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Short communication

A new approach to study of seabird-fishery overlap: Connecting chick feeding with parental foraging and overlap with fishing vessels

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ABSTRACT

Incidental fisheries bycatch is recognised as a major threat to albatross populations worldwide. However, fishery discards and offal produced in large quantities might benefit some scavenging seabirds. Here, we demonstrate an integrated approach to better understand the ecological ramifications of fine-scale overlap between seabirds and fisheries. As a case study, we examined whether foraging in association with a fishing vessel is advantageous for chick provisioning in terms of quantity of food delivered to chicks, in northern royal albatross (*Diomedea sanfordi*) at Taiaroa Head, New Zealand. Fine-scale overlap between albatrosses and vessels was quantified by integrating GPS tracking and Vessel Monitoring Systems (VMS). Meal size delivered to chicks was measured using custom-designed nest balances, and monitoring of attendance of adults fitted with radio transmitters was used in conjunction with time-lapse photography at the nest allowed us to allocate each feeding event to a specific parent. The combination of these techniques enabled comparison of meal sizes delivered to chicks with parental foraging trip durations with or without fishing vessels association. A total of 45 foraging trips and associated chick feeding events were monitored during the chick-rearing period in 2012. Differences in the meal size and foraging trip duration relative to foraging overlap with fisheries were examined using a linear mixed-effect model, adjusted for chick age. Our results, based on three birds, suggest that foraging in association with vessels does not confer an advantage for chick feeding for this population that demonstrated low rates of overlap while foraging. The integrated research design presented can be applied to other seabird species that are susceptible to bycatch, and offers a valuable approach to evaluate habitat quality by linking habitat use and foraging success in terms of total amount of food delivered to offspring.

1. Introduction

Commercial fisheries are prevalent in most oceans globally with substantial impacts on marine ecosystems through alterations of the trophic structure and abundance of both fish stocks and their predators in marine ecosystems (Goñi, 1998; Lewison et al., 2004; Halpern et al., 2008). Seabirds and other predators at the apex of marine food webs are particularly

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vulnerable to such ecosystem perturbations as a result of bottom-up control in plankton-based marine food chains (Frederiksen et al., 2006; Heithaus et al., 2008). Fisheries can influence the dynamics of seabird populations and communities in complex ways, and the effects can be negative or positive (Tasker et al., 2000; Furness, 2003). Incidental mortality of seabirds as bycatch in commercial fisheries is an important global conservation issue (Croxall et al., 2012). Large numbers of seabirds are killed each year by drowning in longline fisheries after becoming caught on baited hooks (Anderson et al., 2011), and in trawl fisheries after getting entangled in nets or colliding with trawl warps (Baker et al., 2007). High levels of such mortality are unlikely to be sustainable and are believed to have led to global population declines in many seabird populations (Lewison et al., 2004; Sullivan et al., 2006), particularly members of the order Procellariiformes (albatrosses, shearwaters and petrels) (Robertson and Gales, 1998; Lewison et al., 2004; Sullivan et al., 2006; Anderson et al., 2011). Currently, 17 of the 22 albatross species are listed as threatened with extinction, making them the most threatened family of birds in the world (IUCN, 2014). Additionally, some fisheries may adversely influence seabird populations through direct resource competition by reducing or depleting the availability of the fish prey on which seabirds depend (Furness, 1982; Hamer et al., 1991; Furness and Tasker, 2000; Tasker et al., 2000; Furness, 2003; Cury et al., 2011).

However, because seabirds are both predators and facultative scavengers, some species might benefit from fishing activities as many commercial fisheries generate considerable quantities of biomass available to scavenging seabirds in the form of bait (Pierre and Norden, 2006), discarded undersized and unwanted catch (Xavier et al., 2004; Louzao et al., 2011), and offal produced during on-board processing (Thompson and Riddy, 1995). An average of 7.3 million tonnes of fishery waste is estimated to have been dumped into the world's oceans each year between 1992 and 2001 (Kelleher, 2005). The utilisation of this abundant food source by seabirds has been shown to have effects on breeding success (Oro, 1996) and population dynamics (Oro et al., 2004), and can even modify individual movement patterns (Bartumeus et al., 2010; Bodey et al., 2014; Collet et al., 2015) and foraging behaviour (Granadeiro et al., 2011; Torres et al., 2011).

