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Deconstructing myths on large gulls and their impact on threatened sympatric waterbirds

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Abstract

Owing to increasing population trends and facultative predatory habits, large gulls have been identified as significant agents of change in the alteration of many ecological communities. Often, they are perceived as negatively impacting the population trends of most sympatric waterbirds. Consequently, culling programs have been implemented to remove adults, chicks and eggs intensively. Here, we review the interactions recorded in the literature between the yellow-legged gull *Larus michahellis* and 10 sympatric waterbirds in the Mediterranean region, all threatened and classified as species of conservation concern. We also used 177 long-term population trends derived from previous studies to study the population dynamics of these species and the culling effort performed. We show that gulls negatively affected survival, fecundity, foraging ecology and nesting habitat availability for many species. However, the annual population growth rates of most sympatric waterbirds showed positive values, even at sites where culling has yet to be initiated and local yellow-legged gull populations are large and increasing. Our results suggest clearly that population increase has not been exclusive of yellow-legged gulls, especially at the regional level. Yet, growth rates of both yellow-legged gulls and sympatric waterbirds were positively associated. Strikingly, the population extinction rate was similar between colonies of yellow-legged gulls and those of sympatric species. Thus, evidence exists to state that the success of gull control programs is relatively low in the long term. We recommend that conservation agencies heed several basic principles of population and community ecology before initiating control, for instance that (1) yellow-legged gulls have bred historically with other bird species and have likely developed defensive mechanisms against this predator and (2) populations of large gulls are regulated by density-dependent mechanisms in both space and time. Incoming European environmental policies on fishing discards and rubbish management should control more naturally and efficiently the density of large gulls and the composition of seabird communities in the long term.

Introduction

Large gulls of the genus *Larus* (e.g. herring gulls *Larus argentatus*, glaucous-winged gulls *Larus glaucescens*, ring-billed gulls *Larus delawarensis*, lesser black-backed gulls *Larus fuscus*, silver gulls *Larus novaehollandiae* and yellow-legged gulls *Larus michahellis*, among others) have shown substantial population increases in the last decades (see Blokpoel & Spaans, 1991 and references therein). Such increases are likely due to a combination of a reduction in human exploitation and disturbance in addition to increased availability of food (household waste on urban tips and offal and fish discarded from commercial fisheries; Migot, 1992; Bosch, Oro & Ruiz, 1994; Sol, Arcos & Senar, 1994; Oro, Bosch & Ruiz, 1995; Pons & Migot, 1995). Owing to their abundance, gulls have been held responsible for altering soil properties and vegetation communities (Otero, 1998; Vidal *et al.*, 1998*a*, 2000; Calviño-Cancela, 2002; García *et al.*, 2002), changing terrestrial insect assemblages on islands (Orgeas, Vidal & Ponel, 2003), affecting other bird species (Bosch, 1996; Martínez-Abraín *et al.*, 2003*a*; Oro *et al.*, 2005) and polluting water supplies (Monaghan *et al.*, 1985; Bosch & Muniesa, 1996; Ferns & Mudge, 2000). Furthermore, gulls in urban environments damage buildings, defecate on cars and pedestrians, make long calls keeping inhabitants awake, kleptoparasitize food from people and make agonistic attacks on people in defence of their offspring. These observations have led to the view of large gulls as an overabundant pest species (Furness & Monaghan, 1987; Coulson, 1991; Vidal, Medail & Tatoni, 1998*b*). Attempts to control gull numbers were implemented at the very beginning of the population recovery stage (i.e. in the 1930s in Europe and in the 1950s in the USA). All culling programs implemented so far have relied on the assumption that large gulls affect the population trends of their prey, host or competitor species. In some instances, this assumption seems justified, as local extinction of several seabird species has been recorded after displacement and habitat occupation by increasing numbers of large gulls (Blokpoel, Tessier & Andress, 1997; Kress, 1997; Anderson & Devlin, 1999).

