IBIS 137: 547–549

Effects of a trawling moratorium on the breeding success of the Yellow-legged Gull *Larus cachinnans*

DANIEL ORO[1], MARC BOSCH[2] & XAVIER RUIZ[1]
[1] *Departament de Biologia Animal–Vertebrats, Universitat de Barcelona, Avda. Diagonal, 645, 08028 Barcelona, Spain*
[2] *Departament d'Ecologia, Universitat de Barcelona, Avda. Diagonal, 645, 08028 Barcelona, Spain*

The establishment of a two month commercial fishing moratorium, which overlapped each year with different stages of the breeding cycle of the Yellow-legged Gull *Larus cachinnans* at the Ebro Delta, Spain, provided the opportunity of testing the effects of food limitation on the breeding success of this species. The study was carried out in 1993, when the chick rearing stage occurred with normal commercial fishing activity and in 1994, when the chick rearing stage overlapped with the trawling moratorium. We recorded diet of the chicks, breeding phenology, clutch size, egg volume, hatching success and productivity of adult birds. There was a highly significant difference in the diet of the chicks between the two years and significantly lower productivity in 1994, whilst the other parameters examined did not change. These results show that a dependence on discards from commercial fishing activities may be a limiting factor in the breeding success of this seabird.

The utilization by seabirds of discarded fish behind fishing vessels has been widely described (Watson 1978, Hudson & Furness 1988, Furness *et al.* 1992, Garthe & Hüppop 1994), and several authors have attributed the growth of many seabird populations to the benefit of this resource (e.g. Nisbet 1978, Blokpoel & Spaans 1990, Dunnet *et al.* 1990). However, the impossibility of preventing the utilization of discards by the scavenging seabirds has not allowed the assessment of this hypothesis (Bailey & Hislop 1978).

On the other hand, the influence of food availability on the breeding ecology of seabirds has been studied extensively (Monaghan *et al.* 1992, Hamer *et al.* 1993, Uttley *et al.* 1994), but few studies have been able to use simultaneous data on prey abundance (see Uttley *et al.* 1994 and references therein). Furthermore, since there are several ways in which seabirds can face declines in food availability (Uttley *et al.* 1994) and food scarcity usually affects the overall breeding season, it is difficult to show significant effects of food shortage on breeding success (e.g. Uttley *et al.* 1994). In this paper, food deprivation was restricted to the chick-rearing stage, without previous adjustments of other breeding parameters. In the Ebro Delta, Spain, there is a large fishing fleet, especially diurnal trawlers (Demestre *et al.* 1987). The width of the continental shelf and the large amounts of nutrients carried by the River Ebro give rise to one of the largest seine-fishing areas in the Mediterranean. Since 1991, a trawl-fishing moratorium has been established each year, affecting the two provinces surrounding the Delta. In some years, this moratorium overlapped with the gulls' breeding season. In 1993, the moratorium started after the chicks fledged, whereas in 1994 the moratorium overlapped with the chick-rearing stage. This provides us with the opportunity to examine the effects of food limitation on this specific stage of the breeding cycle.

METHODS

The study was carried out in 1993 and 1994 in the Ebro Delta, northeastern Spain (40°37′N, 00°35′E). The colony has been described elsewhere (Oro & Martinez 1992) and contained *c.* 1420 pairs in 1993 and *c.* 1700 in 1994.

We recorded breeding phenology, clutch size, egg volume, hatching success and breeding performance of the Yellow-legged Gull *Larus cachinnans* in the Ebro Delta in 2 years with different fishing activity (1993 and 1994). Data on diet composition were collected during the chick-rearing stage, which in 1993 corresponded to a period of normal trawler fishing, whereas in 1994 it corresponded to a fishing moratorium. Chicks, when handled for ringing, regurgitated largely undigested food, which provided a good indication of the items collected by the adults (Mudge & Ferns 1982). These regurgitates were collected and preserved for later identification in the laboratory using our reference collection of fish, mammals and invertebrates from the Ebro Delta. Fish, when partially digested, were identified on the basis of their scales, otoliths and jaws, but identification was usually possible from the entire fish. The quantification procedures always followed the rule of minimum numbers, and we used the percentage of occurrence to compare the diet in the 2 years. In order to avoid categories poorly represented in the diet (Cooper *et al.* 1990), we grouped all prey from rice fields, channels and lagoons of the Delta in one category ("Delta") and occasional prey into another category ("others").

