INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

WORLD METEOROLOGICAL ORGANIZATION

DATA BUOY COOPERATION PANEL

DBCP-XXVI/Doc. 6.2 Rev 1
(31.VIII.2010)

TWENTY-SIXTH SESSION

ITEM: 6.2

OBAN, UNITED KINGDOM
27 – 30 SEPTEMBER 2010

ENGLISH ONLY

REPORT BY THE TASK TEAM ON INSTRUMENT BEST PRACTICES AND DRIFTER TECHNOLOGY DEVELOPMENTS

(Submitted by Bill Burnett, Chairperson TT-IBP, USA)

Summary and purpose of the document

This document contains the report by the chairperson of the DBCP Task Team on Instrument Best Practices and Drifter Technology Development.

ACTION PROPOSED

The Panel will review the information contained in this report and comment and make decisions or recommendations as appropriate. See part A for the details of recommended actions.

Appendices:
A. Report by the Task Team on Instrument Best Practices and Drifter Technology Development
B. Terms of Reference of the DBCP Task Team on Instrument Best Practices and Drifter Technology Development

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

6.2.1 Dr Bill Burnett, Chairperson of the Task Team on Instrument Best Practices and Drifter Technology Development (TT-IBP) reported on the progress during the intersessional period.

6.2.2 The Panel noted with appreciation the following activities of the Task Team:

- Improvement of DBCP documentation related to standards (DBCP TD No. 3, 4, and 37, and OceanSITES QC for biochemical datasets);
- Discussions with the GHRSST regarding enhancing QC feedback mechanisms, and initiating a DBCP-GHRSST Pilot Project designed to address the satellite community needs for drifter data; adaptation of data collection format to permit the transmission of high accuracy SST data from drifters (i.e. 0.01K), and plans for using higher accuracy sensors (0.05K) on E-SURFMAR units;
- Further evaluation and improvement of drogue sensors by the GDP, including through the use of tether strain system;
- Excellent performances of the Iridium telemetry used by some members (France, E-SURFMAR, Canada, Ukraine, UK, South Africa), especially in terms of data timeliness, and the initiation of operational deployments of drifters using this technology;
- Evaluation of the Argos-3 technology (New Zealand, Ukraine in collaboration with France);
- The use of lithium batteries in the polar regions and the Southern Hemisphere to significantly increase life-time (Canada, UK);
- The use of sonic anemometers and the development of specific algorithms for the measurement of wind speed (Canada);
- Efforts by members to better assess their networks, maintain information about sensor calibration, and enhance traceability to standards (e.g. Station Sensor Management System - SSMS - by Canada);
- Implementation of an Ocean Sensor Calibration Laboratory at NDBC to calibrate conductivity sensors and sub-surface temperature sensors;
- The establishment of a Regional Marine Instrument Centre (RMIC) for the WMO Regional Association IV at the NDBC in Mississippi, USA;
- The deployment of SVP-BS drifters with barometers and salinity sensors to validate and calibrate SMOS satellite salinity measurements (France);
- The deployment of SVP-BTC drifters with 80m thermistor strings in the Black Sea and the Bay of Biscay (France/Ukraine);
- Evaluation of the SVP-B mini drifter (Ukraine, GDP);
- Efforts to create and evaluate in-situ mini meteorological markers in polar regions on the basis of SVP-B drifters (Ukraine, Japan).

6.2.3 The Panel then agreed on the following action items:

- The Task Team to identify authors who are willing to provide the updates to DBCP related standards document as listed on the DBCP web site[1] (***action; TT-IBP; Dec 2010***).
- The TC DBCP to submit historical DBCP documents to NOAA for imaging through the Clim ate Database Modernization Programme (CDMP) (***action; TC; Feb 2011***);
- To include appropriate QC procedures for salinity as provided by DBCP members into DBC P TD No. 37 (Guide to Data Quality Control Tests to Perform by a GTS Processing Center) (***action; TC; DBCP-27***).

