ORCA Looking out for Whales and Dolphins

THE STATE OF EUROPEAN CETACEANS 2018

UNIVERSITY OF PLYMOUTH

FOREWORD

Our seas are anything but static and our human lives ever-increasingly impact on them. It's taken us longer to recognise this, since our despoliation of the land has been more visible and obvious. But whilst we have so much more to learn, we have never been more aware what lays beneath the waves. And of how we risk making just as much a mess of it as we have done to our earthly wildernesses.

Whales and dolphins are the nomads of our seas, they follow food, avoid noise, ships and us (most of the time). And it's this transience, this restless interplay with the sea that makes it so hard to be sure, with just a solitary survey every decade, as to what subtle or seismic shifts may be happening to our whales and dolphins.

To remedy this, ORCA covers the parts other surveys cannot (or do not) reach. A whale and dolphin census every ten years is not enough to keep tabs on an animal population that is, more than anything, a reflection of the ebb and flow of the oceans in which they live. ORCA's real-time monitoring and reporting comprehensively fills in the other nine years and stops the Government from saying it can't act in the interests of whale and dolphins when any sort of crisis affecting them occurs because it doesn't have the evidence. This report is that evidence.

So the surveys that ORCA undertake would have to be created if they weren't, through their incredible hard work and the work of their army of volunteers, already in place. The precious, distinct thing about ORCA is the fact that these volunteers, the ones whose tireless efforts, forsaken Sunday morning lie-ins and holidays, aren't hard-core scientists but students, teachers, housewives, pensioners… But don't let anyone ever tell you they are "ordinary" or "unassuming" members of the public. They are extraordinary, and this report is proof of that.

This is proof of the power of citizen science, its ability to inform, change, inspire and educate, and ultimately that we can collectively make a difference.

Chris Packham
Marine wildlife expert and ORCA patron

Sperm whale - Oliver Smart

KEY FINDINGS

The State of European Cetaceans 2018 report is the latest landmark in ORCA's ongoing mission to use citizen science to improve the monitoring and protection of cetaceans (whales, dolphins and porpoise) in UK and European waters. Since 2001, trained volunteer Marine Mammal Surveyors have boarded ferries and cruise ships crossing the north-east Atlantic and beyond, recording the marine wildlife that they observed. This is the third in a series of annual reports and builds on existing publications.

This report in particular looks at how citizen science can be used to better understand changing harbour porpoise distribution and range around the UK, and the associated implications for protection for Europe's smallest cetacean. Another critical part of this report is the examination of the threats that are facing whales and dolphins in European waters. The wide-ranging and cumulative threats that cetaceans face both on a regional and global scale are highlighted.

The State of European Cetaceans reports continue to demonstrate why ongoing regular monitoring of cetaceans is vital. The compilation and analysis of real-time, long-term data are essential to make effective and informed decisions about the protection of our whales and dolphins so urgently need. Utilising ferry and cruise platforms is a highly effective tool to estimate density, distribution and range of these animals in near real-time so that worrying patterns can be identified early.

Whilst citizen scientists can provide an army of watchful eyes thanks to the (extra) ordinary people who volunteer their free time in the name of science and conservation, we also need commitment from governments to take swift and decisive action when evidence shows the growing threat to these animals and the habitats in which they live.

Short-finned pilot whale - Luis Dias

2017 Survey Highlights

Over 13,500 cetaceans recorded

- ORCA Marine Mammal Surveyors documented a record number of cetacean encounters; an incredible 2,256 encounters across both ferry and cruise surveys amounting to 13,818 animals in 2017. Of these, 1,559 groups were identified to species level, consisting of 11,937 individual animals. This is nearly double the amount of animals sighted last year, mainly due to increased survey effort.

> An encounter refers to a single sighting, consisting of one individual or a group of animals of the same species

- Overall, common dolphins were the most frequently sighted cetacean in 2017 with 373 encounters, closely followed by the harbour porpoise (369 encounters).
- More common dolphins were seen in the English Channel in 2017 than previous years, with 68 encounters, making them more frequently seen than harbour porpoise (43 encounters) which were most frequently seen in the North Sea (199 encounters).
- Over 12 years (2006-2017), the five most frequently observed species were harbour porpoise (2,285 encounters), common dolphin (2,076), fin whale (492), minke whale (461), and striped dolphin (365).

North Atlantic right whale: an ORCA first

- Over 25 different species were identified in 2017, including a north Atlantic right whale and rough-toothed dolphins in the Wider Atlantic, the first time these species have been recorded by ORCA surveyors.

Arctic waters: the only blue whale of the year

- The only blue whale sighted this year was in Arctic Waters and this sea region was also the best place to see white-beaked dolphins and humpback whales.

Over 3,000 cetaceans seen from UK ferry network

- There were 627 encounters of cetaceans on ferry surveys this year, consisting of 3,148 individuals.
- The harbour porpoise was the most commonly seen species with 242 encounters followed by the common dolphin (191 encounters).
- Most species were seen on the Portsmouth–Santander–Plymouth route, with 12 species including a sei whale being recorded. The route from Newcastle–Amsterdam was the best for seeing harbour porpoise, and the only orca were observed on the Aberdeen–Lerwick route.

Harbour Porpoise Density Changes

- Harbour porpoise are affected by incidental capture in fishing gear ('bycatch'), which leads to a considerable number being killed each year around the UK. The species is protected by European law, and EU Member States have a legal responsibility to monitor their populations. Prioritising areas of importance requires thorough knowledge of population sizes and trends in abundance. However wide-scale monitoring surveys are currently infrequent, occurring just once a decade.
- Utilising citizen science data collected from platforms of opportunities (ferries and cruise ships) from 2006-2017, harbour porpoise densities were calculated for the English Channel, North Sea and within a limited region of the Celtic Sea. The aim of the study was to provide valuable insights into harbour porpoise distribution and density, highlighting areas of importance.
- There were 1,231 harbour porpoise sightings across 109,524 km of survey effort in the three regions. The small surveyed area of the Celtic Sea between Cornwall and the Isles of Scilly showed the highest density of harbour porpoise (0.07 animals per km^2) followed by the North Sea (0.044 animals per km^2), with low densities (0.006 animals per km^2) in the English Channel.
- Results show that the coast around Cornwall and the Isles of Scilly, and the coast near Aberdeen are important areas for harbour porpoise. Densities remain low in the English Channel compared to adjacent areas but shows areas of importance for harbour porpoise around Plymouth, Calais and the north of the Channel Islands. These areas of higher density in the English Channel are different from earlier studies suggesting that harbour porpoise spatial use may be changing.
- The findings also reinforce the extension of the harbour porpoise range documented in recent years with their distribution range extending from the Celtic Sea and North Sea, into the English Channel.
- Ongoing monitoring is vital to ensure that any changes or fluctuations in distribution and density of species are picked up in near real-time. This is particularly important for harbour porpoise as they are known to be affected by a variety of anthropogenic threats and with their distribution changing, up to date evidence needs to be integrated into management plans to conserve this species.

Harbour porpoise - Brian Clasper

Threats to European Cetaceans

Significant and emerging threats continue to adversely impact whale, dolphin and porpoise populations in Europe and across the globe. Marine litter, pollutants such as polychlorinated biphenyls (PCBs), bycatch, ship strike, and commercial whaling are all threats that, if ignored, will continue to have devastating effects on cetacean habitats and populations.

- Despite being banned more than 40 years ago, PCBs (a group of industrial pollutants) are still having a devastating effect on marine mammals, as high contamination leads to reduced reproductive success. This is particularly evident in some orca populations, with the Scottish resident pod predicted to become extinct in the near future. Some European sea regions have been identified as PCB global hotspots with bottlenose dolphins, striped dolphins and orca exhibiting very high levels in these areas. It is estimated that 80% of global PCBs have not yet been destroyed.

- Thousands of cetaceans die every year as a result of incidental capture and asphyxiation in fishing gear. This is a global problem, with vaquita and north Atlantic right whale populations being on the brink of extinction as a result. However, European waters are affected too, with common dolphin and harbour porpoise being killed most frequently around the UK due to bycatch.

- Whales being struck by vessels is one of the most prevalent threats facing cetaceans today. Ship strike has already led to the decimation of north Atlantic right whale populations. Highest mortalities occur when high densities of shipping activity overlap with high densities of whales that are prone to being hit by ships. The Bay of Biscay and the Mediterranean Sea have been recognised as ship strike hotspots. Fin whales in the Bay of Biscay are particularly at risk, and research is being conducted by ORCA to investigate this threat and the fine-scale behaviours of whales in response to vessels, to help understand and reduce collision risk.

Harbour porpoise - Andy Gilbert

- Evidence of plastic has now been recorded in over 40% of all cetacean species. Ingestion of plastic by marine mammals can lead to blockages in the digestive tract, starvation or suffocation, while continued ingestion of the microplastics leads to inflammation and damage at the cellular level. A recent study in Ireland examining the digestive tracts of stranded cetaceans found 8.5% of individuals showed evidence of plastic contamination. Over the last year, there has been significant awareness of the impact of marine litter on marine life with the UK Government outlining its 25 year plan to reduce plastic consumption, with some businesses pledging to phase out single-use plastics by 2020. However, global annual plastic production is ever increasing, reaching over 320 million tonnes and continues to pose a deadly threat to whales and dolphins.

- Commercial whaling is an ongoing threat misplaced in our modern world. Iceland resumed fin whaling in 2018, with 145 killed, including pregnant individuals and two blue/fin whale hybrids. There was public outcry in many countries, and reports suggest few Icelanders themselves support this practise, or consume the meat. A substantial portion of the fin whale meat has been exported to Japan.

Orca - Helen Alexander

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Acknowledgements

Shipping partners

We would like to extend our overwhelming gratitude to our shipping partners* without whom the survey data collection could not be possible.

*correct as of 2017

Corporate members

Contributors

This report could not have been written without the help and support of other organisations such as; Whale and Dolphin Conservation (WDC), British Divers Marine Life Rescue (BDMLR), Zoological Society of London (ZSL), International Fund for Animal Welfare (IFAW), Natural England, and Environmental Investigation Agency (EIA). Harbour porpoise analyses were conducted by Plymouth University.

ORCA volunteers

ORCA's offshore monitoring programme is entirely reliant on our network of volunteer Marine Mammal Surveyors. Each one plays a role in this vital monitoring work – whether in the past, present or future.

These annual reports are a testament to their skill, time, effort and dedication.

Humpback whale

About ORCA

ORCA is a UK whale and dolphin conservation charity dedicated to the long-term protection of whales, dolphins and porpoise (collectively known as cetaceans) and their habitats in UK and European waters. Founded in 2001, ORCA works to monitor vulnerable cetacean populations and helps to protect threatened marine habitats. Working with governments, research institutions and other conservation charities, ORCA's aim is to create safer places for cetaceans, ultimately promoting the health and well-being of the wider marine ecosystem.

Alongside its dedication to cetaceans, ORCA is passionate about people; the charity's work is as much about people as it is about whales and dolphins. What makes ORCA unique is the way we combine accessible marine education with our conservation activities, allowing us to give people from all walks of life the opportunity to take an active role in marine science and conservation. We are making science less exclusive and more accessible and tangible. We train volunteers to join our survey teams, become Wildlife Officers and support our educational programmes. ORCA's projects reach over 40,000 people of all ages each year, providing memorable educational activities and remarkable wildlife experiences both on and offshore. By doing so, we are empowering local communities to become stewards of whales and dolphins and the marine environments in which they live.

ORCA Wildlife Guide and guests

The Report and its Purpose

The State of European Cetaceans report is the third in a series of annual reports published by ORCA. It summarises the distribution and range of cetacean populations in and around European waters using data collected on platforms of opportunity (namely ferries and cruise ships). This 2018 edition provides an update on the threats that European cetaceans face, and presents key findings from the last 12 months. These include the impact of whales being hit by ships, the devastating impact to both small and large cetaceans when they become victims of bycatch, and the growing impact of marine litter, particularly plastics, on these species.

With ever-increasing commercial pressures impacting our oceans, justifiable concern is building about the health of our marine ecosystems. ORCA's cetacean monitoring programme helps to provide the year-round supporting evidence necessary to assess the health of our whale and dolphin populations in the face of these threats. ORCA's research highlights areas within our seas that are consistently utilised by a range of cetacean species. It is these hotspots that must be given more protection as a matter of urgency.

This report is the culmination of 12 years' of sightings and environmental data collected between 2006-2017 during over 500 surveys. It highlights observations recorded during the 2017 survey season, and uses a long-term dataset collected by citizen scientists to analyse the distribution and density of harbour porpoise. The aim is to influence policy and legislation to protect cetaceans and the waters they inhabit in UK and Europe, creating safer spaces for whales and dolphins. To help achieve this, ORCA distributes this report widely to stakeholders including governments throughout Europe, relevant research bodies, other conservation NGOs and leading academic experts in the field of marine biology. The report is freely available for all online.

Common dolphin - Emma Howe-Andrews

SURVEY OVERVIEW

Minke whale

Survey Methodology

ORCA surveys across line-transects according to distance sampling methodologies, a widely employed technique for estimating cetacean density and abundance. Surveys are conducted by a fully trained team of three or four volunteer ORCA Marine Mammal Surveyors from the vessel's bridge (or other forward facing platform) onboard ferries. A standardised survey protocol is adhered to; ensuring data collection is rigorous and comparable.

Similar methodologies are followed onboard cruise ships; however survey effort is more variable due to different sized teams and passenger engagement being integrated with data collection.

Survey areas

ORCA surveys nine regions (Figure 1): Arctic Waters, North Sea, English Channel, Celtic Sea, Irish Sea, Minches and West Scotland, Bay of Biscay and Iberian Coast, Wider Atlantic and the Mediterranean Sea.

Figure 1: Regions surveyed.

Since 2006, ORCA has conducted 467 dedicated distance sampling surveys on 19 ferry routes in partnership with eight ferry companies, as well as 65 surveys following an effort-based survey methodology in partnership with three cruise companies. A new partnership with Caledonian MacBrayne resulted in three ferry routes being trialled in the Hebrides between Ulapool–Stornoway (UlSt), Oban–Castlebay (ObCa), and Oban–Tiree-Coll–Colonsay (ObTiCo). New routes were surveyed with Brittany Ferries between Plymouth, Roscoff, and Cork (PlRcCo), and Poole and Cherbourg (PoCb).

Sea Region	Route code	Route	Years active	Company
North Sea	NsId	Newcastle – Amsterdam	2009 & 2011 – 2017	DFDS
	NcBg	Newcastle – Bergen	2006 – 2008	DFDS
	HwEb	Harwich – Esbjerg	2008 – 2014	DFDS
	ImGoBvIm	Immingham – Gothenberg – Brevik	2015	DFDS
	AbLw	Aberdeen – Lerwick	2006 – 2017	NorthLink
	DvCi	Dover – Calais	2016 – 2017	DFDS
	Cruise	Various cruises	2006 – 2017	Various cruise partners
Irish Sea	HsPd	Heysham – Douglas	2011 – 2013 & 2016	Isle of Man Steam Packet Company
	Cruise	Various cruises	2008 – 2017	Various cruise partners
Bay of Biscay and Iberian Coast	PlSt	Plymouth – Santander	2006 – 2008	Brittany Ferries
	PlStPm	Plymouth – Santander – Portsmouth	2009 – 2017	Brittany Ferries
	Cruise	Various cruises	2006 – 2017	Various cruise partners
English Channel	PlRc	Plymouth – Roscoff	2014 – 2017	Brittany Ferries
	PlRcCo	Plymouth – Roscoff – Cork	2017	Brittany Ferries
	PmCa	Portsmouth – Caen	2014 – 2017	Brittany Ferries
	PoCb	Poole – Cherbourg	2017	Brittany Ferries
	DvCi	Dover – Calais	2016 – 2017	DFDS
	PmFi	Portsmouth – Fishbourne	2016	Wightlink
	SoCo	Southampton – Cowes	2016	Red Funnel
	Cruise	Various cruises	2006 – 2017	Various cruise partners
Celtic Sea	PzSm	Penzance – St Mary's	2009 – 2017	Isles of Scilly Travel
	Cruise	Various cruises	2009 – 2017	Various cruise partners
Mediterranean Sea	Cruise	Various cruises	2009 – 2017	Various cruise partners
Minches and West Scotland	UlSt	Ullapool – Stornoway	2017	Caledonian MacBrayne
	ObCa	Oban – Castlebay	2017	Caledonian MacBrayne
	ObTiCo	Oban – Tiree – Coll	2017	Caledonian MacBrayne
	Cruise	Various cruises	2009 – 2017	Various cruise partners
Wider Atlantic	Cruise	Various cruises	2009 – 2017	Various cruise partners
Arctic Waters	Cruise	Various cruises	2009 – 2017	Various cruise partners

Table 1: Routes surveyed by ORCA between 2006-2017.

Distance surveyed (effort)

In 2017, ORCA conducted 70 ferry surveys and 15 cruise surveys. The ferry surveys took place with eight ferry companies across 11 ferry routes. Two of these routes were in the North Sea (AbLw and NsId), three within the English Channel (DvCl, PmCa, PlRc), one in the Celtic Sea (PzSm), one traversed the English Channel and Celtic Sea (PlRcCo), one route traversed the English Channel, Celtic Sea and Bay of Biscay (PlStPm), and three routes were piloted in the Hebrides (UlSt, ObCa, ObTiCo; Table 1 and Figure 2). The 15 cruises were conducted on Saga, P&O Cruises and Silversea cruise ships across the north Atlantic and Mediterranean Sea.

