Report of the 4th Meeting of the TPOS 2020 Steering Committee

17-19 October 2017
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1. Opening and Welcome

The fourth meeting of the TPOS 2020 Steering Committee (TPOS 2020 SC) opened at 0830 Tuesday 17 October.

The session was opened by Dr Chris Sabine, Director PMEL who welcomed members to the Lab and provided insights into the way the Resources Forum reacted to the 1st Report and the future work plans of the TPOS 2020 SC. He noted the TRF reaffirmed the importance of TPOS and underpinning weather, climate and ecosystem services; it is not just an El Nino observatory anymore, and needed to consider ecosystem dynamics and fluxes and more. The Resource Forum endorsed all recommendations from TPOS 2020 First Report and all organizations expressed support for beginning to move this project forward based on suggested actions and long-term goals. There was a positive response overall from the Forum and he believes they will do their best to support TPOS 2020 going forward.

The Co-Chairs added their welcome and noted apologies from Steering Committee members Harry Hendon, Dake Chen, Dongchull Jeon and Ken Takahashi. Apologies also received from David Legler and Janet Sprintall.

They noted the issue of clashes with WCRP and CLIVAR meetings.

> ***Action SC-4.1.*** Coordinate scheduling of next TPOS 2020 SC, in consultation with WCRP, CLIVAR (DPO, Co-Chairs)

2. Agenda and Review of Actions

TPOS 2020 SC co-Chair Neville Smith introduced the Agenda (Appendix 1) for the meeting and asked the TPOS 2020 SC to consider the desired outcomes for each session. Appendix 2 contains a list of all participants.

Several items were added under other business/wrap up:

- Consider inputs to:
    - Argo ST meeting;
    - AtlantOS General Assembly;
    - JCOMM 5 item on TPOS;
    - Involvement with Tropical Atlantic Observing System review;
    - Nominations to OceanObs 19 Programme Committee; and
    - Input to GOVST VIII in Bergen, 8 Nov.

It was also noted that item 6 VII "Progress with implementation, including pilots and process studies" should also be considered as a separate agenda item, irrespective of whether it is included as a Chapter in the 2nd Report.

Co-Chair Smith went through the outstanding actions from previous TPOS 2020 SC meetings. He noted:

- Development of performance metrics (other than the obvious ones around delivery of Reports) has progressed slowly but should be retained for now.
- An outline of a possible science capability matrix for TPOS 2020 had been developed and was included with the report of the 3rd meeting. TPOS 2020 SC-4 agreed that this should be further developed.
- Notwithstanding the advice from TRF-2 (see 3 (ii) regarding the deep ocean being placed out of scope), the Steering Committee to maintain a watching brief through the Backbone Task Team on the deep-ocean observing system – implications for the deep-ocean observing system from TPOS 2020 recommendations and actions, and vice versa.
- Some SC-3 items (3-14, 3-26) were not progressed but remain important and have been retained.
- Other items were more on-going in nature and are retained to maintain visibility.
- All other items were completed or closed.

Appendix 4 provides a list of retained actions.

Action SC-4.2. Maintain a watching brief on the deep-ocean observing system – implications for the deep-ocean observing system from TPOS 2020 recommendations and actions, and vice versa – and liaise with DOOS, as appropriate (Backbone Task Team, Andrea McCurdy).

3. Status

3 (i) Overview and future challenges

Co-Chair Kessler provided an overview of intersessional activities and highlighted several of the challenges facing TPOS 2020 in the coming years.

Kessler noted that the 1st Report had established TPOS 2020 as a credible actor. Its seriousness, depth and careful justification has led agencies around the Pacific to appreciate that our proposals are a strong framework for successful evolution of this key program. This was reflected in the feedback from the TPOS 2020 Resource Forum which was overwhelmingly positive. Several activities are underway as a direct result of the 1st Report, including further progress in identifying contributions to the Tropical Moored Buoy Array (TMA) (the latest schematic showing possible contributions is attached below). He noted that there has been vigorous activity in the west: many partners, many nations, many disciplines, for example:

- SPICE-- oceanic connection of subtropics to equator, strong BGC integration
- NPOCE: focus on warm pool and connections to ENSO and monsoon; New ITF moorings.
- Year of the Maritime Continent

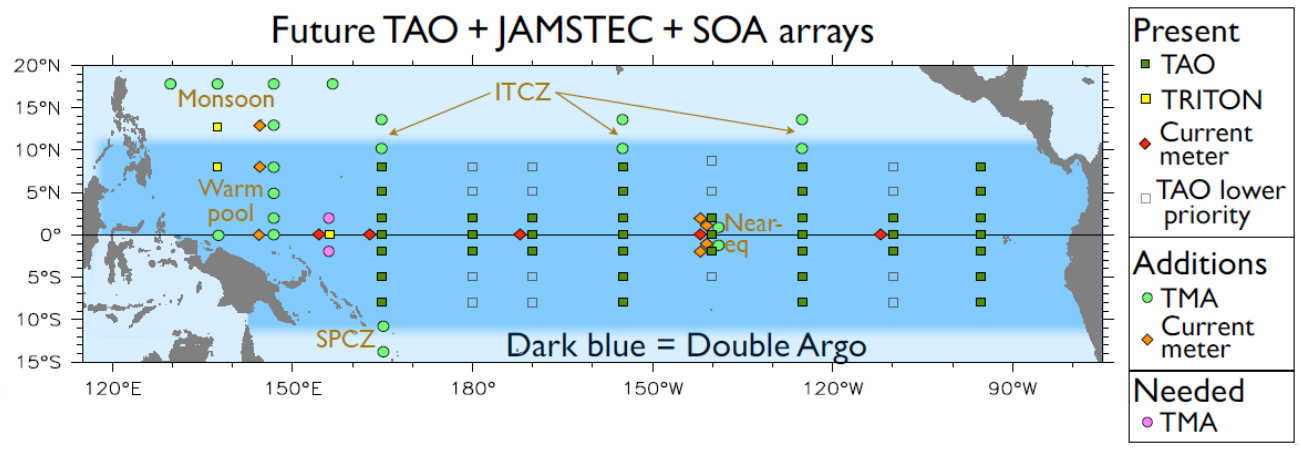

Figure 1. Draft schematic of potential Argo and TMA contributions.

Looking to the future, he noted that integration of information from various sources was fundamental to the TPOS 2020 strategy, but we are not getting the contribution from models that we anticipated. He posed several questions for the TPOS 2020 SC to consider during this meeting:

- What is our role, as in situ observing system planners, in pushing the model and D.A. systems forward?
- Why are we having such a hard time getting the attention of model developers?
- Can we more clearly define the weaknesses of the assimilating models, and thereby focus our observational targets?
- Where will improvement come from? From our process studies (upwelling, coupled interactions)? From sparse "mapped" PBL/mixed layer observations?

The ensuing discussion noted that the TPOS 2020 SC must reduce fuzziness in the TMA plans to the extent it can at this meeting. Several questions focused on the 2nd Report (see Item 6). The modelling aspects prompted ideas around fast coupling, improving data flow, perhaps through a regional reanalysis, and developing climate test beds. Can we have links to (develop access to) the data from past and current process studies and pilots, in a form that models can take up and use? Notwithstanding the fact that this is taken up under items 4 and 6 (a chapter on data flow), the TPOS 2020 SC agreed that the next meeting should include an agenda item on this topic.

Action SC-4.3. Include an item on data flow and access in the agenda of the fifth Steering Committee meeting (Co-Chairs, DPO).

3 (ii) TRF-2 outcomes

Co-Chair Smith noted that both Chris Sabine and Billy Kessler had provided overviews of the TPOS 2020 Resource Forum 2 (TRF-2; 16-17 May, Honolulu) outcomes.

The TPOS 2020 Roadmap document was the Steering Committee's major input. It represented a draft response to the 1st Report for TRF consideration. It was informed by the Qingdao/WESTPAC consultations in April and other consultations in the six months prior. The Roadmap provided a

summary of all TPOS 2020 project activities. The Roadmap draft formed the basis for the TPOS 2020 Resource Forum 2 Report.

Key outcomes included:

- 15 agencies joined the Forum
  - Well led by Craig McLean (NOAA) as Chair, who individually thanked all SC and 1st report authors
- Agency presentations showed considerable optimism around future
- All 1st Report recommendations were endorsed
  - All actions supported (or noted), though with considerable debate along the way!
- Strong engagement, encouragement on biogeochemistry
- Strong engagement, encouragement on new technology development
- Strong support for implementing Pilots

In terms of implementation actions,

- Actions 1-5 were discussed in detail:
  - Challenged us on the schedule detail (e.g. Argo and TMA; W Pacific vs Central Pacific vs Eastern Pacific)
  - Specifics of the Tropical Moored Buoy Array
  - Added action on western Pacific (the 4-6 September workshop)
  - Wanted to tease out detail hidden in fuzzy maps
  - Suggested a "Gantt" chart for implementation
- Added support for SST microwave but otherwise not much additional advice.

TRF-2 endorsed some minor modifications to the Steering Committee terms of reference, including some change in scope (no focus on the deep ocean; softening the scope to include atmospheric considerations). The TPOS 2020 SC/JCOMM MAN Transition and Implementation Task Team terms of reference were endorsed, but no changes were agreed for the Resources Forum itself.

Because of TRF-2 (partly or wholly), chapters on subseasonal variability and new technology were added to the 2nd Report draft outline.

3 (iii) Status of 1st Report recommendations and actions

The Co-Chairs provided an overview of the status of 1st Report Recommendations and Actions.

The Recommendations have generally been received well and, as noted above, were endorsed[1] by TRF-2. Recommendations 1-3 and 16-20 have received the bulk of attention; the recommendations are by nature long-term perspectives.

All Actions have received some attention, but with the western Pacific (Actions 1-5) being the primary focus (see the Western Pacific Task Team report and later discussion on implementation).

[1] The Roadmap and TRF-2 used the term "endorse" if the recommendation generally aligned with members' strategy and they collectively agreed the recommendation was sound scientifically. Other options were to "endorse in part", "note", or "reject".

Action 15 has been completed via a series of meetings with JCOMM MAN, WIGOS and TRF-2 – again see 6B for additional discussion.

During the discussion it was noted that NASA's second Salinity Processes in the Upper Ocean Regional Study (SPURS-2) is taking place in a fresh and rainy area of the eastern Tropical Pacific around 10 N, 125E and that the Steering Committee had previously recognized its direct relevance to TPOS 2020. However, it is not mentioned in the Executive Summary of the 1st Report and is not included when TPOS 2020 lists its Pilot Projects, Process Studies and new technologies. It is referenced in section 7.4.4.4 and 10.2.2 (Saildrone). This oversight is acknowledged and will be addressed in the second Report.

4. Establish Outline/Work plan for 2nd Report

This item provided an opportunity to discuss the high-level outline of the 2nd Report (introduced by Billy Kessler in his overview). The feedback below is ordered as in the original outline.

1. Introduction and Background
2. Observations in support of coupled weather, wave, subseasonal applications

    - The case for including waves as an explicit topic is not strong. It will be deleted for now, pending further consultation.
    - Monsoons and typhoons/tropical cyclones are in scope.
    - This is not a general review of these topics but an analysis of *potential* implications for TPOS.

3. Biogeochemical and ecosystem backbone observations
4. Modeling and data assimilation

    - The title should reflect the focus on coupled modelling and seasonal prediction.
    - It is an assessment not a review.

5. Developing an Eastern Pacific backbone OS

    - Will need to define scope – where does the western Pacific begin? How much of the atmosphere is in scope?

6. The TPOS 2020 Backbone Observing System
7. Progress with implementation

    - Data flow and access seemed a more relevant and impactful topic.
    - Noting that project/process study datasets are often under-exploited – they are hidden either for proprietary interests or because of lack of resources to bring them into the public domain.
    - Returning to the idea of a TPOS 2020 reanalysis (or reanalyses) whereby extant data are re-processed and made suitable as input for data assimilation.
    - Agreed to replace (see the revised chapter list under agenda item 6).

8. An evaluation of modern technologies

Concerned was expressed at the potential length of the 2nd Report, noting that the 1st Report was over 170 pages. It will be important not to repeat or revisit topics already covered in the 1st Report or elsewhere. The Co-Chairs noted that it will be important to remain focused, but also to take the opportunity to state what needs to be said, on topics where TPOS 2020 can add value.

While the process for the 2nd Report will be like the first, not all Chapters will need to go for expert and stakeholder review.

Action SC-4.4. Contact Fabrice Ardhuin, Fangli Qiao and others for guidance on if/where TPOS can add value in wave observations (Sophie, Neville).

5. Task Team and other updates

5 (i) OOPC 20 meeting

Katy Hill provided an update of OOPC activities relevant to TPOS 2020 (the Report from its 20th session can be found through the GOOS web site). She discussed the OOPC 20 forward work plan:

- Communications and engagement on essential ocean variables - published paper(s)
- Review/assessment of the performance of the ocean climate observing system:
  - Ocean heat and freshwater Content
  - Air-sea fluxes/wind/wind stress (with AOPC, TPOS 2020)
  - Boundary Currents and their interaction with the shelf
- Coastal observations (with other GOOS panels, TOPC)
- Input to OceanObs'19

Some of the most interesting conversations occur across the GOOS Panels about multidisciplinary observing system design focussed on capturing phenomena (the dynamic features of the ocean which vary in space and time), this is consistent with the TPOS 2020 focus on capturing Regimes. OOPC plays an 'information broker' role between GCOS and GOOS, as it draws across the 3 panels of GOOS in order to deliver to GCOS, and in addition to GCOS and GOOS, it reports to WCRP, and advises JCOMM. It is the established advocate for ocean observations (physical, climate) through these channels and others and will perform that role for TPOS 2020 and similar regional observing system reviews.

