ATLANTIC WHITE-SIDED DOLPHINS IN THE NORTHEAST ATLANTIC: POPULATION STATUS AND STRUCTURE

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EXECUTIVE SUMMARY

The Atlantic white-sided dolphin (*Lagenorhynchus acutus*) is endemic to the North Atlantic, predominantly inhabiting the cold-temperate and sub-polar waters of the continental shelf and slope. It is one of the most heavily exploited cetacean species in the North Atlantic, and yet also one of the most poorly understood. Although currently classified by IUCN as a species of Least Concern, there has been insufficient directed research into the species, and there is uncertainty as to their population status and structure. This is particularly problematic as, in addition to the anthropogenic threats affecting most dolphin species, Atlantic white-sided dolphins are also thought to be especially vulnerable to climate change, and are subject to ongoing direct takes, mostly in the Faroe Islands. There has been limited assessment of differentiation between putative populations based on genetics or other markers such as diet, pathogens and contaminant levels thus far, but high-resolution genetic analysis is currently in progress to better understand population structure. However, genetic differentiation between populations in the far northeast of the species' range compared with other areas has already been detected. More focused, longer-term survey data are required to obtain clearer information on Atlantic white-sided dolphin distribution and abundance, with sufficient sample sizes, geographic coverage and repeat surveys to detect if populations are declining. The existing abundance estimates have a number of issues that would generally preclude them from use for the purposes of managing directed takes. Passive acoustic monitoring also has the potential to contribute to knowledge on species occurrence and population structure. Atlantic white-sided dolphin vocal repertoire has not yet been fully described, but conducting these analyses would enable the information obtained from the many acoustic datasets which have been collected in the North Atlantic to be maximised, with the potential to detect population-specific differences in vocal repertoire which could improve understanding of population differentiation.

1. INTRODUCTION AND BACKGROUND

Atlantic white-sided dolphins are currently placed in genus *Lagenorhynchus*, comprising six species – three from the Southern Hemisphere (hourglass dolphin (*L. cruciger*), dusky dolphin (*L. obscurus*), Peale's dolphin (*L. australis*)), and three from the Northern Hemisphere (Atlantic white-sided dolphin (*L .acutus*), white-beaked dolphin (*L .albirostris*), Pacific white-sided dolphin (*L. obliquidens*). However, molecular evidence based on both nuclear and mitochondrial DNA data suggests that *L. acutus* and *L. albirostris* are not closely related to any other species in the genus, nor to each other; their early divergence and North Atlantic distribution suggests that both species should be separated taxonomically from the other four *Lagenorhynchus* species (Vollmer et al. 2019). A formal revision of *Lagenorhynchus* taxonomy, although not widely accepted, includes a relatively non-controversial proposal that the Atlantic white-sided dolphin should be classified in its own genus as *Leucopleurus acutus* (Vollmer et al. 2019).

The geographic range of Atlantic white-sided dolphins extends from the western North Atlantic, (central West Greenland in the north to North Carolina in the south) across to the eastern North Atlantic (Svalbard in the north to Brittany in the south), and includes the Norwegian and North Seas, and UK and Irish waters (Vollmer et al. 2015, Cipriano 2018, Vollmer et al. 2019). However details of their distribution patterns are not well-understood throughout the range. The species is generally found in continental shelf and slope waters, in temperatures of between 5°C and 16°C (Cipriano, 2018). In the western North Atlantic, there was an apparent shift in habitat in the 1970s, with Atlantic white-sided dolphins becoming distributed more on the shelf and coastally than offshore, although distribution also appears to vary seasonally across their range (Northridge et al. 1997, Palka et al. 1997).