Yellow-legged gulls typically breed in the Mediterranean, the Iberian Atlantic and Macaronesia, although the species is expanding northwards into central Europe. In Spain and Portugal, culling has been performed especially in the largest colonies: for example, *c.* 25 000, 18 000 and 14 000 breeding adults were, respectively, killed at Medes Island, Balearic Island and Berlenga Island in a few years (see Morais, Santos & Vicente, 1998; Bosch *et al.*, 2000; Muntaner, 2000). Control programs are also regular in Gibraltar (UK), but they are rare in southern France, not yet performed in Morocco, Algeria, Malta, Tunisia, Greece and Lebanon, and prohibited by law in Italy, Slovenia and Croatia (Blondel, 1963; Serra, Melega & Baccetti, 2001; Duhem, 2004). It has been frequently stated that the yellow-legged gull has experienced an excessive increase throughout its breeding range, but no comparative demographic analyses of their spatio-temporal population dynamics with other sympatric species have been carried out to justify this statement. At the same time, the yellow-legged gull is often identified as a threat to the number of sympatric species, and cited as such in all the eight action plans of Annex 1 listed European seabirds (http://europa.eu.int/comm/environment/nature). To assess these assertions and offer an evidence-based conservation for practitioners working on waterbirds, we compared the population growth rates of several waterbird species with that of yellow-legged gulls monitored for decades in the whole Mediterranean region. We also tested the hypothesis that the population growth rates of yellow-legged gulls and sympatric prey species were associated with culling effort (in a negative and positive shape, respectively), measured as the proportion of monitoring years with culling activity. Additionally, we intensively reviewed the scientific literature to locate evidence that predation, kleptoparasitism and competition from yellow-legged gulls threaten the population status of sympatric species (see Vidal *et al.*, 1998*b* and references therein). Finally, we analyzed the suitability and long-term effectiveness of controlling gull populations by an up-to-date review of the literature available since that of Blokpoel & Spaans (1991). All these facts are important as there has been recent concern about the need for conservation practice based on systematic review, to proceed through scientific evidence and not from personal experiences or common sense (Pullin & Knight, 2001; Sutherland *et al.*, 2004).

Methods

We performed a literature search in BIOSIS (1985–2004) on papers dealing with interactions between yellow-legged gulls and other bird species. We dealt exclusively with non-passerine species and hence do not discuss the interaction of gulls with plants and animals other than non-passerine birds. Bird species were grouped into large categories for a more comprehensive data treatment. Owing to varying taxonomic nomenclature of the yellow-legged gull during the last decades, we performed the search so as to cover all possible names given to the species. We also explored books, unpublished works, conference proceedings, non-indexed journals, web pages and PhD dissertations, and finally performed a questionnaire survey among researchers and conservation practitioners from most Mediterranean countries (see below). All the information gathered from these sources was assessed against preset criteria of high scientific quality in order to make our review as systematic as possible (see Pullin & Knight, 2001). We classified impacts in several categories: threat to reproduction (i.e. predation of eggs and chicks and competition for nesting site), survival (i.e. predation on adult birds) and foraging (i.e. kleptoparasitism at colonies and competition at food source). We estimated an index score calculated from the number of times a given impact was noted in the literature. The index score did not necessarily coincide with the number of research works devoted to a specific impact, as some individual works could analyze several impacts simultaneously.

We also obtained population trends from multiple sources (Sadoul *et al.*, 1996; Scarton & Valle, 1998; Díes *et al.*, 1999; Johnson & Sadoul, 2000; Arcamone *et al.*, 2001; Duhem, 2004; Oro, unpubl. data), including personal questionnaires to researchers from the region (southern Europe, northern Africa) on yellow-legged gulls and sympatric waterbird populations. Through these efforts, we obtained 177 population trend estimates (between 1975 and 2004 with at least 12 years of data, totalling 3363 non-zero censuses) of colonies from Portugal, Spain, Gibraltar (UK), Morocco, Algeria, France, Italy, Tunisia, Greece, Cyprus, Lebanon and Turkey. We assessed the number of species that showed values of λ (i.e. the geometric growth rate of a population with discontinuous growth) significantly lower than 1 (the value at which a population is stable) at local and regional levels (including all the available information for each species at different sites). λ was calculated using a regression analysis (using the logarithm as a link function) of N_t with time (as an offset of the model) to obtain the slope of the model and its 95% confidence intervals (CI), and their exponentials corresponded to the realized population growth rate and its CI. This method is suitable because it is robust to both stochastic environments and census errors, and it allows for unequal time census intervals. We performed a generalized linear model (GLM) with a log-link function to test whether population growth rates of sympatric species were inversely dependent on those of the yellow-legged gulls sharing the same breeding site. We also used the geometric mean of breeding numbers of the latter as a factor, to test not only for the effect of growth but also for predator density (Oro *et al.*, 2006). We finally assessed, through linear regressions, the hypothesis that the population growth rates of sympatric waterbird species should increase with an increase in culling effort in any of the monitored populations. As most of the control programs are still ongoing, we discarded the possibility that population growth rates after control programs could be lowered by long phases of new demographic equilibrium at higher carrying capacities.

