ICES Journal of Marine Science, 59: 529–537. 2002
doi:10.1006/jmsc.2001.1175, available online at http://www.idealibrary.com on IDEAL®

Demersal trawling waste as a food source for Western Mediterranean seabirds during the summer

Alejandro Martínez-Abraín, Raquel Maestre, and Daniel Oro

Martínez-Abraín, A., Maestre, R., and Oro, D. 2002. Demersal trawling waste as a food source for Western Mediterranean seabirds during the summer. – ICES Journal of Marine Science, 59: 529–537.

We studied the use of demersal trawler discards by scavenging seabirds at one location in the western Mediterranean (Benidorm, SE Spain) from the end of June to the beginning of October 2000. Yellow-legged gull and Cory's shearwater were the most common species in the study area (52.35%, 35.49%) and behind boats (82.4%, 7.07%). Eight other seabird species were observed in much lower numbers following boats (Audouin's gull 2.6%, black-headed gull 2.3%, sandwich 1.5% , black 0.82% and common terns 0.97%, Balearic shearwaters 1.4%, storm-petrel 0.52% and shags 0.36%). Yellow-legged gulls were present behind trawlers in higher numbers than might have been expected by its abundance at sea, whereas Cory's shearwaters were less so.

The discarded fish (''discard'') comprised mainly of sardine (22.4%), flatfish (19.1%) and horse-mackerel (17.3%) and included fish of a small size (median 10.5 cm) in the main. Yellow-legged gull made the largest use of discards, albeit lower than expected by its Presence Index. Average percentage consumption was about 54% of the edible discards, suggesting that yellow-legged gulls were not highly efficient at catching ''discard''. The average ratio of fish discarded over fish landed was ca. 65%, although the range was very variable (23–175%). Estimates of the energy requirements of yellow-legged gulls and ''energy availability'' from the ca. 8 tonnes of discard produced every fishing day, suggest that trawling waste was probably enough to support a local gull population four times larger than that present during the study period.

Keywords: discards, energetics, fisheries, food, foraging efficiency, seabirds, trawlers, western Mediterranean.

Received 23 July 2001; accepted 12 November 2001.

A. Martínez-Abraín: CPEMN Conselleria de Medio Ambiente, Avda. de los Pinares, 106, 46012 El Saler, Valencia, Spain. R. Maestre: Estación Ornitológica de l'Albufera (SEO/BirdLife), Avda. de los Pinares, 106, 46012 El Saler, Valencia, Spain. A. Martínez-Abraín and D. Oro: Instituto Mediterráneo de Estudios Avanzados (CSIC-UIB), C/Miquel Marqués, 21, 07190 Esporles, Mallorca, Spain. Correspondence to: Alejandro Martínez-Abraín: e-mail: a.abrain@uib.es

Introduction

The utilization of fishery waste by scavenging seabirds has been studied thoroughly during the last decade especially in the northern and southern Atlantic (e.g. Furness *et al.*, 1992; Thompson, 1992; Garthe and Hüppop, 1994; Thompson and Riddy, 1995; Garthe *et al.*, 1996). The situation found in Mediterranean inshore trawling fisheries, on the other hand, has seldom been studied (Carbonell *et al.*, 1997, 1998) and in most cases information is available only in the form of grey publications (e.g. Salas, 1995). The use of fishery waste by seabirds in the western Mediterranean has been addressed only recently by a few researchers (see Oro, 1999 and references therein). In general most studies deal with breeding gulls and little is known about the use that seabirds make of fishery waste outside the breeding season in the western Mediterranean (e.g. Sarà, 1993). However, resource availability during this period can be crucial for winter survival (e.g. Harris and Wanless, 1996; Harris *et al.*, 1998; Marra *et al.*, 1998) and recruitment (Spear *et al.*, 1995).