Table 1. *Percentage of occurrence of food regurgitated by Yellow-legged Gull chicks in 1993 and 1994*

Year	Refuse	Fish[a]	Delta[b]	Others[c]	n[d]
1993	39.1	47.8	13.0	8.7	23
1994	32.8	12.1	56.9	8.6	58

[a] Prey from discards (clupeiforms and benthonic fish).
[b] Prey from rice fields, irrigation channels and lagoons.
[c] Decapoda, Bivalvia and olives.
[d] Number of regurgitates.

We established an arbitrary linear transect through the colony each year. The transect was searched once a day to establish the date of first hatching (until no newly hatched chicks were found) and clutch size, and the length and width of the eggs were measured with callipers to ±0.1 mm. Egg volume (ml) was calculated using the equation of Harris (1964) with $K_v = 0.476$, and the average egg volume was subsequently calculated for every clutch. A group of 14 nests in both 1993 and 1994 was surrounded by netting (50 cm high) just before hatching to facilitate the location of the chicks and to calculate the breeding success.

Differences of breeding phenology (dates of appearance of first hatchlings) between years were tested using the Mann-Whitney U-test. To detect differences in diet, clutch size, hatching success, fledging success and breeding success between the years, contingency tables and the G-test statistic were used. To test the effects of year (1993 and 1994) and clutch size (two- and three-egg clutches) simultaneously, a two-factor ANOVA on the average volume of the eggs in a clutch was used (Zahr 1984). Underlying assumptions of the statistical tests were verified in all cases.

RESULTS

There was a highly significant difference in diet composition between the 2 years ($G_3 = 43.8$, $P < 0.0001$; Table 1). Residuals show that refuse was the only category which was homogeneous in both periods. Higher feeding rates on fish (especially clupeiforms and typically marine Perciformes) were positively associated with periods of active trawling operations, whereas prey from the rice fields, irrigation channels and lagoons became more numerous during the moratorium (Table 1).

Median date of hatching was the same (27 April) in 1993 and 1994 (Mann-Whitney U-test, $z = 1.6$, n.s.). Modal clutch size was three eggs in the 2 years, and a likelihood ratio test showed that clutch size frequency distributions were very similar between years ($G_2 = 0.33$, n.s.). We detected no significant year effect in relation to the average volume of a clutch (ANOVA $F_{1,101} = 0.15$, n.s.) nor a clutch size effect (ANOVA $F_{1,101} = 1.91$, n.s.), and interactions between year and clutch size were also not significant (ANOVA $F_{1,101} = 0.11$, n.s.). Hatching success did not differ significantly between years (Fisher exact test, $\chi^2_1 = 0.37$, n.s.). The number of chicks fledged in the enclosures was significantly higher in 1993 (47%) than in 1994 (22%), both to the number of eggs hatched ($\chi^2_1 = 4.36$, $P < 0.05$) and to the number of eggs laid ($\chi^2_1 = 4.08$, $P < 0.05$; Table 2).

DISCUSSION

In the Ebro Delta, the diet of Yellow-legged Gulls depends markedly on discards from the trawling fleet because, when available, the discards constitute a stable and abundant feeding resource both in time and space (Ruiz *et al.* in press).