6.2.4 The Chair of the Task Team thanked members for their hard work during the intersessional period, and for providing the input for this report. The Panel also thanked Dr Burnett and members of the Task Team for their efforts.

6.2.5 The full report of the Task Team is provided in Appendix A and will be included in the CD-

1 : http://www.jcommops.org/dbcp/community/standards

ROM that will be distributed with the Session final report.

Appendices: 2

APPENDIX A

REPORT BY THE DBCP TASK TEAM ON INSTRUMENT BEST PRACTICES AND DRIFTER TECHNOLOGY DEVELOPMENT

During the intersessional period, the DBCP drifters performed well, in general.

Technical Coordinator Contribution

Best Practices

The Technical Coordinator (TC) developed a matrix of existing documents on the JCOMMOPS website: http://www.jcommops.org/dbcp/community/standards. Many of these documents need to be updated since there are gaps in the matrix. The Task Team should identify the authors who are willing to provide the updates.

The TC complied a draft Technical Document (DBCP #37) entitled "Guide to Data Quality Control Tests to Perform by a GTS Processing Center." The TC also created an update to DBCP Technical Document #3 – "Guide to Data Collection and Location Services Using Argos" as requested by the DBCP to the WMO. This document was reviewed by CLS and the Panel. The TC finalized updates to the SVP-B design manual (DBCP Technical Document #4) to add some information about Iridium Message Formats (now at Version 2.2).

Regarding OceanSITES, the TC sent out a request to all members asking if there was any documentation on Quality Control or Assurance for Biogeochemical datasets. The TC also finalized documents for the OceanSITES QC best practices – http://www.jcommops.org/dbcp/community/standards#QC for the OceanSITES Working Group on Quality Control of Biogeochemical data. This information will be very useful to the Task Team.

The TC prepared a summary and approximate page count of archives for 29 different paper documents to possibly be scanned (13 DBCP Session/Meeting Reports, 2 Additional Meeting reports, 13 Technical Documents – one with a small supplement) by NOAA. The TC also uploaded the Korean version of the DBCP anti-vandalism leaflet to the DBCP website, and began compiling documents to describe existing Quality Control Procedures for Salinity as provided by DBCP members.

Technology Developments

The TC began to discuss and document how JCOMMOPS could assist and be assisted by the Satellite (GHRSST) and modeling communities via QC feedback mechanisms and how the DBCP could put forward a proposal for funding pilot drifters designed to suit satellite data needs. David Meldrum attended the GHRSST Science meeting in June (Peru) and will have feedback on developments needed in drifters to suit the needs of GHRSST. JCOMMOPS prepared a poster for the GHRSST meeting outlining ways for JCOMMOPS/DBCP and GHRSST to cooperate in the future:

http://www.jcommops.org/FTPRoot/DBCP/meetings/2010/GHRSST/DBCP_GHRSST_2010.pdf

The TC added a link on the DBCP website under data – to the tool "iQuam – quality monitor for in situ sea surface temperature," this is an online monitoring tool developed at NESDIS/STAR: the link is http://www.star.nesdis.noaa.gov/sod/sst/iquam/.

JCOMMOPS prepared a proposal to develop the "RRR WMO Database of User Requirements and Observing System Capabilities" on behalf of the WMO. FLEX mooring – the ATLAS mooring will be replaced by the FLEX mooring designed at PMEL (Meinig et al). FLEX is being tested for OceanSITES – KEO and PAPA which have both FLEX and ATLAS concurrently. This offers more

ports and subsurface (Seabird) inductive hourly time-series, stores met data and telemeters the data via Iridium (data uploaded every six hours with more parameters such as wind gusts, solar radiation, longwave, subsurface T/S, pressure currents, barometric pressure, and wind speed/direction). This raises the issue with data sharing as there is currently no pathway to the GTS from the FLEX data stream so discussions are underway between PMEL and Iridium providers.

