Unfamiliar plumage types of Fulmars in the North Atlantic

Robert L. Flood and Hein van Grouw

Abstract We investigate records of three unfamiliar plumage types of the Fulmar *Fulmarus glacialis* in the North Atlantic: extra pale, extra dark and those with a dark distal tail-band. The possible explanations for each case are: 1) aberrant or variant 'Atlantic Fulmar' *F. g. glacialis*; 2) hitherto unrecorded morphs of Atlantic Fulmar; and 3) vagrant 'Pacific Fulmar' *F. g. rodgersii*. We conclude that all records involve aberrant or variant Atlantic Fulmars. A dark distal tail-band noted on about 5% of Fulmars in Spitsbergen is a previously unreported variation.

The Fulmar *Fulmarus glacialis* is a common and well-studied seabird in the North Atlantic, with plumage polymorphism that is thought to be well understood. However, extra-pale and extra-dark birds are occasionally seen, which fall outside the range of established variation. In addition, we discovered that about 5% of birds in Spitsbergen have a dark distal tail-band, which is previously undocumented. This paper summarises our investigation of these unfamiliar plumage aspects.

Fulmar taxonomy

The Fulmar occurs in the North Pacific and in the North Atlantic and two subspecies are recognised: 'Pacific Fulmar' *F. g. rodgersii* breeds in the Arctic zones of the North Pacific, while 'Atlantic Fulmar' *F. g. glacialis* breeds widely in the North Atlantic north of about 45°N. Salomonsen (1965) recognised the race *F. g. auduboni*, for low Arctic and boreal breeders of the Atlantic form, based on morphometrics and morph distribution, and this was followed by, for example, Brooke

Ashley Fisher

188. LL Atlantic Fulmar, Scilly, 8th August 2010.

Ashley Fisher

189. L Atlantic Fulmar, Scilly, 21st October 2011.

(2004) and Onley & Scofield (2007). However, since the variation is complex we treat the Atlantic form as a single subspecies.

Kerr & Dove (2013) found genetic and morphological divergences between the two races of Fulmar that were comparable with some procellariid sister species, and recommended treating them as full species. Divergence of the two has been maintained for around two million years, spanning warm periods with Arctic ice melt that increased the likelihood of movement between the Pacific and the Atlantic, and thus providing opportunities for interbreeding. However, Kerr & Dove found no evidence to support the proposition that Atlantic Fulmar comprises two subspecies.

Typical Fulmar morphs

Both Fulmar subspecies are polymorphic (see

Julian Bell

190. D Atlantic Fulmar, Barents Sea, Russia, 29th September 2010.

Ingvar Sigurðsson

191. DD Atlantic Fulmar, Vestmannaeyjar, Iceland, 4th September 2011.

Box 1. Six morph categories for the Fulmar *Fulmarus glacialis*.
The plumage descriptions exclude the remiges and rectrices, which vary between Atlantic and Pacific Fulmars.

LLL Largely *snowy white* overall.

LL *Whitish* head and neck clearly demarcated from mid bluish-grey mantle, scapulars, back, rump, and upperwing-coverts; light bluish-grey uppertail-coverts (sometimes rump); whitish underparts and underwing-coverts.

L *Light bluish-grey* crown, nape and hindneck grading into mid bluish-grey mantle; mid bluish-grey scapulars, back, rump, uppertail-coverts, upperwing-coverts and underwing-coverts; underparts variable light bluish-grey to whitish, breast always whitish.

D *Mid bluish-grey* overall; breast usually paler but not whitish.

DD *Dark bluish-grey* overall; breast sometimes paler.

DDD *Dark greyish-brown* to *blackish-brown* overall; breast sometimes paler.

Chris Collins

192. LLL Pacific Fulmar, Sea of Okhotsk, 19th June 2014.

Kirk Zufelt

193. LL Pacific Fulmar, California, USA, 9th June 2009.

Box 1 and Appendix 1) and Fisher (1952) recommended four morph categories: double light (LL), light (L), dark (D) and double dark (DD). To these four, Garner (2008) added triple light (LLL) and triple dark (DDD). Fisher's categories have been widely applied in field studies of geographical distribution of morphs (e.g. Drury & Drury 1959, Pennycuick & Webbe 1959, Pashby & Cudworth 1969, van Franeker & Wattel 1982, Camphuysen 1993, Camphuysen *et al.* 1995, Falk & Møller 1995a, van Franeker & Luttik 2008).

There are problems with these morph categories, in terms of the variation within them and drawing a line between them (Appendix 1), but they offer broad guidelines that facilitate research and help to communicate findings. For example, studies have found that extremes in morph in Pacific Fulmar are greater than in Atlantic Fulmar: the lightest light-morph Pacific is paler than the lightest Atlantic Fulmar, and the darkest dark morph is darker (e.g. Hatch & Nettleship 1998). Atlantic birds range from LL to DD (plates 188–191), whereas Pacific birds range from LLL to DDD (plates 192–197). Furthermore, plates 188–191 and 193–196 show that, while LL–DD morphs of the two subspecies are very

similar, separation of typical birds is possible. Key differences are found in the contrast between tail and uppertail-coverts, bill size and structure, and typical bill colours (more detail is given in the captions to plates 188–197).

