

Audubon's Shearwater collected in Skagerrak, Denmark, in September 1912

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The Natural History Museum of Denmark in København (Copenhagen) houses a specimen of *Puffinus* shearwater labelled Barolo Shearwater *P baroli*, collected in Skagerrak on 18 September 1912. We re-identified this specimen as Audubon's Shearwater *P lherminieri* based upon DNA analysis, measurements and assessment of plumage, and we traced the history of the specimen. It represents the first and only record to date of Audubon's in the Western Palearctic. In this paper we present all documentation of this interesting discovery.

Research into the variation and identification of the small black-and-white Barolo Shearwater and Boyd's Shearwater *P boydi* (Flood & van der Vliet 2019) included contact with all museums that held specimens of these shearwaters. A visit to each museum was arranged where possible, otherwise the museum's bird curator was requested to send photographs of the specimen(s). One such case involved the Natural History Museum of Denmark skin labelled '*P assimilis baroli*, Skagerrak, 18.9.1912, adult female' (today, the stretch of water called Skagerak is spelt Skagerrak). The collection manager Jan Bolding Kristensen sent Robert Flood photographs and a note about the specimen published in Danish (Hørring 1942), which concluded that the specimen was a Barolo, not a Manx Shearwater *P puffinus* as stated on the original label (using the old scientific name *P anglorum*; Helms 1914, Hørring 1925, Scheel 1925, Curry Lindahl 1963).

Based on a visual assessment of structural features in the photographs, RF doubted that the specimen was Barolo Shearwater or Manx Shearwater. He loaned the skin through the Natural History Museum at Tring, England. His measurements of the skin, using calipers, largely agreed with Hørring (1942) and fell outside of the range of Barolo (measurements too large) and Manx (measurements too small). The specimen appeared to have a relatively long tail, although the tail-feathers are damaged, making accurate measurement difficult. RF examined the plumage and found

consistency with the plumage of Boyd's Shearwater and Audubon's Shearwater; however, the wings were fixed tight to the body and it was not possible to fully examine the underwings without causing damage to the specimen. Small black-and-white *Puffinus* shearwaters that inhabit the Indian Ocean and Pacific Ocean could therefore not be safely eliminated. Martin Collinson agreed to undertake a DNA analysis of the specimen and JBK agreed to destructive sampling of the specimen (toepad sample). DNA analysis determined that the specimen is an Audubon's and the biometrics and plumage are consistent with this identification.

DNA analysis

A toepad sample was taken from the skin for DNA analysis (see appendix). Using NCBI Nucleotide BLAST, the sequence from the Skagerrak shearwater was compared with previously sequenced shearwaters. This confirmed its identity as Audubon's Shearwater. Its COI sequence was a 100% match for multiple Audubon's sequences and no more than 1 bp different from any Audubon's sequence in GenBank. By comparison, it was 3 bp different from the closest matching Boyd's Shearwater sequences, 4-5 bp different from the closest matching Manx, Little *P assimilis haurakiensis*, Bannerman's *P bannermani* and Barolo Shearwater, and more divergent still from all other shearwater taxa. The result is summarised in figure 1. The identity of the Skagerrak shearwater was not traced to subspecies.

Measurements

Measurements of the wing and bill of the Skagerrak shearwater (Hørring 1942; RF) fall in the central region of the ranges for Audubon's Shearwater (table 1; sources cited in caption). Measurement of the Skagerrak shearwater's wing (192-195 mm, Hørring 1942; 193-195 mm, RF) falls outside the ranges for Barolo Shearwater and Boyd's Shearwater, except for the extreme of one of two ranges for Barolo in Flood & van der Vliet (2019; 170-192 mm) and the extreme of the range for



FIGURE 1 Phylogram based on partial COI showing relationship of Skagerrak shearwater (indicated with red diamond) and all *Puffinus* taxa for which sequence data are available in GenBank. Skagerrak shearwater was identical to multiple Audubon's Shearwater *P. Iherminieri* and divergent from all other shearwater taxa.

