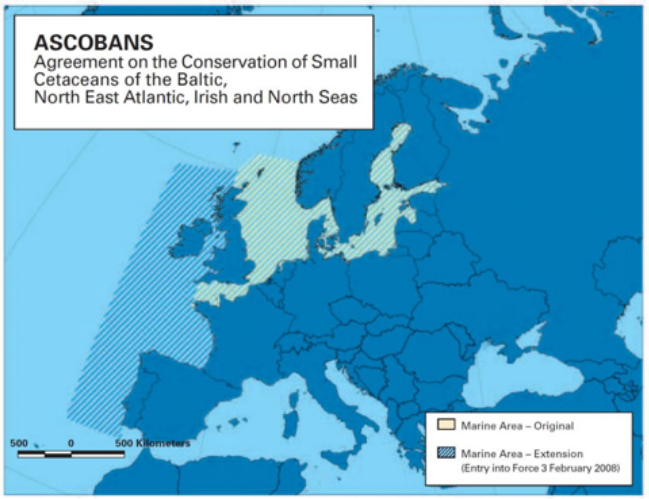
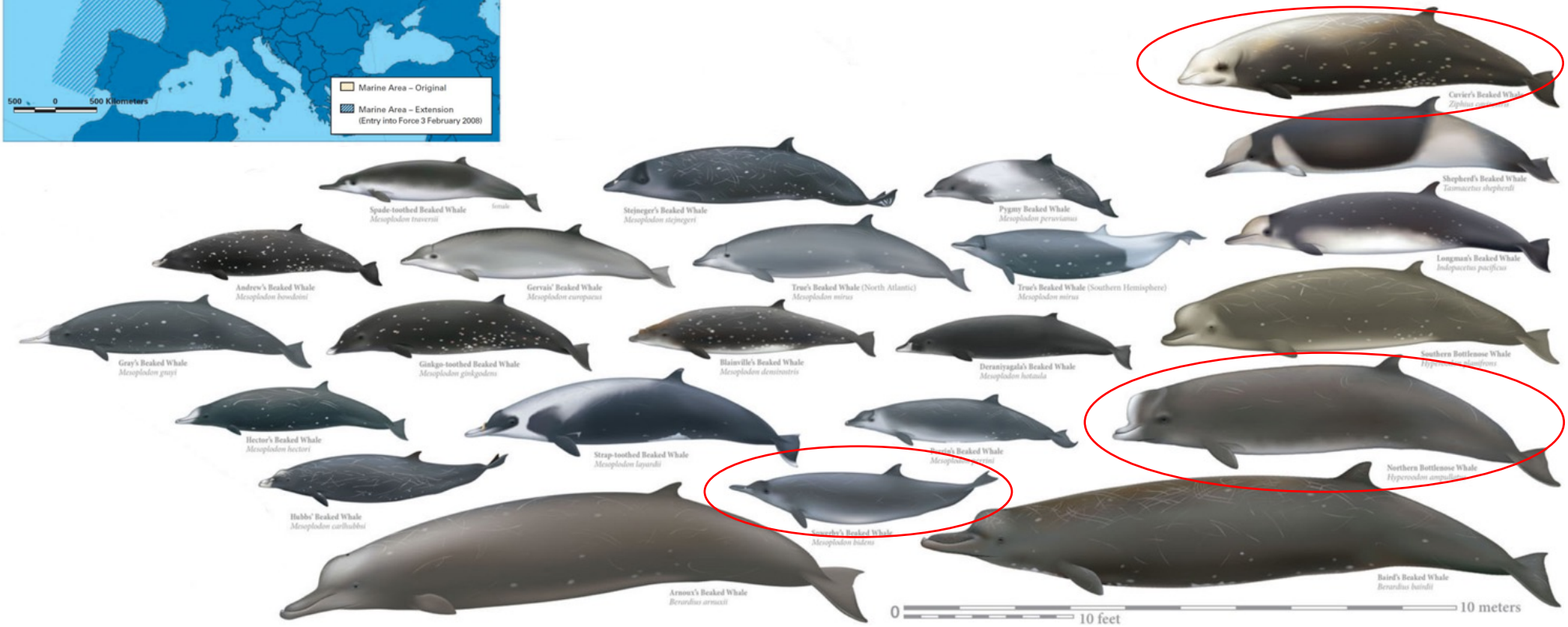
Beaked whales (*Ziphiidae*)

Sascha Hooker
University of St Andrews

Presentation to ASCOBANS 25th Meeting of the Advisory Committee (AC25), 18 September 2019



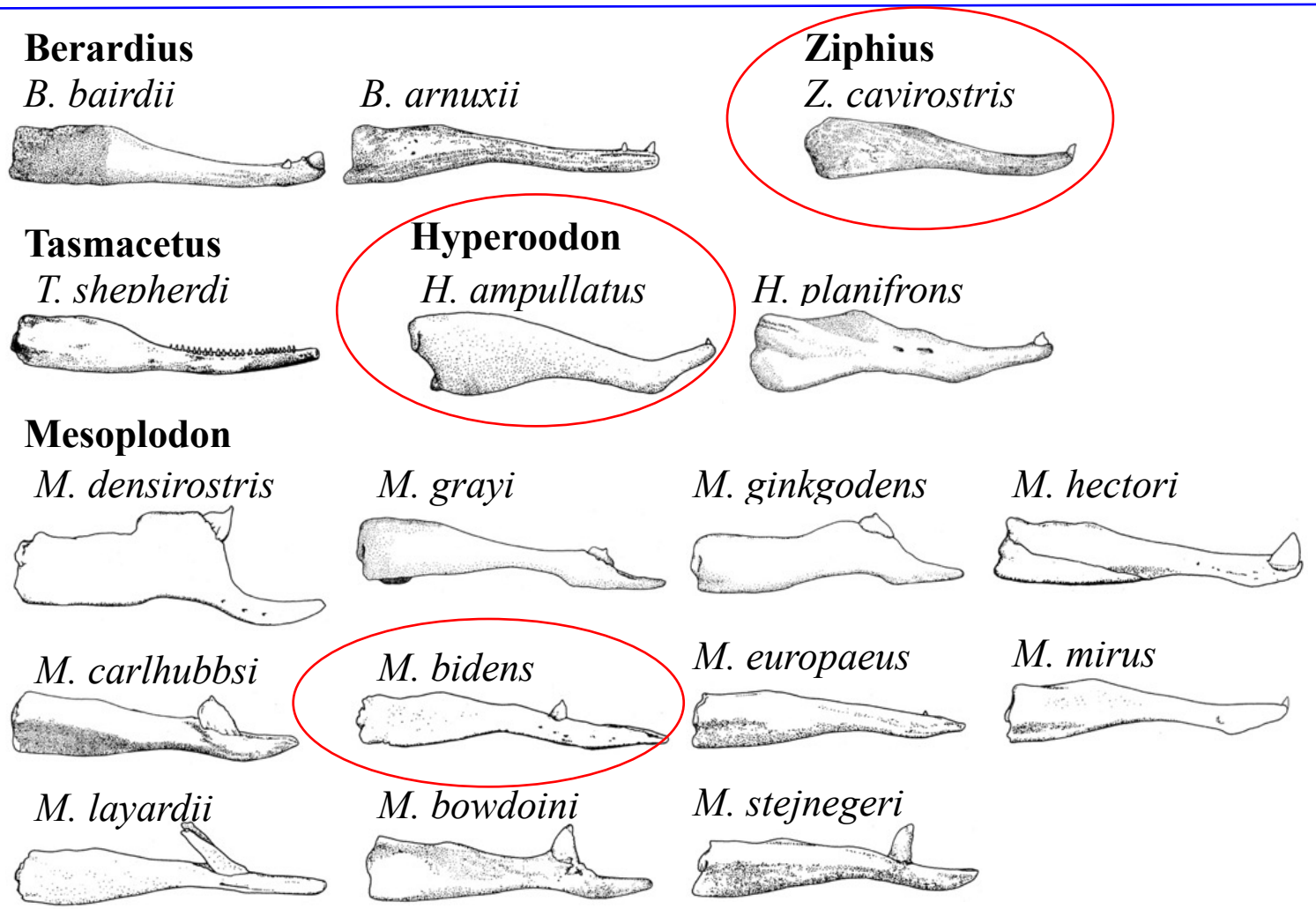
Cuvier's beaked whale
Ziphius cavirostris
Up to 7-7.5m length



Sowerby's beaked whale
Mesoplodon bidens
Up to 5-5.5m length

Northern bottlenose whale
Hyperoodon ampullatus
Up to 8-9m length

Ziphiids: the toothless toothed whales

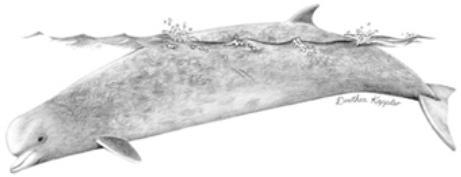


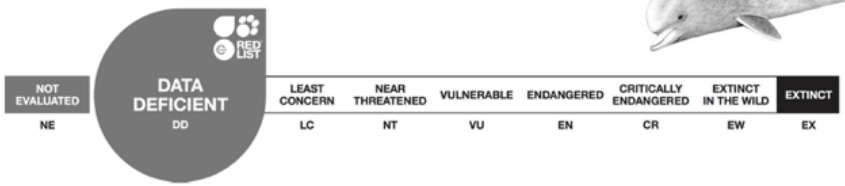
Variation in position, size, and morphology of the lower jaw teeth of adult males.
After Jefferson TA, Leatherwood S, and Webber MA (1993) Marine Mammals of the World. Rome: United Nations Environment Program, FAO.

