Philippine marine capture fisheries under accelerating climate change

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MERF, Inc. (USAID Fish Right Program)

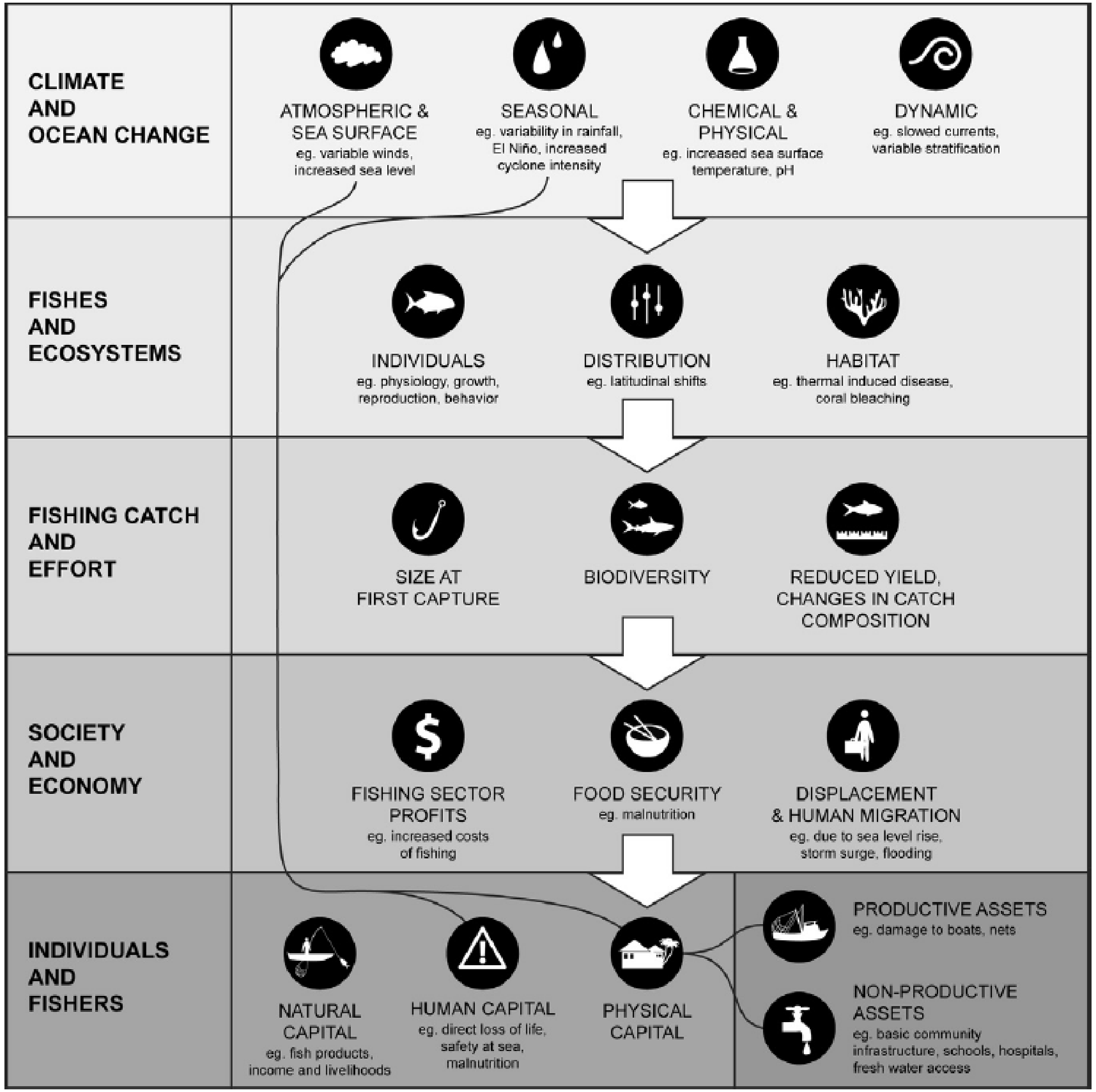
2019 Visayas Regional Scientific Meeting
Summit Hotel, Tacloban City, 20 March 2019

Outline

1. Review of climate impacts on marine fisheries: zoom in on the Philippines
2. Projected habitat suitability changes for the top Philippine marine capture fisheries species
3. Recommendations

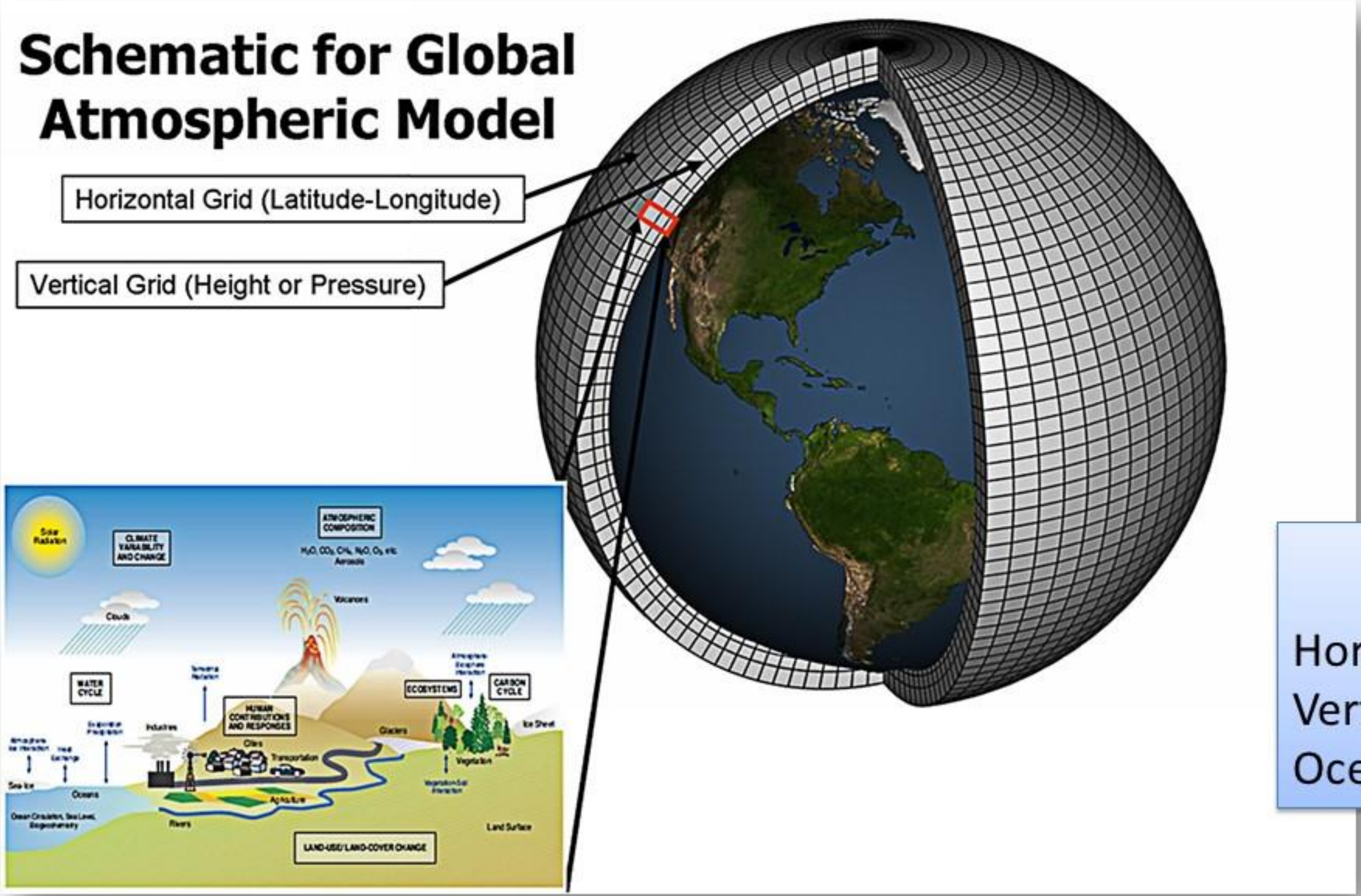
Cascading impacts of climate change

Source: Heenan et al. 2016



1. Projected and historical impacts of climate change on marine fisheries

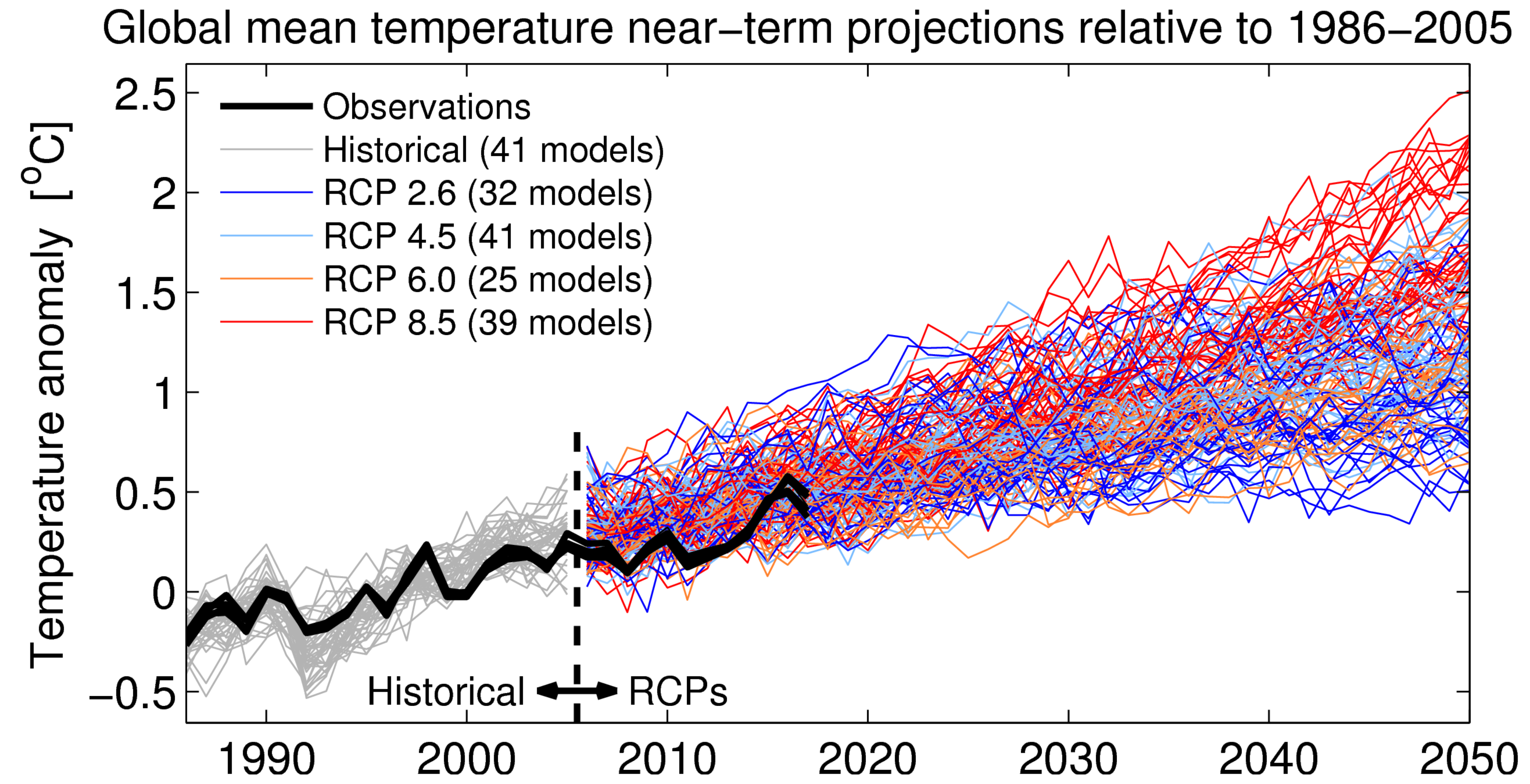
IPCC Models of Climate



Coupled Model Intercomparison Project Phase 5 (CMIP5)

