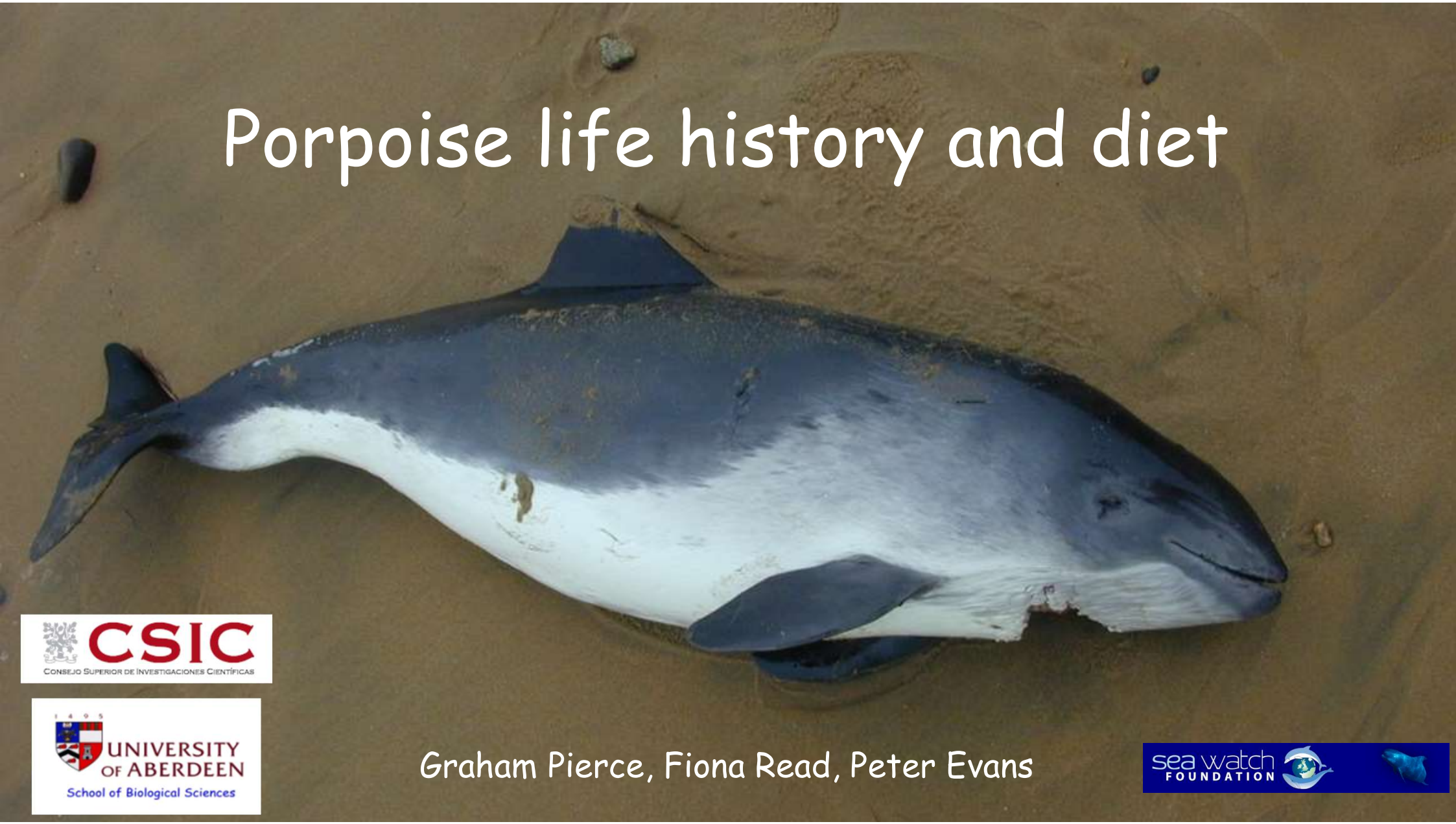
Porpoise life history and diet



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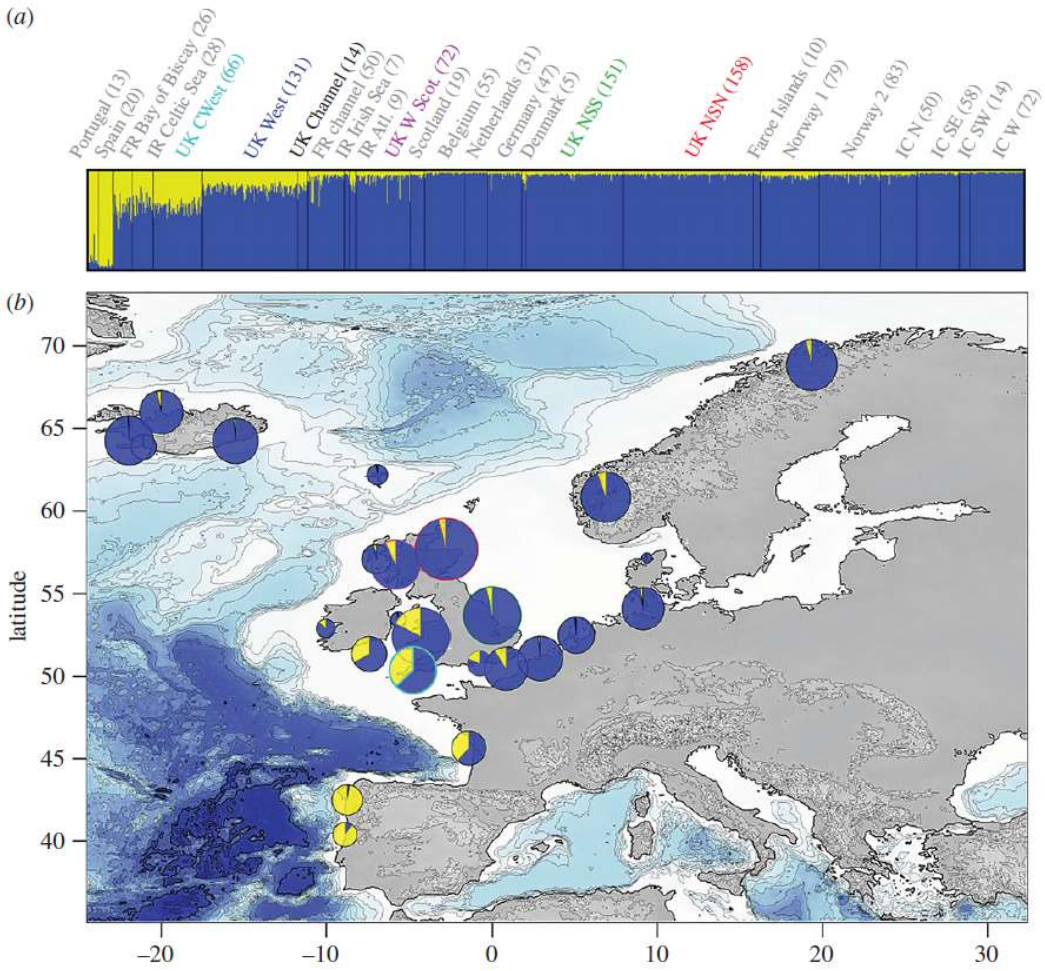
CSIC
Consejo Superior de Investigaciones Científicas

University of Aberdeen
School of Biological Sciences

sea watch FOUNDATION

Porpoise life history + diet



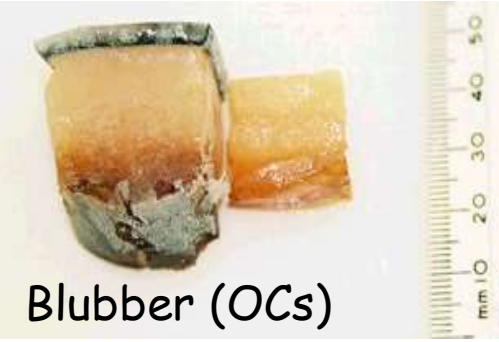
Fontaine et al. (2017), rsos.royalsocietypublishing.org *R. Soc. open sci.* **4**: 160992.

