

The influence of commercial fisheries in daily activity of Audouin's Gull *Larus audouinii* in the Ebro Delta, NE Spain

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The arrivals and departures of Audouin's Gulls *Larus audouinii* from the breeding colony in different commercial fishery situations were studied to assess changes in their daily activity pattern. Gulls arriving to the colony were assumed to show arrivals from the foraging grounds, while those departing from the colony were assumed to show departures to forage. The activity pattern of Audouin's Gulls in the Ebro Delta seemed to depend especially on trawler activity, irrespective of whether night fisheries occurred at the same time. Indeed, gulls seemed to fit their arrivals and departures to the trawler timetable. Audouin's Gull departures from the colony at sunset were always recorded, those being most intense when only night fishing occurred and slightly lower when no fishing vessels were working in the area. These departures were probably related to nocturnal foraging activity, and suggested that this nocturnal activity occurred under any fishing fleet activity situation. When trawlers did not operate, diurnal activity was also recorded, probably associated with foraging trips to rice fields. Any changes in fishery activity, such as the trawler moratorium established in 1991 during the breeding season of Audouin's Gull may affect the feeding ecology of the species and its conservation.



1. Introduction

The use of fishery waste by seabird populations has often been recorded in northern Europe (e.g. Furness et al. 1992, Garthe & Hüppop 1994), southern Africa (Crawford et al. 1992) and Australia as well (Blaber & Wassenberg 1989). Although several authors have associated the exploitation of this foraging resource with the increase in seabird numbers (such as Furness 1982), the impossibility of preventing the utilization of discards by the scavenging seabirds has not allowed the assessment of this hypothesis (Bailey & Hislop 1978). However,

Oro et al. (1995) recorded in the Ebro Delta a decrease in the breeding success of the Yellow-legged Gull *Larus cachinnans* brought about by a trawler moratorium. Thus, the commercial fishery activities in this area affect the food availability for many seabird species breeding there, such as Audouin's Gulls (Oro & Martinez 1992, Paterson et al. 1992).

Audouin's Gull is a rare seabird whose breeding population is endemic to the Mediterranean region. Its population has grown recently since the establishment of a breeding colony in the Ebro Delta (NE Spain) in 1981 (Oro & Martinez 1992).

This increase seems to be related to the use of trawler waste (Oro & Martinez 1992, Paterson et al. 1992, Ruiz et al., in press). In the Ebro Delta area, there is an important fishing fleet, especially diurnal trawlers, because of the high width of the continental shelf and the large amounts of nutrients carried by the Ebro river, which give rise to one of the best seine-fishing places for Clupeids in the Mediterranean. Since 1991, a two monthly trawler moratorium coinciding with Audouin's Gulls' breeding season, was established in the Ebro Delta area. This trawler moratorium eliminated a substantial part of the food resources for the species and brought about both a decrease in its breeding success (Oro & Martinez 1992) and an increase of diet diversity (Ruiz et al. in press).

Here the numbers of Audouin's Gulls arriving and departing from the colony were used to evaluate the changes in the daily activity pattern depending on the commercial fishing activities, and the extent to which this activity pattern can provide as a useful indicator of changes in food availability.

2. Study area and methods

The Audouin's Gull colony is situated in the Punta de la Banya peninsula (40°37'N00°35'E, Ebro Delta N.P., NE Spain), a sandy flat area of 2 500 ha., with a patchily distributed mosaic of salt marshes and small dunes covered by halophilous vegetation. This peninsula holds an Audouin's Gull colony with ca. 10 100 pairs in 1994, about 70% of the total world population (Pedrocchi & Ruiz 1995).

In 1992, the foraging behaviour of the Audouin's Gull was analyzed by counting gulls arriving and departing from the colony. Arrivals to the colony are considered to be birds returning from foraging areas. Censuses were conducted by the author on 38 days between the beginning of April and the end of June from an observation point at one extremity of the colony. The censuses began at dawn and ended at sunset, sampling the following 9 hours each day: 7000–0900 h, 1000–1100 h, 1200–1300 h, 1400–1500 h, 1600–1700 h, and 1800–2100 h. Total observation time was 342 h.

Censuses of gulls were classified according to the existence of the trawler moratorium to test if the differences in fishing activities affected gull activ-

ity. There were nine days in the data without any fishing activity, 18 days with only night fishing, two days with only trawl activity, and nine days with both trawl and nocturnal fishing activities. Given that only two days was with trawler activity were sampled, these data was not taken into account in Audouin's Gull activity comparisons, although this data were included on the graphs.

The diurnal fishing fleet pattern was determined by going on board a trawler during 1992 (3 times) and 1993 (4 times) and recording time of departure, time of hauls and time of arrival to port. Night fishing fleet activity was assessed by consulting the fishermen guilds of the area and the cruise-leader vessels. The time schedule of both trawler and night fisheries is unvarying through the week (see also Martin 1989), and it is therefore easy to assign each day of sampling to a fishing situation.