206-207 Specimens of (from left to right) Barolo Shearwater / Kleine Pijlstormvogel *Puffinus baroli*, female (collected by William R Ogilvie-Grant at Selvagem Grande, Selvagens, on 24 April 1895; Natural History Museum, Tring, England); Boyd's Shearwater / Kaapverdise Kleine Pijlstormvogel *P. boydi*, female (collected by Boyd Alexander at Rombos Islands, Cape Verde Islands, in March 1897; Natural History Museum, Tring, England); Audubon's Shearwater / Audubons Pijlstormvogel *P. Iherminieri*, adult female (collected at Skagerrak, Denmark, on 18 September 1912; Natural History Museum of Denmark, København); and Manx Shearwater / Noordse Pijlstormvogel *P. puffinus*, female (collected by G M Mathews on Skokholm, Pembrokeshire, Wales, on 20 July 1931; Natural History Museum, Tring, England), Natural History Museum, Tring, England, 4 April 2019 (Robert L Flood). Skagerrak Audubon's is clearly smaller than Manx and perceptibly longer than Barolo and Boyd's (excluding bill). Upperside colouration of all four is similar. Underside plumage aspect is similar but note large dark thigh patches of Skagerrak specimen. As here, undertail-coverts often obscured by feet in museum specimens (see plate 209).



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See caption on facing page

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Audubon's Shearwater collected in Skagerrak, Denmark, in September 1912

TABLE 1 Comparison of wing, tail and bill measurements (mm) of Barolo Shearwater *Puffinus baroli*, Boyd's Shearwater *P boydi*, Audubon's Shearwater *P lherminieri* and Skagerrak Audubon's. Data are: mean±1SD, range (sample size) (or only sample size). Sexes combined unless shown otherwise. ¹Olson (2010), ²Howell (2012), ³BWPi (2006), ⁴Silva & Olmos (2010), ⁵Flood & van der Vliet (2019). Additional bill measurements of Skagerrak Audubon's: length of maxillary unguis 12 mm, nasal tube 8 mm, culminicorn 9 mm, maximum depth of maxillary unguis 5.9 mm, nasal tube 8.2 mm, culminicorn 5.5 mm (RF). Manx Shearwater *P puffinus* is much larger, thus not included here.

Species	Wing	Tail	Bill
Skagerrak <i>P lherminieri</i>	192-195	damaged	29
<i>P baroli</i>	173.9±4.9, 165-183 (n=15) ¹ ♂ 184±4.9, 176-190 (n=7) ³ ♀ 179±5.0, 170-185 (n=6) ³ 177.9±5.8 (n=8) ⁴ 181.3±4.1, 170-192 (n=114) ⁵ 177.9±6.6, 168.9-189.2 (n=9) ⁵	71.3±3.7, 67-79 (n=15) ¹ 71.8±3.7, 67-78 (n=14) ³ 75.5±7.8 (n=8) ⁴	(24-28, n=18) ² ♂ 26.1±1.0, 24-28 (n=8) ³ ♀ 25.0±0.6, 24-26 (n=6) ³ 25.7±1.2 (n=8) ⁴ 25.0±0.8, 23.0-26.6 (n=54) ⁵
<i>P boydi</i>	182.2±4.4, 174-188 (n=20) ¹ 188±3.9, 180-193 (n=15) ³ 181.6±11.4 (n=12) ⁴	76.7±2.0, 73-80 (n=20) ¹ 77.6±4.0, 71-84 (n=14) ³ 82.6±7.6 (n=12) ⁴	23-28 (n=20) ² 25.2±1.0, 23-28 (n=14) ³ 25.2±4.7 (n=12) ⁴ 24.5±0.8, 22.9-27.3 (n=42) ⁵
<i>P lherminieri</i>	192-210 (n=20) ²	83-91 (n=20) ²	27-32 (n=20) ²
<i>P loyemilleri</i>	185-195 (n=11) ²	81-88 (n=11) ²	27-31 (n=11) ²

Boyd's in BWPi (2006; 180-193 mm), and just within one standard deviation of data in Silva & Olmos (2010; 181.6 mm ± 11.4 mm, n=12). Measurement of the Skagerrak shearwater's bill (29 mm; Hørring 1942 and RF) falls outside the ranges of measurements for Barolo and Boyd's, except just within one standard deviation of data for Boyd's in Silva & Olmos (2010; 25.2 mm ± 4.7 mm, n=12). The tail is damaged but looks relatively long, conforming with Boyd's and Audubon's. Measurements thus support identification as Audubon's.

Plumage

HEAD Dark cap; whitish gap between cap and gape line. Cap reaching rear of eye. Fairly broad whitish fore supercilium. Freckled/marked posterior lore, broken line markings under eye, moderately marked over ear-coverts.

