Species Distribution Models (SDMs) for sea pen in the Flemish Cap and Flemish Pass area (Northwest Atlantic Ocean)

Standardising and development of Species Distribution Models / Habitat Suitability Models at different spatial scales, and under current and future climate scenarios.

Lisbon (Portugal). 23-25 January 2018

Mar Sacau, Ana García-Alegre, María Grazia Pennino and Pablo Durán

CENTRO OCEANOGRÁFICO DE VIGO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 678760 (ATLAS). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

OUTLINE

1. Description of the Case Study Area

2. Groundfish surveys data:

   - VME distribution
   - Implement NAFO management measures

3. Habitat and biology of sea pens

4. How SDM work

5. Species Distribution Models (SDMs) for the sea pen *Anthoptilum grandiflorum* in the Flemish Cap and Flemish Pass area

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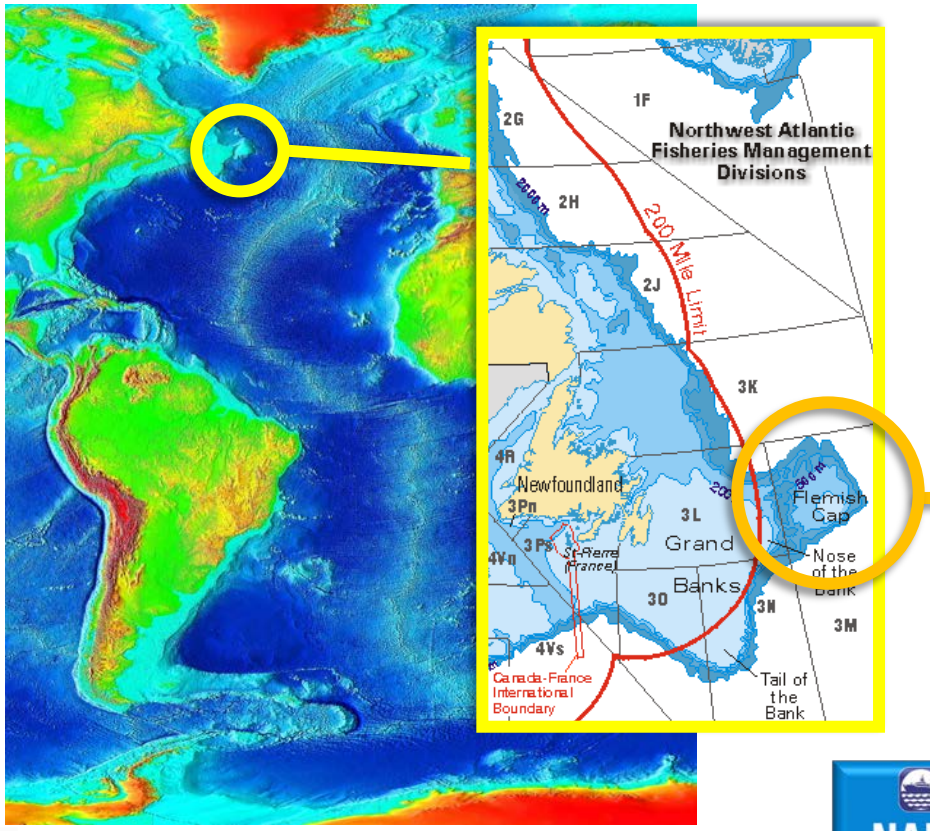
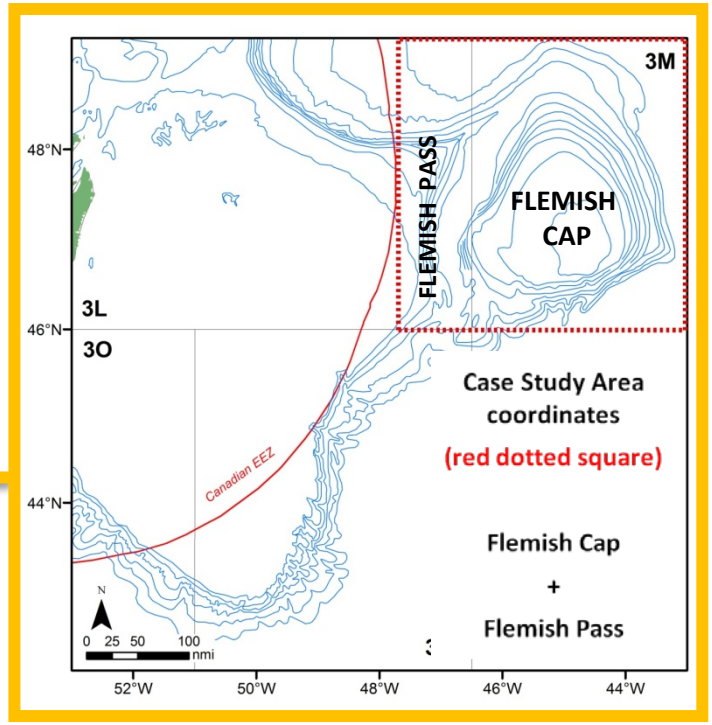
CASE STUDY 11-FLEMISH CAP

Area overview-Geographical setting





NAFO
Northwest Atlantic Fisheries Organization

Oceanic Bank (Plateau)

Located within NAFO Regulatory Area (High-seas) and separated from the Grand Banks by the Flemish Pass

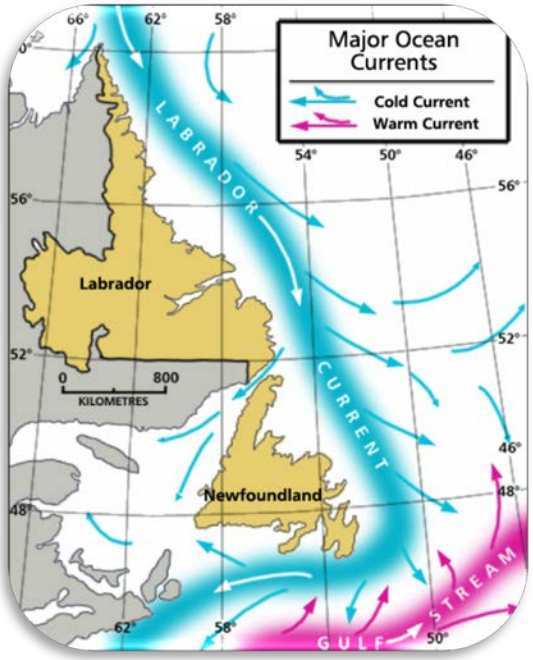
Surface: 4,870 km^2

Radius: 200 km

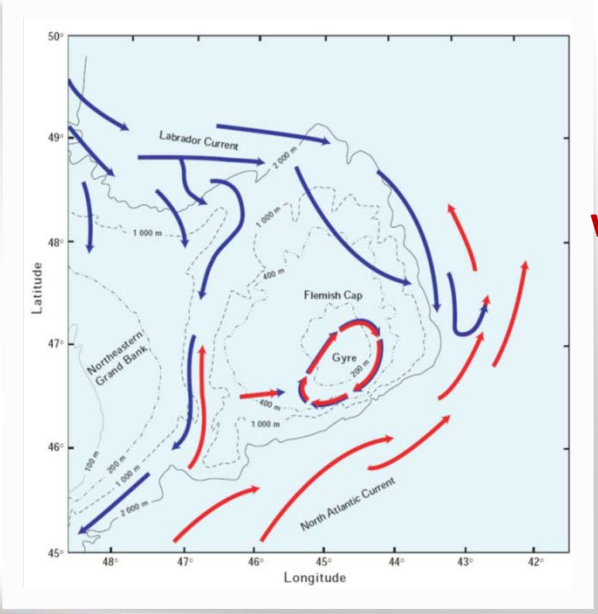
Source: García-Alegre et al. (2017)

