Report of Working Group 40 on *Climate and Ecosystem Predictability*

The fourth business meeting of Working Group (WG 40) on *Climate and Ecosystem Predictability* was held virtually on September 14, 2020. There were 12 WG 40 members in attendance plus two additional participants (WG 40 *Endnote 1*). The meeting was used to survey the current status of the Working Group efforts and plan for next steps, including a one-year extension and potential contributions of WG 40 to new programs including WCRP Lighthouse Activities, NOAA's Climate and Fisheries Initiative, and the UN Decade of Ocean Science. The agenda for the meeting is presented *WG 40 Endnote 2*.

AGENDA ITEM 2
Update on WG 40 Special Issue in *Frontiers in Marine Science*

WG 40 has developed a *Frontiers in Marine Science* research topic entitled "North Pacific climate and ecosystem predictability on seasonal to decadal timescales[1]". This collection of papers draws on the WG 40 Topic Session on "Advances in North Pacific marine ecosystem prediction" at PICES-2019. A total of 10 manuscripts have now been accepted for publication. The topic editors will also contribute an introductory paper and potentially a perspectives paper as well.

AGENDA ITEM 3
Updates on WG 40 marine forecasting research

The following WG 40 members gave research updates:

Antonietta Capotondi discussed predictability of the 2013–2016 NE Pacific marine heatwave, based on a linear inverse model trained on SST and SSH. At 6-month lead, the linear inverse model (LIM) skill is often better than a damped persistence forecast, though it has difficulty reproducing the heatwave evolution from the Gulf of Alaska to the North American west coast.

Masami Nonaka presented an analysis of eddy activity and sea level anomaly predictability in the Kuroshio Extension region. Eddy activity is much more predictable in the downstream region than the upstream region, and the SINTEX-F forecasts have skill at 2-year lead times for sea level anomalies in some regions of the North Pacific, likely related to ENSO.

James Christian presented results from CanESM5 decadal predictions. Potential predictability is lowest in the tropics, while NE Pacific upper ocean heat content has good predictability even at 2- to 5-year lead times.

Fei Chai gave an update on Biogeochemical (BGC) Argo deployments and other autonomous platforms. Fifteen nations have operating BGC Argo floats. The Second Institute of Oceanography (MNR, China) has 16 floats (8 in the water since 2018, 8 more by the end of 2020); they have been able to observe mixing and resulting productivity from passing storms (8- to 10-day frequency).

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[1] https://www.frontiersin.org/research-topics/12240/north-pacific-climate-and-ecosystem-predictability-on-seasonal-to-decadal-timescales#articles

Michael Jacox highlighted a recent *Progress in Oceanography* review paper[2] on seasonal to interannual forecasting, including forecast methods, mechanisms of predictability, and priority developments. He also showed latest results from dynamically downscaled forecasts for the California Current System, which show that dynamical downscaling provides a large bias reduction and moderate improvement in anomaly prediction.

Ryan Rykaczewski discussed predictions of bigeye tuna catch in the central North Pacific, showing a clear progression of cohorts so that catch of small fish may provide several years of predictability for catch of larger fish. He also introduced the new PICES/ICES WG 43 on *Small Pelagic Fish*, which will include task forces on ecological process knowledge, translating process knowledge (including forecasts and projections), and social–ecological approaches.

Akinori Takasuka presented analyses of density dependence in egg production, showing that the spawning stock biomass – total egg production relationship is nonlinear because of density dependence. These relationships are different between species and challenge the paradigm that spawning stock biomass is a suitable proxy for reproductive potential. The results are described in three papers from 2019–2020[3].

Shoshiro Minobe and co-authors recently published a multivariate analysis of 120 marine biological indices from the western and eastern North Pacific[4]. Among the results, the first principal component of these indices is negatively correlated with groundfish and appears to be related to global warming.

Fangli Qiao showed results from First Institute of Oceanography Earth System Model versions 1 and 2. FIO has found that the incorporation of surface waves improves 1- to 6-month lead forecasts. FIO-ESMv2 is being evaluated in reforecast mode and looks to be more skillful than v1. After evaluation of 30 years of reforecasts, the new system will move to one-year operational forecasts.

Samantha Siedlecki presented the latest from the J-SCOPE regional forecasting system, which has now been used to drive hake forecasts that will be presented to the Pacific Fisheries Management Council. Also, an analysis of subsurface temperature variability in the northern California Current System, led by Sulagna Ray, suggested influences of the tropical Pacific, the PDO, the west-central Pacific, and the region just south of the northern CCS.

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[2] Jacox, M. G., M. A. Alexander, S. Siedlecki, K. Chen, Y.-O. Kwon, S. Brodie, I. Ortiz, D. Tommasi, M. J. Widlansky, D. Barrie, A. Capotondi, W. Cheng, E. Di Lorenzo, C. Edwards, J. Fiechter, P. Fratantoni, E. L. Hazen, A. J. Hermann, A. Kumar, A. J. Miller, D. Pirhalla, M. Pozo Buil, S. Ray, S. C. Sheridan, A. Subramanian, P. Thompson, L. Thorne, H. Annamalai, S. J. Bograd, R. B. Griffis, H. Kim, A. Mariotti, M. Merrifield, and R. Rykaczewski (2020), Seasonal-to-interannual prediction of North American coastal marine ecosystems: Forecast methods, mechanisms of predictability, and priority developments, *Progress in Oceanography*, 183, doi:10.1016/j.pocean.2020.102307.