The TPOS 2020 SC noted the significant overlap and common interest in wind, wind stress and air-sea fluxes (Meghan Cronin, Weidong Yu, Tony Lee and Lisan Yu are working in both TPOS 2020 and OOPC activities). Action 6-8, 10-11 and 13 have counterparts in the OOPC work plan, but generally with a broader scope. The OOPC focus on boundary currents also has strong links to the low-latitude western boundary current initiative in TPOS 2020.

The TPOS 2020 SC also noted the recent publication of the National Academies of Sciences, Engineering, and Medicine report on Sustaining Ocean Observations to Understand Future Changes in Earth's Climate (see http://www.nap.edu/24919).

Action SC-4.5. Continue working with OOPC on areas of common interest such as (a) winds and wind stress [Tony Lee, Tom Farrar] and (b) convening a small meeting of flux experts (observations, products) (6-8 people) to design sensitivity experiments [Weller, Yu, Cronin].

5 (ii) Western Pacific TT

Ken Ando introduced the Western Pacific Task Team (WP TT) activities. He noted that the Task Team has met several times during the last year mainly by remote, in particular during preparations for the Resource Forum. He provided brief updates on the Low-Latitude Western Boundary Current Pilot Project (LLWBC) and the two process studies led by the WP TT on the eastern edge and northern edge of the warm pool.

For the LLWBC he noted considerable activity in the region by several agencies (from Japan, China, France, Korea, USA, among others) associated with various projects such as NPOCE, YMC and SPICE. By way of illustration, he showed moorings maintained or planned by FIO and IOCAS (figure below) (more detail is provided under later items).

Ken also provided an update of planned JAMSTEC cruises in support of the Eastern Edge of the Warm Pool and Northern Edge of the Warm Pool (support is not yet guaranteed for all cruises). It is hoped these might provide incentive for others to join (eg, there is interest in using Sail Gliders in the eastern edge study, and other technologies for the northern study).

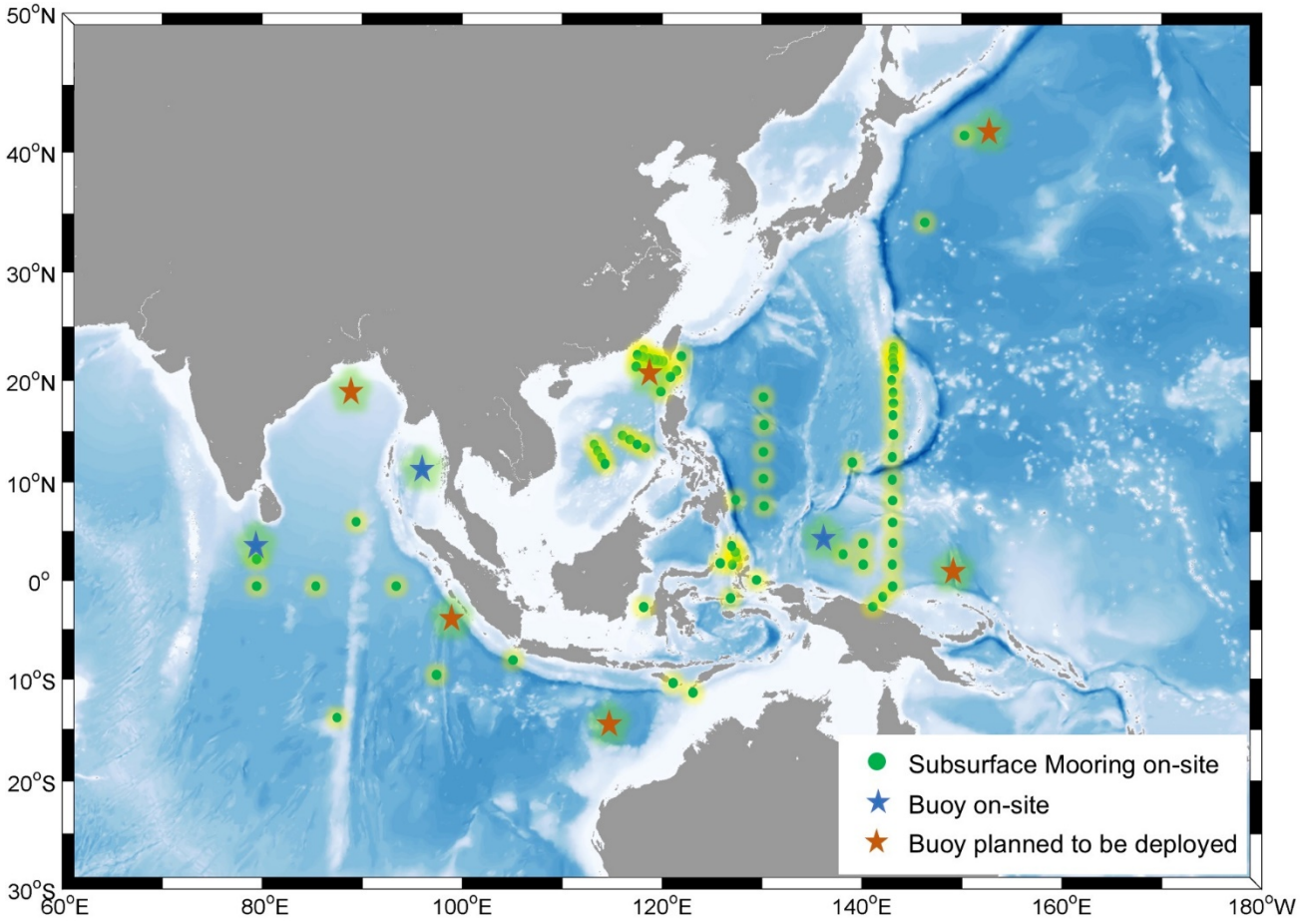

Figure 2. FIO and IOCAS moorings in the western Pacific/Maritime Continent region.

The WP TT maintains three inventories of:

1. Observing projects and data sites. Three types: 1. JCOMM Global Observation Framework (Backbone), 2. CLIVAR Projects, and 3. National or Regional efforts;
2. Past and future cruise plans in the western pacific (west of dateline); and
3. Mooring/Glider Observation Inventories in the western pacific (west of dateline).

These inventories have proven a valuable resource for determining the level of activity (who, where, when) and reveal vigorous research effort at present. The Steering Committee congratulated the WP TT, and those who contributed information to the inventories, on their effort; it provided convincing evidence for optimism in the region.

The presentation of the observation inventories once more generated discussion around data availability and access: How much of the national, regional and research programme data are available and readily accessible for further research and modelling/data assimilation studies? Some of the mooring data (not all) are available through OceanSites, and JCOMM manages all data coordinated through its mechanisms. Data archaeology activities coordinated by JCOMM and IODE also provide additional access (e.g., through the World Ocean Atlas).

For any reanalysis effort, it would be important to identify priorities for data re-processing taking account of likely impacts through data assimilation and other potential uses of the data. Some estimated that as much as 50% of the use will come indirectly through assimilation of gridded (i.e. previously analysed) products.

The Steering Committee concluded that the work undertaken by the WP TT potentially provides a good starting point for a data flow and access project, and for a regional reanalysis.

> ***Action SC-4.6.*** Undertake a high-level audit around data flow and accessibility of Western Pacific observations (i.e., is available or not through JCOMM/IODE, ERDDAP, WOA or other "standard" mechanisms) and identify priorities among those not available (WP TT, May 2018).

Western Pacific Implementation Workshop

The Western Pacific Implementation Workshop was hosted by FIO/SOA in Qingdao, 4-6 Sept. 2017. The Workshop was a direct outcome of the TRF-2 (see item 3 (ii)). The Report from the workshop can be found on the TPOS website.

Key Outcomes

(i) Established a good dialogue on TPOS WP activities (see above)
(ii) Provided additional clarity on the steps for implementation actions from the 1st Report (Backbone part)
- Good dialogue on options for western Pacific Backbone of TPOS
- Proposed to create an *ad hoc* WP Backbone Implementation Pilot Project
    - Part of the TPOS 2020-led Transition and Implementation effort.
    - Duration: now-2020
    - Involvement: open
    - Scope: focus on TMA, Argo (and equivalents)
    - Include new technology: encourage, evaluate
    - Communicate lessons learned for other regions

- Produced an outline of TPOS Tropical Moored Buoy Array
    - Includes "big cross" extensions, JAMSTEC 13N, …
    - Discussed potential contributions to this plan (see Figure 1).
    - Identified key technical issues for discussion
        - full flux configuration; possible BGC extensions; sites; data management, …
        - Need to develop a standard
        - The TMA equivalent of Argo core; with JCOMM T(M)IP?
    - Underway measurements integrated into plan.
- Produced outline of possible 2xArgo plan
    - Floats should have short surface times (minimize dispersion);
    - Case for dedicated deployment along equator;
    - Tentative indications for around 75% of the required floats over 2018-2020 period;
    - Effort may include floats capable of directed rapid shallow cycling; and
    - Should include a BGC-Argo component (see 5 (vi) below for further BGC comments).
- Emphasised importance of existing other networks such as GO-SHIP, SOOP, drifters, …
- Build modelling in as an integral part of the "pilot" implementation in the W Pacific
    - Guiding design; testing effectiveness; testing impact
    - Model sensitivity studies for surface variables
- Follow-up
    - TPOS 2020 SC to further refine the Backbone design (for the 2nd Report)
    - Technical Workshop at SC-4

(iii) Additional discussion and further clarity on the next steps for the LLWBC Pilot (Billy Kessler provided further background under item 6B).

- Significant activities now, and planned, relevant to LLWBC
    - Potential elements of an LLWBC array are or have been in the water for several years or longer, providing a strong basis for planning an ongoing effort;
    - The goal of this sampling is to monitor the mass, heat and property inflows to the tropical Pacific from the west (the "Wyrtki Challenge").
- Review and assessment of status
    - Establish context within TPOS (why monitoring the LLWBC is important and relevant);
    - Assess literature/knowledge as a whole using a diversity of expertise, including experts not directly involved with current work;
    - Refine the EOVs for the LLWBC and the requirements on those EOVs;
    - Use existing LLWBC observations to assess gaps in the system;
    - Bring in modelling, ENSO, … expertise to assess potential for an integrated whole-of-LLWBC approach; and
    - Use independent review to assure credibility.
- Loosely defined or agreed joined-up international plan
    - Use a white paper (and workshop) to do above
    - Develop Implementation Work plan
- Led by TPOS, but coordinated with research:

(iv) Improved understanding of the potential to support process studies

Decision 1 TPOS 2020 SC agrees to create an ad hoc WP Backbone Implementation Pilot Project with the following terms of reference:

a) Purpose: To coordinate implementation activities in the western Pacific, under the guidance of TPOS 2020, and cognizant of JCOMM coordinated activities.
   - Part of the TPOS 2020-led Transition and Implementation effort

b) Scope: Focus follows Actions 1-5 of the 1st Report and associated requirements.
   - Include/encourage testing of new technology and modelling support

c) Report to SC, T&I TT
   - Communicate lessons learned

d) Duration: now-2020

e) Involvement: open

Action SC-4.7. The existing LLWBC documentation (6.1.1 of 1st Report; output of 4-6 Sep Workshop; WP TT reports at SC-4) should be further developed into a pre-proposal "white paper", incorporating a review and assessment of current knowledge and required elements (Janet Sprintall & WP TT; May 2017).

5 (iii) Backbone TT

The Backbone Task Team Co-Chairs, Sophie Cravatte and Susan Wijffels introduced this item. They noted that the BB TT has not met since the publication of the 1st Report, though individual members have been active. The Co-Chairs noted that three members wished to rotate off the Task Team. The Steering Committee agreed that it was important to maintain a strong and active membership.

Action SC-4.8. The Backbone Task Team Co-Chairs, in consultation with the Steering Committee Co-Chairs as needed, reconsider membership of Task Team to meet future priorities (BB TT Co-Chairs, Dec 2017).

On specific actions for which the BB TT is the lead:

1. ***Wyrtki challenge*** – some follow up, but resources still lacking (however, Billy Kessler reported some relevant work flowing from the SPICE glider work; see item 6B).

2. ***Wind project***: A proposal will be submitted to NASA to improve the Cross-Calibrated Multi-Platform gridded surface vector wind product (version CCMP2). Lisan Yu is also planning a new OAFLUX (Ocean-Atmosphere Flux) product, including winds. A talk was also given to an ECMWF Workshop (refer to action SC-3.16).