Distribution and Status

Northern bottlenose

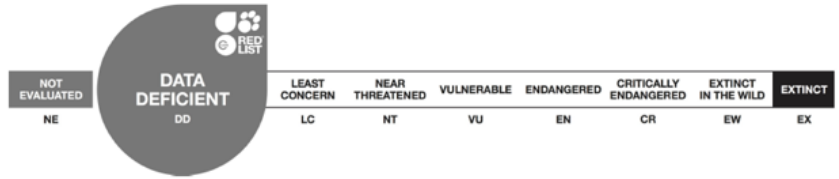
Hyperoodon ampullatus





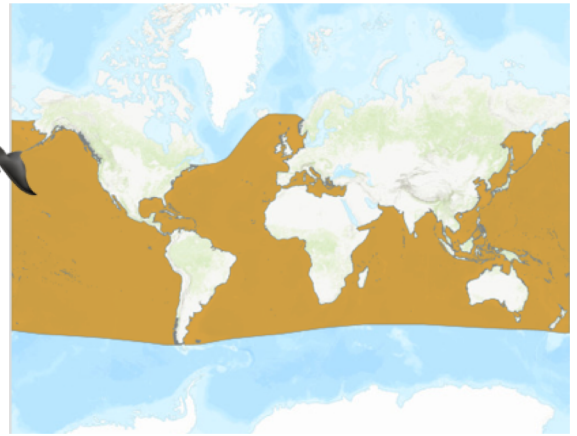
Sowerby's beaked whale

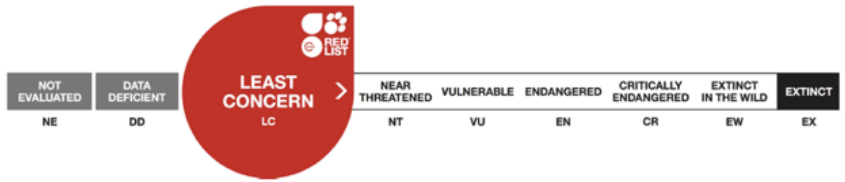
Mesoplodon bidens



Cuvier's beaked whale

Ziphius cavirostris





Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008.
Hyperoodon ampullatus | Mesoplodon bidens | Ziphius cavirostris.

Why are beaked whales so little known?

Deep, long dives
– not at surface for long

Habitat is often far offshore
– at/beyond 1000m contour

Generally shy of boats
- northern bottlenose whales are an exception

Superficially similar to each other
- difficult to identify to species level (aerial and shipboard surveys often identified only to genus level)

Surveys for beaked whales

Sightings surveys problematic

Beaked whales averse to boats

Spend long periods of time at depth

Often have relatively inconspicuous behaviour at the surface

→ low detection rates compared to other cetaceans

Passive acoustic surveys show potential

- echolocation clicks (temporal & spectral properties unique) allow identification
- acoustically active (navigation, foraging, communication)
- temporal presence/ absence from bottom-mounted hydrophones
- density estimation
- hydrophones on ocean gliders and vertical profiling floats provide broad spatial and temporal coverage

Hooker et al. 2019. Frontiers in Marine Science doi: 10.3389/fmars.2018.00514

Beaked whale research

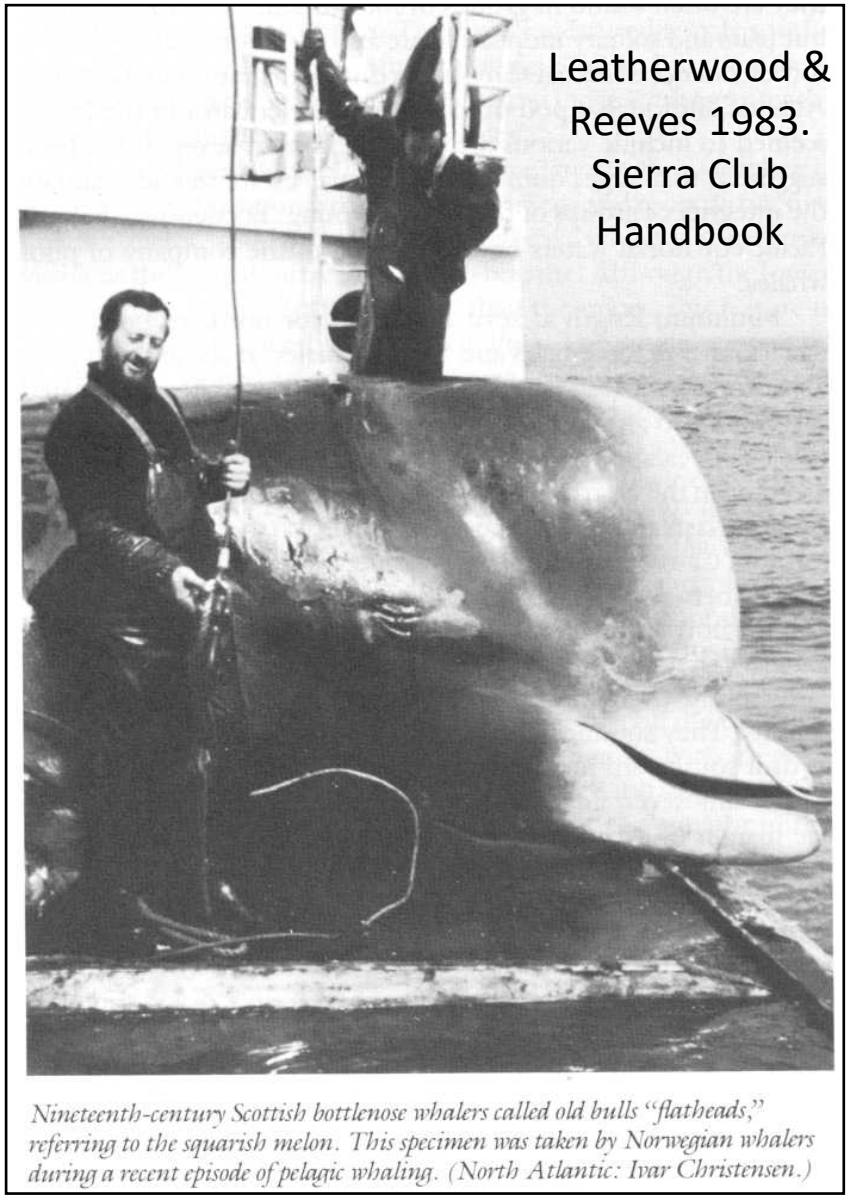
Before 1980s – based on:

Whaling: northern bottlenose whales 64,000 whales taken 1850-1967.

(Baird's beaked whales also taken in N. Pacific)

→ Primarily reproductive and demographic information

Strandings: occasional necropsy of stranded animals



Leatherwood & Reeves 1983. Sierra Club Handbook

Nineteenth-century Scottish bottlenose whalers called old bulls "flatheads," referring to the squarish melon. This specimen was taken by Norwegian whalers during a recent episode of pelagic whaling. (North Atlantic: Ivar Christensen.)

Hooker et al. 2019. Frontiers in Marine Science doi: 10.3389/fmars.2018.00514

Longitudinal studies

Long-term studies: photo-id
→ life history, social structure, population size

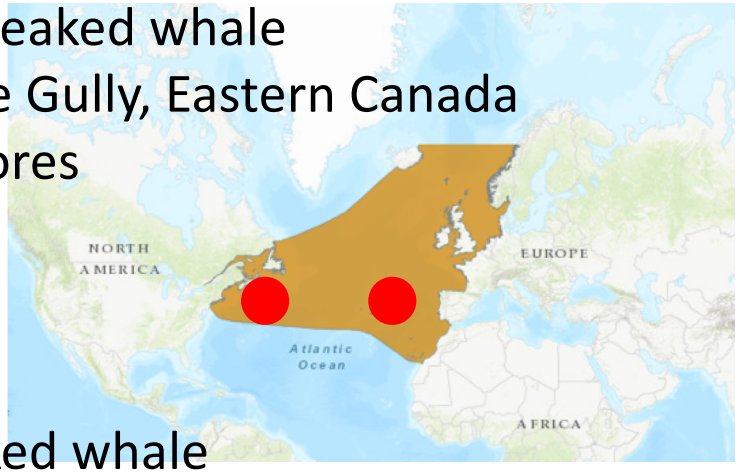
Tag-based efforts
→ individual diving, movements, acoustics
→ population structure, ranges

