Fish associated with floating drifting objects as a feeding resource for Balearic Shearwaters *Puffinus mauretanicus* during the breeding season

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1. Introduction

The taxonomic status of the Balearic Shearwater *Puffinus mauretanicus* has long been disputed (e.g. Bourne et al. 1988), but recent paleontological (Walker et al. 1990, Altaba 1994) and molecular evidence (Heidrich et al. 1998) support its consideration as a distinct species (Snow & Perrins 1998). As such, this shearwater is one of the scarcest and most threatened seabirds in the world, with a global population of some 3,400 breeding pairs, that are restricted to the Balearic Islands in the western Mediterranean (Mayol & Aguilar 1998). Thus, the lack of scientific information on the species, especially during the breeding season, is of particular concern (Mayol 1998).

The feeding behaviour and ecology of the Balearic shearwater are poorly understood, with assumptions usually derived from extrapolations made on the close Manx Shearwater *Puffinus puffinus* (e.g. Le Mao & Yésou 1993). Traditionally considered to feed mainly on small shoaling fish (e.g. del Hoyo et al. 1992), this species also exploits trawler discards (Le Mao & Yésou 1993, Oro & Ruiz 1997, Arcos & Ruiz 1997). Natural feeding methods reported up to now include the direct capture of small shoaling fish by plunge diving and pursuit diving behaviours (Rebassa et al. 1998), the capture of ichthyoplankton at the sea surface (Le Mao & Yésou 1993), and the interaction with sub-surface predators (Oro 1995). In this note we describe a previously unreported feeding strategy for the Balearic Shearwater, consisting of the capture of fish under floating drifting objects, both biotic and abiotic. We also provide data on the potential prey available under these objects, coinciding with the period of our observations.

2. Methods

The observations took place while we surveyed seabirds from the R/V ‘Cornide de Saavedra’ in the western Mediterranean, off the coast of Spain. Balearic Shearwaters occurred commonly in areas of continental shelf, off the eastern coast, between 38º00’N and 42º25’N. This area was prospected between 16 May and 3 June 1999, and seabird censuses were carried out following Tasker et al. (1984). We conducted 282 ten-minute counts distributed throughout the day, from 5:30 to 19:00h GMT. We counted 850 Balearic Shearwaters total, and a mean density of 1.13 birds/km2 was estimated**.** Data on

the fish associated to flotsam was obtained from experiments with Fish Aggregation Devices (FADs) developed between 1995 and 1997 (see details in Deudero et al. 1999, Massutí et al. 1999). These experiments were conducted in approximately the same study area in the western Mediterranean, within the distribution range of the Balearic Shearwater during the breeding season (Abelló & Oro 1999). In this note we analyse data from 18 hauls conducted with an experimental surrounding purse net around FADs, between May and June.

3. Results and discussion

Balearic Shearwaters associated with floating drifting objects on seven occasions (Table 1). On six events the shearwaters were detected in direct flight. When the birds passed over a drifting object, they turned suddenly and stopped or plunged directly close to the drifting object, performing one or more pursuit dives under the object while flapping their wings actively. After that, the birds continued flight in the initial direction. The total time of active association ranged from 10 to 25 s, although the birds could remain resting on water for a while afterwards. The number of birds associated with a drifting object at any one time ranged from one to three, with the exception of 26 birds associated with a large sunfish *Mola mola*, the largest 'drifting object' involved in the reported cases.

Pursuit diving behaviour under the drifting object was observed on five out of seven occasions. On another occasion, the activity of a single bird was limited to just checking the underside of the drifting object by submerging the head from the surface, probably due to a lack of prey. Finally, on the remaining case three birds were observed resting on the water close to a drifting object, presumably after having dived under it. In the cases of diving behaviour that we observed, the first dive started either by plunging (n = 4) or from the surface (n = 1). Subsequent dives (up to three) started always from the surface. Before any surface-dive, the birds looked for potential prey by submerging the head.

Drifting objects observed to attract birds were three wooden boxes, one plastic bag, one small bush, one jellyfish *Rhizostoma pulmo* and one Sunfish *Mola mola*. The last two cases were considered as drifting objects because jellyfish and sunfish usually drift close to the surface in the same manner as inert objects. Sizes of the drifting objects involved in our observations ranged from some 40 cm (the

jellyfish and the plastic bag) to almost 1.5 m (the Sunfish). With the exception of the bush, the rest of drifting objects were completely submerged, just a few cm under the surface. This result was to be expected since the increase of submerged surface in flotsam tends to increase efficacy for concentrating fish (Rountree 1989).

