SIXTH MARINE INSTRUMENTATION WORKSHOP

FOR THE ASIA PACIFIC REGION

"Ensure high quality procedure we take, deliver the ocean data we need"

Hybrid

13-17 December 2021

FINAL REPORT

[page left intentionally blank]

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

SIXTH MARINE INSTRUMENTATION WORKSHOP FOR THE ASIA PACIFIC REGION

Hybrid

13-17 December

2021

FINAL REPORT

NOTES

WMO AND IOC DISCLAIMERS

WMO Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

WMO Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland

Tel.: +(41 22) 730 84 03
Fax: +(41 22) 730 80 40
E-mail: Publications@wmo.int

IOC (OF UNESCO) DISCLAIMER

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariats of UNESCO and IOC concerning the legal status of any country or territory, or its authorities, or concerning the delimitation of the frontiers of any country or territory.

_____

C O N T E N T S

Executive summary..... vii

Workshop report..... 1

Annex I Workshop Agenda 11
Annex II Participants list 21
Annex III Recommendations 21
Annex IV Organizing Committee..... 25
Annex V Acronym 26
Annex VI Background information of Regional Marine Instrument Centres.... 27

EXECUTIVE SUMMARY

WMO-IOC Regional Marine Instrument Centres (RMICs)were established by the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, through WMO Resolution 9 (Cg-XVI) and IOC Resolution XXVI-9. The centres are currently overseen by the WMO Commission for Observation, Infrastructure and Information Systems (Infrastructure Commission) and Global Ocean Observing System (GOOS). The Regional Marine Instrument Centre for the Asia-Pacific Region (RMIC/AP) is based in National Center of Ocean Standards and Metrology (NCOSM) of the Ministry of Natural Resources (MNR) of China.

Following the successful outcome of the previous five workshops on marine instrumentation for the Asia-Pacific region, which were organized by the RMIC/AP from 2011 to 2020, the Sixth Marine Instrumentation Workshop for the Asia Pacific Region was held from 13 to 17 December 2021 in a hybrid mode. The objectives of the workshop were: (i) celebrate the tenth anniversary of RMIC/AP; (ii) reflect on the achievements and contributions of RMICs to UN Decade of Ocean Science for Sustainable Development; (iii) facilitate calibration and maintenance of marine instruments and improve the data quality control of marine observations; (iv) improve the accuracy of data on ocean observation and climate prediction; and (v) cooperate with the WMO Infrastructure Commission, WMO Regional Centres, IOC Ocean Best Practices System (OBPS), Ocean Teacher Global Academy (OTGA), etc., to enhance the regional capacity development.

The workshop covered five sessions and one roundtable meeting. The workshop started with strategies of WMO and IOC to improve the global ocean observation networks and the plans and activities to achieve the Sustainable Development Goals (SDGs). It demonstrated the importance, application and innovation of quality control and quality assurance, narrated the way to formulate and develop better practices, and built a road map from national standards to international standards.

In the round-table meeting, participants agreed on nine major recommendations.

1) Governance of RMICs – short-term perspective

Recommendation 1: WMO Regional Associations, in collaboration with INFCOM, and in consultation with IOC GRAs, to develop a mechanism to survey the Members' needs and requirements for a support from RMICs (and other regional measurement-related centres). The survey to be conducted every 4 years.

Recommendation 2: INFCOM to set up an ad hoc working group (possibly from the membership of SG-OOIS and SC-MINT/ET-QTC) to review:
- current Terms of Reference of Regional Marine Instrument Centres,
- existing RMIC designation/supervision process,

in consultation with the Intergovernmental Oceanographic Commission of UNESCO.

Recommendation 3: The WMO Secretariat, in coordination with the IOC Secretariat and the ad hoc working group (from Recommendation 2) to ensure formal approval and implementation of the updated Terms of References (ToRs) and designation/supervision process.

Recommendation 4: WMO and IOC, jointly to promote existing RMICs capabilities and encourage Members/Member States to offer their capacities as new RMICs, as appropriate.

Recommendation 5: RMICs to test Java tool for self-evaluation and annual reporting (being implanted by RICs) and evaluate its appropriateness for RMICs.

2) Collaboration among regional, measurement-related centres and their support to Members – mid-term perspective

Recommendation 6: WMO Secretariat, in consultation with IOC Secretariat, to set up formal/regular/institutional coordination mechanism at national, regional and inter-regional (global) level, such as interlaboratory and instrument comparisons, workshops and training, personnel exchange, and information and knowledge sharing.

Recommendation 7: WMO Secretariat, in consultation with IOC Secretariat, to hold regular annual meetings of all measurement-related centres, to foster their collaboration.

Recommendation 8: WMO Secretariat, in collaboration with IOC Secretariat, to set up a repository (website) of all measurement-related centres' capabilities and their activities (could be similar to WMO Regional Instrument Centre/RIC website).

3) Streamlining the concepts of regional, measurement-related centres – long term perspective

Recommendation 9: All to consider what benefits or drawbacks of streamlining/integration of the existing concepts of regional measurement-related centres could be, and to share the ideas and views with the WMO Secretariat.

`

The workshop also made other recommendations as follows:

1) Encourage Members to establish broader communications with regional measurement-related centres (in particular, RMICs and RICs).
2) Suggest IOC to launch workshop/training courses to guide Members to learn more about OBPS and to become active participants.
3) Ecology observation is an important component of GOOS, RMIC/AP is glad to provide reference materials to ensure data traceability.

4) Metrology achievements are intimately connected with global measurements and observations. Encourage institutions to enhance the study of observing sensors and calibration methods, as well as emerging technology such as Quantum mechanics, new SI system.
5) Encourage RMICs and RICs to make contributions to collect best practices of in-situ quality assurance, enhance relevant research through organizing inter-comparisons (such as Argo vs. CTD/ Salinometer, Glider vs. Argo, innovative network of buoys, et.)
6) Encourage Tianjin University to share their best practices of hadal glider to Ocean Gliders, also upload the data of FUXING to Argo GDAC.
7) Highlight the inter linkage between National Standards, Best Practices and international standards, and encourage all stakeholders on board to foster development of international standards, regional standards and best practices.
8) Discover the potential interesting areas with ISO, IEEE, OBPS and Regional Centers, for further information sharing, cooperating and mutual recognition.

The workshop thanked NCOSM and MNR of China for continuous support and efforts to the RMICs and regional capacity development. The workshop also thanked the WMO Secretariat for the overall support of the successful organization of the event.

WORKSHOP REPORT

1. Session1: Opening Ceremony and Tenth Anniversary of Regional Marine Instrument Centres (RMICs)

1.1 Dr Yong YAO, Director-General of NCOSM of MNR of China, chaired this session. He expressed the gratitude to the WMO, IOC of UNESCO, and MNR for the persistently support to RMIC/AP since 2011. RMIC/AP upholds for the vision with building a quality stewardship of the full value chain from sensors to the data and from manufactures to the users. RMIC/AP takes it as its responsibility to promote the development of marine instrument comparison technology through establishing a platform on technical communication about marine instrument testing, providing marine observation instrument calibration service as well as sharing marine observation standards, code of practice, and best practices. He highlighted that RMIC/AP, through closer cooperation with WMO, IOC, member states and communities, will make greater contributions to the ocean observation development.

