



atlas

UNDERSTANDING DEEP ATLANTIC ECOSYSTEMS

DOSI

DEEP-OCEAN STEWARDSHIP INITIATIVE

Climate change



D3.3: Changes in biodiversity, GOODS & GES under IPCC scenarios

ATLAS 4th General Assembly 2019 Mallorca

WP3 participants (presented by Telmo Morato)





atlas

Objectives

Model the habitat suitability for six cold-water coral and six deep-sea fish species under current conditions and **forecast changes under future projected climate conditions (RCP8.5 or business-as-usual scenario) for the whole North Atlantic**



Presence only data

6 species of **CWC** and 6 deep-sea **fish**

Model under **current** climate conditions

To forecast distribution under **future** climate scenarios

This approach has been implemented with success on several terrestrial plants and animals

Global Change Biology (2003) 9, 1353–1362

BIOMOD – optimizing predictions of species distributions and projecting potential future shifts under global change

WILFRIED THUILLER
Centre d'Ecologie Evolutive et Fonctionnelle, Centre National de Recherche Scientifique, 1919 route de Mende,
34293 Montpellier Cedex 5, France

Applied Vegetation Science 11: 169–178, 2009
doi: 10.1111/j.1365-3113.2008.218348.x, published online 6 February 2009
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Effects of climate change on the distribution of Iberian tree species

Benito Garzón, Marta ¹; Sánchez de Dios, Raúl ^{1,2} & Sainz Ollero, Helios ^{1,3}

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Original Research Article

Maxent modeling for predicting impacts of climate change on the potential distribution of *Thuja sutchuenensis* Franch., an extremely endangered conifer from southwestern China

Aili Qin ^{4,5,6,7}, Bo Liu ^{4,5,6,7}, Quanshui Guo ^{4,5,6,7}, Rainer W. Bussmann ⁸,
Fangjiang Ma ⁹, Zunji Jian ⁹, Gexi Xu ⁹, Shunxiang Pei ⁶

⁴ Research Institute of Ecology, Environment and Protection, Chinese Academy of Forestry, Beijing, China

⁵ College of Life and Environmental Science, Anhui University of Science and Technology, Huaihua, China

⁶ Institute of Botany, Chinese Academy of Sciences, Beijing, China

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⁹ Experimental center of Forestry in North China, Chinese Academy of Forestry, Beijing, China



	Last year	2019
Model Area	32°N - 76°N 20E° - 78W	18°N - 76°N (Gulf of Mexico) 36°E - 98°W (GoF and the Mediterranean Sea)
Presence data	OBIS	ATLAS data call ICES VME database NOAA's Deep-Sea Coral Data Portal OBIS
Pseudo absences	Random background selection	Standardized selection using environmental profiles of presence data
Modelling approach	MAXENT	Ensemble MAXENT, GAM, RF
Model uncertainty	None	Bootstrap with data replacement (100x)
Model evaluation	Standard cross-validation	Cross-validation using random block selection of training and testing data

1st step; Compilation of data records from OBIS, ICES VME database

NOAA's Deep-Sea Coral Data Portal

2nd Step; ATLAS data call

Data Source	CWC	Fish	Total
ATLAS data call	38,589	148,837	187,426
ICES VME database	30,169	-	30,169
NOAA's Deep-Sea Coral DP	71,497	-	71,497
OBIS	314,354	175,282	489,636
TOTAL	454,715	324,119	778,834

Partner	CWC	Fish	Total
DFO	11,911	93,359	105,270
IEO - MAIORCA	1,492	235	1,727
IEO - MALAGA	136	45	181
IEO - VIGO	520		520
IFREMER	3,576	1,828	5,404
IMAR	5,990	6,103	12,093
MRI	-	44,198	44,198
MSS	715	3,047	3,762
NUIG	199		199
P.P. SHIRSHOV	37		37
TU	9,873		9,873
UEDIN	3,947		3,947
UNC-W	38	8	46
UNI-HB	39	14	53
UOB	116		116
TOTAL	38,589	148,837	187,426

Selection of species

Anthozoa, Order Scleractinia

Lophelia pertusa



Madrepora oculata



Desmophyllum dianthus



Anthozoa, Order Alcyonacea

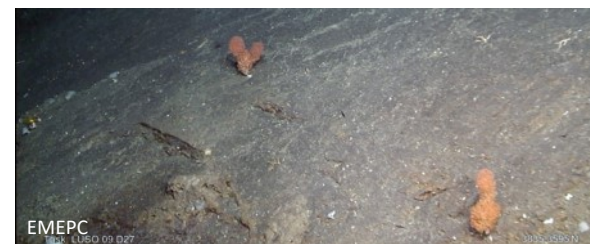
Acanthogorgia armata



Paragorgia arborea



Acanella arbuscula



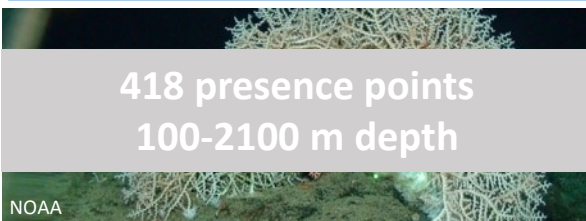
Selection of species

Anthozoa, Order Scleractinia

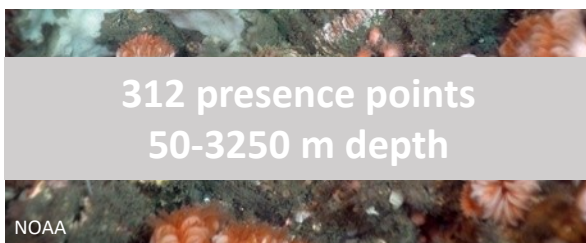
Lophelia pertusa



Madrepora oculata



Desmophyllum dianthus

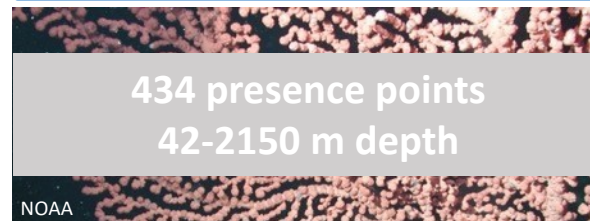


Anthozoa, Order Alcyonacea

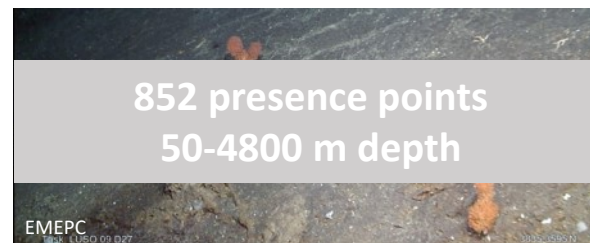
Acanthogorgia armata



Paragorgia arborea



Acanella arbuscula

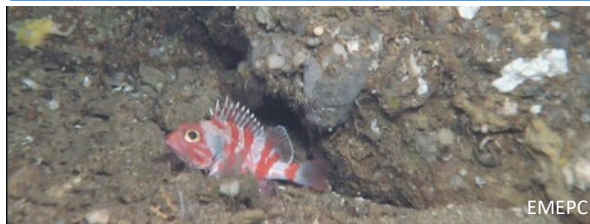


Generate a presence-only database for each species

Selection of species

Fish species

Helycolenus dactylopterus



Sebastes mentella



Gadus morhua



Fish species

Hippoglossoides platessoides



Reinhardtius hippoglossoides



Coryphaenoides rupestris



Selection of species

Fish species

- Helycolenus dactylopterus*
4,508 presence points
20-1800 m depth
EMEP
- Sebastes mentella*
15,476 presence points
10-1630 m depth
Buhl-Mortensen et al, 2017
- Gadus morhua*
52,463 presence points
1-1000 m depth
MarLIN

Fish species

- Hippoglossoides platessoides*
NOAA
56,734 presence points
6-1500 m depth
- Reinhardtius hippoglossoides*
23,491 presence points
10-1700 m depth
MarLIN
- Coryphaenoides rupestris*
MarLIN
3,009 presence points
80-1800 m depth

Generate a presence-only database for each species



Environmental factors

Predictions made using full-extent environmental parameters, which have both a geomorphological and an oceanographical nature.

Static environmental parameters

Depth

Slope

Ruggedness

Benthic Position Index (BPI)

Dynamic environmental parameters

Mean potential temperature at seafloor (K)

Mean dissolved oxygen concentration at seafloor (mol m^{-3})

Mean pH concentration at seafloor (M)

Mean export POC flux to seafloor ($\text{mg C m}^{-2} \text{d}^{-1}$)

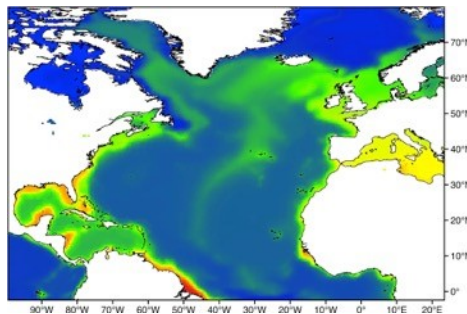
Aragonite concentration (mol m^{-3})

Calcite concentration (mol m^{-3})

Mole concentration of carbonate expressed as carbon in sea water (mol m^{-3})

Mole concentration of aragonite expressed as carbon in sea water at saturation (mol m^{-3})

Mole concentration of calcite expressed as carbon in sea water at saturation (mol m^{-3})



1951-2000



Environmental factors

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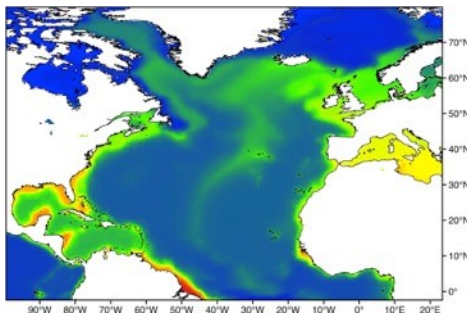
Aragonite concentration (mol m^{-3})

Calcite concentration (mol m^{-3})

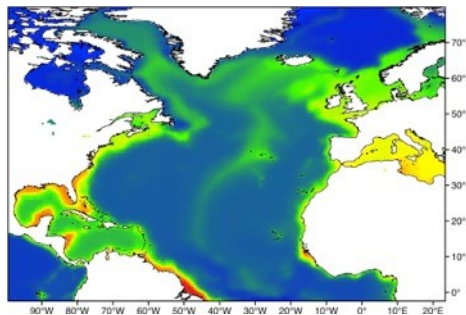
Mole concentration of carbonate expressed as carbon in sea water (mol m^{-3})

Mole concentration of aragonite expressed as carbon in sea water at saturation (mol m^{-3})

Mole concentration of calcite expressed as carbon in sea water at saturation (mol m^{-3})



1951-2000



2041-2060

Coupled Models Intercomparison Project Phase 5 (CIMP5)



Environmental factors

Predictions made using full-extent environmental parameters, which have both a geomorphological and an oceanographical nature.