There is variability in the age and sex composition and group size of Atlantic white-sided dolphin groups, analysed mainly from mass strandings data, which may be related to seasonal changes in distribution and reproductive cycle (Northridge et al. 1997, Cipriano 2018, Pugliares-Bonner et al. 2021). The relatively high occurrence of mass strandings by this species is not well-understood (Geraci et al. 1978, Testaverde & Mead 1980, McKenzie et al. 1997, Palka et al. 1997, Bogomolni et al. 2010, Kinze et al. 2021, Pugliares-Bonner et al. 2021). It is from these mass stranding events that much of the information on physiology, pathology and social structure has been obtained (Mirimin et al. 2010, Pugliares-Bonner et al. 2021). Analysis of the age classes from mass strandings and also of groups of bycaught dolphins caught in the same haul have suggested seasonal segregation in group composition, with larger juveniles often absent from groups of adult and calves during the breeding season (Sergeant et al. 1980, Addink et al. 1997, Rogan et al. 1997, Pugliares-Bonner et al. 2021). Genetic estimates of relatedness of Atlantic white-sided dolphin groups (sampled from mass strandings, bycatch and direct takes) suggest quite fluid, non-kin-based social structure throughout the year, with low levels of relatedness and fairly high levels of genetic diversity within groups (Mirimin et al. 2010, Fernández et al. 2016, Pugliares-Bonner et al. 2021).

2. POPULATION STRUCTURE

The limited studies on population genetic analysis of Atlantic white-sided dolphins undertaken thus far have shown some level of structure; even though it is a highly-mobile, pelagic species. New high-resolution studies currently in progress (see Vollmer et al. (2015) and Gose et al. (2021) for outlines of planned work and some preliminary results) may provide further evidence and better resolution of differentiation within the species. Gose et al. (2021) will also consider evidence of prey shifts, pathogens and contaminants which can be used to infer population structure.

In the western North Atlantic, where the Atlantic white-sided dolphin is currently considered a single management stock by the US National Marine Fisheries Service (NOAA 2020), the distribution of sightings, strandings and incidental takes has suggested there may be some evidence for three population units (Gulf of Maine, Gulf of St Lawrence, Labrador Sea) (Palka et al. 1997), although the discontinuity of sightings between the Gulf of Maine and Gulf of St Lawrence has been less clear since 2007 (NOAA 2020). There is also genetic evidence of fine-scale population structuring in the western North Atlantic, preliminary work using Restriction-site Associated DNA genotyping (RAD-seq) data identifying two significantly differentiated genetic populations which overlap across the entire sampling range (Vollmer et al. 2015).

In the eastern North Atlantic, although work has been limited, analysis of samples from several putative populations in the eastern North Atlantic (Western Ireland, NW British Isles (W-ENA), East Scotland and Shetland Isles (E-ENA), Northern North Atlantic (Faroe Islands and Iceland (NNA)), Southern North Sea and Denmark ('North Sea'), and from the western North Atlantic (western Maine and Massachusetts (WNA)) by Banguera-Hinestroza et al. (2014) has shown some levels of differentiation between areas. Samples from the E-ENA were significantly differentiated from samples from NNA, W-ENA, and WNA, and there was also some degree of differentiation between samples from the North Sea area and from the NNA and E-ENA.

Although differentiation has not been found amongst samples taken from more pelagic, open Atlantic areas, there was some level of differentiation between samples collected in more westerly areas (WNA, W-ENA and NNA) and putative populations in the most easterly areas of the North

Atlantic (Shetland Isles and North Sea). Microsatellite data also showed differentiation between Shetland and the NW British Isles, although sample sizes were small. Analysis also detected differentiation between NNA (Faroes) and E-ENA, and the Faroes and the North Sea (Banguera-Hinestroza et al. 2014). Skull analysis of Atlantic white-sided dolphin specimens from the eastern and western North Atlantic indicated some slight level of separation between individuals from the west and eastern areas which suggested a need for further research (Mikkelsen & Lund 1994).

Pending high resolution analysis (see Gose et al. (2021) for a description of this planned work), the current data support recognition of at least four potential Atlantic white-sided dolphin populations:

- Western North Atlantic (WNA)
- Faroes (NNA), NW British Isles and Western Ireland (W-ENA)
- Shetland Islands and eastern Scotland (E-ENA)
- North Sea between southeast England, Denmark, and southern Norway.

There is currently insufficient genetic evidence to make any conclusions about the population identity or distinctiveness of Atlantic white-sided dolphins from Iceland, Greenland, or the pelagic central North Atlantic.

