

Potential hybridism between free-ranging Risso's dolphins (*Grampus griseus*) and bottlenose dolphins (*Tursiops truncatus*) off north-east Lewis (Hebrides, UK)

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*Hybrid cetaceans have been documented to occur both in the wild and in captivity. Identifying wild hybrid individuals can be problematic in the absence of genetic techniques, but published accounts indicate that intermediate morphological characteristics are often present. Between 2010 and 2013, a land-based and boat-based study of the Risso's dolphin (*Grampus griseus*) was carried out in nearshore waters around the Eye Peninsula located on north-east Lewis, Scotland. Three atypical individuals were photographed which exhibited morphological features intermediate between *Grampus* and the common bottlenose dolphin (*Tursiops truncatus*). These individuals were typically larger in body size than *Tursiops*, and had a dorsal fin shape and size consistent with *Grampus*. Two individuals had coloration most similar to *Tursiops* and the third exhibited extensive white linear scarring consistent with *Grampus*. The intermediate morphology was most apparent in the head shape, with all three individuals exhibiting a defined (in contrast to *Grampus*) but very short (compared with *Tursiops*) rostrum and two having an unusually steep (compared with *Tursiops*) forehead. On one occasion, one of the atypical individuals was observed within a mixed-species school of *Grampus* and *Tursiops*. There were four further sightings of atypical dolphins associated with *Tursiops*-only schools. Atypical dolphins were not recorded within *Grampus*-only schools. These observations are consistent with hybridization between free-ranging Risso's and bottlenose dolphins, the first such occurrence to be documented for these species in UK waters. The context and significance of these hybridization events are unknown.*

Keywords: cetacean, odontocete, hybrid, morphology, species association, interspecific mating, Atlantic Ocean, photo-identification, *Grampus griseus*, *Tursiops truncatus*

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INTRODUCTION

The north-east Atlantic waters to the north-west of Scotland are inhabited by a diversity of baleen and toothed whale species including the Risso's dolphin (*Grampus griseus*, Cuvier, 1812) and the common bottlenose dolphin (*Tursiops truncatus*, Gervais, 1855) (hereafter referred to as 'bottlenose dolphin'). Both of these species occur through a range of habitats in this geographical region, including deep waters along and seaward of the shelf break and nearshore shallow waters (Weir *et al.*, 2001; Reid *et al.*, 2003).

The regular occurrence of Risso's dolphins in the shallow coastal waters of the Minch (located between Lewis and mainland Scotland; Figure 1) has been well-documented (Evans *et al.*, 1993; Atkinson *et al.*, 1998; Weir *et al.*, 2001; Reid *et al.*, 2003; Dolman & Hodgins, 2013). This species was the focus of dedicated studies around the Eye Peninsula on Lewis during the 1990s (Atkinson *et al.*, 1998) and more

recently since 2010 (this study). Worldwide the Risso's dolphin preferentially occurs over topography with steep-sloped bottoms near the outer edge of the continental shelf or upper slope (Jefferson *et al.*, 2014), and its occurrence in nearshore shallow waters around Lewis is therefore less typical.

Risso's and bottlenose dolphins are seen throughout the Hebrides, but bottlenose dolphins are more commonly recorded from The Little Minch southwards (particularly around Mull, Coll, Tiree, and Barra) while the Risso's dolphin is more frequently observed in The Minch and along the Atlantic seaboard (HWDT, 2014). Studies in the area in the 1990s never observed bottlenose dolphins around the Eye Peninsula (Alison Gill, personal communication). However, recent survey effort (between 2010 and 2013) in the same area has recorded bottlenose dolphins in 2011 and 2012, including some mixed-species associations with the Risso's dolphin (WDC, unpublished data).