Static environmental parameters

Depth

Slope

Ruggedness

Benthic Position Index (BPI)

Dynamic environmental parameters

Mean potential temperature at seafloor (K)

Mean dissolved oxygen concentration at seafloor (mol m^{-3})

Mean pH concentration at seafloor (M)

Mean export POC flux to seafloor ($\text{mg C m}^{-2} \text{d}^{-1}$)

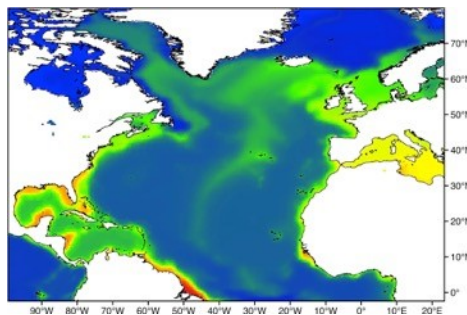
Aragonite concentration (mol m^{-3})

Calcite concentration (mol m^{-3})

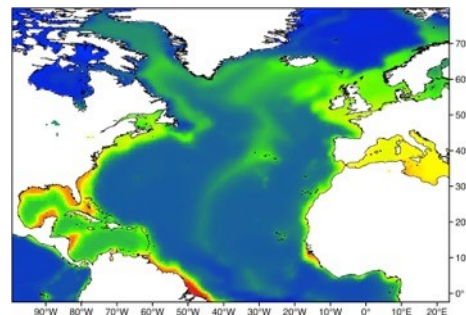
Mole concentration of carbonate expressed as carbon in sea water (mol m^{-3})

Mole concentration of aragonite expressed as carbon in sea water at saturation (mol m^{-3})

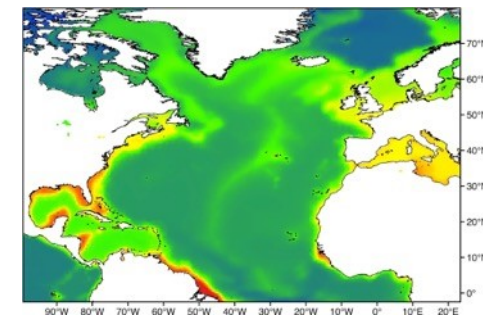
Mole concentration of calcite expressed as carbon in sea water at saturation (mol m^{-3})



1951-2000



2041-2060



2081-2100

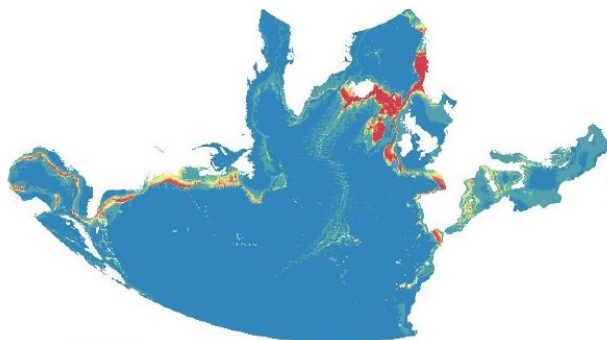
High
Low

Coupled Models Intercomparison Project Phase 5 (CIMP5)

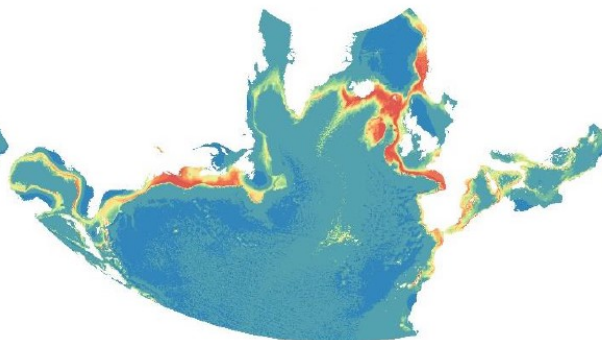


Modelling Approach

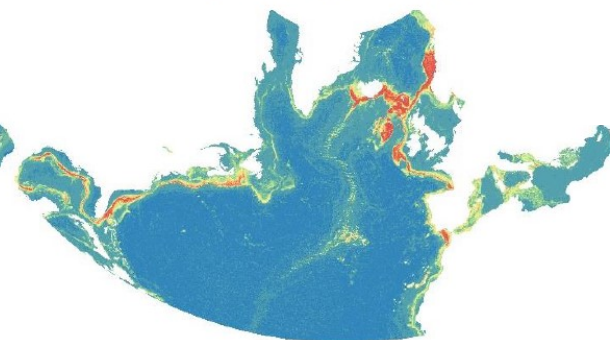
MAXENT



GAM

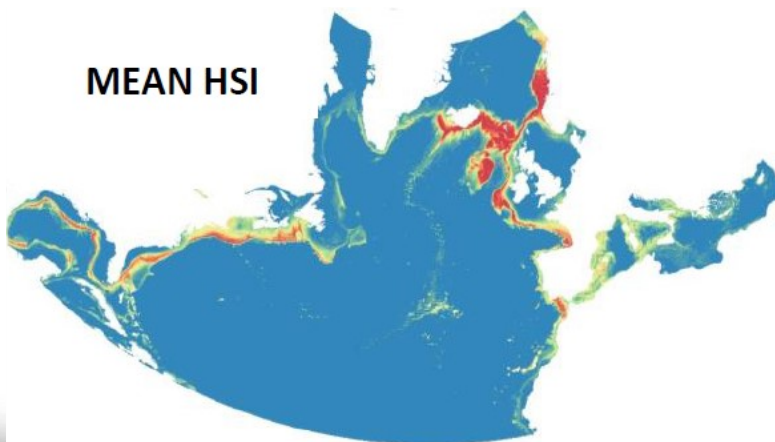


RANDOM FOREST



Ensemble Modelling

MEAN HSI



SD HSI

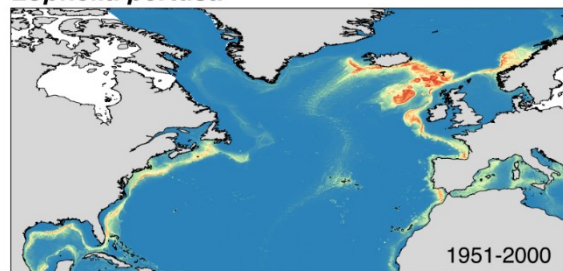




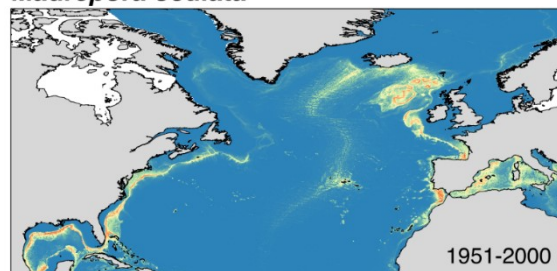
Ensemble- Model performance

Ensemble model predictions

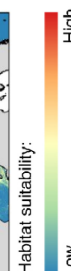
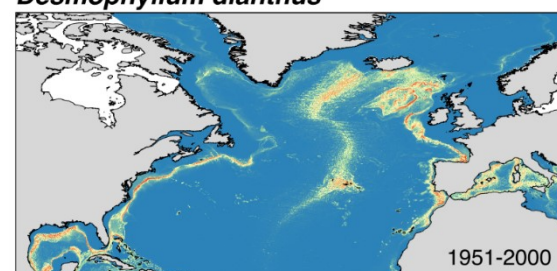
Lophelia pertusa



Madrepora oculata



Desmophyllum dianthus



Models performance

Group	Species	AUC	Kappa		Sensitivity		Specificity		TSS		Thresholds	
			10th	MSS	10th	MSS	10th	MSS	10th	MSS		
Scleractinian corals	<i>Lophelia pertusa</i>	0.91±0.08	0.51±0.31	0.57±0.25	0.9±0	0.88±0.06	0.78±0.18	0.85±0.11	0.68±0.18	0.72±0.17	0.34	0.24
	<i>Madrepora oculata</i>	0.92±0.06	0.31±0.22	0.41±0.19	0.9±0	0.88±0.09	0.77±0.16	0.87±0.07	0.66±0.16	0.75±0.14	0.31	0.20
	<i>Desmophyllum dianthus</i>	0.95±0.03	0.34±0.14	0.39±0.16	0.9±0	0.92±0.07	0.85±0.08	0.86±0.09	0.74±0.08	0.79±0.08	0.33	0.22
Gorgonians	<i>Acanthogorgia armata</i>	0.92±0.05	0.35±0.29	0.43±0.21	0.9±0	0.88±0.06	0.77±0.20	0.89±0.07	0.66±0.20	0.77±0.12	0.26	0.18
	<i>Acanella arbuscula</i>	0.88±0.03	0.22±0.20	0.49±0.20	0.9±0	0.81±0.07	0.60±0.15	0.86±0.10	0.50±0.15	0.67±0.10	0.32	0.19
	<i>Paragorgia arborea</i>	0.95±0.05	0.44±0.18	0.50±0.17	0.9±0	0.90±0.06	0.86±0.13	0.90±0.09	0.76±0.13	0.79±0.12	0.36	0.23
Fish	<i>Helicolenus dactylopterus</i>	0.97±0.03	0.81±0.08	0.84±0.08	0.9±0	0.96±0.02	0.91±0.08	0.88±0.08	0.81±0.08	0.84±0.08	0.54	0.33
	<i>Sebastes mentella</i>	0.94±0.06	0.68±0.22	0.67±0.21	0.9±0	0.95±0.03	0.85±0.15	0.82±0.15	0.75±0.15	0.78±0.13	0.63	0.50
	<i>Gadus morhua</i>	0.94±0.02	0.75±0.01	0.79±0.01	0.9±0	0.99±0.01	0.86±0.01	0.82±0.02	0.76±0.01	0.81±0.01	0.74	0.60
	<i>Hippoglossoides platessoides</i>	0.93±0.01	0.75±0.00	0.80±0.03	0.9±0	0.97±0.04	0.86±0.00	0.84±0.01	0.76±0.00	0.81±0.04	0.73	0.59
	<i>Reinhardtius hippoglossoides</i>	0.87±0.01	0.48±0.05	0.52±0.01	0.9±0	0.90±0.08	0.68±0.05	0.71±0.06	0.58±0.05	0.61±0.02	0.61	0.54
	<i>Coryphaenoides rupestris</i>	0.99±0.01	0.88±0.01	0.93±0.03	0.9±0	0.97±0.02	0.98±0.01	0.96±0.01	0.88±0.01	0.93±0.03	0.63	0.26