Since Yellow-legged Gulls are opportunistic feeders and refuse, the second most important food resource, is also predictable (Donázar 1992), we expected that the gulls would change from one resource to another to compensate for low discard availability. Surprisingly, the occurrence of refuse in the gulls' diet did not significantly increase during the moratorium. This was probably because the low number of available refuse tips in the gulls' foraging area limited the number of specialists on this resource (Monaghan 1980). We estimated the foraging range of Yellow-legged Gulls to be *c.* 40 km around the colony site. This value was obtained

Table 2. *The breeding performance of Yellow-legged Gulls at the Ebro Delta in 1993 and 1994*

	1993		1994		
		n		n	P
Hatching date[a] (mean ± s.e.)	25.9 ± 2.5	54	24.8 ± 2.6	57	n.s.
Clutch size (mean ± s.e.)	2.63 ± 0.48	54	2.58 ± 0.09	57	n.s.
Egg volume (ml) (mean ± s.e.)	82.4 ± 0.91	46	82.7 ± 1.08	39	n.s.
Hatching success[b] (%)	97.4	14	94.7	14	n.s.
Fledging success[c] (%)	47.4	14	22.2	14	<0.05
Breeding success[d] (%)	46.2	14	21.1	14	<0.05

[a] Mean hatching date, expressed as number of days after 1 April.
[b] Number of eggs hatched, expressed as a percentage of the number laid.
[c] Number of chicks fledged, expressed as a percentage of the number hatched.
[d] Number of chicks fledged, expressed as a percentage of the number of eggs laid.

from our data on distances to the coast at which the species is not recorded when making observations from fishing vessels. Within this area, there are only four refuse tips available, and the largest is about 30 km from the colony site (D. Oro, M. Bosch & X. Ruiz, unpubl. data).

However, Monaghan *et al.* (1994) have shown that Guillemots *Uria aalge*, a species in which flight is costly, travel up to six times farther when foraging at times of low food availability. This difference in foraging behaviour can arise because Guillemots in Shetland depend on only one high-energy prey type (Uttley *et al.* 1994) and, thus, attempt to capture larger sandeels (*Ammodytes*) to compensate for the greater distances travelled (Monaghan *et al.* 1994), whilst Yellow-legged Gulls are eclectic in diet composition (D. Oro, M. Bosch & X. Ruiz, unpubl. data), and they only need to balance for the energy invested in collecting the wide array of prey types consumed. Since one of the most expensive energy budgets corresponds to distance travelled (Ricklefs 1984) and the Ebro Delta ecosystem (rice fields, irrigation channels and lagoons) provides adequate prey items (González-Solís *et al.* in press), gulls move to feed on these neighbouring resources instead of flying to forage at refuse dumps. Indeed, during the moratorium, mullet (*Mugil* sp.) taken in the delta constituted the main food resource for the species.

Nevertheless, this change was accompanied by a significant decrease in the breeding success as measured by the number of chicks fledged per pair, whilst, as expected, breeding phenology, clutch size, egg volume and hatching success were unchanged, suggesting that food availability was similar in both years until the establishment of the moratorium during the chick-rearing stage in 1994 caused a food shortage.

These results show that dependence on discards from fishing activities may in fact be a limiting factor for the breeding success of a scavenging seabird. The overall fledging success dropped by 46% in 1994, a decline similar to that recorded by Pons (1992) for Herring Gulls *Larus argentatus* in Brittany after a decrease of 80% in the amount of refuse dumped at a nearby tip.

We are grateful to the following: Albert Bertolero and Xell Genovart for helping in the field work; J.C. Coulson, Lluis Jover and Santi Mañosa for discussing and criticizing earlier drafts; Albert Martinez for his unfailing support, and the Parc Natural del Delta de l'Ebre for providing logistic and technical support. R. Rycroft (EIM Universitat de Barcelona), improved the English text. Research funds were provided by Parc Natural del Delta de l'Ebre, the DGICYT grant PB91-0271 of the Spanish Government and the Instituto para la Conservación de la Naturaleza ICONA.

REFERENCES

Bailey, R.S. & Hislop, J.R.G. 1978. The effects of fisheries on seabirds in the northeast Atlantic. Ibis 120: 104–105.

Blokpoel, H. & Spaans, L. 1990. Superabundance in gulls: Causes, problems and solutions (introductory remarks). Proc. Int. Orn. Cong., XX: 2361–2364.

