POPULATION INCREASE OF YELLOW-LEGGED GULLS *LARUS CACHINNANS* BREEDING ON BERLENGA ISLAND (PORTUGAL), 1974-1994

POPULATIETOENAME VAN GEELPOOTMEEUWEN OP BERLENGA EILAND (PORTUGAL), 1974-1994

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ABSTRACT

The colony of Yellow-legged Gull Larus cachinnans *on Berlenga Island (Portuguese west coast) increased exponentially between 1974 and 1994 at 16% per annum. A population growth model applied to the census data collected since 1974 suggested that immigration to the island must have contributed to this increase, particularly in the 1980's, and the estimated annual average rate of immigration between 1978-87 amounted to at least 19.9%. It is suggested that immigrants may have come from Galician colonies and that the west Iberian Yellow-legged gull populations may form part of a metapopulation system.*

INTRODUCTION

Increases of Herring *Larus argentatus* and Lesser Black-backed *L. fuscus* Gull populations have been reported since the beginning of this century (Chabrzyk & Coulson 1976, Cramp & Simmons 1983, Spaans *et al.* 1987, Migot 1992). The Iberian Yellow-legged Gull *Larus cachinnans* populations have shown similar increases in recent decades (Bárcena *et al.* 1984, Bárcena *et al.* 1987, Vicente 1987, Pérez *et al.* 1994, Mouriño & Abrain 1995, Sol *et al.* 1995). Within the Nature Reserve Berlenga Island off the Portuguese west coast, the largest breeding colony of Yellow-legged Gulls in Portugal is found. The first known estimate of the size of the colony on Berlenga, *c.* 1000 breeding pairs in June 1939, was reported by Lockley (1952). According to Vicente (1987) the breeding population remained stable until 1974 at *c.* 1300 pairs. In 1981 *c.* 3000 pairs bred on the island and in 1983 this figure had increased to *c.* 4800 pairs

(Teixeira 1983). In this paper the last 20 years of census results, from 1974 to 1994 are evaluated. Based on the raw census data and the available information on breeding success on Berlenga, the proportion of immigrants in the population is estimated. It is shown that immigration must have occurred to explain the population growth and it is suggested that the population of Berlenga maybe part of a metapopulation system that probably includes all gull colonies in Galicia.

METHODS

Study area

Berlenga Island is located at 39°25'00"N 9°30'05" W. The island has a length of 1500 m, a width of 800 m and its highest point is 88 m above sea level. It is a granite outcrop with cliffs of varying steepness contouring two plateaux. From June to September the island is daily visited by large numbers of tourists who, despite being strictly advised to walk on the trails, wander over the island and frequently disturb the breeding gulls. The rest of the year the island is inhabited by a few fishermen and some lighthouse personnel. With few exceptions, the vegetation is herbaceous and most plants are typical for the Iberian west coast (Daveau & Girard 1884). Presently five seabird species breed on Berlenga: Cory's Shearwater *Calonectris diomedea*, Shag *Phalacrocorax aristotelis*, Guillemot *Uria aalge*, Lesser Black-backed Gull and Yellow-legged Gull. Nests of Yellow-legged Gulls are found scattered all over the island, except on the steepest cliffs, in the fishermen's settlement or near the lighthouse.

Population size estimates

Because most of the breeding birds return to the colony just before the sunset, colony censuses commenced 1.5 h before the sunset. Counts were made with binoculars standing on one cliff and counting adult birds on the facing cliff. The birds tend to spread more or less homogeneously over the island, permitting us to count the number of birds in one binocular field and then counting the number of binocular fields covering the cliff face. The gulls on the plateaux were counted from the top of the lighthouse, subdividing the plateau into sectors with more or less the same densities and then applying the same method. Unfortunately, this census technique does not permit calculations of the error of the estimate. Vicente (1987) using the same census technique found an error of *c.* 5% based on the standard deviation of at least six counts made under the same weather conditions and at the same time each day. In fact, the number of birds present on the island at dusk varies with the weather conditions (pers. obs.).

All census estimates are from June except for 1994, when a gull control programme commenced, organised by the Portuguese Ministry of Environment.

This cull was in May so we decided to use census data for March 1994, the last one available before the cull. For 1976 and 1977 there are no census data available. So, both the annual colony growth and the average rate of population increase are calculated on the basis of the remaining 17 years of data.