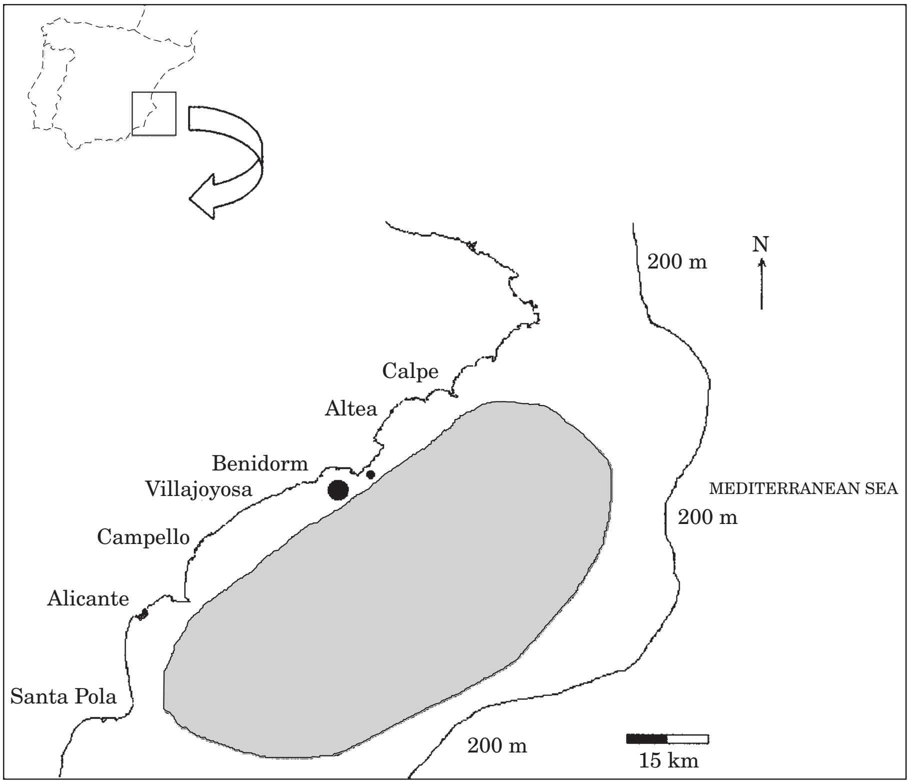

Figure 1. Map of the study area showing Villajoyosa the port from which the cruises began (Villajoyosa), the islands of Benidorm (solid black dots), the 200 m isobath and the approximate limits of the fishing grounds of the trawlers.

In this paper, we consider the utilization of fishery waste from bottom trawling as a food source for scavenging seabirds during the summer, when some seabird species (gulls) have finished their breeding cycle and others (petrels) are completing their breeding season. We also evaluate the availability of fish waste and the energetic needs of seabirds in the study area in order to assess the potential importance of the fish waste to seabirds breeding there.

Study area and methods

The study area was within the foraging range of yellow-legged gulls (*Larus cachinnans*) breeding on the small islands of Benidorm (Alicante, Spain, 38°30′N, 00°08′E), a "Special Protection Area" for the conservation of the European storm-petrel (*Hydrobates pelagicus*). Data were obtained from 22 commercial trawler cruises representing 45 fishing operations on board vessels from Villajoyosa, a fishing port located a few kilometers south of Benidorm (Figure 1). The cruises were carried out during the months of June (2), July (5), August (8), September (8) and October (2) and each lasted about 12 h (from 5–6 am to 5–6 pm). To avoid a possible biasing of the results, sampling was performed on board five different commercial fishing vessels. Boat lengths ranged between 15–23 m, displacement between 10–65 gross registered tonnes and horse power between 82 and 430 hp.

Seventeen cruises took place aboard small boats (fishing range 54–90 m deep) and five aboard larger boats (90–115 m deep). The vesselss did not have any specific target species but the most valued catch was European hake (*Merluccius merluccius*). Trawlers fishing further than 45 km off the coast – mainly for commercial shrimp species at $\geq$300 m deep – were not included in the study. There are 56 trawlers at Villajoyosa but only 35 operate in the study area daily from Monday to Friday. However, 18 trawlers from Campello, Altea and Calpe also operate within the foraging range of the gulls breeding at Benidorm. All of these vessels operate within the limits of the Alicante continental shelf. This shelf has a mean width of 32 km, with a minimum of 23 km off Santa Pola and a maximum of 40 km off Altea. The edge of the shelf is located between 110–140 m deep and the sea-bed surface is predominantly sand and mud (Carbonell *et al.*, 1997) (Figure 1).

The only seabird species breeding in the study area were yellow-legged gulls and storm petrels. The number of breeding gulls for the two islands of Benidorm – used for the development of our energetic index – was estimated at 400 pairs (own data) and its productivity was calculated as the arithmetic mean of all data available in the literature combined with our own data (1.0 fledglings pair^{-1}). The number of non-breeding gulls present around colonies was estimated as five times the number of breeding pairs, according to the ratio of immature-plumaged to adult-plumaged gulls we had observed in smaller colonies (e.g. Campello, Tabarca). The breeding season of yellow-legged gulls ranges from late-March (start of egg laying) to late-June (fledging period) and that of storm petrels from early-May to mid-August. Hence most of the information comes from late in or outside the breeding season for both species.

The species and number of seabirds observed in a transect line were recorded every 10 minutes for about 1 hour within a 250 m-wide band during the first haul of the day, to obtain an index of seabird abundance (birds/km^2) in the area previous to discarding. The distance covered by the boat was calculated from the velocity of the boat and the duration of each haul. During the sorting and discarding phase following each haul – from net lifting to end of discarding – we recorded the species and number of seabirds following the boat every 15 minutes, after Tasker *et al*. (1984). However, when discarding was not done gradually but all at once at the end of the fish-sorting process, we recorded the number of seabirds present behind the boat at that precise moment taking advantage of the fact that seabirds watch boats from a distance until the first discard of the day has taken place. The stage (adult or juvenile) of yellow-legged and Audouin's gulls was recorded both during the transects and discarding phases.