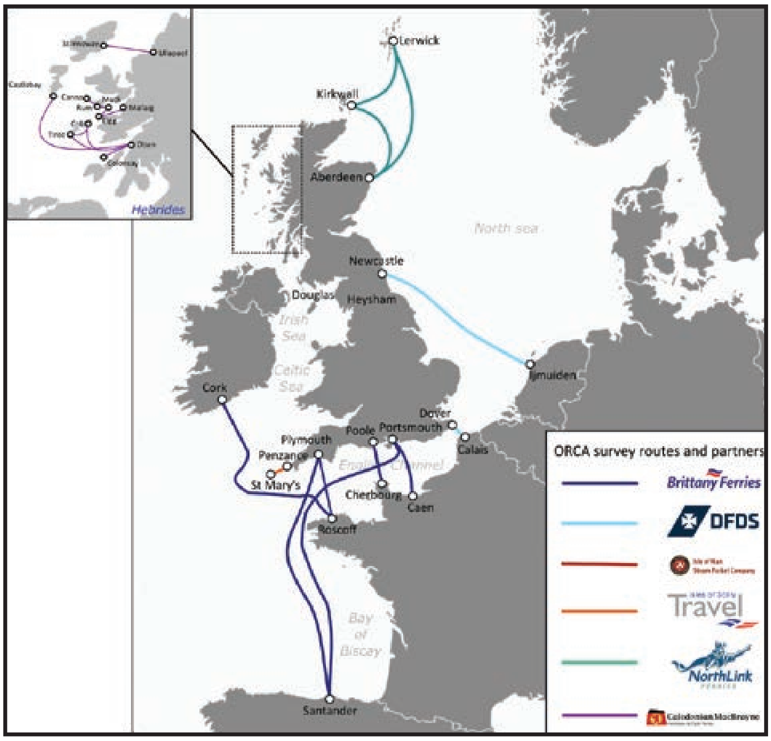

Figure 2: Ferry routes surveyed by ORCA in 2017.

The total surveyed distance in 2017 across all regions was 56,377 km (Figure 3). The most surveyed region was the Bay of Biscay and Iberian Coast (13,716 km), with the least effort recorded in the Minches and West Scotland (908 km) (Figure 4). The greatest number of surveys occurred in the English Channel, with 35 undertaken across the six ferry routes that cross this region. Effort for the Mediterranean Sea, Wider Atlantic and Arctic Waters were confined to cruise surveys.

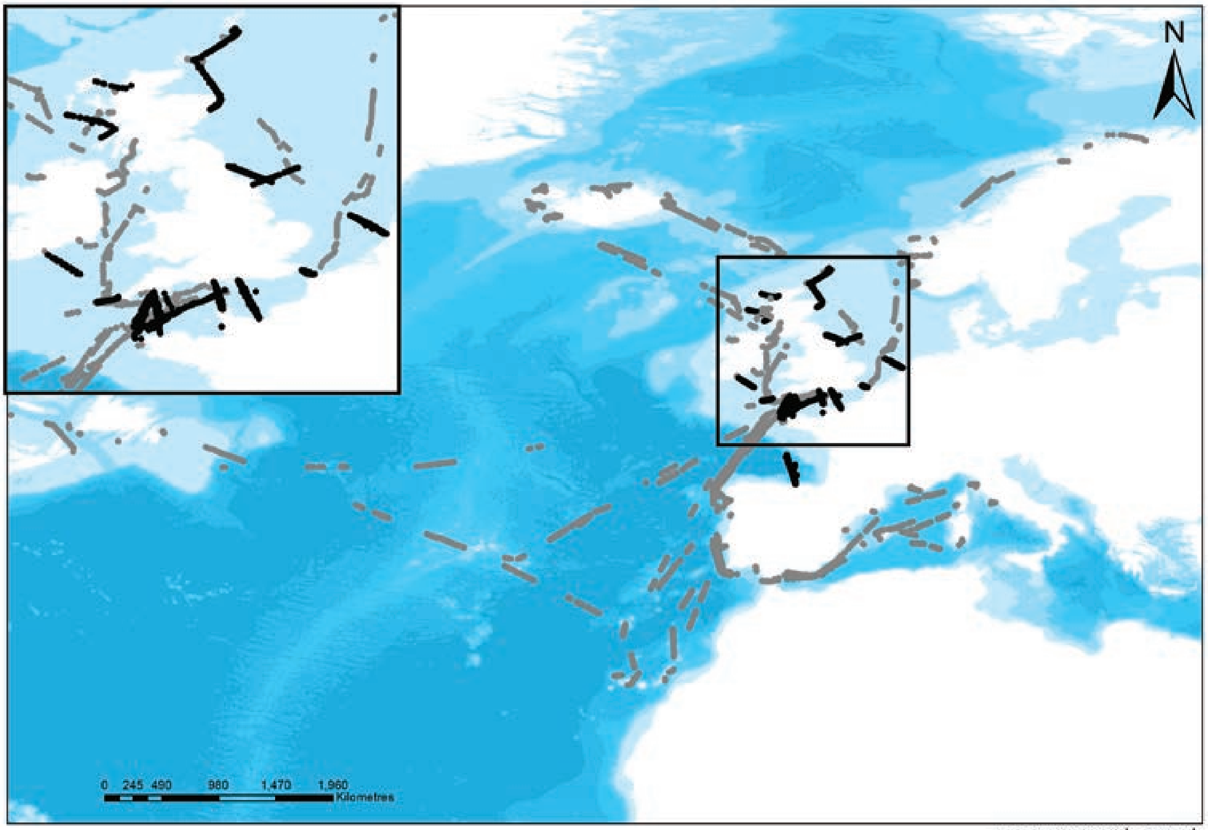

Figure 3: Cruise (grey) and ferry (black) effort in 2017.

www.orcaweb.org.uk

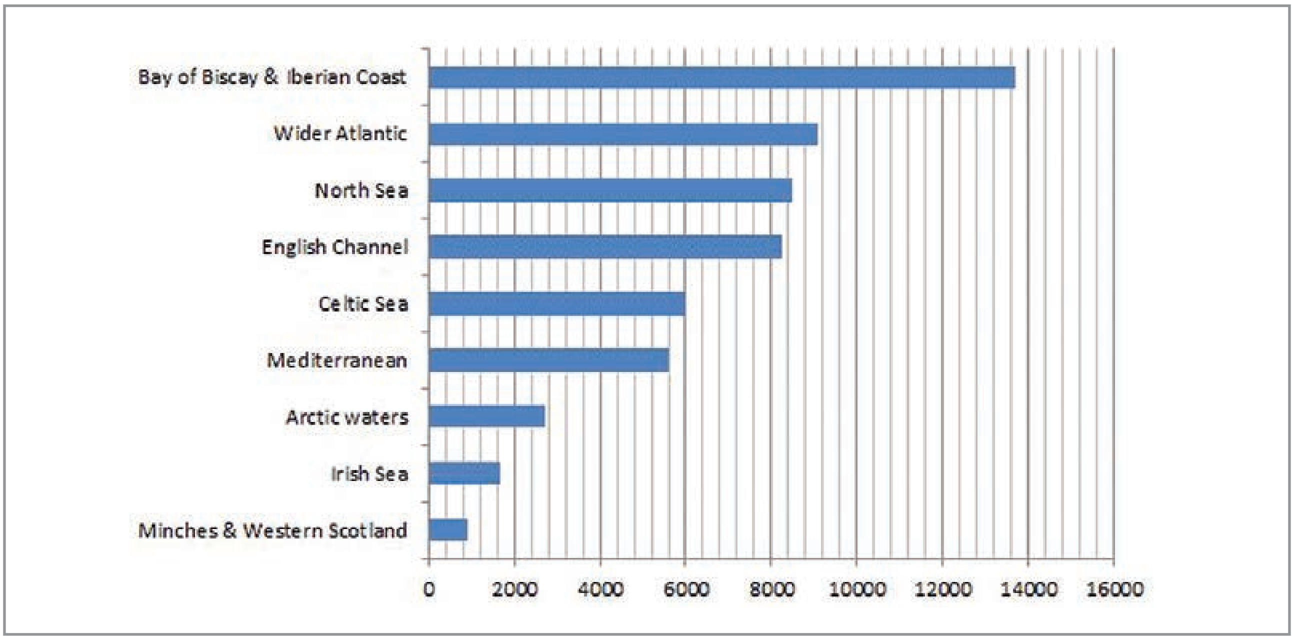

Figure 4: The total amount of effort (km) undertaken within each survey region in 2017.

The greatest amount of effort by ferry route occurred on the Newcastle–Amsterdam route (NsId), with a total of 7,282 km surveyed. The least amount of effort on any single route occurred on the Oban–Tiree–Coll route with 122 km; however this is due to it being a pilot route which has since been surveyed frequently in 2018 (Table 2).

Year	HsPd	HwEb	ImGoBvIm	NcBg	NsId	PlRc	PoCa	PlStPm	PmCa	PzSm	DvCl	AbLw	PmFi	SoCo	PoCb	ObTa	ObTiCo	UlSt	Total
2006				8389				2115											10504
2007				7522				3536											11058
2008		333		7204				4453											11990
2009		1770			704			5459		512									8445
2010		163						4970		1622									6755
2011	588	2544			1855			5692		1364									12043
2012	331	2882			2210			4959		1521									11903
2013	257	2903			4087			4294		1686									13227
2014		6168			7532	1420		5270	212	1878									22480
2015	498		4297		4706	1123		4650	1462	2018									18754
2016	1219				4107	1034		3897	1694	1820	382	916	107	111					15287
2017					7282	3093	2710	6430	2912	4771	730	2109			891	210	122	188	31448
Total	**2893**	**16763**	**4297**	**23115**	**32483**	**6670**	**2710**	**55725**	**6280**	**17192**	**1112**	**3025**	**107**	**111**	**891**	**210**	**122**	**188**	**173894**

Table 2: Total effort (km) undertaken on ferry routes. See Table 1 for route code meanings.

Common dolphin

Sightings

ORCA surveyors reported a record number of cetacean encounters in 2017, with a total of 2,256 encounters across both ferry and cruise surveys, which amounted to 13,818 animals (Figure 5 and Figure 7).

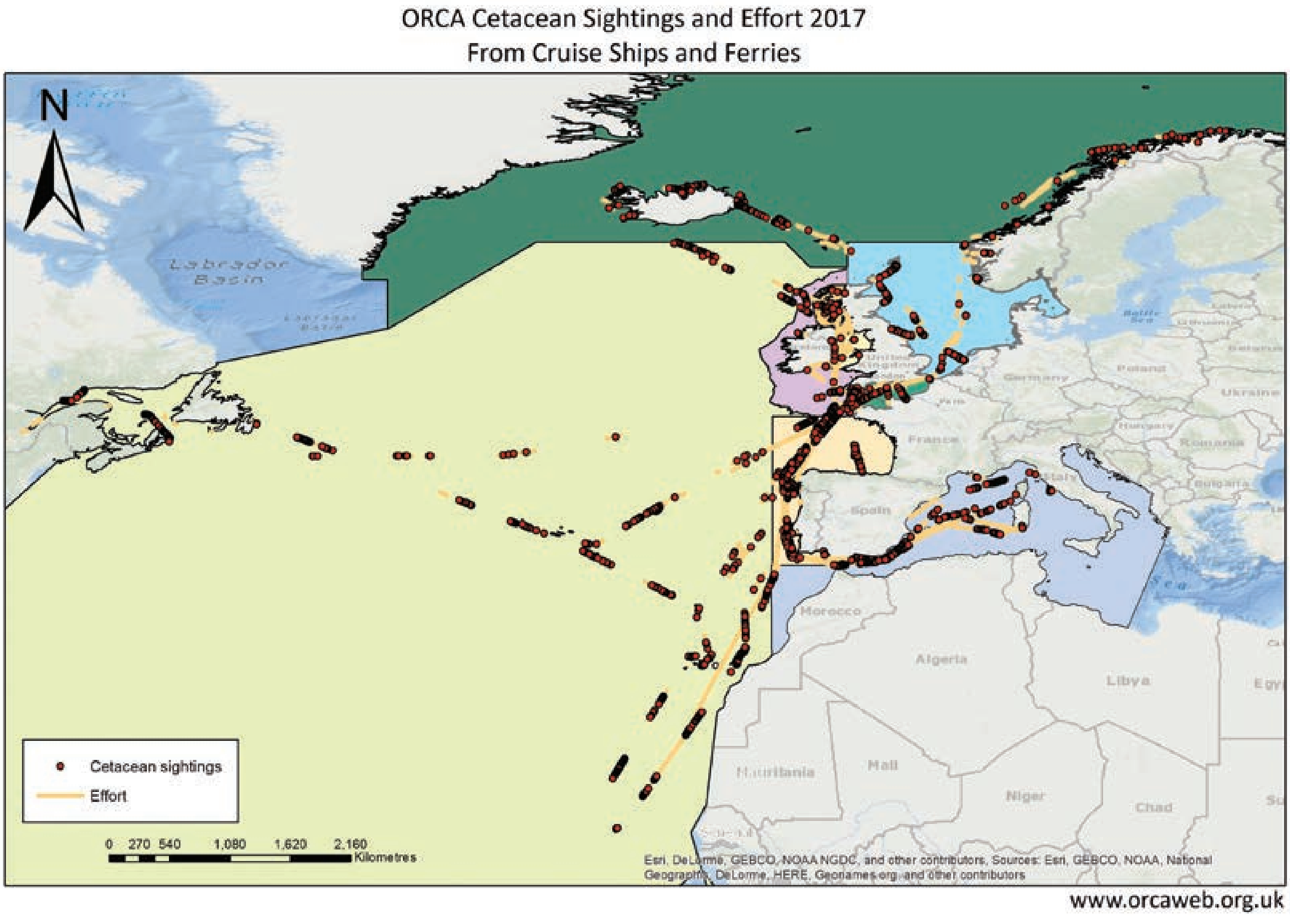

Figure 5: ORCA survey region boundaries with effort (orange lines) and cetacean sightings (red dots).

Of these, 1,559 were identified to species level, consisting of 11,937 individual animals (Table 3). Twenty-five different species were identified, including a north Atlantic right whale and rough-toothed dolphins in the Wider Atlantic, the first time these species have been recorded by ORCA surveyors. Overall, common dolphins were the most frequently sighted cetacean with 373 encounters, closely followed by harbour porpoise (369 encounters). The five most frequently observed species between 2006-2017 were harbour porpoise (2,285 encounters), common dolphin (2,076), fin whale (492), minke whale (461), and striped dolphin (365).

Arctic Waters were the best place to see white-beaked dolphins and humpback whales, and this was where the only blue whale of the year was recorded. More common dolphins were seen in the English Channel this year than in previous years, with 68 encounters, making them more commonly seen than harbour porpoise (43 encounters), which were seen most in the North Sea (199 encounters; Figure 6). Striped dolphins were seen most frequently in the Mediterranean Sea (70 encounters).

Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Harbour porpoise (Phoceona phoceona)	75	61	60	76	83	175	199	271	338	206	369	372	**2285**
Common dolphin (Delphinus delphis)	26	64	58	54	108	143	102	220	129	312	373	487	**2076**
Fin whale (Balaenoptera physalus)	6	14	74	11	6	42	27	28	49	35	95	105	**492**
Minke whale (Balaenoptera acutorostrata)	6	9	9	15	16	36	52	43	79	44	50	102	**461**
Striped dolphin (Stenella coeruleoalba)	4	6	2	12	13	27	16	28	14	23	87	133	**365**
White-beaked dolphin (Lagenorhynchus albirostris)	4	11	3	3	1	28	19	46	79	21	54	43	**312**
Bottlenose dolphin (Tursiops truncatus)	8	9	19	18	8	33	12	24	25	16	30	60	**262**
Humpback whale (Megaptera novaeangliae)			1		1	3	7	10	31	25	32	89	**199**
Sperm whale (Physeter macrocephalus)	3	3	2	7	5	8	2	14	11	13	15	42	**125**
Long-finned pilot whale (Globicephala melas)	2	13	7	10		6	20	2	3	8	6	20	**97**
Cuvier's beaked whale (Ziphius cavirostris)	2	2	3	8	3	10	12	6	8	12	9	15	**90**
Risso's dolphin (Grampus griseus)	1	2	1	2	1	5	4	6	10	3	9	26	**70**
Killer whale (Orcinus orca)	1		1	1		2	4	2	11	9	13	4	**48**
Northern bottlenose whale (Hyperoodon ampullatus)	10	2	3		2	1	1		5	8	1	7	**40**
Sei whale (Balaenoptera borealis)		1			1		2	2	6		5	14	**31**
Blue whale (Balaenoptera musculus)							3	4	3	1	13	1	**25**
Atlantic white-sided dolphin (Lagenorhynchus acutus)	1	1				2	1	1	2	6		6	**20**
Atlantic spotted dolphin *(Stenella frontalis)*												20	**20**
Sowerby's beaked whale (Mesoplodon bidens)		1		1	1	6	1	1	1	2	2	2	**18**
Beluga (Delphinapterus leucas)							6			3	2		**11**
Short-finned pilot whale (Globicephala macroorhynchus)										3	2	4	**9**
Bryde's whale *(Balaenoptera brydei)*											1	3	**4**
False killer whale (Pseudorca crassidens)	1											2	**3**
True's beaked whale (Mesoplodon mirus)		1								1			**2**
North Atlantic right whale *(Eubalaena glacialis)*												1	**1**
Rough-toothed dolphin *(Steno bredanensis)*												1	**1**
Total no. of encounters/No. of cetacean species	**150** 15	**200** 16	**243** 14	**218** 13	**249** 14	**527** 16	**490** 19	**708** 17	**804** 18	**751** 20	**1168** 20	**1559** 23	
Number of surveys per year	19	25	27	28	25	39	43	46	64	64	71	73	
Average no. of encounters per survey	8	8	9	8	10	14	11	15	13	12	16	38	

Table 3: Number of encounters of each species 2006-2017.