Grid spacing

Horizontal: 100 – 250Km
Vertical: 1Km
Ocean: 100m



Global mean temperature near−term projections relative to 1986−2005
Temperature anomaly [°C]
Observations
Historical (41 models)
RCP 2.6 (32 models)
RCP 4.5 (41 models)
RCP 6.0 (25 models)
RCP 8.5 (39 models)
Historical
RCPs
2.5
2
1.5
1
0.5
0
−0.5
1990
2000
2010
2020
2030
2040
2050

CMIP5 Projections of physico-chemical changes

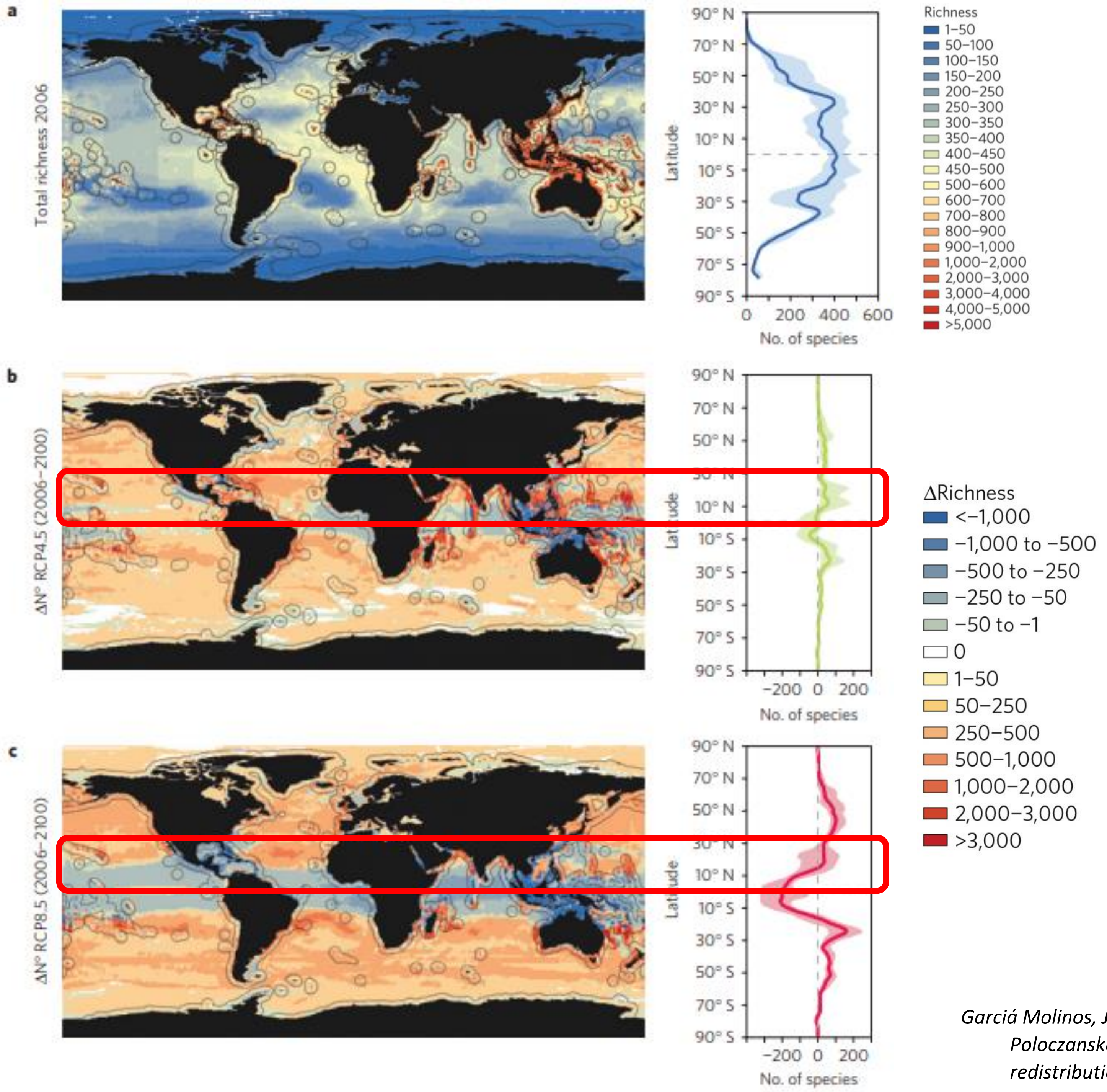
Mean values of change from CMIP5 models within the Philippine EEZ (2100 vs 2005)

Parameter	Trend	RCP 4.5		RCP 8.5		Accuracy		Precision	
		MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
Temperature (°C)	↑	+1.32	0.02	+2.95	0.06	-0.03	0.29	0.68	0.07
Oxygen (ml/L)	↓	-0.09	0.00	-0.20	0.00	0.05	0.07	0.09	0.01
pH	↓	-0.15	0.00	-0.31	0.00	0.02	0.02	0.01	0.00
Phytoplankton Carbon Concentration (mg C/L)	↓	-0.0006	0.0003	-0.0011	0.0005	0.0096	0.0015	0.0057	0.0013

RCP: Representative Concentration Pathway (scenarios of CO_2 trends into the future)
RCP 4.5 (with some mitigation); RCP 8.5 (business-as-usual)

Mora, C., Wei, C.-L., Rollo, A., Amaro, T., Baco, A.R., Billett, D., Bopp, L., Chen, Q., Collier, M., Danovaro, R., Gooday, A.J., Grupe, B.M., Halloran, P.R., Ingels, J., Jones, D.O.B., Levin, L. a, Nakano, H., Norling, K., Ramirez-Llodra, E., Rex, M., Ruhl, H. a, Smith, C.R., Sweetman, A.K., Thurber, A.R., Tjiputra, J.F., Usseglio, P., Watling, L., Wu, T., Yasuhara, M., 2013. Biotic and human vulnerability to projected changes in ocean biogeochemistry over the 21st century. PLoS Biol. 11, e1001682. https://doi.org/10.1371/journal.pbio.1001682

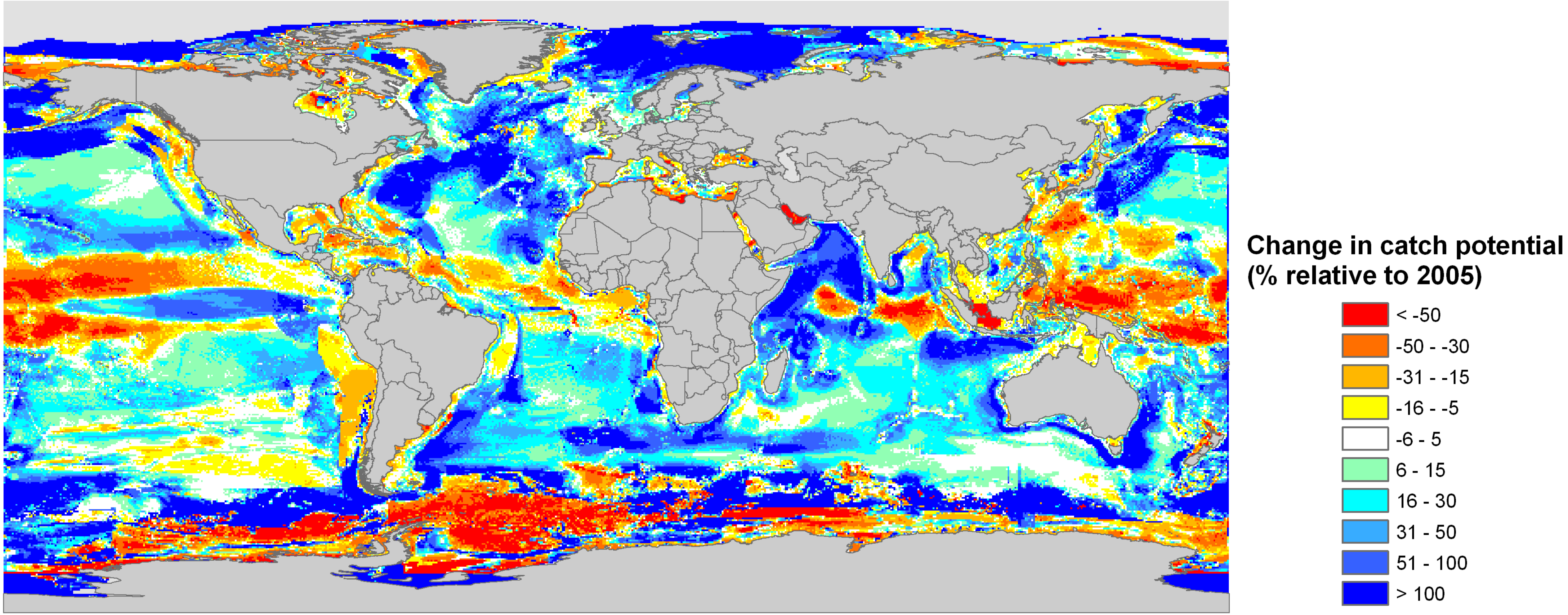
Species richness



- Mitigation could increase species richness

- Business-as-usual global greenhouse gas emissions will lead to species declines

