

JIP Proposal for FEF at BV Paris, 28th June 2023

“Design and Model Testing of Large Diameter Deep Cold Seawater Intake Pipes for FPSOs, FLNGs and OTEC”

Martin G. Brown, Consultant Naval Architect,
Ocean Energy Systems Limited (OESL), Aberdeen.

Prof. Joel Sena Sales Jr.

Federal University of Rio de Janeiro (UFRJ) - Brazil

Backgrounds

- **Martin Brown, Naval Architect (OESL)**
- Project manager Noble Denton FPS Mooring Integrity JIPs
- Vice Chairman – Europe and America, Ocean Thermal Energy Association (OTEA)
- IEC OTEC Standard Convenor



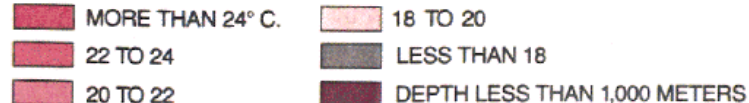
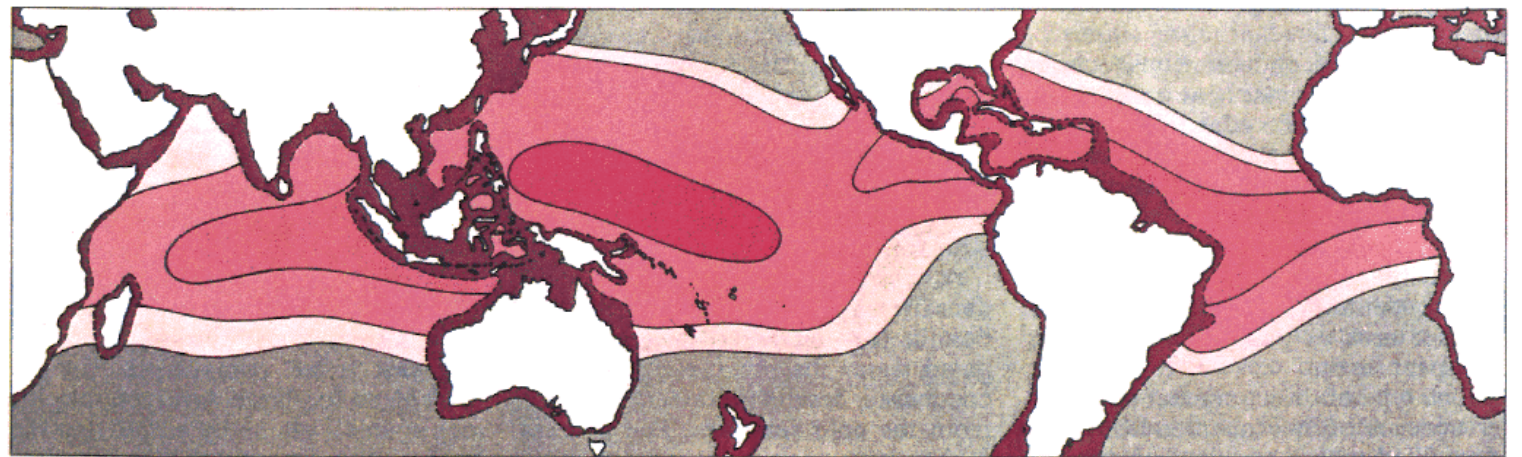
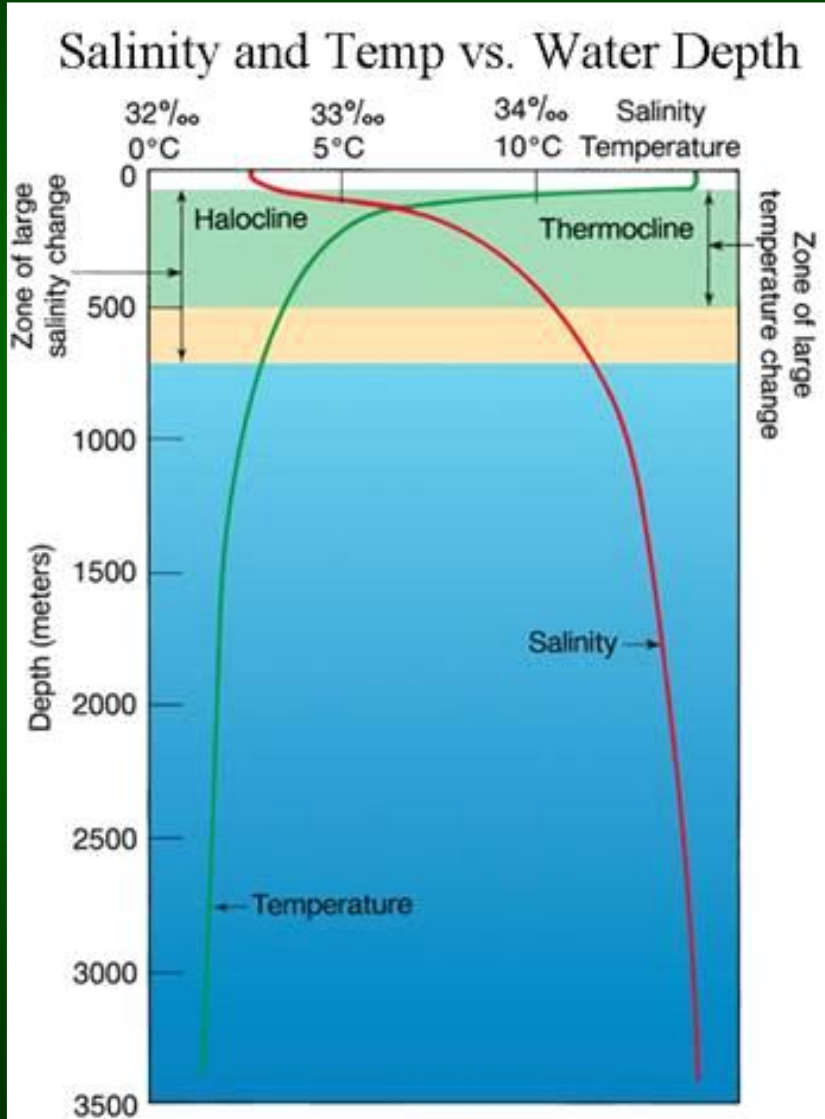
- **Prof. Joel Sena Sales Jr.**
- Prof. Hydrodynamics, Naval Architecture & Ocean Engineering, COPPE/Federal Uni of Rio de Janeiro
- 2015-2018 Manager - Lab of Waves & Currents, LOC/COPPE/UFRJ
- 2010-2015 Offshore Research Manager – LabOceano Ocean Basin
- 2003-2010 Project Manager - LabOceano including Lockheed Martin OTEC Model Tests



