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Effects of trawler discard availability on egg laying and breeding success in the lesser black-backed gull *Larus fuscus* in the western Mediterranean

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ABSTRACT: The availability of trawler discards is likely to have a pronounced effect on the reproduction of seabirds, but this importance is normally difficult to quantify. A comparison between 2 breeding seasons of the lesser black-backed gull, one of them affected by a trawling moratorium, has allowed an assessment of the effects of discard availability on its egg laying. When trawlers operated, diet was dominated by fish from discards, while during the trawling moratorium gulls fed from refuse tips, olive tree fields and especially rice fields. Although neither breeding phenology was different nor was clutch size significantly lower in the year of the trawling moratorium, the volume of the eggs decreased significantly, showing the importance of trawler discard availability as a proximate determinant of egg production of scavenging seabirds. Since the moratorium overlapped with the chick rearing stages in both years, breeding success was probably lower than before the establishment of the trawling moratorium in 1991. However, the breeding success was higher in 1994 than in 1995, when the moratorium overlapped with the entire period of chick growth. Population dynamics of the species is probably affected by changes in trawler discard availability, especially if a trawling moratorium continues for many years.

KEY WORDS: Trawler discards · Food availability · Moratorium · Lesser black-backed gull · Egg-laying · Population dynamics · Reproduction

INTRODUCTION

The relationship between fisheries and the biology of many seabird species has been widely studied, especially in recent decades (e.g. Nettleship et al. 1984, Montevecchi 1993). In some cases, commercial fishing can dramatically affect seabird food webs (e.g. Furness & Ainley 1984, Ryan & Moloney 1988) through over-fishing and depletion of fish stocks. In contrast, seabirds can benefit from the use of fishery waste, especially from trawling of demersal fish, a practice that produces massive new artificial food sources for scavenging birds (e.g. Hudson & Furness 1988, Furness et al. 1992, Camphuysen et al. 1993, Garthe & Hüppop 1994). This increase of food availability seems to be related to the growth of many seabird populations of some scavenging seabird species in northern Europe (see Furness 1982), but the degree of exploitation has normally been difficult to assess (Watson 1978). However, Oro et al. (1995a) showed that a trawling moratorium which overlapped with the chick rearing stage of the yellow-legged gull *Larus cachinnans* affected its breeding success in the Ebro Delta (northeastern Spain). In this area, lesser black-backed gulls *Larus fuscus* also follow the trawlers; they exploit offal and discards, while they rarely catch fish actively (Oro 1995a). The extent of trawler discard exploitation for this species is examined. Since the trawling moratorium overlapped in some years with the courtship feeding and laying stages of the lesser black-backed gull, the changes in its egg laying brought about by the decrease in food availability, as well as the effects on its breeding success, are assessed.

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STUDY AREA AND METHODS

The study was carried out during 1994 and 1995 in the Punta de la Banya, northeastern Spain (Ebro Delta Natural Park, 40° 37' N, 00° 35' E; see Oro & Martínez-Vilalta 1994 for details). The colony contained 79 pairs of lesser black-backed gulls in 1994 and 168 in 1995.

Clutch size and egg volume of lesser black-backed gulls were recorded in 2 years with different trawler activity. The trawling moratorium lasted for 2 mo each year during 1994, the moratorium overlapped with the egg laying stage and ended when chicks were ca 3 wk old, while in 1995 the moratorium started during the hatching stage, when most of the clutches were already laid, and ended when chicks were already fledged. Nests were monitored twice a week to avoid predation by larger yellow-legged gulls (Oro & Martínez-Vilalta 1994), and nests with signs of partial or total predation were not considered in the analysis. 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 then calculated for every clutch. Breeding success was calculated by surrounding some nests with a net 50 cm high just before hatching to facilitate the location of the chicks. The surroundings of the nests were searched to record diet composition. Remains, pellets and regurgitates were collected and preys were identified and quantified following procedures of other studies on diet composition carried out at this colony (Bosch et al. 1994, Ruiz et al. 1996).

To detect differences in diet, clutch size and breeding success, contingency tables and the *G*-test statistic were used. Differences in reproductive phenology (dates of appearance of first eggs) between years were tested using the Mann-Whitney *U*-test. To test the effect of year (1994 and 1995) and clutch size (2- and 3-egg clutches) simultaneously, a 2-factor ANOVA on the average volume of the eggs was used (Zar 1984). Underlying assumptions of the statistical tests were verified in all cases.

RESULTS AND DISCUSSION

A highly significant difference in diet composition was recorded between the 2 years (*G*-test = 234.4, p < 0.0001, n = 377; Table 1). Adjusted standardized residuals showed that consumption of trawler discards (clupeiforms and benthonic fish) was only associated with trawler activity, whereas olives and prey from the rice fields and the Delta ecosystem were positively associated, especially during the moratorium.

