*	1.5 (3)	Benthopelagic
	Berycidae			2.0 (4)	
		£	*Beryx sp.*	1.5 (3)	
		£	*B. splendens*	0.5 (1)	Benthopelagic; 25-1300
Scorpaeniformes	**Scorpaenidae**			**1.5 (3)**	
		£	*Pontinus kuhlii*	1.0 (2)	Bathydemersal; 100-600m
			Scorpaenodes arenai	0.5 (1)	Demersal
Perciformes				**20.2 (41)**	
	Serranidae		*Anthias anthias*	3.5 (7)	Epipelagic; 0-300m
	Apogonidae		*Apogon imberbis*	3.5 (7)	Epipelagic; 10-200m
	Epigonidae		*Epigonus constantiae*	1.5 (3)	Bathydemersal; 200-600m
	Carangidae	£	*Trachurus picturatus*	4.5 (9)	Benthopelagic; 0-370m
	Sparidae			6.9 (14)	
			Unidentified	2.5 (5)	
		£	*Boops boops*	1.5 (3)	Demersal; 0-350m
		£	*Diplodus cervinus*	0.5 (1)	Demersal; 30-300m
		£	*Diplodus sargus*	0.5 (1)	Demersal; 0-50m
		£	*Pagellus bogaraveo*	2.0 (4)	Bentopelagic; 0-700m
	Sphyraenidae		*Sphyraena sphyraena*	0.5 (1)	Pelagic; 0-100m
Unidentified**				**11.3 (23)**	

£ species with commercial interest
* identified through vertebras
** otoliths too broken or eroded to be identified
*** From WHITEHEAD et al. (1986)

types during the chick-rearing period (χ^2=92.5, d.f.=8, p<0.0001). The proportion of fish in the pellets during chick rearing was significantly higher than during the incubation period (χ^2=19.0, d.f.=1 with Yates correction, p<0.0001) as were the proportions of goose barnacle and mollusc (χ^2=19.4 and χ^2=17.1, d.f.=1 with Yates correction, both p<0.0001) whereas the proportion of insects, mammals and refuse were lower during the chick rearing period (χ^2=4.3, χ^2=4.3, χ^2=11.0, respectively; d.f.=1 with Yates correction, all p<0.05). The differences for goose barnacle, fish and mollusc remained significant after sequential Bonferroni correction, but the same was not true for refuse, insects and mammals. For the Graciosa colony, the difference in the proportion of prey types during the incubation and the chick rearing periods was not so marked but it was still statistically significant (χ^2=17.1, d.f.=8, p<0.05). The proportion of mollusc prey was higher during the incubation period (χ^2=4.2, d.f.=1 with Yates correction, p<0.05) but there were no differences for all the other prey types. However, the difference in the proportion of mollusc did not remain significant after sequential Bonferroni correction. We found differences in the proportion of different prey items between Faial and Graciosa colonies, both for the incubation and chick-rearing periods (χ^2=134.9 and χ^2= 59.7, respectively, both d.f.=8 and p<0.0001). The refuse at Graciosa landfill is regularly covered and only one individual gull was observed there during our visit. Nevertheless, refuse was found in more than 20% of pellets; in addition to the landfill there are some small illegal dumps on the island and the gulls are probably also using them.

The percentage of pellets containing refuse in islands with fewer than 20,000 inhabitants was less than half that on islands with more than 55,000 inhabitants (Fig. 4). The proportions of prey types in the pellets collected during the incubation period for São Miguel, Terceira, Graciosa and Faial colonies were significantly different (χ^2=337.9, d.f.=24, p<0.0001). Refuse accounted for 46.2% on Faial, which is significantly less than on São Miguel and Terceira (χ^2=60.8 and χ^2=28.2, d.f.=1, Yates correction, both p<0.0001), but significantly higher than on Graciosa (χ^2= 7.5, d.f.=1, Yates correction, p<0.001). The proportion of birds on Graciosa Island was significantly higher than on Faial, São Miguel and Terceira colonies (χ^2=83.4, χ^2=18.064 and χ^2=4.0, respectively; d.f.=1, Yates correction, all p<0.0001, Table 3).