The vessels made a varying number of consecutive hauls a day, ranging from three (large boats, fishing farther off the coast) to six (small boats, fishing inshore). Birds were recorded in a 180° scan around the boat, from one of the vessel's sides, during transect lines and from the stern of the boat during the census of the seabirds associated with the trawler. The census of the seabirds was continuous after the first discarding since "next hauling" started immediately after the sorting and discarding of fish from the previous haul had ended. Final sorting ended when boats where close to their home port.

In order to assess whether there were seabird species making a greater use of discards than has to be expected from their abundance in the area, we tested the simple null hypothesis that the two most common seabird species followed boats proportionately to their abundance in the area before discarding as obtained from the transect lines. A "Presence Index" was then computed (see for instance Oro and Ruiz, 1997), assuming that all species were equally likely to follow a trawler. We used the average of the largest number of seabirds of each species present behind the boat in each discard operation and the mean of the largest density value of each species on the transect lines. This index was expressed by the residuals of the chi-square distribution obtained from the standardized difference between the observed and expected frequencies. Values below −2 or above +2 were considered to be significant (Zar, 1999).

To estimate the amount of fish discarded we made use of all the fish sorted for discard by one of the fishermen. We estimated the amount of discard in each haul by counting the number of boxes that we were able to fill in with "discard" (each box ranges between 12–15 kg depending on fish species) and multiplying by the number of fishermen discarding. We divided our sample into four equal portions and then estimated the weight of edible and unedible (shells, rocks, plant remains) "discard" in one of the four quarters. Each day a sub-sample of 3–4 kg of fish from one of the hauls was collected to classify and measure the length of all individuals later in the laboratory. When this sub-sample was collected after the last haul the fraction available or not available for seabird consumption was estimated from this smaller sample, rather than from one of the usual quarters. Overall 2036 fish were measured and identified.

To measure feeding efficiency and prey-size selection by seabirds we took fish sorted out for discarding by the fishermen and threw single items overboard – close to the stern of the vessel but from one side, to avoid the turbulence generated by the engines – during the sorting and discarding phase (after Hudson and Furness, 1988). Fish were thrown while the fishermen themselves were discarding to avoid biasing our results (after Garthe *et al*., 1996). In total we threw 1187 fish overboard in 33 "discard" experiments. We noted the size classes and species of the fish captured as well as the seabird species involved. A "Success Index" was calculated based on the average numbers of seabirds observed behind the boat and the number of fish captured by each species. Our null hypothesis here was that the relative frequency of fish capture mirrored the relative frequency of species observed behind the boat, assuming that all species following the boat have an equal probability of obtaining fish (Camphuysen, 1994). This index was also expressed via the residuals of the chi-square distribution obtained from the standardized difference between the observed and the expected frequencies. Manly's "Preference Index" (Krebs, 1989) was used to determine the preference of seabirds for the class sizes of discarded fish:

$$\alpha_j = \log p_j / \Sigma_{j=1}^{m} p_j$$

where α_j = Manly's alpha for the size class of fish j; m = number of fish size classes and p_j proportion of the size class of the fish that are not consumed at the end of the experiment (j=1, 2, 3, . . ., m)=e_j/n_j [e_j=number of fish of size that are not consumed at the end of the experiment and n_j=initial number of fish of size j in the experiment]. The length of fish discarded was grouped into three categories: small (2–10 cm), medium (11–19 cm) and large (20–40 cm).

To test whether there was an association between the amount of fish discarded and the amount of fish landed we obtained the weight of fish landed in each cruise by consulting the catch statistics at Villajoyosa.

To design a rough index of food requirement over food availability for yellow-legged gulls during the study period we assigned an average calorific value of 5 J g^{-1} to "discards" and a food assimilation efficiency of 75% (after Furness *et al*., 1988). The estimate of the basal metabolic rate for yellow-legged gulls was based on Bryant and Furness (1995), where BMR (kJ d^{-1})=2.3 (body mass), considering an average body mass of 1019 g, based on our own data on gulls captured on Benidorm island. The BMR of yellow-legged gulls is probably overestimated since the equation used was developed for Atlantic birds. Since BMR only covers a part of the energy expenditure of seabirds we calculated the "Field Metabolic Rate" (FMR) as 2.5 BMR after Garthe *et al*. (1996).

Presence and success indices were obtained by means of chi-squared goodness-of-fit tests. Contingency tables (together with the G statistic), Mann-Whitney U-test and non-parametric analysis of variance (Kruskal-Wallis H-test) were performed when appropriate. The correlation between fish landed and fish discarded was assessed by Spearman rank correlation. Species diversity of the community following the boats was calculated by means of the Shannon–Weaver index, and differences between indices were compared by means of the t-test proposed by Hutcheson (Zar, 1999). All statistical tests were two-tailed. Mean percentage consumption during "experimental discard" was estimated by weighting the consumption percentage for each fish species by its sample size (after Zar, 1999) and considering only fish species with n>10.