Global Drifter Program/Data Assembly Center Evaluation

The Global Drifter Program/Data Assembly Center (GDP/DAC) has reported previously a reevaluation of drogue status that took place in early 2008 due to extremely noisy submergence values, especially problematic for many ***Technocean*** drifters (***Technocean*** is the largest single contributor to the array). Since the implementation of a tether strain drogue sensor system by ***Technocean*** and other manufacturers, the DAC has been able to assess drogue presence more reliably. These improved drifters represented a significant fraction of the global array by late 2008. During this same period of transition, the fraction of drifters identified as "drogue on" fell from 70% to approximately 50%, suggesting that a significant fraction of drifters in the pre-2008 period were misdiagnosed as "drogue on." From **Technocean**, nearly all of these drifters were equipped with the "wagon wheel" design." For reference, if a manufacturer is meeting the goal lifetime of 450 days for a transmitter and 300 days for drogue attached, approximately 67% of the drifters should have a drogue attached. ***Clearwater*** drifters, which have used the tether strain method for many years, show a steady decline from 60% to 80% in 2000-2005, to 30 % to 50% in 2008-2010. ***Technocean*** drifters appear to be at 70% to 80% until 2008, but were particularly subject to misinterpretation. The faction of ***Technocean*** drifters with drogues dropped to <40% with the implementation of more reliable drogue detection sensors. However, **Technocean** drifters significantly exceeded the 450-day transmission life which would contribute to the lower "drogue on" percentage. Around 60% to 80% of ***Pacific Gyre*** and ***Metocean*** drifters have drogues attached.

In late 2008, **Technocean** stopped using the wagon wheel design and reverted to the earlier "wire" drogue design as well as slightly increasing the tether diameter. The first of these buoys began to be deployed into the network in July of 2009. As of March 31, 2010, 108 of these buoys were transmitting, 31 had grounded, 1 was retrieved and 15 had ceased transmission for unknown reasons. Of the 108 buoys transmitting, 76% still had drogues "on." Of the 47 "dead" buoys, 80% ended their life with the drogues "on." Though not conclusive, given the relatively short period of operating time, these results are encouraging.

This year, the GDP also identified a large series of ***Clearwater*** SVP drifters that had an anomalously high "failed on deployment" rate (7.5%) where the average is ~2% to 3%, and in many cases report short lifetimes after deployment. A large fraction of these drifters reported bad SST values, in many cases after only a few months in the water. This problem has been reported to the manufacture.

In addition, a problem with ***Technocean*** drifters was identified where many days to months pass between deployment time and first data transmissions. This has been reported to the manufacture who determined that there was a possible problem with the magnet separation after deployment. This situation was remedied with an improved magnet attachment method.

MetService NZ Evaluation

During the austral summer (2009/20010) MetService New Zealand deployed 5 ARGOS3 PMT buoys, 40 buoys (10 upgrades and 30 GDC) under the SOPB November 2009 through March 2010, 3 MetService buoys in the Tasman Sea and 2 Iridium buoys in May 2010. The performance of the ARGOS3 and Iridium buoys are reported under their respective Pilot Projects.

UK Met Office Drifter Evaluation

The UK Met Office continues to deploy drifting buoys (with barometers) in the South Atlantic and the Southern Ocean. All drifters purchased have been **MetOcean** units and from 2007 have all been Iridium drifters and a contribution to the Iridium Drifter Pilot Project. Many of the drifters were ordered with lithium batteries in order to evaluate the potential increase in lifetime of the units.

The longest lived Argos drifter (from 5 units deployed) with alkaline batteries operated for 915 days, whereas the longest surviving Argos drifters with Iridium batteries (2 from 4 units deployed) are still operating after 1,180 days (as of August 10, 2010).

The longest lived Iridium drifter (from 10 units deployed) with alkaline batteries operated for 463 days, whereas the longest surviving Iridium drifters with lithium batteries (2 from 11 units deployed) are still operating after over 650 days; a further 7 of these units are currently operating after 260 to 310 days.