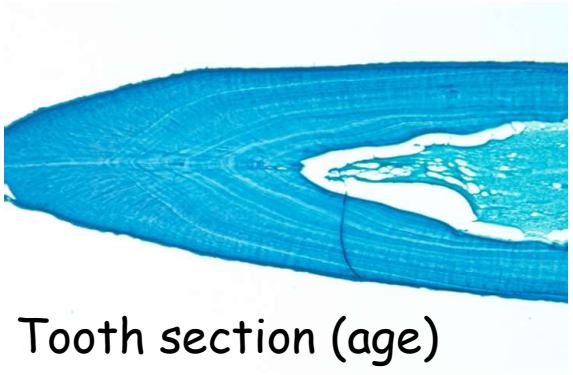
Variation in life history (and diet) may relate to:

- Genetic population structure (e.g. Fontaine et al., 2017)
- Latitudinal temperature variation (in relation to thermal limits, seasonality of resources)
- Distribution and abundance of food resources (e.g. adaptation to feed on particular prey species)
- Distribution of threats: fishery bycatch, pollutants, bottlenose dolphin attacks (e.g. selection for smaller size, earlier breeding)
- Individual characteristics

Life history

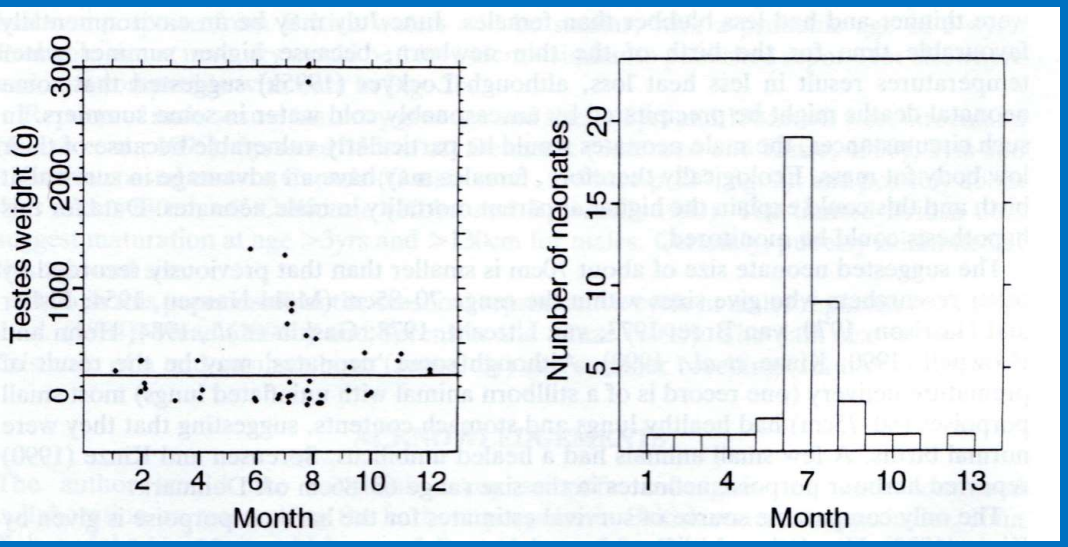
Common dolphin in the lab at IIM CSIC, Vigo Galica, c. 2001





Mating and birth seasons

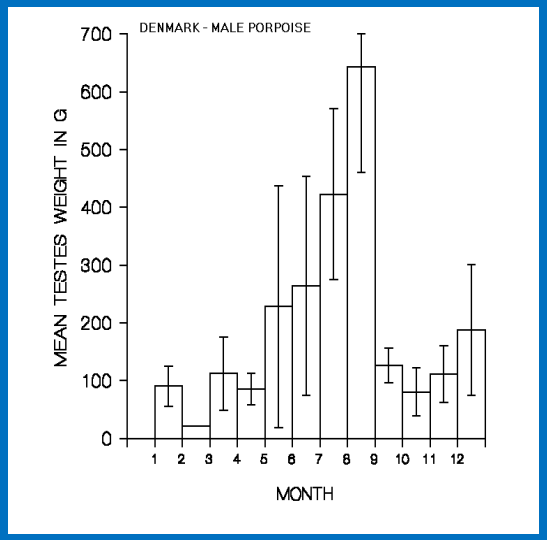
UK

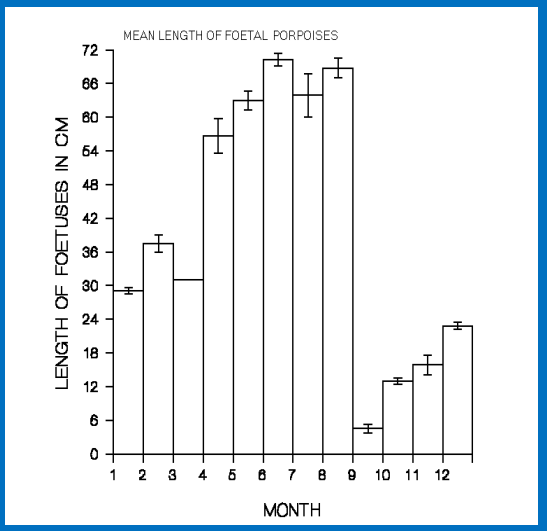


Male testis weight Number of neonates

(from Lockyer, 1995)

Denmark





Male testis weight Foetal length

(from Lockyer & Kinze, 2003)

Life cycle (Scotland 1992-2003)