Results

Yellow-legged gull and Cory's shearwater were the most abundant species in the area before the first discarding operation (first haul), representing 87.8% of the seabirds observed. All other six species recorded were present in lower densities (Table 1). The adult/juvenile ratio was 8.4 for yellow-legged gulls and 3.9 for Audouin's gulls.

After performing an analysis of mean abundance by months (July, August, and September) for the five most common species, we found that both Cory's shearwaters (Kruskall-Wallis test, χ^2=6.46, d.f.=2, p=0.04) and Balearic shearwaters *Puffinus mauretanicus* (Kruskall-Wallis test, χ^2=6.31, d.f.=2, p=0.04) were more abundant in the study area late in the summer, whereas all other species (yellow-legged gulls, Audouin's gulls *Larus audouinii* and black-headed gulls *Larus ridibundus*) were equally abundant in all three summer months.

Table 1. Relative abundance of seabirds in the study area (during first haul) and behind boats (during sorting and discarding). Data for "seabirds at sea" are the means (± s.d.) of the largest number of birds of each species in each line transect (n=22), standardized by the area covered in each transect. Data for "seabirds at boats" are means of the largest number of birds censused after each haul (n=45).

Seabird species	Seabirds at sea (birds/km^2) Mean ± s.d.	Seabirds at boats (birds) Mean ± s.d.
Yellow-legged gull	14.13 ± 11.25	68.2 ± 55.81
Cory's shearwater	9.58 ± 19.15	5.85 ± 10.07
Audouin's gull	1.19 ± 1.69	2.18 ± 3.54
Black-headed gull	0.54 ± 1.19	1.88 ± 7.86
Sandwich tern	0	1.27 ± 1.72
Balearic shearwater	0.60 ± 1.63	1.15 ± 3.56
Common tern	0.16 ± 0.33	0.80 ± 1.75
Black tern	0	0.68 ± 3.04
European storm petrel	0.21 ± 0.49	0.43 ± 2.34
Shag	0.58 ± 1.85	0.30 ± 0.90

To verify whether the composition of the seabird communities were similar regardless of distance from the coast, we measured species diversity for the two groups of boats considered – boats fishing not farther than 28 km off the coast and boats fishing between in the 28 and 47 km zone – and found there was no significant difference (Hutchenson Student's t statistic, ν=19.72, t= − 0.12, p>0.05).

We also tested whether there were differences in seabird abundance depending on the schedule of the cruises and found that there were no significant differences between early morning (0620–0735 h; n=9), late morning (later than 0735 h; n=11) and afternoon cruises (later than 1500 h; n=2) (Kruskall-Wallis test, χ^2=1.3, d.f.=2, p=0.53) consequently we pooled our data, regardless of distance to the coast or time of cruises.

Yellow-legged gull was the most common species (82.4%) following boats (Table 1). All other nine species were present in lower numbers. However, some species were present behind boats (Sandwich tern *Sterna sandvicensis* and black tern *Chlidonias niger*) which were not recorded on transect lines. The adult/juvenile ratio was 6.0 for yellow-legged gull and 4.5 for Audouin's gull.

We found that there were significant differences between observed and expected frequencies of the two most common seabird species following boats (χ^2=19.3, d.f.=1, p<0.001). "Presence Indices" suggest that yellow-legged gull were seen behind boats more often than expected, whereas Cory's shearwater was seen less

Table 2. Number (n), percentage (% n) and length (Mean ± s.d.) of fish discarded from samples collected at the trawlers. The median of the mean lengths is shown. Data come from samples (n=22) ranging 2–3 kg.

