ROLE OF 3D MODELLING TO REDUCE IMPACT ON PORT ENVIRONMENT

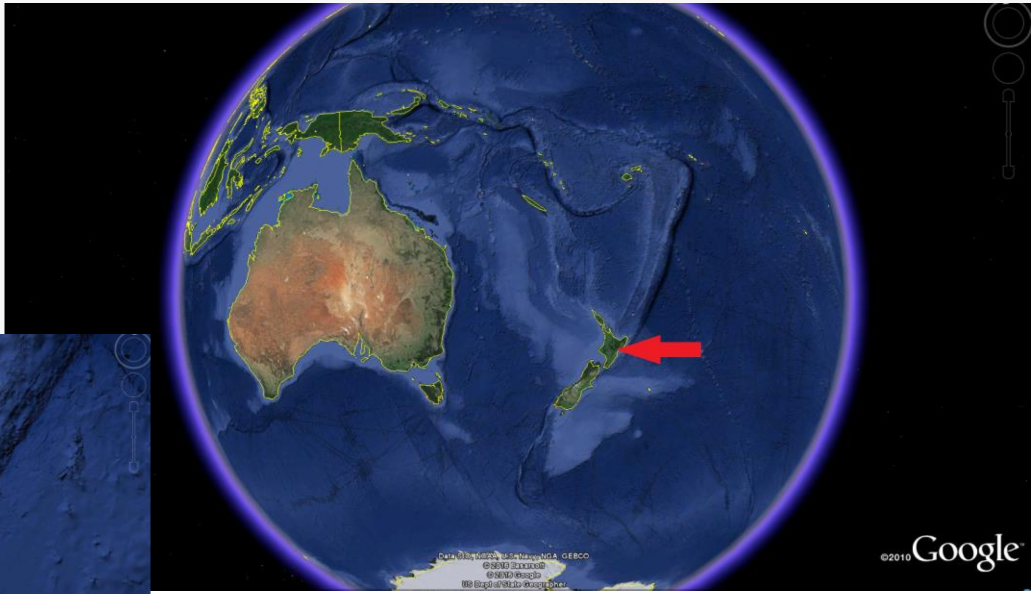
4 APRIL 2016

PECC

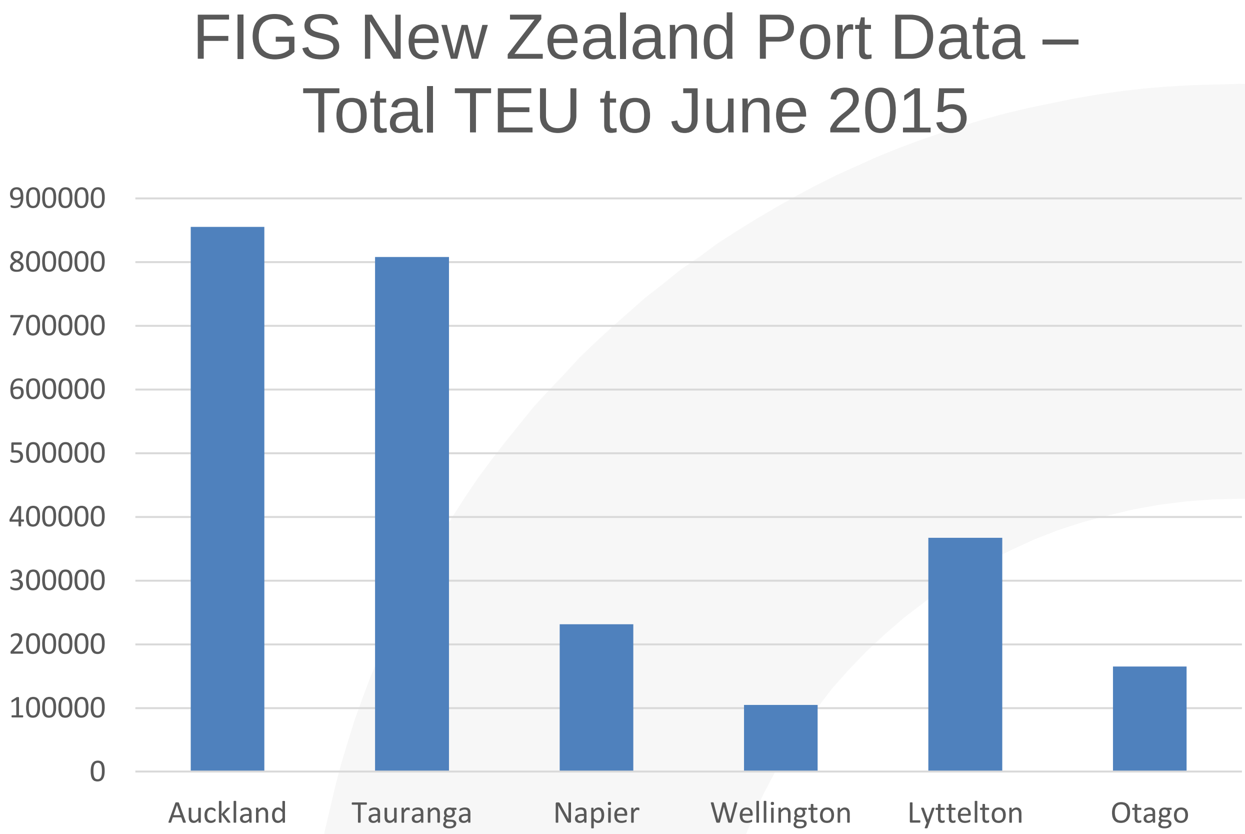
NAPIER PORT

BACKGROUND – NAPIER PORT

- Situated in Hawke's Bay, North Island of New Zealand.
- 4th largest container terminal in New Zealand.
- Services Central North Island.
- 260,000 TEU annually.
- Peak season March to July.
- Owned by the regional council.