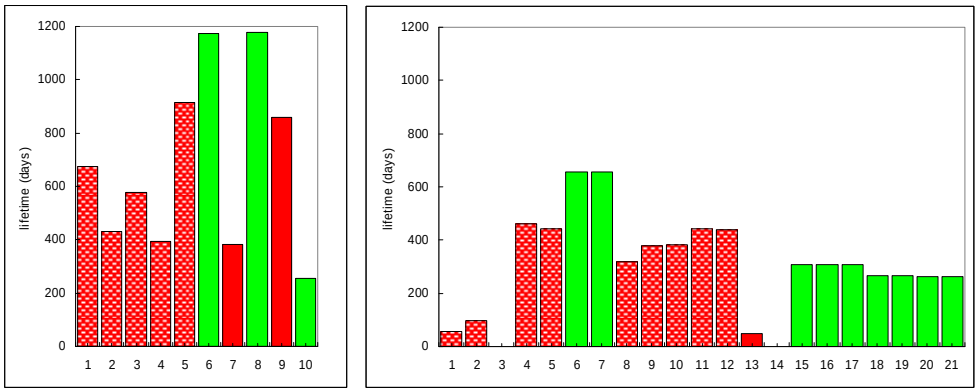

Figure 1. Lifetimes of Argos (left) and Iridium (right) drifters. Active drifters are shown in green, expired drifters in red, units with alkaline batteries are shown by hatched bars and with lithium batteries by solid bars.

Given the anticipated increase in lifetimes, a further 7 Iridium drifters, all with lithium batteries, are on order and planned to be deployed on the Atlantic Meridional Transect cruise in October/November 2010.

US NOAA/National Data Buoy Center Evaluation

The NOAA/NWS National Data Buoy Center upgraded firmware has been installed at all 39 U.S. DART stations and installed diodes on CPU batteries to reduce voltage and making the CPU less susceptible to interrupts; conducted additional testing of CPU boards to identify those boards more susceptible to interrupts. They also replaced plastic coated wire rope in mooring with a fish bite resistant synthetic rope to increase mooring reliability and added a pressure-activated strobe light to Bottom Pressure Recorder (BPR) to aid in recovery at night.

The NOAA/NWS National Data Buoy Center is implementing an Ocean Sensor Calibration Laboratory to calibrate conductivity sensors and sub-surface temperature sensors. This laboratory will support the NDBC Tropical Atmosphere Ocean (TAO) Project and the ocean sensors deployed on the NDBC Weather Buoy Program.

The NOAA/NWS National Data Buoy Center hosted the first ever Joint World Meteorological Organization-Intergovernmental Oceanographic Commission Technical Commission for Oceanography and Marine Meteorology(JCOMM) Regional Marine Instrument Center training workshop April 13 to15, 2010. The workshop was a contribution to the JCOMM Pilot Project for

WIGOS where the NDBC offered to act as Regional Marine Instrument Centers (RMIC) for the WMO Regional Association IV. RMICs are expected to provide facilities for the calibration and maintenance of marine instruments, the monitoring of instrument performance, assistance with regard to instrument intercomparisons, and serve as training facilities. Based on the successful workshop, the JCOMM has decided to move forward with the RMIC concept.

Centre of Marine Meteorology of Météo-France Evaluation

Iridium drifters

Since the last DBCP meeting, the Centre of Marine Meteorology of Meteo-France has been continuing to evaluate the Iridium Short Burst Data (SBD) transmission on operational drifting buoys. Since the 1st of September 2009, 55 Iridium SVP-B drifters built by **Metocean** for E-SURFMAR have been deployed in addition to the 100 deployed earlier. Out of them, 30 were remaining drifters without GPS. The excellent data availability and timeliness for these buoys were confirmed (cf. 2009' report). Their operational lifetime (air pressure correctly measured and reported ashore in real time) was also confirmed: 333 days in average (median: 366 days) for 78 buoys which stopped transmitting after the 1st of January 2008.