Fish species	n	% n	Length	Class size
Horse mackerel (*Trachurus* sp.)	353	17.3	10.3 ± 0.12	Small
Spotted flounder (*Citharus linguatula*)	389	19.1	8.5 ± 0.05	Small
Sardine (*Sardina pilchardus*)	456	22.4	10.7 ± 0.11	Small
Boar fish (*Capros aper*)	13	0.6	8.7 ± 0.24	Small
Bogue (*Boops boops*)	100	4.9	13.1 ± 0.20	Medium
European hake (*Merluccius merluccius*)	33	1.6	11.5 ± 0.34	Medium
Goby (*Gobius* sp.)	53	2.6	6.4 ± 0.52	Small
Seabream (*Pagellus* sp.)	95	4.7	11.6 ± 0.15	Medium
Imperial jerret (*Centracanthus cirrus*)	88	4.3	11.8 ± 0.40	Medium
Triglidae	10	0.5	8.2 ± 0.33	Small
Conger eel (*Conger conger*)	2	0.1	40 ± 7.07	Large
Common sole (*Solea solea*)	12	0.6	8.8 ± 0.46	Small
Trisopterus sp.	27	1.3	15.2 ± 0.84	Medium
Roughfish (*Hoplostethus mediterraneus*)	15	0.7	9.4 ± 0.42	Small
Myctophidae	54	2.6	11.9 ± 0.50	Medium
Black mouthed dogfish (*Galeus melastomus*)	28	1.4	19.9 ± 0.77	Medium
Mendole (*Spicara maena*)	21	1.0	12.9 ± 0.42	Medium
Cusk eel (*Ophidion barbatum*)	11	0.5	14.7 ± 0.28	Medium
Snipefish (*Macrorhamphosus scolopax*)	23	1.1	8.6 ± 0.88	Small
Comber (*Serranus cabrilla*)	24	1.2	8.4 ± 0.16	Small
Anchovy (*Engraulis encrasicholus*)	14	0.7	10.3 ± 0.18	Small
Greater forkbeard (*Phycis blennoides*)	45	2.2	9.3 ± 0.14	Small
Striped seabream (*Lithognatus mormyrus*)	4	0.2	7.5 ± 0.910	Small
Boar fish (*Capros aper*)	9	0.4	7.4 ± 0.83	Small
Red bandfish (*Cepola rubescens*)	4	0.2	18.7 ± 0.59	Medium
Blue whiting (*Micromesistius poutassou*)	63	3.1	14.5 ± 0.10	Medium
Twaite shad (*Alosa fallax*)	39	1.9	13.5 ± 0.47	Medium
Brill (*Scophthalmus rombus*)	11	0.5	11.6 ± 0.22	Medium
Scorpionfish (*Scorpaena* sp.)	2	0.1	10.2 ± 0.53	Small
Saddled seabream (*Oblada melanura*)	4	0.2	10.4 ± 1.77	Small
Bluemouth (*Helicolenus dactylopterus*)	12	0.6	5.1 ± 0.47	Small
Stargazer (*Uranoscopus scaber*)	17	0.8	16 ± 1.18	Medium
Total	2036		10.55	Small

often than expected, from their respective abundances in the area.

Availability of fish waste

Discard composition included 32 taxonomic groups (Table 2). The richness of the "discard" observed in our study was very similar to that observed at the Ebro Delta (29 categories) but much lower than that of Balearic waters (47 categories) according to Oro and Ruiz (1997). The most commonly discarded fish species were sardine *Sardina pilchardus* (22.4%), flatfish (19.1%) and horse mackerel *Trachurus* spp. (17.3%). All other groups recorded were present in lower numbers. These three species, comprising ca. 60% of all discards, were of small size (median 10.5 cm, range 8.5–10.7).

We ran a non-parametric correlation between the weight of fish landed and the weight of "discard" and found that there was no relationship (r_s=0.02, p=0.96, n=10). The ratio of fish discarded to fish landed was very variable and ranged from 23–175%. The median percentage of the ratio was 64.8. The median weight of fish discarded was 145 kg (vessel d)$^{-1}$ and the median weight of fish landed was 209 kg (vessel d)$^{-1}$.

The trawlers operating in the study area generated an average of ca. 8 tonnes of discarded fish each day. Energy availability from these discards was enough to maintain four times the energetic requirements of the local population of yellow-legged gulls (see Table 3), assuming that the effect of other species on discard consumption in the area is negligible and that catching discarded pieces is a density-independent process so that percentage consumption-catching fish remains constant with increasing population size. Hence trawling activity could solely maintain a gull population four times larger (ca. 12 700 gulls) than that present during the study period.

Experimental discards

From all the seabird species that were recorded following the trawlers only yellow-legged gull, Audouin's gull,

Table 3. Energy requirements of yellow-legged gulls and energy equivalents of trawler "discards" in the study area (Benidorm, SE Spain). An index of energy required over energy available is shown (corrected by the average discard percentage consumption and food assimilation efficiency) after Garthe *et al.* (1996).

Population	Gull population (no. individuals)	Energy required ($\times 10^6$ kJ d^{-1})	Energy available ($\times 10^6$ kJ d^{-1})	Index (required/available)
Breeding adults + offspring	1200	1.47	15.56	0.09
Breeding adults + offspring + non-breeding birds	3200	3.9	15.56	0.25

Cory's shearwater and common tern captured fish thrown during "experimental discards". Yellow-legged gulls ate 644 out of the 886 pieces thrown overboard (ca. 73%).

We tested whether seabirds caught fish items proportionally to their abundance behind boats and found that the observed frequencies of fish capture were significantly different compared to those expected from the birds' relative abundance behind trawlers ($\chi^2=33.54$, d.f. = 3, $p<0.001$). The values of the "success index" were only significant for yellow-legged gull and indicate that this species obtained less discards than expected from its abundance behind boats.

Seabird species showed no overall difference in the consumption of the three size classes considered (small: $\chi^2=1.7$, d.f. = 8, $p=0.99$; medium: $\chi^2=2.3$, d.f. = 11, $p=0.99$; large: $\chi^2=0.1$, d.f. = 3, $p=0.99$). Mean percentage consumption of experimentally discarded fish (fish caught/fish thrown) was 58.5% for fish of small size, 49.4% for medium size fish and 46.6% for fish of large size (Table 4), differences among size classes being slightly significant (G-test = 6.53, d.f. = 4, $p=0.04$). Overall percentage consumption in the experiment was 53.3%. When consumption was corrected taking into consideration the proportion of each species in the real "discard" composition, we found a very similar result (54.4%), indicating that fish thrown experimentally mirrored very closely the composition of actual "discard". Differences in the consumption of flatfish (spotted flounder) versus roundfish (sardine and horse-mackerel) in the experiments were not significant ($\chi^2=2.08$, d.f. = 2, $p=0.35$).

