Mapping cetacean distributions in NW European Seas

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PRIFYSGOL BANGOR UNIVERSITY

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NERC SCIENCE OF THE ENVIRONMENT

defra

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Project and Knowledge Exchange Office hosted by Plymouth Marine Laboratory
Funded by the Natural Environment Research Council and the Department for Environment, Food and Rural Affairs

Marine Ecosystems Research Programme

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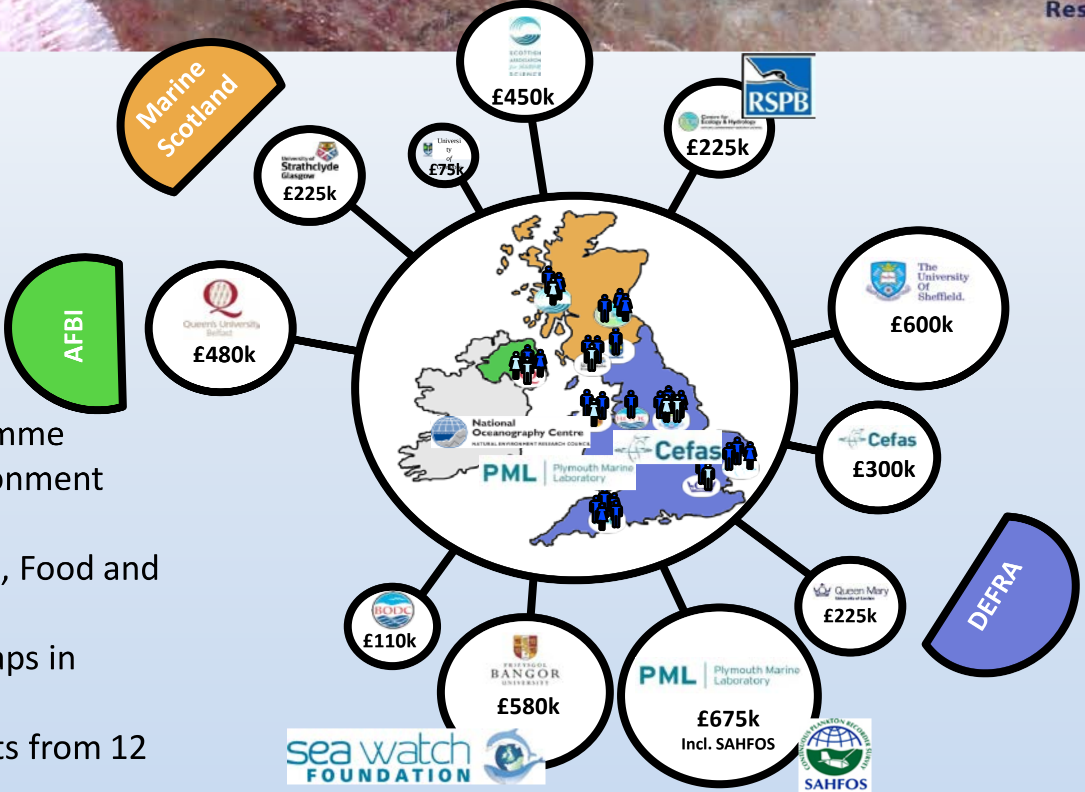

MERP Consortia

- £5m, 5 year research programme
- Funded by the Natural Environment Research Council (NERC) and Department for Environment, Food and Rural Affairs
- Addressing key knowledge gaps in marine ecosystem research
- Involving over 50 UK scientists from 12 research organisations
- Broad and appropriate range of skills

Summary of Work

- Collation of dedicated seabird & cetacean surveys across NW European seas
- Standardisation across surveys by estimating effective strip width and g(0)
- Ecologically informed habitat modelling using environmental variables believed to influence distributions
- Density surface maps with abundance estimates at 10 km & monthly resolution between 1985 and 2017

Thanks to the many organisations contributing data

Cyfoeth Naturiol Cymru
Natural Resources Wales

JNCC
Joint Nature Conservation Committee

marine scotland science
The Scottish Government

National Parks & Wildlife Service

Ifremer

DEPONS

SEAPOP

WWT

NINA
Norwegian Institute for Nature Research

SMRU

C.E.M.M.A.
Coordinadora para o estudio dos mamíferos mariños

Swansea University
Prifysgol Abertawe

spea

WDC
WHALE AND DOLPHIN CONSERVATION

IFAW
International Fund for Animal Welfare

HiDef
AERIAL SURVEYING LIMITED

UNIVERSITÉ
La Rochelle

STIFTUNG TIERÄRZTLICHE HOCHSCHULE HANNOVER

Swansea University
Prifysgol Abertawe

PRIFYSGOL BANGOR UNIVERSITY

CETACEAN RESEARCH & RESCUE UNIT

MWDW
Manx Whale and Dolphin Watch

THE wildlife TRUSTS

Cardigan Bay Marine Wildlife Centre
Canolfan Bywyd Gwyllt Morol Bae Ceredigion

SEO BirdLife

1495
UNIVERSITY OF ABERDEEN

ecomare

museum
Royal Belgian Institute of Natural Sciences

IWDG
www.iwdg.ie
The Irish Whale and Dolphin Group

MARINE life

ORCA
Looking out for Whales and Dolphins

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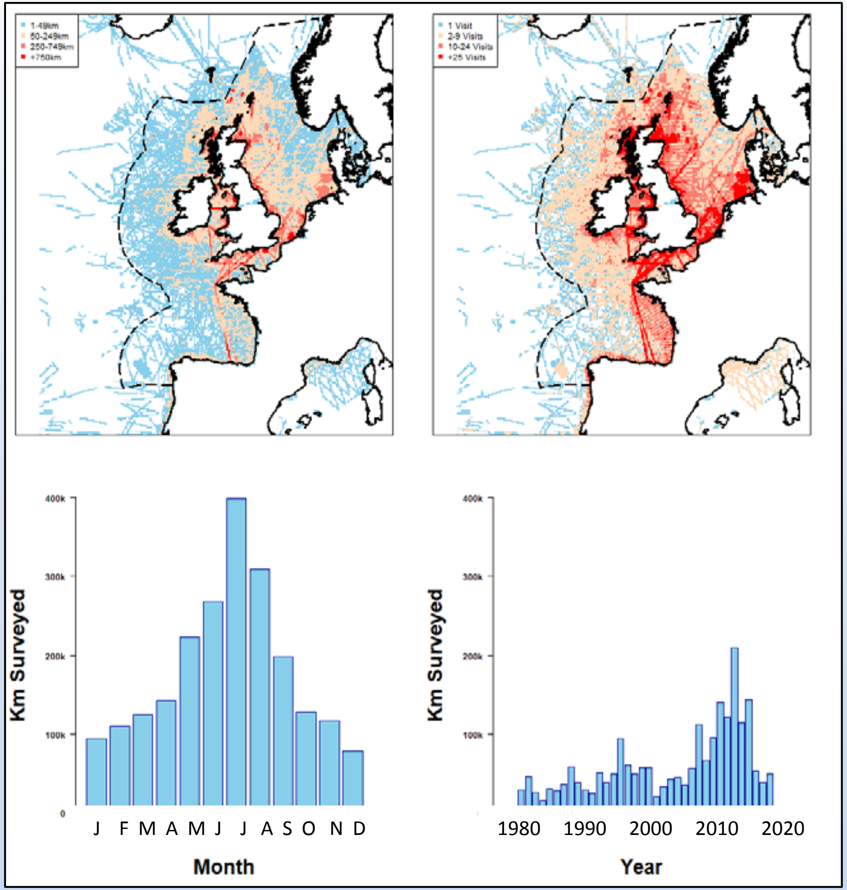
WAGENINGEN
UNIVERSITY & RESEARCH

Data Collation



- 40 main data sources from 11 countries
- 2.6 million km of surveys
- Aerial, digital & vessel effort-based data from 1979 to 2017
- Data used only where sufficient information on survey protocols existed plus variables affecting detection rates
- Cleaned & processed into single spreadsheet

Habitat Modelling: GLM-GEE in a hurdle-model framework

GLM

Linear or quadratic terms

Identify functional relationships

Avoid overfitting relationships

GEE

Survey source/month as the correlation structure

Spatial and temporal autocorrelation

Accounting further for differences among surveys

Hurdle-Model

Presence-absence and count model

Reduces problems with zero inflation and overdispersion

Use knowledge of scale- dependent associations

Standardisation

Summary of *esw* and g(0) calculations across explanatory variables.

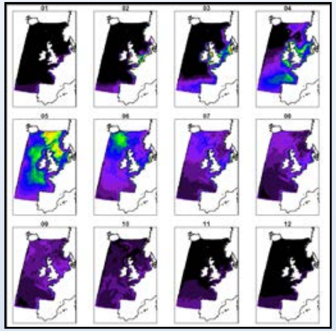
DOL= Bottlenose Dolphin, Common Dolphin, Striped Dolphin, White-Beaked Dolphin, Atlantic White-Sided Dolphin
GOB = Killer Whale, Long-finned Pilot Whale, Risso's Dolphin, **MIN=** Minke Whale, **POR =** Harbour Porpoise, **FIN =** Fin Whale

Group	Measure	LINE	STRIP	2.5m	5m	10m	20m	30m	Aircraft	SS0	SS1	SS2	SS3	SS4
DOL	*esw*	0.38	0.17	0.23	0.26	0.29	0.32	0.34	0.21	0.32	0.3	0.27	0.25	0.23
GOB	*esw*	0.54	0.21	0.4	0.4	0.4	0.4	0.4	0.24	0.44	0.41	0.37	0.34	0.31
MIN	*esw*	0.47	0.18	0.29	0.32	0.34	0.37	0.39	0.24	0.38	0.35	0.33	0.3	0.28
POR	*esw*	0.31	0.17	0.19	0.22	0.26	0.3	0.32	0.16	0.29	0.26	0.24	0.22	0.2
FIN	*esw*	0.73	0.21	0.51	0.51	0.51	0.51	0.51	0.28	0.47	0.47	0.47	0.47	0.47
DOL	g(0)	0.49	0.49	0.6	0.57	0.51	0.4	0.29	0.57	0.58	0.56	0.46	0.44	0.41
GOB	g(0)	0.4	0.4	0.27	0.29	0.33	0.43	0.53	0.57	0.5	0.47	0.38	0.35	0.33
MIN	g(0)	0.5	0.5	0.27	0.33	0.46	0.73	0.9	0.3	0.47	0.49	0.5	0.51	0.52
POR	g(0)	0.25	0.25	0.31	0.29	0.26	0.2	0.15	0.31	0.39	0.31	0.24	0.18	0.14
FIN	g(0)	0.28	0.28	0.17	0.19	0.23	0.32	0.44	0.3	0.28	0.28	0.28	0.27	0.27

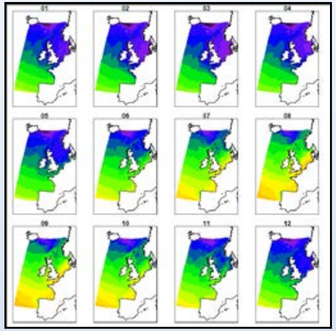
Incorporating Environmental Data

Coarse-scale processes likely to influence prey communities and abundances

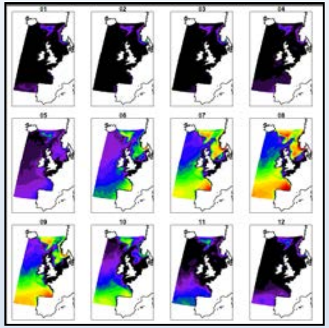
Primary Productivity



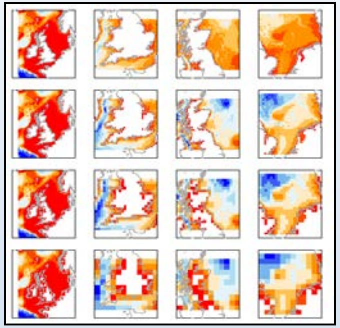
Sea Surface Temperature



Stratification



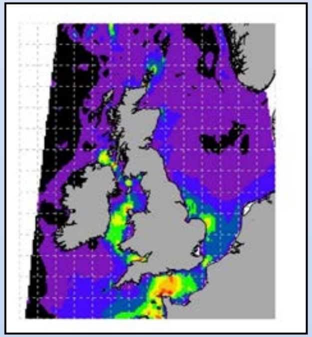
Depth



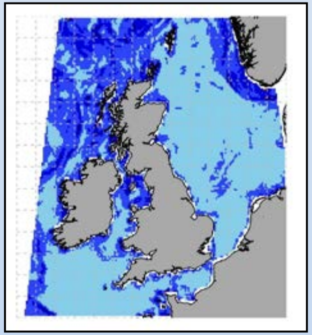
Finer-scale processes likely to influence prey availability

