Lessons Learnt from the DOMS Mooring Parting Accident

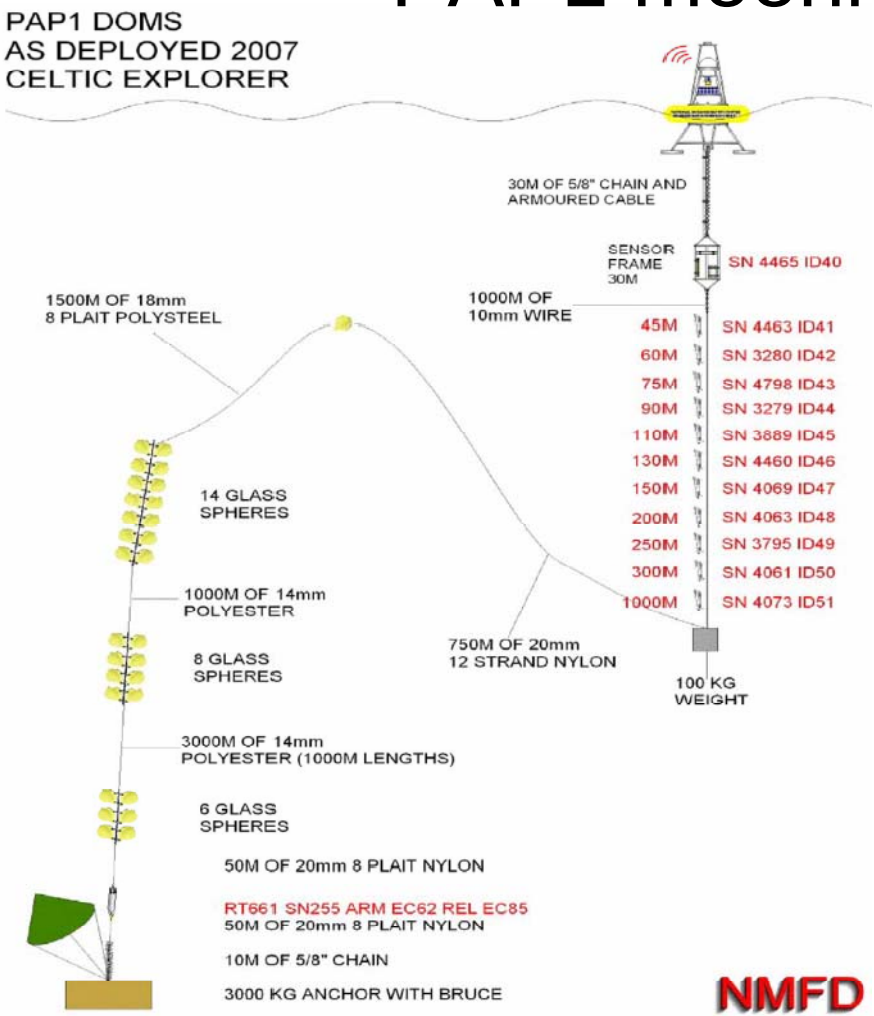
5th UK Moorings Workshop

Mario Brito[1] and Mark Hartman[2]

[1]Underwater Systems Laboratory
[2]Ocean Biogeochemistry and Ecosystems
Contact: {mch,mpb2o07}@noc.soton.ac.uk

Location of the PAP mooring deployed in June 2007. RV Celtic Explorer, cruise CE716. Courtesy of Google Earth.

PAP1 mooring parted



A new multidisciplinary mooring DOMS (Deep Ocean Monitoring Station) was deployed at the PAP time series observatory in June 2007.