Results

The literature search located 82 studies that addressed interactions between yellow-legged gulls and other bird species. We recognize that the index score calculated from these studies could actually represent a measure of researcher expectation (and not a measure of actual impacts), but in most cases such expectation was the result of field (not quantified) observations, dealing especially with predation on nests. The search revealed that the yellow-legged gull was identified as a threat for eight groups of birds: gulls and terns, tubenose petrels, herons and greater flamingos, raptors, waterfowl (including ducks and coots), waders, shags and cormorants, and auks (Table 1). The most commonly reported threat was to reproduction, whereas the lack of studies on habitat competition was probably the result of its complexity at the analytical level (Martínez-Abraín *et al.*, 2003*b*). All eight groups of birds, especially gulls and terns, were affected primarily through predation of chicks and eggs. Although many studies report on the impacts of yellow-legged gulls, the quantification of impacts was generally limited (range 12–56%). For the two groups with a higher index score (tubenose petrels, and gulls and terns), impact was poorly quantified (22 and 36% of the cases, respectively).

At the regional level, the population growth rates of yellow-legged gulls at culled and unculled sites were very similar (CI, of the difference of the means: −0.014 to 0.041), and both values were well within the range of the growth rates of most sympatric species (Fig. 1). No effects of culling on the population trends of yellow-legged gulls and their sympatric species were evident. For example, the population growth rate of 24 local populations of the sympatric Audouin's gull did not increase with an increase in culling effort in any of the monitored populations (coefficient of determination of the fitted regression $r^2 = 0.017$, $F_{1,23} = 0.383$, $P = 0.542$, CI of the slope: −0.002 to 0.001; Fig. 2a). In 61 local populations of 10 species of other sympatric gulls, terns, shorebirds and flamingos, a large variation in growth rate was clearly unrelated to the culling effort performed ($r^2 = 0.030$, $F_{1,60} = 1.803$, $P = 0.185$, CI of the slope: −0.006 to 0.001; Fig. 2b). The proportion of decreasing populations was similar for culled and unculled sites (33 vs. 23%, respectively, $\chi^2_1 = 1.217$, $P = 0.270$). The lack of trend was also apparent for 92 local populations of yellow-legged gulls subjected to different levels of culling effort ($r^2 = 0.004$, $F_{1,91} = 0.385$, $P = 0.537$, CI of the slope: −0.001 to 0.001; Fig. 2c); even where culling was never performed (70% of the sites) growth rates showed a large variation, from large increases to sharp decreases and even extinction (10% of the cases, all at sites with no culling programs). The proportion of decreasing local populations was similar between yellow-legged gulls and that of sympatric species (27 and 25%, respectively). The GLM model (which described correctly the relationship between the dependent and independent variables, goodness of fit of the model: $F_{12,22} = 1.144$; $P = 0.462$) showed that the growth rates of sympatric species were not associated with yellow-legged gull densities (i.e. colony sizes), whereas there was a positive association with their growth rates ($F_{1,36} = 0.551$, $P = 0.463$ and $F_{1,36} = 5.417$, $P = 0.026$, respectively, $r^2 = 0.139$).

Table 1 Scores of the index used to assess the impact of yellow-legged gulls *Larus michahellis* on reproduction (*R*), adult survival (*S*), habitat competition (*H*) and foraging (*F*) of other non-passerine bird species

	Threat on				Quantified (%)	
Species affected	*R*	*S*	*H*	*F*	Yes	No
Gulls and terns	53	1	3	10	36	64
Tubenoses	8	13	0	2	22	78
Herons and flamingos	5	4	0	0	56	44
Raptors	2	0	0	1	–	–
Waterfowl	7	3	0	0	20	80
Waders	7	1	0	0	12	88
Shags and cormorants	2	0	0	2	–	–
Auks	1	0	0	0	–	–
Total	85	22	3	15		

Also shown is the percentage of cases in which the impact was quantified in the literature consulted (only for bird groups with an index score of 8 or higher). None of the studies quantified the impact of gulls on the population growth rate (λ) of prey species (see text).

