WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

DATA BUOY COOPERATION PANEL

DBCP-29
(20-Sep-13)

TWENTY-NINTH SESSION

ITEM: 6.2

PARIS, FRANCE
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ENGLISH ONLY

REPORT ON BEST PRACTICES AND DRIFTER TECHNOLOGY DEVELOPMENTS

(Submitted by Luca Centurioni and Rick Lumpkin, Best Practices working group chairmen)

Summary and purpose of the document

This document provides information on the issue of drifter best practices per the request from the previous DBCP Session in this regard.

ACTION PROPOSED

The Panel will review the information contained in this report and comment and make decisions or recommendations as appropriate.

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

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

6.2.1 Mr Luca Centurioni, Co-chairperson of the Task Team on Instrument Best Practices & Drifter Technology Developments (TT-IBPD), reported on the Panel’s activities during the last intersessional period. During DBPC Session 27, the Panel noted with concern that recent studies had indicated that estimates of drogue loss events since the late 1990s had in many cases been underestimates. The Panel considered that the time was right for a detailed evaluation of the issues surrounding drogue loss and drogue loss detection, and this was carried out by the Global Drifter Program (GDP) over the inter-sessional period. During DBCP Sessions 27 and 28, the Panel noted with concern that drifter lifetimes have dropped below the goal of a half-life of 450 days. Mr Centurioni presented an evaluation and recommendations to improve these problems.

Discussion

6.2.2 The Panel thanked Mr Centurioni and members of the Task Team for the comprehensive report. The Panel formally elected Dr Centurioni to Chair the Task Team during the next intersessional period. The full report of the Task Team is provided in Appendix A of DBCP-29 preparatory document No. 6.2 as well as in the CD-ROM accompanying the DBCP Session final report.

Appendices: 2

APPENDIX A

APPENDIX A

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

1.1 Drogue detection and retention

1.1.1 During DBPC Session 27, the Panel noted with concern that recent studies had indicated that estimates of drogue loss events since the late 1990s had in many cases been underestimates. The Panel considered that the time was right for a detailed evaluation of the issues surrounding drogue loss and drogue loss detection, and this was carried out by the Global Drifter Program (GDP) over the inter-sessional period. The GDP applied a methodology to drifter data to automatically reanalyze drogue presence and results of this study were presented during the Science and Technology session of DBCP-28. The GDP also implemented additional detection techniques, including anomalous downwind motion and transmission frequency anomaly variance, to improve drogue loss detection, and conducted an extensive manual re-evaluation of all ~14,000 drifters in the data base since October 1992 (well before the drogue detection problem contaminated the more recent data).

1.1.2 At DBCP Session 27, it was recommended to establish a detailed chronology of drogue design changes, going back as far as possible and to establish a detailed chronology of drogue loss events from the historical record and then to cross-correlate these two. This analysis was conducted for DBCP-28 and it was determined that there is no connection between the switch in drogue design and the ability to detect drogue presence. However, there was a sharp decrease in the fraction of drifters with drogues concurrent with the phase-in of the mini drifter, a signal which had been hidden prior to the drogue reanalysis of Lumpkin et al. (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 result suggests that the mini drifter design has a far shorter drogue lifetime than the original, larger design: the half-life of the drogue decreased from 300-400 days in 1990—2000, to 75—100 days in 2005—2011, with the decrease most rapid in 2004. However, it was noted at the Session that other changes in drifter design, such as dropping the subsurface float,changing the tether attachment technique, and introduction of a lightweight “wagon wheel” design were approximately concurrent with the phase-in of the mini drifter design and may also have played a role in the lifetime decrease. The GDP PIs noted that simply switching back to the older design is far from an optimal solution, as the older design is considerably more expensive to manufacture and ship, and more difficult to deploy, all factors that would significantly negatively impact the program and its’ partners interests. It is instead most desirable to find solutions to increase the drogue lifetimes on the mini drifters while retaining the strengths of that platform.