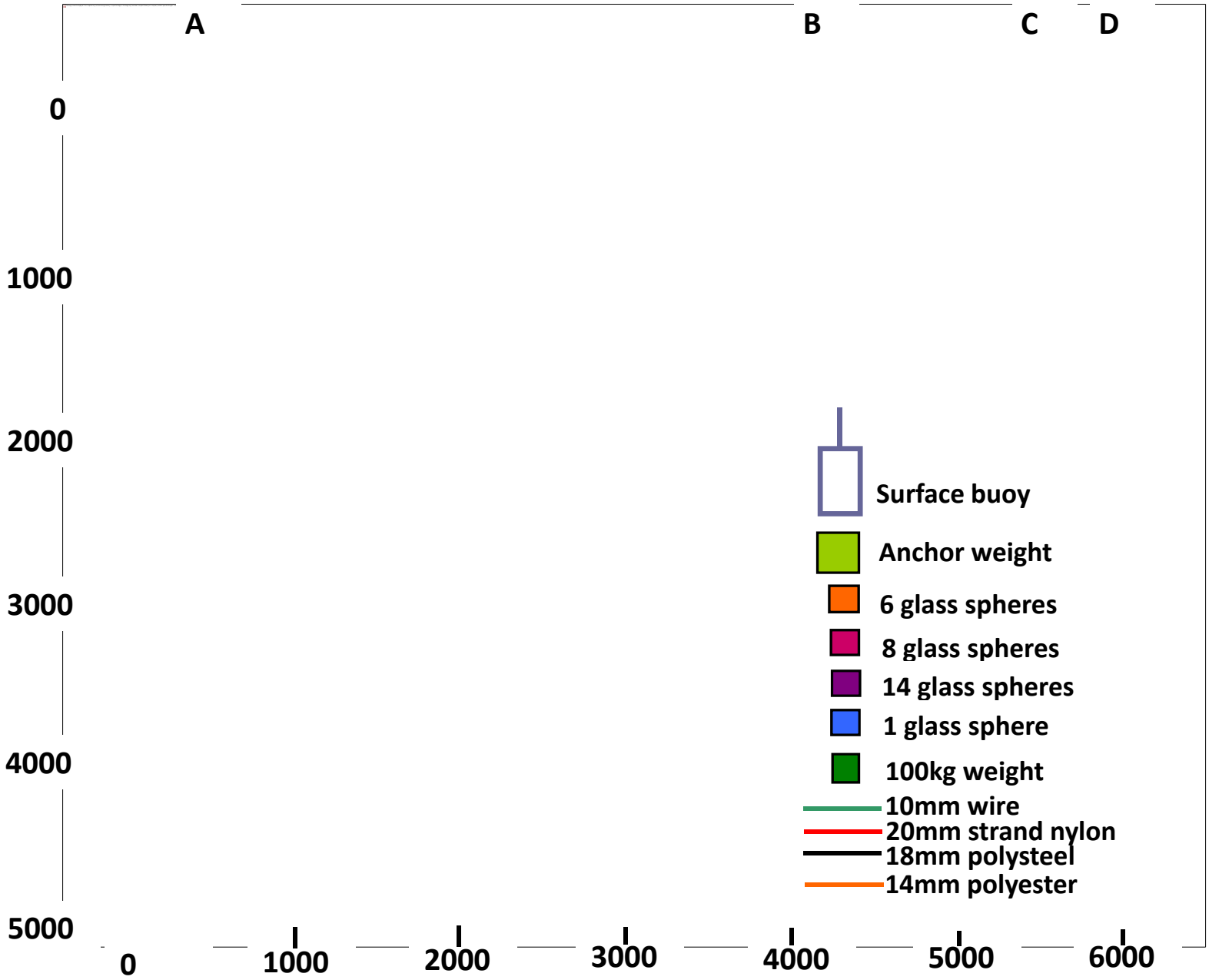
The mooring had a design specification duration of 18 months.

Various features failed and the mooring ultimately parted 47 days after deployment.

The top part of the mooring was recovered by R/V Pelagia in September 2007.

An investigation was conducted to investigate the root cause of the accident.

Lampitt, R., Brito, M.P., Campbell, J., Comben, D., Edwards, T., Griffiths, G., Hartman, M., Hartman, S., Larkin, K., Pagnani, M., Pebody, C. and Waddington, I. (2008) Reliability Case Notes No. 2. PAP 2007: DOMS mooring loss report. National Oceanography Centre Southampton Research and Consultancy Report, 51, 43pp.