1.2 Dr Zhanhai ZHANG, Chief Engineer and Director-General of International Cooperation Department, delivered a keynote speech on behalf of MNR of China. He stressed that, the ocean environment is facing severe pressure and challenge. The United Nations are taking active actions to ensure sustainability by the UN Sustainable Development Goals (SDGs) and Decade of Ocean Science for SDG (Ocean Decade, 2021-2030). He introduced the MNR and stressed upon the significant role of MNR in the development of the RMIC/AP. Dr ZHANG mentioned that MNR has been providing the support and guidance to RMIC/AP to build a regional ocean observation quality assurance pilot project, to promote the regional capacity building and public product services, to provide the free instrument calibration services for developing countries, to organize a series of workshops on ocean observation, and to convert the international comparison of global marine instruments from concept to practice during the past ten years.

He highlighted that, RMIC/AP has been continuously providing guidance and support for the calibration of seawater temperature, salinity, meteorological and marine biochemical sensors to the world as well as trying to address the needs of instrument maintenance after the outbreak of the COVID-19. He encouraged RMIC/AP, under the guidance of WMO and IOC, to promote the development of global ocean standards and metrology, and make positive contributions to the implementation of sustainable development goals and global ocean governance.

1.3 Dr Vladimir Ryabinin, Executive Secretary of IOC /UNESCO, delivered a keynote speech by pre-recorded video. He firstly congratulated on the achievements of RMIC/AP since its establishment, particularly in capacity development activities, Ocean Best Practices (OBP) and Ocean Teacher Global Academy (OTGA), which played an important role in the global ocean and meteorological observation.

He gave an overview of the functions of IOC and whole processes of ocean related activities in the world. IOC established the OBPS which has embraced more than 1500 best practices to normalize the observation activities. The second generation of OTGA projects act as IOC E-learning platform to serve the training activities around the world.

He highlighted that IOC was transformed into more targeted organization, based on the ocean science since 2017, and that it launched the Ocean Decade, as a wide collaboration with the different countries, organizations and thousands of human resources, with the vision of "The Science We Need for the Ocean We Want". More than 350 actions had been adopted by Ocean Decade, 8.4 million dollars had been invested and 24 National Committees from Members/Member States were established. Ocean Decade focuses not only on technical details, but also looks at cultural values, trying to achieve transformative ocean science solutions for the sustainable development, and connecting people and our ocean. The outcomes of Ocean Decade should ensure a clean, healthy, resilient, and productive ocean.

1.4 Dr Anthony Rea, Director of Infrastructure Department of WMO, delivered a keynote speech on behalf of WMO. He expressed that WMO is a specialized UN agency on weather, climate and water, and one of the oldest agencies under the UN umbrella, now embraced 193 Members. He highlighted that the reform has been conducted by WMO since 2020, and that two new technical commissions: the Commission for Observation, Infrastructure and Information Systems (Infrastructure Commission) and the Commission for Weather, Climate, Water and Related Environmental Services and Applications (Services Commission), and the Research Board were established instead of the former eight technical commissions, to ensure the inclusiveness of the weather, climate, water and other relevant environmental areas covered by the WMO. The responsibility and activities of the former Joint technical Commission for Oceanography and Marine Meteorology (JCOMM) had been integrated into these two commissions. The Infrastructure Commission contributes to the development and implementation of globally coordinated systems for acquiring, processing, transmitting and disseminating Earth system observation data, coordination of the production and use of standardized analysis and model forecast fields. WMO new structure comprises also the Joint Collaborative Board with IOC to maintain and facilitate dialogue of both organizations on oceanographic and marine meteorological matters.

He also stressed on the vision 2030, mission and long-term goals of WMO. WMO focuses on improving all parts of the value chain from observations to service delivery to better services to its members, by implementing the new WMO data policy, conducting globally observation activities, maintaining the WMO Information System (WIS 2.0), running the numerical weather prediction system based on the Earth system approach and enhancing the capacity development. He also gave the details of three core initiatives to implement by the WMO strategy, that are: the WMO Unified Data Policy, the Global Basic Observing Network (GBON) and the Systematic Observations Financing Facility (SOFF), and the synergistic operation

mechanism of them.

He highlighted that the ocean data plays a crucial role in climate prediction in line with the WMO's drive towards a more integrated Earth systems strategy. WMO had close linkage with ocean matters under UN system, actively engaged in GOOS. He pointed out that RMIC/AP is a great example of the cooperation between WMO and IOC, which demonstrates the cooperation across national agencies and the international corporations, and provides important support to the quality of data, which is a core function of the global observations.

1.5 Three additional presentations followed after keynote speeches. Ms Liu Haiyan from MNR gave a presentation on "Ocean Standards: A National Perspective". She introduced ocean standardization development in China. Ocean standardization, having undergone 40 years of development, has achieved fruitful results. Ocean standards provide crucial technical support and guarantee for the development of marine causes.

There are 138 national standards and 338 industry standards released, 65 national standards and 463 industry standards are under development and revision. To promote inter-communication, since 2017, 13 standards (7 national standards and 6 industry standards) have been approved for translation into English version, 4 national standards translated into English have been released.

1.6 Dr Emma Heslop, programme specialist for GOOS from IOC and Dr Long JIANG from OceanOPS made the joint presentation on "GOOS Strategy on the role of Standards and Best Practices". Emma Heslop introduced the GOOS 2030 Strategy. GOOS has more than 86 contributing countries, 8,933 in situ observing platforms, 170 satellites and 12 global ocean observing networks. With the increasing awareness of ecosystem, 203 active long-term biological observing programs and 10 BioEco Essential Ocean Variable (EOV) based observing networks had been involved in. It was adopted by IOC in 2019 and also sponsored by WMO. The core of GOOS is the system integration and delivery, the key priorities include developing partnerships for delivery, advocacy and communications. She described that the EOVs gained through different measurement processes have high impact for the science and the society. Each EOV has specification sheets and more information on the space and time scales needed for different applications, and links to resources on best practice and data. The annual report card, under the coordination of Observations Coordination Group (OCG), makes clear monitoring on the the status of the 12 networks.

In addition, she gave some details about the IOC Ocean Best Practices System. It is a fundamental component and underpins the global observing system to ensure the quality, consistency and efficiency of observations across various networks and within networks. OBPS has also been developing the framework of "endorsement" that enables to identify best practices and standards of specific importance for ocean related communities, for example, a "GOOS endorsment" will be given to documents

that cover the whole value chain and life cycle of observation basis driven by the community, which already identified over 50 best practices by the community's evaluation processes. She suggested that RMICs may contribute their experiences to these activities, and that GOOS could benefit from RMIC expertise through improved confidence in observations resulting from robust and well-defined sensor metrology.

Dr Long JIANG said that Ocean OPS is an infrastructure of the GOOS, which monitors the performance of 12 networks. The five-year strategy of Ocean OPS includes five major goals: to monitor the improvement of GOOS, to lead metadata standardization and integration across GOOS, to support and enhance the operations with GOOS, to establish new data stream and network of GOOS, and to shape the Ocean OPS for future. He also illustrated the rough sketch of the data flow, standardization and integration of metadata which serve the requirements of EOV and WIGOS for better understanding of what, when,where, and how of the met-ocean observations.