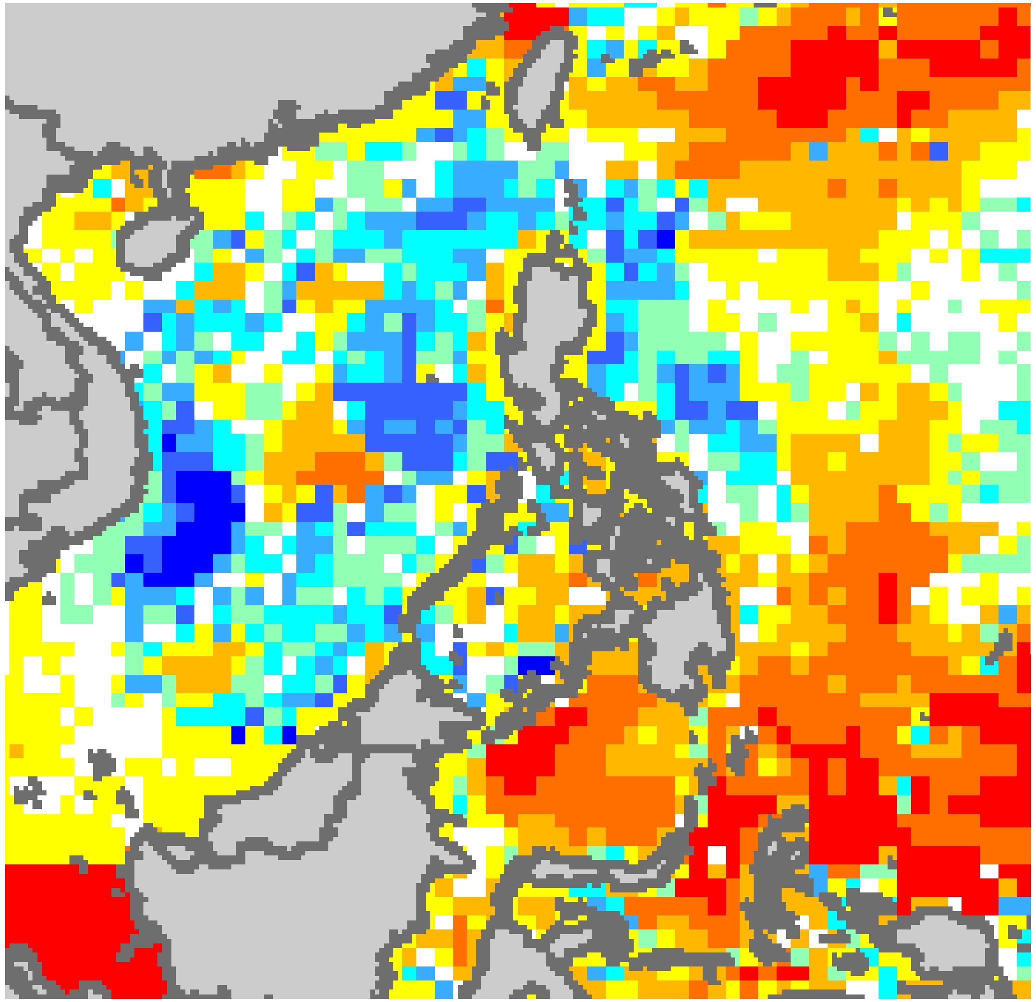
Garciá Molinos, J., Halpern, B.S., Schoeman, D.S., Brown, C.J., Kiessling, W., Moore, P.J., Pandolfi, J.M., Poloczanska, E.S., Richardson, A.J., Burrows, M.T., 2016. Climate velocity and the future global redistribution of marine biodiversity. Nat. Clim. Chang. 6, 83–88. https://doi.org/10.1038/nclimate2769



Catch potential: Expected changes in fish production due to changes in habitat suitability

- 2005 vs 2055; IPCC SRES A1B scenario (mid-century (~2030) peak emissions and declines thereafter).

Cheung WWL, Lam VWY, Sarmiento JL, Kearney K, Watson R, Zeller D, Pauly D (2010) Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, **16**, 24–35.



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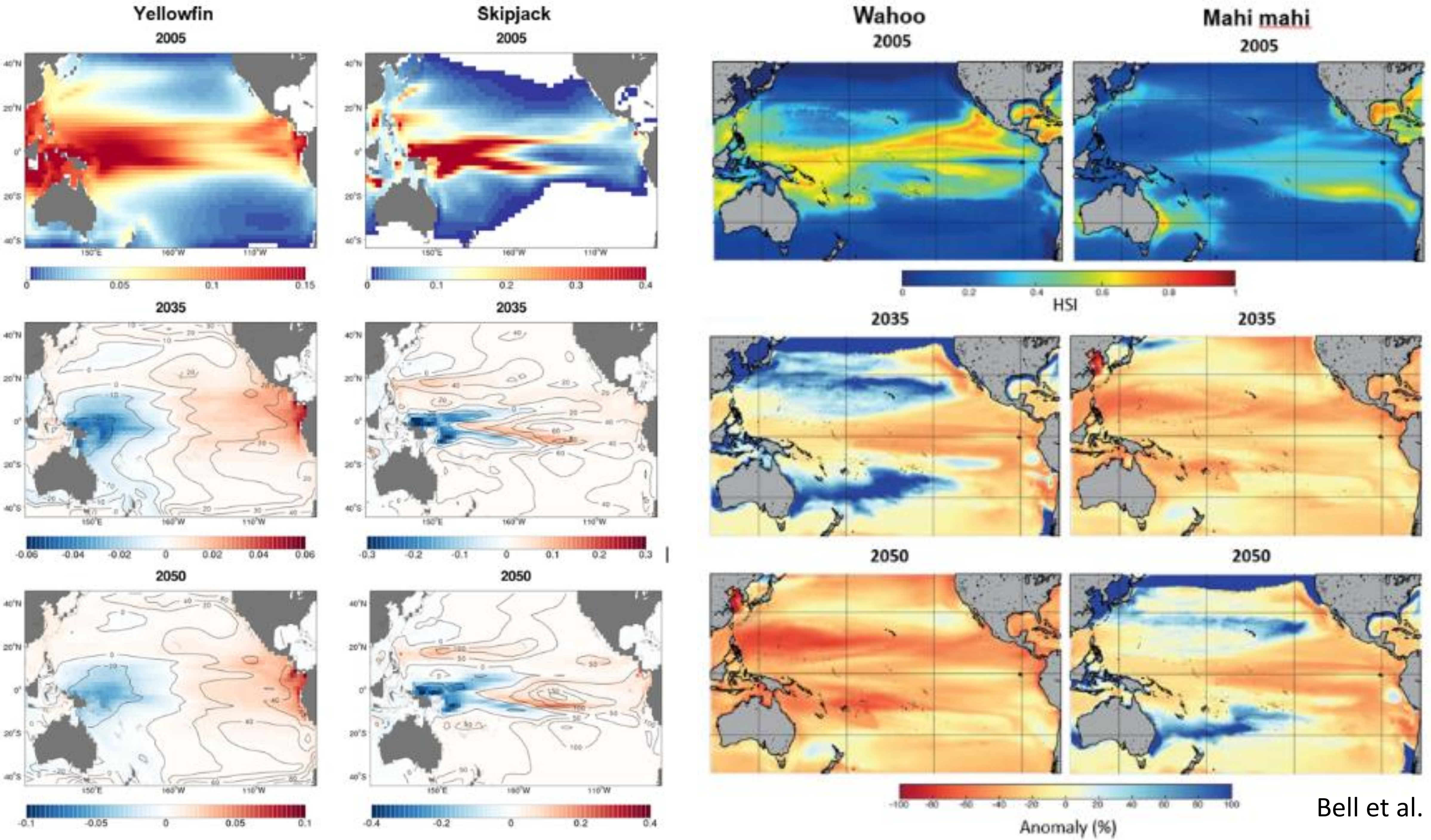
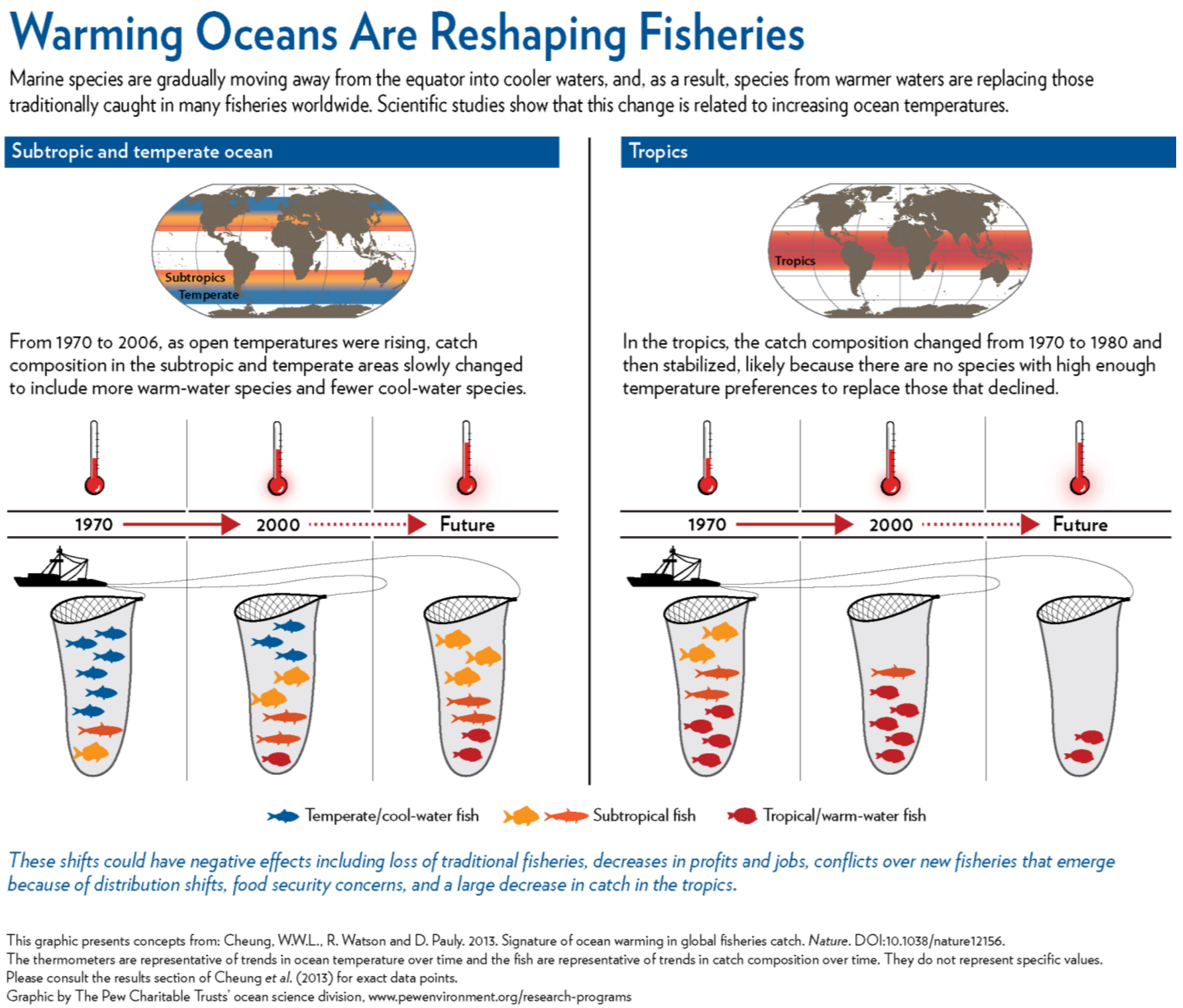