The 25 other Iridium SVP-Bs (delivered in 2009) have been fitted with a GPS. Out of these, six failed at deployment or quickly after. However, it appears the problems were rather due to other manufacture modifications than to the adding of the GPS. During the first part of 2010, **Metocean** worked a lot to bring the quality of SVP-B drifters back at the level it was previously. Good results are expected from the next series.

Over the past 12 months, Meteo-France was also involved in various aspects of the Iridium-PP work through:

- the operation of a few SVP-B prototypes built by **Technocean** and **Pacific Gyre**;
- the purchase and evaluation of 8 SVP-BS (salinity drifters) to **Metocean**;
- the purchase and evaluation of one SVP-BTC (thermistor string) to **Marlin Yug**;
- the making of suitable dataformats for all these different buoys;
- the GTS data transmission for a majority of these buoys.

Improvements in SST measurements

Data users require a better accuracy for SST. This was raised at DBCP-25. Drifting buoys are the best reference to validate (and possibly to calibrate) infrared and microwave satellite measurements. Iridium-PP data formats were adapted in order to allow a resolution of 0.01 K. Although FM-18 BUOY format does not allow to report SST with this resolution, FM-94 BUFR format does.

Metocean agreed to replace former probe YSI 44032 they previously used (accuracy 0.1 K) with probe YSI 46000 (accuracy 0.05 K) on their future buoys delivered to Meteo-France for E-SURFMAR. Calibration will have to be done with care to take advantage of the new probes. The first deployments of HRSST (High Resolution SST) buoys should occur before the end of 2010.

SVP-BS (salinity) and SVP-BTC (temperatures in depth)

In cooperation with LOCEAN, Meteo-France continues to use SVP-BS drifters from **Metocean** and **Pacific Gyre**. In addition to the eight Iridium SVP-BS drifters mentioned here above, 9 Argos SVP-BS from **Pacific Gyre** and 3 from **Metocean** were deployed over the past 12 months. All are fitted with SEABIRD sensors. Results are globally satisfactory. Since the SMOS satellite was launched, *in situ* salinity data has been used to validate and calibrate its remote salinity measurements.

The three Iridium SVP-BTC built by **Marlin** and deployed in the Black Sea by August 2009 ran ashore after a few weeks. A similar drifter (WMO 6200510), purchased by Meteo-France and deployed in the Bay of Biscay (off France) by mid-April 2010, was still correctly working by mid-August. As for those of the Black Sea, this buoy is fitted with a 80-metre long string with 16 sea temperature probes and a hydrostatic pressure sensor at its end. In addition to the temperature values, the buoy reports the depth of each probe according to the pressure value and an algorithm simulating the string shape. Results may be seen at:
http://www.meteo.shom.fr/qctools/svp_odv/svp_dataplot.htm

Environmental Canada Evaluation

Environment Canada (EC) continues to deploy SVP-B and SVP-B/W buoys in three target areas; the Northeast Pacific Ocean, the Northwest Atlantic, as well as the Arctic Basin (primarily north and west of the Canadian Arctic archipelago). EC has continued to contribute to the Iridium Pilot project, with 2 Iridium SVP-B drifters in operation this year. Given the results to date, as well as cost savings future EC SVP-B deployments will use exclusively Iridium telemetry. In addition, we will be utilizing Lithium batteries for all drifting buoy deployments in the Artic, and will be examining the impact (and cost/benefit) of Lithium batteries in the North Pacific and Northwest Atlantic.