Drifting objects usually present associated communities of life forms, mainly represented by postlarval and juvenile fish (Rountree 1993) that are attracted to these objects looking for shelter, prey, or substrate, among other reasons (e.g. Druce & Kingsford 1995). In the western Mediterranean, results from FAD experiments have shown that abundance and biomass, as well as taxonomic and length composition in fish assemblages exhibit seasonal variation, with peaks of density and biomass in spring and autumn respectively (Deudero el al. 1999, Massutí et al. 1999). During May and June, when our observations took place, the most abundant fish species collected under FADs was Blue Jack Mackerel *Trachurus picturatus*, which appeared in 13 of the 18 FAD samples, and represented 98% of the specimens and 86% of the biomass of fish. The average values of density for this species were 609.1 ± 143.2 SE fish/FAD, with a mean ± SE fork length of 8.3 ± 2.1 cm (ranging from 4 to 13.5 cm). Although there is no reliable information on the diet of Balearic shearwaters (e.g. Snow & Perrins 1998), experimental discards performed during the cruise showed that the shearwaters frequently consumed the close Horse Mackerel *Trachurus trachurus*, of sizes ranging from 5 to 25 cm (authors, in prep.). Thus, floatsam seem to represent a source of abundant prey, suitable for the Balearic Shearwater. The peak in biomass, in late summer and autumn, mostly present fish of larger size (Massutí et al. 1999) and would make this resource less appropriate for the Balearis Shearwater during this period.

Direct capture of fish was not observed in any of the seven reported cases. However, this was expected given that Balearic Shearwaters usually swallow their prey underwater (e.g. Rebassa et al. 1998). Furthermore, both the behaviour described and the reported existence of potential prey under drifting objects make it clear that shearwaters associate with drifting objects looking for food. The only similar feeding strategies previously described were the association of seabirds to ice floes (Ainley et al. 1984), to the holopelagic macroalga *Sargassum* (Haney 1986), and to marine turtles (Pitman 1993). Particularly similar was the behaviour of Audubon's Shearwaters *Puffinus iherminierii* feeding under small clumps of *Sargassum* (Haney 1986), which might also be considered as floating drifting objects.

Burger (1988) also reported a clear association of Sooty Shearwaters *Puffinus griseus* with Sunfish *Mola mola*, although no bird was observed feeding actively and the reason for this association remained unexplained (cf. Warham 1996).

The strong seasonality of the fish communities associated with drifting objects suggest that this resource might be of some importance to Balearic Shearwaters only in the late breeding season, during the chick rearing stage (May-June, Snow & Perrins 1998). This period coincides with the spring peak in density of fish under FADs (Massutí et al. 1999), and most fish under drifting objects appear to be of suitable size for the shearwaters. Furthermore, at this time the energetic requirements of the breeding shearwaters are at their highest (e.g. Ricklefs 1983), and fish associated with drifting objects might constitute an important source of extra food, although probably exploited in an opportunistic way. At the same time, drifting objects could also play an important role by signalling suitable feeding areas to the shearwaters, since they tend to accumulate in biologically rich water masses such as convergence fronts (Arenas et al. 1992). A similar phenomenon has been observed for large predators such as tuna, which utilise drifting objects as 'floating reefs' to move between rich water masses (Hall 1992).

The association between Balearic Shearwaters and drifting objects was always recorded in hours of high light levels (see Table 1), even though birds were regularly seen from early morning to late evening. In spite of the low productivity of the western Mediterranean during late spring and summer (Margalef 1984), shearwaters observed during the hours of low light levels and by night could be feeding on planktonic organisms or on their predators, linked to the daily vertical migration. This idea is supported by the observation, during our cruise, of concentrations of Balearic Shearwaters feeding on the surface after sunset, in areas of high concentration of dinoflagellates (red tides) and other planktonic organisms. Since plankton is found in deep waters during the middle of the day, shearwaters would shift to exploit epipelagic and hyponeustonic fish under floating objects at this time. Alternative feeding methods during the hours of high light levels would be the association with sub-surface predators (Oro 1995), and the capture of trawler discards (Oro & Ruiz 1997, Arcos & Ruiz 1997). Indeed, a part of the seven reported cases of association with drifting objects, during our censuses we observed Balearic Shearwaters associated to fishing trawlers (2 instances, 67 birds) and to Striped Dolphins *Stenella coeruleoalba* (one instance, 50 birds). We also observed the direct capture of small shoaling fish, probably Belonidae, in one occasion (28 birds involved).

Although the feeding behaviour described here has not been reported before, other seabirds could also feed on fish associated with floating drifting objects regularly in the western Mediterranean. Indeed, we have observed Yellow-legged Gulls *Larus cachinnans* and Cory's Shearwaters *Calonectris diomedea* associated with floating objects on some occasions, and Cory's Shearwaters were usually seen associated with flotsam containing fish during the FADs experiments (EM, pers. obs.). Studies directed to estimate the abundance of floating drifting objects in the western Mediterranean would help to assess the full significance of the fish communities associated with these objects as a feeding resource for seabirds.

Acknowledgments: We wish to thank all participants on the cruise MEDITS_ES 0595, and particularly its Chief Scientist Dr. Luis Gil de Sola, officers and crew of R/V 'Cornide de Saavedra', for all their support. Thanks also to Marcello Bertellotti, an anonymous referee, and the editor for their helpful comments on a previous draft of this note, and to David Tàbara and Fiona Thomas for a revision of the English text. This study was performed within the frame of the research projects MEDITS 'International bottom trawl survey in the Mediterranean' (DGXIV/IEO/054) and CORY 'Dolphin-fish biological and fishing data in the western Mediterranean' (Ref. 95/73), funded by the European Comission. Financial support was also provided to JMA by the Comissionat per a Universitats i Recerca de la Generalitat de Catalunya (FI/FIAP 99).

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