CASE STUDY 11-FLEMISH CAP

Area overview-Water circulation



Flemish Cap is located within an area of transition between the cold subpolar waters of the **Labrador Current** and warmer waters influenced by the **Gulf Stream.**

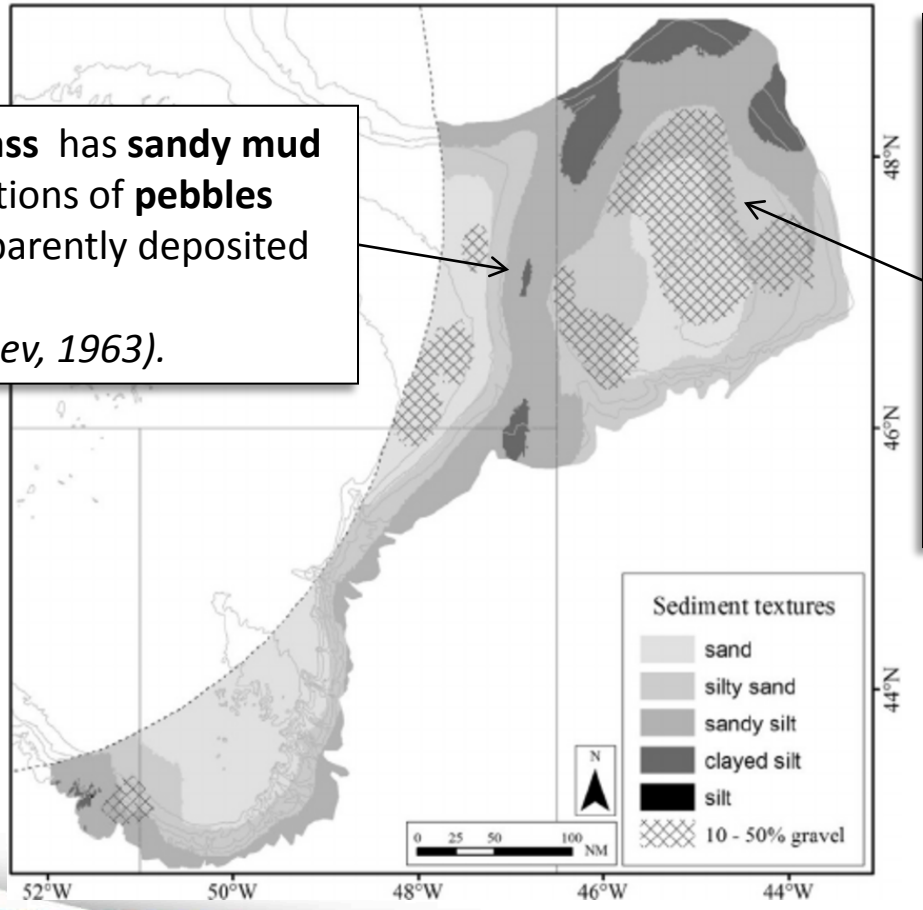


The mixing of the **colder** and **warmer** waters over the plateau produces the characteristic clockwise circulation current over the Cap.

CASE STUDY 11-FLEMISH CAP

Area overview-Surface sediments

The **Flemish Pass** has **sandy mud** with accumulations of **pebbles** and **stones** apparently deposited by icebergs.
(Litvin & Ravchev, 1963).



Most of the **Flemish Cap** is covered with **soft sediments:**

- muddy sand
- sandy mud
- a patch of sand in the central part of the Bank.

Stones are scattered in the entire area.

Sediment texture map classified according to Shepard (1954).

Source: Murillo, 2015

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EU GROUNDFISH SURVEYS

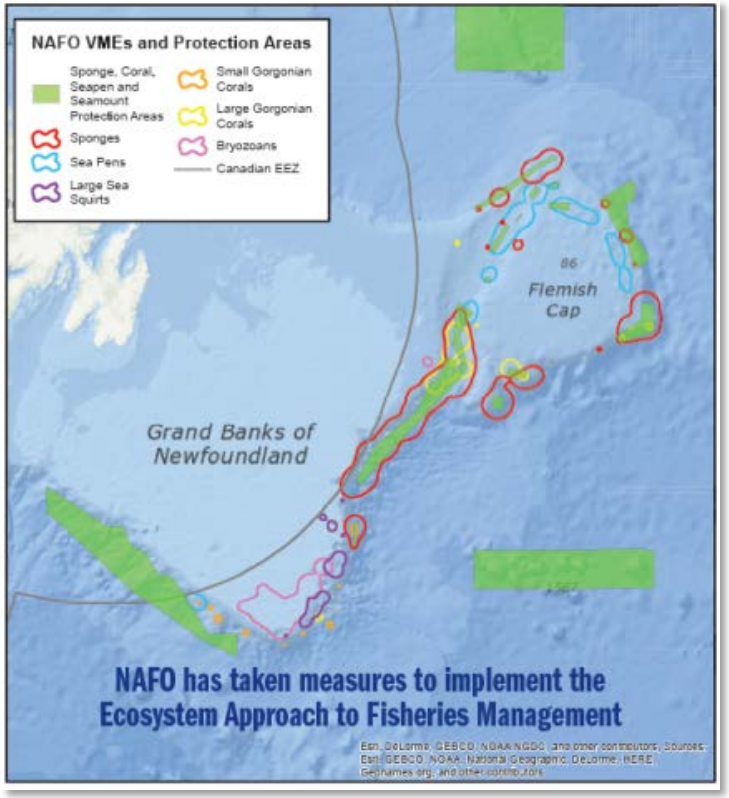
Key data

- Study the VME distribution
- Implement the NAFO management measures in this area