It is arbitrarily assumed that the number of breeding pairs equals half of the number of adults counted in a given census. This may not accurately represent the actual number of breeding pairs, but the only historical data available on the colony size are all counts of adults. An idea about the accuracy of this technique may be achieved by comparing the number of nests baited in the cull made in May 1996 with the census estimate made just before the cull. The error (E) in deriving the number of breeding pairs from the census estimates can be calculated using the formula

$$E_t = \frac{(N_t / 2) - B_t}{N_t}$$

in which N_t is the census result, and B_t is the number of baited nests during the cull in year t. For 1996 the error was 0.065, representing 1316 breeding pairs from a total of 10,863 (L. Morais & C. Santos unpublished data). This value may in fact be lower as some nests were not baited, while all birds were included in the colony census. So the error in the calculation of breeding pairs is not considered in this paper and the number of breeding pairs is derived as stated above. The percent annual colony increase (R) is

$$R = \frac{N_{t+1} - N_t}{N_t \cdot 100}$$

where N_t is the census estimate at year t and N_{t+1} is the census estimate in the subsequent year.

Population growth models

Three expected growth curves of the population are constructed assuming that (1) the population is closed (immigration and emigration do not occur), (2) the population was stable until 1974, (3) all breeders surviving in one year breed in the following year, (4) the population sex ratio is 1:1, (5) the birds fledged from the colony and surviving to mature age return to the natal colony to breed, (6) the average age of first recruitment is four years, and (7) survival rates and productivity are constant from year to year, except when stated otherwise. Both models start with the 1974 population size estimate. Number of breeders at year t is given by:

$$N_t = N_{t-1} \cdot S_{adult} + R_t$$

where N_{t-1} is the number of breeders in the previous year and S_{adult} is the adult survival rate. R_t is the number of recruits in year t, calculated as in:

$$R_t = \frac{N_{t-4}}{2 \cdot P \cdot \Pi S_i}$$

where S_i is the survival rate at ages i = 1, 2, 3, and 4. N_{t-4} is the number of breeders four years before, so $N_{t-4} / 2$ gives the number of breeding pairs at that time and P is the productivity given as number of young fledged per pair. Different productivity values are used for each expected growth curve. For both models I and II P is 0.33 young fledged per pair, from 1974 to 1981, and 0.64 young fledged per pair from 1982 to 1986. The first value is the survival of 10 day old chicks found at Berlenga in 1981(P = 0.33 chick 10 days old pair^{-1}, n = 24 nests; Luís, unpubl. report) and the second was found in 1986 (P = 0.64 young fledged pair^{-1}, n = 45 nests; Dias, unpubl. report). In 1981, the main cause for low fledging success was extensive egging by people, selling the eggs to restaurants and bakeries on the mainland (egg collecting intensity in 1981 amounted to 1.29 egg nest^{-1}, n = 35 nests; Luís unpubl. report). According to Luís (unpubl. report) and later Teixeira (1983), the disturbance of gull chicks by tourists was a further cause for the low fledging success. Those P figures are low in comparison with other gull colonies (Chabrzyk & Coulson 1976, Spaans *et al.* 1987), but the second is similar to the 0.6 and 0.7 young fledged per pair found by Davis (1975) for Herring Gulls on Skokholm (Wales). From 1987 onwards P is set at 1.2 and 1.5 young fledged pair^{-1} in model I and model II respectively.

A third model is constructed using P = 0.5 young fledged per pair until 1986 (a P value slightly higher than the average colony productivity in 1981 and 1986, 0.4850 young fledged pair^{-1}) and P = 1.2 young fledged per pair onwards. Survival rates where deliberately set at high values to determine if the observed population growth could theoretically have occurred without immigration. The first year survival in all models is S_1 = 0.83 and was calculated by Chabrzyk & Coulson (1976) for the Herring Gull. This is the highest first year survival rate found among various Gull studies (see Chabrzyk & Coulson 1976). Based on ringing recoveries, the same authors, assumed that the survival rates after the first year can equal adult survival rates. We assume the same in this paper, with asurvival rate from the second year of life onwards equalling adult survival and $S_2 = S_3 = S_4 = S_{adult}$ = 0.95 (survival rates of several colonies ranging from 85%-96%, various authors see Cramp & Simmons 1983). The estimated number of immigrants is given by the difference between the census estimate and the population size calculated by the model in that year.