Cold Water Source

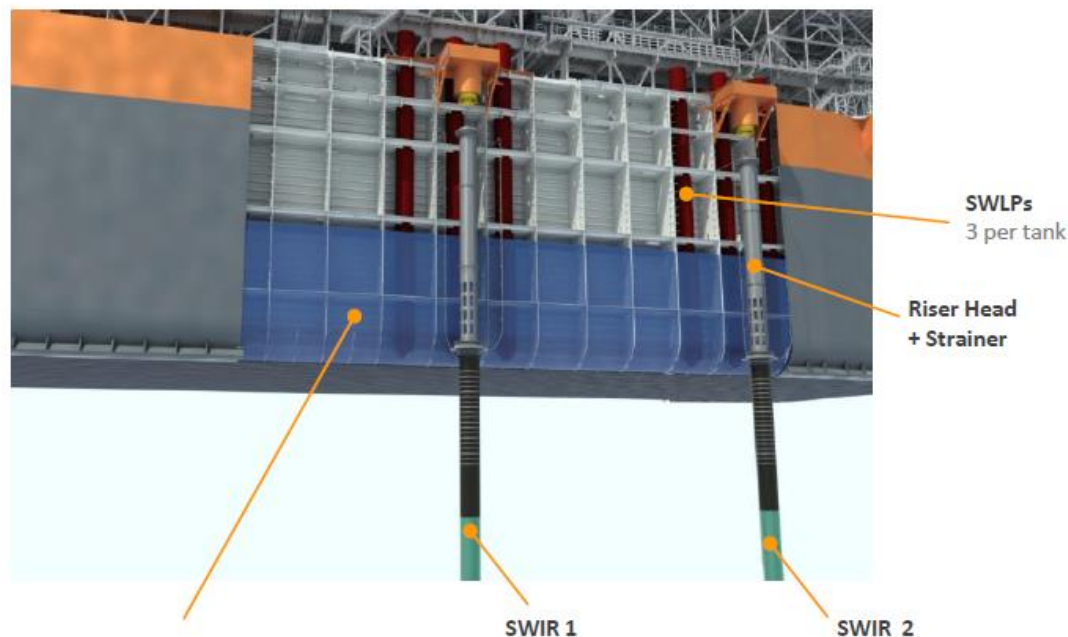
Tropical ocean surface temperature $> 28^{\circ}\text{C}$ at 700 to 1,000m about 4°C all year round due to the thermocline

