

White Paper #14 – Logistical considerations and ship resources

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1. Introduction

The availability of data, information, and products for the in-situ Tropical Pacific Observing System is strongly dependent on two dominant factors: resources in support for the observing system and ship resources necessary for deployments, servicing, and routine observing of the ocean and its overlying boundary layer. This whitepaper will describe resources and logistical (e.g. ship resource) needs for in-situ ocean observing in the Tropical Pacific, how well the current needs are met, and explore the possibilities for increased resources and coordination/governance to address logistical and ship resource needs of the future.

2. Service needs/strategies for TAO/TRITON-class buoys

What are the current cost and ship-time requirements for TAO and TRITON-class buoys? How have these changed historically? What are the cost-drivers and/or limiting logistical factors (e.g. ship time availability/scheduling, piracy, ship-speed, crew scientific expertise, etc) that are the most challenging to overcome to reduce costs and still meet the requirements?

The TAO/TRITON array is a network of deep ocean moorings at 67 sites (55 TAO buoys maintained by the US and 12 TRITON buoys maintained by the Japanese) in the tropical Pacific. Regular maintenance of the array is required to maintain continued integrity of the data. Historically, NOAA's strategy was to visit US buoy every 6-8 months for maintenance and replace each buoy every 12-16 months. The NOAA ship *Ka'imimoana* (KA) was dedicated to providing ship time, approximately 280 days per year, to service the US TAO buoys to meet these requirements and provide additional support for other requirements (see next section). The data return rate for the US TAO buoys has been excellent (80% or better) before mid-2012. Constrained ship resources from NOAA continues to be a key challenge to servicing the TAO array, deploying additional elements of TPOS, and supporting research endeavors in the Tropical Pacific.

This requirement of 280 days for US servicing in order to maintain the historical performance measure could change if NOAA chose to lengthen the service intervals, used a faster ship, and/or used a different mix of ships and routing to reduce transit time.

Beyond technological improvements such as sensor and battery life, non-technical issues such as buoy vandalism shape the requirements for ship servicing. Vandalism is common in areas of commercial fishing and is well-documented (http://www.gc.noaa.gov/gcil_buoys.html) (Figure 2.1). NDBC recently initiated a program to monitor and identify (through use of on-buoy

cameras) ship traffic near and adjacent to select TAO buoys. It is too early to assess the potential success of such efforts, but testing solutions to widespread limiting factors such as vandalism could help reduce servicing requirements.

Because of the retirement of the KA, in 2012 and 2013 NOAA expanded its use of chartered commercial vessels to fulfill TAO servicing needs. However such ships have somewhat more limited capabilities and opportunities for deployments of other observing instruments, research field work, and hydrographic casts throughout the tropical Pacific.

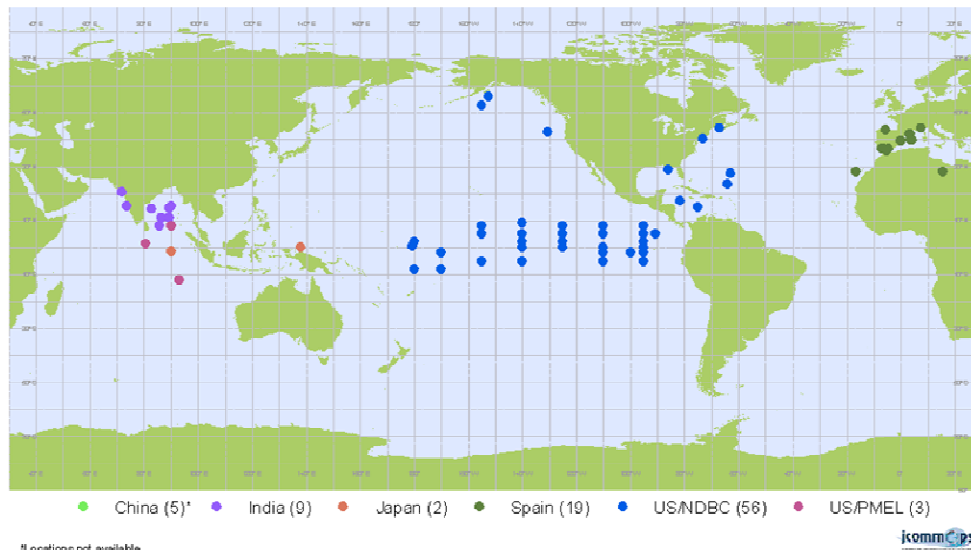


Figure 2.1 – 2012-2013 Vandalism events as reported by DBCP member countries.