NAFO
Northwest Atlantic Fisheries Organization

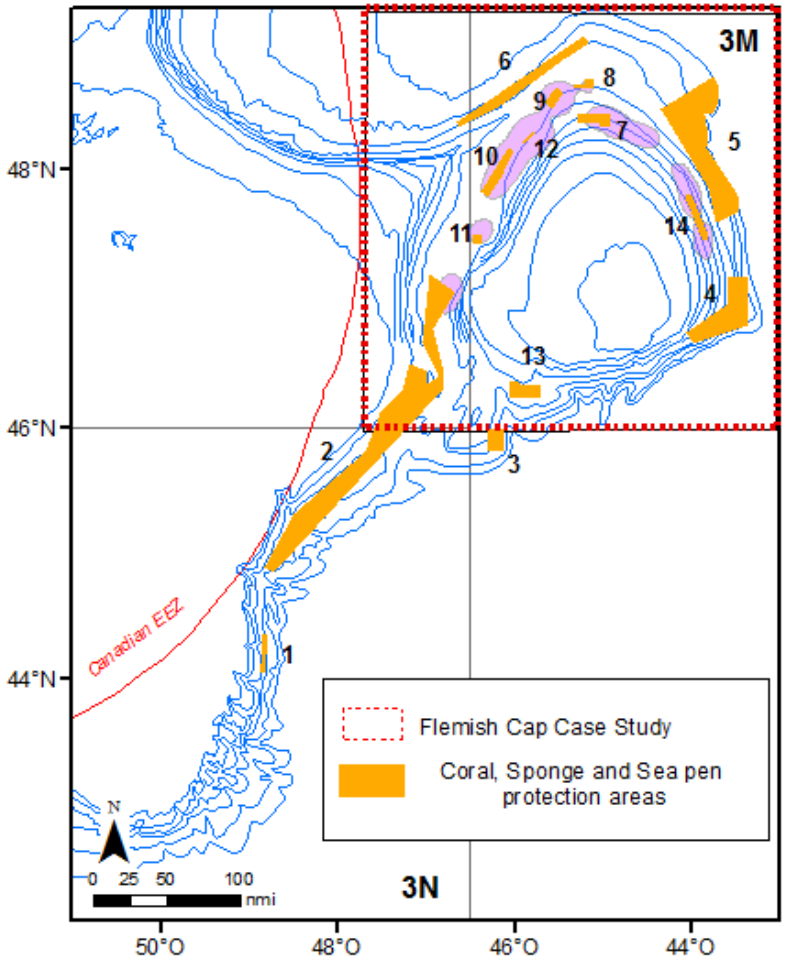
NAFO has identified 8 categories of VME

SPONGE GROUNDS
LARGE GORGONIANS
SMALL GORGONIANS
SEAPENS
ERECT BRYOZOANS
LARGE SEA SQUIRTS
CERIANTHID ANEMONES
CRINOIDS

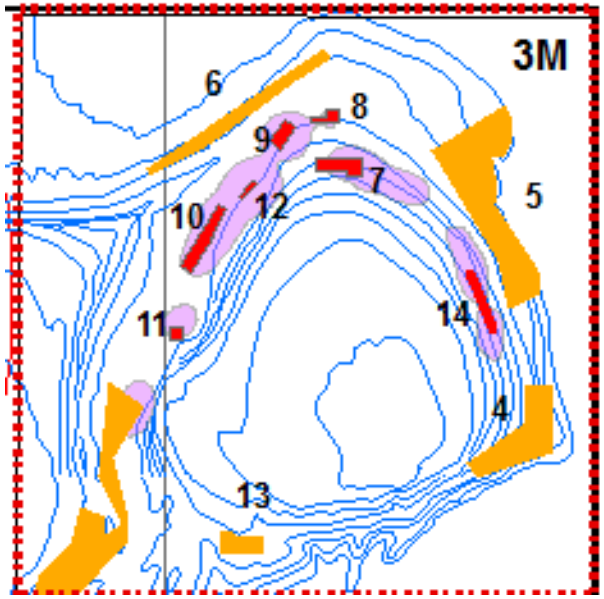


VME in the NAFO Regulatory Area

NAFO Current management measures on VMEs



Between 2010 and 2016 **fourteen closures** (**12 569 km²**) were established within this area to protect various VMEs.



7 closures (1133 km²) are covering a system of sea pens VME.

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HABITAT AND BIOLOGY OF SEA PENS

- Colonial marine cnidarians (order Pennatulacea). Morphology simple with a single stem called 'rachis' populated with feeding polyps and a bulbous base 'peduncle' which anchors the colony.

- Key structural components of soft-bottom (mud or sand) VMEs in the NRA.

- Indicator of VMEs: Conservation is essential to preserve marine biodiversity.

Photos taken from:
Northwest Atlantic Fisheries Centre (NAFC), 80 East White Hills Road, St. John's NL
vonda.wareham@dfo-mpo.gc.ca

Funiculina quadrangularis
(NL ID Code 8938)

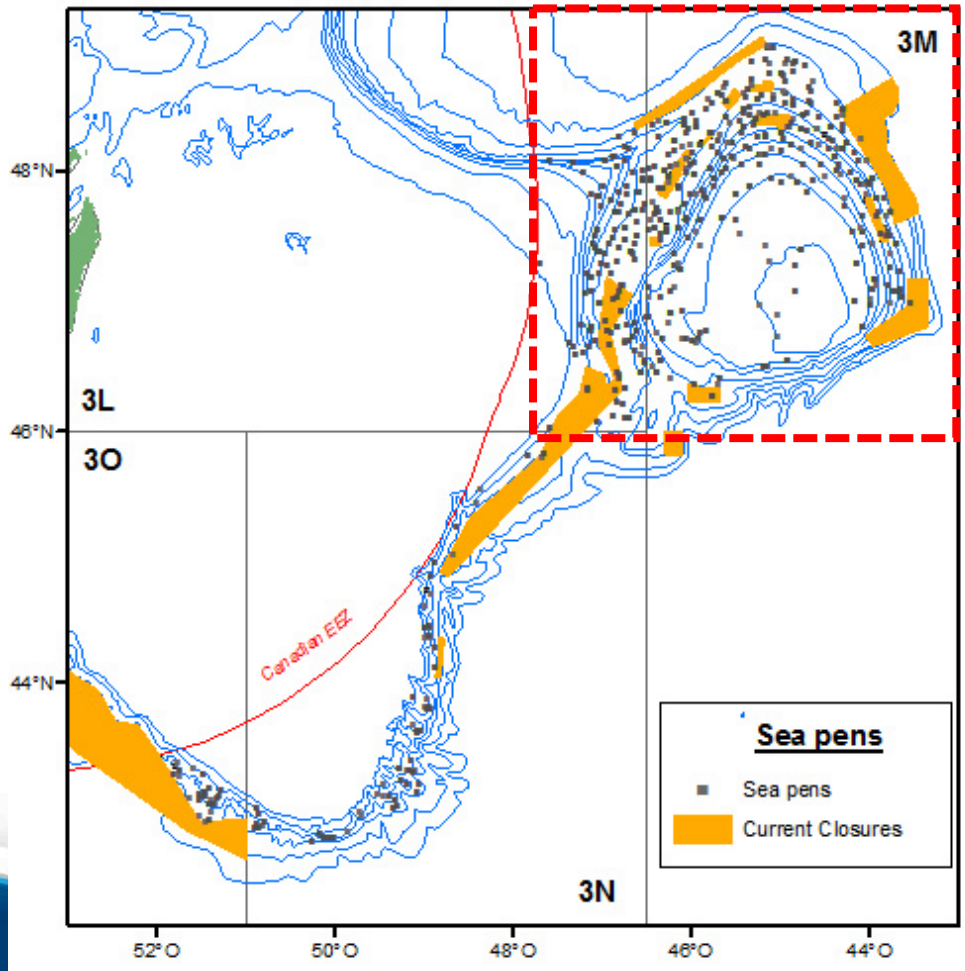
Halipteris finmarchica
(NL ID Code 8936)

Anthoptilum grandiflorum
(NL ID Code 8937)

Photo taken from NAFO WGESA 2017 report

Halipteris finmarchica (sea whip) approx. 50 cm – 100 cm in length commonly found around the northern flanks the Flemish Cap.