Results - Variable importance

		Depth	Slope	BPI	EPC	Temperature	Aragonite	Calcite
Scleractinian corals	<i>Lophelia pertusa</i>	-	0.06±0.04	0.05±0.06	0.26±0.10	0.41±0.13	0.36±0.04	-
	<i>Madrepora oculata</i>	-	0.16±0.09	0.07±0.05	0.40±0.06	0.47±0.14	0.14±0.09	-
	<i>Desmophyllum dianthus</i>	-	0.27±0.13	0.05±0.04	0.48±0.20	0.44±0.15	0.11±0.13	-
Gorgonians	<i>Acanthogorgia armata</i>	-	0.19±0.12	0.05±0.05	0.29±0.20	0.15±0.05	-	0.35±0.12
	<i>Acanella arbuscula</i>	-	0.09±0.06	0.03±0.04	0.21±0.15	0.17±0.08	-	0.41±0.06
	<i>Paragorgia arborea</i>	-	0.06±0.05	0.08±0.05	0.35±0.27	0.15±0.09	-	0.59±0.05
Fish	<i>Helicolenus dactylopterus</i>	0.64±0.26	0.17±0.22	0.19±0.21	0.24±0.17	0.45±0.03	-	-
	<i>Sebastes mentella</i>	0.65±0.22	0.17±0.23	0.17±0.22	0.43±0.17	0.38±0.11	-	-
	<i>Gadus morhua</i>	0.70±0.15	0.15±0.17	0.14±0.17	0.40±0.09	0.27±0.13	-	-
	<i>Hippoglossoides platessoides</i>	0.64±0.11	0.12±0.14	0.11±0.13	0.41±0.12	0.29±0.12	-	-
	<i>Reinhardtius hippoglossoides</i>	0.64±0.26	0.22±0.30	0.23±0.30	0.50±0.16	0.48±0.14	-	-
	<i>Coryphaenoides rupestris</i>	0.67±0.16	0.21±0.19	0.16±0.22	0.41±0.10	0.20±0.20	-	-

