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Listen to the ocean

Satellite-derived environmental drivers for top predator hotspots

Peter Miller

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South West Marine Ecosystems 2017
21 Apr. 2017, Plymouth University

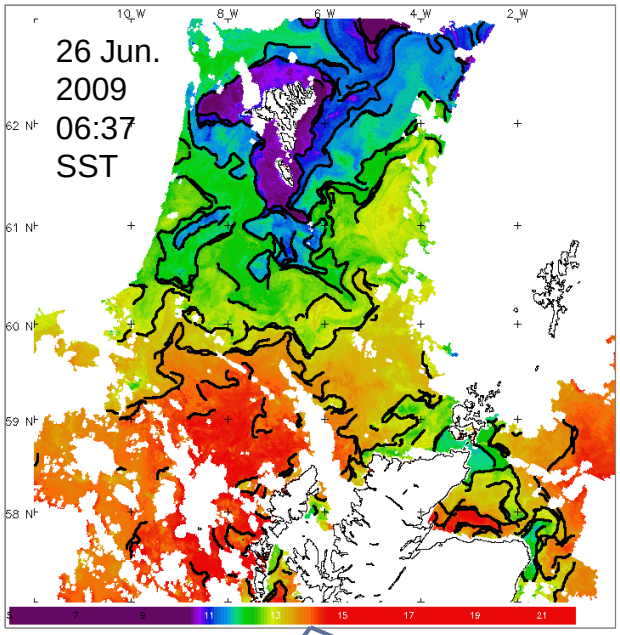
Satellite environmental drivers for hotspots

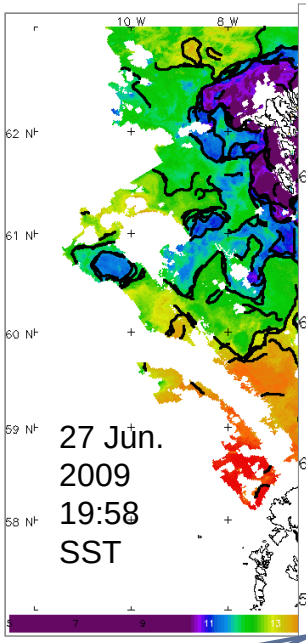
Satellite environmental drivers for hotspots

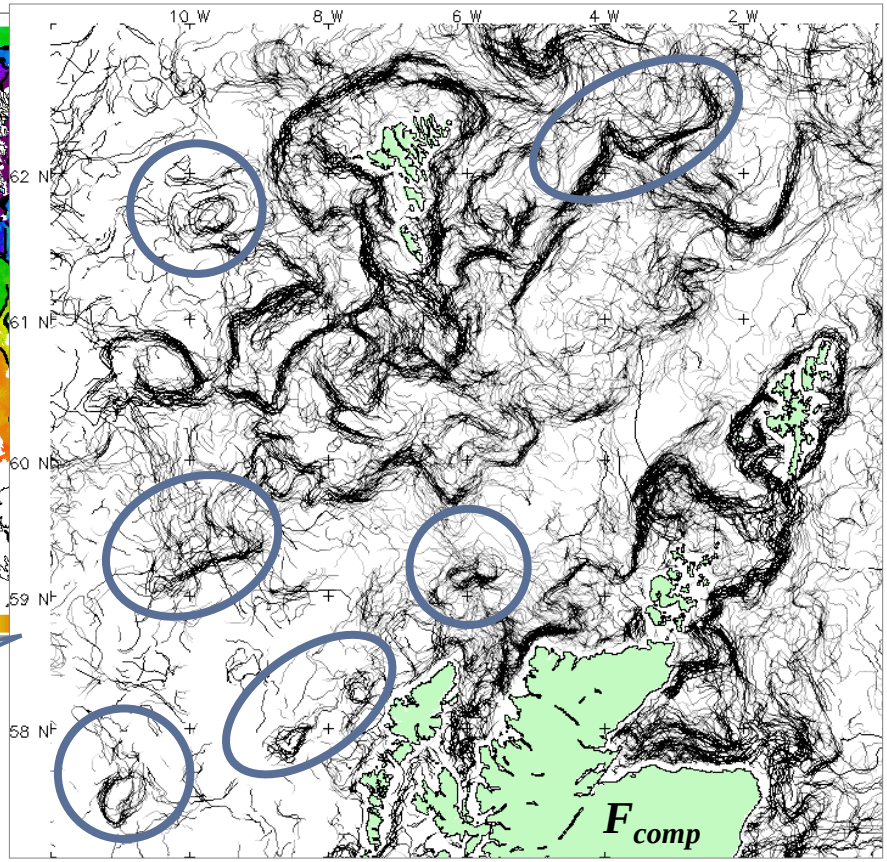
- Introduction to satellite products for ecology
- Environmental drivers for 2016
- Predictions of top predator hotspots

