VLVnT2009 Athens 15 October 2009

DELOS
Deep-ocean Environmental Long-term Observatory System

Phil Bagley, Monty Priede
Oceanlab, University of Aberdeen

Instituto Nacional de Investigação Pesqueira
Centro de Investigação Pesqueira do Namibe
Ministério das Pescas
República de Angola

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

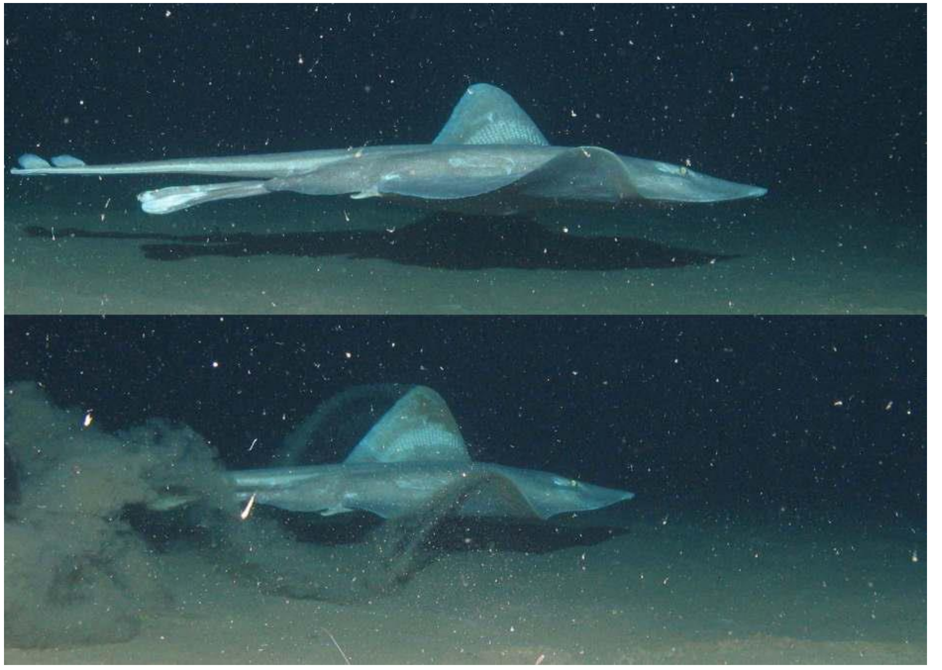
Deep sea research – the problem

- Deep ocean biological research to date has mostly consisted of short-term studies (< 12 months)
- Research surveys regularly discover new habitats and communities previously unknown to science;
- Lack of historical data that can be used as a basis for baseline knowledge and prediction

Baird's smooth head
Alepocephalus bairdii

Deep sea research – the problem

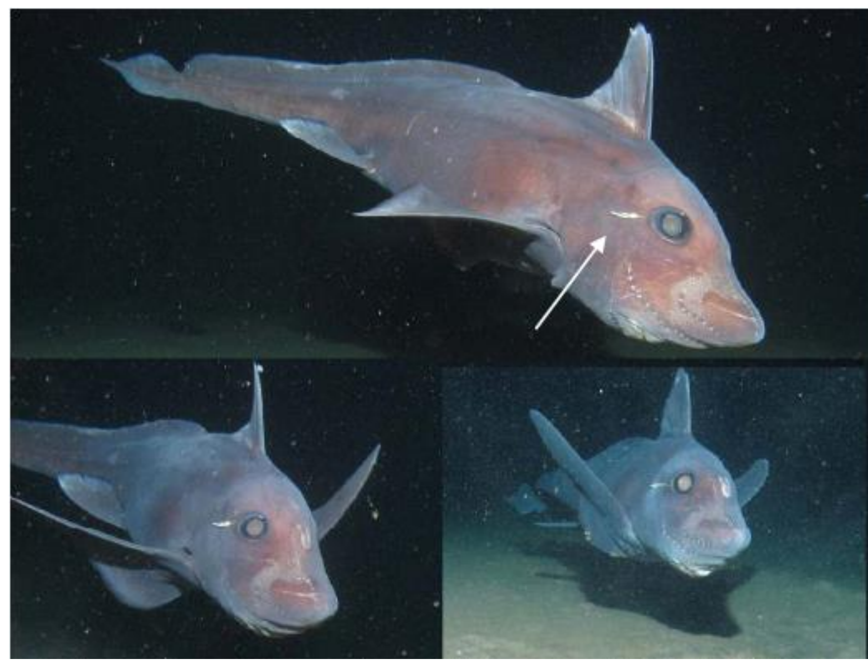
- In the few longer term studies (> 5 years) we have seen considerable variability and changes in dominant fauna over decadal time scales.



Deep-water skate
Bathyraja spp.

Deep sea research – the problem

- If the natural environment is so variable how do we determine in oil production areas whether changes are due to natural variability or due to anthropogenic (man made) influences?



Chimaera *Hydrolagus affinis*

Long-term monitoring

- Measure and monitor deep ocean biodiversity
- Develop an understanding of deep ocean natural variability over the long-term
  - Therefore differentiate between anthropogenic (oil production/ fishing etc) and natural changes
  - Monitor pace of recovery from any unforeseen impacts

BP

- BP operations are gradually extending into deep water areas (e.g. off Angola)
- BP wanted to gain a better understanding of the deep water environment
- Requested assistance from leading deep ocean biological research institutes

M B A R I

UNIVERSITY of GLASGOW

Galveston

UNIVERSITY OF ABERDEEN

Oceanlab

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Instituto Nacional de Investigação Pesqueira
Centro de Investigação Pesqueira do Namibe
Ministério das Pescas
República de Angola