4TH LARGEST CONTAINER TERMINAL IN NZ



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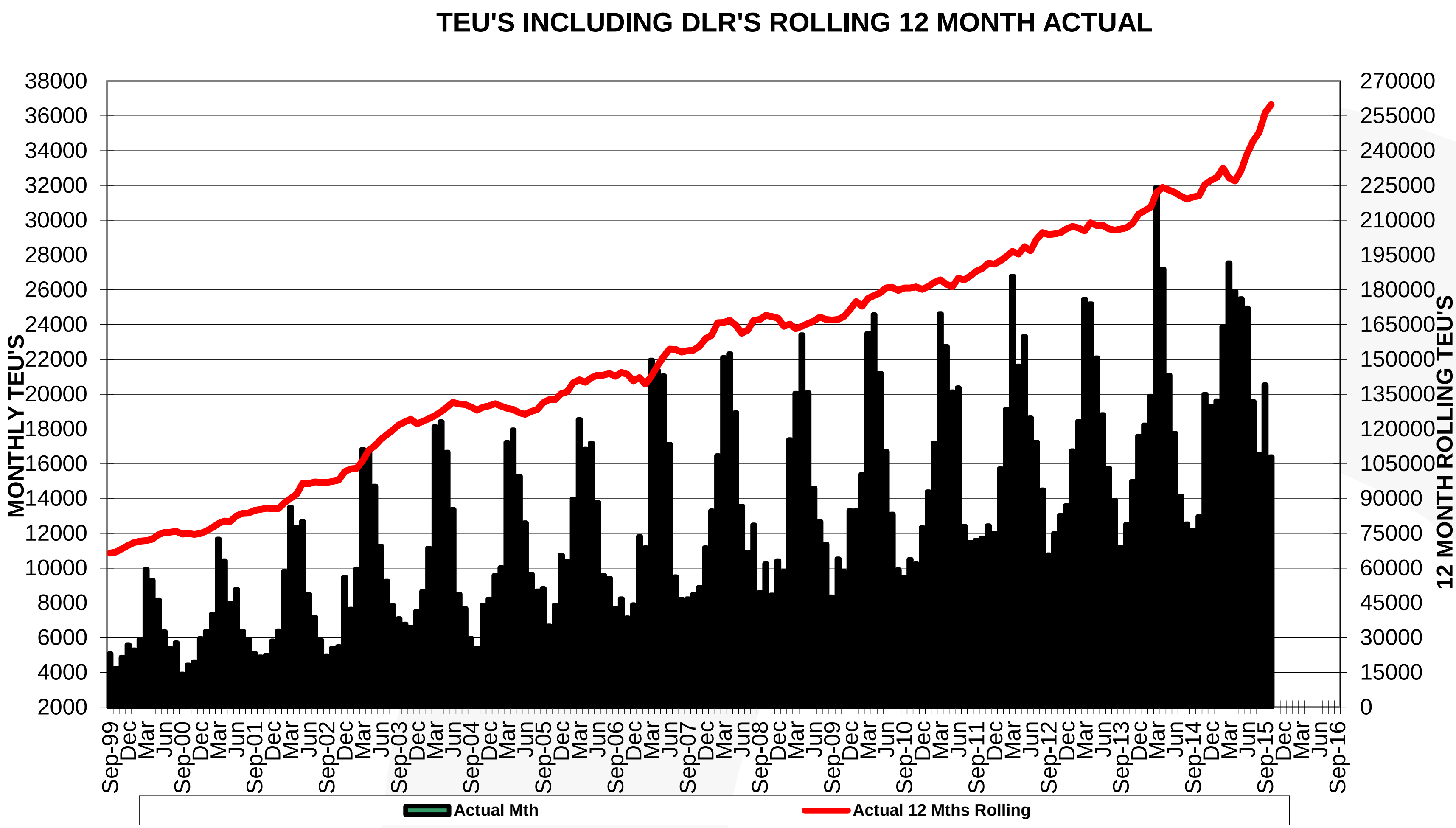
TEU'S ROLLING 12 MONTH ACTUAL

NAPIER PORT



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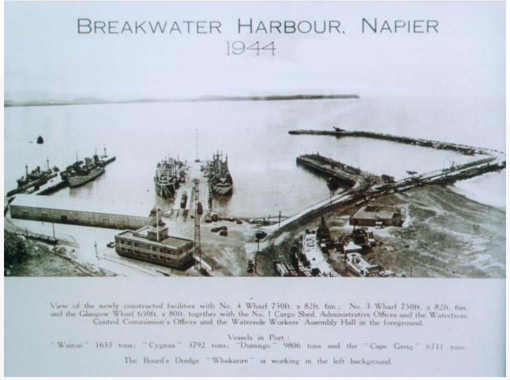
1892

1915



1944

1954

1976

1993

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SURGE PORT

- The Port suffers from long period infragravity (IG) waves, with periods 50-120 seconds.
- These waves are typically created from sets of normal swell waves crossing shallow water or shorelines.
- Source, directions etc.. not well understood and understanding is empirical.
- Cause vessels to surge at the berth, causing high mooring loads, and potentially mooring line failures.
- Napier Port used port supplied ‘Shore Lines’ to manage vessels in high IG situations.
- Difficult to predict the impact of developments such as breakwaters and channel deepening on IG wave climate.

FUTURE CHALLENGES

- Continued growth in both containerised and bulk cargo
- Larger vessels, up from maximum 4500TEU to 6500TEU and beyond.
- Increase in LOA (~300m).
- Increase in beam.
- Increase in draft.
- Major ports in New Zealand are already gearing up for larger vessels.
- Napier Port must be ready, or risk losing ship calls.