In order to understand the historical evolution of this problem, the GDP component at the Scripps Institution of Oceanography (SIO,Luca Centurioni, PI) has gathered and reviewed the history of drogue design changes. To address the potential shortcomings in the mini drifter design, SIO has re-designed the tether attachment in order to make it more resistant to stress and torque, and has enhanced the waterproofing seal. The GDP has now issued recommendations to the manufacturers, and intends to use the SIO drifter as a reference design after the test phase is concluded.

1.1.3 The half-life is the expected lag after which 50% of drifters can be expected to lose their drogue, based on current performance. If all drifters lose drogues before dying, calculating half-life is easy: drogue ages are sorted, and the halfway/median value is the half-life. However, this is complicated in practice because many drifters die with drogues attached. Neglecting these (particularly those that retained drogues for an extended time) will bias the results low. To deal with this, an “at least” half life can be calculated as follows: For drifters that died with drogue attached: the “death age” is used in place of age at drogue loss. The drogue half-life is then calculated using all ages. In a second iteration, all “death age” values that are less than the drogue half life are removed, and the half life is recalculated. These steps are repeated until all “death ages” are greater than the half life. Resulting half-lives (in days) by manufacturer are as follows for drifters deployed in these years:

Manufacturer	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
Clearwater	61	72	101	104	95	84	>247
DBi	*	*	*	*	*	>288	>217
Marlin-Yug	197	152	72	57	167	*	0
Metocean	299	>373	269	224	77	89	>115
Pacific Gyre	>282	210	200	241	248	>202	>183
SIO	*	*	*	*	*	*	>98
Technocean	30	45	33	63	77	154	>62

“*” indicates not enough data; >X indicates that most drifters died before losing their drogues, or that most are still alive with drogues attached.

The following table indicates the percent of drifters which lost their drogues in less than 90 days after deployment, as a function of deployment year:

Manufacturer	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
Clearwater	61%	55%	36%	30%	36%	39%	14%
DBi	*	*	*	*	*	25%*	9%
Marlin-Yug	0%	0%	41%	46%	36%	*	43%
Metocean	18%	13%	17%	26%	40%	46%	35%
Pacific Gyre	28%	20%	23%	17%	10%	16%	25%
SIO	*	*	*	*	*	*	33%
Technocean	61%	65%	78%	53%	46%	27%	31%

* 4 prototype buoys

The following table indicates the percent of drifters which lost their drogues in less than 10 days after deployment, as a function of deployment year:

Manufacturer	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
Clearwater	6%	7%	4%	7%	7%	5%	2%
DBi	*	*	*	*	*	0%	4%
Marlin-Yug	0%	0%	24%	33%	9%	*	43%
Metocean	7%	8%	13%	6%	12%	6%	8%
Pacific Gyre	7%	8%	12%	8%	2%	4%	7%
SIO	*	*	*	*	*	*	24%
Technocean	27%	10%	11%	10%	9%	3%	14%

1.1.4 As the detection of drogue loss is vital to oceanographic users of drifter data, it was recommended to reactivate dormant actions to deploy intensively instrumented drifters that would allow detailed characterisation of drogue performance and attendant stresses on its connection to the buoy hull. SIO has worked with Pacific Gyre on a re-design of the tether attachment in order to make it more resistant to stress and torque. The drifter includes temperature and pressure sensors at the top and the bottom of the drogue (SVP2PT). These drifters are still waiting to be deployed on an opportunistic basis as personnel and ship time become available.

To reflect these changes, SIO has revised the instructions for drogue construction. The revision calls for 600 density or higher rip-stop cordura nylon, double fabric along seams, end tacking, schedule 40 PVC rings all-over, and the use of a spider wheel (rather than, say, the wagon wheel technique).