JAMSTEC has relied on the R/V Mirai for 60-100 days per year (the ship-cost was from 2400K to 4000K US\$ per year) to service the array of TRITON buoys. The maintenance and ship time cost has decreased due to the technological buoy improvements and developments by JAMSTEC engineers. The current ship time requirement has been effectively reduced to one half of the original cost. Looking ahead, JAMSTEC has decided to allocate ship-time for the western Pacific TRITON based on an annual research proposal. Because of increased requirements from Japanese science communities including geology, seismology, along with total budget cuts to JAMSTEC from our government, the sea days provided to R/V Mirai was decreased originally from 280 days per year to 190 days at present, with less in the future. Consequently, JAMSTEC decided to increase mooring servicing interval from one-year to 18 months for all TRITON and m-TRITON buoys, and to stop measurements along 130E, will relay one site to Indonesia, and will stop two sites at 5°N 147°E and 8°N 156°E.

3. Service needs/strategies for other in-situ elements (e.g. Argo, drifters, hydrography, etc) of the TPOS

What are the current cost and ship-time requirements for other (not TAO) in-situ elements of the TPOS? What are the cost-drivers and/or limiting logistical factors (e.g. deployment scheduling, EEZ issues, crew scientific expertise, etc) that are the most challenging to overcome to reduce costs and still meet the requirements?

3.1 Global Drifter Program (GDP)

Aside from the TAO servicing cruises, drifter deployments in the Tropical Pacific are few and far between. Of course, there are one-off opportunities from the US Coast Guard and/or Navy while transiting through these regions, but because few shipping lines transect the central equatorial Pacific; the options here are extremely limited. The GDP has a very limited budget and historically has had drifters deployed on a volunteer basis. Thus a reduction of servicing cruises for TAO buoys, without alternate deployment opportunities, will result in reduced surface drifters in the Tropical Pacific.

3.2 Argo

The vessel requirements for Argo floats and gliders are quite different than those for moorings, repeat hydrography and other conventional oceanography. Argo floats deployments in the tropical Pacific have piggy-backed on the TAO/TRITON servicing cruises. Additional deployments have been achieved through other research vessel deployments, dedicated cruises such as the 28-m research vessel, R/V Kaharoa (over 1200 floats deployed since 2004, including in the tropical Pacific), and of sailing vessels such as the Lady Amber. Dedicated deployment cruises for floats are not often considered ship charters (typically we send no one on board) but as contracts for the deployment of floats. The bottom line is the cost per float deployment runs about \$5K per float using a vessel the size of Kaharoa and perhaps \$3K per float for smaller vessels. In recent years, with the use of smaller sailing vessels (coordinated through JCOMMOPS), such as the Lady Amber, the cost has been reduced to approximately half. The Lady Amber is available for chartering deployments and this can be arranged through the ship coordinator at JCOMMOPS. International partners such as Australia and New Zealand have been willing to share such costs with the U.S., and there is growing international interest.

3.3 SOT-SOOP (e.g. XBT)

Whilst a number of SOOP-XBT lines which transit the tropical Pacific are declared active (Figure 3.1), the yearly map of 2013 (Figure 3.2) shows that only a few lines are regularly occupied.