The importance of fishery waste for seabirds has been demonstrated through assessments of the relative contribution of fishery waste to the overall diet, either by stomach contents or stable isotope analysis (Freeman and Wilson, 2002; Votier et al., 2004; Bugoni et al., 2010). The beneficial effects of feeding on fishery waste have been documented as reduced foraging costs in wide-ranging seabirds. For example, breeding northern gannets (*Morus bassanus*) with a higher proportion of fishery wastes in their diet performed shorter foraging trips (Votier et al., 2010). Similarly, non-breeding cape gannets (*Morus capensis*) that extensively fed on fishery wastes spent less time flying and exhibited reduced diving effort, and despite the lower calorific value of fishery wastes, compared to natural prey, they showed high survival (Grémillet et al., 2008). These examples indicate that fishery wastes may serve as a predictable and easy-to-access food source, allowing birds to satisfy energy requirements with reduced foraging costs (but see Oro et al. (2013) for potential adverse effect of such predicable food source from human). In contrast, breeding cape gannets showed increased diving effort in an attempt to provide their young with higher-quality natural prey, rather than abundant but lower-quality fishery waste, in the face of scarcity of natural prey (Grémillet et al., 2008). A few studies have shown that parents of some species of seabirds collect higher-quality food for provisioning offspring than for feeding themselves (Davoren and Burger, 1999; Hodum and Hobson, 2000; Cherel, 2008). Taken together, it might be suggested that, for some populations, the quality of fishery wastes is good enough for non-breeders that must meet only their own energetic needs to survive, but not for breeders faced with the higher energetic demands associated with raising chicks (but see, e.g. Garthe et al., 1996, Furness, 2003, Yorio and Caille, 2004).

It is widely accepted that both the quality and quantity of food fed to seabird chicks has a strong influence on growth patterns and survival rates (Barrett et al., 1987; Croxall et al., 1988; Becker and Specht, 1991; Weimerskirch and Lys, 2000). A large quantity of food alone can enhance growth rate and development of vital organs, as well as accumulation of fat deposit in seabird chicks, resulting in greater fledging mass (Takenaka et al., 2005). Most studies on seabirds have shown that heavier or larger chicks have a higher likelihood of fledging success and post-fledging survival (Perrins et al., 1973; Phillips and Furness, 1998; Sagar and Horning, 1998). Therefore, it would be advantageous for parent birds to increase the quantity of food delivered to chicks so long as this can be achieved with limited extra energetic costs. We are unaware of any previous studies that have addressed the potential ecological advantages of foraging with fishing vessels for seabirds raising chicks, in terms of quantity of food delivered to chicks. As shown in previous studies, wide-ranging seabirds can easily locate fishing vessels, up to 30 km away and target them for feeding opportunities (Bodey et al., 2014; Collet et al., 2015), but might only associate with vessels 50% of the time if they have the opportunity to do so (Torres et al., 2013). This indicates that parent birds might choose to forage in association with fishing vessels that produce an easy-to-find and -capture food source in order to deliver more food to chicks. Even if chicks are already well-fed, additional food would be beneficial because chicks may be able to build up additional fat reserves and this could increase post-fledging survival (Phillips and Hamer, 1999).

Northern royal albatross (*Diomedea sanfordi*) is endemic to New Zealand and is classified as Endangered according to the IUCN Red List of Threatened Species (IUCN, 2014). This species has been observed attending fishing vessels for fishery wastes at relatively moderate rates compared to other Procellariiformes (Richard et al., 2011a). Analysis of regurgitations from nestlings of northern royal albatross suggested that some of the main food items were likely obtained by scavenging on discards (Imber, 1999). Like other albatrosses, this species has been reported killed as bycatch in commercial fisheries that use trawl and longline gear (Richard et al., 2011b; Richard and Abraham, 2013; Jiménez et al., 2014). In recent risk assessments of fishery bycatch, northern royal albatross was identified as a species at risk from fisheries in New Zealand waters (Richard and Abraham, 2013) and also in the Western and Central Pacific Ocean (Waugh et al., 2012). Previous tracking studies of northern royal albatrosses clearly show that albatrosses coincide in time and space with commercial fisheries within a window of 25 km and 30 min of fishing events in the New Zealand EEZ during the incubation period