A
B
C
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0
1000
2000
3000
4000
5000
0
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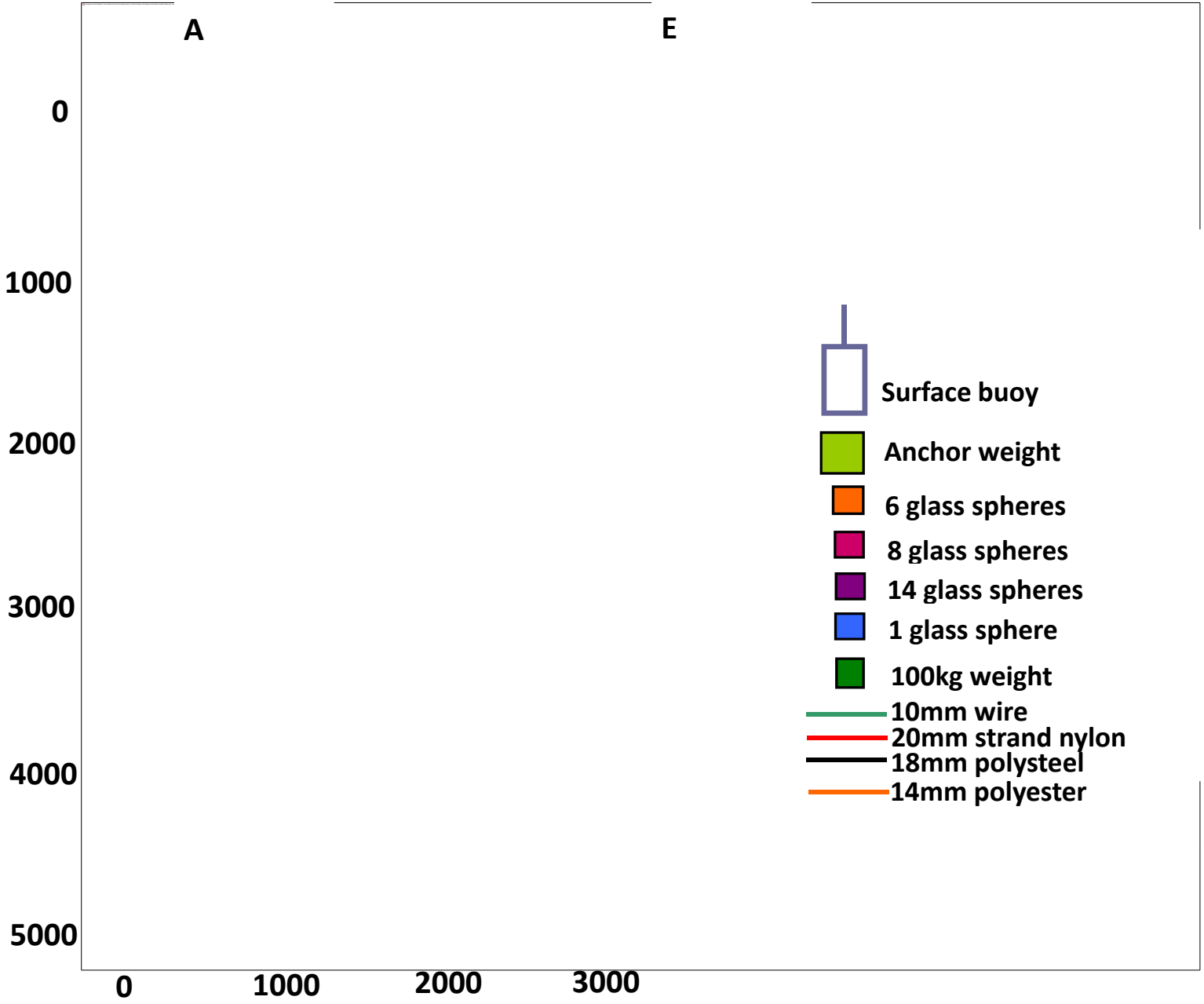
4000
5000
6000
Surface buoy
Anchor weight
6 glass spheres
8 glass spheres
14 glass spheres