The use of synthetic rope is being evaluated by SIO, since the wire rope tether is most likely the weakest aspect of the drogue design. SIO has built 20 drifters with alternate material. A pilot array with these modifications was deployed to rigorously field-test the drogue lifetime of this modification but the results were inconclusive. To better understand the point of failure, an array of 14 drifters was moored off the SIO pier in November 2012. This test was inconclusive too. A variety of drogue attachments, wire ropes of different diameters and synthetic ropes are being tested at SIO, PacificGyre and DBi. It is worth noting that DBi drifters using a larger (5/32”) space-lay clearly outperform all other manufacturers at the 90-day point. At the time of writing, SIO has initiated using even larger ¼” space-lay tethers and the evaluation is ongoing.

1.2 Drifter lifetime

1.2.1 During DBCP Sessions 27 and 28, the Panel noted with concern that drifter lifetimes have dropped below the goal of a half-life of 450 days.

1.2.2 Below is the lifetime statistics as a function of manufacturer and deployment year, for all drifters and for drifters which quit due to non-“external” reasons (not picked up or ran aground, or died at high latitudes where ice may have destroyed the drifter). Drifters are considered alive if they have at least one sensor reporting to the GTS and/or the drogue on. The half-lives are reported as follows in days, with “*” indicating that not enough drifters were deployed to calculate a half-life, and “>X” is a minimum estimate indicating than more than half are still alive:

Manufacturer	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
All drifters:							
Clearwater	210	206	253	217	163	140	180
DBi	*	*	*	*	*	>278	>217
Marlin-Yug	752	577	78	162	466	*	>308
Metocean	356	373	396	384	211	190	146
Pacific Gyre	103	212	231	284	284	203	158
SIO	*	*	*	*	*	*	135
Technocean	394	522	497	476	262	148	53
"Quit" drifters:							
Clearwater	232	251	217	213	160	159	191
DBi	*	*	*	*	*	>278	>274
Marlin-Yug	849	635	856	634	>911	*	>284
Metocean	395	403	456	445	274	224	167
Pacific Gyre	159	264	598	336	345	242	214
SIO	*	*	*	*	*	*	160
Technocean	563	676	959	656	292	193	54

Note: DBi drifters were first deployed at the end of 2011 so “maximum potential” half-life is comparatively lower

Another way to present lifetime problems is to highlight the fraction of drifters deployed in a given year that died within 90 days of deployment:

Manufacturer	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
Clearwater	8%	7%	11%	11%	26%	27%	13%
DBi	*	*	*	*	*	25%	9%
Marlin-Yug	0%	0%	6%	0%	18%	*	14%
Metocean	4%	7%	5%	6%	5%	11%	18%

Pacific Gyre	21%	12%	12%	17%	4%	5%	8%
SIO	*	*	*	*	*	*	6%
Technocean	13%	9%	8%	4%	11%	32%	55%

In summary:

- The half-life of drifters in operation for GTS purposes is still far from the goal of 450 days.
- ***Clearwater***: drifter half-life was 210—253d during 2006—2009, but decreased to 140—180d in 2010—2012. The fraction that died within 90d of deployment increased from 7% in 2005 to 27% in 2011, and fell to 13% in 2012. **Clearwater is no longer in business.**
- ***Metocean:*** drifter half-life was 356—396d until 2010 when it fell to 211d and reached a minimum of 146d in 2012. The fraction that died within 90d of deployment was 4-7%, increasing to 18% in 2012.
- ***Pacific Gyre***: demonstrated generally increasing half-lives and decreasing percent of short-lived drifters through the period 2006—2010 but decreased sharply to 158d in 2012 (with PMTs running as PTTs). The percentage of drifters that died within 90d of deployment improved between 2006 and 2010, started to rise again in 2012 and reached 8% in 2012. Corrective actions to improve the construction of battery packs and for an energy efficient use of the PMT transmitters have been taken by the company. Several drifters have been retrofitted and a 2013 performance evaluation is pending.
- ***Technocean*****:** half-life was ~400—500d until 2010, when it fell below 300d in 2010, to 148d in 2011 and to 53d in 2012. The fraction dying within 90d of deployment was ~10% until 2011, when it jumped to 32%, and jumped to 55% in 2012. **Technocean is no longer in business.**
- ***Marlin-Yug*****:** half-life was 78-752d until 2010 and in excess of 308 days in 2012. The fraction of drifters quitting within 90d increased from 0-18% in 2016-2010 and was 14% in 2012. Large fluctuations in these statistics are due to the relatively low numbers of MY drifter deployed each year.
- ***DBi*****:** half-life was larger than 278 days in 2011 and larger than 217 days in 2012. It should be noted that the first buoys were deployed in late 2011. The fraction dying within 90d was 25% in 2011 and dropped to 9% in 2012. Note that DBi was using only PTT transmitters in the 2011-2012 periodCorrective actions to fix a firmware bug were taken in 2012 and the effect should be seen in the 2013 statistics. As of August, 2013, half-life was above 300 days.
- ***SIO*****:** half-life for the first generation of SIO drifters was 160d (with PMT running as PTT, thus consuming a large amount of power). The other issue affecting the lifetime was the mechanical failure of the battery packs. The fraction dying at less than 90d was the lowest amongst manufacturers in 2012 due to the ruggedized design of the surface expression of the SIO drifters. Corrective actions in late 2012 and early 2013 included dismissing the PMT/A2 methodology and fully potting the battery packs.
- PTTs versus PMTs: the mean and half-lives of PMT drifters used as PTTs is considerably shorter than those using PTTs. More PMTs died less than 180 days after deployment (51% for PMT vs. 37% for PTTs, with corresponding half-lives of 189d vs. 273d, since 1/1/2005). At the time of writing the practice to use PMT as PTT has been discontinued. Only PMT/A3 and Iridium drifters are being produced and all of the PTT operating as PTT drifters still on land as of October 2012 were retrofitted as PMT/A3 drifters
- Iridium drifters have a half life of 224 days, with 53% quitting before 180 days. This performance not yet as good as Argos drifters, and is far below the 450 day goal. A large SVP-I array is being deployed in 2013 and a full evaluation of the performance and more energy efficient Iridium drifters is expected in mid-2014.

1.2.3: Two main factors are known to affect the drifter lifetime:

- Faulty battery packs: battery packs assembled from poor quality cells have now been eliminated from the GDP array, and are largely responsible for the dramatic lifetime decreases in 2010—2011 documented in 1.2.2. Only packs made of industrial grade Duracell batteries were used in GDP 2012 drifters. As it was discovered in early 2013 that

Panasonic batteries have even better construction characteristics, the US GDP is now recommending their use. A second cause of concern is that battery packs not properly secured can result in individual cells getting damaged on deployment or due to mechanical shock while deployed. SIO is looking into ways to secure individual cells through potting. Techniques for potting battery packs have been explored with promising preliminary results. Potting techniques need to be implemented carefully as alkaline cells produce hydrogen during discharge so venting routes need to be considered. Details on the methodology are available through Dr. Centurioni and the drifter engineers at SIO.

