WORLD METEOROLOGICAL ORGANIZATION	**INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)**
DATA BUOY COOPERATION PANEL	DBCP-30/ Doc. 7 Rev. 1 (2-Oct-14)
THIRTIETH SESSION	ITEM: 7
WEIHAI, CHINA 27-31 OCTOBER 2014	ENGLISH ONLY

REPORT BY THE ACTION GROUPS

(Submitted by the Action Groups)

SUMMARY AND PURPOSE OF DOCUMENT

This documents includes in its appendices the reports from the DBCP Action Groups on their respective activities during the last intersessional period.

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 Global Drifter Programme (GDP)
B. Report by the Tropical Moored Buoy Implementation Panel (TIP)
C. Report by the EUCOS Surface Marine Programme (E-SURFMAR)
D. Report by the International Buoy Programme for the Indian Ocean (IBPIO)
E. Report by the DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP)
F. Report by the International Arctic Buoy Programme (IABP)
G. Report by the WCRP-SCAR International Programme for Antarctic Buoys (IPAB)
H. Report by the International South Atlantic Buoy Programme (ISABP)
I. Report by the Ocean Sustained Interdisciplinary Timeseries Environment observation System (OceanSITES)
J. Report by the International Tsunameter Partnership (ITP)

DISCUSSION

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

7.1 Under this agenda item, the Panel was presented with reports by the DBCP Action Groups. Each group maintains an observational buoy program that supplies data for operational and research purposes. The implementation of buoy deployments is also coordinated through global, regional, or specialized Action Groups.

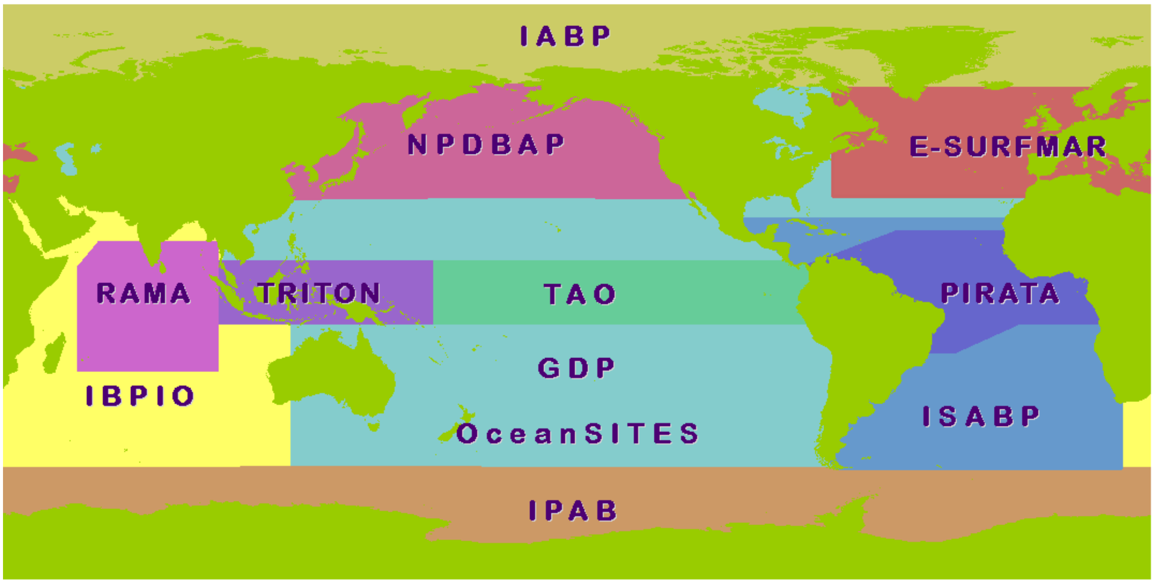


Figure 1: The regional extent of several of the DBCP Action Groups.

7.2 The reports included:

(i) **E-SURFMAR:** Surface Marine programme of the Network of European Meteorological Services, EUMETNET (verbal presentation by Jean Roland (France), representing the E-SURFMAR officers);
(ii) **GDP:** Global Drifter Programme (verbal presentation by Rick Lumpkin (USA) on behalf of the GDP);
(iii) **IABP:** International Arctic Buoy Programme (verbal presentation by Dr. Ignatius Rigor (USA), representing IABP);
(iv) **IBPIO:** International Buoy Programme for the Indian Ocean (verbal presentation by Mr Graeme Ball (Australia), Chairperson of the IBPIO);
(v) **IPAB:** WCRP-SCAR International Programme for Antarctic Buoys (verbal presentation by Petra Heil (USA) on behalf of the IPAB);
(vi) **ISABP:** International South Atlantic Buoy Programme (verbal presentation by Mayra Pazos (USA), representing the ISABP);
(vii) **NPDBAP:** DBCP-PICES North Pacific Data Buoy Advisory Panel (verbal presentation by Mr Shaun Dolk (USA), technical coordinator of the NPDBAP);
(viii) **OceanSITES**: OCEAN Sustained Interdisciplinary Timeseries Environment observation System (verbal presentation by the Technical Coordinator, Ms Kelly Stroker, representing OceanSITES project office);
(ix) **TIP:** Tropical Moored Buoys Implementation Panel (verbal presentation by Dr Iwao Ueki (Japan) on behalf of the TIP);
(x) **ITP:** International Tsunameter Partnership (verbal presentation by Dr Venkatesan (India) on behalf of the ITP).

7.2 The full reports of the action groups are provided in Appendices A to J, and will be reproduced in the Panel's Annual Report.

Appendices: 10

APPENDIX A

REPORT BY THE GLOBAL DRIFTER PROGRAMME (GDP)

(Report submitted by Rick Lumpkin, NOAA/AOML, USA)

1) Summary

Name of Action Group	Global Drifter Program
Date of report	15 September 2014
Overview and main requirements addressed	Global Drifter Program (GPD). Goals: 1. Maintain a global 5x5° array of 1250 satellite-tracked surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations of mixed layer currents, sea surface temperature, atmospheric pressure, winds and salinity; and 2. Provide a data processing system for scientific use of these data. These data support short-term (seasonal to interannual) climate predictions as well as climate research and monitoring.
Area of interest	Global ocean
Type of platform and variables measured	Lagrangian drifters measuring surface velocity, SST; some drifters also measure sea level pressure, wind, salinity, and/or sub-surface temperature profiles
Targeted horizontal resolution	5 degree x 5 degree (1250 units)
Chairperson/Managers	Dr Rick Lumpkin, NOAA/AOML, USA Dr Luca Centurioni, SIO/CIMEC, USA
Coordinator	Operations Manager: Mr Shaun Dolk, NOAA/AOML, USA
Participants	Numerous national and international institutions
Data centre(s)	GDP Data Assembly Center (DAC) – Manager: Ms Mayra Pazos, NOAA/AOML, USA
Website	http://www.aoml.noaa.gov/phod/dac/
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	None other than DBCP
Current status summary *(mid-2013)*	Annual size of array was 1144 drifters. Current size as of 15 September 2014 is 1395 drifters.
Summary of plans for 2015	Maintain array at ~1250 drifters

2 Deployment plans for 2015

Deployments in the period 1 August 2013 through 31 July 2014 are shown in Fig. 1. A total of 1660 drifters were deployed during this period, compared to 1472 drifters last year, in order to return the array above the goal of 1250 drifters. The array began this period at 1007 drifters.

In the coming year, the GDP Deployment Plan is:

Operational Buoy Deployments	800
Consortium Research Buoy Deployments	200
Total Deployments in 2013-2014	1000

More deployments may be needed to fill gaps in the global array as they develop, and will be conducted if more drifters are available for deployment.

In addition to the regular deployment opportunities provided by vessels of opportunity and regularly occurring research cruises, nnotable deployments planned for August 2014-July 2015 include:

- ~ 80 SVP drifter deployments in the equatorial Pacific, during TAO mooring cruises (~ 10 deployments per line)
- 20-25 SVPB drifter deployments in the N. Pacific, during the annual DART cruise
- 30 SVPB drifter deployments in the S. Pacific from the R/V *Araon*
- ~40 SVPB drifter deployments in the Indian Ocean, during RAMA mooring cruises
- 10 SVPB drifter deployments in the Indian and Pacific Oceans from the R/V *Kaharoa*
- 10 SVP drifter deployments in the tropical Atlantic Ocean from the MV *Explorer*
- 20 SVP drifter deployments in the equatorial Pacific from the MV *Explorer*
- 10 SVPB drifter deployments in the Indian Ocean from the MV *Explorer*
- ~50 SVP drifter deployments in the Pacific Ocean by the US Coast Guard
- 40 SVPB drifter deployments in the Drake Passage
- 20 SVPB drifter deployments in the SE Pacific Ocean by new GDP partners at the University of Valparaiso
- ~30 SVP drifter deployments in the equatorial Pacific by GDP partners in Peru, Columbia, Chile, and Ecuador
- ~20 SVP drifter deployments in the Pacific Ocean during the Blue Planet Odyssey sailing event

3 Data management

3.1 Distribution of the data

The drifter Data Assembly Center (DAC) assembles, quality controls and interpolates data from approximately 1300 drifters per month from all GDP national and international partners, from all oceans of the world. These data are made available through the web with a delayed time of 3—4 months. As of the time of writing this report (mid-August 2014),quality-controlled data are available through September 2013, and data through March 2014 should be available within a week. These data can be accessed at http://www.aoml.noaa.gov/phod/dac/dacdata.php.

3.1.1 Data policy

The DAC, located at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) has access to drifters from GDP partners that have given Service Argos permission to make these data available to the DAC. In return the partners have access to all quality controlled and interpolated data available in the database via the World Wide Web. Non-interpolated quality controlled data and raw data are made available via ftp transfer upon request.

3.1.2 Real-time data exchange

All data from drifters in the GDP's programs are disseminated via GTS as soon as drifters are deployed. The GDP monitors data going out on the GTS, and transmissions of sensors producing bad data or transmissions from grounded drifters are removed from the GTS data stream.

As of 11 August 2014, there were 1379 GDP drifters transmitting good quality data on the GTS. Other GDP partners are expected to distribute their drifter data on the GTS as soon as deployments have occurred. The GDP does not monitor GTS data timeliness and relies on operational centres to report on these issues.

3.1.3 Delayed mode data exchange

Drifter data (raw data, edited non-interpolated and interpolated data) are archived at AOML. The quality controlled data bases are currently available through September 2013, and an update through March 2014 is planned for release by late August 2014. These datasets are also sent to Integrated Science Data Management (ISDM), the RNODC for drifter data, for permanent archival and further distribution. The DAC has sent all data through 2011 to ISDM; a new data set covering 2012-2013 will be sent shortly.

Metadata for GDP drifters are received at the DAC directly from drifter manufacturers who send standardized specification sheets for batches of identical drifters prior of delivery of the instruments. Portions of this metadata are extracted and are made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dacdeployed.html. Specification sheets are archived at the DAC. Deployment date, date of last transmission, drogue off and cause of death metadata are determined during quality control of the dataset and are made available through the web at www.aoml.noaa.gov/phod/dac/dirall.html. These web pages are interrogated by JCOMMOPS to gather information for their metadata systems.

The DAC is developing tools to quality control Iridium drifter data and include it in the database. Iridium data is current received weekly from Meteo-France and SIO via FTP.

3.2 Data quality

Methodology and results from an automatic drogue presence reassessment was published in the *Journal of Atmospheric and Oceanic Technology* (Lumpkin, R., S. Grodsky, M.-H. Rio, L. Centurioni, J. Carton and D. Lee, 2013: Removing spurious low-frequency variability in surface drifter velocities*. J. Atmos. Oceanic Techn*., **30** (2), 353—360, doi:10.1175/JTECH-D-12-00139.1). This article also described the criteria used for a full manual reevaluation of drogue presence completed by the drifter DAC.

4) Instrument practices

Technical supervision and developments related to the design of the SVP drifter are led by the Scripps component of the GDP. These developments aim to standardize and improve the drifter design. In the previous years, this has included:

- Ruggedized tether attachment for strength and water infiltration implemented across the drifter fleet;
- Recommendation for high quality batteries issued to manufacturers and implemented;

- Design of ruggedized battery packs;
- Recommendation for more accurate SST (0.05°C) issued to manufacturers and implemented by SIO;
- Recommendation for ruggedized drogue design issued to manufacturers and implemented;
- New tether material (synthetic rope) is currently under evaluation.

The following tables summarize deployments, deaths, etc. for drifters by year and by manufacturer, calculated through the end of December 2013. Half-lives are reported as a function of the deployment year of a drifter (e.g. the half-life for 2012 is for all drifters deployed in 2012). The appearance of "*" indicates that there were not enough values to make the calculation. A half-life of ">X" is a minimum estimate, indicating that more than half are still alive or still have drogues attached; the final value will be larger. In this table, salinity drifters and wind drifters have not been included. Note that "quit" drifters are drifters which are believed not to have been picked up or ran aground, and also excludes all drifters that died poleward of 55 degrees latitude. In other words, "quit" drifters are those likely to have died from internal reasons such as battery failure.

NUMBER OF DEPLOYMENTS

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	0	0	0	0	4	158	281
Metocean	220	143	216	199	219	153	100
Pacific Gyre	113	270	264	231	357	199	281
SIO	0	0	0	0	0	103	256

NUMBER OF DEATHS

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	0	0	0	0	1	52	174
Metocean	110	186	150	233	258	201	81
Pacific Gyre	99	193	206	225	271	385	226
SIO	0	0	0	0	0	49	172

PERCENT "QUIT" (number which "quit" divided by number deployed)

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	*	*	*	*	25%	15%	31%
Metocean	30%	87%	37%	67%	69%	80%	54%
Pacific Gyre	53%	37%	43%	61%	51%	134%	57%
SIO	*	*	*	*	*	20%	29%

HALF-LIFE (DAYS)

Manufacturer	2007	2008	2009	2010	2011	2012	2013
All drifters:							
DBi	*	*	*	*	364	259	>261
Metocean	370	396	384	211	190	150	>193
Pacific Gyre	212	231	284	284	208	190	>244
SIO	*	*	*	*	*	137	151
"Quit" drifters:							
DBi	*	*	*	*	364	324	>358
Metocean	402	456	445	274	221	187	>217
Pacific Gyre	262	598	336	345	236	227	>357
SIO	*	*	*	*	*	201	>303

PERCENT LIVED <90 DAYS (all causes of death)

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	*	*	*	*	25%	9%	7%
Metocean	7%	5%	6%	5%	11%	18%	11%
Pacific Gyre	12%	12%	17%	4%	5%	7%	4%
SIO	*	*	*	*	*	5%	8%

DROGUE HALF-LIFE (DAYS)

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	*	*	*	*	279	227	>237

Metocean	>373	269	224	77	89	107	>158
Pacific Gyre	210	206	241	248	207	>228	>214
SIO	*	*	*	*	*	66	>151

PERCENT THAT HAD DROGUE OFF <90 DAYS

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	*	*	*	*	25%	11%	12%
Metocean	13%	17%	26%	40%	46%	37%	19%
Pacific Gyre	20%	21%	17%	10%	16%	21%	9%
SIO	*	*	*	*	*	40%	21%

PERCENT THAT HAD DROGUE OFF <10 DAYS

Manufacturer	2007	2008	2009	2010	2011	2012	2013
DBi	*	*	*	*	0%	4%	2%
Metocean	8%	13%	6%	12%	6%	11%	9%
Pacific Gyre	8%	11%	8%	2%	4%	7%	0%
SIO	*	*	*	*	*	24%	1%

5) Evolution of the Global Drifter array, 1 August 2013—31 July 2014

The growth of the array through 11 August 2014 is shown in Fig. 2. For the period 1 August 2013-31 July 2014, the array had an average size of 1144 drifters, compared to 994 drifters average last year. The greater number was due to improved lifetimes and increased deployments during the intersessional period. This period began with the array at 1013 drifters and climbing, reaching a maximum of 1401 on 23 June 2014. Through the remainder of the period, the array size fluctuated in the range 1389—1399.

Annex

Status maps and graphics

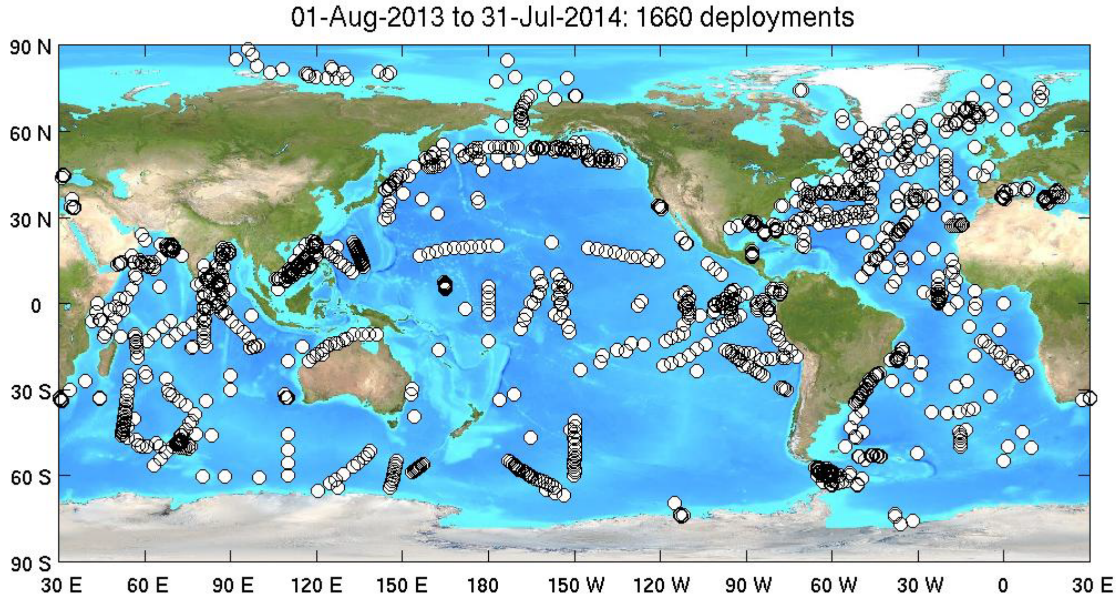


Fig. 1: Global Drifter Program deployment locations during the year.

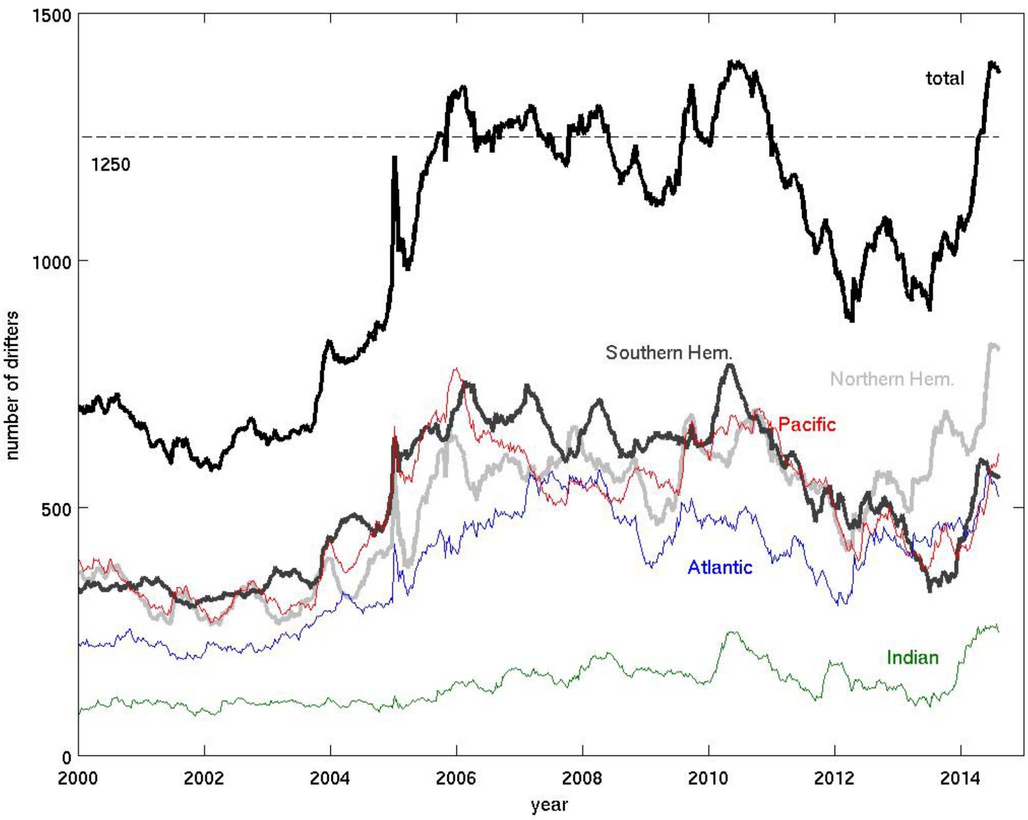


Fig. 2: Size of global drifter array, total (black) and in various subregions (color). Atlantic/Indian divided at 25°E in the Southern Ocean, Atlantic/Pacific at 70°W in the Southern Ocean, Indian/Pacific at 125°E south of Timor.