The occurrence of mixed-species associations in sympatric cetacean species provides opportunities for interspecific sexual interaction and the potential for hybridization (Bérubé, 2009). Although infrequently observed, hybrids between various odontocete species have been recorded, both in the wild and

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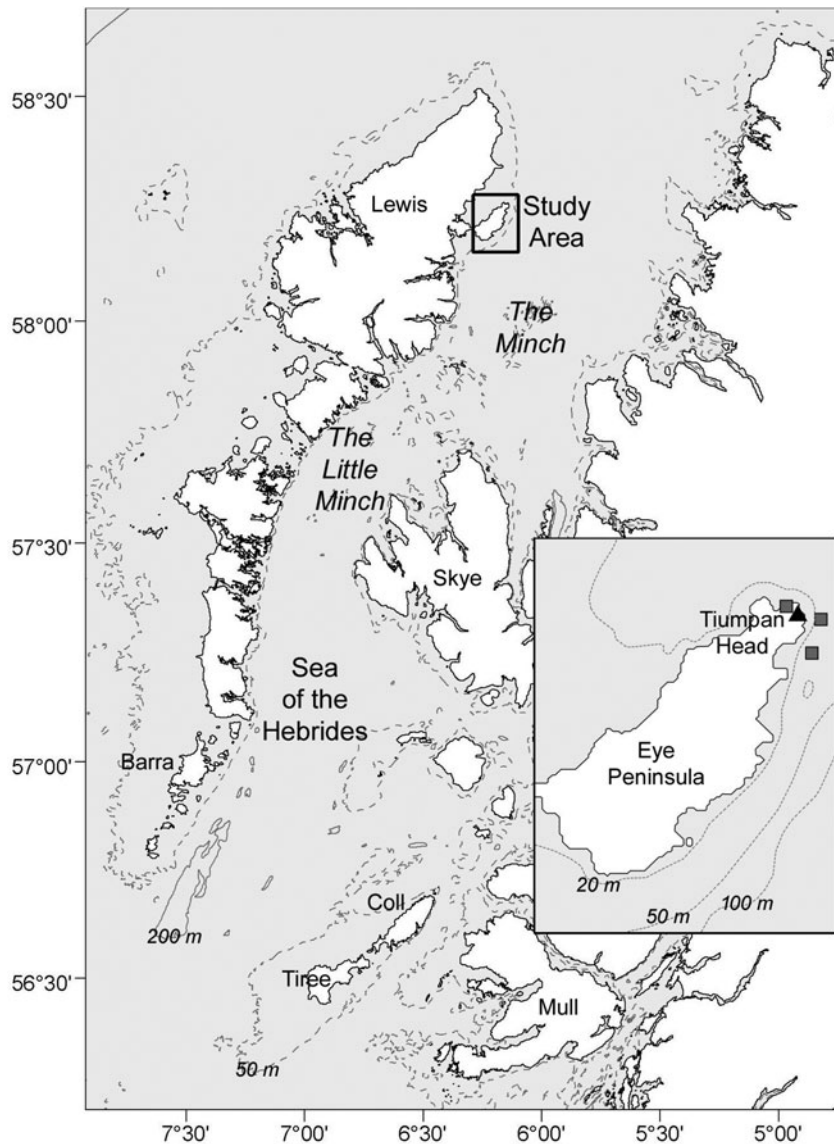


Fig. 1. Location of the Eye Peninsula study area (north-east Lewis, UK) and places mentioned in the text. The inset shows the location of the shore-based study site from which four sightings were recorded (black triangle) and the locations of three boat-based sightings (grey squares) (see Table 1).

in captivity (Sylvestre & Tasaka, 1985; Reyes, 1996; Herzing & Johnson, 1997; Karczmarski, 1997; Herzing *et al.*, 2003; Bérubé, 2009). Suspected wild cetacean hybrids are typically observed without prior knowledge of parental interactions. Therefore their detection and identification in the field is problematic and the number of documented incidences in the wild to date is limited (for a review, see Bérubé, 2009). Collecting genetic evidence to verify the occurrence of live wild hybrid dolphins is logistically difficult, and has associated welfare considerations (biopsying wild cetaceans is intrusive and potentially risky; e.g. Bearzi, 2000). However, morphological analyses of captive-born hybrid dolphins indicate that the offspring consistently exhibit intermediate characteristics of both parent species (Sylvestre & Tasaka, 1985; Zornetzer & Duffield, 2003). Consequently, the occurrence of individuals exhibiting intermediate morphological characteristics in the field may represent a valid method of identifying wild-born hybrids.