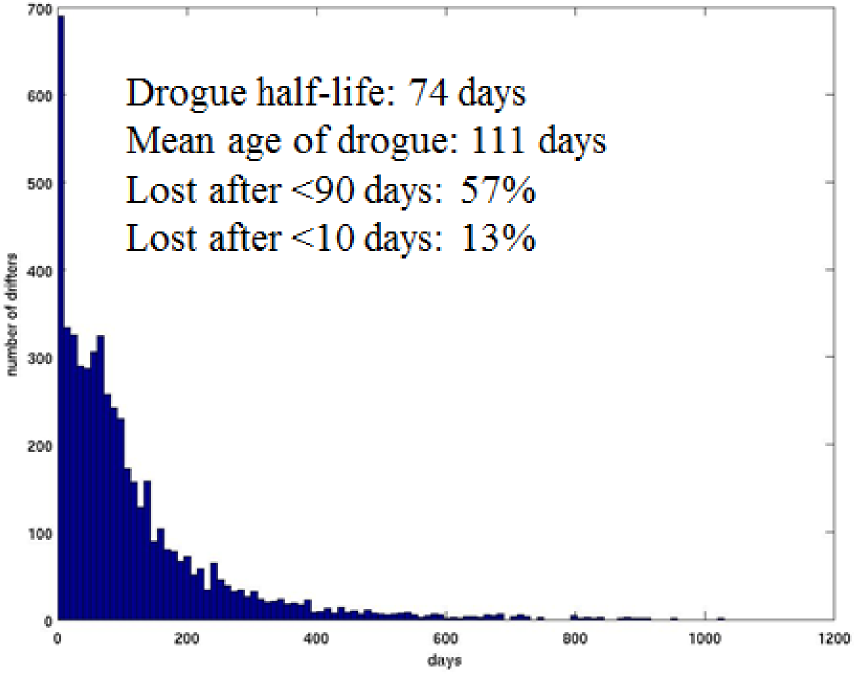
- Argos 2 vs Argos 3: it is now understood that some PMT modems running in Argos 2 mode are not energy efficient and shorten the drifter lifetime considerably. This factor is partially responsible for decreased lifetimes in 2012—2013. All undeployed drifters manufactured in 2012 with PMTs operating in A2 were retrofitted to run as Argos 3. The operation has some risks as this will be the first large implementation of Argos 3 GDP drifters, but it was decided, based on the results of the Argos 3 pilot project, that the benefits of lower energy drain outweigh the risks of this operation. Simultaneously, an array of approximately 200 Iridium drifters is being deployed by the GDP to compare the energy budget of the two types of drifters, i.e. Iridium vs Argos 3.
- A likely explanation in the dramatic recent decline of the drifter’s life could be linked to the increased power demand that resulted from the implementation of PMT and strain gauge. The need for more power might exacerbate the problems connected with the structural integrity of the battery pack, where the failure of one or more cell strings (the standard GDP battery back is made of four series of 8 D cells connected in parallel to provide 56Ah) brings the battery capacity below a critical level. The GDP is now asking the manufacturers to reduce the sampling of the strain gauge to once every 4 hours.

1.2.4: The task team reminds the Panel that manufacturing improvements yielding longer drogue and/or drifter lifetimes will not be reflected immediately in the size and performance of the global drifter array. Remotely-stored drifters with known manufacturing problems will in some cases continue to be deployed, and drifters already deployed will affect half-life calculations through 2013. Furthermore, there is an intrinsic lag from design and manufacturing to shipping, to deployment in significant quantities. As of this writing, the global array still experienced ~120 deaths per 1250 drifters per month (including drifters that run aground or are picked up), an anomalously high death rate attributable to the factors described in this report. Please refer to the GDP report for the latest updates on the status of the GDP array. As drifters with reliable batteries, optimized transmission strategies and more robust drogues and tethers are deployed, we anticipate the number of drogues returning toward the goal of 1250 drifters through 2013 and the drogue lifetimes of drifters deployed in 2013 to increase.