1 glass sphere
100kg weight
10mm wire
20mm strand nylon
18mm polysteel
14mm polyester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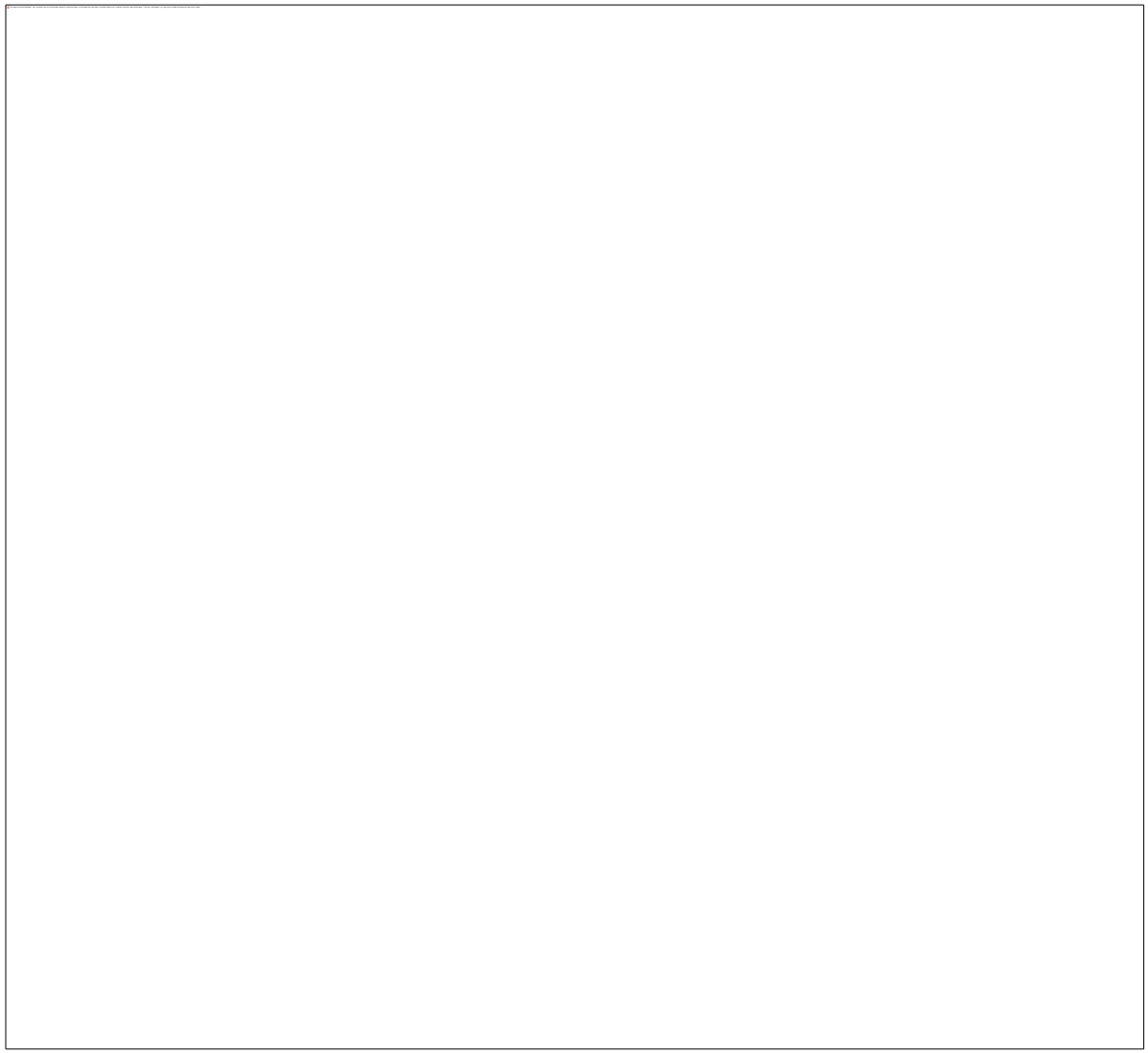
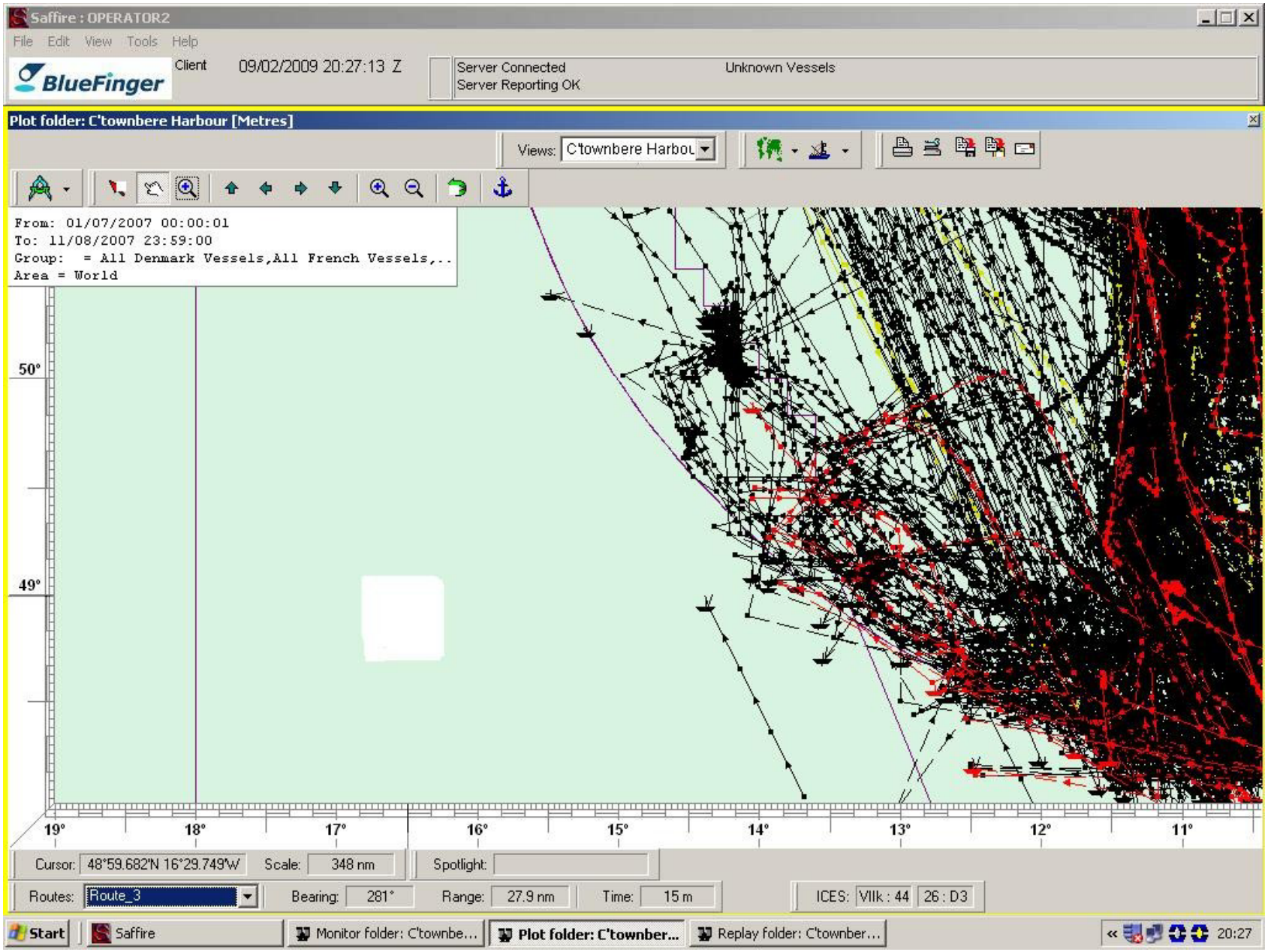
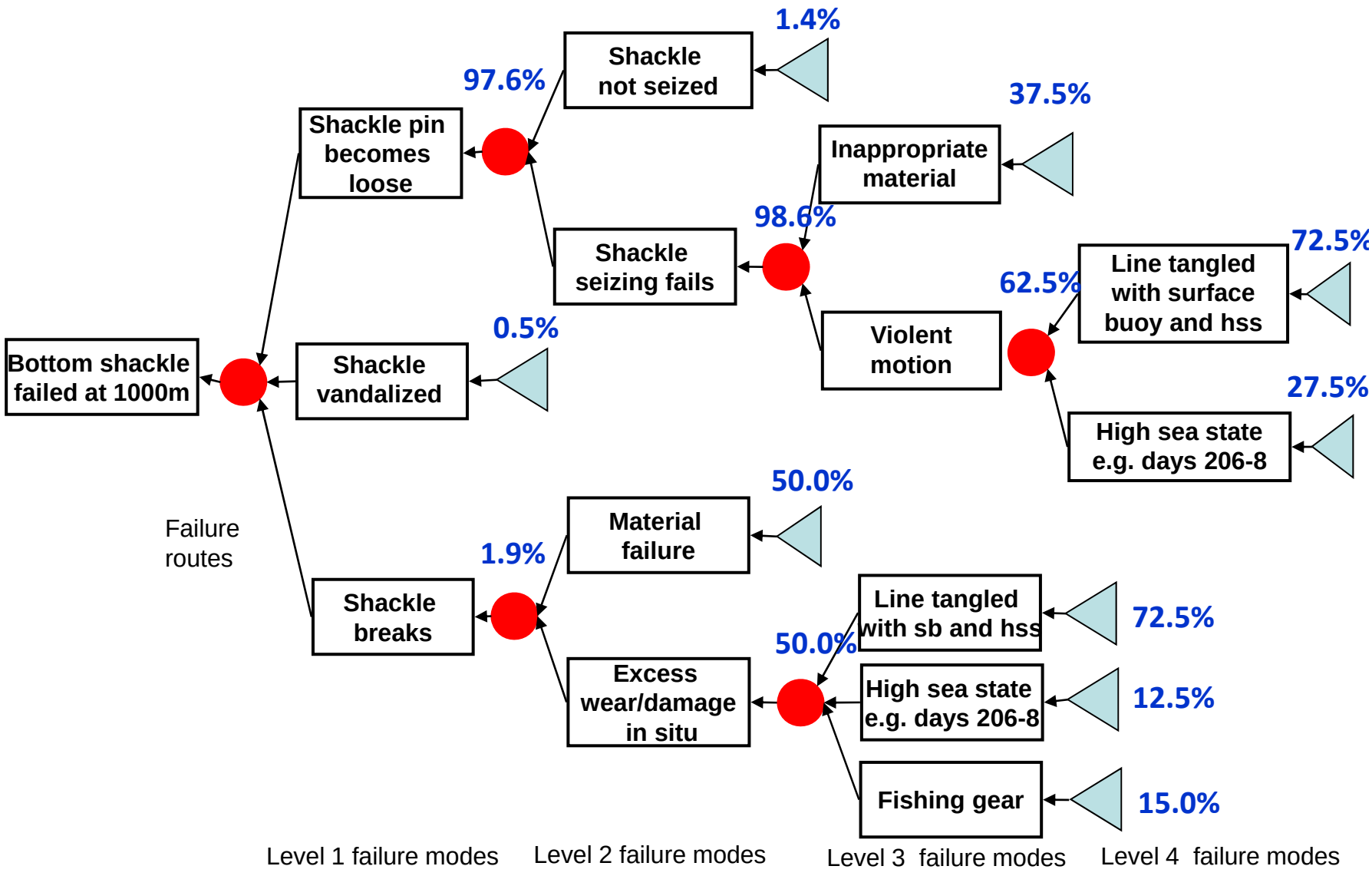