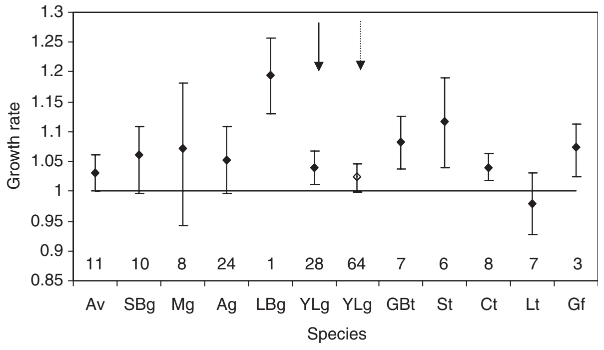

Figure 1 Mean population growth rates (during 1975–2004, whenever data were available) of all the study species at the regional level (number of local populations considered above the *x*-axis): avocet (Av), slender-billed gull (SBg), Mediterranean gull (Mg), Audouin's gull (Ag), lesser black-backed gull *Larus fuscus* (LBg), yellow-legged gull *Larus michahellis* (YLg: the solid and dashed arrows show the culled and unculled yellow-legged gull colonies, respectively), gull-billed tern (GBt), sandwich tern (St), common tern (Ct), little tern (Lt) and flamingo (Gf). The open dot shows the colonies where yellow-legged gulls have not been culled. The line of population stability (λ = 1) is shown, as well as 95% the confidence intervals of mean λ values.

Discussion

Is the yellow-legged gull actually a predatory species?

Our review confirms that yellow-legged gulls are aggressive birds that may exclude sympatric species from nesting