Banguera-Hinestroza et al. (2014) found that populations of Atlantic white-sided dolphins have reduced mtDNA nucleotide diversity throughout their distribution range, and may therefore be vulnerable to further loss in diversity when subject to threats such as bycatch and direct takes. No management units have been proposed for the species in the NE Atlantic, but the authors suggest that 'the northeastern region of the North Atlantic merits separate management, given evidence for isolation of the regional population there…and ongoing impact from the drive fishery in the Faroes' (see Section 5.2.). Given the limitations of currently available data and analyses, the precautionary approach would be to use separate management units for most or all of the identified sub-populations.

3. ABUNDANCE ESTIMATES

There are several different abundance estimates for white-sided dolphins in the North Atlantic. The most recent come from 2015/2016 when there were various different surveys covering much of their range in the NE and NW Atlantic (SCANS III (Hammond et al. 2017), NASS Icelandic and Faroese shipboard surveys (Pike et al. 2019), and NOAA surveys in the NW Atlantic (NOAA 2020, Palka 2020)). All of these surveys had some potentially problematic issues related to species identification, group size estimation and estimation of detection probability. In each of the surveys the number of sightings positively identified as Atlantic white-sided dolphins was less than 20. In the NASS surveys, observations of white-beaked and white-sided dolphins were combined to estimate detection probability; sightings identified as *Lagenorynchus* but not to species level were apportioned across strata based on the proportions of the two species identified in that stratum. In the NW Atlantic, observations of Atlantic white-sided and common dolphins were similarly combined. Surveys by Norway have also generated estimates for large areas west of Norway from the North Sea to Barents Sea, but only for white-sided and white-beaked dolphins combined. For the purposes of generating abundance estimates, these surveys also assumed that any unidentified dolphin was *Lagenorynchus*, due to historic predominance of the two members of this genus in the area, although the authors acknowledge this might have introduced some bias as other genera are also known to occur in the survey area (NAMMCO 2019).

None of the surveys takes account of responsive movement. Whilst white-beaked dolphins commonly approach vessels to bow ride, this is less commonly reported for Atlantic white-sided dolphins. These differences in observed behaviour and response to vessels make combining the detection functions for the two species problematic, in addition to their very different habitat preferences, ecology and prey, making grouping them together inappropriate.

Pike et al. (2019) note that dolphins were not the target species of the NASS surveys and that this may explain the relatively high number of unidentified sightings. They recommend that 'If estimates for dolphins become a priority, observers should receive additional training in dolphin identification, possibly by including dolphin experts as observers. Further effort may also have to be allocated towards closing on some dolphin groups to obtain accurate species identifications and group sizes'.

The estimates since 2007 are summarised in Table 1. The limited data on population structure do not allow the abundance estimates to be assigned to discrete populations or management units. The estimate of most recent relevance to the directed takes in the Faroe Islands is the NASS estimate from 2015 (Pike et al. 2019). However, this estimate has an unusually low estimate of the probability of detecting an animal directly on the survey trackline (referred to as g(0)), which is less than half of the estimate from the T-NASS survey in 2007 or the Norwegian surveys (Pike et al. 2020). This is surprising and results in an increase from an uncorrected estimate of 40,173 to the corrected estimate of 131,022.

Table 1. Abundance estimates of Atlantic white-sided dolphins in North Atlantic since 2007

Name of survey	Area	Year/period	Corrected estimate	95% CI	CV	g(0) (shipboard surveys)	Comment	Reference
T-NASS	Faroe islands extending further south of Iceland to around 52°N	2007	81,008	27,993-234,429	0.54	0.70	Combined white-sided and white beaked to estimate detection function and g(0). Unidentified *Lagenorhynchus,* allocated to species based on proportion of sightings identified of each species	Pike et al. (2020)
CODA	West of British Isles	2007					Not analysed for an abundance estimate, but 13 sightings from 3,451km of effort	
NASS	Faroe islands extending further south of Iceland to around 52°N	2015	131,022	35,251-486,981	0.73	0.31	Combined white-sided and white beaked to estimate detection function and g(0). Unidentified *Lagenorhynchus,* allocated to species based on proportion of sightings identified of each species	Pike et al. (2019)
SCANS III	North Sea and west of British Isles	2016	15,510	4,389-54,807	0.72	0.46		Hammond et al. (2017)
US and Canada	Labrador to the U.S. east coast, which covered nearly the entire western North Atlantic	2016	93,233	26,652-326,147	0.71	0.64	Combined white-sided and common dolphins to estimate detection probability	NOAA (2020), Palka (2020)