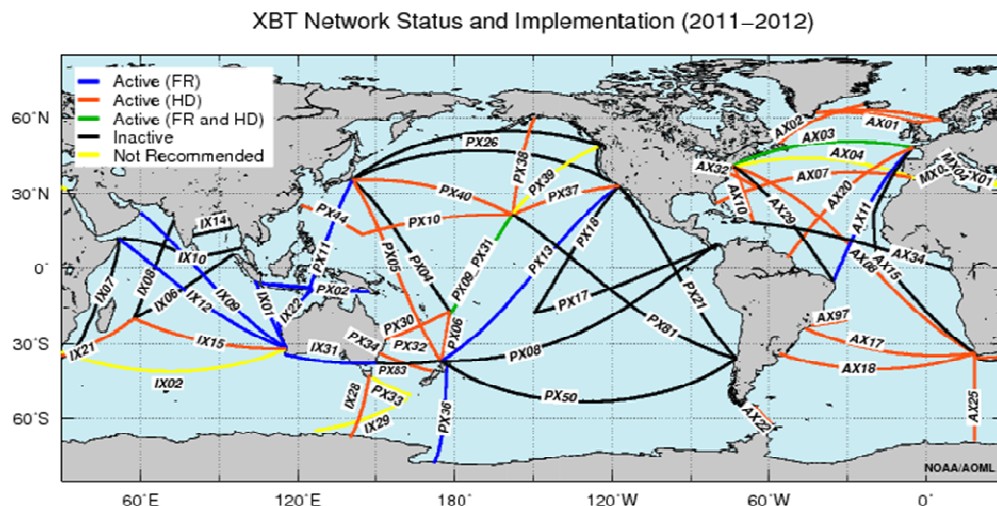


Figure 3.1 – XBT Network Status and Implementation (2011-2012).

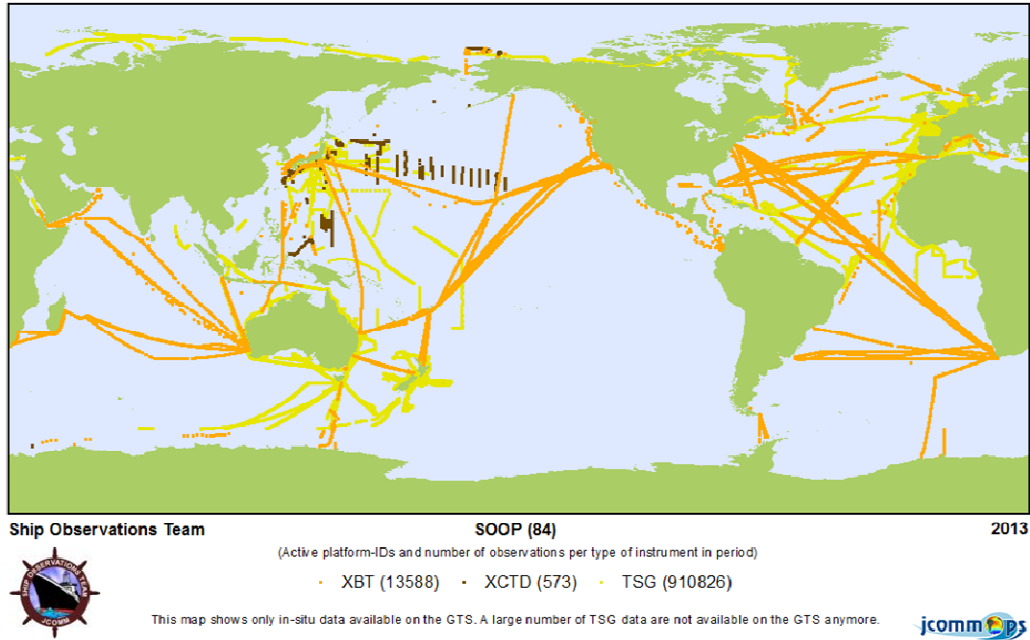


Figure 3.2 – XBT Network Status in 2013.

3.4 SOT-VOS

Even on a yearly basis, the number of Voluntary Observing Ships in the tropical Pacific is poor compared to other ocean basins, and there are almost no VOSclim ships that provide high-quality data.