Environment Canada has also had some initial discussions with **MetOcean** regarding a new type of SVP-B buoy that will utilize a Gill Sonic Anemometer to attempt to estimate wind speed a direction more accurately (and directly) than the existing acoustic SVP-B/W buoys. It is understood that there are significant challenges associated with the development of algorithms to provide useful estimates wind speed/direction given the impact of continuous wave action and submergence of the buoys. The power requirements of the sensor will also need to be carefully assessed. The design is also of significant interest for on-ice, and on-land deployments in the Canadian Arctic (with deployment via ice breaker or even aircraft landing on-ice). We are hoping to be able to test and verify the initial version of the design from **MetOcean** pending additional discussions with the company, and welcome the contribution of other interested buoy manufactures and National Meteorological Services.

Finally Environment Canada has been working towards the implementation of a new system that will improve the management of key weather observing assets (all networks), and status of site maintenance/calibration. The Station Sensor Management System (SSMS), will allow for more comprehensive and accurate tracking of assets, and include detailed calibration reports for every sensor at each station. The resulting system will allow for improved traceability of calibration results, information on mean-time of failure of specific make/model of sensors and other components (i.e. transmitters, power modules, solar panels etc.). It will over time also provide the ability to track the costs associated with the maintenance/calibration of each station, or class of station in the EC weather observing networks (including Marine buoys and ships). Testing and verification will occur in September with the launch of the system to our operational networks by November of this year.

Marine Hydrophysical Institute and Marlin-Yug Ltd Comments

The jobs in 2009-2010 were carried out according to the Iridium, ARGOS3 and WMD Pilot Projects as well as to the TT-IBP needs reviewed in the DBCP web page “Standards and Best Practice.”

New prototypes of Iridium SVP-BTC80/RTC/GPS and SVP-B/RTC/GPS were developed and evaluated for the reporting period (Figure 2). All the buoys have new controller and software to remove the problems, which took place in previous prototypes of Iridium drifters. Real Time Clock (RTC) introduced in **Marlin** buoys since 2007, now has the GPS synchronization for the drifter’s clock. Three temperature-profiling drifters were successfully tested in the Black Sea, while one

drifter is under study after deployment by Météo-France in May 2010 in the Central Atlantic. One of the experiment's goals was the determination of data continuity, when hourly messages have large volumes, as well as continuity of hourly GPS locations.

Three Iridium SVP-B drifters (two with GPS and one without GPS) were deployed by SAWS in the South Atlantic. The goal was the same, evaluate the continuity of observations and GSP locations when drifting under tough weather conditions in the Southern Ocean. Active participation occurred when discussing the parameters of new Iridium data formats for further generations of Iridium drifters.

The first prototype of ARGOS3 SVP-B/RTC drifters was developed at the end of 2009 (Figure 3). Large numbers of preliminary laboratory tests of new electronics were carried out. Two experimental buoys were deployed in the Black Sea by Marine Hydrophysical Institute in November 2009. one buoy came ashore after 102 days in operation, while the second buoy continues operating in the Sea on August 1, 2010. Different statistics have been accumulated about the operation of these drifter's applications. Eight modified SVP-B/RTC drifters were built and shipped in July 2010 to the Pilot Project participants, which will be tested in different areas and under different weather conditions. Technical proposals for the SVP-BTC80W wave-estimating drifter was developed and sent to the PP-WMD Steering Team for evaluation.

New versions of the SVP-B mini drifter (34-cm float and 61-cm drogue) with new packaging techniques were developed (Figure 4). This buoy is the first step to correspond with the DBCP requirements about automatic self-deployment after being dropped from 20 meters height when the ship has a speed of 25 knots velocity. Five buoys were build and sent to NOAA for an comparison study.

Some efforts were undertaken to progress the polar investigations. This work has been realized together with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) with the goal to create and evaluate in-situ mini meteorological markers on the basis of SVP-B drifters (Figure 5). The Argos-GPS ice marker with barometric channels has 2.2 km full weight and has to keep its operation for 6 months, when minus 30^{o}C environmental temperatures. Two markers were built. One marker was intended for deployment at the North Magnetic Pole after 900-km afoot delivery by Japanese adventurer. Unfortunately, the marker was put on ice after 700-klm away, traced via marker, because of too thin ice for further travel. Another marker was delivered and deployed on Geographical North Pole during the North Pole Environmental Observatory (NPEO-2010) meeting.