Tidal Fronts

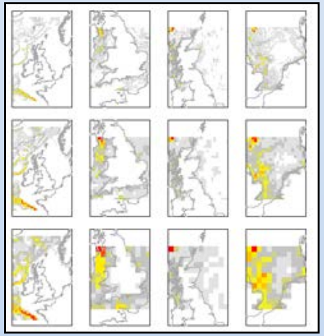
Current Speed



Eddy Potential

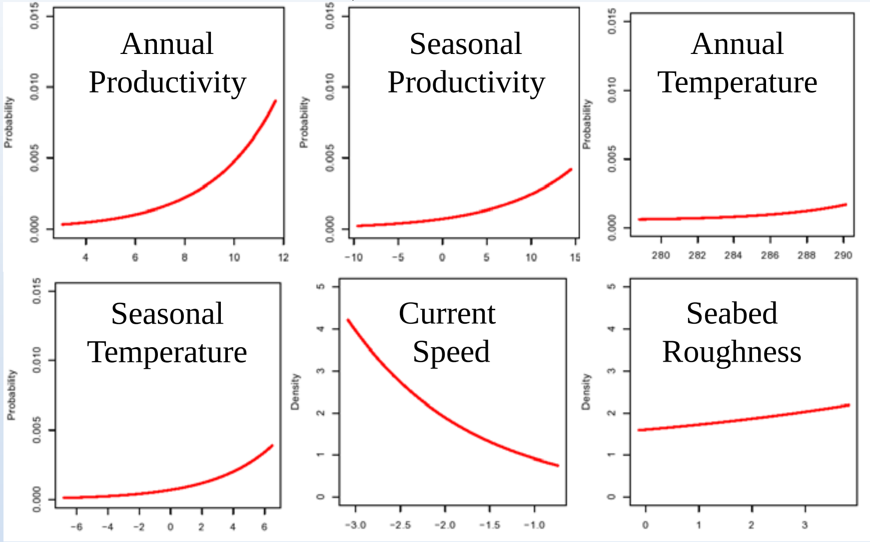


Seabed Roughness



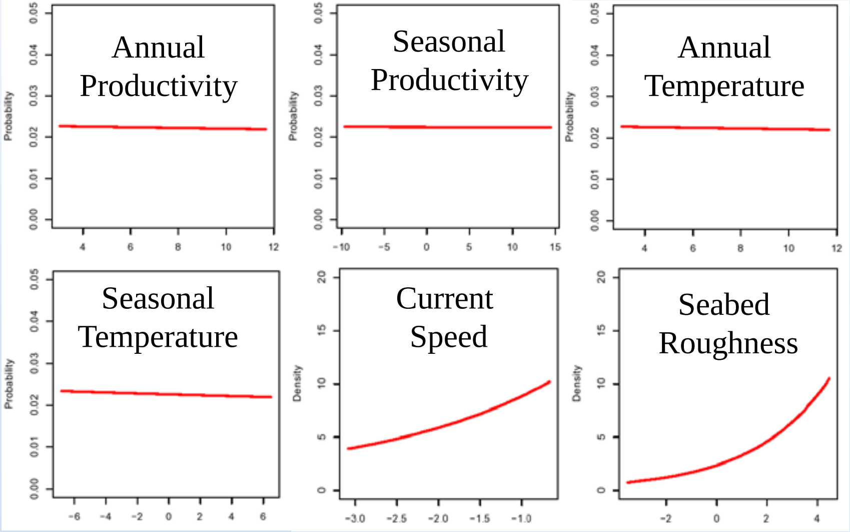
Functional Relationships – Bottlenose Dolphin

a) Coastal



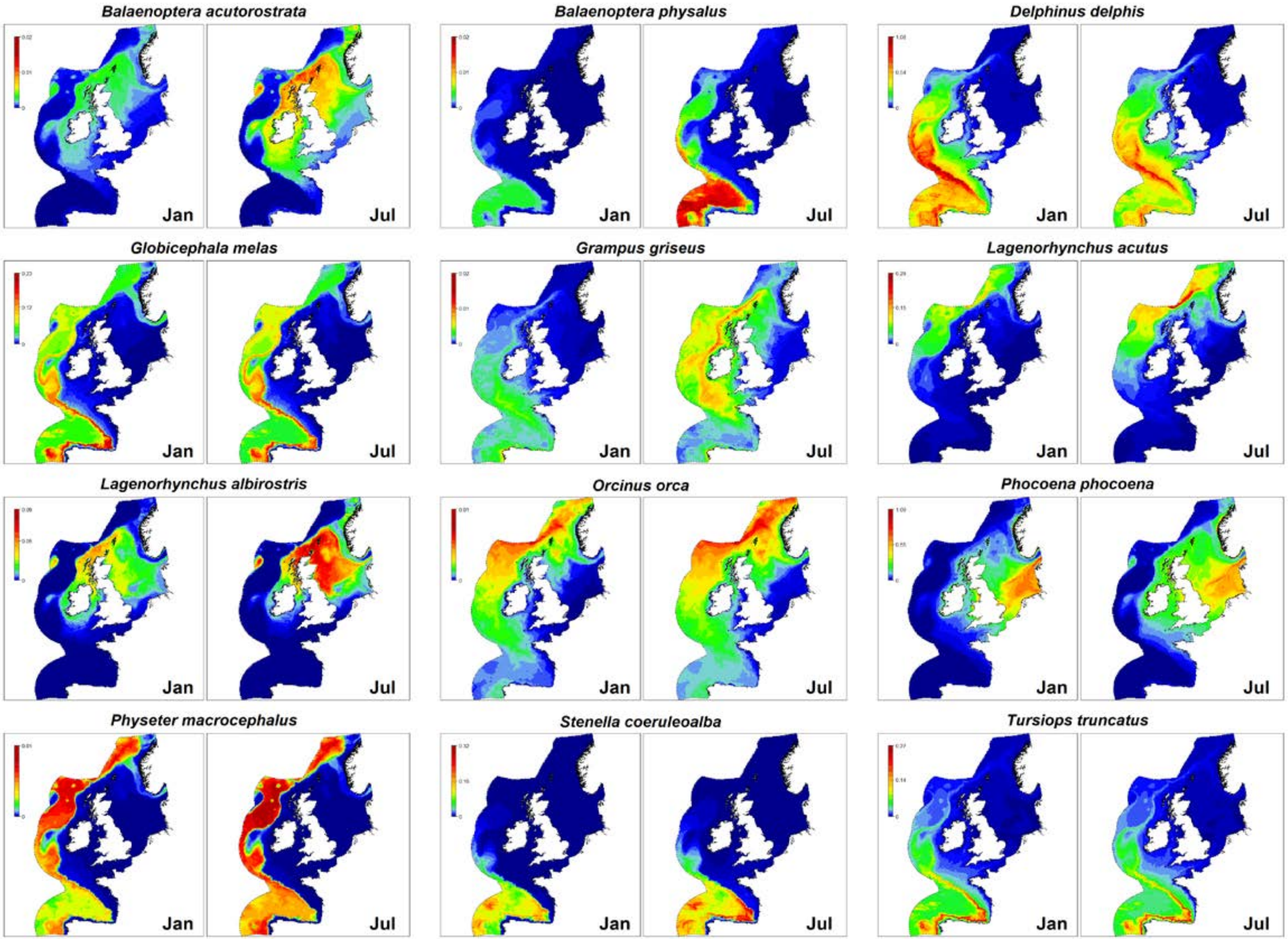
- Strong positive relationship with annual productivity
- Strong negative relationship with current speed

b) Offshore



- No relationship with productivity or temperature
- Strong positive relationship with current speed & seabed roughness