This paper describes three ‘atypical’ dolphins with mixed morphological characteristics that were photographed in

2011 and 2012 during cetacean fieldwork off Lewis, north-west Scotland. We provide evidence to suggest that these individuals may be the result of hybridism between wild Risso’s and bottlenose dolphins.

MATERIALS AND METHODS

This fieldwork utilized a combination of land- and boat-based methods as briefly described below.

Land-based surveys were conducted from a fixed land-based site (approximately 50 m above sea level) at Tiumpan Head, on the Isle of Lewis (Figure 1). Data were collected using a standardized scan sampling protocol (Pierpoint *et al.*, 1998), during which a single observer slowly scanned across a predefined sector of sea using 7×50 reticulated binoculars with built-in compass. Whenever cetaceans were sighted, standardized data were logged including species, group size, behaviour, distance from shore and direction of

Table 1. Survey effort (in sea state ≤ 3) and sightings of Risso's (*Grampus griseus*) and bottlenose (*Tursiops truncatus*) dolphins during field survey work at north-east Lewis between 2010 and 2013.

Year	Survey effort (h)		Number of sightings		
	Shore-based	Boat-based	<i>Grampus griseus</i>	<i>Tursiops truncatus</i>	Mixed <i>Grampus</i> and <i>Tursiops</i>
2010	48.6	26.6	14	0	0
2011*	16.5	39.1	7	1	1
2012	15.4	30.8	2	5	2
2013	0	14.6	3	0	0

*, excludes one sighting comprising an atypical dolphin (ATD₂) seen travelling with a dolphin of uncertain identity (IND₄).

travel. A total of 80.4 h of land-based survey effort (sea state ≤ 3) was carried out between 2010 and 2012 (Table 1).

Vessel-based surveys were focused primarily on photo-identification methods, carried out under licence and therefore designed to maximize encounters with dolphins. Different vessels were used in each year. In 2010, the survey vessel was 'MV Puffin', approximately 5 m motor boat. In 2011, the survey vessel was 'MV Fish n' Trips', a 6 m motor boat and in 2012 a 6.5 m rigid inflatable boat (RIB) also named 'MV Fish n' Trips' was used.

The boat survey route depended on prevailing weather conditions and on whether sightings had been reported from land-based sites. Two observers searched continuously from the port and starboard sides respectively and the vessel position was continually recorded at 1 min intervals using a handheld Garmin GMAP 76CSx GPS. Whenever cetaceans were seen standardized data (including position, species, group size and behaviour) were logged and the boat was manoeuvred carefully towards the animals to attempt photo-identification. A total of 111.1 h of boat-based survey effort (sea state ≤ 3) was carried out between 2010 and 2013 (Table 1).

Photo-identification was attempted from both the shore site (when dolphins passed sufficiently close to the cliff) and from the boat. Photographs of dorsal fins and other body marks were taken using a Canon 7D digital SLR camera with a 100–400 mm lens. The photography and subsequent cataloguing of individual dolphins was carried out by a single person (the lead author), according to standard protocols (Würsig & Jefferson, 1990).

RESULTS

A total of 26 groups of Risso's dolphins, six groups of bottlenose dolphins and three mixed-species groups were recorded off north-east Lewis between 2010 and 2013 (Table 1). Three individual 'atypical' dolphins (ATD_{1–3}) were photo-identified during 2011 and 2012 (Table 2), the only years in which bottlenose dolphins were recorded. All of the sightings of atypical animals occurred in close proximity to Tiupan Head (Figure 1).

