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Short Note

Can the Camera Lie? A Nonpermanent Nick in a Bottlenose Dolphin (*Tursiops truncatus*)

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Methods to monitor individuals within marine mammal populations are important for understanding many aspects of their ecology. Long-lasting natural marks have been used in mark-recapture studies to identify individual marine mammals since the 1970s (Würsig & Würsig, 1977) and have enabled researchers to follow individuals over varying temporal scales from weeks to years. Long-lasting natural marks vary across species but commonly include tissue loss (nicks) in dorsal fins of small delphinids (e.g., bottlenose dolphins) or tail flukes of large whales (Hammond et al., 1990), skin colouration in large whales (e.g., Sears et al., 1990), callosities in right whales (Payne et al., 1983), or distinctive pelage patterns in pinnipeds (Hiby & Lovell, 1990). In all cases, photographic-identification (photo-ID) can be used to capture images of the natural marks to match them against a catalogue of known individuals. Identification through natural markings relies on mark longevity, although natural changes are known to occur. For example, as a bottlenose dolphin (*Tursiops truncatus*) ages, its dorsal fin nicks can change. Further, pieces of tissue can be lost and nick shapes can become altered, but, for well-studied populations, good temporal resolution of survey effort generally ensures these changes are tracked. However, to our knowledge, missing tissue from a bottlenose dolphin dorsal fin has never been shown to experience tissue regrowth. Fortunately, for many bottlenose dolphin populations, animals also exhibit other potentially less permanent marks, such as tooth rake scratches and skin lesions, that provide the possibility for matching within and between years (Williams et al., 1993; Wilson et al., 1999; Marley et al., 2013).

The population of bottlenose dolphins off the east coast of Scotland has been part of a photo-ID study since 1990 (Wilson et al., 1999; Cheney et al., 2014). The population is small, approximately 200 individuals, with a high proportion (56%) of dolphins with nicks in their dorsal fins (Cheney et al., 2013, 2014). The animals are resident, and individuals of both sexes have been resighted consistently for more than 20 y. Many individuals show tissue loss on the trailing edge of their dorsal fins that, in many cases, has been permanent for more than a decade (Cheney et al., 2013). In addition, some nonpermanent mark types, such as scratches and skin lesions, have been shown to persist within and across years (Wilson et al., 1999). The well-marked nature of this population gives high certainty to both within and between year individual matches (Corkrey et al., 2008; Cheney et al., 2014).

Advances in marine mammal photo-ID studies have been aided by the advent of digital photography (Markowitz et al., 2003). Digital photography allows the collection of a greater number of images compared to traditional slide film, including more instant feedback in the field and greater options for digital analysis and storage. Digital photography is now used widely, if not exclusively, for photo-ID studies within the marine mammal community. Digital photography has been used exclusively in studies of bottlenose dolphins off the east coast of Scotland since 2002 (Cheney et al., 2014).

Herein, a dorsal fin nick on a bottlenose dolphin that appeared and then disappeared within a day is documented, and the possible causes and implications for those carrying out photo-ID studies are discussed.

Data were collected on 20 June 2011 in an area commonly used by this population during the summer months (Quick & Janik, 2012; Cheney et al., 2013). All research effort took place in sea conditions of Beaufort 2 to 3 at the mouth of the

Tay estuary (56° 28' 04.7" N, 2° 39' 50.4" W). All data were collected from a 7.5-m aluminium boat with a Yamaha 225-hp outboard engine, using standardised photo-ID survey procedures for this population (see details in Cheney et al., 2014). All photographs were taken by NQ, who is experienced with photographing this bottlenose dolphin population, using a Canon 50D and Canon 70 to 200 mm lens that have been used in this study area since 2009. All photographs were 8.0 megapixel JPEGs, had a bit depth of 24, dimensions of 3,456 by 2,304 pixels, and horizontal and vertical resolution of 72 dpi. Images were taken at a fixed shutter speed of 1/1250 s and an ISO of 200. The focal length and aperture (F-stop) were adjusted automatically by the camera using the standard auto-focus settings. At 0846 h (GMT), a group of 12 dolphins (best estimate) were encountered, and attempts were made to photograph all of these individuals. The encounter lasted 80 min, finishing at 1006 h (GMT). Post-processing of all the photographs, including grading the picture quality and initial matching, was undertaken using established project protocols (Wilson et al., 1999; Cheney et al., 2013) by BC, who has accomplished this task for the past 10 y.