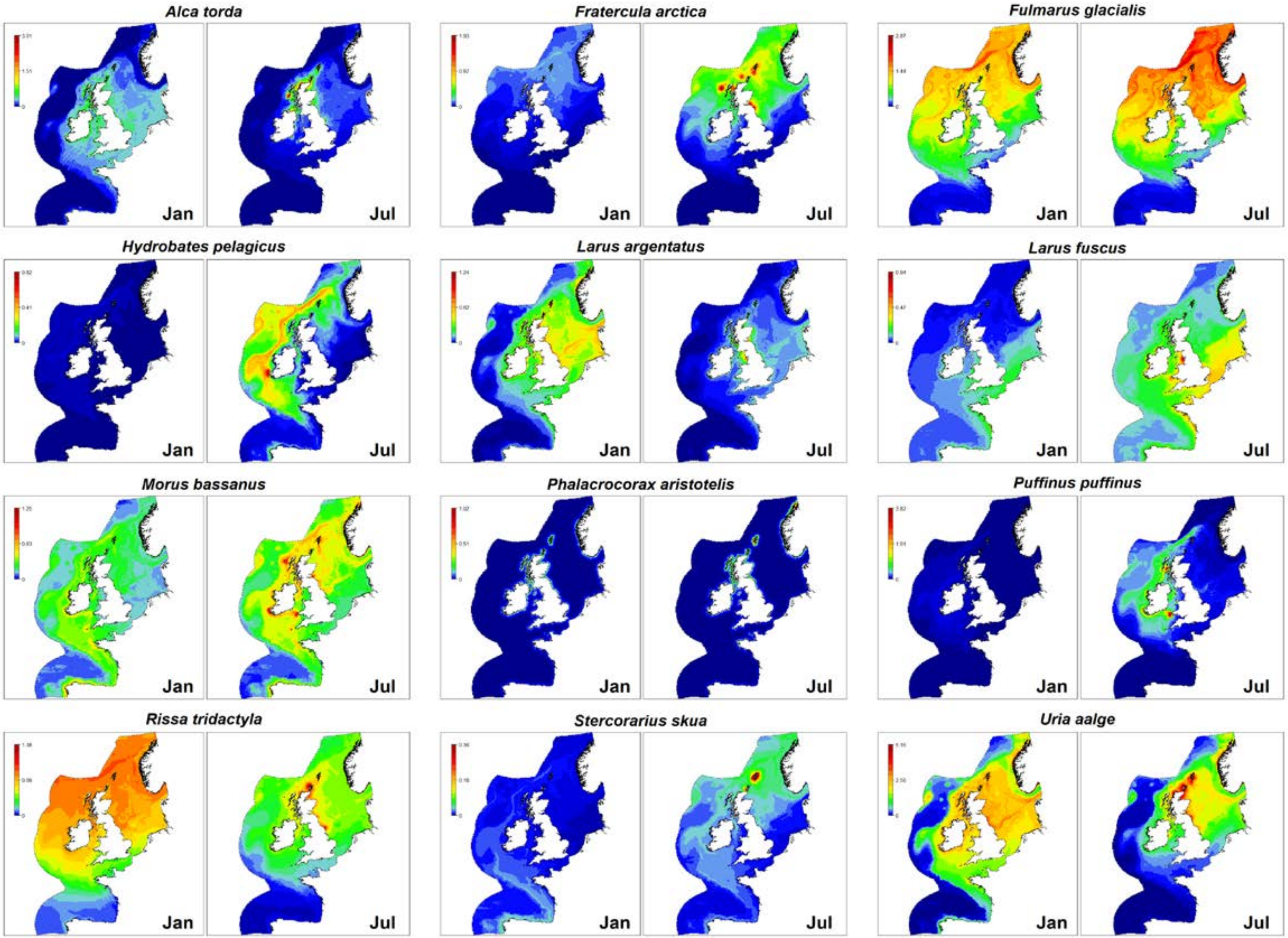
Spatial Patterns – Cetaceans



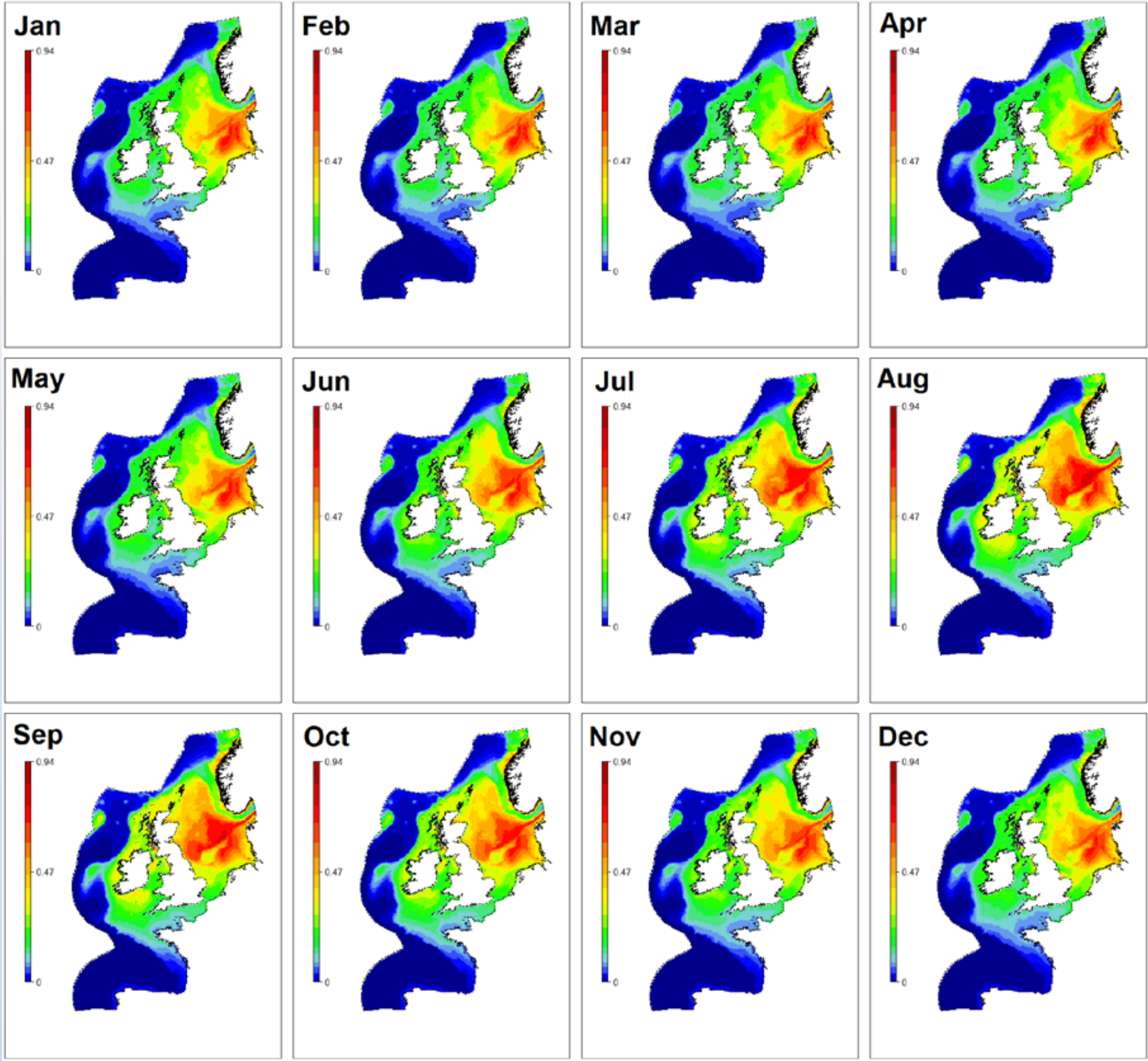
1.2 million individuals

Spatial Patterns - Seabirds

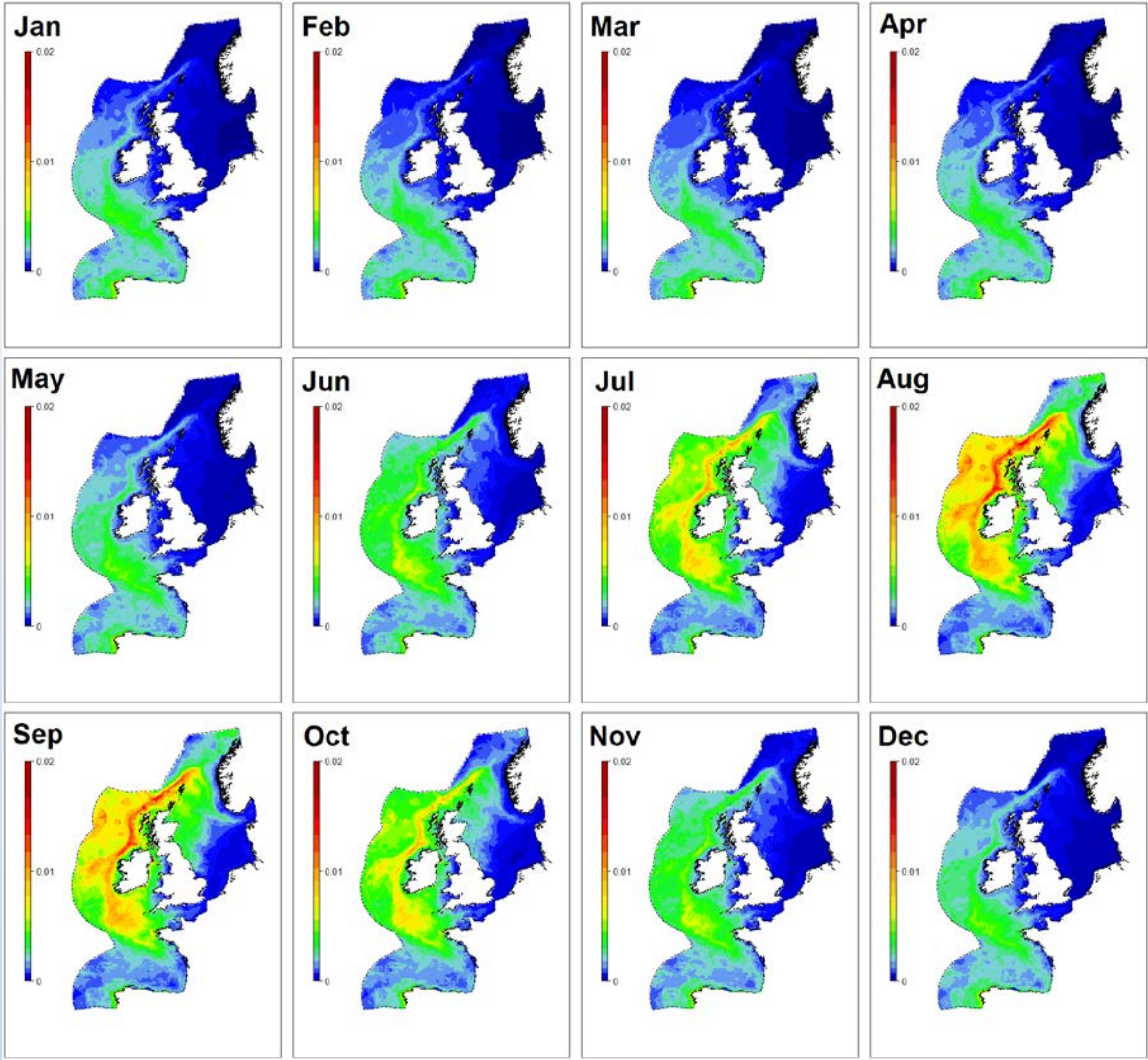
6.4 million individuals



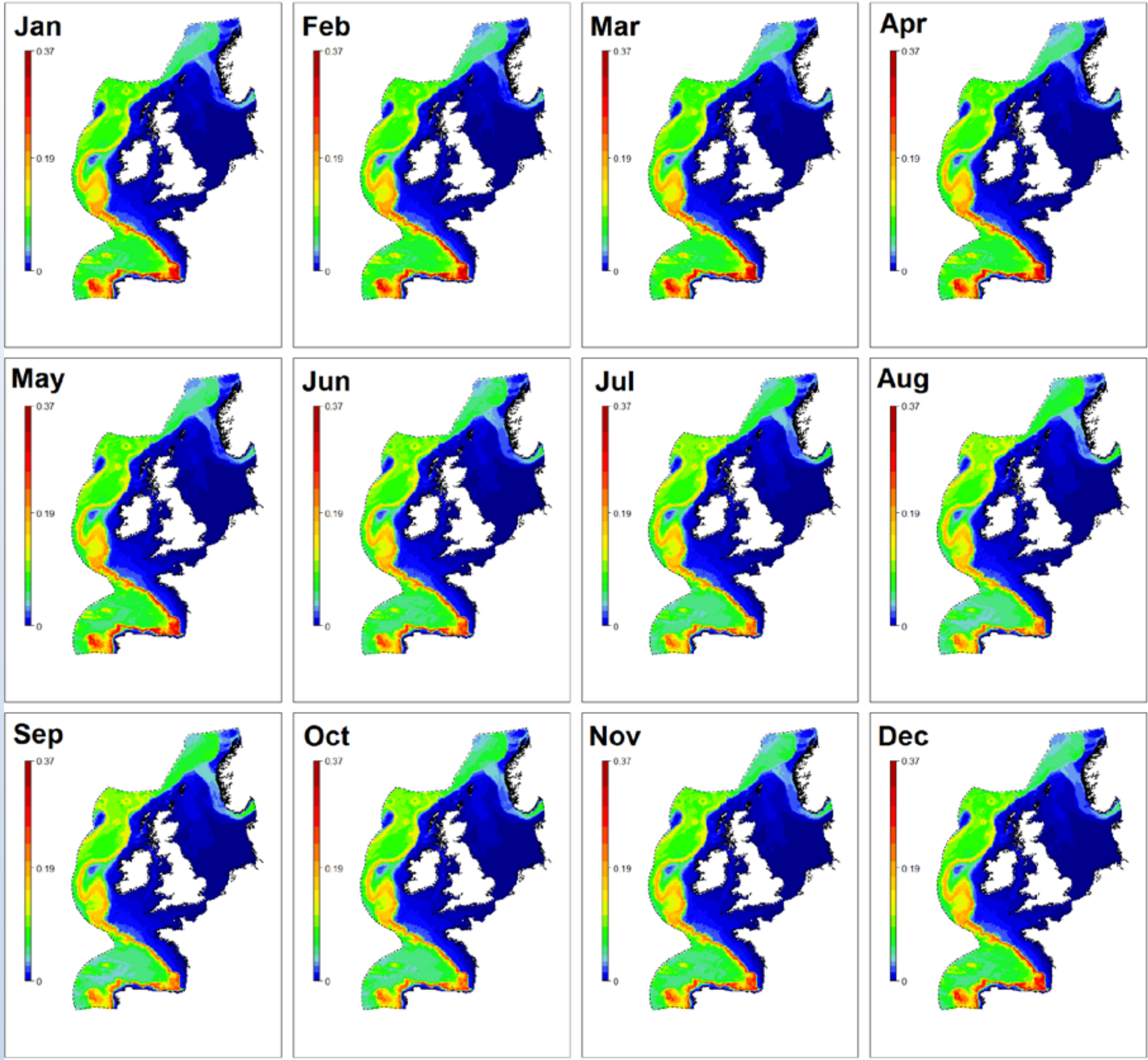
Monthly Trends: Harbour Porpoise



Monthly Trends: Risso's Dolphin

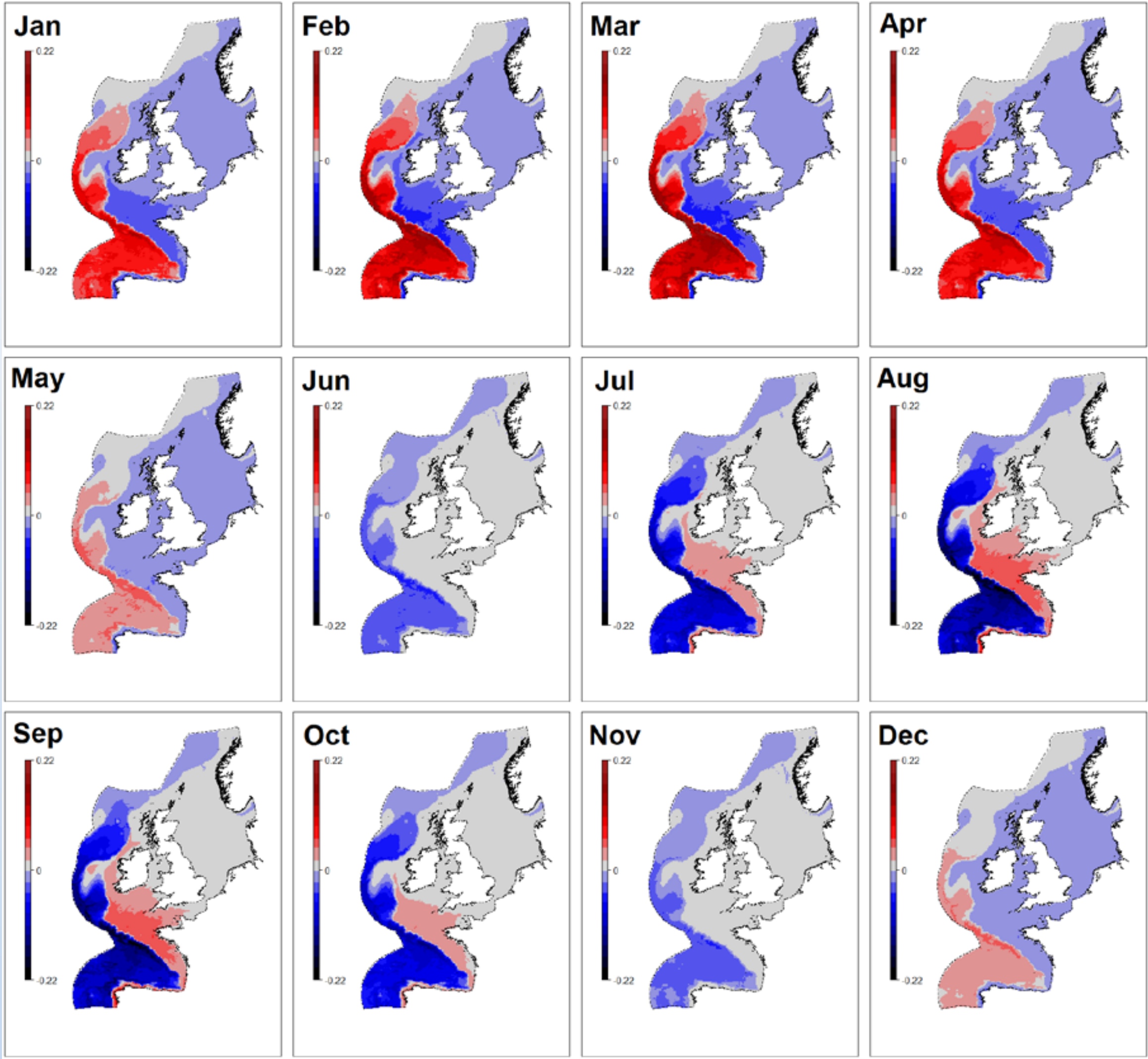