Comparisons among censuses during different fishing activities were carried out by Kruskal-Wallis tests. For *a posteriori* pairwise tests, a modified Tukey test was used, the Dunn nonparametric multiple comparison Q-test (Zar 1984). Total arrivals and departures before 1100 h ("morning" censuses) and after 1400 h ("afternoon" censuses) were separated, since a decrease in the activity at 1200–1300 h was recorded analyzing the shapes of the graphs, which results were not considered in the comparisons.

3. Results

Although fishing vessels have different activity patterns in different weather, there is a uniformity in time departures and time of first and last hauls. The most predictable haul time is the last one, normally at 1500 h for the diurnal trawl fleet and 06 00 h for nocturnal vessels. The number of hauls is variable in diurnal trawl vessels (normally 2–3, but sometimes only 1, depending on the type of fish they want to catch or the yield of the hauls), whereas it is more constant for nocturnal vessels (normally 2, because they always fish on clupeids) (Fig. 1).

Fig. 2 shows the Audouin's Gull arrivals to the breeding colony. There seem to be two different arrival patterns: First, when there was no trawler activity, there was a peak in arrivals in the early morning hours. Second, when trawlers

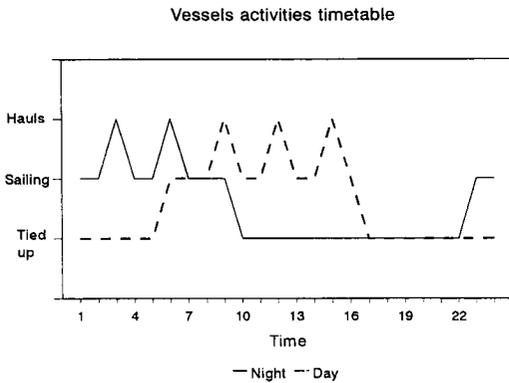


Fig. 1. Graphic representation of the fishing vessels timetable in the Ebro Delta area, referred to both diurnal and nocturnal fleets. This is the most common pattern of vessels activity, although different changes in timetables can occur (see text).

operated, there was a double peak, one in the early morning (lower than in the previous case) and another in the early afternoon. When comparing the three fishing activity situations with a sample size large enough (only at night, both at night and day and no activity), significant differences were found among the percentages of gulls arriving both in the morning (Kruskal-Wallis H-test $_{18,9,9} = 18.20, p < 0.001$) and afternoon censuses (Kruskal-Wallis H-test $_{18,9,9} = 18.99, p < 0.001$). According to pairwise comparisons, when both night and trawler vessels went fishing, arrivals were significantly less frequent in the mornings and more frequent in the afternoons (Table 1).

Fig. 2 also shows the Audouin's Gull departures from the breeding colony. In this case, it seems that there was a similar departure pattern for the four fishing activity situations, with a double peak in early morning and late afternoon. However, when trawlers operated, the morning peak departure seems to be displaced and very concentrated in midmorning. Comparing the three fishing activity situations as with arrivals analysis (see earlier paragraph), significant differences were also found among the percentages of departures both in the morning (Kruskal-Wallis H-test $_{18,9,9} = 19.47, p < 0.001$) and afternoon censuses (Kruskal-Wallis H-test $_{18,9,9} = 15.15, p < 0.001$). Once again, in pairwise tests, arrivals were sig-

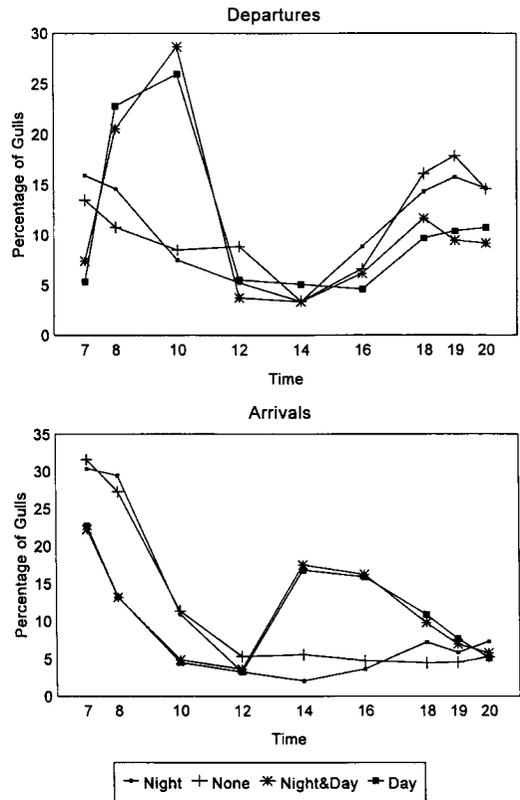


Fig. 2. Percentage of Audouin's Gulls (average of the total gulls censused each day) departing from and arriving to the colony during the breeding season, relative to the fishing activity of the fleet in the area and time of day. Hours showed in the X-axis are the time when the one hour observation period started.

nificantly less frequent in the mornings and more frequent in the afternoons when both night and trawler vessels went fishing (Table 2).

Table 1. Dunn-type Q test comparisons among the Audouin's Gull arrivals to the colony under three different fishing activity situations.