Discussion

Seabird species associated to trawlers

The abundance of yellow-legged gulls near the fishing vessels during the summer may be explained by the presence of breeding colonies of the species on the islands of Benidorm. It is known that gulls exploit "discards" mainly for chick rearing during the breeding season (see Furness *et al.*, 1992; Oro *et al.* 1995). "Discards" are also commonly exploited in the study area by adults rather than by juveniles outside the breeding season, although the high adult/juvenile ratio observed could only reflect an earlier dispersal of juveniles compared to adults (e.g. Oro and Martínez-Vilalta, 1994). European storm-petrels also breed locally but do not make use of trawler waste during the summer probably because this comprises mainly fish of unsuitable size and because almost no offal is generated by the fishery, contrary to what happens in fisheries elsewhere (see Furness *et al.*, 1992; Thompson, 1992; Thompson and Riddy, 1995; Garthe *et al.*, 1996). Storm petrels were rare at boats also in Majorca and the Ebro Delta (Oro and Ruiz, 1997). The relative absence of Audouin's gulls on the transects and behind the boats was surprising considering that the largest colony in the world (10 189 pairs in 1999, own data) is located only 270 km further north and that thousands of migrant birds must cross the study area during the summer (Oro and Martínez-Vilalta, 1994). It seems that Audouin's gulls migrate closer to the coast and do not exploit trawling discards during their migration (Arcos *et al.*, 2001). Cory's shearwaters were common in the area, and following the boats, even though their colonies were located more than 100 km from the study area (see Oro and Ruiz, 1997). Breeders can forage at large distances from colonies and it is impossible to assess whether the birds in the study area were breeders or non-breeders on the basis of plumage as this does not differ with age. The higher abundance of Cory's shearwaters in the study area late in the summer possibly reflects a higher presence of adults at sea during the chick-rearing stage *versus* the incubation stage. The low abundance of Balearic shearwaters in the area and following trawlers is also surprising (e.g. Sarà, 1993; Conejero and Beaubrun, 2000), especially at the beginning of our study when birds breeding on the Balearic Islands start to disperse and should be more numerous, given the records from neighboring areas (Arcos and Ruiz, 1997). Some shags were observed following trawlers, indicating that this species can forage opportunistically, although there are very few previous records of seabirds of the genus *Phalacrocorax* following trawlers (Blaber and Wassenberg, 1989). However, shags were present behind

Table 4. Number of each class size of fish discarded experimentally. Small (2–10 cm), Medium (11–19 cm), Large (20–40 cm). Percentage consumption of each species and size class is indicated between brackets.

Species	Small	Medium	Large	Total
Horse-mackerel (*Trachurus* sp.)	76 (67.1%)	95 (55.8%)	0	171 (60.8%)
Goby (*Gobius* sp.)	12 (41.7%)	3 (100%)	0	15 (53.3%)
Sardine (*Sardina pilchardus*)	87 (47.1%)	265 (49.1%)	4 (100%)	356 (49.2%)
European hake (*Merluccius merluccius*)	4 (75%)	9 (100%)	1 (100%)	14 (92.9%)
Seabream (*Pagellus* sp.)	4 (50%)	46 (37.0%)	0	52 (36.6%)
Imperial jerret (*Centracanthus cirrus*)	4 (25%)	62 (48.4%)	12 (50%)	78 (47.4%)
Bogue (*Boops boops*)	7 (85.7%)	103 (60.2%)	0	110 (61.8%)
Spotted flounder (*Citharus linguatula*)	115 (65.2%)	51 (37.3%)	0	166 (56.6%)
Common pandora (*Pagellus erythrinus*)	0	6 (100%)	0 (100%)	6
Triglidae	3 (66.7%)	9 (100%)	0	12 (91.7%)
Conger eel (*Conger conger*)	0	2 (100%)	18 (44.4%)	20 (50%)
Common sole (*Solea solea*)	12 (25%)	0	0	13 (23.1%)
Mendole (*Spicara maena*)	2 (100%)	4 (100%)	2 (100%)	8 (100%)
Cusk eel (*Ophidion barbatum*)	3 (33.3%)	5 (80%)	1 (100%)	9 (66.7%)
Snipefish (*Macrorhamphosus scolopax*)	22 (36.4%)	0	0	22 (36.4%)
Paracentropistis sp.	7 (85.7%)	0	0	7 (85.7%)
Dragonet (*Callionymus* sp.)	0	2 (50%)	0	2 (50%)
Mackerel (*Scomber scombrus*)	0	0	1 (0%)	1 (0%)
Anchovy (*Engraulis encrasicholus*)	5 (20%)	4 (75%)	0	9 (44.4%)
Greater forkbeard (*Phycis blennoides*)	20 (85%)	56 (42.9%)	1 (100%)	77 (54.5%)
Striped seabream (*Lithognatus mormyrus*)	10 (70%)	0	0	10 (70%)
Marbled electric ray (*Torpedo marmorata*)	0	1 (100%)	0	1 (100%)
Boar fish (*Capros aper*)	0	3 (0%)	0	3 (0%)
Red bandfish (*Cepola rubens*)	0	0	2 (100%)	2 (100%)
Silver scabbard-fish (*Lepidopus caudatus*)	0	0	3 (33.3%)	3 (33.3%)
Blue whiting (*Micromesistius potassou*)	8 (37.5%)	5 (0%)	0	13 (23.1%)
Brill (*Scothphalmus rhombus*)	0	6 (100%)	0 (100%)	6
Greater weever (*Trachinus draco*)	0	1 (100%)	0 (100%)	1
Total	403 (58.3%)	739 (52.1%)	45 (57.8%)	1187 (54.4%)