He took the wave-climate studies as example to show the metadata standardization. He also presented the details of the monitoring capacities of OceanOPS and invited the members to share more data through the WMO Global Telecommunication System (GTS). He pointed out that over 2700 instruments had been deployed in Pacific region and that measurements are monitored by OceanOPS and suggested that RMIC/AP may engage more in this field. He introduced the "Odyssey Project", which is a new project under the Ocean Decade umbrella, led by Ocean OPS, that aims at improving the coverage and data availability globally for the ocean observation, which already had deployed over 100 Argo floats. It is a good case to show the OceanOPS coordination with shipping communities to deploy the instruments to improve the data availability.

1.7 Dr. Feng ZHOU, from Second Institute of Oceanography (SIO) of MNR, delivered the presentation about "China's Intensifying Participation in GOOS towards Expanding Ocean Observations for Sustainable Development Needs". The West Pacific and Northern Indian ocean are the key research areas of SIO. Tropical Pacific Observing System (TPOS) is maintained by Tropical Atmosphere Ocean (TAO) and Triangle Trans-Ocean Buoy Network (TRITON) buoys for the past years. Due to the TRITON's drawback, Prof. Dake CHEN had proposed the big cross array in western tropical Pacific to make contributions to TPOS. MNR of China had support one cruise in 2020, and another cruise will be arranged in 2022. Three Tier buoys, one test buoy and 28 Argo floats had been deployed in this area, details may be found in the final reports of TPOS 2020.

He also introduced the observation cooperation between SIO and Association of Southeast Asian Nations (ASEAN), for example, the workshops that had been organized, a 120-day cruise in East Indian Ocean and the Bay of Bengal, joint cruises in Exclusive Economic Zones (EEZs) of Sri Lanka, Myanmar and 15 Argo floats, one buoy and six moorings had been deployed in 2019-2020. He also shared experience of data quality control, for example, the wet test (comparison) between Chinese

Yingyue Buoy and Japanese TRITON buoy. The current data from Acoustic Doppler Current Profiler (ADCP) showed great consistency and the pattern of salinity and temperature is found similar.

SIO acts as Argo Data Center in China. The standard procedures of Argo Data calibration had been demonstrated in his presentation. He added that the biogeochemical (BGC) data such as dissolved oxygen and chlorophyll comparison between the water samplers in laboratory and in situ sensors, as well as the sensors from different brands will be conducted to achieve the goal of quality control.

2. Regional Measurement-related Centres: From Concept to Practice

2.1 Mr. Krunoslav Premec from the WMO Secretariat gave a presentation on Infrastructure Commission, Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT), and regional measurement-related centres. He first informed about the WMO reform that integrated the previous eight technical commissions into two technical commissions (infrastructure, services) and the research board. He then briefed on INFCOM structure. INFCOM is led by the president and three vice-presidents, and its work is conducted by four standing committees and six study groups. Later, Mr Premec focused on activities of SC-MINT and measurement-related centres. These centres play a key role in implementation of the WMO strategy for traceability assurance. The centres include Regional Instrument Centres (RICs), Regional Radiation Centres (RRCs), and Regional Marine Instrument Centres (RMICs). A brief comparison of ToR between RICs and RMICs displayed in the WMO-No. 8 was also presented.

Mr Premec further introduced RIC designation, assessment and reconfirmation process as per WMO Resolution 17 (EC-73) and described WMO Radiation Centres at global and regional levels, as well as WMO SC-MINT Measurement Lead Centres and Regional WIGOS Centres in operational and pilot modes. Mr Premec shared SC-MINT priorities in the coming years: Support to GBON, SOFF and Data policy; Audit and certification of WMO Measurement-related Centres; Environmental Sustainability of Observations; Tiered Network Approach – criteria; Emerging technologies - Evolution of Global Observing Systems; Updated measurement-related regulatory and guidance publications (e.g., WMO-No. 8)

2.2 Mr Ben Churchill, Head of WMO Regional Office for Asia and South-West Pacific, gave a comprehensive introduction to WMO Regional Associations reform, priorities, and related activities in WMO Regional Association II (RA II). He first introduced the matrix concept and working structure of WMO RA II, in the context of WMO five long term goals. He then briefed on major partners in the region. He gave a good coverage of RA II operating plan 2021-2024 that placed ocean observations as one priority via time-limited projects.

Regarding regional centres on WMO Integrated Observing System (WIGOS), WMO Information System (WIS), Global Data Processing and Forecasting System (GDPFS), Instrument and Training, he updated on the first regional WIGOS centres that have been recently designated as operational in Beijing and Tokyo. He also highlighted 32 GDPFS and 10 WIS centres, and six measurement-related centres in RA II. In addition, there are 14 regional training centres in RA II and five virtual labs.

2.3 Dr Lingling YUAN from NCOSM, reported for RMIC-AP. She first recalled the necessity to establish RMIC in the region and gave a short introduction of NCOSM capacities in standardization, metrology and quality supervision under the overall management of MNR China. Activities include instrument calibration services at national and regional levels, five training workshops, for example, workshop on salinity measurements, joint pilot deployment of instruments, instrument intercomparisons (with Commonwealth Scientific and Industrial Research Organisation of Australia, Japan Agency for Marine-Earth Science and Technology, etc.), and Standards and Best Practices. NCOSM has also set up sustained collaboration on thematic areas with Data Buoy Cooperation Panel, GOOS OCG, and International Ocean Data and Exchange (IODE), and domestic and other international partners.

2.4 Mr Xu ZHAO from National Centre for Meteorological Metrology (NCMM), China Meteorological Administration (CMA) reported on Metrology Service of RIC – Beijing. He introduced a brief history of the centre dated from 1954 and designated as RIC in 1996. He also provided an overview of measurement-related centres and capacities and qualifications in China. He then showed core businesses of NCMM, and showcased air pressure, temperature, humidity, air velocity, precipitation, solar and terrestrial radiation, etc. He also briefed on international cooperation activities in metrology training over the years. At the end, Mr Zhao shared future activities of NCMM in solar and terrestrial radiation, air electricity and visibility, as well as their goal to establish metrology ability for new observational instruments.

2.5 Mr Shigeoka Hiroumi reported key activities of RIC-Tsukuba, based in Meteorological Instrument Center, Japan Meteorological Administration (JMA). RIC-Tsukuba provides calibration and non-radiation-related measurements services for WMO RA II Members. It assists Japan International Cooperation Agency (JICA) for synergy of expertise of RIC Tsukuba in instrument calibration. It also aims at improving quality of meteorological data. RIC-Tsukuba has established cooperation with RIC-Beijing and RIC-Manila. RIC-Tsukuba supported capacity development activities, such as calibration and maintenance of meteorological instruments in RA II, interlaboratory comparison (ILC) in RA II, RA V and RA VI, etc.

2.6 Mr Sasaki SHUN reported on key activities of Regional Radiation Centre, Tokyo, JMA. RRC-Tokyo started solar radiation measurements from 1930s and was designated as WMO RRC in 1965. He introduced a concept diagram of calibration of

solar radiation instruments within the framework of WMO. Then he highlighted series of activities of RRC-Tokyo in the past decades, including regional pyrheliometer comparison (RPC) every five years and national intercomparisons. He informed that the next RPC of RA-II will take place in January 2023 and will welcome other national radiation centres to join.