APPENDIX B

REPORT BY THE TROPICAL MOORED BUOY IMPLEMENTATION PANEL (TIP)

(Report submitted by Paul Freitag, NOAA/PMEL, USA)

1) Summary

Name of Action Group	The Tropical Moored Buoy Implementation Panel (TIP)
Date of report	15 September 2014
Overview and main requirements addressed	The Tropical Moored Buoy Implementation Panel (TIP) oversees the design and implementation of the following components: • The Tropical Atmosphere Ocean / Triangle Trans-Ocean Buoy Network (TAO / TRITON), a central component of the ENSO Observing System, deployed specifically for research and forecasting of El Niño and La Niña; • The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) • The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA)
Area of interest	The tropical ocean regions as part of an integrated approach to observing the climate system to address the research needs of CLIVAR and the operational strategies of GOOS and GCOS. Pacific Ocean: 8°N to 8°S; Atlantic Ocean: 20°N to 10°S; Indian Ocean: 15°N to 25°S.
Type of platform and variables measured	Tropical moorings with surface meteorological and sub-surface oceanographic sensors measuring: Surface wind, air temperature, relative humidity, SST and SSS on all surface moorings. Air pressure, precipitation, short wave radiation, long wave radiation on some surface moorings. Sub-surface temperature profiles down to 500m-750m on all surface moorings. Salinity profiles as deep as 750m on some surface moorings. Current velocity on some moorings. Also, biogeochemical measurements, including CO_2 and O_2 on select moorings. Some moorings also have specialized instruments to measure turbulence dissipation. Subsurface ADCP moorings measuring velocity profiles in the upper few hundred meters. Some have additional single point current meters at deeper levels.
Targeted horizontal resolution	Tropical Pacific Ocean: 70 moorings ; Tropical Atlantic Ocean: 19 moorings ; Tropical Indian Ocean: 46 moorings
Chairperson/Managers	Dr. Mike McPhaden, PMEL, USA, Chairman Dr. Kentaro Ando, JAMSTEC, Japan, Vice-Chairman
Coordinator	Mr H. Paul Freitag, PMEL, USA
Participants	TAO/TRITON: NOAA National Data Buoy Center (NDBC),NOAA Pacific Marine Environmental Laboratory (PMEL), Japan Agency for Marine-Earth Science and Technology (*JAMSTEC)* PIRATA: NOAA PMEL, NOAA Atlantic Marine Oceanographic Laboratory (AOML), L'Institut de recherche pour le développement (IRD), Meteo-France, Instituto Nacional de Pesquisas Espaciais (INPE), Diretoria de Hidrografia e Navegacao (DHN**)**

	RAMA: NOAA PMEL, JAMSTEC, Indian National Center for Ocean Information Services (INCOIS), National Institute of Oceanography (NIO), Agency for the Assessment and Application of Technology (BPPT), Ministry of Marine Affairs and Fisheries (KKP), First Institute of Oceanography (FIO), Agulhas and Somali Current Large Marine Ecosystems (ASCLME), Bay of Bengal Large Marine Ecosystem (BOBLME) program, University of Tasmania and the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia.
Data centre(s)	PMEL, NDBC,JAMSTEC, NIO
Website	http://www.pmel.noaa.gov/tao/global/global.html
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	• CLIVAR/GOOS Indian Ocean Panel 10th Session 8-12 July, 2013, Li Jang, China • PIRATA-18/TAV 22-25 October 2013, Venice, Italy • Tropical Pacific Observing System Review, 27-30 January 2014, La Jolla, USA. • CLIVAR GOOS Indian Ocean Panel 11th session, The Hague, Netherlands, 14-15 July 2014 • CLIVAR Pacific Ocean Panel, The Hague, Netherlands, 14-15 July 2014 • Ninth Annual Indonesia – U.S. Ocean and Climate Observations, Analysis and Applications Partnership Workshop, Jakarta, Indonesia, 20-23 August 2014 • TPOS-2020 Steering Committee 1st meeting, Ansan, Korea, 6-9 October, 2014 • IndOOS Resource Forum, Phuket, Thailand, 31 October 2014 • PIRATA-19/Tropical Atlantic Climate Variability, Recife, Brazil, 3-6 November 2014
Current status summary *(September 2014)*	TAO/TRITON: 41 of 55 TAO, 8 of 10 TRITON surface moorings reporting data. PIRATA: 18 of 18 surface moorings reporting data. RAMA: 18 of 27 surface moorings reporting data.
Summary of plans for 2015	TAO/TRITON: Maintain 68 mooring array. 2 TRITON sites to be retired. PIRATA: Maintain 18 mooring array RAMA: Maintain 34 sites. Possibly add more if ship time is available.

2 Deployment plans for 2015

TAO/TRITON: NDBC 7 cruises, JAMSTEC 1 cruise
PIRATA: AOML/PMEL 1 cruise, IRD 1 cruise, INPE 1 cruise
RAMA: PMEL/INCOIS 3 cruises (possibly more), JAMSTEC 1 cruise, NIO 1 cruise, PMEL/BPPT/BKMG 1 cruise, FIO/BPPT 1 cruise, PMEL/SAPPHIRE TBN

3 Data management

3.1 Distribution of the data

Most surface data are telemetered in real time and are placed on the GTS. Autonomous Temperature Line Acquisition System (ATLAS) and TRITON data (the majority of systems in TRITON, PIRATA, RAMA) are telemetered via the Argos system and are placed on the GTS by the French Space Agency (CLS). ATLAS Refresh data (the majority of systems in TAO) are telemetered via Iridium and placed on the GTS by NDBC. Real-time data plus delayed-mode data (data of higher temporal resolution than are available in real time and data from subsurface moorings) are available via web based distribution from

PMEL (www.pmel.noaa.gov/tao/disdel/disdel.html),
NDBC (tao.noaa.gov),
JAMSTEC (www.jamstec.go.jp/jamstec/TRITON/real_time/delivery/
www.jamstec.go.jp/iorgc/iomics/datadisplay/buoysummary.php?LANG=0
and NIO (www.nio.org/index/option/com_nomenu/task/show/tid/2/sid/18/id/5).

FIO's Bai-Long mooring telemeters data via Iridium which are available via the web at this time. FIO plans to have Bai-Long data placed on the GTS by the China Meteorological Service. During the period September 2013 through August 2014 the PMEL web pages had more than 14M hits and delivered more than 490K data files in response to more than 65K user requests. In addition to web page deliveries, more than 1.6M files were delivered via FTP.

3.1.1 Data policy

Data are freely available on the web and distributed via the GTS in real-time.

3.1.2 Real-time data exchange

ATLAS moorings place daily mean meteorological and oceanographic observations and some (about 10 per day on average) hourly meteorological observations on the GTS using Argos2 PTTs. ATLAS Refresh systems, designed to make observations comparable to legacy ATLAS systems using newer, more commercially available sensors, transmit 10-min data via Iridium, with hourly observations placed on the GTS. TRITON and m-TRITON buoys submit hourly mean meteorological and oceanographic data to the GTS: TRITON via Argos2 PTTs and m-TRITON via Argos3 PMTs. Compared to the volume of ATLAS data received at PMEL, more than 90% is typically reported on the GTS by CLS. Most operational centers receive nearly all ATLAS data placed on the GTS, with the exception of the ECMWF which typically reports volumes of about 75%, presumably due to stricter latency criteria.

Daily average data return for the period 1 July 2013 through 30 June 2014 was 38% for TAO, 84% for TRITON, 86% for PIRATA and 54% for RAMA. Abnormally low TAO data return was in large part due to delays in maintenance cruises. The average TAO mooring age (time period since deployment) was 16 months as of July 2014, with 42 of 55 TAO moorings having been deployed for more than the design lifetime of 12 months, and one having been deployed for 3 years. TAO maintenance cruises in the latter half of 2014 should result in all but one site being replaced within

the past year, and all those with new ATLAS Refresh systems. Primary reasons for data loss in RAMA were a high incidence of vandalism coupled with long mooring deployment periods at some sites. Of 27 surface mooring sites in RAMA implemented by July 2014, 5 have not been maintained for more than 2 years due to lack of cruise opportunities.
The survival rate for ATLAS moorings in RAMA since initial deployments in 2004 is 84%, compared to 90% for TAO (1980 to 2010) and 93% for PIRATA (1997-2014).

3.1.3 Delayed mode data exchange

Delayed mode data (*i.e.,* data retrieved after mooring recovery) are archived at the web sites listed in 3.1 above. System metadata are available at the web sites listed in 3.2 and 4 below.

The TAO web site (http://www.pmel.noaa.gov/tao/), PIRATA web site (http://www.pmel.noaa.gov/pirata/), and RAMA web site (http://www.pmel.noaa.gov/tao/rama/) provide various information including scientific background, technical information, present status of the arrays, a bibliographies of refereed publications, history of cruises, and additional information.

3.2 Data quality

Data quality control procedures are described at www.pmel.noaa.gov/tao/proj_over/qc.html for ATLAS moorings and at www.jamstec.go.jp/jamstec/TRITON/real_time/overview.php/po.php for TRITON moorings.

4) Instrument practices

Sensor specifications and calibration procedures are described on a number of web sites:

- www.pmel.noaa.gov/tao/proj_over/sensors.shtml
- http://tao.ndbc.noaa.gov/proj_overview/sampling_ndbc.shtml
- http://www.jamstec.go.jp/jamstec/TRITON/real_time/overview/
- http://www.jamstec.go.jp/iorgc/iomics/projectoverview/1_b3_eng.html

RAMA mooring specifications from PMEL, JAMSTEC and NIO are also listed in the Supplement to RAMA: The Research Moored Array for African—Asian—Australian Monsoon Analysis and Prediction (McPhaden, et al., 2009)

After testing and comparison of real-time (daily averaged) and delayed mode (10-minute) data alongside ATLAS moorings for several years, NDBC's ATLAS Refresh moorings have replaced ATLAS Legacy moorings at 49 of 55 TAO sites. All but 1 of the remaining ATLAS sites should be replaced with Refresh systems by the end of 2014. Refresh systems telemeter 10-min resolution data via Iridium each hour, and data are placed on the GTS.

China's First Institute of Oceanography (FIO) implemented the 8°S 100°E RAMA site in February 2010 and has maintained the site on an annual basis since then. The FIO mooring, named Bai-Long was designed to make meteorological and ocean measurements comparable to ATLAS moorings. PMEL and FIO have incorporated data from the Bai-Long mooring into PMEL's Tropical Moored Buoy web pages which display and distribute RAMA data from ATLAS and TRITON moorings.

PMEL's T-Flex mooring system, intended to replace the legacy ATLAS moorings in RAMA and PIRATA, is essentially equivalent to ATLAS, while using more commercially available components and providing higher temporal resolution data in real time. Seven prototype systems have been deployed for comparison with ATLAS systems. Replacement of some ATLAS systems in PIRATA and/or RAMA with T-Flex systems will begin in 2015.

PMEL and FIO are conducting land-based, side-by-side tests of meteorological sensors from ATLAS, T-Flex and Bai-Long moorings to ensure uniformity of measurements within RAMA.

The ATLAS Refresh, T-Flex and Bai-Long mooring systems telemeter data via Iridium. NDBC submits ATLAS Refresh data onto the GTS. PMEL has developed methods to do the same for T-Flex and FIO plans for China's Meteorological Service to do so for Bai-Long.

5) Other issues

5.1 RAMA Implementation and Maintenance

The number of RAMA sites implemented stands at 34 (74% complete). Two new moorings (an ATLAS and a subsurface ADCP) were implemented at 0°, 67°E in August 2014.

Between July 2013 and June 2014, 151 sea days were provided by India, Japan, Indonesia, Australia and China in support of RAMA. During this period 23 RAMA moorings were serviced. As of September 5, 2014, 18 of 27 surface moorings were reporting data.

PMEL is investigating the availability of suitable ships in Seychelles to maintain or implement RAMA/ATLAS moorings in the western basin along 55°E.

5.2 Array enhancements

Meteo-France provides barometers to maintain surface pressure measurements at 4 RAMA sites and 1 PIRATA site.

CO_2 and additional biochemical (e.g., pH, O_2, chlorophyll, turbidity) measurements are made on several TAO moorings by PMEL (http://www.pmel.noaa.gov/co2/moorings/) and on several PIRATA buoys by LOCEAN (http://www.lodyc.jussieu.fr/CO2tropiques/) and the Leibniz Institute of Marine Sciences at the University of Kiel (IFM-GEOMAR). China's Bai-Long moorings deployed in RAMA included CO_2 measurements in 2011 and 2012, and are scheduled to resume in 2015. A PMEL CO_2 system supported by the Bay of Bengal Large Marine Ecosystem Project (BOBLME) was deployed on a RAMA mooring in November 2013. The University of Tasmania has provided fluorometers for two RAMA moorings.

Dalhousie University's Ocean Tracking Network (OTN) program has deployed acoustic telemetry receivers on nearly all PIRATA moorings, adding additional biological monitoring capabilities to the array by tracking marine animals. Prior to these PIRATA additions, the OTN network of more than 1000 receivers worldwide were deployed primarily in coastal locations.

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 15 instruments are deployed on 7 moorings.

5.3 International cooperation and capacity building

A number of formal bilateral agreements have been created between agencies of the United States, India, Indonesia, Australia and ASCMLE to help complete and sustain RAMA. A 5-year Implementing Arrangement between NOAA and KKP expired in 2013. A new Implementing Arrangement between NOAA and Indonesia's Meteorological, Climate, and Geophysical Agency is being developed. The ASCLME Project ended in March, 2014. A program named SAPPHIRE to continue work in the area is being developed.

To facilitate and coordinate resources that may be applied to the Indian Ocean Observing System, an IndOOS Resource Forum (IRF) was established in 2009. The Forum will hold its fifth meeting in October 2014 in Phuket, Thailand.

The Korea Institute of Ocean Science & Technology (KIOST) maintains 3 subsurface ADCP moorings near TAO moorings along 165ºE. This work is being conducted under the context of a Joint Project Agreement between NOAA and the Ministry of Oceans and Fisheries, Republic of Korea. The 3rd “Korea-US Oceanic and Atmospheric S&T Workshop” was held in Vienna, VA, USA on 30 May 2014. Proposals are being solicited for a Korea-US cooperation project named “Blue Ocean”. Korea plans to launch a new research vessel in 2016, with the potential for support of TAO/TRITON and/or RAMA.

Three engineers from NIOT visited PMEL and NDBC in August 2013 during which time they gained knowledge of NOAA’s mooring systems, instrument preparation, and data processing. One member of the NIOT team joined PMEL and INCOIS on a Bay of Bengal cruise in November/December 2013 on which a RAMA mooring was enhanced with CO_2 and other biochemical instrumentation.

Dr. Chunlin Ning from FIO’s Bai-Long mooring project is visiting PMEL for a six-month period in 2014. In addition to reviewing PMEL’s mooring designs and instrument preparation, a side-by-side, land-based comparison of PMEL and FIO meteorological sensors will be documented to ensure uniformity in RAMA observations. Dr. Ning also intends to join PMEL and AOML on a PIRATA cruise in January 2015.

5.4 Research experiments

The US is conducting a multi-year (2008-2014) process study within RAMA with the addition of 9 subsurface ADCP moorings in the region spanning 2.5°N to 4°S and 78°E to 83°E.

A new initiative, the Second International Indian Ocean Expedition (IIOE-2) is under development for 2015-2020.

5.5 Vandalism

Damage to buoys and theft of instrumentation continues to be a concern, especially at sites near areas of intense fishing activity such as the far eastern and western equatorial Pacific, the Gulf of Guinea and equatorial Indian Ocean. In response, some TRITON sites which have been vandalized heavily are now deployed without meteorological sensors. Details and metrics of vandalism experienced in TAO/TRITON, PIRATA and RAMA are given in the DBCP Working Group on Vandalism Report.

5.6 Piracy

In addition to vandalism, well-publicized piracy events have resulted in the delay of RAMA implementation off Africa and in the Arabian Sea. Lloyds of London defines an Exclusion Zone (EZ) north of 12°S and west of 78°E in which additional premiums apply to insure commercial vessels. INCOIS contracted Sea Marshalls to be stationed aboard MoES RAMA cruises within the EZ in 2012 and 2013. South Africa would not permit the RV Algoa to enter the EZ in 2013. Although pirate attacks have diminished in the past several years, both in number and distance from Somalia, Lloyds has not reduced the area of the EZ. Given the reduction in threat, an August 2014 PMEL/INCOIS RAMA cruise entered the EZ, during which time best anti-piracy practices were performed, but without security personnel on board. The cruise was fully successful, implementing 2 new moorings near 0°, 67°E, and completed without incident. Reported pirate attacks in the Gulf of Guinea have increased in number, exceeding those in the Indian Ocean.

While primarily occurring in near shore waters and far from PIRATA moorings, these reports are of concern for future cruises in that region.

	2010	2011	2012	2013	2014 (through August)
Vessels Hijacked	51	27	7	0	0
Vessels Boarded	16	17	1	0	0
Vessels Fired Upon/ Attempted Boarding	119	122	24	9	2

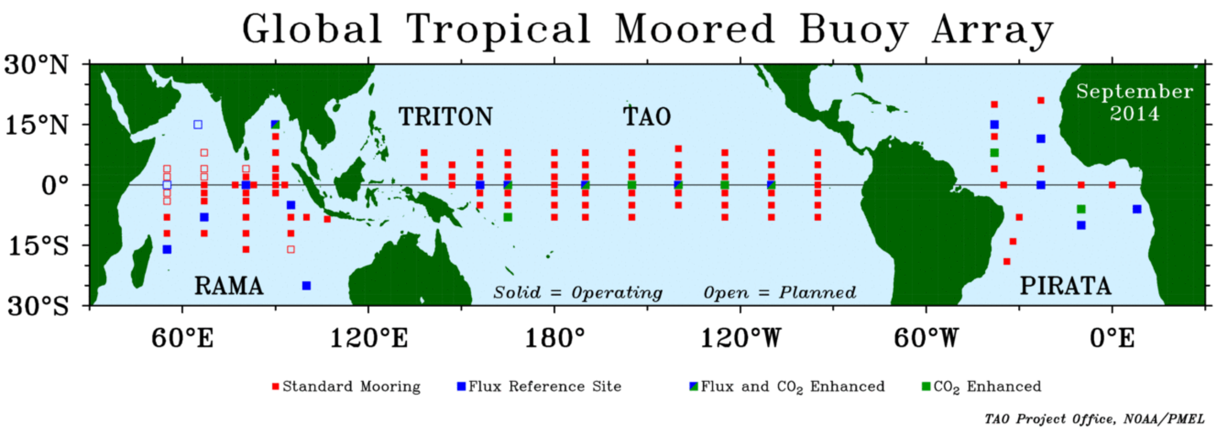
Table of reported acts of piracy in the Indian Ocean from 2010 to 2014.
Source: U.S. Office of Naval Intelligence

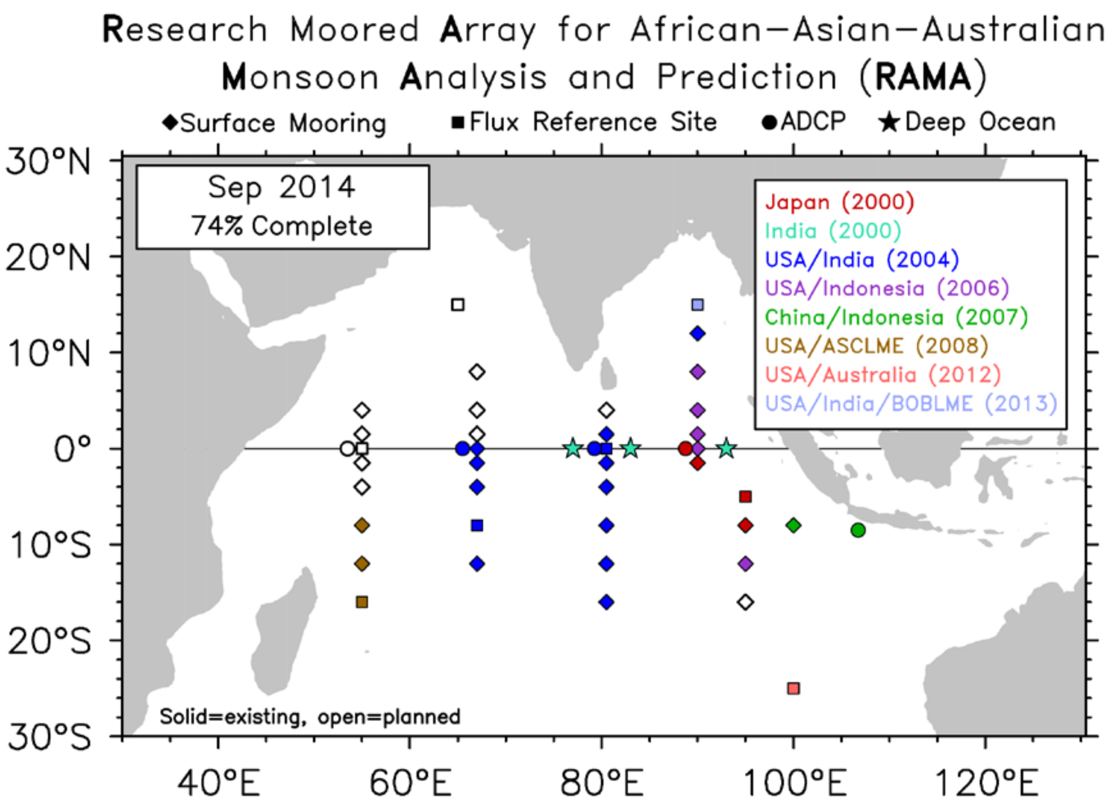
5.7 Retirement of some Pacific TRITON Sites

In 2000 JAMSTEC assumed responsibility for 12 TAO sites between 137°E and 156°E, which established the TAO/TRITON array. At the same time, JAMSTEC established 4 additional TRITON moorings along 130° and 138°E. Several TRITON mooring sites have been retired in the past 2 years: 3 of the 130°/138°E sites in 2013, and 2 of the original TAO/TRITON sites in 2014. Two additional sites are to be retired in 2015. JAMSTEC plans to continue maintenance of 8 of the original 12 TAO/TRITON sites.

