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# Diving behaviour of wildlife impacted by an oil spill: A clean-up and rehabilitation success?

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A B S T R A C T

The value of rehabilitating oiled wildlife is an on-going global debate. On October 5, 2011, the cargo vessel *C/V Rena* grounded on Astrolabe Reef, New Zealand (NZ), spilling over 300 tonnes of heavy fuel oil. As part of the *Rena* oil spill response, 383 little blue penguins (LBP, *Eudyptula minor*) were captured, cleaned, rehabilitated and released back into a cleaned environment. This research investigates foraging behaviour changes due either to the oil spill or by the rehabilitation process by comparing the diving behaviour of rehabilitated ($n = 8$) and non-rehabilitated ($n = 6$) LBPs and with LBP populations throughout NZ. Stabile isotope analysis of feathers was also used to investigate diet. There were no foraging behaviour differences between rehabilitated and non-rehabilitated LBPs and the overall diving behaviour of these LBPs have similar, if not less energetic, foraging behaviour than other LBPs in NZ. This suggests the rehabilitation process and clean-up undertaken after the Rena appears effective and helps justify the rehabilitation of oiled wildlife across the world.


## 1. Introduction

Oil is a significant contributor to the pollution and contamination of the marine environment (Peterson et al., 2003). There are many sources of oil pollution, from natural leakage to large-scale oil spills caused by well blowouts (Jerneloev, 2010; Allan et al., 2012) or marine vessel incidents such as collisions, sinkings or groundings (Wolfaardt et al., 2009; Sammarco et al., 2013). One of the most visible and publically scrutinised effects of an oil spill is the impact on wildlife, with both oiled carcasses and live affected animals on beaches and shorelines (Piatt et al., 1990; Furness and Camphuysen, 1997). Without human intervention, the majority of oiled wildlife will die and of those that survive, many could suffer long term sub-lethal toxic effects of oil ingestion (Fry and Lowenstine, 1985; Burger and Fry, 1993). Seabirds are particularly vulnerable to oiling as external contamination results in exhaustion, drowning and/or hypothermia due to the disruption of their feather structure by oil (Clark, 2001). There have been several notable oil spill events where capture, cleaning and rehabilitation of oiled wildlife has occurred. These include the *Exxon Valdez* oil spill in Prince William Sound, Alaska in 1989 (Piatt and Lensink, 1989; Piatt et al., 1990; Stewart et al., 1991) and the *Prestige* oil spill, off Spain, Portugal and France in 2002 (Garcia et al., 2003). The *Treasure* spill in South Africa in 2000 was renowned for its large scale rescue and rehabilitation of approximately 19,000 African penguins (*Spheniscus demersus*) as well as the pre-emptive capture and relocation of 19,500 unoiled penguins to Cape Recife (800 km away from the spill) to prevent them from becoming oiled (Crawford et al., 2000; Wolfaardt et al., 2008). The *Deepwater Horizon* oil spill in 2010, at the Macondo oil well in the Gulf of Mexico, resulted in 250,000–400,000 tonnes of oil spilled over three months (Jerneloev, 2010; Allan et al., 2012). The most impacted wildlife species during this spill was the critically endangered Kemp's Ridley turtle (*Lepidochelys kempii*), with 500 found dead or debilitated. Not all turtles affected had obvious signs of oiling and indirect effects from the oil spill response may also have caused some impacts. 70,000 turtle eggs were transported to the east of Florida to reduce exposure to the oil and to hopefully assist recruitment in the next cohort (Safina, 2011).

