**WORLD METEOROLOGICAL ORGANIZATION**

DATA BUOY COOPERATION PANEL

THIRTIY-SECOND SESSION

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ITEM: 7.2

ENGLISH ONLY

# REPORT BY THE TASK TEAM ON MOORED BUOYS (TT-MB)

*(Submitted by Robert Jensen (USA), Chair, TT-MB)*

**SUMMARY AND PURPOSE OF DOCUMENT**

This document contains the report by the chairperson of the DBCP Task Team on Moored Buoys.

**ACTION PROPOSED**

The Meeting is invited to note the information contained in this document when discussing how it organises its work and formulates its recommendations.

**Appendices**: **A.** Report by the Task Team on Moored Buoys

**B.** Terms of Reference of the DBCP Task Team on Moored Buoys

## DISCUSSION

7.2.1 Dr Robert Jensen (US), Chairperson of the Task Team on Moored Buoys (TT-MB), reported on the Task Team activities during the last inter-sessional period. Over the last few years the metadata needing to be collected for moored buoy systems has been defined and an initial system for its submission to JCOMMOPS was set up in February 2015, with documentation and submitted metadata available via ftp://ftp.jcommops.org/DBCP/metadata/. At time of writing moored buoy metadata have been submitted by Brazil, Canada, Chile, France, Germany, Greece, India, Italy, Japan, New Zealand, Portugal, Slovenia, South Korea and US. Other moored buoy operators are requested to generate and provide their metadata to the DBCP-TC. Defining the metadata content for fixed platforms still needs to be progressed.

7.2.2 The Task Team was instrumental in the development and validation of the BUFR template (3-15-008) for moored buoy data, which was declared operational in May 2014. By July 2016 8% of moored buoys were reporting their data in BUFR only, 26% in both BUFR and TAC (Traditional Alphanumeric Code) and 66% in TAC only. Those moored buoy operators not issuing their data in BUFR (3-15-008) are requested to do so at the earliest opportunity, with parallel (BUFR and TAC) data distribution (as many operational centres are not yet ready to handle the BUFR data) until such a time it is agreed the TAC will be ceased. It is hoped that validation of the draft BUFR template for offshore platforms (3-15-017) will be validated over the autumn months.

7.2.3 Recommendation 16 from DBCP-31 was to establish a group within the TT-MB to facilitate exchange of information on ASV test and evaluation. A web-page has been set up on the DBCP web-site (http://www.jcommops.org/dbcp/overview/evaluation_usv.html) to collect and disseminate information on experiences with unmanned surface vehicles. The DBCP Scientific and Technical Workshops will also provide a forum for presenting the latest results, with three ASV talks (to be) presented during the DBCP-32 session. Careful evaluation of ASV-based metocean measurements is required before they can be considered as a viable alternative to moored buoys.

7.2.4 The TT-MB has coordinated with TT-TC to define the performance metrics for national and coastal buoy networks. The metrics were implemented in early 2016.

7.2.5 During the year a number of technical developments to the various moored buoy systems and networks have been made, including:

Brazil: No input received.

Canada: Beginning in 2016, Environment and Climate Change Canada (ECCC) Marine Networks was tasked by Senior Executives to conduct a comprehensive review of the moored buoy network in the Pacific and Atlantic Coasts. The aim of the project is to deliver a cost effective network that is tailored to the needs of its primary users. The project will focus on technology refresh, community best practices, review of data management practices and in-depth analysis of user requirements. In addition, a Request for Information will be posted in October to solicit interest for ship tendering services from private industry.

The project will leverage an ECCC developed Geo-spatial Needs Index tool that considers various factors affecting the requirement for where monitoring stations are located and needed most, which will be used to determine the best location for moored buoys in the Atlantic and Pacific Coast. In addition a similar AVOS needs index tool has been developed that leverages the needs index tool and will assist in the recruitment and suitability of new ships to ECCC's AVOS program.

ECCC Marine Networks has procured a SV3 Waveglider and is in the process of developing a test plan to understand the efficacy of the technology in Canadian waters. ECCC will be looking to partner with Dalhousie University and Department of Fisheries and Oceans to learn more about this emerging technology. In addition a 3M Triaxys spectral wave system is presently in operation in the Halifax Harbor, currently data is not transmitted to the GTS, but is stored locally on an onboard SD card.