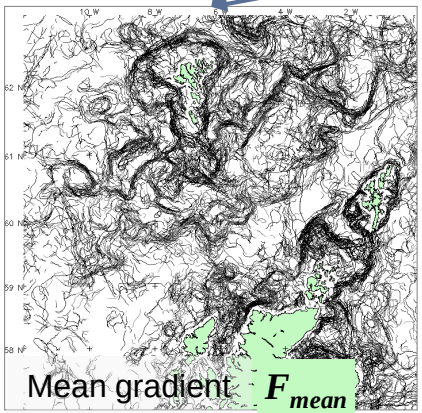
An obvious ocean front

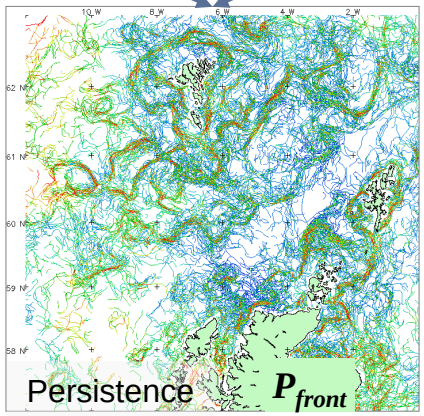
Detecting oceanic fronts

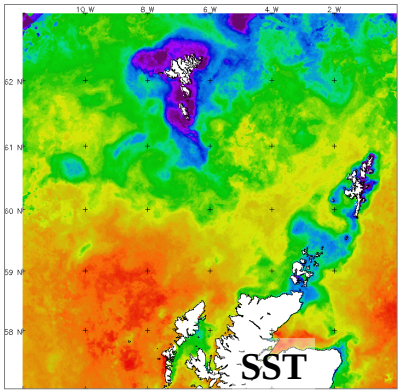






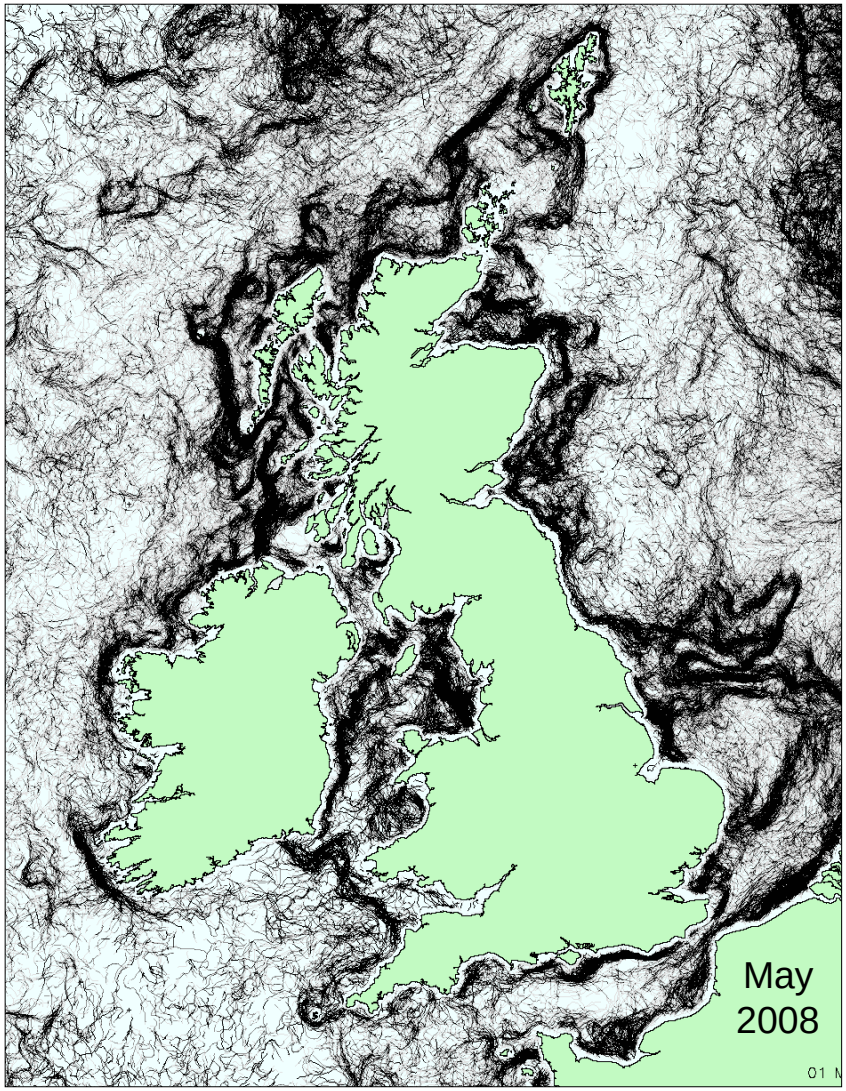


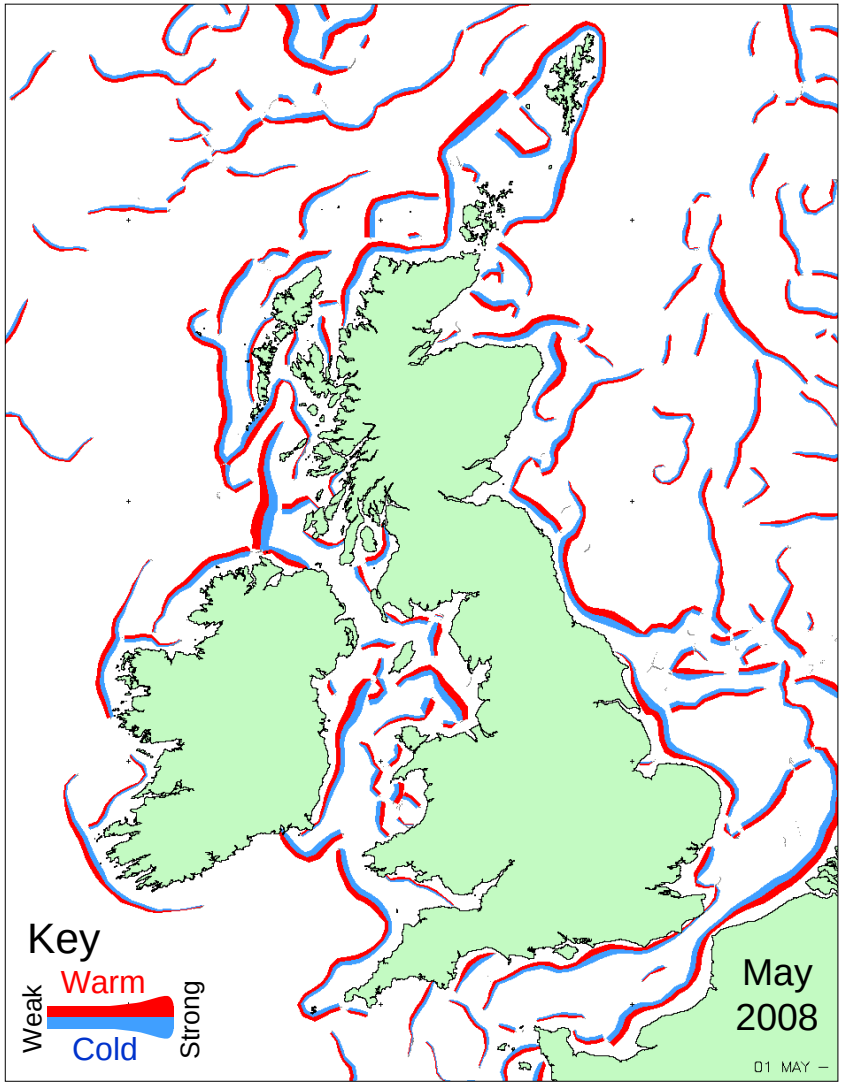




Miller, P.I., (2009) Composite front maps for improved visibility of dynamic oceanic fronts on cloudy data, *Journal of Marine Systems*.

Ocean fronts: from spaghetti to synoptic chart

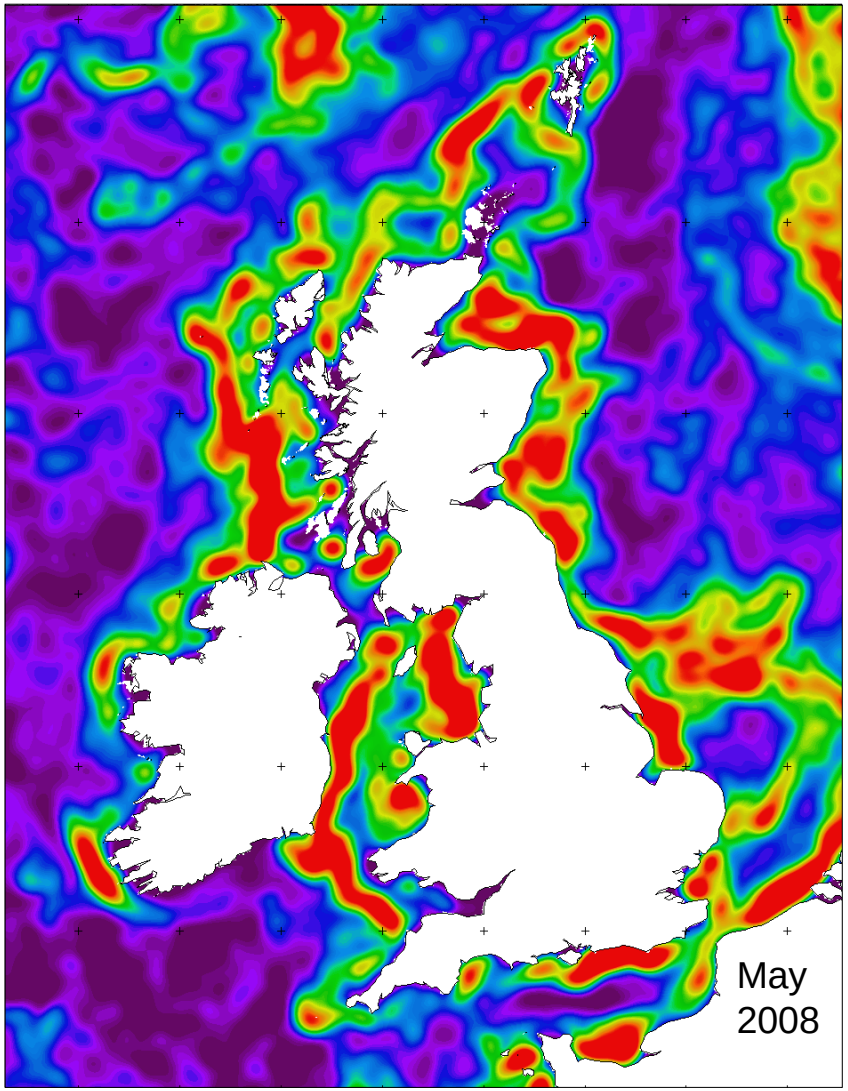




Miller, P.I., (in preparation), A line clustering algorithm with application to simplifying ocean front maps derived from satellite data, *Remote Sensing of Environment*.