Unfamiliar plumage types

Over the last 12 years or so we became aware of three unfamiliar plumage types of Fulmars in the North Atlantic, all three of which bear some resemblance to Pacific Fulmar:

1. An *extra-pale* Fulmar seen during a pelagic trip off Scilly in April 2003 resembled a LLL Pacific Fulmar (Flood *et al.* 2007). A few years later, extra-pale Fulmars seen during a seawatch off

Brian Sullivan

194. L Pacific Fulmar, California, USA, 14th October 2007.

Brent Stephenson

195. D Pacific Fulmar, Alaska, USA, 4th August 2007.

Brian Sullivan

196. DD Pacific Fulmar, California, USA, 19th January 2008.

John Puschock

197. DDD Pacific Fulmar, Alaska, USA, 25th May 2013.

Co. Mayo raised the same possibility of being Pacific birds (Garner 2008).

2. An *extra-dark* Fulmar photographed 130 km south of Fastnet in February 2009 suggested a DDD Pacific Fulmar (R. McLaughlin *in litt.*).

3. During a trip to Spitsbergen in June 2014, RLF noted that about 5% of Fulmars had a *dark distal tail-band*, covering up to 20% of the length of the tail. This plumage characteristic has not previously been reported in Atlantic Fulmars, while a contrastingly dark tail or broad dark distal tail-band is typical of most Pacific Fulmars.

The vagrancy potential of Pacific Fulmar

In the light of these unfamiliar plumage types resembling Pacific Fulmar, what is the possibility of that subspecies reaching the North Atlantic at the present time? The closest breeding colonies of Pacific Fulmar to the North Atlantic are light-morph birds on St Matthew and Hall Islands, in the north Bering Sea (60°30'N 172°45'W; population estimate 450,000 birds, Hatch & Nettleship 1998). A journey of 3,500 km through the Bering Strait, across the Chukchi Sea and the Beaufort Sea would bring them to Atlantic Fulmar colonies on Devon Island, in the Canadian Arctic (76°14'N 89°12'W; population estimate 50,000 birds, Hatch & Nettleship 1998) (fig. 1). Light-morph Pacific Fulmars predominate in high latitudes of the Pacific (the reverse of the situation in the Atlantic) so a vagrant would most likely be a light morph. Navigating the oceanic Arctic flyway presumably becomes more likely as global warming causes the summer ice cap to shrink.

There is evidence that vagrant seabirds have used this flyway, most notably with regard to certain North Pacific alcids which have occurred in the North Atlantic. These include an Ancient Murrelet *Synthliboramphus antiquus* off Lundy, Devon, in 1990–92 (Waldon 1994), a Long-billed Murrelet *Brachyramphus perdix* at Dawlish, Devon, in 2006 (Rylands 2008) and Tufted Puffins *Fratercula cirrhata* in southwest Sweden in 1994 (Haraldsson 1995) and on the Swale, Kent, in 2009 (Wright 2011). Meanwhile, from the Atlantic, Manx Shearwaters *Puffinus puffinus* appear to be colonising the northeast Pacific (Howell 2012), while a Northern Gannet *Morus bassanus* was found in the Farallon Islands, California, in 2012 (blog.aba.org).

Satellite tracking of Atlantic Fulmars shows them moving a cumulative distance of over 1,600 km in just two weeks (Falk & Møller 1995b), while an Atlantic Fulmar breeding on the Scottish coast travelled over 6,000 km in under 15 days while incubation foraging (Edwards *et al.* 2013). Purely in terms of distance, therefore, passage via the Arctic flyway is entirely feasible for a Pacific Fulmar. This flyway may have played a part in the Fulmar's evolution. There are several theories (Voous 1949; Howard 1969, 1984;

Plates 188–197. The morphs of Atlantic *Fulmarus g. glacialis* and Pacific Fulmars *F. g. rodgersii*. The extremes in morph are greater in Pacific Fulmar (lighter light morph, darker dark morph). The randomly distributed dark markings were observed on a number of Atlantic Fulmars in Spitsbergen in June, and several Pacific Fulmars off California in September. A number of field marks separate Atlantic from Pacific Fulmar. Contrast between tail and uppertail-coverts is normally lacking in Atlantic (but see main text for Atlantic Fulmars with a dark distal tail-band), whereas the tail is normally much darker than the uppertail-coverts in Pacific Fulmar. In Pacific, the visible tail is either wholly or mainly dark, in the latter case appearing as a broad distal tail-band (plates 193 & 195). The contrast is less obvious in darker morphs. Bill size and structure – the bill of Atlantic Fulmar is fairly large, heavy, and blunt-ended, especially in boreal populations, whereas the bill of Pacific is relatively long, slender, and less blunt-ended (although the bill is more robust on males than females in both subspecies). Typical bill colours of Atlantic range from largely bluish-grey or pinkish and yellowish (plate 188) to these same base colours but with extensive dark markings (plate 190). In Pacific, the bill is typically plainer and ranges from pinkish- or greenish-grey with a yellowish tip (plate 194) to yellowish with a more orange tip (plate 193) and a variable dark band at the base of the ungues (the plates that cover the bill tip). Our study found that the colour of the nasal tubes is important. On many Atlantic Fulmars the nasal tubes are dark, especially on intermediate and dark morphs (plates 189–191) while they are rarely if ever dark on any morph of Pacific (plates 192–197).

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Fig. 1. The Arctic flyway, between the North Pacific and the North Atlantic. The red line shows the shortest route (c. 3,500 km) between the closest colonies of Pacific Fulmars, on St Matthew and Hall Islands, in the north Bering Sea, and Atlantic Fulmars on Devon Island, in the Canadian Arctic. This is the most likely route for a Pacific Fulmar to reach the North Atlantic.