ECCC will continue the commitment to the METAREAS II project and with the cooperation from other Government of Canada Departments and Academia will deploy 10-15 drifter buoys in the Canadian Arctic to increase atmospheric monitoring.

France: During the intersessional period 2 FR moored buoys were replaced so that all the FR MB (Antilles - 4100300, Côte d'Azur - 6100001, Lion - 6100002) are now equipped with a new AWS system and transmit, through Iridium, hourly messages following the BUFR Template 315008 (no more TAC messages for these buoys). Lion is equipped since one year and everything is working well. Raw data of these buoys are available on the website: http://www.meteo.shom.fr/real-time/ .

All the buoys are equipped with: standard meteorological sensors plus: 1 global and 1 infrared radiation sensors, 1 salinity sensor (SBE37), and 1 omnidirectional waverider. For Lion: 2 salinity sensors are added alongside the mooring line (depth: 120 and 200m). Two sensors must be added by -10m and -50m. For Côte d'Azur: a nitrate sensor is added, in cooperation with LOV (Laboratoire d'Océanographie de Villefranche-sur-Mer), at a depth of 40m. For the 2 moored buoys in the Mediterranean Sea area: subsurface sensors are installed on the mooring lines: 20 sea surface probes (SP2T) from a depth of 6m to 260m.

Next service on Lion (by the end of September or October 2016) will be the opportunity to reinstall the autonomous directional waverider (TRIAXYS) using the new compressed format and to compare both waveriders installed on the buoy.

UK: Further deployments of new design moored buoys (Hydrosphere/Mobilis hulls) with spectral wave capability to replace legacy designs have been made. Presently there are 4 new design systems in operation alongside 4 legacy systems. During the year the moored buoys at Aberporth (to be replaced by a waverider) and Turbot Bank were decommissioned as funding was withdrawn. Evaluation of moored buoy wave measurements is continuing as a contribution to the PP-WET, with 3 months of collocated data from a legacy Balmoral buoy (with heave sensor) and a waverider at Aberporth, and also 5 months of data from a Hydrosphere/Mobilis buoy with both Triaxys and MOSE sensors fitted, for 2 of these months there is also collocated waverider data. A limited further evaluation of the 'AutoNaut' ASV carrying a Met Office AMOS (Autonomous Marine Observing System - as used on ships) has also been carried out; this identified a number of technical problems that are being addressed by the AutoNaut manufacturers with further trials planned for autumn 2016.

India: India has deployed a mooring in Svalbard Arctic and collected data continuously for 2 years from 2014 to 2016 and new mooring with biogeochemical and pCO2 sensors are deployed. For this work in arctic team led by Dr. R Venkatesan received prestigious National Geoscience award from President of India. India has developed moored buoy called "Prakruti" to transmit 106 parameters in real time. Under Indo-US and Indo-UK collaboration, observational tools Gliders, Argo floats, Ship board measurements were conducted in the Bay of Bengal. MoU will be signed between JAMSTEC Japan for observation studies. Under Indo-South Africa collaboration, staff from Department Environmental Authority, South Africa had been exposed to moored buoy observation and data collection and further collaboration MoU is being signed Reliability analysis of mooring is conducted and paper is published in MTS Journal Issues with connectors and cables are being faced. Standardization of oceanographic sensor need to be undertaken to ensure reliable performance of sensors considering cost involved in ship time and valuable data.

US (PMEL): In the past year PMEL's T-Flex mooring systems replaced legacy ATLAS moorings at 4 RAMA and 3 PIRATA sites. Additional T-Flex replacements are planned for the coming year. Hourly T-Flex data are reported on the GTS in BUFR format with Bulletin Header IOBX08 KPML. WMO numbers for T-Flex moorings take the 7-digit analog of the 5-digit code for the previous ATLAS system at the same site. For example, the WMO number for the first T-Flex mooring implemented (4°S 81°E in RAMA) is 2300010 (vs 23010 for the previous ATLAS moorings at that site). During the past year PMEL supported 5 cruises in the Indian Ocean to service PMEL RAMA moorings, 3 cruises in the Atlantic to service PIRATA moorings, and 2 cruises in the Pacific to service Ocean Climate Stations (OCS) moorings. The draft of the First Report on the Tropical Pacific Observing System (TPOS) 2020 was posted to the TPOS 2020 website: http://www.tpos2020.org in August 2016 and is available for download, review, and comment.