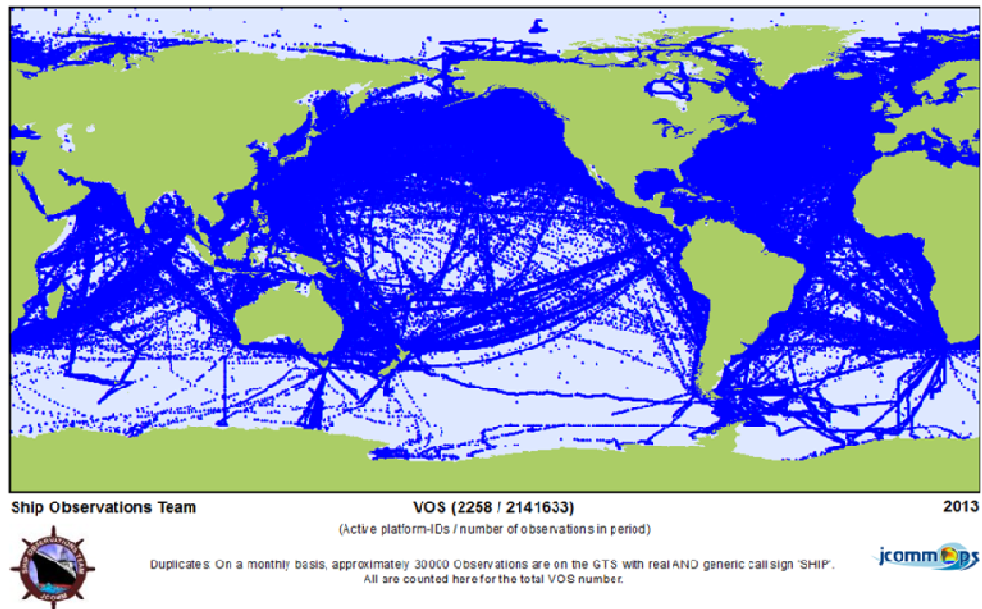


Figure 3.3 – Global overview map of VOS routes.

4. Observing system performance, monitoring tools/diagnostics (current and future)

What monitoring tools/diagnostics are current being used to monitor the state of the TPOS? What improvements and/or new tools would help?

The global ocean observing arrays are monitored at JCOMMOPS with the DBCP Technical Coordinator responsible for the moored and drifting buoys, the Argo Technical Coordinator (TC) responsible for the Argo float status, and the Ship Logistics coordinator responsible for vessel availability and SOT coordination in the region. The DBCP TC works with program operators to receive updates on the status of the TAO, RAMA and PIRATA arrays as well as monitors the data available via the GTS. In the case of the PIRATA and RAMA buoys, maintenance updates are received via direct emails on a weekly basis from NOAA/PMEL. Monthly updates are received from the NOAA/NDBC for the TAO array on percentage of data reported, but there is currently no automated or reported mechanism on maintenance for the TAO array. The DBCP TC monitors closely the GTS distribution and creates monthly maps on availability of data. At present, the tools and statistics are created by the DBCP TC, however in the future; these tools will be available to all program managers and operators on a more dynamic basis as JCOMMOPS improves its website.

The coordination of ship schedules and maintenance is necessary and needs to be improved. JCOMMOPS will work with programs to prepare and maintain an updated database with ships that can perform the necessary replacements, installations, and maintenance of TAO/TRITON moorings. This will require communication and updates from the operators of all networks on future plans and a goal is to have an online system where the operators can enter this information and it is tracked by JCOMMOPS. At that point, all of this valuable information could be viewed by any interested member of the community.

Monitoring of observational density by variable is possible through use of GTS feeds and some such tools are available via JCOMMOPS and OSMC, but there are known issues of completeness and timeliness associated with relying on a single GTS access node. Moreover, data not reported via GTS are not represented in such tools.

5. TPOS Performance/Data Return

Describe the data return rate of the TAO array and other TPOS elements. Are there regions where the return rate suggests that some observing strategies are better than others? From a logistics and resources point of view, what metrics are needed?

Overall, the metrics for TPOS performance have been pursued by each observing component (TAO, TRITON, Argo, drifters, satellites, etc). Such an approach fails to consider like measurements (e.g. subsurface temperatures/salinities from TAO, TRITON, XBT, hydrography, and Argo) for addressing key requirements. Moreover, for some components (e.g. TAO), the metrics for performance have focused on data return by the entire system. While this has driven good data return performance for many years, it fails to capture any connection to impacts on research and/or models, as well as any desired outcomes such as research findings and better forecasts. Recent efforts by OOPC and others (see <http://www.globalchange.gov/what-we-do/assessment/indicators-system>) to develop and expand current ocean indicators, along with an appropriate suite of products, should also be considered. In summary, Suitable metrics on

observing performance and downstream information and capabilities need to be developed and promoted.

The data return rate in the TRITON project has been one important indicator, and the ship-time dedicated to TRITON has been determined one or two years in advance. So, we could decide how many buoys we will service in advance for keeping high data return rate at least from buoys we will maintain in future, and it gave us time to decide how we maintain (and recently stop) our array.