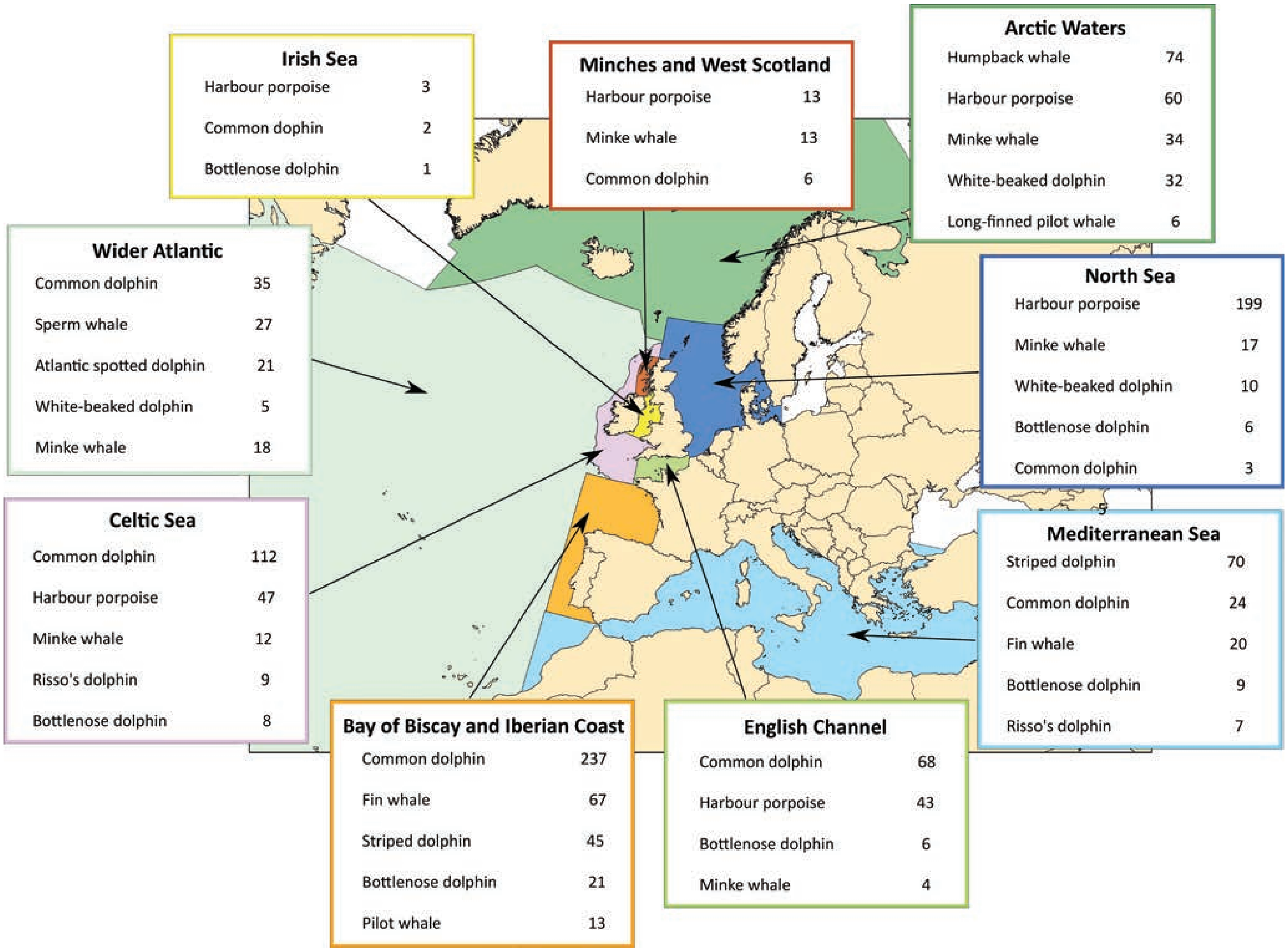

Figure 6: Most frequently seen cetacean species in each sea region during 2017.

Sightings by ferry route

There were 627 encounters of cetaceans on ferry surveys this year, consisting of 3,148 individuals, of which 513 encounters were identified to species level (Table 4). The harbour porpoise was the most commonly seen species with 242 encounters followed by the common dolphin (191 encounters). Most species were seen on the Portsmouth–Santander–Plymouth route, with 12 species including a sei whale being recorded. Newcastle–Amsterdam was the best for seeing harbour porpoise, and the only orcas were observed on the Aberdeen–Lerwick route.

Species	AbLw	DvCl	NsId	PlRc	PlStPm	PmCa	PzSm	ObCa	ObTiCo	UlSt	PoCb	Total no. of encounters
Harbour porpoise *(Phocoena phocoena)*	65	3	87	2	10	23	37	4	0	7	4	242
Common dolphin *(Delphinus delphis)*	2	0	1	18	107	0	62	1	0	0	0	191
Minke whale *(Balaenoptera acutorostrata)*	4	0	5	0	3	0	4	6	2	2	0	26
Fin whale *(Balaenoptera physalus)*	0	0	0	0	12	0	0	0	0	0	0	12
Bottlenose dolphin *(Tursiops truncatus)*	3	0	3	0	2	0	1	0	0	0	1	10
White-beaked dolphin *(Lagenorhynchus albirostris)*	3	0	5	0	1	0	0	0	0	0	0	9
Striped dolphin *(Stenella coeruleoalba)*	0	0	0	0	7	0	1	0	0	0	0	8
Cuvier's beaked whale *(Ziphius cavirostris)*	0	0	0	0	6	0	0	0	0	0	0	6
Long-finned pilot whale *(Globicephala melas)*	0	0	0	0	3	0	0	0	0	0	0	3
Risso's dolphin *(Grampus griseus)*	0	0	0	0	1	0	2	0	0	0	0	3
Sperm whale *(Physeter macrocephalus)*	0	0	0	0	1	0	0	0	0	0	0	1
Killer whale *(Orcinus orca)*	1	0	0	0	0	0	0	0	0	0	0	1
Sei whale *(Balaenoptera borealis)*	0	0	0	0	1	0	0	0	0	0	0	1
Total number of encounters in 2017	**78**	**3**	**101**	**20**	**154**	**23**	**107**	**11**	**2**	**9**	**5**	**513**

Table 4: Number of encounters for identified cetaceans 2006-2017.

Common dolphin

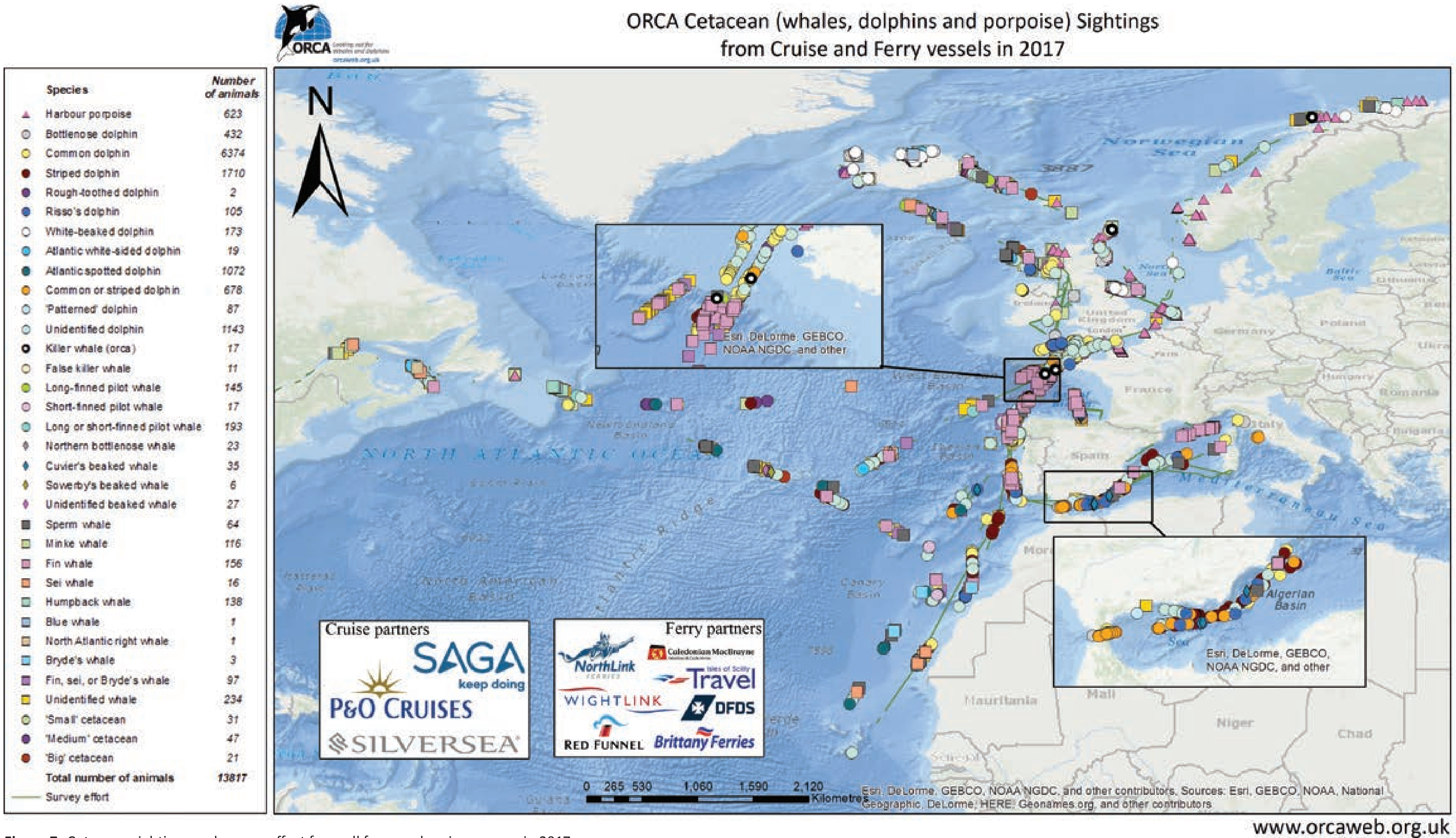

Figure 7: Cetacean sightings and survey effort from all ferry and cruise surveys in 2017.

CONTRIBUTING TO CETACEAN CONSERVATION

ORCA is committed to the conservation of cetaceans through evidence-based science. Long-term monitoring has accumulated a large dataset covering a wide area, allowing spatial and temporal trends to be investigated. These data are analysed in-house and by undergraduate and postgraduate students at a variety of universities to explore changes in distribution, population dynamics and densities. Results from these studies are disseminated in this report, in peer-reviewed publications, and through interfaces with scientific working groups and panels in order to affect policy and positive change.

Humpback whale

Variability in Harbour Porpoise Density: Implications for Conservation in UK Seas

Contributor: *Kimberly Nielsen* (University of Plymouth), supervised by *Dr Clare Embling* (University of Plymouth) and *James Robbins* (ORCA, University of Plymouth)

Introduction

The harbour porpoise is a small cetacean limited to cold, temperate and subpolar waters in the Northern Hemisphere. They are the only porpoise species occurring in the north-east Atlantic, and their expansive distribution and prevalence in coastal waters makes them an important indicator species. Many higher predators are indicator species as variation in their distribution and density may reflect underlying environmental change (Gilles *et al.,* 2011). Although harbour porpoise occur commonly in shelf-seas, historical hunting pressure, habitat degradation, pollution, and incidental fisheries mortality in European and UK waters has given reason for concern (Hammond *et al.,* 2002; Viquerat *et al.,* 2014; Peschko *et al.,* 2016). In the UK alone, it was estimated that nearly 1,500 individuals were bycaught in gillnets during 2015 Northridge et al., 2016.

The European Union's Directive on the Conservation of Natural Habitats and of Natural Fauna and Flora (Habitats Directive) was formed as the primary regulatory body for conservation and diversity, including the provision of protective actions for cetaceans. Harbour porpoise are listed as a species of interest under Annex II and Annex IV, requiring Member States to establish Special Areas of Conservation (SACs) in addition to providing full protection of all life stages throughout their range.

Prioritising areas of importance requires thorough knowledge on population sizes and trends in abundance, but due to their wide range, inconspicuous nature, and small size, harbour porpoise are particularly difficult to spot at sea (Prescott & Gaskin, 1981; Embling *et al.,* 2010; Oakley *et al.,* 2016). Detection is influenced by conditions related to both survey methods as well as localised oceanographic and environmental conditions. There is a gradual reduction in detectability with increasing distance (Hammond *et al.,* 2002) and a sharp decrease for surveys conducted in Beaufort sea states ≥ 3 (Teilmann, 2003). The most accurate estimates of absolute abundance come from dedicated, purpose-designed surveys which allow extensive spatial coverage of a study area. In the north-east Atlantic, the best available information on distributions and population sizes is provided by SCANS (Small Cetacean Abundance in the North Sea and Adjacent Waters) which survey cetaceans in European and UK shelf-seas along randomly placed transect lines (Hammond *et al.,* 2002; Hammond *et al.,* 2013; Hammond *et al.,* 2017). Purpose-designed surveys are intensive and require employed research platforms (vessels and/or aircraft); therefore they are conducted infrequently and data collection tends to be limited to favourable sighting conditions in summer months. These "snapshots" of abundance lack information on inter- and intra-annual variability and fine-scale long-term trends (Evans & Hammond, 2004).

Where large-scale surveys of absolute abundance leave large temporal gaps between surveys, long-term studies in more specific areas can be employed to assess inter-annual variation. Platforms of opportunity serve as an inexpensive base for conducting research along consistent crossings over extensive time scales. In this way, data collected onboard such vessels have increased temporal coverage, and regular monitoring may provide more power for early detection of population changes – and their possible connection to anthropogenic threats – in the stretches between large-scale surveys (Viqueret *et al.,* 2014).

This study aims to derive valuable insights into harbour porpoise distribution and density in the Celtic Sea, English Channel, and North Sea by accounting for imperfect detection of animals to correct spatially explicit models of density. Information garnered from this study may complement existing estimates from large-scale surveys to better manage important areas for these animals, and mitigate threats.

Methods

Study area and data collection

Line-transect surveys were conducted from ferries in three regions surrounding the UK: in the Celtic Sea, English Channel, and North Sea (Figure 8). Survey effort in the Celtic Sea was constrained to a crossing from Penzance to St. Mary's on the Isles of Scilly. Ferries departing from the south coast of England crossed the English Channel along four different routes (Plymouth–Santander–Portsmouth, Plymouth–Roscoff, Portsmouth–Caen, Dover–Calais). Surveys in the North Sea were conducted along five routes (Harwick–Esbjerg, Immingham–Gothenberg–Brevik, Newcastle–Amsterdam, Newcastle–Bergen, Aberdeen–Lerwick).

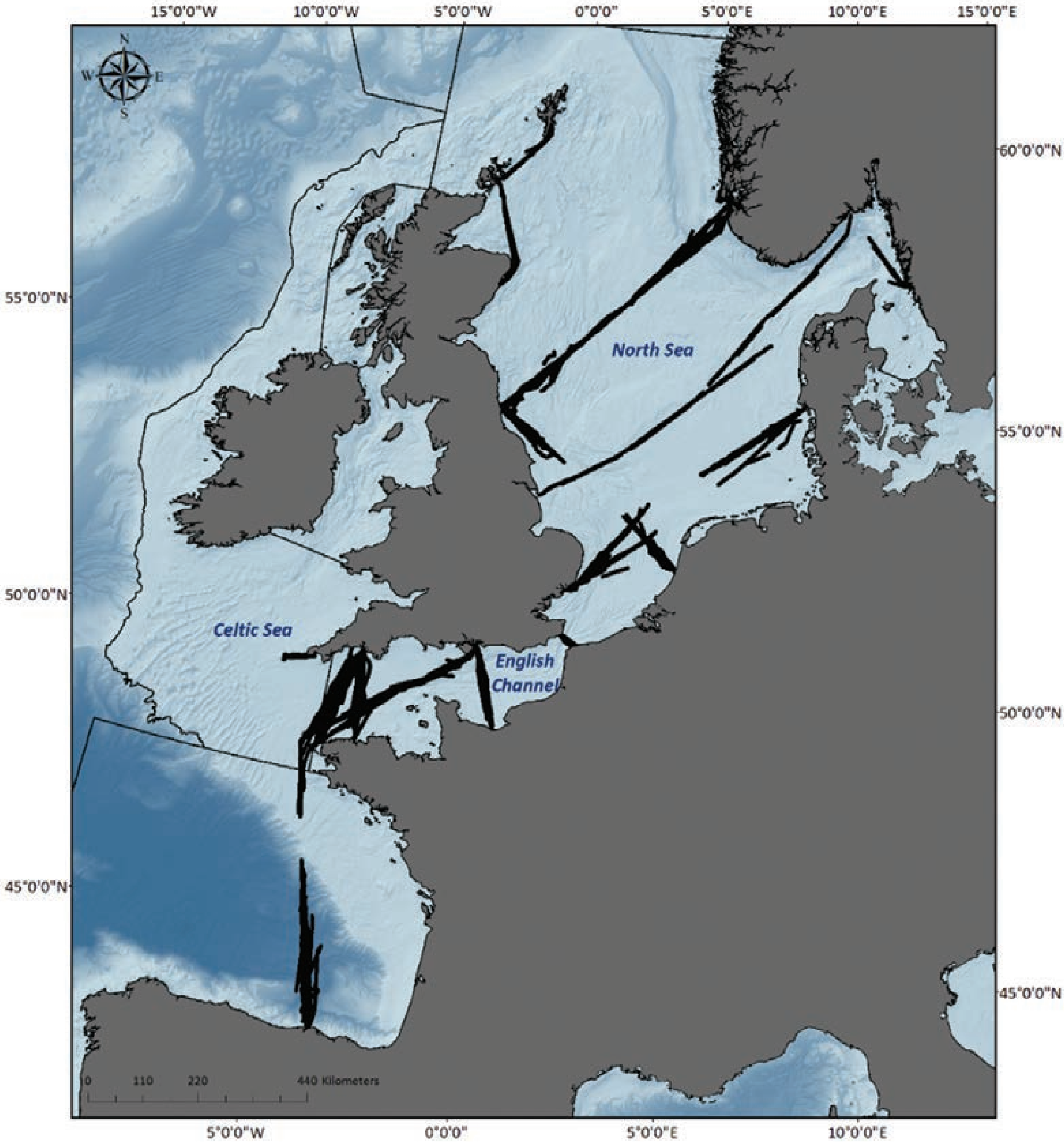

Figure 8: Study sites in the Celtic Sea, English Channel, and North Sea. Black lines show effort along ferry routes from 2006-2017 and grey lines outline the boundaries of OSPAR regions (base map made using GEBCO bathymetry data, with deepening waters represented by a light to dark blue colour scale).