UNIVERSITY OF ABERDEEN Oceanlab

DELOS

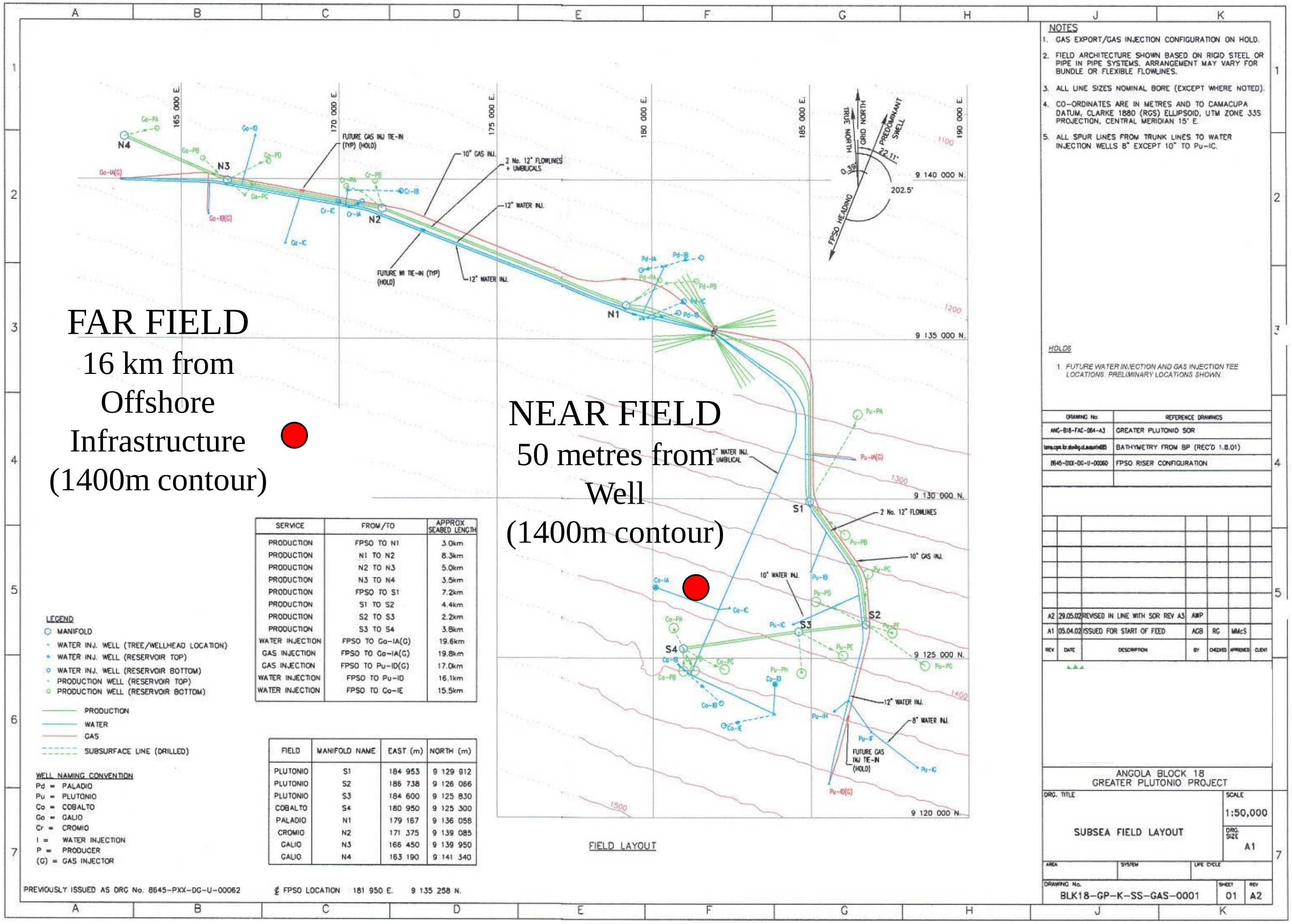
- The DELOS steering committee was established
  - To oversee all aspects of the project
  - Approve original Oceanlab experimental design
  - Oversee data distribution and analysis
  - Ensure scientific quality

Cusk eel *Holcmycteronus asuamses*

DELOS Concept

UNIVERSITY of ABERDEEN Oceanlab | bp | Sonangol | SSI

Block 18 off Angola



SERVICE	FROM/TO	APPROX SEABED LENGTH
PRODUCTION	FPSO TO N1	3.0km
PRODUCTION	N1 TO N2	8.3km
PRODUCTION	N2 TO N3	5.0km
PRODUCTION	N3 TO N4	3.5km
PRODUCTION	FPSO TO S1	7.2km
PRODUCTION	S1 TO S2	4.4km
PRODUCTION	S2 TO S3	2.2km
PRODUCTION	S3 TO S4	3.8km
WATER INJECTION	FPSO TO Go-IA(G)	19.6km
GAS INJECTION	FPSO TO Go-IA(G)	19.8km
GAS INJECTION	FPSO TO Pu-ID(G)	17.0km
WATER INJECTION	FPSO TO Pu-ID	16.1km
WATER INJECTION	FPSO TO Co-IE	15.5km