the boats only when these were fishing closer to the coast (<28 km off the coast) suggesting either a low dependence on discards or a smaller foraging range than other species.

Discard features

Most fish discarded were suitable for seabird consumption because of their small size but only 54% was consumed. This low consumption is in strong contrast with estimates from the Ebro Delta (72%) and Majorca (64%) (Oro and Ruiz, 1997). The three most commonly discarded groups (sardines, flatfish and horse-mackerel) were swallowed with great efficiency at the Ebro Delta (100%, 94%, 93%) where Audouin's gull is the commonest species behind trawlers; however, percentages were lower at Majorca (50%, 78%, 87%) where yellow-legged gulls were the most common followers. Our overall (54%) and partial percentages (49%, 57%, 61%) resemble more closely data from Majorca than data from the Ebro Delta. These results suggest that Audouin's gull is more efficient than yellow-legged gull at catching this type of "discard", probably because of its more specialized fishing habits (e.g. Oro, 1998; Arcos *et al*., 2001). Other studies also recorded differences in seabird species efficiency at feeding on "discards" (e.g. Furness *et al*., 1992; Camphuysen, 1995). Flatfish were consumed with the same success as roundfish, although flatfish species are typically considered to be less attractive for seabirds (Garthe *et al*., 1996). The high consumption of flatfish in this study probably stems from the relatively small amount of flatfish discarded (e.g. see Camphuysen, 1994).

The absence of a significant correlation between fish landed and discarded indicates that "discard" percentage is highly unpredictable and that the amount of "discard" cannot readily be deduced from catch statistics. However, this finding is contrary to results previously reported for the western Mediterranean (Oro and Ruiz, 1997). Differences between zones may arise owing to physiographical factors (i.e. width of the shelf, nature of the bottom etc) or even to market factors (such as the price of fish in the market or the vigilance of fishermen especifically devoted to clupeoid fishing, if both types of fisheries are practiced by boats in the same port or region.

Acknowledgements

This paper is contribution No. 4 to the LIFE-NATURE program BA 3200/98/447 "Conservation of island SPAs in the Valencian Region" financed by the Generalitat Valenciana (Conselleria de Medi Ambient) and the E.U. We are very grateful to José Santamaría for his help collecting field data and to the skippers and crews of the "Galandú", "Sana", "Puig Campana", "Cantal" and "Pau". Juanjo Izquierdo helped in several ways throughout the study. We thank Mario Giménez from SEO/BirdLife for discussing with us several aspects of the work. Raquel Goñi from the Instituto Español de Oceanografía and Paco Ruiz from the Conselleria de Agricultura (Generalitat Valenciana) provided unpublished reports on discards. The Fishermen's associations of Villajoyosa, Altea, Calpe and Sant Carles de la Ràpita provided valuable information. Diana Bowler gently reviewed our English. Our gratitude goes as well to Bob Furness and two anonymous reviewers.

References

Arcos, J. M., and Ruiz, X. 1997. Balearic and Yelkouan Shearwaters feeding extensively on discards in the Western Mediterranean. Proc. 21st Colonial Waterbirds Society Annual Meeting, p. 24. Lafayette, USA.

Arcos, J. M., Oro, D., and Sol, D. 2001. Competition between yellow-legged *Larus cachinnans* and Audouin's gulls *Larus audouinii* associated to commercial fisheries: the influence of the season and the fishing fleet. Marine Biology, 139: 807–816.

Blaber, S. J. M., and Wassenberg, T. J. 1989. Feeding ecology of the piscivorous birds *Phalacrocorax varius*, *P. melanoleucos* and *Sterna bergii* in Moreton Bay, Australia: diets and dependence on trawler discards. Marine Biology, 101: 1–10.

Bryant, D. M., and Furness, R. W. 1995. Basal metabolic rates of North Atlantic seabirds. Ibis, 137: 219–226.