Data related to cetacean sightings and environmental conditions were collected between 2006 and 2017 using distance sampling methodologies (Buckland *et al.,* 2001). Two observers were stationed on either side of the platform at the bow of the vessel, monitoring on either side of the transect from 270° to 90°, with a 10° crossover at the bow. Visibility, sea state (Beaufort), relative swell height, precipitation, glare and vessel position were noted every 30 minutes at a minimum. When harbour porpoise were first detected, the sighting angle from the transect was measured using an angle board and distance was estimated by reticle binoculars. Species, behaviour (such as fast swimming, feeding, or bow-riding), group size, and cue (breaching, dorsal fin, blow) were also recorded.

Detection function estimation

The detection function investigates the relationship between the probability of detection and the perpendicular distance from the transect line. Reticle measurements and angles from the transect to each harbour porpoise sighting were used to calculate perpendicular distances to detected groups. After preliminary data exploration, the data were stratified to fit models specific to the Celtic Sea, English Channel and North Sea.

The package 'Distance' (Miller, 2017) in R (R Core Team, 2017) was used to fit a detection function unique for each of the three study regions by estimating the probability of detecting harbour porpoise at distances. The calculation assumes that all groups directly ahead of the vessel on the line of travel are detected with certainty (g(0)=1) (Buckland *et al.,* 2001). Although such certainty is unlikely, especially for inconspicuous harbour porpoise, the true value of g(0) could not be calculated with the employed single platform survey technique (Berrow *et al.,* 2014). The second assumption of distance sampling relies on recording distances based on an animal's original location, before responsive movement occurs (Buckland *et al.,* 2001). Harbour porpoise are not only highly mobile predators, but are also sensitive to noise (Bernd & Evans, 2002); because of this, the possibility that individuals were detected after responsive movements, such as swimming away from or towards the vessel, could not be eliminated. To reduce bias, exact measurements were smeared into distance intervals, or 'bins', by selecting cutpoint boundaries between 0 m and the truncation distance (w). Truncating outliers improves the fit of detection functions by removing sightings recorded at the greatest distances. Different truncation distances and cutpoint locations were investigated to maximise goodness of fit scores.

Model variations of hazard-rate and half-normal key terms were run to test the significance of vessel speed, platform height, visibility, swell, sea state, and group size on detection probability. A model was selected for each region by retaining those covariates with most influence on detection (chi-square for binned data, $p<0.05$) and by minimising Akaike's Information Criterion (AIC). The effective strip width (ESW; Figure 9), which is the distance from the transect where as many porpoise were detected beyond it as were missed within it, was calculated from truncation distances and the detection probability arising from the detection function.

$$\hat{P}_a = \int_o^w \frac{g(x)dx}{w} = \frac{ESW}{w}, \qquad \text{(eqn. 1)}$$

where: w = truncation distance

$g(x)$ = probability of detection directly on the transect, and

ESW = effective strip width.

The ratio of recorded harbour porpoise sightings and detection probability provided an estimate of relative abundance (Buckland *et al.,* 2001):

$$\hat{N} = \frac{n}{\hat{P}_a}, \qquad \text{(eqn. 2)}$$

where: n = number of sightings, and

$\hat{P}_a$ = estimated probability of detection.

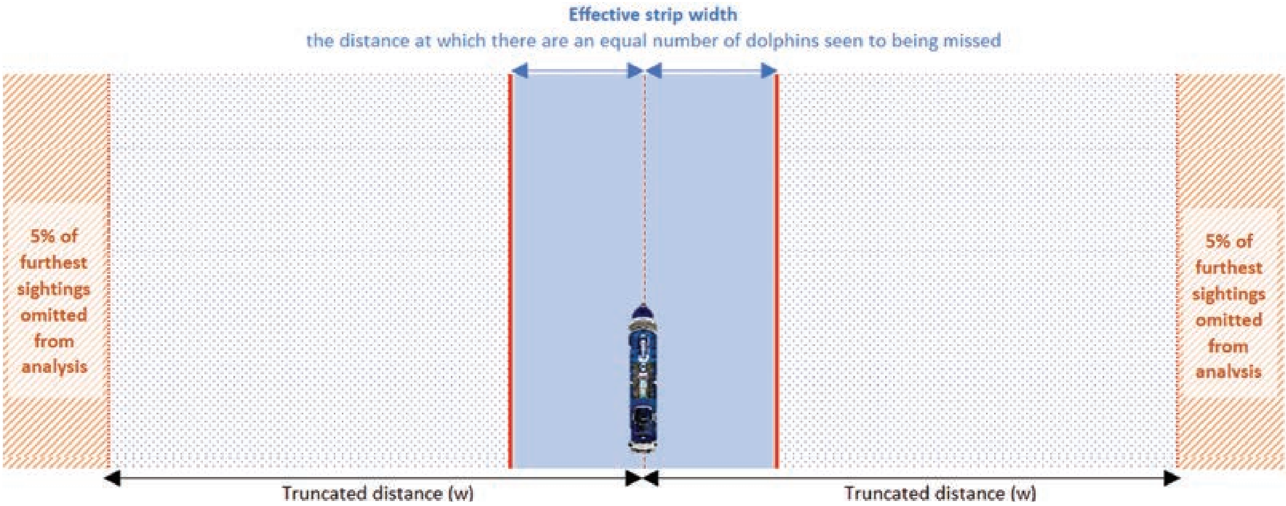

Figure 9: Visualisation of ESW and truncation of distances, with an example 5% of sightings truncated.

Density estimation

Density Surface Models (DSMs) are spatial models adjusted for imperfect detection in order to test the significance of environmental covariates on patterns in density (Miller *et al.*, 2013). Generalised Additive Models (GAMs) were fitted to segments of the trackline of an appropriate size that fits the coarsest environmental covariate resolution (~7 km). All distance measurements and segmentation were done in an Albers Equal Area projection to maintain accuracy for Europe. GAMs for each region included a response variable of segment-specific abundance derived from the detection function, an offset of segment area (2wL), and environmental covariates.

Static and dynamic covariates were selected based upon either a direct connection to harbour porpoise ecology from other studies or because they serve as proxies for processes thought to drive distribution (Table 5). Research has shown that harbour porpoise are often associated with coastal areas in shallow waters of the continental shelf and feed in high energy environments with high levels of biological activity (Tynan *et al.,* 2005; Embling *et al.,* 2010; Booth *et al.,* 2013). Sea surface temperature (SST) and surface chlorophyll-a concentration, were included as indicators of primary productivity. Mixed layer depth (MLD), surface-seabed temperature difference calculated from SST and bottom temperatures, were selected as proxies for the ecological parameters of the water column. Research on water column features in the UK described this vertical change in temperature in three ways: well-mixed (0-0.5°C), frontal (0.5-2.0°C), or stratified (>2.0°C) (Connor, 2006). Covariates were overlaid in ArcGIS (Esri, 2017) using WGS 1984 Geographic Coordinate System and sightings were attached to the relevant centroids of segments through spatial joins and exported for analyses in R.

	Covariate	Resolution	Time series	Source
Physiographic	Depth (m)	30 arc seconds		Seafloor depth from GEBCO bathymetry, slope derived in ArcGIS
	Slope			
	Distance to coast (m)			Distance to closest shoreline calculated in ArcGIS
Surface layer	SST (°C)	~4 km^2	Monthly average 2006-2017	NASA, MODIS level 3
	Chlorophyll (mg/m^3)	~4 km^2	Monthly average 2006-2017	NASA, MODIS level 3
Water column	MLD (m)	~7 km^2	2006-2014	EU Copernicus Marine Service Northwest Shelf Reanalysis product
			2014-2017	EU Copernicus Marine Service Northwest Shelf Forecast product
	Surface-seabed temperature difference (°C)	~ 7 km^2	2006-2014	Calculated from EU Copernicus Marine Service Northwest Shelf Reanalysis product
			2014-2017	EU Copernicus Marine Service Northwest Shelf Reanalysis product

Table 5: Visualisation of ESW and truncation of distances, with an example 5% of sightings truncated.

Spatial abundance was modelled with respect to covariates using non-linear smooths in the package 'dsm' for R (Miller, 2017). After checking for collinearity by ensuring independence of covariates (Pearson correlation coefficient < 0.70), a backwards stepwise process was used to build a GAM for each region with significant covariates ($p < 0.05$) using thin-plate regression splines, maximum shrinkage, and tensor smooths in combination with the restricted maximum likelihood (REML) optimisation method to avoid overfitting in models where covariates may be functions of each other (Wood, 2011). Insignificant covariates ($p > 0.05$) were removed and the model was refitted. SST and chlorophyll values were logged. Variations were run using Tweedie and negative binomial distributions, and the number of knots (k) in each smooth was adjusted to explore significance, basis complexity, and deviance explained. Selection was ultimately based on balancing minimised REML (dependent on uniform terms), maximised deviance explained, and parsimony. The 'best' fit model for each region was tested for concurvity, a measure of how much a smooth can be explained by one or more of the other smooths in the model (Wood, 2004).

Abundance was estimated from each of the North Sea, English Channel, and Celtic Sea models by using a Horvitz-Thompson-like estimator across a prediction grid, with segment area as an offset. Uncertainty was accounted for by calculating standard error and coefficients of variance (CV), and density was calculated by

$$\hat{D} = \frac{\hat{N}}{2wL}, \qquad \text{(eqn. 3)}$$

where: $\hat{N}$ = relative abundance corrected for imperfect detection, and
$2wL$ = segment area.

Density predictions for each segment were attached to a fishnet grid at a resolution of 7 x 7 km. The spatial distribution of harbour porpoise across the study area was assessed to look for inter- and intra-annual trends within April to August 2014-2017 as the amount of effort was comparable during this period.

Harbour porpoise - Andy Gilbert

Results

A total of 1,231 harbour porpoise sightings along 109,524 km of effort from 2006-2017 were included in the analyses. Survey effort varied between routes and regions dependent on attaining access to survey platforms on ferries, and the number of available routes increased over time.

Detection probability

Celtic Sea

A total of 267 sightings were recorded along 12,486 km of effort, and after truncation beyond perpendicular distances of 650 m, 251 sightings (94%) were used to fit the detection function. Group size, ranging from one to ten individuals, and vessel speed were shown to have the biggest effect on harbour porpoise detection. The final hazard-rate key detection function provided an ESW of 147 m and a detection probability of 0.23 (Figure 10a).

English Channel

A total of 210 sightings were recorded along 62,834 km of effort along five different routes, and after truncation of outliers beyond perpendicular distances of 405 m, 191 sightings (91%) were used to fit the detection function. The final hazard-rate key function showed that detection decreased significantly in higher sea states ($p < 0.05$). A narrow ESW of approximately 40 m provided a detection probability of 0.10 (Figure 10b).

North Sea

A total of 919 sightings were recorded along 60,914 km of effort, and after truncation of outliers beyond perpendicular distances of 600 m, 805 sightings (88%) were used to fit the detection function. The final hazard-rate key function showed a significant effect of group size, as smaller groups were less detectable at greater distances ($p < 0.001$). An ESW of 95 m provided a detection probability of 0.16 (Figure 10c).

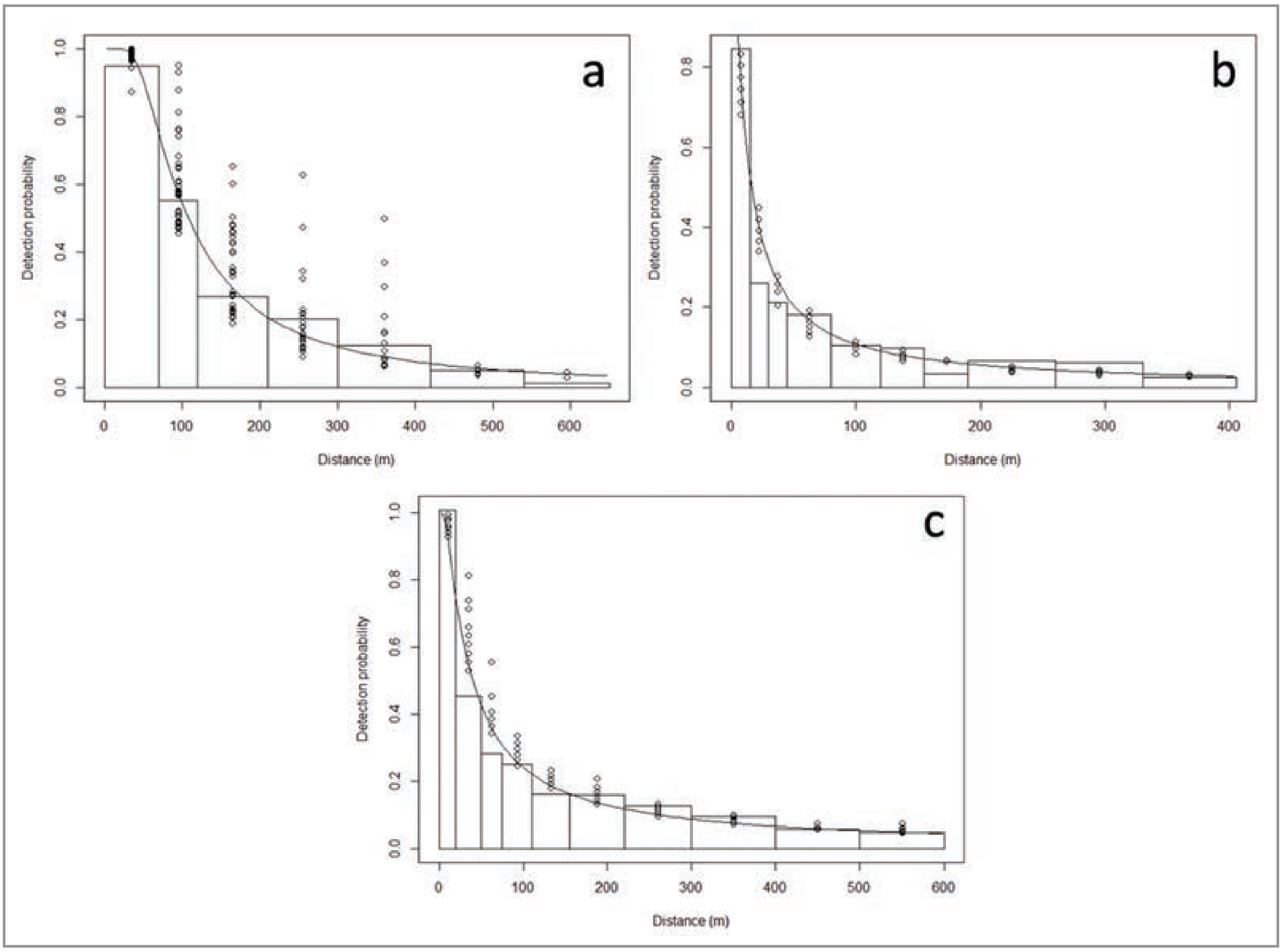

Figure 10: Hazard-rate detection functions for a) Celtic Sea, b) English Channel, c) North Sea showing the influence of perpendicular distance and conditions on the detection of harbour porpoise.

Distribution and density

Celtic Sea

The best-fitting GAM for predicting density along the Celtic Sea route explained 12.5% deviance by using thin-plate regression splines. Smooths of distance to coast, SST and a linear term of bathymetric slope had the most influence on density. Harbour porpoise were concentrated along the coast, with density decreasing steeply with increased distance from shore in the first 10 km (Figure 11a). There was a slight preference for warmer SST from ~13-18°C (Figure 11b), and for steeper slopes (Figure 11c). On average, density along the route from Penzance to St Mary's was highest at 0.070 individuals / km^2 (CI 0.055–0.085), and densities showed inter-annual variation with no clear trend in changes (Figure 17). The model predicts high-density hotspots close to the coast, especially near Penzance (Figure 12).