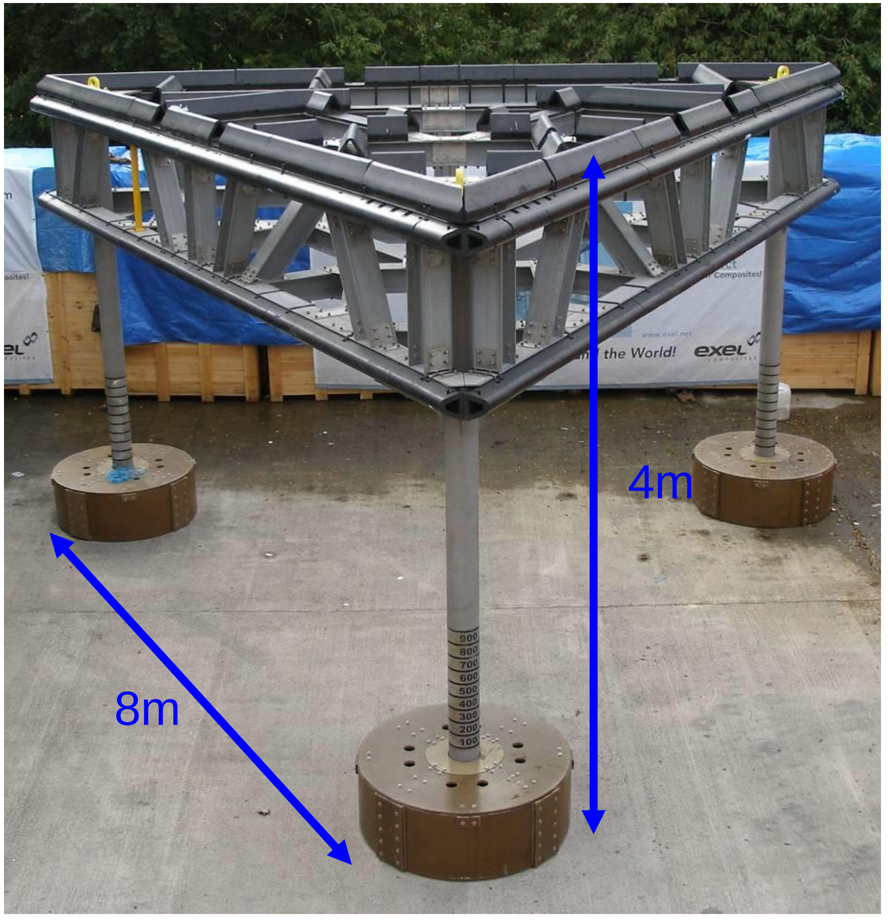
FIELD	MANIFOLD NAME	EAST (m)	NORTH (m)
PLUTONIO	S1	184 953	9 129 912
PLUTONIO	S2	186 738	9 126 066
PLUTONIO	S3	184 600	9 125 830
COBALTO	S4	180 950	9 125 300
PALADIO	N1	179 167	9 136 058
CROMIO	N2	171 375	9 139 085
GALIO	N3	166 450	9 139 950
GALIO	N4	163 190	9 141 340

℄ FPSO LOCATION 181 950 E. 9 135 258 N.

UNIVERSITY of ABERDEEN Oceanlab

DELOS

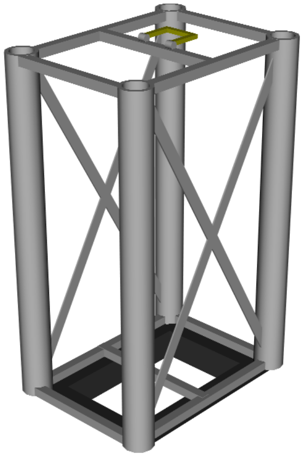
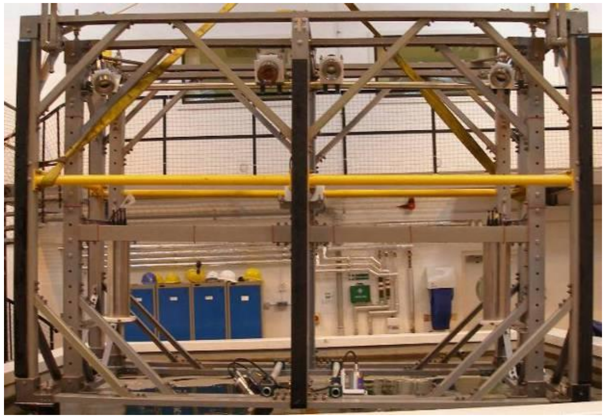
- DELOS consists of two parts (part A)
  - Two sea floor docking station;
  - Non corrosive glassfibre construction
  - Remains on sea floor for 25 years;
  - Geometry defined by the scientific requirements:
    - Near sea bed;
    - Minimise sea floor impacts;
    - Minimise sediment re suspension by ROV intervention;
  - Sensor geometry requirements:
    - Camera field of view;
    - Acoustic field of view;
    - Minimise sampling error due to structure.



DELOS

- DELOS consists of two parts (part B)
  - Five observatory modules, slotted into docking station by ROV
  - Recovered to surface by ROV for service every 6 months for service and data offload
  - Returned to the docking station for a further 6 months
  - Repeated for 25 years