Two of the atypical dolphins were photographed on single occasions: ATD₁ (Figure 2A) within a mixed-species school of Risso's and bottlenose dolphins in 2011 and ATD₃ (Figure 2C) with five bottlenose dolphins during 2012. ATD₂ (Figure 2B) was photographed in two sightings in 2011 and two sightings in 2012, once together with an animal of uncertain species (IND₄ (Figure 2D); see below) and three times in association with schools of bottlenose dolphins (including one further occasion where IND₄ was present) (Table 2).

One atypical dolphin was observed within a mixed-species school of Risso's and bottlenose dolphins. With the exception of sighting number two (uncertain group composition), the remaining sightings all involved atypical animals travelling within bottlenose-only schools (Table 2). Atypical dolphins were never recorded within a Risso's-only school.

The morphological characteristics of the three atypical dolphins are described below.

ATD₁

This was immediately noted to be a particularly large animal, with an estimated body size approximately 50% larger than the accompanying bottlenose dolphins. The dorsal fin was prominent and very broad-based, being double the size of the bottlenose dolphins and slightly larger than the fins of the accompanying Risso's dolphins. The head shape was intermediate between Risso's and bottlenose dolphins, with a sloped forehead and a very short (cf. bottlenose) but defined rostrum (Figure 2A). Overall body coloration was a uniform dark grey with little scarring or white lesions/patches visible; however, the weather was overcast and details of body coloration were obscured. This animal was observed within a mixed-species school of bottlenose and Risso's dolphins (Table 2).

Table 2. Details of seven sightings off north-east Lewis in which three atypical dolphins (ATD), consistent with the potential hybridization between free-ranging Risso's (*Grampus griseus*) and bottlenose (*Tursiops truncatus*) dolphins, were photographed at north-east Lewis between 2010 and 2013.

Sighting Number	Date	Sighting time		Platform	Group type	No. of animals					ATD Reference Number
		Start	End			Total	Atypical dolphins	<i>Grampus griseus</i>	<i>Tursiops truncatus</i>	Unknown*	
1	24 August 2011	14:53	15:04	Land	Mixed species	7	1	4	2	0	ATD ₁
2	25 August 2011	09:39	09:52	Land	Uncertain*	2	1	0	0	1	ATD ₂
3	25 August 2011	10:13	10:17	Land	Single species	9	1	0	7	1	ATD ₂
4	21 August 2012	17:08	18:00	Land	Single species	8	1	0	7	0	ATD ₂
5	22 August 2012	10:21	11:27	Boat	Single species	9	1	0	8	0	ATD ₂
6	19 September 2012	10:25	10:59	Boat	Mixed species	9	0	1	7	1	N/A*
7	4 October 2012	09:20	09:43	Boat	Single species	6	1	0	5	0	ATD ₃

*, these records relate to a further individual (IND₄) which was also suspected to be atypical.