	stock: all of the Gulf of Maine and Gulf of St. Lawrence populations and part of the Labrador population							
Norwegian surveys	North Sea up to the Barents Sea	2008-2013	163,688	112,673-237,800	0.18	0.85	Combined estimate for white-beaked and white-sided, probably dominated by white-beaked; all unidentified dolphins classed as *Lagenorynchus*	NAMMCO (2019)
Norwegian surveys	North Sea up to the Barents Sea	2014-2018	187,482	112,434-312,624	0.24	0.87	Combined estimate for white-beaked and white-sided, probably dominated by white-beaked; all unidentified dolphins classed as *Lagenorynchus*	NAMMCO (2019)

4. ACOUSTICS

The Atlantic white-sided dolphin acoustic repertoire includes clicks, whistles and buzzes (Steiner 1981, Hamran 2014), but has not yet been well-described. Its vocalisations are amongst the most poorly understood of any delphinid species. The spectral and temporal structure and features of echolocation clicks in delphinids are related to their sound production morphology, allowing some acoustic characteristics to be inferred from anatomical features and vice versa. However, as neither click characteristics nor sound production morphology have been well-studied in Atlantic white-sided dolphins, it is not currently feasible to use acoustics to infer evolutionary relationships, or examine sound production morphology to determine putative echolocation click features (Vollmer et al. 2019). Nevertheless, patterns of banding in the spectral peaks of the clicks of some *Lagenorhynchus* species have been found (Soldevilla et al. 2008, Calderan et al. 2013), and preliminary work suggests Atlantic white-sided dolphins may also produce clicks with spectral peak banding (Hamran, 2014), but further, more detailed work is needed to properly describe their repertoire.

Characterising Atlantic white-sided dolphin acoustic repertoire and investigating whether the species does produce spectrally banded clicks, will not only be useful for providing indirect taxonomic information, but will also be a valuable survey tool to increase understanding of Atlantic white-sided dolphin distribution, habitat use, and potentially population differentiation. The multiple acoustic datasets which have been collected from national and international acoustic monitoring programmes which could be analysed for Atlantic white-sided dolphin occurrence can only be accessed if the vocal repertoire of this species has been adequately described. The current lack of knowledge of Atlantic white-sided dolphin vocalisations also hampers the development of deep learning tools for acoustic automated species identification. Using these new tools, it would be possible to assess seasonal occurrence and potentially abundance and population structure. If spectral banding in echolocation clicks is discovered, this will be particularly helpful in the development of deep learning classification.

5. ANTHROPOGENIC IMPACTS

In common with most small cetaceans, Atlantic white-sided dolphins are subject to a range of anthropogenic impacts including fisheries bycatch, accumulation of contaminants, underwater noise, and prey depletion (Gose et al. 2021). Owing to the primarily offshore distribution of Atlantic white-sided dolphins, fisheries interactions and impacts are poorly understood and documented (MacLeod 2004). However, the species is known to be vulnerable to bycatch by a variety of different gear types including trawls (pelagic, bottom, mid-water), and various types of gill net (Addink et al. 1997, Couperus 1997, Kinze et al. 1997, Palka et al. 1997, Craddock et al. 2009). However limited data mean bycatch in Atlantic white-sided dolphins is largely unquantified.