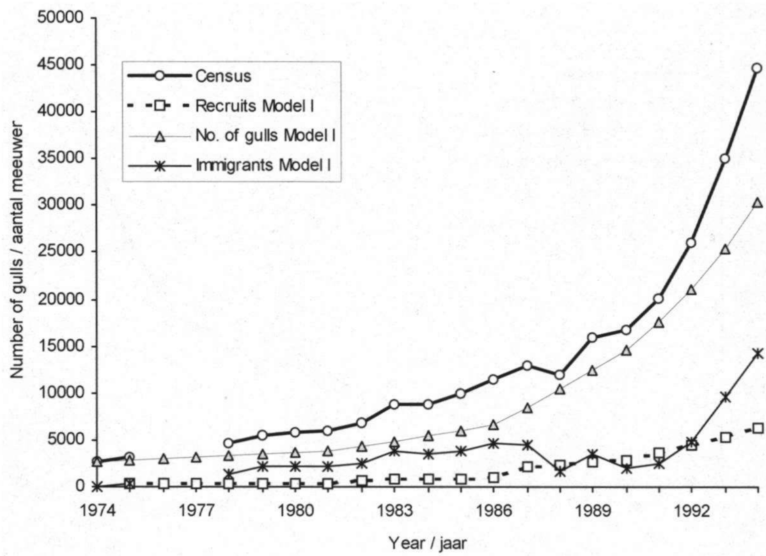

Figure 1. A comparison of censuses' estimates of Yellow-legged Gulls from Berlenga colony 1974-1994 and the population growth, immigrant and recruit curves outputted by model I (see methods for model assumptions and parameters' values).

Figuur 1. Een vergelijking van de telresultaten van Geelpootmeeuwen op Berlenga gedurende 1974-94 en de populatiegroei, immigratie en recruitment curves op basis van Model I (zie methoden voor aannames en parameters).

RESULTS

Historical data on colony size

Apparently, the colony remained more or less stable at around 1000 pairs between 1939 and 1974. Since then an increase began (Teixeira 1983, Vicente 1987, Luís unpubl. report, Dias unpubl. report). In 1981, gull nests were located mainly on 25 to 75 m high cliffs (Luís unpubl. report). Between 1981 and 1985, the number of breeding gulls increased with about 41% (5950 to 8410 nests; Luís unpubl. report, Dias unpubl. report), resulting in an expansion of the breeding area towards the plateau, while the mean density of nests remained the same. Egg collecting practices exist at least since 1883 (Daveau & Girard 1884) and even after the island has been given protection by law by declaring it a Nature Reserve in 1981, and while egging is now prohibited, the practice still

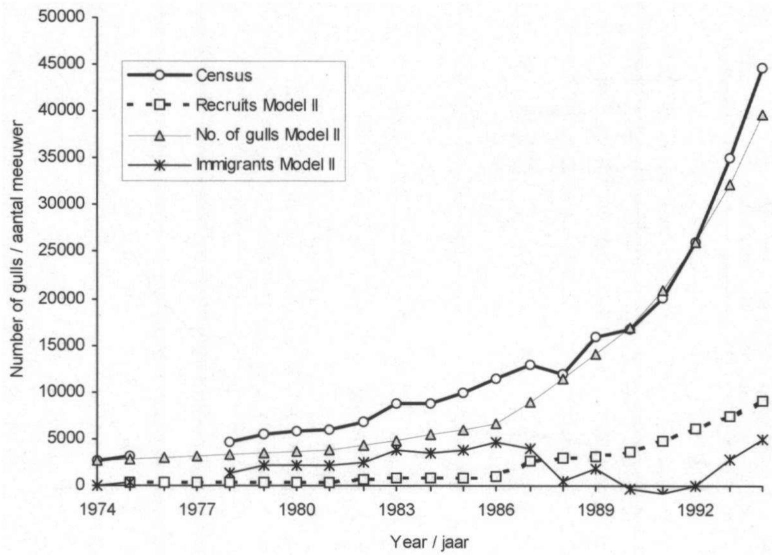

Figure 2. A comparison of censuses' estimates of Yellow-legged Gulls from Berlenga colony 1974-1994 and the population growth, immigrant and recruit curves outputted by model II (see methods for model assumptions and parameters' values).