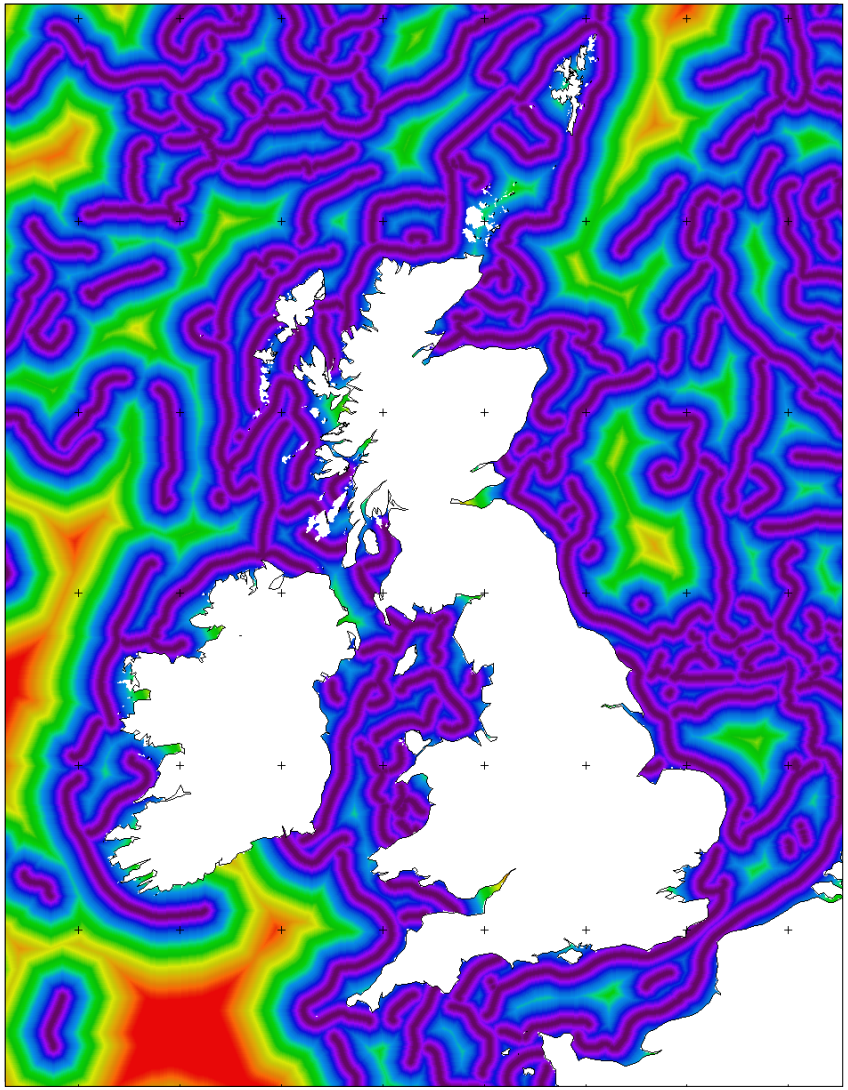
Ocean front metrics

Front strength



Low High

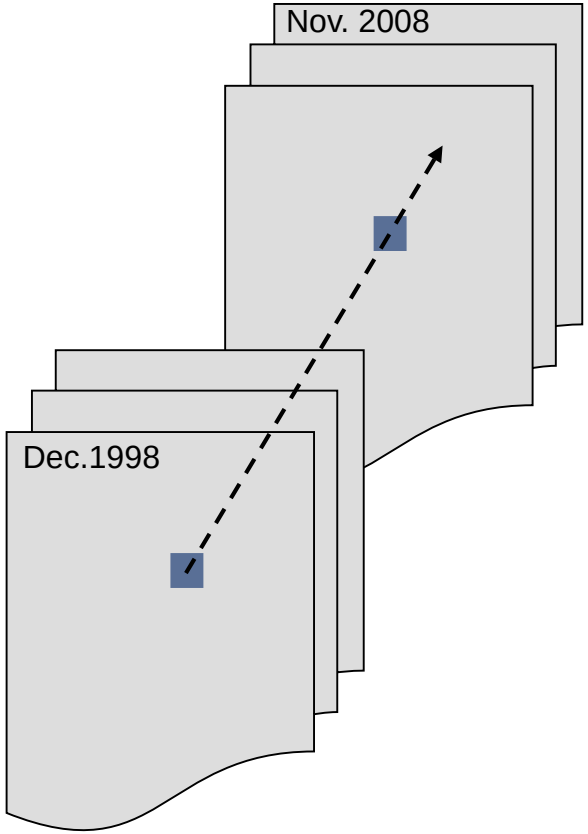
Front distance

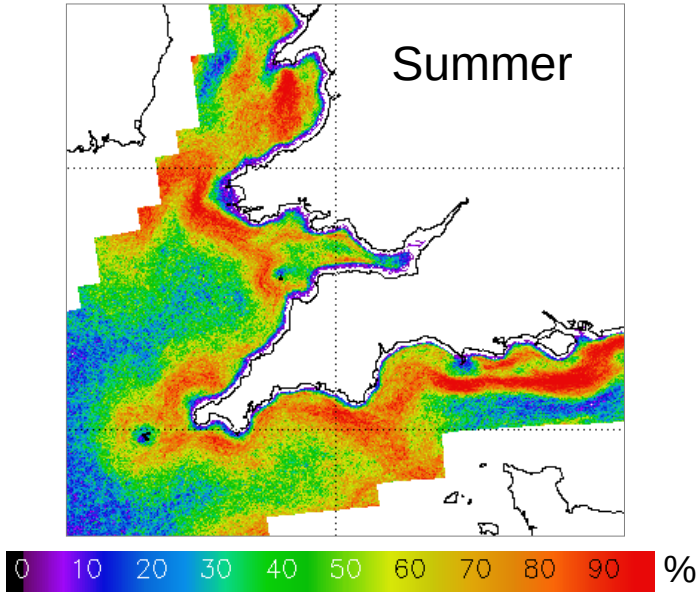


Low High

Frequently observed ocean fronts

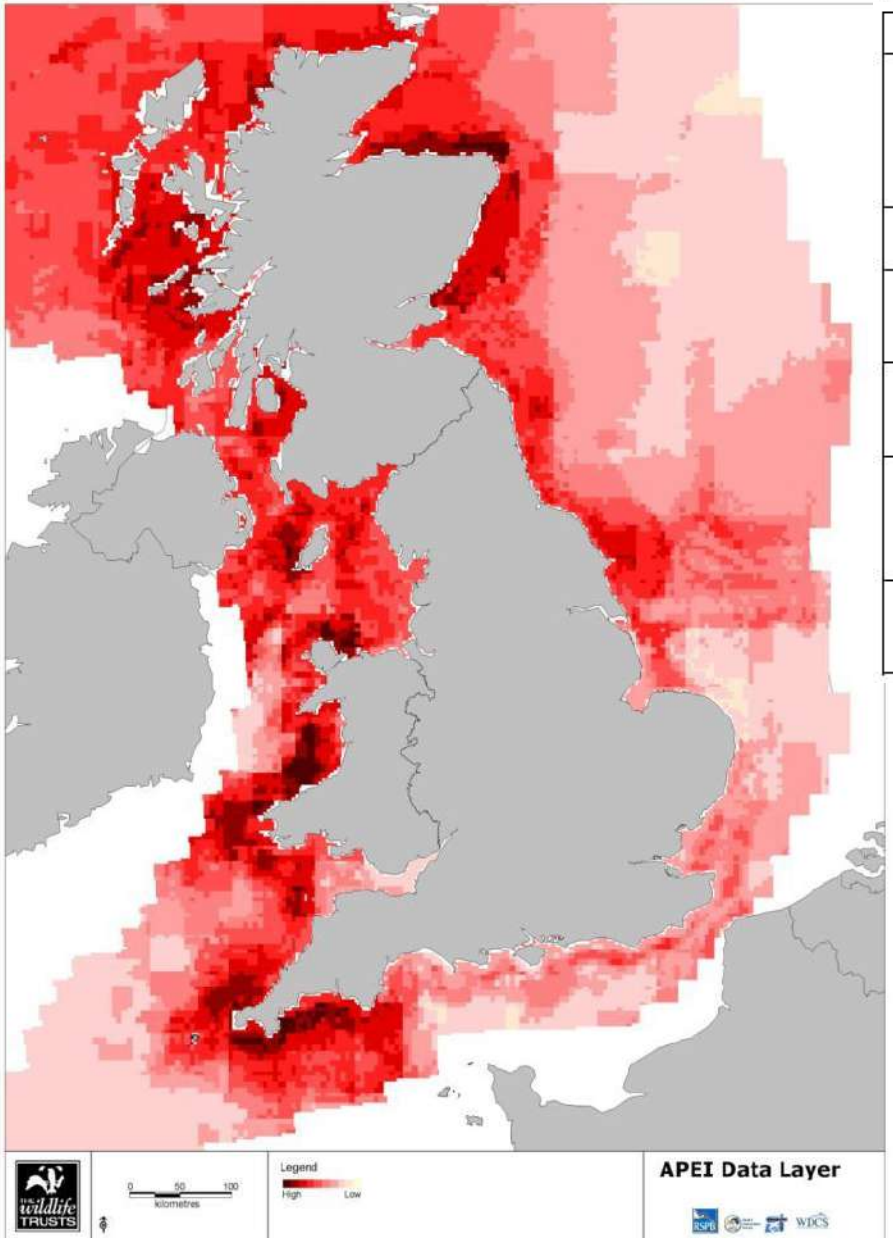
- Huge unique archive: >30,000 AVHRR passes 1999-2008
- Developed and tested methodology to analyse persistent fronts in time series
- Percentage of months in which strong front observed = Frequent fronts





Miller, P.I. & Christodoulou, S. (2014) Frequent locations of ocean fronts as an indicator of pelagic diversity: application to marine protected areas. *Marine Policy*.

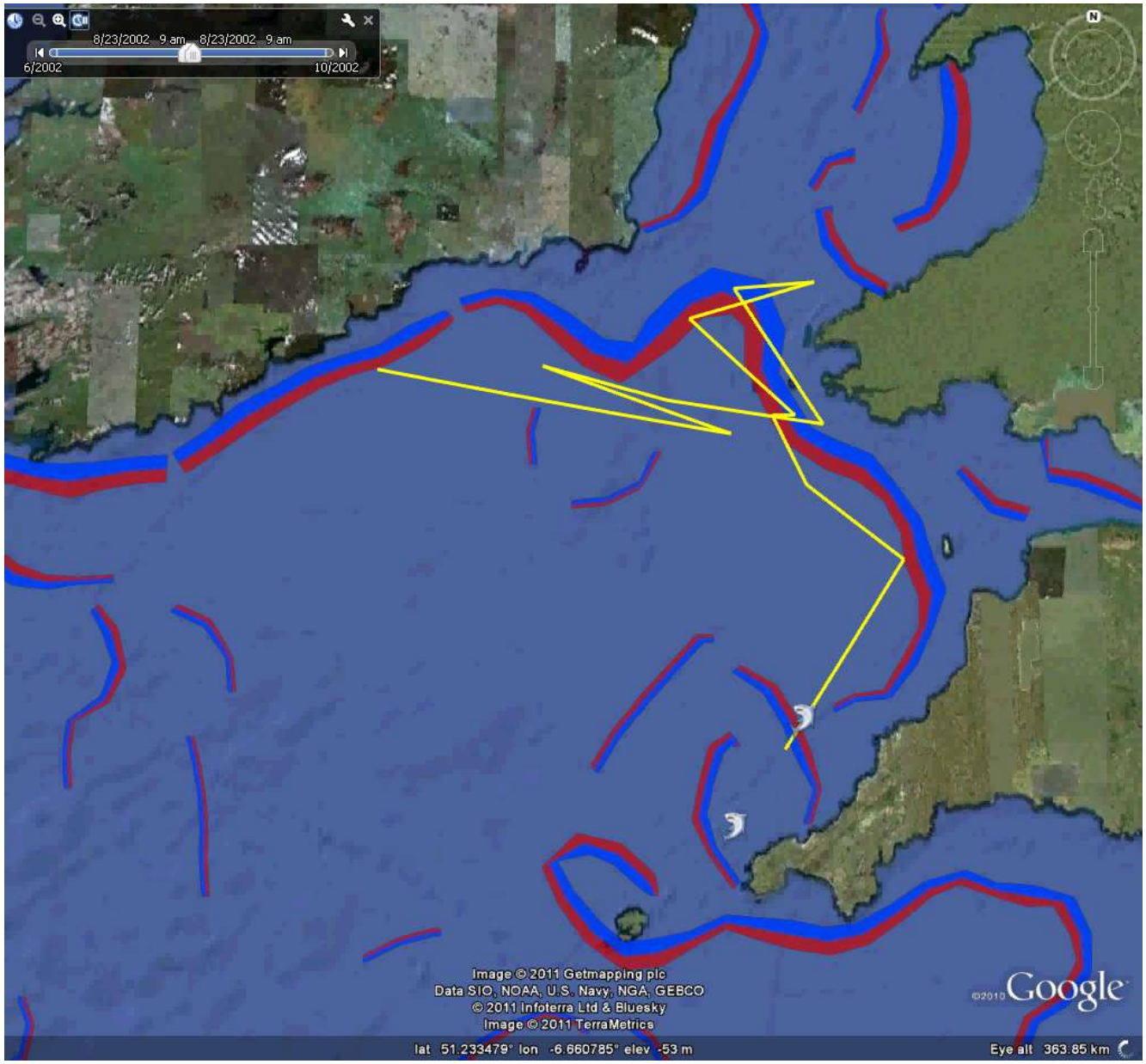
Areas of Pelagic Ecological Importance



Field Name	Field Description	Scoring
TF_Class	Thermal front data which indicates percentage of time that a summer frontal system is present within each grid cell. These percentages were then classified.	1/2/3
RSPB_Class	Classification score for RSPB foraging radii data	0/1/2/3
WDCS_Class	Whale and Dolphin Conservation Society data for important areas for marine mammals.	0/1/2/3
NS_Class	Cefas and ICES nursery and spawning data based on plankton surveys.	0/1/2/3
BS_Class	Classification score for Marine Conservation Society and Shark Trust basking shark sightings data layer.	0/1/2/3
AEI_Score	Total score represented as sum of all other columns (excluding the Grid ID field).	