Deep water is relatively pure and free of pathogens so biofouling of process equipment will be less



Redundancy needed plus only ≈1m dia, 700m Intake depth

Seawater intake riser



Sump Tank

Water Ballast tank that will accommodate SWIR + SWLPs will be called **sump tanks**

Eli Gomes, MSc PhD
Principal Topsides Engineer
Shell Brazil

QUICK SUMMARY:

- **Communicating Vessels Concept**
- Captures water at ~700m water depth
- Water at 8°C -> CM and SW systems mainly impacted
- Water flow rate is up to 15500m³/h
- Systems are installed in New Builds / During Conversion
- 2 SWIRs per FPSO
- Systems are **100% redundant**
- **SWLPs are located inside the tank** and captures water from inside of the tank
- 3 SWLPs per tank -> Total 6 SWLPs on the FPSO
- Water Ballast tanks will be converted to **Sump tanks**. Sump tanks are necessary to act as a "buffer" for the SWLPs
- System is located at Starboard (Opposite from Riser Balcony)

Guilherme Pinto, SBM Offshore

Topsides Optimization

OVERALL TOPSIDE IMPACT EVALUATION



Lower Seawater Supply Temperature

Lower SW Lift Pumps flowrate and power.
Improved consumers efficiencies.
Lower heat transfer areas.

Lower Cooling Medium Supply Temperature

Lower CM Pumps flowrate and power.
Lower heat transfer areas.

Heat Ingress and Insulation for SW and CM Piping

SW and CM piping may require insulation.

GTGs Inlet Air Cooling

Increased GTGs performance.
Increased GTG power output.
Reduced Fuel Gas consumption.
Reduced CO₂ emissions.

Gas Cooling in Gas Processing Plant

Reduced compressors power requirement.
Increase in condensate recycle to oil system.

Gas Cooling for Dehydration

Reduction of Dehydration Package.

Gas Cooling for Hydrocarbon Dew pointing

Reduction or removal of Mechanical Refrigeration Unit.

Increased Oil Recovery

Increase in oil flow to cargo tanks.

Improved Filtration for Water Injection

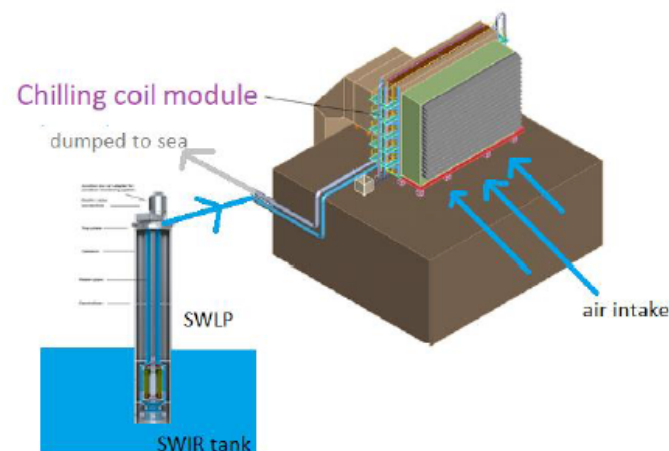
Reduced cleaning frequency for basket filters and back-washable filters.
Reduced cartridges exchange for cartridge filters.