US (Ocean Observatories Initiative-OOI: New ocean observing platforms, including very capable moorings, are on line now as part of the U.S. National Science Foundation's Ocean Observatories Initiative (OOI). Four high latitude sites in the open ocean are occupied: the Gulf of Alaska, the Irminger Sea, the Argentine Basin, and a South Pacific Site at 55°S, 90°W. At each site a surface

mooring is paired with a nearby taut subsurface mooring with profilers to make observations from the sea surface to the sea floor. Two taut, subsurface moorings are deployed at the other two corners of a triangle, with sides roughly ten times the water depth. Up to five ocean gliders add to the spatial sampling capabilities and to observing the vertical structure near the surface. Thus, the surface forcing and the response and variability of the full water column as well as the mesoscale variability are observed. A multidisciplinary suite of sensors, real-time delivery of data, and high bandwidth, two-way communication are further features of these new observatories. All data are freely available, and annual cruises are made to service the sites. More information is available at http://oceanobservatories.org .

US (NOAA/NDBC): The National Data Buoy Center (NDBC) is deploying a sophisticated new Self-Contained Ocean Observing Payload (SCOOP) in its operational buoy network as a technology refresh initiative. The legacy payloads are labor intensive to build and difficult to deploy successfully. SCOOP is a smaller, lower cost, more reliable, modular payload that is easier to build, deploy and reduces the life cycle cost of maintaining the buoy array. SCOOP also increases observational capabilities, reduces reporting latency, extends the range of some measurements, and improves the accuracy of others. Details of these enhanced capabilities will be provided in the presentation. NDBC has extensively tested SCOOP including bench testing, shock and vibration testing, and field testing of three prototypes in the Gulf of Mexico over a one-year period. In 2015, NDBC deployed six SCOOP payloads in the Atlantic, Caribbean and Gulf of Mexico near existing moorings. Based on the quality of the SCOOP payload data compared to adjacent mooring, NDBC proceeded to deploy seven SCOOP payloads as operational stations. NDBC expects to replace all legacy weather buoys with SCOOP over the next five years.

US (USACE): The USCE in collaboration with NOAA/NDBC, Environment Canada and AXYS Corporation continue to collect wind-generated wave spectra (and Fourier directional parameters) at the Buoy Farm located in Monterey Canyon, CA. A 6N buoy equipped with three NOAA/NDBC sensors (inclinometer, HIPPY, and 3DMG-motion sensor), a TRIAXYS Next Wave II Wave Sensor, and an AXYS Watchman, and payload packages. Also deployed is a NOAA/NDBC 3D buoy with dual sensors (HIPPY and 3DMG), and a Datawell Directional Waverider buoy. The data sets are being analysed as part of an intra-measurement evaluation, and documented as part of the DBCP-ETWCH Joint Pilot Project on Wave Measurement Evaluation and Testing. Also, studies are being conducted at two dual sensor buoy sites in the Atlantic and Pacific and a foam buoy intra-measurement evaluation. Planning is underway for an extensive testing of the NOAA/NDBC SCOOP buoy system as part of a collaborative effort between the USACE and NOAA/NDBC to be conducted in 2017.

7.2.6 The meeting agreed to continue to progress the following DBCP-31 workplan actions, which should be carried over into the workplan for 2016-17.

Action 6. Provide deployment and platform metadata information [for moored buoys] to DBCP-TC.

Action 16. Centers must switch to using BUFR template for [drifting and] moored buoys ([templates TM315009 for drifters and] TM315008 for moorings) as soon as possible. Note that parallel BUFR/TAC dissemination will be required for some time to allow operational centres to be ready for the change.

Action 18. The Panel recommended correcting the time stamp data according to WMO-8, draft CIMO guide and WMO-544 for meteorological data. A DBCP Technical Document should be produced to clarify these issues. Note action will be on moored buoy operators to implement the recommended time stamping for data issued in BUFR.