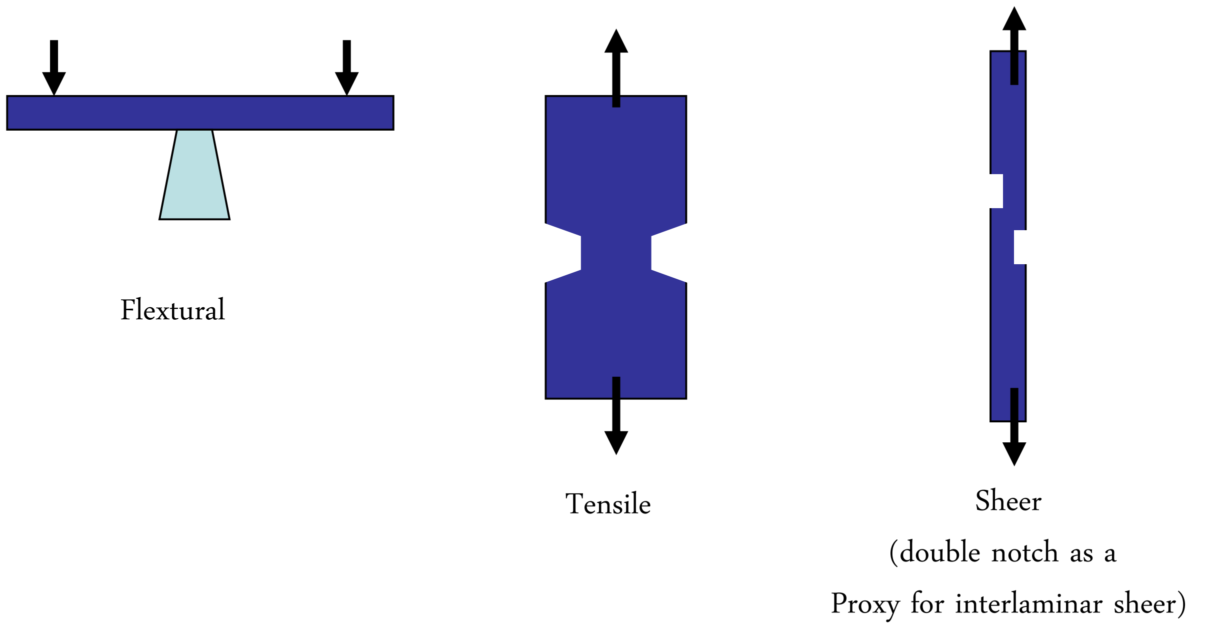


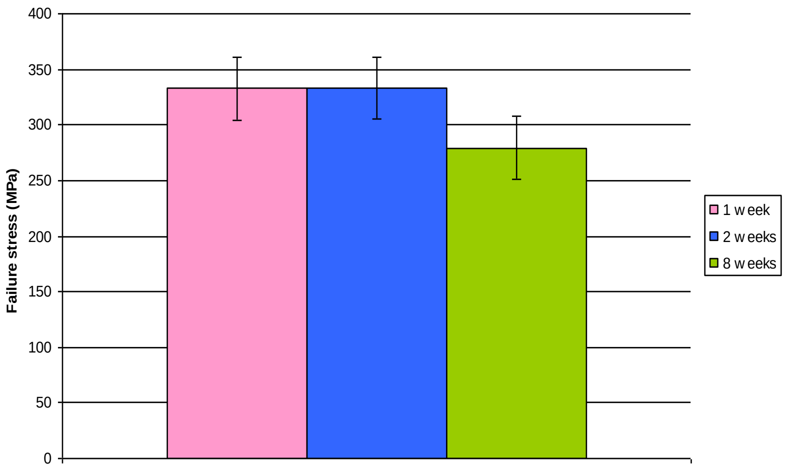
DELOS

Materials Selection

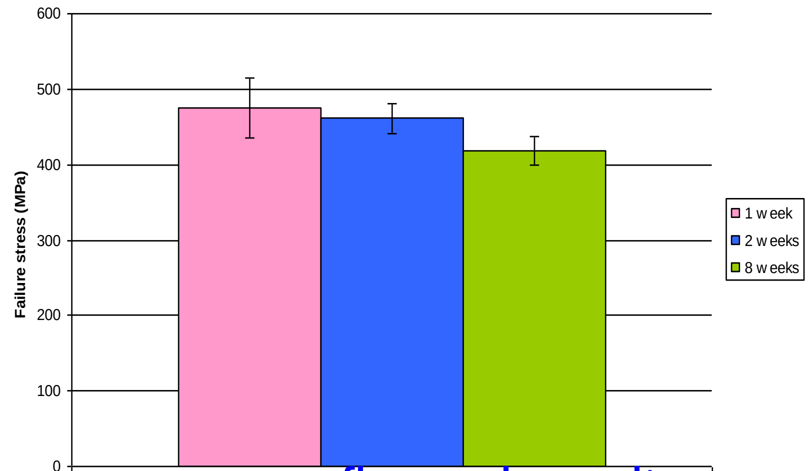
- No data on performance of glassfibre deployed long term in deep ocean
- Testing carried out at NPL (UK)
  - Samples aged (elevated temperatures) and pressure cycled