Reduced SRP Membranes Clean In Place and Changeout Frequency

Increased SRP uptime
Increased SRP membranes life-span

Deaeration Vessel

Less dissolved O₂ in seawater
Colder temperature requires more vacuum

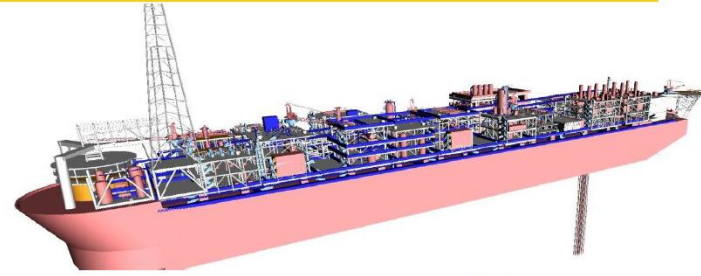
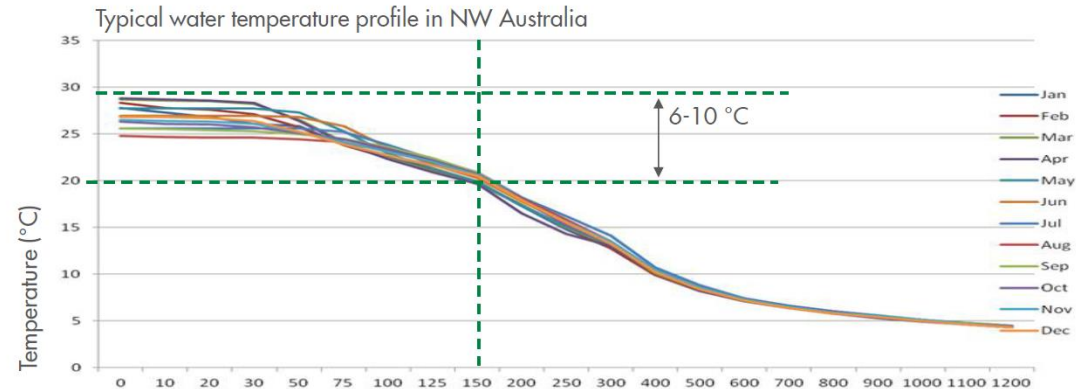


Nine (9) Deep Water Steel Risers, Shell Prelude FLNG

WATER INTAKE RISERS

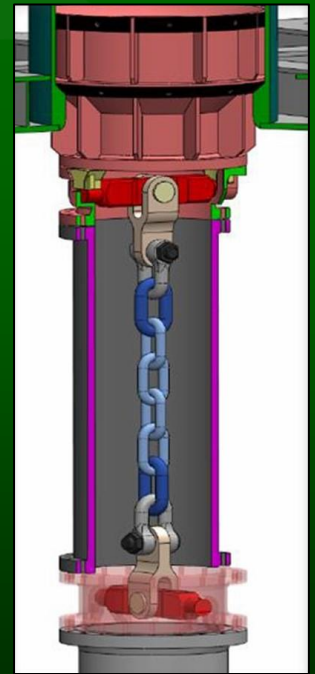
- New concept to deliver 50,000 m³/h of cooling water
- Incentive to go deeper: 150m below sea level
- Sparing philosophy: Allow for 1 spare riser
- Retreavable for maintainance & inspection
- 25 years of service life
- Concept development started 2004

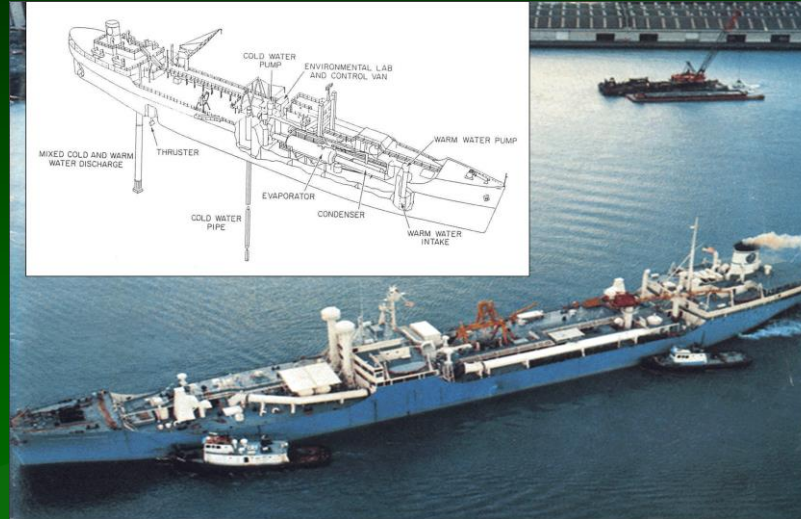
Avoid collision with moorings & risers



Water intake risers

- Designed to survive 10,000 year environmental conditions, including tropical cyclones
- Courtesy Mike Efthymiou





