

Review of the diet and foraging behaviour of three species of tubenoses breeding in the Maltese Islands

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Introduction

Malta holds globally important breeding populations of Scopoli's Shearwater *Calonectris diomedea*, Yelkouan Shearwater *Puffinus yelkouan*, and Mediterranean Storm-petrel *Hydrobates pelagicus melitensis*. The three species of Procellariiformes are highly pelagic seabirds that feed exclusively at sea, making use of Maltese waters for foraging, but also forage in high sea areas and in Italian, Libyan and Tunisian waters during the breeding season. The EU LIFE+ Malta Seabird Project (2011-2016) LIFE10 NAT/MT/090 and the EU LIFE Yelkouan Shearwater Project (2006-2010) LIFE06/NAT/MT/097 have identified Marine Important Bird Areas for the Maltese populations of these three species of tubenoses, including their foraging hotspots in the Maltese Fishing Management Zone (25 nm). However, it is also crucial to identify the relevant prey the birds are taking from these areas, especially for assessing interactions with fisheries and aquaculture. Here we present a review of the diet and foraging behaviour of the three aforementioned species. In combination with information on key areas at sea that these species use, information on important food sources and foraging behaviour are important further steps in assessing (and if necessary) mitigating threats imposed on these seabirds by fisheries.

Material and methods

We carried out a desk study, reviewing thoroughly all accessible and most relevant publications on the diet and foraging behaviour of the three seabird species (two for Mediterranean Storm-petrel, one for European Storm-petrel *Hydrobates pelagicus pelagicus*, three for Yelkouan Shearwater, one for Scopoli's Shearwater and three for Cory's Shearwater *Calonectris borealis*). Additionally, we included data collected as part of the EU LIFE+ Malta Seabird Project carried

out between 2011–2016, personal observations of BirdLife Malta staff and other Maltese seabird researchers.

Results

We compiled the results of diet studies and feeding behaviour for the three seabird species. Diet was analysed by identifying prey species from regurgitated samples or stomach content and by isotope analysis of feathers.

- **Mediterranean Storm-petrel** *Hydrobates pelagicus melitensis*

The Mediterranean Storm-petrel is a pelagic seabird endemic to the Mediterranean that feeds on marine food sources (Table 1). Mediterranean Storm-petrels are present throughout Maltese waters during the breeding season as suggested by the telemetry using radio tracking and vessel based observations during the 2012 and 2013 breeding seasons under the EU LIFE + Malta Seabird Project.

Mediterranean Storm-petrels dive for their prey to a mean depth of 146cm and up to 500cm depth (Albores-Barajas *et al.* 2011). Mediterranean Storm-petrel feeding during the breeding season may alternate long trips spending all day out feeding at sea, and short trips feeding close to the colony during the night (Albores-Barajas *et al.* 2011, B. Metzger obs.). This behaviour has also been recorded in the Atlantic populations (D’Elbee & Hemery 1998).

Based on this review, European Storm-petrels typically feed on small fish, crustaceans etc. Tuna fish farms are a seasonal supplementary food source in Malta. During vessel-based observations conducted by the EU LIFE + Malta Seabird Project and observations by Maltese birders Mediterranean Storm-petrels were regularly seen around Bluefin Tuna fish pens in the southeast of Malta, 6–9km off Marsaskala. The Bluefin Tuna *Thunnus thynnus* are fed with a mixture of mashed small pelagic fish, squid and shrimp, which produce a dense oil-slick sometimes extending for several kilometres over the surface. This attracts considerable numbers of Mediterranean Storm-petrels (Borg 2012).

