Impact of ocean warming on sustainable fisheries management

Natalia Serpetti, A.R. Baudron, M.T. Burrows, B.L. Payne, P. Helaouët, P.G. Fernandes, J.W. Bentley, M.T. Burrows, J.J. Heymans

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....the past and the present

"The increase of world population amplified humanity's impact on the environment. To provide space, food, and resources in a sustainable way into the distant future is without question one of the large, serious challenges for our generation".

In this context, the number of overfished stocks around the world has tripled, FAO recently stated that 1/3 of the assessed fisheries worldwide are "pushed beyond their biological limits".

…moreover overfishing is intensified by the catches of unwanted loss of billions of fish and invertebrates along with top predators

....and the future.....

Fishing-induced ecosystem changes often occur in regions already impacted by changing environmental conditions under influence from both <u>natural climate variability</u> and <u>climate change affects</u>...

.....the management is getting even more challenging.....

Fishery and climate impacts are generally assessed over short- and long- time scales respectively, however these pressures co-occurred and it's important to untangling their conflicts and/or synergies on impacting marine ecosystems.

EwE of the West Coast of Scotland



Haggan, N. and T. J. Pitcher, 2005. Fisheries Centre research reports. T. F. Centre. Vancouver, B.C., Canada, University of British Columbia. 13: 67.
Bailey et al., 2011. The West of Scotland Marine Ecosystem: A Review of Scientific Knowledge. Marine Scotland Science Report 0911.
Alexander et al., 2015. Investigating the recent decline in gadoid stocks in the west of Scotland shelf ecosystem using a foodweb model. ICES Journal of Marine Science 72(2): 436-449.
Serpetti et al., 2017. Impact of ocean warming on sustainable fisheries management informs the Ecosystem Approach to Fisheries." Scientific Reports 7(1): 13438.

The facts.....

- Since the last 30 ye reduction of fishin to protect cod (in
- Since 2000, in this have thrived and other ga (esp. herring) continue to

Because **saithe** and **hake** are strong predators of other gadoids and pelagic species respectively.....

Importance of considering predation and competition in <u>fishing</u> <u>management policy</u>

Why?

Could warning climate also helped these changes?

Results: water temperature hindcasting The Hadley Centre Global Sea Surface and IPCC future scenarios



Methods: adding the temperature species preferences and water temperature time-series



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Impact of ocean warming on sustainable fisheries management informs the Ecosystem Approach to **Fisheries** Accepted: 20 September 2017 Published online: 18 October 2017

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Results: water temperature predictions



R ² , p-value	SST	AMO_smoothed	AMO_unsmoothed	NAOI	PP_anomaly
SST	1	0.65	0.67	0.36	0.50
AMO_smoothed	***	1	082	-0.22	0.72
AMO_unsmoothed	***	* * *	1		
NAOI	**	_	**	1	0.25
PP_anomaly	**	***	**	_	1



Results: water temperature predictions

Temperature 60-55N, -10--4E (sea) Jan-Dec AR5 CMIP5 subset





Time

Results: scenarios



- Status quo: fishing mortality set at 2013 value
- MSY: fishing mortality (F) set at advised MSY (F_{MSY})
- MSY+RCP2.6: F_{MSY}+ RCP 2.6
- MSY+RCP4.5: F_{MSY}+ RCP 4.5
- MSY+RCP6.0: F_{MSY}+ RCO 6.0
- MSY+RCP8.5: F_{MSY}+ RCP 8.5

Species	F _{status quo}	F _{MSY-Single Species} (stock assessment)
Cad	2003-2013	0.10
Cod	0.43	0.19
Haddock	0.18	0.37
Whiting	0.14	0.18
Saithe	0.06	0.32
Hake	0.018	0.27

Biomass

Status quo: fishing mortality set at 2013 value

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MSY+RCP2.6 MSY+RCP4.5 MSY+RCP6.0 MSY+RCP8.5

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Investigating the potential impacts of ocean warming on the Norwegian and Barents Seas ecosystem using a time-dynamic food-web model