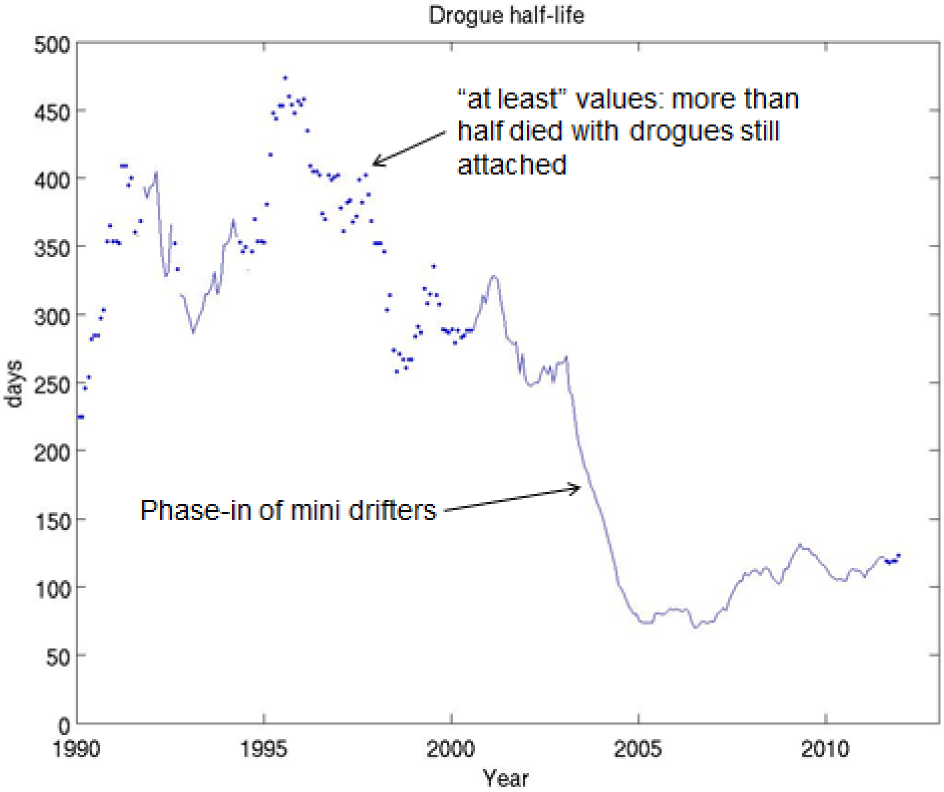
1.3: Summary: The demands of the oceanographic community for a less expensive, easy-to-deploy drifter led to a number of changes that have led to decreased reliability of deployed drifters. Along with the redesign of the system into a mini-drifter, the following issues have occurred:

The subsurface float was dropped,
The tether attachment technique was changed,
ARGOS-3 replaced ARGOS-2 as the communication method in some drifters, and
Inferior batteries were provided to vendors.
A large batch of GDP Iridium drifters is being deployed for evaluation.

The GDP is working to address and remediate each of these changes and tests are being conducted to determine their success.



Histogram of drogue lifetime for all manufacturers, January 2005—March 2012. A large number of drifters lose their drogues very quickly; the overall half-life was 74 days.



Half-life of drifters calculated in a running one-year window centred on the date shown in the figure. A sharp drop in the drogue half-life is approximately concurrent with the phase-in of the mini drifter design in the mid-2000s.

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. 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 Richard Crout, NDBC (TT Chairperson);
Mr Pierre Blouch, Météo-France
Mr Shaun Dolk, NOAA / AOML
Mr Paul Freitag, NOAA / PMEL
Mr Michel Guigue, CLS
Mr Chris Marshall, Environment Canada
Mr Sergey Motyzhev, Marlin Yug
Ms Mayra Pazos, NOAA / AOML
Dr M Ravichandran, INCOIS
Mr Jean Rolland, Météo-France
Mr R. Venkatesan, NIOT, India
Mr David Murphy, Sea-Bird Electronics, USA

Mr Andy Sybrandy, Pacific Gyre (TT Co-Chairperson);
Ms Emily Daniel, MetOcean
Ms Julie Fletcher, MSNZ
Mr Frank Grooters, KNMI
Mr Robert Jensen, USACE
Mr David Meldrum, SAMS
Dr Luca Centurioni, SIO
Mr Steve Piotrowicz, NOAA
Dr. Tim Richardson, Liquid Robotics
Mr Jon Turton, UK Met Office
Mr Bill Woodward, CLS America
Technical Co-ordinator, DBCP

The Co-chairperson is representing the manufacturers and is selected on a rotating basis.