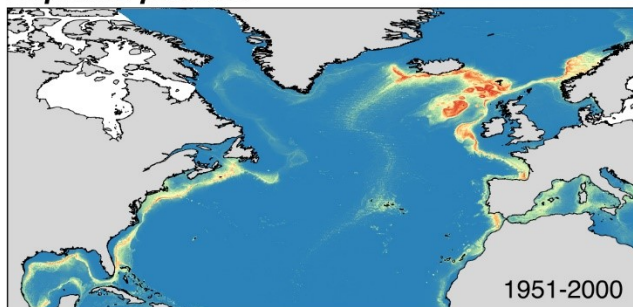


Predictions - Scleractinian corals

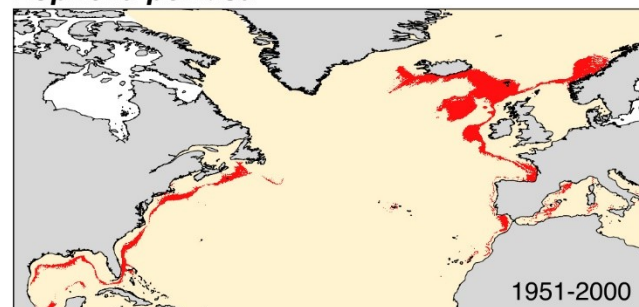
1951-2000

2081-2100

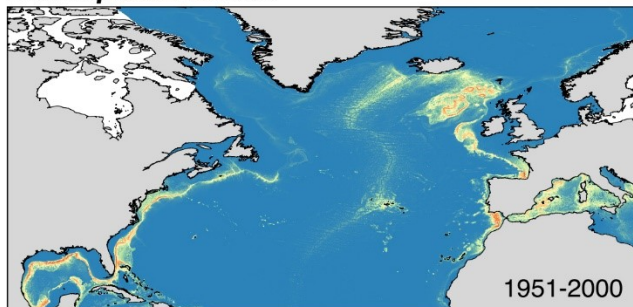
Lophelia pertusa



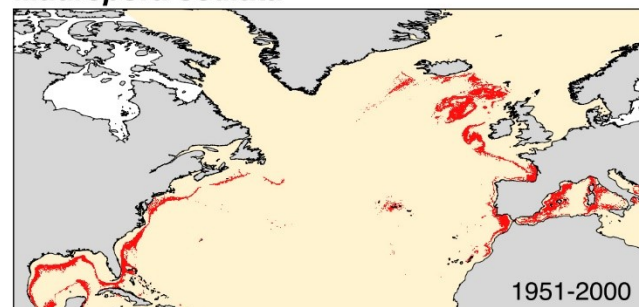
Lophelia pertusa



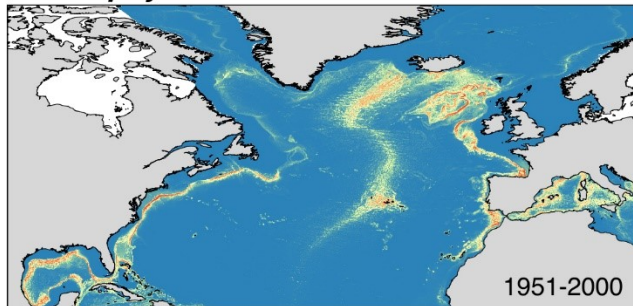
Madrepora oculata



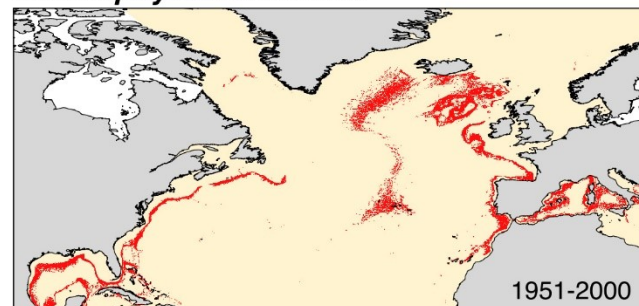
Madrepora oculata



Desmophyllum dianthus



Desmophyllum dianthus



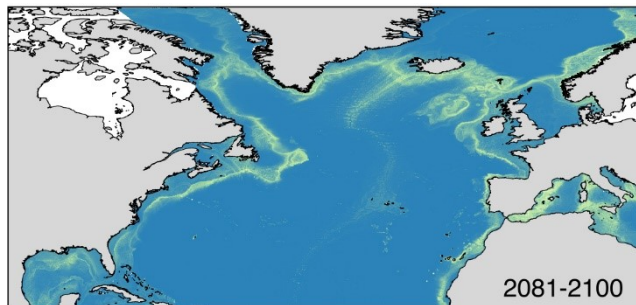


Predictions - Scleractinian corals

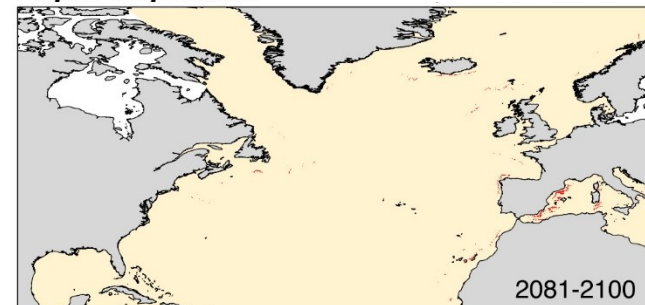
1951-2000

2081-2100

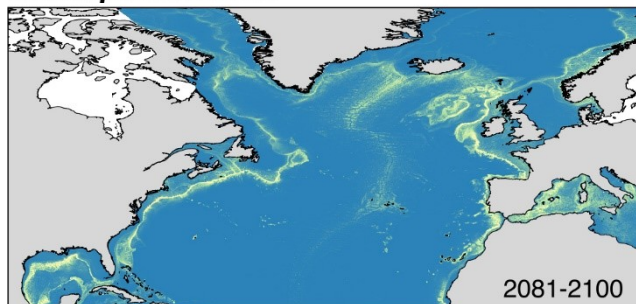
Lophelia pertusa



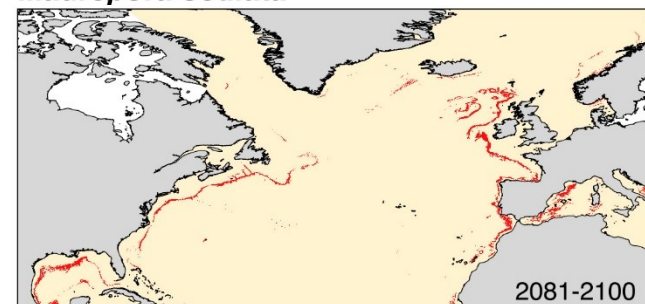
Lophelia pertusa



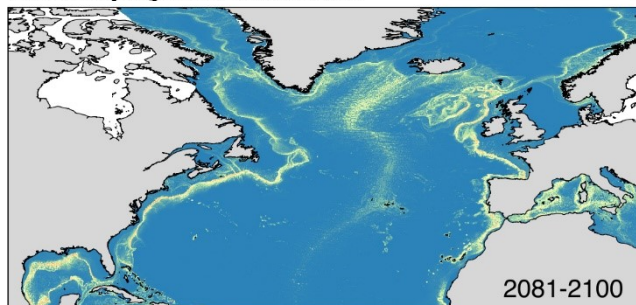
Madrepora oculata



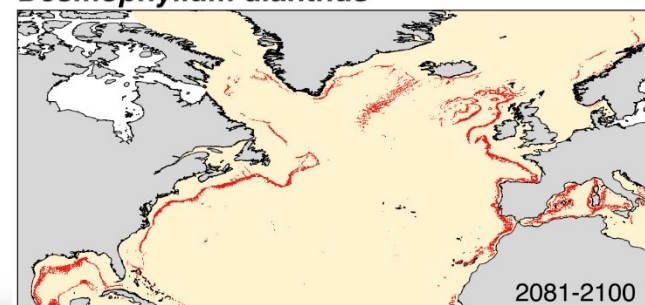
Madrepora oculata



Desmophyllum dianthus



Desmophyllum dianthus

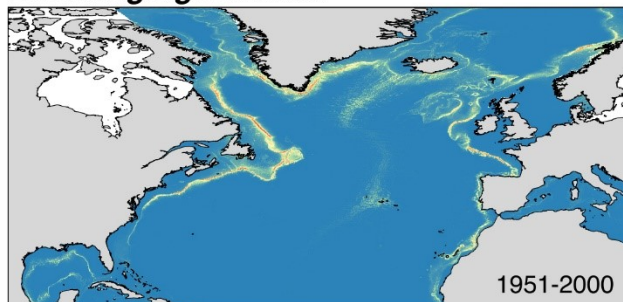


Predictions - Gorgonians

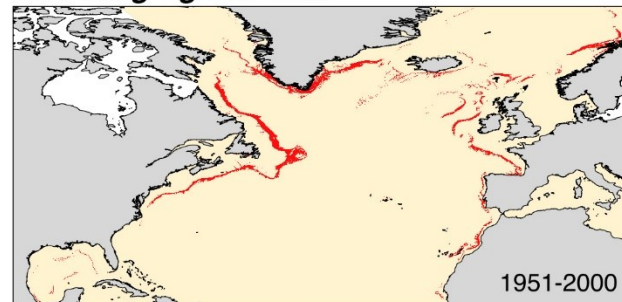
1951-2000

2081-2100

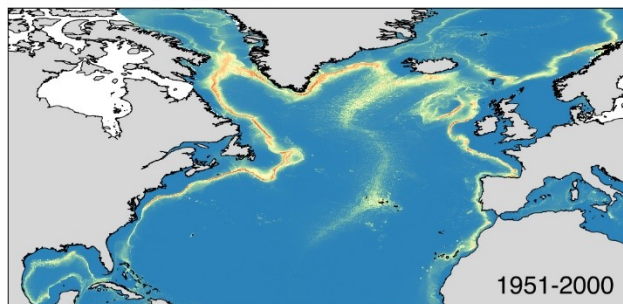
Acanthogorgia armata



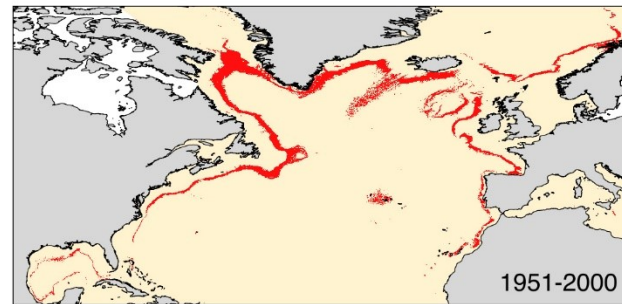
Acanthogorgia armata



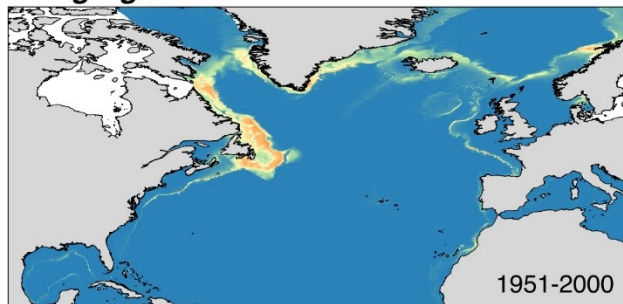
Acanella arbuscula



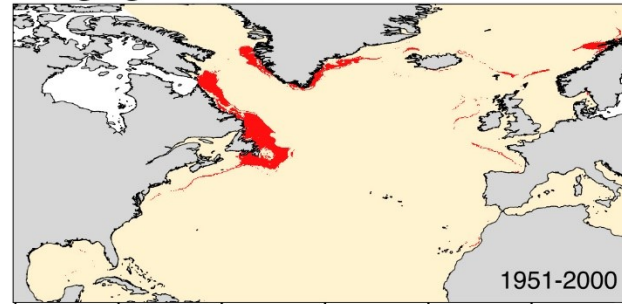
Acanella arbuscula



Paragorgia arborea



Paragorgia arborea

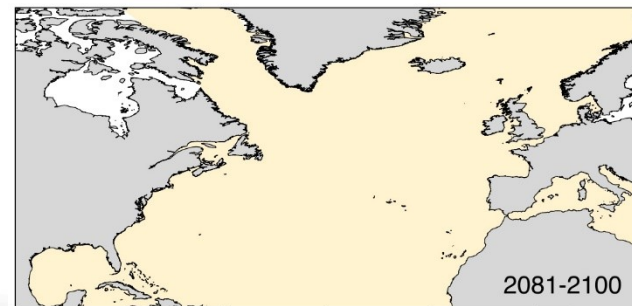
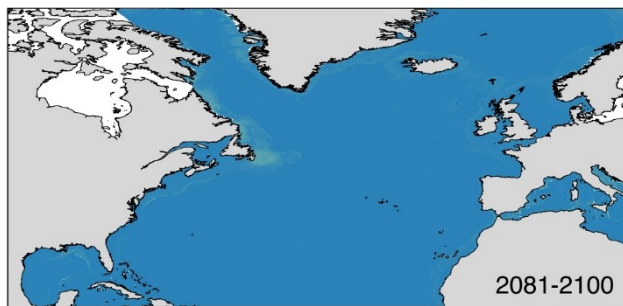
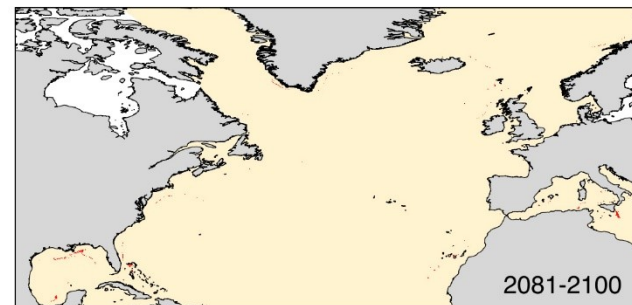
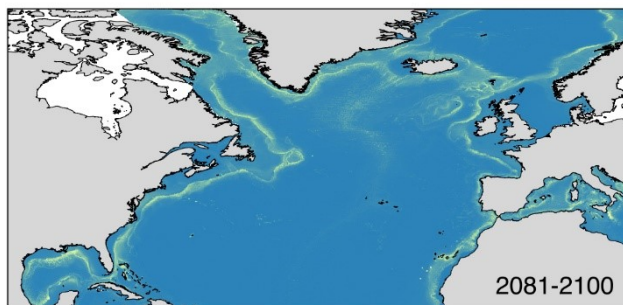
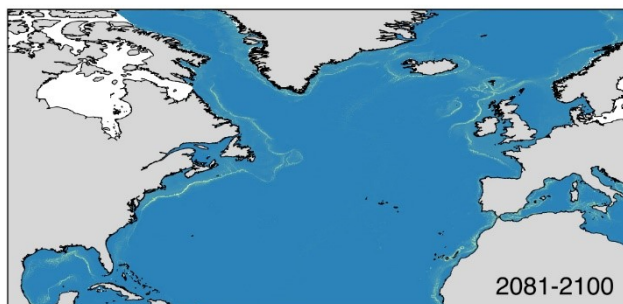


100°W 80°W 60°W 40°W 20°W 0° 100°W 80°W 60°W 40°W 20°W 0° 10

Predictions - Gorgonians

1951-2000

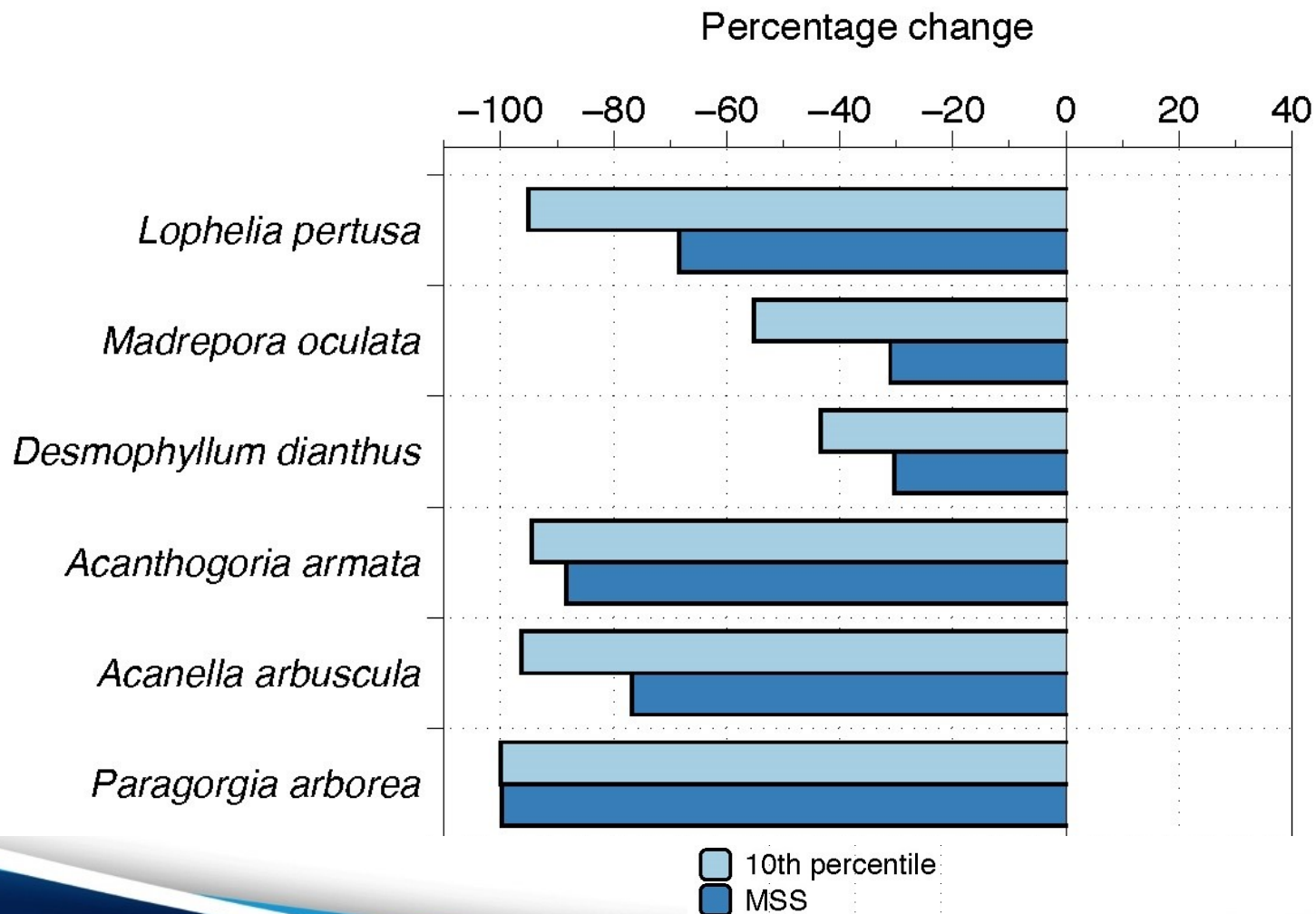
2081-2100





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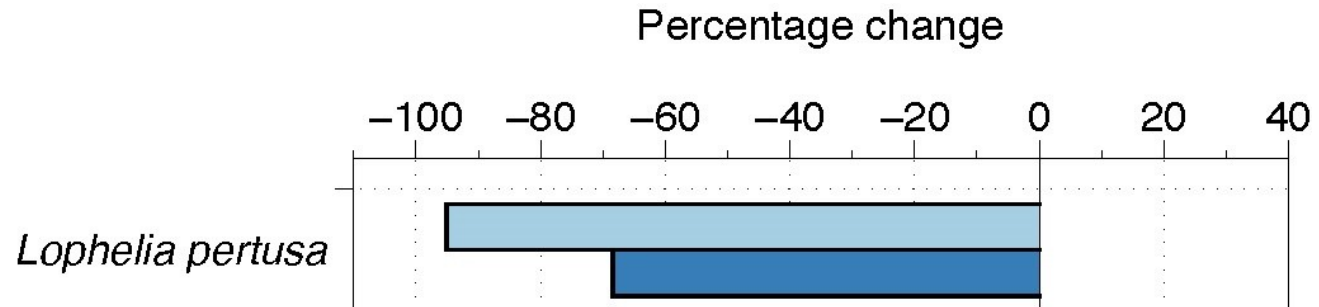
Predictions – Change in Suitable habitat