Hans Henrik Larsen

Peter Nielsen

198 & 199. Aberrant Herring Gulls *Larus argentatus*; Hirtshals Østhavn, Denmark, 4th November 2012 (left) and Århus Centralhavn, Denmark, 12th December 2010. These plates provide a helpful comparison between qualitative aberration that results in a change of colour (198), and quantitative aberration that results in a lighter shade of the given colour (199). In plate 198 this is the result of the brown mutation (qualitative). Parts of the primaries which are normally black appear brown, while normally grey areas are in part cream-coloured (e.g. mantle and upperwings). However, the strong bleaching effect is already visible; the most exposed parts of the brown regions of the primaries are paler, and some scapulars and upperwing-coverts (presumably older ones) are much paler than others. In plate 199 the plumage aspect is the result of dilution, where pigment is diluted to the same degree over the entire plumage (quantitative). As a result, normally black areas are mid grey, mid-grey areas are light grey, and light-grey areas are whitish.

Box 2. Terminology and explanations for colour aberrations in birds used in this paper. See van Grouw (2013) for a fuller discussion.

Melanins are pigments responsible for many colours that we see in feathers and bare parts. ***Eumelanin*** is the most common type and, depending on concentration and distribution, gives black, grey and dark brown. ***Phaeomelanin*** in high concentration gives reddish-brown, in low concentration yellowish-brown. However, Fulmars have only eumelanin.

Albinism is absence of melanin pigment in the feathers, skin and eyes, giving all-white plumage, pink feet and bill, and red eyes. (A bird is either albino or not albino, and never partial albino.) Albinism causes poor eyesight, so wild albino birds rarely survive for long and are rarely encountered. Note that albino is frequently incorrectly ascribed to birds with aberrant white feathers.

Qualitative melanin reduction is incomplete melanin synthesis *resulting in a colour change* (e.g. feathers which are normally black are brown or cream-coloured). It is more common than quantitative melanin reduction. Two types feature in this article. **Ino** is a weak to strong qualitative reduction of both melanins – black in normal feathers is light brown in the dark form of ino and cream in the light form; birds have pink feet and bill (and pinkish eyes in the light form). **Brown** is a qualitative reduction of eumelanin – black in normal feathers is brown, with feet, bill and eyes unaffected. This is one of the most common colour aberrations.

Quantitative melanin reduction is a reduction in the number or size of melanin granules, otherwise known as **dilution,** *resulting in a lighter shade of the given colour* (e.g. black in normal feathers is mid grey, mid grey is light grey, light grey is whitish), with feet, bill and eyes unaffected (e.g. plate 199). Less common than qualitative melanin reductions.

Bleaching A secondary effect of aberrant pigmentation, especially qualitative reduction, is that colours bleach unusually quickly. Feathers become almost white (e.g. plate 210). The type of aberration involved is then very difficult to distinguish because colour clues are lost.

Grizzle is an aberration in which each feather contains a mixture of feather barbs which are white, and others which are normally coloured. After each moult, the number of white barbs increases, until the bird becomes almost completely white.

Kerr & Dove 2013), but the simplest is that Fulmars from the North Pacific arrived in the North Atlantic during interglacials and became geographically isolated during subsequent glacial periods. An alternative theory, based on present-day distribution, invokes an Atlantic origin for the Fulmar and subsequent passage through the Arctic flyway into the North Pacific.

Other causes of unfamiliar plumage types

In addition to vagrancy of Pacific Fulmar, there are two further potential explanations for records of unfamiliar plumage types: aberrant or variant Atlantic Fulmars, or hitherto unrecognised morphs of Atlantic Fulmar. We investigated these records by researching the literature, studying museum skins, gathering field records and analysing photographs. Our combined knowledge of field identification, moult and colour aberrations in birds (genetics) was crucial in getting to grips with the results of our investigation.

Extra-pale Fulmars

We found that extra-pale Fulmars are rare in the North Atlantic. We reviewed all records to assess whether they offered examples of one or more of the following: aberrant/variant Atlantic Fulmar, hitherto unrecorded LLL Atlantic Fulmar or vagrant LLL Pacific Fulmar. We now know that most, if not all, reported albino Fulmars are in fact not albino (see Box 2) and we can assume that in the great majority of cases these birds are either genuine LLL or represent inherited aberrations other than albino. We report claimed albinos with this caveat.

Ómar Runólfsson

Eirik Grønningsæter

200 & 201. Aberrant L or D Atlantic Fulmars; Sandgerði, Iceland, 1st June 2009 (left); Norway, 11th September 2009 (right). The base colour, or pigmentation, of the remiges hardly differs among the four morph categories of Atlantic Fulmar; in other words LL and DD Fulmars have similarly coloured dark grey remiges, though there is variation in the extent and contrast of the pale patch at the base of the inner primaries and the primary greater coverts. The light grey of the primaries of the two birds in these photos thus indicates a quantitative pigment reduction, or dilution – which results in a lighter shade of grey. Many different mutations are known that cause quantitative reduction. Some are easy to recognise, others result in pigment reductions (as for these Fulmars) that are so similar that they are hard to distinguish. As here, dilution mutations generally do not affect the bare parts. Normally, dilution mutations affect pigment to the same degree over the entire plumage (e.g. dark grey becomes mid grey, mid grey becomes light grey, etc.). Based on the difference in depth of colour between the remiges (light grey) and the mantle (whitish), we suspect that these Fulmars are both genetically L or D.