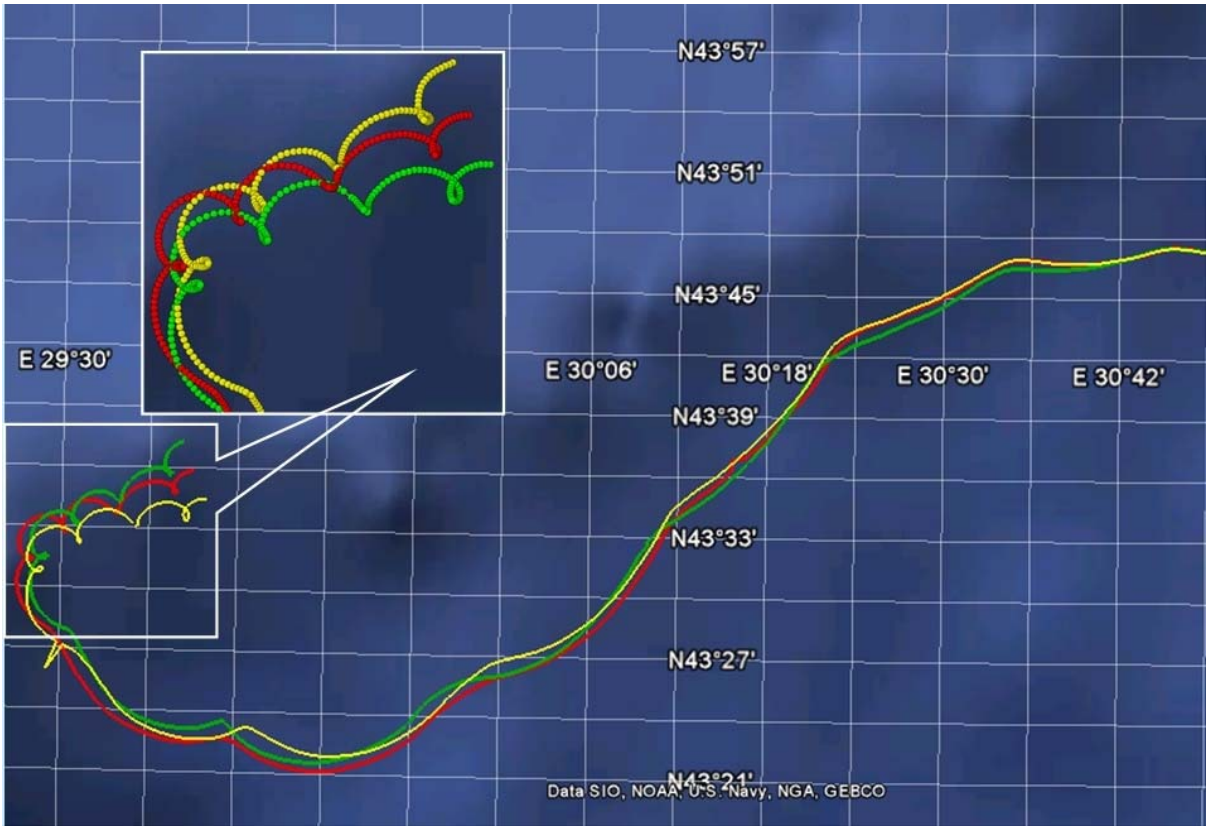

Figure 2. SVP-BTC80 in the Black Sea.

Figure 3. ARGOS3 buoys in the Black Sea.

Figure 4. Automatic deployed drifter.

Figure 5. Placing of the marker.

APPENDIX B

TERMS OF REFERENCE OF THETASK TEAM ON INSTRUMENT BEST PRACTICES & DRIFTER TECHNOLOGY DEVELOPMENTS

(as adopted at DBCP-XXIV)

Note: The DBCP Evaluation Group is being merged into this Task Team.