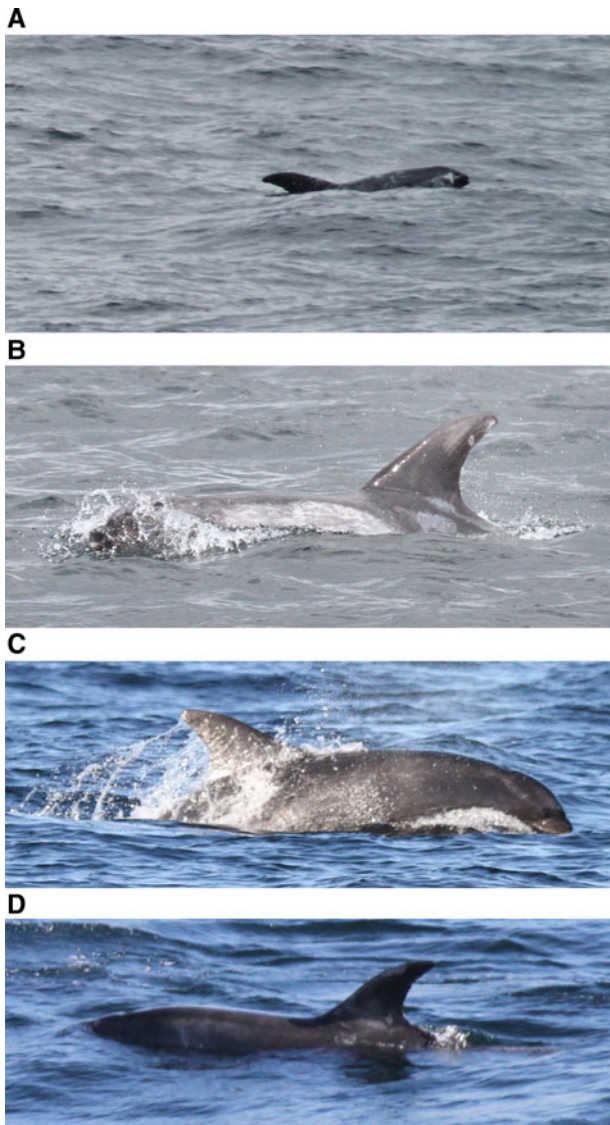


Fig. 2. (A) Photograph of atypical dolphin 1 (ATD₁) photographed off north-east Lewis. ATD₁ exhibits morphological characteristics consistent with hybridization between Risso's and bottlenose dolphins; (B) photograph of atypical dolphin 2 (ATD₂) photographed off north-east Lewis. ATD₂ exhibits morphological characteristics consistent with hybridization between Risso's and bottlenose dolphins; (C) photograph of atypical dolphin 3 (ATD₃) photographed off north-east Lewis. ATD₃ exhibits morphological characteristics consistent with hybridization between Risso's and bottlenose dolphins; (D) photograph of one suspected atypical dolphin (IND₄) photographed off north-east Lewis.

ATD₂

This animal had similar (possibly slightly larger) body and dorsal fin size to a Risso's dolphin and was estimated to be approximately 25% larger than accompanying bottlenose dolphins. It was also Risso's-like in coloration, exhibiting a uniform grey base colour but with extensive white linear scarring and some white lesioning on the flanks (Figure 2B). Although body size, coloration and the broad dorsal fin were similar to a Risso's dolphin, the head comprised a rounded melon, distinct crease and well-defined short beak resembling the morphology of a bottlenose dolphin. Moreover, this animal was observed accompanying bottlenose dolphins on three occasions, two of which involved the

presence of three mother/calf pairs, and IND₄ on one occasion (Table 2), but was not observed with Risso's dolphins.

ATD₃

This animal resembles a bottlenose dolphin in overall body size and appearance (coloration and dorsal fin shape). However, the head shape is atypical, with a more sloped and less-rounded melon than a bottlenose dolphin and a less distinct crease than usual (Figure 2C). The rostrum is particularly short when compared with a typical bottlenose dolphin.

IND₄

In addition, a further individual (IND₄) was photographed that was also suspected to be atypical (Figure 2D). This animal was observed twice in association with ATD₂ and once in a mixed-species school of Risso's and bottlenose dolphins (Table 2). It had similar overall appearance to a bottlenose dolphin, with a uniform dark body colour and areas of lesioning. One poor-quality image also suggested the presence of a rounded melon and a short well-defined beak. However, it was noted to be 25% larger in body size than accompanying adult bottlenose dolphins and with a prominent large dorsal fin (Figure 2D). The species affiliation of this animal was uncertain.