3. ***Deep observations*** (Actions SC-2.12, SC-2.13, SC-3.24). The first Deep-Ocean Observing System (DOOS) workshop discussed a regional pilot that would overlap TPOS 2020 interests (near the Clarion-Clipperton Fracture Zones; CCFZ). The international mining community is interested in sea-bed resources in the region and it is likely they will be interested in questions about baseline conditions in physical/ecosystem parameters in CCFZ, though details remain uncertain. A CCFZ Pilot will be developed in the next 6-8 months and TPOS 2020 could potentially bring its interests (e.g., the Pilot observation station at Clipperton Is., 6.1.5 of the 1st Report) into the plan. It would seem to be in TPOS 2020's interest to keep this line of communication active

The DOOS workshop more generally highlighted several areas where DOOS and TPOS 2020 interests intersect, mainly through the common use of platforms (e.g. deep profiling floats providing upper ocean profiles, and TPOS Argo profiles penetrating to 2000m). The dependencies at the process/mechanistic level were less clear. This suggests TPOS 2020 should retain the focus suggested by TRF-2, but maintain an active dialogue with the deep ocean community.

Action SC-4.9. The Backbone TT to maintain a watching brief on a possible DOOS Clarion-Clipperton project (see also Action SC-4.2; Andrea McCurdy for DOOS; BB TT).

N.B. This action replaces Actions SC-2.12, SC-2.13 and SC-3.24.

4. ***ARMOR3D project***: An internship was completed with CLS studying the relative impacts of altimeter, subsurface T and S and other data in the tropical band in the ARMOR3D product, in terms of barrier layer thickness and depth of the 20°C isotherm, but results are not definitive.

The Steering Committee noted that none of the pilots/studies mentioned in the 1st Report have been developed to the stage where they can directly inform the design of the Backbone. The LLWBC Pilot is probably closest. However other projects, such as the NOAA new technology projects, SPURS-2 and JAMSTEC technology trials will impact the way TPOS 2020 responds to the Backbone design.

Several activities, including those mentioned at items 3 (i), 5 (i) and 5 (ii) need oversight or input from the Backbone TT and will impact the Backbone chapter of the 2nd Report:

- The so-called fuzzy TMA map needs to be finalized (see item 6B), including recommended locations for moorings and a schedule for transition.
- JAMSTEC and SOA have tabled proposals that go beyond the considerations of the 1st Report (e.g., TMA sites beyond 10N; mooring lines into the extra-tropics; and so-called super-sites). The science requirements behind these plans must be considered and, as appropriate, the Backbone design adjusted.
- Proposed Argo enhancements, including BGC Argo and any so-called Argo equivalents need to be discussed with the Argo Steering Team.
- The Transition and Implementation Task Team, including the Western Pacific Implementation project (see Decision 1 above), will need technical advice from the Backbone Task Team as implementation progresses, but noting that much of the implementation will be "bottom up" and naturally engage the BB TT.

Action SC-4.10. The Backbone Task Team to develop guidance for the phased implementation and transition of the Backbone components, initially beginning in the western Pacific, and including more detailed specifications for Argo and the TMA (non-fuzzy map) and indicative schedule for consideration of the T&I TT (BB TT, Steering Committee Co-Chairs, Apr 2018)

Action SC-4.11. Co-Chair Kessler to participate in Argo ST meeting 20 to discuss TPOS 2020 plans (Billy Kessler, March 2018).

5 (iv) Planetary Boundary Layer TT

The Planetary Boundary Layer Task Team (PBL TT) Co-Chairs, Meghan Cronin and Tom Farrar introduced this item. They noted progress on several actions (SC-3.8 and SC-3.31) but less movement on the key actions around wind issues and flux issues (SC-3.22) and finalisation of the "fuzzy" diagram (SC-3.30). The latter was the focus of item 6B. With reference to action SC-3.8, Weidong Yu informed SC-4 that the 5th CFOSAT Science Team Workshop was being held in Beijing October 18th -20th, 2017 and undertook to report back on any relevant issues.

> ***Action SC-4.12.*** Weidong Yu to report on the outcomes of the 5th CFOSAT Science Team Workshop (Weidong Yu, Dec 2017).

With reference to the SC-3.22, Katy Hill previously reported on related discussions in OOPC (see item 5 (i)) and noted that progress may be aided by joining forces. Neville Smith noted that he and Lisan Yu had developed a 2-pager on fluxes as part of the OOPC 20 meeting, but the small meeting needed to define the next steps had yet to take place.

For winds, Tom Farrar noted several developments, including the proposal mentioned by the Backbone TT:

- August 2017 BAMS article on SMAP winds ("Regardless of Rain")
- Highlights of "Wentz report" (Wentz et al., 2017. Evaluating and Extending the Ocean Wind Climate Data Record. IEEE J. Selected Topics in Applied Earth Observations and Remote Sensing. Volume: 10, Issue: 5, May 2017)
- McGregor et al (2017) work examining CCMP winds vs TAO; buoy impact hard to quantify
- Chiodi and Harrison (2017) work on the value of TAO winds for simulating ENSO SST anomalies (Andi Chiodi provided a science presentation which is summarized below).

With respects to PBL processes more generally, they noted the US CLIVAR Summit Process Study and Model Improvement (PSMI) Panel session on TPOS process studies earlier in the year and raised the possibility of developing process science teams for both the wind and flux issues (like the US CLIVAR Process Teams). They would typically attract support for a post-doc and/or a workshop and would be focused, finite-term projects.

Billy Kessler noted that one outcome of the PSMI session is a proposal for a "Workshop on Bridging Sustained Observations and Data Assimilation in Advance of Next Gen TPOS", tentatively scheduled for May-August next year (further details are given under item 5 (vii)).

The Steering Committee supported the idea of process science teams and suggested this should be developed around the wind issues in the first instance.

> ***Action SC-4.13.*** [Replacing SC-3.22] Develop a 2-page outline for a tropical wind process science team, joint with OOPC (Tom Farrar, Tony Lee, Dec 2017).

The PBL TT Co-Chairs also reported on progress with direct flux measurements (Pilot 6.1.4) through the deployment of Direct covariance flux systems (DCFS) on the SPURS-2 mooring and on a Saildrone (this project is in part supported by the NOAA New Technology initiative). Results will be reported at subsequent meetings.

The Steering Committee encouraged further development of the Pilots/Studies relevant to the PBL TT, giving priority to those that seem likely to engage and offer good prospects for success (see Action SC-3.6).

Andy Chiodi (PMEL) provided a short presentation on simulating ENSO SST anomalies with MOM 4 using TAO winds and other analysed wind products. TAO/Triton winds on their own provide usefully accurate simulations of end-of-year ENSO Nino 3.4 SSTA conditions; none of the other products (NCEP, NCEP2, ERA-Interim, CCMP v1, 2) do as well. Spurious offsets complicate interpretation. More work is needed to learn how best to combine satellite & in situ winds for purposes of understanding the upper equatorial Pacific Ocean variability and state of the coupled tropical Pacific system.

Billy Kessler noted that we are trying to understand regional sensitivity (for example, western Pacific moorings) and so some further sensitivity studies might be useful.

5 (v) Eastern Pacific TT

Yolande Serra introduced this item on behalf of the Co-Chairs of the Eastern Pacific Task Team (EP TT). The Co-Chairs met prior to SC-4 to discuss progress, particularly around Pilot and Process Studies. Yolande noted that there had been little Task Team activity over the intersessional period (a meeting was planned post-SC4) but that several relevant papers had been published by EP TT members (e.g., Serra Review paper on ocean rainfall observation, QJRMS, in revision; Takahashi and Martínez on the strong coastal El Niño in 1925 in the far-eastern Pacific**,** Climate Dynamics, 2017).

OTREC (Organisation of Tropical East Pacific Convection) was funded and will take place in summer 2019 to observe convective heating in the far eastern Pacific and western Caribbean. Ken Takahashi has been pursuing collaborations with NOAA and the Ulsan National Institute of Science and Technology in Korea for various research lines.

Yolande provided a brief account of progress with the EP TT Pilots/Studies.

6.1.2: Eastern Pacific equatorial-coastal waveguide and upwelling system

- Propose more Argo floats (better if BGC Argo) off-shore, including shallow profiles every 5 days near the coast;
- Korean project along Peruvian coast is likely not going to happen;
- Data sharing: Continue to work with the other countries to get their data shared. Includes trying to get Peru to share data with the global community (Action SC-3.14); and
- Propose paring down from original pilot study proposed in Report #1 in order to make it more tractable/feasible.

6.1.5 Climate observing station at Clipperton Island.

- EP TT has proposed to include atmospheric soundings and a C-band radar to capture convective structure on the French cruise (the so-called PASSION FRUIT proposal, Fall 2019). The proposed cruise will follow (or overlap with) OTREC (see above).

6.2.4 East Pacific ITCZ/warm pool/cold tongue/stratus system

- Pared down from initial process study in Report #1 to be more tractable.

- Proposing:
    - North-South transect from roughly 5°N to 20°S in boreal spring, possibly down and back to get a repeat transect. Fall measurements available from EPIC 2001, but a repeat in boreal fall would be ideal.
    - Include ship-board surface flux system, C-band radar, radiosonde launches at least 2xdaily, sub-daily subsurface observations of near surface currents and ocean state variables (not measured by Argo).
    - Saildrone with ADCP to capture upper ocean currents around ship? Provide spatial sampling of surface fluxes around ship?

Yolande also noted the continued issues with TMA vandalism (see item 6, Chapter 5, Developing an Eastern Pacific Backbone OS) and data sharing, both real-time and access to historical datasets (Actions SC-3.14 and Action 9 from the 1st Report).

Some new members have been added to the EP TT (Kris Karnauskas and Gustavo Laos) and the focus now will be on moving the agenda forward (which in turn is the focus of the proposed Chapter in the 2nd Report).

The Steering Committee recognized that, unlike the western Pacific, there are no immediate possibilities for either a change in paradigm (around data sharing) or for significant new investments.

Neville Smith noted the unexpected rapid development of ideas around Clipperton Is and the high-prominence of eastern Pacific climate services at the recent UN Oceans Conference does provide some reason for optimism. There is no "silver bullet" for the resource issues but making progress on some of the issues would make it a far more attractive proposition. He also noted the value of the inventories being compiled by the WP TT and suggested the EP TT may wish to begin a similar exercise.

> ***Action SC-4.14.*** Examine the feasibility of compiling inventories of (a) observational networks, (b) research and other cruises, and (c) mooring deployments in the eastern Pacific (EP TT, for inclusion in 2nd Report).

5 (vi) Biogeochemistry TT

The Co-Chairs of the Biogeochemistry Task Team, Pete Strutton and Adrienne Sutton, introduced this item.

They began by showing some recent results on surface pCO_2 and nutrient variability by Sayaka Yasunaka and Shinya Kouketsu, respectively, both from JAMSTEC. The distribution of surface of pCO_2 data allowed calculations of the e-folding scale (zonal, meridional) and consequent mapping error resulting from optimal interpolation of the data. The nutrient data are sparser, and a neural network approach was used to analyze interannual scales of variability on the 25.0γ density surface.

The pCO_2 study yielded e-folding scales of 6º in latitude, 17º in longitude, and 2 months in time. On these scales, pCO_2 observations can resolve pCO_2 and CO_2 flux interannual variability, but the recent decrease in the number of observations in the central to eastern tropics makes it marginal. Winds are important for driving pCO_2 flux.

Nutrient observations are too sparse in the central to eastern tropics to clarify interannual spatio-temporal variability. However, using the spatio-temporal variability of salinity, it is possible to detect

dissolved oxygen and nutrient variabilities (e.g., using GLODAPv2-type data). There is generally lower nutrient levels along equator during El Nino due to weaker upwelling. In the eastern tropics, the proposed density of BGC Argo would detect such signals.

The BGC TT Co-Chairs noted the proposed JAMSTEC cruises in support of the Northern Edge and Eastern Edge process studies (see item 5 (ii)) will likely include biogeochemistry components, as well as operational and existing hydrographic lines (i.e. 137E and 15E) by JMA. There has been a diverse field campaign within SPICE in the western Pacific, and biogeochemistry measurements have been included in the PASSION FRUIT proposal submitted by Sophie Cravatte.

Two NOAA Funded Projects include BGC components: the Saildrone Project (Saildrone CO2 Systems) and the BGC Argo Study with Steve Riser.

Adrienne also noted that there are five papers recently published in Science on NASA's Orbiting Carbon Observatory (OCO-2), including a couple on the 2015-16 El Nino: (http://science.sciencemag.org/content/358/6360).

This item, and the following item on the 2nd Report Chapter on biogeochemical and ecosystem backbone observations, was supported by a presentation from Chris Sabine on the role of the Equatorial Pacific in global carbon cycling. He showed that CO_2 at the Hawaii Ocean Timeseries Station (HOTS) at ALOHA is rising at the same rate as that measured at Mauna Loa. This increase is matched by a corresponding decrease in the pH (acidity) at ALOHA.

There are around 35 moored CO_2 systems around the global oceans. There is more variability at all time scales than anticipated (for pCO_2 flux), particularly interannual variability. Changes in pCO_2 flux are hard to detect in the presence of such variability. Lots of ecosystems are altered due to the rising temperature and CO2 in the ocean/atmosphere, and the responses require a lot of observations to tease apart the gains and losses. The balance between temperature and biophysical controls determine the net flux. Looking at the Aragonite saturation state (using a base map from 2015), models and moorings do not agree well, especially in the equatorial Pacific.

The equatorial Pacific is a critical region for understanding ocean carbon uptake and storage, but also has the largest interannual variability of any ocean region. A suite of sensors is critical for monitoring the balance of physical and biogeochemical controls on the seawater CO_2 and inform models that make future projections.