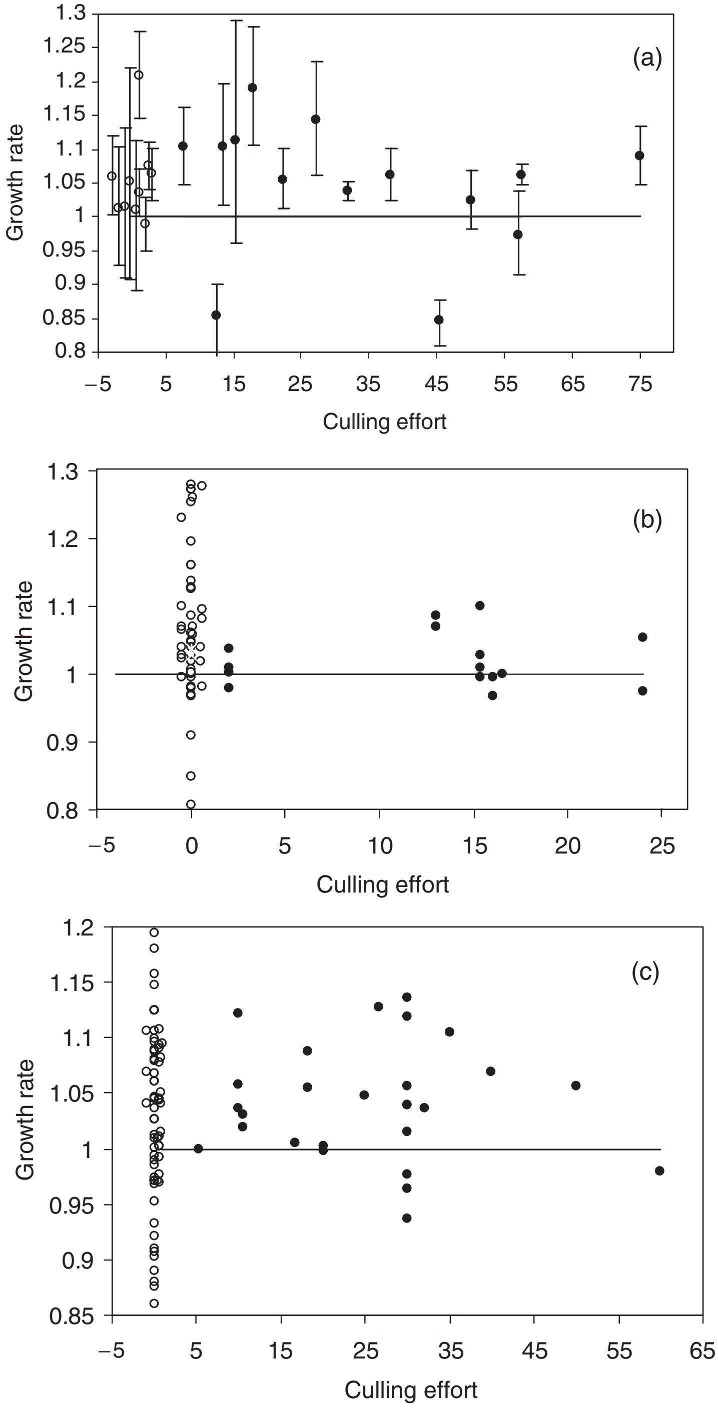

Figure 2 Mean local population growth rates (during 1975–2004, whenever data were available) of (a) Audouin's gulls, (b) other sympatric species (see Fig. 1) and (c) yellow-legged gulls *Larus michahellis* , all in relation to the culling effort (as the proportion of years with control programs operating related to the total number of years with population estimates) at each of the sites. Open dots show the colonies where yellow-legged gulls have not been culled. The line of population stability ($\lambda = 1$) is shown. The values with no culling were spread out to show them all. For the sake of simplicity, the 95% confidence intervals of mean values are shown only for Audouin's gull local populations (a).

habitats and that they prey on a large range of waterbirds, from small to some larger species, such as greater flamingo chicks, Balearic shearwaters, lesser black-backed gulls or parasitic skua adults (Oro, unpubl. data). Anecdotal records of predation on migrant passerines, game birds, steppe birds, rabbits, snakes and lizards also exist. We also confirmed that the species has increased throughout its breeding range. This increase, together with scavenging behavior and the growing disturbances at harbors and urban areas, has fostered a hostile public attitude toward this species (see also Spaans, Van Swelm & Vogel, 1996). We believe that these facts have created a negative state-of-mind against the species that extends to many wildlife biologists and conservation managers because they have to address public complaints (see also Fernandez, 1997). With a few exceptions, all literature on Mediterranean coastal colonial birds cited yellow-legged gulls as a threat (see Nagy & Crockford, 2004 for threatened European birds), but these citations are based on anecdotes and myths rather than the systematic appraisal of the evidence, as most conservation practice should be (Pullin & Knight, 2001; Sutherland *et al*., 2004). The impact of yellow-legged gulls has even been cited as being greater than that caused by terrestrial carnivores (Ruiz-Olmo, Blanch & Vidal, 2003, p. 223). Paradoxically, these references did not provide a quantitative and thorough analysis of the interactions, although this does not document the lack of the impact. The 37 quantitative studies document that interactions are frequent and typical of an opportunistic scavenger and facultative bird predator (Oro *et al*., 2006). Predation by large gulls on the eggs and chicks of smaller species can actually decrease breeding success (Spear, 1993) and especially affect dispersal (see Oro, Pradel & Lebreton, 1999) and recruitment (Finney *et al*., 2003), influencing in turn local population dynamics and even local extinctions (Kress, 1997; Oro, 2003; Martínez-Abraín *et al*., 2003*b*; Oro *et al*., 2006). However, observational data suggests that large gulls depredate mainly neglected eggs and chicks (following human disturbances – including research – or floodings) or chicks undersized in broods (see also Swennen, 1989; Oro, 1996*b*, 2002; Schauer-James & Murphy, 1996; Oro *et al*., 2004*a*). Other forms of interaction, such as kleptoparasitism, are also performed by other gulls (including the endangered Audouin's gull) and terns (Oro, 1996*a*; Stienen, Brenninkmeijer & Geschiere, 2001). Additionally, interspecific competition for food during breeding does not appear to affect the reproductive success of sympatric species either (Finney *et al*., 2001; Martínez-Abraín *et al*., 2003*a*), even when the carrying capacity of the community is attained (Oro *et al*., 2006). Indeed, in foraging grounds, some species surpass yellow-legged gulls owing to their superior flying skills (Arcos, Oro & Sol, 2001).