Robert Flood

202. This aberrant Atlantic Fulmar (Scilly, 24th April 2003) illustrates the effect of grizzle or some form of dilution. This bird appears most convincingly like a LLL Fulmar, with scapulars and upperwing-coverts unusually pale, yet the remiges are dark grey, like a typical Fulmar. Grey and black colours in feathers are the result of eumelanin and different arrangements of these pigment granules reflect light differently, giving a range of colours – black when arranged in an equally spread fashion, grey when clumped, while in-between arrangements give shades of grey. Most mutations affect a pigment equally over the entire plumage, but at least two mutations affect pigment arrangements one way in one area of the plumage but another way in another area, as for this Fulmar. One mutation is called grizzle, the other is a form of dilution; without handling the bird it is difficult to judge which is involved in this case.

Pre-1950 records

Fisher (1952) collated reports of 'extra pale' Fulmars, which included several British records, all from St Kilda, in the Outer Hebrides. Such 'entirely white' birds were noted by N. MacKenzie, who lived on the island from 1829 to 1843. R. Wilson exhibited an albino from St Kilda at the Glasgow Natural History Society in 1905, while William Eagle Clarke made reference to an albino, collected from St Kilda in 1910, in the Royal Scottish Museum. E. Baxter and L. Rintoul described a bird taken from St Kilda in 1919 with a 'dull crimson bill and horn-coloured tip' and 'delicate-pink feet'. C. J. Carroll claimed an albino (pink eyes, legs and feet) obtained in 1908 (probably Britain). Fisher (1952) saw four birds on St Kilda in 1939 with white backs and mantles, but pigmented eyes, and one or two more on subsequent visits.

The specimen Clarke referred to remains in the National Museums Scotland and close examination of the down layer, especially on the back and mantle, shows remaining pigment of a brownish tone. This, combined with a bill lacking pigment, confirms that it is an aberrant

bleached ino (NMS-Z.1910.192: St Kilda, August 1910). The 'white' birds from St Kilda seen by Baxter, Rintoul and Fisher were, according to their descriptions, very likely dark ino (i.e. pigmented eyes, but bill and feet not pigmented). It seems that the ino gene was/is not uncommon in the St Kilda population.

For other regions, Fisher (1952) noted Andersen's report of a white bird in the Faroe Islands with 'no trace of grey on the back feathers; even the beak was white', while Snouckaert van Schauburg claimed an albino in Iceland in 1908. (The latter is currently in the Netherlands Biodiversity Centre Naturalis, Leiden, and is a bleached brown; plate 207.) In Norway, A. Nathorst saw a completely white bird on Jan Mayen in 1899, while L. Münsterhjelm claimed an albino in 1910 near Bear Island, and G. Bertram and D. Lack saw two birds in 1932 'almost completely white on back and wings'. In Greenland, A. Bertelsen recorded two white birds. On Spitsbergen, Count Zeil killed a white bird in 1870 – 'shiny like silk' with typical-coloured bare parts, O. le Roi saw a bird that was 'quite white' and A. Koenig shot one in 1908 that was pure white. (The specimen of Koenig's bird is in the Alexander Koenig Museum, in Germany, and is a bleached brown; plate 204.)

In addition to Fisher's review, Koenig (1911) mentioned white specimens present in Cambridge Museum and in the Natural History Museum at Tring (NHM Tring). The Tring specimen is still held in the American Museum of Natural History (AMNH) in New York and the bird, a female, is a bleached brown (AMNH 527166: Mull, Argyll, June 1902). Koenig also referred to a white specimen pictured in *A Monograph of the Petrels* (Godman 1907–10). This specimen, collected in the Greenland Sea in 1893, is held at NHM Tring and is a bleached brown (plate 205).

Eirik Grønningsæter

203. Aberrant D or DD Atlantic Fulmar, Norway, 4th September 2010. The brownish tone visible in some feathers indicates a *qualitative pigment reduction*. The two most likely candidates are ino and brown. Different mutations from the ino gene (alleles – two or more alternative forms of a gene that arise by mutation) are known to occur in many species, indicating that the ino gene mutates easily (which does not mean that it is more likely to occur than the brown mutation). Depending on the allele, the degree of melanin synthesis differs, and in the darker forms of ino the result can appear similar to that from brown. However, in brown the pigmentation of the bare parts (notably the feet and bill) is scarcely affected, while in any form of ino the bare parts show little visible melanin (van Grouw 2013). The pink bill and feet of this individual thus indicate an ino mutation. Based on the remaining colour, this ino Fulmar is genetically D or even DD. The patchiness is simply due to bleaching, where older feathers are more bleached. Feathers affected by qualitative pigment reduction bleach quickly and completely; assuming that this individual survived, it would have been almost white just a couple of months later.