Figuur 2. Een vergelijking van de telresultaten van Geelpootmeeuwen op Berlenga gedurende 1974-94 en de populatiegroei, immigratie en recruitment curves op basis van Model II (zie methoden voor aannames en parameters).

still existed in 1986 (Dias unpubl. report). Disturbance caused by egging was considered the main cause of the low chick survival in 1981 (0.33 ± 0.64 chicks of 10 days old pair^{-1}, n = 24 nests). The intensity of egg collecting amounted to 1.29 egg per nest (range 1 - 6 eggs, n = 35 nests; Luís unpubl. report). In later years, depredation of eggs and young by adult gulls was probably the main cause of low fledging success. In 1986, 0.64 young fledged per nest (n = 45 nests), and 27.9% of the eggs laid disappeared before hatching (Dias unpubl. report). In 1995, the fledging success in an unculled area was 0.43 young per pair (n = 30 nests) and 63.3% of the eggs laid in those nests were depredated by gulls (calculated from Rainha unpubl. report). In 1986, Dias (unpubl. report) found several regurgitates from chicks contained other gull chicks. Teixeira (1983) mentioned that disturbance of unfledged young by tourists was a further cause of breeding failure. According to a nature reserve warden(Paulo Crisóstomo pers.

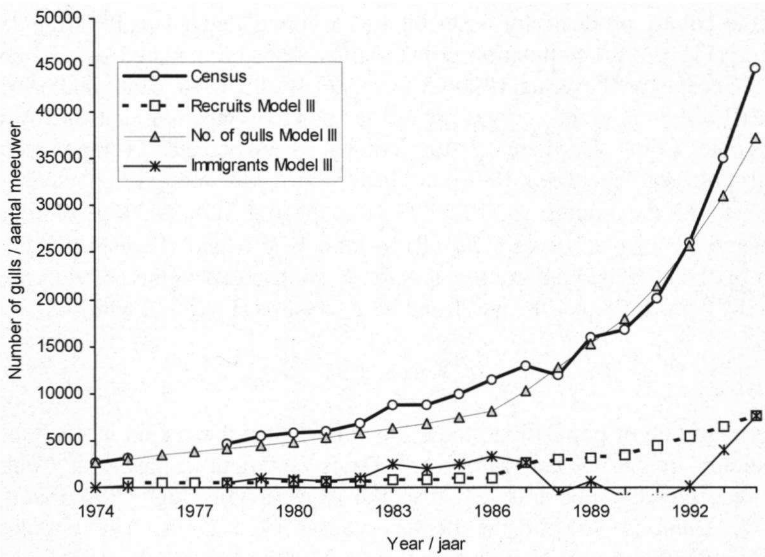

Figure 3. A comparison of censuses' estimates of Yellow-legged Gulls from Berlenga colony 1974-1994 and the population growth, immigrant and recruit curves outputted by model III (see methods for model assumptions and parameters' values).

Figuur 3. Een vergelijking van de telresultaten van Geelpootmeeuwen op Berlenga gedurende 1974-94 en de populatiegroei, immigratie en recruitment curves op basis van Model III (zie methoden voor aannames en parameters).

comm.), only after 1985 the prohibition for camping outside the camping area was fully accomplished. Some furtive egg collecting still occurs today and fishermen crossing the colony still disturb the breeding gulls, causing depredation of eggs and young by other gulls (pers. obs.).

Census results from 1974 to 1994 and population growth models

The colony increased at an average rate of 16.1% ± 12.2% year^{-1} (mean ± SD, n = 17 years) between 1974 and 1994, ranging from -7.7% in 1987/88 to 34.6% in 1992/93. Except for 1987/88 when it reached its minimum, the population increased exponentially, which may be considered typical for a population were intra-specific competition is low or absent.

Although all parameters in the models are set at high values (see methods), the colony censuses in almost all years were clearly higher than expected on the basis of the population growth models (Figs 1, 2 and 3). Even when the colony productivity is set high (1.5 young fledged pair^{-1}) from 1986 onwards (Fig. 2), the population growth still cannot be matched by the model output. Except for the years 1990-92 in model II and 1988, 1990 and 1991 in model III, the immigrant's curves are always positive, meaning that birds might have come from elsewhere to the colony. The percent average rate of immigration year^{-1} between 1978 and 1987, when the immigration values are positive for all the models, is 37.7% ± 3.81% (mean ± SD), 37.2% ± 4.32% and 19.9% ± 6.72% (n = 10 years for all) in models I, II and III respectively. As shown by the models, immigration apparently contributed to the colony growth, especially from 1978 to 1987 and from 1992 onwards (Figs. 1, 2 and 3).