- Three 1.2 m diam HDPE pipeline bundle, 2,250 feet long (686m)
- CWP Launch, Tow and Upend successfully carried out off Hawaii.
- 3 pipe bundle, custom designed large GIMBAL at top



1980/1 OTEC-1

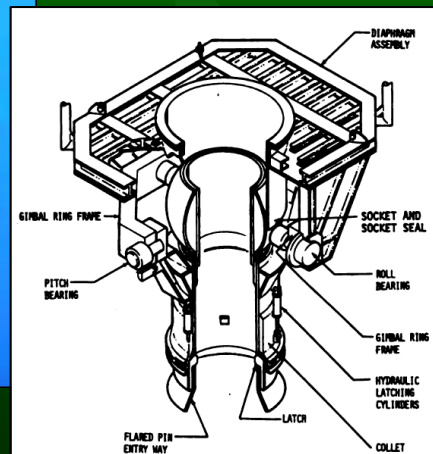
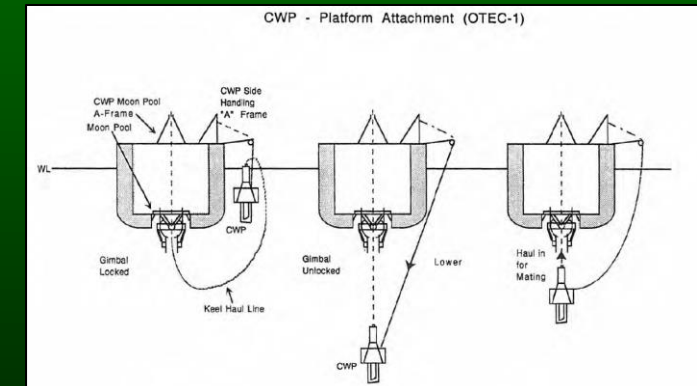
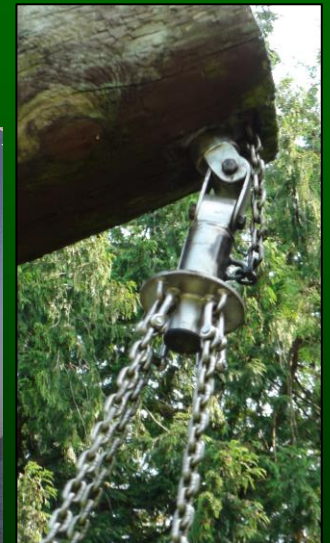
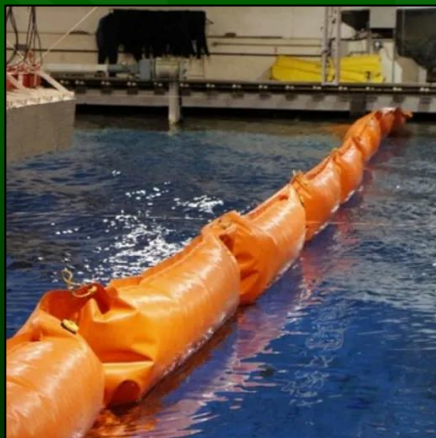
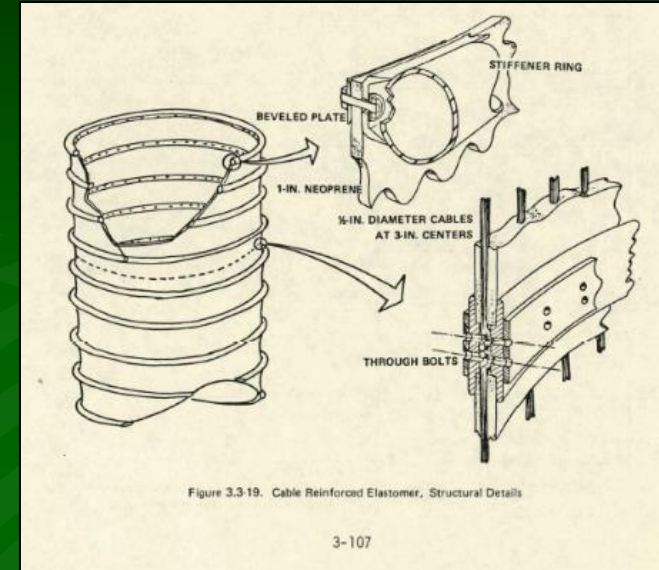
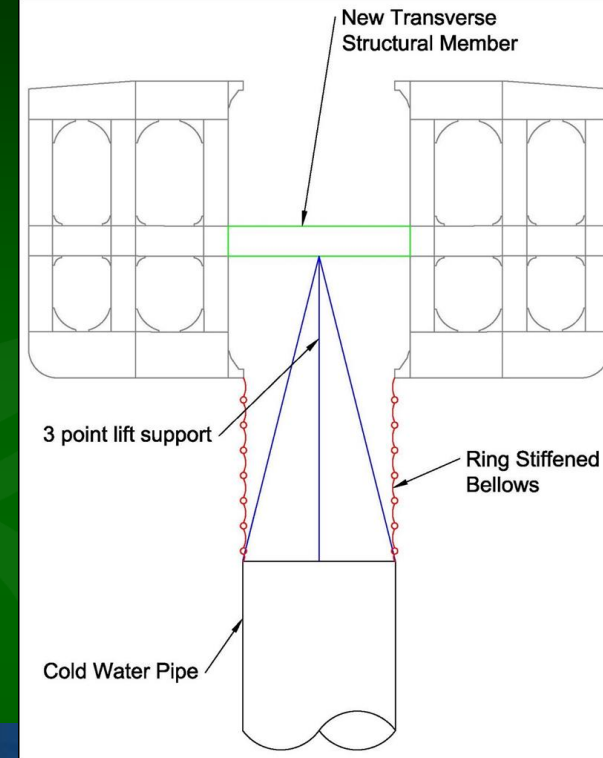
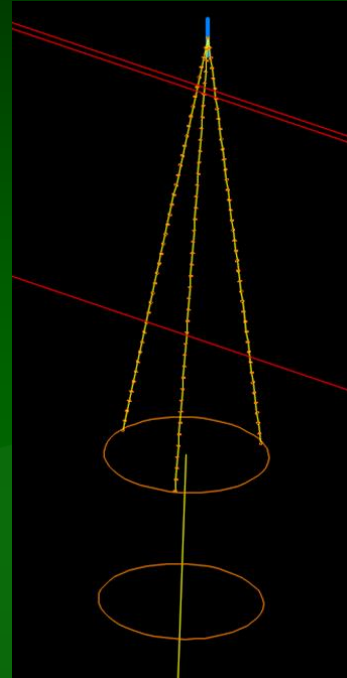