Surface buoy position with watch circles (Mercator).


Saffire : OPERATOR2
File Edit View Tools Help
BlueFinger
Client
09/02/2009 20:27:13 Z
Server Connected
Server Reporting OK
Unknown Vessels
Plot folder: C'townbere Harbour [Metres]
Views: C'townbere Harbou
From: 01/07/2007 00:00:01
To: 11/08/2007 23:59:00
Group: = All Denmark Vessels,All French Vessels,..
Area = World
50°
49°
19° 18° 17° 16° 15° 14° 13° 12° 11°
Cursor: 48°59.682'N 16°29.749'W
Scale: 348 nm
Spotlight:
Routes: Route_3
Bearing: 281°
Range: 27.9 nm
Time: 15 m
ICES: VIIk : 44 26 : D3
Start
Saffire
Monitor folder: C'townbe...
Plot folder: C'townber...
Replay folder: C'townber...
20:27

Event Tree


Bottom shackle failed at 1000m
Failure routes
Shackle pin becomes loose
Shackle vandalized
Shackle breaks
97.6%
0.5%
1.9%
Shackle not seized
Shackle seizing fails
Material failure
Excess wear/damage in situ
1.4%
98.6%
50.0%
50.0%
Inappropriate material
Violent motion
Line tangled with sb and hss
High sea state e.g. days 206-8
Fishing gear
37.5%
62.5%
72.5%
12.5%
15.0%
Line tangled with surface buoy and hss
High sea state e.g. days 206-8
72.5%
27.5%
Level 1 failure modes
Level 2 failure modes
Level 3 failure modes
Level 4 failure modes

Level	N	Failure Mode	Likelihoods
5	**4**	Line tangled with sb and high sea state	**43.6%**
4	**3**	Inappropriate material for the shackle seizing	**36.1%**
6	**5**	High sea state e.g. days 206-8	16.5%
3	**2**	Shackle not seized	1.37%
3	**6**	Material failure	0.94%
4	**7**	Line tangled with sb and high sea state	0.68%
2	**1**	Shackle vandalised	0.55%
4	**8**	High sea state e.g. days 206-8	0.12%
4	**9**	Fishing gear	0.14%
		Total	**100%**

Failure modes identified using the fault tree analysis. Three experts assessed all evidence collected from the investigation.

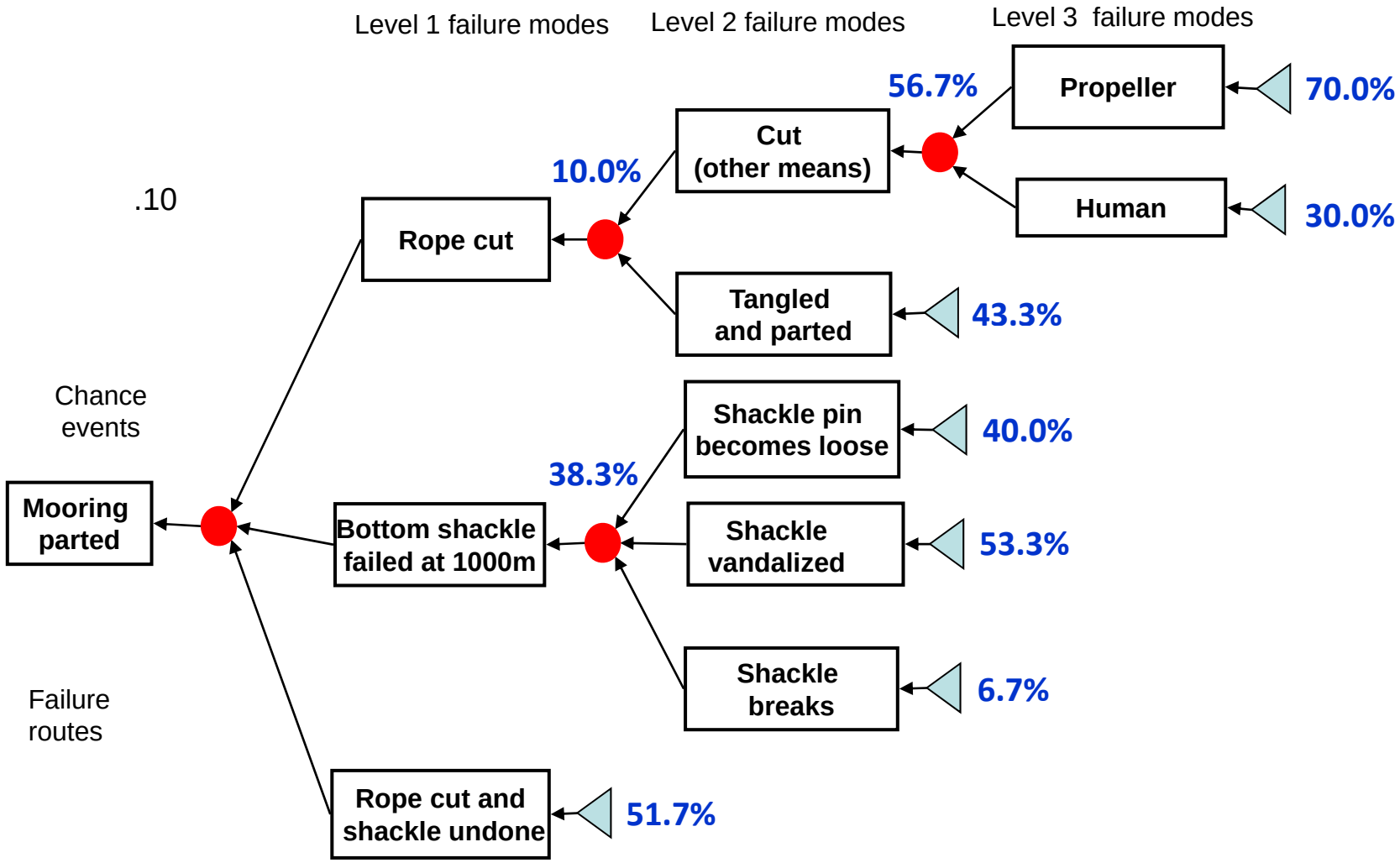
Design fault was considered to be the root cause for the parting of the mooring.