Monthly Trends: Long-finned Pilot Whale



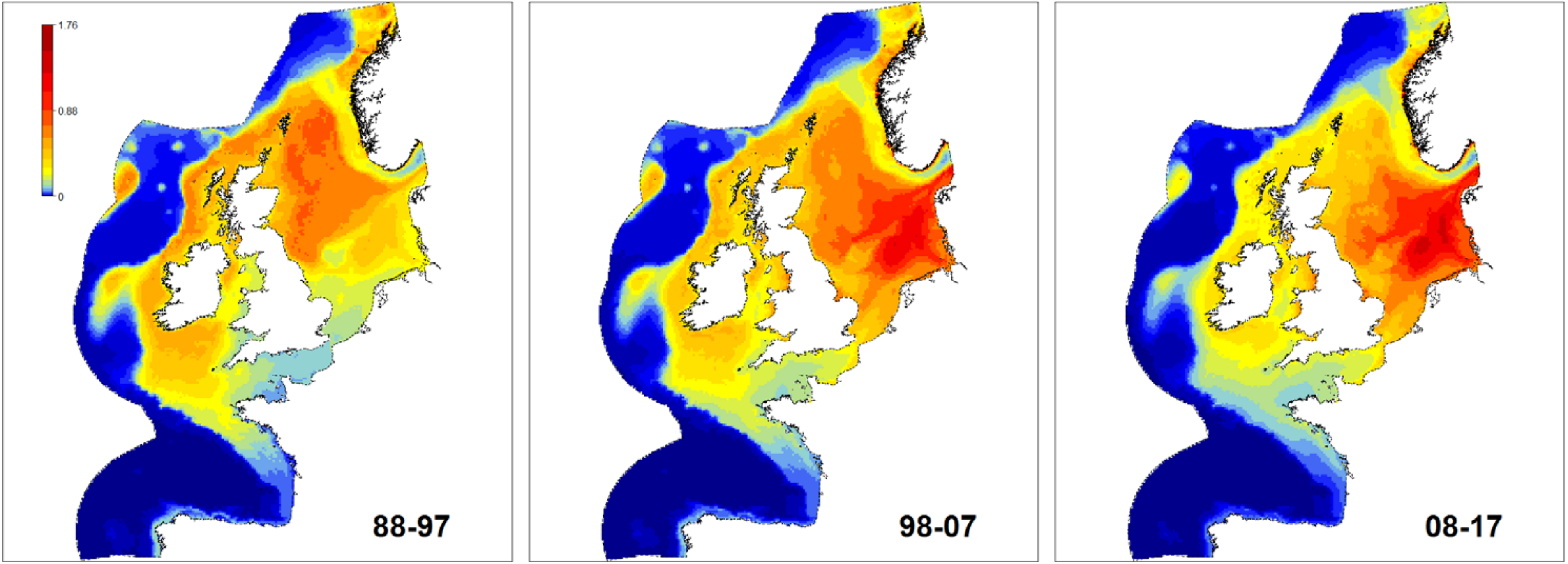
Inshore-Offshore Movements: Common Dolphin

- % deviation from the annual mean for each month of the year
- Red denotes positive and blue negative deviations
- Results show a movement towards the shelf edge west of Ireland and into the Bay of Biscay between Dec & May