2.7 Ms Xuejiao LIN reported on activities of Regional WIGOS Centre -Beijing, hosted by Meteorological Observation Centre, CMA. She first described the designation process of RWC-Beijing from 2017 until endorsement in late 2021. She briefed on core functions of RWC that are regional coordination, guidance, oversight and support of WIGOS implementation and operational activities at the regional and national levels (day-to-day level of activities), including mandatory functions to manage Regional WIGOS metadata, performance monitoring and incidents, as well as optional functions of which RWC-Beijing is capable to deliver.

2.8 Mr Minematsu Hiroaki reported on key activities of RWC Tokyo, JMA. He also reflected on the development of RWC Tokyo from 2018 to its designation in September 2021. He first focused on RWC mandatory functions on metadata management and WDQMS, and then on the optional functions. He also showed joint operations of RWCs in RA II, by grouping Members in the region. In addition, he introduced WIGOS project phases, from survey, workshop, report and actions to enhance availability and quality management support for the National Meteorological and Hydrological Services in surface, climate and upper air observations, and to develop support in satellite data, products, and training.

2.9 Mr Drago Groselj, chair of SC-MINT/Expert Team on Quality, Traceability and Calibration (ET-QTC), presented experience with WMO RIC system and potential for improvement. He stressed that many RICs are accredited to ISO/IEC 17025. There are now 16 RICs globally in all WMO RAs. He recalled ToR of WMO RICs on capacities and corresponding functions. He further noted that calibration capacities vary greatly over these RICs, regarding different variables, and traceability assurance services for Members. He then highlighted capacity building activities and ILCs in the past years. Lastly, he encouraged non-accredited RICs to strive for the accreditation as soon as possible. He further requested RICs to promote their functions and capabilities in collaboration with RAs to increase awareness of RICs capabilities and their missions. He also encouraged RICs to consider activities beyond their geographic regions.

2.10 Round-table Meeting on Coordination of RMICs, RWCs, RICs.

All participants of regional centres, representatives of WMO and IOC attended the round-table discussions on coordination of regional centres. The session was moderated by Mr Fan Jiang (NCOSM) and Mr Krunoslav Premec. Discussions were focused on short-term, middle-term and long-term perspective. Topics that were discussed include: governance of regional marine instrument centres; collaboration

among regional measurement-related centres and their support to Members in mid-term, and streamlining the concepts of regional, measurement-related centres in long term perspective, in consultation with partner organization(s) and national centres. Following nine recommendations were agreed to by the round-table participants and supported by all workshop participants:

1) Governance of RMICs – short-term perspective

Recommendation 1: WMO Regional Associations, in collaboration with INFCOM, and in consultation with IOC GRAs, to develop a mechanism to survey the Members' needs and requirements for supporting from RMICs (and other regional measurement-related centres). The survey to be conducted every four years.

Recommendation 2: INFCOM to set up an ad hoc working group (possibly from the membership of SG-OOIS and SC-MINT/ET-QTC) to review:
- current Terms of Reference of Regional Marine Instrument Centres,
- existing RMIC designation/supervision process,
in consultation with the Intergovernmental Oceanographic Commission of UNESCO.

Recommendation 3: The WMO Secretariat, in coordination with the IOC Secretariat and the ad hoc working group (from Recommendation 2) to ensure formal approval and implementation of the updated ToRs and designation/supervision process.

Recommendation 4: WMO and IOC, jointly to promote existing RMICs capabilities and encourage Members/Member States to offer their capacities as new RMICs, as appropriate.

Recommendation 5: RMICs to test Java tool for self-evaluation and annual reporting (being implanted by RICs) and evaluate its appropriateness for RMICs.

2) Collaboration among regional, measurement-related centres and their support to Members – mid-term perspective

Recommendation 6: WMO Secretariat, in consultation with IOC Secretariat, to set up formal/regular/institutional coordination mechanism on national, regional and inter-regional (global) level, such as interlaboratory and instrument comparisons, workshops and training, personnel exchange, and information and knowledge sharing.

Recommendation 7: WMO Secretariat, in consultation with IOC Secretariat, to hold regular annual meetings of all measurement-related centres, to foster their collaboration.

Recommendation 8: WMO Secretariat, in collaboration with IOC Secretariat, to set up a repository (website) of all measurement-related centres' capabilities and their activities (could be similar to WMO RIC website).

[NOTE: Background information of RMICs was included in Annex VI]

3) Streamlining the concepts of reginal, measurement-related centres – long term perspective

Recommendation 9: All to consider what benefits or drawbacks of streamlining/integration of the existing concepts of regional measurement-related centres could be, and to share the ideas and views with the WMO Secretariat.

3. Ocean Best Practices — Instrument Calibration

3.1 Dr Andrea Merlone, chair of the SC-MINT/Expert Team on Measurement Uncertainty (ET-MU) and chair of the International Bureau of Weights and Measures (BIPM)/Working Group on Environment, from Italian institute of metrology, presented BIPM activities and interactions with WMO. He gave the details about the new International System of Units (SI) and its influence on observations. He demonstrated the close interactions between metrology achievements and global meteorology. The related projects included instruments in-field calibration, ILCs, and the research of the thermometer calibration of a Conductivity, Temperature, and Depth (CTD) in a water pressure tank.

3.2 Dr Xiaojuan FENG from China National Institute of Metrology introduced the history of both definition of kelvin and the temperature traceability. She then reported on the Quantum Kelvin, and the frontier research of Nitrogen-Vacancy (NV) center in diamond used in the future ocean temperature measurements.

3.3 Dr Jianqing YU from NCOSM, described the implementation of laboratory/on-site calibration of marine instruments (e.g., CTD, ADCP, bio-chemical sensors, meteorological sensors, temperature sensors, tide gauges, buoys). NCOSM works as an authorized legal metrological verification institution which is accredited in accordance with ISO/IEC 17025 general requirements for the competence of testing and calibration laboratories. This guarantees that the calibration would be internationally mutually recognizable. In addition to calibration of instruments/sensors, NCOSM is able to carry out environmental test, especially the water pressure test to find out if underwater instruments' hull can stand under deep water pressure.

3.4 Dr Carmen Garcia Izquierdo from Spanish National Institute of Metrology gave the report of Calibration of Thermometers for Marine Applications, especially on thermistors calibration and quality control. Thermistors have high sensitivity with small size and fast time constants. She introduced the procedure of calibrating thermistors with fixed points (the Triple point of water 0.01 ºC, and the Melting point of Gallium, 29.7646 ºC), and by comparison to Standard Platinum Resistance

Thermometers.

3.5 Mr Xiaoyan YU, from NCOSM, introduced CTD calibration facilities. The standard measuring instruments for temperature calibration include Standard Platinum Resistance Thermometers (SPRT), Water Triple Point / Gallium Melting point and Constant temperature seawater baths; and for salinity (conductivity) include Chinese Standard Seawater and high precision laboratory salinometers; and for pressure (depth) include Piston Gauges (Hydraulic and Pneumatic) in a constant temperature and humidity laboratory conditions.

3.6 Dr Shixu GUO from China Metrology University presented his efforts on in-situ ADCP calibration of both its theories and applications. High precision frequency offset acoustic signal is used to simulate water velocity. This method was tested both in a lake and in the inner sea. In future, it can promote the opening of calibration interfaces for ADCP, improve the relevant calibration standards, and promote the on-site calibration and laboratory calibration of ADCP in small pools.

