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Editorial: North Pacific climate and ecosystem predictability on seasonal to decadal timescales

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Editorial on the Research Topic
North Pacific climate and ecosystem predictability on seasonal to decadal timescales

The present Research Topic aims to collect studies on all aspects contributing to marine ecosystem predictability and prediction, including observational and numerical studies, with a focus on the North Pacific Ocean north of 30°N. The scope of this Research Topic includes studies of climate predictability and climate-marine ecosystem relationships as the basis of marine ecosystem predictability. This Research Topic is organized by the Working Group on “Climate and Ecosystem Predictability”, a joint working group between the North Pacific Marine Science Organization (PICES) and Climate and Oceans, Variability, Predictability and Change (CLIVAR). PICES is an intergovernmental organization for marine science over the North Pacific, that includes the countries along the North Pacific rim, i.e., the United States of America, Japan, People's Republic of China, Canada, Republic of Korea, and the Russian Federation. CLIVAR is one of six global core projects of the World Climate Research Programme. These international science organizations and projects have played important roles in the ocean and climate sciences. This working group is the first joint working group between PICES and CLIVAR, demonstrating the increasing need for collaboration between physical ocean/climate studies, the main area of CLIVAR, and marine biological studies, the major focus of PICES.

The Research Topic includes twelve original papers and one perspective paper. The perspective paper by Minobe et al. outlined several steps required for marine biology forecasts, typically involving global climate model prediction of the physical environment, regional downscaling of those physical conditions, and marine biological estimation based on the physical environment. The paper reviewed existing projects pursuing physical ocean/climate prediction at lead times ranging from subseasonal to multi-annual, pointed out existing bottlenecks for using physical predictions to make marine biological forecasts, and described lessons learned from physical predictions. The workflow suggested by Minobe et al. is based on the assumption that the physical environment influences marine ecosystems on the timescales of interest but not vice versa. It is interesting to note that one paper in the Research Topic studied causality in the other direction, i.e., biology influencing physical conditions; using numerical experiments Ma et al. reported that the presence of phytoplankton substantially increases the subduction rate of the subtropical mode water and the central mode water in the North Pacific.

Four papers studied oceanic variability using data analysis and numerical modeling. Miyama et al. reported frequent occurrences of marine heatwaves in the Northwestern Pacific near Japan between 2010 and 2016 in summer, associated with a weakened first intrusion of the Oyashio current and increased frequency of warm core eddies detached from the Kuroshio Extension (KE) to the north of the KE. Nonaka et al. studied the intrinsic and atmospheric-forced components of KE eddy activity using an ensemble of ocean general circulation model runs with 0.1-degree horizontal resolution. They found that the intrinsic variability is dominant in the upstream KE, and in the downstream KE on interannual timescales. The atmospheric forced component, on the other hand, is dominant on decadal timescales in the downstream KE, in association with Rossby waves propagating from the central North Pacific with four-year time lags, implying potential predictability. Doi et al. investigated the predictability of sea-surface height using a climate prediction system and found a high predictability region in the central North Pacific at about 2-year lead time. Song et al. reported that the seasonal prediction skill of sea-surface temperatures is substantially better when the Ensemble adjustment Kalman filter is used for their data assimilation rather than Projection Optimal Interpolation, especially in the central North Pacific. They also found that inclusion of a wave model improves prediction in the Kuroshio-Oyashio Extension region.

Two papers described how the large-scale physical ocean and climate influence marine biology. Ma et al. investigated how fishery catches from China, Chinese Taipei, Japan and Korea are influenced by large scale climate modes including the Pacific Decadal Oscillation (PDO), the North Pacific Gyre Oscillation (NPGO) and the El Niño-Southern Oscillation, and found fishery-climate relationships to be non-stationary. By analyzing 120 marine biological indicators from the western (29 time series) and eastern (91 time series) North Pacific, Yati et al. found that the first principal component of the biological indicators is characterized by a long-term trend with multi-decadal fluctuations with the largest negative impacts on groundfishes (Figure 1). They found that this mode is strongly related to global warming. It is worth noting that their first mode is consistent with previous studies that analyzed a large number of biological indicators, but earlier studies did not investigate the impact of global warming (see references in Yati et al.).