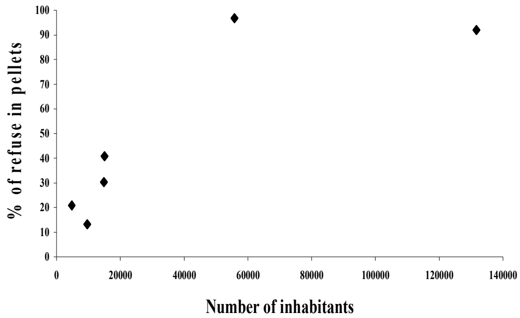

Fig. 4. Relationship between number of inhabitants and the percentage of refuse in the pellets for the different islands.

Pellets collected on Pico and São Jorge include both incubation and early chick rearing period due to the dates of collection. We found significant differences in the proportion of prey types between these two colonies (χ^2=165.3, d.f.=8, p<0.0001).

The only inland colony, Lagoa do Fogo, had the smallest percentage of marine items (Table 3), but we found no relationship between the ratio area/coastline for each island and the abundance of marine and terrestrial items in pellets (Fig. 5).

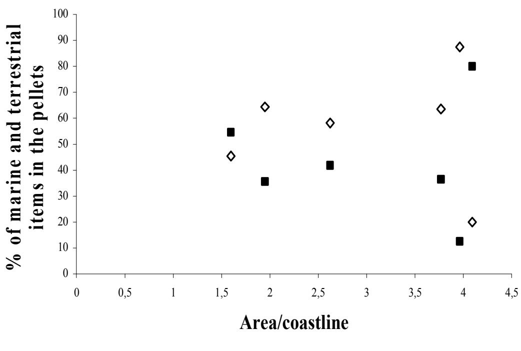

Fig. 5. Relationship between area/coastline ratio for each island and the percentage of marine (open diamonds) and terrestrial (black quadrates) items in the pellets.

Regurgitates from adults and chicks

Forty-six regurgitates, seven from adults and 39 from chicks were collected at Faial colony. The food regurgitated by adults included rice, mushrooms, corn, meat, bones (possibly chicken) and earthworms. Chick regurgitates included mainly fish (43.8%), meat (25.6%) and earthworms (10.3%); the remaining 20% being made up by molluscs, goose barnacles, vegetable matter and unidentified items.

DISCUSSION

The census yielded an estimate of 4,249 pairs of Yellow-legged Gulls distributed over 32 colonies, which represents an increase of almost 60% since the previous survey conducted in 1984 (Table 2). The rate of increase in the archipelago seems to be lower than at other localities. The western Mediterranean population of Yellow-legged Gull is currently estimated to be increasing at a rate of between 7 and 10% per year (THIBAULT et al. 1996), while the Azorean population is increasing at an average annual rate of only 2.3%, as deducted from the 1984 and 2004 estimates. On the French Mediterranean coast there was an average annual increase of 6.9-7.8% for the period 1966-1976 (SNOW & PERRINS 1998) and in the Balearic Islands, Spain, there was an annual increase of 3% for the period 1983-1987 (RODRIGUEZ 1999). Recently, in La Palma, Canary Islands, RAMOS (2003) found an annual increase of 8.3% for the period 1987-2002.

Gulls are also spreading their distribution in the archipelago; eight new breeding sites were discovered but in total they comprised less than 4% of the population. All the colonies monitored but one (Lagoa do Fogo inland crater) were coastal. The main concentrations of gulls were found on São Jorge (980 pairs), Terceira (904 pairs), and São Miguel (820 pairs). The growth of the breeding population resulted mainly from the increase in previously existing colonies, especially at Ilhéu do Topo, Mistério da Prainha and Ilhéus das Cabras (Table 1).

Isolated breeding pairs were located on Flores, Santa Maria and São Miguel islands and it is possible that our survey overlooked other cases due to the difficulty in detecting isolated pairs. We found considerable differences in the percentage increase amongst the different islands, with Santa Maria, São Miguel and Graciosa showing increases much smaller than the other islands. Only one colony was detected in Graciosa, Ilhéu de Baixo, which compared with other colonies of the archipelago registered only a small increase in numbers (23%). Terceira Island registered the largest increase, regarding both breeding pairs and number of colonies. Five new colonies comprising 128 pairs were found on the island.

Gulls were detected in a total of 14 islets and sea stacks (Table 1), which accounted for more than 55% of the breeding population. The presence of gulls on these islets is probably limiting the distribution of terns in the archipelago and, excluding Ilhéu da Vila, which has been a traditional large colony for Roseate and Common Terns, most of these islets occupied by gulls had none or only small numbers of breeding terns in 2004; this was the case of Ilhéu das Cabras W (50 pairs of Common Tern), Ilhéu do Topo (37 pairs of Common Tern) and Ilhéu de Baixo (3 pairs of Common Tern).