Post-processing positively identified 12 individuals (five adult females, one adult male, and six individuals of unknown sex, including four calves), matching the best boat-based estimate. Of these 12 individuals, ten were identified from high-quality fin photographs (see Wilson et al., 1999, for grading criteria). Of these ten individuals, eight (seven adults and one calf) had been previously photographed and were positively matched to identified animals in the catalogue. The remaining two animals (one adult and one calf) were assigned new identification numbers (1121 and 1122) after independent confirmation by two of the authors (BC and NQ). The two remaining animals that were not captured in high-quality fin images were calves, distinguishable by body colouration and size, and captured in echelon position with their assumed mothers.

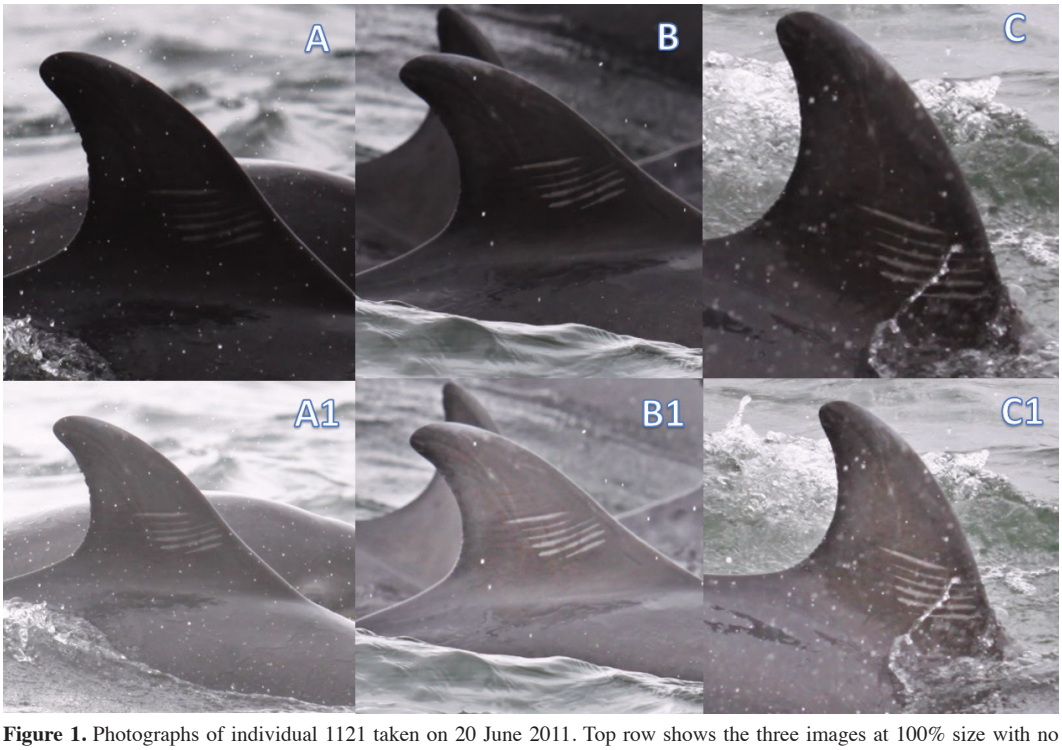

Figure 1. Photographs of individual 1121 taken on 20 June 2011. Top row shows the three images at 100% size with no enhancements. Bottom row shows the same three images with gamma adjustment (Mizroch, 2007) to enhance subtle marks. The first image (A & A1) taken at 0942 h (GMT) show multiple nicks on the trailing edge of the fin. The second image (B & B1), also taken at 0942 h (GMT) but after image A, shows a clean trailing edge. The third image (C & C1), taken at 1047 h (GMT) during a second encounter of the same animal, also exhibits a clean trailing edge. Images A and C are considered high-quality shots; Image B is considered to be of lower quality. Images A1, B1, and C1 clearly show the same fin shape; the teeth rakes and white skin lesions show a convincing match despite the nicks.

Individual 1121 was identified in 15 photographs in this encounter, including three high-quality photos from the left side and one from the right side. All but one of these images showed the animal with a smooth trailing edge of its dorsal fin (Figure 1, Panel B). However, the 11th of the 15 pictures taken of this individual showed a series of nicks down the trailing edge of the fin (Figure 1, Panels A & A1) that appear only in this one photograph. The individual had distinctive scratch marks and lesions on the right side of its fin that allowed apparently unequivocal matching (Figure 1).

Individual 1121 was also captured in high-quality photographs on the next encounter on the same day with no apparent nicks (in a group of, best estimate, 15 individuals; Figure 1, Panels C & C1); and three further trips in 2011, one in 2012, and three in 2013 (Table 1; Supplementary Figure S1 (Supplementary Materials for this short note are available on the *Aquatic Mammals* website: www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147). No nicks were seen on the trailing edge of the fin of individual 1121 in any of the other photographs taken in 2011. No other dolphin matching the picture shown in Panel A of Figure 1 (with the "nicks") has ever been captured in a subsequent high-quality photograph.