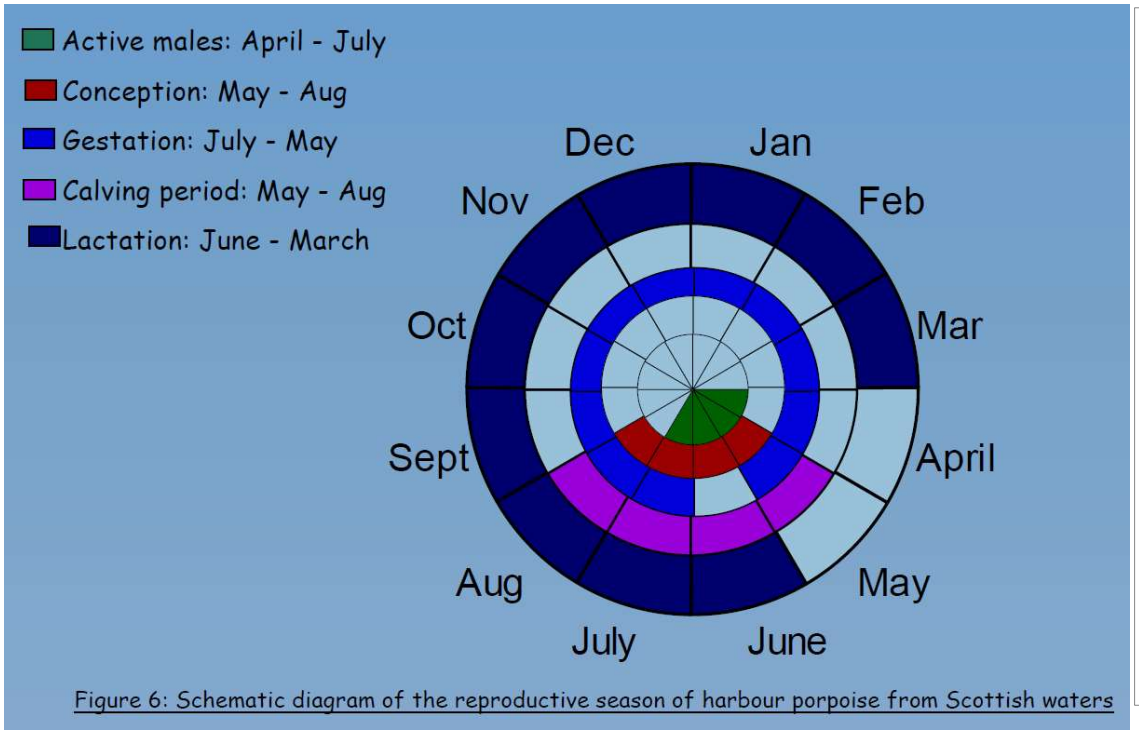
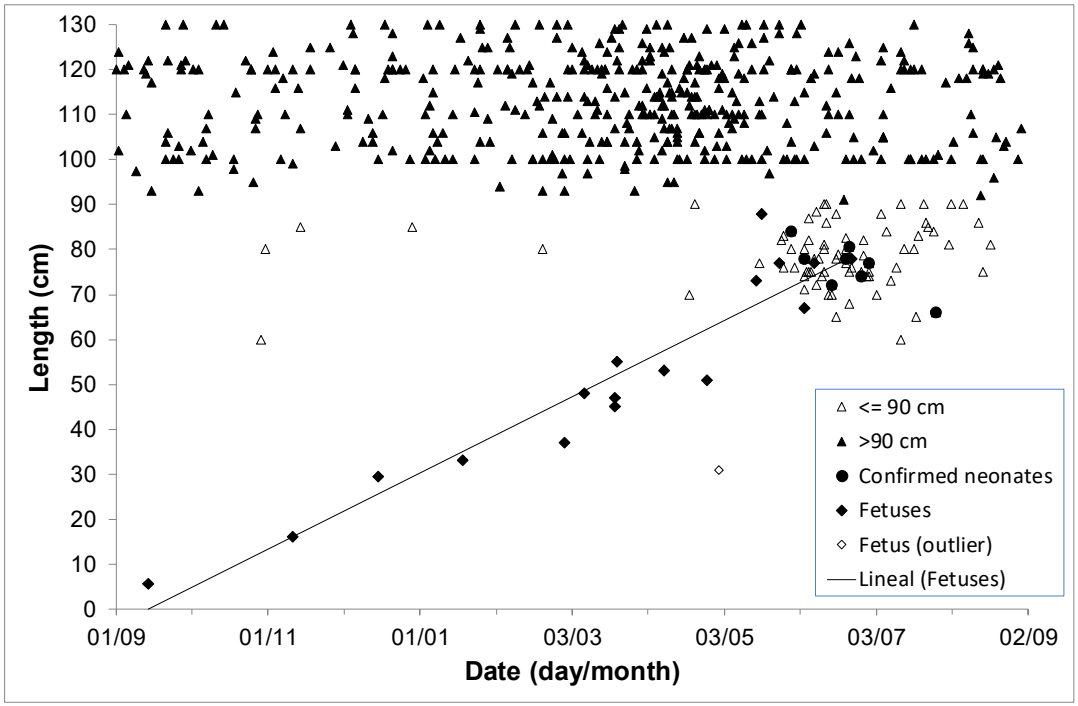


Figure 6: Schematic diagram of the reproductive season of harbour porpoise from Scottish waters

Learmonth et al. (2005) (ECS)

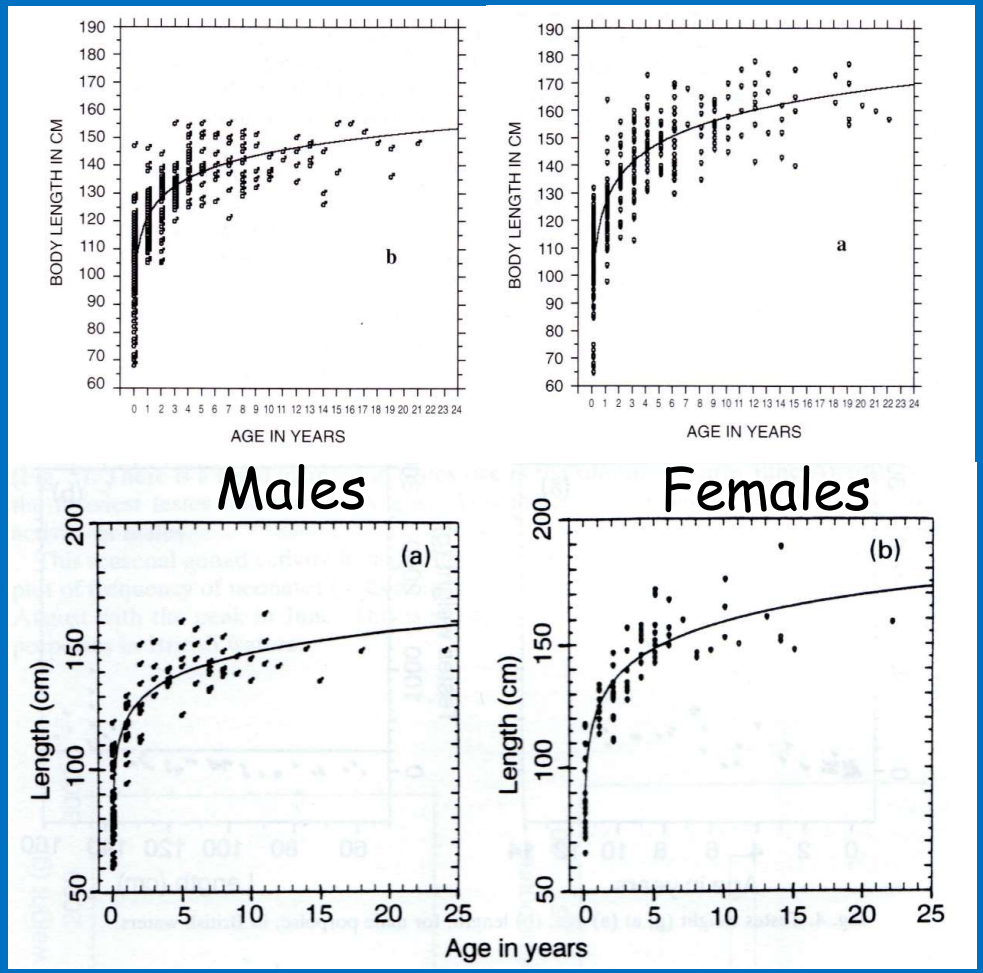


Learmonth et al. (2014), MMS

In general: Gestation Period: 10-11 months
Lactation Period: 4-10 months
Calving Interval: 1-2 years

Growth: length v age

Denmark



UK

Lockyer (1995), Lockyer & Kinze (2003)

Newborn calf:
65-85 cm

Mean adult lengths:
160 cm (female)
145 cm (male)

Max. adult lengths:
189 cm (female)
163 cm (male)