Miller, P.I. & Christodoulou, S. (2014) Frequent locations of ocean fronts as an indicator of pelagic diversity: application to marine protected areas. *Marine Policy*.

Many pelagic animals use fronts for foraging



Basking shark tracked with GLS tag

24 Aug. – 15 Oct. 2002

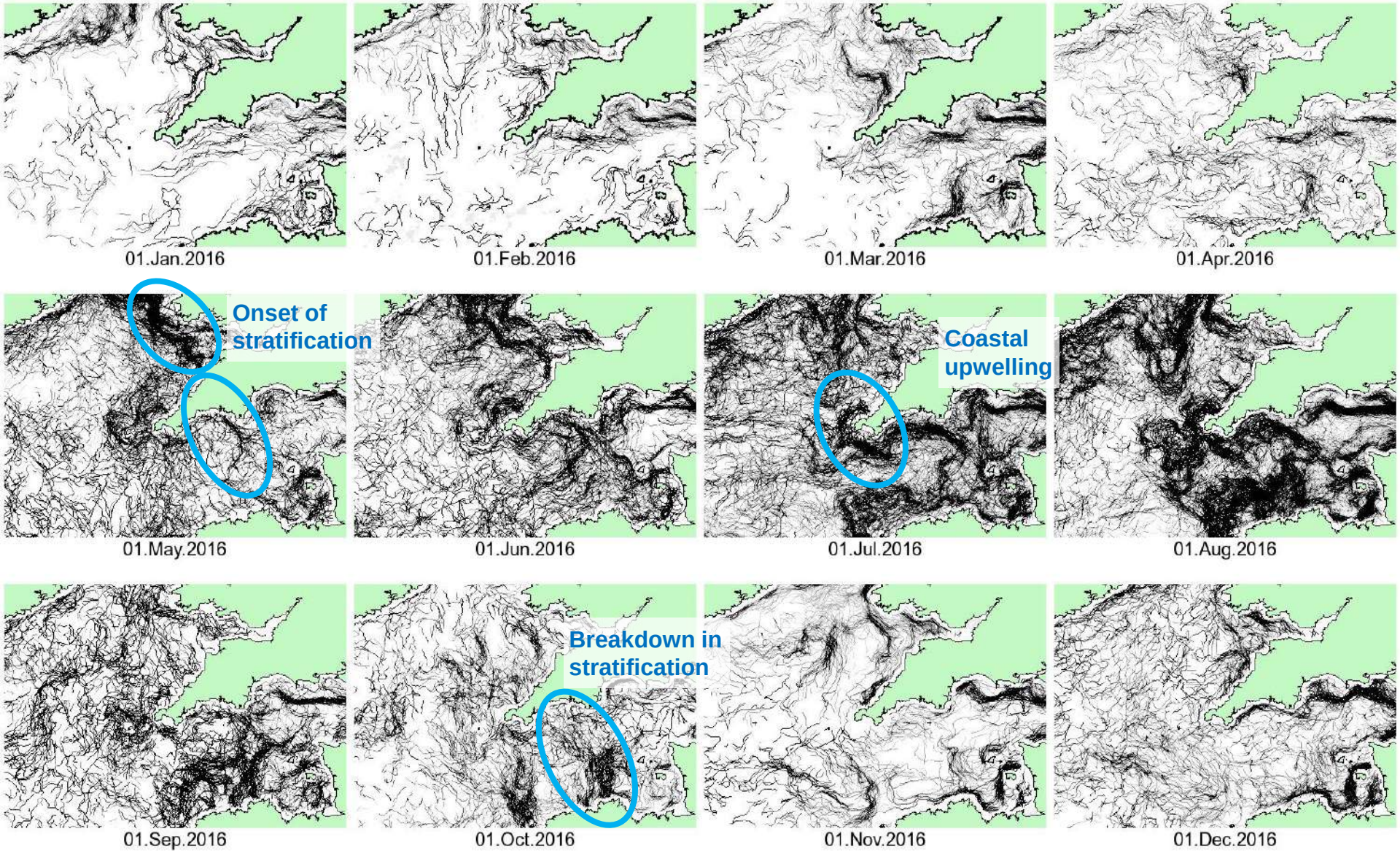
Key

Miller, P.I., Scales, et al. (2015) Basking sharks and oceanographic fronts: quantifying associations in the north-east Atlantic. *Functional Ecology*

Satellite environmental drivers for hotspots

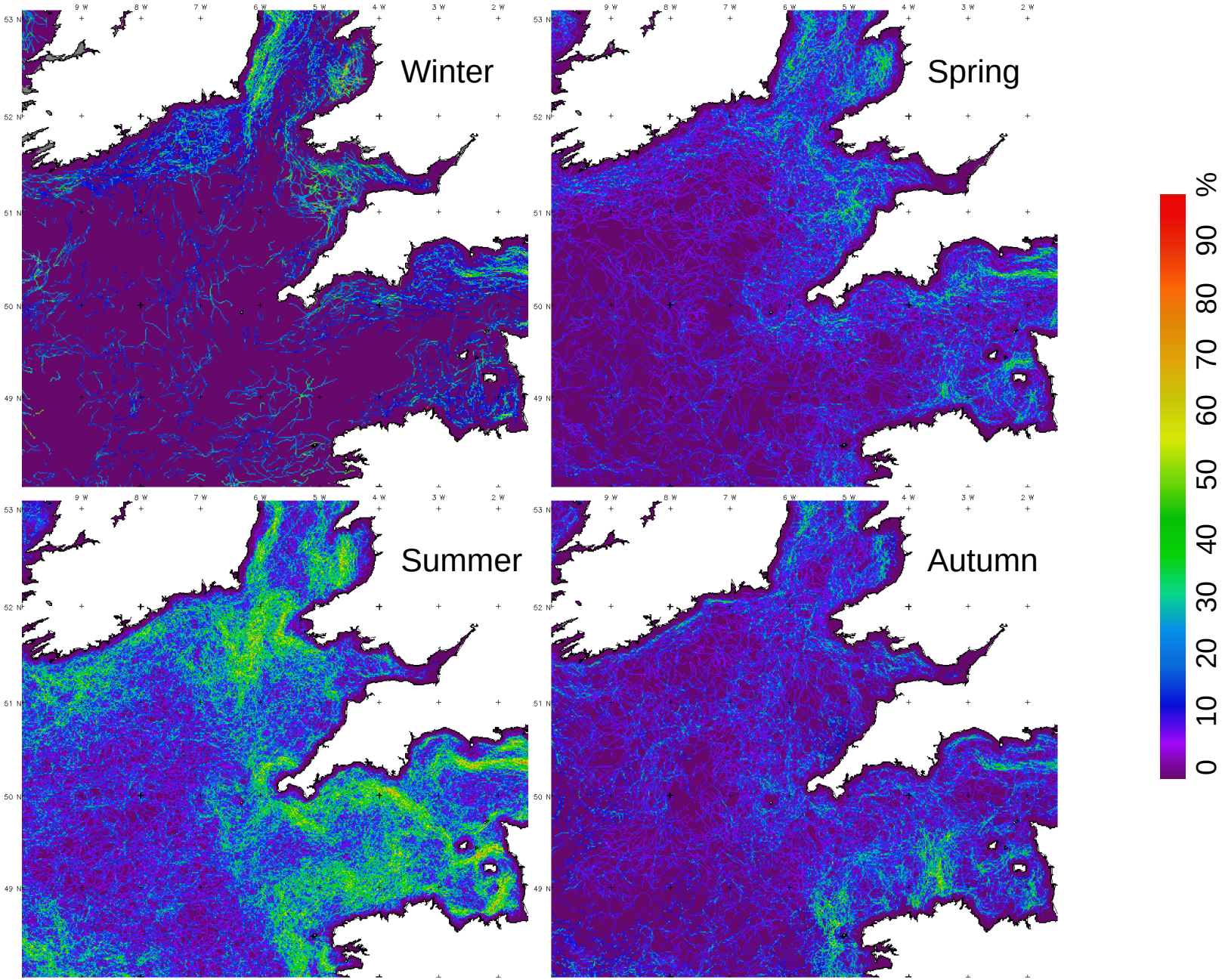
- Introduction to satellite products for ecology
- Environmental drivers for 2016
- Predictions of top predator hotspots