A number of explanations can be considered as to the cause of the appearance and then disappearance of the nicks seen in Figure 1, Panel A: (1) the tissue was altered between images; (2) there is some form of temporary structure attached to or obscuring the fin during this one image; (3) the images shown are of two different dolphins, and the marks are not unique; and (4) the image does not show a true representation of the fin.

Several studies across cetacean species have documented the permanent nature (at least over the duration of their studies) of dorsal fin nicks, and they have used these natural marks as the basis for longer-term (across years) individual identification (Smolker et al., 1993; Wells & Scott, 1999; Wilson et al., 1999; Gowans & Whitehead, 2001; Auger-Méthé & Whitehead, 2007). The high-quality photographs of individual 1121 during the two encounters on 20 June 2011 were taken between 0853 and 1047 h (GMT). The ten (three high quality) images before the one taken at 0942 h and the nine (four high quality) images taken afterwards show the animal with a smooth trailing edge of its dorsal fin. Therefore, it seems impossible, within this period of time, that the tissue of the dorsal fin was damaged. There are no obvious signs of fresh laceration, abrasion, or wound. This process also would have needed to occur twice—initially, to create the series of nicks seen in the photograph, and then to smooth out these nicks through further tissue loss. If such a trauma had occurred to the fin, we would expect a jagged rather than smooth fin edge and the presence of blood or pink tissue.

It is possible that some form of temporary structure is attached to or obscuring the fin during this one image. This could be a flap of skin that fell off after this photograph. This seems unlikely as it was not seen in the three photographs prior to the one with the nick. It could also be some form of marine life or flotsam. This again seems unlikely as the transition between the nicks and the main part of the fin appear smooth, and the colouration is consistent. The commensal barnacle *Xenobalanus globicipitis* is known to attach to the trailing edge of cetacean fins (Kane et al., 2008; Carrillo et al., 2015), but there have been no records of barnacles attaching to bottlenose

Table 1. Sighting history of individual 1121, including number of photographs taken and number of high-quality photographs used for positive identification