Returns of data in regions near coastal area (e.g. north of New Guinea) has generally lower data return rate, but demonstrations of gliders in some coastal regions (e.g. Solomon Sea) have been working well. Would glider measurements be appropriate near coastal region?

6. Assessment of current and future resources (ships and maintenance) in the Tropical Pacific

Considering all of the above requirements for ship time and servicing resources for sustaining a TPOS, what resources have been made available to support the TPOS? How has this changed in time? In times of constrained resources, how are decisions made on servicing priorities (how should this process be improved)? What additional ship resources could be solicited to address needed requirements? What are the pros and cons of commercial chartering? What are the prospects for engagement of additional international sponsors of TPOS and what should be done to enlist such support? What types of arrangements (e.g. multi-lateral agreements, resource forums, etc) are likely to be beneficial towards sustaining the TPOS of the future?

The past two decades of sustained observing in the tropical Pacific has catalyzed new research and supported the growth of operational ocean, weather, and climate forecasting enterprises. However, the financial underpinnings of some of these observing systems are somewhat fragile and subject to change without warning.

Many countries have been supporting components of TPOS. Such support is often dependent on national priorities, availability of funding, and even on the success of independent research proposals evaluated amongst many others for limited research funds. Additionally, support for the TPOS has historically been provided through both operational (e.g. for US-TAO) and research enterprises (Japan-JAMSTEC) and for many of the other in-situ ocean observing components that needs to be factored into future development and support considerations.

6.1 Ship resources

An inventory of available ships capable of contributing towards the TPOS and those ships capable of servicing deep moorings is currently being prepared through the Ship Coordinator at JCOMMOPS. However, this is beyond the scope of this paper and will be available in 2014. Chartering ships from the private sector has also been used (e.g. by the US for TAO and Argo) and can be coordinated through JCOMMOPS.

JCOMMOPS works on worldwide integrated ship coordination. Across the different programs, information are gathered on operational needs on the one side (deployments, retrievals and maintenance of different instrument types) and matched with opportunities on the other side (merging research cruise information from different sources, volunteer and charter vessels).

Different ship types and corresponding operation complexity (professional, advanced, basic) must be distinguished, and are all coordinated by JCOMMOPS:

- Research vessels establishing campaigns in, or transiting the tropical Pacific, offering in particular free of charge deployment opportunities with qualified staff, and dedicated equipment for professional operations
- Research or survey vessels chartered for TPOS operations. JCOMMOPS cooperates with a global ship operator and can provide cross-program solutions for all needs and instrument types and numbers. The available fleet also comprises innovative and economic multi-purpose vessels for substantial missions, and approved sailing survey ships such as Lady Amber for advanced operations - at lowest daily rates.
- Commercial ships, in particular vessels recruited by JCOMM's Ship Observations Team for the VOS and SOOP programs, offering basic, but free operations: Gathering of underway data (S,T,C, meteo), XBT/XCTD launches and deployment opportunities whilst transiting the target zone, but often from deck heights of 10 meters and more, and at speeds of up to 20 knots.
- Sailing ships, in particular fleets organized in rallies (without competition) or races, allowing for facilitated logistics and training (clear schedules) and basic operations (deployments, retrievals, meteo data) of smaller number of instruments, but at safe deployment speed and close to the sea level, and with additional potential in education and communication dimensions. A pilot project has been carried out successfully in November 2013 in the tropical Atlantic (JCOMMOPS/NOAA-AOML) and first operations are now planned in the tropical Pacific in 2015.

The ship coordinator position was established to gather, compile and distribute information on available ship time, or to search for solutions for specific queries. Forms are available at JCOMMOPS to transmit your needs in standardized structure. OceanSITES recently provided detailed information on ship requirements per instrument type, which can now be matched with specifications of available ships. The aim is to provide this for all programs, included in the JCOMMOPS database for access amongst all interested parties.

6.2 Expanding and Coordinating International Support

Increased international support (particularly for ship resourcing) of TPOS is likely to be possible in the coming decade, and should be encouraged through appropriate mechanisms (e.g. joint research projects, partnerships, bilateral agreements, etc). With increased sponsorship possibilities and the need to better strategize how best to sustain and evolve the TPOS, some consideration of coordination (governance if you will) is necessary. There are a few successful models already in place for other basin-scale ocean observing that may provide guidance for a successful TPOS.