Recommendations and actions will be framed in the 2nd Report Chapter on biogeochemical and ecosystem backbone observations.

5 (vii) Modelling and Data Assimilation TT

The Co-Chair of the Modelling and Data Assimilation Task Team (M&DA TT) Arun Kumar introduced this item. Like some other Task Teams, M&DA TT have not been active over the past year.

He noted that the GODAE OceanView OSEVal Task Team had recently met and discussed activities related to the proposed Pilot Projects 6.1.6 and 6.1.7. Yosuke Fujii communicated that they resolved to provide an Observing Impact Statement for TPOS, hopefully during 2018, and involving multiple centres. He also noted work on SMOS data that should be relevant to TPOS 2020. Arun argued that fully establishing the Pilot Project 6.1.7, building on the work that is already underway, would be helpful for TPOS 2020.

Arun showed some of his own work comparing the consistency of surface wind stress among six different reanalysis products (including its dependence before and after the implementation of the TMA), and longitudinal and latitudinal length scales of variability for different time scales.

Arun discussed improving the efficacy of use of TPOS 2020 observations; model biases need to be reduced. He argued we need to define what specific role TPOS 2020 can play in promoting community awareness of this as an issue and accelerating the progress in reduction of model biases and advancing data assimilation systems (Chapter 4 of the 2nd Report is one such role). Data requirements for ENSO prediction, however, are not well understood; multiple interpretations for variations in forecast skill, and its dependence on the observing system can be made. He cited results from Newman and Sardeshmukh (2017; GRL) that posit we may be near the predictability limit of tropical Indo-Pacific sea surface temperatures models, and from Huang et al. (2017) (Reforecasting the ENSO Events in the Past 57 Years (1958–2014), J. Climate) that show skill prior to 1978 is comparable to later years, even though the subsurface observation density is vastly different.

Arun also referred to the "Workshop on Bridging Sustained Observations and Data Assimilation in Advance of Next Gen TPOS" scheduled for first week of May 2018, and hosted by US CLIVAR. The draft goals include:

- Facilitate collaboration to design and conduct observing system simulation experiments (OSSEs).
- Further develop process studies that would point most clearly to particular model improvements.
- Identify the key observations to constrain numerical ocean and coupled Earth system models.
- Discussion co-located surface and subsurface observations for coupled data assimilation.

The Steering Committee welcomed the initiative from US CLIVAR and noted the important role such a meeting may play in drafting the 2nd Report and, in particular, the Chapter on '*The current state of coupled models for sub-seasonal to interannual predictions'*.

> ***Action SC-4.15.*** The Steering Committee to be kept informed of the development of this Workshop, noting that it is under the lead of US CLIVAR, not TPOS 2020 (Billy Kessler).

The Steering Committee also noted that the Pacific Upwelling and Mixing Physics (PUMP) process study lacked a clear leader and suggested M&DA should take on this role, with input from other Task Teams as needed.

The Steering Committee also noted:

- The potential regional opportunities, as highlighted under items 5 (ii) and 5 (v) and in the discussion of reanalyses under item 3 (i).
- The potential opportunities to apply and develop models in pilot and process studies (e.g., LLWBC, PUMP, Clipperton) and for specific topics (e.g., fast coupling, the Workshop above). The M&DA TT should be proactive in facilitating progress rather than waiting to be asked for advice.
- The opportunities to further develop Pilots 6.1.6 and 6.1.7.

- The need for M&DA member input to Chapters 2 (subseasonal), 4 (coupled prediction) and 6 (evolution of the Backbone), among others.
- Consider TPOS contributions to the WCRP/CLIVAR September Boulder meeting.

Action SC-4.16. Scope a TPOS 2020 reanalysis for the Western Pacific and/or TPOS region whereby extant data are made accessible and re-processed suitable as input for data assimilation, and the requirements on the potential reanalysis systems and the evaluation of products are specified (M&DA TT, BB TT, WP TT).

Action SC-4.17. M&DA TT to provide leadership and facilitate progress on (a) Pilot Projects 6.1.6 and 6.1.7, (b) the PUMP process study, bringing in other TTs as appropriate, (c) modelling contributions to other pilots/process studies, and (d) contributions to the US CLIVAR Workshop (May 2018) and the WCRP meeting in Boulder, Sep 2018 (M&DA TT).

6. Second Report Chapters

Chapter 1. Introduction and background

[Not discussed]

Chapter 2. Coupled weather, wave and subseasonal applications

Neville Smith introduced this item and noted that some consultation had taken place with Harry Hendon (SC Member), Arun Kumar (SC and M&DA Co-Chair), Yuhei Takaya (incoming SC members) and Oscar Alves (M&DA member) before SC-4. Any decision here should be subject to additional feedback from this group after the meeting.

One point made in communication Yuhei et al was that the subject of this Chapter is largely one of active research; observational requirements at the level of EOVs for subseasonal and shorter time scales are largely unknown at this time, at least beyond the surface (e.g., SST, wind, OLR/precipitation). The Steering Committee acknowledged this point but also noted that coupled weather prediction, (coupled) typhoon/tropical cyclone prediction, and sub-seasonal outlooks are close to mainstream and so there is a responsibility to document what is known and foreshadow where TPOS might be relevant in the future.

The Steering Committee confirmed that observational wave requirements should not be an explicit focus (but see Action SC-4.4), but noted waves and wave-driven processes will be part of the Chapter.

The following comments were made against the Chapter outline:

1. Introduction
    - Why is TPOS interested, noting that it is not just a western Pacific interest?
2. Background

- Discuss drivers: use, applications, R&D, but build from 2.6 of the 1st Report as far as possible.
- Coupled Numerical Weather Prediction (input from WGNE, GOV CM TT, ...)
- Subseasonal including intraseasonal variability/MJO, monsoons, BSISO (S2S, …)
- Severe weather (typhoons, TCs, etc)

3. Requirements (on EOVs)

    - Acknowledge this will likely end up with broad statements and little detail since this is an active area of research. Only elaborate where topic is not covered in first report, and where we have a reasonable expectation the TPOS is relevant. We are not reviewing NWP, hurricane forecast system *per se* but assessing points of likely relevance to TPOS and its societal impact.
    - Monitoring intraseasonal variability – partly (wholly?) covered in 1st Report and embedded in BB design
    - Coupling at shorter time scales
        - Diurnal cycle and mixed layer (some basis in 1st Report)
    - Severe weather: Typhoons/tropical cyclones/hurricanes
    - Sub-seasonal scales of variability: monsoons, MJO, BSISO (boreal summer intraseasonal oscillation)
    - Where requirements on EOVs are not clear, the requirements may be couched in terms of processes.

4. Recommendations (for observing system, for R&D)

    - Implications for existing backbone design (e.g. around diurnal cycle SST, winds/wind stress
    - Recommended Backbone enhancements (if any)
    - Needed O(S)SEs and/or impact studies → probably most important part
    - Support for process Studies

5. Actions, next steps, summary

The Steering Committee expressed some nervousness about reaching too far - only elaborate where the topic is not covered in the first Report, or where we have a reasonable expectation that TPOS is of first order relevance. The Introduction must temper expectations beyond what is relevant to TPOS.

The outline of this Chapter is included in Appendix 3.

Chapter 3. Biogeochemical and ecosystem backbone observations

The BGC TT Co-Chairs led the discussion, referencing the discussion under item 5 (vi) and Chris Sabine's presentation.

Chris Sabine's presentation provided considerable background and motivation for why TPOS has a BGC component. Some of this background has been covered in the 1st Report (e.g., section 2.6.7 and parts of Chapter 3, including 3.3) and this can be used as a basis. Similarly, there is no need to remake the case for relevant recommendations (e.g. 13 and 14) and action (e.g. 12) unless there is new evidence available to strengthen and/or modify them. Discussion of oxygen minimum zones was included in the 1st Report after the first round of expert comments but the need to understand oxygen minimum zones (present under all upwelling systems) and hypoxic layers probably needs additional elaboration. Impacts on coral reefs from ocean acidification and bleaching (elevated temperatures) may also need additional attention.

Further information is now available on pCO_2, nutrient and oxygen variability and scales (see 5 (vi)), including from the planning for and initial deployments of BGC-Argo floats (e.g. in SOCCOM in the Southern Ocean). One strategy builds on the knowledge of seasonal and interannual variability as shown in Chris Sabine's presentation and targets the scales of that variability. In this scenario the global density of BGC Argo floats would need to be around one profile per 5-6 degree box every 10 days (around ¼ to ⅓ the density of Argo). Another approach cited by Pete and Adrienne was to target provinces – quoting from the Argo bioregion analysis: *Uniform global coverage by biogeochemical floats might not be the optimal strategy for Biogeochemical-Argo … Deploying floats in specific biogeochemical provinces (e.g., western boundary currents. eastern boundary upwelling regions, and equatorial zonal jet systems), with sparser coverage in places of relatively low biogeochemical activity (e.g., the centers of subtropical gyres) might prove to be a more efficient and cost-effective sampling strategy*.

The rest of the presentation focused on possible recommendations and solutions:

- Surface CO_2 observation from ships (e.g. GO-SHIP, regular lines by operational agencies) and moorings;
- Water column O_2 observations – moorings and Argo
- Profiling floats
    - BGC Argo Implementation Plan offers suggested regions of observations
    - 1000 active floats recommended globally => around 200 for TPOS (50 per year on 4-year lifetimes)
- Nutrient Observations – ship based, NO_3 from moorings Argo, drifters, perhaps Saildrone
- Satellite ocean color – polar orbiting and GEO
- Best thing to do for biology and ecosystem community is design an array that can accommodate sensors in future
- Support for process and pilot studies.

The SC-4 discussion highlighted the need to build the case, particularly through attention to processes and mechanisms (e.g., see Chris Sabine's presentation) in the early sections of the Chapter (the equivalents of Chapters 2 and 3 of the 1st Report). The Steering Committee also encouraged the BGC TT to be bold with the Chapter, including their treatment of marine ecosystem requirements. The Marine Ecosystem Analysis and Prediction Task Team of GOV might be willing to contribute/lead on some of these discussions, particularly around lessons to be gleaned for BGC/ecosystem models.

The Steering Committee Co-Chairs emphasised that the 2nd Report is a real opportunity to press the case; our stakeholders are eager for advice, and there is good evidence of interest and engagement

at the scientist level. The opportunity is probably unique within the context of TPOS 2020; the Chapter can push the boundaries but still be evidence-based and sound scientifically.

The outline of this Chapter is included in Appendix 3.

Chapter 4. The current state of coupled models for sub-seasonal to interannual predictions

The SC Co-Chair, Neville Smith, introduced this item. He noted that this idea had been floating around for some time and had been discussed with members of the Steering Committee, some members of the M&DA Task Team, at the Qingdao workshops, and with TRF-2 (but with no direction forthcoming). The motivation can be found in discussions from all three past Steering Committee meetings, the 1st Report, as well as in the opening presentation by Billy Kessler (item 3 (i)). In establishing the TPOS 2020 Project, prediction is one of the three primary goals, yet the models and data assimilation systems that underpin most subseasonal to seasonal and interannual prediction (S2IP) systems have large biases and systematic errors, as noted under both items 3 (i) and 5 (vii). The Modelling and Data Assimilation Task Team was created in part to address such issues, and projects like 6.1.6 and 6.1.7 of the 1st Report do contribute to improved understanding of the issues.

For climate change modelling and simulations, the Coupled Modelling Intercomparison Project (CMIP) serves as the systematic means for evaluation and testing of models and, very importantly, is accompanied by a regular assessment of the literature through the IPCC assessment process (see, for example, Flato et al 2013, *Chapter 9 - Evaluation of Climate Models*. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change). While there are many activities that might together be regarded as the S2IP equivalent of CMIP (including projects of CMIP itself), there is no counterpart of the regular assessment provided by IPCC. This Chapter aims to bridge that gap. Neville emphasised that the Chapter:

- Is an assessment, not a model prediction/intercomparison;
- It will assess the literature, not coordinate a set of experiment;
    - "Models" should be read as models and data assimilation;
- Will be restricted to subseasonal-to-interannual prediction – not interdecadal;
    - S2IP seems the mostly like area for high impact
    - The interface with Chapter 2 will need to be managed.
    - Other modelling activities can be picked up under other Chapters or in the Reports of the Steering Committee.

Some additional comments were provided against the Chapter outline:

4.1. Background
- Define scope, 1st Report basis, background as above

4.2. Models for S2IP and their characteristics
- Use production centre documentation; consolidated overview (not parameter by parameter)

4.3. Model development and tuning
- Systematic errors workshop; AR5 Chapter 9 and Guilyardi article

4.4. Techniques for assessing model performance
- Simulation of variability and extremes
- Can draw on WCRP groups' experience

4.5. Observations in support of model development and evaluation
- I.e. model requirements wrt EOV

4.6. Model performance for prediction and applications
- Evaluation of peer-reviewed and grey literature
- Several existing studies to draw on
- Do not include downscaling

4.7. Outstanding questions and issues
- Can put link to process studies here

4.8. Recommendations
- Recommendations for change

A judgment will have to be made regarding how wide the net should be cast in terms of models. CMIP provides the filter for IPCC assessments. We would like to embrace the best models in this class, whether they are used in operational centres or not, but there will have to be a published basis for including them; that is, we will not consider systems that are under development.