Passive acoustic monitoring
→ long term and seasonal monitoring

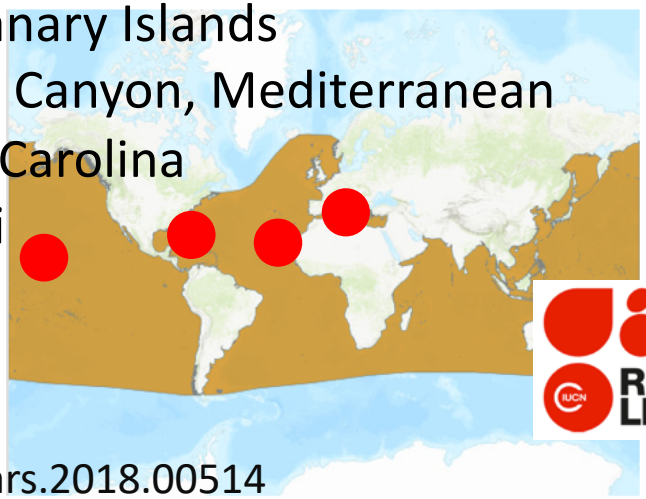
Genetic studies
→ genetic diversity, connectivity

Northern bottlenose
The Gully, Eastern Canada
Jan Mayen

Sowerby's beaked whale
The Gully, Eastern Canada
Azores



Cuvier's beaked whale
The Canary Islands
Genoa Canyon, Mediterranean
North Carolina
Hawaii



Hooker et al. 2019. Frontiers in Marine Science doi: 10.3389/fmars.2018.00514

Bottlenose whale: population status

Historic whaling areas

1. Scotian Shelf
2. Baffin-Labrador
3. East Greenland-Iceland-Jan Mayen-Faeroes
4. Southwest Svalbard
5. Andenes, northern Norway
6. More, western Norway

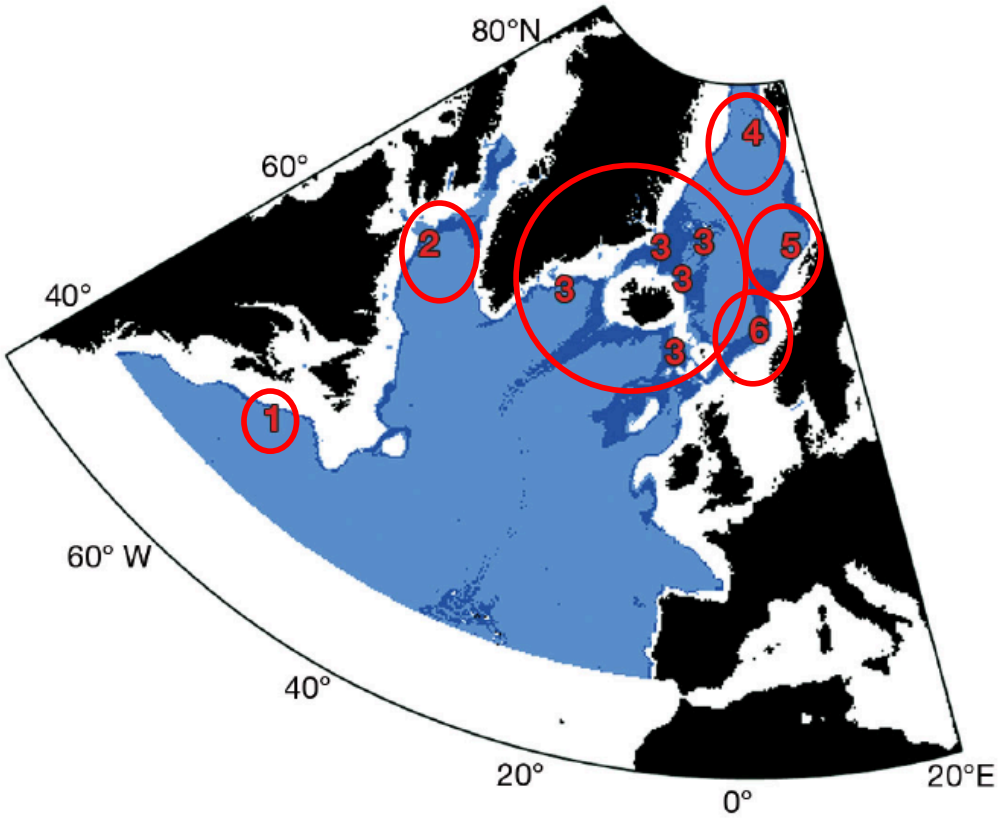


Fig. 1. General distribution of northern bottlenose whales in the North Atlantic (light blue), shown by waters greater than 500 m deep and north of 37.5°N (note: the northern parts of Baffin Bay and the Mediterranean Sea do not seem to be usual habitat for this species). Preferred habitat (800–1800 m deep) is shown in dark blue. The 6 centres of whaling operations are shown: (1) Scotian Shelf; (2) Labrador and southern Baffin Bay; (3) East Greenland, Iceland, Jan Mayen and the Faeroe Islands; (4) Svalbard; (5) Andenes; and (6) Møre

Whitehead & Hooker et al. 2012. Endangered Species Research 19: 47–61.

Historical exploitation

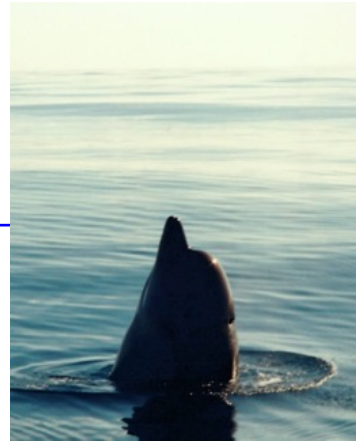
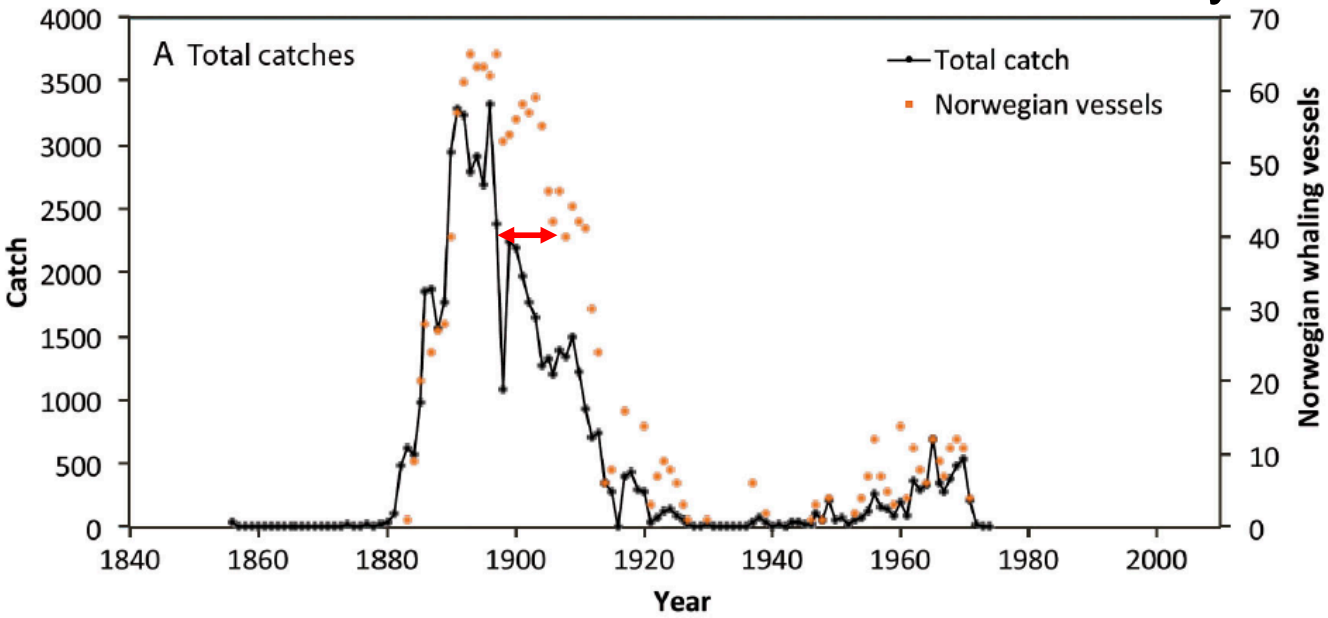


Table 1. Approximate numbers of bottlenose whales caught by different hunts in different population centres of the North Atlantic (from Benjaminsen 1972, Christensen & Ugland 1983, Reeves et al. 1993, Bloch et al. 1996), based upon Table 2 of International Whaling Commission (2012). Gaps indicate no data available (it is assumed that there are no catches)

Whalers	Dates	Scotian Shelf	Labrador–Baffin	Iceland/ E. Greenland	Faeroes	Svalbard	Andenes, Norway	Møre, Norway
Faeroe Is.	1584–1993				740			
UK	1856–1893		264	1643				
Norway	1882–1930			←		56 389[a]		→
Norway	1937–1973			2277		1795	241	740
Norway	1969–1971		818					
Canada	1962–1967	87						

[a]Sum of animals caught in Iceland/E. Greenland, Faeroes, Svalbard, Andenes and Møre

Number of bottlenose whales taken annually:



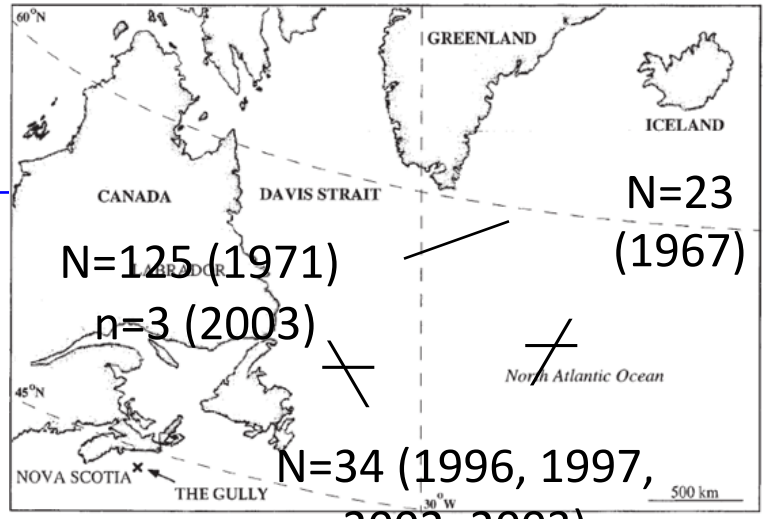
Overexploitation shown by lag between catch numbers and whaling vessel numbers

Whitehead & Hooker et al. 2012. Endangered Species Research 19: 47–61.