Thermal fronts 2016

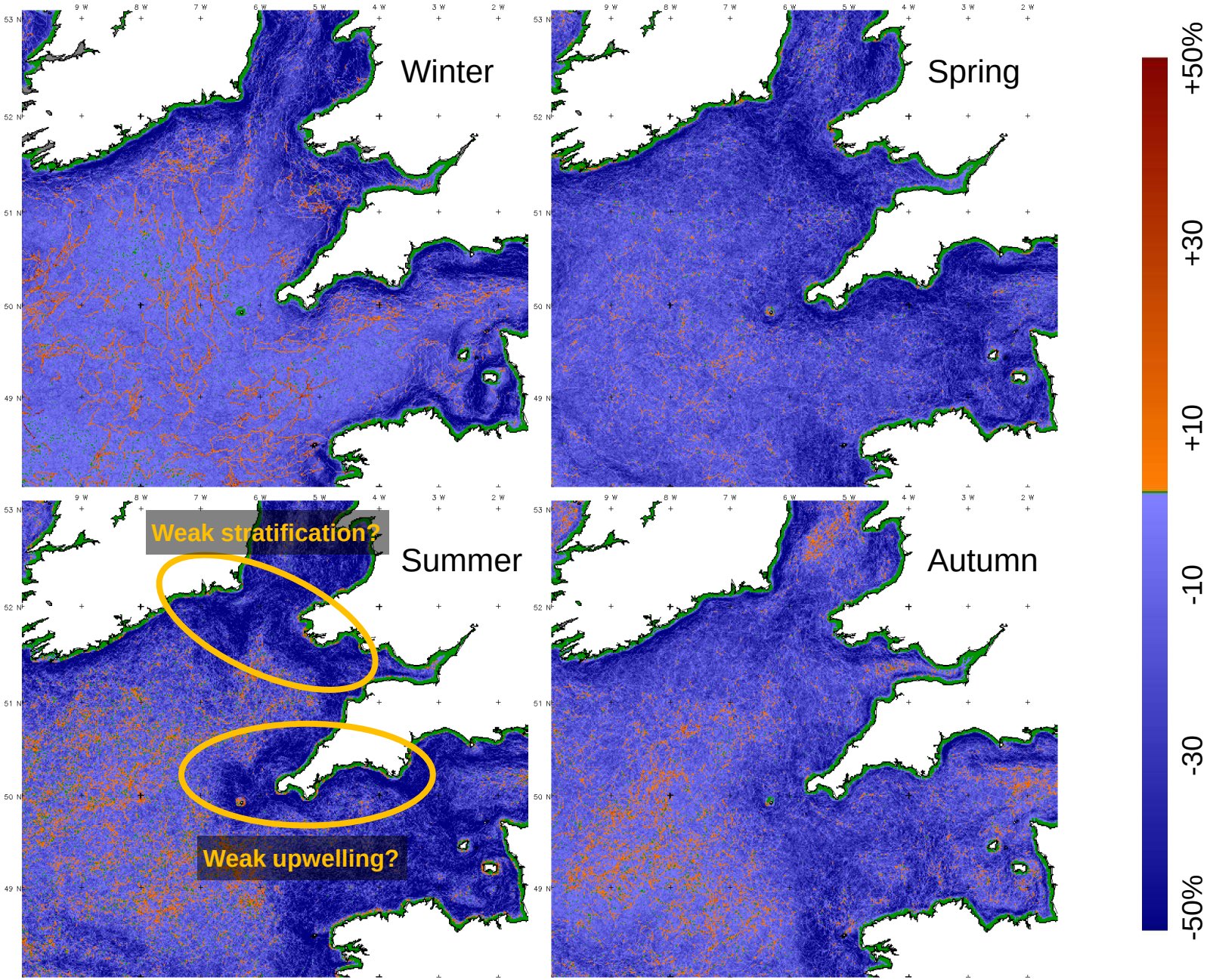


Monthly thermal front maps, from AVHRR 1km resolution daily SST data (PML)