The assessment and recommendations will be biased toward oceanographic aspects, since that is the point of relevance to TPOS, but it will also need to consider atmospheric aspects.

The Steering Committee suggested a clear articulation of the objectives of the Chapter will be required up front. For example,

1. How well do coupled S2IP models simulate reality (i.e., how close is their natural state to nature)?
2. How well do model and data assimilation systems integrate observations? To what extent are observations used to counter-balance biases versus initialization of the natural modes of variability>?
3. How well do coupled S2IP perform, and what role do observations play in that performance? To what extent do systematic errors mitigate against exploiting the potential predictability of the system?

The outline of this Chapter is included in Appendix 3.

Chapter 5. Developing an Eastern Pacific Backbone OS

While a pathway forward for the western Pacific has emerged quite quickly from the publication of the 1st Report (as discussed under item 5 (ii)) and in item 6bis), the same is not true for the eastern Pacific. Scientific understanding, logistics, vandalism and resources all contribute to uncertainty. While opportunities for progress are being explored (item 5 (v)), the Steering Committee concluded

that a Chapter in the 2nd Report providing more detail on the implementation strategy for the tropical eastern Pacific[2] Backbone would be useful.

Yolande Serra led the discussion on a possible structure/outline for Chapter 5 of the 2nd Report. The following points are order against that outline.

5.1 Introduction
5.2 Background building on Report 1 (e.g. 2.6)
- Phenomenological background; characterization of eastern Pacific (ocean fronts, diurnal cycle, upwelling/mixing, ITCZ/cold tongue/stratus system, coastal waves/upwelling, …
- TPOS and global context
- Relevant recommendations and Actions from 1st Report

5.3 Building knowledge, engagement and experience
- Process studies (e.g. pared down 6.2.4 ITCZ/warm pool/cold tongue/stratus; 6.2.1 PUMP)
  - Commentary around need to understand where coupled models have reached; may change approach
- Pilot studies, e.g.
  - Pared down 6.1.2 - equatorial-coastal waveguide and upwelling
  - Joint participation in 6.1.3 – biogeochemistry
  - 6.1.5 - Clipperton Is. Hopefully building on PASSION FRUIT cruise, DOOS common interest
- Vandalism/logistics - Trial of new technology at 95W (see action below)

5.4 Enabling regional activities
- Enhancing data access and product availability for the region
- Building inventories of observation networks, cruises, moorings, research studies

5.5 Toward an enhanced and sustainable EP Backbone
- Develop schedule for transformation of eastern Pacific TMA
- Develop plan for enhanced Argo, noting that threats to the viability of 95W dictate that 2xArgo provide additional redundancy. BGC-Argo, perhaps focused on the eastern Pacific province should be included in planning.
- Toward a Clipperton Is climate observing station
- Possible supporting model experiments, e.g. within OTREC and/or for a regional reanalysis
- Building on regional partnerships and data resources

5.6 Recommendations and actions
5.7 Summary

Yolande noted that the EP TT would meet in early November to discuss the status of the studies and the approach to this Chapter.

The outline of this Chapter is included in Appendix 3.

[2] The tropical eastern Pacific marine realm is defined as from the southern tip of the Baja California Peninsula in the north (i.e. near 110W) to northern Peru in the south, but following the coast rather than a lat-long box. For TPOS purposes we usually think of it extending to at least 110W, including Clipperton Island and the Galapagos, but otherwise intentionally leave the definition vague.

Chapter 6. The TPOS 2020 Backbone Observing System

The purpose of this Chapter is, first to provide a recap of recommendations and actions from the 1st Report and, as appropriate, provide background for any update or changes. Second, based on the preceding chapters and other developments not covered by the 1st Report, consider any new recommendations and/or for the Backbone. Finally, summarise progress with implementation and detail any barriers for consideration by the TPOS 2020 sponsors. The Roadmap provided to TRF-2 is a convenient starting point.

The following outline was agreed:

6.1 Introduction
6.2 Update on the 1st Report Backbone recommendations and actions
6.3 Synthesis of possible enhancements and changes, including from earlier chapters
6.4 Recommendations and changes
6.5 Progress with implementation, including guidance from pilots and process studies
6.6 Summary

The Steering Committee noted that this Chapter may be shifted to follow Chapters 7 and 8. The outline of this Chapter is included in Appendix 3.

Chapter 7. TPOS data flow and access

[Note that the original agenda included a chapter on implementation and pilot/process projects; this will now be absorbed in 6 or taken up in the TPOS 2020 SC-5 Report. 6B below summarises implementation and pilot/process discussions at SC-4.]

The idea of enhancing accessibility and utility of tropical Pacific observations arose during the discussion of several items during this meeting. The TPOS 2020 focus and its primary stakeholders place it in a good position to generate activity that will enhance the value of the tropical Pacific observational record through improved quality, improved access and enhanced usability. Many similar activities are sponsored under JCOMM and IODE; TPOS 2020 could add value through its knowledge of relevant research datasets (e.g., through the WP TT inventories) and dedicated reprocessing activities attached to reanalysis projects.

There is also untapped potential to improve real-time and near real-time exchange of data over and above what is achieved through the GTS. JCOMM has already undertaken a pilot to enhance access using OPeNDAP/ERDDAP and the OpenGTS project. TPOS 2020 could consider a data exchange pilot attached to, for example, the Western Pacific Implementation Project.

The Steering Committee emphasised that there is no intent to create a comprehensive data and information management project within TPOS 2020. Rather, through specific focused initiatives, TPOS 2020 can enhance the effectiveness and relevance of established systems.

Kevin O'Brien provided input on the potential use of ERDDAP. Neville Smith then provided the following outline based on discussions during the SC-4 session.

1. Background
    - Why is this chapter needed?
        - Improving accessibility

        - Improving consistency
        - …
2. Essential elements and requirements
    - Essential ocean data management elements
    - The many lives of TPOS data (Balmaseda et al, La Jolla)
    - Build on but do not repeat background in La Jolla whitepaper #13
    - JCOMM and WIS DM elements
3. Quick turn-around data requirements
    - Improvements needed in the fast delivery mode
    - Data policies – addressing barriers (e.g. EP)
    - OpenGTS/ERDDAP Pilot
4. Delayed and re-processed data streams
    - Improving accessibility, usability
        - Use WP inventories as example
        - Lowering barrier for modelling, assimilation
    - Potential for consolidation, standardisation
    - Integrate data from the various platform (ERDDAP)
5. Recommendations, actions
6. Summary

The Steering Committee noted that further consultation may be required before the structure of this Chapter is finalised. The outline of this Chapter is included in Appendix 3.

Chapter 8. An evaluation of emerging technologies

The discussion on this Chapter was prefaced by several presentations on potential innovative approaches for the TPOS Backbone.

6.8.1. Surface Wave Gliders (Kentaro Ando)

Ken described the results of an open sea trial off Okinawa/Japan during 2016 whose aims were (a) to establish the operating procedures for deployment and recovery using a small boat, and (b) to check the stability of data and cruising over one month. A second trial was conducted near Palau in the western Pacific to confirm the logistics for operating from a diving boat, and to evaluate the data from a surface buoy and Wave Glider. The Wave Glider completed more than 20 circuits around the buoy and tested a towed thermistor line (to around 10 m); the Wave Glider could move at around 1 knot. The surface met instruments were damaged during high seas.

The Wave Glider now has three sets of met sensors (Wind S/D, Ta, RH, SW, LW, Bar), SST and SSS, a thermistor chain, and an ADCP (300kHz; 100 meters depth).

Further trials are planned within the YMC in the eastern Indian Ocean and off Palau during late 2017 and during 2018.

6.8.2. Saildrone – Bringing new capabilities to TPOS (Meghan Cronin)

This is one of the projects supported through NOAA's "In Situ Technologies to Contribute to the Tropical Pacific Observing System (TPOS 2020) Project".

Meghan noted that the Saildrone is 'Off the shelf' and includes sensors for wind, currents air temp, relative humidity, air pressure, water temperature and a BGC Suite (by Sutton et al: air pCO2, Chla, CDOM, red backscatter, dissolved oxygen, water pCO2) (among other measurements). The data from the trial that is currently being conducted (it is presently circling the SPURS-2 site) are being evaluated.

The potential uses in TPOS include:

- As a pseudo-mooring: probably not best application of the technology because it does not exploit its mobility.
- For repeat cross-sections: e.g. back and forth across fronts.
- For adaptive sampling – for example, following the eastern edge of the warm pool moving during ENSO; this exploits a Saildrone strength; will be tested next year.
- As a potential alternative platform for moorings in high vandalism regions, such as 95 W.

Saildrone Inc. use a different business model: you pay for the data, not the platform. A fully loaded platform with BGC is around ~$1M/year. This includes ship time, data management and insurance (in case a Saildrone is lost).

6.8.3. Enhanced operational TAO moorings (NDBC, PMEL) (Billy Kessler)

This too is one of the projects supported through NOAA's "In Situ Technologies to Contribute to the Tropical Pacific Observing System (TPOS 2020) Project".

The aim of this project is to test enhancements that will provide better resolution of the mixed layer and its response to forcing, including subsurface velocity profiles. The trials are being conducted on operational TAO moorings – straightforward integration if/when needed. Five test deployments are currently in the water and two more are to be deployed next year.

Access to real-time upper ocean velocity profiles has the potential to be a game changer. Measurements of equatorial divergence – much of the Ekman outflow happens above the range of deeper ADCPs – should improve understanding and monitoring of the surface-mixed layer-thermocline communication and the role of diurnal cycle.

Over an eight-month period the difference between daily-averaged current meter measurements and daily-averaged ADCP data is 3 cm/s; the target signals are about an order of magnitude larger. They are currently analysing the data to detect any fish-related bias or other ADCP problems. Other questions to be answered include: How many sites would we need? Regimes or broadscale? Is a 1-year pilot enough, or do they need to be ongoing?

6.8.4. A trial of surface autonomous vessels?

These presentations, along with the discussions on the follow up to Action 9 from the 1st Report and on the eastern Pacific Chapter (see item 5 (v)), led to Meghan and Yolande to propose a Pilot around alternative approaches for high-risk regions like the 95W line.

Data returns from 95 W are among the lowest of all the lines maintained by NOAA, principally because of vandalism. JCOMM and other groups have several initiatives aiming to mitigate such risks but, to date, without significant impact. Locations at and near the equator are at most risk.

Meghan and Yolande noted that 3 or 4 Saildrones operating along 95W could be a substitute for the surface measurements from moorings along that line. The Saildrone would not replicate the high-frequency point measurements of a mooring, but would return high-frequency measurements continuously along its path. Subject to the analysis of data from the present trial, there is a persuasive case for investigating the viability of autonomous surface vessel platforms for meeting TPOS 2020 requirements.

The TPOS 2020 Steering Committee agreed that a pilot study focused on 95W would be timely in terms of the elevated risk at 95W and generally informative for network options into the future. The pilot might include:

(a) A desk-top study. Given the stated requirements for the eastern Pacific (Chapters 2 and 3 of the 1st Report) and Recommendations, how well does (i) the present arrangement (TMA plus others) meet those requirements? (ii) The present networks and 2xArgo? (iii) The transformed TMA (but with reduced return) and 2xArgo? (iv) No 95W but continuous transects by autonomous vehicles like the Saildrone? Or (v) some other optimized mix of platforms? For each a rough estimate of cost should be included.

(b) A trial of autonomous technology. Based on the design consideration and recommendations from (a), conduct a parallel trial of new technology over 12 months to test and compare the information return compared with the target requirements.

(c) An evaluation based on the results of (a) and (b) to provide recommendations for the future.

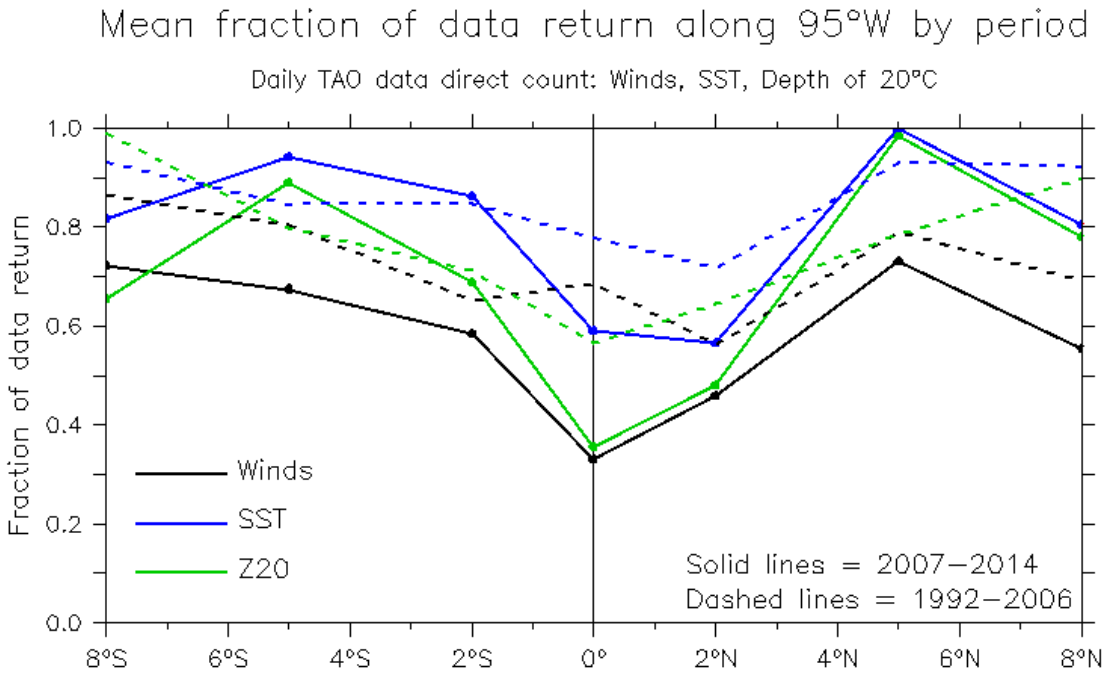

Figure 3. (From NOAA/PMEL) Mean fraction of data returned along 95W.