Modern field records

There is no modern equivalent of Fisher's review and relatively few extra-pale Fulmars are documented in the post-1950s literature. Not many seabirders that we contacted record the plumage details of unusual Fulmars. However, two sets of records reveal the frequency of occurrence of extra-pale birds along the east coast of England. Brett Richards has seawatched throughout the year at Flamborough, Yorkshire, from 1987 to date. In that time he observed three extra-pale birds. Kevin Shepherd has seawatched regularly from Sheringham, Norfolk, in about 20 years since 1975, during which time he observed four extra-pale birds. The descriptions of the Fulmars' plumage from the two observers indicate aberrant birds. Of particular note, one seen by KS bred successfully in a small colony at Sheringham during 1988–90 (fledglings were typical LL). The breeding adult was very pale overall, indicating strong bleaching. Since qualitative pigment reductions are more common than

Till Töpfer, ZFMK

204. Aberrant Atlantic Fulmar, Sicherheits-Hafen, Spitsbergen, collected 17th June 1908 (specimen at Alexander Koenig Museum, Bonn; ZFMK 4031; female). This mounted specimen has been on public display for about 100 years and so both plumage and bill are completely bleached, suggesting an albino. The red glass eyes chosen by the taxidermist confuse matters further. However, an illustration of the same individual when living (inset), from Koenig (1911), clearly shows a *blackish* eye colour, while the down layer still shows signs of pale brownish melanin, indicating that the bird's original appearance was the result of a qualitative melanin reduction. The pigmentation in the bill indicates that this Fulmar is affected by brown rather than ino mutation.

quantitative reductions, and the former bleach more quickly and more completely, it seems likely that the bird was aberrant ino or brown rather than diluted. The sex of the breeder was not noted (the sex of a bird is a strong pointer to whether it is aberrant or not, since both ino and brown are recessive sex-linked in inheritance; in the wild, almost all ino and brown individuals are females).

Other museum specimens

We uncovered a number of 'white' Fulmar specimens in museum collections that were not recorded in the literature. For example, the National Natural History Museum in Copenhagen, Denmark, holds three 'white' Fulmars from Greenland (ZMUC 52.884: Umanak, Greenland, 1872; ZMUC 52.885: Umanak, Greenland, June 1885; and ZMUC 52.917: Egedesminde, Greenland, 1899). Although the specimens *look* white overall, all three show melanin pigmentation in their down. In other words, we have the effect of an inherited pigment

Hein van Grouw

205. Aberrant Atlantic Fulmar, Greenland Sea (75°26'N 10°W), collected 1893 (specimen at NHM Tring; BMNH 1893.10.8.10). The inset is a close-up of the down layer of the specimen, showing brownish pigmentation. Although this was described and depicted as a 'white Fulmar' by Godman (1907–10), brownish pigmentation in some feathers that were less affected by the light, such as underwing-coverts and down, together with melanin in the bill, tells us that the aberrant whitish plumage of this bird is the result of brown mutation and further bleaching by light.

aberration combined with bleaching. The bill pigmentation of specimens 52.884 and 52.917 appears unaffected and the remaining melanin in the down layer has a grey rather than brown tone, together indicating quantitative melanin reduction resulting in some form of dilution. The down of specimen 52.885, on the other hand, shows some brown and cream colours, and the bill lacks visible pigment, together indicating a qualitative melanin reduction, most likely ino.

Another 'white' specimen, in the Faroese Museum of Natural History in Thorshavn (museum no. 7), was collected locally on 22nd March 1948. The brownish-grey down layer, in combination with a pigmented bill, indicates a bleached brown bird. Moreover, every year in the Faroe Islands, thousands of new fledglings too fat and heavy to fly are caught just offshore, and almost every year some are found to have an aberration, typically dilution, ino or brown (Jens-Kjeld Jensen *in litt.*).

Case studies

Unfortunately, we will never know the actual condition of most of the extra-pale Fulmars mentioned above, which lack detailed descriptions, photographs or specimens. It is impossible to be certain whether the birds had aberrant plumage, which we suspect, or whether they were genuine LLL, Atlantic or Pacific. However, we explored these possibilities by examining museum skins and photographs of live birds, and the captions to plates 200–207 summarise our key findings.

To recap, we failed to find irrefutable evidence of LLL Fulmars in the North Atlantic. All 12 of the extra-pale museum skins and photographed live birds that we examined were aberrant Atlantic Fulmars with inherited melanin reduction – dilution (4), grizzle or some form of dilution (1), ino (2), and brown (5) – with the extra-pale appearance often exaggerated by rapid bleaching of aberrant feathers.

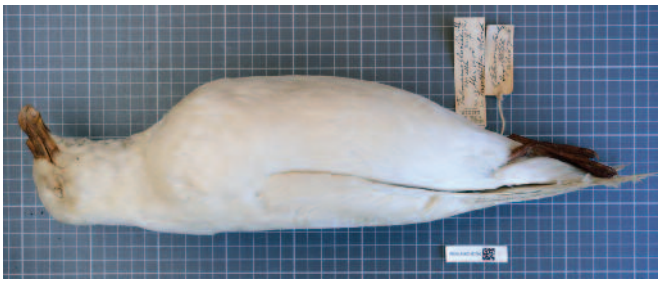
Extra-dark Fulmars

We found that extra-dark Fulmars – which could be aberrant or variant, hitherto unrecorded DDD Atlantic Fulmar or vagrant DDD Pacific Fulmar – are extremely rare in the North Atlantic.