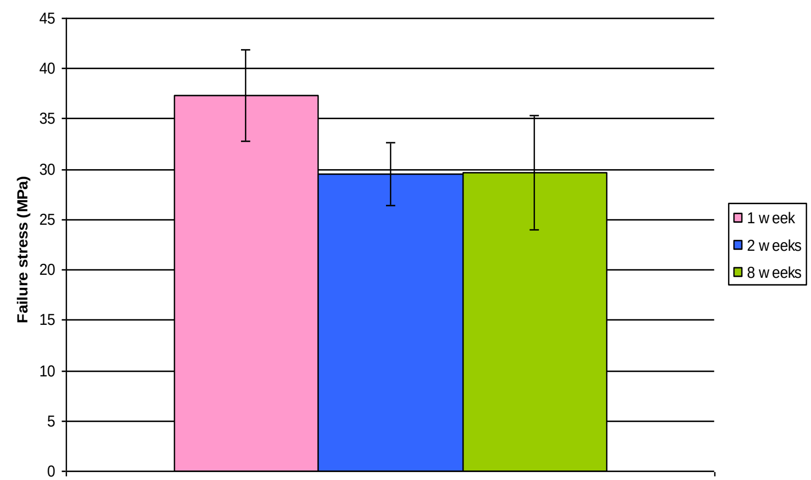
Materials Selection



– average tensile results



– average flexural results

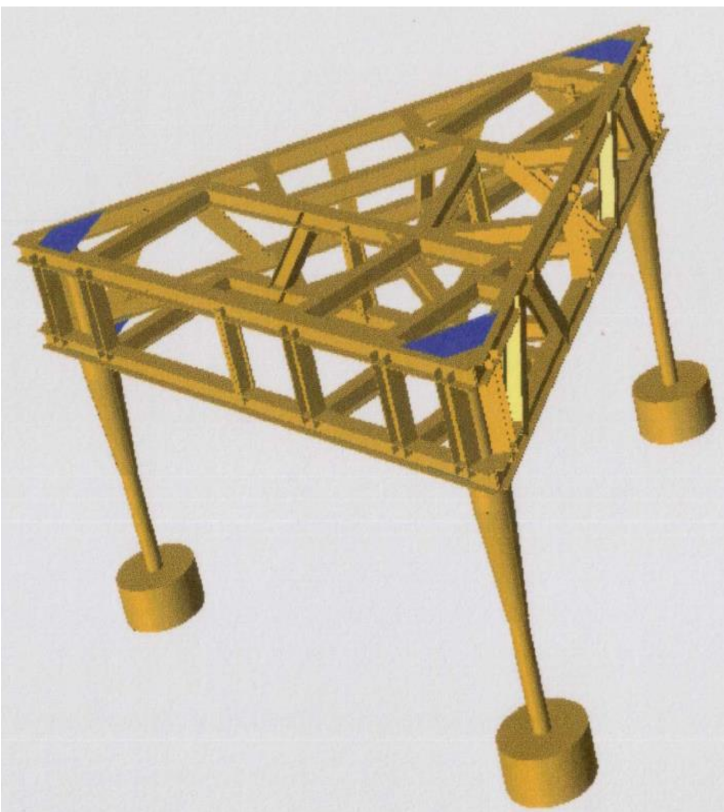


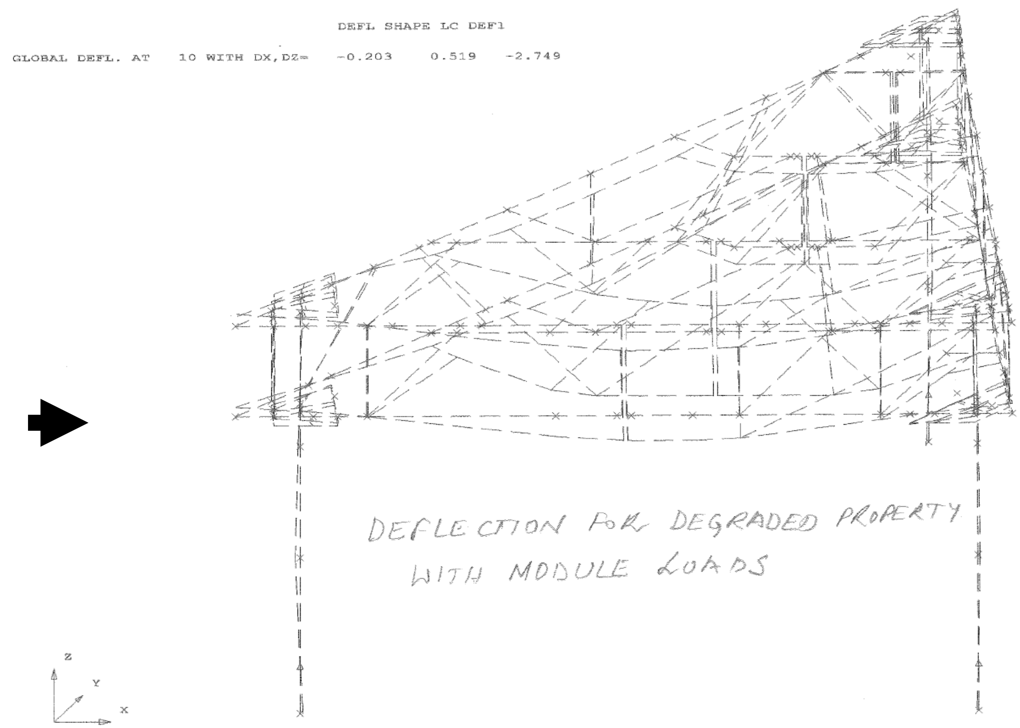
– average shear results

- Moderate decline in material properties with time
- However still within design specification

Structural Analysis

- 12 different load cases considered to fully characterise system operation



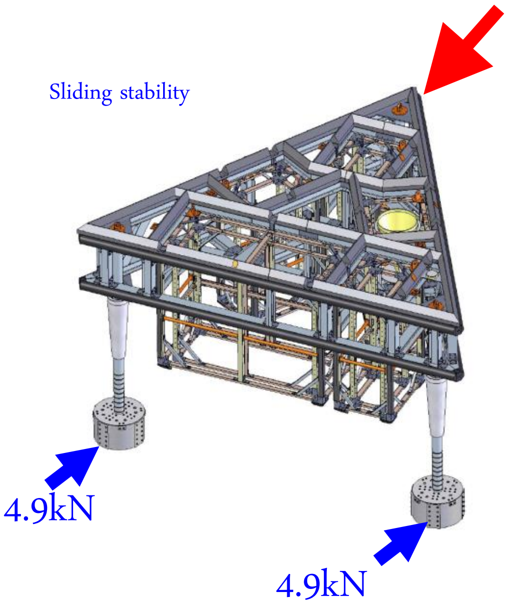


Degraded material properties, all modules in place- max deflection = 27.5mm

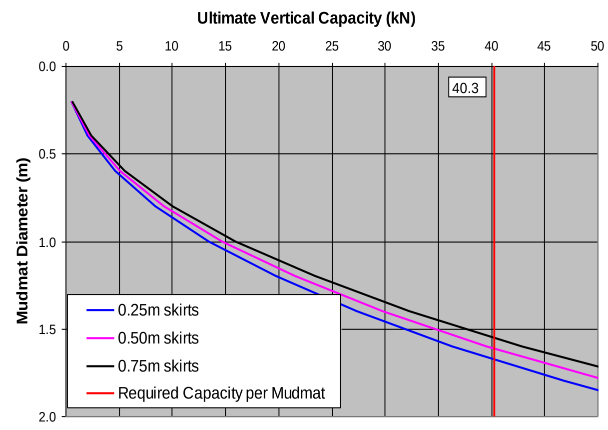
Foundation Design

- Foundation Design required:
  - –Make sure system remains in place for 25 years
  - –mud mat dimensions for operational load bearing capacity
  - –Installation ballast requirements
  - –Sliding capacity
  - –Overturn stability

