Habitat use of European shags (*Phalacrocorax aristotelis*) at an operational marine renewable energy site during non-breeding

Countries around the globe are increasingly turning to renewable energy technologies to meet their electricity production demands and greenhouse gas emissions reduction targets. However, there are concerns about the negative effects of these technologies on in many cases already struggling wildlife. Seabird breeding numbers in the UK, for instance, have decreased by 9% since 2000, with seabirds contending with decreases in forage fish and more frequent severe storms in addition to being at risk of collision and displacement from offshore renewable energy developments. The UK has a large renewable energy resource in the form of wind, waves, and tides, and is already harnessing these in projects such as Nova Innovation's tidal turbine array at Bluemull Sound, a channel between the islands of Yell and Unst, Shetland. This channel is also used by a declining and vulnerable seabird, the European shag (*Phalacrocorax aristotelis*). Shags are particularly vulnerable to negative interactions with underwater tidal turbines because they can dive up to 61 metres (and therefore within range of tidal energy devices) while foraging and do so in places with strong tidal currents.

Apart from knowing that shags use Bluemull Sound, it is unclear how important the channel is to shag foraging in the area and whether this translates to real, measurable, overlap with the turbine array. Bird-borne biologgers can give very high-resolution information about shag locations (via GPS) and their dive depths (via in-built pressure sensors), however where nests are inaccessible, such as is the case at Bluemull Sound, tracking studies have not been possible. Fortunately, daytime roosts along and near the channel are more accessible and present a unique opportunity to gain rare insights on how shags of all post-fledging ages use the area outside of the breeding season. A team of researchers and ringers was therefore assembled to test the feasibility of catching and deploying biologgers on roosting shags at the site. While fieldwork was originally planned for September 2020, the covid-19 pandemic pushed the project back a year.

Over the course of 2 weeks in mid-September 2021, both single and double panel mist nets (12m long; mesh size of 60x60mm), and a 7.5 x 3.5 m whoosh net were used to catch and deploy 12 GPS-GSM biologgers on four adult, three sub-adult and five juvenile shags at Bluemull Sound (60° 41' 32.679"N, 0° 59' 12.8544" E, Figure 1). The 30 g transmitters (for details: https://www.ornitela.com/30g-transmitter) were attached using the glue mount method to trimmed lower back feathers (Figure 2). Not only were the catching methods trialled a success, the data provided by these 12 individuals will now help to assess what level of risk Nova's turbines pose to the shags, and fill knowledge gaps surrounding how post-fledging shags use tidal channels and their surrounding habitat outside of the breeding season. Preliminary visualization of the tracking data suggests that shags are variable in their use of the channel, that this may be age-dependant, and that they explore areas beyond their breeding season foraging range (Figure 3). This has implications for future tidal energy developments in Shetland and beyond as well as for shag non-breeding ecology. This research is part of a Bryden Centre-funded University of the Highlands and Islands PhD project started in 2018

that investigates how seabirds use strong tidal current environments and the potential for interactions with tidal energy devices.

Natalie Isaksson, November 2021

Figure 1. A shag roost at Bluemull Sound, with a double-panel mist net set-up visible in the bottom left. Photo credit: Samuel Langlois Lopez

Figure 2. Adult European shag with GPS logger attached to lower back. Photo credit: Elizabeth Masden.

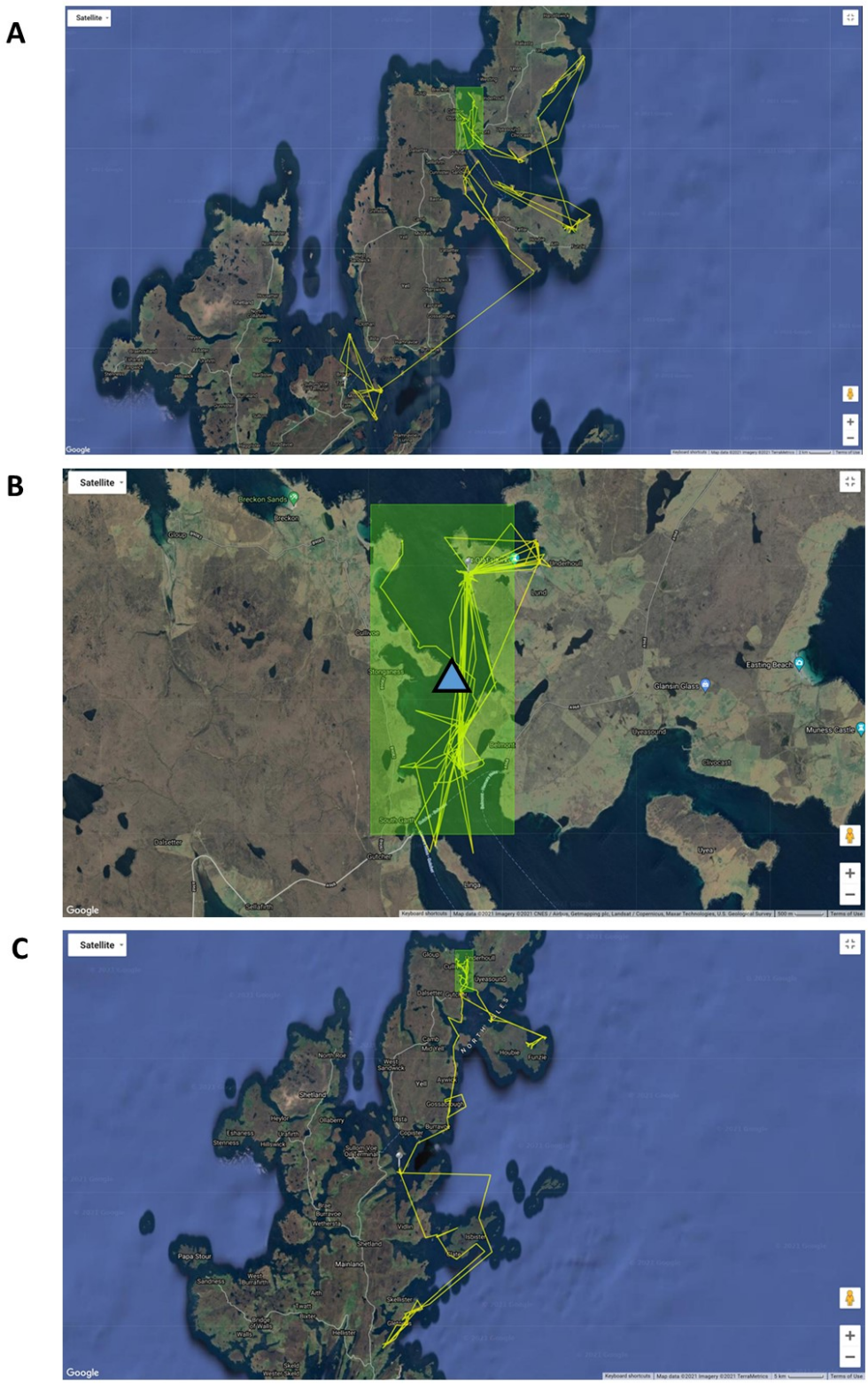

Figure 3. Illustrative GPS tracks from a) a juvenile, b) 2nd year, and c) adult European shag over ca. 2 weeks in September 2021, with Bluemull Sound marked as green rectangle and approximate tidal turbine site marked with blue triangle in b).