Action 78. The Panel urged the DBCP task team on moored buoys to consider an agenda item for DBCP-32 to explore options and cooperative mechanisms toward the international operational cooperation for recovering moored buoys gone adrift.

7.2.7 In terms of recommendations from DBCP-31, Recommendations 14, 17 and 21 relate to Actions 16 and 18. Other Recommendations from DBCP-31 were:

Rec 15. to progress work on validating the BUFR template for offshore platforms (3-15-017) and (Action 17 from DBCP-30) to develop a suitable template for ASVs. To be continued as an action in the 2016-17 workplan.

Rec 16. to help coordinate work being carried out by various panel members on the evaluation of ASVs through the web-site and DBCP annual Scientific and Technical Workshop as a forum for presenting latest results. To be continued as an action in the 2016-17 workplan.

Rec 18. New BUFR template submitted to WMO IPET-DRMM for fixed offshore platform data (3-08-017) to be validated. This is hoped to be done over the autumn months.

Rec 19. Define metadata content for fixed platforms (Action 48 from DBCP-31 to be carried across to 2016-17 workplan).

Rec 20. TT-MB to define performance metrics for national/coastal buoy networks. Completed.

Rec. 22. Capture knowledge and lessons learned on use of met and oceanographic sensors in a DBCP Technical Document. Action 19 from DBCP-31 to be carried across to 2016-17 workplan.

Rec 23. To develop a suitable BUFR template for Autonomous Surface Vehicle (ASV). Action 17 from DBCP-30 to be carried across to 2016-2017 workplan.

Rec 24. To establish a group within the TT-MB to facilitate exchange of information on ASV test and evaluation. See section 7.2.3.

7.2.8 Recommendations for new Actions for the 2016-17 workplan. [Any new recommendations can be included here.]

7.2.9 The Panel thanked Dr Jensen and the members of the Task Team for the report. The full report of the Task Team is provided in Appendix A of DBCP-32 preparatory document No. 7.2, and will be included in the DBCP Annual Report for 2016.

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# APPENDIX A

# REPORT BY THE TASK TEAM ON MOORED BUOYS (TT-MB)

## 1. Moored Buoy Operational Summary Reports

### 1.1 Environment and Climate Change Canada Moored Buoy Network

1.1.1 Environment and Climate Change Canada (ECCC) Marine Networks provides meteorological and oceanographic observations from 47 moored buoys, ~25 drifter buoys and ~53 automated volunteer observing ships (AVOS). Since 2008, ECCC's Marine Networks has tracked moored buoy data availability, in 2015 the overall data availability across Canada was 84%; regionally data availability was 91% in the Pacific region and 72% in the Atlantic region. Difference in data availability can be attributed to the loss of 3 moored Atlantic buoys since 2013, transmission and technological failures and lack of ship tendering to maintain and replace buoys.

### 1.2 Tropical Moored Buoy Array

1.2.1 PMEL continues to service the Tropical Moored Buoy Arrays in RAMA and PIRATA. Over the past year, PMEL serviced 22 RAMA moorings and supported servicing of 18 PIRATA moorings. Comparable maintenance of the arrays is planned for the coming year.

1.2.2 PMEL will expand the T-Flex implementation in RAMA and PIRATA, with approximately 10 new T-Flex replacements planned for 2016-2017. All T-Flex moorings are reporting on the GTS in BUFR format.

1.2.3 PMEL and GEOMAR are currently testing integrated oxygen sensors for transmitting real-time dissolved oxygen data over IRIDIUM. The plan is to initially deploy 8 oxygen sensors on 3 moorings along 23°W in PIRATA.

1.2.4 Other Recent enhancements to tropical mooring observations include: Dalhousie University's Ocean Tracking Network (OTN) program has deployed acoustic telemetry receivers on all PIRATA surface moorings and 20 RAMA moorings, adding additional biological monitoring capabilities to the array by tracking marine animals. Additional deployments on RAMA and TAO moorings are planned. Oregon State University continues to deploy microstructure measuring instruments (known as ChiPods) on tropical moorings in TAO, PIRATA and RAMA. At present a total of 24 instruments are deployed on 6 moorings.