The Indian Ocean Observing System (IndOOS) Resource Forum (IRF) has been set up to facilitate the allocation and alignment of resources in the Indian Ocean to achieve a sustained, basin-wide ocean observing system. IRF activities include the following:

- Review the requirements for the implementation of IndOOS as established by the Indian Ocean (climate) Panel (IOP) and the Scientific Steering Committee for

- Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER);
- Facilitate and coordinate resources that may be applied to the system, especially ship time for the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA); and
 - Encourage scientific and technological initiatives, in the participating countries, to meet the objectives of IndoOS.

Similarly, for the Pilot Research Moored Array in the Tropical Atlantic (PIRATA), a Resources Board has been established to implement the array based on the following criteria:

- Identification of infrastructure needed for implementation (ship time, laboratory, technical support, etc.),
- Implementation must occur on a not to interfere basis with the backbone,
- Schedule of implementation,
- Funding requirements/cost justification,
- Identification/source of funding.

Both the IRF and PIRATA Resources Board share common traits of 1) encouraging stakeholders to routinely discuss in appropriate venues system requirements, operational considerations, system advances, and resourcing needs/gaps; 2) encouraging cross-dialogue amongst those operating the systems, product and knowledge developers, end-users, and those sponsoring the observing arrays to improve system sustainability and encourage progress towards a range of goals.

A similar approach to governance and coordination should be considered for TPOS. Discussions on the potential to form a TPOS Resources forum will be carried out after the TPOS Workshop. The TRF could meet to monitor and critique the rationale for implementation of the TPOS Plan, as it is articulated by TPOS - 2020, with input from the Ocean Observations Panel for Climate, the CLIVAR Pacific Science Panel, Pacific Island GOOS, DBCP TAO Implementation Panel (TIP) and other relevant expert - bodies. Based on its deliberations, the TRF will work to facilitate and coordinate the provision of the resources required for TPOS evolution, implementation, and maintenance by member institutions, similar to the IRF for the Indian Ocean and the PIRATA Resources Board for the Atlantic. The TRF activity will promote contributions from institutions in the participating countries, with a view toward fully implementing the TPOS Plan by 2020 and sustaining TPOS thereafter. Such an approach was also recommended at the POGO (Partnership of Observation for Global Ocean) 15th meeting, held in Hobart Australia hosted by CSIRO and IMAS.

7. Recommendations

- 1) Logistical requirements (e.g. deployments and servicing by ships) will continue to be a potentially limiting factor in the development of TPOS for the coming decade.
- 2) A new suite of useful products, indicators, and access tools should be developed to better take advantage of an “integrated” TPOS that depends less on specific observational platforms and focuses instead on integration across TPOS, e.g. against

variable-based requirements

- 3) Tools to monitor the state of the integrated TPOS are needed to identify gaps and document the evolution of the system
- 4) More effort is required to identify deployment and servicing needs, and coordinate potential opportunities (e.g. ships, cruises) to address them. The JCOMMOPS ship coordination will be helpful here, and the community should provide JCOMMOPS with all related information (needs and opportunities).
- 5) US research engagement in support of TPOS (and in particular TAO) needs to be strengthened to encourage and strengthen ties to international research partners, to advance research and technology development, and observing system development.
- 6) Increased international support (particularly for ship resourcing) of TPOS is likely to be key and will be possible in the coming decade, and should be encouraged through appropriate mechanisms (e.g. joint research projects, partnerships, bilateral agreements, etc).
- 7) The formation of a TPOS Resource Forum should be considered to encourage multi-partner coordination of observing system support to address key observing requirements and evolution of the TPOS.
- 8) Increased communication, dialogue, and interaction between research and operational USERS (supporters of TPOS) are needed to insure requirements are updated, observations are fully utilized, and feedback on value/impact/assessment of observations by the forecasting communities is considered. Engagement with the Resource Forum would insure gaps, needs, and progress towards strategic goals are discussed and addressed.
- 9) Partnerships leading to an improved TPOS should be predicated on mutual interests of all partners for advancing research and/or operational forecasting capabilities.
- 10) International partnerships in support of TPOS should include coordination and sharing of observing technologies. Technical exchanges between the US and Japan have not been occurring for some time. As TPOS moves forward, such exchanges across all the tropical mooring buoy arrays (TAO, TRITON, RAMA, and PIRATA) need to be an integral activity amongst all partners.