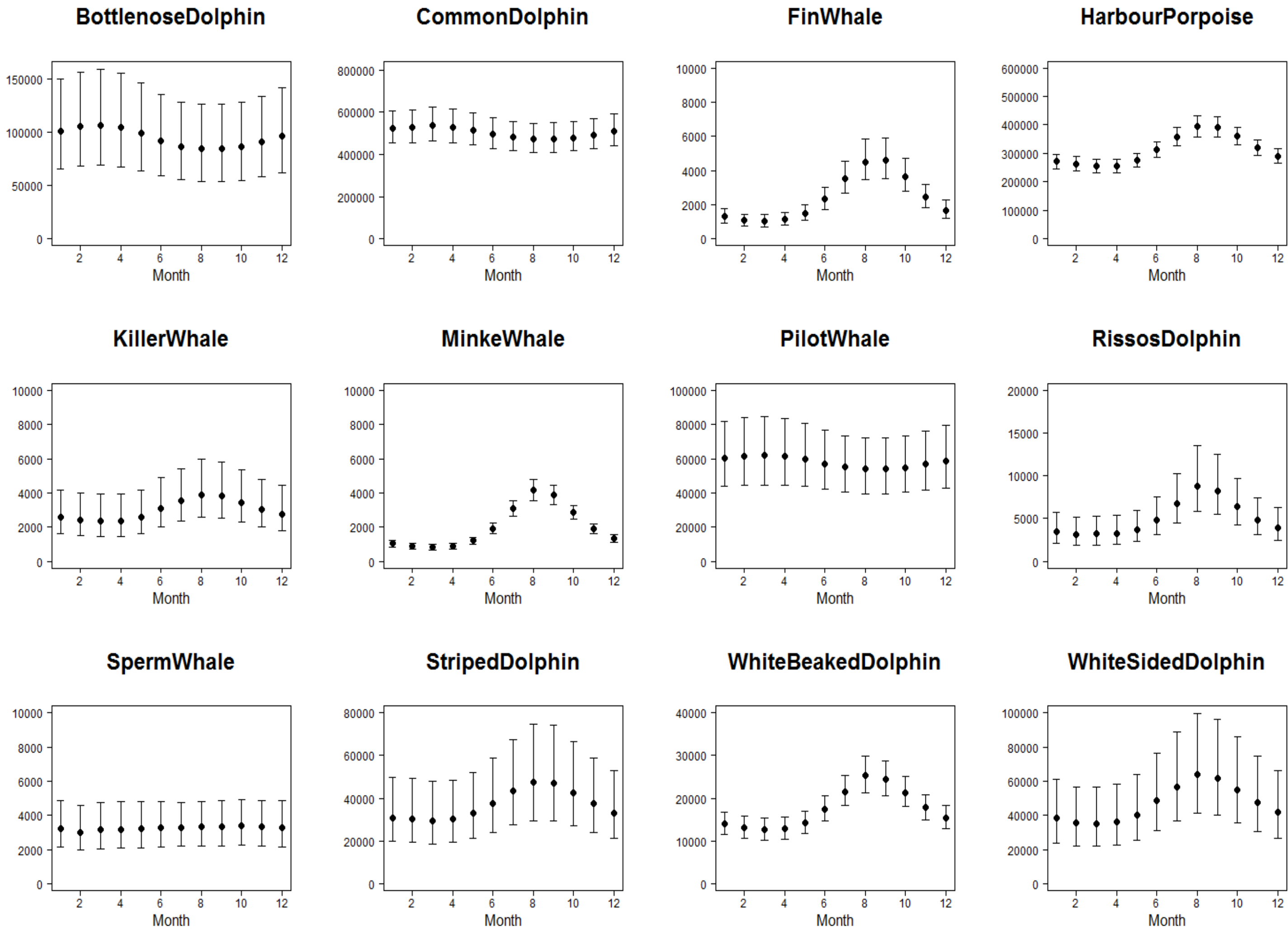


Long-term Trends in Harbour Porpoise Distribution

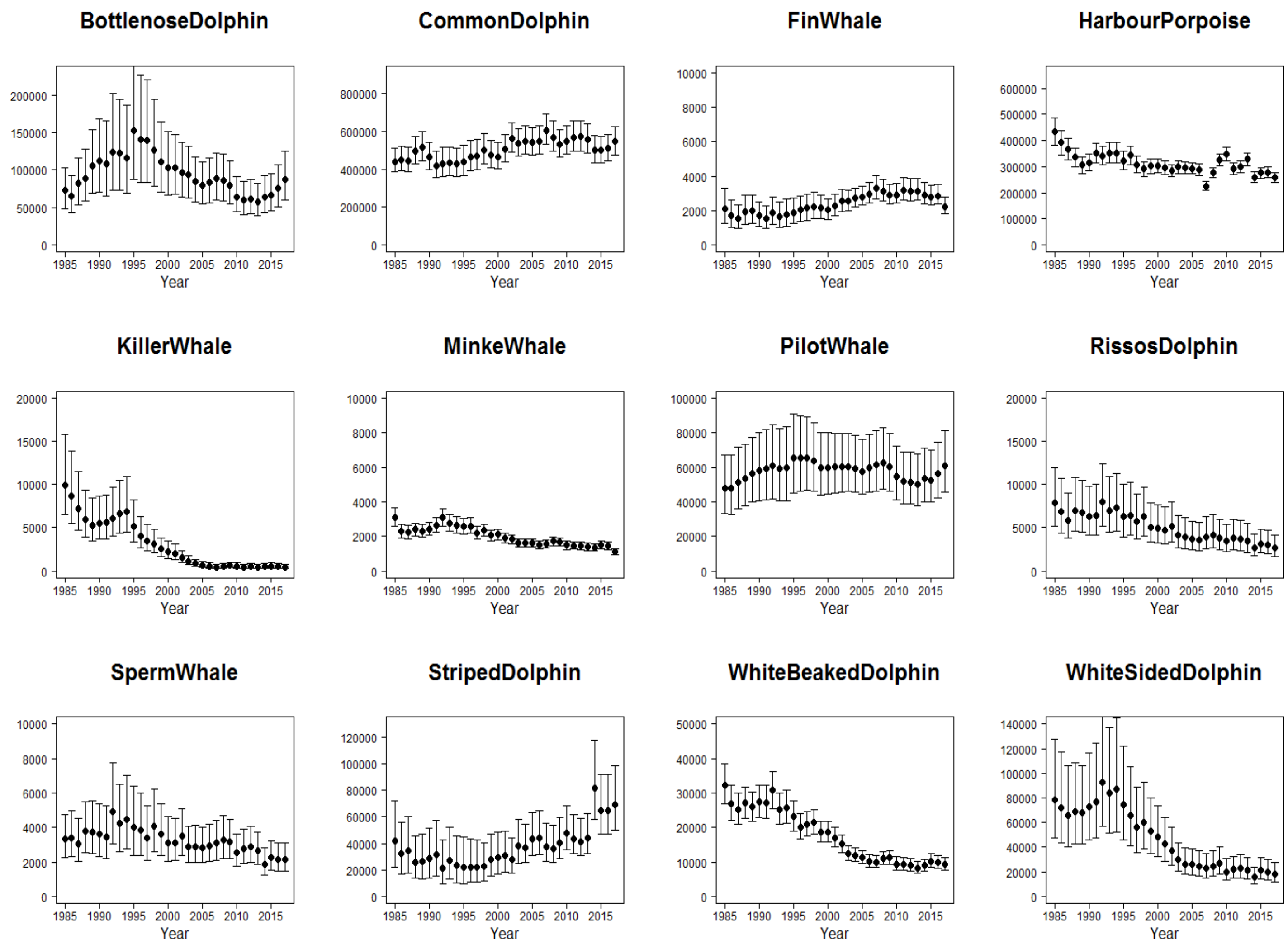
Phocoena phocoena



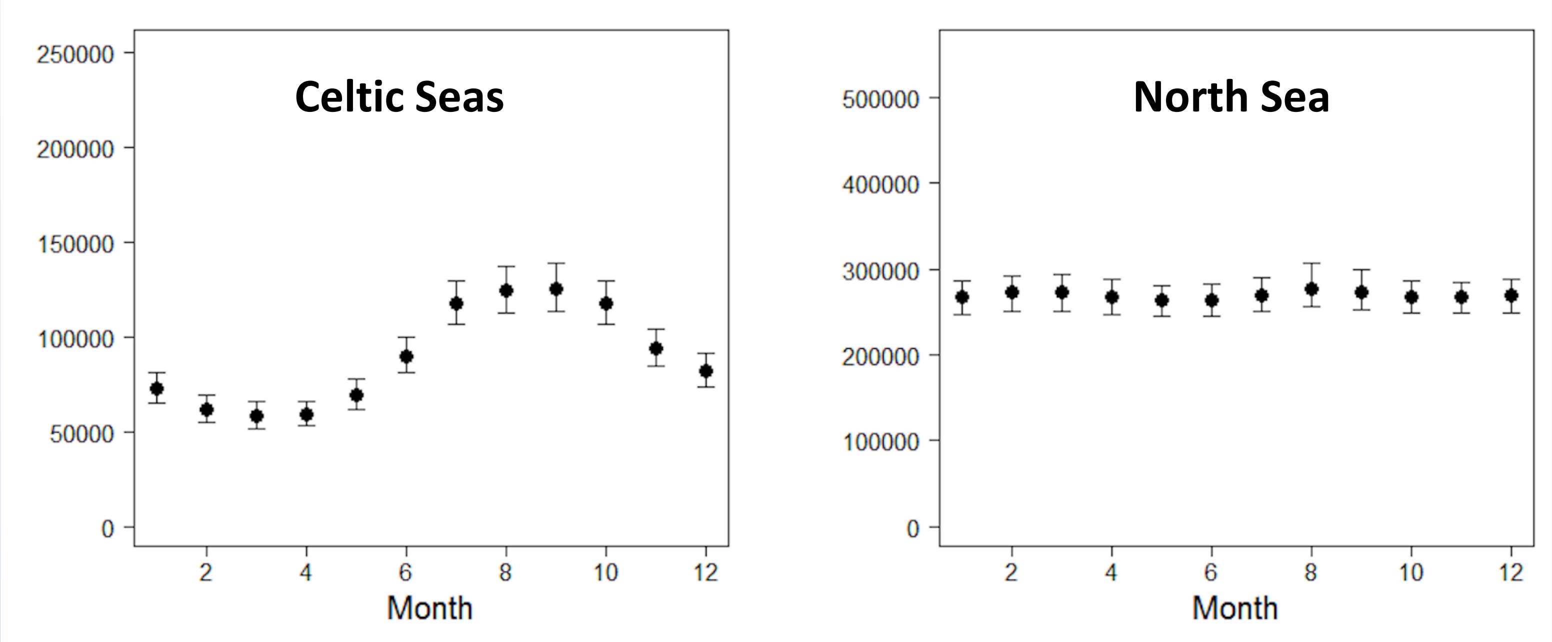
Seasonal Patterns: Cetaceans



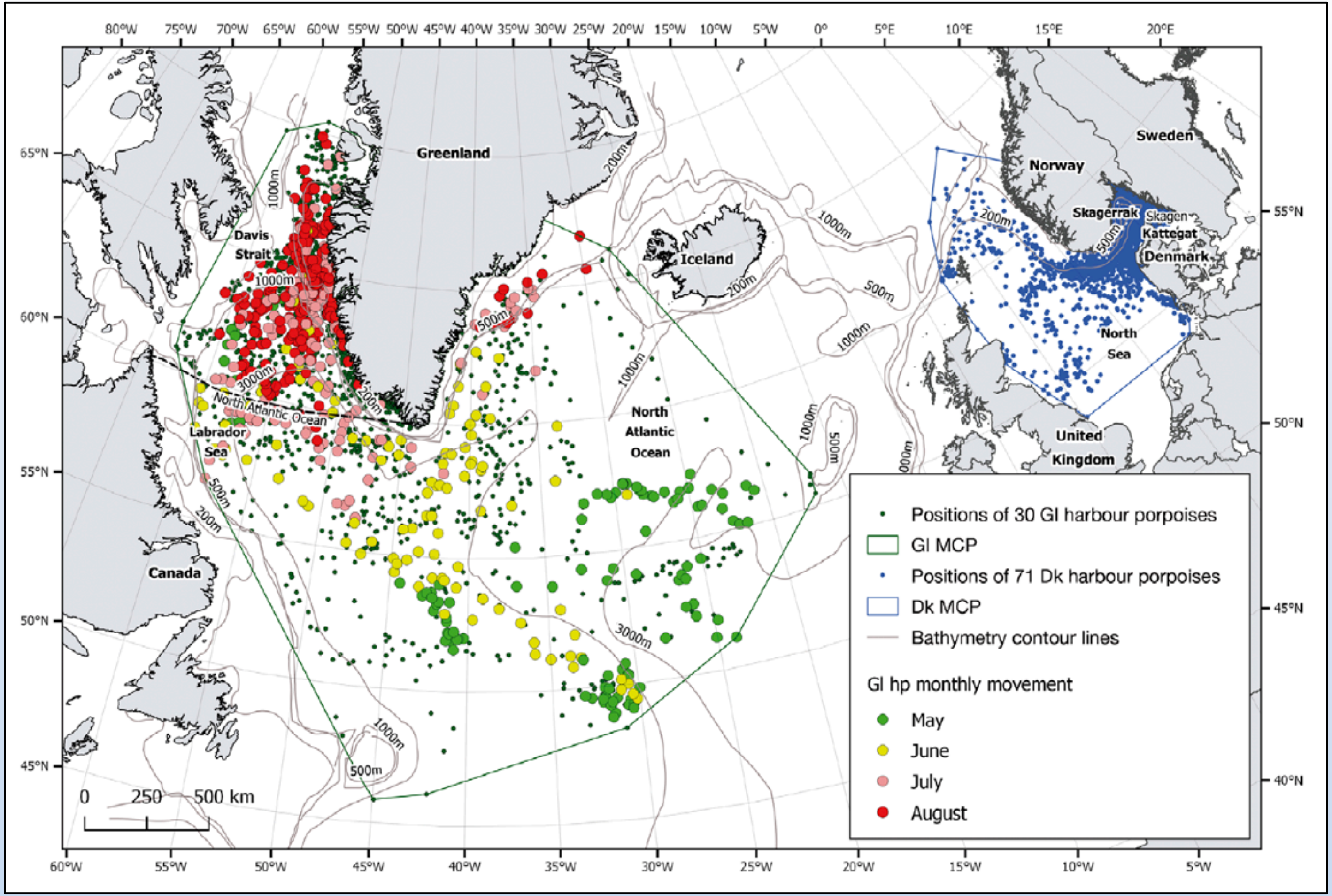
Annual Patterns: Cetaceans



Seasonal Patterns: Harbour Porpoise



Harbour Porpoise Movements



Source:
Nielsen *et al*., 2018

Future Impact and Policy Relevance

- Density surface mapping, abundance estimates, population trends (for Marine Strategy Framework Directive)
- Identification of persistent species density hotspots (for Marine Protected Areas)
- Identification of areas of high biodiversity & biomass (for Ecologically or Biologically Significant Areas & Key Biodiversity Areas)
- Risk mapping (for marine spatial planning & ecosystem services)

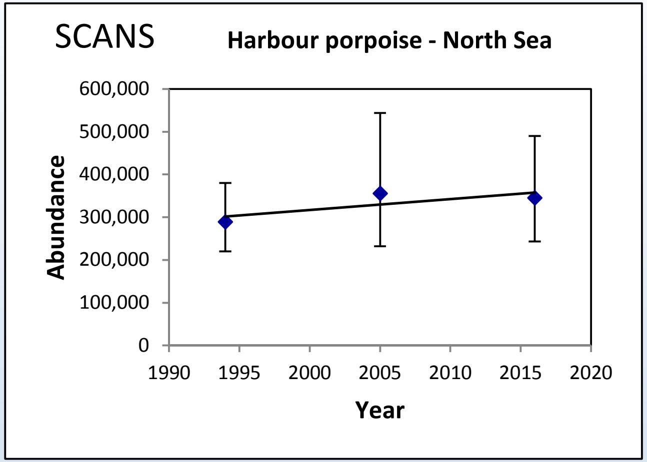
How can the evidence be used? – MSFD indicators

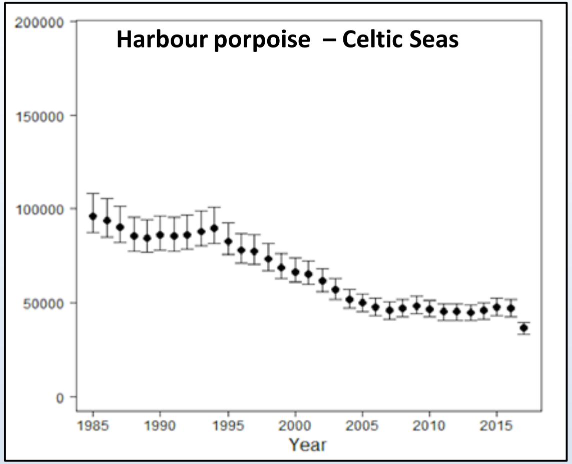
- M4: *Abundance at the relevant temporal scale of cetacean species regularly present*