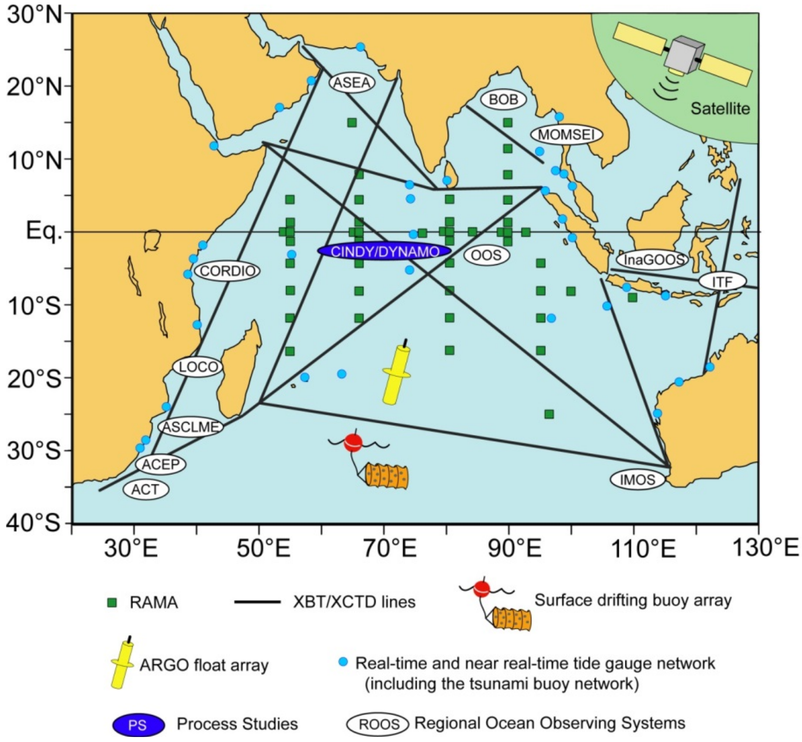
Annex

Status maps and graphics

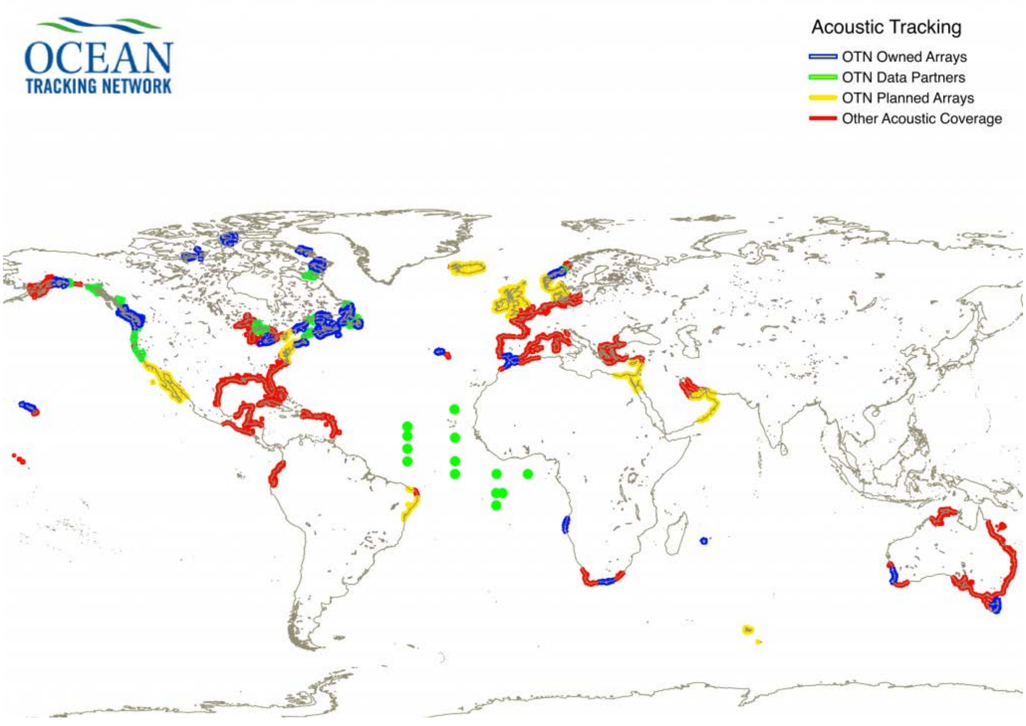




Indian Ocean Observing System (IndOOS)



OCEAN TRACKING NETWORK
Including PIRATA sites in tropical Atlantic



APPENDIX C

REPORT BY THE EUCOS SURFACE MARINE PROGRAMME (E-SURFMAR)

(Report submitted by Jean Rolland, Météo France)

1) Summary

Name of Action Group	**Operational Service of the Network of European Meteorological Services, EUMETNET (E-SURFMAR)**
Date of report	31 July 2014
Overview and main requirements addressed	The EUMETNET operational service E-SURFMAR is an optional programme involving 19 out of the 31 EUMETNET members, who fund the activity on a GNI basis. Its main objectives are to coordinate, optimise and progressively integrate the European meteorological services activities for surface observations over the sea – including drifting and moored buoys, and voluntary observing ships. E-SURFMAR is responsible for coordination of buoy activities carried out by the European meteorological services, and the programme supports a Data Buoy Manager (DBM) to manage these activities. The DBM is supported and advised by the E-SURFMAR Expert Team-Data Buoy (ET-DB). E-SURFMAR ET-DB is an action group of the DBCP.
Area of interest	Ocean areas potentially affecting NWP over European countries. This covers the North Atlantic Ocean north of 10°N and the Mediterranean Sea (90°N-10°N; 70°W - 40°E).
Type of platform and variables measured	Drifting buoys: air pressure, SST, (wind) Moored buoys: air pressure, wind, air temperature, SST, waves (directional spectra), relative humidity.
Targeted horizontal resolution	250 km x 250 km, >100 drifting buoys, 4 moored buoys for satellite calibration/validation.
Chairperson/Managers	Manager E-SURFMAR: Mr Pierre Blouch, Météo-France Chairperson, Expert Team-Data Buoy (ET-DB): Mr Jon Turton, UK Met Office
Coordinator	Data buoy Manager: Mr Gilbert Emzivat, Météo-France
Participants	Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, The Netherlands, Norway, Portugal, Serbia, Spain, Sweden, Switzerland, and the United Kingdom.
Data centre(s)	Météo-France as SOC ISDM (Canada) as RNODC/DB
Website	http://www.eumetnet.eu/, http://esurfmar.meteo.fr (restricted working area web site for E-SURFMAR participants)
Meetings	ET-DB meets once a year. ET-DB11 Exeter 21-22 May 2014
Current status (mid-2014)	109 E-SURFMAR drifting buoys in operation (74 Iridium, 35 Iridium upgrades) + 50 others reporting AP. 4 E-SURFMAR supported moored buoys in operation, plus a further 45 others operated by members.
Summary of plans for 2015	Maintain a network of 100 drifting buoys, and the 4 reference moored buoys in operation.

2 Deployment plans for 2015

The drifting buoys will be deployed from various locations (Canada, Iceland, France, Norway, UK, USA, ...) in the Atlantic Ocean. Drifters from GDP are regularly upgraded with barometers and deployed in the North Atlantic Ocean by vessels plying from North America to Iceland, from North America to Europe and from Europe to North America. Within the allocated budget more than 100 buoys (including 30 upgrades (Iridium)) will be deployed in the E-SURFMAR area of interest in the coming twelve months. New deployment routes will be investigated.

E-SURFMAR will continue to be involved in the GHRSST/DBCP Pilot Project in which the DBCP collaborates with the Group on High Resolution Sea Surface Temperature (GHRSST) to make measurements of 0.01°C precision from drifters.

E-SURFMAR will continue to deploy buoys in the Arctic Ocean through IABP.

The 4 E-SURFMAR moored buoys K5 (59.1N – 11.5 W), M6 (53.1N – 15.9W), Cabo Silleiro (42.1N – 9.4W) and Lion (42.1N – 4.7E) are operated by United Kingdom, Ireland, France and Spain. At present, Cabo Silleiro, K5 and Lion are equipped to report directional wave spectra. Spectra data from K5 and Lion are disseminated on GTS by the Met Office. It is expected that a version of the system developed by the Met Office for K series buoys will be also installed on M6 in due course.

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

ESURFMAR encourages free and open access to data, in the spirit of WMO data exchange policy defined in WMO Congress Resolution 40 (Cg-XII). All basic meteorological and oceanographic data are coded in the appropriate WMO code forms and disseminated on the WMO Global Telecommunication System (GTS)

3.1.2 Real-time data exchange

All the data are put on the GTS as quickly as possible.

The processing chain at Météo-France producing GTS reports from Iridium SBD data was consolidated. The chain is able to produce FM13-SHIP, FM18-BUOY or FM94-BUFR messages. The distribution of BUFR messages allows to transmit the data of the drifters having a resolution of 0.01K for SST.

All the drifters operating are now using Iridium. This improves the data timeliness (see Annex). The number of daily observations carried out on to the GTS was about 2,500. The target (90%) of the percentage of data received within 50 minutes was maintained. This results from efforts made during recent years to have all buoys reporting through Iridium.

The mean lifetime (for Air Pressure) of the SVP-B drifters increased to 357 days (253 days last year). One hundred and eight buoys failed to report air pressure measurements.

The availability of moored buoy data depends on the number of buoys operating. More than 80 hourly observations per day, except one gap in February and March 2014 due to M6 's breakdown, have been reported from E-SURFMAR buoys to the GTS.

3.1.3 Delayed mode data exchange

The raw data from drifters are archived at “Centre de Meteorologie Marine” (CMM) at Meteo-France.
Data inserted onto the GTS are routinely archived by various centres (for drifting buoys ISDM, GDP, Coriolis…, Meteorological Services for drifting and moored buoys).
Archived data from drifters are also used to produce surface currents deduced from the buoys movement on a weekly basis
The metadata collection system at JCOMMOPS is used for drifting buoys.
E-SURFMAR members are invited to compile Moored Buoy Metadata in line with the metadata variables defined on the DBCP website (http://www.jcommops.org/dbcp/data/metadata.html).

3.2 Data quality

The web page giving access to the Quality Control (QC) tools was maintained. The transmission delays onto the GTS are monitored (see http://www.meteo.shom.fr/qctools). Monthly statistics and 14-day graphs are available for all surface marine observations through the same interface. Buoys reporting in BUFR are monitored as those reporting through BUOY or SHIP alphanumeric messages. The blacklists, automatically issued for air pressure every day, are used to identify and correct potential problems.

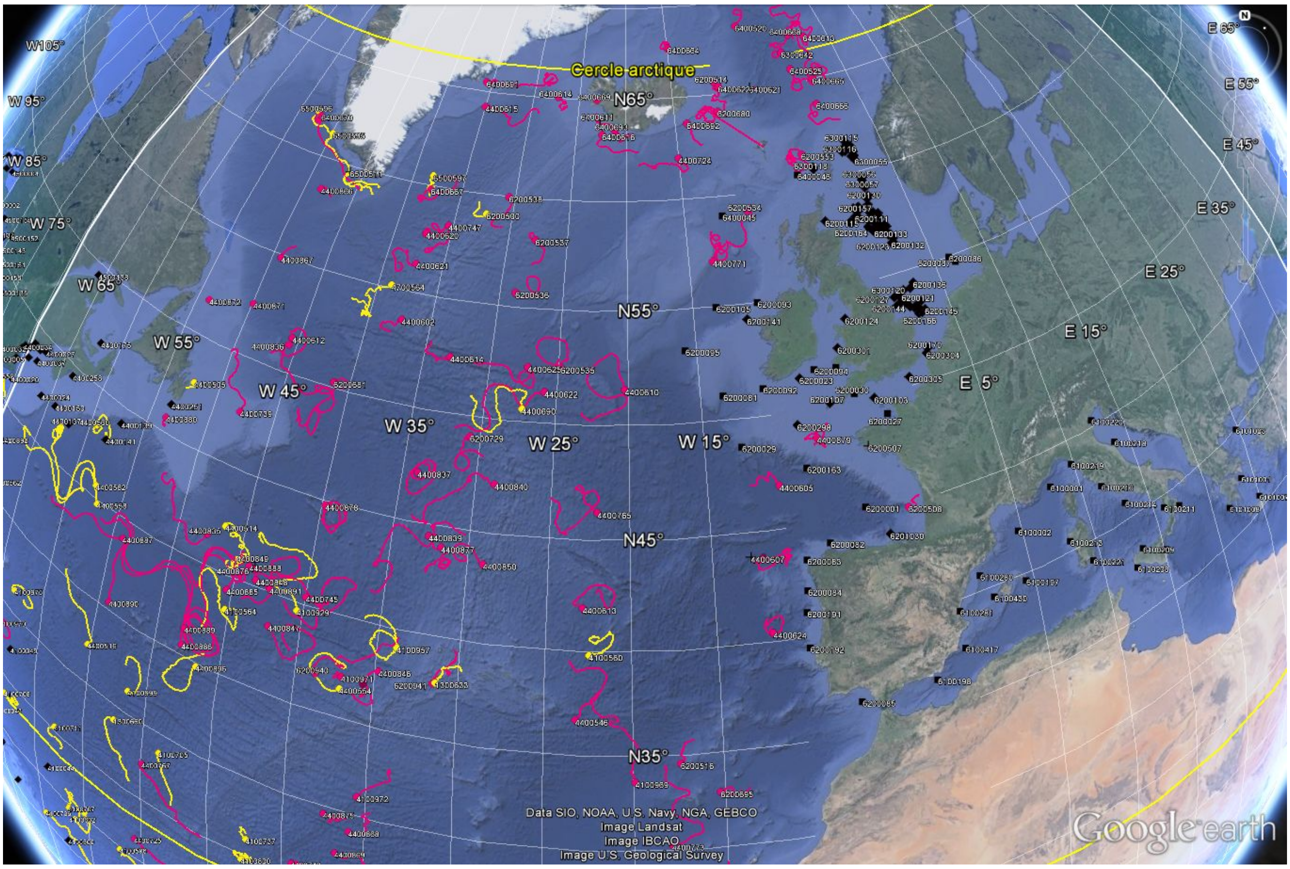
For drifters the Air Pressure (AP) differences from the French model outputs the target of 1% of Gross Errors was achieved. The RMS of AP differences (about 0.5 hPa) still has a seasonal variation, being higher in winter than in summer.

For moored buoys the Air Pressure (AP) differences with the French the target of 0.5% of Gross Errors was achieved. The RMS of AP differences was about 0.6 hPa.

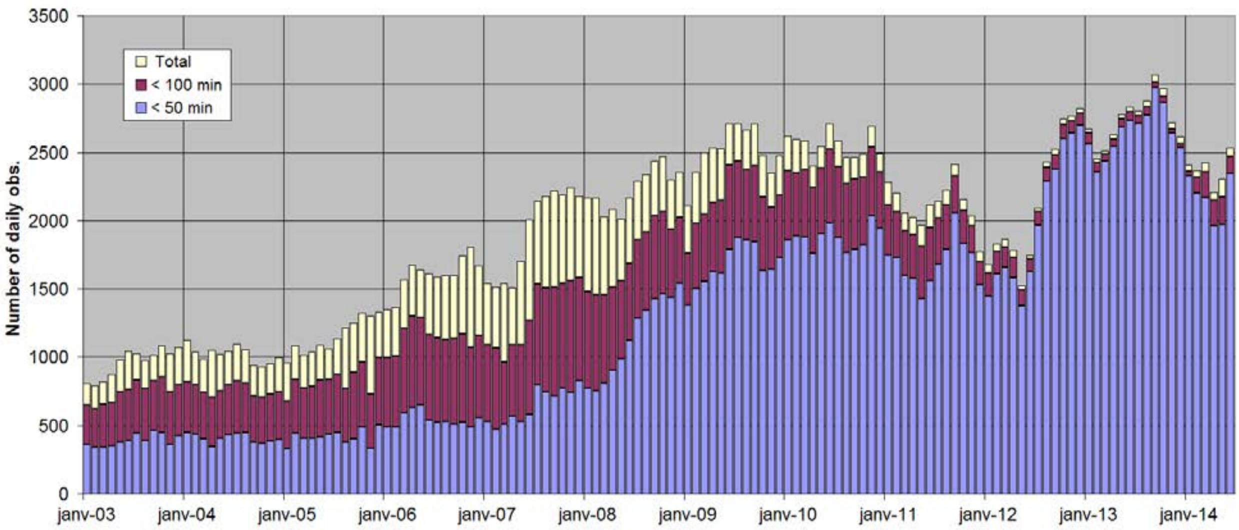
4) Instrument practices

ESURFMAR drifting buoys uses recommended DBCP formats.

Annex



Drifting buoy trajectories and moored buoy positions
(June 2014)



Drifting buoys data availability

APPENDIX D

REPORT BY THE INTERNATIONAL BUOY PROGRAMME FOR THE INDIAN OCEAN (IBPIO)

(Report submitted by Jean Rolland, Météo France)

REPORT BY THE DBCP ACTION GROUPS TO THE THIRTIETH SESSION OF THE DBCP

(Weihai, China, 27-31 October 2014)

1) Summary

Name of Action Group	**International Buoy Programme for the Indian Ocean (IBPIO)**
Date of report	28 October 2014
Overview and main requirements addressed	The International Buoy Programme for the Indian Ocean (IBPIO) was formally established at a meeting in La Reunion in 1996. The primary objective of the IBPIO is to establish and maintain a network of platforms in the Indian Ocean to provide meteorological and oceanographic data for both real time and research purposes. More specifically, the IBPIO supports the World Weather Watch Programme (WWW); the Global Climate Observing System (GCOS); the World Climate Research Programme (WCRP); the Global Ocean Observing System (GOOS); tropical cyclone forecast and monitoring; as well as the research activities of the participating institutions. The programme is self-sustaining, supported by voluntary contributions from the participants in the form of equipment and services (such as communications, deployment, storage, archiving, co-ordination...).
Area of interest	Indian Ocean North of 55°S and between 25°E and 120°E (130°E in the North of Australia)
Type of platform and variables measured	Drifting buoys: Air pressure, SST, (wind) Moorings: air pressure, wind, air temperature, SST, waves, relative humidity, SSS, current…
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Mr Graeme Ball, BoM, Australia
Coordinator	Mr Gilbert Emzivat, Météo-France
Participants	Australia (ABOM), France (Météo-France), India (NIO, NIOT, INCOIS), Kenya (KMD), South Africa (SAWS), Mozambique (EMU); USA (GDP, Navoceano), TIP (Tropical Moored Buoy Implementation Panel).
Data centre(s)	ISDM (Canada) as RNODC/DB, Météo-France as SOC AOML, NOAA/PMEL
Website	http://www.shom.fr/meteo/ibpio

Meetings	Annual meetings in conjunction with DBCP meetings. IBPIO 17 in WeiHai (China) in October 2014
Current status (mid-2014)	236 drifters (213 with Air Pressure) 47 moored buoys (32 for RAMA 70% of the planned 46 site array)
Summary of plans for 2015	Maintain a network of 150 drifters at least. Maintain the moored buoy arrays.

2 Deployment plans for 2015

IBPIO participants are regularly encouraged to maintain their contributions of buoys, or to fund barometers to equip SVP drifters provided by GDP. Météo-France, ABOM and SAWS, regularly, fund barometer upgrades in the Indian Ocean. More than 200 drifters are planned to be deployed during the next intersessional period, of which 1/4 at least will be equipped to transmit through Iridium (Action by ABOM, GDP, Météo-France).

Efforts are aimed at filling data gaps in the tropical regions, primarily during the Tropical Cyclone season. In the southern tropical area the buoys are provided by NOAA/GDP and will include about 10 (Iridium) barometer upgrades funded by Météo-France. The ABOM is likely deploy 15 drifting buoys between the central Indian Ocean and the Australian coast. NIO plans to continue to provide and deploy drifters in the Arabian Sea and in the Bay of Bengal (about 30 in 2014-2015).

RAMA maintenance will continue in the coming year with a potential for sea days to be provided by up to 6 countries in support of up to 34 moorings. The number of research vessels in the Indian Ocean capable of mooring maintenance is limited. The number of moorings actually serviced will be dependent on the availability of ship time.

NIOT is maintaining a network of 12 deep sea buoys with subsurface measurements radiation and precipitation sensors (Ocean Observation Systems, OOS): there are 7 sites in the Bay of Bengal and 5 in Arabian Sea. These OMNI buoys are similar to RAMA moorings but also include current measurements. Another Indian made OMNI buoy, designed to collect and transmit 104 parameters, is installed and working in Arabian Sea. These OMNI buoys systems have given new scientific in-sight into oceanic processes during cyclones in the Bay of Bengal, and provided valuable data during land fall of Cyclone Phailin, resulting in the saving of many lives. NIOT also operates 5 tsunami buoys and has installed 4 coastal buoys. A newly designed buoy with video cameras off Goa, on the west coast of India, provides live video streaming through 3G telemetry. The Indian satellite INSAT provides data calibration and validation of a twin buoy with fluorescence sensor in Arabian Sea. Additionally, 2 drifters designed by India, were successfully tested at sea using INSAT telemetry. India plans to install a mooring in Southern Ocean in 2016 for biogeochemical studies. Under an INDO US collaborative project, one FLUX mooring by WHOI USA will be installed in Bay of Bengal during November 2014

In the southern part of the Indian Ocean (South of 40S), the deployment of SVP-B drifters provided by GDC and upgraded by Météo-France (about 20 Iridium units) should continue. The ABOM expects to deploy 13 SVP-B drifters in this area over the next 12 months including 8 upgrades. These deployments will be supported by the RV Marion Dufresne during her rotations between La Reunion, Crozet, Kerguelen and Amsterdam Islands.

In addition to the drifters upgraded by Météo-France and ABOM, GDC plans to provide SVP-B drifters for deployment in the Southern Indian Ocean.

In the sub-tropics (between the Tropic of Capricorn and 35 S) the ABOM will most likely deploy 6 SVP-B, including 2 near the Indian Ocean Gyre.

The SAWS, through the PMO in Cape Town, will continue to coordinate the deployment of drifters on behalf of GDP, ABOM and Météo-France from voyages to Marion Island. The ABOM plans to provide 2 SVP-B buoys for deployment from the scheduled voyages in 2015.

As in previous years, the GDP remains the biggest contributor to the IBPIO, with about 150 planned drifters deployments (upgrades included).

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

IBPIO encourages free and open access to data, in the spirit of WMO data exchange policy defined in WMO Congress Resolution (Cg-XII). All basic meteorological and oceanographic data are coded in the appropriate WMO code form and inserted to the Global Telecommunication System (GTS)

3.1.2 Real-time data exchange

All the data are placed on the GTS as quickly as possible.

The processing chain at Météo-France producing GTS reports from Iridium SBD data was maintained. The chain is able to produce FM13-SHIP, FM18-BUOY or FM94-BUFR messages.

The use of the Iridium communication system continued. One hundred and twenty three drifters using Iridium were deployed (35 last year). This improves the data timeliness. Two hundred and ninety six drifting buoys (154 last year) were deployed of which more than 90% measured air pressure (SVP-B). The number of daily observations on the GTS decreased to 1500 by April 2013 (see Annex) due to the decline in number of operating drifters. By the end of 2013, the number of daily observationshad increased to 3000, and is now at about 5000. At the end of June 2014, the percentage of data received within 50 minutes was about 65%, due to the use of the Iridium system and the improvment of the Argos system in respect of timeliness.

In June 2014, 16 of the 26 RAMA surface moorings were reporting on the GTS (WMO ID's 14040, 14042, 14043, 23001, 23002, 23003, 23008, 23009. 23010, 53005, 53006, 53040, 53056, 53057, 56053, 56055), and all 12 deep sea NIOT moored buoys (7 in Bay of Bengal and 5 in Arabian Sea) were reporting.