3.7 Dr R. Venkatesan from National Institute of Ocean Technology, India, presented on how to calibrate the related sensors on the moored buoys deployed in the coastal and offshore waters to measure and transmit both meteorological parameters and hydrological parameters. These parameters include wind speed, atmospheric pressure, precipitation, solar radiation sensor, air temperature and humidity, etc. They also conducted the comparison of current profile between surface downward looking ADCP and upward looking ADCP.

3.8 Ms Chaoying SHI, from NCOSM, introduced metrological test technology of marine instruments in ecology monitoring in China. These instruments include turbidity sensors, pH sensors, Dissolved Oxygen (DO) sensors, Seawater Nutrients Analyzers, etc. Calibration can effectively control the error of the sensors. The sensors measurements will drift with time when they are deployed at sea for a long time, which will cause large deviation. She also introduced the process of studying standard seawater and Reference Material (Standard Seawater, seawater-based pH, PO43--P), based on best practices.

4. Quality Control and Quality Assurance (QC&QA) of Networks

4.1 Mr Thierry Carval from French Institute for Ocean Science (IFREMER) delivered two presentations, first one on Real-time quality controls of Argo & BGC-Argo. IFREMER is one of the Global Data Assembly Centres (GDAC) in charge of the real-time and delayed-mode data management of Argo. Argo data management mainly have three steps, principal investigator for a series of floats, data assembly centre for a series of Principle Investigators (PIs) and global data assembly centres for all the DACs. Real-time QC conducted by 26 automatic tests and delayed mode QC conducted by observations are scrutinized and adjusted by a scientist.

He also introduced the process of data flow, data distribution and data formats, the unique and global DOI is assigned to Argo data. Finally, he took the Copernicus marine in situ TAC data flow as an example to show the state of art of in situ QC.

4.2 Mr Thierry Carval continued with the presentation on Quality Control and Quality Assurance of Ocean Gliders. The Ocean Gliders program coordinates glider deployment and observation activities, monitoring, collecting, and dissemination of the data in real-time and delayed mode. He highlighted that the ocean boundary currents, storms, and water transformation are the key areas for observation. EU Copernicus Marine service aggregates vertical profiles from Ocean Gliders and WMO GTS, 2.3 million ocean vertical profiles from 423 gliders, among them there are 82% from Ocean Gliders.

Until now three Ocean Gliders GDACs had been established. Only few parameters have their real-time model QC procedures, while more is on the way. Everyone's Gliding Observatory (EGO) quality control manual for CTD (Conductivity, Temperature, Depth) and BGC data, describes two levels of quality control. The first level is the real-time system that performs a set of agreed automatic checks. Adjustment in real-time can also be performed and the real-time system can evaluate quality flags for adjusted fields. The second level is the delayed-mode quality control system.

4.3 Dr Jiayi XU from Tianjin University made a presentation about The Control Strategy and Low Power Consumption of Deep FuXing. He highlighted that Deep FuXing is a self-sustaining profile buoy over 4000 meters depth, which can detect water depth of four thousand meters, operated with more than 100 cycles, and its mass is at most 56 kg with an 8 kg load and with Beidou and Iridium satellite communications.

He introduced the sea trials of Deep FuXing No. 6, which was deployed on 8 August 2019, and 48 cycles over 4000 meters have been operated and the profile data of temperature and salinity are measured. The temperature is basically consistent with World Ocean Atlas (WOA) 2018, and the salinity is within 0.01PSU compared with WOA 2018. The data quality is good and meets the observation requirements of the international Argo plan. He also mentioned a hardware-in-loop (HIL) simulation system that is used for experiments to decrease the cost and the long experiment period of sea trials.

4.4 Dr Marc le Menn from Naval Hydrographic and Oceanographic Service (SHOM, France) presented on Quality Assurance and Quality Control of High Resolution Sea Surface Temperature (HRSST) Drifters. The EUMETSAT trusted project was designed to build a network of 150 surface drifters for the validation of temperatures measured by the Sentinel satellites of the Copernicus project. A high-resolution temperature sensor, with a resolution of 1 mK, and a hydrostatic pressure sensor are integrated in a module called MoSens, which can be calibrated in batches of 10 and

get the measurement uncertainties for each sensor.

He highlighted that the deviations of HRSST measurements are more dependent on cooling and warming of the water than on the air temperature through the laboratory experiment. During the in situ comparison, two drifter buoys were compared with a CTD profiler and a reference thermometer SBE 35 from SeaBird. The results show that without any correction, HRSST values are in the standard dispersion range of the SBE 35 and the deviations compared to the CTD and the SBE 35 are inferior to 0.01 °C. One year after deployment, one of the drifters was compared with a mooring nearby, and the maximum drift was of + 0.0039 °C/year.

4.5 Dr Mark Bushnell, an IOOS consultant, gave the presentation on Advances in QC/QA by pre-recording video. The Integrated Ocean Observing System (IOOS) of USA, established Quality Assurance/Quality Control of Real Time Oceanographic Data (QARTOD) project which formulated 13 manuals for past decade. Dr Bushnell used the data of tide gauge as example to demonstrate the details of QARTOD. The level of QC was divided into three required, strongly recommended and suggested. He encouraged manufactures to embed the standardization QC test in their instruments. He highlighted that the quality control data directly from sensors to the end users without delay will benefit the stakeholders of ocean observation.

He gave the processes of in situ QA, as a case study, and compared the data between the sensors and air oxygen as the single point in situ re-calibration, which may improve the data drift of dissolved oxygen observation of Argo float. He stressed on the importance of uncertainty calculation of observation and encouraged the audience to contribute to the related work, such as Ocean Uncertainty Quantification (UQ) which is organized by US CLIVAR.

4.6 Ms. Fangfang WAN from National Marine Data and Information Service (NMDIS) of MNR introduced China's Centre for Marine Meteorological and Oceanographic Climate (CMOC/China) and its Data Processing and Sharing Service. She expressed that CMOC/China was the first CMOC accepted into the Marine Climate Data System (MCDS), provisionally in 2012, formally in 2015. It has wide-range of activities, with a special focus on the Asia-Pacific region, which include collecting, processing and integrating marine meteorological and oceanographic climate data, conducting high level data quality control, research and developing oceanographic, marine-meteorological products, as well as providing capacity building support for countries in the region.

She highlighted that the data and data product of CMOC/China are freely available on its website (http://www.cmoc-china.cn). CMOC/China attached great importance to international cooperation and communications and had carried out good exchanges with such projects and institutions as International Comprehensive Ocean-Atmosphere Data Set (ICOADS), Data Buoy Cooperation Panel (DBCP), Atlantic Oceanographic and Meteorological Laboratory (AOML), European Marine Observation

and Data Network (EMODnet), etc.

4.7 Dr Peng Wang from Tianjin University delivered the presentation on system design of hybrid driven Hadal Glider serving in full ocean depth. He introduced the progress of an innovative hybrid-driven hadal glider (HG), Petrel-XPLUS, that is designed to realize the observation in hadal zone. The concept of multi-material combined pressure hull (MPCH) is proposed to meet the performance requirements of bearing high hydrostatic pressure and compensating the additional net buoyancy generated by the variation of the seawater density. An innovative dual-equal-eccentricity attitude regulating mechanism (DARM) is designed to realize the vertical diving movement. The angle adjusting ability of this mechanism is 86.7% better than the traditional way of single eccentric attitude adjustment mechanism.