LIMITATIONS

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TRADITIONAL THINKING

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SUSTAINABLE DEVELOPMENT

Society

- Maintain or enhance community amenities, such as beaches and surf breaks.
- Minimise visual impacts.
- Minimise noise impacts.
- Minimise impact on recreational fisheries.

SUSTAINABLE DEVELOPMENT

Environment

- Minimise short and long term impact on environmentally sensitive areas such as Pania Reef.
- Minimise impact of sediment transport, which can affect existing natural processes.
- Minimise the use of construction material, in particular natural sources such as limestone or gravel.
- Maximise the beneficial use of dredge material.

SUSTAINABLE DEVELOPMENT

Economic

- Be long term financially viable and allow the Port to continue functioning profitably over time.
- Consider life cycle costs.
- Support local industry, through providing a competitive and economically viable service.
- Support local jobs and industry.

SUSTAINABLE DESIGN

NAPIER PORT

Means reduction or elimination of the proposed breakwater!:

- Reduction in short and long term costs.
- Reduction in material usage.
- Minimise change in wave climate and subsequent impacts.
- Minimise direct impact on seabed.
- Less visual impact.

CAN THIS BE DONE WHILST KEEPING THE DEVELOPMENT FEASIBLE?

MODELLING APPROACH

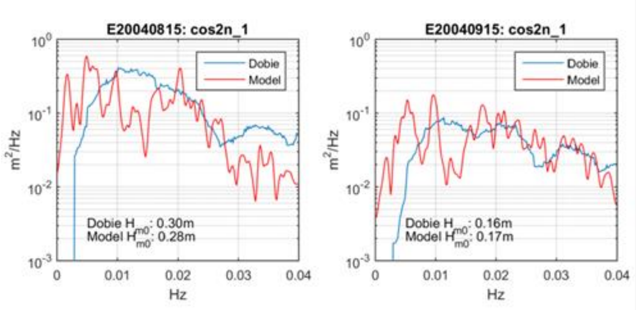
NAPIER PORT

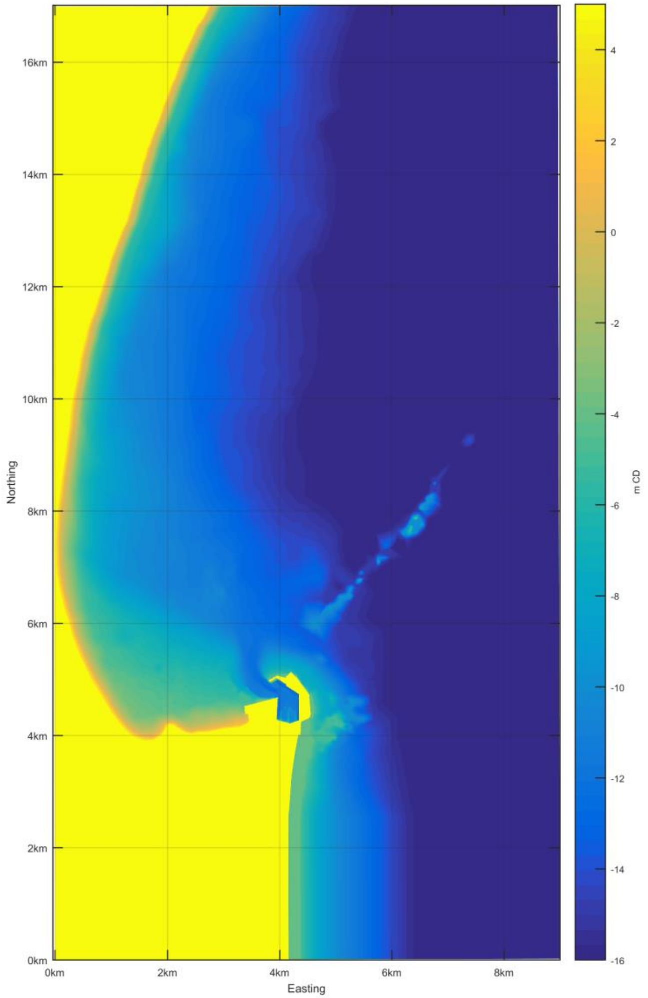
Dynamic Mooring Analysis (DMA)