Bell et al. 2017

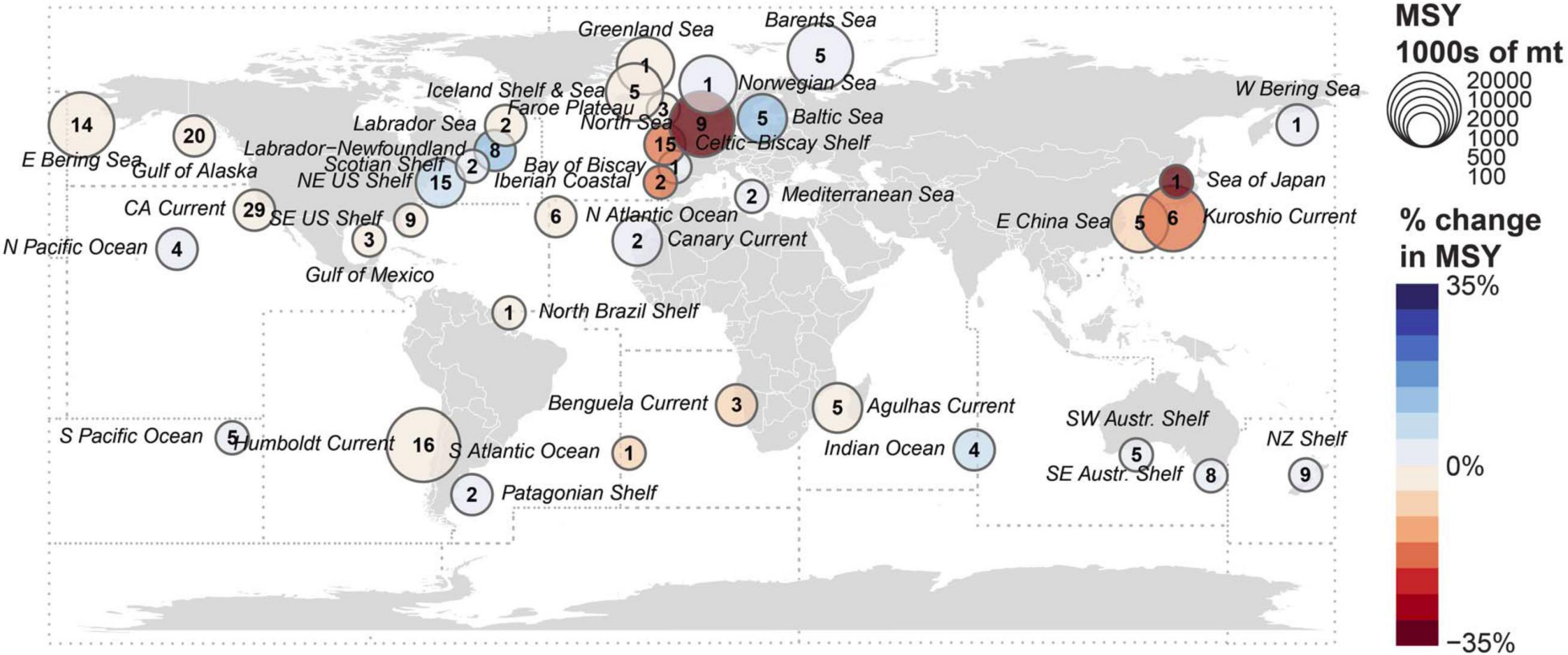
It's already happening…

Signatures of climate change impacts on fisheries are being documented globally

Cheung et al. 2013



Warmer waters → reduced carrying capacity



Free, C.M., Thorson, J.T., Pinsky, M.L., Oken, K.L., Wiedenmann, J., Jensen, O.P., 2019. Impacts of historical warming on marine fisheries production 983, 979–983. https://doi.org/10.1126/science.aau1758

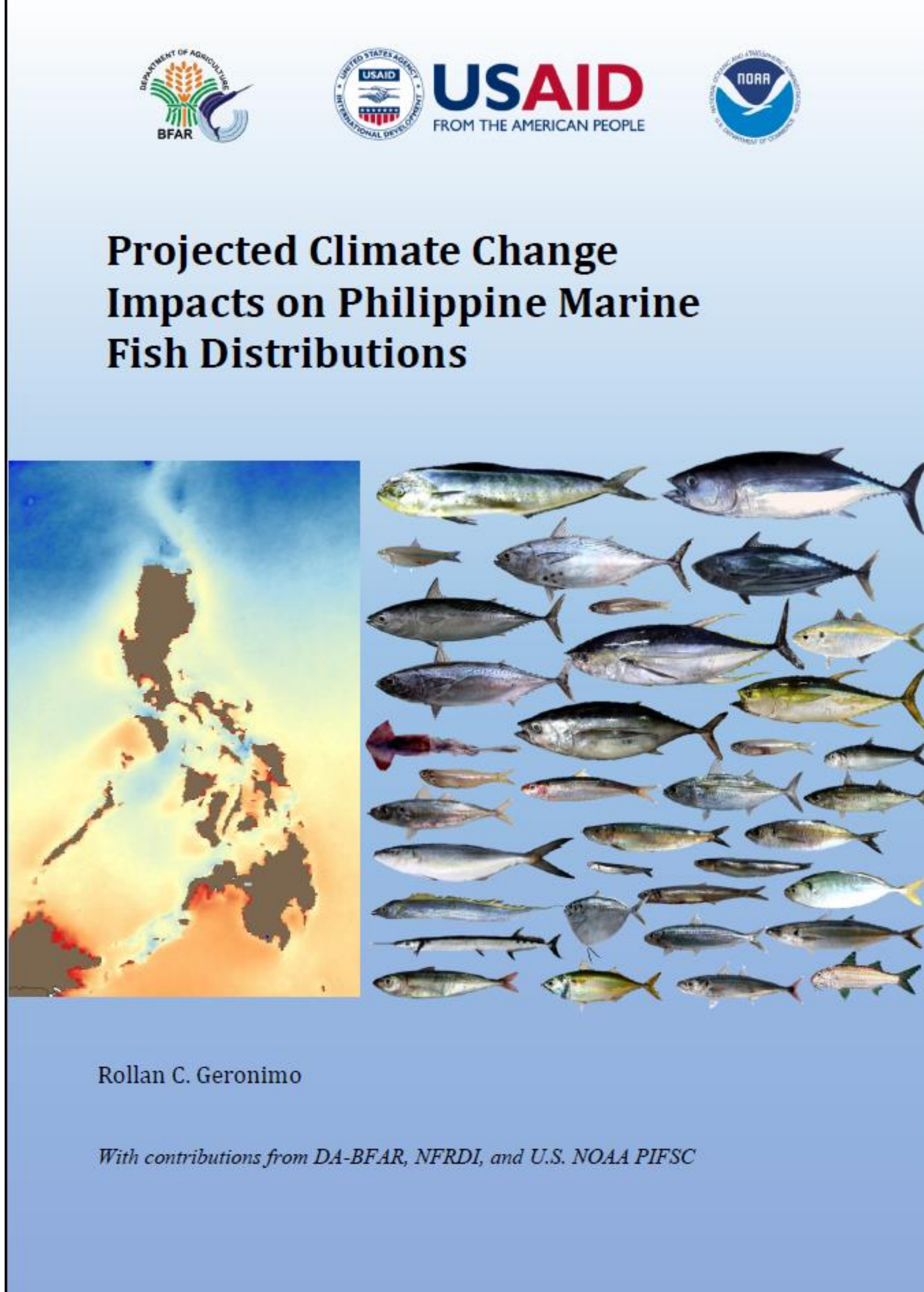
POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE ECONOMICS OF FISHERIES

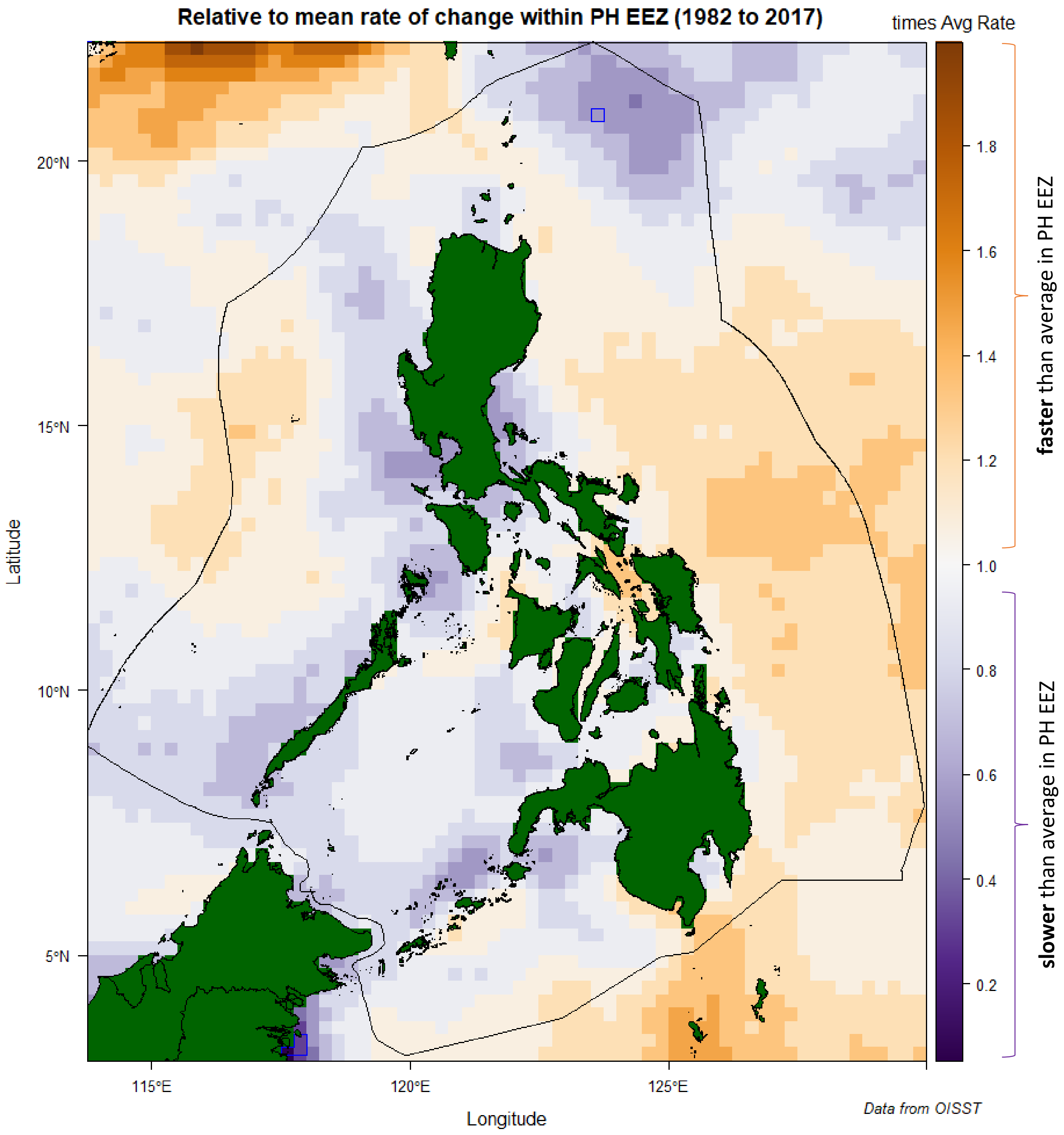
Based on information from published literature