He demonstrated a comprehensive survey in the Mariana Trench by Petrel-X PLUS HG. Three completed profiles over more than 10 000 m are achieved, of which the maximum diving depth is 10 619 m. The average horizontal position deviation of the three profiles is 2.018 km. The relevant data of hadal zone is obtained including CTD, environmental noise and underwater image. He highlighted that Tianjin University is glad to enhance the capacity building in region, and also make the contributions to ocean best practices.

4.8 Prof. Jun Sun from China University of Geosciences gave the presentation on marine phytoplankton carbon calculation and its carbon sink. He introduced the processes of China's carbon peak and carbon neutrality potential and pointed out the artificial upwelling and iron fertilization experiment that are the two ways to increase carbon sink as the marine biological pump, and eight pathways to the marine carbon sink: marine fishery carbon sink, coastal wetland, microbial carbon pump, negative emission and increasing carbon sink of ecosystems, marine geological carbon sequestration and land and ocean coordinating carbon neutrality. He gave the details about the marine phytoplankton carbon sink based on species and community level and the new findings of biological carbon pump. He stressed that offshore carbon neutrality needs more research, that the land and ocean negative emissions are a good start and that the artificial ecosystem operation is the key priority.

5. Ocean Best Practices — Interdisciplinary Contributions to OBP

5.1 Dr Johannes Karstensen from Helmholtz Centre for Ocean Research Kiel (GEOMAR, Germany) gave a presentation on the IOC Ocean Best Practices System (OBPS) and the endorsement framework for Best Practices documents and other media (e.g., video). The IOC OBPS is a system that assists all ocean communities in developing and adapting best practices in ocean observing. OBPS has been established in 2016 and was officially accepted an IOC project in 2019. It consists of eight workpackages and several Task Teams, the latter are led by external members

of the global community to address topical issues. OBPS maintains a permanent and open access repository (hosted by the IODE) that currently includes more than 1550 documents/media. A specific search interface is available that makes use of semantic search algorithms to map media content against globally accepted vocabularies for its queries. OBPS assists the ocean community in developing and adapting BP. The "convergence" process includes activities that help communities in creating summary documents from various resources (e.g. making use of the OBPS repository metadata). The "endorsement" process is designed for global/large scale organizations to highlight BP documentation that is of particular relevance for them (e.g. "GOOS endorsement") and is integrated via respective metadata into the OBPS repository.

5.2 Ms Xuwen Feng from the SIO of MNR gave a detailed introduction of Marine Technology Subcommittee (ISO/TC8/SC13). First, she briefly introduced the visions and strategy of ISO and ISO/TC8/SC13. The terms of references of ISO/TC8/SC13 are as follows: Standardization of test methods; Operation, design, construction and logistics of equipment; Systems, infrastructure and technology used for observation; Exploration and protection of the ocean and sea areas. Then she gave an introduction to the working items and the future focus of ISO/TC8/SC13. At last, she called for more cooperation on the development of international standards.

5.3 Dr Christoph Waldmann from University of Bremen, gave an introduction to the Value of Standards for Ocean Science and Technology from the perspective of Institute of Electrical and Electronics Engineers (IEEE). He introduced the Oceanic Engineering Society Standing Committee on Standards' (OES-SCS) Standards Strategy and the importance of standards and then introduced the Structure of the Framework for Ocean Observing. He highlighted that Essential Ocean Variables (EOVs) should be based on relevance, feasibility, cost effectiveness criteria, and he called for reaching agreement on how to ensure data quality, raise trust in collected data and information，and harmonize practices and procedures.

5.4 Ms Yanli LEI from Institute of Oceanology of Chinese Academy of Sciences (CAS) gave a presentation on Development and Technology of International Standards for Marine Survey in Seabed Area: A Case Study of ISO/23040. She shared the case study of how to develop an international standard of ISO based on a national standard. She introduced the contents and techniques of the case study standard, which provides technical support and standard guarantee for relevant international cooperation.

5.5 Dr Chengjun SUN from the First Institute of Oceanography of MNR, gave a presentation on Microplastic Research in the South China Sea and Importance of Protocol Standardization. Firstly, she presented the research on micro plastics (MP) in South China Sea (SCS). About 28000 tonnes of MP had been found in upper 200 m of water in SCS, but a lack of data on sediment, biota and deep water still exist. There is a great need for standardization of the related methods to increase the

efficiency and accuracy of MP observation, because each media has their own features and need customized techniques to analyze. She described detailed practices about ocean water sampling, including water column sampling and surface water sampling, and MP analysis in the laboratory. She called for more collaboration to develop the standards or best practices on MP sampling and analytical methods.

5.6 Dr Peng ZHAO from Hainan University gave a presentation on Estimation Method of Maricultural Seaweed and Bivalve Carbon Sink – Carbon Stock Variation Method. Firstly, he introduced national blue carbon policies and then gave detailed introduction of the mechanisms of costal blue carbon, as well as the goals, contents and methods of the blue carbon. Then he generally introduced the construction of blue carbon standard system. Lastly, he shared the experiences of developing a marine industry standard on blue carbon.

5.7 Dr Jihong ZHANG from Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences reported on Technical Code of Practice for Investigation and Assessment of Carbon Stock in the Blue Carbon Ecosystems—Seagrass Bed. She introduced the general background of the standard, and pointed out the current status of seaweed and bivalve mariculture in the world. Mariculture was possible option for enhancing marine CO2 uptake and storage, both from a national and a global perspective. Then she gave a detailed introduction of the formulation of this industry standard from the approval procedure to the technical contents. She also introduced the application of the standard in Sungo Bay.

After all the presentations, local organizer Ms Fangfang Chen and WMO Secretariat Mr Krunoslav Premec led review of draft recommendations from each day of the workshop.

Closure of the workshop

Dr Dominique Berod concluded the workshop. He thanked colleagues of local host, Ministry of Natural Resources and National Center of Ocean Standards and Metrology, organizing committee, and Secretariats. He further noted with appreciation the quality and diversity of presentations not only touched upon ocean and climate, but also water quality, ecosystem and so on that WMO Earth System approach is embracing on. He reassured WMO’s continuous support to RMICs together with IOC in the coming years for the benefits of Members.