Bottlenose whale populations

10 microsatellites F_{ST}

mitochondrial DNA (mtDNA) control region sequences (434 bp) Φ_{ST}



	BAFFIN - LABRADOR		ICELAND	
	F_{ST}	Φ_{ST}	F_{ST}	Φ_{ST}
SCOTIAN SHELF	0.243 (p<0.0001)	0.0456 (p<0.05)	0.0276 (p<0.0001)	0.0315 (p=0.12)
LABRADOR			0.0000 (p=0.4)	-0.0150 (p=0.72)

mtDNA diversity was very low in all populations

– pattern possibly due to deep-diving ecology

Dalebout et al. 2006. Molecular Ecology 15:3115-29

Distinct populations

Measurements: Scotian Shelf animals 0.7m smaller

Calving: August (Scotian Shelf); April (Baffin-Labrador)

No photo-id matches between Scotian Shelf and 9 IDs in Baffin-Labrador

Contaminants: significant differences between both CYP1A (biomarker for exposure to aromatic hydrocarbons) and blubber contaminants between 33 samples on Scotian Shelf and 3 from Baffin-Labrador

Photo-identification: <200 animals in Scotian Shelf would be very small total population for large range if this included Labrador animals

Whitehead & Hooker et al. 2012. Endangered Species Research 19: 47–61.

Bottlenose: population estimates

Scotian Shelf: 163 animals (CI 119-214) (photo-id 1988-2003)

→ declared Endangered by COSEWIC in 2002

Baffin-Labrador: lower encounter rate than Gully

→ declared Special Concern by COSEWIC in 2011

Iceland and Faeroes: T-NASS 2007: 26 sightings, Iceland (no $popl_n$ estimate)

12 sightings, Faeroes ($popl_n$ estimate 16284)

Norway: Andenes – "very rare", **More** – no sightings

No indication of recovery, and only faint signs of extant populations"

Svalbard – more encouraging, 12 sighted in 2780nm survey (2008)

Whitehead & Hooker et al. 2012. Endangered Species Research 19: 47–61.

Bottlenose whale: stranding rates

Stranding rates may indicate population trajectories

Faroes – drop between 1910-1990 suggests major depletion.

Ireland and UK – relatively stable

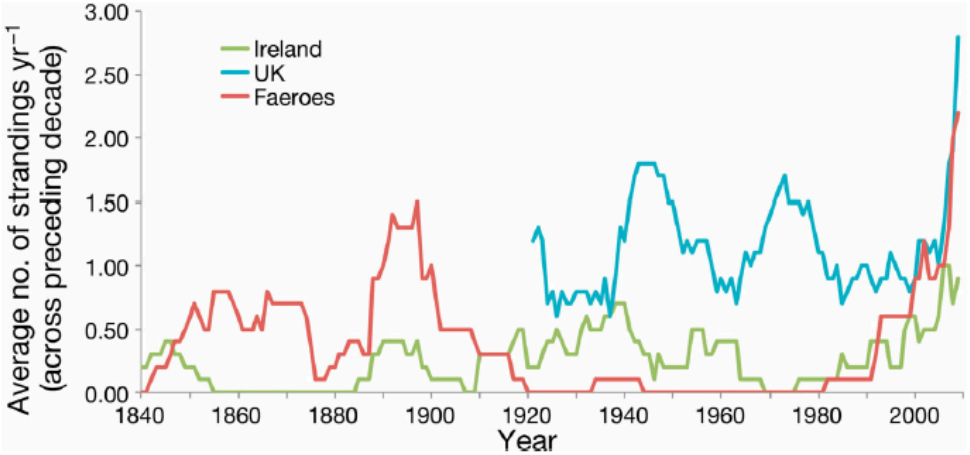


Fig. 3. Rates of strandings from the Faeroes (data from Bloch et al. 1996, www.vmr.fo/Default.aspx?ID=7125), Ireland (data from Rogan & Hernandez-Milian 2011) and the UK (data from Natural History Museum and Zoological Society London available from 1913). The moving average calculated for the decade preceding each year is shown

2000-2010 – dramatic increase (also for other species not hunted)

suggests either:

- increased reporting probability
- increase in natural or anthropogenic causes of strandings

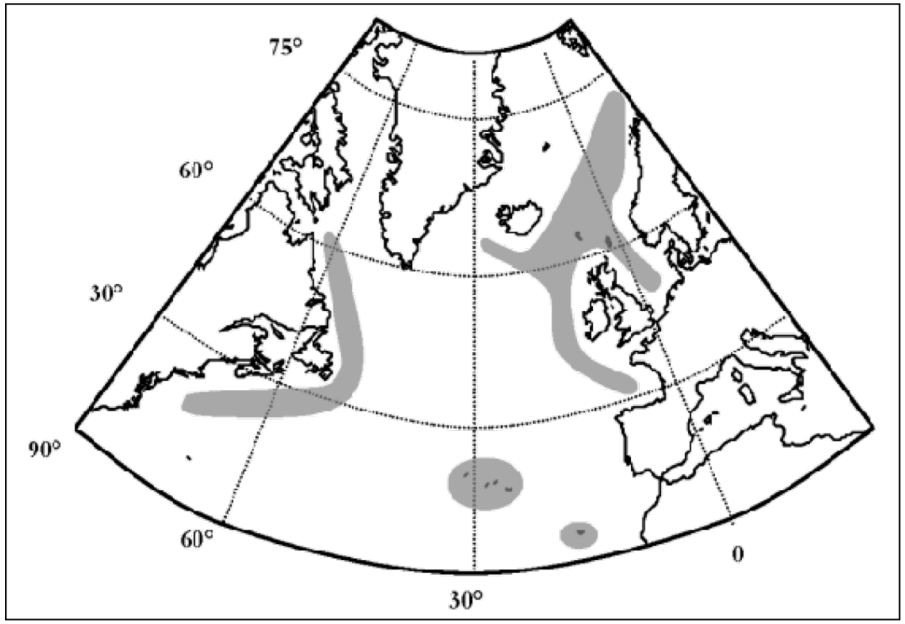
Whitehead & Hooker et al. 2012. Endangered Species Research 19: 47–61.

Sowerby's: population status

Canada

COSEWIC: Special Concern

Photo-id conducted in Gully, eastern Canada – some resightings across days and years.



Fisheries and Oceans Canada. 2017. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. iv + 46 pp.

Over a 23-year study period (i.e. 1988-2011), annual increase of 21% in incidental sightings of Sowerby's beaked whales (the first reported sighting was in 1994).

Whitehead 2013. Can. J. Zool. 91: 141–148

Cuvier's: population status

Fig. 2. Adult female stranded in Vindenes in 2017. Photo: Arild Breistøl

Most common and abundant of the beaked whales

Worldwide population likely well over 100,000, but no information on trends.

First record for Norway, 2011 and 2017 (Bachara & Oien, 2017)

Global assessment of genetic diversity:

- little movement of Cuvier's beaked whales between ocean basins
- distinct subpopulation in the Mediterranean Sea
- high degree of isolation and low maternal gene flow among oceanic, and in some cases, regional populations
- market product purchased in South Korea grouped with North Atlantic haplotypes, suggesting violation of international trade ban

Dalebout et al. 2005. Molecular Ecology 14: 3353–3371

Beaked Whales: Life History Data

GUESSES

Data input for energetic models - survival and reproduction of beaked whales

Species	Length of gestation g_t (days)[a]	Neonate / maternal length at birth L_b (%)	Calf / maternal length at weaning L_w (%)	Time to weaning W (days)[a]
Hyperoodon ampullatus	365[41]	0.46[14]	0.86[41]	365[41]
M. bidens	365	0.48[63]	0.77[70] (immature)	365
Ziphius cavirostris	365	0.4[89]	0.78[90] (subadult)	365

New et al. 2013 PLoS ONE 8(7):e68725

"large gaps in our knowledge of their life-history traits"

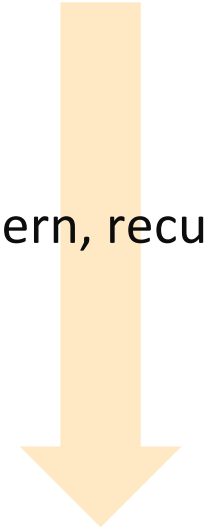
studies are few and so these estimates are very likely incorrect