Action SC-4.18. Develop a pilot study to test and evaluate the feasibility of deploying autonomous surface vessels to partly or wholly replace fixed point moorings where

the return rate from moorings is unacceptable or marginal (EP and PBL TTs; Pilot proposal ready by Feb/March 2018).

6.8.5. Outline of Chapter 8

The Co-Chairs noted that the TPOS 2020 Review in La Jolla in January 2014 did include a White Paper on emerging technology (White Paper #12 – Emerging technology: D. Rudnick, C. Meinig, K. Ando, S. Riser, U. Send, and T. Suga, Jan 2014) and that this might provide a convenient starting point for Chapter 8 of the 2nd Report.

With respect to evaluation, Katy Hill noted that Matt Mowlem (NOC, UK) had discussed this issue with the JCOMM Observation Coordination Group through a presentation on "Assessing/integrating new technologies", building on work that had been done within Atlantos (Work Package 6). His presentation built on the Technology Readiness Levels used by NASA and adapted by NOAA and others (technical readiness level), and attempted to bring such concepts into the framework for ocean observing. There are important differences between technology readiness (How ready is that particular technology for 'operational' deployment – can it operate reliably?) and readiness for deployment as part of a sustained observing system. The 2nd Report is more focused on the latter. The Chapter will focus on technologies that have at least been proven to operate reliably in a scientific environment.

The following outline was proposed:

8.1. Introduction and Background
8.2. Emerging in situ technologies
8.3. Remote sensing
8.4. Evaluation of readiness for Backbone
8.5. Gaps
8.6. Summary

Chapter 9. Summary and conclusions

[Not discussed]

Neville Smith concluded by providing a rough outline of the process for the 2nd Report which would generally be like that used for the first.

The first task is to finalise the 2nd Report outline; the draft that emerged from SC-4 is in Appendix 3.

Action SC-4.19. The extended Steering Committee should review the 2nd Report outline as given in Appendix 3 with a view to finalisation by the end of November.

Action SC-4.20. The Steering Committee Co-Chairs to seek agreement on Coordinating Lead Authors for each Chapter (Dec 2017).

The following draft schedule was proposed:

- 1st draft ~ end of March
- Expert review April (focus on new material)

- 2nd draft start of July
- Stakeholder review July-August – all chapters
- Revised draft early October
- SC review Oct/Nov
- Publish 31 December 2018

There will be regular calls as was done for the phases 2 and 3 of the 1st Report, progressively moving through the Report. The possibility of a Lead Author meeting will be left open for now.

Action SC-4.21. NS/BK to finalise schedule for the drafting of the Report (Nov 2017)

6B Implementation and Pilot/Process Studies

Transition and Implementation Task Team

Neville Smith provided a brief account of the establishment of the TPOS 2020/JCOMM MAN Transition and Implementation Task Team (T&I TT). He noted that at SC-2 it was agreed that a mechanism would be required to follow through on TPOS 2020 recommendations and action and to oversee the transition from a fixed-term focussed project (TPOS 2020) to normal intergovernmental/international coordination (see Figure 3). The TPOS 2020 SC created an *ad hoc* Transition and Implementation Group (as it was known then) to liaise with JCOMM and other relevant bodies. The terms of reference for a more formal structure were presented to SC-3 (agreed) and then, in turn, to the Inter-Commission Coordination Group on the WMO Integrated Global Observing System (ICG-WIGOS-6) on 12 January 2017 and the 13th session of the JCOMM Management Committee (JCOMM MAN 13) on 20 Jan 2017. In the former case, the primary purpose was to find a formal mechanism by which National Meteorological and Hydrological Services (NMHSs) could participate in the work of TPOS 2020; ICG-WIGOS agreed to recognize TPOS 2020 as a Pre-Operational Regional Pilot. In the latter case the purpose was to bring JCOMM MAN in as a partner in the transition and implementation process; JCOMM MAN 13 formally endorsed the Terms of Reference, with some small modifications. TRF-2 also endorsed the Terms of Reference for the TPOS 2020/JCOMM Transition and Implementation (Cross Cutting) Task Team which can be found in the Appendix of the TRF-2 Report.

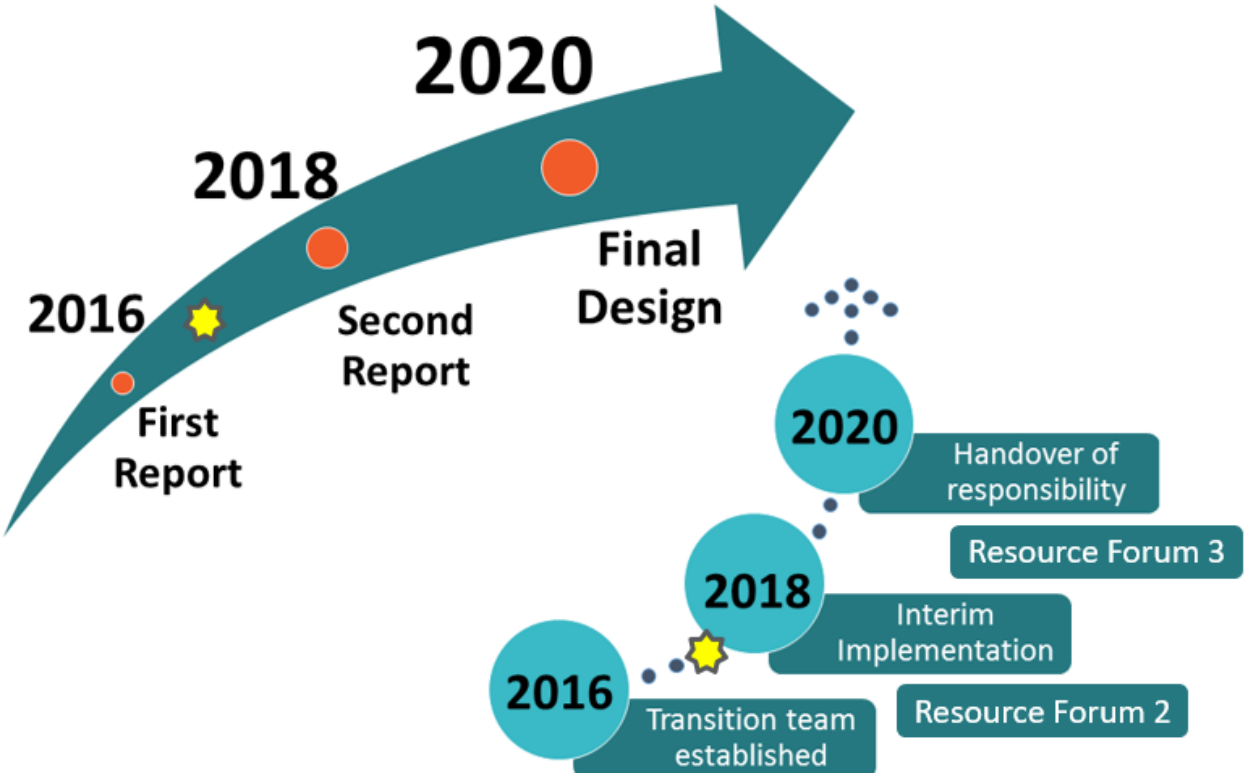

Figure 4. Schematic showing the sequence of science advice (reports) and implementation stages through to the end of the TPOS 2020 Project.

The T&I TT met for the first time on 25 September 2017. At present TPOS 2020 is providing the Chair (Neville Smith) and the DPO is supporting T&I TT through Katy Hill. The revised terms of reference require a vice-Chair (not yet determined) and up to 10 ordinary members (we will start with 2-4). Relevant materials (documents, presentations, etc.) can be found on the TPOS 2020 web site.

To date, the only Steering Committee participation has been through the SC Co-Chair. Given the Backbone Task Team's primary role providing oversight for the Backbone, the Steering Committee agreed that the Backbone TT should provide an ex-officio member of the T&I TT.

Action SC-4.22. The Backbone Task Team to participate ex-officio as a member of the T&I TT, as required (Co-Chairs, BB TT Co-Chairs).

Further clarification of staged implementation actions

Section 7.4 of the 1st Report provided an explanation of the required and staged implementation actions. However, some aspects were left "fuzzy" (as depicted in Figure 7.2 of that Report), and in the intervening period attempts have been made to reduce or remove that fuzziness. Billy Kessler provided an update under item 3 (i), noting that discussions prior to TRF-2 and during the 4-6 September Qingdao workshop have helped clarify some issues.

The Co-Chairs emphasised the urgency for closing off this discussion and providing a final recommendation, at least from the perspective of the Steering Committee. Stakeholders may well assign different priorities depending upon their own interest.

Billy Kessler then led a discussion of Figure 1. The following points were discussed.

- If 165E is to be the location of the extended line west of the dateline, then it must extend further south to intersect the SPCZ.
    - In terms of implementation, we need to figure how far south we need to go to be below the mean SPCZ and balance this need against the practical constraints of deployments in EEZs.
    - Northern extension in west needs to be in mean dry area; the first one is in the mean maximum precipitation region
- For the ITCZ:
    - Important to include dry regime
    - Getting regime diversity important- also getting rainy regime; middle extension needed to sample zonal scales of surface met, humidity
    - Southerly extension at 125 could be shifted to 110 to get better coverage in double ITCZ region – not resolved.
    - Otherwise, agreement on north and south extensions in Figure 1.
- For 140W (increased density north/south density - 0,1,2, N/S), chosen because of the long velocity record. Agreed.
- Ken Ando noted the far west equatorial mooring is difficult to maintain, but has been occupied for 15 years by JAMSTEC; science says to keep it though.

Decision 2 The Steering Committee agreed on the preferred location for all mooring lines except for the southerly extension at 125W (see Action SC-4.23). The Backbone Task Team will use Figure 1 as the starting point for considering additional extensions and/or modifications.

Action SC-4.23. The PBL TT to provide advice on the southerly extension at 125 and whether it should be shifted to 110W to get better coverage in double ITCZ region. The advice in the first instance should be based purely on scientific considerations; supplementary advice may be provided taking account of implementation risks.

Timing/sequencing of implementation

The Co-Chairs noted that while planning for the western Pacific was proceeding quickly, it was unlikely new deployments would occur before 2019. There is a considerable lag between decisions being made and resources being available. It is possible equatorial Argo deployments, especially in west, may occur earlier. The 1st report recommended a phased transition to the new TMA. The Report did not recommend the closure of any sites but did support a new set of priorities.

Given there remains considerable discussion on the precise details of Figure 1 (which agencies will do what, and when), the likely schedule for changes in the western Pacific (first deployments in 2019), and the desire to undertake some additional analysis before proceeding, the implementation detail for the first set of changes for TPOS will probably remain open for another 12 months. The transition to the new configuration will thus probably occur during 2019-2020.

Progress with the LLWBC Pilot Project

Pacific LLWBC Pilot (BK) Billy Kessler provided additional background on the LLWBC Pilot Project. The outcome of those discussions was reported under item 5 (ii) and the action captured in Action SC-4.7.

7. National and Agency Updates

7 (i) NOAA

Kathy Tedesco provided a NOAA report. She noted that is developing a TPOS Implementation Strategy Outline and it is being applied to the following activities:

- Backbone Changes and Impact Studies
- Pilot studies/New technology
- Modeling Improvements
- Process Studies (including CPTs)

The Outline includes consideration of:

- Anticipated Benefits/Needs
- Partners
- Proposed Activities
- Schedule, Deliverables and Costs
    - Near-term actions 2017-2019 within existing budgets; and Strategic actions 2019-2021 and beyond: new funds)
- Relevance (to TPOS Plans, 1st Report)

She noted NOAA's support through the "In Situ Technologies to Contribute to the Tropical Pacific Observing System (TPOS 2020) Project" (referring to the presentations under item 6(8)) and foreshadowed the possibility of another call based on the 1st Report and discussions at this meeting.

Kathy was wondering how the SC might help in refining the existing guidance, including around new technology and whether something akin to a town hall meeting might be used as part of such a process.

The Steering Committee noted Kathy's comments and provided general feedback.

The SC Co-Chairs noted that around 16 activities (Pilots, Process Studies, new technology initiatives) are identified (prioritised) within the first Report. To this should be added the 13 high priority Actions, not counting the one associated with Pilots/Studies. While SC-4 has pared some back (6.1.2, 6.2.4), others have probably grown in terms of expectations (e.g. 6.1.5, Clipperton). Moreover, we have considered and supported a modelling workshop; the creation of a Western Pacific Implementation Pilot; scoping of a data reprocessing and reanalysis pilot; scoping and initiation of a 95W autonomous surface measurement pilot; and initiation of the concept of process science teams.