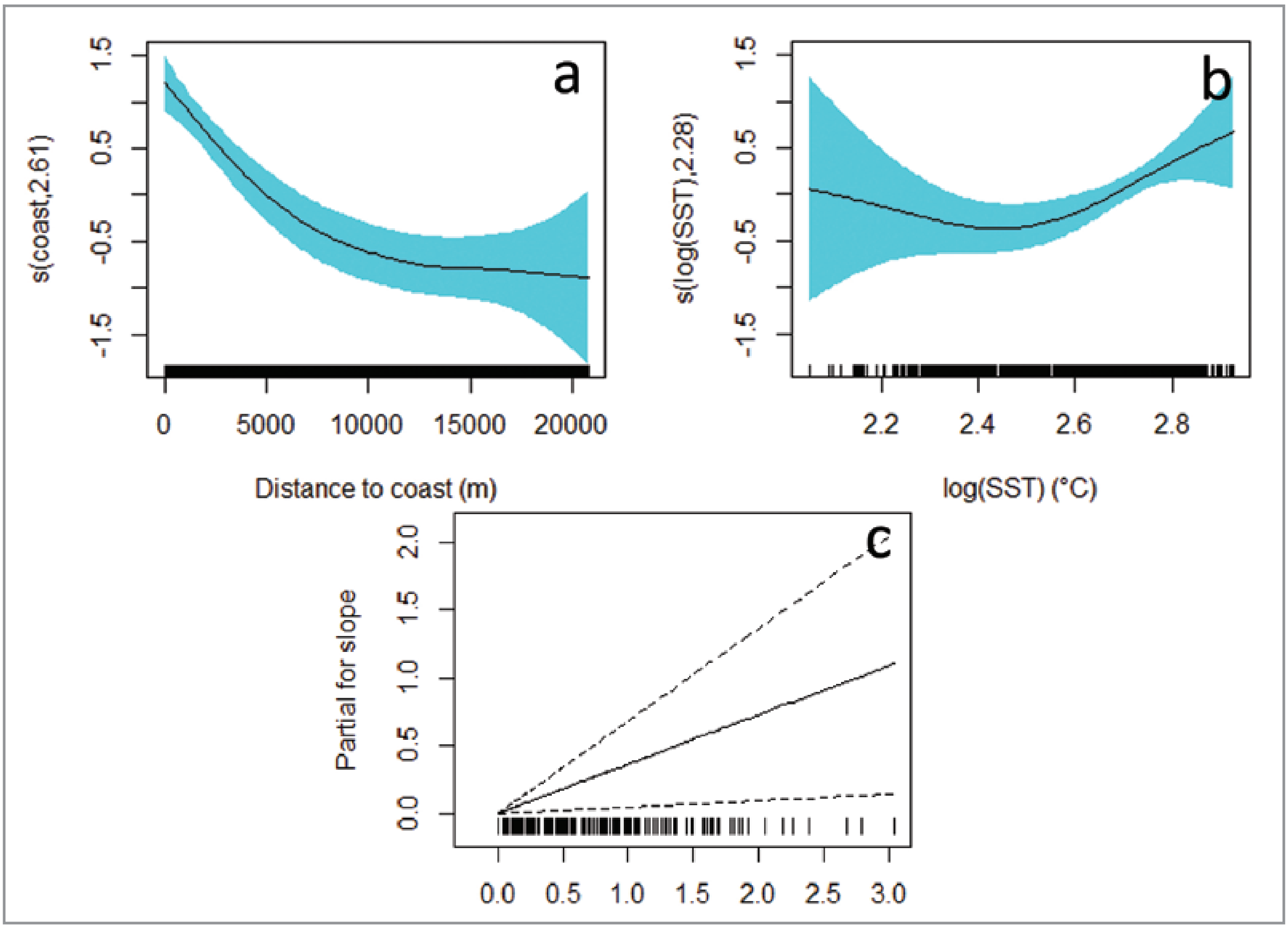

Figure 11: The influence of environmental covariates on harbour porpoise density in the Celtic Sea a) distance from coast, b) log(SST), c) slope. 95% confidence intervals are shaded in blue for the smooths, and by dotted line.

English Channel

The final model with thin-plate regression splines retained univariate smooths of SST, surface-seabed temperature difference, and a bivariate spatial smooth explained 14.3% deviance. Harbour porpoise abundance increased along with rising SST up to ~13.5°C (Figure 13a). Fewer porpoise were observed where surface-seabed temperature differences were greatest (>2°C; Figure 13c), indicating a positive relationship with well-mixed and frontal zones.

Mean density was 0.006 porpoise / km^2 (CI 0.005–0.007), which was relatively stable between years (Figure 17). The model predicts high-density hotspots in the eastern Channel, particularly in the Strait of Dover and near the coast of Caen. Harbour porpoise were less likely to be along the south-western sections (Figures 14).

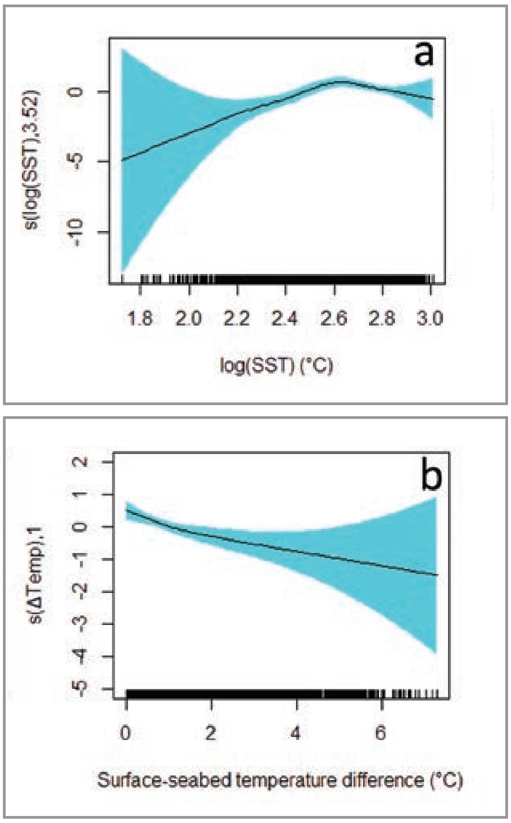

Figure 13: The influence of a) log(SST) and b) surface-seabed temperature difference on the distribution of harbour porpoise. 95% confidence intervals are shaded in blue. Rug plots on the x-axes show the observed distribution of data.

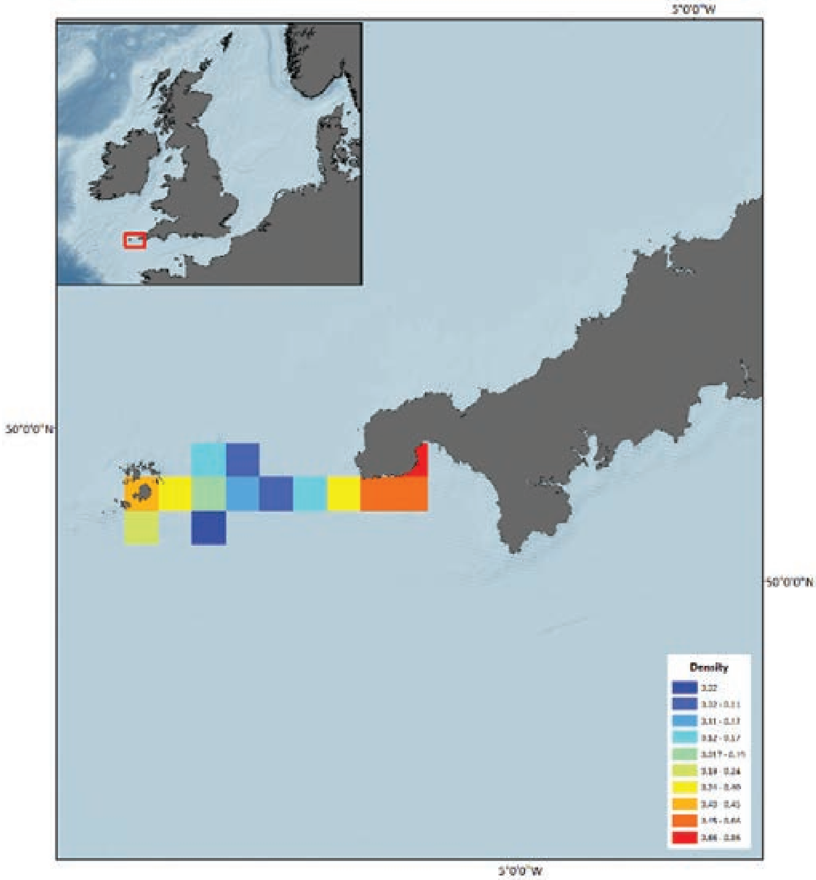

Figure 12: Density estimates (harbour porpoise per km^2) from April to September for each year surveyed in the Celtic Sea 2009-2017. Warmer colours are representative of higher densities.

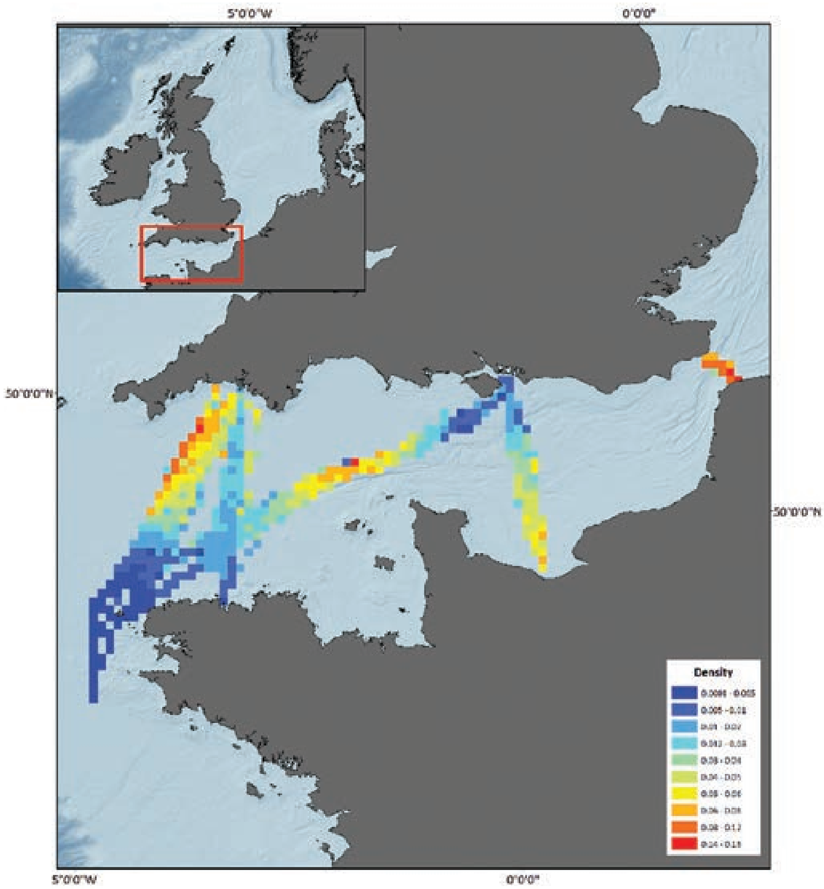

Figure 14: Density estimates (porpoise per km^2) in the English Channel. Warmer colours represent higher densities.

North Sea

The selected model retained univariate smooths of chlorophyll-a concentration, the change in surface-seabed temperature, and a bivariate spatial smooth using thin-plate regression splines. Harbour porpoise distributed along these routes showed preference for surface waters for a peak chlorophyll-a concentrations around 2.7 mg/m3 (Figure 15a). A clear positive relationship was shown where the surface-seabed temperature difference was greatest, representing a highly stratified water column (Figure 15b).

Density in the North Sea was 0.044 porpoise / km^2 (CI 0.039–0.049), with a gradual increase between 2006-2017, however inter-annual variation was apparent (Figure 17). There were high-density hotspots off the coast of Scotland on the route from Aberdeen to Lerwick and at the southern extent of the region approaching the Netherlands and Denmark. Harbour porpoise were less likely to occur offshore in the North Sea (Figures 16).

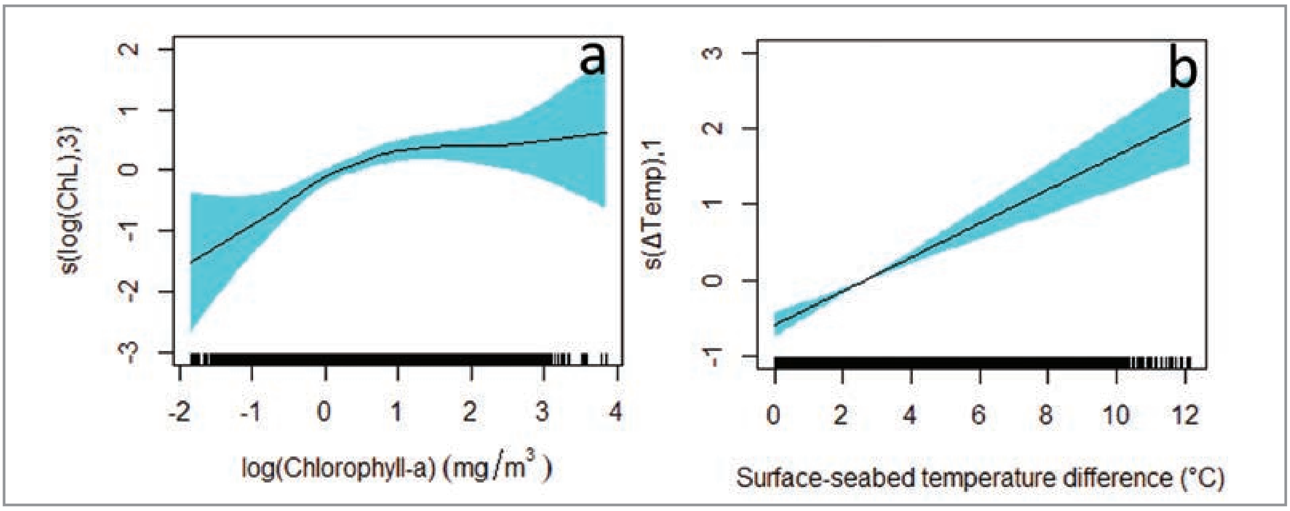

Figure 15: The influence of a) log(chlorophyll-a) and b) surface-seabed temperature difference on harbour porpoise occurrence. 95% confidence intervals are shaded in blue. Rug plots on the x-axes show the observed distribution of data.

Harbour porpoise

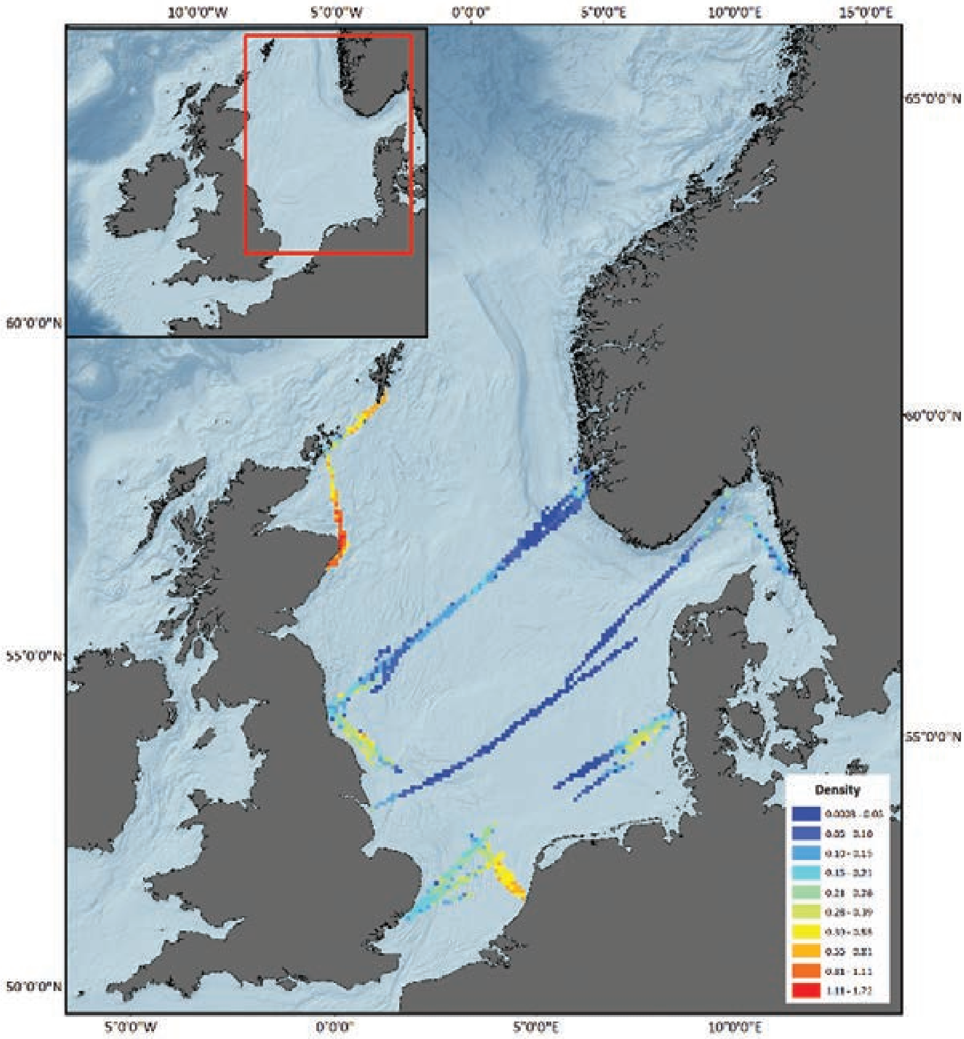

Figure 16: Density estimates (harbour porpoise per km²) in the North Sea. Warmer colours are representative of higher densities.