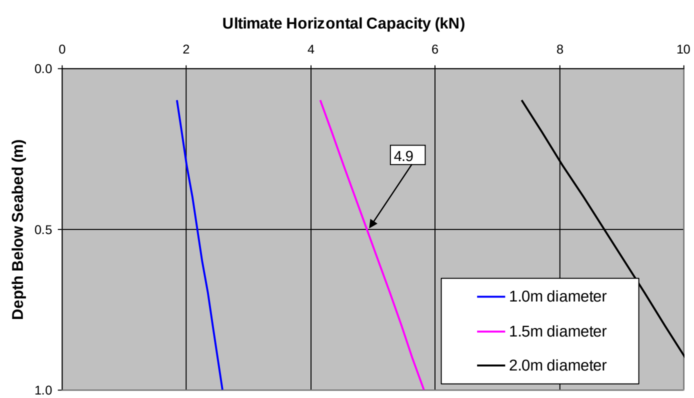
Foundation Design



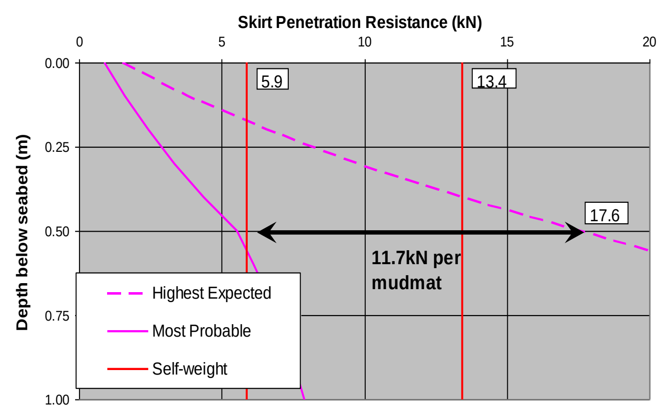
Overturning stability
22.6 kN steady state load
91.4 kN Peak



Vertical Mudmat Capacity



Horizontal (Sliding) Mudmat Capacity

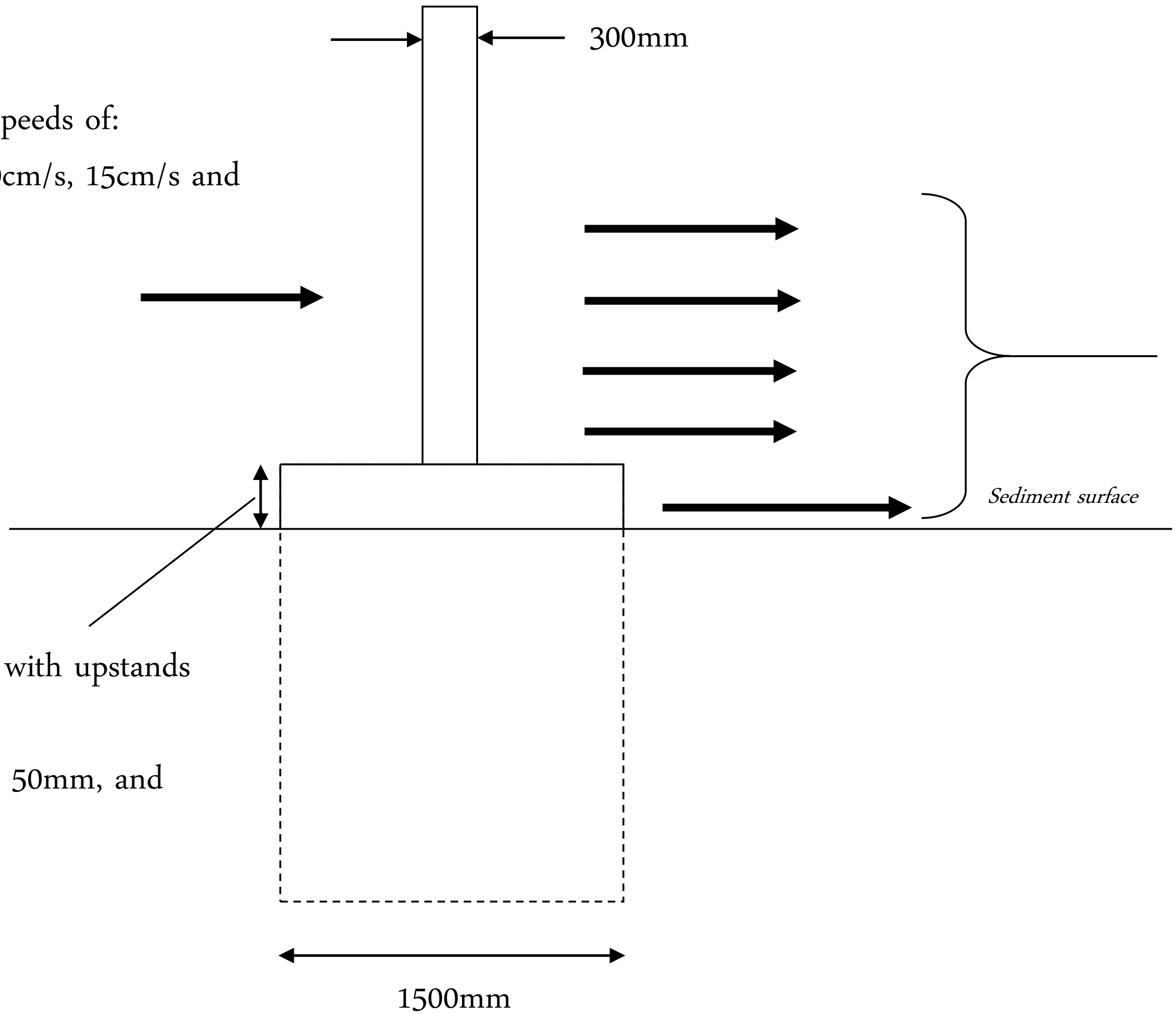


Mudmat Skirt Penetration Resistance - 1.5m diameter

Hydrodynamic Analysis

Current speeds of:

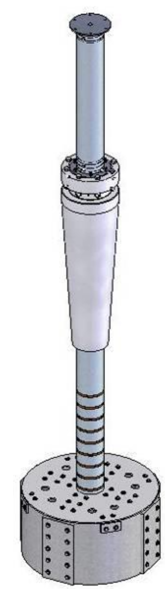
5cm/s, 10cm/s, 15cm/s and 20cm/s



Model 5 discrete heights above sediment surface. From as close to bottom as possible to a height of 500mm above bottom.