Length at age is *very* variable

Area	Maximum length (cm)	Maximum age (years)	Length at sexual maturity (cm)	Age at sexual maturity (years)	Length at physical maturity (cm)	Age at physical maturity (years)	Pregnancy rate (presence of foetus)	Females (Read, 2016)
NWIP	202 (n = 127)	18 (n = 71)	161-202 (n = 60)	5.5 (n = 60)	185 (n = 60)	10 (n = 60)	0.54 (n = 13)	Read et al. (2012)
Galicia, NW Spain	202 (n = 38)	9	166 (n = 35)	3	n/a	n/a	n/a	Lopez (2003)
Portugal (1981-1994)	208 (n = 22)	n/a	n/a	n/a	n/a	n/a	n/a	Sequeira (1996)
Scotland (1992-2004)	173 (n = 227)	20 (n = 132)	119-148 (n = 111)	4.6 (2-5) (n = 111)	164 (157-171)	~5	0.42 (n = 33)	Learmonth et al. (2014)
UK (1985-1994)	189 (n = 96)	22 (n = 96)	n/a	n/a	160	n/a	n/a	Lockyer (1995; 2003)
Ireland (2001-2003)	175 (N=27)	11 (N=21)	n/a	n/a	n/a	n/a	n/a	Pierce et al. (2004)
Denmark (1938-1998)	189	23	136-151 (n = 59)	3.6 (2-5) (n = 59)	160	n/a	n/a	Lockyer & Kinze (2003)
The Netherlands	160 (N=19)	12 (N=14)	n/a	n/a	n/a	n/a	n/a	Pierce et al. (2004)
France (2001-2003)	192 (N=14)	24 (N=9)	n/a	n/a	n/a	n/a	n/a	Pierce et al. (2004)
West Greenland (1988-1989, 1995)	166 (n = 85)	14 (n = 85)	138-142 (n = 85)	3.6 (n = 84)	154 ± 2.6	n/a	n/a	Lockyer et al. (2003)
Iceland (1991-1997)	189 (n = 96)	22 (n = 96)	n/a	n/a	160	n/a	n/a	Ólafsdóttir et al. (2003)
Gulf of Maine (1989-93)	168	17*	n/a	3.4 (2-4) (n = 99)	158 ± 1.56	~7	0.93 (n = 14)	Read & Hohn (1995)

Area	Maximum length (cm)	Maximum age (years)	Length at sexual maturity (cm)	Age at sexual maturity (years)	Length at physical maturity (cm)	Age at physical maturity (years)	Males (Read, 2016)
NWIP	189 (N=136)	19 (N=77)	154-171 (N=47)	3.8 (N=47)	162 (N=47)	10 (N=47)	Read et al. (2012)
Galicia, NW Spain	176 (N=27)	9	155	5	n/a	n/a	Lens (1997), Lopez (2003)
Portugal (1981-1994)	175 (N=15)	n/a	n/a	n/a	n/a	n/a	Sequeira (1996)
Scotland (1992-2004)	170 (N=252)	20 (N=138)	116-144 (N=64)	5.7 (3-6) (N=64)	151 (147-155)	~5	Learmonth et al. (2014)
UK (1985-1994)	163 (N=114)	24 (N=114)	>130 (N=114)	>3 (N=114)	145	n/a	Lockyer (1995; 2003)
Ireland (2001-2003)	157 (N=19)	n/a	n/a	n/a	7.5 (N=14)	n/a	Pierce et al. (2004)
Denmark (1938-1998)	167	23	130-135.5 (N=96)	2.93 (2-3) (N=96)	145	n/a	Lockyer & Kinze (2003)
The Netherlands	147 (N=5)	12.5 (N=2)	n/a	n/a	n/a	n/a	Pierce et al. (2004)
France (2001-2003)	165 (N=17)	14 (N=12)	n/a	n/a	n/a	n/a	Pierce et al. (2004)
West Greenland (1988-1989, 1995)	158 (N=91)	17 (N=91)	127 (123-130)(N=91)	2.45 (N=94)	142 ± 1.7	n/a	Lockyer et al. (2003)
Iceland (1991-1997)	165 (N=794)	16 (N=615)	~135 (N=526)	~1.9-2.9 (2-5) (N=526)	150	n/a	Ólafsdóttir et al. (2003)
Gulf of Maine (1989-93)	157	15*	n/a	>3 (3-4) (N=31)	143 ± 1.25	~5*	Read & Hohn (1995)

Life history regional summary

- Females reach a larger maximum size than males
- Iberian animals tend to be larger
- Iberian animals tend to mature at larger size
- Maximum age = 24 (Lockyer, UK)… are lower values in some more recent studies due to small sample size?
- Age at maturity estimates may depend on methodology and sample size (how many 2-6 year olds in the sample)
- Pregnancy rates in stranded animals are biased downwards by inclusion of sick animals (max = 0.93, Gulf of Maine)

Improving estimates of pregnancy rate

	Number Mature	Number Pregnant	Pregnancy rate (%)	ASM (Yrs)
All UK data	127	37	29	4.73
All data minus conception period	76	26	34	
COD infectious disease	68	15	22	4.63
COD infectious disease minus conception period	30	13	26.5	
COD trauma	42	13	31	4.92
COD trauma minus conception period	20	10	50	

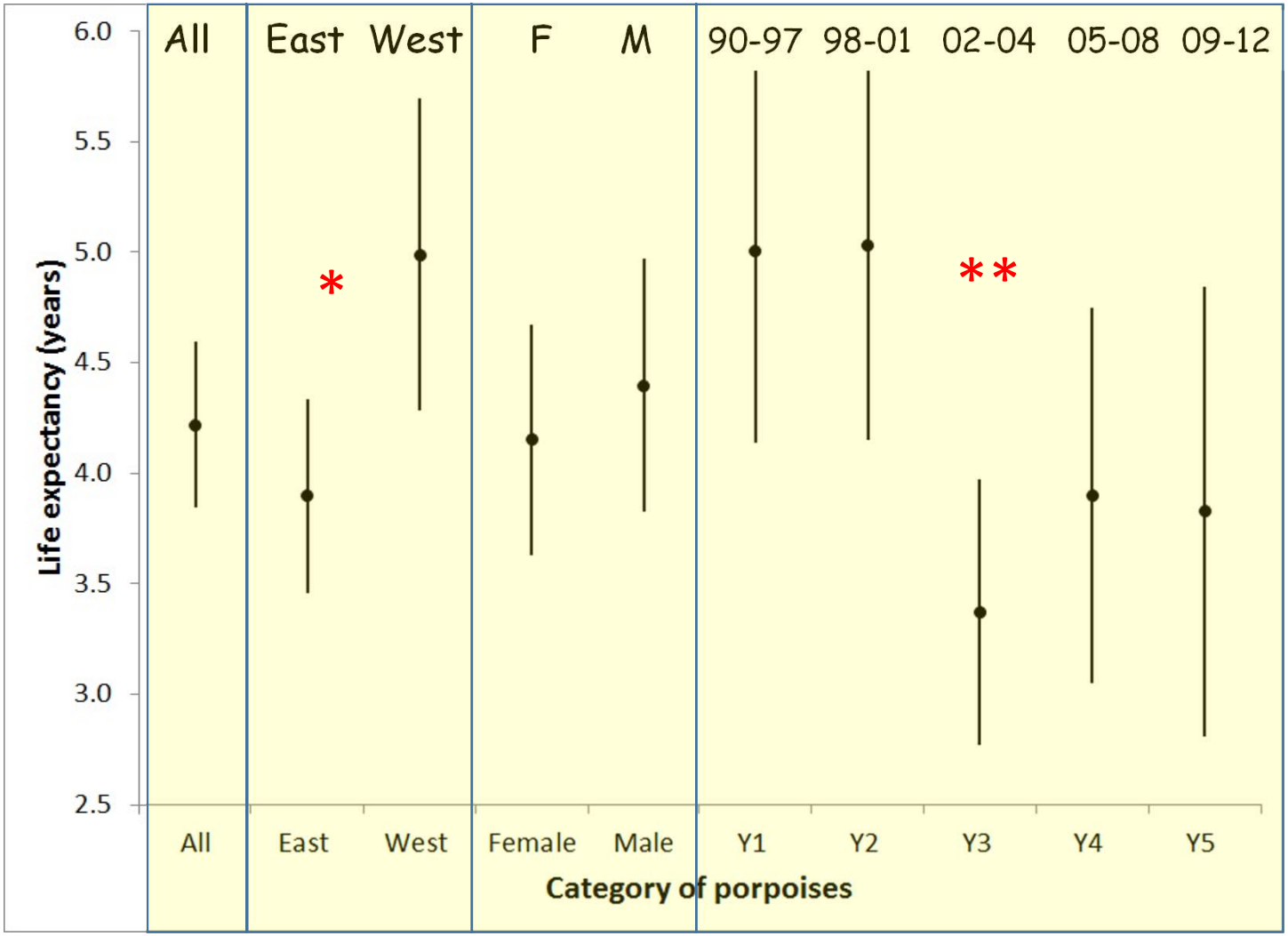
Murphy et al. (2015)