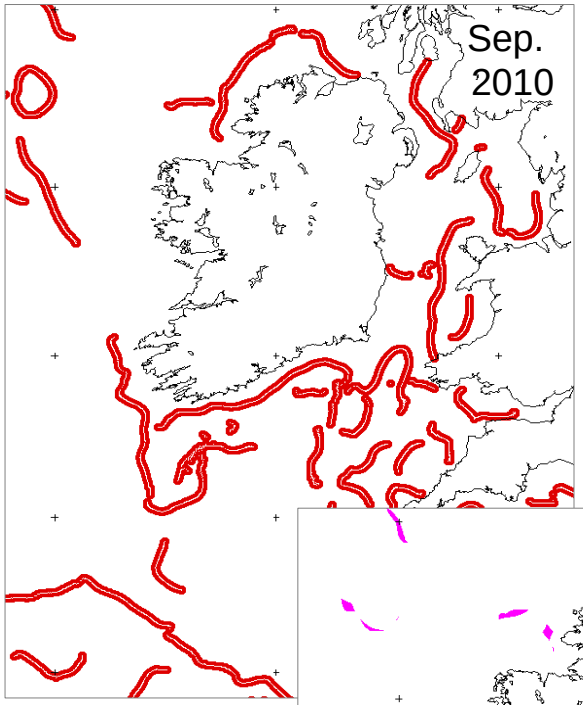
Ocean front frequency



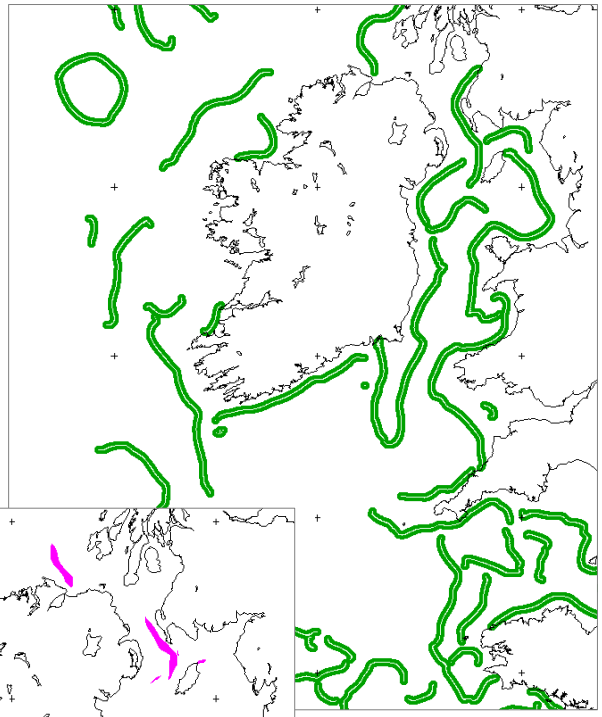
Anomaly in thermal front frequency



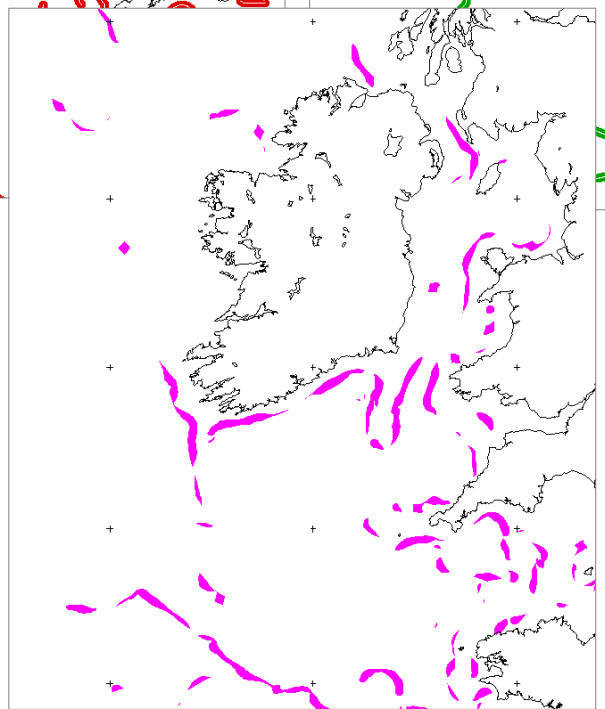
Thermal and chlorophyll front fusion



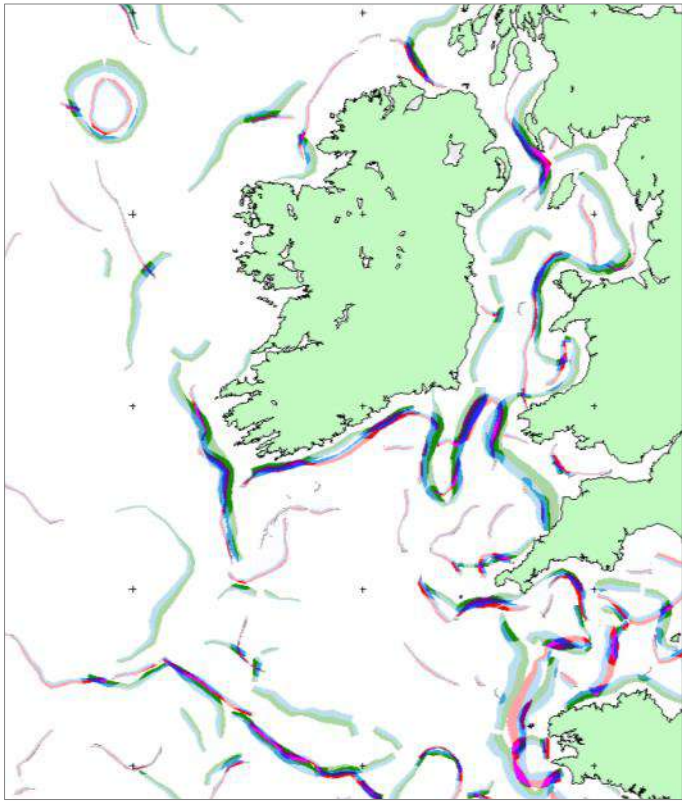
Thermal fronts
Dilated



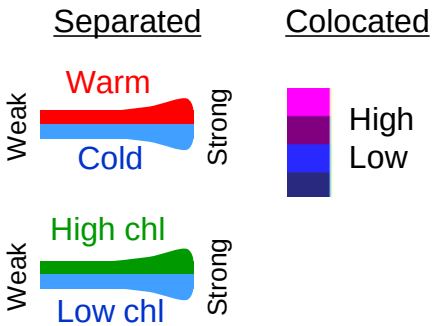
Chl-a fronts
Dilated



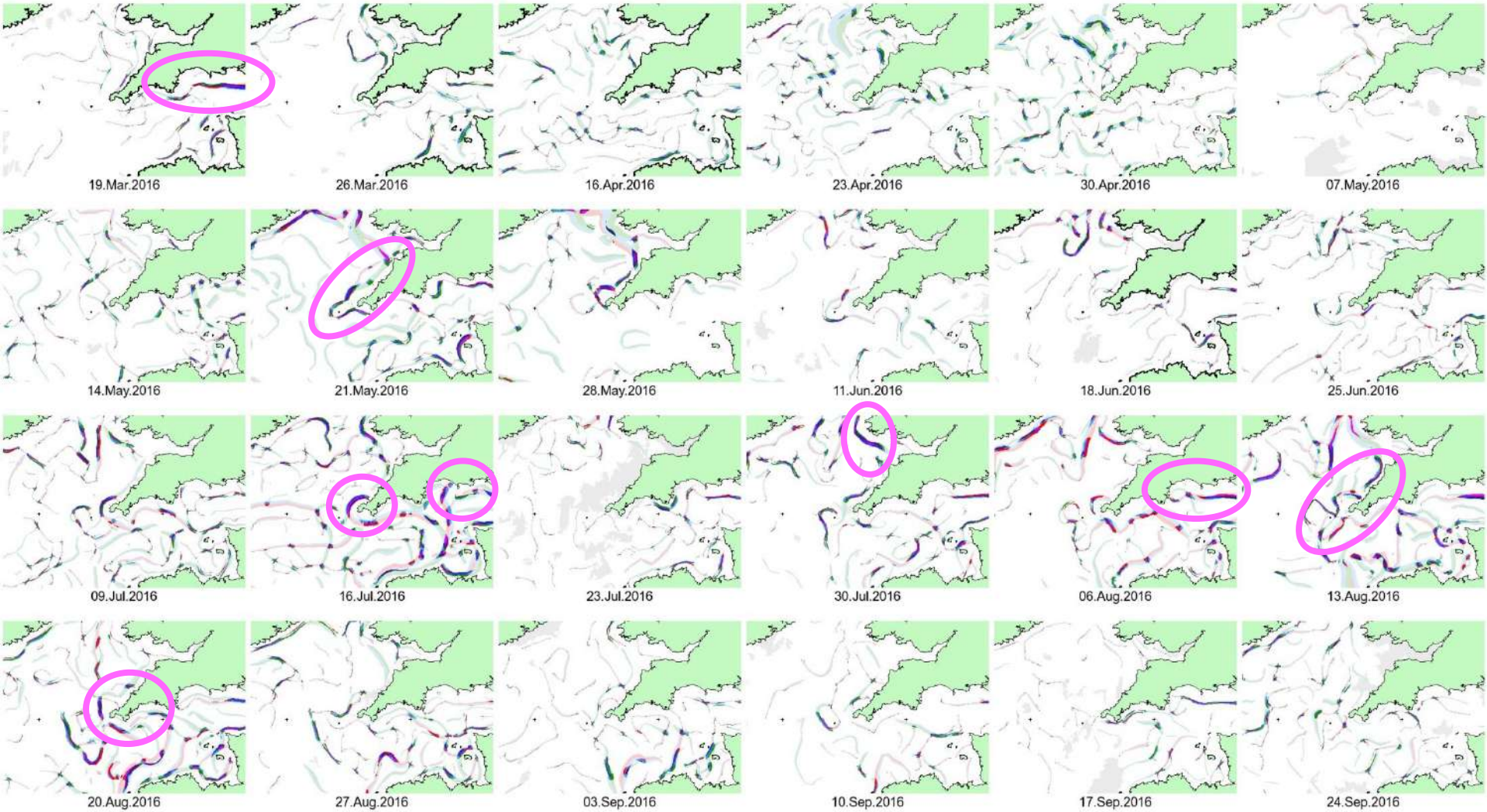
Front fusion
mask

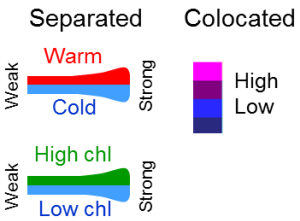


Front fusion map



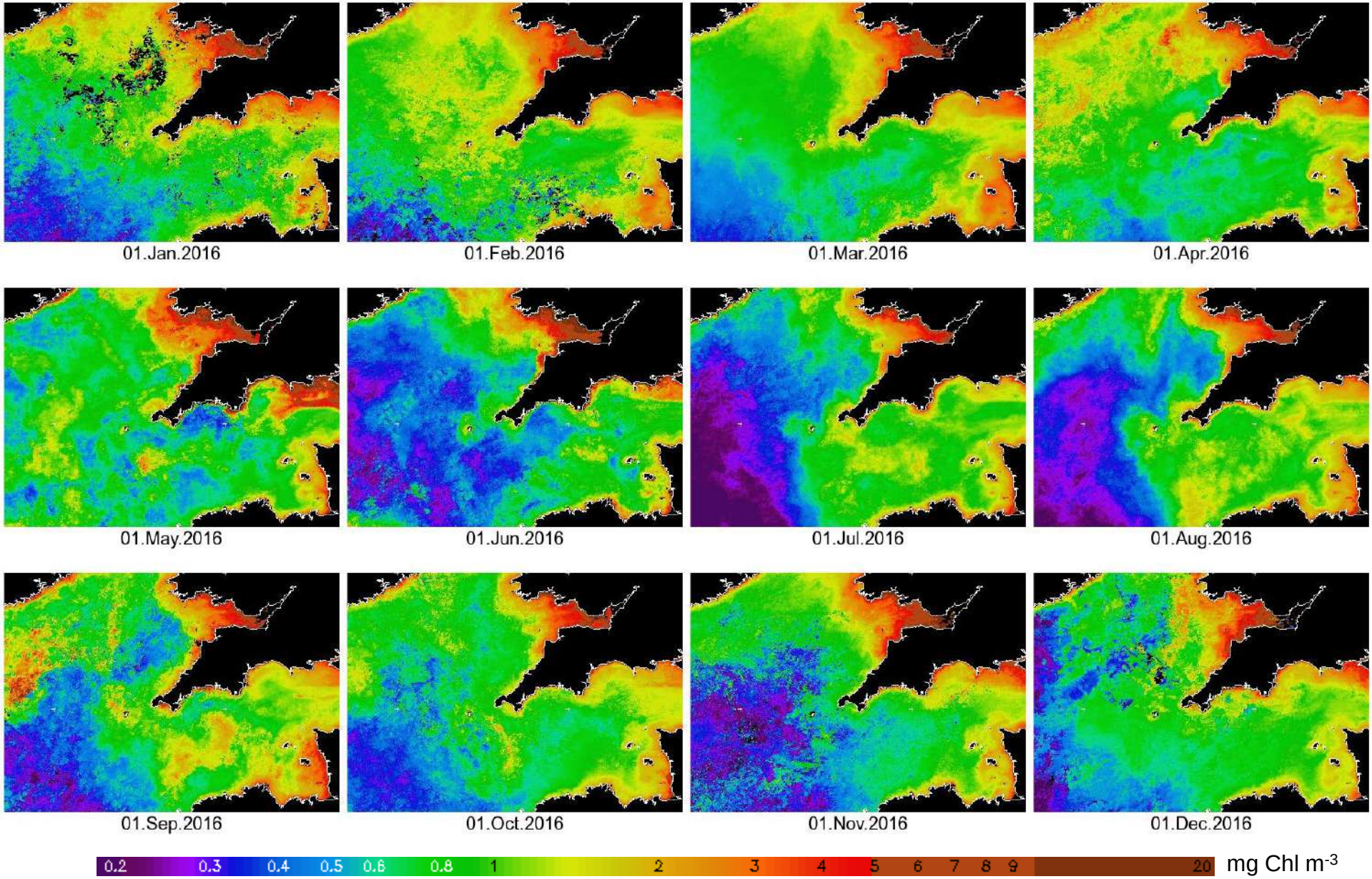
Front fusion maps - bio-active?





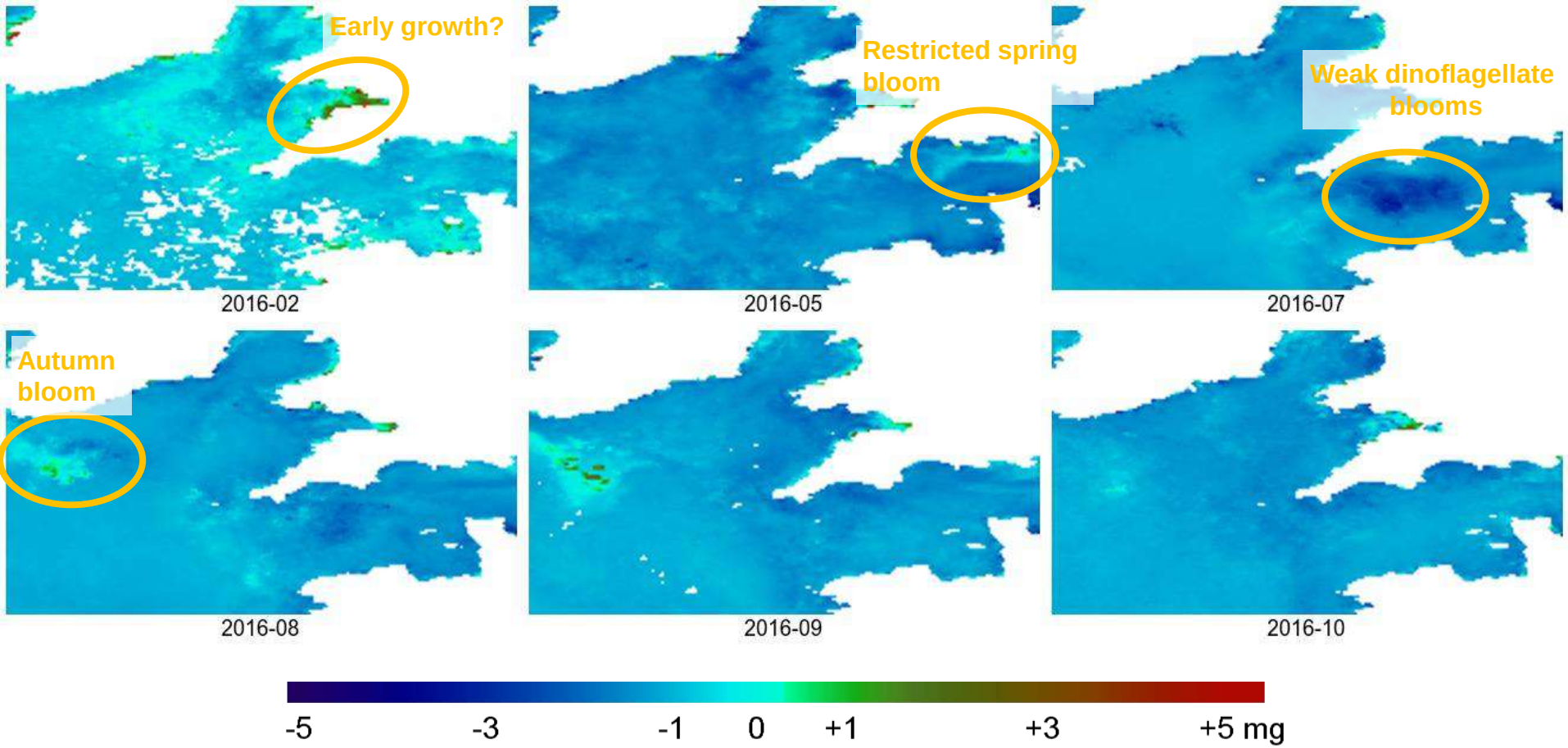
Weekly fusion of simplified thermal and chl-a front maps, from AVHRR and Aqua-MODIS 1km data (PML)