The SC Co-Chairs further noted that, from the perspective of scientific relevance and potential impact for TPOS 2020, the Steering Committee is unlikely to provide any more detailed guidance other than that that will be provided with the 2nd Report (this will be evident by SC-5). However, as is evidenced by the interest in western Pacific implementation, the LLWBC Pilot and Clipperton, our stakeholders are already beginning the process of aligning these possibilities with their own priorities and agendas. The Steering Committee stands ready to provide advice into such activities, but cannot pick winners for individual agencies (NB: NOAA was not asking us to do this).

The Steering Committee will seek opportunities for town-hall type events.

7 (ii) SOA

Weidong Yu provided this report and he began by highlighting the drivers (societally relevant factors) for China:

- Typhoon/Wave/Surge
- Asian Monsoon
- El Niño
- Indian Ocean Dipole
- Eutrophication/HAB/Red/Green Tide
- Ocean Anoxia
- Degradation of the marine ecosystem

Chinese rainfall variability is forced by local processes (monsoon's land-ocean-atmosphere interaction) and externally (ENSO, IOD, PDO etc.). Recent study (Wang et al. 2013) reveals that the Northwestern Pacific Subtropical High (centred around 20N, 130-140E) provides a good prediction source for East Asian Monsoon Rainfall and this has implications for the "optimal" TPOS from the Chinese perspective (Figure 1 and Figure 2 reflect such priorities). Near the equator, westerly wind events, heat flux (MJO) and subsurface variability are the requirements most relevant from their perspective.

SOA's draft zero-order plan then is:

1. Support the equator buoys to the dateline, /w collaboration
2. Support 2-3 meridional lines to ITCZ, /w collaboration
3. Intensify the typhoon source region by mixed buoy/mooring array
4. Enhanced Argo deployment over Western North Pacific, /w coordination
5. Enhanced observation with chemical/biological payloads

SOA's "call for action" also highlights (a) the model community becoming more involved in TPOS development, (b) promotion of technical collaboration/transfer, and (c) data management protocols. For 9a) Weidong provided several examples of where model improvements are needed. The latter was one focus of the Workshop held during the evening of 19 October.

The Steering Committee was encouraged by these efforts.

7 (iii) JAMSTEC

Ken Ando provided some additional information (most was covered under item 5 (ii) and item 6.8.1).

1. TRITON maintenance: JAMSTEC will maintain three sites, 0-156E, 8N137E, and 13N137E. They will try to install pCO2 at 13N, 137E next year.
2. Wave Glider test: See 6.8.1.
3. Proposals: JAMSTEC have developed several research cruise proposals: eastern edge of warm pool (ship time in 2019), and northern edge of the warm pool (ship time in 2018 and 2020). These proposals are under review.

The Steering Committee welcomed the continued support for TRITON and the investment in emerging technology and potentially in two process studies.

7 (iv) France (IRD, and Coriolis)

Sophie Cravatte provided some additional information on scientific French-Mexican cooperation around Clipperton and noted that the Atalante ship will be sent to the Pacific Ocean in 2019. Proposals are being prepared now, with the involvement of TPOS 2020 teams, as reported previously.

French Argo floats will also be deployed in 2018 in the Western Pacific.

8. Report from the DPO

Andrea McCurdy from the DPO led this discussion. She noted some changes in the organisational structure of TPOS 2020 with the creation of the Transition and Implementation Task Team. She recognized and thanked all members of the DPO (and their lines of support) and noted the likely lines of support for 2018 and beyond.

Andrea also provided a brief summary of her work in the review of the Framework for Ocean Observing and invited Steering Committee members to contact her if they wished to provide comment/feedback.

The Steering Committee noted that Andrea would be stepping back from the role leading the DPO but would stay engaged in TPOS 2020 through DOOS and OceanObs ’19 and, to the extent resources allow, maintain inputs on project management and the web. The Steering Committee expressed its thanks to Andrea for her leadership through the first 3+ years of the Project.

9. Other Business

9 (i) Confirm annotated outline of 2nd Report

The Steering Committee agreed the high-level outline of the 2nd Report.

9 (ii) Agreed terms of reference for the WP Implementation Pilot Project

See Decision 1 under item 5 (ii).

9 (iii) Consider inputs to:

- Argo ST meeting
  - See Action SC-4.11.
- AtlantOS General Assembly

  Action SC-4.24. Katy Hill to report back from AtlantOS GA on matters relevant to TPOS 2020, including the OSSE workshop evaluation of emerging technology.

- JCOMM 5 item on TPOS
  - Offline discussions resolved the issue with the (then draft) JCOMM V Decision 7.1/6.
  - Neville Smith and Katy Hill will contribute to a side event on TPOS 2020 and YMC.
- Involvement with Tropical Atlantic Observing System review;
  - Katy Hill and Neville Smith have been invited to join the Tropical Atlantic Observing System review steering committee, representing OOPC and TPOS 2020, respectively.
- Nominations to OceanObs 19 Programme Committee
  - It was decided not to nominate anyone to the Programme Committee noting that Weidong Yu (sponsors) and Tony Lee (programme committee) are already engaged.
- Input to GOVST VIII in Bergen, 8 Nov
  - Neville Smith will provide a presentation to GOV VIII (remotely), focused on modelling and data assimilation.

9 (iv) Review actions

Neville Smith reviewed the actions that will be carried forward (it was agreed that 3.21, 3.22 and 3.24 have been superseded and could be closed) and the main new actions agreed at SC-4 (Appendix 4).

9 (v) Next meeting

Offline discussions with Kentaro Ando indicated JAMSTEC would be happy to host the next Steering Committee meeting. The Co-Chairs provisionally supported the JAMSTEC option but asked for other expressions of interest.

10. Close

The Co-Chairs closed the meeting at 1645 on Thursday 19 October.

A separate technical workshop on western Pacific implementation was held immediately after. The Report of that Workshop is attached at Appendix 5.

Appendix 1 SC-4 Agenda

0830 Tue 17 Oct

ITEM 1: OPENING AND WELCOME

- Introduction and local welcome by C. Sabine
- Logistics overview

ITEM 2: AGENDA AND REVIEW OF ACTIONS (NS)

- Agree agenda and consider desired meeting outcomes
- Review TPOS 2020 SC past actions

ITEM 3: STATUS

- Overview and future challenges (BK)
- TRF-2 outcomes
- Status of 1st Report recommendations and actions

ITEM 4: ESTABLISH OUTLINE/WORK PLAN FOR 2ND REPORT

- Agree High-level structure (chapter headings)
- Discuss/agree process, timeline
- Discuss potential Coordinating Lead authors

ITEM 5: TT STATUS AND OTHER UPDATES

- ❖ Update from the March 2017 OOPC meeting (KH)
- ❖ Western Pacific
  - TT activities (KA)
  - WESTPAC meeting April; WP TT Workshop Qingdao (September) (NS, BK, WY)

0830 Wed 18

ITEM 5 (CONTINUED)

- ❖ Backbone (SCr, SW)
- ❖ Planetary Boundary Layer (MC, TF)
- ❖ Eastern Pacific (YS)
- ❖ Biogeochemistry (AS, PS)
- ❖ Modeling and Data Assimilation (AK)

ITEM 6: 2ND REPORT CHAPTERS

II. Coupled weather, wave and subseasonal applications

III. Biogeochemical and ecosystem backbone observations

IV. The current state of coupled models for sub-seasonal to interannual predictions

0830 Wed 19
ITEM 6 (CONTINUED)

V. Developing an Eastern Pacific backbone OS

VI. The TPOS 2020 Backbone Observing System

VII. TPOS data flow and access

[Replaced Progress with implementation, including pilots and process studies]

VIII. An evaluation of new technologies

ITEM 7: Update on national initiatives

a. China

b. Japan

c. US

d. …

ITEM 8: DPO update

ITEM 9: Other business

- Agree on annotated outline of 2nd Report
- Agree terms of reference for WP Implementation Pilot Project
- Review actions

ITEM 10: Close (mid-afternoon)

Appendix 2 SC-4 Participants

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Appendix 3 Outline of 2nd Report

1. Introduction and background
2. Coupled weather and subseasonal applications
   - 2.1. Introduction
   - 2.2. Background
   - 2.3. Requirements (on EOVs)
   - 2.4. Recommendations (for observing system, for R&D)
   - 2.5. Actions, next steps
   - 2.6. Summary
3. Biogeochemical and ecosystem backbone observations
   - 3.1. Biogeochemical and ecosystem processes of the tropical Pacific
   - 3.2. EOV requirements for the tropical Pacific
   - 3.3. Biogeochemical and ecosystem requirements of the backbone observing system
   - 3.4. Required actions
   - 3.5. Summary
4. The current state of coupled models for sub-seasonal to interannual predictions
   - 4.1. Background
   - 4.2. Models for S2IP and their characteristics
   - 4.3. Model development and tuning
   - 4.4. Techniques for assessing model performance
   - 4.5. Observations in support of model development and evaluation
   - 4.6. Model performance for prediction and applications
   - 4.7. Outstanding questions and issues
   - 4.8. Recommendations
   - 4.9. Summary
5. Developing an Eastern Pacific backbone OS
   - 5.1. Background
   - 5.2. Building knowledge, engagement and experience
   - 5.3. Enabling regional activities
   - 5.4. Toward an enhanced and sustainable EP Backbone
   - 5.5. Recommendations and actions
   - 5.6. Summary
6. The TPOS 2020 Backbone Observing System
   - 6.1. Introduction
   - 6.2. Update on the 1st Report Backbone recommendations and actions
   - 6.3. Synthesis of possible enhancements and changes, including from earlier chapters
   - 6.4. Recommendations and changes
   - 6.5. Progress with implementation, including pilots and process studies
   - 6.6. Summary
7. TPOS data flow and access
   - 7.1. Background
   - 7.2. Essential elements and requirements

Appendix 4 SC-4 Consolidated Decisions and Actions

Decisions

Decision 1 TPOS 2020 SC agrees to create an ad hoc WP Backbone Implementation Pilot Project with the following terms of reference:

a) Purpose: To coordinate implementation activities in the western Pacific, under the guidance of TPOS 2020, and cognizant of JCOMM coordinated activities.
- Part of the TPOS 2020-led Transition and Implementation effort

b) Scope: Focus follows Actions 1-5 of the 1st Report and associated requirements.
- Include/encourage testing of new technology and modelling support

c) Report to SC, T&I TT
- Communicate lessons learned

d) Duration: now-2020

e) Involvement: open

Decision 2 The Steering Committee agreed on the preferred location for all mooring lines except for the southerly extension at 125W (see Action SC-4.23). The Backbone Task Team will use Figure 1 as the starting point for considering additional extensions and/or modifications.

Actions Carried Over

Action SC-2.18: TPOS 2020 performance metrics (A. McCurdy, N. Smith)

Action SC-3.1: Consider the development of a science capability matrix (or similar device) to summarise the links from high-level objectives through to recommendations and actions (TPOS 2020 SC Co-Chairs, DPO and KT; April 2018).

Action SC-3.6: Further develop Pilot/Process studies into "implementation strategy" style documents, with guidance on who may contribute, when, and in what form (Study authors, Task Teams, SC, by July 2018)

Action SC-3.13: DPO to keep track of regional planning activities e.g. in China and Peru/South America and any input needed from TPOS 2020 SC (as part of engagement plans) (DPO, ongoing).

Action SC-3.14: Explore options for a small project demonstrating the utility and benefits of data exchange (Ken T, NS; May 2018)

Action SC-3.20: Develop a slide deck highlighting the scientific background, rationale, Recommendations, Actions, and key technological/scientific challenges of the First Report (DPO with TPOS 2020 SC, Jan 2018)

Action SC-3.26: TPOS 2020 SC Chairs to discuss with Ken, Carmen, DongChull how to take forward and support activities in the Eastern Pacific Task Team (April 2018)

Action SC-3.43: SC Co-Chairs to liaise offline with respect to SC membership and membership/terms of reference for TTs (Ongoing, SC Co-Chairs)

Actions from SC-4

Action SC-4.1. Coordinate scheduling of next TPOS 2020 SC, in consultation with WCRP, CLIVAR (DPO, Co-Chairs)

Action SC-4.2. Maintain a watching brief on the deep-ocean observing system – implications for the deep-ocean observing system from TPOS 2020 recommendations and actions, and vice versa – and liaise with DOOS, as appropriate (Backbone Task Team, Andrea McCurdy).

Action SC-4.3. Include an item on data flow and access in the agenda of the fifth Steering Committee meeting (Co-Chairs, DPO).

Action SC-4.4. Contact Fabrice Ardhuin, Fangli Qiao and others for guidance on if/where TPOS can add value in wave observations (Sophie, Neville).

Action SC-4.5. Continue working with OOPC on areas of common interest such as (a) winds and wind stress [Tony Lee, Tom Farrar] and (b) convening a small meeting of flux experts (observations, products) (6-8 people) to design sensitivity experiments [Weller, Yu, Cronin].