Two forms of interaction with the most likely conservation concern at a global level are habitat competition and adult predation. Competition for nesting habitat may also decrease breeding success and increase dispersal following occupation of sub-optimal habitats (Parnell *et al*., 1988; Croxall & Rothery, 1991; Cairns, 1992; Blokpoel *et al*., 1997; Kress, 1997; Anderson & Devlin, 1999). It has been shown that Audouin's gulls, slender-billed gulls and little terns avoid breeding sites where yellow-legged gulls are already reproducing (Oro, 2002; Martínez-Abraín *et al*., 2003*b*; Oro *et al*., 2004*a*, respectively), although the last two species also avoid other large gulls such as Audouin's gulls. A conservation problem appears when suitable, high-quality sites are in short supply or have been altered, as may be the case in the Mediterranean (Martin, Thibault & Bretagnolle, 2000). Predation on breeders can also be higher in altered ecosystems (Gilchrist, 1999), where food from human activities (e.g. refuse tips and fishing discards) allows large and scavenging predatory seabirds to increase their populations (Votier *et al*., 2004). Food stress caused by incoming regulation of these human activities has increased levels of foraging on alternative resources such as predation on smaller species (Stenhouse & Montevecchi, 1999), as it has been recorded for great skuas *Catharacta skua* in the North Sea (Oro & Furness, 2002; Votier *et al*., 2004).

Gull control programs: an up-to-date review on their success and suitability

Since the general review of Blokpoel & Spaans (1991), a number of new studies (published and unpublished) on the effectiveness and suitability of gull control programs are now available. This has allowed us a systematic review to take the results of primary research and to evaluate them in the present meta-analysis, following recent recommendations of evidence-based conservation practice (Sutherland *et al*., 2004; Pullin & Knight, 2005). Before this study, it was generally indisputable that populations of large gulls and other species with similar management concerns (e.g. great cormorants) decreased following control programs (Alvarez, 1992; Wanless *et al*., 1996; Bosch *et al*., 2000; Frederiksen, Lebreton & Bregnballe, 2001). However, data from our study (Fig. 2c) and from the studies of others shows that the success of gull control programs is relatively low in the long term (see also Defos du Rau *et al*., 1997; Bosch, 2004). At large spatial scales, some colonies showed a population decrease and extinction even in the absence of culls (the extreme case was extinction of yellow-legged gulls in the whole of Lebanon; see Masri, 1995). Yet, an increase in culling effort resulted in neither a decrease of yellow-legged gull growth rate nor an increase of the sympatric species. Furthermore, growth rates of sympatric species were independent of gull densities, whereas growth rates varied in parallel, suggesting the importance of carrying capacity in the population dynamics of competing species in communities (Cadiou & Yésou, 2006; Oro *et al*., 2006). The literature also suggested that prey population may be influenced by control programs, either by reoccupying the space (Blokpoel *et al*., 1997; Harris & Wanless, 1997; Kress, 1997; Anderson & Devlin, 1999) or by increasing breeding parameters (Guillemette & Brousseau, 2001). Nevertheless, a reduction in the number of gulls may not lead to a similar reduction in conflicts, owing to density-dependent recovery of gull numbers or the presence of predatory specialists that may be omitted from a general cull by chance (Coulson, 1991; Spear, 1993; Finney *et al*., 2001; Frederiksen *et al*., 2001; Guillemette & Brousseau, 2001; Oro *et al*., 2005). Furthermore, some studies have pointed out that prey breeding conditions do not always improve markedly after culling (Côté & Sutherland, 1995, 1997; Harris & Wanless, 1997), and that control has to be continued for years (with a great funding effort) because numbers can recover extremely rapidly after cessation of programs (Thomas, 1972; Duncan, 1978; Prueter & Vauk, 1988; Spaans *et al*., 1996; Wanless *et al*., 1996; Cadiou & Jonin, 1997; Anderson & Devlin, 1999; Guillemette & Brousseau, 2001).