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Predictions – Change in Suitable habitat



Significant **reduction** of the suitable habitat for cold-water corals

Acanthogorgia armata

Acanella arbuscula

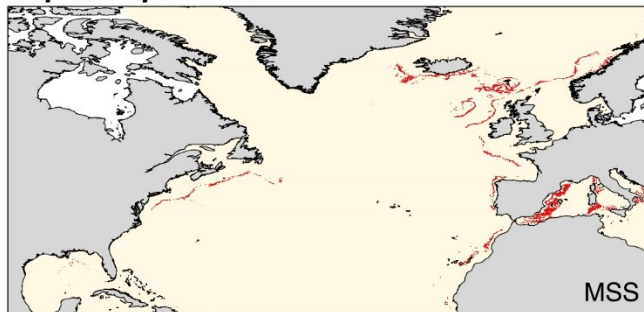
Paragorgia arborea

□ 10th percentile
■ MSS

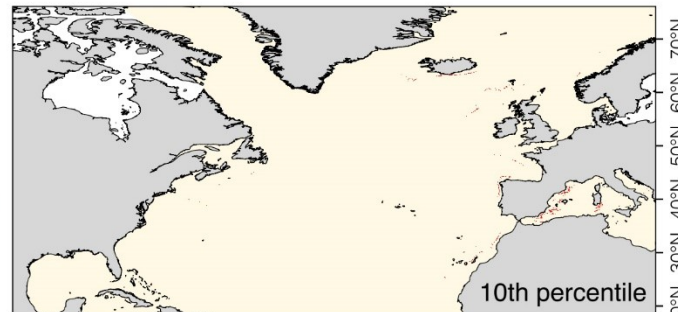
Climate Refugia - Corals

MSS

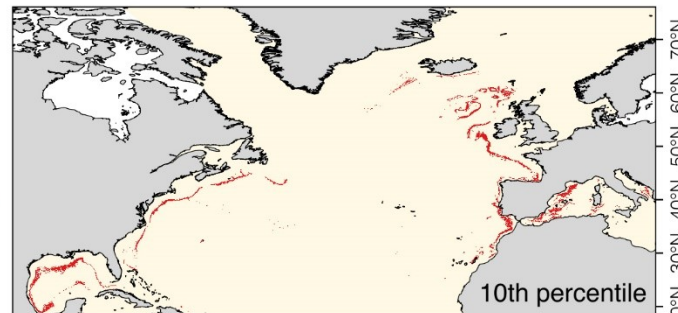
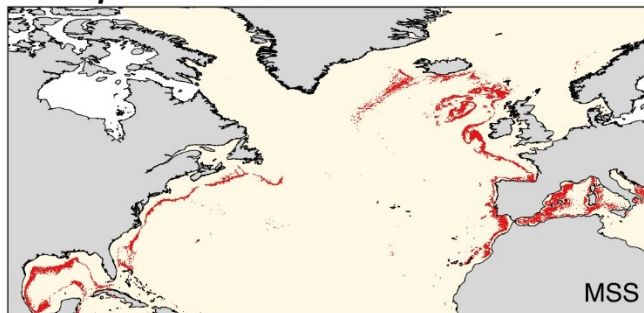
Lophelia pertusa



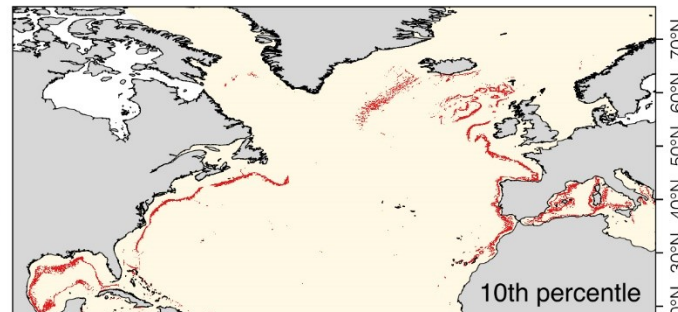
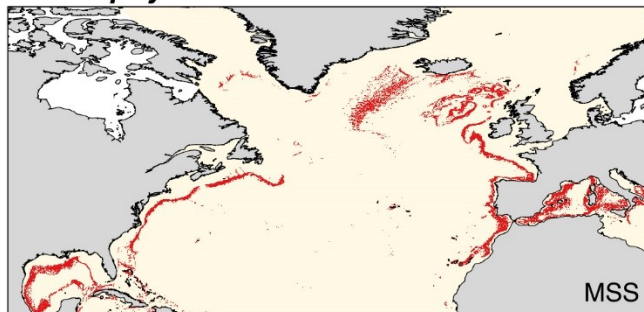
Q10



Madrepora oculata



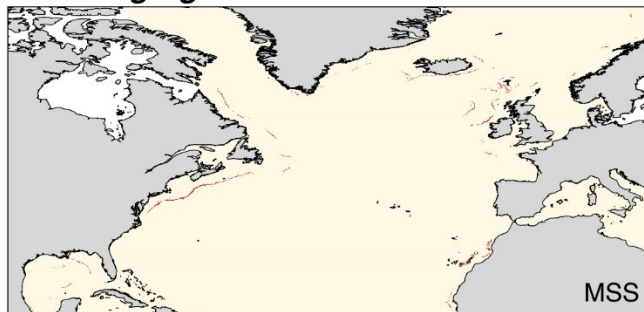
Desmophyllum dianthus



Climate Refugia - Corals

MSS

Acanthogorgia armata



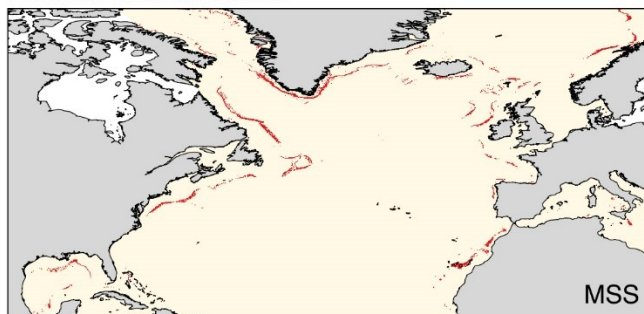
MSS

Q10

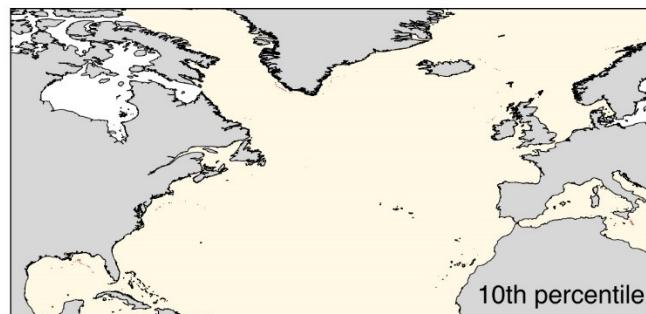


10th percentile

Acanella arbuscula

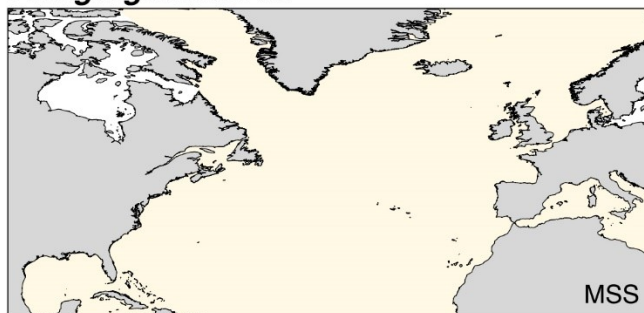


MSS

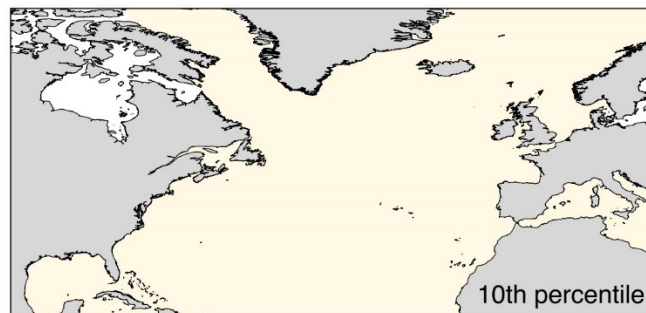


10th percentile

Paragorgia arborea



MSS

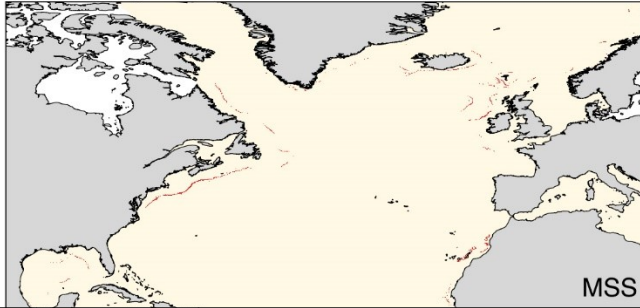


10th percentile

Climate Refugia - Corals

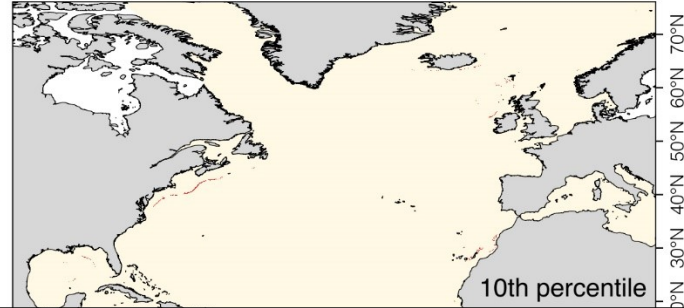
MSS

Acanthogorgia armata



MSS

Q10



10th percentile

Should these areas be considered
priority areas for conservation?