Improving estimates of pregnancy rate

Country/ Region	Sampling period	Pregnancy rate	ASM Yrs	Reference
UK (All stranded + by-caught porpoises)	1990-2012	34% (n=76)	4.73 (n=250)	Murphy et al. (2015)
UK (Trauma sample)	1990-2012	50% (n=20)	4.92 (n=112)	Murphy et al. (2015)
Denmark	1985-1991	73% (n=33)		Sorensen & Kinze (1994)
Iceland	1991-1997	98% (n=74)	3.2 (n=269)	Olafsdottir et al. (2003)
Gulf of Maine, Bay of Fundy, NW Atlantic	1989-1993	93% (n=14)	3.27 (n=11)	Read & Hohn (1995)

Murphy et al. (2015)

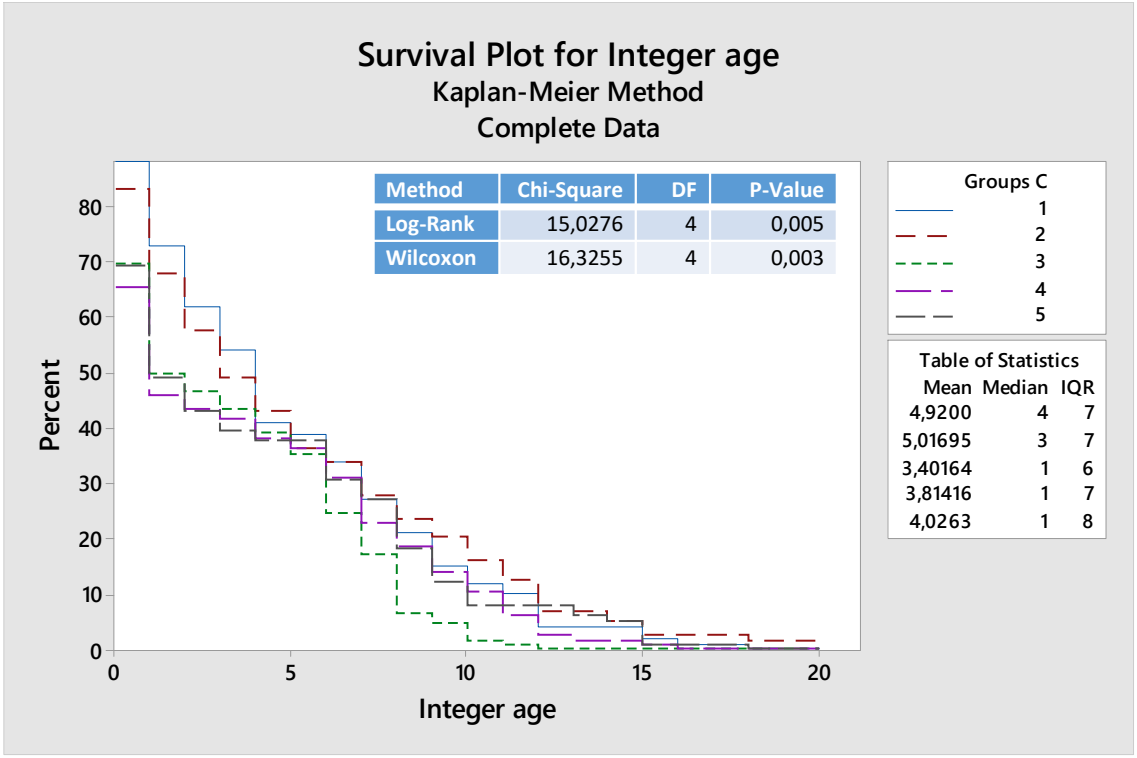
Life expectancy, Scotland (Kaplan-Meier non-parametric distribution analysis)



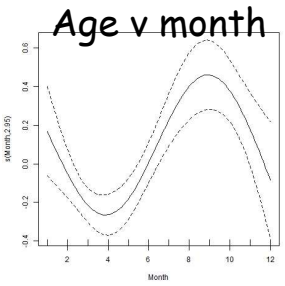
Pierce et al. (2015), ECS

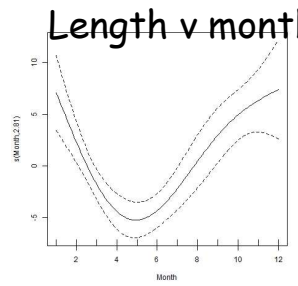
Mortality trends from strandings

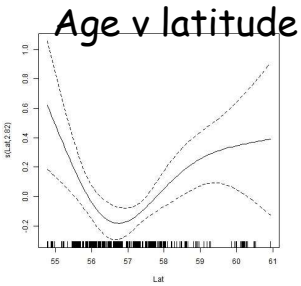
Scotland
569 ages, divided into 5 time-periods:
1990-1997
1998-2001
2002-2004
2005-2009
2010-2017

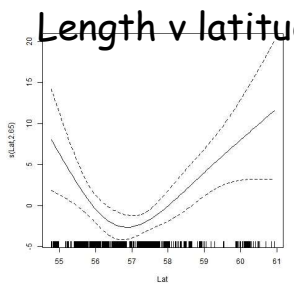


- Are the age data biased?
- They show similar trends to those in length data



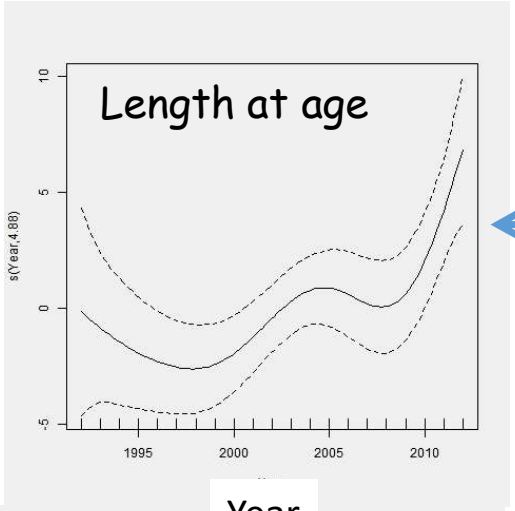


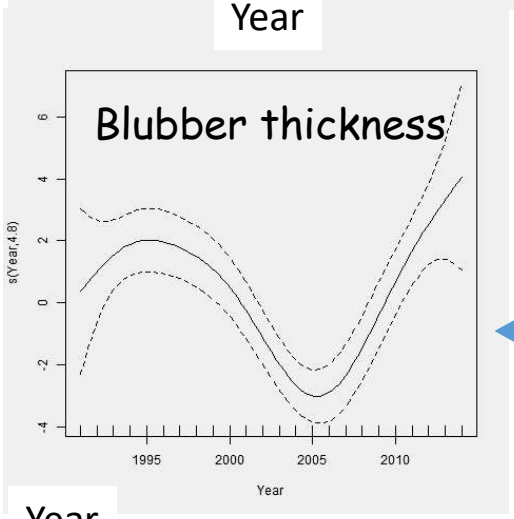




Survival in Scottish porpoises was lowest during 2002-04… and is still lower than in the late 1990s