SEA PEN DISTRIBUTION DATA (2007-2017)



- EU Spain and Portugal Flemish Cap Survey: **Flemish Cap (Div. 3M)**
- EU-Spain 3L Survey: **Nose of the Grand Bank (Div. 3L)**

Anthoptilum grandiflorum
Depth interval: ~ 200-1370 m

Halipteris finmarchica
Depth interval: ~ 320-1370 m

Funiculina quadrangularis
Depth interval: ~ 324-1258 m

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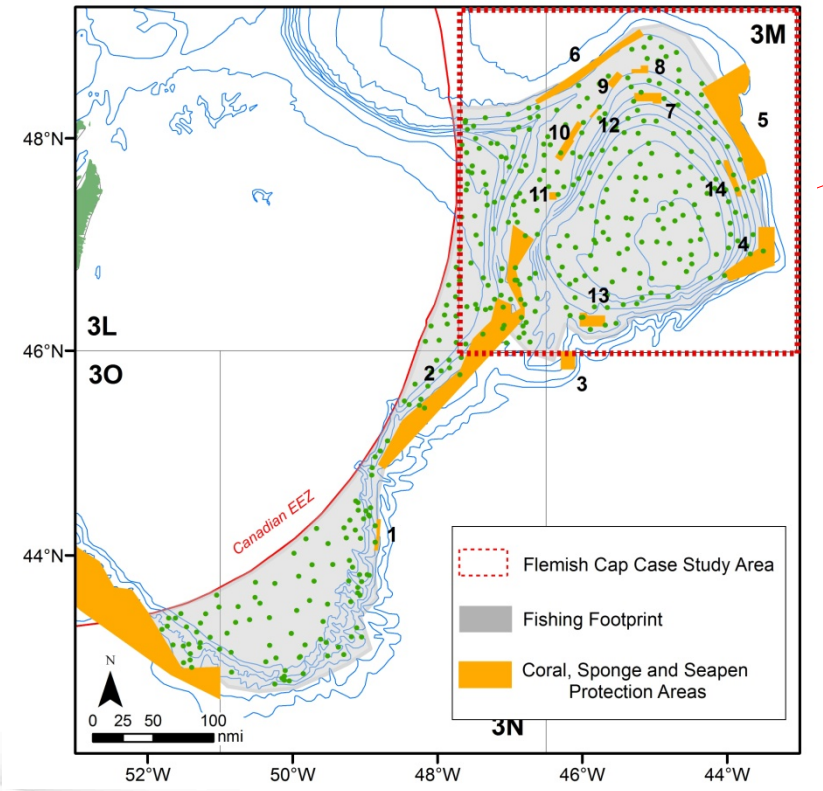
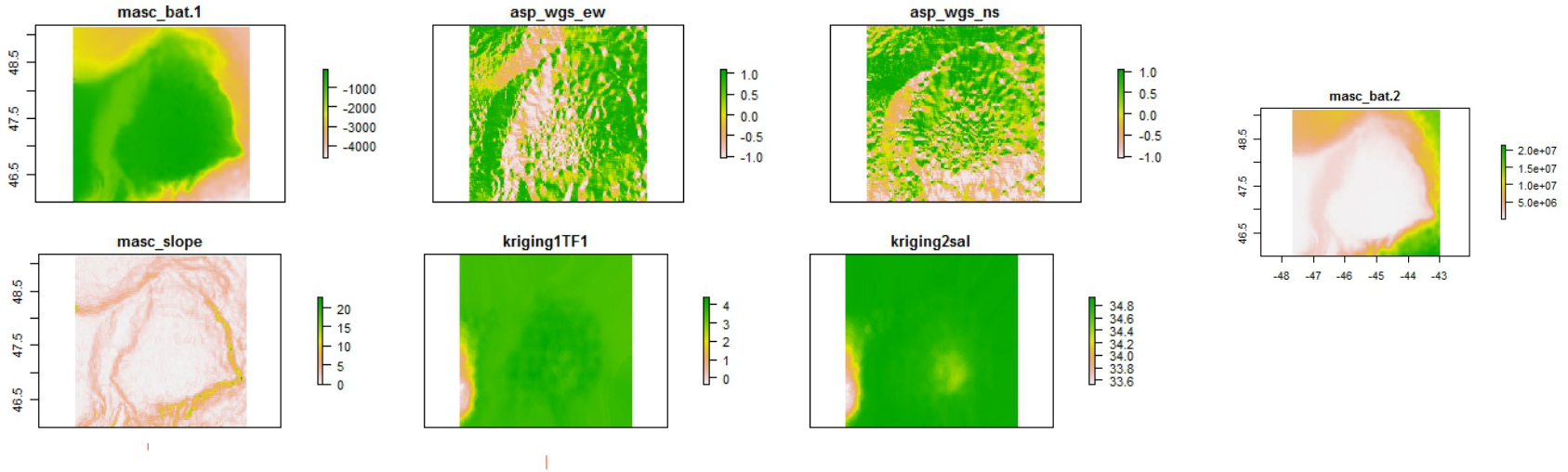
In the most general sense, here's how SDM works!

(1) Locations of occurrence of a species are <u>compiled</u>:



LON	LAT	WEIGHT	PRES
-46.54603	47.26116	0.242409486	1
-45.18167	46.60250	0.000000000	0
-47.22475	46.32708	0.000000000	0
-45.54502	48.17106	0.265283362	1
-45.71942	48.30437	0.829487371	1
-43.66000	47.32167	0.000000000	0
-47.47767	46.35658	0.000000000	0
-44.02954	48.08524	0.040835484	1