IMPACTS	REGIONS	CATCH	PRICES	COST	
				Fishing	Adaptation
Shift in distribution of species	Arctic	• **Catch potential**: increase • Invasion of warmer water species	↓	↓	↑
	Temperate	• **Catch potential**: no change • Changes in species composition resulting from both species gains and losses	Not yet known	Not yet known	↑
	Tropics	• **Catch potential**: decrease • Species losses	Not yet known	↑	↑
Ocean acidification	Global	• **Catch potential**: decrease	↑	↑	↑
Expansion of oxygen minimum zones	Global	• **Catch potential**: decrease	↑	↑	↑
Reduction in body size	Global	• No change	↑	No change	↑
Increased variability	Global	• No change	↓ Variable ↑	↑	↑
Increased extreme weather	Global	• **Actual catch**: decrease	↑	↑	↑

Sumaila et al. 2011 – Nature Climate Change

2. Projected Changes in Habitat Suitability for Top Marine Capture Fisheries





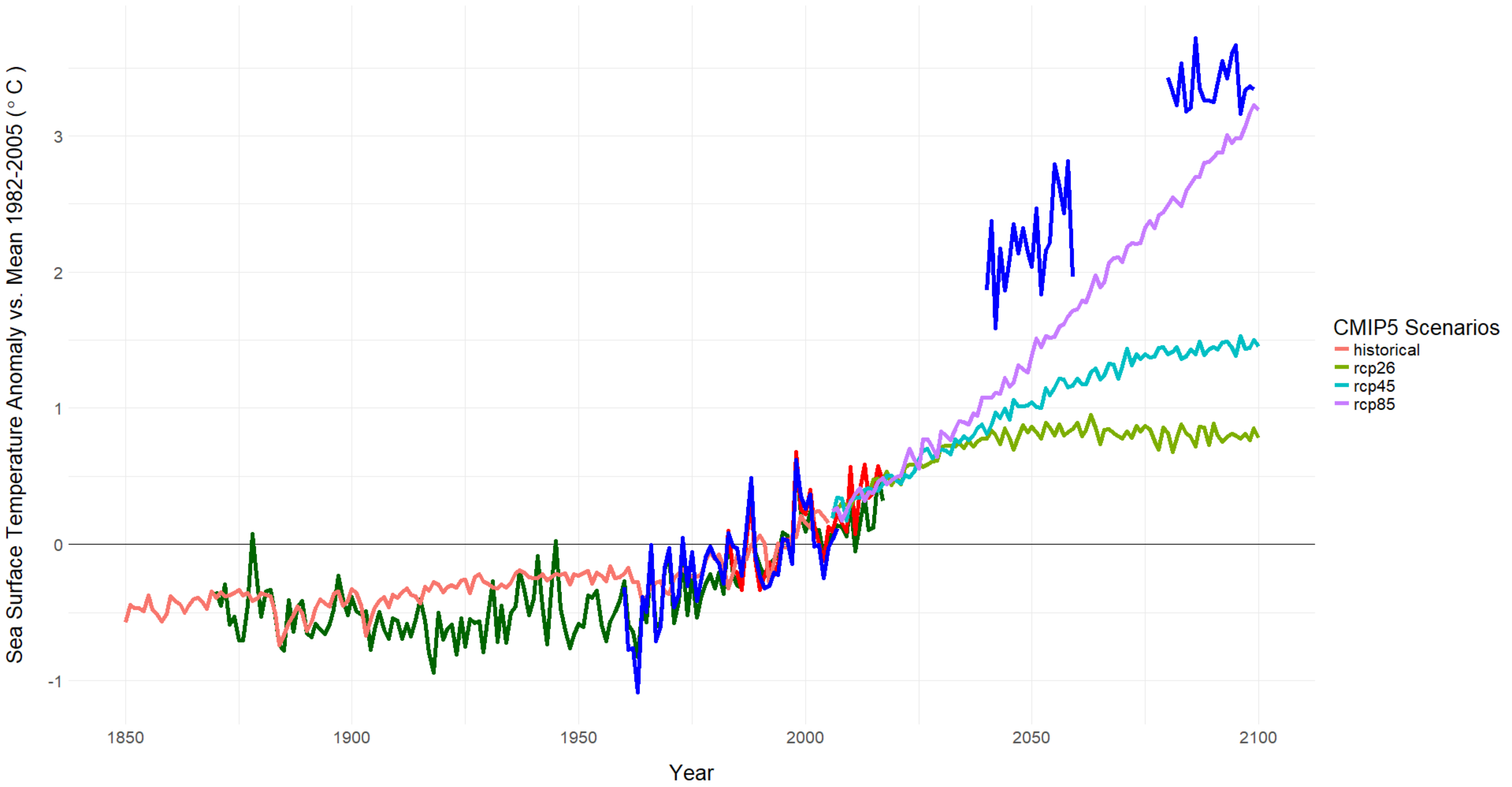
Sea Surface Temperature Trends

- Dataset: OISST
- Trends are Theil-Sen slopes calculated from annual mean SST for 34-year period (1982 to 2016)
- All pixels have p-value ≤ 0.05 based on Mann-Kendall Trend test except for those inside the blue polygons.
- Mean rate of change inside PH EEZ = 0.2°C/decade
- *** Convert this into an anomaly map by subtracting with space-time average for PH EEZ. Also, add PH EEZ overlay.

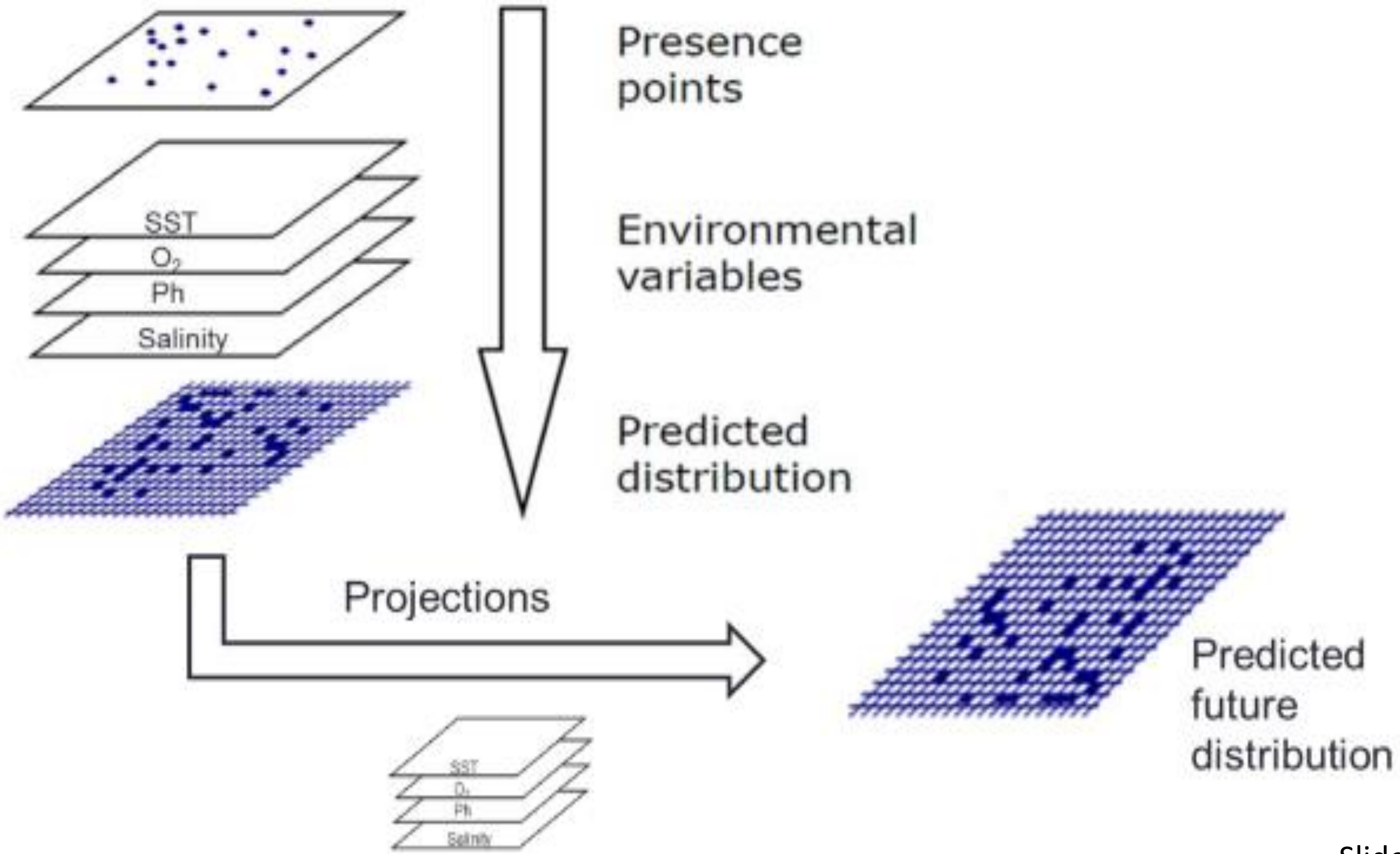
Projected changes in Sea Surface Temperatures

Dark green (HadISST)
Red (OISST)
Blue (CTROMS)
Other colors (CMIP5; as in legend)