E.g., Hawaii: calving interval for Ziphius ~6 years

Two calves stayed with mothers >2years (Baird pers comm)

Potential Threats

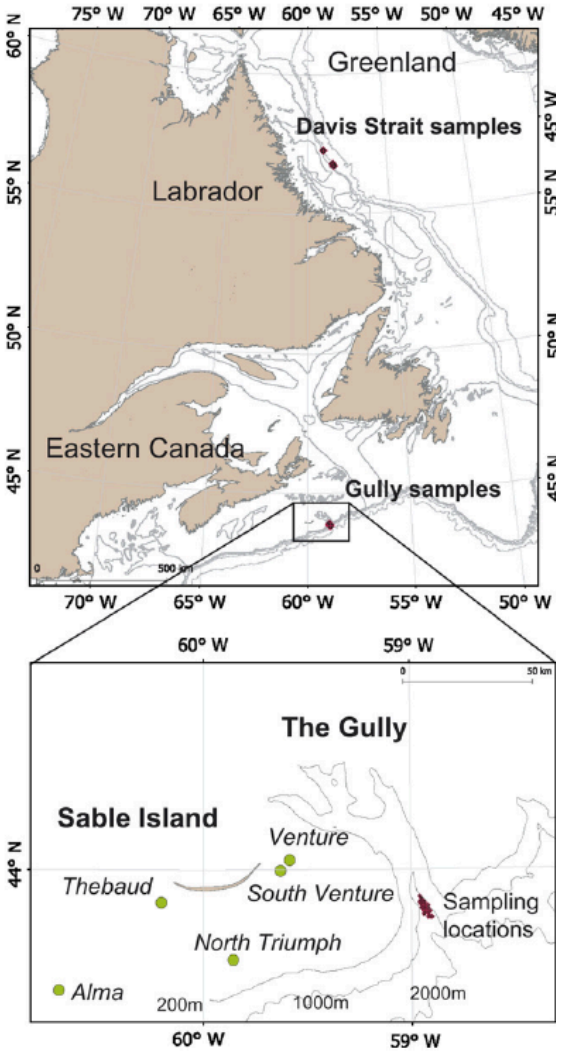
- Exposure to contaminants [low concern, unknown]
- Interactions with vessels [low concern, recurrent]
- Interaction/entanglements with fishing gear [medium concern, recurrent]
- Anthopogenic noise
  - Chronic [medium concern, continuous]
  - Acute [high concern, recurrent]



Increasing concern

Bottlenose whale contaminants

	Prior to construction	5 years after drilling
Gully	7m, 13f	9m, 7f
Outgroup - Labrador		2m, 1f



Concentrations of PCBs and organochlorine compounds similar to other north Atlantic odontocetes
Some increases between 1996 and 2003

Gully vs. Labrador:

- Higher levels of circulating aromatic compounds (shown by CYP1A expression) in Labrador
- Higher blubber contaminants in Gully – particularly DDTs

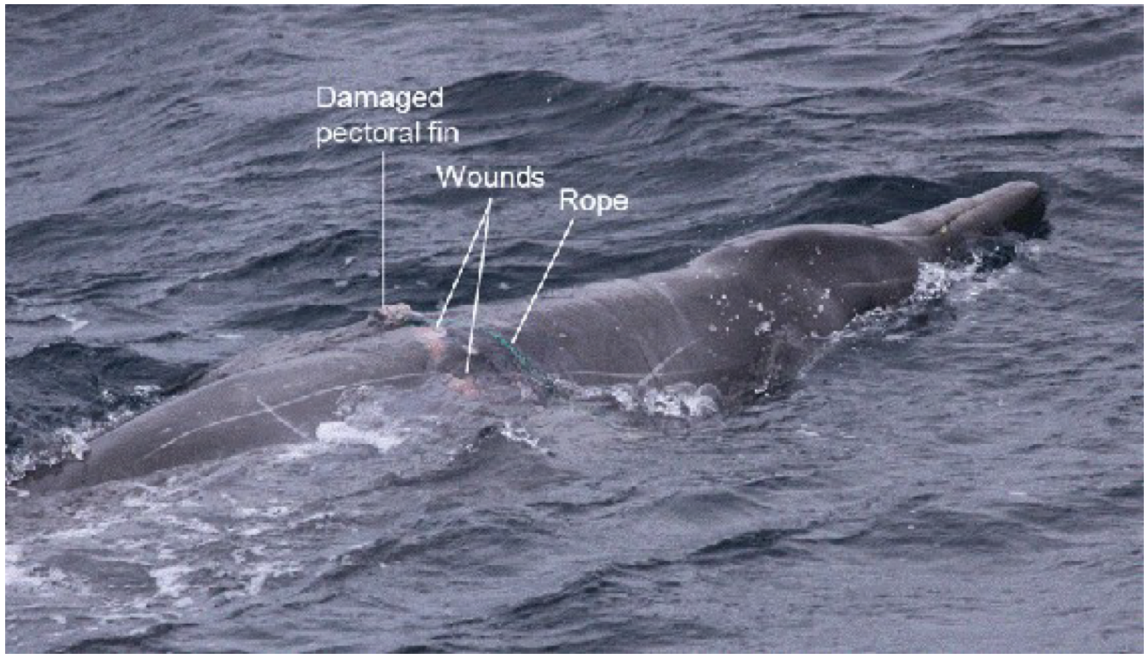
Hooker et al. 2008. Environmental Pollution.

Vessels and Fishing Gear

Ship strikes

Bycatch and entanglement

- Bottlenose and Sowerby's



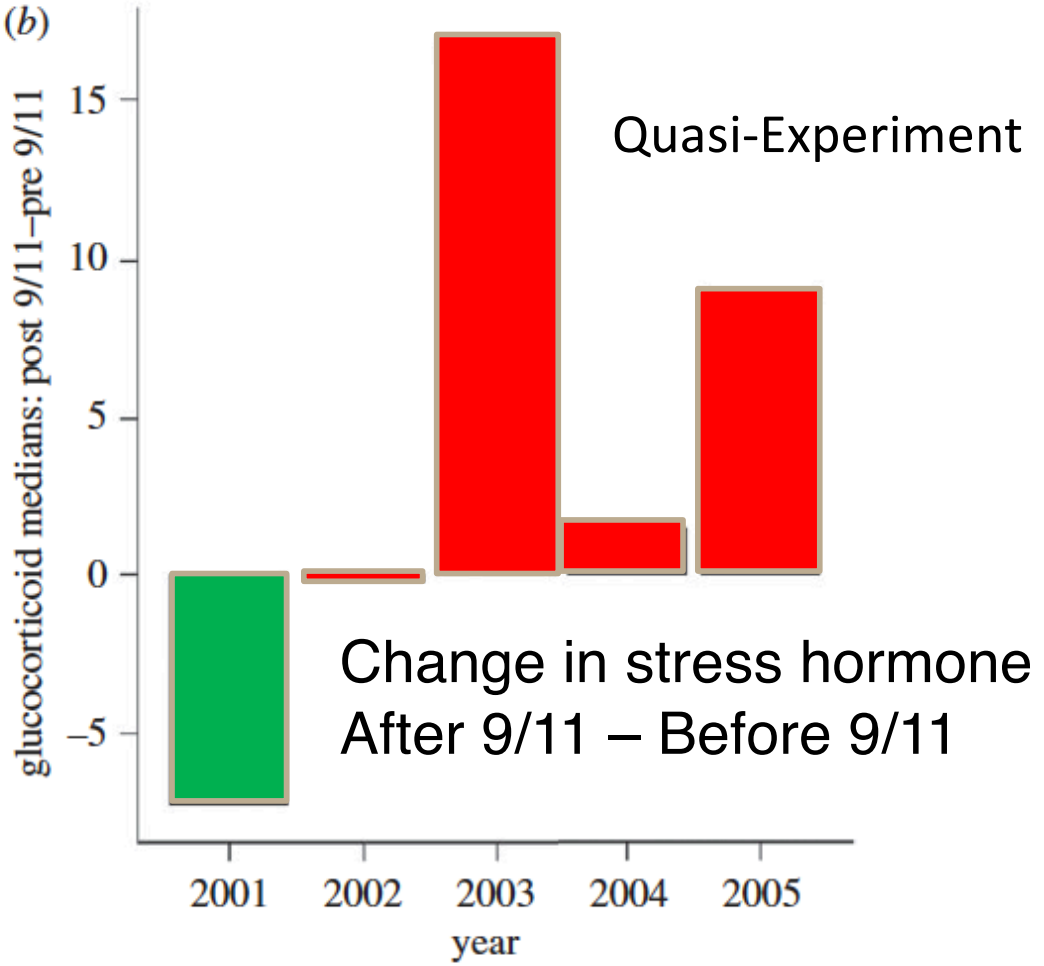
An entangled Sowerby's Beaked Whale floating on its side in the Gully, which was discovered and freed during the summer of 2013. Rope and fresh wounds are visible on the body and pectoral fin.
Photo credit: K. O'Brien, Whitehead Lab, Dalhousie University.