DISCUSSION

The average rate of population increase is higher than that found in many other gull colonies (e.g. 10% and 13% year^{-1}, Davis 1975 and Chabrzyk & Coulson 1976, respectively), but it is less than the exceptionally high 20% found by Davis & Dunn (1976) for the Lesser Black-backed Gulls. The population increase at Berlenga is 5.7 times more than that on the Medes Islands in Spain in a similar period (Carrera 1987 cited by Bosch *et al.* 1994). The improvement of the young survival from 0.33 chicks 10 days old pair^{-1} in 1981 to 0.64 chicks 40 days old pair^{-1} in 1986 (Luís unpubl. report and Dias unpubl. report, respectively) could be the combined result of both the more effective presence of wardens on the island after 1981, who may have significantly reduced gull disturbance by tourists, egging, and immigration. Luís (unpubl. report), assumed that chick survival was approximately at a similar level before 1981, suggesting that the colony still was able to grow without immigration. In those years, survival rates were rather high, particularly for the first year birds , and the gulls may have been supported by abundant and predictable food resources during winter. Unfortunately, evidence for the latter is not available. However, gulls ringed at Berlenga in 1995-97 were frequently seen at the nearby Peniche fishing harbour and rubbish tip and at rubbish tips and fishing harbours along the rest of the west Portuguese coast (pers. obs.). In several of those fishing harbours, huge amounts of fish with low commercial value are thrown to the gulls by the fishermen (pers. obs.). Assuming that the same happened before 1981 and knowing that in several other gull colonies the most common reason for increasing numbers is the increased availability of food at rubbish tips (Hunt 1972, Pons 1992, Noordhuis & Spaans 1992, Vermeer 1992, Sol *et al.* 1995) and discards and offal from fishing boats (e.g. Hunt 1972, Furness *et al.* 1992), Luís (unpublished report), this explanation would be acceptable. However, using a fledging success of 0.5 young fledged pair^{-1} between the years 1974 and 1986 (Fig. 3), higher than what was found in 1981, the colony was still able to grow, but not so fast as it did and the actual growth is not matched by the model output.

It can be argued that higher productivity values could be used from 1974 to 1986. However, the available data suggests that the productivity at Berlenga must have been low during these years as a result of egging and disturbance (Luís unpubl. report, Teixeira 1983). It is also important to notice that the productivity found in 1981 could in fact be lower, as the chicks were followed only until 10 days old. We suspect that the productivity of the colony in the early 1990s may also be lower than the values used in the models. The low fledging success found in 1995 (Rainha unpubl. data) is similar to that found by Spaans *et al.* (1987) for Herring Gulls at Terschelling (The Netherlands), after a dramatic increase in colony numbers, mainly attributable to depredation by conspecifics. Assumptions 3 (there is no intermittent breeding) and 5 (100% of the birds fledged from Berlenga surviving to mature age return to the natal colony to breed) of the population growth models are not necessarily true. Intermittent breeding is known to occur in the congeners Herring Gull and Lesser Black-backed Gull (Calladine & Harris 1997) and the degree of philopatry also varies from colony to colony (Chabrzyk & Coulson 1976, Coulson *et al.* 1982). Remembering this, and knowing that survival rates are exaggerated to maximise the estimated colony growth, and that the models assumed that the population is closed, the exponential growth of the colony has to be explained by immigration. The calculated curve of immigrants in model I suggest that their numbers increased exponentially since 1990. If this kind of immigration increase is unlikely to occur, than the population growth in that period could be explained by a higher productivity in the colony between 1987 and 1989 (in excess of the 1.2 young fledged pair^{-1} used in model I). For 1986 the productivity is known, and it was lower (0.64 chick. pair^{-1}, Dias unpubl. report). However, this explanation does not seems plausible if we consider that the major cause for the low productivity found in 1986 was depredation by conspecifics (Dias unpubl. report) which increases together with colony density (Spaans *et al.* 1987).

