Final Report

2021

Executive Summary

Final Report of TPOS 2020

August 2021

Coordinating Lead Authors: William S. Kessler[1], Sophie Cravatte[2]

Lead Authors: Peter G. Strutton[3], Adrienne J. Sutton[1], Arun Kumar[4], Yuhei Takaya[5], Harry Hendon[6], Kevin O'Brien[7,1], Neville Smith[8], Susan E. Wijffels[9], Janet Sprintall[10], Andrew T. Wittenberg[11], Kentaro Ando[12], Katherine Hill[13], William Large[14], David Legler[15], Kathy Tedesco[15], Sandy Lucas[16]

Contributors: Olaf Duteil[17], Yassir A. Eddebbar[10], Boris Dewitte[18], Yolande Serra[7], Stephen G. Penny[19], Kenneth Connell[1], Dean Roemmich[10], Tong Lee[20], Carol Anne Clayson[9], Shayne McGregor[21], Meghan F. Cronin[1], J. Thomas Farrar[9], Jessica Masich[7,1], Karen Grissom[22], Etienne Charpentier[23], Cheyenne Stienbarger[15], Brittany Croll[15], Feng Zhou[24], Dake Chen[24], Fei Chai[24,25], Xiaohui Xie[24], Weidong Yu[26], Iwao Ueki[12], Tatsuya Fukuda[12], Makito Yokota[12], Yasuhisa Ishihara[12], Sarah Purkey[10], Stephen Riser[27], James Edson[9], Masaki Katsumata[12], Akira Nagano[12], Kunio Yoneyama[12], Dongxiao Zhang[7,1], Aneesh Subramanian[28]

See Appendix D for the complete list of authors, contributors and reviewers. Affiliations for authors listed above appear on the next page.

This report is GOOS-268, PMEL contribution number 5219 and CICOES contribution number 2021-1128.

Please use the following citation for the full report:
Kessler, W.S., S. Cravatte and Lead Authors, 2021: Final Report of TPOS 2020. GOOS-268, 83 pp. [Available online at https://tropicalpacific.org/tpos2020-project-archive/reports/]

Affiliations

[1] Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA
[2] LEGOS, Université de Toulouse, IRD, CNES, CNRS, UPS, Toulouse, France
[3] Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia
[4] Climate Prediction Center, National Centers for Environmental Prediction, NOAA, USA
[5] Department of Atmosphere, Ocean, and Earth System Modeling Research, Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan
[6] Bureau of Meteorology, Melbourne, Australia
[7] The Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA, USA
[8] GODAE Ocean Services, Canterbury, Australia
[9] Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[10] Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA
[11] Geophysical Fluid Dynamics Laboratory, NOAA, Princeton, NJ, USA
[12] JAMSTEC, Research Institute for Global Change, Yokosuka, Japan
[13] National Oceanography Centre, Southampton, United Kingdom
[14] National Center for Atmospheric Research (NCAR), Boulder, CO, USA
[15] Global Ocean Monitoring and Observing Program, NOAA, Silver Spring, MD, USA
[16] Earth System Science and Modeling Division, Climate Program Office, NOAA, Silver Spring, MD, USA
[17] GEOMAR - Helmholtz Centre for Ocean Research
[18a] Centro de Estudios Avanzado en Zonas Áridas (CEAZA), Coquimbo, Chile
[18b] Departamento de Biología, Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile
[18c] Millennium Nucleus for Ecology and Sustainable Management of Oceanic Islands (ESMOI), Coquimbo, Chile
[19a] Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, USA
[19b] Physical Sciences Laboratory, NOAA, Boulder, CO, USA
[20] JPL, California Institute of Technology, Pasadena, CA, USA
[21] School of Earth Atmosphere & Environment, Monash University, Clayton, Australia
[22] National Data Buoy Center, NOAA, Stennis Space Center, MS, USA
[23] World Meteorological Organization, Geneva, Switzerland
[24] Second Institute of Oceanography, MNR/SOA, China
[25] University of Maine, Orono, ME, USA
[26] Sun Yat-Sen University, Guangzhou, Guangdong, China
[27] School of Oceanography, University of Washington, Seattle, WA, USA
[28] University of Colorado Boulder, Boulder, CO, USA

Executive Summary

The TPOS 2020 project is a once-in-a-generation opportunity to enhance and redesign the international Tropical Pacific Observing System (TPOS). Begun in response to the 2012-2014 crisis of the TAO and TRITON moored arrays, the effort included agencies, stakeholders and researchers worldwide, reflecting the global effects of tropical Pacific variability and the necessity of adequate observations to support research and prediction.