In many countries, the presence of oiled and distressed birds on coastlines results in oiled wildlife response operations to rescue and rehabilitate these oil-contaminated birds. Although numerous oiled wildlife responses have occurred over the past 30 years (Newman et al., 2003), there is controversy surrounding a response regarding the effectiveness of rehabilitation as a conservation tool (De la Cruz et al., 2013). Opponents of oiled wildlife response argue that rehabilitation is an expensive anthropogenic need to lessen the stress of oiled wildlife and has very little or no conservation value (Sharp, 1996; Wolfaardt et al., 2009). In contrast, proponents argue that it is a worthy animal welfare and conservation tool that contributes to the post-spill recovery of populations with many recent studies showing effective post-release survival (i.e. Barham et al., 2006; Altwegg et al., 2008) and reproduction rates (i.e. Wolfaardt et al., 2009) often equivalent to non-oiled, non-rehabilitated control animals (i.e. Altwegg et al., 2008). Importantly, the arguments for or against rehabilitation, with respect

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to post-release survival and reproduction of rehabilitated wildlife, is based on only a few post-release monitoring studies (De la Cruz et al., 2013). This highlights the need for continued longer-term post-release monitoring surveys to better determine survival, behavioural changes and reproductive rates of rehabilitated wildlife (Parsons and Underhill, 2005; Wolfaardt et al., 2009).

On October 5, 2011, the *C/V Rena* grounded on the Astrolabe Reef, Bay of Plenty, New Zealand (NZ), spilling over 300 t of heavy fuel oil and cargo. Over 2000 animals were recorded to die during the oil spill and clean-up process, while 383 little blue penguins (LBP, *Eudyptula minor*) and other bird species were captured, cleaned, rehabilitated and released back into a cleaned environment (Sievwright, 2014). Penguins are unique during oil spills because they can be impacted at multiple 'oiling points' due to their lifestyle — i.e. in the sea while foraging, on the coastline when coming ashore on foot and by passing oil to their cohorts in the nest. A two-year post-release research programme to monitor survival and productivity of both oiled/rehabilitated and non-oiled/non-rehabilitated LBPs was undertaken (Sievwright, 2014). Findings from this research showed that the survival was reduced for both groups in the first six months following the spill and clean-up process however, the survival probabilities of both groups increased thereafter and remained high and stable over the two year period (Sievwright, 2014). Monitoring of the breeding success of the same groups found that productivity of rehabilitated penguins was slightly reduced in the year after the spill compared with non-rehabilitated pairs. However, these reductions were within ranges reported for other LBPs throughout Australia and NZ (Sievwright, 2014). These findings suggest the cleaning/rehabilitation process was effective at treating and reversing most negative effects of oil-contamination on the post-release survival and productivity of rehabilitated penguins. One of the factors not investigated during the monitoring research, and a factor never previously studied for oil rehabilitated wildlife, is the potential changes in foraging behaviour due either to the effects of the oil spill in the environment or by the rehabilitation process for LBPs. Here we investigate the diving behaviour and diet (using feather stable isotope analysis) of rehabilitated and non-rehabilitated LBPs to compare their diving behaviour both between the two groups and with other LBPs populations throughout NZ. The objective of this research is to investigate if foraging behaviour changes occurred for the C/V Rena rehabilitated LBPs due either to the oil spill or by the rehabilitation process.

## 2. Material and methods

### 2.1. Little blue penguins

Little blue penguins are the smallest penguins in the world, reaching approximately 40 cm in length and 1 kg in weight as an adult (Robertson and Heather, 2005). During the day, LBPs forage in shallow coastal waters feeding on squid and a variety of small shoaling fish (Gales and Green, 1990; Gales and Pemberton, 1990; Flemming et al., 2013). Their foraging area is usually restricted to within 20 km of their nest or roost sites, however there is variation in foraging destinations and trip lengths depending on time of year and food availability (Ropert-Coudert et al., 2009; Chiaradia et al., 2010; Flemming et al., 2013). LBPs are considered epipelagic, shallow divers (i.e. they forage in the uppermost part of the ocean where there is sufficient sunlight to allow photosynthesis to occur and visual prey capture; Chiaradia et al., 2007). LBPs generally breed September to February, however timing can vary with latitude and between years (Gales, 1985). Eggs are laid in burrows or under other covered areas including rocks, vegetation, driftwood and in artificial structures such as wooden nest boxes and drain pipes (Perriman and McKinlay, 1995). Generally, two eggs are laid with incubation lasting approximately 35 days (Chiaradia and Kerry, 1999) with chicks constantly brooded by their parents for 21 days after hatching. Both parents undertake incubation and brooding with one parent out foraging while the other incubates or guards the chicks until chicks can thermoregulate, at which time they are left alone during the day and are only visited at night to be fed (Williams, 1995).