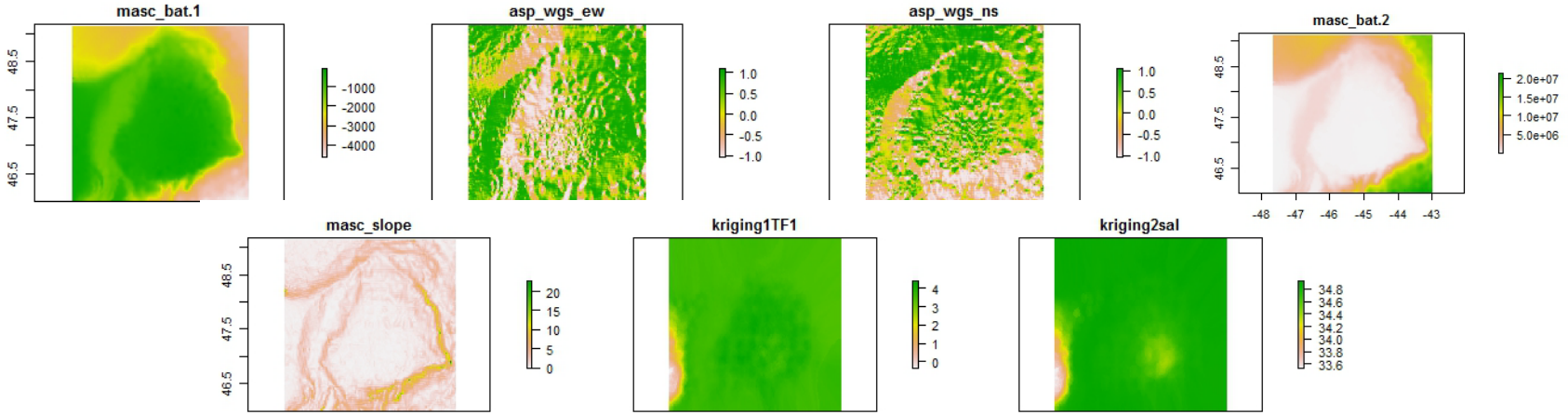
(2) Values of environmental predictor variables at these locations are extracted from raster data



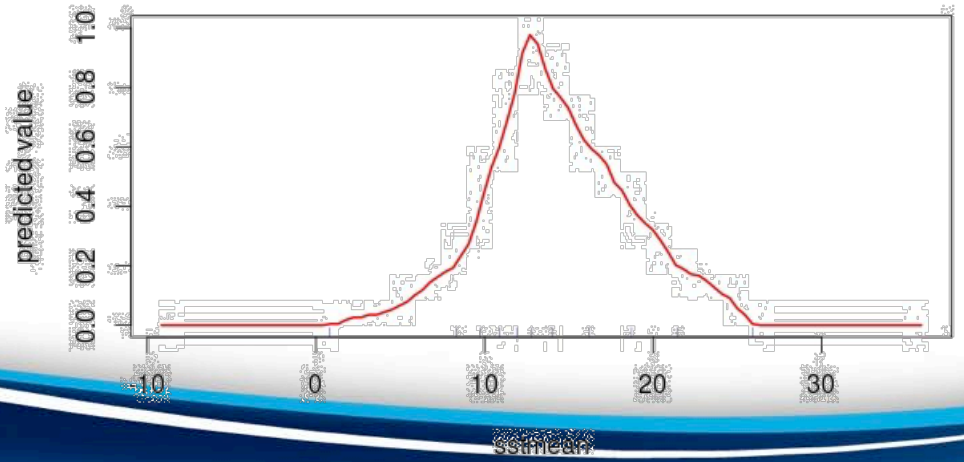
Environmental values for each location

Lon	Lat	PesoT	pres	masc_bat.1	asp_wgs_ew	asp_wgs_ns	masc_slope	kriging1TF1	kriging2sal	masc_bat.2
-44.83417	47.38083	0.000000000	0	-185.9413	0.93877946	-0.287788693	0.19583070	3.7054894	34.60584	34574.16
-45.90083	46.85750	0.000000000	0	-290.9620	0.62654740	-0.775350811	0.07840865	3.9830651	34.83067	84658.89
-45.93699	47.58487	0.110468464	1	-407.1042	-0.84042254	0.538590610	0.35721549	4.0494967	34.85781	165733.83
-44.01167	47.50583	0.119000000	1	-471.7993	0.75729803	0.647029576	0.49415056	4.0076795	34.87114	222594.60
-47.56858	47.87175	0.000000000	0	-333.7332	0.81912881	0.530054551	0.37282085	3.0832529	34.61917	111377.87
-46.60083	46.97250	0.028000000	1	-575.0803	-0.99320559	0.109179542	2.32596805	3.6939640	34.86914	330717.35
-45.80293	48.44899	0.153667459	1	-1192.1396	-0.93119398	0.341506007	0.58701918	3.5479038	34.87935	1421196.85
-45.89885	48.23524	0.027054793	1	-1023.8333	-0.12169373	0.992505031	0.77145164	3.6097877	34.86917	1048234.55

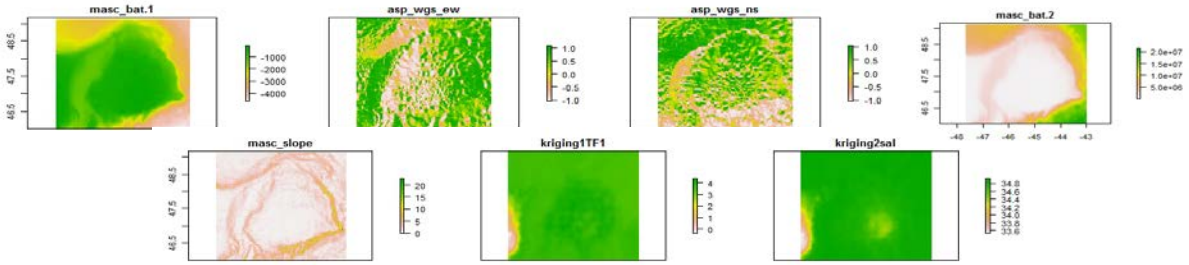
(3) The environmental values are used to fit models to understand the relationship among species and variables.



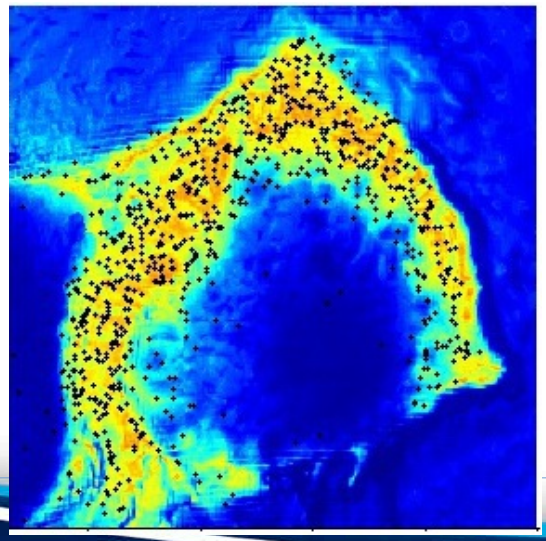
$$p(x) = e^{(\lambda_1 x_1 + \ldots + \lambda_n x_n)}$$



(4) Once we know the relationship among species and the environmental variables we can extrapolate it and predict the probability of occurrence of the studied species in the entire area on interest.