Surface chlorophyll 2016



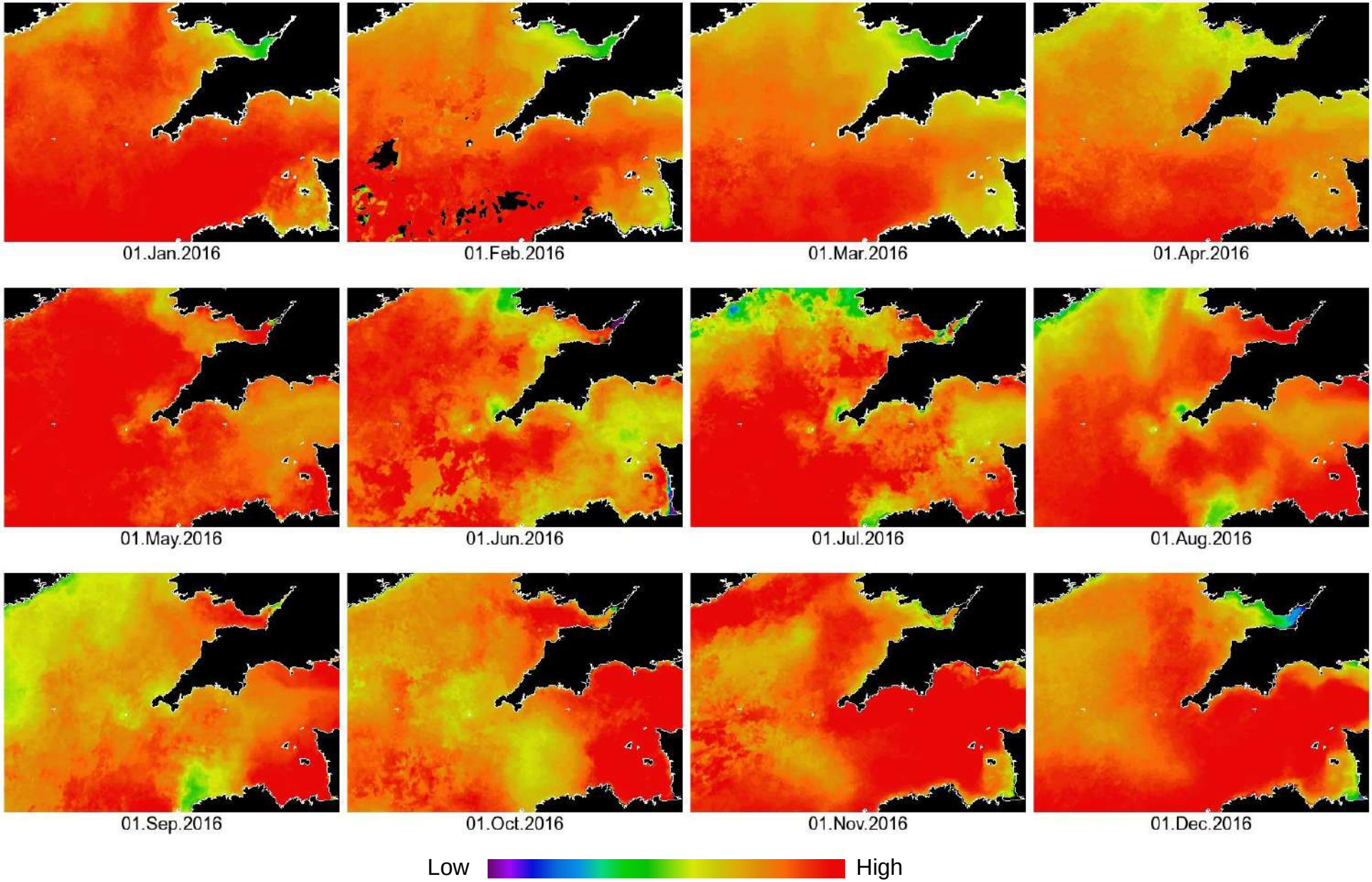
Aqua-MODIS 1km resolution OC3 chlorophyll algorithm, NEODAAS-Plymouth

Anomaly in surface chlorophyll



ESA Climate Change Initiative 4km resolution monthly anomaly based on monthly climatology (v2.0, 1997-2013)

Sea-surface temperature 2016



AVHRR 1km resolution monthly SST composites, variable colour scale, NEODAAS-Plymouth

Satellite environmental drivers for hotspots

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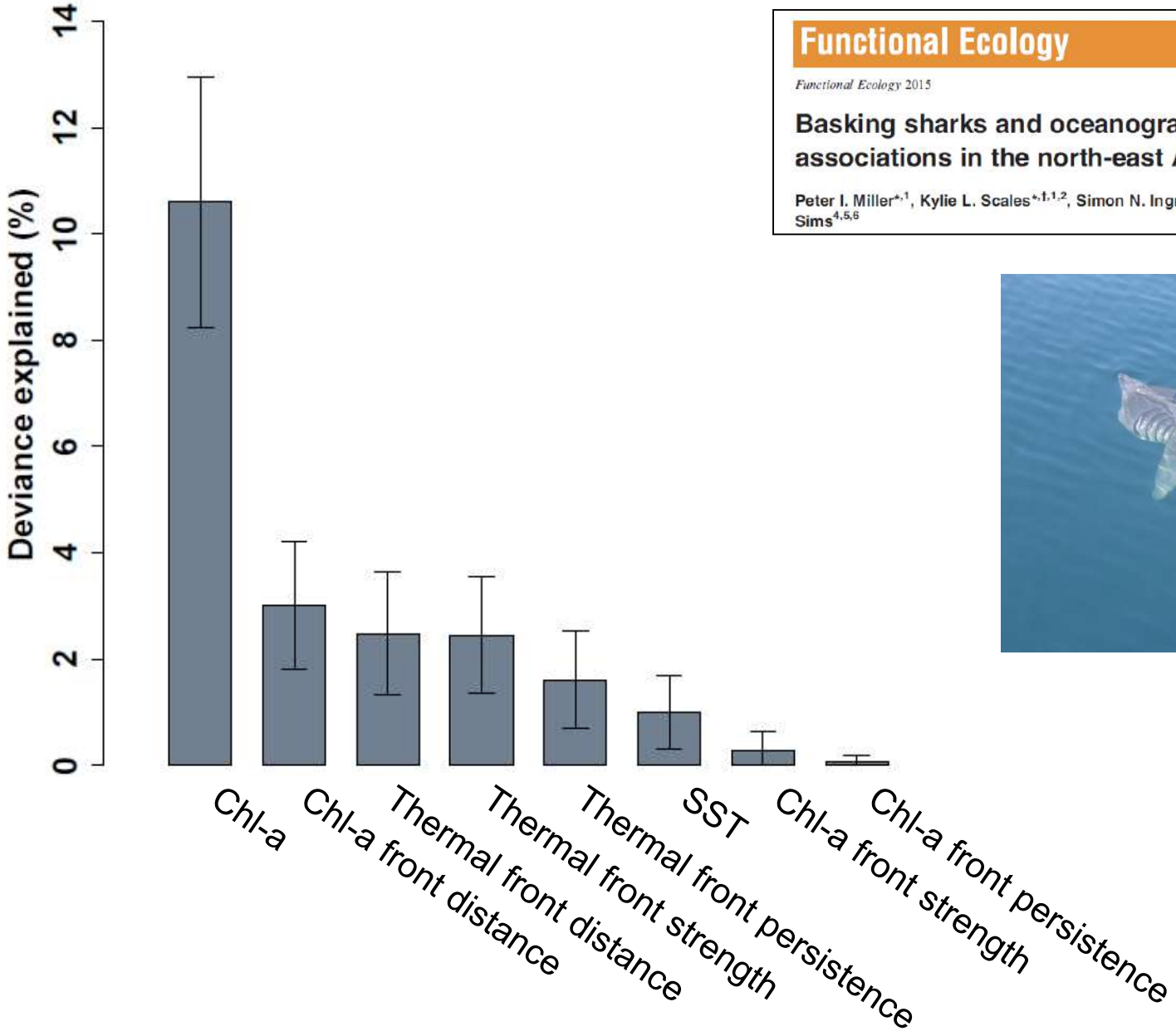
Predicting basking sharks habitat



Functional Ecology

Functional Ecology 2015 doi: 10.1111/1365-2435.12423

Basking sharks and oceanographic fronts: quantifying associations in the north-east Atlantic

Peter I. Miller*[,1], Kylie L. Scales*[,1,1,2], Simon N. Ingram[3], Emily J. Southall[4] and David W. Sims[4,5,6]

Predicting dolphin habitat

- Broad-scale foraging:
  - Seasonal;
  - Seabed slope;
  - Shelf-sea front density.

- Fine-scale foraging:
  - Seasonal;
  - Tidal mixing.