UPPERPARTS Dark feathering on upperside essentially overall blackish-brown. No evidence of 'saddlebags' (ie, extension of white feathers from underside onto rump-feathers). Shortish neck tab forward of shoulder.

UNDERPARTS Whitish underbody to vent with large dark thigh patches. Longest lateral undertail-coverts all dark, mid-length ones having dark outer web and some dark markings on inner web, shortest ones having dark outer web only. Undertail-coverts whitish except for largely dark longest ones.

UNDERWING Dark markings distally on longest axillaries, underwing otherwise inaccessible.

The considerable amount of dark in the undertail-coverts of the Skagerrak shearwater eliminates Barolo Shearwater. C 20% of Barolo have limited dark markings to the tip of the longest uppertail-coverts, while the rest are unmarked (Flood & van der Vliet 2019). The plumage and plumage variation of Audubon's and Boyd's Shearwater are very similar. C 30% of Audubon's have far more extensive dark markings in the underwing greater secondary coverts than any Boyd's and this may be diagnostic (Flood & Fisher 2020) but the fixed wings of the Skagerrak skin prevented inspection of this feature. Thus, the plumage of the Skagerrak shearwater is consistent with Audubon's but does not eliminate Boyd's (see plate 206-214).



208 Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, adult female (collected at Skagerrak, Denmark, on 18 September 1912; Natural History Museum of Denmark, København), Natural History Museum, Tring, England, 4 April 2019 (Robert L Flood). Note dark cap reaching rear of eye, fairly broad whitish fore supercilium, freckled/marked posterior lore, broken line markings under eye, moderately marked over ear-coverts. Head pattern of Audubon's is variable but Skagerrak bird shows common pattern. Note also relatively long bill and that areas which may have been bluish have become mustard coloured. **209** Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, adult female (collected at Skagerrak, Denmark, on 18 September 1912; Natural History Museum of Denmark, København), Natural History Museum, Tring, England, 4 April 2019 (Robert L Flood). Undertail-coverts are often obscured by feet in museum specimens. Here, feet were carefully lifted and isolated from longest uppertail-coverts, which evidently are all dark, while shorter ones are whitish, which is common pattern in Audubon's. **210** Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, adult female (collected at Skagerrak, Denmark, on 18 September 1912; Natural History Museum of Denmark, København), Natural History Museum, Tring, England, 4 April 2019 (Robert L Flood). As here, some Audubon's Shearwaters have dark (sub)terminal markings on longest axillaries.



211 Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, Hatteras, North Carolina, USA, 25 August 2018 (*Kate Sutherland*) **212** Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, Hatteras, North Carolina, USA, 28 May 2018 (*Peter Flood*). Head pattern of both birds similar to Skagerrak Audubon's (plate 208). 'Saddlebags' are variable in Audubon's and are absent in Skagerrak shearwater and Audubon's in plate 212. Feet and legs are lowered in plate 211, revealing more extensive dark in undertail-coverts compared with Skagerrak shearwater but this difference is not unusual. Note relatively long tail.



Range and vagrancy of Audubon's Shearwater

In the North Atlantic, *P l herminieri* breeds in the Lesser Antilles and Bahamas archipelagos. Presumably, it was this taxon recently discovered breeding in Cuba (Casariego et al 2007). It colonised Bermuda (Bradlee 1906) after Boyd's Shearwater was extirpated in the 17th century following colonisation by humans and human introduction of invasive predators, although it too was extirpated in the early 1980s (Amos 1991, Trimm 2004, Trimm & Hayes 2005, Olson 2010; David Wingate in litt). *P l loyemilleri* breeds on islets off north-western Panama, northern Venezuela and north-eastern Brazil (Trimm 2004, Trimm & Hayes 2005, Lopes et al 2014), and presumably it is this taxon that breeds at Fernando de Noronha, north-eastern Brazil (Silva & Olmos 2010), in the South Atlantic just south of the Equator.

In the South Atlantic, bone fossils indicate that Audubon's Shearwater was once well-established on St Helena (Olson 1975), and mineral encrusted bone fragments of an individual were found on Ascension (Olson 1977), possibly a member of the original seabird community and extirpated by rats (Weber & Weber 2019). Live individuals examined from Levelwood, St Helena, in February 1976 (slide/photograph at NHM, Tring) and Botswainbird islet, Ascension, in March 1959 (moulting; Stonehouse 1962; slide/photograph at NHM, Tring) may have been vagrants from the North Atlantic, which would be evidence of long-distance vagrancy but could also have been the last remnants of the once previously established population (further sightings of Audubon's in this region would be of great interest to seabird researchers).