Control programs within the meta-population framework

Programs can have limited local effects due to dispersal; to be effective, they need to be applied at a large geographical scale (Brooks & Lebreton, 2001; Frederiksen *et al.*, 2001; Oro, 2003). Because wild animals do not observe administrative boundaries, adjusting their management to socio-political realities can represent a challenge for conservation agencies (see also Gordon, Hester & Festa-Bianchet, 2004). A further complementary management consequence of culling is the triggering of dispersal to other breeding sites, with unexpected consequences at seabird community composition beyond the area of control (Aguilar, Fernández & Mayol, 1994; Bosch *et al.*, 2000; Muntaner, 2000; Oro, 2003). For these reasons, there has recently been increasing concern about the suitability of controlling predators to enhance the survival of threatened species (Côté & Sutherland, 1995, 1997; Schneider, 2001).

The need to manage food resources from human origin

While protection of space and cessation of human persecution have also benefited the accompanying species (see Figs 1 and 2), management of food from human origin seems the most effective way of controlling populations of large gulls (see also Pons, 1992; Bosch *et al.*, 1994; Sol, Arcos & Senar, 1995; Cadiou & Jonin, 1997; Arcamone *et al.*, 2001). Paradoxically, this exploitation of human food resources has also benefited threatened species such as Audouin's gull or the Balearic shearwater (Oro, 1999; Arcos & Oro, 2002). The tendency for the near future is that refuse tips will be progressively closed or properly managed and fishery waste will be reduced, following the implementation of European Union environmental policies (Gewin, 2004). Although reduction of food availability can alter the environmental features of the last decades (Crawford *et al.*, 1989; Votier *et al.*, 2004), it should lower the carrying capacity of the environment, triggering density-dependent mechanisms such as infectious diseases. For example, botulism has been reported to be the principal cause of recent declines in Irish colonies of the herring gull (Mitchell *et al.*, 2004). These declines have been so pronounced that this species now meets the requirements to be included in the Red List in Ireland and the Amber List of Birds of Conservation Concern in the UK (Mitchell *et al.*, 2004). Here and in other countries, large gull species are showing complex dynamics, with regions showing unexpected declining trends (Mitchell *et al.*, 2004; Cadiou & Yésou, 2006).

Accounting for some principles in population ecology

Although all forms of aggressive interactions on smaller species and habitat competition are evident from our literature review, they are probably not quantitatively very different compared with other predator–prey systems in food chains, especially when prey is not the primary foraging resource of the predator (Côté & Sutherland, 1995; Ricklefs & Miller, 2000; Oro *et al.*, 2006). Managers should heed that yellow-legged gulls have bred sympatrically for thousands of years with many other species, which should have developed evolutionary mechanisms to defend against this predator. As predators, they should also be viewed as part of the ecosystem, removing individuals with low reproductive value (Swennen, 1989). Populations of large gulls are also regulated by density-dependent mechanisms in both space and time (Oro *et al.*, 2006). Although in particularly extreme cases yellow-legged gulls can facilitate extinction of local populations, regional trends of monitored species in the Mediterranean do not suggest a conservation concern, except with little terns, the smallest species. Importantly, the effects of predatory gulls (e.g. extinction or decline) on their prey should not be assessed at the local population scale but rather at the metapopulation scale, which should be the true unit of management of birds with high dispersal capabilities (such as seabirds and waterbirds in general; see Martínez-Abraín, Oro & Jimenéz, 2001; Martínez-Abraín, Sanchez & Oro, 2002; Martínez-Abraín *et al.*, 2004; Oro, 2003). It is also known that breeding sites at the metapopulation level do not have the same quality, and that habitat heterogeneity (including yellow-legged gull densities) is essential for metapopulation functioning, the rescue effect or source–sink systems. Some conservation agencies should accept that some of the populations under their management responsibility may not perform better, have a high risk of extinction or depend largely on immigration from the outside (Oro *et al.*, 2004*b*). As a final corollary, massive culling programs of yellow-legged gulls (and probably of other large gulls) are not justified on the basis of the knowledge cumulated so far, at least for protecting other bird species. Other conservation actions, such as the promotion of habitat restoration at large spatial scales, should have greater benefit for the whole community. In the Mediterranean, there is a dramatic loss of suitable habitat in coastal areas due to very ancient human occupation and development. This problem should concentrate most on conservation efforts, especially when funding devoted to conservation (particularly in northern Africa) is lower than in both European and American countries.

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