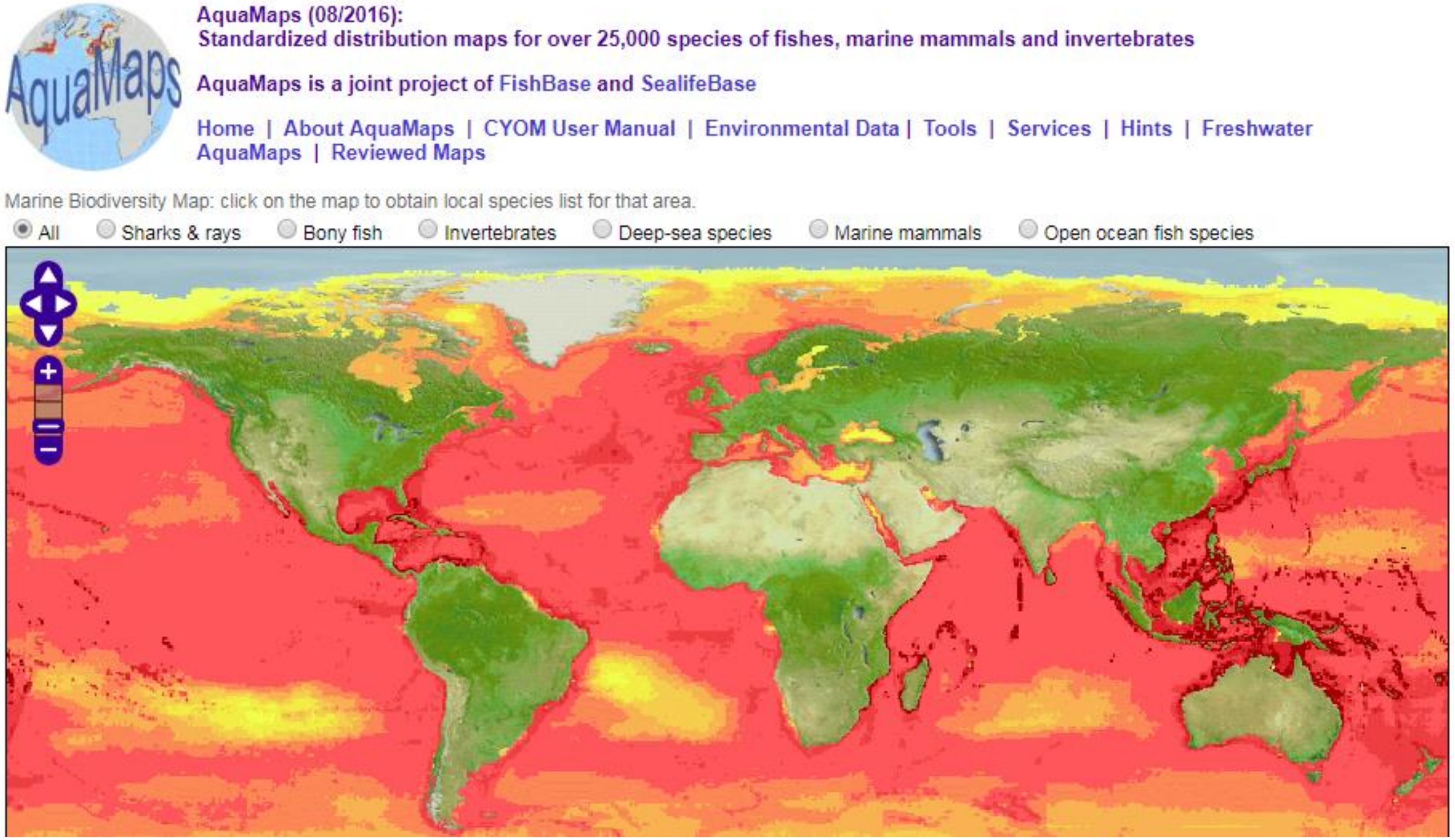
Projected Changes in Sea Surface Temperature anomaly within Philippines' EEZ* compared to 1982 to 2005 average



Distribution models



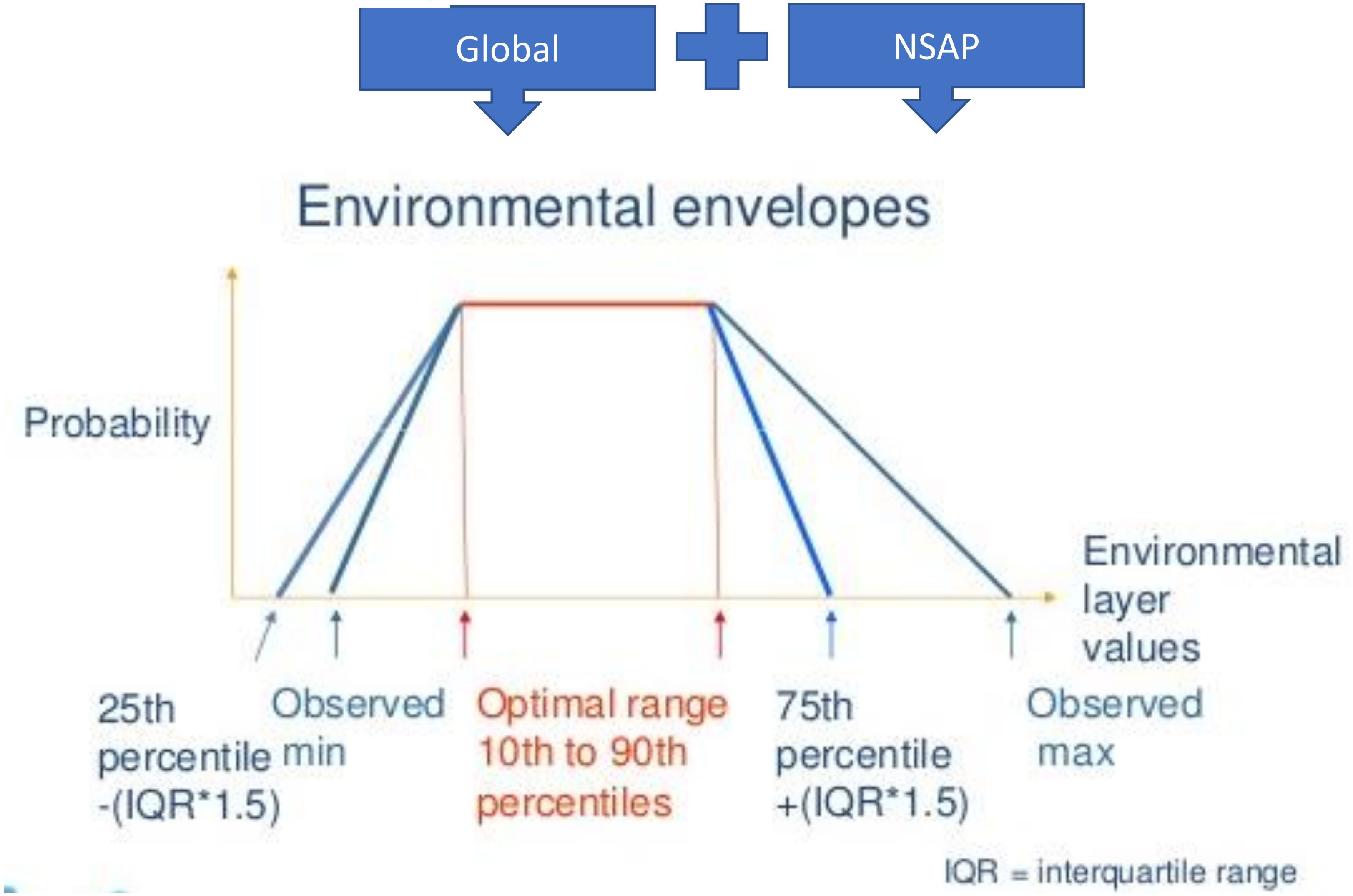
Slide from Joana Boavida-Portugal



Aquamaps

- Global database of standardized marine species distribution maps using relative suitability indices
- 0.5° x 0.5° resolution
- Uses global occurrence data from global biodiversity and taxonomy database
- Significantly lacking occurrence information in the tropics

Aquamaps



Updated the occurrence records to include local information from the BFAR-NFRDI National Stock Assessment Program data.

Used regional climate forecasting model with higher resolution than what was used in current Aquamaps website

Environmental Predictors:

1. Temperature
2. Salinity
3. Primary production

Kaschner, K., K. Kesner-Reyes, C. Garilao, J. Rius-Barile, T. Rees, and R. Froese. 2016. AquaMaps: Predicted range maps for aquatic species. World wide web electronic publication, www.aquamaps.org, Version 08/2016.

Anchovy
1. *Encrasicholina devisi*
2. *Encrasicholina heteroloba*
3. *Encrasicholina punctifer*
4. *Stolephorus commersonnii*
5. *Stolephorus indicus*

Mackerel
6. *Rastrelliger brachysoma*
7. *Rastrelliger faughni*
8. *Rastrelliger kanagurta*
9. *Scomber japonicus*
10. *Scomberomorus commerson*

Sardine
11. *Amblygaster clupeoides*
12. *Amblygaster leiogaster*
13. *Amblygaster sirm*
14. *Escualosa thoracata*
15. *Sardinella fimbriata*
16. *Sardinella gibbosa*
17. *Sardinella lemuru*

Scad
18. *Atule mate*
19. *Decapterus kurroides*
20. *Decapterus macarellus*
21. *Decapterus macrosoma*
22. *Decapterus maruadsi*
23. *Decapterus russelli*
24. *Decapterus tabl*
25. *Selar boops*
26. *Selar crumenophthalmus*
27. *Selaroides leptolepis*

Tuna
28. *Auxis rochei*
29. *Auxis thazard*
30. *Euthynnus affinis*
31. *Katsuwonus pelamis*
32. *Thunnus alalunga*
33. *Thunnus albacares*
34. *Thunnus obesus*
35. *Thunnus tonggol*