Chronic noise

Sound is critical. Beaked whales use sound to navigate, forage, socialize

Increasing ocean noise is likely detrimental

Stress Hormones in Right Whale Feces Dropped After 9/11 in 2001 but not Later Years



Rolland et al. 2012. Proc. Roy. Soc. Lond. B. Ship noise and stress in whales

Acute noise

1991
Simmonds & Lopez-Jurado

Whales and the military

nature
International journal of science

scientific correspondence

1998
Frantzis

Does acoustic testing strand whales?

2003
Jepson et al.

Gas-bubble lesions in stranded cetaceans

Was sonar responsible for a spate of whale deaths after an Atlantic military exercise?

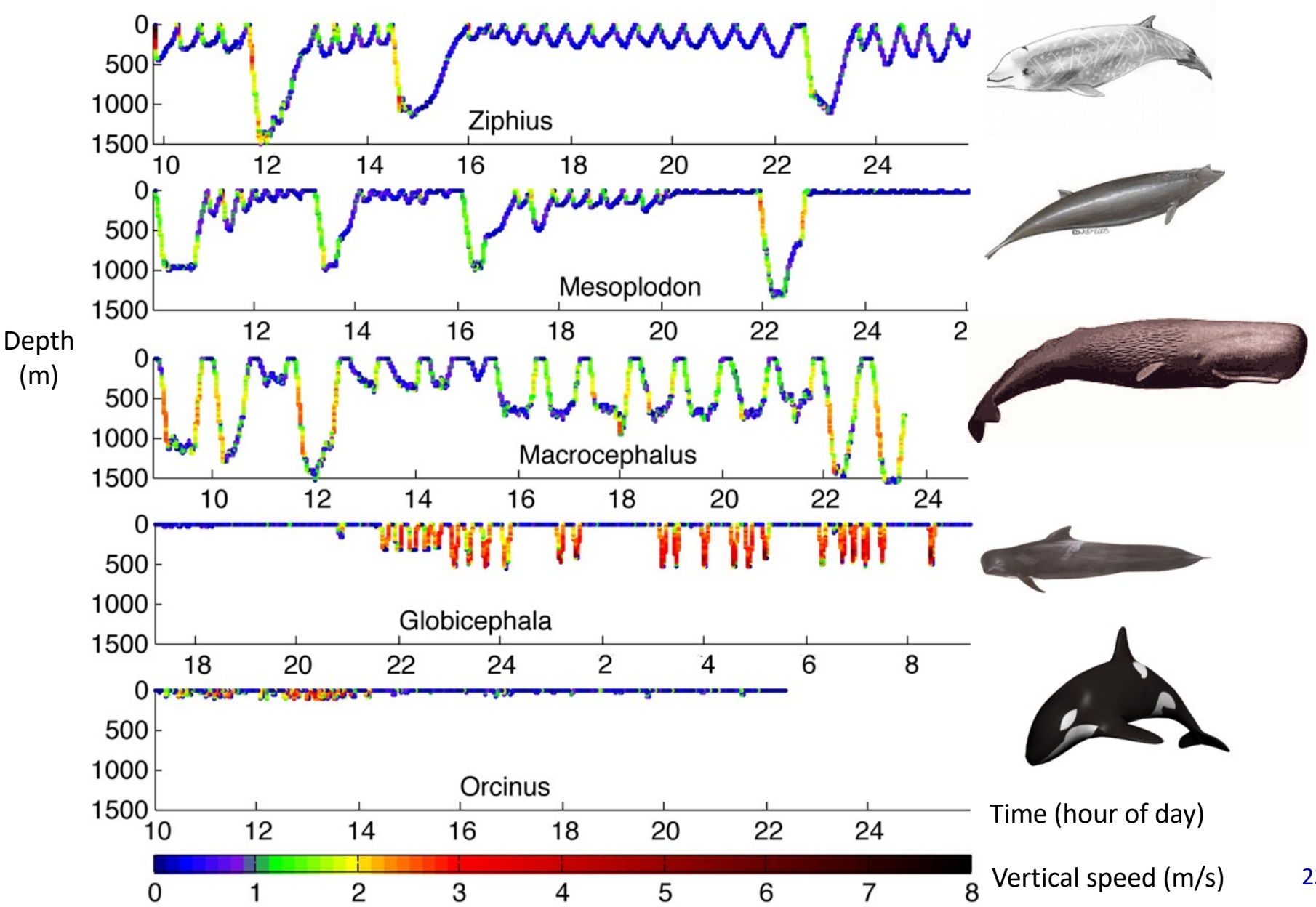
Beaked whale strandings associated with sonar exposure

Gas-bubble disease, induced in supersaturated tissue by a behavioural response to acoustic exposure, is a plausible pathologic mechanism