Jacob W. Bentley*, Natalia Serpetti, Johanna Jacomina Heymans

Jacob W. Bentley 💿 1*, David E. Hines², Stuart R. Borrett^{2,3}, Natalia Serpetti¹, Gema Hernandez-Milian⁴, Clive Fox¹, Johanna J. Heymans^{1,5}, and David G. Reid⁶ ICES Journal of Marine Science (2019), doi:10.1093/icesjms/fsz003

Fishers' knowledge improves the accuracy of food web model predictions

Jacob W. Bentley^{1,*}, Natalia Serpetti¹, Clive Fox¹, Johanna J. Heymans^{1,2}, and David G. Reid³

Response functions to temperature

Q/B



'Pros and Cons'

- Taking in consideration a more sensitive thermal niche envelop
- Overestimating the scaling consumption off a narrow range of optimal conditions (especially under warming conditions)





Ecological Modeling

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

Modelling the cumulative spatial-temporal effects of environmental drivers and fishing in a NW Mediterranean marine ecosystem

Marta Coll^{a,b,c,*}, Jeroen Steenbeek^{a,b}, Jordi Sole^c, Isabel Palomera^{b,c}, Villy Christensen^d

'Pros and Cons'

- Active link with Aquamaps/Ecospace, drag
 the functions directly into EWE
 Uniform distribution of population between
 - 10th-90th percentiles of the distributions

Retrospective analysis of the influence of environmental drivers on commercial stocks and fishing opportunities in the Irish Sea

Jacob W. Bentley¹ | Natalia Serpetti¹ | Clive J. Fox¹ | Johanna J. Heymans^{1,2} David G. Reid³

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SCIENTIFIC REPORTS

OPENFuture scenarios of marine
resources and ecosystem
conditions in the Eastern
Mediterranean under the impacts
of fishing, alien species and sea
warming

X. Corrales^{1,2}, M. Coll^{2,3}, E. Ofir¹, J. J. Heymans^{4,5}, J. Steenbeek^{2,3}, M. Goren⁶, D. Edelist⁷ & G. Gal¹

Hindcasting the dynamics of an Eastern Mediterranean marine ecosystem under the impacts of multiple stressors

X. Corrales^{1,2,*}, M. Coll^{2,3}, E. Ofir¹, C. Piroddi², M. Goren⁴, D. Edelist⁵, J. J. Heymans⁶, J. Steenbeek^{2,3}, V. Christensen⁷, G. Gal¹





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Predicting marine species distributions: Complementarity of food-web and Bayesian hierarchical modelling approaches

M. Coll^{a,b,1,*}, M. Grazia Pennino^{c,d,e,1}, J. Steenbeek^b, J. Sole^a, J.M. Bellido^{e,f}

Response function built using species distribution statistical models 'Pros and Cons'

High accuracy for the specific case of study
 Not possible to infer the same function for other ecosystems



Most species showed a "Gaussian" They performed a large analysis evaluated the the man able denvertion for relist filoution asymmetrical apes distributions for many species (cold-

left-skewed)

They modelled variation between tropical Tropical species, cold- left-skewed and temperate guilds in the shape of

- standard deviations to define pecies-specific thermal-abundance skewness were calculated using a

split-Gaussian function



nature climate change

Letter Published: 25 November 2019

Ocean community warming responses explained by thermal affinities and temperature gradients

Michael T. Burrows [⊡], Amanda E. Bates, Mark J. Costello, Martin Edwards, Graham J. Edgar, Clive J. Fox, Benjamin S. Halpern, Jan G. Hiddink, Malin L. Pinsky, Ryan D. Batt, Jorge García Molinos, Benjamin L. Payne, David S. Schoeman, Rick D. Stuart-Smith & Elvira S. Poloczanska



Areas with warming (the North Atlantic) see strong shifts towards warm-water species dominance"

Temperature scenarios

With climate change....





by 2050 11.3°C by 2100 12.5°C

<u>Conclusion</u>: response functions to temperature: shape matters! and we need to test the model sensitivity to these shapes

Thank you to all my co-authors

A.R. Baudron, M.T. Burrows, B.L. Payne, P. Helaouët, P.G. Fernandes, J.W. Bentley, M.T. Burrows, J.J. Heymans

and to all of you for listening



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