

LEG-LOOP HARNESS DESIGN FOR ATTACHING EXTERNAL TRANSMITTERS TO SEABIRDS

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SUMMARY

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Many techniques have been used to attach telemetry equipment to wild birds for both short-term (single-season) and long-term (multiple-season) studies. Most attachment techniques designed for long-term retention of transmitters by seabirds have used a backpack style chest harness. This approach may cause discomfort and irritation under the wing. We describe a new leg-loop harness technique that we employed with mixed success on two polar-nesting seabirds: South Polar Skuas *Catharacta maccormicki* and Northern Fulmars *Fulmarus glacialis*. The appropriateness of this or any harness package is species-specific, and we experienced differing results—the leg-loop harness performed satisfactorily with skuas, but nest abandonment and probable adult mortality were the rule in fulmars. We believe the leg-loop design offers a suitable alternative to chest harnesses for some species and telemetry applications.

Key words: Northern Fulmar, *Fulmarus glacialis*, South Polar Skua, *Catharacta maccormicki*, transmitter attachment, harness design, behavioral effects, reproduction, survival

INTRODUCTION

Research from oceans around the world has demonstrated that seabirds are effective indicators of marine ecosystem conditions, but most information has come from colony-based studies because of the challenges of following seabirds while they are at sea (e.g. Cairns 1987, Frederiksen *et al.* 2006). However, recent technological advances and miniaturization in telemetry equipment have allowed new insights into marine bird movements and ecology (Jouventin & Weimerskirch 1990, Phillips *et al.* 2003, Shaffer *et al.* 2003). This information has included data on environmental variables during flight, behavior while away from the colony, and the remarkable distances birds travel to forage and migrate (e.g. Weimerskirch & Wilson 2000, Shaffer *et al.* 2006). These types of data improve our understanding of animal energetics and effects of environmental stress, and also assist in identifying key marine habitats (e.g. Tremblay *et al.* 2005).

Many types of attachment techniques have been used for short-term (single-season) applications, including gluing, taping or cable-tying devices to feathers or skin (e.g. Raim 1978, Anderson *et al.* 2004, Votier *et al.* 2004). Long-term (multiple-season) applications have included implanting transmitters surgically (e.g. Meyers *et al.* 1998, Hatch *et al.* 2000), attaching devices to bands (e.g. Weimerskirch & Wilson 2000, Phillips *et al.* 2003) or attaching them with harnesses (e.g. Nicholls & Warner 1968, Dwyer 1972, Amlaner *et al.* 1978, Rappole & Tipton 1991, Falk & Møller 1995, Nicholls *et al.* 2002). Despite the utility of these techniques, the response of various birds to the attachment of devices varies considerably. Some seabirds respond well to small attachments (e.g. Croll *et al.* 1992), and others exhibit altered behavior (Wilson *et al.* 1986, Wanless *et al.* 1988, Ristow *et al.* 2000, Söhle *et al.* 2000) or increased mortality (Hatch *et al.* 2000). For example, albatrosses and petrels are a group of seabirds

that rely heavily on aerodynamics and are particularly sensitive to factors that disrupt their proper wing loading (Warham 1990). Thus, devices used on procellariiform birds may have to be particularly small (<3% body mass) and attached without harnesses to minimize effects on behavior or reproduction (Phillips *et al.* 2003).

In this paper, we describe a harness technique that we used to deploy VHF and satellite transmitters on two seabird species, with varying success. The technique has the advantage of not affecting the chest and wings, which is thought to create discomfort during flight for seabirds (Phillips *et al.* 2003) and to cause under-wing irritation (Anderka & Angehrn 1992).

METHODS

As part of a study on the ecology of high-arctic Northern Fulmars *Fulmarus glacialis* nesting at Cape Vera, Devon Island, Nunavut (76°15'N, 89°15'W; Mallory *et al.* 2008), we required an effective means of attaching transmitters for up to two years. This species is prone to abandon nests upon handling (e.g. Falk & Møller 1995). At high latitudes with 24-hour sunlight, geolocator technology (e.g. Weimerskirch *et al.* 2002) would not allow us to assess local movements, and so we elected to use VHF and satellite transmitters.