Our results suggest that immigration was the key factor, at least in the 1980's. It is known that Yellow-legged Gull colonies at Galicia, Spain, have increased since the 1970s (Bárcena *et al.* 1984, Bárcena *et al.* 1987) and were still increasing in the early 1990s (Mouriño & Iglesias unpubl. report, Pérez *et al.* 1994, Mouriño & Abrain 1995). The main colony there is located at Cies Islands Natural Park, 42°15'04''N 8°53'30''W, and according to Pérez *et al.* (1994), it is the largest known colony of the species. Based on ringing recoveries of birds ringed as chicks in Galician colonies, Munilla (1997) suggests that a migratory flux from Galicia to the northern half of the Portuguese coast may exist. Since Berlenga is the southernmost of the large Yellow-Legged Gull colonies in the Iberian Atlantic coast, it is likely that immigrants may originate from Galician colonies. Recent data on birds ringed as chicks at Berlenga show that younger birds disperse farther than the Iberian coasts from the British Isles (2nd winter seen on a Gloucester landfill, 51°51'N 2°16'W, by J. Sanders, pers. comm.), to northern France (2nd winter seen at Oleron island, 45°55'N 1°20'W, by R.Besson & A. Kim, pers. comm.), south Spain (2nd winter seen at Marbella by J. Marchamalo, pers. comm.) and Morocco (two 1st winters seen at Oued Souss, 30°25'N 9°37'W, by A. Deutsch and J. Troop, pers. comm.). Once a gull is settled in a given colony, the tendency is to start breeding in that colony (Chabrzyk & Coulson, 1976). As subadult gulls are more mobile, many can establish sites in non-natal colonies (Chabrzyk & Coulson, 1976). Berlenga colony may belong to a metapopulation system receiving immigrants from the northern Spanish populations. If so, any measures such as culling or egg and nest destruction taken locally to reduce population growth are useless. Following Sol *et al.* (1995), who say that "...whenever these species are considered a problem, management of refuse tips to limit their exploitation by gulls is probably the most direct and long-lasting means of controlling their population size.", we would like to add that the reduction of the amounts of discards and offal produced in fisheries offshore and in harbours would also contribute to a more successful control of the population size of Yellow-legged Gulls in Portugal.

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SAMENVATTING

De eerste schatting van het aantal broedende Geelpootmeeuwen *Larus cachinnans* op Berlenga voor de kust van Portugal bedroeg 1000 broedparen in 1939. In elk geval tot en met 1974 bleef de populatie min of meer stabiel op ruim 1000 paren, maar in 1981 werden ongeveer 3000 paartjes geteld. In 1983 was de populatie gegroeid tot 4800 paren en na een periode met een exponentiële toename werd in 1994 een niveau van ongeveer 22.500 paren gevonden (Figure 1-3). Door middel van drie modellen, elk met iets verschillende uitgangspunten en aannames (uitgelegd in de methode), werd getracht om na te gaan of deze groei kon worden verklaard door de jongenproductie in de kolonie zelf, of door immigratie van broedvogels uit andere kolonies. Het model ging uit van (1) een gesloten populatie, (2) een stabiele populatie tot en met 1974, (3) alle broedvogels overleven in een jaar en broeden in het daaropvolgende jaar, (4) de sexratio is 1:1, (5 en 6) de uitgevlogen jongen keren gemiddeld na vier jaar terug in de kolonie als broedvogels en (7) zowel overleving als productiviteit zijn van jaar tot jaar constant. Aan de laatste aanname werd 'gesleuteld' door steeds

andere waardes in te vullen en te zien hoe het model 'zich gedroeg'. Van 1974 tot 1994 was de gemiddelde groei van de kolonie 16.1% ± 12.3% per jaar (uitersten -7.7% in 1987/88, 34.6% in 1992/93). De overleving van jongen was tamelijk laag en ook verdwenen veel eieren. Belangrijke factoren voor de tegenvallende broedresultaten waren eierzoeken tot in 1981, verstoring van broedende meeuwen en kuikens door toeristen en vissers en nadat de populatie sterk was gegroeid kannibalisme. Geconcludeerd wordt dat zeker in de jaren tachtig de meeste groei verklaard kan worden door immigratie. In 1994 begon het Portugese Ministerie voor Milieu met een bestrijdingsprogramma. Geconstateerd wordt dat dit programma gedoemd is te mislukken zo lang de rijke voedselbronnen voor meeuwen in het gebied (visafval en vuilnishopen) niet worden aangepakt.

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Yellow-legged Gulls *Larus cachinnans Geelpootmeeuwen (photo M.F. Leopold)*