Field records

Fisher (1952) noted V. C. Wynne-Edwards' 1950 report from Cape Searle, Canada, of a high proportion of 'really dark' Fulmars, as dark as a Sooty Shearwater *Puffinus griseus*. It is highly improbable, however, that a large proportion of Fulmars seen would be DDD. In February 2014, RLF saw a particularly dark Fulmar off Scilly, but it appeared dark bluish-grey, not dark greyish- or blackish-brown like a DDD Pacific Fulmar. Garner (2008) mentioned an extra-dark bird off Killybegs, Co. Donegal, in February 1998, while records of DD Fulmars from Whitburn, Co. Durham, include an 'impressive chocolate-brown bird' in January 2013 that

Skarphéðinn G. Þórisson



Pepijn Kaminga

206 & 207. Aberrant Atlantic Fulmars, Borgarfjörður Eystri, Iceland, 3rd June 2004 (left); Iceland, collected 14th May 1908 (specimen at the Netherlands Biodiversity Centre Naturalis, Leiden; RMNH 187193; female). The specimen, although appearing wholly white and superficially like an albino (as it was originally thought to be), has a brownish down layer, vestiges of brown in a number of feathers, and a pigmented bill, which indicate that it is a bleached brown. Similarly, the pigmented bill and some pale brownish-coloured feathers on the wings and back (fresh, not yet bleached) show that the individual in plate 206 is also a bleached brown.

Ingvar A. Sigurðsson

208. DD Atlantic Fulmar, Heimaey, Iceland, 1st March 2014. In recent winters, Ingvar Sigurðsson has encountered a few apparently extra-dark Fulmars off Heimaey. This is a typical example. It is dark, but the colour is dark bluish-grey (rather than dark greyish- or blackish-brown, as a DDD Pacific Fulmar), while the bill is fairly large, heavy, and blunt-ended and the nasal tubes are dark. These characteristics indicate Atlantic Fulmar.

could have been DDD (S. G. Addinall, P. Hindess, M. Newsome *in litt.*).

In addition, we received photographs of six particularly dark Fulmars, of which plate 208 shows an example. None of the six qualify as DDD in our opinion. In all cases, the plumage aspect appears dark bluish-grey (although some showed brownish tones that were probably due to bleaching of old feathers) and typical of DD birds rather than the dark brownish- or blackish-grey of DDD Pacific Fulmars. Of note, five of these DD Atlantic Fulmars were photographed during January–

Rónán McLaughlin

209. Aberrant DD Atlantic Fulmar, 130 km south of Fastnet Rock, off Co. Cork, 24th February 2009. The inset shows the original image, while the main plate is adjusted using the known head colours of the adult Northern Gannet *Morus bassanus* for reference. In the original, the bird appears dark brownish, resembling a DDD Pacific Fulmar. The tail looks rather dark and shows weak contrast with the somewhat paler rump and uppertail-coverts, also suggesting Pacific Fulmar. The strongest clue that this is an Atlantic Fulmar is in the colour and pattern of the bill, in particular the dark nasal tubes. Pacific Fulmars of all morphs rarely, if ever, show dark nasal tubes (e.g. plates 192–197). Furthermore, the bill looks robust and more typical of Atlantic Fulmar, although, depending on viewing angle, the bill of Pacific can appear robust. The adjusted image reveals a bird less brownish than the original, while the head and neck feathers look convincingly dark bluish-grey as for a typical DD Atlantic Fulmar. The explanation that best fits the evidence is that this is a DD Atlantic Fulmar suffering from food deficiency (see text).

April off Iceland, Norway or England, indicating winter movement of high-Arctic dark morphs to lower latitudes.

John Puschock

210. DD or DDD Pacific Fulmar, Alaska, USA, 31st May 2010. This bird shows dark plumage superficially similar to the Fastnet Fulmar in plate 209. However, some dark-morph Pacific Fulmars, like this one, become strongly bleached toward the end of the moult cycle, and show patchy upperwings with strongly bleached greater coverts. The primaries look healthy though – none are short and the whitish at the base of the inner primaries is typical. This bird's appearance is the result of a mix of strongly bleached older feathers and fresher, dark feathers, not food deficiency.

The Fastnet Fulmar

An extra-dark Fulmar was photographed south of Fastnet Rock, off Co. Cork, in February 2009 (plate 209). A subsequent internet-based discussion of the images included an opinion that it was a Pacific Fulmar. Dark-morph Pacific Fulmars can show a somewhat similar colour and upperwing pattern (plate 210), but our conclusion is that the Fastnet Fulmar was an Atlantic Fulmar (see caption to plate 209).

The widespread lack of pigmentation, mainly in the feather bases, indicates a dietary rather than a genetic deficiency. Such a deficiency stems from insufficient extraction of tyrosine (an amino acid essential to melanin synthesis and pigmentation in feathers) from the bird's food. Compare the pattern in the primaries of the Fulmar with that of a Carrion Crow *Corvus corone* known to be affected by food deficiency during primary moult (van Grouw 2012; plate 211). The lack of pigment in the Fastnet Fulmar's primaries is not uniform, so it did not occur during the juvenile moult, when all primaries would be equally affected, but during a subsequent complete moult. P1–P8 and the respective greater primary coverts – replaced at the same time – are affected by food deficiency, while P9 and P10 (the outermost) are barely affected, presumably having been replaced as feeding conditions improved. Furthermore, P6–P8 are short compared with P9–P10, a malformation known to occur in food deficiency. Other regions of the plumage also show reduced pigment, notably some

Olivier Poncin

211. Aberrant Carrion Crow *Corvus corone*, Brussels, Belgium, 21st April 2010. This provides a good example of the patchy appearance that can result from food deficiency. During the bird's last wing moult, P1–P3 were unaffected and have normal pigmentation. P4 shows the first signs of food deficiency, while P5–P7 are strongly affected, and extensively whitish (as are S1–S2, which are shorter than normal). The problem of food deficiency was at least partly overcome, however, since P8–P10 are only weakly affected.

median secondary coverts, scapulars, and uppertail-coverts. The tail feathers are unaffected, which is expected given that tail moult occurs toward the end of or following wing moult (*BWP*).