### 1.3 PMEL OCS Stations

1.3.1. In addition to the tropical arrays, PMEL Ocean Climate Stations (OCS) continues to contribute to the OceanSITES network of time series reference sites with two stations: the Kuroshio Extension Observatory (KEO), located south of the Kuroshio Extension at 144.6°E, 32.3°N, and Station Papa, located in the eastern subarctic Pacific at 144.9°W, 50.1°N. KEO was recently serviced in July/August 2016 and Papa was serviced in June/July 2016.

### 1.4 TPOS 2020

1.4.1. The draft of the First Report on the Tropical Pacific Observing System (TPOS) 2020 was posted to the TPOS 2020 website: http://www.tpos2020.org in August 2016 and is available for download, review, and comment. The objectives of the TPOS 2020 are to redesign and refine the TPOS to observe ENSO and advance scientific understanding of its causes, to determine the most efficient and effective observational solutions to support prediction systems for ocean, weather and climate services, and to advance understanding of tropical Pacific physical and biogeochemical/ecosystem variability and predictability. The draft TPOS 2020 First Report summarizes the TPOS 2020 requirements and basis, design principles, integration, future evolution, and implementation.

## 1.5 NOAA/NDBC (No input received)

## 1.6 USACE moored buoy network

1.6.1 The US Army Corps of Engineers (USACE) continues to operate and co-operate 64 buoys along the US coast, the Hawaiian Islands, Puerto Rico, Guam, Marshall, and Saipan, collaborated with other US Federal (US Navy, NOAA/IOOS), State (California, Virginia) agencies, local, and industry partners. Three new deployments occurred, Cape Cod, MA, Wallops Island, MD, and Onslow Bay, NC. Data are disseminated via the Coastal Data Information Program (CDIP). All wave measurements are obtained from Datawell Directional Waverider buoys. IRIDIUM communications are used in 95% of the sites, with planned transition over the next year to 100%. Real-time data return on the deployed buoys is ~95%. Complete data return (~99 to 100%) occurs when the on-board flash drive is recovered, processed, and analyzed. However with some partner buoys the return is slightly lower (data gaps amounting to days/weeks) because of delays in re-deployment of a replacement, bad batteries from the manufacturer, and/or weather delays. Failures of the system generally are a result from vessel collisions.

## 1.7 Met Office moored buoy network

1.7.1 Four new design Hydrosphere/Mobilis buoys with dual Axys Watchman data collection systems, Iridium transmission systems and autonomous Triaxys spectral wave systems are presently in operation at K7, E1, Brittany and Gascogne. The system at E1 (operated with Plymouth Marine Laboratory) has a single meteorological system as the 'other side' is used by PML to handle data from their oceanographic sensors. In addition the buoy has a winching system designed to lower/raise their bio-geochemical sensors out of the water for cleaning. The system at L4 utilizes a Met Office AMOS (Autonomous Marine Observing System - as used on ships) alongside an AirMar weather station, on a PML Hippo Marine buoy hull. All the other Met Office moored buoys are legacy systems (Balmoral hulls, CR10x/PC42) still in operation (at K2, K4, K5 and PAP), these will be replaced by new design systems over the coming years. During the year the moored buoys at Aberporth (to be replaced by a waverider) and Turbot Bank were decommissioned as funding was withdrawn.

1.7.2 Issues to be addressed are (i) proliferation of different configurations (Triaxys/Watchman) with different transmitted data formats (binary format for Triaxys wave data introduced which will replace all other formats); (ii) plan to replace Watchman's with a CR1000-based system (still under development); (iii) plan to migrate data processing to the 'converged' Observations Processing System (Hermes/MDG) which will deliver moored buoy data to GTS in BUFR (TM 3-15-008), but not expected until 2017.

1.7.3 Wave data: we have collected 3 months of collocated data from a legacy Balmoral buoy (with heave sensor) and a waverider at Aberporth, and also 5 months of data from a Hydrosphere/Mobilis buoy with both Triaxys and MOSE sensors fitted, for 2 of these months we also have collocated waverider data. The data needs to be processed into a format suitable for use with CDIP waveEVAL tool.