### 2.2. Study sites and animal captures

The diving behaviour of LBPs was examined at Leisure Island/Moturiki, Mt Maunganui, Tauranga, NZ (37° 37′51″S,176° 11′06′E; Fig. 1) in late October 2014 during their egg incubation stage of breeding. Leisure Island is a 3.1 ha rocky island that is 100 m offshore and connected to the mainland by a 20 m wide strip of sand. The island is predominantly covered in grasses, scrub and short native bush. There are an estimated 100 LBP nests on Leisure Island (Sievwright, 2014). The island and surrounding area was oiled during the *C/V Rena* and in total 383 LBPs were captured, cleaned and rehabilitated, with 347 of these released back on to the island and surrounding areas after being microchipped so they were identifiable as penguins that had been rehabilitated (Allflex Compact Pocket Microchip). Concurrently 361 penguins from the same area that were not oiled during the oil spill were also captured and microchipped to be incorporated into the post-release monitoring study as "control" animals.

Twenty penguins (10 rehabilitated and 10 non-rehabilitated) were captured and tagged with time-depth recorders (TDRs, Lotek LAT1400, 6 g, 30 × 10 mm) and VHF transmitters (3 g, 20 × 8 mm, Sirtrack, Havelock North, NZ). To aid in streamlining, the recorders and transmitters were taped together before being attached to the lower back of the

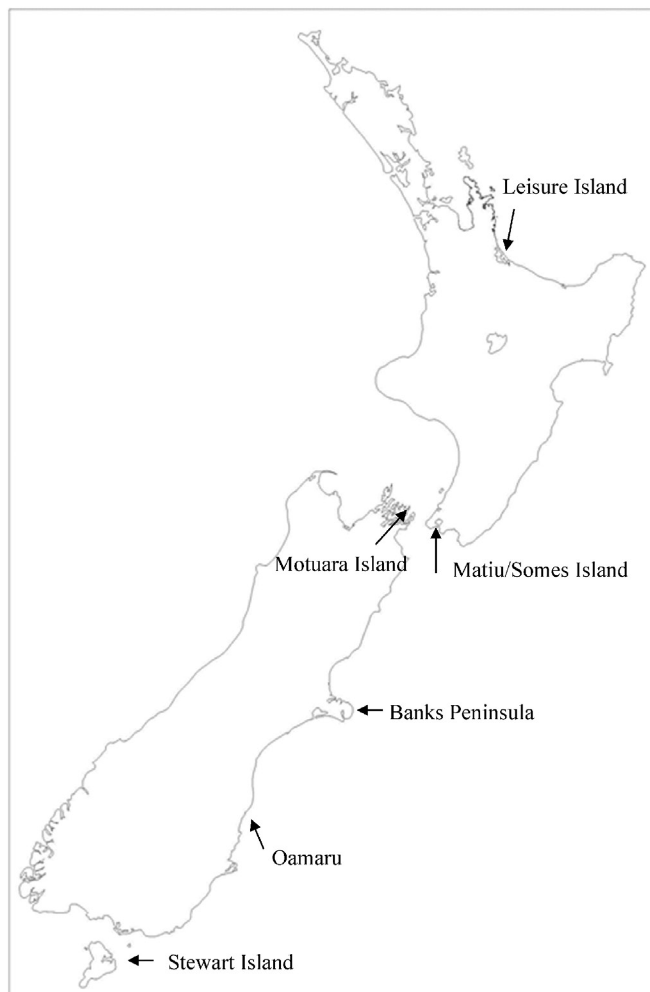


**Fig. 1.** Map of New Zealand showing all locations where the foraging behaviour or stable isotope analysis of little blue penguins (*Eudyptula minor*) have been studied.