Date	Trip no.	Encounter no.	No. of photos of individual 1121	No. of high-quality photos of individual 1121	Total photographs taken during encounter
20 June 2011	1424	2776	15	4	153
20 June 2011	1424	2777	5	4	103
28 June 2011	1426	2788	9	4	191
18 August 2011	1439	2857	17	8	100
25 August 2011	1441	2863	1	1	123
14 July 2012	1467	2953	11	2	279
10 June 2013	1503	3124	6	2	223
5 August 2013	1523	3210	2	1	189
10 August 2013	1524	3220	2	2	71

dolphins off the east coast of Scotland. The fin edge may also be obscured by a dolphin or wave behind the animal. Although the head of another animal can be seen directly behind the fin, this dolphin is at an angle where it is unlikely that any part of its fins are directly behind the dorsal fin of individual 1121, and there is no evidence of any other individual present between these two animals. The contrast between the background water (behind the second dolphin) suggests a wave is not causing the nicks seen on the fin, and there are no waves visible between the two animals. There are a number of water droplets in the photograph that may be shadowing or obscuring the fin edge, but to produce this series of nicks from water drops seems unlikely.

If the matching for this individual had relied on a single photograph and a single distinguishing feature, the most likely interpretation would be that the images shown are of two separate animals. However, this individual has multiple other unique, albeit less permanent, marks that can be used for matching, both within the encounters in 2011 (Figure 1) and also across years (see Supplementary Figure S1). The most obvious distinguishing mark is the series of horizontal scratches on the right side of the dorsal fin (Figure 1). Although many individuals have rake marks of this type, the patterning and number vary considerably among individuals. These types of rake marks, although not considered permanent, are commonly resighted on individuals of this population over multiple years (see Supplementary Figure S2). It seems highly unlikely that two individuals could have identical fin shapes and multiple identical tooth rake marks and skin lesions. Fin shape was also consistent across the left and right sides of the individual, and no left hand side image of this individual showed any existence of nicks (Supplementary Figure S3).

In total, we took 153 photographs during this first encounter. If our pictures represent two individuals, then we captured just one photograph of the nicked animal and three high-quality and eleven lower-quality, yet identifiable, photographs of the un-nicked animal. Also, if this was the case, the un-nicked individual was then seen on a further six trips between 2011 and 2013 (Table 1), and the nicked animal was never seen again, despite ten further trips in the same area in 2011. All the other individuals identified during this encounter were also all seen again (on between one and three trips in 2011 and on between three and nine trips from 2011 to 2014). We, therefore, are confident that this is one individual.

During the 25 y of our dolphin photo-ID project, 94% of animals with nicks have been seen in more than one encounter, and no animals with nicks have ever been seen in only one single high-quality photograph. In the first encounter, the group size estimate from the field was 12 individuals. Although we only captured high-quality fin shots of ten animals, the other two animals were calves and were clearly seen multiple times within the encounter photographs. We, therefore, are confident that all animals during the encounter were captured. Urian et al. (2015) state that good image quality is necessary to avoid false positive and false negative matches of individuals. Our study utilises a well-established grading criteria (Wilson et al., 1999) that is one of the two most widely cited lists of criteria for scoring image quality (Urian et al., 2015). The angle of the dorsal fin to the camera can conceal subtle nicks and marks on the trailing edge; however, our grading procedure discounts pictures that are "off-angle," and all the photographs used in this example are considered parallel. We are confident that our grading process is strict and robust to incorrect assignment of an individual through picture quality.

The nicks do not appear to have been produced by a stuck or dead pixel (Savazzi, 2011) or corrected by pixel mapping or resampling. A stuck pixel would appear solid in colour, be in contrast to the surrounding pixels, and would be evident across images. This is not the case here. Similarly, a dead pixel would appear black, which although closer in colour to the dolphin fin, the pattern of nicks seen on the fin edge does not look consistent in shape with a series of dead pixels. Also, these dead pixels would be evident across all the photographs. The 50D camera does not have an inbuilt ability to automatically perform pixel mapping or resampling (Canon Online Support, pers. comm.), and there have been no modifications to any of the images. It may be that something in the lens has produced an artefact on this image, but we would expect this to appear on all images captured during the encounter. The focal length (195 mm) was near the extent of the zoom, and perhaps there is a fault with the lens, but we have a number of other high-quality pictures at this focal length that appear to be true representations of the dolphins.