In 2003, initial trials attaching transmitters to fulmars using traditional, backpack-style techniques were unsuccessful. Birds immediately abandoned their nests and moved out of VHF receiver range (or possibly died). In 2004, we tried a modified version of a figure-eight leg-loop harness to attach transmitters to Northern Fulmars at Cape Vera and to South Polar Skuas *Catharacta maccormicki* in a separate project examining movements of breeding skuas near Palmer Station, Antarctica (64°46'S, 64°03'W). This technique was previously designed to attach transmitters to

passerines (Rappole & Tipton 1991) and had been modified for shorebirds (Sanzenbacher *et al.* 2000), but to our knowledge, leg-loop-style harnesses had not been deployed to attach telemetry equipment to seabirds or to any bird species over 80 g. In June and July 2004, we used a three-metre noose pole to capture 17 incubating fulmars. After capture, we attached 11 VHF transmitters and six satellite transmitters using the leg-loop technique (Table 1). In June 2005, we attached another two satellite transmitters to incubating fulmars (Fig. 1), and in January 2005, we used the same technique to attach two transmitters to incubating skuas in Antarctica. Both skuas were captured on their nest by a researcher who approached them and placed a hoop landing net (50×100 cm, 1.5-m handle) over them.

Harness and attachment procedure

The leg-loop harness method consisted of a 100-cm starting length of Teflon tape (Bally Ribbon #8476, Natural Brown, 6.35 mm width: Bally Ribbon Mills, Bally, PA, U.S.A.) which was either threaded through the three mounting loops built into the rectangular satellite transmitters (one top loop and two side loops, Fig. 2) or folded in half whereby the bight in the tape was pushed through a length of heat-shrink tubing (approximately four centimetres, used to encapsulate the cylindrical VHF tags) leaving an eyelet at the top of the tag. In the latter case, the tailing ends of the tape were then fed through the eyelet to create two leg-loops; the heat-shrink tubing added approximately three grams to the transmitter package. In either case, the two leg-loops that were formed were slipped over each leg of the bird and cinched down snugly and evenly at the transmitter, until only a “small” finger could be easily slid under both of the leg-loops. We ensured that no primary or rectrix feathers were caught in the leg-loops, and we also confirmed good blood circulation by pressing the foot with a fingertip and watching for rapid blood vessel refill. The transmitter rested over the lower back and synsacrum area anterior to the uropygial gland (Figs. 2 and 3).

A reef knot was tied at the appropriate length and the free ends were clipped and glued using quick-drying glue [i.e. Loctite Superglue (Loctite, (Rocky Hill, CT, USA))] to prevent fraying.

In the case of the rectangular transmitters, quick-drying glue was used to glue the ends directly to the sides of the transmitter. Depending on bird size, the final length of the Teflon tape was approximately 60 cm after trimming. Other non-abrasive materials may be used as harness ligature in place of Teflon tape, but we recommend Teflon tape if the intended harness retention time is greater than a few months. Before releasing the bird, we held it so that it could flap its wings and shake its body. This allowed the harness to fall into a natural position and allowed the researcher to re-check the fit of the harness before release.

RESULTS

Northern Fulmars

In 2004, all 17 fulmars were captured during incubation, and were held for a mean (\pm standard deviation) of 21.7 ± 4.5 minutes (range: 16–35 minutes) during transmitter attachment. Fulmars weighed 754 ± 104 g (range: 620–1000 g), and therefore the different types of transmitters represented $1.6\% \pm 0.7\%$ (range: 0.9%–2.9%) of adult body mass (without Teflon tape, which would add another 0.4%). Upon release, fulmars flew out of sight, and so we could not assess their immediate responses to the transmitters.

The VHF transmitters sent information for eight days on average and for a maximum of 19 days (Table 1). However, those estimates must be regarded as the minimum for transmitter attachment, because the birds could have abandoned their nests and moved out of range of the receiver while still transmitting data. Fulmars with satellite transmitters fared better; data were received for two to 32 weeks, although only two birds transmitted for more than 100

TABLE 1
Characteristics of transmitters attached using a leg-loop method to
Northern Fulmars *Fulmarus glacialis* and South Polar Skuas *Catharacta maccormicki*

Quantity	Species	Manufacturer	Model	Dimensions (mm)	Mass (g)	Retention time [mean days (range)]	Effects on birds
3	Fulmar	Microwave Telemetry ^a	PTT-100	62×18×12.5	18 (44–199)	106	1 of 3 birds continued to incubate; all nests failed; none of these birds returned in following year
3	Fulmar	Microwave Telemetry ^a	PTT-100	54×18×17	20	91 (14–226)	1 of 3 birds continued to incubate; all nests failed; none of these birds returned in following year
11	Fulmar	Lotek Wireless ^b	MBFT-4	11×43	7.7 (1–19)	8	2 of 11 birds continued to incubate; none of these birds returned in following year
2	Fulmar	Northstar Science and Technology ^c	PTT-100	50.8×22.6×16	20	238	Both birds continued to incubate; 1 nest failed; transmitters still functioned until battery failure
2	Skua	Microwave Telemetry ^a	PTT-100	54×18×17	20	45	Recaptured and removed; no sign of feather wear, abrasion or discomfort; continued rearing young

^a Columbia, MD, USA.