The DBCP Task Team on Instrument Best Practices & Drifter Technology Developments shall:

Instrument Best Practices and Quality Management

1. When required by the DBCP, evaluate quality of buoy data produced by specific types of buoys, as well as functioning, efficiency;

2. Review existing practices for automatic real-time buoy data quality control, and delayed-mode buoy data quality control, and possibly suggest design changes for improvement (sensors, hardware, software, data formats) in liaison with the Task Team on technological developments;

3. Address instrument evaluation issues; suggest specific tests and / or evaluation deployments in different sea conditions to DBCP members in order to evaluate buoy quality as described in (1) above;

4. Share experience and results of evaluation with the DBCP and other interested parties;

5. Review and recommend Best Practices; work on specific technical issues in order to facilitate standardization and liaise with the other DBCP Task Teams as appropriate (e.g., DBCP recommended Argos message formats); and

6. Define specific criteria for evaluation purposes (e.g. ocean areas, definition of acceptable quality data, e.g., early failures, lifetimes, delays, accuracies, resolutions, etc.);

Drifter technology developments

7. Investigate developments in the fields of sensor technology, on-board processing, buoy hardware, hull design, energy generation and storage in order to better meet user requirements in terms of the range, reliability and quality of observed parameters and their cost-effectiveness;

8. Regularly review and document operational and upcoming satellite telemetry systems in terms of their ability to address user requirements such as bandwidth, timeliness, availability, geographical coverage, reliability, service quality, technical support, energy consumption and cost;, and make specific recommendations to the communications service providers on required / desired enhancements;

9. Review operational platform location systems, and whether they meet the user requirements;

10. Propose to the DBCP and its Executive Board any evaluation activities and pilot

projects that it deems beneficial to data buoy operators;

11. Propose recommendations, both upon request and unsolicited, to the Argos Joint Tariff Agreement. Such recommendations shall be passed via the DBCP Executive Board or the DBCP as appropriate; and

12. Evaluate, test, and promote buoy designs that are resistant to vandalism;

General

13. Review all relevant JCOMM Publications to make sure they are kept up to date, comply with Quality Management terminology, and adhere to the WMO Quality Management Framework (QMF);

14. Provide the DBCP Executive Board and the DBCP, both upon request and unsolicited, with technical advice needed for addressing the issues above; and

15. Submit reports to the DBCP Executive Board and to the DBCP at its annual session that describe intersessional activities and propose a Workplan for the next intersessional period.

Membership:

The membership is open to all Panel members. The Chairperson, appointed by the Panel , has selected the following team members:

- Dr Bill Burnett, NDBC (TT Chairperson);
- Mr Pierre Blouch, Météo-France;
- Mr Shaun Dolk, NOAA / AOML;
- Ms Julie Fletcher, MSNZ;
- Mr Paul Freitag, NOAA / PMEL;
- Mr Frank Grooters, KNMI;
- Mr Michel Guigue, CLS;
- Mr Ken Jarrott, BOM;
- Mr Robert Jenson, USACE;
- Mr Chris Marshall, Environment Canada;
- Mr David Meldrum, SAMS;
- Mr Sergey Motyzhev, Marlin Yug;
- Mr Peter Niiler, SIO;
- Mr Christian Ortega, CLS;
- Ms Mayra Pazos, NOAA / AOML;
- Mr Steve Piotrowicz, NOAA; and
- Dr V. Rajendran, NIOT.
- Dr M Ravichandran, INCOIS
- Dr. Tim Richardson, Liquid Robotics
- Mr Jean Rolland, Météo-France;
- Mr Andy Sybrandy, Pacific Gyre;
- Mr Jon Turton, UK Met Office;
- Ms Hester Viola, Technical Co-ordinator, DBCP;
- Mr Bill Woodward, CLS America;

_____