3.1.3 Delayed mode data exchange

Data are routinely archived by various centres (for drifting buoys ISDM, GDP, Coriolis…, Meteorological Services for drifting and moored buoys).

Archived data from drifters are also used to produce surface currents deduced from the buoys movement on a weekly basis

The metadata collection system at JCOMMOPS is used for drifting buoys.

PMEL's Tropical Moored Buoy website displays and distributes the RAMA data (http://www.pmel.noaa.gov/tao/rama/).

3.2 Data quality

The transmission delays onto the GTS are monitored through the Météo-France QC tools webpage: http://www.meteo.shom.fr/qctools. Monthly statistics and 14-day graphs are available for all surface marine observations through the same interface. Buoys reporting in BUFR are monitored in the same manner as those reporting through the BUOY or SHIP character-based codes. The blacklists, automatically issued for air pressure every day, are used to identify and correct potential problems.

The number of daily messages sent onto the GTS increased from 1500 to about 5000 during the intersessional period.

For drifters the Air Pressure (AP) differences from the French model outputs were lower than 0.5% of Gross Errors. The RMS of AP decreased to 0.5 hPa.

4) Instrument practices

IBPIO drifting buoys uses recommended DBCP formats (DBCP-M2 for Argos, formats published on Iridium PP website for Iridium).

NIOT is following best of practise method vetted by NOAA MPEL and NDBC.

A mooring engineer from China's First Institute of Oceanography (FIO) is visiting PMEL from May through October, 2014. Instrumental design of PMEL and FIO mooring systems deployed in RAMA will be compared and data compatibility will be documented. He will also participate on a PIRATA mooring cruise in early 2015 to become familiar with PMEL field operation practices.

5) Issues: maintenance of moored buoys

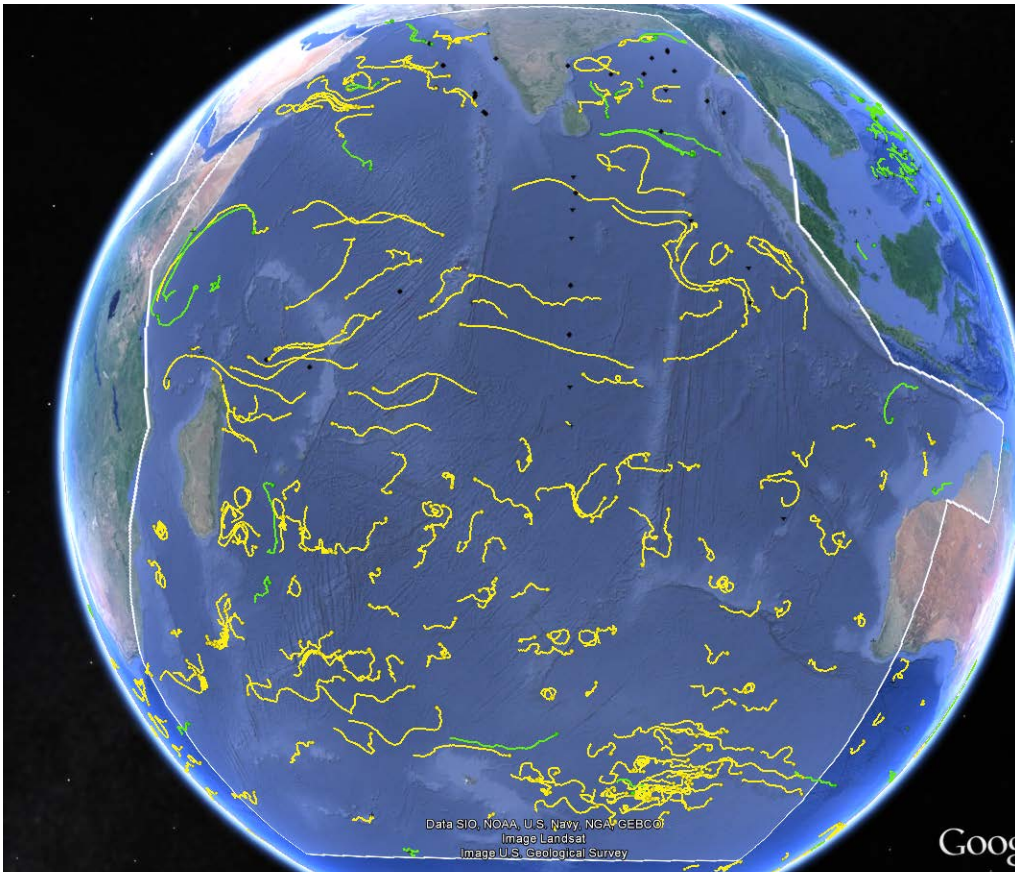
Between July 2013 and June 2014, 151 sea days were provided in support of RAMA sites. Sea days were provided by Japan, India, Indonesia, China and Australia. During this period 23 moorings were serviced, including the implementation of 1 new site at 1.5°S, 67°E. A PMEL ATLAS mooring deployed at 16°S, 55°E broke its mooring and became fixed on a reef in the Mozambique Channel. The mooring was recovered by the US Navy. Fifty-five (55) surface drifters and 20 Argo floats were deployed on RAMA cruises in the past year.

A PMEL ATLAS mooring in the Bay of Bengal was enhanced to include CO_2 measurements. This effort was a collaborative effort of PMEL, BOBLME and NIOT.

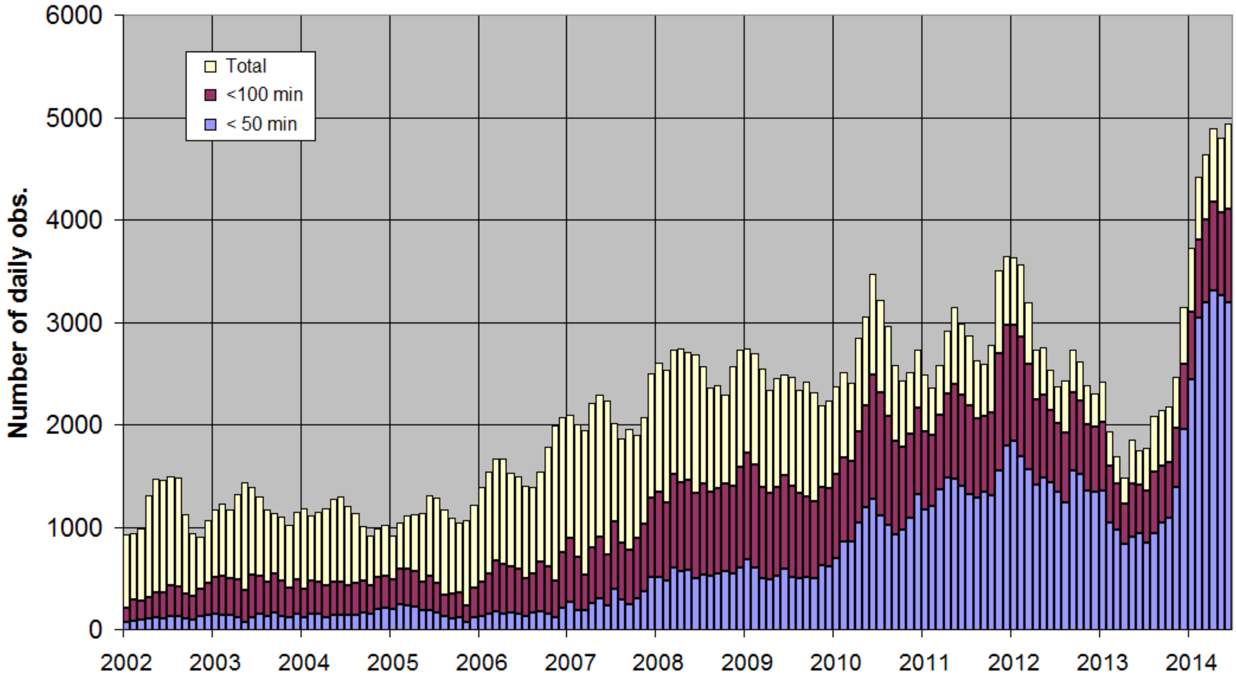
Damage to buoys and theft of instrumentation continues to be a problem, especially at sites near areas of intense fishing activity. In addition to vandalism, well-publicized piracy events have resulted in the suspension of RAMA implementation off Africa and in the Arabian Sea. The occurrence of piracy has decreased in recent years and events have largely been limited to areas near the Somalia coast and the Gulf of Aden. Despite the decline, Lloyds of London has not reduced the size of their Exclusion Zone. Based on the reduction in risk, RAMA cruises aboard Indian research vessels in the central equatorial Indian Ocean will be conducted in 2014 without embarking sea marshals for security.

In order to maintain Indian moored buoys between 2013 to 2014 eleven cruses were undertaken. Vandalism of Indian buoys has declined as a direct result of improving awareness amongst fishermen, regional cooperation and shifting to safer locations. No piracy incidents were reported in the Arabian sea.

ANNEX



Drifting buoys trajectories (June 2014)



Drifting buoys data availabilty

APPENDIX E

REPORT BY THE DBCP-PICES NORTH PACIFIC DATA BUOY ADVISORY PANEL (NPDBAP)

(Report submitted by Shaun Dolk, NOAA/AOML, USA)

1) Summary

Name of Action Group	**DBCP-PICES North Pacific Data Buoy Advisory Panel (NPDBAP)**
Date of report	31 July 2014
Overview and main requirements addressed	The goals of the NPDBAP are to deploy 60 SVPB drifters a year, and maintain 75 active buoys in the region.
Area of interest	North Pacific Ocean and marginal seas generally north of 30°N
Type of platform and variables measured	Lagrangian drifters measuring sea level pressure, SST, and sea-surface velocity
Targeted horizontal resolution	5° x 5°
Chairperson/Managers	Co-Chairperson for the NE Pacific: Chris Marshall, MSC, Canada Co-Chairperson for the NW Pacific: Position vacant and to be proposed by PICES
Coordinator	Mr Shaun Dolk, NOAA / AOML
Participants	Al Wallace, Chris Marshall, Joe Linguanti, Ignatius Rigor, and Shaun Dolk
Data centre(s)	Drifter Data Assembly Centre (DAC) Integrated Science Data Management (ISDM), Canada
Website	http://npdbap.noaa.gov/
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	Yearly meetings usually held in conjunction with DBCP meetings. Next meeting planned 24 September, 2013 in Paris, France
Current status summary *(mid-2013)*	From 01 August 2013 to 31 July 2014, 127 drifters were deployed in the North Pacific Ocean. Of the 127 drifter deployments, 109 units were equipped with barometer sensors and the remaining 18 drifters were standard SVP type drifters.
Summary of plans for 2015	The goal for 2015 is to deploy 100 drifters, of which, 70 drifters will be equipped with barometer sensors.

2 Deployment plans for 2015

Both the GDP and Environment Canada will continue to utilize ships of opportunity for drifter deployments, while also looking for new possibilities within the Canadian and United States Coast Guards.

3 Data management

3.1 Distribution of the data

The drifter Data Assembly Center (DAC) assembles, quality controls and interpolates data from approximately 1300 drifters per month from all GDP national and international partners, from all oceans of the world. These data are made available through the web with a delayed time of 3—4 months. As of the time of writing this report (July 2014), data are available through Sep. 2013. These data can be accessed at http://www.aoml.noaa.gov/phod/dac/dacdata.php.

3.1.1 Data policy

The DAC, located at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) has access to drifters from GDP partners that have given Service Argos permission to make these data available to the DAC. In return the partners have access to all quality controlled and interpolated data available in the database via the World Wide Web. Non-interpolated quality controlled data and raw data are made available via ftp transfer upon request.

3.1.2 Real-time data exchange

All data from drifters in the GDP's programs are disseminated via GTS as soon as drifters are deployed. The GDP monitors data going out on the GTS, and transmissions of sensors producing bad data or transmissions from grounded drifters are removed from the GTS data stream.

The GDP does not monitor GTS data timeliness and relies on operational centres to report on these issues.

3.1.3 Delayed mode data exchange

Drifter data (raw Argos data, edited non-interpolated and interpolated data) are archived at AOML. These datasets are also sent once or twice a year with a 6-month delay to Integrated Science Data Management (ISDM), the RNODC for drifter data, for permanent archival and further distribution. The DAC is currently preparing to send data through Dec 2009 to ISDM.

Metadata for GDP drifters are received at the DAC directly from drifter manufacturers who send standardized specification sheets for batches of identical drifters prior of delivery of the instruments. Portions of this metadata are extracted and are made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dacdeployed.html. Specification sheets are archived at the DAC. Deployment date, date of last transmission, drogue off and cause of death metadata are determined during quality control of the dataset and are made available through the web at www.aoml.noaa.gov/phod/dac/dirall.html. These web pages are interrogated by JCOMMOPS to gather information for their metadata systems.

3.2 Data quality

4) Instrument practices

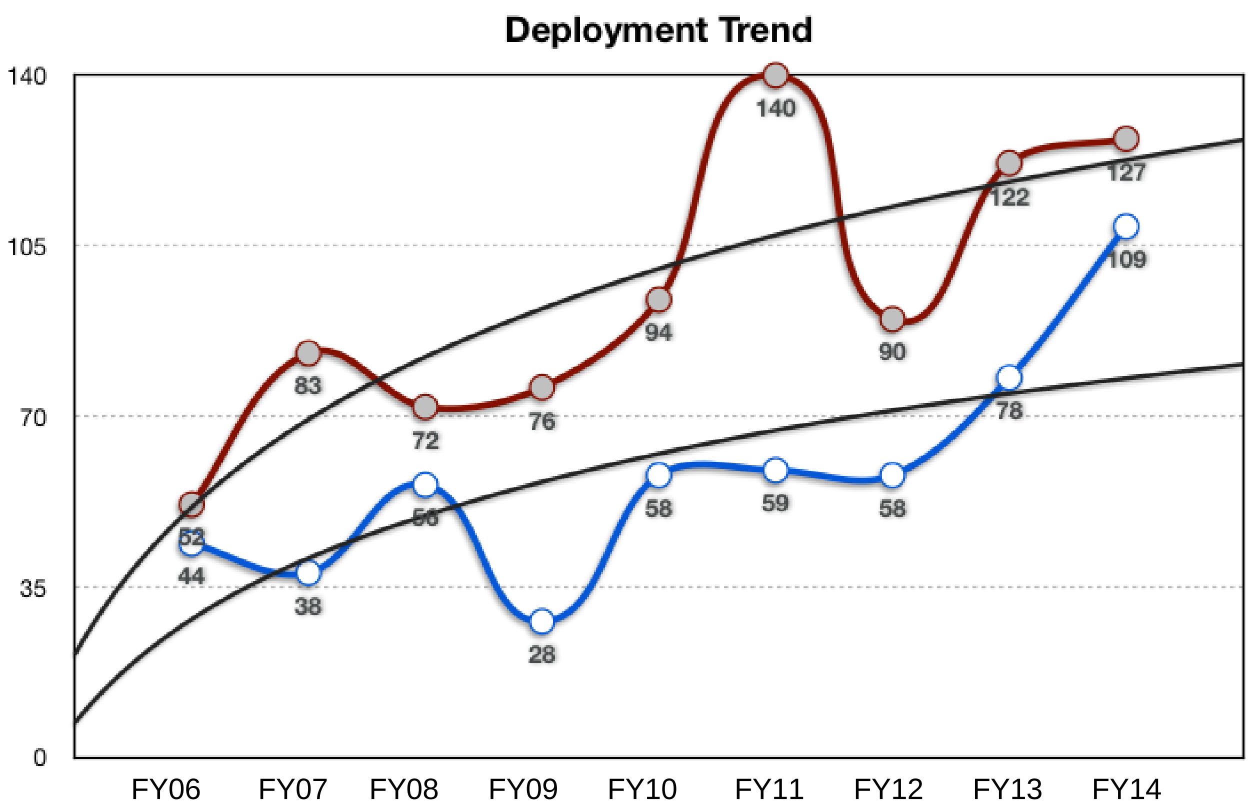
5) Other issues as needed

Annex (optional)

Status maps and graphics

Deployment Trend

	Total	SVPB	SVP	SVPW	SVPBW	SVPG
FY2006	52	44	6	0	2	0
FY2007	83	38	44	1	0	0
FY2008	72	56	16	0	0	0
FY2009	76	28	35	0	0	13
FY2010	94	58	13	1	0	22
FY2011	140	59	81	0	0	0
FY2012	90	58	32	0	0	0
FY2013	122	78	44	0	0	0
FY2014	127	109	18	0	0	0



=Total Deployments =SVPB Deployments =Logarithmic Trendline

APPENDIX F

REPORT BY THE INTERNATIONAL ARCTIC BUOY PROGRAMME (IABP)

(Report submitted by Ignatius Rigor, USA)

1) Summary

Name of Action Group	WCRP/SCAR International Programme for Antarctic Buoys (IPAB)
Date of report	1 October 2014
Overview and main requirements addressed	Participants of the IABP continue to work together to maintain a network of drifting buoys on the ice of the Arctic Basin to provide meteorological and oceanographic data for real-time operational requirements and research purposes including support to the World Climate Research Programme (WCRP) and the World Weather Watch (WWW) Programme.
Area of interest	Central Arctic Ocean and its marginal seas, excepting Exclusive Economic Zones, where agreements of the Coastal States have not been obtained
Type of platform and variables measured	Buoys on ice and/or in water measuring: Basic meteorological variables such as atmospheric air pressure and air temperature. Other variables such as: atmospheric pressure tendency, air chemistry (e.g. ozone), snow and sea-ice properties, as well as sub-surface oceanographic characteristics (e.g. temperature and salinity)
Targeted horizontal resolution	250 km x 250 km
Chairperson/Managers	Chairperson: Christine Best, Meteorological Service Canada
Coordinator	Ignatius Rigor, Polar Science Center, University of Washington, USA
Participants	Participants range from Science Institutions to Universities to Government Agencies. http://iabp.apl.washington.edu/overview_participants.html Participant contributions are shown on this site http://iabp.apl.washington.edu/overview_contributions.html
Data centre(s)	
Website	http://iabp.apl.washington.edu/
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	Annual meetings spring or early summer in the Northern Hemisphere. 24th Annual Meeting of the International Arctic Buoy Programme [IABP], hosted by the Alfred Wegener Institute Bremerhaven, GERMANY, May 26-28, 2014. We are tentatively planning to have our next meeting at the Polar Science Center,

	Applied Physics Laboratory, University of Washington in May, 2015.
Current status summary *(mid-2014)*	188 buoys were reporting, 133 of which have barometers, and/or surface temperatures sensors (Fig. 1).
Summary of plans for 2015	Summer is the primary deployment season in the Arctic. Participants will deploy 70+ buoys ranging from: SVP's providing surface air pressure, buoys providing air pressure and air temperature, Ice Mass Balance buoys, Oceanographic Profiling buoys measuring temperature and salinity to great depths and buoys that measure atmospheric air components such as ozone. Plans for future years will be similar.

2 Deployment plans for 2014

Deployment plans for 2015 will be posted on the IABP web page http://iabp.apl.washington.edu/overview_deploymentplans.html. As plans and opportunities for deployments become known, Participants are encouraged to contact the IABP Coordinator Ignatius Rigor Ignatius@uw.edu.

3 Data management

3.1 Distribution of the data

Most of the meteorological and oceanographic data is posted on the GTS. Much of the ice data and atmospheric chemistry data are available from Participants' web pages. Efforts continue to have those using Iridium communication to find means to post data to the GTS.

3.1.1 Data policy

Data exchange policies of the Participants for that data not getting onto the GTS has not been catalogued. However, most Participants have web sites that display data and/or graphs of the data.

3.1.2 Real-time data exchange

Details on percentage of data distributed on GTS.
Details on data timeliness (i.e. reception time at operational meteorological services minus observation time), including known problems, possible solutions, statistics, etc.

3.1.3 Delayed mode data exchange

Data are available from http://iabp.apl.washington.edu as well as ISDM. Data are also archived at the World Data Center for Glaciology (www.nsidc.org), the U.S. National Science Foundation's Cooperative Arctic Data and Information Service (www.AONCADIS.org).
Collection of and distribution of metadata is an ongoing task of the Coordinator. We plan to provide metadata through the IABP web server (iabp.apl.washington.edu), and produce netCDF data files containing the metadata information.

3.2 Data quality

Feedback is ad hoc. Data is suppressed when noted to be questionable. The IABP Coordinator participates in the buoy QC forums of the DBCP and JCOMM, and performs day-to-day QC of the data. More thorough QC of the data is performed during the analysis and production of the research data bases.

4) Instrument practices

We are currently in the midst of a sensor intercomparison for the various buoys/instruments that we use to observe polar meteorology and oceanography at the Arctic Observing Experiment (AOX) test site in Barrow, Alaska.

Data analyses procedures for the Arctic are documented in journal papers. As part of our efforts to collect and provide the metadata, details on instruments and other procedures will be provided through our web pages.

5) Other issues as needed

Our challenges remain the same, i.e. maintaining the network of buoys in an ocean of increasingly dynamic sea ice, and deploying buoys in the Eurasian Arctic.