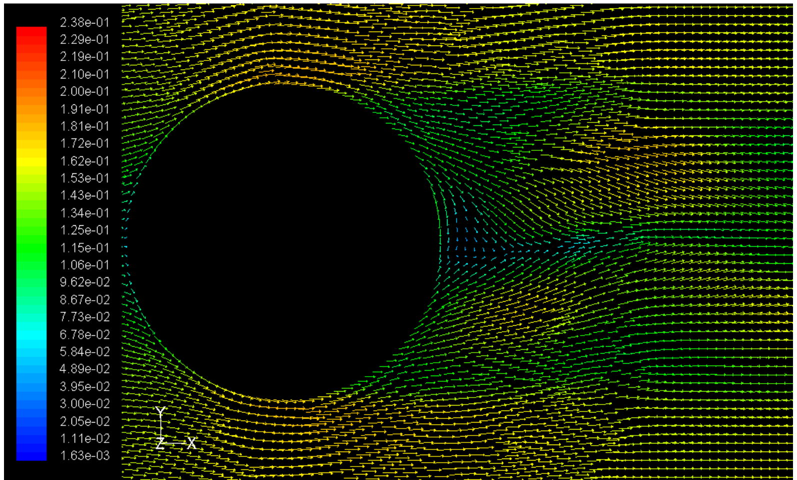
Model with upstands of :