ANNEX I

AGENDA

Day 1: 13 December 2021

TIME(UTC+0)	SUBJECT	LEAD
Opening Ceremony and Tenth Anniversary of RMICs Chair: Yong Yao Rapporteurs: Long Jiang, Fan Jiang		
08:00-08:05	Opening Remarks	Yong Yao Director General NCOSM
08:05-08:15	Keynote from Ministry of Natural Resources	Zhanhai Zhang Chief Engineer MNR
08:15-08:35	Keynote from IOC IOC and UN Ocean Decade	Vladimir Ryabinin Executive Secretary, IOC
08:35-08:55	Keynote from WMO WMO Reform, Strategy and Ocean Activities	Anthony Rea Director of Infrastructure WMO
08:55-09:00	Group Photo	
09:00-09:20	Ocean Standards: A National Perspective	Haiyan Liu MNR
09:20-09:40	GOOS 2030 Strategy, Implementation and OceanOPS	Emma Heslop, IOC/Long Jiang, OceanOPS
09:40-10:00	China's Intensifying Participation in GOOS towards Expanding Ocean Observations for Sustainable Development Needs	Feng Zhou SIO

Day 2: 14 December 2021

TIME(UTC+0)	SUBJECT	LEAD
Regional Measurement-related Centres: From Concept to Practice Chair: Lingling Yuan Rapporteurs: Krunoslav Premec, Fangfang Chen		
08:00-08:15	INFCOM/SC-MINT and regional measurement-related centres	Krunoslav Premec WMO
08:15-08:30	WMO Regional Association Reform, Priorities and Related Activities in RA II	Ben Churchill WMO
08:30-08:45	Report from Regional Marine Instrument Centre (RMIC)-RA II	Lingling Yuan NCOSM
08:45-08:55	Metrology Service of (RIC) – Beijing	Xu Zhao CMA
08:55-09:05	Key activities of Regional Instrument Centre (RIC) – Tsukuba	SHIGEOKA Hiroumi JMA
09:05-09:15	Key activities of Regional Radiation Centre (RRC) – Tokyo	SASAKI Shun JMA
09:15-09:25	Key activities of Regional WIGOS Centre (RWC) – Beijing	Xuejiao Lin CMA
09:25-09:35	Key activities of Regional WIGOS Centre (RWC) – Tokyo	MINEMATSU Hiroaki JMA
09:35-09:45	Experience with WMO RIC system and Potential for Improvement	Drago Groselj SC-MINT/ET-QTC
09:45-10:00	Q&As	
10:00-11:00	Round Table Meeting on Coordination of RMICs, RWCs, RICs (By invitation)	RMICs/RWCs/RICs

Day 3: 15 December 2021

TIME(UTC+0)	SUBJECT	LEAD
Ocean Best Practices — Instrument Calibration Chair: Jianqing Yu Rapporteurs: Xiaoyan Yu, Minghua Mu		
08:00-08:15	From New International System of Units to Environmental Observations: BIPM Activities and Interactions with WMO	Andrea Merlone INRIM
08:15-08:30	Quantum Kelvin and its Application in Ocean	Xiaojuan Feng NIM
08:30-08:45	Calibration Facilities from RMIC/AP	Jianqing Yu NCOSM
08:45-09:00	Calibration of Thermometers for Marine Applications	Carmen Garcia Izquierdo CEM
09:00-09:15	CTD Calibration Facility of NCOSM	Xiaoyan Yu NCOSM
09:15-09:30	In-Situ ADCP Calibration	Shixu Guo China Jiliang University
09:30-09:45	Calibration of Sensors for Moored Buoys	R.Venkatesan NIOT
09:45-10:00	Metrological Test Technology of Marine Instruments in Ecology Monitoring	Chaoying Shi NCOSM

Day 4: 16 December 2021

TIME(UTC+0)	SUBJECT	LEAD
Quality Control and Quality Assurance (QC&QA) of Networks Chair: Qiu Jiang Rapporteurs: Fangfang Chen, Fan Jiang		
08:00-08:15	Argo and BGC-Argo Real Time Quality Control	Thierry Carval IFREMER
08:15-08:30	Quality Control & Quality Assurance of Ocean Gliders	Thierry Carval IFREMER
08:30-08:45	The Control Strategy and Low Power Consumption of Deep FuXing	Jia-yi Xu Tianjin University
08:45-09:00	Quality Assurance and Quality Control of HRSST Drifters	Marc le Menn SHOM
09:00-09:15	Advances in In-Situ Quality Assurance and Quality Control	Mark Bushnell NOAA (Record)
09:15-09:30	CMOC/China & its Data Processing and Sharing Service	Fangfang Wan NMDIS
09:30-09:45	System Design of Hybrid Driven Hadal Glider Serving in Full Ocean Depth	Peng Wang Tianjin University
09:45-10:00	Marine phytoplankton carbon calculation and its carbon sink	Jun Sun Tianjin Univ. Science&Tech

Day 5: 17 December 2021

TIME(UTC+0)	SUBJECT	LEAD
Ocean Best Practices — Interdisciplinary Contributions to OBP Chair: Hairong Tang Rapporteurs: Hua Chen, Wen'na Zhang		
08:00-08:15	The IOC Ocean Best Practices System and the Endorsement of Best Practices	Johannes Karstensen GEOMAR
08:15-08:30	Introduction of ISO TC-8/ SC-13	Xuwen Feng SIO
08:30-08:45	The IEEE Perspective on the Value of Standards for Ocean Science and Technology	Christoph Waldmann University of Bremen
08:45-09:00	Development and Technology of International Standards for Marine Survey in Seabed Area: A Case Study of ISO/23040	Yanli Lei Institute of Oceanology CAS
09:00-09:15	Microplastic Research in the South China Sea and Importance of Protocol Standardization	Chengjun Sun FIO (Record)
09:15-09:30	Estimation Method of Maricultural Seaweed and Bivalve Carbon Sink – Carbon Stock Variation Method	Jihong Zhang YSFRI
09:30-09:45	Technical Code of Practice for Investigation and Assessment of Carbon Stock in the Blue Carbon Ecosystems—Seagrass Bed	Peng Zhao Hainan University
09:45-10:15	Wrap up and Closing	WMO/IOC/NCOSM

ANNEX II

LIST OF PARTICIPANTS

Name	Country
EASTY Imtiaj	Bangladesh
MALORNY Kai	Canada
HONGQI Shi	China
JIANG Fan	China
JIANQING Yu	China
LEE Jian	China
LI Yong	China
LIU Shuang	China
PENG Wang	China
REN Wei	China
SUN Chengjun	China
WANG Xiaoyong	China
YAO Yong	China
YU Xiaoyan	China
ZHAO Xu	China
ABDELAZIZ Mohamed	Egypt
ALY-ELDEEN Mohamed	Egypt
HENEISH Rasha	Egypt
CARVAL Thierry	France
HESLOP Emma	France
JIANG Long	France
KUJABIE Abubacarr	Gambia
KARSTENSEN Johannes	Germany
WALDMANN Christoph	Germany
BREFO Divine Gabriel	Ghana
CHEUNG Anson	Hong Kong, China
CHOW Chi-Kin	Hong Kong, China
LAM Ching-chi	Hong Kong, China
LAU Dickson	Hong Kong, China
ACHARYA Raja	India
JOSEPH Jossia	India
KALYANI M.	India
KRISHNAMOORTHY Ramesh	India
RANGANATHAN SUNDAR	India
VENKATESAN R.	India
PRATAMA Khafid	Indonesia
RIAMA Nelly	Indonesia
LAYEGHI Behzad	Iran (Islamic Republic of)

Name	Country
YELTAY Aizat	Kazakhstan
ALBLOUSHI Yasser	Kuwait
NOUNI Nabil	Morocco
KNOWLES Steve	New Zealand
KALHORO Noor Ahmed	Pakistan
AL JAHDALI Arwa	Saudi Arabia
AL-THUKAIR Assad	Saudi Arabia
HALWANI Hamza	Saudi Arabia
KHAYYAT Badee	Saudi Arabia
GROSELJ Drago	Slovenia
JARDINE Rydall	South Africa
IZQUIERDO Carmen	Spain
BEROD Dominique	Switzerland
PREMEC Krunoslav	Switzerland
SRERURNGLA Anucha	Thailand
KHAMMARI Lotfi	Tunisia
BUSHNELL Mark	United States of America
LIU Chunying	United States of America
NANGLE John	United States of America
THURSTON Sidney W.	United States of America
DUONG Do	Viet Nam

ANNEX III

1 Recommendations from the Roundtable Meeting

1) Governance of RMICs – short-term perspective

Recommendation 1: WMO Regional Associations, in collaboration with INFCOM, and in consultation with IOC GRAs, to develop a mechanism to survey the Members' needs and requirements for a support from RMICs (and other regional measurement-related centres). The survey to be conducted every 4 years.