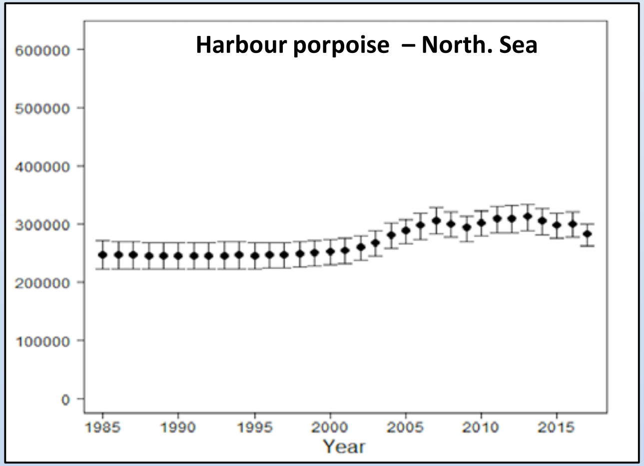
- Large-scale synoptic surveys are currently every 11 years due to resource constraints but this limits ability to determine trends

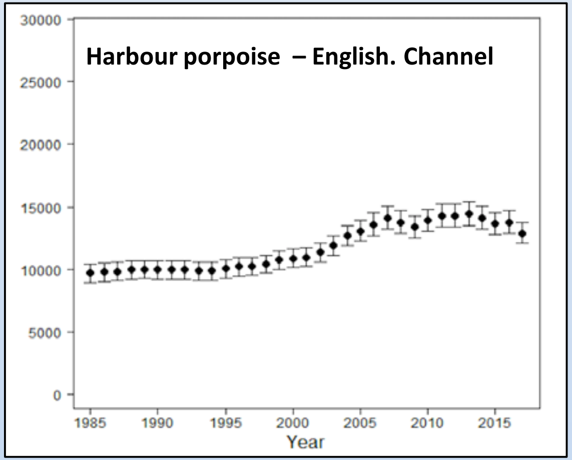
- Gap filling with spatio-temporal trends from high intensity studies

Sources: MERP Project; Hammond *et al.*, 2017: SCANS III Report

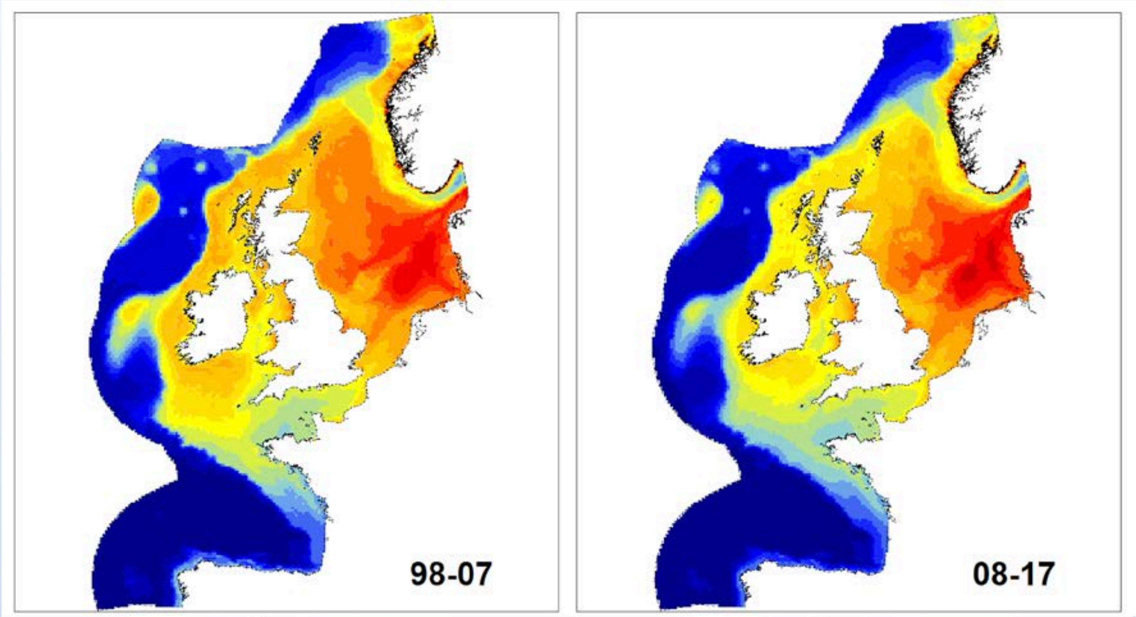


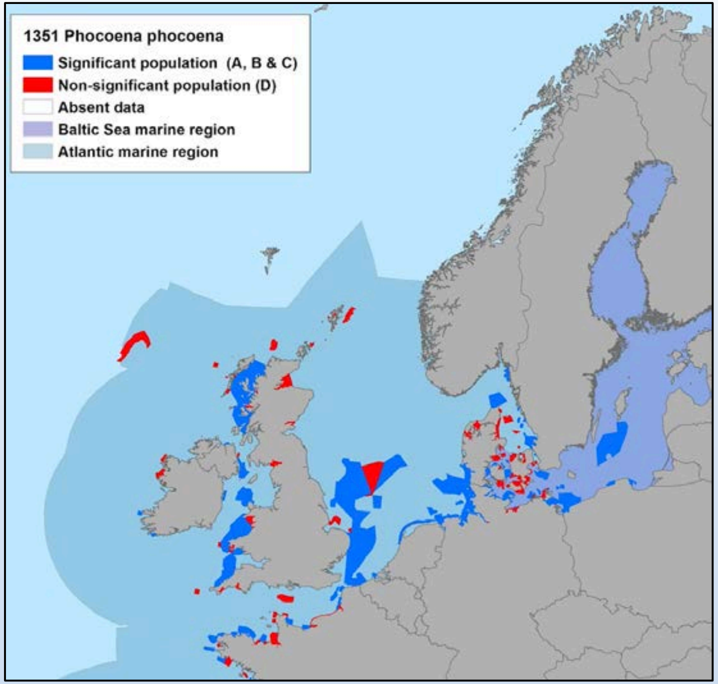






How can the evidence be used? - Marine Protected Areas





- Consideration of density surfaces over large-scale can identify hotspots beyond national boundaries – see, for example, area west of Denmark

Species Diversity, Biomass & Abundance

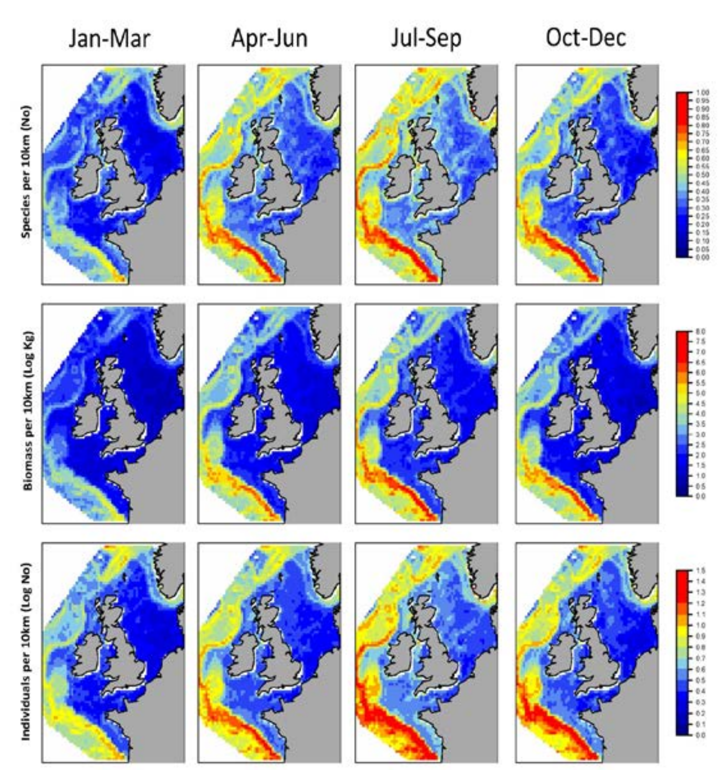
a) Seasonal modelled relationships for cetacean communities

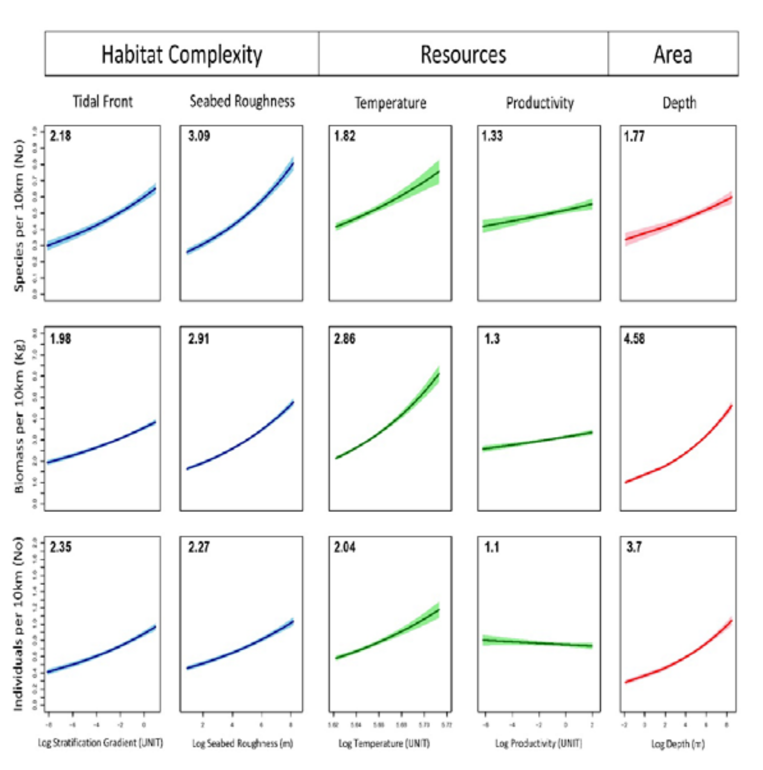
b) physical & oceanographic features, prey resources

No, of spp.

Biomass

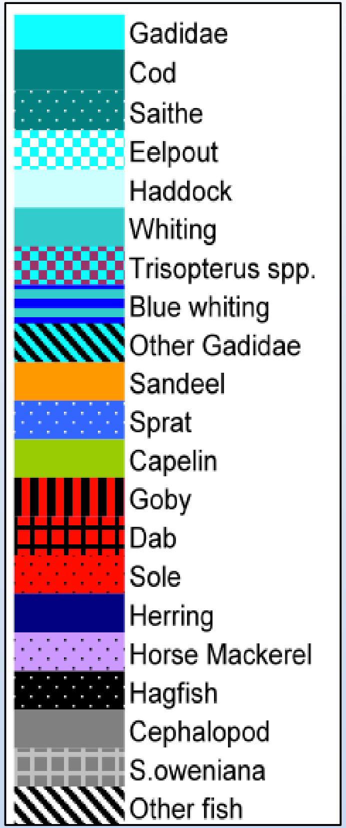
Abund.