The increase in gull numbers from 1984 to 2004 could be partly attributed to the fact that during 1984 no nest counts were attempted, causing the estimates to be less reliable in some colonies. This is particularly relevant for Flores Island where in 2004 all the colonies were surveyed by transect counts. However, the biases due to method are probably small (WALSH et al. 1995). Furthermore, our results are probably slightly underestimated because Corvo Island was not surveyed and because due to intermittent breeding (non breeding in individuals that have previously bred) some birds will not be included in the nest counts. Several studies have documented intermittent breeding in seabirds (e.g. KADLEC & DRURY 1968; BRADLEY et al. 2000). For example, CALLADINE & HARRIS (1997) report that 33% and 37% of previously breeding Herring Gulls *Larus argentatus* and 34% and 40% of previously breeding Lesser Black-backed Gulls *L. fuscus* failed to breed in two successive years.

There have been many studies linking the population increase of gulls to the availability of food from refuse dumps (MUDGE & FERNS 1982, BLOCKPOEL & SPAANS 1990) and from fisheries offal and discards (FURNESS et al. 1992). Gulls have no direct competitors in the Azores and probably benefit from recent development of fisheries and increases in rubbish dumps. The foraging range of the herring gull, similar in size and feeding habits to the Yellow-legged Gull, has been estimated to be 40 km (WITT et al. 1981). Most of the largest gull colonies in the Azores have refuse sites well within this distance and it is therefore not surprising that pellets collected in several colonies indicate that in some colonies the birds are largely dependent on rubbish dumps to feed. This conclusion is supported by the large numbers of individuals, both adults and immatures, observed feeding at the rubbish dumps of the main islands, Terceira and São Miguel. Garbage production in the archipelago has only been monitored since very recently and it is not know how much it has changed over the last decades. But even if the human population in the Azores increased by less than 2% between 1991 and 2001 (http://www.ine.pt/), we can assume that the garbage production has increased due to changes in consumption habits and a massive increase of tourism in the archipelago over the last decade. In 1998, 88% of the total solid waste production in the archipelago was disposed on rubbish dumps and only 12% was going to controlled landfills (ANONYMOUS 2001). The situation has considerably changed since then but in some islands is still precarious. We visited rubbish dumps and landfills on São Miguel, Terceira, Faial, Graciosa and Flores and found considerable numbers of gulls feeding on all of them except on Graciosa, where the rubbish is regularly covered and only one gull was observed.

Being highly opportunistic birds, Yellow-legged Gulls make extensive use of available food and feed on a large variety of prey in the Azores. The differences in the frequency of occurrence of different prey across colonies suggest major spatial and temporal variation in the availability of food. Despite the bias inherent to using pellets, this method is still one of the most frequently used when studying seabird diets (DUFFY & JACKSON 1986; ZIJLSTRA & VAN EERDEN 1995; VOTIER et al. 2001) because it allows an assessment of important dietary components through the collection of large samples that can be easily obtained causing minimum levels of disturbance to the colony. Analysis of pellets will underestimate the importance of items that produce little indigestible remains (JOHNSTONE et al. 1990), like earthworms that were found in regurgitates of both adults and chicks. Similarly to our results, studies on herring gull have also found high frequencies of vegetable matter in pellets (e.g. DAVIS 1956; MORTON & HOGG 1989; NOORDHUIS & SPAANS 1992; NOGALES et al. 1995). The vegetable matter could be ingested deliberately or incidentally when gulls feed on earthworms and other invertebrates.

BOSH et al. (1994) reported that more than 60% of food ingested by Yellow-legged Gull in the Medes Islands was garbage. In the Azores, these values varied significantly among islands and were only surpassed in São Miguel and Terceira Islands, with 91.9% and 96.8% respectively, containing essentially chicken (91.4% and 76.7% for São Miguel and Terceira, respectively). Similar results have been reported by ANNETT & PIEROTTI (1999) who found that the major food types of Western Gulls *Larus occidentalis* were garbage from which > 90% was chicken. On a study with Yellow-legged Gulls breeding in the French Mediterranean, DUHEM et al. (2003) showed that landfills were the preferred food source, even when gulls were breeding on islands far from landfills. It has also been found that in some colonies, proximity of refuse dumps increases hatching success (DUHEM et al. 2002). However it has also been demonstrated that gulls using the scavenging mode of foraging and taking high-refuse diets are much less successful at reproduction, having smaller clutches, reduced hatching success, and shortened reproductive life-spans (ANNETT & PIEROTTI 1999). Previous diet studies of the Yellow-legged Gull in the Azores (HAMER et al. 1994; RAMOs et al. 1998) did not find refuse in the pellets in Mistério da Prainha (Pico) and Ilhéu do Topo (São Jorge); however in the present study these values were 30.25 and 13.1% respectively.