Table 1. Percentage of prey occurrence in the diet of lesser black-backed gulls in 1994 and 1995, depending on trawler activity. (n: number of samples)

	Trawler[a]	Delta[b]	Fields[c]	Shellfish[d]	Refuse	n
Trawling moratorium	0	71.7	16.8	8.9	6.2	113
Trawler activity	63.3	26.7	0	10.0	3.3	30

[a]Prey from trawler discards (clupeiforms and benthonic fish)
[b]Prey from rice fields, irrigation channels and lagoons
[c]Prey from fields (olives, gastropods)
[d]Prey from shellfish fleet discards (bivalves, shrimp)

Median date of laying was very similar in both years (Mann-Whitney *U*-test, z = 0.8, not significant, n = 86; Table 2). Modal clutch size was 3 eggs in both years. Although clutch size decreased in the year of the trawling moratorium, differences were not significant (*G*-test = 1.36, df = 2, p = 0.51, n = 77; Table 2). A significant year effect was detected in relation to the average volume of a clutch (ANOVA, F = 13.3, p < 0.001, n = 77), while neither clutch size effect (ANOVA, F = 28.6, p = 0.25, n = 77) nor interactions between year and clutch size (ANOVA, F = 38.2, p = 0.19, n = 77) were detected (Table 2). Breeding success was significantly lower in 1995 than in 1994 (χ^2 = 5.0, df = 1, p = 0.02; Table 2).

In the Ebro Delta area, there is a large fishing fleet which includes an especially high number of diurnal trawlers, because the extensive breadth of the continental shelf and the large amounts of nutrients carried by the Ebro River give rise to one of the best seine-fishing zones for clupeids in the Mediterranean (Demestre et al. 1987, Martín 1989). Although lesser black-backed gulls may exploit discards from other fisheries, such as the shellfish fleet, most of the marine prey come from trawler discards, since trawlers represent 60% of fishing boats and 98% of total power operating in the area (Demestre et al. 1987, Martín 1989, Oro 1995b). More-

Table 2. Laying dates, average number of eggs laid per clutch and mean volume (cm^3) of clutches of lesser black-backed gulls at the Ebro Delta (Spain) in 1994 and 1995. ns: not significant

	1994	n	1995	n	p
Median laying date	7 May	46	4 May	40	ns
Clutch size (mean ± SE)	2.53 ± 0.11	43	2.71 ± 0.10	34	ns
Volume (mean ± SE)	66.70 ± 0.71	43	70.60 ± 0.76	34	0.001
Breeding success[a] (%)	26.0	19	5.7	13	0.02

[a]Number of chicks fledged, expressed as % of the number of eggs laid

over, these trawlers discard large amounts of sardines *Sardina pilchardus*, especially when this fleet catches anchovies *Engraulis encrasicholus* (Oro 1995b). Fish is high-protein prey, and thus very important for egg formation (Bolton et al. 1992). Indeed, when the trawling moratorium overlapped with the egg laying period, lesser black-backed gulls laid smaller eggs, suggesting that high-quality food availability decreased significantly, probably affecting female body condition (Houston et al. 1983, Bolton et al. 1993). Nevertheless, neither breeding phenology nor clutch size were significantly different when trawlers did not operate. Egg size may indeed be reduced before clutch size when resources for egg formation are limited (Martin 1987, Bolton 1991). However, the detrimental effects of the trawling moratorium on the egg laying of Audouin's gull at the study site (Oro et al. 1995b) were much higher than those recorded for lesser black-backed gulls. The seabird exploitation of feeding resources from the Delta ecosystem (such as American crayfish *Procambarus clarckii*, aquatic beetle *Hydrous pistaceus* or leech *Hirudo medicinalis*) may partly compensate for the lack of trawler discard availability, but only after April, when rice fields are flooded (González-Solís et al. 1996). Audouin's gull starts to breed in April, but prey from rice fields was available to those species breeding later, such as the lesser black-backed gull. Moreover, clutch size may not be primarily determined by food availability in lesser black-backed gulls (Hiom et al. 1991, Bolton et al. 1992). As recorded for the yellow-legged gull at this site, the breeding success of lesser black-backed gulls is expected to be affected by the trawling moratorium (Oro et al. 1995a). Results showed that breeding success was significantly lower in 1995, when the lack of discard availability affected the entire chick rearing stage, while in 1994 the availability of discards was again normal when chicks were ca 3 wk old, probably increasing their chances for survival (Oro et al. 1995b).

The trawling moratorium in the Ebro Delta may not be considered a stochastic limiting factor such as wrecks, predator invasion or oil spills. It seems that the moratorium will continue for the next several years, so it will probably affect the recruitment rates and will reduce subsequent breeding populations (Cairns 1992). The effects of the trawling moratorium on other parameters of population dynamics such as adult mortality are unknown, but higher long-term costs of reproduction are expected for lesser black-backed gulls. Future changes in fishery policies, reduction of fishing fleets or commercial exploitation of sardines caught by trawlers may also decrease discard availability and consequently affect the reproductive effort, the survival rates and the population dynamics of seabird species breeding in this area in the coming years.