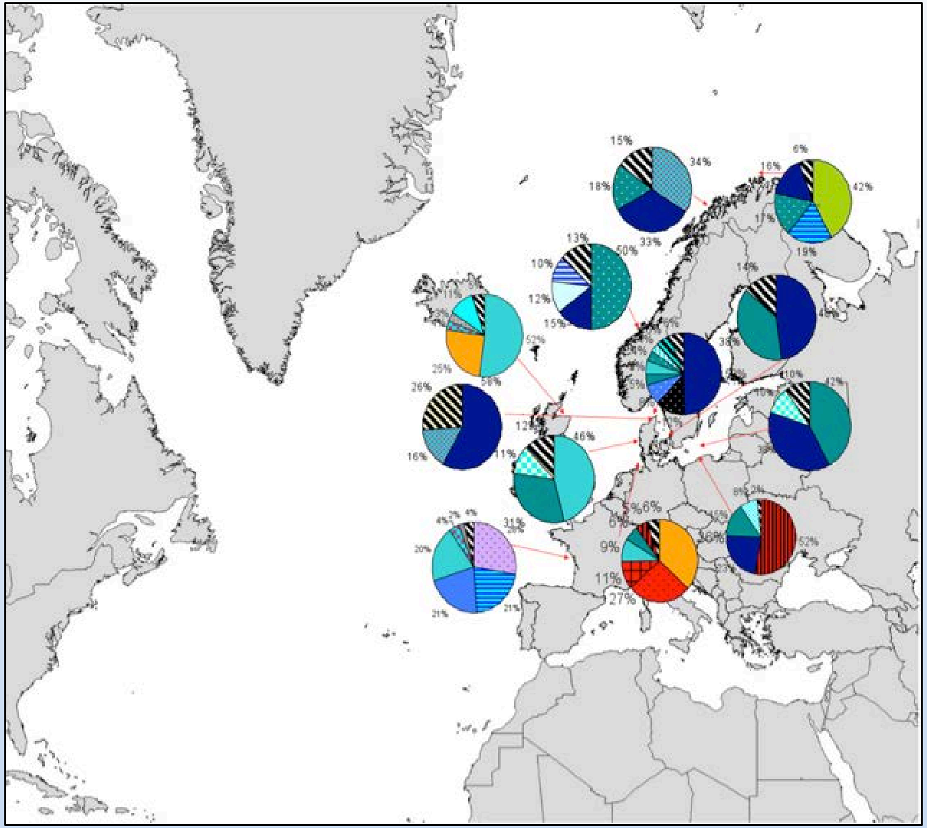




Collating Prey Data

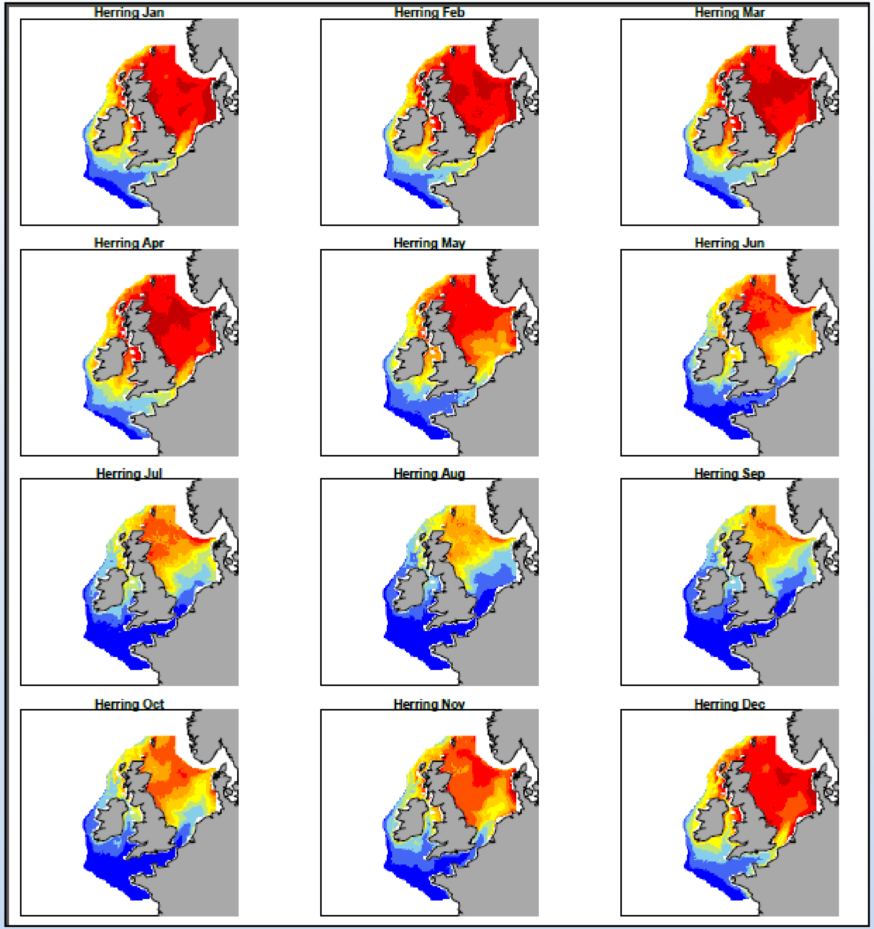
Harbour Porpoise diet in NW Europe (by weight)





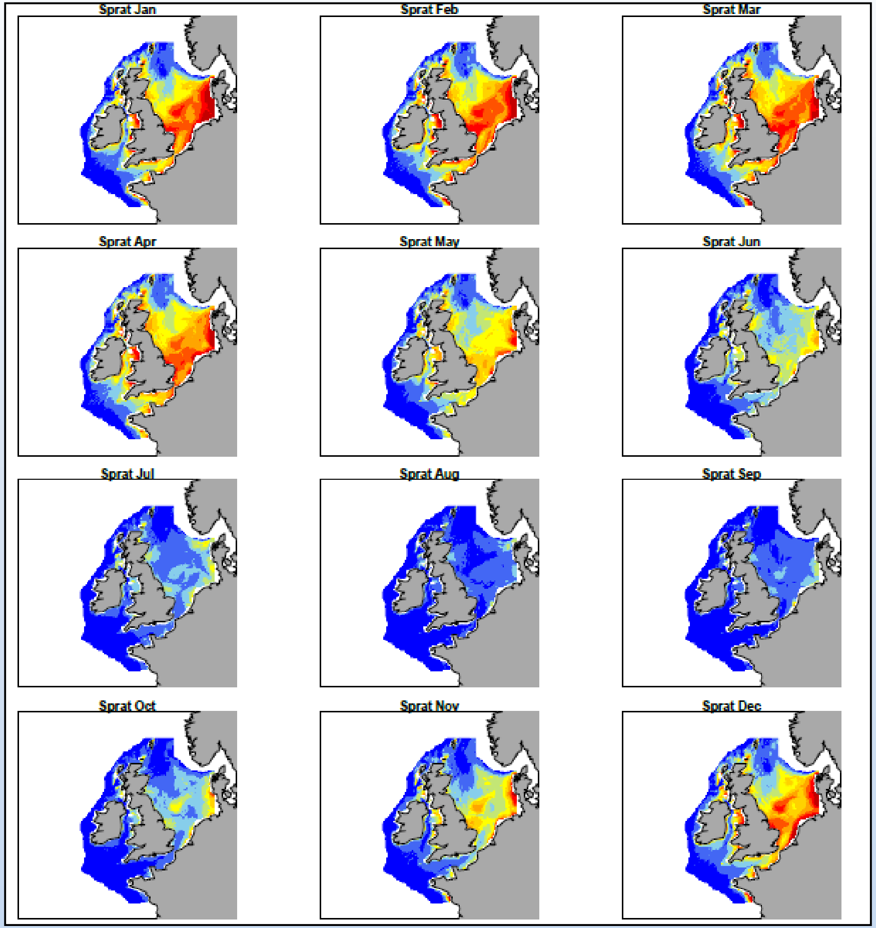
Prey Maps

Modelling of monthly prey distributions: *Herring*



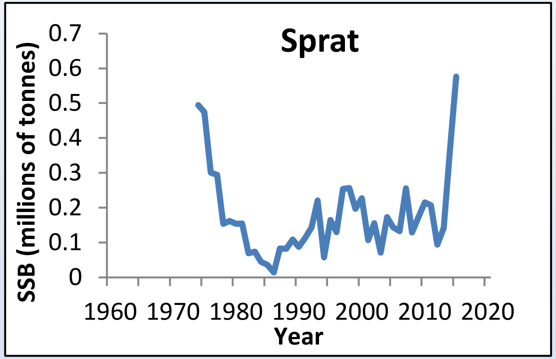
Prey Maps

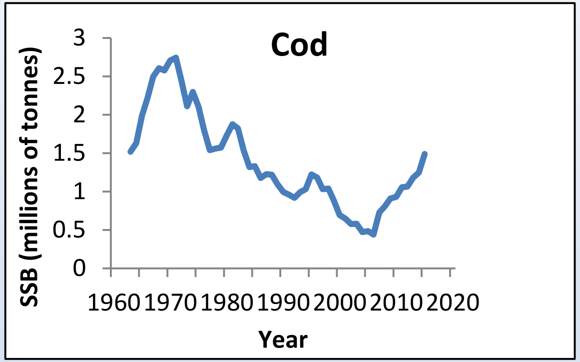
Modelling of monthly prey distributions: *Sprat*