Previous studies on gull diet in the Azores have found much higher occurrences of fish (HAMER et al. 1994, RAMOS et al. 1998) in the pellets than this study; nevertheless species diversity was small with Boar Fish (*Capros aper*) prevailing in up to 98.6% of the fish pellets, RAMOS et al. 1998). Boar fish has been detected in the diet of several other predators in the Azores (MORATO et al. 2003) and probably exhibits strong variation in abundance among years. It seemed to have reached a peak of abundance in 1995 and 1996 but has not been so abundant ever since and was not detected in our study. Ilhéu do Topo (São Jorge) had the lowest proportion of fish in the pellets with only 3.6% of the total, however it had the highest proportions of molluscs, goose barnacles and insects. This is in contrast with the findings of HAMER et al. (1994) who reported fish in 89.4% of total pellets, vs. 8.2% for goose barnacles and 0.6% for molluscs. This might indicate a decrease in fish stocks surrounding that colony or might be due to differences in sampling dates; our samples were collected in May and those of HAMER et al. (1994) in August.

The presence of meso and benthopelagic fish species in Yellow-legged Gull pellets has been reported in previous studies conducted in the archipelago (HAMER et al. 1994; RAMOS et al. 1998). HUDSON & FURNESS (1988) postulated that these species may be made available to surface predators as discards from fisheries. The present study has once more found the presence of deep-water fish species. Even if some species might become available through fishery activity, the presence of several species from the Myctophidae family is harder to explain. This family was represented by 79 otoliths of 10 different species, the most abundant being *Electrona rissoi*, a species that also occurs in other seabird species diets in the Azores (terns - MEIRINHO 2000; Cory's Shearwater *Calonectris diomedea*, Bulwer's Petrel *Bulweria bulwerii* and Madeiran Storm Petrel O*ceanodroma castro* – V. Neves unpublished data). 31% of the 35 different fish species present in the gull pellets have commercial interest (Table 4). Fishery waste is a large food supply for gulls of the British Isles (FURNESS et al. 1992), but in the Azores discards and offal are rare. However sometimes fishermen will carve some of the fish caught and use it as bait. In this way some fishes might become available to the birds, as in the case of the Berycidae family. The low frequency of occurrence of these species corroborates the possibility that they are consumed by gulls only when made available by fishermen.

The differences in diet found between incubation and chick-rearing at the Faial colony suggest that adults shift their diet to more nutritious prey types when they are rearing their chicks. Prey items such as fish and to some extent goose barnacle and mollusc increased, and food with low nutritious value such as insects decreased. This shift in diet between incubation and chick rearing has been detected before in other gull studies. On a study conducted with Western Gulls ANNETT & PIEROTTI (1989) showed that chick hatching triggers dietary switches.

Pellets from Graciosa colony had larger percentages of birds than any other colony, probably because the site where gulls breed also holds colonies of several small petrel species (MONTEIRO et al. 1996)

The presence of the mollusc *Janthina janthina* in the pellets probably reflects seasonal food availability. During the months of April and May *J. janthina* can occasionally be very abundant at sea nearby Faial and Pico Islands and large strandings have also been recorded during these months at Porto Pim beach (Faial) (L. Barcelos, pers. Com.).

Gulls are expanding in the archipelago and it is important to monitor numbers and distribution during the forthcoming years. The progressive replacement of rubbish dumps by landfills following new environmental policies will reduce an important source of food for the gulls and might result in a larger predatory pressure on other seabirds, such as the Roseate Tern. Priority sites to monitor include Ilhéu da Vila and Ilhéu das Contendas; both are of major importance to Roseate Terns and have held isolated breeding pairs of Yellow-legged Gulls since the last few years. In 2005 two gull pairs bred at Ilhéu da Vila (J. Bried pers. Com.). It is important to act in this early stage of colonization when control measures are not so onerous and ensure higher probabilities of success.

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