Previous reports in the WP

Two Audubon's Shearwaters have been claimed in Britain. John Gould supplied an Audubon's to the Natural History Museum in London, England, 'said to have been killed in Devonshire – Mr Whiteley' but it was not included in his book 'Birds of Britain' and so it has been dismissed (Witherby 1924, Bourne 1992). Also, an Audubon's was apparently found alive on a beach near Hastings, Sussex, England, on 7 January 1936 (Harrison 1936). Audubon's was not included in the British list (British Ornithologists' Union 1971), because for petrels the recommendations of Bourne (1967) were followed and 'Hastings rarities' were excluded (Nicholson & Ferguson-Lees 1962). However, Bourne (1992) suggested that the nominate subspecies of Audubon's could reach Britain (thus potentially north-western Europe) but there have been just a few candidates mentioned

from much effort in shore-based watching and pelagic trips around Britain and Ireland and off north-western Europe (Flood & Fisher 2020). Field identification would be extremely difficult as the slightly smaller Boyd's Shearwater is nearly identical in structure and plumage.

The birds of Israel checklist on the Israeli Birding website (www.israbirding.com; accessed 14 December 2019) mentioned four records (1985, 1989, 1992, 1999) listed as Audubon's Shearwater, apparently using the old taxonomy where many taxa were lumped under that name (eg, as in Harrison 1985). Indeed, the bird on 18-21 June 1992 (Shirihai et al 1995, Shirihai 1999) was first thought to be a new species to science '*P atrodorsalis*' but it and the 15 May 1999 bird have now been accepted as Tropical Shearwater *P bailloni* (Sapir & Israeli Rarities & Distribution Committee 2007, Haas 2012). The two earlier records are listed as Persian Shearwater *P persicus* (Shirihai 1996).

Other regional checklists that we have seen with Audubon's Shearwater (eg, Gibraltar) use a taxonomy that lumps Audubon's, Barolo and Boyd's Shearwater. The taxon involved in the Gibraltar sightings almost certainly was Barolo.

Origin of specimen and identification history

The Skagerrak specimen was first mentioned in Helms (1914) with reference to taxidermist Arner Ludvig Valdemar Manniche, and subsequently by Hørring (1925) and Scheel (1925). The latter made reference to rentier Hans Pedersen's bird skin collection where the specimen was kept. All of these sources identified the specimen as Manx Shearwater.

Helms (1914) states that the specimen had been caught on board a boat in the Kattegat Sea. All later references and the label on the specimen only mention Skagerrak (Hørring 1925, 1935, 1942, Scheel 1925). Indeed, Hørring (1925) and Scheel (1925) both mention that the specimen was shot from a ship in Skagerrak, indicating that Helms (1914) was not only incorrect about the location but also incorrect in stating that the specimen was caught on board a boat. Given that Pedersen was considered a most reliable source of information when it comes to his bird skin collection, both at the time and subsequently, and Hørring (1935, 1942) gave no reason to doubt the origin of the specimen or its general provenance, we conclude that changes to both the locality and collection method result from Pedersen's research into the origin of the specimen.

Following Pedersen's death in February 1935, a



213 Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, male (collected by J L Bonhote at Washerwoman Cay, Andros, Bahamas, on 12 May 1902), Natural History Museum, Tring, England, 17 May 2019 (*Robert L Flood*) **214** Audubon's Shearwater / Audubons Pijlstormvogel *Puffinus lherminieri*, female (from collection of G S Miller Jr; collected at Green Key, Bahamas, on 4 April 1889), Natural History Museum, Tring, England, 17 May 2019 (*Robert L Flood*). Plates show extremes of dark in undertail-coverts: in plate 213 fully dark, in plate 214 only longest undertail-coverts are dark as Skagerrak Audubon's.



part of his skin collection was transferred as a willed gift to the Natural History Museum of Denmark (Hørring 1935, 1942). When Richard Hørring on behalf of the museum received the skin collection, he noticed a shearwater identified as Manx Shearwater, labelled 'Skagerak, 18.9.1912', that looked too small for a Manx. Based on measurements in Witherby (1924), he reidentified the specimen as Barolo Shearwater, even though both bill and wing measurements were longer than the ranges given in Witherby (1924). To this he added that Witherby (1924) had only 11 skins at his disposal, a too small sample size, and that the specimen must be a large Barolo (Hørring 1942). Hørring did consider Boyd's Shearwater but eliminated it because the specimen did not have the predominantly black undertail-coverts shown in Witherby (1924). Today, we know that this is a variable feature on both Boyd's and Audubon's Shearwater, where extensively white undertail-coverts do occur (Lee 1988, Howell 2012, Flood & van der Vliet 2019, Flood & Fisher 2020).