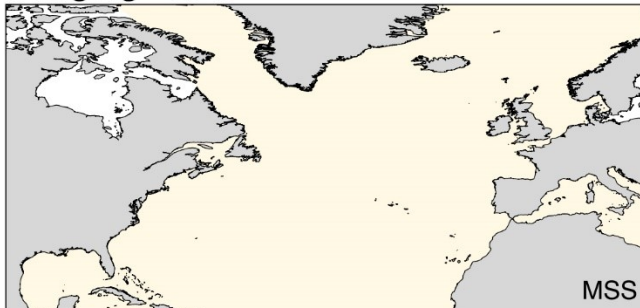


MSS

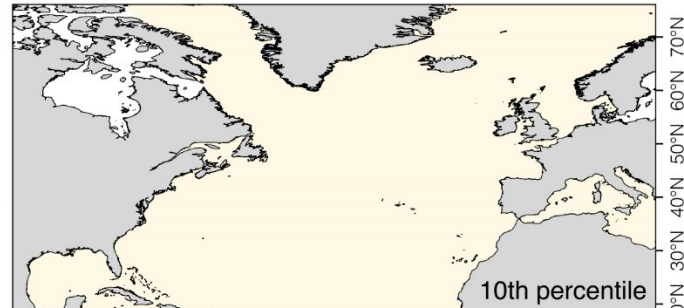


10th percentile

Paragorgia arborea



MSS



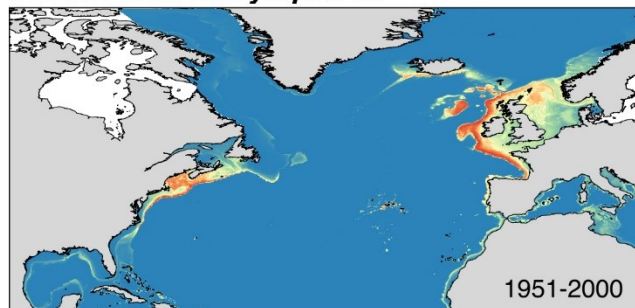
10th percentile

Predictions – Fish 1

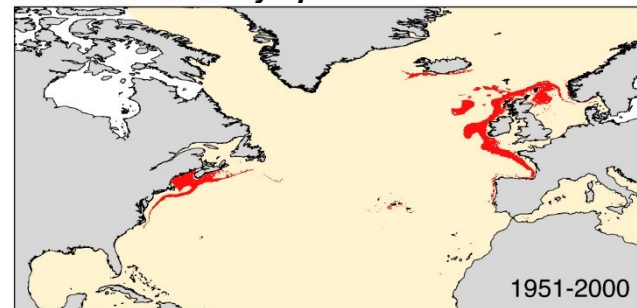
1951-2000

2081-2100

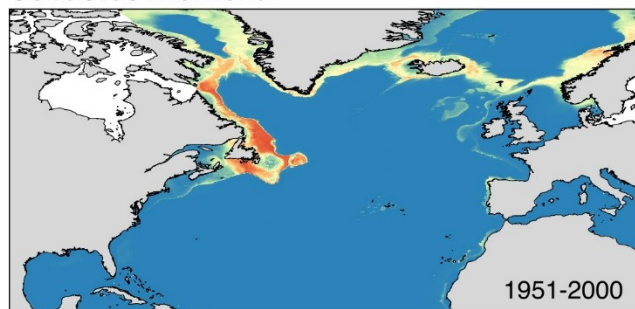
Helicolenus dactylopterus



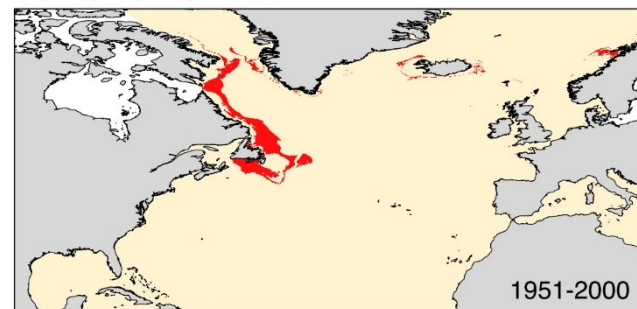
Helicolenus dactylopterus



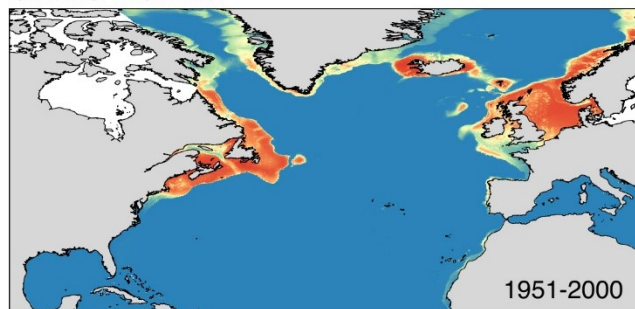
Sebastes mentella



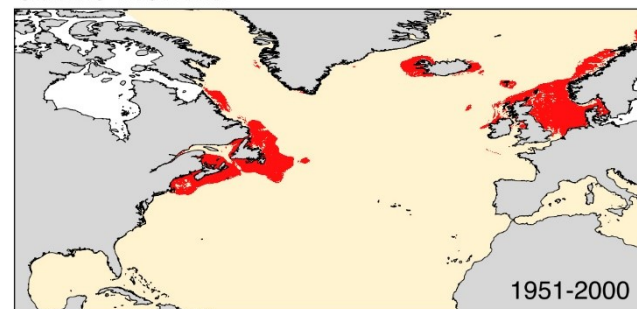
Sebastes mentella



Gadus morhua



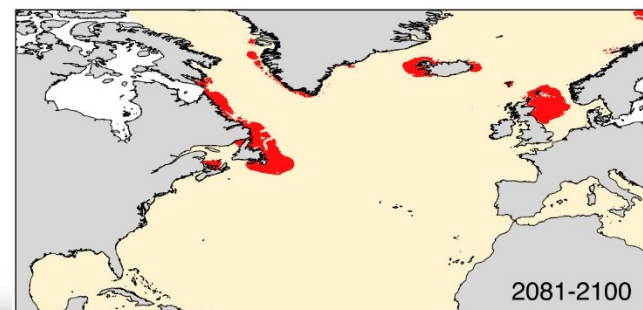
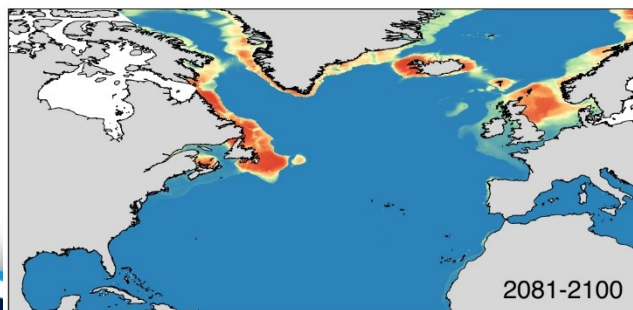
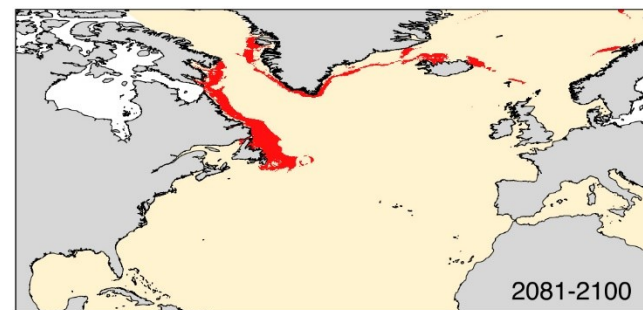
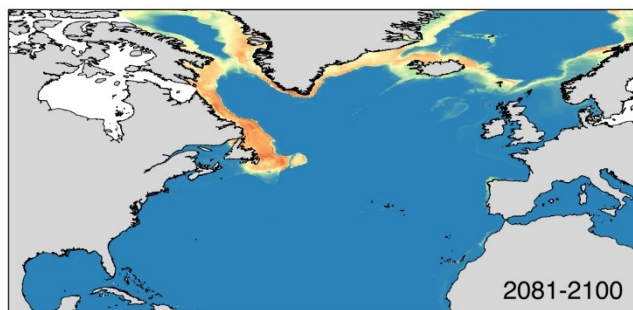
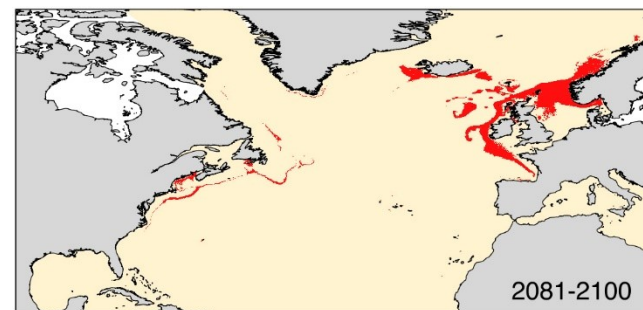
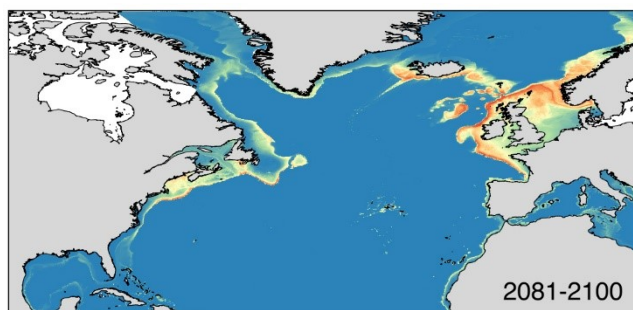
Gadus morhua