DISCUSSION

Opportunities for hybridism

As noted by Bérubé (2009), cetacean hybrids are most common within genera where the different species have similar life histories and habitat requirements. Clearly, two species must overlap in habitat in order to provide opportunities for social interaction and mating. Additionally, opportunities for interspecific mating would be greatest amongst species that regularly form mixed-species associations. Risso's dolphins and bottlenose dolphins are two species which overlap in habitat in many geographical regions and are known to form mixed-species schools. The occurrence of mixed-species schools comprising these two species have been reported from areas as varied as California (Bearzi, 2005), the Gulf of Mexico (Maze-Foley & Mullin, 2006), the west coast of Africa (Weir, 2011) and the Indian Ocean (Ballance & Pitman, 1998). However, most of those associations have been observed in offshore, deep waters rather than from the coastal neritic habitat documented in this paper. This is presumably because the Risso's dolphin is predominantly found in habitat seaward of the shelf edge in most of its geographical range (Jefferson *et al.*, 2014). Nevertheless the species does occur in a wide range of habitats from the coast to deep oceanic waters, and the shelf waters along the Atlantic seaboard of Britain and Ireland are one notable geographical region where the species regularly inhabits relatively shallow, coastal waters (Reid *et al.*, 2003). A mixed-species association between bottlenose and Risso's dolphins has been recorded in very shallow, nearshore habitat on at least one previous occasion (Jefferson *et al.*, 2014). In this paper we report three mixed-species associations between the two species in the coastal waters off Lewis, including at least one in which an atypical individual was present. Collectively,

these accounts indicate that the associations between these two species regularly occur throughout the world and in a wide range of habitats, and clearly provide opportunity for hybridism between the species.

HYBRIDISM BETWEEN RISSO'S AND BOTTLENOSE DOLPHINS

The atypical individuals described here are consistent with hybridism between free-ranging Risso's dolphins and bottlenose dolphins for three reasons: (1) the morphological characteristics of the three individuals appeared intermediate between those two species; (2) their occurrence within schools of one (or both) of those two species; and (3) the three observations of mixed-species schools of those two species within the study area. In particular, the pronounced, broad-based falcate dorsal fins seen on all three of the individuals were consistent with Risso's dolphin, while their short, defined beaks were consistent with (though shorter than) the bottlenose dolphin (however, the forehead in ATD₁ was far more sloped than in a bottlenose dolphin). Given the absence of molecular data to confirm the genetic affiliation of these animals, we cannot be certain that these animals are hybrids between Risso's dolphins and bottlenose dolphins and cannot rule out that these are hybrids involving other sympatric species such as *Lagenorhynchus* or *Globicephalus*. However, other instances where hybrids have been initially described by morphological traits and then later confirmed by molecular analysis (e.g. Spilliaert *et al.*, 1991; Bérubé & Aguilar, 1997) suggest that the identification of hybrids based on observed morphological features is reasonable.

This is not the first evidence for hybridism between wild Risso's dolphins and bottlenose dolphins in north-west Europe. On 31 May 1933 three dolphins stranded in Blacksod Bay, County Mayo in Ireland, and all showed intermediate morphological and skeletal characteristics relating to both the bottlenose dolphin and the Risso's dolphin (Fraser, 1940). Two had short well-defined beaks (6.4 and 8.9 cm respectively) and the third animal lacked a beak and had a strongly-sloped forehead (Fraser, 1940). This seems comparable in description to the short beaks photographed in ATD₂ and ATD₃, and the sloped forehead photographed in ATD₁. Generally, the stranded animals described by Fraser (1940) had rostrums that were shorter and wider, tooth counts lower, and craniums wider than found in the bottlenose dolphins, and he considered hybridism between Risso's and bottlenose dolphins to represent the most likely explanation. Despite the observations reported in this paper, no wild hybrids between the two species have been reported stranded to date in UK waters (Paul Jepson & Andrew Brownlow, personal communications).

Several confirmed incidences of hybridism between Risso's and bottlenose dolphins have been recorded in captivity (Sylvestre & Tasaka, 1985; Shimura *et al.*, 1986). While we acknowledge that the circumstances of captivity produce behaviours that would not occur naturally in the wild, these records at least provide evidence that hybridism between the two species is possible and that such hybrids may reach maturity. Sylvestre & Tasaka (1985) compiled 13 accounts of hybrids born to captive Risso's and bottlenose dolphins, all of which occurred at Enoshima Marineland in Japan. The offspring bore intermediate morphological traits between their two parental species, one individual having

the colour of a bottlenose dolphin with a small and distinct rostrum, a dorsal fin shape that was the same as a Risso's dolphin, and a melon a little bit more predominant than in bottlenose dolphins (Sylvestre & Tasaka, 1985). None reached physical maturity. However, a hybrid dolphin born to a female bottlenose dolphin and a male Risso's dolphin at Minami Chita Beachland in Japan in 1993 (Cetabase, 2013) is still alive, indicating that these hybrids can live long enough to reach physical maturity. The morphological features described in these captive hybrids are very similar to those we describe here for wild atypical animals photographed off Lewis.