Annex

Status maps and graphics

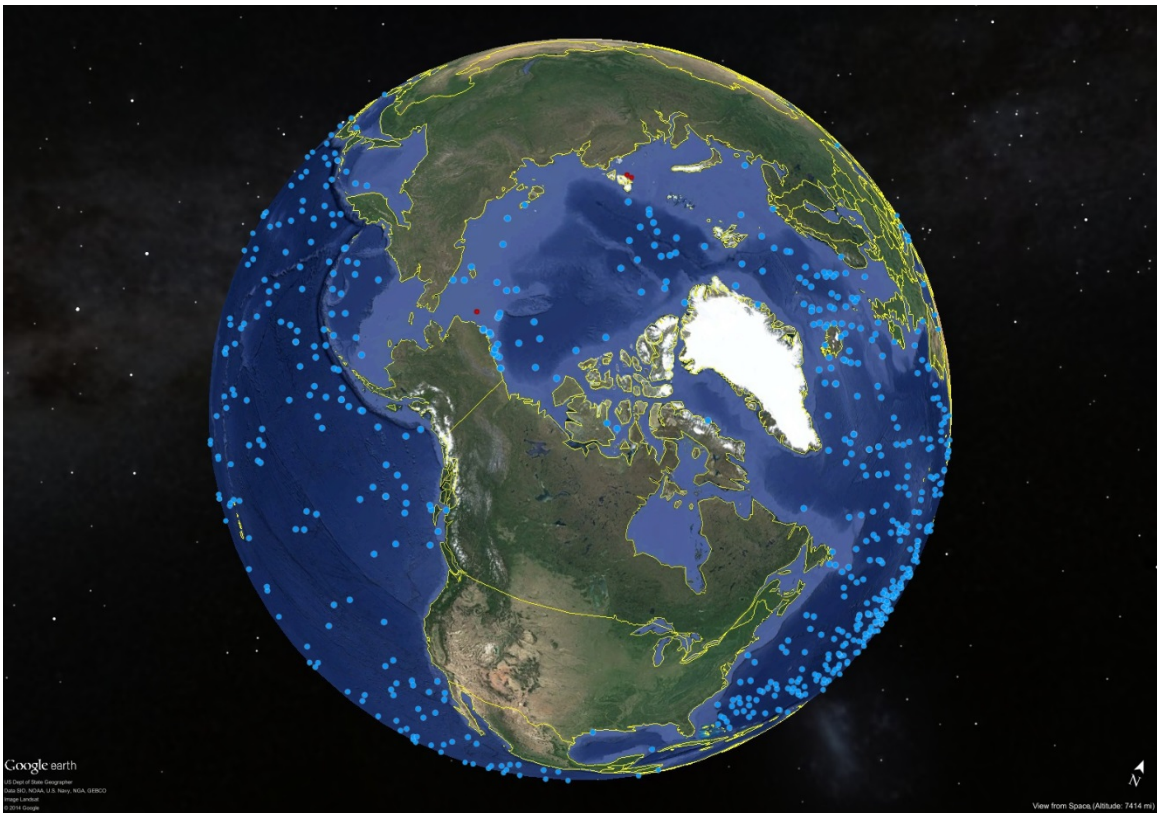


Figure 1. Map of buoy positions on May 2014 from JCOMMOPS. 188 buoys were reporting, 133 of which have barometers, and/or surface temperatures sensors. Many of these buoys were deployed in tight clusters in the Beaufort Sea north of Alaska.

APPENDIX G

REPORT BY THE WCRP-SCAR INTERNATIONAL PROGRAMME FOR ANTARCTIC BUOYS (IPAB)

(Report submitted by Christian Haas, Canada)

1) Summary

Name of Action Group	WCRP/SCAR International Programme for Antarctic Buoys (IPAB)
Date of report	31 Aug 2014
Overview and main requirements addressed	The Participants of the WCRP/SCAR International Programme for Antarctic Buoys (IPAB) work together to maintain a network of drifting buoys in the Southern Ocean, in particular over sea ice, to provide meteorological and oceanographic data for real-time operational requirements and research purposes. The IPAB was established in 1994 and became an Action Group of the Panel in October 1994.
Area of interest	South of 55°S and that region of the Southern Ocean and Antarctic marginal seas within the maximum seasonal sea-ice extent.
Type of platform and variables measured	Ice buoys measuring the following: Minimum variables: Buoy position Basic variables: Buoy position, atmospheric pressure and SST Other variables: Air temperature, ice and/or snow temperature, atmospheric pressure tendency, wind speed and direction, snow accumulation, other sea-ice properties and oceanographic variables
Targeted horizontal resolution	500 km x 500 km
Chairperson/Managers	Dr Petra Heil, AAD and ACE CRC, Hobart, Australia
Coordinator	Dr Christian Haas, York University, Toronto, Canada; Dr. Ignatius Rigor, University of Washington, Seattle, USA
Participants	- Alfred Wegener Institut, Germany - Australian Antarctic Division, Australia - Bureau of Meteorology, Australia - British Antarctic Survey, UK - Finnish Institute for Marine Research, Finland - GI, University of Alaska Fairbanks, USA - IARC, University of Alaska Fairbanks, USA - National Ice Center, USA - National Snow and Ice Data Center NSIDC, USA - ISDM/MEDS, Dept. of Fisheries and Ocean, Canada - Meteorological Service NZ LTD, New Zealand - Norwegian Polar Institute, Norway - Polar Science Center, Univ. of Washington, USA - National Institute of Polar Research, Japan - JAMSTEC, Japan - Programma Nazionale di Ricerche in Antartide, Italy

	- DAMTP, UK - SAMS, UK - York University, Toronto, Canada - CLS/Service Argos, France - South African Weather Service, South Africa- Meteorological Office, UK - CRREL, USA
Data centre(s)	Alfred Wegener Institute for Polar and Marine Research, Germany: http://www.pangaea.de/search?q=ipab National Snow and Ice Data Center NSIDC, USA: http://nsidc.org/data/docs/daac/nsidc0084_ipab_antarctic_buoys.gd.html
Website	http://www.ipab.aq/
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	An IPAB participants meeting was held in Hobart, Tasmania, on March 8, 2014, in conjunction with the IGS sea ice symposium. http://seaice.acecrc.org.au/igs2014/scientific_workshops/ipab-meeting/ IPAB participants reported during the annual meeting of the International Arctic Buoy Programme in Bremerhaven, Germany, on May 26-28, 2014. The next IPAB participants meeting may be held together with the annual IABP meeting, scheduled to take place in Seattle, WA, in May or June 2015.
Current status summary *(mid-2014)*	1. >50 buoys were deployed during AWI Polarstern cruises in Weddell Sea, June - Aug 2013 and Jan-Mar 2014. Buoys of various types (SVP, IMB, snow, AWS) contributed by AWI, Ant CRC, FMI, WHOI. 2. 10 SVPs were deployed by USIPAB during NPB cruise in Feb 2014, in Ross Sea sector between 140 and 150 W, 55 and 65 S The Meteorological Services of South Africa, Australia, and New Zealand continue to operationally deploy numerous SVP's in the Southern Ocean, primarily north of the sea ice edge.
Summary of plans for 2015	Main deployments will be during a German icebreaker cruises to the Weddell Sea in Dec 2014/Jan 2015, and during USIPAB cruise to Ross/Amundsen Sea in January/February 2015.

2 Deployment plans for 2015

- AWI Polarstern cruise to Weddell Sea (ANT 30-3), Dec 2014 - Jan 2015; have plans to deploy 6 snow and IMB buoys, 12 SVPs, 2 Bio-Phys stations; invite additional contributions by other participants
- The USIPAB program will continue to deploy a number of buoys in the Ross/Amundsen/Bellingshausen Sea during February and March 2015.
- The Meteorological Services of South Africa, Australia, and New Zealand will continue to operationally deploy numerous SVP’s in the Southern Ocean, primarily north of the sea ice edge.

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

Data are generally freely distributed among IPAB participants as part of general scientific collaboration. Participants are encouraged to submit their data to the IPAB coordinator upon completion of their own scientific analyses.

3.1.2 Real-time data exchange

Participants are encouraged to transmit their data to the GTS. Most of the buoys deployed by the USIPAB program transmitted to the GTS. Other participants are overwhelmed by new requirements due to increased usage of Iridium transmission.

3.1.3 Delayed mode data exchange

We work closely with the Integrated Science Data Management Service (ISDM) of the Department of Fisheries and Ocean (DFO), Canada on the reception, archiving, and posting of IPAB GTS data.

3.2 Data quality

Data quality is an ongoing issue. QC is performed by the individual science groups, or by some national data centres and the DBCP when data are transmitted to the GTS.

4) Instrument practices

N/A

5) Other issues as needed

- GTS transmission of data remains a challenge; need to raise awareness of buoy operators
- Small number of buoys and short survival times remain important challenges, as does GTS transmission.
- Need boost for YOPP

Annex (optional)

Status maps and graphics

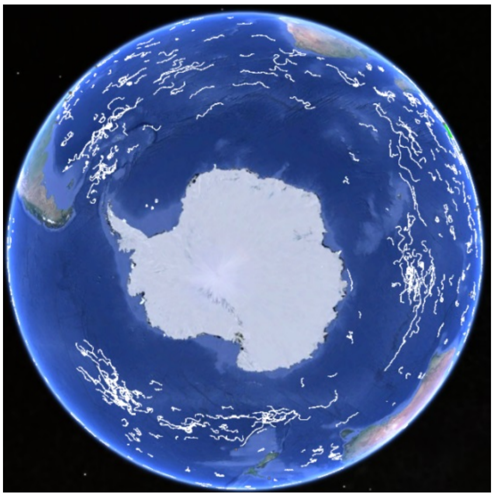


Figure 1: Status of Southern Ocean GTS buoy network, June 2014. Downloaded from the Integrated Science Data Management Service (ISDM) of the Department of Fisheries and Ocean (DFO), Canada (http://isdm.gc.ca/isdm-gdsi/drib-bder/KML/MonthlyKML-eng.htm)

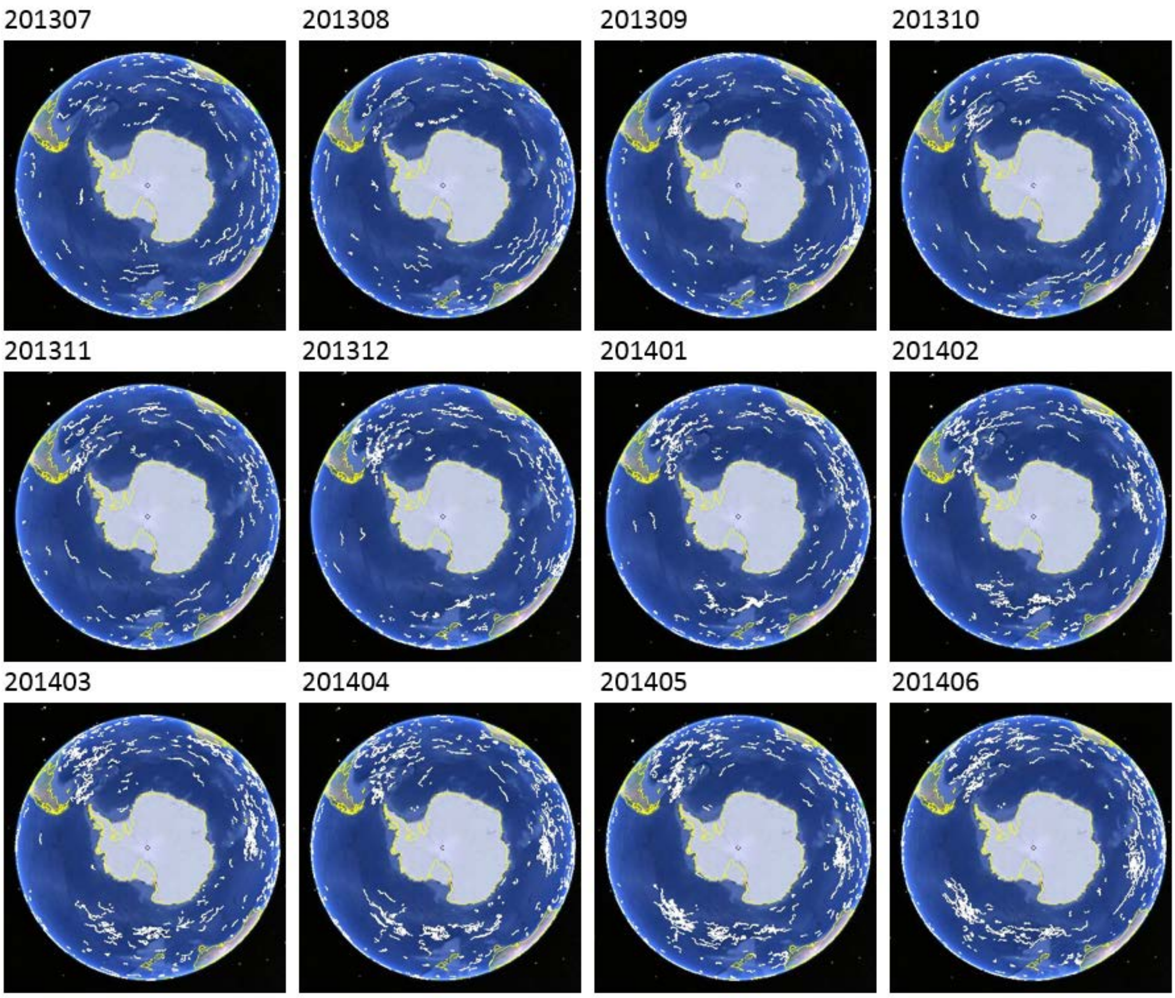


Figure 2: Status of Southern Ocean GTS buoy network, July 2013 to June 2014. Downloaded from the Integrated Science Data Management Service (ISDM) of the Department of Fisheries and Ocean (DFO), Canada (http://isdm.gc.ca/isdm-gdsi/drib-bder/KML/MonthlyKML-eng.htm)

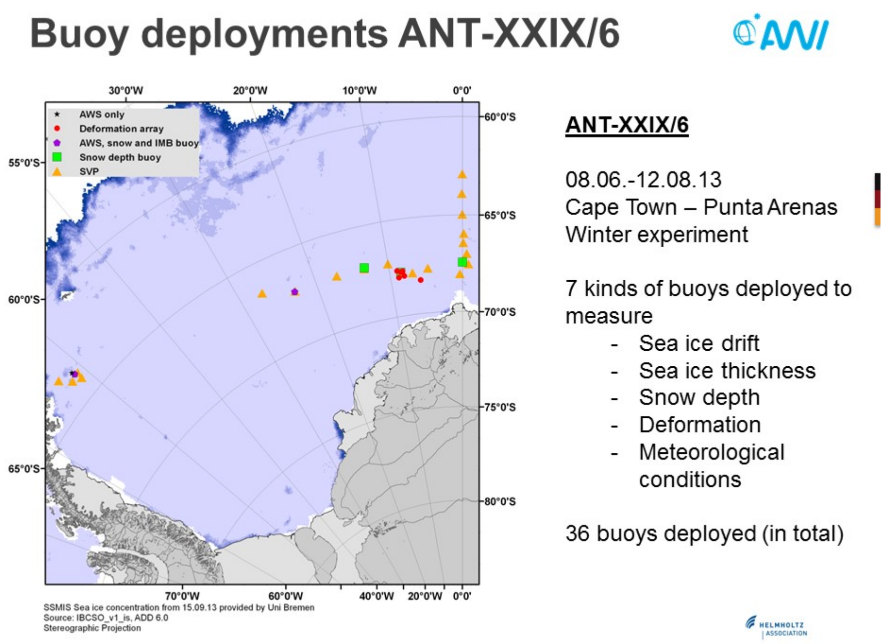


Figure 3: Buoy deployments by Alfred Wegener Institute (AWI) during Polarstern cruise Ant 29/6. Map provided by Sandra Schwegmann (AWI).

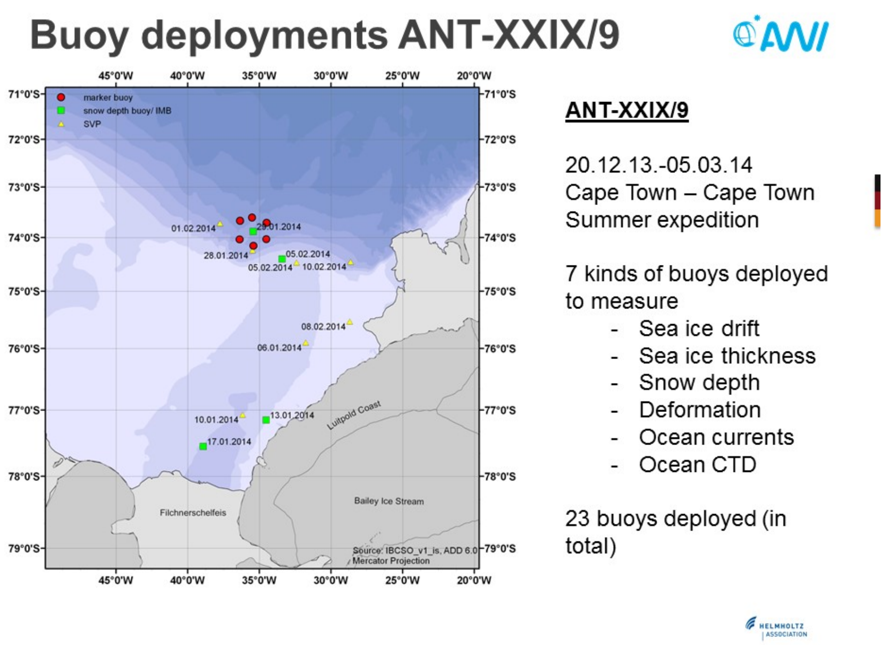


Figure 4: Buoy deployments by Alfred Wegener Institute (AWI) during Polarstern cruise Ant 29/9. Map provided by Sandra Schwegmann (AWI).

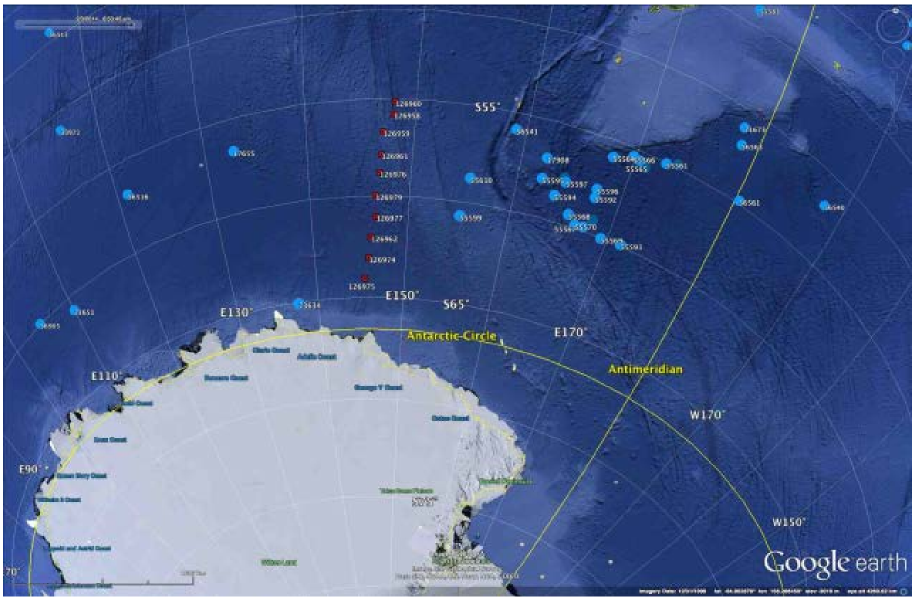


Figure 5: Deployments of SVPs by USIPAB in February 2014. Map provided by Ignatius Rigor (UW/PSC).

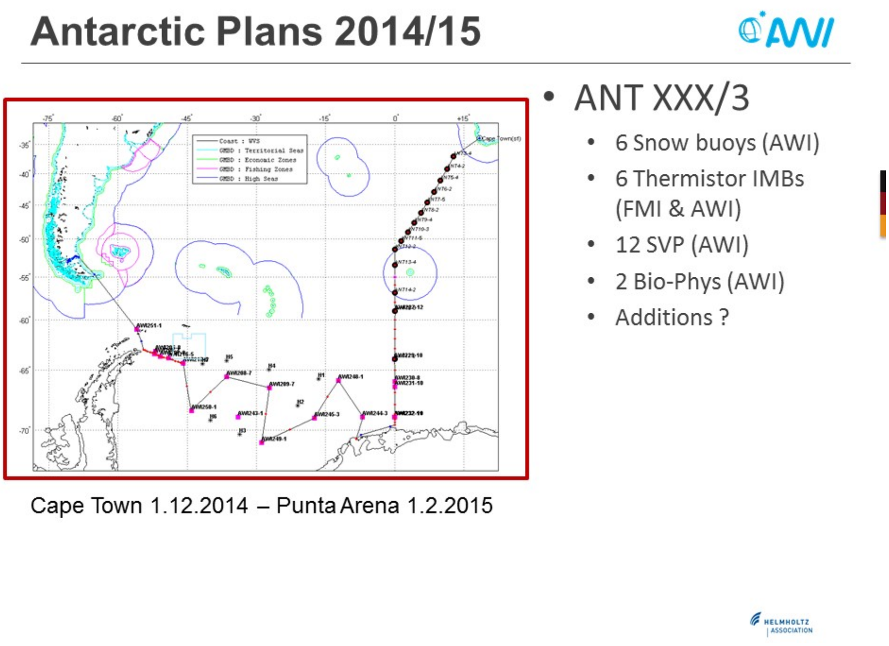


Figure 6: Planned buoy deployments by Alfred Wegener Institute (AWI) during Polarstern cruise Ant 30/3 in Dec 2014 / Jan 2015. Map provided by Marcel Nicolaus (AWI).

APPENDIX H

REPORT BY THE INTERNATIONAL SOUTH ATLANTIC BUOY PROGRAMME (ISABP)

(report submitted by Mayra Pazos, NOAA/AOML, USA)

1) Summary

Name of Action Group	
Date of report	31 July 2014
Overview and main requirements addressed	The main objective of ISABP is to establish and maintain a network of platforms in the Tropical and South Atlantic Ocean in order to provide meteorological and oceanographic data for both real-time and research purposes. The task includes support to the World Weather Watch Programme (WWW), the Global Climate Observing System (GCOS), the World Climate Research Programme (WCRP), and the Global Ocean Observing System (GOOS), as well as to the research activities of participating institutions.
Area of interest	South Atlantic Ocean north of 55S plus Tropical Atlantic Ocean up to 20N (90° W to 30°E)
Type of platform and variables measured	Lagrangian drifters measuring sea level pressure, SST, salinity and sea-surface velocity
Targeted horizontal resolution	5 degrees x 5 degrees
Chairperson/Managers	Mr Ariel Troisi, SHN, Argentina
Coordinator	Mayra Pazos, AOML-NOAA, USA Johan Stander, SAWS, South Africa, Santjie.DuToit, SAWS, SA
Participants	Countries interested in the region (Brazil, US, Argentina, South Africa, Tristan Is.)
Data centre(s)	Historical drifter data are assembled, quality controlled at AOML, Miami, then sent to ISDM for archival and further distribution. Real time data is also archived at ISDM, GTS is handled by the AOML GDP
Website	http://www.jcommops.org/dbcp/isabp/index.html http://www.oceatlan.org/isabp/en/
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	Meetings are held every other year, normally in May-July. Last meeting, ISABP- 13 took place in Buenos Aires, Argentina, on April 19, 2010
Current status summary *(mid-2013)*	As of September 8, 2014, there were a total of 154 drifters in the South Atlantic region, (66 SVP, 88 SVPB).
Summary of plans for 2015	Continue to address observational gap areas specially, in the Gulf of Guinea and Angola Basin; pursue recommendation of conducting studies and evaluate the impact of drifter pressure data and SST on the skills of numerical weather forecasting models for the region; continue to increase number of SVPB in the region.

