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Growth of seaweed species on GLS logger attachments

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Tracking seabirds with Global Location Sensors (GLS) is a well-established method for assessing year-round movements and behaviour (Strøm *et al.* 2021; Wakefield *et al.* 2009). With the current and future planned expansion of offshore wind farms (OWFs) around the North Sea, tracking studies in recent years have used loggers including GLS to quantify potential impacts of this expansion in the marine space on seabirds (Peschko *et al*. 2020; Pollock *et al*. 2021). In such studies concurrent monitoring of potential tagging effects is important to 1) ensure that there is minimal impact on bird condition and behaviour, and 2) to ensure that arising data are meaningful, i.e., are reflective of 'natural' behaviour. Common Guillemots *Uria aalge* (hereafter 'Guillemot'), are a commonly tracked seabird species in studies quantifying potential impacts on seabirds due to likely impacts of OWFs on their foraging behaviour (Furness *et al*., 2013; Peschko *et al*., 2024). Despite the frequency of studies fitting Guillemots with GLS, studies reporting the potential or realised tagging effects in this species are rare (e.g. Bennett *et al.* 2024). Here we report a potential source of tagging effects arising from using GLS attachments in Guillemots.

From 2017 to 2019, Guillemots were fitted with MK3006 GLS (Biotrack Ltd, Wareham, UK) at Whinnyfold, Scotland (57°22'59.0"N 1°52'22.9"W) as part of a multi-colony auk tracking study funded by the renewables company Vattenfall investigating interactions with OWFs (see Buckingham *et al.*, 2022). GLS were secured to tarsus-mounted plastic attachment rings via a cable tie. A band of self-amalgamating tape was wrapped around the GLS before being secured with the cable tie to prevent the GLS from slipping free of the attachment (Figure 1).

a) b)

Figure 1. Geolocator attachment rings (yellow) attached to an MK3006 GLS via a cable tie. Self-amalgamating tape is present in between the cable tie and the GLS that is either untrimmed a), or trimmed and ready for deployment, b). White arrows indicate untrimmed self-amalgamating tape in a).

The majority of GLS deployed on Guillemots at Whinnyfold were recovered in the following years (82% by 2022, n = 90/110 GLS deployed in total across all study years). As GLS are archival they must be recovered from birds to obtain data. However, as with most seabird-borne GLS studies, some GLS were not recovered in part due to birds carrying GLS evading subsequent capture attempts, i.e., due to trap shyness, or the target birds not actively breeding. Several previously GLS-tagged Guillemots were observed present at the Whinnyfold colony in 2024 during fieldwork for a separate study deploying further GLS on Guillemots and other seabird species. During this work two Guillemots carrying GLS deployed in 2017 (coloured lime), and 2019 (coloured red) were observed with growths of seaweed species, an *Ulva* sp. and a *Porphyra* sp. respectively, growing from the side of the GLS facing away from the attachment ring in the 2024 breeding season (Figure 2).

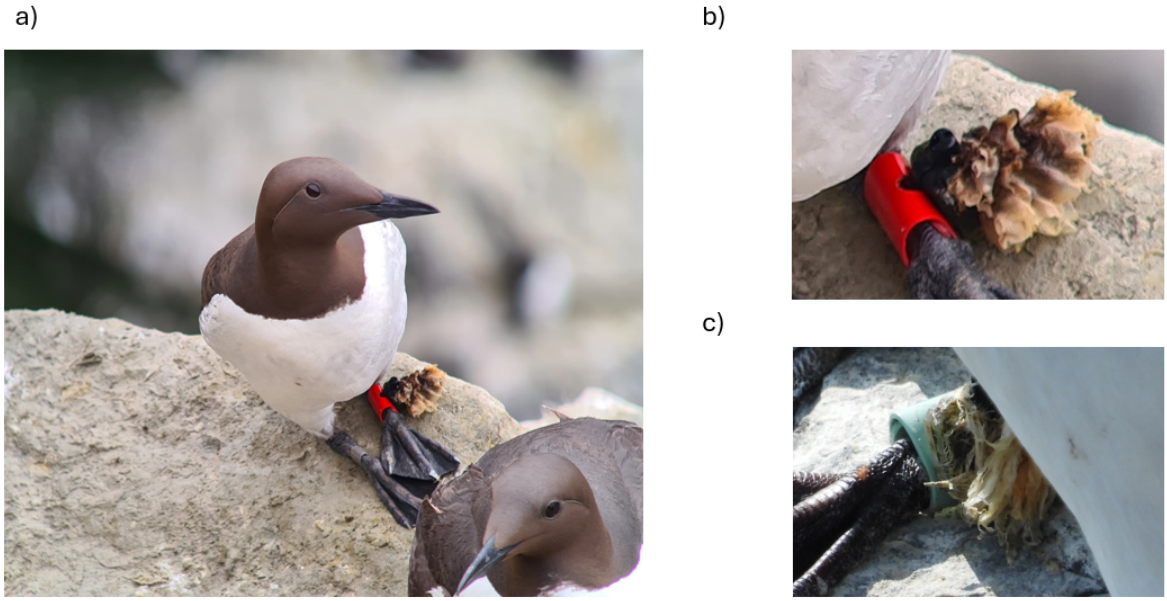

Figure 2. a) Full-size image of *Porphyra* sp., likely Tough Laver *Porphyra umbilicalis* growing on self-amalgamating tape surrounding an MK3006 GLS on a Common Guillemot *Uria aalge*, b) magnified images of this growth, and c) an *Ulva* sp. All photographs taken by Ewan Weston at Whinnyfold on the 2 July (a) and the 8 of May (c) 2024.