Table 1. Diet of the European Storm-petrel (*Mediterranean and Atlantic subspecies*)

Study	Location	Main prey	Methodology
Albores-Barajas <i>et al.</i> 2011	Marettimo Island (Italy)	Fish (in volume and number). Mainly Mediterranean sand eel <i>Gymnammodites cicerellus</i> around 4 cm. Opossum Shrimps (Misydacea) when feed close to the colony.	Regurgitate samples (25 samples) 2007–2009
D'Elbee & Hemery 1998	Bay of Biscay (France). Atlantic populations	Fish main prey in volume (Gadidae, Gobiidae, Myctophidae and Ammodytidae). Microzooplankton (Copepoda, Euphausiacea, Chaetognatha, Anthomedusae, and meroplanktonic Larvae), and suprabenthic intertidal organisms (mainly isopods Cirolanidae) present. In volume Zooplankton (52%) and littoral and intertidal benthic organisms (37%).	Regurgitate samples (76 samples) 1984–1991
J.J. Borg pers. comm.	Filfla (Malta)	Small fish and crustaceans	Regurgitate samples (12 samples) 2009-2011
B. Metzger obs.	Filfla (Malta)	Small fish	Opportunistic regurgitate samples 2012–2014

- **Yelkouan Shearwater** *Puffinus yelkouan*

The Yelkouan Shearwater is a pelagic seabird endemic to the Mediterranean that feeds on marine food sources. It preys mainly on sardines and anchovies (Table 2). Yelkouan Shearwater has a wide diet (Peron *et al.* 2013) that can change along the breeding season (Bourgeois *et al.* 2011). It benefits from fishing activities and follows trawlers discarding fish (Arcos *et al.* 2001). Yelkouan Shearwaters can dive to a maximum depth of 30m, with frequent dives deeper than 10m (Peron *et al.* 2013).

Based on this review, Yelkouan Shearwaters typically feed on small fish, crustaceans and cephalopods in variable proportions depending on the breeding stage.

Table 2. Diet of the Yelkouan Shearwater.

Study	Location	Main prey	Methodology
Zotier 1997	Provence coast (France)	Equal relative occurrence of fish: Clupeids (<i>S. pilchardus</i> (sardine) and <i>Sprattus sprattus</i>), Engraulids (<i>E. encrasicolus</i> (anchovy), and Scombrids (<i>Scomber sp.</i> (mackerel)); and crustaceans (<i>Meganyctiphanes sp.</i>) Crustaceans more abundant during the pre-laying period and fish during the chick rearing.	Unknown
Bourgeois <i>et al.</i> 2011	Hyères archipelago (Provence coast, France)	Fish is the main prey, both in terms of relative occurrence (84.6%) and relative biomass (99.7%): epipelagic fish as main prey Clupeids (mainly <i>S. pilchardus</i> (sardine)), Engraulids (<i>E. encrasicolus</i> (anchovy) and mesopelagic and demersal species (Gadids and <i>Scomber sp.</i>) as secondary fish prey types. Crustaceans (Euphasiacea and Decapoda) main prey type in terms of relative number (63.2%), but with low relative occurrence (19.2%) low biomass. Crustaceans major prey type during the pre-laying period (relative number: 88.8%) but low biomass.	Stomach contents and regurgitates (26 samples) 2004–2007
Peron <i>et al.</i> 2013	Hyères archipelago (Provence coast, France)	Range from being exclusively zooplankton-based to exclusively fish-based during the breeding season.	Stable isotopic analyses (70 first primary feathers (P1) and 72 cover feathers) 2011–2012
B. Metzger obs.	Maltese archipelago	Small fish and squid till 4–5cm long	Opportunistic regurgitates samples 2012–2016

- **Scopoli's Shearwater** *Calonectris diomedea*

Scopoli's Shearwater is a pelagic seabird endemic to the Mediterranean that feeds on marine food sources (Table 3). It preys mainly on medium-sized to small fish 4–25cm and squid 2–15cm. (UNEP-MAP-RAC/SPA 2014, Sara 1989). They obtained the prey from active catch or opportunistically from fishery discards. Scopoli's Shearwater rarely dives more than 4m (Péron C., unpublished results).

It was considered as a subspecies of Cory's Shearwater *Calonectris diomedea diomedea* until 2014 (del Hoyo *et al.* 2014). The studies available are focussed on the closely related Cory's Shearwater *Calonectris borealis* that breeds and feeds mainly in the Atlantic. The only diet studies available for Scopoli's Shearwater we are aware of are from Maurizio Sara in the 1980s in the central Mediterranean.