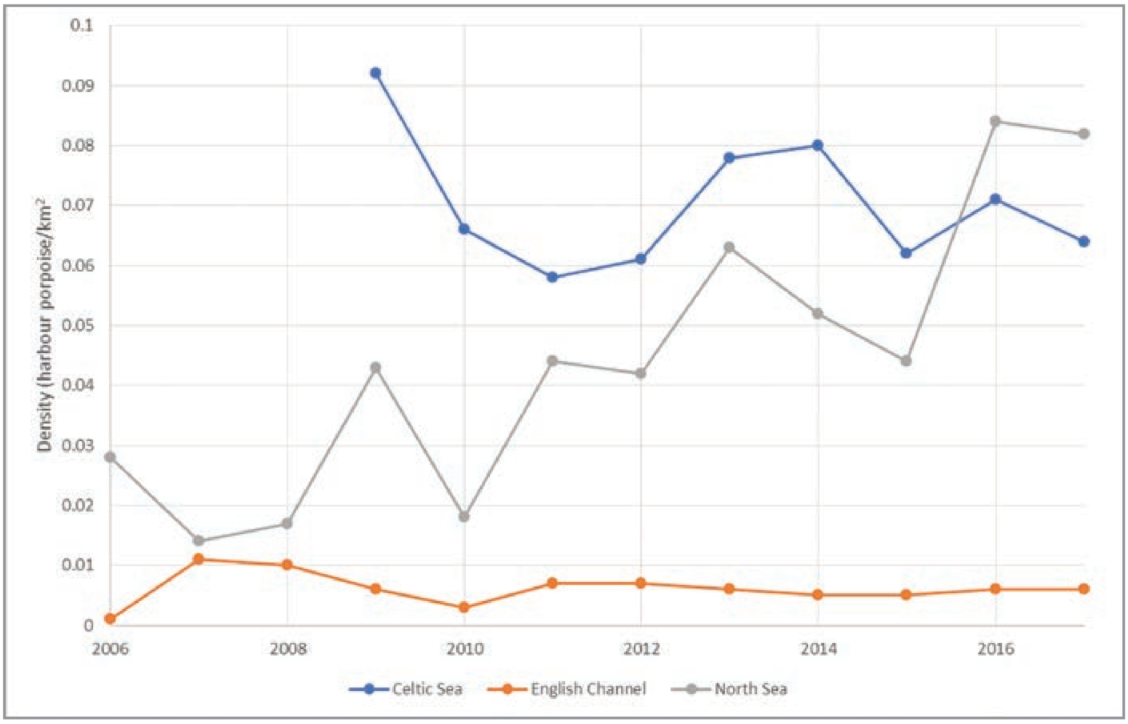

Figure 17: Density estimates in the Celtic Sea, English Channel, and North Sea in 2006-2017.

Discussion

Harbour porpoise are notoriously difficult to observe at sea, which is highlighted by the low detection probabilities estimated between 0.10 and 0.23. Densities were estimated utilising distance sampling methodologies to correct for animals missed by observers. Whilst these are widely used, it is not often that citizen scientists take part in such standardised surveys which allow analyses of these cryptic species' distribution and changes in density.

The survey route in the Celtic Sea, that was constrained to a small section between Cornwall and the Isles of Scilly, had the highest density of harbour porpoise (0.07 animals per km^2), followed by the North Sea (0.044 animals per km^2), with low densities (0.006 animals per km^2) in the English Channel. Densities in the North Sea appear to be slowly increasing across the study period, which is corroborated by SCANS III and suggests a marginal increase in abundance between 1994 and 2016 (Hammond *et al.,* 2017).

Several studies including SCANS I-III (Hammond *et al.,* 2017) and SAMM ('Suivi Aerien de la Megafaune Marine'; Laran *et al.,* 2017) have documented a range extension of harbour porpoise into the English Channel between 1994 and 2016. Whilst we can only comment on the last decade of this, harbour porpoise densities appear to be relatively stable within this time across the entire region. However, it appears that the middle of this region may have had minimal presence until relatively recently. Further work is required to investigate whether citizen science data can pick up gradual changes in distribution such as that observed between large-scale surveys.

Environmental conditions and spatial relationships influencing the density of harbour porpoise was region specific; however density in all regions was influenced by SST or chlorophyll concentrations, which can be a proxy for primary productivity. Animals in the North Sea associated with higher concentrations of chlorophyll, and highly stratified waters. Conversely, animals in the English Channel showed preference for less stratified waters. Density was highest when SST was between 13-18°C in the Celtic Sea, whereas animals in the North Sea preferred slightly cooler waters.

Whilst the results do correct for imperfect detection beyond the trackline and the amount of survey effort, density is still likely underestimated. The survey design does not allow for double platform techniques to be used to calculate g(0), the probability of recording animals on the trackline itself. SCANS-III calculated a g(0) of 0.221, which had large implications for the correction of estimates. Due to the uncertain g(0), density values themselves should be viewed with caution, although changes in density suggested in this project are applicable as they are all equally uncorrected for g(0). Despite the uncertain value of g(0), the probability of detection used for analysis was similar between SCANS-III and this study, with 0.156, and between 0.10-0.23 respectively.

Whilst densities in the English Channel are still low compared to adjacent regions, our results may show areas of importance for harbour porpoise around Plymouth, Calais, and north of the Channel Islands, which may be useful for future conservation management. These areas of higher density are different to those with higher encounter rates reported between 1998-2002 (Kiszka *et al.,* 2007), suggesting that fine-scale spatial use is changing, as well as the wider-scale range extension reported by Hammond *et al.,* 2017.

With apparently changing distributions, it is important to continue monitoring to facilitate up to date knowledge on the distribution and density of species. This is particularly important as changing environmental conditions may alter the distribution of marine animals further (Gambaiani *et al.,* 2009), leading to new overlaps with anthropogenic threats. As robust, wide-scale surveys are infrequently undertaken it is important for additional monitoring programmes to complement these, and 'fill in the gaps'. Citizen science has the potential to complement wide-scale surveys and highlight fine-scale distributions over a longer period to maintain an up to date understanding of the state of European cetaceans.


Harbour porpoise - Andy Gilbert

Cetacean Monitoring Networks

Monitoring projects that utilise platforms of opportunity can often repeatedly sample the same stretch of water, gathering vast quantities of information on animal occurrence. However, they cover limited spatial extents as they cannot move beyond the range of the vessels. Due to the non-random nature of survey locations, results on these routes cannot be extrapolated beyond the travelled line and visible distance. However, multiple survey routes can be travelled to provide a good indication of distribution in a region. There are many organisations surveying European waters, and collaborations can further extend the spatial coverage, providing a better understanding of distributions and changes in populations.

There are several collaborative networks, including the Joint Cetacean Protocol (JCP), an initiative organised by the Joint Nature Conservation Committee (JNCC) that collates and analyses data collected from various sources on cetaceans around the UK. The European Cetacean Monitoring Coalition (ECMC) is a network of European organisations that collect data onboard ferries, with some of the data contributing to JCP. The purpose of these networks is to collate enough spatial and temporal data to gain a comprehensive insight into the occurrence of cetaceans in the studied area. Whilst JPC and ECMC are UK-focussed, others exist in European waters such as the Fixed Line Transect Mediterranean monitoring Network, using a similar protocol in the Mediterranean Sea.

Humpback whale

Collaboration in the Mediterranean

The Fixed Line Transect Mediterranean monitoring Network (FLT Med Net) is a network of research bodies that use ferries as platform of observation to perform systematic surveys along several transboundary transects.

The network is coordinated by the Italian Institute for Environmental Protection and Research (ISPRA), in collaboration with many research bodies from Italy, France, Spain, Tunisia and Greece. All partners share the same protocol to survey vertebrate marine species listed in the Habitat Directive (such as cetaceans, marine turtles and seabirds) and their main threats (such as maritime traffic and marine litter). The surveys are undertaken along most of the routes all year round across several Mediterranean countries such as Italy, France, Spain, Greece, Tunisia and Morocco. Researchers and university students are involved in the data collection; more than 20 scientific partners take part in the data collection, protocol definition, and data analysis. Five ferry companies collaborate, actively hosting researchers onboard and allowing the data collection from the vessel's bridge.

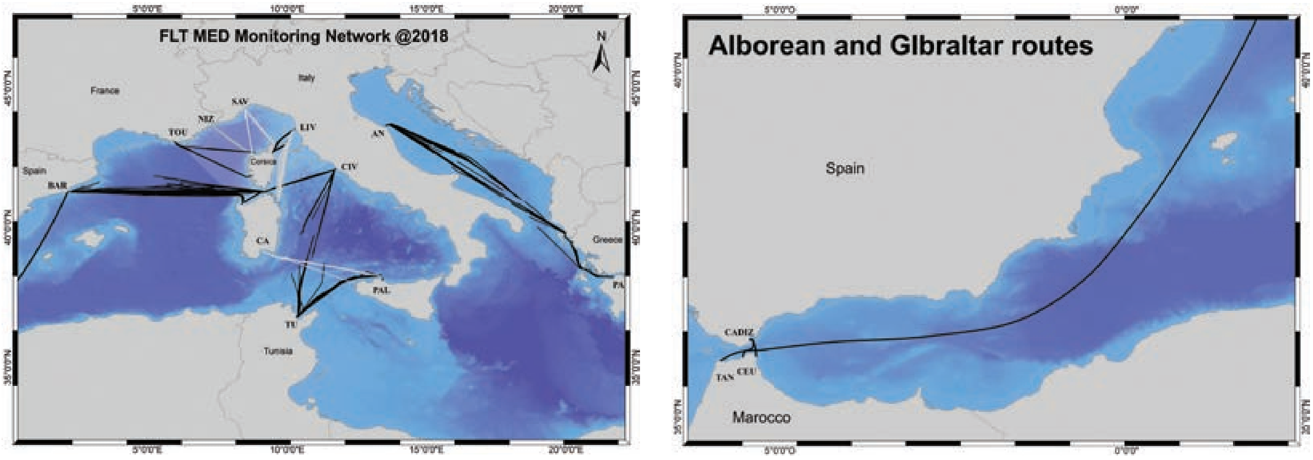

Figure 18: Routes surveyed by the Fixed Line Transect Mediterranean monitoring Network.

Data on animals are collected following distance sampling methodologies whilst marine litter is collected using a strip transect protocol. Since 2007 the network surveyed more than 300,000 km along ten fixed routes (Figure 18), with thousands of cetacean sightings. The most sighted species were fin whales and striped dolphins, followed by bottlenose dolphins, sperm whales, Cuvier's beaked whales, long-finned pilot whales, common dolphins, and Risso's dolphins. The network also recorded more than a thousand sightings of marine turtles. Seasonal and inter-annual changes in animal distribution are investigated throughout the Mediterranean basin.

The network regularly produces scientific papers in peer-reviewed international journals (see appendix), university theses and reports on species presence, distribution, behaviour and interaction with threats. Among the recent published articles, many investigated species presence and distribution for conservation purposes, habitat use, long-term trends, correlation with remote sensed variables and threats such as maritime traffic and marine litter. The FLT Med Net data also contribute to the reporting on the conservation status of cetaceans for EU Member States under article 11 of the Habitat Directive.

THREATS AND ISSUES

Our oceans are facing significant threats as a result of modern society and our interaction with the marine environment. Damage can be caused by a variety of threats and the combined pressure from these threats is devastating the unique wildlife in our waters, meaning urgent action is required to safeguard the biodiversity we enjoy for future generations.

This section outlines just a few of the anthropogenic threats facing cetaceans today, including bycatch, ship strike, commercial whaling and marine pollution. These threats can lead to cetaceans stranding on shores, an occurrence which is also highlighted. It is critical that policymakers act quickly to mitigate the damage we have inflicted upon the marine environment. For effective measures to be put in place, monitoring programmes are vital to investigate long-term changes in populations and acute impacts of more immediate threats.

Minke whale - Phoebe Smith

Commercial Whaling

Contributor: *Jennifer Lonsdale* (Environmental Investigation Agency)

Around 2.9 million whales are estimated to have been killed by commercial whaling fleets operating around the globe in the 20th century (Rocha *et al.,* 2014). Illegal and unreported whaling means that even higher levels of depletion are likely to have occurred. Global whale populations were decimated, driving several to the brink of extinction. Sperm whales, for example, were reduced to about 30% of their pre-whaling population and blue whales by up to 90% (Environmental Investigation Agency & Animal Welfare Institute, 2018).

The moratorium on commercial whaling enacted by the International Whaling Commission (IWC) in 1982, and implemented in 1986, saved several whale species from extinction and allowed populations to recover. It is one of the world's most effective conservation and welfare measures of the 20th century and continues to provide vital protection today.

However, over three decades after implementation of the moratorium, Norway, Iceland and Japan continue to hunt whales using loopholes in the IWC's Convention, setting their own catch limits.

- Article VIII of International Convention for the Regulation of Whaling (ICRW) allows IWC Contracting Governments to 'kill, take and treat whales for purposes of scientific research' (special permit whaling; IWC, 1946). Japan uses Article VIII to authorise its special permit whaling, products from which are sold in Japan.

- Norway lodged an objection to the moratorium and may therefore issue its own catch limits.

- As a founding member of the IWC, Iceland did not formally object to the moratorium and was therefore bound by it. However, special permit whaling took place from 1986-1990. It left the IWC in 1992 and re-joined in 2002, lodging a disputed reservation to the moratorium that it has used to justify its commercial catch limits since 2006. Eighteen IWC Contracting Governments objected to its reservation.

These three countries have killed at least 38,629 whales since 1986, when the moratorium came into effect (EIA-AWI, 2018). In addition, since 2008 over 9,300 tonnes of fin and minke whale products have been exported to Japan from Norway and Iceland. They registered reservations to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I listings that ban international trade in whale products and can therefore effectively ignore this ban (CITES, 2013).

Fin whale - Dave Chilcott

Norway

Norway ignores the moratorium and kills more whales than Iceland and Japan combined. It carried out special permit whaling (reportedly for scientific research) between 1988 and 1994, killing 289 minke whales. It then resumed commercial whaling in its Exclusive Economic Zone (EEZ) in 1993 and in total it has killed 14,326 minke whales since the moratorium was implemented (EIA-AWI, 2018).

The Norwegian Government set a whaling catch limit of 999 minke whales in 2017 with 432 actually killed. The 2018 catch limit was increased by 28% to 1,278 and permits were issued to 15 vessels. However only 11 vessels used them and 454 minke whales were killed.

From 2011 to 2017, Norwegian whalers killed 1,095 male minke whales and 2,884 females of which 2,003 were pregnant (EIA-AWI, 2018). Removing pregnant females and mothers with dependent calves has further impacts on the population.

The Government acknowledges that there are problems with the industry due to the failure to recruit more fishermen to whaling. The market also faces a glut of whale meat and in 2017, around 60 tonnes were given away because the products could not be sold before the expiry of the one-year shelf life. In 2018, in response to the oversupply, the Norwegian Råfisklaget Sales Association (which sets conditions for sales of whale meat) required that whalers secure a sales agreement for all their whale meat, fixing the price and quantity, before they started hunting (EIA-AWI, 2018).

On 12th September 2017, the European Parliament passed a resolution clearly emphasising the EU position with regard to the cruel and unsustainable practice of whaling. It clearly called on Norway to end its whaling activities and sent a strong message to the European Commission that steps must be taken to halt the transhipment of Norway's whale meat exports to Japan through EU ports. The EU and other IWC member governments have also applied repeated diplomatic pressure on Norway to end its whaling.

Iceland

Not having lodged a formal objection to the moratorium, between 1986 and 1990, Iceland authorised special permit whaling, taking 292 fin whales and 70 sei whales (IWC, 2017). It left the IWC in 1992 and re-joined with a disputed reservation to the moratorium on commercial whaling and grants itself catch limits for fin and minke whales in its EEZ.

Minke whale - Billy Heaney

Since 2006, 453 minke and 851 fin whales have been killed in Iceland. No fin whales were killed in 2016 and 2017 but in 2018, Iceland recommenced its fin whaling killing 145 individuals, along with six minke whales (Fiskitofa, 2018). A substantial amount of fin whale meat was shipped to Japan.

In addition, two rare hybrid blue/fin whales, one of which was pregnant were also killed. DNA tests confirmed that both had fin whale fathers and blue whale mothers. People in Iceland do not consume fin whale, raising very serious questions about what will happen to the meat from the hybrid whales. It cannot be exported to Japan since Iceland and Japan's CITES reservations only relate to fin and not blue whales. If the products from pure fin whales have been mixed with those from the two hybrids, they will not be permitted to be traded either (WCL, 2018).

The Director of the Hvalur whaling company, Kristján Loftsson stated that during the two-year hiatus in fin whaling, research had been undertaken into the uses for whale meat, bones and blubber as medicinal and food additives including iron supplements (Iceland Monitor, 2018).

Meanwhile, there has been a decline in the number of minke whales killed in Iceland. The enlargement of the whale sanctuary in Faxafloi Bay (overlooked by Reykjavik) means that whalers have to hunt whales further offshore. At the end of July 2018, the head of the whaling company IP-Utgerd Ltd, Gunnar Jonsson, confirmed that minke whaling has ended, telling the Morgunbladid newspaper, "We need to go much farther from the coast than before, so we need more staff, which increases costs."

Icelandic public support for whaling has diminished in recent years. A 2018 survey by the Iceland poling company Market and Media Research found 34% in favour of whaling compared to 60% in 2013. A number of parliamentarians called for a thorough review of the reputational impact of whaling on Iceland's fishing, agriculture and tourism before new whaling quotas could be issued. They also called for an assessment comparing the income and export earnings and jobs generated by the whaling industry with other economic sectors. The Prime Minister Katrín Jakobsdóttir, a member of the anti-whaling Left Green party, indicated that new fin whaling quotas would not be issued until the completion of the review which is due to be undertaken by the end of 2018.

Diplomatic pressure from the EU and other countries internationally has been repeatedly placed on Iceland calling on it to end its whaling and exports to Japan.

Disregard for a precautionary approach

When the moratorium was adopted, the IWC asked its Scientific Committee to develop a precautionary approach to setting commercial whaling quotas in the future, should the moratorium ever be lifted. The Revised Management Procedure (RMP) was adopted by resolution in 1994 (IWC, 1994a) as an element of a Revised Management Scheme (RMS; IWC, 1994b) that would be used to manage any resumed whaling. The RMS has never been adopted.