Both Guillemots with growth observed on their attachments were actively breeding in 2024. However, despite attempts to recapture the individuals, they could not be recaught. Consequently, confident identification of the seaweed to species was not possible, as for laver sp. and *Ulva* sp. close examination, often using a microscope, is required to achieve this. Speculatively, the two species were identified as a species of laver, likely Tough Laver, *Porphyra umbilicalis,* and an *Ulva* sp. Both are families of seaweed that grow in cold and shallow seas and have a distribution throughout the North Sea and North Atlantic (Bunker *et al.* 2017). Laver species can survive lengthy period of exposure to the air and are generally an annual species, growing to maturity in just a couple of months. As such, the size of growths we observed were unlikely to have been present on the GLS attachments for more than two to three months. In both cases, the growths were no longer present by mid-July. The ledge where both Guillemots were observed has been regularly observed and actively used for various projects in almost all years (2021, 2023, 2024) after the original deployment from 2017-2019. Attempts have also been made in all subsequent years to look for and recapture any birds observed to be carrying a GLS. In no other cases at this site have growths of any seaweed species been observed.

The growth of marine organisms on GLS attachments have been noted previously in seabirds, specifically of barnacles (Dunn *et al*. 2021, ‘acorn’ or *Semibalanus* barnacles; Phillips *et al*. 2007, 'goose' or *Pedunculata* barnacles). Indeed, Dunn *et al*. (2021) reports observations of such growths in the

same cohort of Guillemots at Whinnyfold as this note in 2019. Such growths are likely to be unusual, given the number of GLS that have been deployed on a wide range of seabird species and the relative scarcity of observations of marine biota growths of GLS. However, tagged Guillemots may also be more likely to be found with such growths given that they spend much of their time on and in the sea during the non-breeding season (Bennett *et al.* 2024). This may explain why three out of four reported observations of marine biota growing on GLS attachment in UK seabirds occur in Guillemots. It must also be considered that many seabird tagging sites in the UK are not visited as often as sites such as Whinnyfold and the Isle of May (Dunn *et al.* 2021). At both sites, fieldworkers are present and observing tagged birds for much of the breeding season unlike many other colonies where tagging takes place, so increasing the likelihood of recording observations of marine biota on GLS attachments where this occurs. Further, the lifecycle of many seaweed species in particular results in growths largely between September and March alone (Bunker *et al.* 2017). Consequently, seaweed growths on GLS attachments may occur more frequently than reported, both outside of the breeding season and at colonies where birds are less commonly observed.

As with those other studies reporting growths on GLS the seaweed growths originated from the self-amalgamating tape surrounding the GLS. Clearly, self-amalgamating tape provides a medium for growth suitable for a range of marine species. As discussed in Dunn *et al*. (2021), growth of organisms on loggers and their attachments alters their profile, and therefore may increase drag and so affect the foraging capabilities of Guillemots. Guillemots are a deep-diving species, capable of diving up to c. 180 m (Piatt *et al.* 1985), and so any increases in drag through the water column are likely to have a greater impact on foraging efficiency and dive energetics if growth were sufficient to change the dive profile of an individual. However, given that Guillemots are wing-propelled divers (Gaston & Jones 1998), impacts of growths on attachments on foraging efficiency and diving capability are also likely to be lower than in foot-propelled diver species. Although laver and *Ulva* sp. may reach several metres in length (Bunker *et al.* 2017), given that they are short-lived and that they have delicate basal attachment they are also unlikely to reach a great size before they are either removed by the bird or fall off during diving behaviour and so likely have only short-lived impacts on drag.

MK3006 GLS are rarely able to record data beyond three years, largely due to limitations of battery life. Consequently, it is unlikely that the GLS of both birds observed with seaweed growth were still actively recording data in 2024 (five- and seven-years post-deployment). Given the extent of the seaweed growth, it is likely that the light sensor, and hence location estimations, of the logger would be compromised were growth of this extent to be present during the battery life of the tag. Therefore, we would like to echo those recommendations of previous notes to trim all excess self-amalgamating tape from GLS deployments to prevent any potential for an increase in drag for birds during foraging and migration etc., and to reduce the likelihood of any growth compromising light sensors (Dunn *et al.*2021; Phillips *et al.* 2007). We would also encourage others in the field deploying and retrieving GLS devices to record and report any other observations of marine biota growing on attachments to aid better understanding of the frequency and likely impact of such occurrences.

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