Predictions – Fish 1

1951-2000

2081-2100

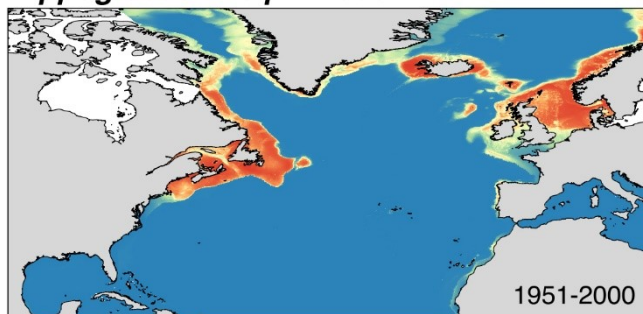


Predictions – Fish 2

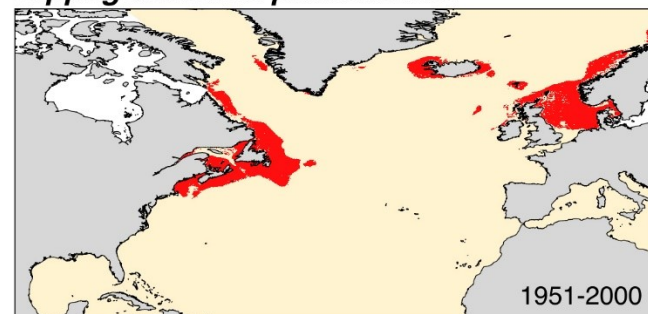
1951-2000

2081-2100

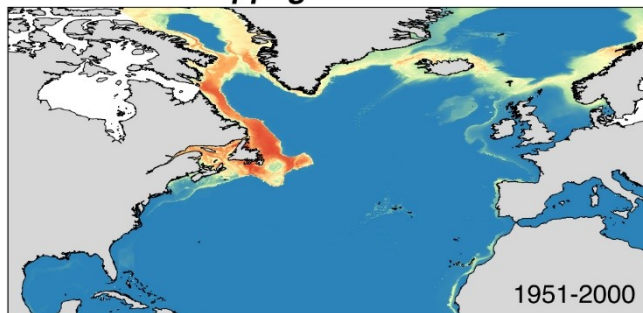
Hippoglossoides platessoides



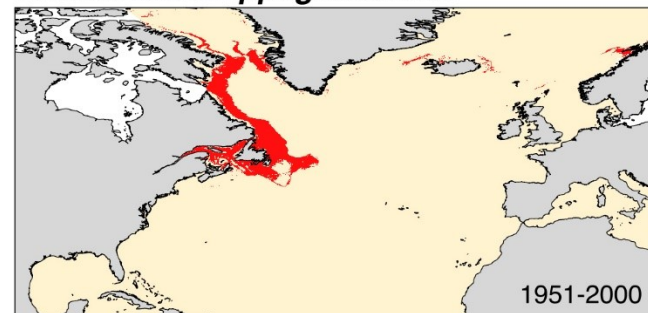
Hippoglossoides platessoides



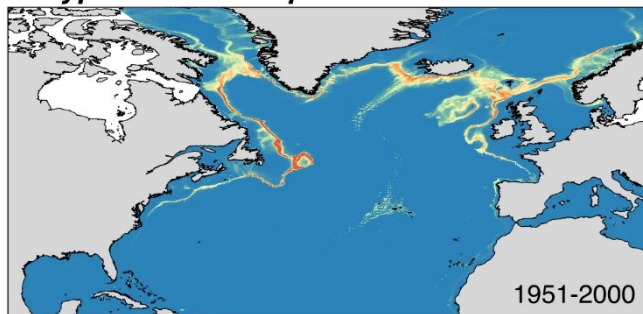
Reinhardtius hippoglossoides



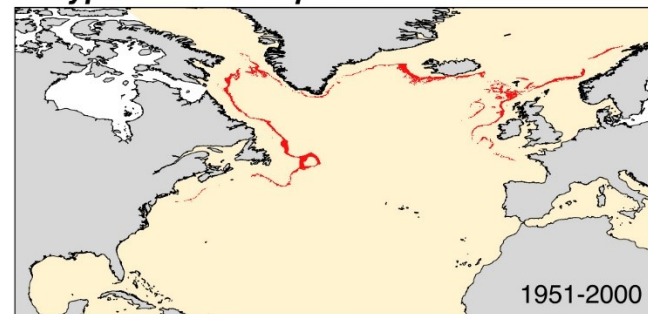
Reinhardtius hippoglossoides



Coryphaenoides rupestris



Coryphaenoides rupestris

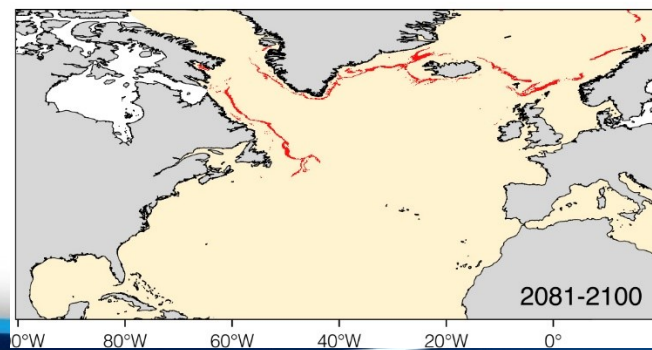
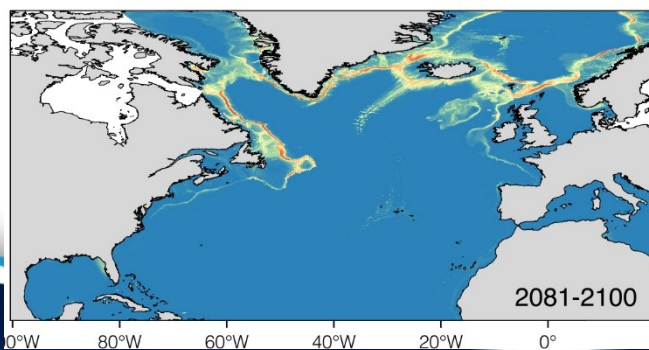
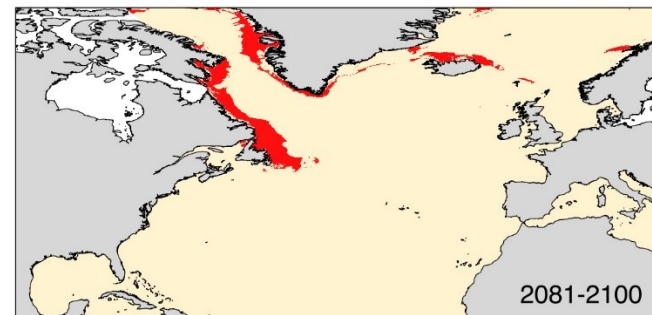
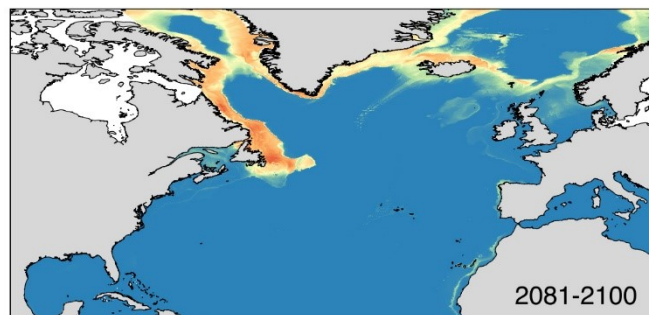
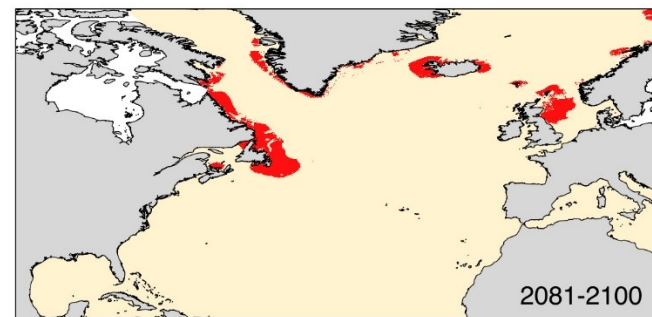
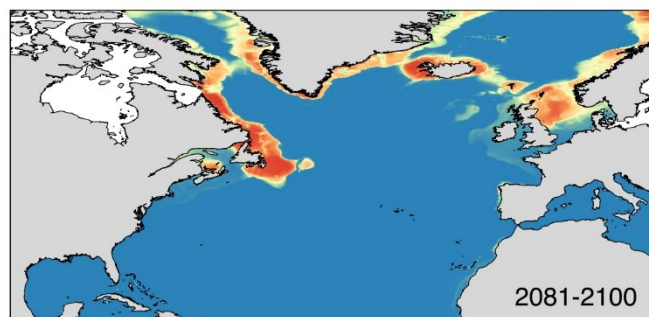