The RMP includes a key element, the tuning level – the fraction of the whale population that would be left after 100 years of hunting with catch limits set by the RMP. The higher the tuning level, the lower the catch limit calculated. It also includes a provision to ensure catch limits would not result in a whale population being overexploited. The tuning level of the RMP was set by the Commission at 0.72 but is not authorised to be used until the moratorium is lifted.

Norway and Iceland both set their catches at levels much greater than would have been calculated if the tuning level of 0.72 had been used.

The inherent conditions of whaling, firing a harpoon from a moving platform (the vessel) into a swimming whale increases the risk of wounding the animal and inflicting distress and pain. It reduces the instantaneous death rate and can prolong time to death (TTD). The IWC seeks to ensure whale hunts are as humane as possible, but there are significant welfare concerns about Iceland, Norway and Japan's whaling operations.

The IWC requests that Contracting Governments submit reports on the methods used to kill whales and the effectiveness of those methods. Norway submits minimal information. Iceland and Japan refuse to submit any data. All three repeatedly state that they prefer to submit information to the North Atlantic Marine Mammal Commission (NAMMCO), the membership of which is limited to Iceland, Norway, Greenland and the Faroe Islands. Japan participates in some of its work.

Iceland has collected minimal data on TTD rates but has not provided any credible data on the minke whale hunts. Data on TTD collected in 2014 from 50 of the 137 fin whales killed reported eight had not died instantly and had to be shot a second time. One took 15 minutes to die (Øen, 2015).

Norway submits minimal welfare data to the IWC and has no mandatory reporting of TTD of instantaneous death rate in its hunts. Recent data collected by fisheries inspectors showed 222 instantaneous deaths and an average TTD of one minute. The median TTD for the 49 whales was six minutes and one taking 20-25 minutes to die (EIA-AWI, 2018).

Despite international pressure calling Iceland, Norway and Japan to cease commercial whaling, this barbaric practise continues with more evidence emerging that fewer individuals support whaling or consume whale meat in Europe. Combined with the devastating impact on whale populations and associated welfare concerns, it is hard to see how these countries can justify their continued whaling activity.

Plastics

At the end of 2017, the BBC's Blue Planet II highlighted the issue of plastics in the oceans. This coverage informed the public about a broad issue that many people were unaware of. This garnered a lot of attention, both with the general public and in the media. This surge in interest led to the issue being talked about in Parliament, with a bottle deposit return scheme discussed. The UK Prime Minister outlined a 25 year plan to phase out plastics, though many businesses have improved upon this by vowing to phase out single-use plastics by the end of 2020. This is a step towards reducing single-use plastic production and preventing irresponsible disposal, which will ultimately reduce the amount of plastic making its way into the oceans.

Global annual plastic consumption had reached over 320 million tonnes in 2016 (Surfers Against Sewage, 2018). Whilst research into marine pollution is not a new field, there is an increasing public awareness of the issues associated with it and extensive research is now being carried out into specific aspects of the problem. Marine litter, especially plastics which frequently float (Andrady, 2011), can accumulate in large quantities, such as the Great Pacific Garbage Patch (GPGP). The GPGP has been well-studied, with new research showing that it consists of at least 79 thousand tonnes of plastic, inside of an area of 1.6 million km^2 – four times greater than previous estimates (Lebreton *et al.,* 2018).

Plastic floating in the marine environment can also entangle animals, including cetaceans, which can occur when curious individuals investigate debris, or more frequently in areas of high-density debris. Items such as fishing nets, packing straps or moored buoys can come into contact with animals, and often result in injury, drowning or strangulation (Fossi *et al.,* 2018). Entanglement can also have less immediate impacts, such as reducing fitness by increasing the energetic cost of travel and foraging, or reducing efficiency of predator avoidance (Mattsson *et al.,* 2015). Approximately 17% of cetacean species have been reported with entanglements (Baulch & Perry, 2014).

Ingestion of plastic has been recorded in 44% of all cetacean species with a range of feeding techniques (Baulch & Perry, 2014). This can have a wide range of impacts, from no discernible impact through to digestive tract obstruction and starvation, or suffocation (Sheavly & Register, 2007). The ingestion of small plastics can lead to inflammation, damage at the cellular level, or changes in molecular pathways (Mattsson *et al.,* 2015). A study on the digestive tracts of stranded cetaceans in Ireland found plastic in 8.5% of individuals (Lusher *et al.,* 2018). Historically, focus has been on macroplastics (Franeker *et al.,* 2018), however studies are now reporting the ingestion of microplastics of less than 5 mm (e.g. Besseling *et al.,* 2015). These bioaccumulate in marine predators, such as cetaceans and can even be ingested by filter feeders such as baleen whales. When bioaccumulation occurs in long-lived animals, it can lead to the disruption of biological processes and negatively affect reproductive fitness (Rochman *et al.,* 2014).

Filter feeders may ingest plastic directly whilst taking in hundreds or thousands of cubic metres of water a day, or by ingesting contaminated prey (Fossi *et al.,* 2012; Setala *et al.,* 2014). The density of microplastics in the Mediterranean Sea suggests that fin whales inhabiting these waters could intake 3,600 microplastic particles each day (Fossi *et al.,* 2014). Ingestion of such particles can lead to the blocking of adequate nutrient absorption, or cause damage to the digestion tract, and the particles themselves can harbour high levels of toxins and organic pollutants (Germanov *et al.,* 2018).

Fish in plastic debris - Mae Dorricott

Marine Pollutants: PCBs

Contributor: *Paul Jepson* (Zoological Society of London)

Polychlorinated biphenyls (PCBs) are a group of industrial pollutants that are still having devastating effects on higher predators including many cetaceans, despite being widely banned more than 40 years ago. They are man-made organic chemicals that were commercially produced from the 1930s. PCBs had industrial applications and were used in transformers and capacitors, flame-resistant coatings, paint and machinery.

After they were found to be toxic with impacts on human health and the environment, they were banned in Europe in the 1980s (Van den Berg *et al.,* 1998). Despite this ban, PCBs from sources such as existing open application sources (paint, coatings and machinery), landfills and stockpiles continue to enter the environment (Figure 19). PCBs can persist in the environment for extended periods of time, and are having a continued impact on cetaceans.

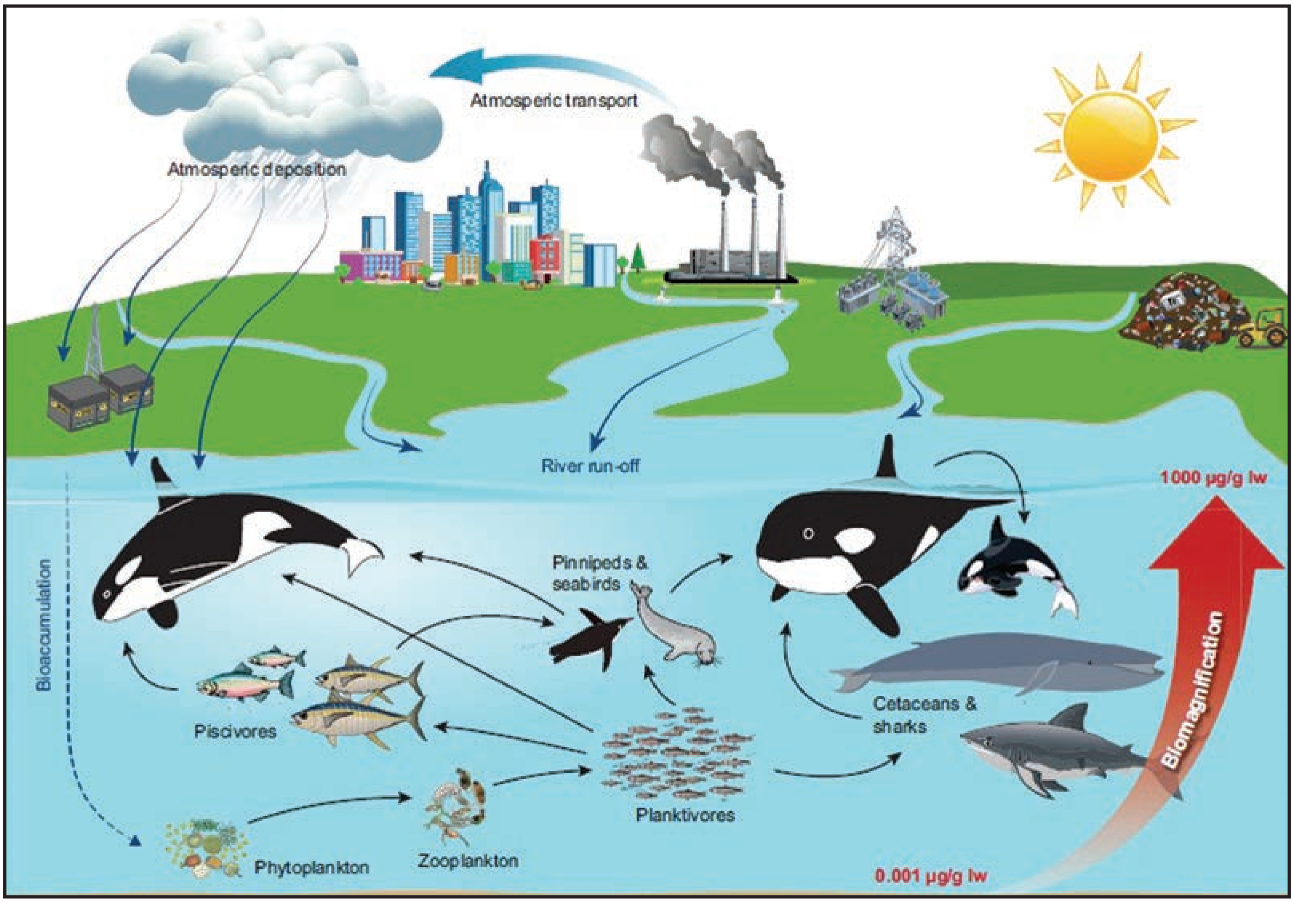

Figure 19: The environmental transfer of PCBs from source to top predators (Desforges *et al.,* 2018).

PCBs can enter the food-chain through absorption by microorganisms, where they work their way up and bioaccumulate in long-lived predators (such as cetaceans) that store these pollutants in their blubber. Predators that eat large fish such as tuna or sharks, or other marine mammals are at greatest risk of accumulating large doses of PCBs. Toxicity is dose-dependent, with higher concentrations leading to greater impacts. One of the greatest impacts of PCBs is reduced reproductive success, which greatly influences the health of small populations with low recruitment (Jepson *et al.,* 2016).

Some European locations, including the western Mediterranean Sea and south-west Iberian Peninsula, are global PCB hotspots. Marine mammals here are likely to contain high concentrations of PCBs, with bottlenose dolphins, striped dolphins and orca exhibiting high levels in these areas (Jepson *et al.,* 2016).

Orca have the highest PCB exposures on Earth (Jepson & Law, 2016). A recent study found that ten out of 19 orca populations investigated are rapidly declining, with these animals potentially at risk of extinction within a few decades (Desforges *et al.,* 2018). Animals in industrial areas that feed at high trophic levels are at greatest risk. Greenland, Canary Islands, Hawaii, Japan, Brazil, north-east Pacific Bigg's, Strait of Gibraltar, and the western Scotland population all possess PCB levels that are predicted to cause population declines (Desforges *et al.,* 2018). Populations in Japan, Brazil, the north-east Pacific Bigg's, the Strait of Gibraltar and the UK are all expected to collapse completely within 100 years. PCB concentrations were lower in remote populations (Alaskan residents, Antarctic type C, Canadian Northern residents, Crozet Archipelago, Eastern Tropical Pacific, and Norwegian populations) and these groups are predicted to double their net population size. Prey selection affects PCB load, with populations that have switched from low to high PCB contaminated prey (for example, fish to seals) exhibiting increased exposure, with populations such as north-east Scotland and Greenland now predicted to collapse (Vongraven & Bisther, 2014).

The conclusion that many orca populations are at immediate risk and are currently declining is one that warrants urgent action. It is estimated that 80% of global PCBs have not yet been destroyed, and many countries will not meet current targets to avoid further PCBs leaching into the environment. Intervention is required if orca populations and other affected species are to be saved from collapse.

Orca - Elizabeth Riley

Bycatch

Contributor: *Sarah Dolman* (Whale and Dolphin Conservation)

In UK and European waters thousands of cetaceans die every year as a result of incidental capture and asphyxiation in fishing gear. This is usually referred to as 'bycatch'. Recent estimates of the annual UK fisheries toll include over 1,500 small cetaceans (Northridge *et. al.*, 2017), and increasing levels of baleen whale entanglements (Ryan *et al.,* 2016). The most common victims of bycatch in UK waters are the harbour porpoise and common dolphin; although the diversity of odontocete (or toothed cetaceans) species that get entangled also includes bottlenose dolphin, Risso's dolphin, striped dolphin, white-beaked dolphin, Atlantic white-sided dolphin and pilot whales. Baleen whales are also victims of bycatch; more commonly referred to as 'entanglement' and in the UK minke whales and humpback whales are primarily affected. Despite international, national and regional regulatory policies to limit and reduce incidental capture in fishing gear, bycatch remains one of the foremost threats to marine mammals and there are still no robust estimates for total bycatch in UK waters.

This year, like every year for the last few decades, there have been very high levels of common dolphin bycatch in the north-east Atlantic. Many of the individuals stranded along the coast of Cornwall during the winter months have demonstrated signs of rope marks or external injuries from fishing gear and the south and south-west coast of England are recognised as one of a number of European hotspots for common dolphin strandings. It is a similar picture for those washed up on Irish and French shorelines this year. For every dolphin observed bycaught on board a fishing vessel it is estimated that approximately ten more have died (Peltier *et al.,* 2016), but this figure may be even higher as factors such as weather, wind and tides mean that some bycaught individuals may not end up as strandings and will therefore go undetected.

Harbour porpoise with monofilament net marks - CSIP-ZSL

The highest levels of common dolphin bycatch in the English Channel and Bay of Biscay is primarily reported in pelagic (midwater) trawl fisheries, particularly pair-trawls, where a net higher than a three-storey house and almost as wide as a football pitch is dragged through the water between two fishing vessels, targeting schooling fish. Dolphins sometimes swim into the nets to feed on the catch and can become trapped, or are caught as the net is hauled in. The large numbers of common dolphin strandings reported in the south-west show a strong seasonal pattern, occurring in the winter months during the open season of the pair-trawl fishery (de Boer *et al.,* 2012). Little to no monitoring currently occurs in a large part of the offshore fleet such as pelagic freezer trawlers and high vertical opening trawlers.

Fisheries that use static nets are also recognised as a particular threat to many marine mammals. Fishermen set and then leave these types of nets hanging stationary in the water column for periods of hours or days to catch passing fish. The nets, which can be kilometres in length, are currently of particular concern in Portuguese and Spanish waters for common dolphin and striped dolphin bycatch, and for bottlenose dolphins in Andalusian waters.

Harbour porpoise are highly prone to bycatch in bottom-set, static nets, such as gillnet and tangle net fisheries, due largely to their feeding habits on or near the seabed (Wisniewska *et al.,* 2016). High levels of harbour porpoise bycatch have been recorded in gillnets in the Celtic Sea and North Sea and such levels are likely to be unsustainable, representing a real threat to the UK's populations of porpoise and a serious welfare concern.

The majority of porpoise and dolphins caught in fishing nets will die following a painful struggle. If these individuals are unable to rise to the surface to breathe they will close their blowhole and suffocate (Moore & van der Hoop, 2012; de Quirós *et al.,* 2018). Even those who manage to escape may still continue to suffer due to the injuries they have sustained, such as broken bones, internal bleeding and amputations, as well as stress. Bycatch is therefore not only a conservation concern, but is also a major welfare concern.

Large whale entanglement occurs when fishing gear, such as ropes, buoys and nets become wrapped around the animal, often leading to the animal's death, or serious injury. Ropes and lines can cause deep lacerations, tissue damage and haemorrhaging. This can result in infection and cause extreme pain for protracted periods of time. Entanglements also inhibit the animals' foraging abilities as they tow heavy fishing gear through the water leading to exhaustion and starvation. In some cases, the individual is unable to reach the surface to breathe, resulting in suffocation.

Bycaught harbour porpoise - Rod Penrose / CSIP-MEM

Entanglements in UK waters appear to be increasing, particularly with humpback whales in shellfish creels (pots) in Scottish waters (Ryan *et al.,* 2016). Creel fishing involves the use of a string of baited pots, left in the water for a period of time. These are connected with a rope and each end of the rope is floated to the surface with a buoy. Thousands of creel sets are deployed around the UK coastline. As the whale swims through the water column open-mouthed to catch prey, they accidentally take the creel lines into their mouth, and this is how most entanglements appear to commence. The lines often become increasingly entangled around the humpbacks large pectoral fins (up to five meters long), body and tailstock. At up to 18 meters in length, humpback whales are large, strong animals and have been known to carry the gear with them for long distances. In 2017, a humpback whale became entangled in creel lines off the Devon coastline on two separate occasions. Fortunately for this individual, it was successfully cut free by British Divers Marine Life Rescue as the line was just around the tailstock and not through the mouth.

Common dolphin with rope marks - CSIP-ZSL

Smaller whale species have higher entanglement mortality rates as they have less strength to tow the fishing gear, often becoming anchored by the lines. At a maximum length of ten meters, minke whales are less likely to reach the surface to breathe whilst entangled and will inevitably suffocate (Knowlton *et al.,* 2016). Therefore, many entangled minke whales are likely to die and sink without being reported; meaning the full extent of the issue is not truly understood. An examination of stranded minke whales by the Scottish Marine Animal Stranding Scheme (SMASS) reported that half of all necropsied minke whales in Scottish waters show signs of entanglement.