We believe that the most likely explanation is that the image does not show a true representation of the fin and is caused by some anomaly during the image capture. All our images are JPEG format, and we acknowledge issues associated with artefacts of JPEG compression from RAW image files. We also acknowledge problems with unformatted or old memory cards and older or poorer quality sensors that could result in artefacts or ghosts in an image, especially under extreme light levels and with fast moving subjects. It was suggested by Mizroch (2007) that JPEG format files should not be used in the field for photo-ID as

the JPEG format does not capture the reality of the image nearly as well as the RAW format. Mizroch (2007) states that accurate matching requires accurate presentation of fine marks and scars, that JPEG files do not show fine marks well if the image is too dark or too light, and that JPEG files can show pixel edges when enlarged.

In their recent review of recommendations for photo-ID methods, Urian et al. (2015) state that if image quality is lost during conversion from RAW to JPEG format to an extent that it compromises the matching process, then the marks being considered are probably too subtle. We agree with these recommendations, and our images support that image brightness can enhance marks as can be seen from the subtle fin lesions on the fin (Figure 1). Also, although there are benefits to the RAW format, we do not feel that the nick or the teeth rakes in the image are subtle and, therefore, should not suffer loss through compression to JPEG. JPEG compression may lose subtle marks and pixelate images, which is not what we see in the image in which the nicks are evident and look sharp, and the horizontal scratches can be clearly seen. Our camera, lens, and memory cards were 2 y old, and we reformatted our memory cards regularly throughout the season. However, we cannot rule out that something in the compression process has created this nick as an artefact. If this nick is an artefact as a result of the JPEG compression process, shooting RAW images alongside JPEG images could help to mitigate this potential problem.

In conclusion, we believe that the anomalous photograph is of individual 1121 and that the image is not a true reflection of the fin. However, we remain uncertain as to the exact cause of this anomaly. To determine if this anomaly has been recorded in other dolphin populations, we discussed these findings with a number of experienced photo-ID researchers. Of the seven researchers, none considered the image to be of a different individual, and all agreed that some anomaly in the image capture or compression, or the documentation of a nonpermanent structure around the fin (e.g., water droplets) that is not clear in the image, was a more likely explanation (D. Claridge, Bahamas Marine Mammal Research Organisation, Bahamas; J. Durban, National Oceanic and Atmospheric Administration (NOAA), Southwest Fisheries Science Center, USA; H. Fearnbach, NOAA Southwest Fisheries Science Center, USA; T. Genov, Morigenos–Slovenian Marine Mammal Society, Slovenia; S. Ingram, Plymouth University, UK; K. Parsons, NOAA Alaska Fisheries Science Center, USA; K. Urian, Duke University, USA, pers. comm., March 2016).

The bottlenose dolphins off the east coast of Scotland have high mark rates and well-established individual sighting histories that allowed us to fully scrutinise this photograph and make an evidence-based decision that it is of individual 1121. For consistency, we have not assigned the image with the nick to individual 1121 because we believe the picture quality to be compromised. However, for other marine mammal populations, where individuals are less well marked and/or seen less frequently, or where grading and matching procedures are less stringent, an anomaly like this could be very difficult to spot. This would result in an increased chance of false negative matches that would create "ghost histories" of individuals, leading to overestimates of population abundance and underestimates of survival rates (Yoshizaki et al., 2009; Urian et al., 2015). Investigation of the sighting history of individuals in our population suggests anomalies such as this are not a common problem. Since digital photography commenced, only two nicked individuals have been seen during a single encounter, and none have been captured in only one photograph. Even so, we encourage others to similarly investigate, and we welcome responses that may indicate other possible technical causes for what we have seen.

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