2 Deployment plans for 2015

Details on deployment plans, and opportunities for next year.

Deployments during the last year (July 2013 through June 2014) are shown in Figure 1. There were a total of 110 drifters deployed in the region, 52 SVP, 52 SVPB and 6 with salinity sensors. Of the total number, 15 failed on deployment (12 SVP and 3 SVPB). Efforts to populate hard to reach areas (i.e. Gulf of Guinea and Angola Basin) continued during the intersessional period. Deployments were carried out by US vessels, the Brazilian Navy, South Africa Weather Service (SAWS), the Falkland Islands, Tristan da Cunha, South Thule fishing vessels and several others.

There were 49 drifters, all SVPBs, deployed between 55̊ S and 65̊ S in the South Atlantic that were part of a regional study from various groups, most of which made it to the ISABP region soon after deployment. This year there were far more than usual deployments in this area taking advantage of new opportunities such as the Brazilian Navy's Southern Ocean cruise in an effort to recover back to our array size goal of 1250 drifters in the water. Figure 2 shows these deployments.

The GDP deployment plans from June 1, 2013 – May 31, 2014 are as follows:

Tropical Atlantic (200S – 300N):	SVP=220	SVPB=80
Extra Tropical Atlantic (400S – 200S):	SVP=50	SVPB=25
Southern Atlantic (600S – 400S):	SVP=0	SVPB=115

There will be a reduction in the number of SVPBs deployed in the Extra Tropical Atlantic region, but the total number of deployments in the area remains the same.

3 Data management

3.1 Distribution of the data

These data are assembled and quality controlled at the GDP Drifter Data Assembly Centre. The historical data are available through the DAC web page (http://www.aoml.noaa.gov/phod/dac/dacdata.php), the near real time data (GTS data) are available through the web page: http://www.aoml.noaa.gov/phod/trinanes/xbt.html and from ISDM web (http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/drib-bder/index-eng.htm).
Brazilian Buoy Program has its data available at http://www.goosbrasil.org/produtos/pnboia.php, for moored and drifting buoys.

3.1.1 Data policy

Following current standards, ISABP promotes timely, free and open data exchange.

3.1.2 Real-time data exchange

All data from drifters are disseminated via GTS as soon as drifters are deployed. These data are monitored and taken off GTS when sensors stop giving good quality data. As of September 8, 2014, there were 154 surface drifters in the South Atlantic region transmitting good quality data on the GTS. (South Atlantic Region defined to be 200N to 550S). Last year there were 109 around the same time of the year.

3.1.3 Delayed mode data exchange

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Updates of the raw, quality controlled and interpolated data sets are sent to ISDM, the RNODC for drifter data, once a year, for further archival and distribution. AOML has sent data to ISDM through December 2011, and it is in the process of preparing a new update that will include data through December 2013. The delay in the data submission was due to a change of processing systems at AOML.

Metadata from GDP drifters are collected at the DAC directly from the manufacturers, archived and made available on the deployment log at the DAC web page www.aoml.noaa.gov/phod/dac/deployed.html

3.2 Data quality

4) Instrument practices

5) Other issues as needed

Figure 3 shows the status of the drifter array in the region. As of September 8, 2014 there were a total of 154 drifters actively reporting, 66 SVP and 88 SVPBs.

Annex (optional)

Status maps and graphics

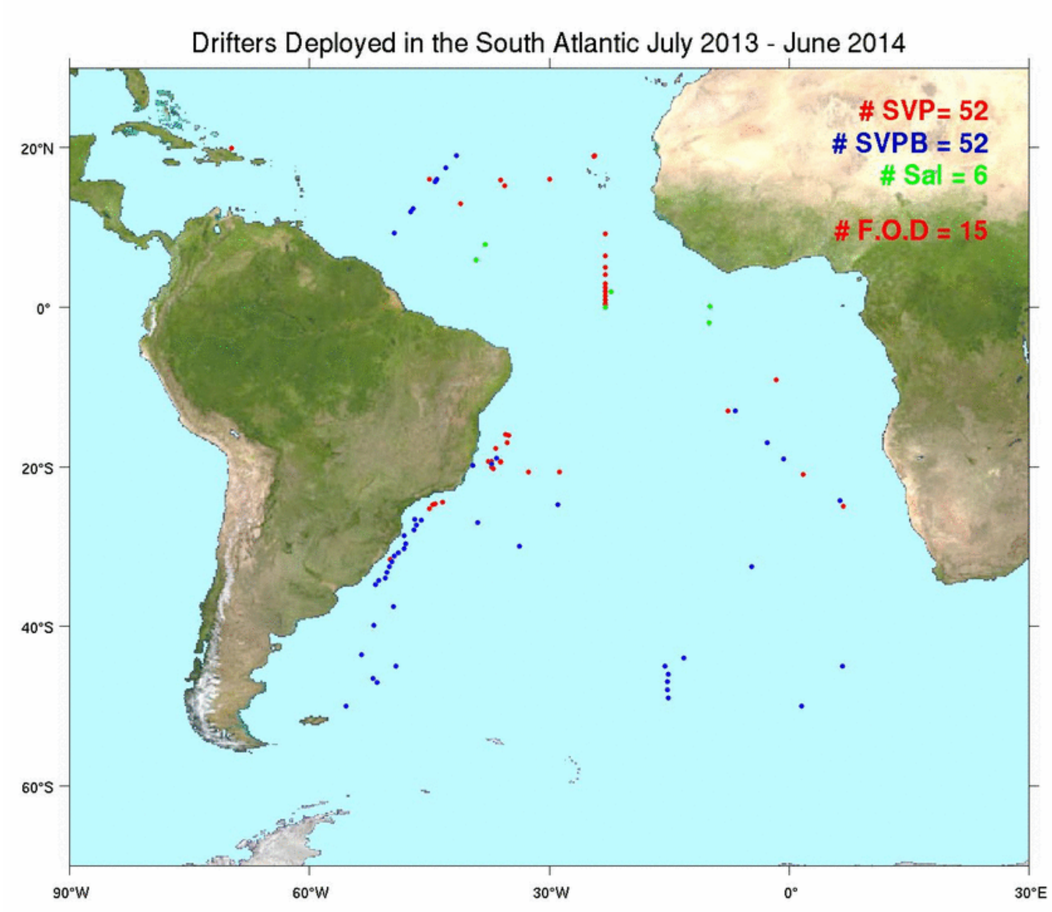

Figure 1. Deployment locations. A total of 110 drifters were deployed in the area.

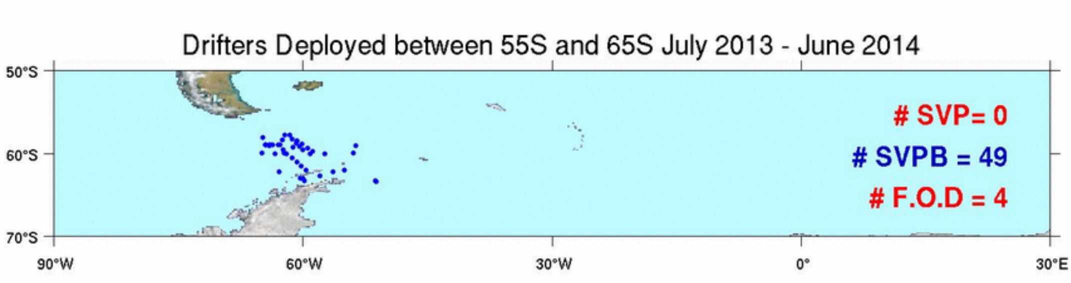

Figure 2. Deployment locations between 550S and 650S. A total of 49 drifters were deployed, all SVPBs

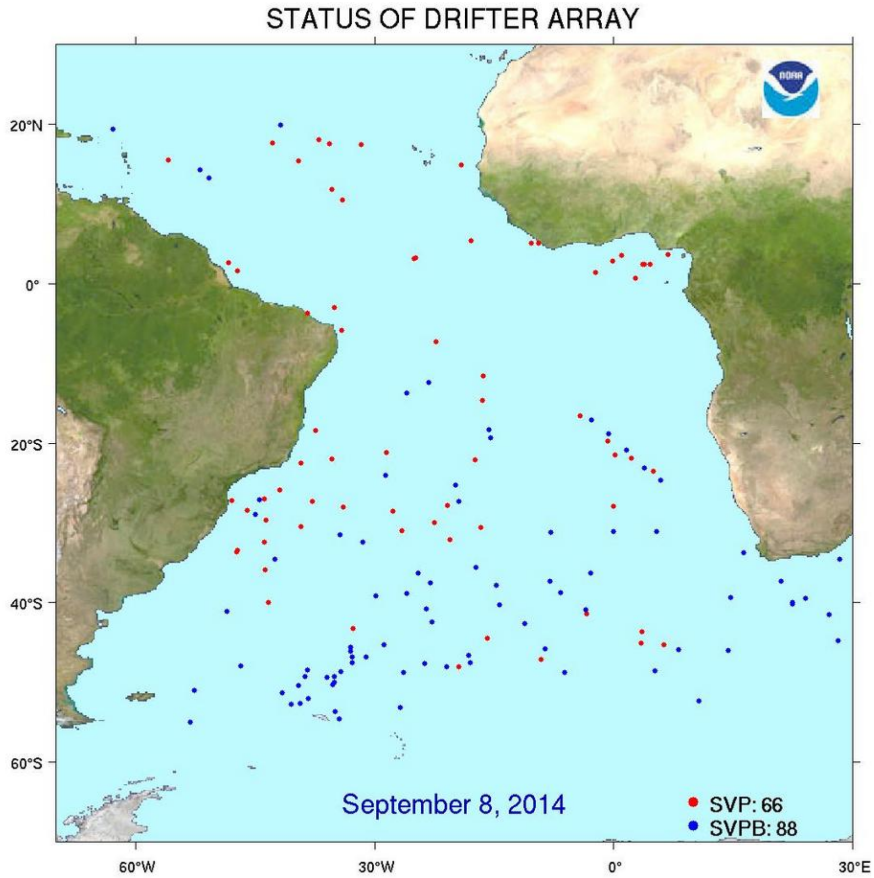

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Figure 3. Status of the South Atlantic Array as of September 8, 2014. A total of 154 drifters were present in the region.

APPENDIX I

REPORT BY THE OCEAN SUSTAINED INTERDISCIPLINARY TIMESERIES ENVIRONMENT OBSERVATION SYSTEM (OCEANSITES)

(Report submitted by Ms Kelly Stroker, OceanSITEs Coordinator, JCOMMOPS)

1) Summary

Name of Action Group	**OceanSITES**
Date of report	15 August 2014
Overview and main requirements addressed	OceanSITES is a worldwide system of long-term, deepwater reference stations measuring dozens of variables and monitoring the full depth of the ocean, from air-sea interactions down to 5,000 meters.
Area of interest	Global
Type of platform and variables measured	Deep-water reference stations
Targeted horizontal resolution	Key and representative sites covering the global ocean
Chairperson/Managers	Uwe Send, SIO Bob Weller, WHOI
Coordinator	Kelly Stroker, Project Office
Participants	Executive Committee, Steering Team Members, and Data Management Team Members
Data centre(s)	2 Global Data Assembly Centers IFREMER Coriolis (FTP). ftp://ftp.ifremer.fr/ifremer/oceansites/ US NDBC (FTP). ftp://data.ndbc.noaa.gov/data/oceansites/
Website	www.oceansites.org
Meetings *(2013)* *Planned 2014*	**2013** 9th Steering Committee and 6th Data Management Team Meetings in Seoul, Korea May 27-30, 2013 http://www.oceansites.org/meetings/index.html **2014** 10th Steering Committee and 7th Data Management Team Meetings in Recife, Brazil Nov 3-6, 2014 http://www.tav-pirata19.com/index.php
Current status summary *(August-2014)*	The OceanSITES Network consists of over 200 reference sites in the deep-ocean plus an additional 72 standard meteorological sites (TAO, RAMA, PIRATA). One of the goals of OceanSITES is to have data freely available, in real-time if possible. Currently there are 82 sites transmitting data in real-time to a local or

	regional data centre (Figure 1). OceanSITES has an active Data Management team that works with site PIs to share data in a common NetCDF format. The format specifications have been developed by the DMT in collaboration with the Steering Committee and Exec Board. Currently only around 30% of these sites are submitting data to one of the Global Data Assembly Centers (GDAC) in this format (Figure 2). At the 2011 La Jolla OceanSITES meeting, it was decided to make use of the many existing OceanSITES platforms in deep water to make an "instant" contribution towards the gap in deep-ocean observations as identified at OceanObs09. OceanSITES at over 50 sites around the world already carry deep temperature/salinity (T/S) sensors. OceanSITES members had a goal to deploy another 50, which requires 50 sensors for the initial deployments and another 50 for swapping out and calibrations (Figure 3). OceanSITES PIs have pledged to add such sensors to their existing moorings and as of August 2014 another 24 sensors were installed with an additional 6 are planned in the coming year(s). In addition to the sensor contribution by PIs, OceanSITES has a pool of matching sensor for the swap-outs via donations from institutions, agencies and companies. The community has nearly 50 instruments in the “pool” for exchanging and adding to sites around the world thanks to a number of generous donations but in particular, the donation of 22 instruments by the UK National Oceanograpy Centre in Southampton (Figure 4). In 2014, the OceanSITES Data Management Team worked on version 1.3 of the Data Format Reference Manual (formerly User’s Guide). The new Reference Manual was published in June 2014 and the community is encouraged to follow the new guide when preparing their data. The OceanSITES Data Management Team welcomed a new Chair, Julie Thomas of Scripps Institute of Oceanography. Dr. Thomas has stepped in to replace the departure of the previous chair nearly 3 years ago. The DMT welcomed Dr. Thomas and he leadership. The DMT then continued to hold regular monthly meetings via Webex. The OceanSITES Executive Committee set regular meeting times at once a month and held these throughout the year.
Summary of plans for 2013-2014	In November 2014, OceanSITES will hold a meeting in Recife Brazil jointly with the Tropical Atlantic Variability/PIRATA and the Brazil-European Union (EU) Dialogues in Marine Research Meeting. The OceanSITES Executive Committee will continue to meet regularly as will the Data Management Team. The DMT is still working on several new documents that will be published to assist user’s of OceanSITES data and possible new

	contributors: 1) a new document entitled “How to Become an OceanSITES Member”, 2) a new document entitled “How to work with the GDACs”, 3) a new document entitled “How to Access OceanSITES Data”. Finalization of concrete metrics for OceanSITES which the executive committee has been working. The 3 disciplines will have small teams to write White papers 1) Air sea flux 2) Physical time-series (ocean circulation, deep changes) 3) Biogeochemical and ecosystem Formalization of the processes and procedures for managing the deep ocean temperature/salinity program, and establishment of the next set of sites to be instrumented. Review and finalization of new products and indicators. Publish the updated *Minimalist OceanSITES Interdisciplinary Network (MOIN)* document (backbone network of minimalist identical multi-disciplinary sites) and hold a MOIN Workshop in early 2014 Work closely with other communities and attend meetings when appropriate. For example, • Hydrophone sites – LIDO • Ocean Tracking network • Deep Ocean initiative • INDEEP- Intern Network for scientific investigation of Deep sea ecosystems • Ocean Acidification, IOCCP Increase data holdings at the OceanSITES GDACs Finalization of OceanSITES data archive with NOAA’s National Oceanographic Data Center (NODC). Formal archive to be functioning in early 2015. Participation in the Partnership for the Observation of the Global Ocean (POGO) meeting in Tenerife, Spain in January. OceanSITES will welcome a new Project Office, Ms. Champika Gallage. Ms. Gallage will join the JCOMMOPS team from Environment Canada. She will start in October 2014 and be stationed with the rest of JCOMMOPS in Brest, France.

2 Deployment plans

There are 7 planned sites to be included in the OceanSITES network (Figure 1).

Acquisition of new deep ocean temperature/salinity instruments and determination of which existing OceanSITES will be added to the deep ocean temperature/salinity time series observing array.

3 Data management

3.1 Distribution of the data

3.1.1 Data policy

The data flow within OceanSITES continues to be carried out through three organizational units: PIs, DACs, and the GDACs. The Principal Investigator (PI), typically a scientist at a research institution, maintains the observing platform and the sensors that deliver the data. He or she is responsible for providing the data and all auxiliary information to a Data Assembly Center (DAC). The DAC assembles OceanSITES-compliant files from this information and delivers these to the two Global Data Assembly Centers (GDACs), where they are made publicly available. The GDAC distributes the best copy of the data files. When a higher quality data file (e.g. calibrated data) is available, it replaces the previous version of the data file. The user can access the data at either GDAC, cf. section “GDAC organization”. Archive of preliminary or real-time data is currently under discussion with NOAA’s National Oceanographic Data Center and World Data Center (NODC-WDC) for Oceanography.

3.1.2 Real-time data exchange

Approximately 40% of the OceanSITES array is exchanging data in real-time. However only 26% of the OceanSITES have data on the GTS (this does not included the standard meteorological buoys).

3.1.3 Delayed mode data exchange

A requirement of all OceanSITES members is exchange of data free and openly. The goal is to make all data available in the standard OceanSITES NetCDF format on one of the 2 GDAC centers. At present around 1/3 of the members are providing data in this format and we hope to see this number increase. In 2013, we did see new sites added to the GDAC distribution. These sites are: Aloha, EC1, MAK-Indonesia, PYLOS, E2M3H. Details on all the sites can be found in the OceanSITES site catalog. Many OceanSITES members are distributing data in other formats from sites in their own institution and do not have adequate resources to format the data into the proper format. The DMT and the GDACs are working with these members.

3.2 Data quality

OceanSITES data are partially transmitted in real-time and relayed to regional or national Data Assembly Centers (DACs). The DACS are responsible for applying automated real-time quality control tests to identify and flag grossly bad data. Data that pass the automated QC tests are broadcast on the GTS, apart from those purposely withheld for validation purposes. All data, with flags, are relayed to Global Data Assembly Centers (GDACs) in Brest, France, and at NDBC/USA. The GDACs maintain complete (mirror) datasets, and make all data available from one place in a unified format, initially via ftp directories, later through user-friendly interfaces.

4) Instrument practices

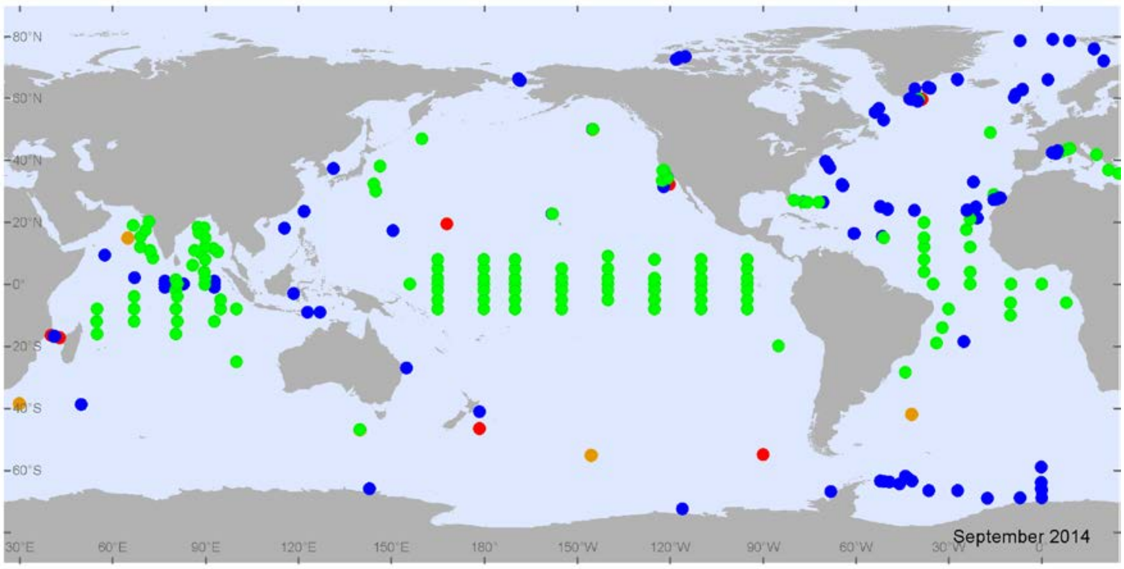
OceanSITES does not have a set of instrument handling standards and best practices of its own, but OceanSITES has an expectation that the PI-provided data have been collected according to such community-approved standards.

OceanSITES provides the following capabilities to this effect:

- OceanSITES science meetings serve as discussion forums where PIs can (and have done in the past) discuss such standards and practices.
- The OceanSITES data format requires the data provider to quantify uncertainty in the metadata, with optional information on instrument accuracy and precision.
- The OceanSITES data format provides a metadata field that can hold optional calibration information.
- The OceanSITES data format provides metadata fields that link to external documentation, meant among other things for documentation of instrument handling and practices, as well as institutional websites and science publications.
- OceanSITES efforts would benefit from a community-supported set of documents on instrument handling and best practices, a vision for which would be:
    - one document per instrument type and method
    - each document citable, e.g. via DOI
    - documents to be under version control

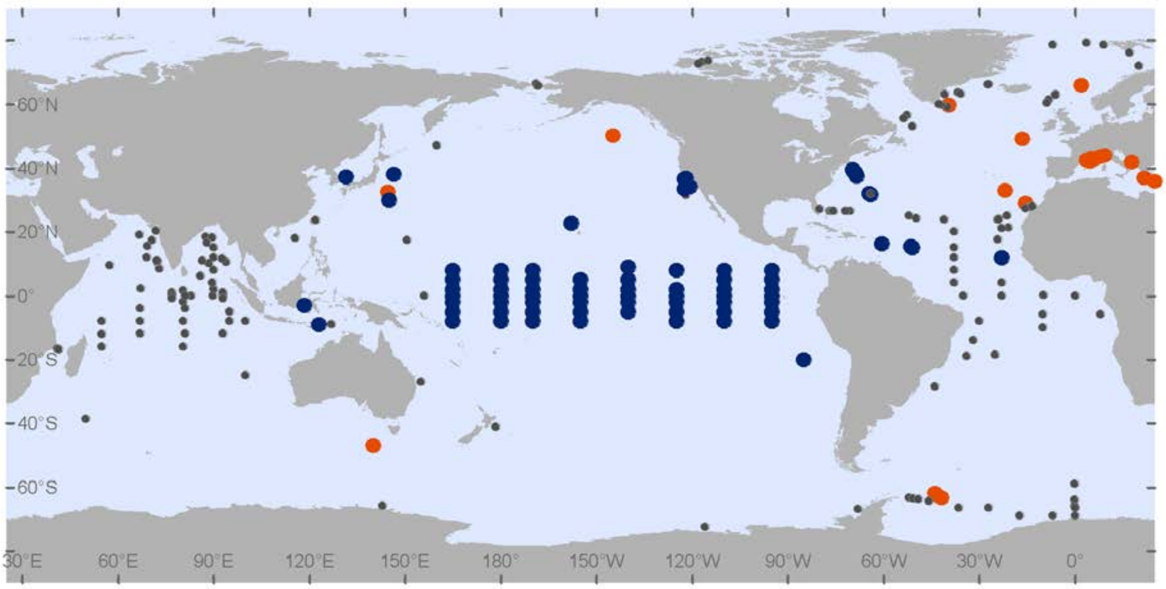
Annex (optional)

Status maps and graphics



● Real-Time Data (148) ● Delayed-Mode Data (136) ● Planned (7) ● Discontinued (10)

Figure 1 - Current status of the OceanSITES network (August, 2014).