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LITERATURE CITED

Bolton M (1991) Determinants of chick survival in the lesser black-backed gull: relative contributions of egg size and parental quality. J Anim Ecol 60:949–960

Bolton M, Houston D, Monaghan P (1992) Nutritional constraints on egg formation in the lesser black-backed gull: an experimental study. J Anim Ecol 61:521–532

Bolton M, Monaghan P, Houston DC (1993) Proximate determination of clutch size in lesser black-backed gulls: the roles of food supply and body condition. Can J Zool 71: 273-279

Bosch M, Oro D, Ruiz X (1994) Dependence of yellow-legged gulls (*Larus cachinnans*) on food from human activity in two western Mediterranean colonies. Avocetta 18: 135–139

Cairns DK (1992) Population regulation of seabird colonies. In: Power DM (ed) Current ornithology, Vol 9. Plenum Press, New York, p 37–62

Camphuysen CJ, Ensor K, Furness RW, Garthe S, Hüppop O, Leaper G, Offringa H, Tasker ML (1993) Seabirds feeding on discards in winter in the North Sea. EC DG XIV research contract 92/3505. NIOZ Rapport 1993:8, Netherlands Institute for Sea Research, Texel

Demestre M, Lleonart J, Martín P, Recasens L, Sánchez P (1987) Evolución de las capturas mensuales de Peces, Moluscos y Crustáceos y de algunas especies de interés comercial en Cataluña en el periodo 1979–85. FAO Fish Rep 395:92–100

Furness RW (1982) Competition between fisheries and seabird communities. Adv mar Biol 20:225–302

Furness RW, Ainley DG (1984) Threats to seabird populations presented by commercial fisheries. ICBP Tech Rept 2: 701–708

Furness RW, Ensor K, Hudson AV (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 (1996) Seasonal variation of waterbird prey in the Ebro Delta rice fields. Colon Waterbirds 19 (in press)

Harris MP (1964) Aspects of the breeding biology of the gulls *Larus argentatus, L. fuscus* and *L. marinus*. Ibis 106: 432–456

Hiom L, Bolton M, Monaghan P, Worrall D (1991) Experimental evidence for food limitation of egg production in gulls. Ornis Scand 22:94–97

Houston DC, Jones PJ, Sibly RM (1983) The effect of female body condition on egg laying in lesser black-backed gulls *Larus fuscus*. J Zool, Lond 200:509–520

Hudson AV, Furness RW (1988) Utilization of discarded fish by scavenging seabirds behind whitefish trawlers in Shetland. J Zool, Lond 215:151–166

Martín P (1989) Dinámica de la pesquería de arrastre en Cataluña. PhD thesis, Univ of Barcelona

Martin TE (1987) Food as a limit on breeding birds: a life-history perspective. A Rev Ecol Syst 18:453–487

Montevecchi WA (1993) Birds as indicators of change in marine prey stocks. In: Furness RW, Greenwood JJD (eds) Birds as monitors of environmental change. Chapman & Hall, London, p 217–266

Nettleship DN, Sanger GA, Springer PF (eds) (1984) Marine birds: their feeding ecology and commercial fisheries relationships. Proc 8th Pacific Seabird Group Symposium. Canadian Wildlife Service, Bedford

Oro D (1995a) Audouin's gulls *Larus audouinii* associate with sub-surface predators in the Mediterranean Sea. J Orn 136:465–467

Oro D (1995b) The influence of commercial fisheries in daily activity of Audouin's gull *Larus audouinii* in the Ebro Delta, NE Spain. Ornis Fenn 72 (in press)

Oro D, Bosch M, Ruiz X (1995a) Effects of a trawling moratorium on the breeding success of the yellow-legged gull *Larus cachinnans*. Ibis 137:347–349

Oro D, Jover L, Ruiz X (1995b) The effects of trawl moratorium on some breeding parameters of Audouin's gull *Larus audouinii* in the Ebro Delta, NE Spain. In: Tasker ML (ed) Threats to seabirds: Proceedings of the 5th International Seabird Group conference. Seabird Group, Sandy, Bedfordshire, p 33

Oro D, Martínez-Vilalta A (1994) Factors affecting kleptoparasitism and predation rates upon a colony of Audouin's gull (*Larus audouinii*) by yellow-legged gulls (*Larus cachinnans*) in Spain. Colon Waterbirds 17:35–41

Ruiz X, Oro D, Martínez-Vilalta A, Jover L (1996) The feeding ecology of Audouin's gull *Larus audouinii* in the Ebro Delta. Colon Waterbirds 19 (in press)

Ryan PG, Moloney CL (1988) Effect of trawling on bird and seal distribution in the southern Benguela region. Mar Ecol Prog Ser 45:1–11

Watson PS (1978) Seabirds at commercial trawlers in the west Irish Sea. Ibis 120:107–108

Zar JH (1984) Biostatistical analysis. Prentice Hall, London

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