Figure 11. Gimbal/Diaphragm Assembly.



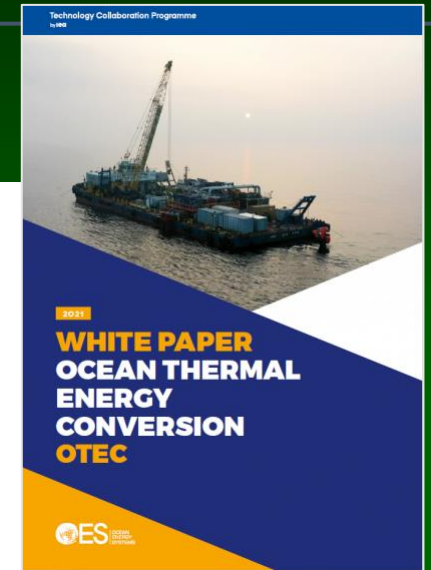
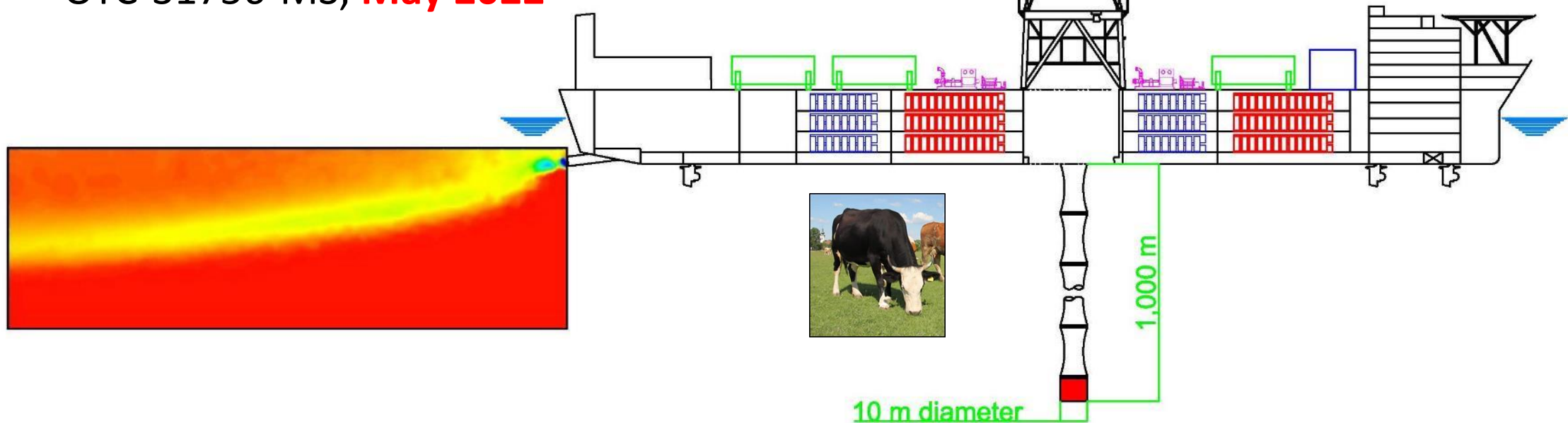
CWP Step Change - New 3 Point Decoupling Joint

- Attachment has to cope with six degrees of freedom movement
- Decouples platform motions from the CWP
- Flexible bellows provides continuity for transport of cold sea water to the surface platform