1.7.4 The MASSMO (Marine Autonomous Systems in Support of Marine Observation) project is being led by the National Oceanography Centre (NOC) and the Met Office will continue to engage with this project to progress the evaluation of new marine autonomous platforms for metocean measurements. Met Office AMOS (Autonomous Marine Observing System) systems have been installed on the NOCS-owned AutoNaut and C-Enduro vehicles to operate alongside their standard AirMar sensor package. Further evaluations are planned for autumn 2016.

## 1.8 Indian Moored Buoy Network

1.8.1 Under the Ocean Observation Network program of the Ministry of Earth Sciences, National Institute of Ocean Technology (NIOT) has established the moored buoy network in the Indian Seas. Currently 18 moored buoys are working in Northern Indian Ocean region. Four coastal buoys and one CAL VAL buoy for satellite data validation are transmitting through GPRS/INSAT telemetry. Deep sea instrumented OMNI buoys are equipped with meteorological and oceanographic sensors up to 500m depth transmitting data in real time through INMARSAT telemetry with a data return of more than 93%. Wave measurements are

being conducted along the coast and deep sea. Also India his maintaining 4 ADCP mooring in southern Bay of Bengal in deep ocean and 15 wave rider buoys in along the coast In addition 4 tsunami buoys are moored at sea.

### 1.9 Arctic Observation (No input received)

*The Chair of the Task Team on Moored Buoys thanks members for their efforts in maintaining and improving their moored buoy networks and exchanging their data, and for the inputs provided for this report.*

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## APPENDIX B

## TERMS OF REFERENCE OF THE DBCP TASK TEAM ON MOORED BUOYS (TT-MB)

*(as adopted at DBCP-24)*

***The DBCP Task Team on Moored Buoys shall:***

1. Review and document operational moored buoy systems and their underlying requirements;

2. Liaise with the different communities deploying moorings, including TIP, OceanSITES, seabed observatories, as well as national moored buoy programmes (coastal and global), and promote the development of multi-disciplinary mooring systems;

3. Liaise with the GOOS Scientific Steering Committee (GSSC) and its technical sub-panel for Integrated Coastal Observations (PICO) to facilitate synergy between advances in GOOS implementation and the development of operational capabilities, in particular, for sustained coastal observations, analysis and related services by using mooring systems;

4. Liaise with the JCOMM Expert Team on Wind Waves and Storm Surges (ETWS) regarding the need for in situ wave observations;

5. Compile information on opportunities for the deployment and / or servicing of moored buoys;

6. Monitor technological developments for moored data buoys and liaise with the Task Team on Technological Developments on satellite data telecommunication aspects;

7. Review all relevant WMO and IOC Publications on Instrument Best Practices (e.g., JCOMM, CIMO) to make sure they are kept up to date, address WIGOS issues, and comply with Quality Management terminology;

8. Provide the DBCP Executive Board or the DBCP with technical advice needed for developing moored buoy programmes, including the issues above; and

9. Report to the DBCP Executive Board and the DBCP at its biennial Sessions, with periodically updated Workplans supporting implementation.

***Membership:***

The membership is open to all Panel members. The Chairperson[1] and Vice-Chair are appointed by the Panel:

Dr. Robert Jensen, USACE, (TT Chairperson)
Mr Shannon McArthur, NOAA/NDBC (TT Vice-Chairperson)

Mr Gilbert Emvizat, Meteo-France
Ms Champiks Gallage, DBCP-TC
Mr Chris Marshall, Env Canada
Mr Chun Lin Ning, FIO China
Cdr Felipe Santos, NHC Brazil
Mr Val Swail, Env Canada
Mr Ariel Troisi, SHN
Mr Kenneth Connell, NOAA / PMEL
Mr Michel Guigue, CLS
Mr Chris Meinig, NOAA / PMEL
Mr Tim Richardson, Liquid Robotics
Mr Johan Stander, SAWS
Mr Andy Sybrandy, Pacific Gyre
Mr. Jon Turton, UK Met Office

1 The Chair and Co-Chair of the Task Team should not be in a situation of conflict of interest.

Dr Hedinn Valdimarsson, MRI Iceland
Dr Robert Weller, WHOI
Dr R. Venkatesan, NIOT, India
Mr Scott Woodruff, NOAA

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