5.1. Climate change vulnerability

Atlantic white-sided dolphins are also thought to be particularly vulnerable to climate change impacts (MacLeod 2009, Lambert et al. 2014, Fernández et al. 2016). In marine mammals, observed impacts of climate change include geographical range shifts to higher latitudes and/or range contractions, often in response to shifts in prey distribution (Evans & Waggitt 2020, Gose et al. 2021). Data from North-West Europe collated as part of the Marine Ecosystems Research Program (MERP) (Waggitt et al. 2020) have suggested a downward abundance trend for Atlantic white-sided dolphins over the last three decades over the study area as a whole (Evans & Waggitt 2020), which may be related to changes in distribution associated with prey, although as previously described, survey coverage in areas of Atlantic white-sided dolphin distribution is poor and uneven.

5.2. Directed takes

Atlantic white-sided dolphins have been hunted in Norway, Newfoundland, Greenland, Canada and the Faroe Islands (Cipriano 2018). In Greenland, hunting is allowed year-round, and there are no quotas or catch limits, although numbers are reported annually. However, data from between 1992 and 2020 comprise combined catches of white-beaked and Atlantic white-sided dolphins as there was no Greenlandic name to distinguish between the two species prior to 2020 [1].

The drive hunt for Atlantic white-sided dolphins in the Faroe Islands takes place year-round, peaking in August and September (Bloch & Mikkelsen 2018). There are catch records available from 1872 onwards, showing that 12,067 Atlantic white-sided dolphins were taken between 1872 and 2021 (Bloch & Mikkelsen 2018)[2]. Although catch frequency had decreased after 2006, in 2021, 1428 were killed in a single drive hunt. Table 2 shows annual catches from 1992 to 2021, totalling 7603 dolphins caught and killed.

Table 2. Annual catches of Atlantic white-sided dolphin by the Faroe Islands, 1992 – 2021[3]

Year	Catch total	Year	Catch total	Year	Catch total
1992	47	**2002**	773	**2012**	0
1993	377	**2003**	186	**2013**	430
1994	258	**2004**	333	**2014**	0
1995	151	**2005**	312	**2015**	0
1996	152	**2006**	622	**2016**	0
1997	350	**2007**	0	**2017**	488
1998	438	**2008**	1	**2018**	256
1999	0	**2009**	170	**2019**	8
2000	255	**2010**	14	**2020**	8
2001	546	**2011**	0	**2021**	1428
TOTAL					**7603**

6. CONSERVATION LISTING

The International Union of the Conservation of Nature (IUCN) currently classifies Atlantic white-sided dolphins as Least Concern (Braulik 2019), although this current classification was made before the 2021 take of 1428 animals in the Faroes (see Section 5.2.).

In the US, Atlantic white-sided dolphins are not listed as threatened or endangered under the US Endangered Species Act, and the Western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. From the available data, the estimated average annual human-related mortality does not exceed limits set under the US Marine Mammal Protection Act (NOAA 2020).

[1] https://nammco.no/topics/atlantic-white-sided-dolphin/
[2] *ibid*
[3] *ibid*

In the EU, Atlantic white-sided dolphins are listed under Annex IV of the Habitats Directive 92/43/EEC, which prohibits all forms of deliberate takes of this species. The species is also listed in Appendix II of CITES, the Convention on International Trade in Endangered Species of Wild Flora and Fauna, and in Appendix II of CMS, the Convention on the Conservation of Migratory Species of Wild Animals (only North and Baltic Sea populations). The species is also covered by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS).

7. DATA DEFICIENCY IN RELATION TO EXPLOITATION

The Atlantic white-sided dolphin is one of the most heavily exploited cetacean species in the North Atlantic and yet also one of the most poorly understood. The IWC Scientific Committee has recently noted that the species is 'generally considered to be data deficient' although work is planned which is expected to 'inform the delineation of management units for conservation' in the future (IWC 2021).