^b Newmarket, ON, Canada.

^c King George, VA, USA.

days. However, we were unsure whether two of the three solar-powered transmitters were still functioning during fall migration, because the solar chips could have been covered by back feathers and thus prevented from recharging at high latitudes. We suspected that problem for two reasons: First, one fulmar with a solar-powered transmitter sent data for 199 days, but those data were much more sporadic than were the data for the fulmar with a battery-powered transmitter, suggesting insufficient solar charging. Second, in 2005, we noticed that fulmars effectively preened feathers over transmitters, such that it was impossible to detect the transmitter were it not for the antenna (Fig. 1).

Of the 17 fulmars to which transmitters were attached in 2004, only four (24%) continued to incubate their egg for at least a week, and only one (6%) appeared to rear a chick. Nest predation could have influenced abandonment. At least four eggs disappeared from nests that could be observed from the top of the cliff on the same day a transmitter was deployed. In 2005, none of the 17 birds instrumented the previous year returned to their nest sites.

In 2005, to minimize the risk of abandonment, we paid greater attention to capturing birds when both members of the pair were present at the nest during incubation (i.e. one mate would stay at the



Fig. 1. A Northern Fulmar *Fulmarus glacialis* equipped with a satellite transmitter. Note antennae extending from just anterior to the tail, and that the transmitter is completely covered by back feathers.

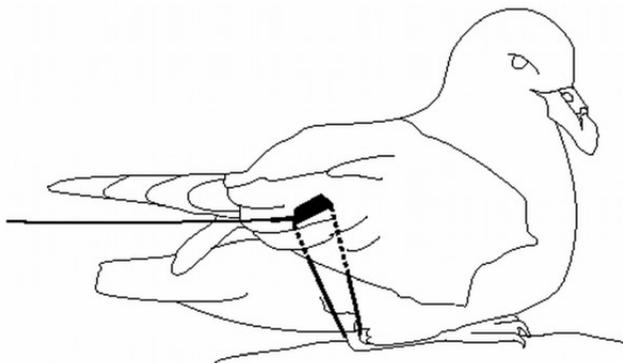


Fig. 2. Schematic of the leg-loop harness attachment to a Northern Fulmar *Fulmarus glacialis*, with Teflon tape loops extending around each leg, and the transmitter resting anterior to the uropygial gland.

nest while we captured the other for transmitter attachment). Two birds were captured and fitted with transmitters as in 2004. One bird continued to attend its nest site into chick-rearing; the other lost its egg within a week after being released. A replacement egg was twice added to the latter nest and each was incubated, but eventually the nest failed during late incubation. Data on movements from both birds harnessed in 2005 continued to be transmitted for 238 days, at which time batteries failed.

We did not conduct detailed time–activity budgets to compare the behaviours of birds at the nest before and after transmitter attachment. However, we did monitor the birds at their nest sites following transmitter attachment, and intermittently if a bird was on the nest in the following weeks. Once the feathers near the transmitter were preened into place, birds did not appear to spend greater amounts of time in comfort movements or preening as compared with nearby breeding birds lacking transmitters.

South Polar Skuas

In 2005, two skuas were captured during incubation and were held for ≤ 20 minutes during transmitter attachment. In both cases, the non-telemetered mate returned to the nest site during attachment, which likely prevented any egg loss. Both telemetered skuas flew directly to nearby freshwater ponds to bathe and preen after tag attachment, returning to the nest site within 20 minutes.

Telemetered skuas were resighted and their nest contents were checked at least once each week following tag attachment. Both pairs reared young. No obvious change in behaviour was observed, although we did not conduct time–activity budgets to compare the behaviours of birds at the nest before and after transmitter attachment. Telemetered skuas were recaptured, and the tags were removed 45 days after deployment. In both cases, no signs of feather wear or skin abrasion were observed.