Scopoli's Shearwater feeds alone or in association with tuna schools and cetaceans. (UNEP-MAP-RAC/SPA 2014, Sara 1989). It follows trawlers to benefit from fishing discards and longline vessels (Sara 1989, Laneri *et al.* 2010). Fishing discards are an important source of food and modifies their foraging behaviour (Bartumeus *et al.* 2010).

In Cory's Shearwater diet depends on food availability. The diet varies between years (Granadeiro *et al.*, 1998; Xavier *et al.*, 2011; Neves *et al.*, 2012) and the breeding cycle (Neves *et al.*, 2012). Change in diet generally reflects a change in prey abundance or access to prey (Xavier *et al.* 2011).

Based on this review, Scopoli's Shearwater typically feed on pelagic fish and cephalopods.

Table 3. Diet of Scopoli's and Cory's Shearwater

Study	Location	Main prey	Methodology
Sara 1989 Scopoli's Shearwater	Linosa	Mainly pelagic fish (63.4%): Blue whiting (<i>Micromesistius poutassou</i>), Mackerel (<i>Trachurus trachurus</i>), European anchovy (<i>Engraulis encrasicolus</i>), Silver scabbardfish (<i>Lepidopus caudatus</i>), Cephalopoda (26.7%), and Crustacean (Euphasiacea)	Stomach contents (9 samples) and regurgitations (64 samples) 1983, 1986–1987

Afan <i>et al.</i> 2014 Scopoli's and Cory's Shearwaters	Chafarinas Archipelago	Mainly pelagic fish	Stable isotope analysis of feathers (26 Scopoli's Shearwaters and 5 Cory's Shearwaters) 2011
Alonso <i>et al.</i> 2012 Cory's Shearwater	Berlengas island (Continental Portugal) and Selvagem islands (Atlantic Ocean)	Mainly fish: mixture of shelf pelagic fish (<i>Scomber colias</i> , <i>Sardina pilchardus</i> , and <i>Belone belone</i>) and offshore pelagic fish (<i>Naucrates ductor</i> and Exocoetidae). Cephalopods very frequent	Stomach contents (88 samples) 2010
Neves <i>et al.</i> 2012 Cory's Shearwater	Azores	Mainly fish: Blue jack mackerel <i>Trachurus picturatus</i> the most abundant, and <i>Cubiceps gracilis</i> , <i>Scomberesox saurus</i> and <i>Maurolicus muellerii</i> . Cephalopod (Histoteuthidae, Ommastrephidae and Cranchiidae)	Stomach contents (959 samples) 1998–2000, 2002

Discussion

Mediterranean Storm-petrel, Scopoli's Shearwater and Yelkouan Shearwater feed mainly on fish, crustacean and squid. It is likely Scopoli's Shearwater has a similar diet in terms of species groups and similar foraging behaviour to Cory's Shearwater. Cory's Shearwater and Yelkouan Shearwater vary their diet along the breeding season and between years. This means that they could have flexible feeding strategies depending on the resources availability, and it is proved the habitat quality is a key factor for the dual foraging strategy (Cecere 2014). It is known that they feed in high productivity areas that may coincide with fishing areas.

The knowledge of the prey species of Scopoli's Shearwater, Yelkouan Shearwater, and Mediterranean Storm-petrel combined with the foraging areas is a key element to identify the

important foraging areas. This allows identifying possible conflicts and interactions with human activities such as fisheries.

There are few studies that focus on this subject and some of them are not from the Mediterranean populations. A diet study of the three species is necessary to be carried out in Malta. Moreover, determining interactions between fisheries and seabirds in the Maltese waters as well as in important foraging areas outside Maltese waters, mainly South of Sicily, Gulf of Gabès in Tunisia and North of Libya, should be a priority in the coming years. This would allow for assessment of threats faced by birds at sea.

In 2016, the Maltese government has designated eight marine Special Protection Areas (mSPAs) under the Birds Directive in order to protect the important areas at sea for Scopoli's Shearwater, Yelkouan Shearwater, and Mediterranean Storm-petrel. The assessment of fisheries and their interaction with seabirds will be crucial to secure a correct management of the protected areas.

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