Trends in life history parameters



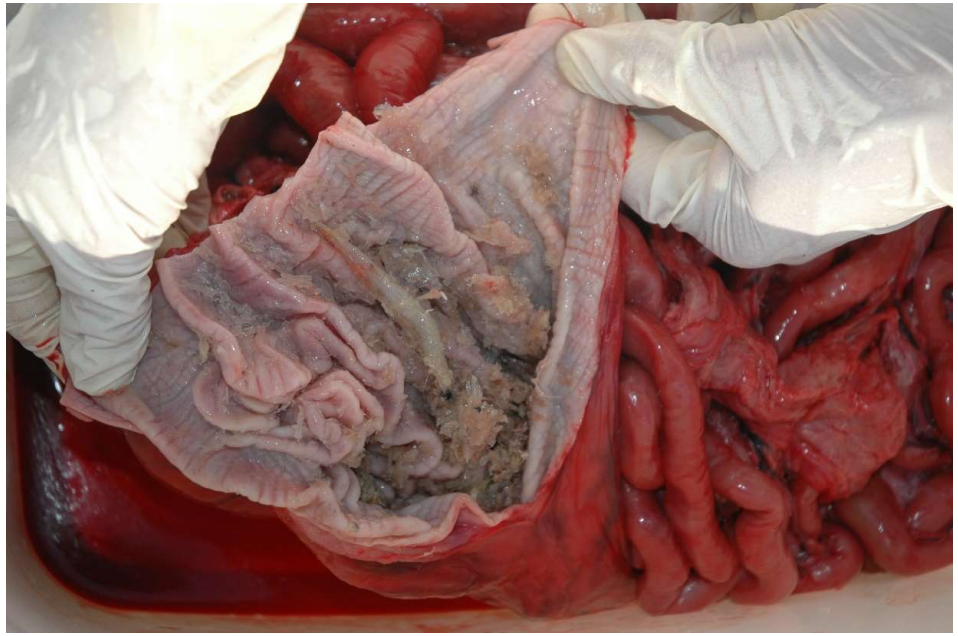


- Growth rate is related to sex, latitude and year: length-at-age has increased in the last few years
- Weight at length relates to month, latitude and longitude
- Age at maturity shows no spatial or temporal variation
- Blubber thickness is related to sex, length, month and year: it fell from 1995-2005, then increased.

Pierce et al. (2015), ECS

Diet

"Harbour porpoises eat approximately ten percent of their body weight in fish per day. Their diet mainly comprises gobies, whiting, sand lances, herring and sprats. These mammals are in constant danger of starvation. Other major causes of death include drowning after becoming entangled in fishing nets on the seabed, and being hunted and eaten by grey seals. These findings are from research carried out by Mardik Leopold from IMARES Wageningen UR."



https://phys.org/news/2015-11-harbour-porpoises-large-oily-fish.html#jCp

What is the value of dietary data?

- Insight into foraging behaviour: functional responses, opportunist/specialist, preferences (e.g. fatty fish)
- Insights into predator (+ prey) distribution + habitat
- Insights into stock identity
- Identify and quantify trophic links in food webs, ecosystem models
- Insight into interactions with fisheries (e.g. bycatch) and other predators (e.g. grey seals, bottlenose dolphins)
- Identify threats to status (e.g. dependence on certain prey)
- Sentinel role (e.g. detect fish stock depletion)

Diet

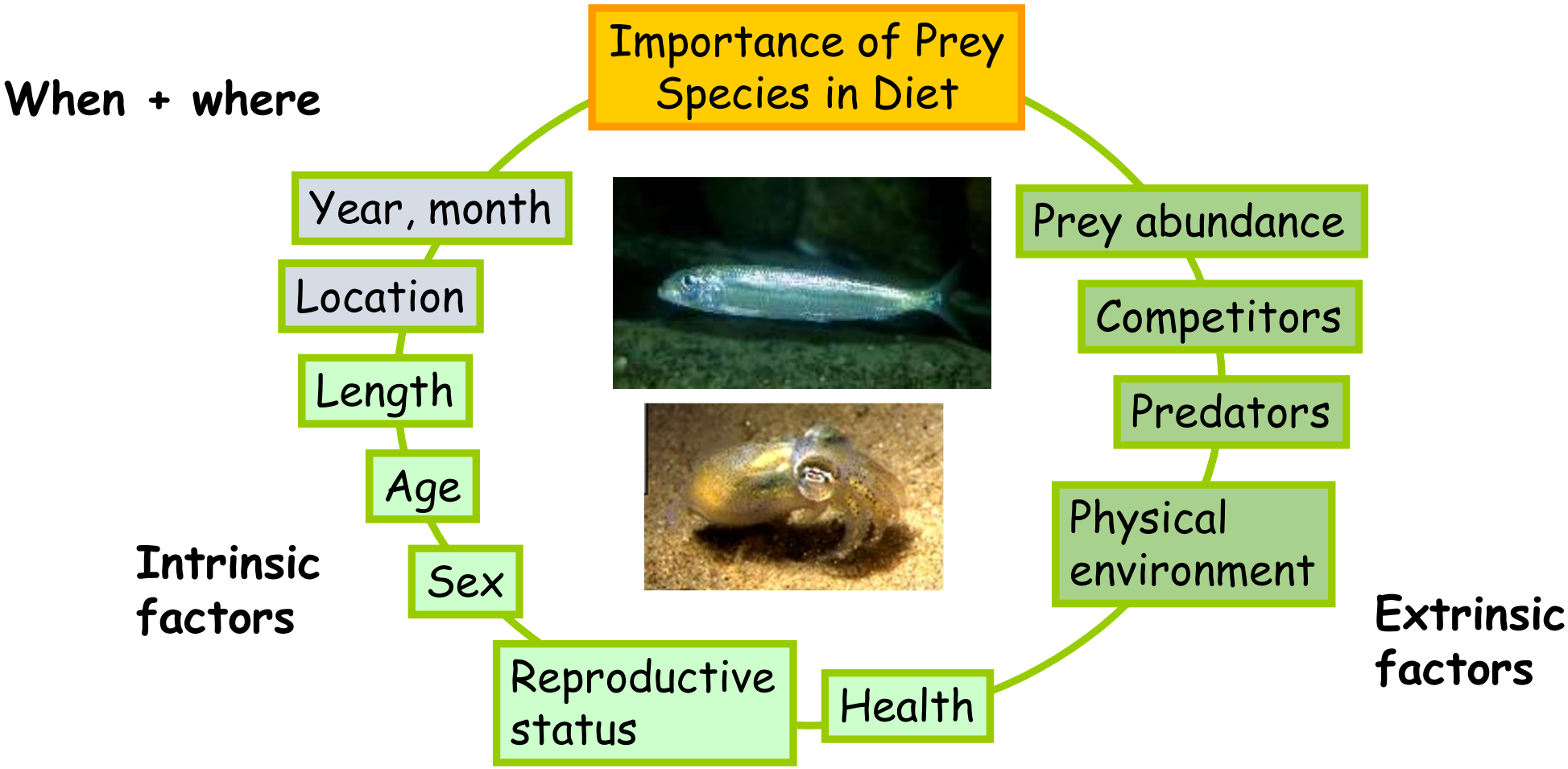
Why diet matters to a porpoise

- Porpoises need to feed "near continuously" (high metabolic rate) – starvation risk
- Poor nutritional quality of food can lead to health problems in seals and dolphins
- Prey depletion
- Exposure to bycatch mortality
- Exposure to predators
- Contaminant bioaccumulation
- Parasite transfer
- Ingestion of plastics