The functional explanations for the formation of mixed-species cetacean associations primarily comprise foraging advantages and predator avoidance, although there could be additional social and reproductive advantages (Stensland *et al.*, 2003). While interspecific mating could happen during relatively brief interactions between species, our observations of associations between bottlenose and Risso's dolphins around Lewis are suggestive of a more stable affiliation between the species. Predation (from sharks or killer whales, *Orcinus orca*, (Linnaeus, 1758)) is unlikely to be a primary driver for multi-species associations in Scottish waters, although killer whales are occasionally sighted in the study area (Nicola Hodgins, personal observation). Strandings evidence from stomach contents indicates that Risso's and bottlenose dolphins exhibit different prey preferences in Scottish waters. The octopus *Eledone cirrhosa* (Lamarck, 1798) comprised almost 90% of the total reconstructed prey weight of stranded Risso's dolphins (mostly from the north and west coasts) (Macleod *et al.*, 2013), while sampled bottlenose dolphins (mostly from the east coast) fed upon a variety of benthic and mid-water fish and some cephalopods (Santos *et al.*, 2001). Consequently, the functional explanation for this association remains unclear, and they may rather have some type of social basis as has been suggested for other odontocete species associations (e.g. Melillo *et al.*, 2009). Whatever the driver may be, the existence of these associations provides opportunity for hybridism.

Hybrids originating in captive situations are most likely to be the result of lack of mate choice due to their artificial confinement. However, this is not always the case; a captive hybrid in Japan born to a female bottlenose dolphin and a male Risso's dolphin was apparently conceived even though a mature male bottlenose dolphin was present in the same pool at the time of the matings (Sylvestre & Tasaka, 1985). The driver for interspecific matings amongst wild cetacean species is even less clear, although such matings have been documented for a number of sympatric cetacean species (see Bérubé, 2009). The context of these matings may be varied and not necessarily reproductive, with alternative explanations including 'practice' matings by immature animals to improve adult reproductive success and to diffuse aggressive tension between species (Melillo *et al.*, 2009). Not all interspecific matings seem to lead to conception and hybridization. For example, matings between wild bottlenose and Atlantic spotted (*Stenella frontalis*, Cuvier, 1829) dolphins in the Bahamas are very frequent, and yet only a single possible hybrid has been reported (Herzing *et al.*, 2003). Nevertheless, the number of reported hybrids is likely to increase as advances in molecular analysis techniques and biopsy sampling are made. Indeed, DNA analysis is now providing

evidence of hybridization events that occurred in the past. For example, recent evidence suggests that past hybridization between spinner (*Stenella longirostris*, Gray, 1828) and striped (*S. coeruleoalba*, Meyen, 1833) dolphins was of sufficient frequency to produce a new species, the Clymene dolphin (*S. clymene*, Gray, 1846) (Amarel *et al.*, 2013).

The observations of three atypical dolphins off north-east Lewis are consistent with hybridization between free-ranging Risso's and bottlenose dolphins, the first such occurrence to be documented for these species in UK waters. The context and significance of these hybridization events is unknown. Since wild cetacean hybrids are rare, the occurrence of four atypical dolphins consistent with hybridism in one small geographical region is highly unusual. However, the three hybrid animals reported by Fraser (1940) in Ireland indicate that this is not an altogether unprecedented scenario. If these individuals do indeed represent hybrids, it raises interesting questions regarding their fertility, lifespan and relatedness.

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