100°W 80°W 60°W 40°W 20°W 0° 100°W 80°W 60°W 40°W 20°W 0° 10

Predictions – Fish 2

1951-2000

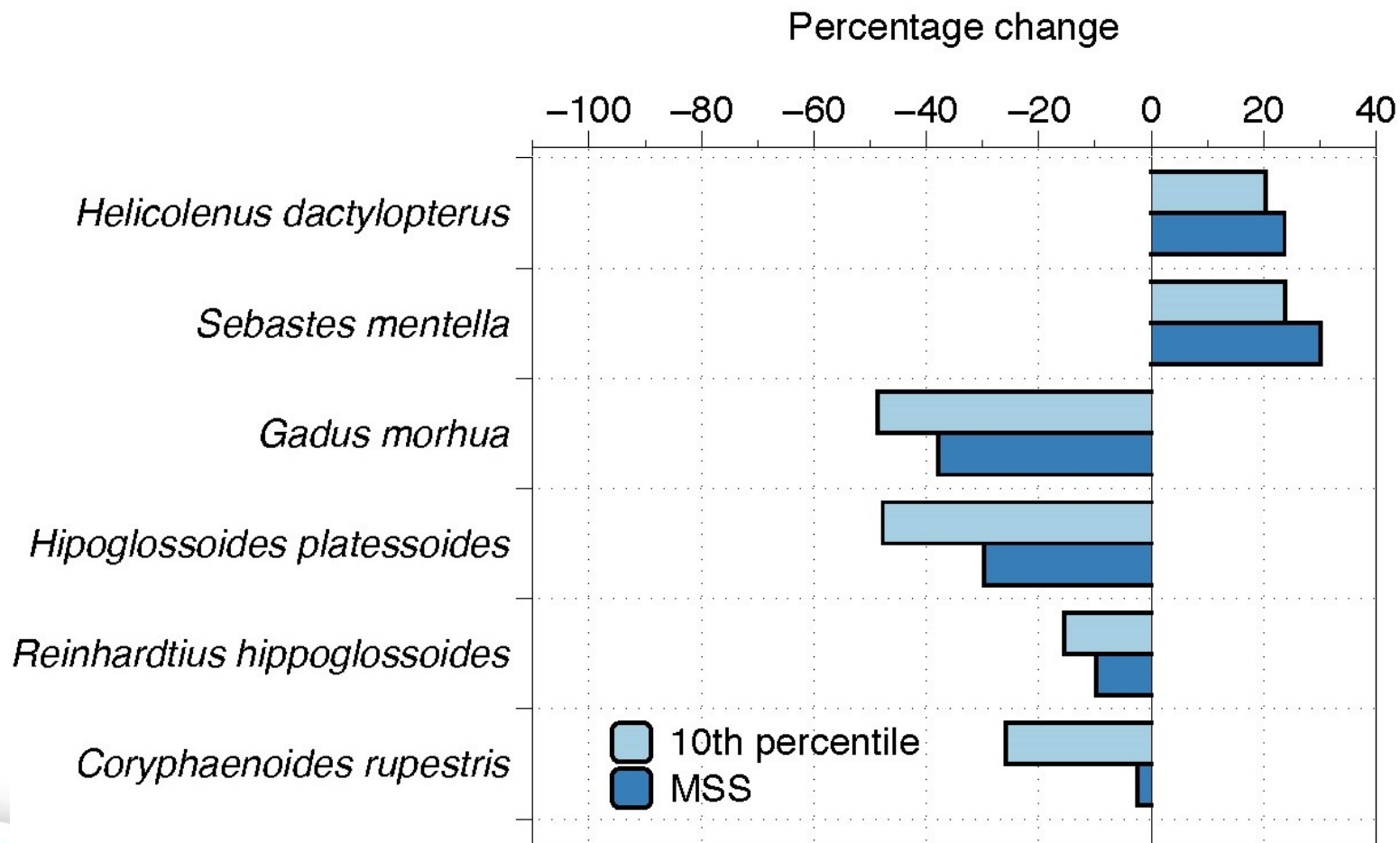
2081-2100





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Predictions – Change in Suitable habitat

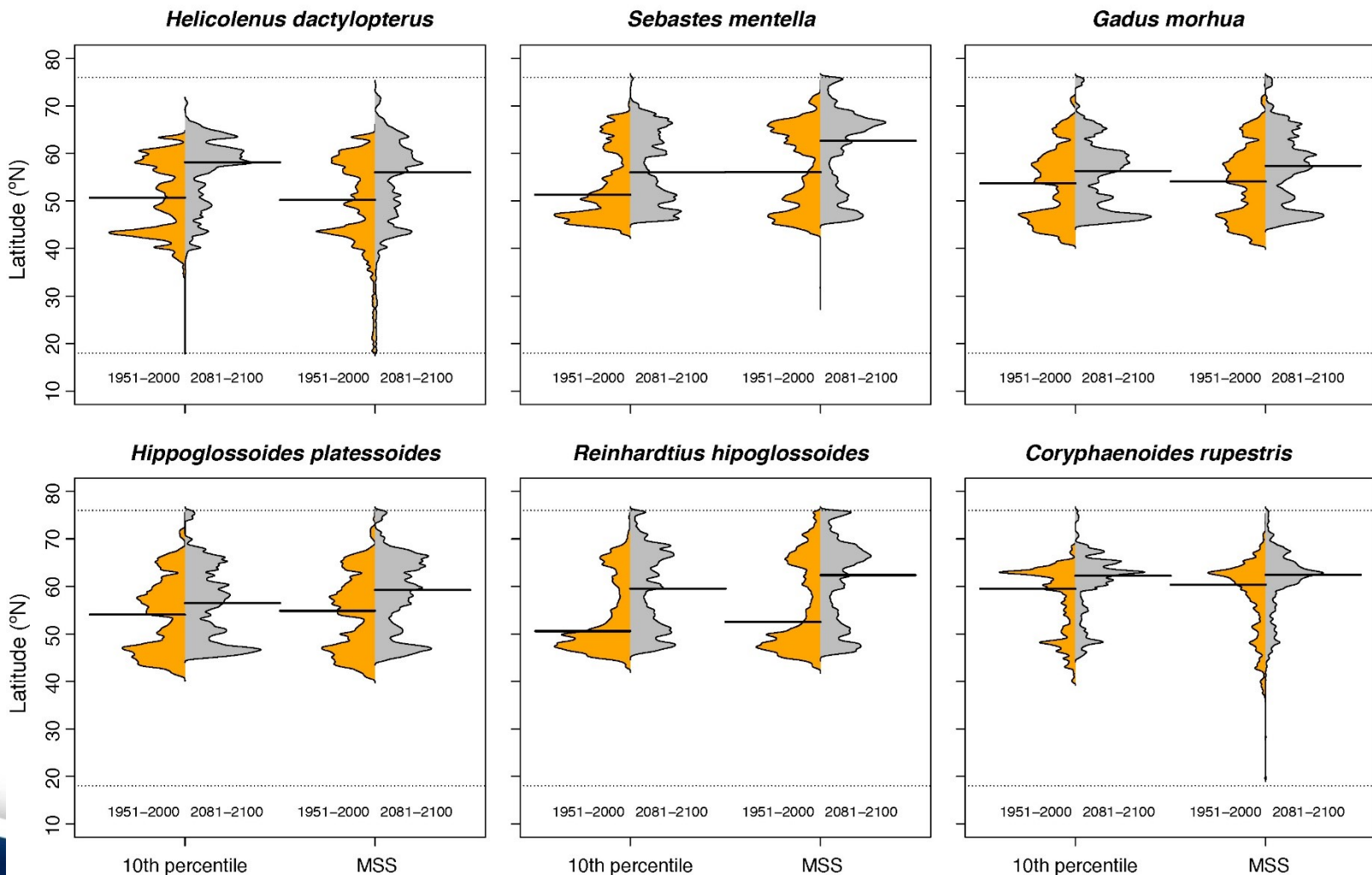




Results - Fishes

Change in latitude

- 1951–2000
- 2081–2100

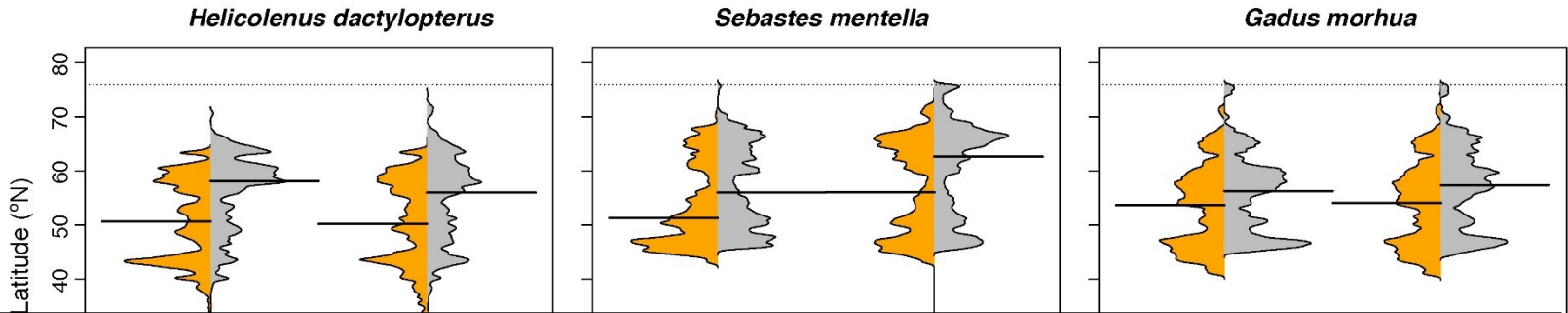




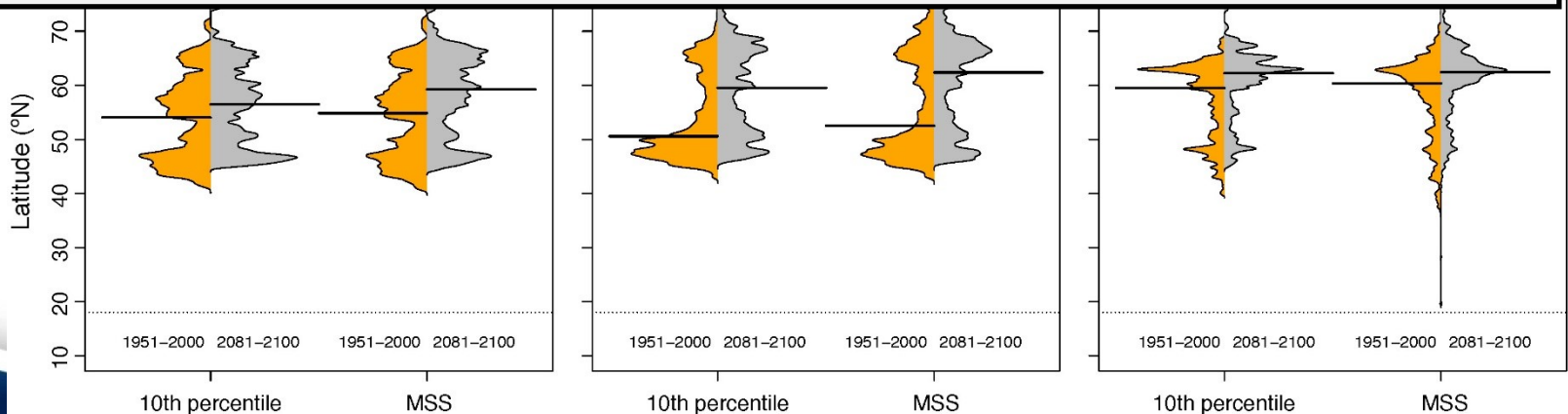
Results - Fishes

Change in latitude

- 1951–2000
- 2081–2100



Predicted **poleward migration** of many
deep-sea fish species





CWC species could be facing a **significant reduction** in the suitable habitat towards 2100

Deep-sea fish could face a **poleward shift** in response to climate change

Climate refugia areas may be considered **priority areas** for conservation



SDM seem to be **useful and promising** tools to predict climate change might affect deep sea ecosystems

However there are important **caveats and limitations**:

- Species capacity to adapt
- Uncertainties on biological and environment data
- Uncertainties in scenarios of future conditions
- Model uncertainties
- Coarse spatial coverage and resolution



Acknowledgements



Food and Agriculture
Organization of the
United Nations



DEEP-OCEAN STEWARDSHIP INITIATIVE
Climate change



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DOSI/FAO climate change and fisheries workshop
Woods Hole (USA), Aug-2017



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