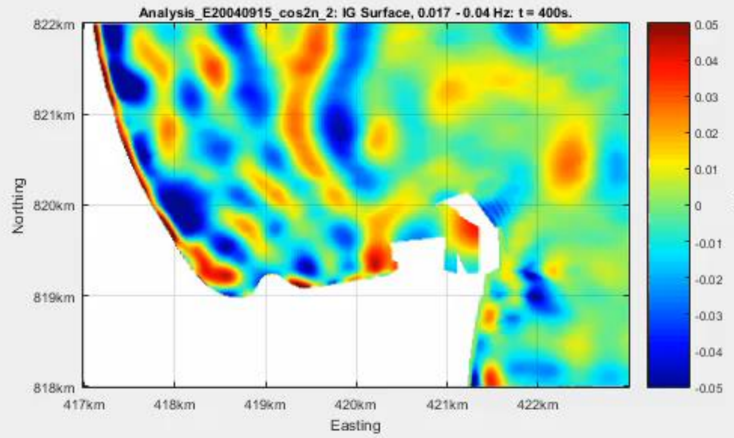
- To provide ‘real-time mooring analysis to calculate impact of various breakwater options.
- Accurate representation of IG waves, the likely key limiting factor
- Use the largest data set of wave data possible.
- Analyse different mooring arrangements, including mooring line properties.
- Include fender dynamics in analysis.
- Provide likely operational performance of the proposed berth.
- Assess alternative mooring devices.

BOUSSINESQ MODELLING

- A boussinesq model was developed using Mike21.
- A very large domain to best model the generation of IG waves, and their behaviour in the bay.
- Calibrated using the Ports wave buoy data and previous IG wave recording (Dobie Instrument).



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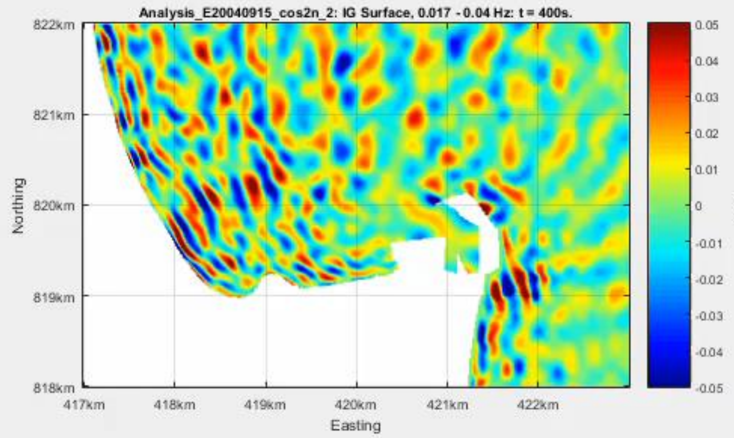
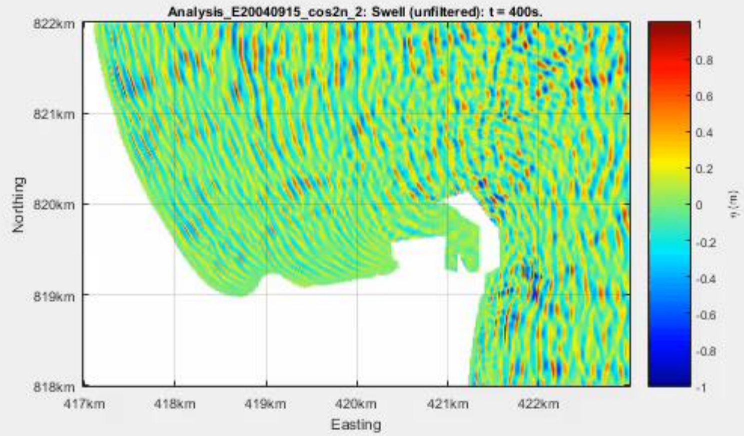
Northing
Easting
822km
821km
820km
819km
818km
417km
418km
419km
420km
421km
422km
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
η (m)