The UK meets its obligations to monitor and mitigate cetacean bycatch under Regulation 812/20045 and through the EU Habitats Directive, the Marine Strategy Framework Directive (MSFD) and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), but significant shortcomings have been identified, including the limited range of areas, vessel sizes and gear types to which monitoring and mitigation obligations apply, leaving significant sectors of the fleet unmonitored and poor implementation by non-UK Member States. Current potential mitigation measures include acoustic deterrent devices, fishing gear modification and closed areas. Bycatch rates of harbour porpoise in UK fisheries are reported to be much lower in gillnets equipped with pingers, acoustic deterrent devices. However, it is unclear if pingers have an effect on dolphin bycatch rates. Despite industry recognition of the issue and the development of new technologies, bycatch remains a major threat to UK and European cetaceans.

Bycatch is a global issue, with an estimated 300,000 cetaceans caught every year (IWC, 2016) and some populations have been pushed to the brink of extinction as a result. The vaquita (*Phocoena sinus*), the world's smallest porpoise inhabiting the upper Gulf of California in Mexico is regarded as the most endangered marine mammal in the world, with less than 30 individuals remaining. The vaquita shares its habitat with the totoaba fish, a species whose bladder is highly prized in Asia and is traded illegally through Mexico, the US and China. This has resulted in a significant depletion of the vaquita population, to a non-viable level, due to bycatch in gillnets set for the totoaba (Rojas-Bracho & Reeves, 2013). Despite numerous conservation efforts and the totoaba fishery being an illegal industry, the vaquita still remains at high risk of extinction.

Entanglement in static fishing gear is the leading cause of detected mortalities of large whales in the north-west Atlantic (van der Hoop *et al.,* 2013). The north Atlantic right whale is an endangered species numbering less than 500 individuals and entanglement in static pot gear lines is a primary cause of death in US and Canadian waters (Dolman & Moore, 2017). Entanglement involving the head region is the most common point of attachment for north Atlantic right whales, which can result in direct reduction in feeding efficiency (Johnson *et al.,* 2005). Post-entanglement survival rates are 25% lower than conspecifics and those towing fishing gear have been reported to die over periods of six months (Robbins *et al.,* 2015). There are cases where entanglement can persist for multiple years (Moore & van der Hoop, 2012). Despite efforts to reduce this risk through modified fishing gear, entanglement remains a serious threat to north Atlantic right whales.

Our understanding of marine mammal bycatch is limited by the lack of monitoring and reporting on a global scale (Read *et al.,* 2006). As bycatch of cetaceans remains a significant conservation and welfare concern, there is an urgent need for improved avoidance and mitigation measures both in Europe and around the world.

Ship Strike

Contributor: *Russell Leaper* (International Fund for Animal Welfare)

Common dolphin with propeller injuries -CSIP-ZSL

Whales being struck by vessels is one of the most prevalent threats facing cetaceans today (Peel *et. al.*, 2018). As mammals, whales spend a portion of their time at the surface to breathe which may be extended to interact socially, feed or to recover from the energetic demands of feeding at depth (Constantine *et al.,* 2015). When at the surface, whales share this space with maritime traffic, and are at risk of close-encounters and collisions (Izadi *et al.,* 2018). The actual occurrence rate of ship strikes is still largely unknown, and is likely to be significantly under-reported (Williams & O'Hara, 2010; Rockwood *et al.,* 2017). It is thought that this is in part due to collisions not being felt on large vessels over 100 m in length (Peel *et. al.*, 2018). Large whale species are particularly susceptible due to a limited ability to manoeuvre away from vessels at close-proximities, or do not attempt to move at all (Nowacek *et al.,* 2004).

Maritime traffic is expected to increase alongside human populations, with larger and faster ships being built to satisfy the need for transport of our goods; an estimated 90% of which are currently transported by sea. It is therefore important that we understand this threat to our large marine mammals and attempt to mitigate it. The highest mortalities occur where high densities of shipping activity overlap with high densities of whales, and therefore an understanding of at-risk whale populations, habitat use and areas where they are most threatened is important for conservation (Rockwood *et al.,* 2017).

An integrated approach is required to understand and mitigate ship strikes. Threatened animals are not only those inhabiting areas of high shipping activity; behaviour also changes the level of risk (Baumgartner *et al.,* 2017; Soldevilla *et al.,* 2017). Some species spend a higher proportion of their time at the surface than others, which is often further linked to the time of day. Bryde's whales have been found to perform shallower nocturnal dives, and spend large proportions of their time near the surface (Constantine *et al.,* 2015), 88% of their time at night is spent within depths reached by the hull of large commercial vessels (Soldevilla *et al.,* 2017). There is also evidence that other species, such as fin whales, are more likely to be nearly hit by ships closer to times of darkness (ORCA, unpublished data). Some species, particularly baleen whales, are less capable of identifying the

Risso's dolphin victim of ship strike - CSIP-MEM risk of oncoming ships at range and are therefore less able to take timely action.

Overlaps between species vulnerable to ship strike, and high density of shipping traffic can also have non-lethal impacts. Close-encounters change behaviours of animals, with respiration rates and dive times often altering when at close proximity, which is an avoidance behaviour and likely to be a stress-related response (Nowacek *et al.,* 2007). Stress from sources such as these close-encounters has the potential to alter distributions and foraging behaviour, leading to reduced fitness.

Data on the risk to whales are not available for many regions for appropriate decisions to be made, and the prevalence of this threat is area and species-dependent, with some populations showing relatively low frequency of ship strike injuries – such as a population of bowhead whales (*Balaena mysticetus*), where 2% of individuals have been visibly impacted (George *et al.,* 2017).

Many populations and species of whale are still recovering from historic whaling, and modern threats may hinder recovery, or in some cases impact the survival of an already endangered species. The north Atlantic right whale (hereafter 'right whale') once frequented European waters, but was hunted to near-extinction in the north-east Atlantic. A population in the north-west survived with low numbers; however modern threats such as bycatch in fishing gear, and ship strike have decimated a substantial percentage of their already reduced population. This population has been further impacted by a lack of newborn calves being reported this year in their known calving area, suggesting that a reduction in breeding adults may have had further consequences. Alternatively there may be additional areas important to this key life stage that are undiscovered and as such, unprotected. In 2008, Seasonal Management Areas (SMAs) were implemented with mandatory speed restrictions for vessels over 20 m in length in an area known for high abundance of right whales to reduce collision risks (Laist *et al.,* 2014; van der Hoop *et al.,* 2015). In addition, Dynamic Management Areas (DMAs) recognising inter-annual variation in habitat use, were set up ad-hoc with voluntary speed limits where right whale aggregations were recorded outside of SMAs. This combined approach to mitigate risks to the right whale population from interactions with vessels has been largely successful with a reduction in


Fin whale victim of ship strike

mortality rates of 2.0 before the implementation of these managed areas, to a rate of 0.33 after management (van der Hoop *et al.,* 2015).

Re-routing vessels is not appropriate for every area of risk, as vessels may coincide with broadly distributed whales that cannot be practically circumnavigated (Constantine *et al.,* 2015). A combined approach with the reduction of overlap between vessels and whales, and speed restrictions is likely to be the best solution for this threat. Further implementation of speed restrictions will also benefit cetaceans as higher speeds correlate with a higher noise output, which can have damaging and disruptive effects (Nowacek *et al.,* 2007; Leaper *et al.,* 2014).

Last year's report outlined ORCA's innovative research project exploring the risk of fin whales being hit by ships in the Bay of Biscay. This region has a high density of vessels passing through it, and is visited by large numbers of fin whales with peaks in late spring and summer. The 2017 research project collected data on fin whale behaviour in the presence of a large ferry that regularly passes through the area. The results from this are currently being submitted for peer-reviewed publication and highlight that close-proximity to the ship changed the whale's behaviour and respiration rate. This work is being built upon, using Brittany Ferries vessels as a research platform and in collaboration with the Sea Mammal Research Unit who have provided camera equipment to aid research. This equipment allows highly accurate data to be collected on fine-scale behaviour and locations in relation to the vessel which should provide a greater understanding of how bridge crews can best react around these whales to limit collisions, and to quantify risks.

Anthropogenic Noise

Contributor: *Rebecca Walker* (Natural England)

Cetaceans live in an underwater world of sound. They use sound for essential biological and ecological aspects of their lives, including navigation, communication (sometimes across thousands of kilometres), finding and capturing prey and avoiding predators. Scientists are still learning about the complex ways that cetaceans use sound.

Anthropogenic noise in the ocean has increased over the last 100 years from various activities including shipping, marine industry, such as wind farms or oil and gas exploration, and naval sonar. Noise can impact cetaceans in many different ways, depending on the intensity, frequency and nature (for example, continuous or impulsive) of the sound source.

Loud impulsive noises, such as those from wind farm installation, oil and gas exploration or underwater explosions, can cause death or physical injury at very close ranges. At greater distances these noises can also temporarily or permanently damage an animal's hearing, causing them to become deaf at certain frequencies (Erbe *et. al.*, 2018). Their hearing may or may not recover, with potential consequences on their survival as it may impact their ability to find prey. Continuous underwater noise, for example shipping or operational wind farms, is unlikely to cause physical or acoustic injury, but it can mask communication, an individual's ability to detect predators or disturb animals from important feeding or resting areas, potentially leading to a decrease in long-term health. Certain types of naval sonar have been shown to cause rapid behavioural changes in deep diving marine mammals, causing them to cease feeding, but also surface too quickly, leading to something akin to decompression sickness (the bends), and resulting in death and subsequently sometimes stranding on the coast (Fernandez *et al.,* 2005; Cox *et al.,* 2006; Filadelfo *et al.,* 2009).

Cuvier's beaked whale - Ross Wheeler

Strandings

Contributor: *Stephen Marsh* (British Divers and Marine Life Rescue)

Cetaceans regularly strand ashore, with hundreds of strandings reported each year around the UK. Cetaceans can strand alive (often being unable to return to their natural environment unaided) or dead (after dying at sea and washing ashore). Strandings can be of a single individual, or a mass stranding (two or more animals [excluding mother calf pairs] within the same geographical region and tidal cycle). Investigating strandings not only allows us to examine emerging and long-term threats to these animals, but it can also indicate population levels and species distributions on a local and seasonal scale, providing an insight into the health of these populations.

The occurrence of strandings depends on a combination of factors, including the distribution and abundance of cetaceans, their prey, and causes of mortality, as well as winds and currents that can carry carcasses to the shore (Saavedra *et al.,* 2017). It is worth noting that an increase in strandings may not mean an increase in the level of threats, but may mean that the population numbers are increasing. In the UK, the Natural History Museum and the Cetacean Strandings Investigation Programme have been collecting data on strandings since 1913.

Cetaceans can strand due to natural reasons such as disease, parasitic infection, abscesses, old age, lack of a food supply, geomagnetic alterations, weather events, or maternally dependent calves becoming separated from their mothers. These can affect the animal's ability to feed, to combat tidal currents or swell, leading to stranding. Anthropogenic activities, such as bycatch, entanglement, ship strike, noise exposure and the accumulation of toxins (for example PCBs) can also lead to strandings. The reason for stranding is often unclear; however some cases can be attributed and data can provide insights into areas of risk, causes and seasonality of strandings events. It should be noted that a majority of cetaceans will die at sea, with their bodies sinking onto the sea bed, and therefore are rarely recorded (Faerber & Baird, 2010).

Stranded common dolphin - Dan Jarvis

Mass strandings

Mass strandings can also happen naturally, and pilot whales are notorious for mass strandings due to strong social bonds within their family pod. If one animal is compromised then others in the pod will likely stay with it, and if close to shore may succumb to a falling tide. Every mass stranding of long-finned pilot whales in the UK since 1913 has happened on a spring tide (Marsh, 2016), when twice a month the combined gravitational pull of the moon and sun create extra high and extra low tides that can catch animals unaware during these extreme tidal ranges. Over 60% of mass stranded pilot whales in the UK have been successfully refloated (British Divers Marine Life Rescue, personal communication) as many of these are likely to be healthy individuals. Occasionally a mass stranding can be averted by skilled shepherding of pods out of danger, further reducing mortality rates. These rescue statistics are among the best seen globally.

A mass mortality event is similar to a mass stranding, but the associated strandings take place over a longer timescale and across a wider geographical area. A recently published report documents the stranding of 30 sperm whales in the southern North Sea, across five countries and over a five week period in early 2016 (Ijsseldijk *et al.,* 2018). All of the sperm whales that stranded were immature males. The younger individuals that make up bachelor pods travel to subpolar regions to avoid competition for food with females in warmer waters. They return to tropical breeding areas each year, and it is likely that this pod was travelling south from Norwegian feeding grounds, but a navigational error resulted in them entering the North Sea, rather than travelling around northern Scotland and out into the Atlantic Ocean. The depth of the North Sea becomes progressively shallower further southwards, and has historically been a hotspot for sperm whale strandings. Fourteen mass mortality events including more than four sperm whales have been recorded in the southern North Sea since the 16th century, all being in similar coastal locations and between the months of November and March, indicating this annual migration. The North Sea, being relatively shallow, does not contain enough of the preferred large, deep sea cephalopod prey for sperm whales and the lack of depth and gently shelving seabed is known to create a hazard for the species.

In this recent event, the smallest sperm whales stranded in the Netherlands, and the largest in England. Twenty-seven animals were necropsied or sampled, and the animals were in fair to good nutritional condition with no evidence of disease or trauma prior to stranding. Parasitic load, bacterial and fungal pathogens were at relatively normal levels, and nine individuals contained marine litter; although this was not believed to be the cause of stranding. There were no acoustic, military or environmental events during the stranding period or directly prior to the strandings that were thought to be a cause (IJsseldijk *et al.,* 2018). The conclusion is that this event was probably natural, with no unusual anthropogenic activity associated with it.


Sperm whale stranded at Skegness - CSIP-ZSL

Another unusual mass mortality event is ongoing at the time of writing, with dozens of beaked whales stranding in Ireland, Scotland, the Faroes, and Iceland. This may be the largest mass mortality event of beaked whales ever recorded, with over 80 being discovered so far. Many of these animals are in varying states of decomposition, suggesting that they died at sea. Advanced stages of decomposition mean that it is difficult to attribute the cause of death through initial examinations.

Beaked whale strandings have been correlated to acute anthropogenic noise, such as those produced by low to mid frequency military sonar (Filadelfo *et al.,* 2009), and certain acoustic surveys. Whilst no cause has yet been established for this recent event, the impact of noise is a possibility. Exposure can lead to temporary or permanent hearing damage, or gas embolism ('the bends') caused by a drastic change in behaviour (Fernandez *et al.,* 2005; Cox *et al.,* 2006), and stranding can occur as quickly as four hours after exposure (Jepson *et al.,* 2003).

Continued monitoring and reporting of stranded animals is imperative, to rescue those that are appropriate and practical to do so, and to collect data to provide an insight into the prevalence of threats.

Stranded harbour porpoise - Dan Jarvis

CONCLUSION

There are many threats to marine mammals in European waters and beyond. As highlighted by the case of the north Atlantic right whale, cetaceans may be affected by multiple stressors. These can accumulate, with heterogeneous impacts causing stress, reduced fitness, and sometimes death to these animals.

As our environment is changing, threats to our cetaceans become increasingly dynamic, and continued monitoring is essential to have an up to date understanding of these animals' distribution and trends in their occurrence. Long-term monitoring projects are essential to track these changes and provide policymakers with current information. Whilst large-scale surveys are the ideal method for gaining these data, financial and logistical constraints often do not allow these to be carried out frequently. Therefore, data from non-traditional methods such as citizen science can complement these surveys.

Long-term monitoring is important to understand the state of cetaceans, and to identify any changes within a population. Equally, research focussed on threats and their impact is important, which can be gathered through targeted projects and provide an insight into how cetaceans are impacted. Changes in policy have been proven effective for the conservation of at-risk cetacean populations; however research findings need to be implemented into mitigation measures by policymakers. Ultimately, researchers and stakeholders in the marine environment must be included in discussions for appropriate management to be practical and effective.

Common dolphin - Shenaz Khimji

Humpback whale

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APPENDIX

Fixed Line Transect Mediterranean monitoring Network - marine species and threats (FLT Med Net)

Scientific partner: ISPRA, CIMA Research Foundation, EcoOcean Institut, Accademia del Leviatano onlus, Gaia Research Institute , Ketos , ATUTAX, Capo Carbonara MPA, University of Pisa, University of Turin, University of Milano, University of Barcelona, University of Palermo, University of Cadiz, CNR-ISMAR, Anton Dohrn.

Ferry companies: Corsica Sardinia Ferry; Grimaldi Lines; Tirrenia CIN; Minoan; CTN

The following research Peer reviewed publications have been recently produced with the FLT Med Network dataset:

Peer reviewed publications recently produced with the FLT Med Network dataset:

Presence and distribution

Pace, D. Mussi, B. Airoldi, S. Alessi, J. Arcangeli, A. Atzori, F. Azzolin, M. Campana, I. Celona, A. Fiori, C. Giacoma, C. Gnone, G. Luperini, C. Mangano, R. Miragliuolo, A. Moulins, A. Nuti, S. Pellegrino, G. Rosso, M. Salvioli, F. Tepsich, P. Tringali, M. (2018). New insights on the presence and distribution of the endangered short-beaked common dolphin *Delphinus delphis* in italian waters. *Biologia Marina Mediterranea.* **22** (1). 262 – 263.

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Mark Carwardine
Marine wildlife expert, photographer and ORCA patron

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