Another possible explanation is that food deficiency led to suspended moult after replacing P1–P8, and that P9–P10 are full-length feathers from the previous generation. However, this is unlikely because small and indistinct pale areas in P9–P10 indicate mild food deficiency, while these primaries are not obviously old and worn.

In summary, we failed to find irrefutable evidence of DDD Fulmars in the North Atlantic. Fulmars superficially resembling DDD Pacific Fulmar turned out to be moderately bleached DD Atlantic Fulmars. The plumage aspect of the Fastnet Fulmar is the result of food deficiency, and the extra-dark appearance of the original photograph is at least partly due to photographic effects.

Peter Dunn

Peter Dunn

Marc Fasol

212–214. Atlantic Fulmars, Spitsbergen, Svalbard, July 2014 (first two show a light morph, the third D/DD). These photos illustrate the variation in dark distal tail-bands discovered in Spitsbergen Fulmars. The bird in the top photo shows a distinct, complete dark tail-band, about 20% of the length of the tail, while the other two show distinct but incomplete bands. Fulmars with dark distal tail-bands often have dark blotches in the rest of the plumage, which is apparent in these photos; note also the dark nasal tubes, typical of most L–DD Atlantic Fulmars.

Fulmars with a dark distal tail-band

The Spitsbergen population

In Isfjorden, Spitsbergen, in June 2014, RLF observed and videoed a Fulmar with an obvious dark distal tail-band, covering about 20% of the length of the tail. Several more L and D Fulmars with similar tail-bands were subsequently videoed by RLF and photographed by Marc Guyt and Peter Dunn. In all, about 5% of the Fulmars had dark distal tail-bands of one sort or another (see plates 212–214 and www.youtube.com/watch?v= Yt863ziMkTw). Morphs ranged from L to D (few LL or DD occur in Spitsbergen). We found that bands may be quite broad (c. 20% of the tail length) or narrow, complete or partial, symmetrical or asymmetrical. In some birds, the distal tail (except the whitish tips) looked indistinctly darker than the basal tail, the relative amounts being variable, which could be considered a variation of a dark distal tail-band.

Subsequently, photographs and information of similar birds were solicited through Martin Garner's Birding Frontiers blog (www.birdingfrontiers.com). Photographs taken in Spitsbergen were received from Darryl Spittle (in June 2012) and Alan McBride (in July 2013), while Brett Richards sent us details of a Fulmar with a fairly narrow blackish distal tail-band off Flamborough in January 2009 and another with dark tail corners in March 2012. Hadoram Shirihai reported a census of plumage types across the main Arctic breeding areas in summers 2004–08, during which he noted various types of dark tail-bands on 2–5% of intermediate- and dark-morph Fulmars.

Although a dark distal tail-band is suggestive of Pacific Fulmar (plates 193 & 195), we concluded that the Spitsbergen birds are Atlantic Fulmars. The tail-bands, as far as we have seen, cover at most 20% of the visible tail. Most Pacific Fulmars show a wholly dark tail or occasionally a broad distal band (typically 80% or more of the length of the visible tail) contrasting with paler rump and uppertail-coverts; the contrast is least obvious in darker morphs (Onley & Scofield 2007; Garner 2008; Howell 2012). Furthermore, photographs show the Spitsbergen Fulmars with robust bills and the majority with dark nasal tubes, unlike Pacific Fulmars.

We came up with three possible explanations for dark distal tail-bands in Spitsbergen Fulmars: 1) an ancestral gene from/shared with Pacific Fulmar (i.e. a throwback from the past, supporting the Pacific to Atlantic speciation theory mentioned earlier); 2) a gene recently passed on from Pacific Fulmars through introgression; and 3) aberration in the way pigment granules are distributed (which may or may not be inherited), potentially a morph rather than an aberration given the apparent number of birds carrying the genetic make-up for a dark tail-band. Further research is required to explore these possibilities.

A tideline corpse in Portugal

Magnus Robb drew our attention to a LL Fulmar found on a beach at Praia de Albarquel near Setúbal, Portugal, in January 2009 by António Xeira (plate 215). It had a mid-

António Xeira

215. LL Atlantic Fulmar, Praia de Albarquel, Portugal, January 2009. The visible tail is mid grey with narrow whitish tips, showing clear contrast with the whitish uppertail-coverts and rump, which suggests Pacific Fulmar. However, identification as Atlantic Fulmar was suggested by bill structure and colour, and confirmed by DNA analysis.

grey tail with narrow whitish tips contrasting with whitish uppertail-coverts, and in this respect resembled Pacific Fulmar. Peter de Knijff analysed feathers using mtDNA typing, and found a cytochrome-*b* sequence ruling out Pacific Fulmar and matching Atlantic Fulmar. The robust bill structure and nasal tubes with extensive dark markings were also consistent with Atlantic Fulmar.