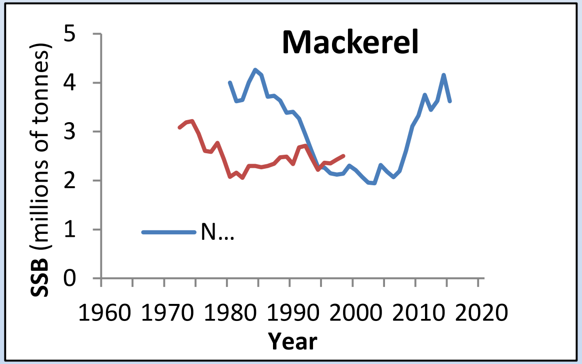


Collating Prey Data

Temporal trends in fish spawning biomass







Collating Prey Data

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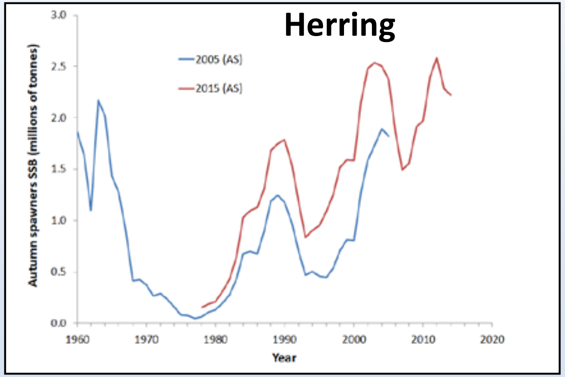
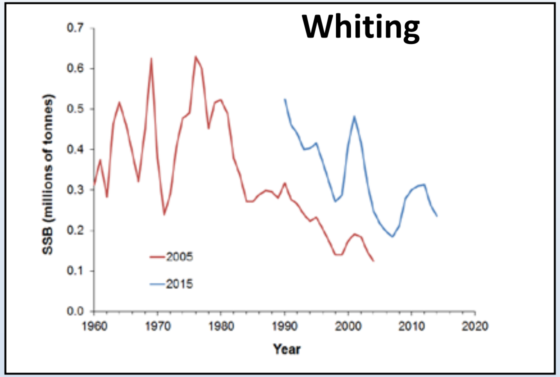
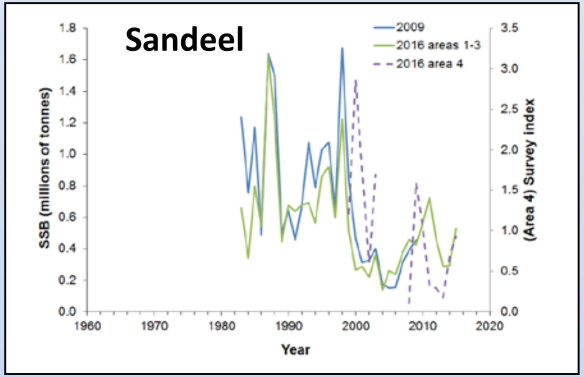
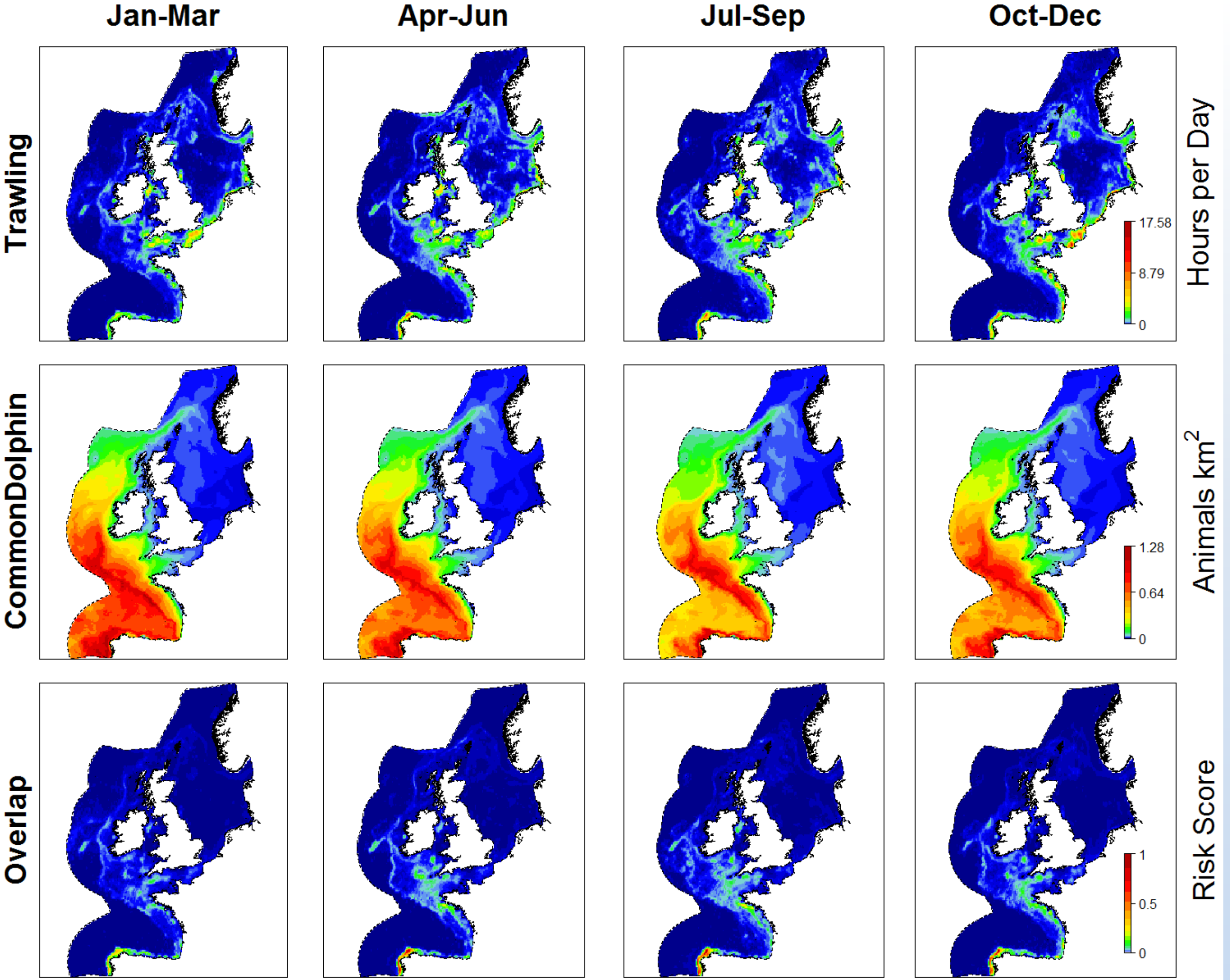






Risk Mapping: Common Dolphins & Trawling



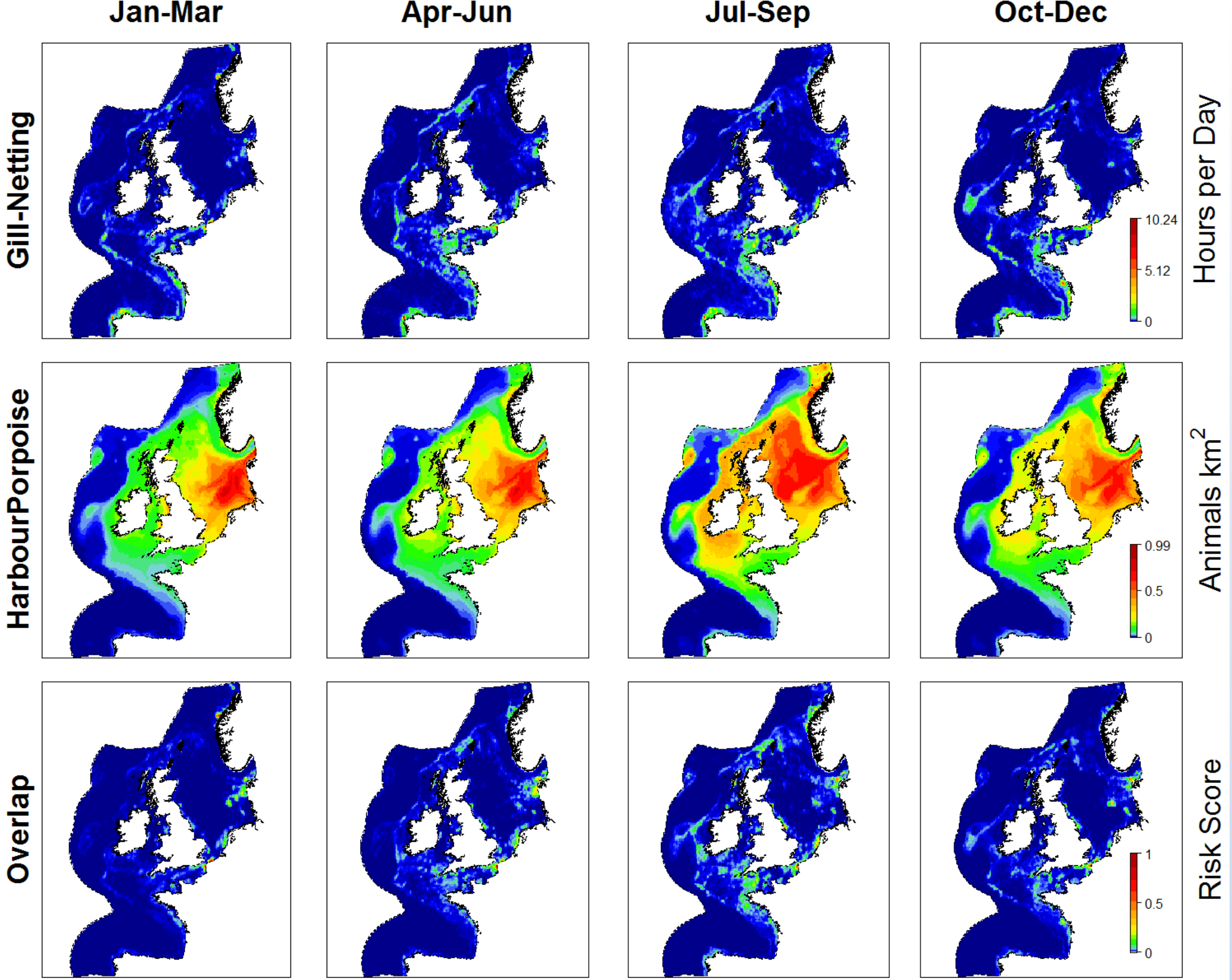
Main Risk Areas

- Channel Western Approaches
- Northwest France
- Northwest Spain

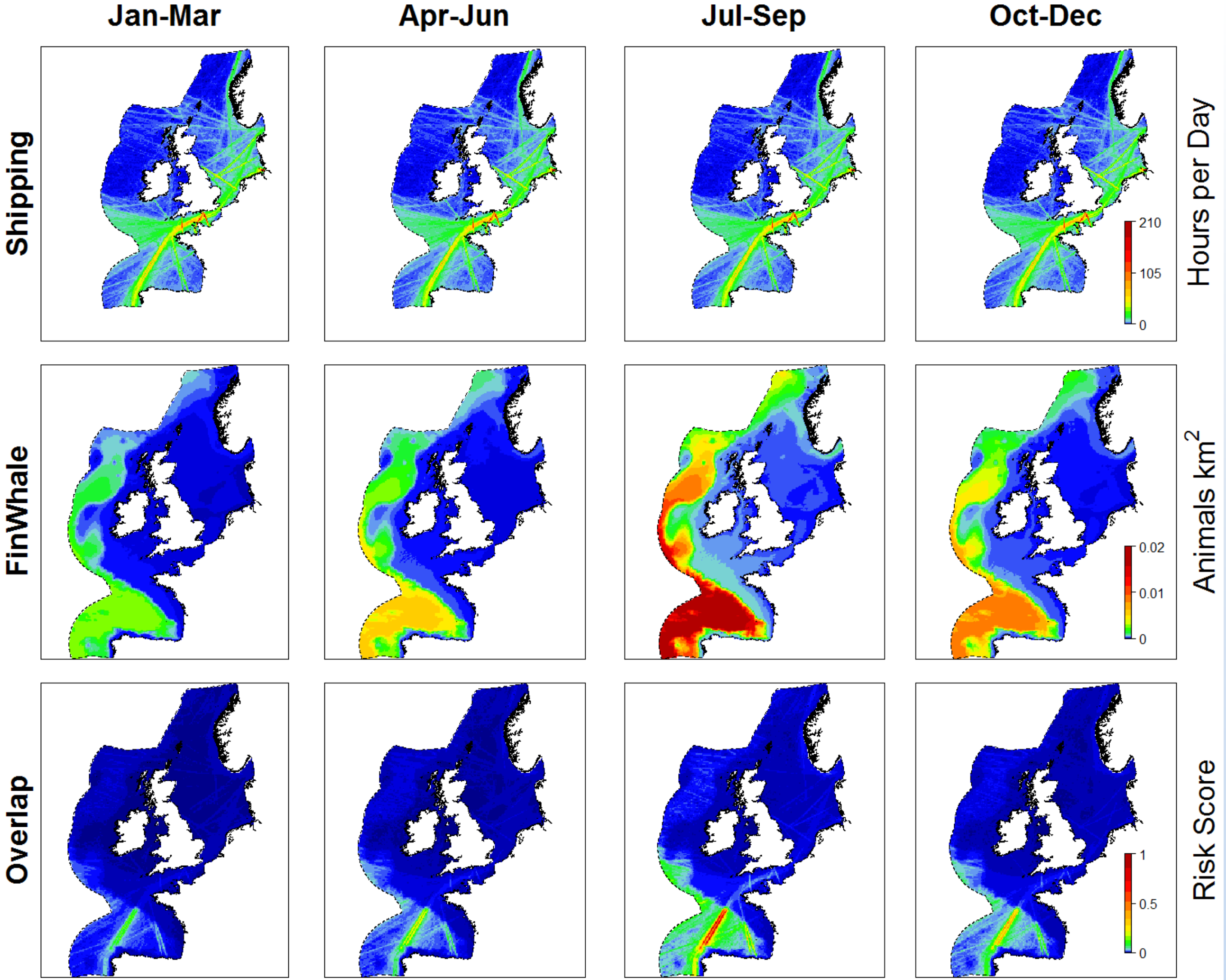
Risk Mapping: Harbour Porpoise & Static Gillnets

Main Risk Areas

- West of Norway & Denmark
- Southwestern North Sea
- Eastern English Channel
- Celtic Sea & SW Approaches



Risk Mapping: Fin Whales & Shipping



Main Risk Areas/times

- Western Bay of Biscay
- North-West Spain
- Mainly Jul-Dec

Products

- New distribution maps for all the major cetacean & seabird species in NW European seas
- Modelled density surface plots & abundance estimates by month and by year from 1985-2017
- Modelled outputs of cetacean & seabird habitat preferences
- Identification of diversity, biomass & density hotspots in NW European seas
- Risk maps for potential impacts of different human pressures

Looking Forward

- Incorporate new cetacean & seabird survey data
- Refine models, incorporating more prey information
- Refine plots of human pressures
- Refine vulnerability & sensitivity indices
- Develop cumulative pressure risk maps
- Predict responses to climate change