In addition to the current lack of management units in the NE Atlantic, the existing abundance estimates have a number of issues that would generally preclude them from use for the purposes of managing directed takes. Most estimates in the NE Atlantic have been based on fewer than 20 sightings which were positively identified as Atlantic white-sided dolphins and hence have had to pool sightings with white-beaked dolphins in order to estimate strip widths. Estimating group size for white-sided dolphins is also challenging especially during surveys which were not specifically designed to facilitate dolphin group size estimation. Several surveys also included sightings of dolphins which were only identified as *Lagenorynchus* species and then apportioned to either white-beaked or Atlantic white-sided. Resulting abundance estimates (even excluding the uncertainty associated with apportioning unidentified dolphins and pooling with other species to obtain a detection function) have high CVs (>0.7) whereas a CV of 0.3 or less is usually considered indicative of a reliable estimate. In the NW Atlantic, sightings were often classified as Atlantic white-sided/common dolphin and so estimates rely on pro-rating unidentified sightings between these two species.

In 2021 the Scientific Committee of NAMMCO noted that it 'saw a possibility to assess white-sided dolphins in the Faroe Islands on the basis of the information available, but concluded that there was insufficient information to carry out a full assessment for other areas' (NAMMCO 2021). Thus, to date it has not been possible to conduct a scientific assessment of the conservation implications of the levels of directed takes of Atlantic white-sided dolphins. The number taken in 2021 was of a similar magnitude to the reported deliberate catches in the North Atlantic of all the other cetacean species combined in 2020. This is a serious concern given the lack of information in order to assess how the takes may affect the population.

8. RESEARCH RECOMMENDATIONS

Data deficiency is a critical concern in relation to Atlantic white-sided dolphin conservation. None of the anthropogenic threats or their long-term effects is well-understood, and survey coverage has been insufficient or inadequate, often focusing mainly on other species. As with many pelagic dolphin species, there is a risk of Atlantic white-sided dolphin favourable conservation status being greatly overstated, and any declines being undetected. As highlighted by Ashe et al. (2021), prioritising which species to focus conservation resources on is not straightforward, and often ends up disproportionately concentrating on species which are in crisis and at imminent risk of extinction. This is often to the detriment of apparently abundant populations which may, however, be declining largely unnoticed. However identifying large populations that are in decline is challenging in the absence of sufficient data and/or if statistical power is low. The following recommendations for research and policy should be considered with some urgency:

Population structure: more detailed investigation into population structure is required. Current studies (see Vollmer et al. (2015) and Gose et al. (2021)) are expected to improve knowledge on population structure through high-resolution analysis, which should assist with designating management units. However, it has already been demonstrated that there is differentiation between putative populations in the far northeast compared to the other areas.

Distribution and abundance: both aerial and vessel-based surveys are expensive, and occur rarely, especially in areas of Atlantic white-sided dolphin occurrence. Therefore any future surveys should ensure that Atlantic white-sided dolphins are a higher priority within that survey in terms of species identification (it is inappropriate, for example to group white-sided and white-beaked dolphins together), group size estimates and detection probability, so that these rare opportunities to collect distribution and abundance estimates are maximised.

Acoustics: the vocal repertoire of Atlantic white-sided dolphins has not been well-described, so it is currently not possible to use the acoustic data collected in the North Atlantic, especially using long-term moored acoustic recorders, to improve knowledge of Atlantic white-sided dolphin spatio-temporal occurrence and distribution. This relatively straightforward task would enable the development of acoustic species classifiers, with the potential for using Deep Learning algorithms which would unlock extensive datasets which could be analysed for Atlantic white-sided dolphin vocalisations.

Management units: whilst there is still little information on population structuring, the precautionary approach would be to use separate management units for most or all of the sub-populations currently identified (See Section 2.)

Conservation legislation: as noted by Ashe et al. (2021), pelagic dolphin populations are often not listed under national endangered species legislation and there is thus little incentive to study the population-level impacts of anthropogenic threats. A reconsideration of how pelagic species are listed under national legislation might expedite future conservation actions.

Exploitation: the lack of available information to assess how takes may affect populations is a serious concern. In the absence of such data, there is a pressing need for a precautionary approach to any future exploitation of the species in the NE Atlantic. The establishment of management units which reflect the currently-understood population structure and associated abundance estimates would contribute to assessments of the conservation implications of directed takes. For the current situation which lacks such information, there is no basis to determine whether the level of takes will result in depletion.

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