Camphuysen, C. J. 1994. Flatfish selection by herring gulls *Larus argentatus* and lesser black-backed gulls *Larus fuscus* scavenging at commercial beamtrawlers in the southern North Sea. Netherlands Journal of Sea Research, 32: 91–98.

Camphuysen, C. J. 1995. Herring Gull *Larus argentatus* and Lesser Black-backed Gull *L. fuscus* feeding at fishing vessels in the breeding season: competitive scavenging versus efficient flying. Ardea, 83: 365–380.

Carbonell, A., de Rainieri, S., and Martín, P. 1997. Discards of the western Mediterranean trawl fleets. Unpublished report. Instituto Español de Oceanografía. Palma de Mallorca. 142 pp.

Carbonell, A., Martin, P., de Rainieri, S., and WEDIS team 1998. Discards of the western Mediterranean trawl fleets. Rapp. Comm. Int. Mer Médit., 35: 392–393.

Conejero, S., and Beaubrun, P. C. 2000. Corys Shearwater *Calonectris diomedea* and Levantine Shearwater *Puffinus yelkouan* (Procellariidae) in the Gulf of Lions during July 1994. *In* Monitoring and Conservation of Birds, Mammals and Sea Turtles of the Mediterranean and Black Seas, pp. 104–105. Ed. by P. Yésou, and J. Sultana. Malta. 320 pp.

Furness, R. W., Hudson, A. V., and Ensor, K. 1988. Interactions between scavenging seabirds and commercial fisheries around the British Isles. *In* Seabirds and other marine vertebrates: competition, predation and other interactions, pp. 240–268. Ed. by J. Burger. Columbia University Press, New York, USA. 339 pp.

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

Garthe, S., and Hüppop, O. 1994. Distribution of ship-following seabirds and their utilization of discards in the North Sea in summer. Marine Ecology Progress Series, 106: 1–9.

Garthe, S., Camphuysen, K., and Furness, R. 1996. Amounts of discards by commercial fisheries and their significance as food for seabirds in the North Sea. Marine Ecology Progress Series, 136: 1–11.

Harris, M. P., and Wanless, S. 1996. Differential responses of guillemot *Uria aalge* and Shag *Phalacrocorax aristotelis* to a late winter wreck. Bird Study, 43: 220–230.

Harris, M. P., Wanless, S., and Elston, D. A. 1998. Age-related effects of a nonbreeding event and a winter wreck on the survival of Shags *Phalacrocorax aristotelis*. Ibis, 140: 310–314.

Hudson, A. V., and Furness, R. W. 1988. Utilization of discarded fish by scavenging seabirds behind whitefish trawlers in Shetland. Journal of Zoology, 215: 151–166.

Marra, P. P., Hobson, K. A., and Holmes, R. T. 1998. Linking winter and summer events in a migratory bird by using stable-carbon isotopes. Science, 282: 1884–1886.

Oro, D. 1998. Audouin's Gull account. *In* The birds of the western Palearctic, pp. 47–61. Ed. by M. A. Ogilvie. Oxford University Press, Oxford, UK.

Oro, D. 1999. Trawler discards: a threat or a resource for opportunistic seabirds? *In* Proc. 22 Int. Ornithol. Congr., Durban, pp. 717–730. Ed. by N. J. Adams, and R. H. Slotow. BirdLife South Africa, Johannesburg.

Oro, D., and Martínez-Vilalta, A. 1994. Migration and dispersal of Audouin's Gull *Larus audouinii* from the Ebro Delta colony. Ostrich, 65: 225–230.

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

Oro, D., and Ruiz, X. 1997. Exploitation of trawler discards by breeding seabirds in the northwestern Mediterranean: differences between the Ebro Delta and the Balearic Island areas. ICES Journal of Marine Science, 54: 695–707.

Salas, M. 1995. Estudio de seguimiento de descartes y vertidos capturados por la actividad de arrastre. Unpublished report. Conselleria de Agricultura, Pesca y Alimentación. Generalitat Valenciana. 141 pp.

Sarà, M. 1993. Feeding habits of Cory's shearwater (*Calonectris diomedea*) in the central Mediterranean Sea. *In* Estatus y conservación de aves marinas, pp. 213–220. Ed. by J. S. Aguilar, X. Monbailliu, and A. M. Paterson. SEO, Madrid. 386 pp.

Spear, L., Sydeman, W.J., and Pyle, P. 1995. Factors affecting recruitment age and recruitment probability in the Western Gull *Larus occidentalis*. Ibis, 137: 352–359.

Tasker, M., Jones, P. H., Dixon, T., and Blake, B. F. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk, 101: 567–577.

Thompson, K. R., and Riddy, M. D. 1995. Utilization of offal and discards from "finfish" trawlers around the Falkland Islands by Black-browed Albatross *Diomedea melanophris*. Ibis, 137: 198–206.

Thompson, K. R. 1992. Quantitative analysis of the use of discards from squid trawlers by Black-browed Albatrosses *Diomedea melanophris* in the vicinity of the Falkland Islands. Ibis, 134: 11–21.

Zar, J. H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey. 663 pp.