Fishing activity	Time	$Q_{0,001,3}$	Difference
Night vs. night and day	Morning	3.91	$P < 0.001$
	Afternoon	7.01	$P < 0.001$
Night vs. none	Morning	0.30	$P > 0.5$
	Afternoon	0.35	$P > 0.5$
None vs. night and day	Morning	3.65	$P < 0.001$
	Afternoon	6.38	$P < 0.001$

4. Discussion

Witt et al. (1981) recorded Audouin's Gulls diurnal activity in the Chafarinas Islands and found a higher frequency of departures in late afternoon. They concluded that much of the foraging activity takes place at night, and most of the fish was caught actively. In contrast, in the Ebro Delta colony, the feeding ecology of Audouin's Gull depends strongly on trawler discards. When trawlers operated, benthonic and mesopelagic preys such as Pleuronectiforms or Anguilliforms (coming from discards) occurred in 68% of the gull regurgitates, while during the trawler moratorium these types of prey were not recorded. Moreover, the foraging niche width increased during the trawler moratorium, since gulls also fed in the rice fields, refuse tips and dunes (Population diversity index DI with trawler activity \bar{x} (SE) = 1.5 (0.2); DI during trawler moratorium \bar{x} (SE) = 2.7 (0.3) (Ruiz et al. in press). Audouin's Gulls also increased their foraging range during the trawler moratorium (Arcos & Oro unpubl.) and they performed alternative foraging strategies such as interspecific kleptoparasitism on smaller seabird species (Oro in press). The effects of the trawler moratorium have affected greatly not only the breeding success of Audouin's Gulls (Oro & Martinez 1992), but also those of other seabird species which exploited the trawl discards resource, such as the Yellow-legged Gull (Oro et al. 1995). Audouin's Gulls benefit from following trawlers through decreasing foraging effort (since trawl discards are temporal and spatial expectable resources), and through an increase of temporal niche dimension, since trawlers in the Ebro Delta operated only by day and Audouin's Gulls are a nocturnal specialist predator on clupeids. The difference in the

feeding benefit between trawler and night fleets arises from the differences in fishing strategies and commercial interests: while the night fleet is specialized in catching sardines (and also discards little), trawlers concentrate on catching anchovies *Engraulis encrasicolus* and they generate large amounts of discards, most of them sardines. Moreover, while 66 trawlers operate in the area (total power = 21270 HP, $\bar{x} \pm SD = 299.6 \pm 239.1$ HP), only 4 night fishing vessels work there (total power = 362 HP, $\bar{x} \pm SD = 90.0 \pm 29.6$ HP) (Martin 1989, Oro unpubl.).

The exploitation of fishing discards from both diurnal and nocturnal fisheries is very common in seabirds and has often been recorded (e.g. Hudson & Furness 1988, Furness et al. 1992, Hario 1990, Garthe & Hüppop 1993). The results presented here showed a different activity pattern depending especially on the trawler activity in the area. Two different Audouin's Gull activity patterns can be defined: the first corresponds to when only night vessels worked or when no fishing activity occurred in the area. Under these situations, Audouin's Gulls seem to increase their foraging activity at night. Departures were recorded in late afternoon, probably when gulls went to follow night fishing vessels and to catch clupeids actively (Beaubrun 1983). The diurnal activity was probably related to foraging trips to rice fields, refuse tips and ecotonic habitats, such as the shore or the dunes. The second pattern corresponds to when trawler activity occurs: departures occurred mainly in midmorning, when the first haul normally occurs, and arrivals were concentrated in early afternoon, when trawlers return to the port. It seems therefore that Audouin's Gulls follow the trawl vessels from the first haul until the last haul in early afternoon, probably staying away from the colony all this time. Even though lower, the nocturnal activity seems to be maintained even when trawlers operated, suggesting that there were probably differences among individuals in foraging preferences (McCleery & Sibly 1986).

Although radio telemetry should have been used to record individual differences in time budgets and foraging preferences (McCleery & Sibly 1986, Wanless et al. 1988, Uttley et al. 1994), the results recorded here indicated the changes in Audouin's Gulls colony attendance relative to

Table 2. Dunn-type Q test comparisons among the Audouin's Gull departures from the colony under three different fishing activity situations.

Fishing activity	Time	$Q_{0.001,3}$	Difference†
Night vs. night and day	Morning	3.80	$P < 0.001$
	Afternoon	3.71	$P < 0.001$
Night vs. none	Morning	0.85	$P > 0.5$
	Afternoon	0.12	$P > 0.5$
None vs. night and day	Morning	4.02	$P < 0.001$
	Afternoon	3.11	$P < 0.01$

fishing activities. These results complement those previously obtained from the Ebro Delta, showing the dependence of Audouin's Gulls and other seabirds on trawler discards (Oro & Martínez 1992, Bosch et al. 1994, Oro 1995, Oro et al. 1995, Ruiz et al. 1994). For the Audouin's Gull in the Ebro Delta, the exploitation of this foraging resource seems to be the most important factor to explain the amazing growth of this colony and indicates the importance of trawler activity for its conservation.

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