Functional Ecology

British Ecological Society

Functional Ecology 2014, **28**, 206–217 doi: 10.1111/1365-2435.12146

Scale-dependent foraging ecology of a marine top predator modelled using passive acoustic data

Enrico Pirotta[1*], Paul M. Thompson[2], Peter I. Miller[3], Kate L. Brookes[2†], Barbara Cheney[2], Tim R. Barton[2], Isla M. Graham[2] and David Lusseau[1]

Predicting seabird habitat

- Latitude
- Longitude
- Year
- Season
- Effort
- Bathymetry
- Bathymetry spatial gradient
- Distance to coastline
- Mean chlorophyll a concentration
- Temporal change in chlorophyll a during season
- Spatial chlorophyll a concentration gradient
- Mean sea surface temperature
- Temporal change in SST during season
- Spatial sea surface temperature gradient
- Mean sea surface temperature anomaly
- Density of fronts
- Distance to front
- Mean sea surface height

Biological Conservation 156 (2012) 94–104

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Comparison of five modelling techniques to predict the spatial distribution and abundance of seabirds

Steffen Oppel [a,*], Ana Meirinho [b], Iván Ramírez [b], Beth Gardner [c], Allan F. O'Connell [d], Peter I. Miller [e], Maite Louzao [f,g]

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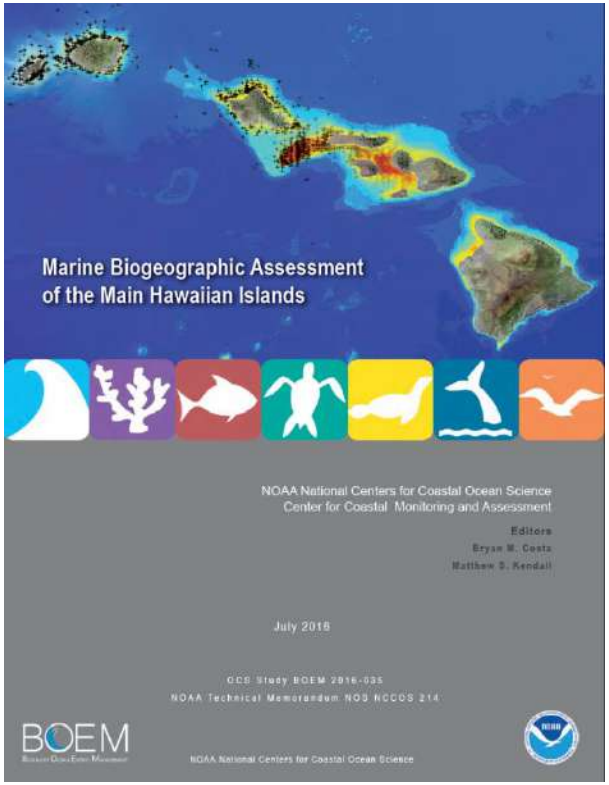
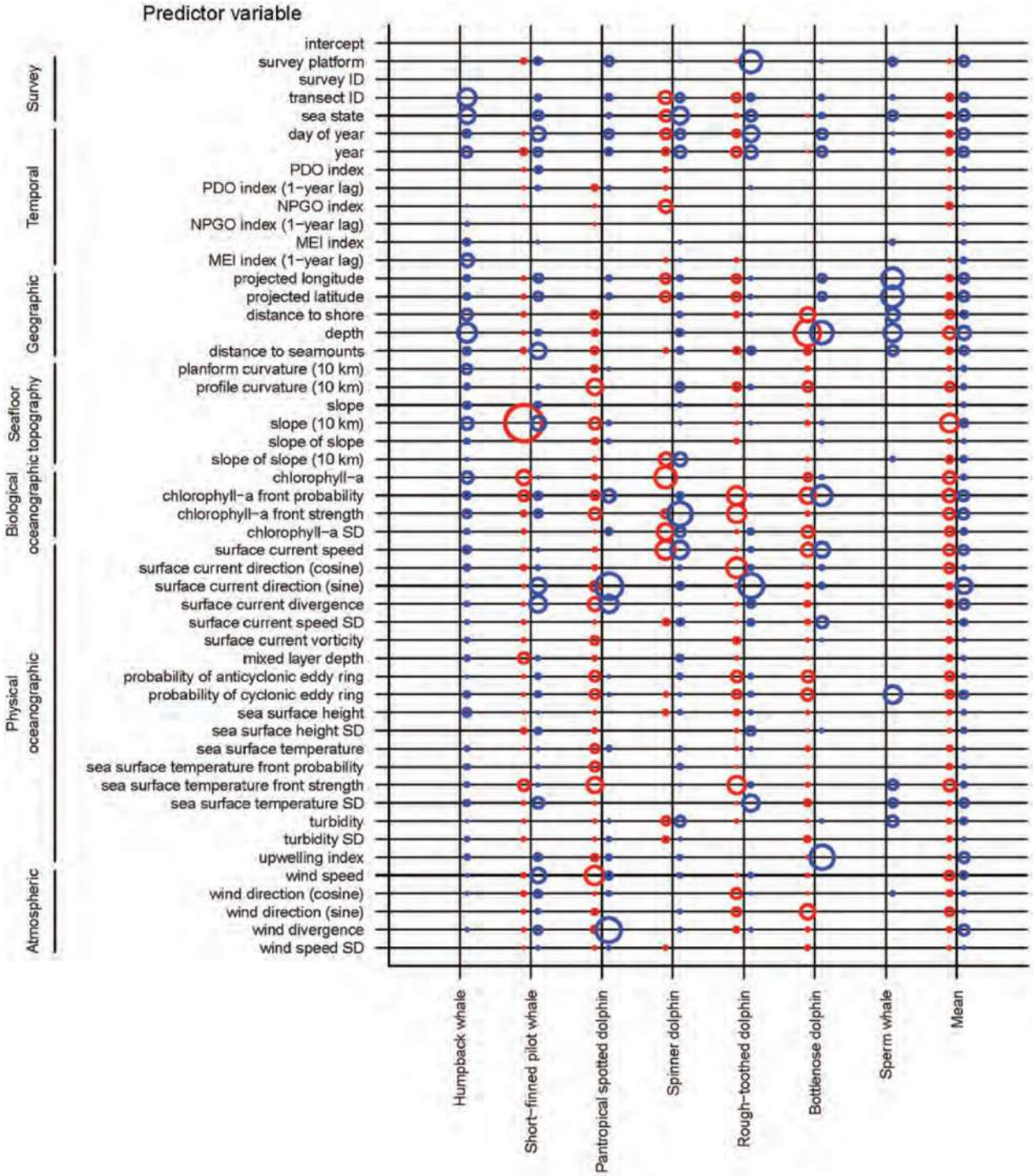
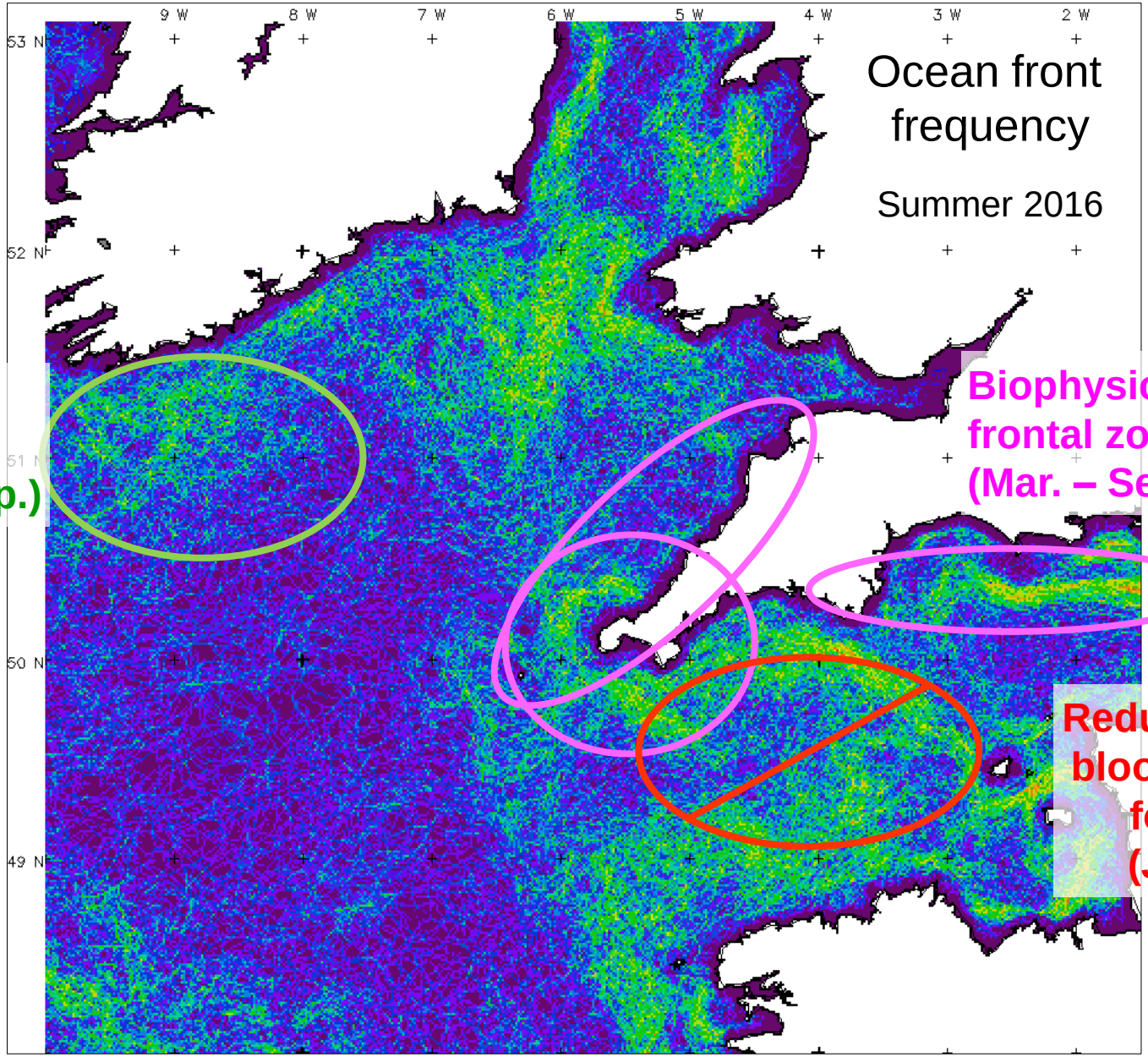
Predicting cetacean habitat





Satellite prediction of 2016 predator hotspots



Weak spring bloom (Mar.–May)

Autumn bloom (Aug.–Sep.)

Biophysical frontal zones (Mar. – Sep.)

Reduced summer blooms, limiting food chain (Jul.–Aug.)

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Satellite environmental drivers for hotspots

- Introduction to satellite products for ecology
- Environmental drivers for 2016
- Predictions of top predator hotspots
- Any questions?

Peter Miller - pim@pml.ac.uk @PeterM654

PML ocean fronts: tinyurl.com/pmlfronts

Satellite data: neodaas.ac.uk