Analysis_E20040915_cos2n_2: IG Surface, 0.017 - 0.04 Hz: t = 400s.
Northing
Easting
822km
821km
820km
819km
818km
417km
418km
419km
420km
421km
422km
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
η (m)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Northing
Easting
822km
821km
820km
819km
818km
417km
418km
419km
420km
421km
422km
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
η (m)

ANSYS – AQWA

- Dynamic Mooring Analysis performed in ANSYS – AQWA.
- Waves within the harbour modelled with AQWA, using Mike21 model as input boundary condition.
- Mike21-AQWA coupling calibrated.
- Multiple mooring configurations.
- 264 ‘runs’ with joint probability representing a typical year.

CRITERIA

- Mooring Lines – 55% of Max Breaking Load (OCIMF Guidelines).
- Side Shell Pressure – 200kPa.
- Vessel Motions – PIANC (1995).

Table 4-3: PIANC Motion Criteria

Motion	Limitation Criteria for a 100% Cargo Handling Efficiency	Limitation Criteria for a 50% Cargo Handling Efficiency
Surge	1m peak to peak	2m peak to peak
Sway	0.6m peak to zero	1.2m peak to zero
Heave	0.8m peak to peak	1.2m peak to peak
Roll	3deg peak to peak	6deg peak to peak
Pitch	1deg peak to peak	2deg peak to peak
Yaw	1deg peak to peak	1.5deg peak to peak

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NATURAL FREQUENCIES

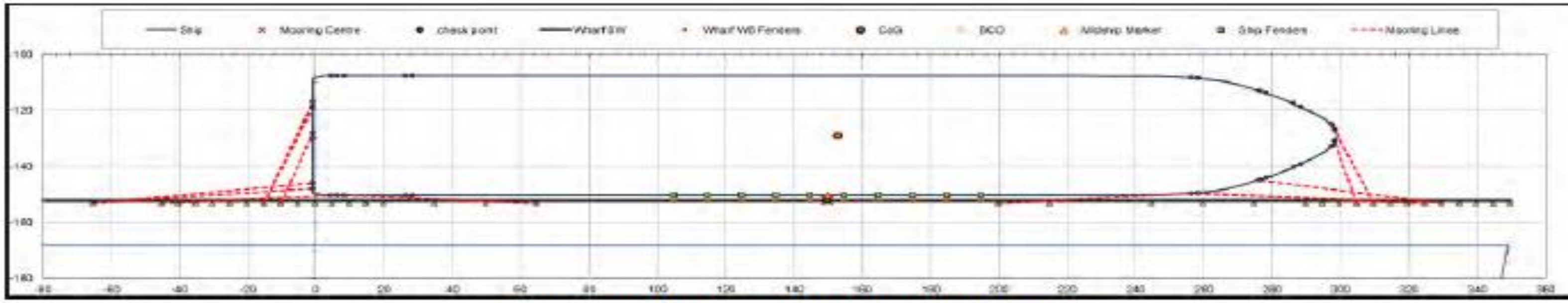

Figure 6-1: Mooring Configuration 1

Table 6-1: Natural Periods of the Moored Ship Mooring Configuration 1

Mode	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
Natural Period [Sec]	68	33	29	23	20	15