Action SC-4.6. Undertake a high-level audit around data flow and accessibility of Western Pacific observations (i.e., is available or not through JCOMM/IODE, ERDDAP, WOA or other "standard" mechanisms) and identify priorities among those not available (WP TT, May 2018).

Action SC-4.7. The existing LLWBC documentation (6.1.1 of 1st Report; output of 4-6 Sep Workshop; WP TT reports at SC-4) should be further developed into a pre-proposal "white paper", incorporating a review and assessment of current knowledge and required elements (Janet Sprintall & WP TT; May 2017).

Action SC-4.8. The Backbone Task Team Co-Chairs, in consultation with the Steering Committee Co-Chairs as needed, reconsider membership of Task Team to meet future priorities (BB TT Co-Chairs, Dec 2017).

Action SC-4.9. The Backbone TT to maintain a watching brief on a possible DOOS Clarion-Clipperton project (see also Action SC-4.2; Andrea McCurdy for DOOS; BB TT).
N.B. This action replaces Actions SC-2.12, SC-2.13 and SC-3.24.

Action SC-4.10. The Backbone Task Team to develop guidance for the phased implementation and transition of the Backbone components, initially beginning in the western Pacific, and including more detailed specifications for Argo and the TMA (non-fuzzy map) and indicative schedule for consideration of the T&I TT (BB TT, Steering Committee Co-Chairs, Apr 2018)

Action SC-4.11. Co-Chair Kessler to participate in Argo ST meeting 20 to discuss TPOS 2020 plans (Billy Kessler, March 2018).

Action SC-4.12. Weidong Yu to report on the outcomes of the 5th CFOSAT Science Team Workshop (Weidong Yu, Dec 2017).

Action SC-4.13. [Replacing SC-3.22] Develop a 2-page outline for a tropical wind process science team, joint with OOPC (Tom Farrar, Tony Lee, Dec 2017).

Action SC-4.14. Examine the feasibility of compiling inventories of (a) observational networks, (b) research and other cruises, and (c) mooring deployments in the eastern Pacific (EP TT, for inclusion in 2nd Report).

Action SC-4.15. The Steering Committee to be kept informed of the development of this Workshop, noting that it is under the lead of US CLIVAR, not TPOS 2020 (Billy Kessler).

Action SC-4.16. Scope a TPOS 2020 reanalysis for the Western Pacific and/or TPOS region whereby extant data are made accessible and re-processed suitable as input for data assimilation, and the requirements on the potential reanalysis systems and the evaluation of products are specified (M&DA TT, BB TT, WP TT).

Action SC-4.17. M&DA TT to provide leadership and facilitate progress on (a) Pilot Projects 6.1.6 and 6.1.7, (b) the PUMP process study, bringing in other TTs as appropriate, (c) modelling contributions to other pilots/process studies, and (d) contributions to the US CLIVAR Workshop (May 2018) and the WCRP meeting in Boulder, Sep 2018 (M&DA TT).

Action SC-4.18. Develop a pilot study to test and evaluate the feasibility of deploying autonomous surface vessels to partly or wholly replace fixed point moorings where the return rate from moorings is unacceptable or marginal (EP and PBL TTs; Pilot proposal ready by Feb/March 2018).

Action SC-4.19. The extended Steering Committee should review the 2nd Report outline as given in Appendix 3 with a view to finalisation by the end of November.

Action SC-4.20. The Steering Committee Co-Chairs to seek agreement on Coordinating Lead Authors for each Chapter (Dec 2017).

Action SC-4.21. NS/BK to finalise schedule for the drafting of the Report (Nov 2017)

Action SC-4.22. The Backbone Task Team to participate ex-officio as a member of the T&I TT, as required (Co-Chairs, BB TT Co-Chairs).

Action SC-4.23. The PBL TT to provide advice on the southerly extension at 125 and whether it should be shifted to 110W to get better coverage in double ITCZ region. The advice in the first instance should be based purely on scientific considerations; supplementary advice may be provided taking account of implementation risks.

Action SC-4.24. Katy Hill to report back from AtlantOS GA on matters relevant to TPOS 2020, including the OSSE workshop evaluation of emerging technology.

Appendix 5 Report of Western Pacific Technical Workshop

19 October 2017, TPOS SC-4, PMEL, Seattle, USA

1. Background to Workshop

The TPOS Co-Chairs welcomed participants to the workshop, noting discussions that had taken place during the TPOS 2020 SC-4 over the three days prior. Workshop participants are listed at the end of this Report.

N. Smith provided background on the meeting. He referred to the discussions of the Western Pacific Implementation Workshop, held in Qingdao, 3-4 September 2017 – see http://tpos2020.org/49qwaihgw48/. Those discussions highlighted the need for deeper technical discussions around the implementation of the Western Pacific Tropical Moored Buoy Array (hereafter WP-TMA).

There were 2 agenda items:

1. Developing a description of a standard/core TPOS mooring
2. Technical specifications/guidance for TPOS TMA

For the latter, the idea is that TPOS builds on the existing TMA and Indian Ocean RAMA experience and operate a Pilot Implementation Project for the Western Pacific for 3 -5 years to oversee and manage piloting, transition and implementation and evaluation of changes to the TMA and Argo, among other things. We have preliminary indications of a significant response to the requirements outlined in the 1st Report, but in practice some tuning needs to be done to be sure we have the requirements satisfied as well as we can. The TPOS 1st report provided broad guidance on what those moorings should be capable of, but we need to write this down in more detail and this small workshop is a start on that process.

For the first item, we are cognizant of the description of "core Argo", a description that facilitates an orderly and systematic implementation of the Argo program. Some documentation already exists and our tentative plan is to work with the JCOMM Tropical Moored Buoy Implementation Panel (TIP) to develop a standard that will provide similar guidance, first for the TPOS TMA in the Western Pacific, but eventually for all tropical moorings.

2. Toward a core TPOS 2020 TMA description

A description of core Argo is provided at http://www.argo.ucsd.edu/Argo_core_activities.pdf. Dean Roemmich and Susan Wijffels provide some additional elaboration.

The original concept has been expanded to include high latitudes and marginal seas. Standards of sampling and standards of accuracy are now included (e.g., sampling to 2000m every 10 days, the accuracy of sensors, quality of data, etc.). Key parameter lists, accuracy targets, and timeliness of the data would be useful.

Ken Connell provided some background on tropical moorings and noted that the original ATLAS description had provided a de facto minimum standard since 1984. This description included the primary sensors (wind speed and direction, air temperature, humidity, 10 temperature sensors

below the surface) and was used when the original tropical Pacific deployments were extended by JAMSTEC/TRITON and then to the Atlantic (PIRATA) and the Indian Ocean (RAMA).

Ken Ando noted that a crucial step in their initial implementation was parallel deployments and sharing of technical/engineering knowledge (PMEL, JAMSTEC). After initial testing, four TRITON buoys were deployed around the 156E line for direct intercomparison/intercalibration with the TAO ATLAS moorings (period 12-18 months). Such overlaps are recommended in the GCOS Principles.

Weidong Yu confirmed that they would be interested in a similar strategy for their deployments in the Western Pacific.

A question was posed concerning the regional applicability of this Core definition (e.g., should it just be 10S-10N or applicable through the tropics as a whole). Meghan Cronin and Ken Connell indicated that a general single Core description is probably OK; care has to be taken to not take the Core description beyond the configuration that behind TAO and TRITON achievements. There was also a question around the need for ancillary measurements to accompany deployment and/or servicing; it was agreed that such measurements were important and should be mentioned in the Core definition. Further discussion is needed on the required specificity in the documentation, e.g. around currents and/or resolution of the mixed layer. The NDBC will need to be brought into the discussions at an appropriate time.

Finally, it was noted data delivery (latency, quality assurance and quality control) is an integral element and should be included in the Core description.

The Workshop agreed that the documentation of a "Core Tropical Mooring Array" (the running title for now) should begin with the ATLAS description, incorporating developments for TAO/TRITON, PIRATA and RAMA. Work on this documentation should begin in parallel with the development of the Western Pacific component of the TMA and, as appropriate and after consideration by the DBCP, with the TIP. The "Core Tropical Mooring Array" documentation should be brief and focus in the minimum configuration, with flexibility for enhancements.

The Workshop also supported the importance of over-lapping deployments, as new contributions were being brought into the TMA. Such good practice should be captured in the documentation, as should the need for supporting measurements for calibration.

TPOS 2020 agreed to lead and support the development of the Core Tropical Mooring Array Document, but subject to decisions by JCOMM/DBCP. Initial guidance could be included in the 2nd Report and formalized as a JCOMM technical document ("best practice").

3. Technical specifications/guidance for TPOS TMA

The 1st TPOS 2020 Report noted that the Western Pacific would be an initial priority; the Qingdao workshop was the first step in responding to this priority.

Weidong Yu outlined SOA plans for the Western Pacific TMA during the TPOS 2020 SC-4 meeting. He noted that while deployments would likely begin in 2019, work on technical specifications (and the definition of Core) could be progressed during 2017-2018. He emphasized there was no urgency to considering detail such as the depth of sensors and/or new sensors, e.g. for biogeochemistry.

The workshop discussed quality control issues, informed by a description of best practice in Argo. Susan Wijffels noted they had adopted a metadata "standard" included with all transmitted data, that was checkable (parsable) by machine.

Weidong Yu noted that their intention was to send data initially through PMEL, as they do with RAMA and as was done initially by JAMSTEC for TRITON. Part of developing technical specifications and guidance will involve engineers from FIO/SOA visiting PMEL (and perhaps JAMSTEC) to develop skills/expertise.

There was then a discussion of QC practices. Susan Wijffels noted that in Argo, the originators of the data (the float operator) are responsible for quality control and quality assurance. In some cases, this role may be performed by a third party, under an agreement with the operator. A similar practice operates for tropical moorings, but the number of operators is much smaller, and PMEL has provided services for some operators.

Meghan Cronin described current practices for TAO quality control. Data can be flagged in real-time (automated screening) and such flags are monitored to check for any systematic issues. After mooring recovery, the full resolution data are used for post-processing and calibration; data are flagged rather than corrected. Susan Wijffels noted that Argo did miss some opportunity to standardize/share automatic screening approaches and experience (code, scripts, logic), including around WMO code changes, and suggested that this should be included in the considerations. Strong coordination was needed to ensure consistent application of flags.

Management of metadata is also important – the complexity of current operations means different sensors, sensor depths, etc. are always being implemented and it is critical, particularly for detection of climate change, that metadata are managed efficiently and effectively. Meghan Cronin noted that OceanSites has a different set of standards.

Billy Kessler noted that mirroring the PMEL web site at JAMSTEC was a useful way of delivering a consistent external face of TAO/TRITON and contributed to a positive end-user experience.

The workshop agreed that the establishment of a data management team within TPOS 2020 would facilitate the necessary coordination and adoption of effective practices. This team would use the implementation activities in the Western Pacific as an initial focus.

Weidong Yu noted that the regular SOA NOAA Collaborative Meetings could be useful for further cooperation between the USA and China.

The Workshop also noted a rotating technical workshop for technicians and engineers might be a useful adjunct to the above-mentioned actions.

4. Next Steps

1. Ken Connell will attend the upcoming DBCP meeting and will report on the outcomes from this workshop. He will report back on the outcomes of the DBCP (TIP) considerations.
2. PMEL, JAMSTEC and FIO/SOA to provide contact points (email addresses) noting that the participants in this workshop are in effect the foundation participants of the Western Pacific Implementation Pilot Project (see TPOS 2020 SC-4 Report).
3. Weidong Yu will provide updated information on probable mooring locations and the schedule for deployment as it becomes available, noting that TMA implementation in the western Pacific also involves NDBC and JAMSTEC.
4. Consultation with NDBC is required.
5. Consultation with OceanSites may be needed as this initiative progresses

6. The DPO will support follow-up activities (lead initially with Guang Yang). The TPOS 2020 Co-Chairs will continue to facilitate activity until such time as the implementation Task Team is established with designated leadership.
7. A schedule of activities needs to be developed (Co-Chairs)

5. Workshop Participants

Neville Smith (Co-Chair TPOS 2020 SC)
Billy Kessler (PMEL, Co-Chair TPOS 2020 SC)
Ken Ando (JAMSTEC, TPOS 2020 SC member and WP TT Co-Chair)
Weidong Yu (FIO/SOA, TPOS 2020 SC member)
Susan Wijffels (WHOI, Argo ST and TPOS 2020 SC member)
Dean Roemmich (Scripps, Argo ST and TPOS 2020 SC member)
Meghan Cronin (PMEL/NOAA, TPOS 2020 SC member)
Dr. Iwao Ueki (JAMSTEC, TPOS 2020 PBL task team)
Mr. Yasuhisa Ishihara (JAMSTEC, division leader of long term observation technology division)
Ken Connell (PMEL/NOAA, TIP member)
Dr. Lin LIU (FIO/SOA, CLIVAR-GOOS Indian Ocean Panel member)
Dr. Yue Fang (FIO/SOA, IIOE-2 Theme on circulation and monsoon climate)
Dr. Chunlin Ning (FIO/SOA, chief buoy engineer)
Guang Yang (TPOS 2020 DPO, FIO/SOA, Qingdao)
Lucia Upchurch (TPOS 2020 DPO, PMEL/NOAA)
Katy Hill (GCOS/GOOS, TPOS 2020 DPO)