Cox et al. 2006. J. Cetacean Res. Manage. 7:177–187

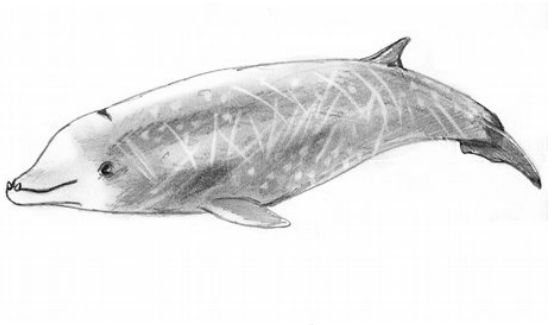
Diving behaviour

Data © WHOI



Decompression sickness

Data © WHOI



Hooker et al. 2012. Proc. Roy. Soc. Lond. B. Marine mammals and DCS

Controlled exposure experiments

Baird's beaked whale

Stimpert et al.2014

Blainville's beaked whale

Tyack et al. 2011

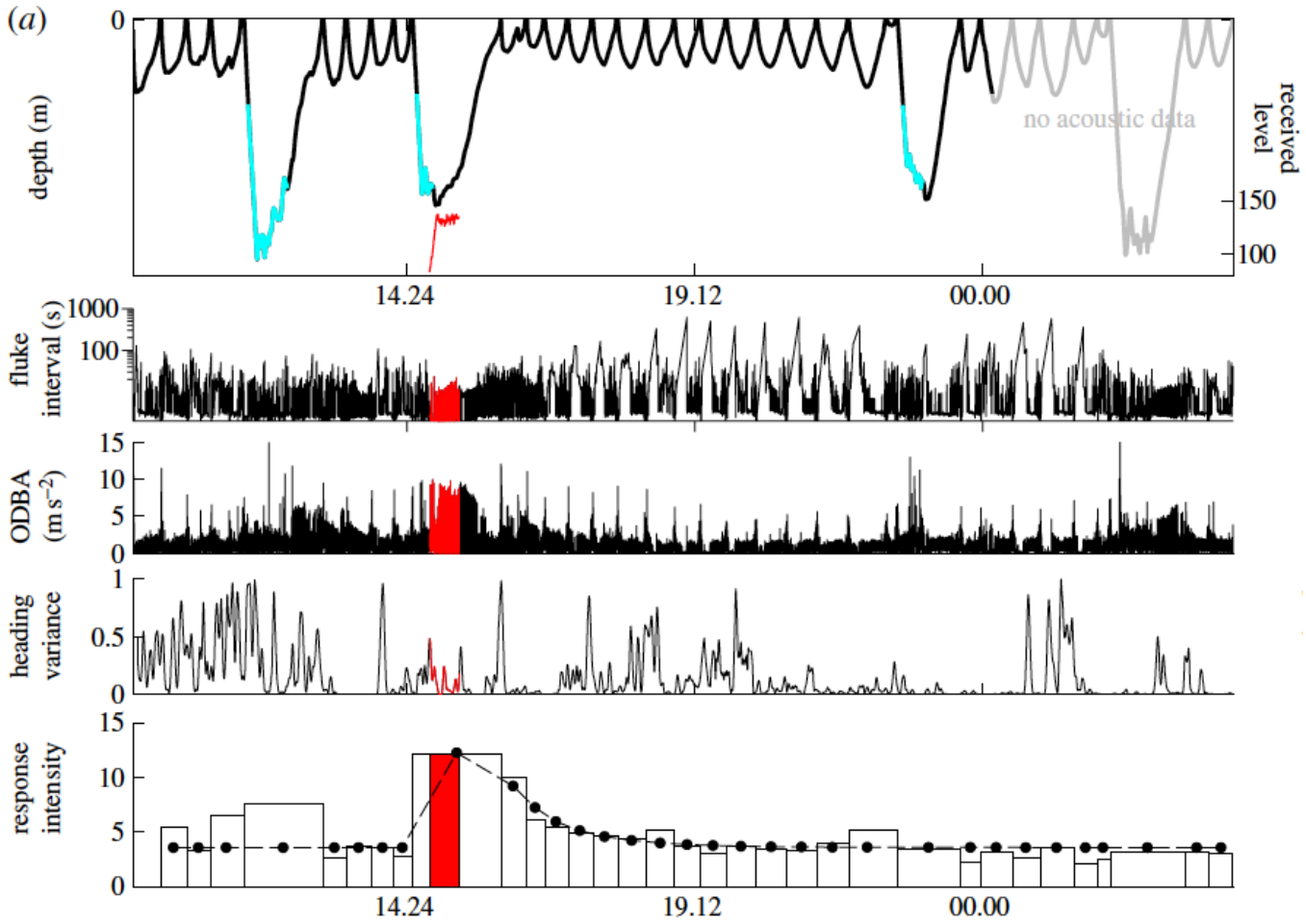
Cuvier's beaked whale

DeRuiter et al. 2013

Falcone et al. 2017

Northern bottlenose whale

Miller et al. 2015



DeRuiter et al. 2013

Consistent reaction –

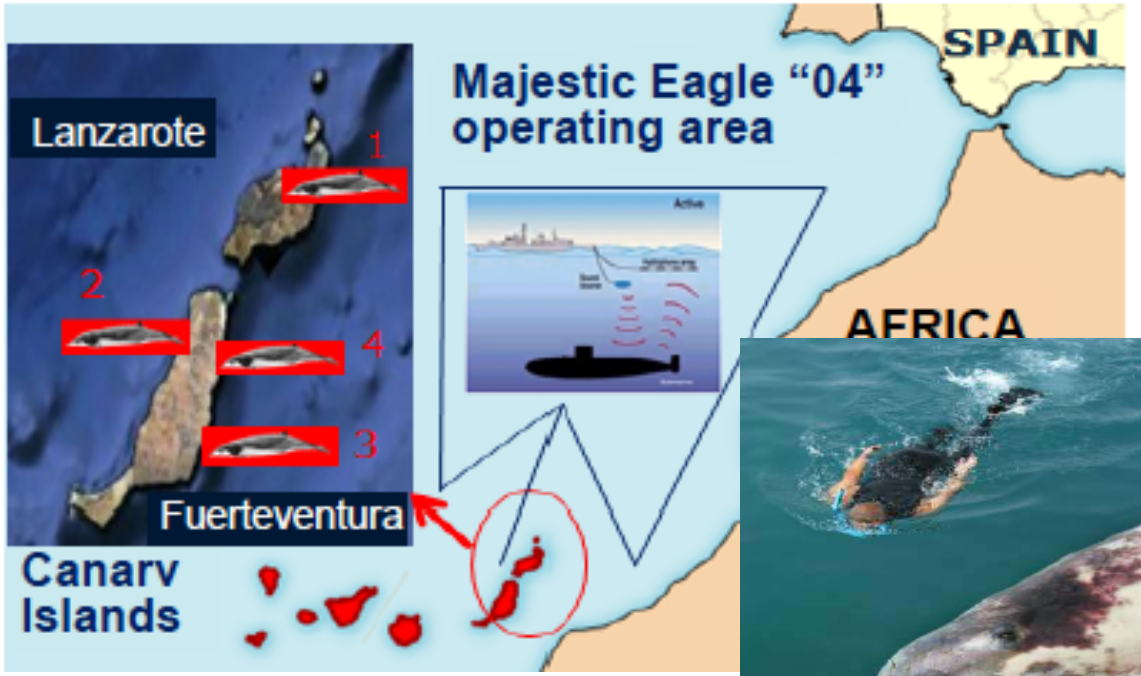
Avoidance

Cessation of echolocation

Directed travel away from source

Hooker et al. 2019. Frontiers in Marine Science doi: 10.3389/fmars.2018.00514

Atypical strandings



Canary Islands, July 2004.

4 Cuvier's beaked whales

"Atypical" mass stranding

Whales died at sea

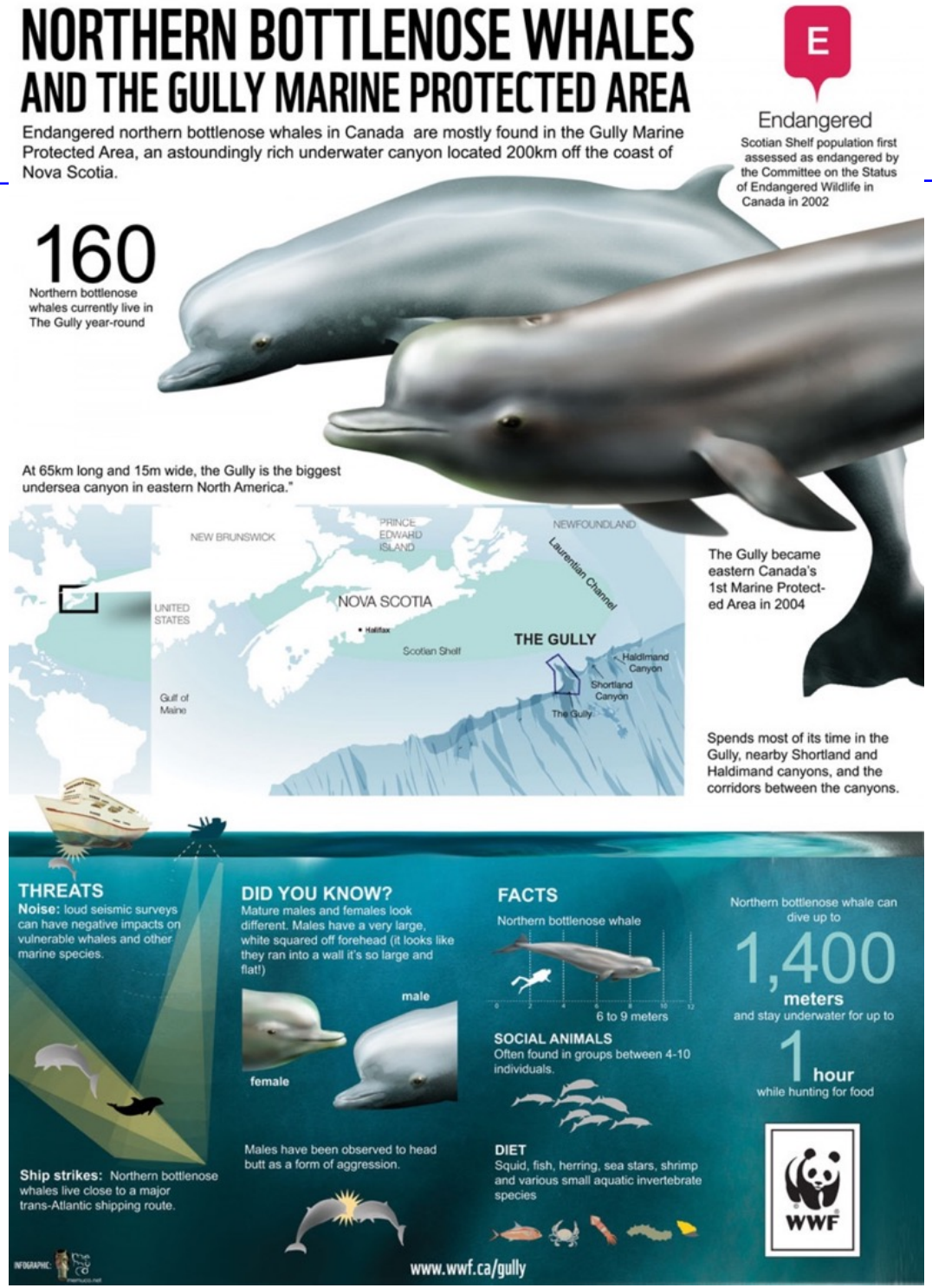
Temporally and spatially associated with sonar

→ EU parliament recommendation and Spanish government resolution established anti-sonar moratorium around the Canary Islands in 2004

2004-2011. No further strandings

Fernandez et al. 2012. J Marine Sci Res Dev 2:107

Marine Protected Areas



Spatial protection around high use areas

Where are high use areas in ASCOBANS marine area + extension?

Needs effective prohibition/exclusion of threat activities

Effective protection for noise impacts requires buffer zone such that received sound levels within the Protected Area are minimized.

Beaked whale mass stranding: summer 2018

Iceland (July - Sept):
12 live-stranded bottlenose whales
3 Cuvier's beaked whales (decomposed)

Photo: Eyþór Árnason, Fréttablaðið

Ireland (August):
20 Cuvier's beaked whales stranded decomposed

Updated total >80 dead beaked whales

Western Scotland (August):
15-18 Cuvier's beaked whales stranded decomposed over 2-3 weeks



https://www.bbc.co.uk/news/uk-scotland-45643374

Images: SMASS

Beaked whale strandings: summer 2019

Sweden (August 2019):

3 male Sowerby's beaked whales

Skaggerat coast

https://www.bohuslaningen.se/nyheter/sotenäs/val-hittad-död-i-åbyfjorden-ytterligare-en-skadad-1.16898271