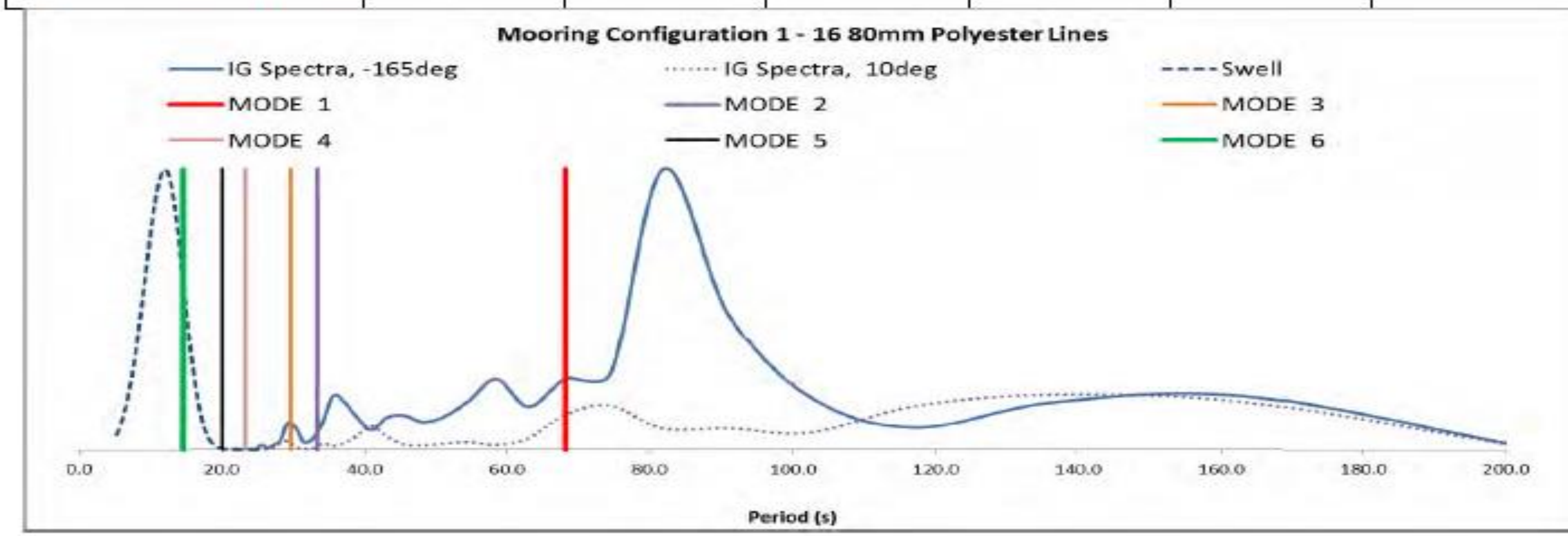

Figure 6-2: Natural Periods vs Spectral Energy

KEY FINDINGS

- Mooring limits generally driven by wind and IG waves.
- IG waves are not dependent on a breakwater extension, and hence a breakwater extension has limited effect to mooring effectiveness.
- Mooring line elongation properties important, for instance Dyneema Lines were found to be too stiff and exceed loads much earlier than polyester.
- Initial analysis of ShoreTension® units, indicated potential significant reductions of vessel movement.
- Potential for further refinement of mooring configurations likely to lead to further improvements.
- Port confidence that high utilisation can be achieved.

Mooring Configuration	PIANC Availability Criteria			Days Criteria Exceeded (50% availability)
	100%	50%	Exceeded (50% availability)	
Mooring Configuration 1	69.7	87.9	12.1	44.3
Mooring Configuration 2	69.4	89.2	10.8	39.3
Mooring Configuration 3	69.8	85.0	15.0	54.7
Mooring Configuration 4	Does not meet criteria			

FURTHER WORK

- Further development of the Mike21 hydrodynamic model, with increased resolution of boundaries.
- Multiple wave recording currently being undertaken to refine and calibrate the hydrodynamic model.
- Further investigations of ShoreTension® and MoorMaster.

QUESTIONS

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