$$p(x) = e^{(\lambda_1 x_1 + \ldots + \lambda_n x_n)}$$



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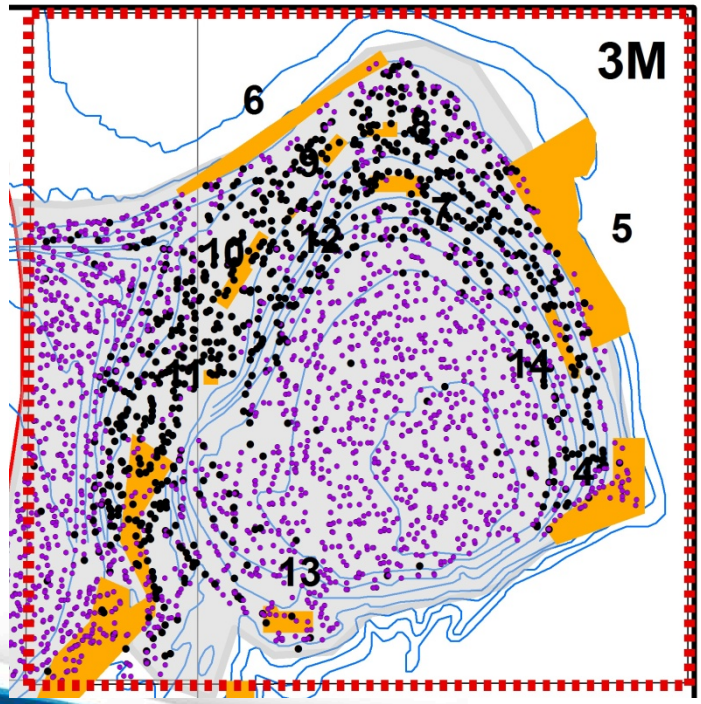
DATA USED TO RUN THE SDM

Anthoptilum grandiflorum (2007-2017)

- PRESENCES (n= 879)
- ABSENCES (n=2159)

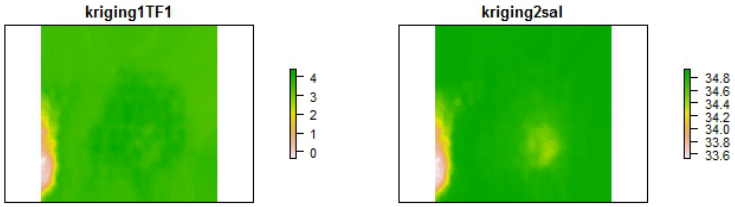


Anthoptilum grandiflorum
(most common species around Flemish Cap)

Environmental data:

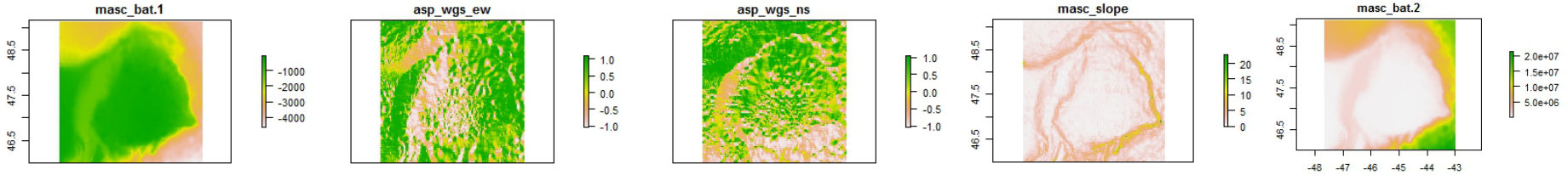
- Oceanographic variables: Bottom Temperature and Bottom Salinity.

CTDs 1988-2017. From Flemish Cap and Flemish Pass Surveys



Resolution: ~ 1 km

- Bathymetric features: bathymetry (from *www.marspec.org)*, slope, and orientation of the seabed.



Resolution: ~ 1 km

A number of **alternative modeling algorithms** have been applied to our data:

Presence-only data:

BIOCLIM

Maximum Entropy (MAXENT)

Presence/absence data:

Regression models:

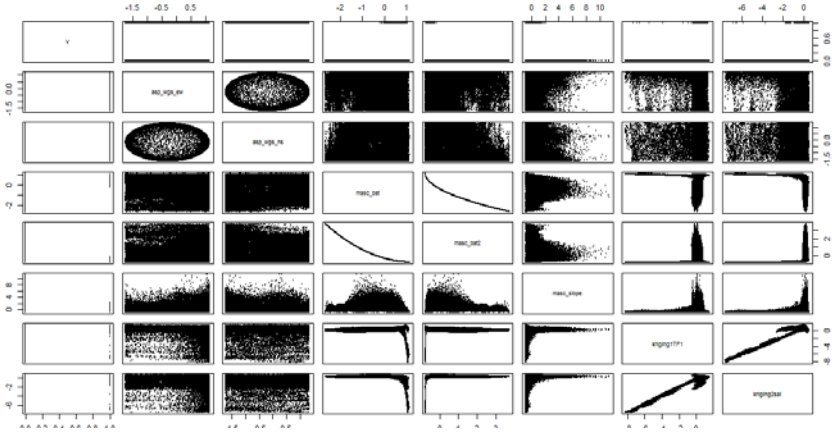
- Generalized Linear Models: (GLMs),
- Generalized Additive Models (GAMs)
- Generalized Additive Mixed Models (GAMMs),
- Boosted Regression Trees (BRTs),
- Bayesian approach

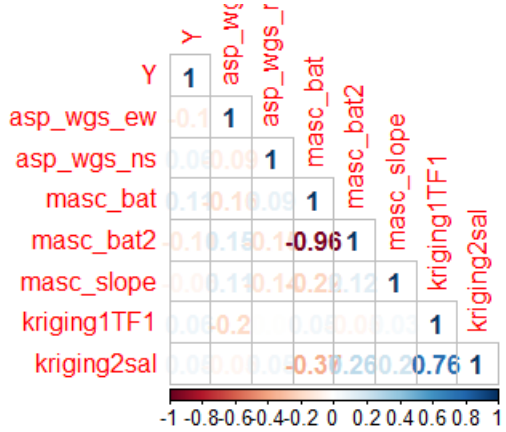
Before running the models…

Explanatory analysis on:

- **Collinearity**
- **Correlation**
- **Linearity**

Of the variables





Model selection

To “implement” the model selection you need:

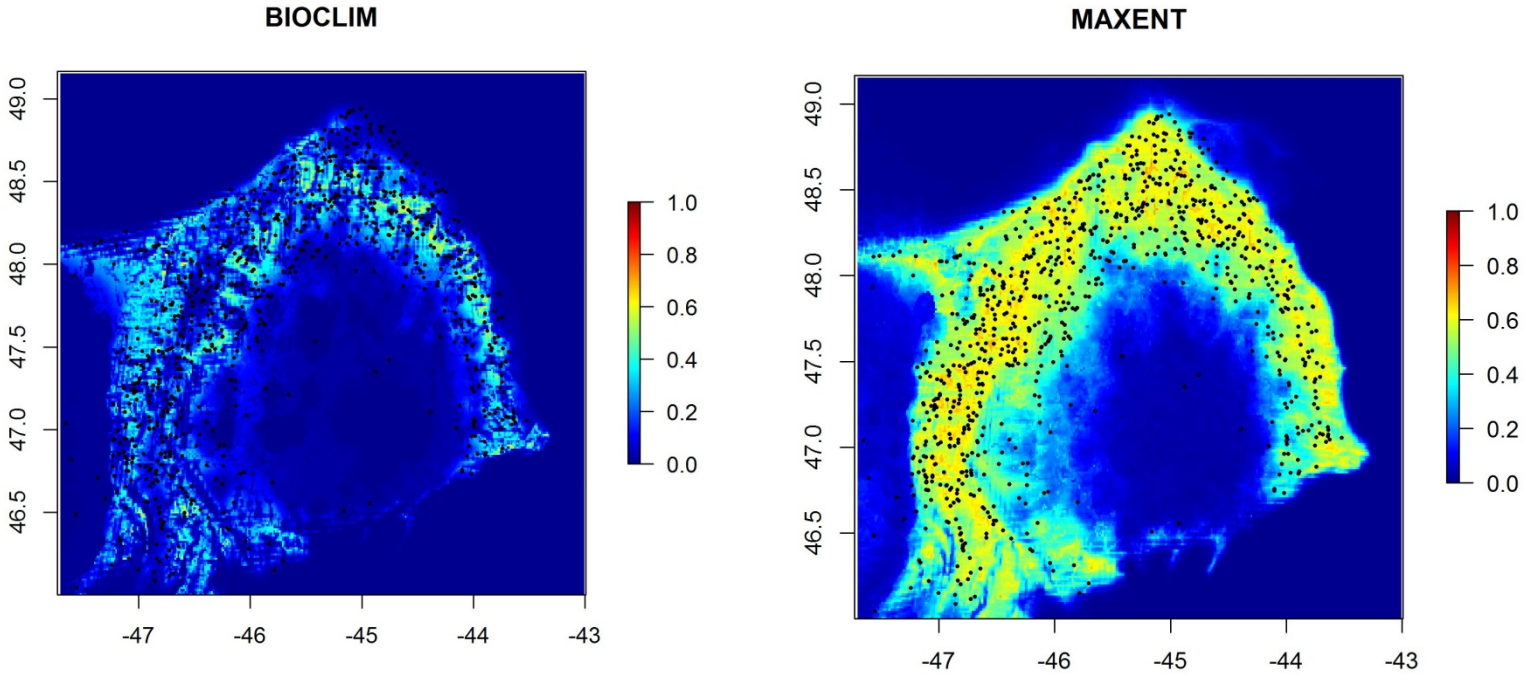
-**Check multicollinearity between predictors** (e.g. Draftsman’s plots, Pearson correlation index, Variance inflation factor (VIF));

-**A criterion to compare models** (e.g. Akaike’s Information Criterion (AIC), R2, Deviance Information Criterion (DIC))

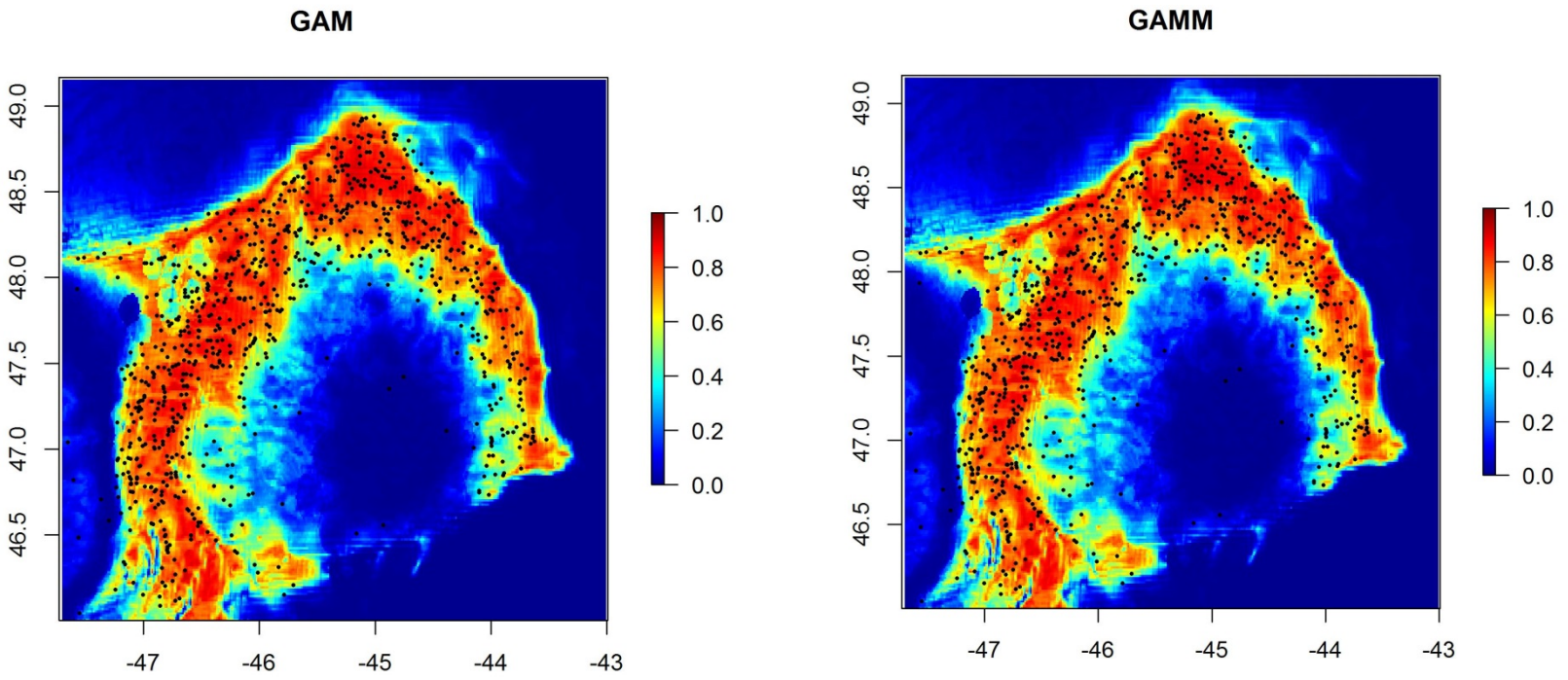
Aim: find the best compromise between fit and complexity.