DISCUSSION

The responses of Northern Fulmars and South Polar Skuas to transmitters attached with leg-loop harnesses differed considerably. Our initial attempts with fulmars resulted in altered reproductive

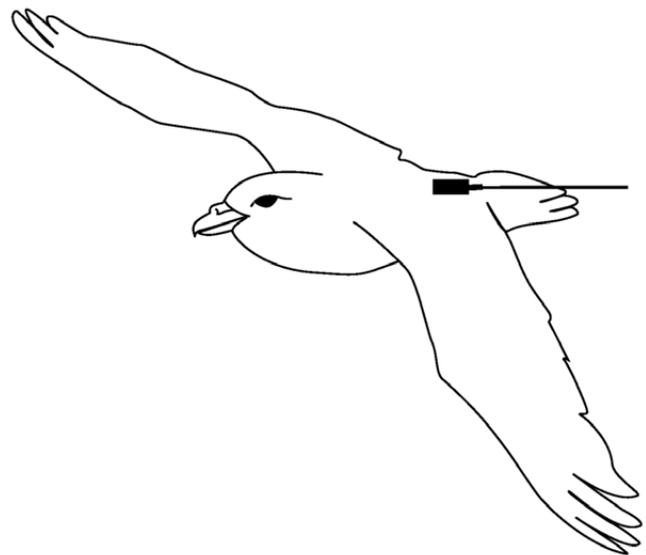


Fig. 3. Schematic of the position of the transmitter attached using the leg-loop harness, on a flying Northern Fulmar *Fulmarus glacialis*.

behaviour through immediate nest abandonment and possibly in death. However, in 2005, we refined our technique, notably minimizing the chances of nest depredation during the period after transmitter attachment, and pairs continued to incubate their eggs. Those deployments furnished data until the batteries died in the winter (Mallory *et al.* 2008). Attachment to skuas worked well, with skuas continuing normal breeding activities during deployment and after transmitters were removed (although we did not monitor them for a long period). After completing our field seasons, we found that another researcher, who developed the leg-loop technique for use on seabirds independently, had good success with long-term tracking of Pomarine Jaegers *Stercorarius pomarinus* (Troy 2007) and Glaucous Gulls *Larus hyperboreus* (US Satellite Laboratory 2006) in Alaska. In 2008, we had good success with this technique tracking two Herring Gulls *Larus argentatus* (MLM unpubl. data), but poor success with three Black-legged Kittiwakes *Rissa tridactyla* (A.J. Gaston pers. comm.). Nonetheless, the main limitations with this technique appear to come from attaching transmitters to fulmars, perhaps because of issues similar to those previously reported for telemetry of other petrels (Phillips *et al.* 2003).

Most Northern Fulmars (79%) deserted their nests within 14 days of transmitter attachment. Arctic fulmars commonly abandon their nests even after routine handling (i.e. banding, MLM unpubl. data). Furthermore, fulmars have poor reproductive success and high rates of nest abandonment even under natural circumstances in which they are not disturbed (Hatch & Nettleship 1998). The rate of abandonment we observed using the leg-loop harness with fulmars was typical of routine handling at our study site (MLM unpubl. data) and not higher than expected compared with other fulmar telemetry studies (e.g. Falk & Møller 1995).

Two other studies have been published in which transmitters were attached to fulmars, but lack of a standardized protocol rendered them not directly comparable to ours. Falk & Møller (1995) had 100% nest desertion for fulmars in East Greenland to which transmitters were attached with a harness during incubation (as in our study), but they used 48-g transmitters representing 4.7%–5.5% body mass (i.e. 2.1–4.5 times heavier than the range of the devices we used). Phillips *et al.* (2003) suggested that problems occur for many albatrosses and petrels when transmitters heavier than 3% body mass are attached, contrary to the accepted “5% criterion” (Caccamise & Hedin 1985). Thus, the mass of the transmitters may have contributed to desertion in the Greenland study. In contrast, Weimerskirch *et al.* (2001) found no desertions by fulmars equipped with transmitters of a similar size to ours (20–30 g), but they attached the devices to chick-rearing birds and used cable ties and epoxy. Based on parental investment theory, birds that are closer to realizing reproductive success in a breeding season should risk more to rear their offspring (Montgomerie & Weatherhead 1988), so the timing of the manipulations could explain the high success in the study by Weimerskirch *et al.* (2001). In support of that hypothesis, Falk & Møller (1995) also found that chick-rearing fulmars returned earlier to the nest after transmitter attachment than did incubating fulmars.