Pedersen's catalogue of his bird skin collection (CN 909) revealed only that he bought the shearwater or had it stuffed by taxidermist Manniche (Hørring 1942). When approached by Hørring, Manniche had no recollection of the specimen, which Hørring noted was to be expected since Manx Shearwater was unexceptional to collectors and taxidermists of the time. There is no further information about the origin of the bird. Hørring (1942) concluded that in all likelihood the bird was collected/delivered by a Danish fisherman. This would not be unusual at that time, as many rare birds in Denmark have been brought ashore by Danish fishermen for natural history museums or private bird skin collections, either caught in yarn, on hook line or shot.

The provenance of the Skagerrak shearwater was accepted when identified as Manx Shearwater and when reidentified as Barolo Shearwater, so the shearwater entered onto the Danish list as Barolo. It was removed from the list in 2013 because Skagerrak is a large stretch of water that transcends Denmark, Norway and Sweden, and the location in the original accounts of the shearwater apparently were no more specific than Skagerrak. It was concluded that Danish territory had not been proven (Ortvad et al 2015). In fact, Skagerrak is a strait running between the south-eastern coast of Norway, the western coast of Sweden and the Jylland (Jutland) peninsula of Denmark, connecting the North Sea and Kattegat Sea. It includes parts of today's exclusive economic zone (EEZ, 200 nautical miles zone) of not only Denmark but

also Norway and Sweden. However, our investigation found evidence that the specimen was shot by a Danish fisherman (Hørring 1942). Danish fishing in Skagerrak at the time was predominantly coastal, from small fishing vessels, and it is very unlikely that Danish fishing in the Skagerrak was conducted outside of the current EEZ of Denmark. Based on our thorough literature study and our study of the specimen, the Danish rarities committee has recently included the Skagerrak Audubon's Shearwater in the Danish list of birds (Kent Olsen in litt).

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Samenvatting

AUDUBONS PIJLSTORMVOGEL VERZAMELD IN SKAGERRAK, DENEMARKE, IN SEPTEMBER 1912 In de collectie van het Natuurhistorisch Museum van Denemarken in København (Kopenhagen) bevindt zich een balg van een pijlstormvogel *Puffinus*, verzameld in het Skagerrak op 18 september 1912, gelabeld als Kleine Pijlstormvogel *P baroli*. Dit exemplaar is nu gherdetermineerd als Audubons Pijlstormvogel *P Iherminieri* gebaseerd op DNA-analyse, maten en bestudering van het verenkleed. Tevens werd de geschiedenis van het exemplaar achterhaald. Het betreft het eerste en tot nu enige geval van Audubons in de WP. In dit artikel wordt alle documentatie van deze interessante ontdekking gepresenteerd.

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APPENDIX Procedure of DNA analysis

DNA was isolated from a toepad sample using a QIAgen QIAamp DNA Micro Kit following the manufacturer's instructions, with the addition of 0.1 M dithiothreitol to the proteinase K digest. Two fragments of the mitochondrial COI gene were amplified using the primers: PufCOIF1 (5'-GGATTCGGAACTGACTAG-3'), PufCOIR1 (5'-CCT-GCTCCTGCTTACTG-3'), PufCOIF2 (5'-CAATCAACT-CATATACAACAGC-3') and PufCOIR2 (5'-CTGGGAGTGA-

GAGTAGGAG-3'), using PCR conditions as described in Hebert et al (2004). The PCR products were separated by electrophoresis on a 1.5% agarose gel and extracted using the QIAgen QIAquick Gel Extraction Kit and sent for Sanger sequencing by Source Bioscience (Nottingham, England). The returned sequences were aligned in CLC Sequence Viewer 8, checked by eye and concatenated to give a 233 bp fragment of COI sequence (Accession No LR742719).