Recommendation 2: INFCOM to set up an ad hoc working group (possibly from the membership of SG-OOIS and SC-MINT/ET-QTC) to review:
- current Terms of Reference of Regional Marine Instrument Centres,
- existing RMIC designation/supervision process,
in consultation with the Intergovernmental Oceanographic Commission of UNESCO.

Recommendation 3: The WMO Secretariat, in coordination with the IOC Secretariat and the ad hoc working group (from Recommendation 2) to ensure formal approval and implementation of the updated Terms of References (ToRs) and designation/supervision process.

Recommendation 4: WMO and IOC, jointly to promote existing RMICs capabilities and encourage Members/Member States to offer their capacities as new RMICs, as appropriate.

Recommendation 5: RMICs to test Java tool for self-evaluation and annual reporting (being implanted by RICs) and evaluate its appropriateness for RMICs.

2) Collaboration among regional, measurement-related centres and their support to Members – mid-term perspective

Recommendation 6: WMO Secretariat, in consultation with IOC Secretariat, to set up formal/regular/institutional coordination mechanism at national, regional and inter-regional (global) level, such as interlaboratory and instrument comparisons, workshops and training, personnel exchange, and information and knowledge sharing.

Recommendation 7: WMO Secretariat, in consultation with IOC Secretariat, to hold regular annual meetings of all measurement-related centres, to foster their collaboration.

Recommendation 8: WMO Secretariat, in collaboration with IOC Secretariat, to set up a repository (website) of all measurement-related centres' capabilities and their activities (could be similar to WMO Regional Instrument Centre/RIC website).

3) Streamlining the concepts of regional, measurement-related centres – long term perspective

Recommendation 9: All to consider what benefits or drawbacks of streamlining/integration of the existing concepts of regional measurement-related centres could be, and to share the ideas and views with the WMO Secretariat.

2 Other Recommendations:

1) Encourage Members to establish broader communications with regional measurement-related centres (in particular, RMICs and RICs).
2) Suggest IOC to launch workshop/training courses to guide Members to learn more about OBPS and to become active participants.
3) Ecology observation is an important component of GOOS, RMIC/AP is glad to provide reference materials to ensure data traceability.
4) Metrology achievements are intimately connected with global measurements and observations. Encourage institutions to enhance the study of observing sensors and calibration methods, as well as emerging technology such as Quantum mechanics, new SI system.
5) Encourage RMICs and RICs to make contributions to collect best practices of in-situ quality assurance, enhance relevant research through organizing inter-comparisons (such as Argo vs. CTD/ Salinometer, Glider vs. Argo, innovative network of buoys, et.)
6) Encourage Tianjin University to share their best practices of hadal glider to Ocean Gliders, also upload the data of FUXING to Argo GDAC.
7) Highlight the inter linkage between National Standards, Best Practices and international standards, and encourage all stakeholders on board to foster development of international standards, regional standards and best practices.
8) Discover the potential interesting areas with ISO, IEEE, OBPS and Regional Centers, for further information sharing, cooperating and mutual recognition.

ANNEX IV

ORGANIZING COMMITTEE

1. Dominique Berod, WMO, Head of Division
2. Krunoslav Premec, WMO, Scientific Officer
3. JIANG Long, OceanOPS, Technical Coordinator
4. JIANG Fan, Local Organizer, NCOSM of MNR
5. CHEN Fangfang, Local Organizer, NCOSM of MNR
6. Juliet Hermes, liaison with IOC, Professor
7. Drago Groselj, Chair of SC-MINT/ET-QTC

_____

ANNEX V

Acronyms List

ADCP	Acoustic Doppler Current Profiler
BGC	BioGeoChemical/BioGeoChemistry
BIPM	International Bureau of Weights and Measures
CTD	Conductivity, Temperature, and Depth
CEM	Spanish National Institute of Metrology
CMA	China Meteorological Administration
CAS	Chinese Academy of Sciences, China
FIO	First Institute of Oceanography, China
HRSST	Global High Resolution Sea Surface Temperature
IEEE	Institute of Electrical and Electronic Engineers
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer, France
INRIM	Istituto Nazionale di Ricerca Metrologica, Italy
IOC	Intergovernmental Oceanographic Commission of UNESCO, France
IOOS	Integrated Ocean Observing System
IUCN	International Union for Conservation of Nature, Switzerland
MOC	Meteorological Observation Center of CMA, China
MNR	Ministry of Natural Resources, China
NCOSM	National Center of Ocean Standards and Metrology, China
NIM	National Institute of Metrology, China
NIOT	National Institute of Ocean Teachnology, India
NOAA	National Oceanic and Atmospheric Administration, USA
NMDIS	National Marine Data and Information Service, China
OES	Oceanic Engineering Society, IEEE
RIC	Regional Instrument Centre
RMIC	Regional Marine Instrument Centre
RRC	Regional Radiation Centre
RWC	Regional WIGOS Centre
QA	Quality Assurance
QC	Quality Control
SI	International Standards of Units
SIO	Second Institute of Oceanography of MNR, China
SHOM	Service Hydrographique et Océanographique
TJU	Tianjin University, China
TUST	Tianjin University of Science and Technology
WIGOS	WMO Integrated Global Observing System
WMO	World Meteorological Organization, Switzerland
YSFRI	Yellow Sea Fisheries Research Institute, China

ANNEX VI

Background of Regional Marine Instrument Centres

1. Terms of Reference of Regional Marine Instrument Centres
   https://goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=16948
2. The WMO-IOC Network of Regional Marine Instrumentation Centres (RMICs)
   https://goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=7166
3. Previous RMICs meetings
   a. 2011 RMIC-RA-II-1: https://oceanexpert.org/event/784
   b. 2012 RMIC-RA-II-2: https://oceanexpert.org/event/1186
   c. 2013 RMIC-RA-II-3: https://oceanexpert.org/event/1328
   d. 2014 RMIC-RA-II-4: https://oceanexpert.org/event/1506
   e. 2018 RMIC-RA-II-5: https://oceanexpert.org/event/2260
      (jointly with DBCP-PI-3 workshop)

   f. 2010 RMIC-RA-IV-1: https://oceanexpert.org/event/558
   g. 2016 RMIC-RA-IV-2: https://oceanexpert.org/event/1790
   h. 2016 RMIC coordination: https://oceanexpert.org/event/1839

   i. 2013 RMIC-RA-I-1: https://oceanexpert.org/event/1395