GDAC Data ● IFREMER (21) ● NOAA/NDBC (79) • No GDAC (184)

Figure 2 - OceanSITES submitting data to one of the GDACs.

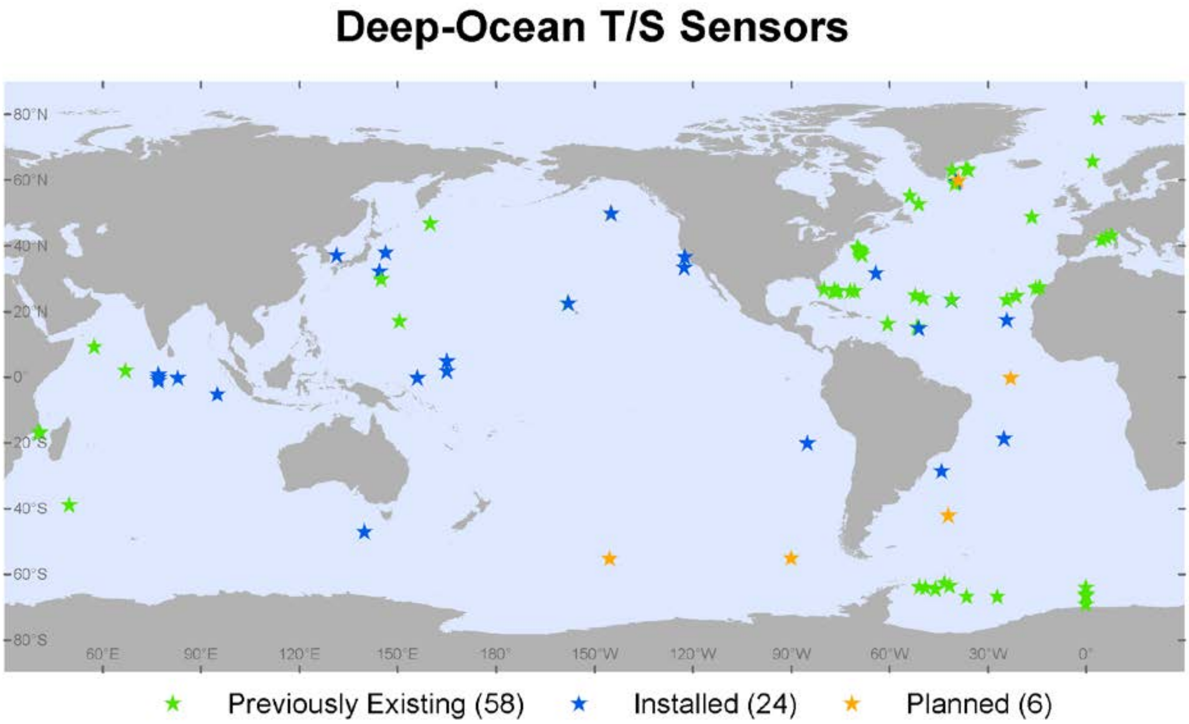


Figure 3 - Status of the deep-ocean temperature and salinity sensors.

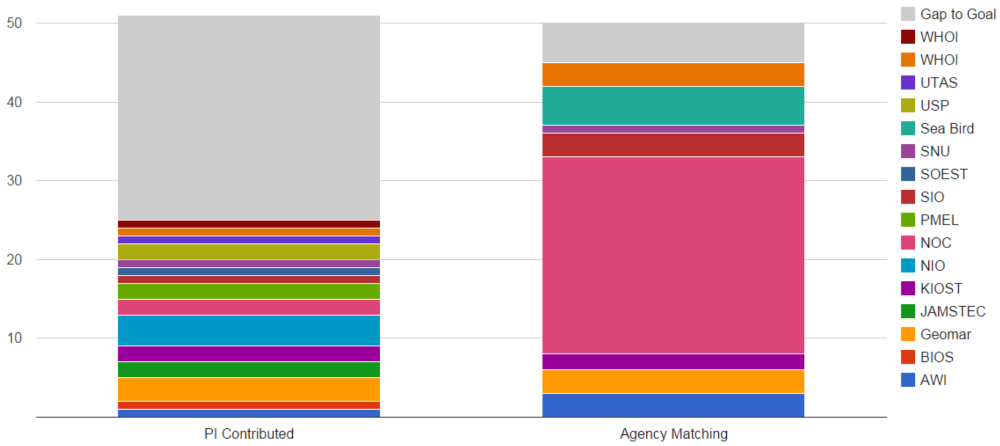


Figure 4 - Chart showing the matching contributions and the PI contributions by agency. The gap to fulfil the goal of 50 is shown in gray.

APPENDIX I

REPORT BY THE INTERNATIONAL TSUNAMETER PARTNERSHIP (ITP)

(Report submitted by Venkatesan, India)

1) Summary

Name of Action Group	**International Tsunami Partnership (ITP)**
Date of report	15 September 2014
Overview and main requirements addressed	Activity since last report (DBCP-29): status of Tsunameters; (appendix A); issues/enhancements to data sharing, technological developments, challenges, other
Area of interest	Discussion Topic 1: Develop a forum for a coordinated dialogue between IOC TOWS and JCOMM DBCP to promote a global sensing strategy for tsunamis, which identifies gaps and promotes collaboration to meet these gaps. DBCP ITP can serve as a technical collaborator in the dialog and provide a link between TOWs and DBCP Discussion Topic 2: the year's progress in partnerships -- e.g. US/Chilean discussions to enhance sensing in the Southern Chilean Trench.
Type of platform and variables measured	Surface expressions (buoys and autonomous vehicles) and deep ocean water level recording devices
Targeted horizontal resolution	IOC Tsunami Programme: http://www.ioc-tsunami.org/index.php?option=com_content&view=featured&Itemid=93&lang=en Promotes a coordinated but regionalized approach to awareness, risk assessment, observation networks and early warning systems
Chairperson/Managers	Dr. Venkatesan,; Mr. Stephen G. Cucullu
Coordinator	Kelly Stroker
Participants	DBCP Representatives
Data centre(s)	Various
Website	http://www.jcomm.info/index.php?option=com_oe&task=viewEventRecord&eventID=1504
Meetings *(meetings held in 2013/2014; and planned in 2014/2015)*	Technical information exchange between NOAA NDBC and National Institute of Ocean Technology Ministry of Earth Sciences -- April 1, 2014. Intergovernmental Oceanographic Commission Seventh Meeting of the Working Group on Tsunami and other Hazards related to Sea-Level Warning and Mitigation Systems (TOWS-WG) 12 - 13 February 2014, Paris, France TOWS-WG 2015 *to be determined*
Current status summary *(mid-2013)*	Refer to Appendix A
Summary of plans for 2015	Refer to Section 2.

2 Deployments Accomplished 2013/2014 & plans for 2015

2013/2014:

Australian -- Bureau of Meteorology --three service voyages were conducted or initiated in the last 12 months.

Indian Ocean
This voyage was undertaken in October 2013 using the *PMG Pride* out of Townsville, QLD, Australia. The following activities were undertaken:

- Replace STB surface buoy at 56001 (Indian Ocean 1) with DART II buoy
- Replace STB surface buoy at 56003 (Indian Ocean 2) with DART II buoy

Tasman Sea voyage
This voyage was undertaken in March 2014 using the *Pacific Conquest* out of Gladstone, QLD, Australia. The following activities were undertaken:

- Bottom-pressure recorder at 55015 (Tasman Sea 1) changed
- Surface buoy at 55042 (Tasman Sea 2) re-placed following electronic payload failures

Coral Sea voyage
This voyage is currently underway (August 2014) using the *PMG Pride* out of Townsville, QLD, Australia. The following activities are planned:

- Surface buoy and bottom-pressure recorder at 55012 (Coral Sea 1) to be replaced by complete East-To-Deploy (ETD) system
- New ETD system to be deployed at 55023 (Coral Sea 2) following buoy mooring vandalism in July 2013

2015:

The NOAA/NWS Tsunami Program will hold its level at the US mandated strength of thirty-nine (39) operational stations. The NOAA/NWS Program is currently focusing on engagements with the Chileans on increasing sensing capabilities at the southern Chilean Trench.

With regard to testing and evaluation of new equipment within NOAA, PMEL **engineers** deployed a **Deep-ocean Assessment and Reporting of Tsunamis** (DART®) 4th generation monitoring system off the coast of Oregon in September of 2013. This system is an enhanced version of the DART®-ETD (Easy to Deploy) technology developed at NOAA-PMEL that incorporates advancements in sensors, software and power management to detect and measure near-field tsunami with unprecedented resolution. An improved pressure sensor will be able to detect and measure a tsunami closer to the earthquake source providing valuable information to warning centres even faster.

Solicitation for procurement of commercial of the shelf (COTS) Tsunameter technology is currently underway at the NOAA National Data Buoy Center (NDBC) using newer mid-frequency acoustics communication. The plan is to deploy this system in the Gulf of Mexico where higher than normal currents and warn water eddies make taut moorings with low frequency acoustic transducers impractical to sustain.

The INDIA Tsunami program maintains a seven Tsunami buoy network (Five from Indian tsunami buoy called *Sagar Bhoomi* & two from SAIC) in Indian Ocean Region and there is no plan to add more tsunami buoys in the Indian Ocean region. NIOT is adopting new technologies to improve the performance and reliability of tsunami buoy network.

Australian -- Bureau of Meteorology -- Two service voyages are planned for the next 12 months.

Tasman Sea:
All present equipment in the Tasman Sea is due to be replaced with two STB systems in February 2015.

Indian Ocean:
Routine maintenance for the Indian Ocean tsunameters will be brought forward to July 2015. This maintenance will changeover buoys, BPRs and moorings at both stations.

3 Data management

3.1 Distribution of the data (USA) -- The NOAA National Data Buoy Center receives data from its buoys via Iridium constellation. The data are delivered to the National Weather Service Telecommunications Gateway (NWSTG) which then distributes the data in real-time to two Tsunami Warning Centres (TWCs) via NWS communications and nationally and internationally via the Global Telecommunications System. The bottom pressure recorders of US owned buoys may be placed in high resolution event mode via two way communications initiated by the TWCs or NDBC mission control centre personnel.

Indian tsunami buoy data sets are delivered to Indian Ocean Tsunami Warning Centre INCOIS.

Data from Australian tsunameters is transmitted on the GTS. There are no other data sharing arrangements currently in place, e.g. for 15-sec data from recovered bottom-pressure recorders. Data is also available through NOAA's National Data Buoy Centre (e.g. http://www.ndbc.noaa.gov/station_page.php?station=55012&type=2&seriestime=20140412201900&startyear=0000&startmonth=00&startday=00&endyear=0000&endmonth=00&endday=00&submit=Submit)

3.1.1 Data policy

Distribution of data has been largely centralized in the west with other partners relying on localized distribution and more of a regionalized approach. Through agreement with NOAA, Russia, Thailand, and Chile have provided the data feed to NOAA-NDBC and the US TWCs. The data for those partners' stations are displayed on the NOAA-NDBC Website. The control of high resolution data or "event mode triggering" for those stations remains with the host countries. Several additional countries make their data available to the GTS (refer to the annex). Two SAIC data are shared and NIOT buoy data will be shared.

Indian Tsunami buoy data INCOIS is sharing to NDBC site for global data distribution along with other Tsunami warning centres. India has procured the bottom pressure recorder from Sonardyne, UK and the remaining components are developed in India only. Currently India is developing Bottom Pressure Recorder for technology indigenization.

3.1.2 Real-time data exchange

As shown in the Annex, a significant portion of the users are making their real time data available through the GTS. There continues to be a positive trend and is a notable event in international collaboration. Approximately, 77 percent of the deployed Tsunameters are providing data through the GTS.
India is making data available through GTS to NDBC website

3.1.3 Delayed mode data exchange

The US recovers and analyzes the data recovered from BPR flash storage. Short durations of high resolution data can be recovered via two way iridium communications if requested by TWCs.

India is sharing the data through GTS and CREX format data being exchanged to NDBC centre.

3.2 Data quality

The NDBC publishes its *Handbook of Automated Data Quality Control Checks and Procedures* on its website; specifically, at the following URL:
http://www.ndbc.noaa.gov/NDBCHandbookofAutomatedDataQualityControl2009.pdf

The mode of exchange of the above data shall be through Global Telecommunication System (GTS) on through any other appropriate is to be implemented jointly by the India Meteorological Department (IMD) and the Indian National Center for Ocean Information Services (INCOIS). The real time access to the data to various international agencies is extended on request to the NTWC and RTWP operated by India at the INCOIS, Hyderabad

4) Instrument practices

The NDBC will share details on best practices and processes used to ensure traceability and accuracy with users. The NDBC is identified as a Regional Marine Instrumentation Center (RMIC) and has conducted several international meetings on this topic at its Stennis Space Center, Mississippi facility.   NDBC is developing a publicly facing website which will provide best practices used in its RMIC

NIOT India follows best of practices and methods to ensure accuracy in provided data to users.

These two regional centres have collaborated closely and shared information over the last several years.

Several partners have conveyed recent experience with Mid-Frequency acoustic technology (e.g. Japan) used in areas where high ocean currents were hindering mooring survivability when used in conjunction with typical low frequency acoustic systems. This item warrants future updates as this has been one of the significant challenges to maintaining tsunameter moorings.

5) Other issues as needed

Action Item 1: Finalization of ITP Tsunameter Standard; for promulgation as finished document by DBCP 31. See latest draft at the end of the Annex.

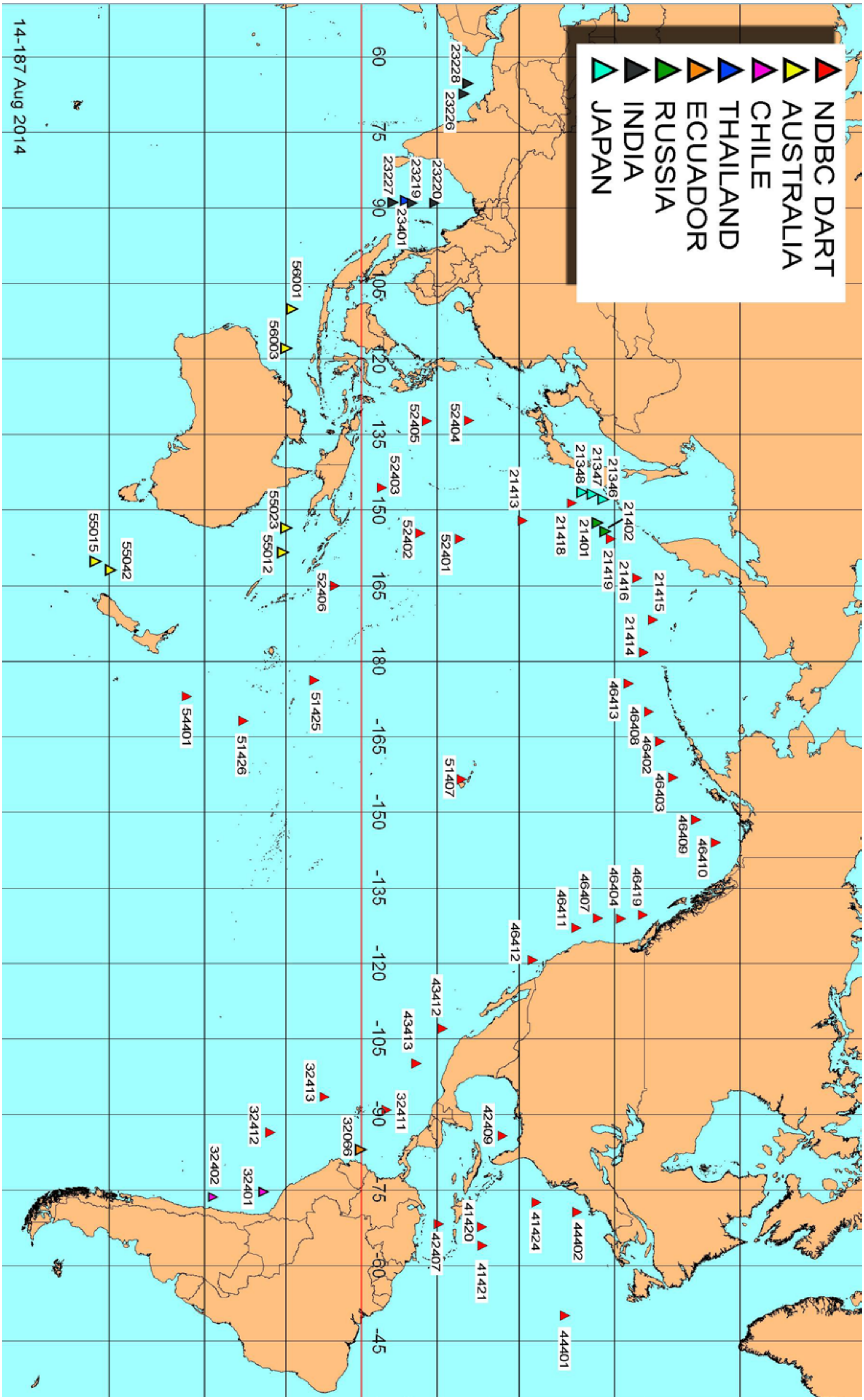
Action Item 2: Call for approximate locations of tsunameters (specifically those not currently shared on GTS). Request information by DBCP 31.

Contributions: Technical input for this report provided by partnering nations as well as from key vendors -- SAIC and Sonardyne International Ltd.

Annex (optional)

Status maps and graphics

Global Tsunameter Network								
Country	Planned Network	Currently Operational	Tsunameter Types	Local Reception	Data to GPS	Data to FTP	Data Formats	Vandalized Stations
Australia	6	4	SAIC - STB SAIC - ETD	Yes	Yes	No	NOAA-DART BUFR/CREX	Yes; 1 event
Chile	3	2	SAIC - DART - II SAIC - STB	Yes	Yes	Yes	NOAA-DART	-
China	2	2	DART - STB	Yes	No	No	NOAA-DART BUFR	Yes; 3 - 5 events
Ecuador	2	2	EBM22TS Mediterráneo Señales Marítimas (MSM)	Yes	Yes	Yes	NOAA-DART	-
India	7	7 5 NIOT 2 SAIC	SAIC-STB Indian Buoy Sagar Bhoomi - Sonardyne	Yes	Yes INCOIS	No	BUFR/CREX	-
Indonesia	14	-	InaBuoy SAIC-ETD	Yes	No	No	Local Format NOAA-DART	-
Japan	6	3	SAIC-STB-MF	Yes	Yes	No	CREX	-
Malaysia	3	-	-	Yes	No	No	-	-
Republic of Korea	2	-	-	-	-	-	-	-
Russia	3	2	SAIC-STB SAIC-ETD	No	Yes	Yes	NOAA-DART	-
Thailand	3	1	SAIC-STB Environtec	No Yes	Yes Yes	Yes No	NOAADART -	No No
USA	39	33	DART - II	Yes	Yes	Yes	NOAA-DART	No


14-187 Aug 2014
NDBC DART
AUSTRALIA
CHILE
THAILAND
ECUADOR
RUSSIA
INDIA
JAPAN
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Tsunameter Equipment Performance Standards and Guidelines

Issue: **2.0**

Date:

Originator:

APPENDIX J

Table of Contents

Document Change Record

Version	Date	Originator	Change Comments
1.0	7 Sep 2007	Ken Jarrott	First Issue after review by ITP Meet #2, Jakarta
2.0	15 Aug 2014	S. Cucullu	Re-sending Draft for Finalization

Review Cycle

Version	Next Due	POC	Change Comments
2.0	1 Oct 2016	ITP Chair	Recommended Changes -- Yes (included) or No

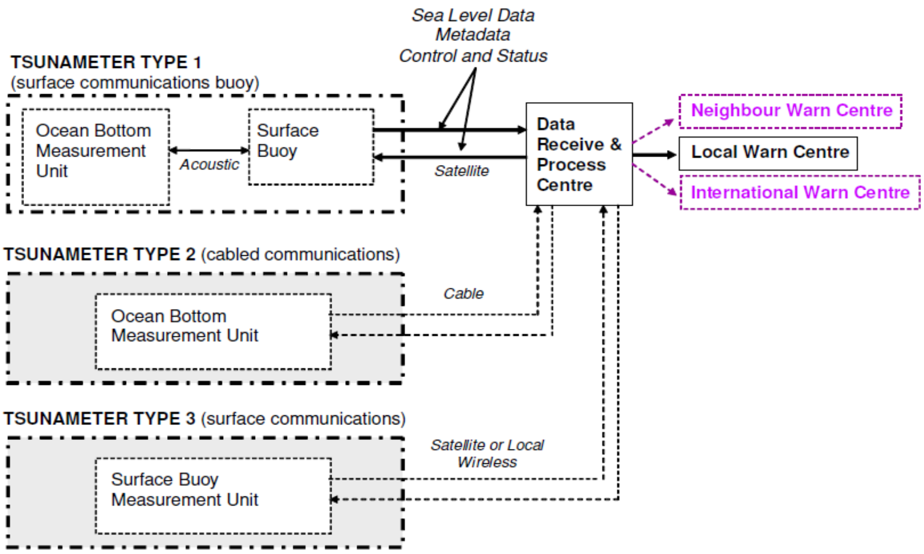
1. SCOPE AND PURPOSE

1.1 Scope

This document sets out functional, performance and other operational characteristics for deep ocean tsunami detection stations that will meet the requirements of local, regional and ocean-wide tsunami warning systems. Compliance with these guidelines and with their related quality assurance processes will enable warning centres, equipment purchasers, operators and non-warning-centre data users to have confidence in a tsunameter's performance, data quality and interoperability, regardless of the specific equipment's design or source of supply.