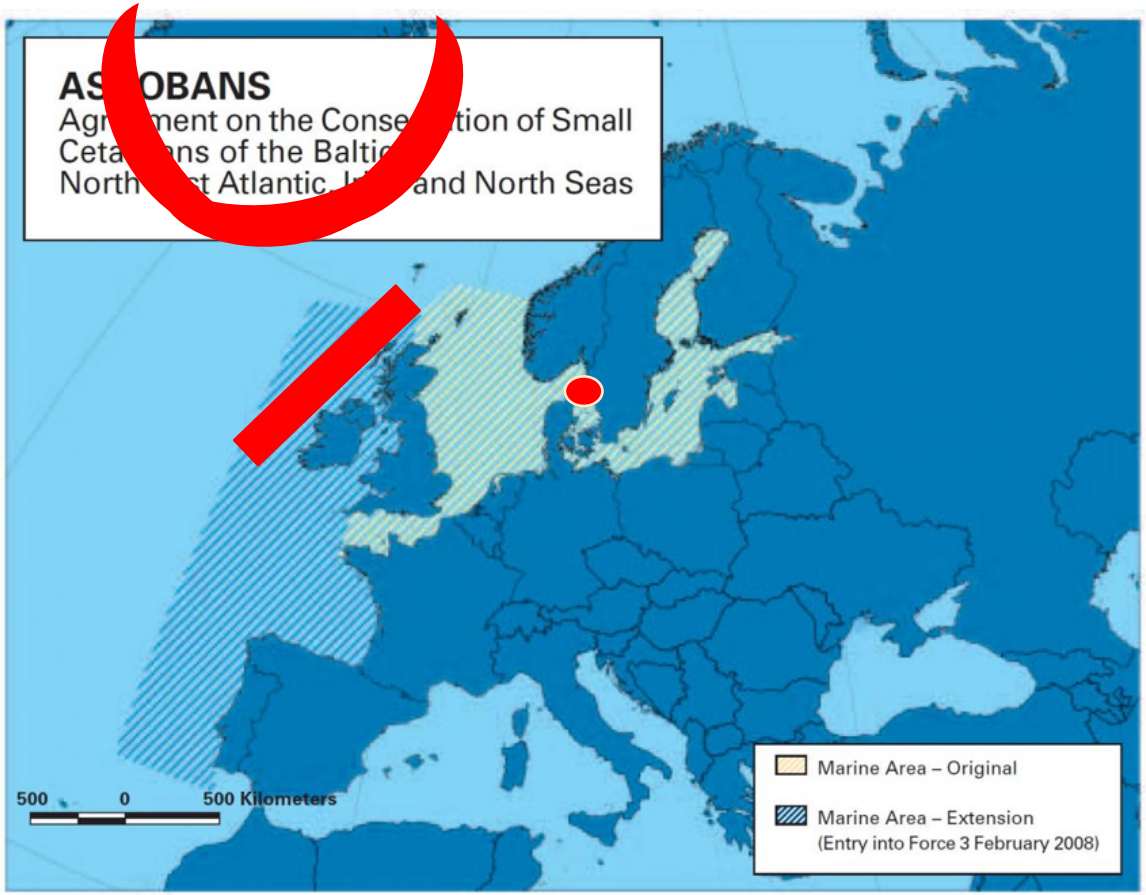
Beaked whale strandings

Atypical stranding events

Involved all three beaked whale species

Highly likely active sonar operation was involved

Military have said that they were operating under current mitigation protocols



ASCOBANS

Resolution No. 4, 5th meeting of the Parties 2006

Adverse Effects of Sound, Vessels and Other Forms of Disturbance on Small Cetaceans

Invitation to Parties and Range States to

(1) Develop, with military and other relevant authorities, effective mitigation measures including environmental impact assessments and relevant standing orders to reduce disturbance of, and potential physical damage to, small cetaceans

2018 events suggest:

- Current mitigation protocols are not effective
- Mitigation protocols need to be changed

https://www.ascobans.org/sites/default/files/document/MOP5_2006-4_SoundVesselsDisturbance_1.pdf

ASCOBANS: Intersessional Working Group on the Assessment of Acoustic Disturbance

17th ASCOBANS Advisory Committee Meeting AC17/Doc.4-08 (WG) 2010

6.1 Military sonars and civil high-power sonars

Planning should include:

collection of field survey data; modelling and development of informed estimates; confirmation of conditions for sound propagation; avoidance by Navies of important oceanographic features; further development of passive acoustic monitoring (PAM)

Real-time Mitigation

Post-exercise Monitoring & Reporting

a. Post-exercise monitoring

b. Transparent reporting to national authorities should occur, so that effectiveness and compliance to guidance can be monitored and appropriate adaptive management can be applied.

Was all (or even any) of this done?

https://www.ascobans.org/sites/default/files/basic_page_documents/AC17_4-08_ReportWGAcousticDisturbance.pdf

Lessons from ACCOBAMS?

Resolution 4.17

6. *Mandates* the Agreement Secretariat to develop, on the basis of the reports submitted by States Parties, a typology of activities within the region that have been approved and include a noise component, so that in the occurrence of an unusual event, such as a mass stranding, it will be possible to examine the possible causes;

Guidelines: to address the impact of anthropogenic noise on cetaceans

- for (military sonar and civil) high power sonar
- for seismic surveys and airgun uses
- for coastal and offshore construction works
- for offshore platforms
- for Playback & Sound Exposure Experiments
- for shipping
- for other mitigation cases (tourism, disposal and decommissioning)

http://www.accobams.org/new_accobams/wp-content/uploads/2016/06/ACCOBAMS_MOP4_Res.4.17.pdf

The Herald Feb 24, 2006

Sonar test fears for marine mammals,

Ian Bruce Defense Correspondent

Roger Gentry, a marine expert at the US National Oceanic and Atmospheric Administration, said the arrival of a new generation of quiet submarines . . . raised the stakes against whales and dolphins. "*We are seeing military sonar used in habitats where it has never been used before. Navies have to work closer to shore than ever before. The same seabed canyons favoured by marine mammals are the perfect hiding places for submarines hoping to launch a sneak attack. Warfare has changed and so has the threat to those creatures*."

We need more effective safety procedures in place so that we do not continue to kill beaked whales

Future beaked whale research

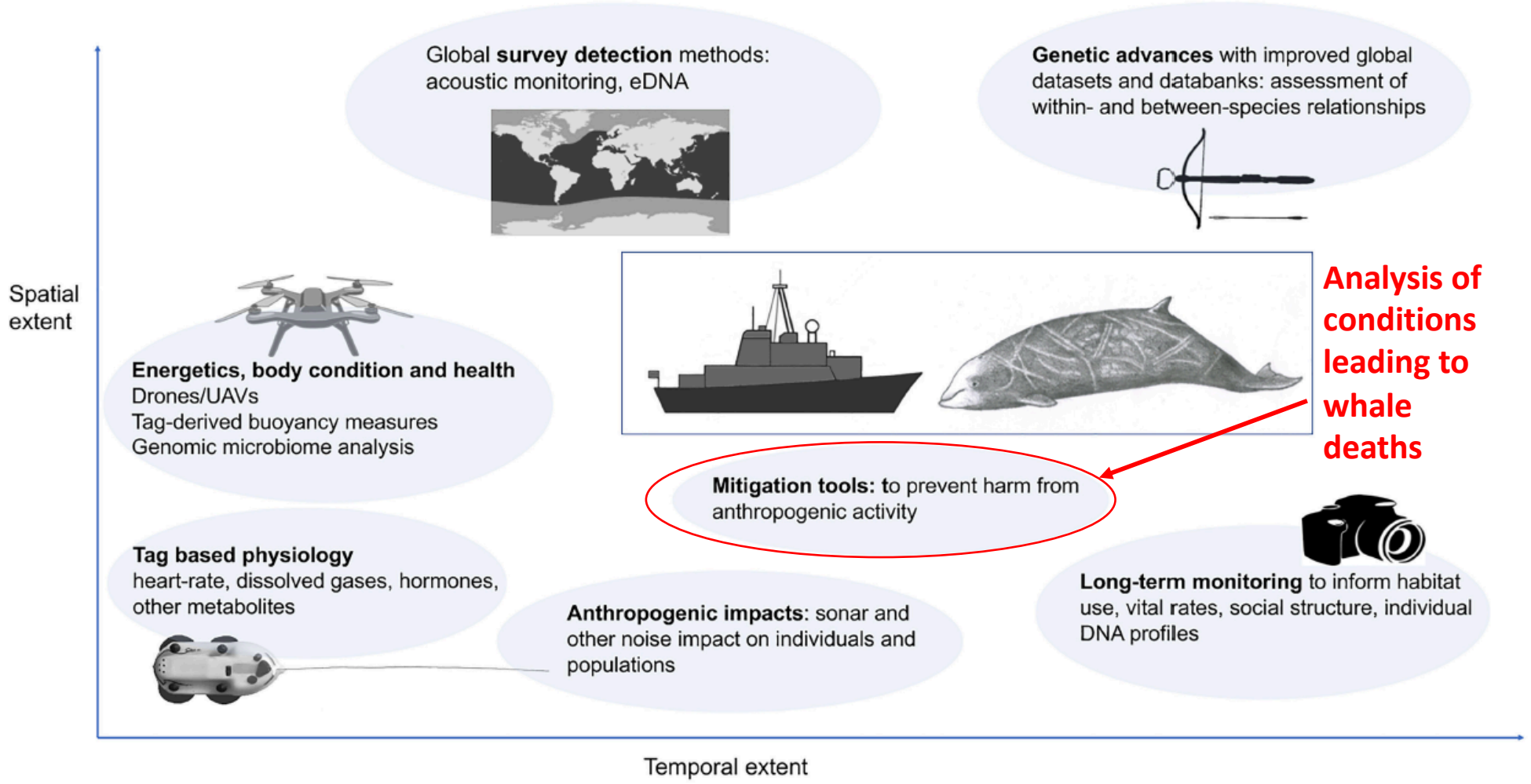


FIGURE 2 | Suggested future directions for beaked whale research vary in terms of both spatial and temporal extent. See text for more information on each.

Hooker et al. 2019. Frontiers in Marine Science doi: 10.3389/fmars.2018.00514