Methodological considerations

- Stomach or whole digestive tract
- Hard parts/whole prey or molecular ID
- Otoliths or all hard parts
- All otoliths or undigested otoliths
- Uncorrected or corrected otolith sizes
- Correction for residence time
- Weighted or unweighted averages
- Long-term diet: stable isotopes and fatty acids; use of recording structures

Dietary variability



Dutch porpoise diet and foraging behaviour

Dutch porpoise diet: summary, variation and relationship with North Sea fish abundance

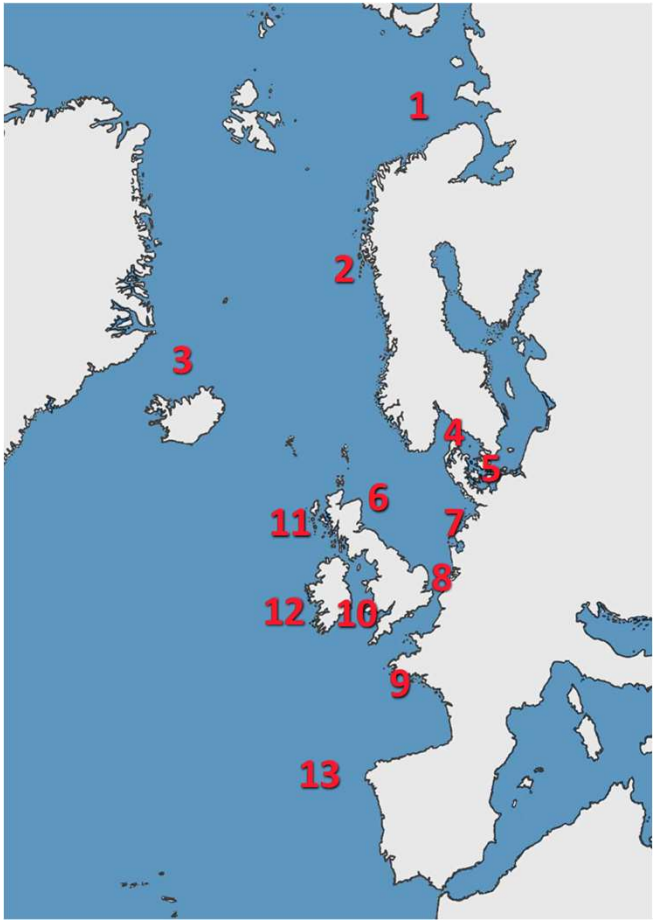
Main prey categories	% Freq Occur.	Mean %N	Length effect	Year effect	Month effect
Sandeels	41.9	15.3	+ ***	**	Sp ***
Gobiidae	66.3	49.3	- ***	+ ***	W>S ***
All Gadids	36.8	14.7	+ ***	***	
Whiting	30.5	10.8	+ ***	**	
Trisopterus	8.6	1.2	+ ***		W>S *
All Clupeids	29.7	7.6		***	W>S ***
Herring	21.9	2.5		+ ***	W>S ***
Sepiolidae	7.4	2.3		***	W>S **

	Sandeel in diet	Gobies in diet	Gadidae in diet	Whiting in diet	Clupeids in diet	Herring in diet	Sepiolids in diet
Sandeel stock	ns	ns	Positive ***	Positive **	Negative **	Negative *	Positive **
Whiting stock	Negative ***	Negative ***	Positive ***	Positive ***	Negative ***	Negative ***	Positive **
Nor. pout stock	Positive *	ns	ns	ns	ns	ns	ns
Herring stock	ns	Positive *	Negative **	ns	Positive ***	Positive ***	Negative ***

Results suggest herring *and* whiting are "preferred" prey + generally opportunistic predation

Pierce et al (2016) ECS; data 1986-2013 from Mardik Leopold, Okka Bangma, Begoña Santos

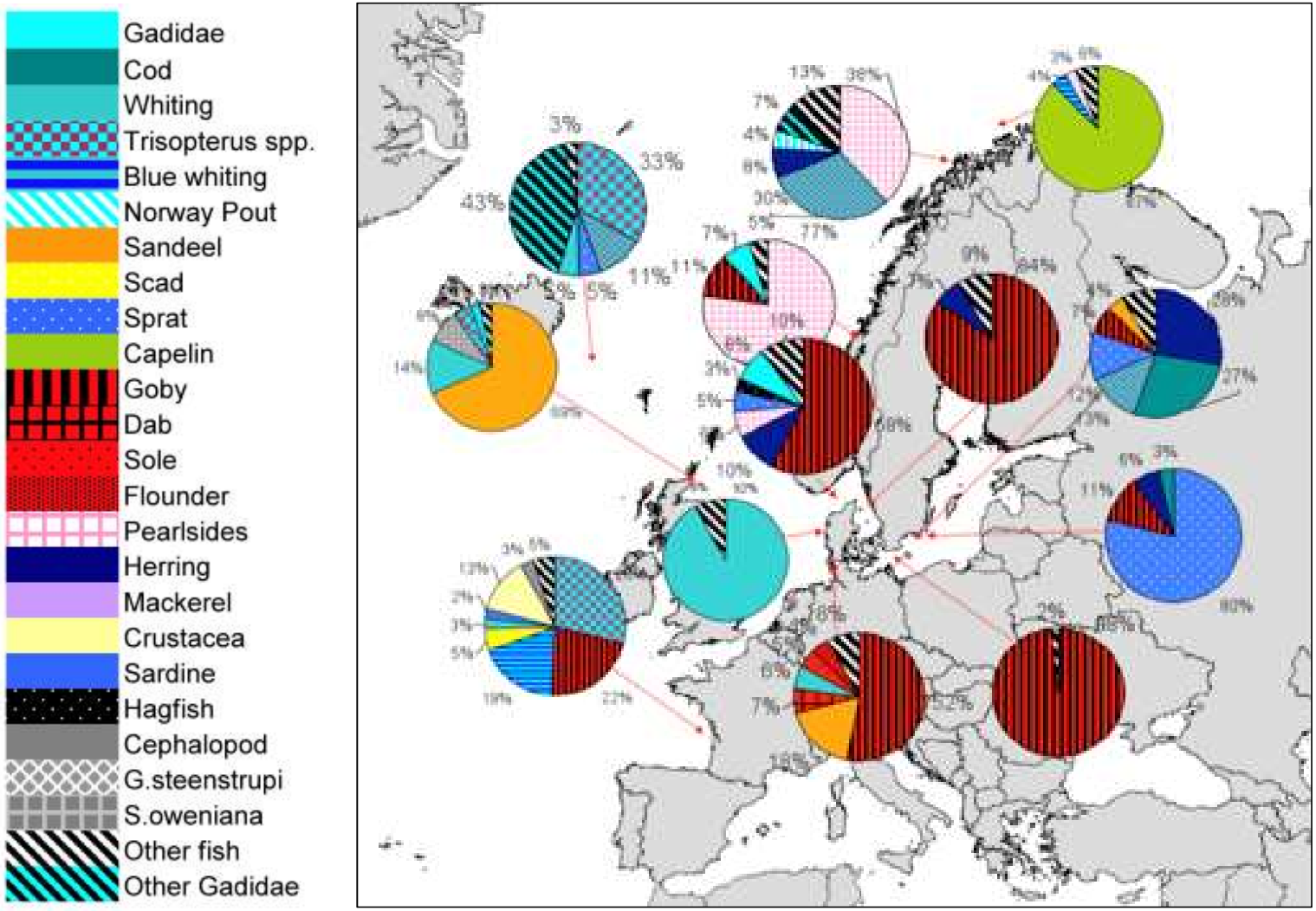
Geographic Variation in Harbour Porpoise Diet