Three papers investigate how regional physical conditions influence marine biology and how well marine biological conditions can be estimated using physical conditions. Gomez et al. found that the presence of swordfish is strongly related to warm core eddies around the Kuroshio Extension. Kuriyama et al. studied the spatial shared dynamics of temperature, salinity and ichthyoplankton abundance in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) data, using an Empirical Dynamic Method known as "co-prediction". Their findings help identify the spatial structure of the physical and biological dynamics of the California Current System. Muhling et al. examined the performance of statistical models, including machine learning models, for fish habitat estimation in the California Current System. They found that models trained over periods without substantial marine heatwaves can be unreliable for the estimation of fish species and ages during marine heatwave conditions.

The other two papers investigated marine ecosystem forecasts with seasonal or multi-annual prediction lead times. Malick et al. examined the forecast skill of Pacific hake distributions, combining a statistical model for hake with regionally downscaled ocean forecasts provided by JISAO's Seasonal Coastal Oceanic Prediction of the Ecosystem (J-SCOPE). Navarra et al. used a physical-biological linear inverse model (LIM) for the prediction of fishery indicators (estimated biomasses, landings, and catches) in the Northwest Pacific, and found that the LIM outperforms persistence for up to 5-6 years. The influence of the physics on the biological indicators was found to play an important role in the forecast skill, with Rossby wave propagation from the central to western North Pacific potentially being responsible for the skill at multi-annual lead times.

The papers collected in this Research Topic clearly indicate the influence of physical ocean/climate conditions on marine ecosystems, as well as the importance and potential of prediction studies spanning from physics to biology. Some of the papers in this Research Topic have already had outstanding influence on the research community. At the time of writing, Muhling et al. have been cited by other publications 21 times and Miyama et al. 17 times. The study of Miyama et al. was also used as a

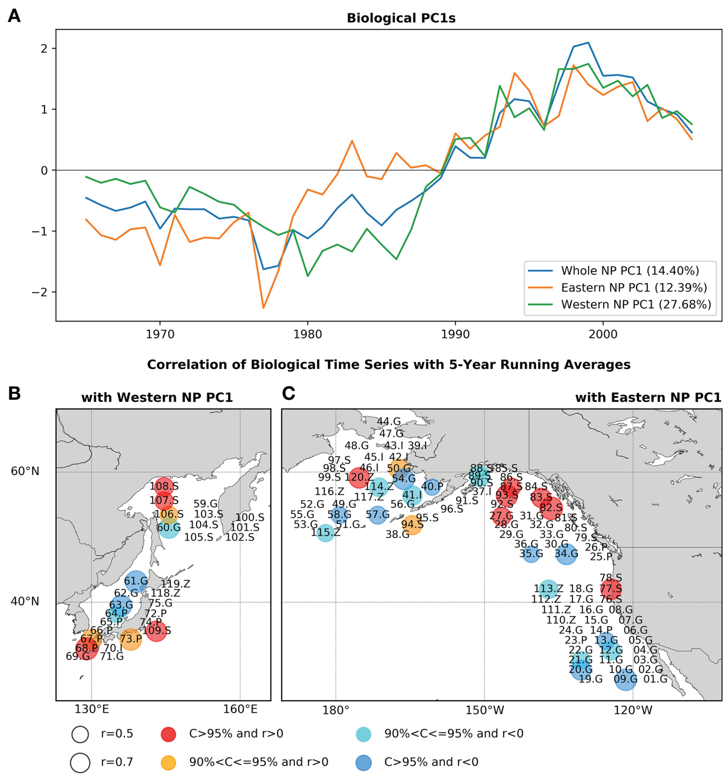

FIGURE 1
(A) The first Principal Components (PC1s) for the whole North Pacific (NP), eastern NP and western NP marine biological time series, and statistically significant correlations of marine biological time series **(B)** with the western NP PC1, **(C)** with the eastern NP PC1. Before calculating correlations 5-year running means are applied to PC1s and marine biological time series. In **(B, C)**, numbers indicate species ID in Table 1 of Yati et al., while S, G, P, Z and I indicate salmon, groundfish, small-pelagic, zooplankton and invertebrate, respectively. Circle size indicates the absolute values of correlations and colors of the circles (red, orange, cyan, blue) indicate the sign of correlations and the corresponding confidence levels. (After Yati et al.).

motivation for the new PICES working group on "Climate Extremes and Coastal Impacts in the Pacific". Yati et al. have been cited by the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Working Group II, in two chapters (Cooley et al., 2022; Shaw et al., 2022).

In the future, the importance and necessity of marine biological forecasting, especially those relating biological responses to physical variability, will further increase. Since marine biological forecasting can be conducted for many species, regions and timescales, a vast number of new studies is required. The topic editors hope that the present Research Topic illustrates the potential in this exciting and emerging research field.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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