The TPOS 2020 redesign aims to take full advantage of the diverse remote and in situ techniques available today, fitting them together as an integrated system. We seek to accelerate advances in technology, and in understanding and predicting tropical Pacific variability, and thereby to broaden the stakeholder base by increasing the value of the TPOS to the supporting agencies and to other users of the data and its products. The plan recognizes that models and the wide utility of their assimilation products are an essential element in this integration.

Our First (Cravatte et al., 2016; hereafter R1) and Second (Kessler et al., 2019b; hereafter R2) Reports laid out detailed rationales and plans for this redesign and enhancement, and specified the ocean and atmosphere variable requirements for its success. This Third and Final Report (also referred to as R3) does not repeat results or analyses from the earlier reports (their summary recommendations are restated here in Appendix B). This shorter report is an update that resolves remaining issues where possible now, and defines questions for our successors. Instead of a full restatement here, we refer to relevant sections of our earlier reports. All three reports were subject to an extensive review process; as such they represent a broad community view that, together, form elements of a whole.

This Final Report updates progress since the earlier reports in biogeochemical observations (section 2.1), prediction modeling (2.2), data management and access (2.3), the backbone moored array (2.4) and the oceanic connection to the subtropics via western boundary currents (2.5).

Beyond the TPOS 2020 redesign and enhancement, ongoing scientific advice will be necessary for the future evolution of the arrays, within the WMO Integrated Global Observing System (WIGOS). As a “WIGOS Pre-operational Regional Pilot” the next incarnation of the project will continue to require clear connections to the intergovernmental entities. Chapter 3 proposes a post-2020 governance structure (3.4) to enable scientific evaluation of potential changes (3.2) and the needed intergovernmental connections (3.3). The conclusion section 4 provides some lessons learned.

Recommendations from our previous reports express the main conclusions of TPOS 2020. Those are restated in Appendix B. The following are additions and refinements explained in the indicated sections of this Final Report.

Biogeochemistry, biology and ecosystems

This Final Report clarifies previous recommendations for oxygen observations, describes future pilot studies for moored oxygen measurements in the eastern Pacific, and suggests a way forward for derived products and ecosystem observations.

R3/Recommendation 1 We reaffirm the complementarity between oxygen observations on moorings along 95°W (for high temporal resolution) and BGC-Argo (for broader sampling). [2.1.1][1]

R3/Recommendation 2 Annual CTD O_2 and biogeochemical sampling from instrumented TMA service vessels is needed. Twice per year sampling is encouraged, including additional inorganic carbon variables when achievable. [2.1.1]

R3/Recommendation 3 A BGC-Argo strategy for independent validation of sensors is needed, likely via discrete bottle samples on TMA service cruises. [2.1.1]

R3/Recommendation 4 Greater effort should be devoted to entraining ecological observations from moorings and ships (could include acoustic observations of zooplankton and fish, listening for tagged fish, environmental DNA). Consultation with relevant international panels on fisheries and ecosystems are recommended. [2.1.2]

R3/Recommendation 5 Encourage development of gridded biogeochemical products from expanded TPOS observations (chlorophyll, carbon, nitrate, O_2, pH, pCO_2). [2.1.3]

Modeling studies and progress

This Final Report responds to recent model and prediction center developments with specific recommendations to take fullest advantage of these opportunities.

R3/Recommendation 6 Encourage the evolving coordination between prediction centers to better document the model biases, and to monitor the efficacy of observations used in S2S forecast systems. These should include periodic assessments across the operational centers, and coordinated OSE or OSSE experiments with multiple forecast systems.[2.2]

R3/Recommendation 7 Encourage process studies leading to improved process parameterizations, towards reducing the model biases that degrade the efficacy of observational initializations. [2.2]

TPOS data flow and access

R3/Recommendation 8 Improve interoperability and integration of data, working through the GOOS Observations Coordination Group. [2.3]

[1] [] Bracketed numbers refer to sections of this Final Report/R3.