Conclusion

All the extra-pale and extra-dark Fulmars that we studied in detail turned out to be Atlantic Fulmars affected by some kind of aberration – dilution, grizzle, ino or brown – or by food deficiency. We suspect that other extra-pale and extra-dark birds that we found reference to, but which had little or no description of their plumage aspect, were also aberrant birds. So, while not entirely solving the puzzle of extra-light and extra-dark Fulmars in the North Atlantic, hard evidence has so far revealed only birds with some form of aberrant plumage, and we found no good evidence of LLL or DDD Fulmars in the Atlantic.

In addition, we discovered that about 5% of Fulmars in Spitsbergen have a dark distal tail-band somewhat like Pacific Fulmar. However, the structure, colour and pattern of the bill, among other features, are characteristic of Atlantic Fulmar. As a result, the criteria for separation of Atlantic and Pacific Fulmars require some modification.

Of course, our work does not rule out the possibility that Pacific Fulmar might occur in the Atlantic. We have made a reasonable case for its vagrancy potential and will certainly remain on the lookout (checking all morphs, not just extra-pale and extra-dark birds).

With questions remaining about the north/south reversal in the morph distribution of Pacific and Atlantic Fulmars, greater extremes in morph in Pacific Fulmar, and yet-to-be explained dark tail-bands in Atlantic Fulmar, we suggest that the 'familiar' Fulmar is in fact veiled by mysteries and puzzles.

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Robert Flood is an independent seabirder, who jointly rediscovered the presumed-extinct New Zealand Storm-petrel *Fregetta maoriana* and pioneered the well-known Scilly Pelagics. His main interest and ongoing research is into the identification of tubenoses. Major projects include the new-concept multimedia ID guides to North Atlantic seabirds, and a field guide to seabirds of the Atlantic. **Hein van Grouw** has been a Bird Curator since 1997. His main interest and ongoing research is into the occurrence and identification of colour aberrations in birds. This research will, hopefully, result in an internationally recognised nomenclature for colour abnormalities in wild birds that reflects the nature and causes of each abnormality.

Appendix 1. Notes on morphs and genes.

It can be difficult to draw a line between the morph categories introduced in the main text. For example, it is difficult to distinguish LL from L where there is only a hint of light bluish-grey over the crown to hindneck, and to distinguish D from DD where the shade of grey lies between mid and dark bluish-grey. The problem is accentuated by intensity and colour of ambient light. Variation in ambient light influences the apparent shade of grey of feathers. The vagaries of ambient light at sea are well known to experienced seabirders and photographers. For example, Flood & Fisher (2012) included Martin Elliott's illustration of the changing tone of grey in the upperwings of a Fea's Petrel *Pterodroma feae* as it flies past. Assessing 'true' colours in photographs is also problematic. For example, colour can appear to change as intensity of light changes, and due to photographic effects. Accordingly, we made every effort to calibrate colours in photographs used in this article, including using colour-calibration software for computer screens. Furthermore, variation occurs within morph categories (Falk & Møller 1995a). For example, some D Atlantic Fulmars are light bluish-grey on the crown, nape, throat and breast, but have very dark

upperwings and back, while others are nearly uniformly light or mid bluish-grey without falling into the DD category.

Much of this paper focuses on aberrant plumages and colour morphs, and the distinction between the two is not exactly clear-cut. Aberrant plumage colours in birds are not uncommon, and aberrant forms sometimes represent a significant portion of the population. In such cases, birds with the aberrant plumage are then considered to be a colour morph and the species is said to be polymorphic. For example, a dark distal tail-band occurs in about 5% of Atlantic Fulmars in Spitsbergen and birds showing this feature could be considered a morph.

Dark morphs are often associated with melanism, which is an increase of melanin above typical levels. However, darker plumages can be the result of other inherited causes (van Grouw & Nolazco 2012). Rearrangement of the same quantity of melanin granules in the feathers can darken the appearance of feathers. An inherited increase of melanin is mainly the result of mutations of the MC1R gene. The role of the MC1R gene is confirmed for many species in which dark morphs occur regularly, for example Snow Goose *Anser caerulescens* and Arctic Skua *Stercorarius parasiticus* (Mundy 2005). Three different morphs are recognised in the Arctic Skua – light, intermediate, and dark – and in this species the MC1R-allele for dark is incompletely dominant over light (alleles are two or more alternative forms of a gene that arise by mutation). If we symbolise dark with 'A' and light with 'a', then we can assign the following genotypes to the three morphs (phenotypes): dark = AA, intermediate = Aa, and light = aa.

Whether MC1R or another gene plays a role in the Fulmar's colour morphism is not yet certain (Kerr & Dove 2013), but this is unimportant within the scope of this article. The involvement of three alleles of the responsible gene may be a possible scenario to explain the colour morphs of the Fulmar. If we make this assumption, and also assume that the two 'darkening' alleles are partially dominant, then we can symbolise and put them in order of dominance as follows: $A^D > A > a$. With this in mind, LL birds have genotype aa, while DD birds have A^DA^D. Birds with genotype A^Da and Aa may differ slightly in colour but can both be categorised as 'light', while A^DA and AA may both fit the characteristics of 'dark'. This is hypothetical and further research is needed.

Inherited colour aberrations with a 'bleaching' effect like brown (Tyrp1), ino (Slc45a2) and the many dilution mutations can occur across the recognised colour morphs of the Fulmar as there appears to be no linkage between any of the responsible genes. If it occurs in a LL bird, then the result may be nearly white plumage. In D and DD birds, the fresh plumage shows more colour, simply because there was more colour in the first place, but nevertheless can appear to be lighter than a normal LL bird, and will readily bleach to white.