One of the problems with working on High Arctic fulmars is that any handling of the bird, even banding efforts, usually results in the manipulated bird moving off its nest for a period of a few hours, and this period is often long enough for avian predators, usually Glaucous Gulls, to find and depredate the exposed egg. Falk & Møller (1995) replaced fulmar eggs with dummy eggs to

prevent this problem, something we did not do. Thus, it is unclear whether the desertion rates found in their study and ours were attributable to effects of the transmitters and harnesses or to a response to depredated nests. However, we also found 100% nest abandonment among 18 fulmars captured in early incubation to which we glued small (less than four grams) VHF transmitters to back feathers. Given that those birds had lightweight transmitters and no harnesses, we suggest that nest abandonment may be more related to stage of breeding or nest predation than to the direct effects of transmitter attachment (by any technique). Had our interest been solely migration and wintering movements of birds, attaching transmitters during chick-rearing might have overcome some of the problems we encountered, as occurred for Falk & Møller (1995) and Weimerskirch *et al.* (2002). We caution, however, that most fulmars to which any type of transmitter is attached do not return to breed the following year, and thus reproductive success in both the current and the subsequent year can be markedly reduced by handling or telemetry. Given that fulmars exhibit high mate- and nest-site fidelity (Hatch & Nettleship 1998), the fact that we did not observe any of the birds telemetered in 2004 at their nest sites in 2005 suggests most of them failed to return to the colony and may have died.

A second problem we encountered was the effectiveness of solar-powered transmitters. These units may be unsuitable for polar seabirds at very high latitudes. They appear to be susceptible to inadequate recharging, perhaps because of frequent poor-light conditions in fog over water, and less intense or less direct light exposure at high latitudes. However, we also believe that we could have used more padding under the transmitter to keep it above the deep down and contour feathers of the fulmars (Fig. 1), which might have helped solar recharging. Researchers may wish to clip back feathers immediately around the transmitter to prevent solar cells from being covered.

Despite the high rate of nest desertion we observed after attaching telemetry equipment to fulmars, we believe that the leg-loop harness has utility as a technique to deploy such equipment on certain seabirds, notably the Laridae. Our data on skuas and those from Glaucous Gulls support that conclusion.

To our knowledge, the work by Troy (2007) is the only other study to use harness attachment methods with skuas. However, two other studies involving transmitter attachment to skuas used other techniques. In one study examining South Polar Skuas during three consecutive chick-rearing periods (2000–2003, W. Fraser unpubl. data), short-term (harness-free) attachment methods were explored. Transmitters were attached to back feathers, which proved unsuccessful because the birds eventually preened the tags off. In the second study, cable ties were used to mount seven 10-g VHF tags on the central pair of tail feathers of Great Skuas *Stercorarius skua*, with no apparent effects on breeding or foraging behaviour (Votier *et al.* 2004). Similarly, we tail-mounted nine-gram VHF transmitters on 13 South Polar Skuas during our 2004 study and found the same benign results that we had observed with the harnessed individuals. We suggest that tail-mounting is the most appropriate method for skuas in short-term applications with lightweight transmitters (1% or less of body mass); the leg-loop harness is an effective attachment method when transmitters are required to remain in place for more than one month, or in cases in which the transmitter would be too heavy or awkward to affix to tail feathers (i.e. satellite transmitters).

Based on our study and on research with two additional species in Alaska (Troy 2007, US Satellite Laboratory 2006), the use of the leg-loop harness in deploying transmitters on certain seabirds (notably skuas and gulls) appears to be an effective solution for long-term tracking that avoids undue physical discomfort [e.g. irritation and abrasion to the wings, commonly observed with traditional backpack style chest harnesses (Anderka & Angehrn 1992)]. The method has shown no obvious negative effects on four of five larid species on which it has been used. In contrast, although we used it successfully in tracking the migration of High Arctic fulmars (Mallory *et al.* 2008), attaching transmitters with this technique clearly reduced fulmar reproductive success and may have caused the deaths of many adults. For sensitive species such as fulmars (and possibly other petrels—Phillips *et al.* 2003), further investigation is needed into the effects of transmitters on reproductive success and survival, including specifically

- the possible physiological effects of carrying a transmitter (Irvine *et al.* 2007);
- the effect of breeding stage (i.e. chick-rearing stage as compared with incubation stage) at the time of transmitter attachment on risk of abandonment; and
- the efficacy of reducing nest predation (e.g. using dummy eggs) during transmitter attachment procedures.

Pending completion of such studies, we caution against the use of harnesses (leg-loop style, or other) for attaching transmitters to fulmars.

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