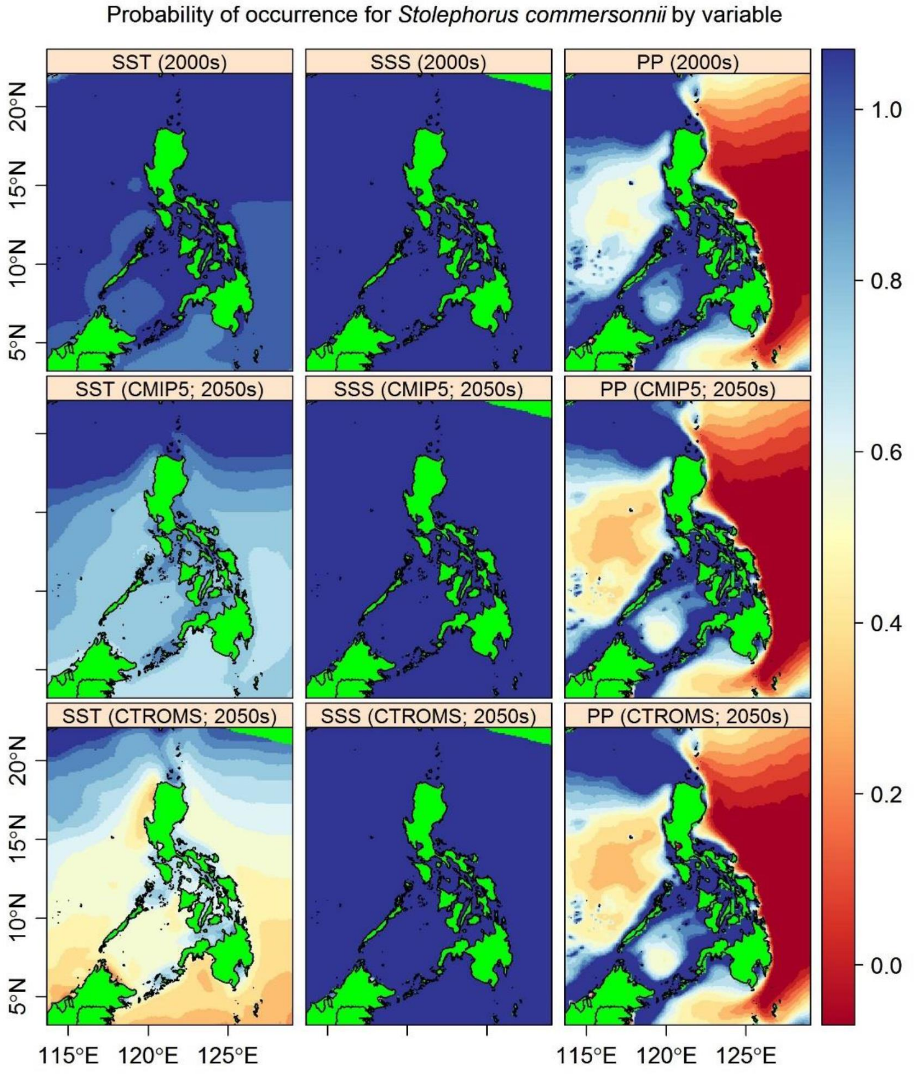
Squid
36. *Sepioteuthis lessoniana*
37. Uroteuthis duvaucelii
38. *Uroteuthis edulis*

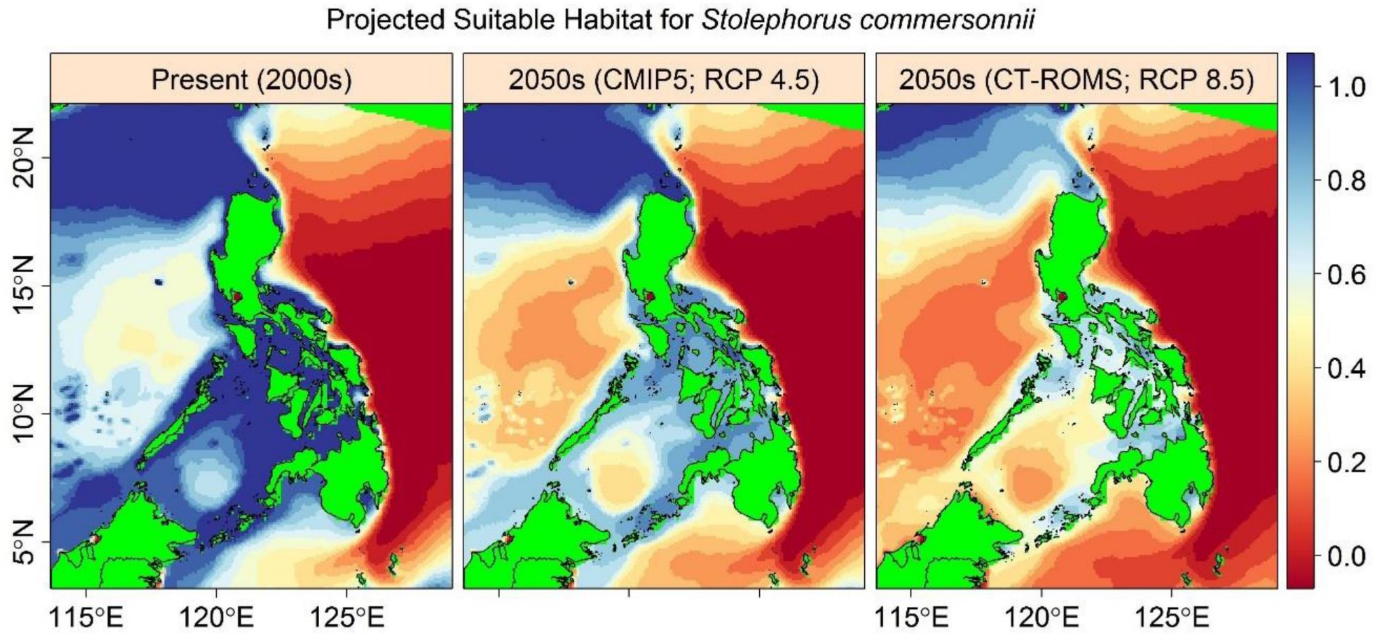
Miscellaneous small pelagic
39. *Ablennes hians*
40. *Dussumieria acuta*
41. *Mene maculata*
42. *Spratelloides delicatulus*
43. *Spratelloides gracilis*
44. *Trichiurus lepturus*

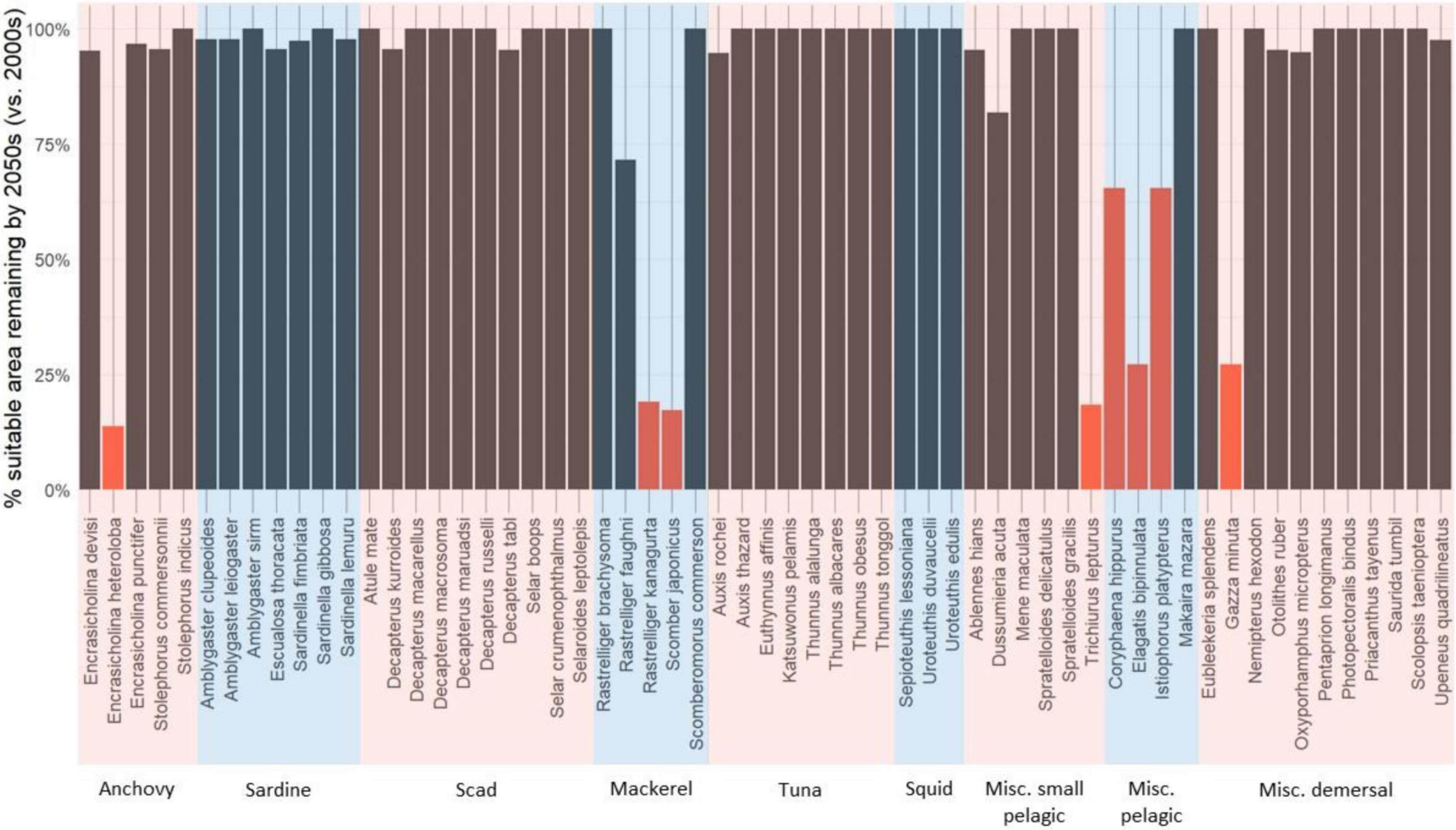
Miscellaneous pelagic
45. *Coryphaena hippurus*
46. *Elagatis bipinnulata*
47. *Istiophorus platypterus*
48. *Makaira mazara*

Miscellaneous demersal
49. *Eubleekeria splendens*
50. *Gazza minuta*
51. *Nemipterus hexodon*
52. *Otolithes ruber*
53. *Oxyporhamphus micropterus*
54. *Pentaprion longimanus*
55. *Photopectoralis bindus*
56. *Priacanthus tayenus*
57. *Saurida tumbil*
58. *Scolopsis taenioptera*
59. *Upeneus quadrilineatus*

Stolephorus commersonnii **ANCHOVIES**
Commerson's anchovy (*"Dilis"*)







% suitable area remaining by 2050s (vs. 2000s)
100%
75%
50%
25%
0%
Encrasicholina devisi
Encrasicholina heteroloba
Encrasicholina punctifer
Stolephorus commersonii
Stolephorus indicus
Amblygaster clupeoides
Amblygaster leiogaster
Amblygaster sirm
Escualosa thoracata
Sardinella fimbriata
Sardinella gibbosa
Sardinella lemuru
Atule mate
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Rastrelliger faughni
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Auxis thazard
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Thunnus albacares
Thunnus obesus
Thunnus tonggol
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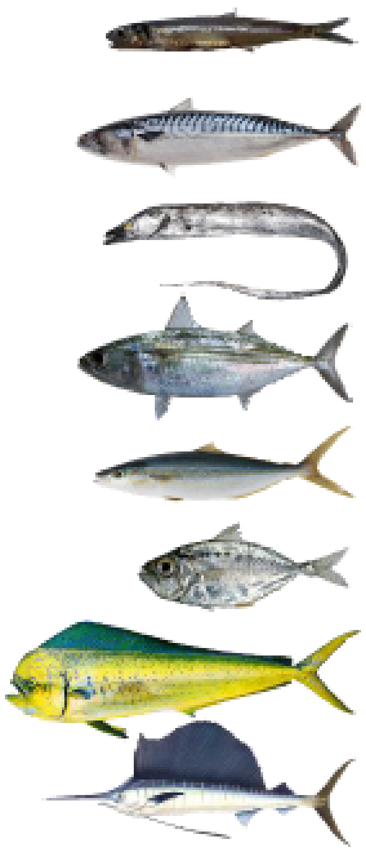
Sardine
Scad
Mackerel
Tuna
Squid
Misc. small pelagic
Misc. pelagic
Misc. demersal