Backbone moorings

In R1 and R2, several recommendations for the tropical moored array (TMA) were imprecise; these are further clarified in this Final Report, with explicit priorities stated:
Northward and southward extensions had been recommended, but with approximate locations.
Salinity enhancements had been recommended, but their depths and locations were approximate.
Near-surface velocity measurements had been recommended at every site; priorities are now stated.

R3/Recommendation 9 New moorings are required at 10°N at 110°W, 170°W, 165°E. Moorings further poleward are also recommended, but research is required to specify the measurements needed and their specific locations (Figure 2). [2.4.1]

R3/Recommendation 10 Pilot moorings enabling research on the SPCZ are needed before specific sites can be recommended (Figures 2 and 4). [2.4.2]

R3/Recommendation 11 Highest priority for TMA salinity measurements are shown in Figure 5: In the warm pool and its eastern extension: at moorings along the western equator from 137°E to 170°W, and on the 165°E meridional line from the SPCZ at 5°S across the equator to 5°N. Also at two long-term historical sites (0°,140°W; 0°,110°W), and under the ITCZ at 8°N,110°W. [2.4.3]

R3/Recommendation 12 Second priority (highly desired) for TMA salinity measurements are most of the other Warm Pool sites (and near its eastern edge) at 2°N and 2°S from 137°E to 170°W. Also at the remaining equatorial sites, under the SPCZ further south (8°S,165°E), and at 140°W, 2°S and 2°N (Figure 5). [2.4.3]

R3/Recommendation 13 Salinity should be measured at dense vertical resolution (1m; every 5m to 30m, then every 10m to 80m, and at 100m). The complementary role of short-cycle Argo floats should also be considered. [2.4.3]

R3/Recommendation 14 Highest priority for near-surface point current meters are shown in red in the top panel of Figure 8: Equatorial sites where longterm subsurface ADCPs already exist; along 140°W from 2°S to 2°N where subsurface ADCPs will be added; and on all Tier 2 moorings (thus also at 5°S and 5°N,140°W). [2.4.4]

R3/Recommendation 15 Second priority for near-surface point current meters are shown in blue in Figure 8: at all other equatorial sites, and at 2°S-2°N at 110°W, 140°W, 170°W, 165°E. Also at 9°N,140°W under the ITCZ. [2.4.4]

R3/Recommendation 16 We recommend that Tier 2 sites (giving mixed layer ADCP velocity profiles above about 60m) be rotated among several locations during the next few

years to gain more experience before providing final recommendations. Figure 8 (bottom panel) suggests likely locations for these pilot sites. [2.4.4]

LLWBC/ITF system

The low latitude western boundary currents (LLWBC) of the north and south Pacific Ocean, including the Indonesian Throughflow (ITF), play crucial roles in ocean dynamics and climate variability on both regional and global scales. In R1 and R2, we recommended a pilot study in this area. In this Final Report, we report on progress made on pilot work as well as unresolved and ongoing issues that require additional attention.

R3/Recommendation 17 Encourage community workshops (e.g., under the auspices of the CLIVAR PRP) to bring together the three regional-focus efforts (northern and southern WBCs, ITF) towards an organized combined sampling program. [2.5.3]

R3/Recommendation 18 Encourage engagement of modeling efforts towards solving the difficult problems of complex bathymetry, mixing and tides, and the strong narrow near-shore currents that characterize this system. [2.5.3]

Considerations for the future

R3/Recommendation 19 Develop a rolling evaluation of the overall and ongoing effectiveness of the TPOS for research and prediction system goals. [3.1]

R3/Recommendation 20 Develop an explicit, independent structure to assess the capabilities, role and readiness of possibilities for inclusion in the backbone.[3.2]

R3/Recommendation 21 Encourage GOOS to consider best practices for broad stakeholder engagement, including both research and operational drivers. [3.3]

R3/Recommendation 22 We recommend a three-part primary governance structure, centered on a Scientific Advisory Committee to provide scientific advice to sponsoring agencies and the intergovernmental bodies, and to integrate new knowledge from the research community. A Stakeholder group would work to align resources and assess success. An Implementation Coordination Group would provide a forum for sharing technical advice and considerations, and coordinate field operations, sampling specifications and testing (Figure 9). [3.4]