Bad seizing of the shackle may also have contributed to the accident

Upon recovery…

- On 2nd October 2008 all of the expected mooring was recovered except for a single top 17" sphere, 750m of nylon rope and a 100kg weight.
- The upper 1500m rope section of the mooring had been cut.
- Long line fishing gear (hooks and line) entangled were found entangled with the rope.
- The rope had been stopped off several times and there was antifouling paint along lengths of the rope.

Event Tree



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Level	N	Failure Mode	Likelihoods
1	1	Rope cut and shackle undone	**51.7%**
3	2	Bottom shackle failed- shackle vandalized	20.4%
4	3	Bottom shackle failed - shackle pin becomes loose - inappropriate material	5.67%
5	4	Bottom shackle failed - shackle pin becomes loose – line tangled with sb and hss	6.84%
2	5	Rope cut – tangled and parted	4.33%
3	6	Rope cut – human	3.97%
5	7	Bottom shackle failed - shackle pin becomes loose – high sea state e.g. days 206-8	2.59%
3	8	Rope cut – propeller	1.7%
3	9	Bottom shackle failed - shackle breaks – material failure	1.28%
4	10	Bottom shackle failed - shackle breaks – line tangled with sb and hss	0.93%
3	11	Bottom shackle failed- shackle pin becomes loose - shackle not seized	0.21%
4	12	Bottom shackle failed - shackle breaks – fishing gear	0.19%
4	13	Bottom shackle failed - shackle breaks – high sea state e.g. days 206-8	0.16%
		Total	**100%**

Failure modes. Fishing activity is deemed the top reason for the parting of the top side of the mooring.

Implementation of learnt lessons

1: Change design so there is no floating horizontal line to tangle with the surface float.

2: Incorporate restraints on shackles to reduce damage at junctions.

3: Put an AIS proximity sensor on the surface buoy which will automatically transmit the identity of a nearby vessel.

4: Surround mooring with guard buoys.

5: Install proximity activated camera on surface buoy with satellite transmission.

6: Acoustic warning of approaching ship.

7: Develop communication with tuna fishermen (possibly through ICCAT) both to encourage them to avoid the area and to design more durable moorings.

8: Advise location on all charts and in fishermen's magazines.