Preliminary Results

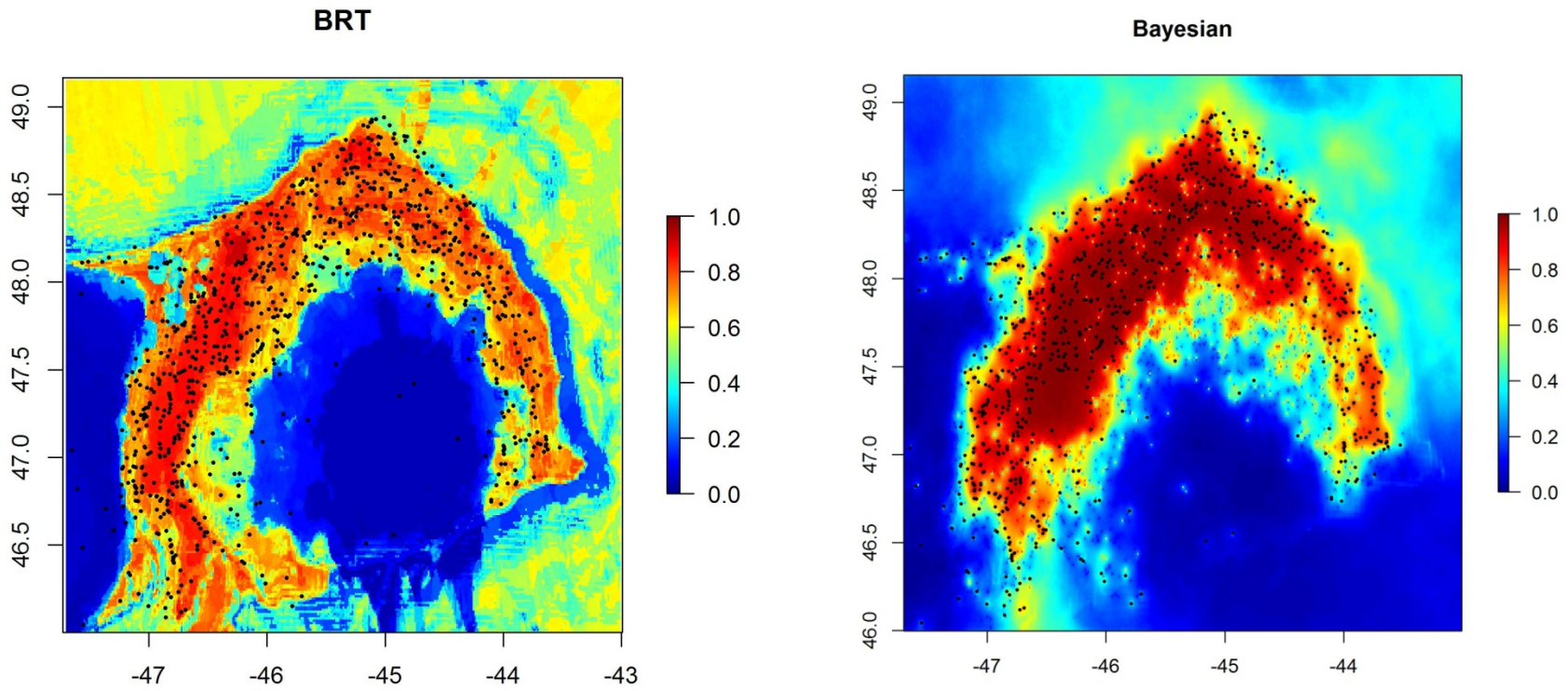
Maps below show preliminary Species Distribution Modeling (SDM) results obtained for the *Anthoptilum grandiflorum* deep-water pennatulacean coral in the Flemish Cap and Flemish Pass area together with presence records (black dots).



BIOCLIM and MAXENT model result for *Anthoptilum grandiflorum*



GAM and GAMM model results for *Anthoptilum grandiflorum.*



BRT and Bayesian model results for *Anthoptilum grandiflorum*

Which model is the best ?

Model Evaluation (needed to verify how good the prediction is):

-See the correlation among predicted and observed occurrence

-Cross-validation:

Training dataset (~ 80% of the observations)	Validation dataset (the remaining ~20%)
↓	↓
Used to run the model again and find the relationship between the species occurrence and environmental variables	Used to verify how much of the predicted presences and absences were really observed

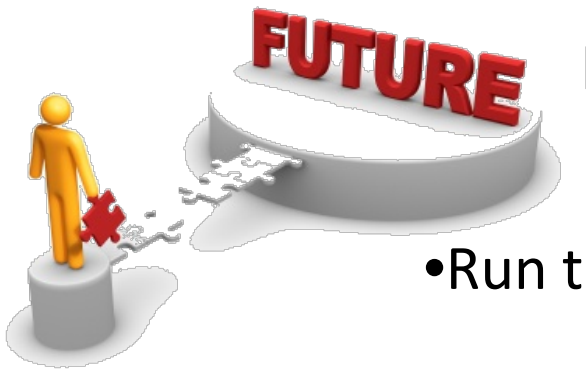
Quality of the prediction:
- AUC (from 0 to 1)
- True Skill Statistics (TSS). From -1 to +1

Which model is the best ?

AUC , True Statistic Skills (TSS) and correlation of the different models

	AUC	TSS	r
MAXENT	0.83	-	-
GAM	0.82	0.32	0.51
GAMM	0.82	0.32	0.46
BRT	0.83	0.33	0.56
B-HDM	0.85	0.36	0.6

Aim: find the best compromise between fit and complexity.



- Include more environmental variables (i.e. bottom currents; substratum type)
- Run the algorithms to different deep-sea species
- Discuss the most appropiated modelling approach
- Discuss the best alternative to incorporate oceanographic variables to the model (Temperature, Salinity, currents…)

Thank You!

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CENTRO OCEANOGRÁFICO DE MURCIA

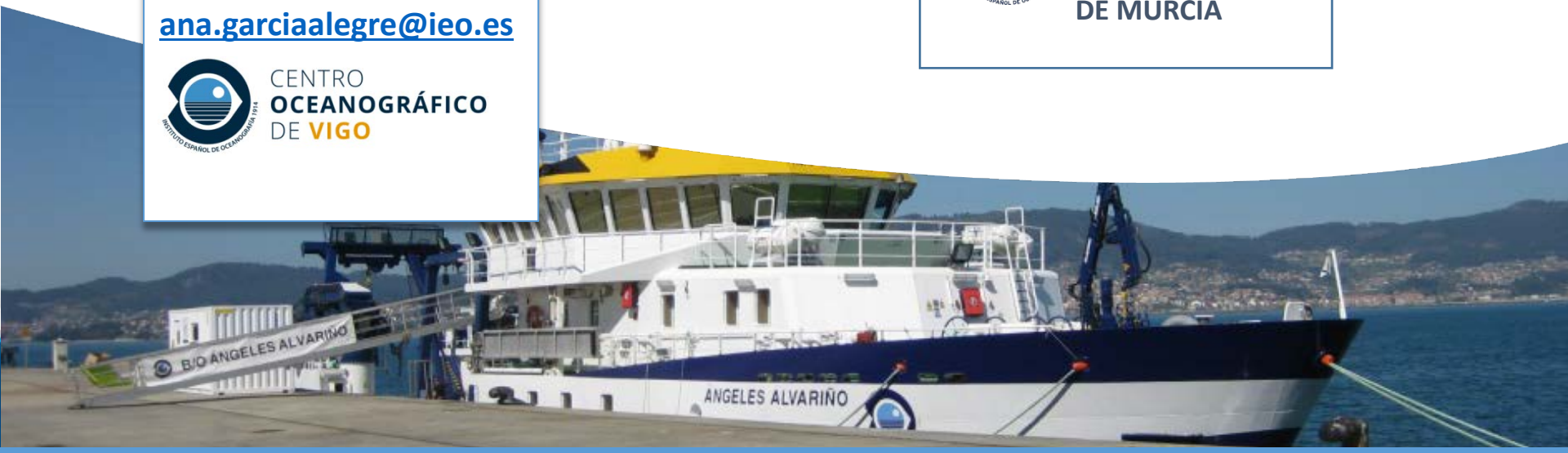

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Image credit: IEO