25mm, 50mm, and 75mm

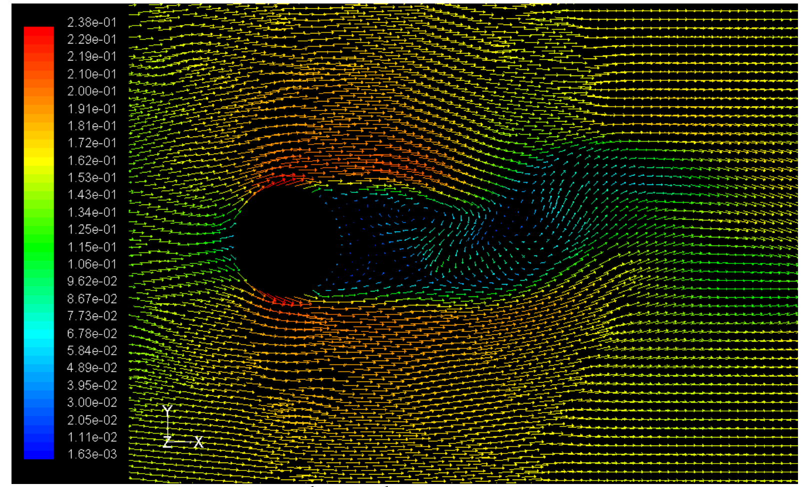


Hydrodynamic Analysis

5 cm/s currents, 50mm upstand



2.5 cm above bottom

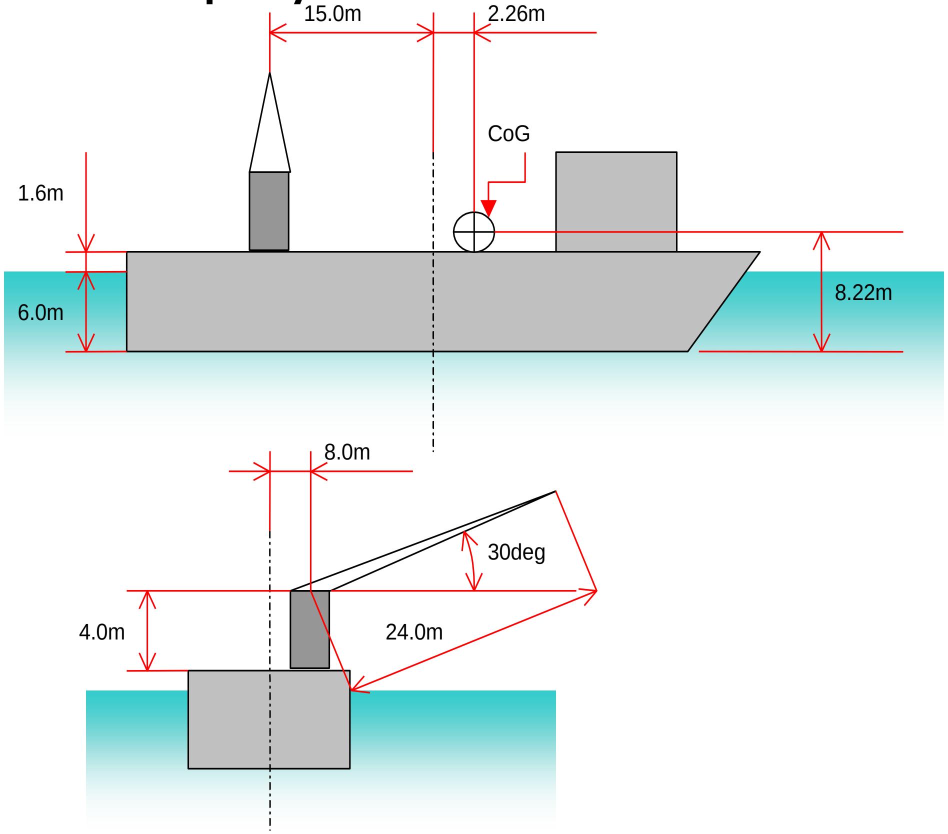


10 cm above bottom

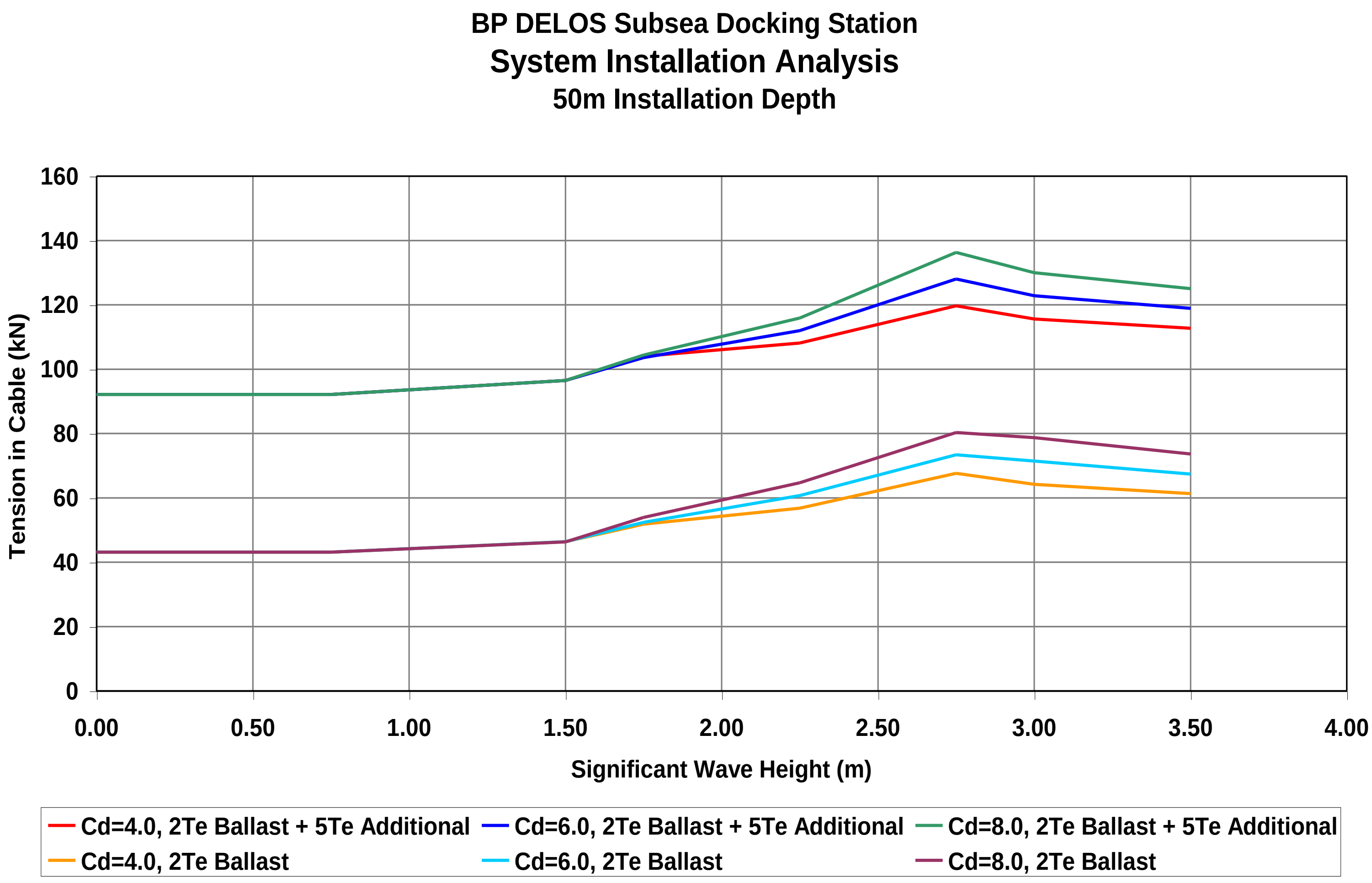
- Analysis of sediment suggests at current speeds above 20cm/s fine sediment particle re suspension is possible.
- Hydrodynamic analysis shows turbulent current speeds are possible that are greater than 20cm/s at prevailing current speeds of 15cm/s
- Long-term current meter data shows prevailing current speeds approaching 15cm/s possible in September to November
- Actual installed upstand only 2.5cm and leg diameter reduced in light of hydrodynamic analysis

Installation Analysis

- Preliminary installation analysis conducted to consider deployment of DELOS frame
- Assumed frame deployed from side of vessel using crane



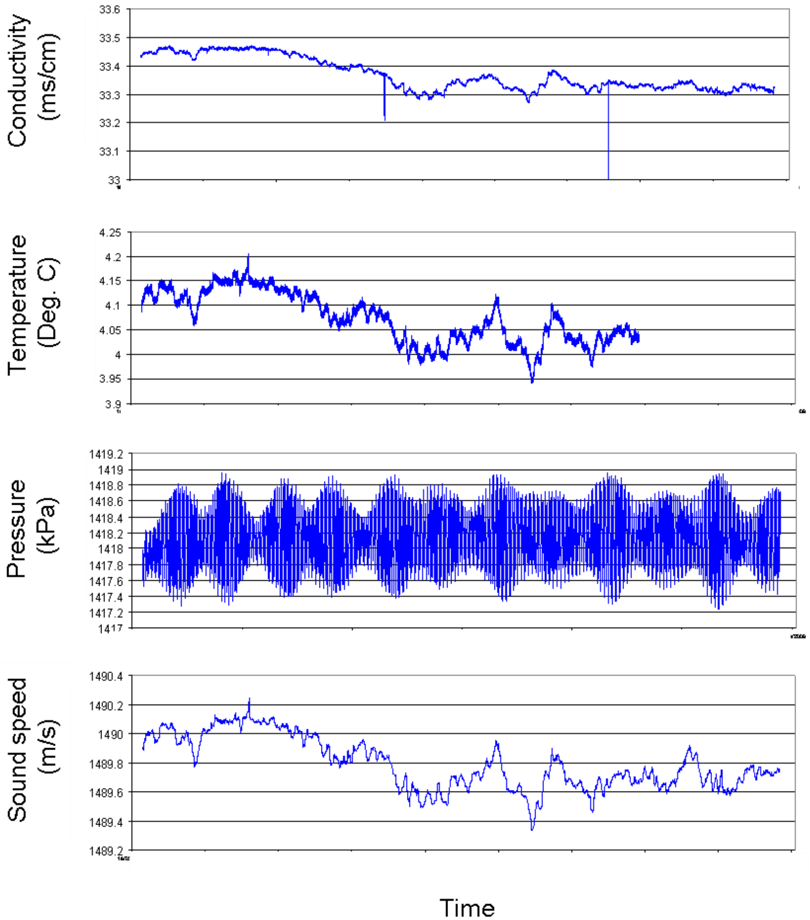
Installation Analysis



DELOS Installed February 2009

- First service completed August 2009
- Next service Feb 2010

Example data from August 2008 service



Conclusions

- Significant time and cost involved in design, analysis, and modelling
- Foundation design, and structural analysis very important – oil industry expertise indispensable
- DELOS “stepping stone” towards a fully cabled system
- 6 monthly service enables corrosion issues & instrument failures to be addressed

Installation February 2009