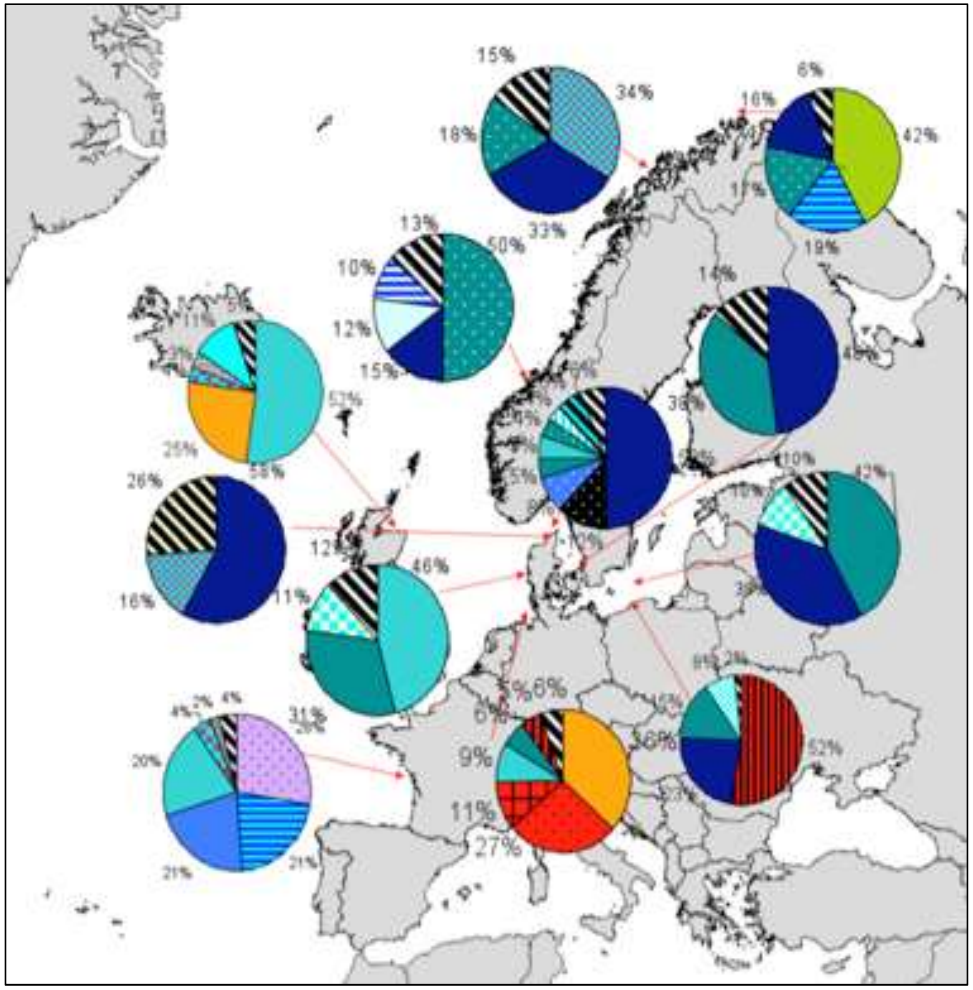
	Principal Species
1	Capelin, herring
2	Herring, gadoids
3	Capelin, Atlantic cod, sandeels
4	Herring, cod, whiting
5	Cod, herring, whiting, gobies, hagfish, *Trisopterus*, saithe
6	Sandeels, whiting, *Trisopterus*
7	Sole, cod, sandeels
8	Whiting, sandeels, sprat, herring, gobies, smelts
9	Blue whiting, scad, hake, sardine
10	Sprat, whiting
11	Sprat, whiting
12	Whiting, herring, *Trisopterus*
13	*Trisopterus*, Blue whiting, scad, silvery pout, gobies, sandeels

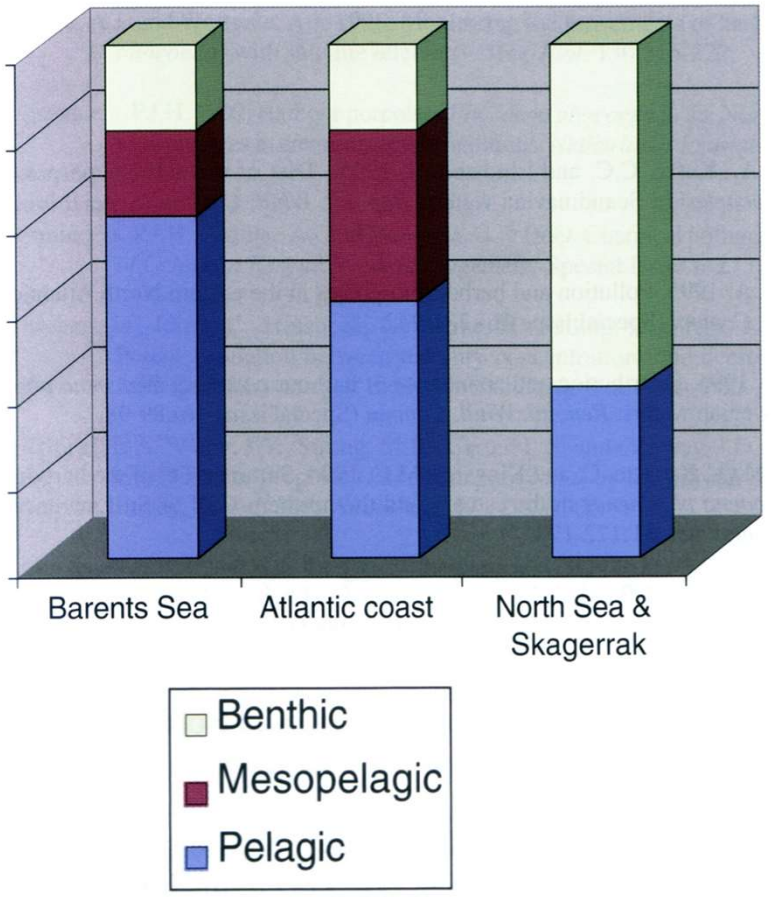
(Desportes, 1985; Lick, 1991; Aarefjord et al., 1995; Benke & Siebert, 1996; Rogan & Berrow, 1996; Martin, 1996; Berggren, 1996; Santos, 1998; Borjesson et al. 2003; Santos & Pierce, 2003; Santos et al. 2004, Spitz et al. 2006; Read et al. 2012; Sveegard et al. 2012; Koponen, 2013; Schelling et al., 2014; Leopold et al., 2015; Ross et al., 2016; Andreasen et al., 2017; Mafouz et al. 2017)

HARBOUR PORPOISE DIET IN NW EUROPE (BY NUMBER)



HARBOUR PORPOISE DIET IN NW EUROPE (BY WEIGHT) + FORAGING HABITAT





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"Knowledge of its basic ecology is essential for developing successful management plans to protect and conserve this species."

From: "Identifying critical habitat of the endangered vaquita (*Phocoena sinus*) with regional $d^{13}C$ and $d^{15}N$ isoscapes of the Upper Gulf of California, Mexico", published July 2018