The guidelines are intended to assure a level of consistency between the behaviour and performance of any tsunameter product, but not to constrain technical innovation by suppliers. No particular technical implementation is assumed, although the primary focus is to elaborate the characteristics of the dominant tsunameter design at the time of writing – an ocean floor pressure sensor reporting via an acoustic modem link to a moored surface buoy with satellite communications to a land-based data processing centre. An alternate cable-connected system is illustrated in the diagram below, while other technologies (e.g. GPS surface buoys) might potentially realise the same function in near-shore locations. To the extent that the role and modes of operation of these alternate systems is similar to that of the "Type 1" tsunameter, these guidelines will apply. However, specific treatment of these technologies may be warranted in future document releases.

Some tsunameter designs either support or are routinely integrated with other sensors, in a multi-role platform. While multi-role solutions can provide extra value from the same observation platform, and platform flexibility is to be encouraged, this document only deals with tsunami monitoring and reporting functions.



1.2 Origins and Future Development

This guide has been framed with input from developers, suppliers and operators of tsunameter equipment, and users of their derived data products. It reflects the current understanding of the

tsunami phenomenon, and the current requirements of warning centres that are operating, or planning to operate, on a local, national or ocean-wide scale. The data delivery and command response times should meet the needs of warning centres and threatened communities close to the source of the tsunami.

The guide will be adapted to meet revised warning system or scientific requirements. It may be supplemented to address technology implementations that merit separate treatment.

1.3 Authority and Change Control

The guide is published by the International Tsunameter Partnership Group (ITP), which reports through the

IOC/ International Cooperation Group / Data Buoy Cooperation Panel (DBCP). The ITP was established with endorsement of the ICG/IOTWS and its Pacific Ocean equivalent (ICG/PTWS). It is an international forum for promoting interoperability, technical development, and mutual support across the community of developers, suppliers and operators of deep ocean tsunami monitoring stations.

Amendments or updates to this guide will be authorised by the ITP Chair. Significant amendments will be reviewed by ITP members before such authorisation.

2. TERMINOLOGY

Tsunameter: An instrument that monitors sea surface levels in the open ocean and which reports sea level data in near-real time to tsunami warning centres. Tsunami warning centres use the data to assess the presence or absence of a tsunami wave and to determine wave attributes that are pertinent to tsunami forecasts and warnings. “High Resolution” Data: Sea level data measured with high temporal resolution, typically at one minute or less sample times, for tsunami event detection and wave characterisation.

3. STRUCTURE OF DOCUMENT

Tsunameters are technically complex, mission-critical systems operating in a harsh environment, with high reliability expectations and relatively high acquisition and ownership costs. Practical tsunameter designs reflect design and cost tradeoffs between performance, robustness, energy consumption, service intervals, and operational flexibility.

The guide covers the small number of mandatory requirements needed to satisfy the primary function of sea level measurement and reporting for tsunami warning purposes. It also provides guidance or best practice targets for other characteristics that, while not mandatory, influence operational utility or ownership costs. Explanatory rationales are used to put those “soft” requirements or targets into context.

4. OVERVEW OF REQUIREMENTS

The attributes of a tsunameter pertinent to its primary sea level measurement and reporting function and its practical utility in tsunami warning systems, are:

General

- Support for multiple modes of operation, including high-rate event reporting during tsunami events, low-energy background or “heartbeat” reporting modes, and modes that facilitate testing, equipment configuration or diagnostics etc. for engineering development, product acceptance, and deployment operations.

Measurement and Reporting

- The quality and timeliness of sea level data streams (including relevant metadata) for the purposes of real time situation analysis and event forecasting by warning centres
- Ability to measure and report tsunami phenomena for research purposes (small tsunami below the interest range of warning centres are of value in forecast system and model refinement)
- Reliability and continuity of data streams (lack of data gaps or latencies that could compromise warning decisions or notification times)
- Consistency and performance traceability between tsunameters, regardless of origin or national custodian.

Operating / Deployment Range

- Flexibility (lack of undue constraints) on deployment sites, operating depth, and ocean conditions

System Sustainability and Life Cycle Attributes

- Ease of handling / deployment
- Reliability, safety and maintainability
- Service intervals and unattended on-station endurance

5. DETAILED REQUIREMENTS

5.1 General

The majority of requirements and guidance statements in this document apply in principle to tsunameters regardless of their technical implementation. Some material unavoidably relates to the underwater communications for units using an ocean floor sensor to a surface communications buoy and to operating modes specific to that form of tsunameter. These topics may be disregarded for systems that do not employ that technology.

5.2 Modes of Operation

Tsunameters shall support the following modes of operation:

1. Continuous Reporting mode
2. Deployment Test mode(s) for testing or integrity checking prior to deployment, during deployment, or immediately after deployment
3. Engineering test / configuration / diagnostics modes
4. Background Reporting mode** – regular reporting of sea level at a rate sufficient to reveal tidal forcing and to confirm effective operation of the system

> NOTE: ** *"Type 1" tsunameters using an ocean bottom unit and a surface communications buoy use a background reporting mode as a strategy for managing constrained energy budgets and communications costs. It may not be necessary in other (e.g. cabled) design solutions. The following descriptions of the background reporting mode and transitions between background and continuous (event) reporting modes need not apply to such implementations.*

<u>Continuous Reporting Mode</u>: The tsunameter shall enter Continuous Reporting Mode, with continuous reporting of high-resolution data from the Ocean Bottom Unit and the Surface Buoy, by self-triggering of the ocean bottom unit, after detection of a measurement anomaly

(i.e. discrepancy between the measured water column height and the predicted value that exceeds a threshold value).

The ability to initiate continuous reporting by remote trigger (command) from an operations centre is highly desirable. This feature should be incorporated in future product developments. The continuous reporting mode shall be able to be terminated by remote command, by expiry of a user-settable time limit, or, after a self-triggering event, on expiration of the sea level anomaly that triggered the mode.

<u>Background Reporting Mode</u>: reports average water column heights and other status information at scheduled intervals. This data stream confirms proper equipment function, and enables warning centres receiving the data to verify operational status of the station, to exercise data ingestion functions, and to maintain operator training levels.

<u>Deployment Test Mode(s)</u>:

- Pre-deployment Test Mode: will enable critical pre-deployment instrument checks on board a deployment vessel, including transmissions of equipment internal status, and exercise of underwater and sea-to-shore communications
- In-Deployment Test Mode: will enable reception on a ship of data that monitors the progress of the deployment, enables in-situ operational tuning of instrument parameters, and confirms the healthy functioning of the equipment after deployment

<u>Operational Management Engineering Test / Diagnostics Modes</u>: Tsunameters shall support a range of test or management operations that allow operators to remotely configure user settable operating parameters, perform diagnostics or status checks, generate test data streams, update internal clocks, or carry out limited life cycle upgrades or corrective actions, e.g. the download of firmware upgrades or patches.

5.3 Primary Functions and Performance

Data quality, availability and timeliness are the primary requirements of warning centres.

5.3.1 Sea Level Measurement

The sea level measurement must capture the tsunami wave signal (amplitude and phase) for waves of period between 5 – 40 minutes, and of amplitudes down to 3cm or less.

The capacity to resolve small waves is important if the tsunameter is only exposed to peripheral (side lobe) energy from a large tsunami. Small tsunami events are also valuable for exercising and refining forecast and modelling processes more regularly than could occur with large tsunami events.

Absolute accuracy of total water column height is not an important measurement attribute. Tsunameters need only resolve changes at the ocean surface over a range of a few metres. Confidence in the tsunameter's response to small amplitude tsunami waves can be derived by observing its response to larger scale tidal forcing over the range that includes tsunami disturbances. The integrity of the measured tidal responses can be established by comparison with ocean tidal predictions for that site.

Reporting / Measurement Units: The measurement units used internally to the tsunameter, and reported between the tsunameter and the processing centre are a matter of design choice. They may be a directly sensed parameter, such as pressure, or a derived measurement, such as water column height. For the purposes of this document, the term "reading" or "sea level measurement" refers to the measured or reported parameter, with measurement characteristics referring to the derived estimate of water column height.

The communications from the processing centre to warning centres or other data users needs to comply with separately defined interoperability and data exchange standards.

Measurement Range / Sea Bed Unit Depth: 500m – 6,000m (range / measurement performance may be achieved through configuration variants).

Measurement Accuracy: Absolute accuracy is not critical (see above) however the excellent resolution and long-term stability is required.

Measurement Resolution of Surface Disturbances: ≤0.5cm required, with ≤0.3 cm desirable.

Internal Measurement Sampling (Averaging) Interval: ≤30 seconds. Recommended to be 15 seconds (for consistency with common practice for tsunameter products).

5.3.2 Time Stamping of Data and Time Stamp Drift

All sea level data samples shall be time stamped at the time of measurement in the Ocean Bottom Unit. The time stamp drift of the internal clock over the unattended life of the bottom unit shall be < 2 minutes and preferably < 1 minute. It is highly recommended that all data messages be time/date stamped with internal clock time and external GPS time to verify offset.

Where external clock synchronisation is implemented (e.g. through a GPS reference in the Surface Buoy), clock updates shall be performed with no interruption to the continuous measurement regime under all operating conditions.

Time Stamp of Messages at Time of Transmission to Processing Centre Time stamping of transmissions to the processing centre is not required, but the capacity to do so may be helpful as an engineering aid to communications link performance analysis.

5.3.3 Ocean Bottom Unit Storage of High Resolution Data

Short Term Storage of High Resolution Data

Regardless of the mode it is in, the Ocean Bottom Unit shall retain a short term record of high-resolution data (at the internal Measurement Sampling Interval) for a period prior to present measurement and reporting interval. In Background Reporting mode, the buffer enables the tsunameter to recover and transmit high resolution data for conditions immediately prior to internal or external tsunami event triggers.

The Ocean Bottom Unit shall maintain a buffer of high resolution data (at the internal Measurement Sampling Interval) for a period of at least 30 minutes prior to the current measurement and reporting interval.

5.3.4 Longer Term Storage and Remote Access to High Resolution Sea Level Data

It is desirable for the tsunameter to hold a medium–to-long term store of high resolution (less than or equal to 1 minute averaged, 15sec preferred) data that can be downloaded on request from a processing centre. This is to support analysis of events or conditions that do not coincide with a tsunami event trigger, either during the course of a tsunami event, or for post-event analysis.

The tsunameter shall support on-command access to a long term store of high resolution sea level data (less than or equal to 1 minute averaged data, or at full Measurement Sampling Interval). That data record shall span at least the last seven (7) days, and would preferably extend to the whole deployment period. The internal memory of the Tsunameter shall record the 15 sec integrated data like temperature compensated and uncompensated pressure data, temperature data, tide predicted data and pressure difference between raw and predicated pressure. Stored data of pressure and temperature on the Ocean Bottom Unit is extremely valuable to science and should be submitted to the proper archiving centre (National Geodetic Data Center (USA) for example)

5.3.5 Sea Level Data Reporting

Data Reporting – Background Reporting Mode

In Background Reporting Mode, the tsunameter will report sea level readings with time resolution sufficient to accurately capture tidal forcing for correlation with ocean tide models.

Recommended measurement sampling rate: 15sec-1min spot sample on 15 minute readings

Recommended reporting interval (to processing centre): 6 hours or less.

Data Reporting – Continuous Reporting Mode

In Continuous Reporting Mode, tsunameter sampling intervals must be sufficient to resolve wave amplitude and phase (time of arrival) for use with forecast models. Short reporting intervals are needed to support rapid situation assessment and warnings determinations. End-to-end data lag times from the taking of a reading in the Ocean Bottom Unit to data arrival at a processing centre should not contribute more than a few minutes of warning delay.

Measurement Sample Rate: requires 1 minute averaged readings or better.

Reporting Interval (to processing centre): ≤ 5 mins, preferably ≤ 3 mins

Processed Measurement Availability (including communications and reporting delays from Ocean Bottom Unit to Processing Centre): ≤5 mins

5.3.6 Reporting of Metadata and Other Information

In addition to sea level measurements, the Ocean Bottom Unit and Surface Buoy need to communicate other parameters or status information. Where equipment configuration status is not fully defined by reporting from the tsunameter, external configuration recording and change management systems are to be applied at the processing centre.

The following classes of metadata and engineering data are recommended:

- Metadata or ancillary data related to the primary measurements
    - Seafloor level temperature or other parameters pertaining to the primary sensor performance (e.g. the variance of measurement samples)

- Configuration data
    - Equipment ID / configuration references for whole station or key sub-systems
    - Revision state of firmware
- Engineering Data related to equipment status and performance monitoring
    - Battery voltages or other energy status indicators of bottom unit such as Battery % used
    - Tilt angle of Ocean Bottom Unit
    - Error codes or system health status flags
    - Communications link performance indicators, such as bit error rates, numbers of message re-transmissions before successful receipt, data latency metrics
    - GPS location of Surface Buoy
    - Battery health of surface buoy system
    - Dummy data transmission (GPS location of health of surface buoy) from surface buoy if no data received in sea bottom unit.
    - It is highly recommended that surface buoy be designed with two identical electronic systems to provide redundancy in case one of the units fails. (The Background reporting mode transmissions are handled by both electronic systems on a preset schedule. The continuous reporting Mode transmissions, due to their importance and urgency, shall immediately be transmitted by both systems simultaneously.

The frequency of such reporting, whether with every data record or by scheduled reports, or by external interrogation, is not prescribed, and may vary by design choice.

Tilt Sensor: It is highly recommended that the Ocean Bottom Units with fixed communication links be fitted with a tilt sensing mechanism to confirm orientation on the ocean floor. This additional sensing will facilitate expedient confirmation during deployment operations as well as providing confirmation over the tsunameter's working life that the orientation of the bottom platform remains within the acceptable bounds for proper operation of underwater communications links.

5.3.7 In-situ Tsunami Signal Processing and Triggering of Continuous Reporting

Tsunameters operating in Background Reporting mode shall be able to self-trigger a transition to continuous high data-rate reporting on detection of a sea level anomaly that may represent the passage of a tsunami.

The Mofjeld Algorithm [*http://www.ndbc.noaa.gov/dart/algorithm.shtml*] has been applied for some time to recognize tsunami-induced differences between measured and predicted sea level values. Its adoption is recommended.

The triggering threshold (typically in the range 3cm – 8cm) for such detection shall be remotely programmable to accommodate local ocean noise conditions.

5.4 Handling of Errors or Anomalous / Fault Conditions

The electronics systems of the tsunameter should incorporate built-in capacity to detect fault conditions, or lock-up conditions, and to log and report error codes for such conditions as supply voltage or measurement anomalies, or software lock-up conditions.

Tsunameters should have both an internal "watch-dog" reset function and a capacity for remote command of a system reset of both the Ocean Bottom Unit and the Surface Buoy. The recovery from such resets should preserve pre-programmed user settable parameters, including the tsunami threshold level.

5.5 Communications Links

The end-to-end performance of communications links from the Ocean Bottom Unit through to the Surface Buoy and Processing Centre operation is critical to the reliable and timely delivery of data to warning centres. Basic design objectives are reduction of inherent channel latency, high success rates in data or message delivery, and minimisation of data gaps.

The required performance standards for data delivery may vary between warning centres. To assist tsunameter product inter-comparisons, and to enable warning centres and tsunameter operators to *assess data delivery performance against their particular standards, data delivery measures are required that encompass the whole chain, including the tsunameter-to-shore communications link. Recommended end-to-end performance measures are separately defined in the ITP guidance document: "Tsunameter Data Communications Performance Measures".*

<u>Ocean Bottom to Surface Communications</u> In Type 1 tsunameters, the underwater communications link is technically demanding, and is subject to continuing technology refinement and innovation.

To support the capture, analysis and inter-comparison of communications link performance, and to provide a basis for design refinement, it is recommended that tsunameters capture and transmit relevant internal link meta-data; this includes but is not limited to:

- Data latency between the time of making a sea level measurement (the measurement time stamp) and the time of receipt by the Surface Buoy
- Bit error rate of the link
- Statistics on the success rate of message receipt (packets or messages received first time, numbers of packets requiring multiple retries, etc)
- Length and incident rate of data gaps (messages or data not received)
- The number of attempts the bottom unit performed retransmission prior to the confirmation of the reception of data
- A message that the surface buoy polled the data from the bottom unit after not receiving data in background reporting mode; this can be used to ensure the functionally of bottom unit
- Location information needed to ascertain the relative distance and orientation between the surface buoy and the bottom platform

<u>Communications to Processing Centre</u> Communications solutions are preferred that present no obstacle to deployment locations across the globe or across the extent of a coherent region of operation, either through a truly global solution (such as Iridium) or through configurable communications options or product variants that provide suitable regional or local coverage.

<u>Data format:</u>

In order to ensure the data may be widely disseminated to the needed regional warning centres, it is recommended that widely accepted traditional observation templates be used. This includes BUFR/CREX. Again, the purpose of this is to provide a flexible data representation table driven code form (TDCF) for reporting water column heights recorded by the Bottom Pressure Recorder (BPR).

5.6 Secondary Operational Characteristics

5.6.1 Deployment Range and Flexibility

<u>Operating Environment – Sea Conditions</u> Tsunameter physical design and construction standards should not unduly limit deployment locations. Guidelines are:

1 Operation within specification in a steady state Beaufort 6 sea state*[1]

2 Survival in Beaufort 11 sea state*[1]

3 No undue constraints on bottom conditions for Ocean Bottom Unit, including ability to operate with an ocean floor inclination of up to 10 degrees, preferably up to 20 degrees.

[1] * : While flexibility of deployment region is desirable from a single product, product variants may be used to achieve cost effective coverage of a wide range of deployment environments.

In addition, tsunameter designs should not unduly limit suitable deployment locations because of ocean current limitations. Anticipated current profiles should be taken into account when choosing a tsunameter type or configuration options for a deployment location.

5.6.2 Ease of Deployment

The tsunameter's physical design, in conjunction with ship-board facilities or work processes, should as far as possible maximise the range of vessels that are capable of conducting deployment or recovery operations, and the range of conditions under which a deployment or recovery can be conducted with safety. They should also aim to minimise the requirements for rare or specialised crew skills to achieve safe and efficient deployment. The value of these provisions to a particular tsunameter operator may vary according to local access to vessels and crew, or the ability to combine tsunameter missions with other marine operations.

5.6.3 Safety

Tsunameter design, materials and fabrication standards shall ensure compliance with relevant electrical safety and hazardous materials regulations.

Designs using batteries that may produce corrosive or explosive gases (e.g. Hydrogen gas) shall have appropriate means for isolating those gases from contact with electronics, or removing or neutralising those gases.

5.6.4 Vandalism

For deployments in areas subject to vandalism, physical protective measures or signage shall be used to reduce the prospect of damage to the tsunameter.

5.7 Operating Life and Maintenance Characteristics

The need for ship operations for deployment and servicing is a substantial contributor to tsunameter ownership costs, and constrains reaction times to equipment failures, with consequence to data availability to warning centres. Tsunameter designs should aim to achieve inherent reliability and physical robustness of equipment, and to deliver a capacity for extended operating periods without service intervention.

Ocean Bottom Units for "Type 1" tsunameters currently are fitted with flotation devices and acoustic releases, to enable recovery and servicing by ships. Disposable Ocean Bottom Units with extended unattended service life beyond current generation products may present opportunities for simplified product designs and product and life cycle cost reductions.

5.7.1 Unattended Operating Life of Tsunameter Equipment

<u>Surface Buoy Service Interval</u>: shall be > 1 year, preferably >2 years (current best practice)

<u>Ocean Bottom Unit Service Interval</u>: shall be > 2 years, preferably >4 years (current best practice).

5.7.2 Reliability and Maintainability Characteristics

TBD

6 TEST AND QUALITY ASSURANCE PROCESSES

Tsunameters are characterised by relatively new and evolving technology, small-scale production, and deployment in remote and harsh environments. They have a mission-critical role, and fault rectification or rework in the field incurs high costs. This places particular importance on product quality assurance at all stages prior to deployment.

The following list of test and quality assurance processes and records is recommended to assure high confidence in successful deployment and operation of the equipment. The tests apply to mature product testing and qualification phases, and not to development tests that might be used to prove the product design.

Manufacturing Tests

- Primary sensor test report/results: test conditions specified, and key test measurements to be traceable to certified instrument standards
- Functional testing of key and components and sub-systems prior to assembly
- Hull pressure testing of deep ocean equipment canisters and surface buoy
- Burn in and functional acceptance testing of electronics payloads and interconnections
- Function and data communications tests of integrated product (all communications links) -continuous test duration exceeding 1 day
- Pressure testing of integrated Ocean Bottom Unit and all associated cables
- End to End System Testing

Pre Deployment Tests (conducted prior to ship loading and during deployment voyage)

- Continuous operation of the tsunameter during transit to deployment site, and monitoring of communications, including bi-directional communication
- Engineering readout of equipment status, internal error or status flags.

Post Deployment Tests

- Check of bottom unit tilt angle in deployed location
- Check of communications using test data streams
- Continuous monitoring of sea level data transmissions for period of at least 1 hour after appropriate stabilisation period (e.g. temperature stabilisation of ocean bottom instrumentation)
- Tuning of thresholds for tsunami event triggering.
- Check the Bottom unit settled position and surface buoy anchor settled position and calculate the distance (to achieve proper acoustic communication)
- Check of clock drift

Retrieval:

- Bottom unit should be designed with some pressure activated radio beacon, strobes or flag to simplify retrieval.
- Bottom unit Buoyancy module can be designed such a way that when it is surface the acoustic unit can be submerged in to water so that the direction and distance shall be calculated by acoustic deck unit.