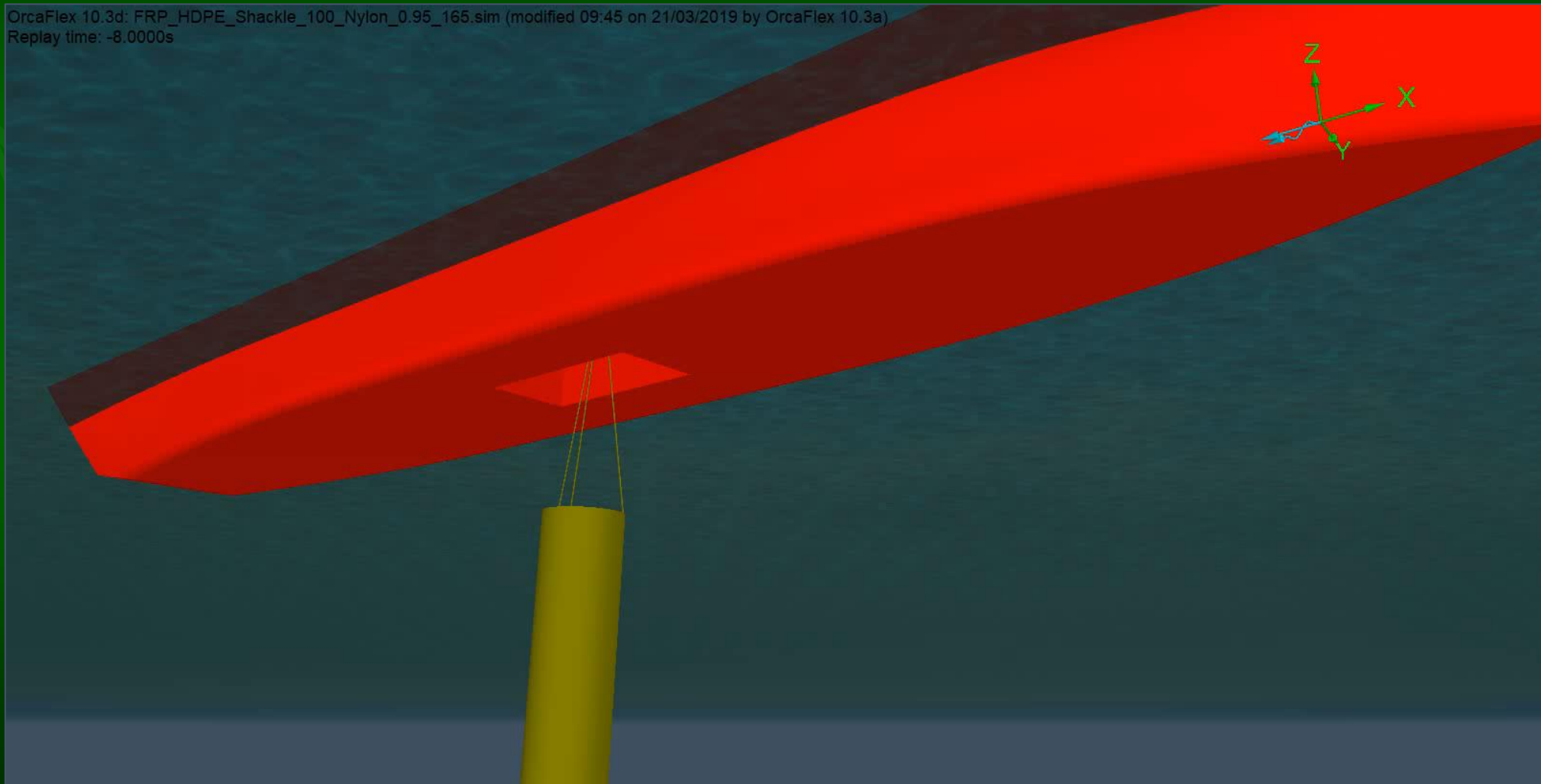


Brown, M., Brown, G.
OTC-31756-MS, **May 2022**



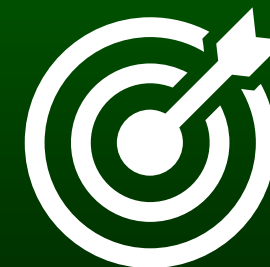
Video Orcaflex Dynamic 100 year Cyclone Simulation – Within Allowable Values

OrcaFlex 10.3d: FRP_HDPE_Shackle_100_Nylon_0.95_165.sim (modified 09:45 on 21/03/2019 by OrcaFlex 10.3a)
Replay time: -8.0000s



JIP OBJECTIVES

- Resolve CWP (Cold Water Pipes) design issues for different pipe sizes
- Develop detailed design guidelines for numerical modelling and analysis of CWP designs
- Generating experimental and field data for free hanging pipes – calibrate models
- Develop a solution for gimbal or other connections of CWP with floating unit
- Propose installation procedures for CWP plus in situ inspection & repair
- Investigation of alternative materials
- Advance CWP Technical Readiness Level (TRL)

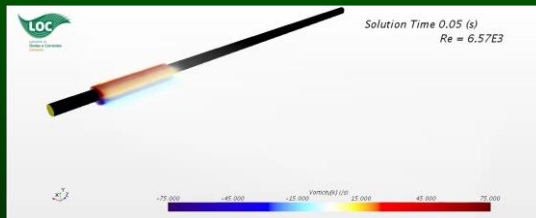


Outline Roadmap/ TRL Development

Phase 1

Pipe sizing study.
Past projects.
Numerical model
Small scale tests
at FLUME (LOC)
Hydrodynamic
Analysis

API17N : TRL2



Phase 2

Big scale tests
at DEEP WATER
OCEAN BASIN
(LABOCEANO) –
possibly Phase1

Structural
analysis

API17N : TRL4

OTEC CWP TESTS AT LABOCEANO (2009)
SOURCE: LOCKHEED MARTIN
AND DOE



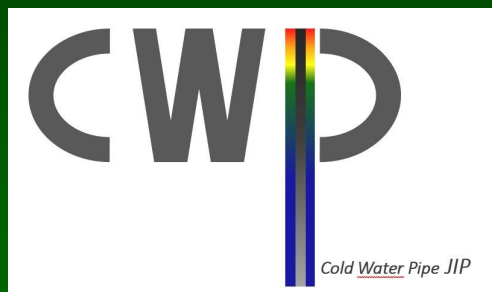
Phase 3

Field tests
With
Instrumented
Hanging Pipe at
Campos Basin from
existing asset

Approval
in Principle from
Class



NAVCON RISER SENSORS



Please get in contact if of interest



LABORATORY OF WAVES AND CURRENTS

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