Top species affected by climate change

- Will experience widespread marine / ocean conditions that go beyond present and historical occurrence thresholds



- *Enhcrasicolina heteroloba* ("bolinaw") [13%; 0%]
- *Scomber japonicus* ("tangigue") [17%, 0%]
- *Trichiurus lepturus* ("espada") [18%, 0%]
- *Rastrelliger kanagurta* ("alumahan") [19%, 0%]
- *Elegatis bipinnulata* ("salmon") [27%, 2%]
- *Gazza minuta* ("sapsap") [27%, 2%]
- *Coryphaena hippurus* ("durado") [65%, 7%]
- *Istiophorus platypterus* ("malasugi) [65%, 7%]

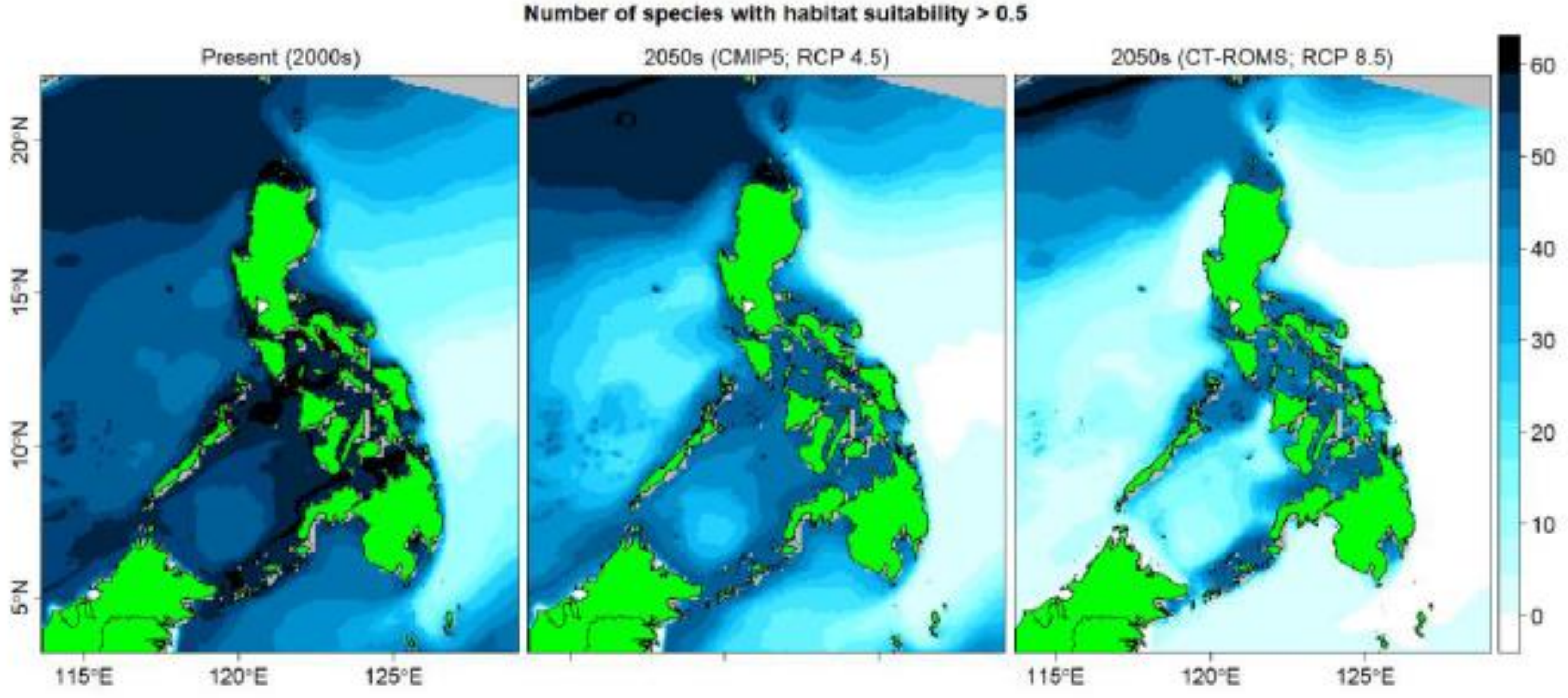
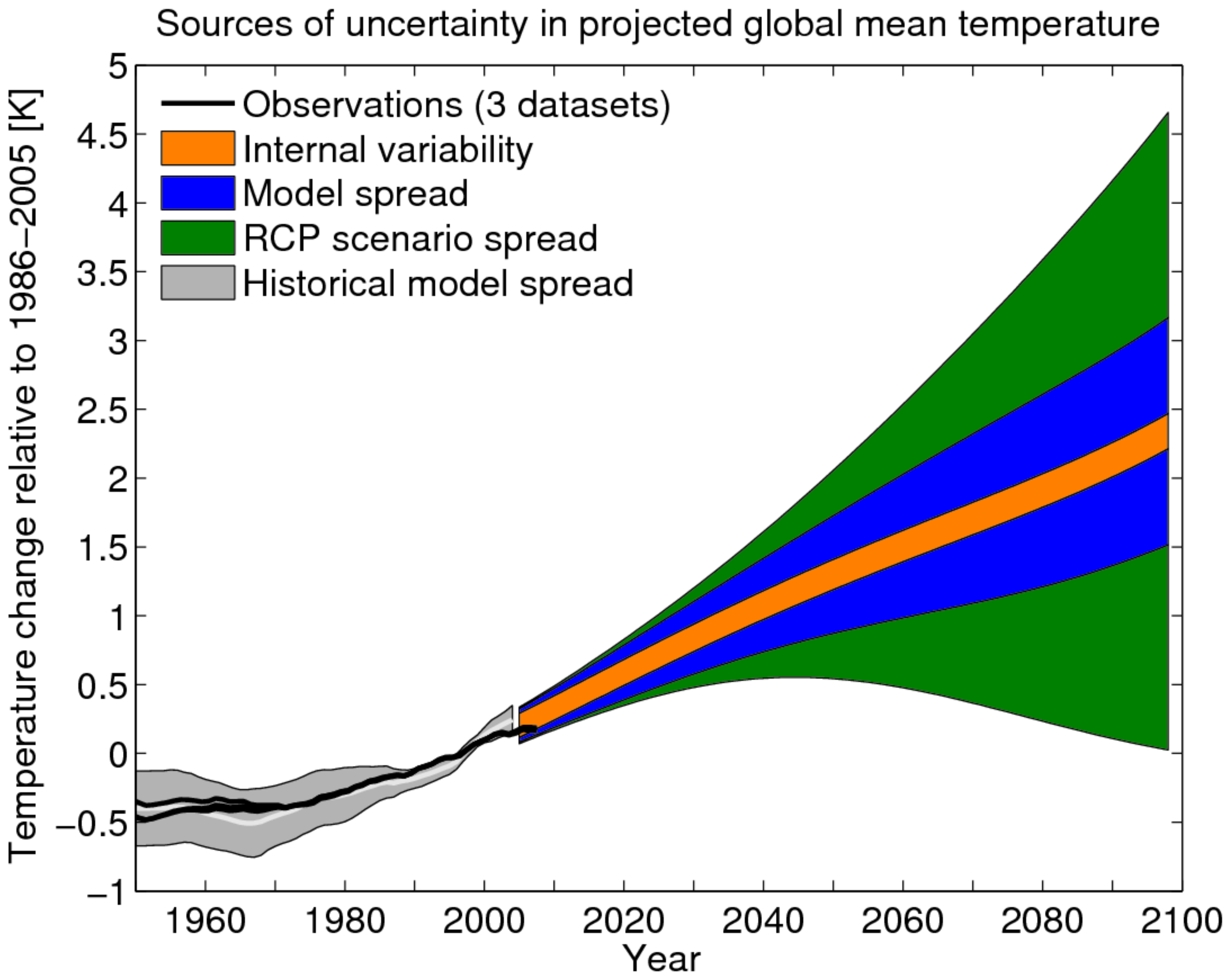


Figure 10. Number of species with habitat suitability score of greater than 0.5 for present and the two future climate change scenarios.

3. Fisheries governance in an uncertain climate future

Uncertainty

- Various sources of uncertainty in model projections
- Uncertainty in model projections increases with increasing duration from starting point
- Range of future possibilities need to be explored



COPING	ADAPTATION
Short-term and immediate	Practices and results are sustained
Oriented towards survival	Oriented towards longer-term livelihood security
Not continuous	A continuous process
Motivated by crisis; reactive	Involves planning
Often degrades the resource base	Uses resources efficiently and sustainably
Prompted by a lack of alternatives	Focused on finding alternatives
	Combines old and new strategies and knowledge

Table I. Examples of human interventions to boost adaptation of marine systems

Intervention	Description
Protection	Reduce or remove other stressors (climate and non-climate) from natural systems to increase the capacity of the species or ecosystems to respond to climate change, *i.e.* to enhance resilience
Restoration	Restoration of populations or habitats to moderate sensitivity to climate stressors, *e.g.* restoration of coastal vegetation
Translocation	Proactive relocation of species or habitats to areas with suitable environmental conditions
Assisted evolution	Increasing the rate of evolution through, *e.g.*, selective breeding and pre-conditioning of individuals to changed environmental conditions

Cheung 2018 – J Fish Biol

Recommendations

1. Improved understanding of fish – environment interactions and relations (e.g., ENSO and fish abundance patterns; drivers of primary productivity; etc.)
2. Adaptive management more relevant now more than ever
3. Projections are not all negative; proactive governance instead of reactive to prevent sudden collapse of species and, at the same time, take advantage of emerging species-on-the-move
4. Invest in high-resolution and locally parameterized regional climate and ocean models in partnership with neighboring country scientists
5. Continue and even expand monitoring programs
6. Philippine Ocean Atlas

Tuna catch declining in GenSan on El Niño

Manila Times 5 Apr 2010 BY A

G ENERAL SANT
Tuna catch is declin
southern Philippine
warm climate contin
fect the ocean's temp

El Niño spares tuna fishing in Mindoro Strait — officials

posted February 09, 2016 at 12:01 am *by* **Robert A. Evora**

fishing

d cold

ago will

catch

NATION 314 SHARES

El Niño to slash fish catch by 20%–BFAR

By: Ronnel W. Domingo- @inquirerdotnet Philippine Daily Inquirer / 03:30 AM February 05, 2016

At least 100,000 fisher folk throughout the archipelago will be needing alternative sources of livelihood as the strong El Niño is expected to reduce the normal fish catch by at least one-fifth

LATEST STORIES MOST

SPORTS
Alab holds off

Maraming salamat!

rollan@hawaii.edu