Cooper, R.J., Martinat, P.J. & Whitmore, R.C. 1990. Dietary similarity among insectivorous birds: Influence of taxonomic versus ecological categorization of prey. Studies in Avian Biol. 13: 104–109.

Demestre, M., Lleonart, J., Martin, P., Recansens, L. & Sánchez, P. 1987. Evolución de las capturas mensuales de Peces, Moluscos y Crustáceos y de algunas especies de interés comercial en Catalunya en el periodo 1979–1985. FAO Rapp. Pêches 395: 92–100.

Donázar, J.A. 1992. Muladares y basureros en la biología y conservación de las aves en España. Ardeola 39: 29–40.

Dunnet, G.M., Furness, R.W., Tasker, M.L. & Becker, P.H. 1990. Seabird ecology in the North Sea. Neth. J. Sea Res. 26: 387–425.

Furness, R.W., Ensor, K. & Hudson, A.V. 1992. The use of fishery waste by gull populations around the British Isles. Ardea 80: 105–113.

Garthe, S. & Hüppop, O. 1994. Distribution of ship-following seabirds and their utilization of discards in the North Sea in summer. Mar. Ecol. Prog. Ser. 106: 1–9.

González-Solís, J., Bernadí, X. & Ruiz, X. In press. Seasonal variation of waterbird prey in the Ebro Delta rice fields. Colonial Waterbirds.

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P. & Burns, M.D. 1993. The influence of food supply on the breeding ecology of Kittiwakes *Rissa tridactyla* in Shetland. Ibis 135: 255–263.

Harris, M.P. 1964. Aspects of the breeding biology of the gulls. Ibis 106: 432–456.

Hudson, A.V. & Furness, R.W. 1988. Utilization of discarded fish by scavenging seabirds behind whitefish trawlers in Shetland. J. Zool. Lond. 215: 151–166.

Monaghan, P. 1980. Dominance and dispersal between feeding sites in the Herring Gull (*Larus argentatus*). Anim. Behav. 28: 521–527.

Monaghan, P., Uttley, J.D. & Burns, M.D. 1992. Effect of changes in food availability on reproductive effort in Arctic Terns. Ardea 80: 71–81.

Monaghan, P., Walton, P., Wanless, S., Uttley, J.D. & Burns, M.D. 1994. Effects of prey abundance on the foraging behaviour, diving efficiency and time allocation of breeding Guillemots *Uria aalge*. Ibis 136: 214–222.

Mudge, G.P. & Ferns, P.N. 1982. The feeding ecology of five species of gulls (Aves: Larini) in the inner Bristol Channel. J. Zool. Lond. 197: 497–510.

Nisbet, I.C.T. 1978. Recent changes in gull populations in the western North Atlantic. Ibis 120: 129–130.

Oro, D. & Martinez, A. 1992. The Audouin's Gull colony at the Ebro Delta. Avocetta 16: 36–39.

Pons, J.-M. 1992. Effects of changes in the availability of human refuse on breeding parameters in a Herring Gull *Larus argentatus* population in Brittany, France. Ardea 80: 143–150.

Ricklefs, R.E. 1984. Some considerations on the reproductive energetics of pelagic seabirds. Studies in Avian Biol. 8: 84–94.

Ruiz, X., Oro, D., Martinez, A. & Jover, L. In press. Feeding ecology of Audouin's Gull *Larus audouinii* at the Ebro Delta. Colonial Waterbirds.

Uttley, J.D., Walton, P., Monaghan, P. & Austin, G. 1994. The effects of food abundance on breeding performance and adult time budgets of Guillemots *Uria aalge*. Ibis 136: 205–213.

Watson, P.S. 1978. Seabirds at commercial trawlers in the west Irish Sea. Ibis 120: 107–108.

Zahr, J.H. 1984. Biostatistical Analysis. London: Prentice-Hall.

Submitted 10 October 1994; revision accepted 2 December 1994