[3] Takasuka, A., M. Yoneda, and Y. Oozeki (2019), Density dependence in total egg production per spawner for marine fish. *Fish and Fisheries*, 20: 125–137, https://doi.org/10.1111/faf.12327.
Takasuka, A., M. Yoneda, and Y. Oozeki (2019), Disentangling density-dependent effects on egg production and survival from egg to recruitment in fish. *Fish and Fisheries*, 20: 870–887, https://doi.org/10.1111/faf.12381.
Takasuka, A., M. Yoneda, and Y. Oozeki (2021), Density-dependent egg production in chub mackerel in the Kuroshio Current system. *Fisheries Oceanography*, 30: 38–50, https://doi.org/10.1111/fog.12501.

[4] Yati, E., S. Minobe, N. Mantua, S. Ito, and E. Di Lorenzo (2020), Marine ecosystem variations over the North Pacific and their linkage to large-scale climate variability and change. *Frontiers in Marine Science*, 7, https://doi.org/10.3389/fmars.2020.578165.

AGENDA ITEM 4
Relevant new or upcoming activities

World Climate Research Program (WCRP) Lighthouse Activities

Shoshiro Minobe and Antonietta Capotondi informed the group of new developments in WCRP. WCRP has four core projects, one of which is climate and ocean variability, predictability, and change. The WCRP Strategic Plan for 2019–2028 has been finalized and they are now working on the Implementation Plan. WCRP is also developing a number of Lighthouse Activities. One of them, explaining and predicting earth system change, aims to design and take steps toward delivery of an integrated capability for observation, explanation, early warning, and prediction of earth system change. Another, the WCRP Academy, seeks to establish one or more targeted capacity exchange climate programs working with established education providers.

NOAA Climate and Fisheries Initiative

Michael Jacox presented the current status of NOAA's Climate and Fisheries Initiative, a U.S. effort to deliver operational regional ocean forecasts in support of living marine resource management in the NE Pacific, NW Atlantic, and Arctic. Key aspects include advancing regional modeling capacity, data delivery, and fisheries tools. The Initiative was described in a white paper (currently in internal circulation) and an Implementation Plan is now being developed.

FUTURE Science Program and the UN Decade of Ocean Science

Steven Bograd updated the Working Group on FUTURE and PICES coordination with the UN Decade of Ocean Science (UNDOS). FUTURE will carry on into a third phase, and is well positioned to contribute to the UNDOS, which has "a predicted ocean" as one of its goals. A planning workshop in August 2020 focused on the North Pacific region and highlighted PICES potential role. A Study Group on *United Nations Decade of Ocean Science* was formed at PICES-2020 to coordinate DOS activities, ultimately looking to develop a DOS program with climate and ecosystem predictability as a focal point. Existing PICES working groups including WG 40 are highly relevant, though many are ending. New working groups in this space should be considered (*e.g.*, predictability and impacts of extremes).

AGENDA ITEM 5
Next steps

The most pressing point of deliberation was whether to request a one-year extension for WG 40. The Working Group members were enthusiastic in discussions about climate and ecosystem predictability research and the potential of the WG to contribute more. It was decided to submit a request for a one-year extension (which has since been approved). In the coming year, WG 40 aims to wrap up with (i) expanded discussions on key ecosystem predictability questions and applications, and contributions of WG 40 (and PICES more broadly) to this field, (ii) help establish a new working group with a focus on extremes in coastal environments, to include broad PICES participation including members from WG 36, 40, and 41, and S-HAB, and (iii) potentially a *Frontiers in Marine Science* perspectives paper suggesting guidelines for marine ecosystem prediction studies using physical climate/ocean forecasts.

WG 40 Endnote 1

WG 40 participation list

Members

Michael Jacox (USA, PICES Co-Chair)
Masami Nonaka (Japan, PICES Co-Chair)
Antonietta Capotondi (USA, CLIVAR Co-Chair)
Shoshiro Minobe (Japan, CLIVAR Co-Chair)
Ryan Rykaczewski (USA, CLIVAR Co-Chair)
Fei Chai (China)
James Christian (Canada)
Caihong Fu (Canada)
Chan Joo Jang (Korea)
Vladimir Kulik (Russia)
Samantha Siedlecki (USA)
Akinori Takasuka (Japan)

Members unable to attend

China: Ying Bao, Jinqiu Du
Korea: MinHo Kwon, Chung Il Lee
Russia: Yury Zuenko
USA: Emanuele Di Lorenzo

Observers

Steven Bograd (USA, FUTURE SSC Co-Chair)
Fangli Qiao (China)

WG 40 Endnote 2

WG 40 meeting agenda

1600 – 1800 PDT, Monday, 14 September 2020 (2300 – 0100 UTC)

1. Welcome and introduction (Nonaka/Jacox)
2. Update on WG 40 special issue in Frontiers in Marine Science (Minobe)
3. Updates on WG 40 marine forecasting efforts
4. Relevant new or upcoming activities
   - WCRP Lighthouse Activities (Minobe/Capotondi)
   - NOAA Climate and Fisheries Initiative (Jacox)
5. Discussion of next steps
   - PICES' contribution to UN Decade of Ocean Science (Bograd)
   - Potential WG 40 extension and/or follow-on (all)
   - Final reporting (Jacox)
6. Final comments (Co-Chairs)
7. Adjourn