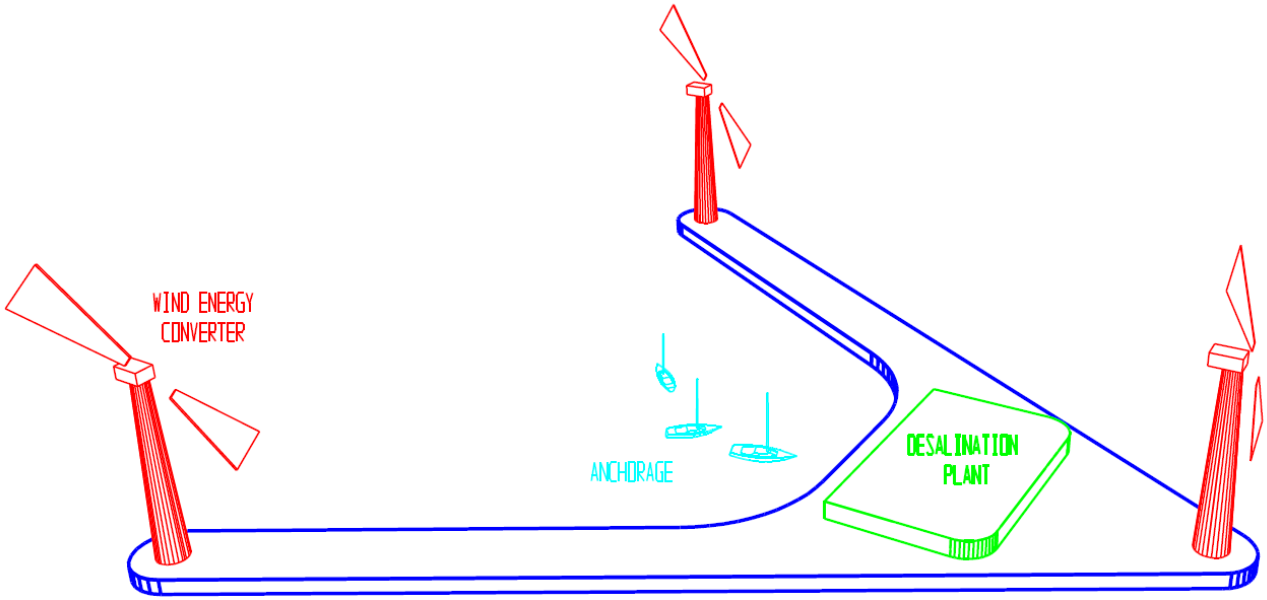
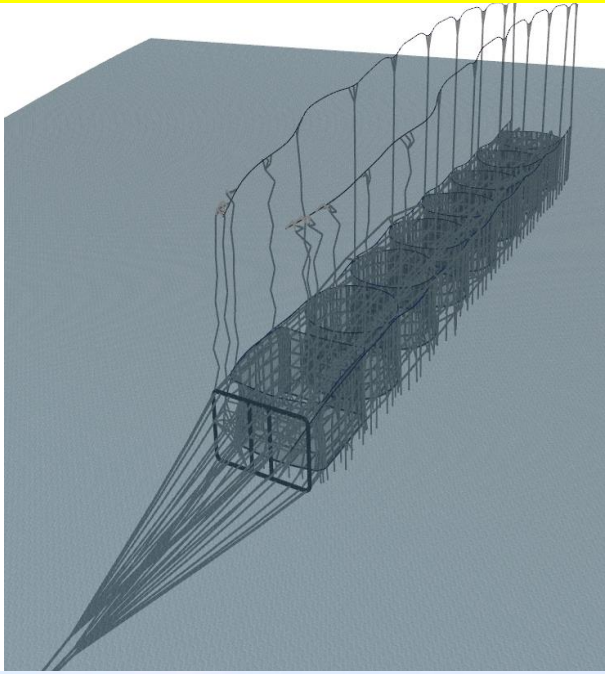
Environmental Conditions Offshore Israel, their Design Aspects, and Concepts of Floating Structures

Nitai Drimer, Technion – Israel Institute of Technology, Mechanical Engineering



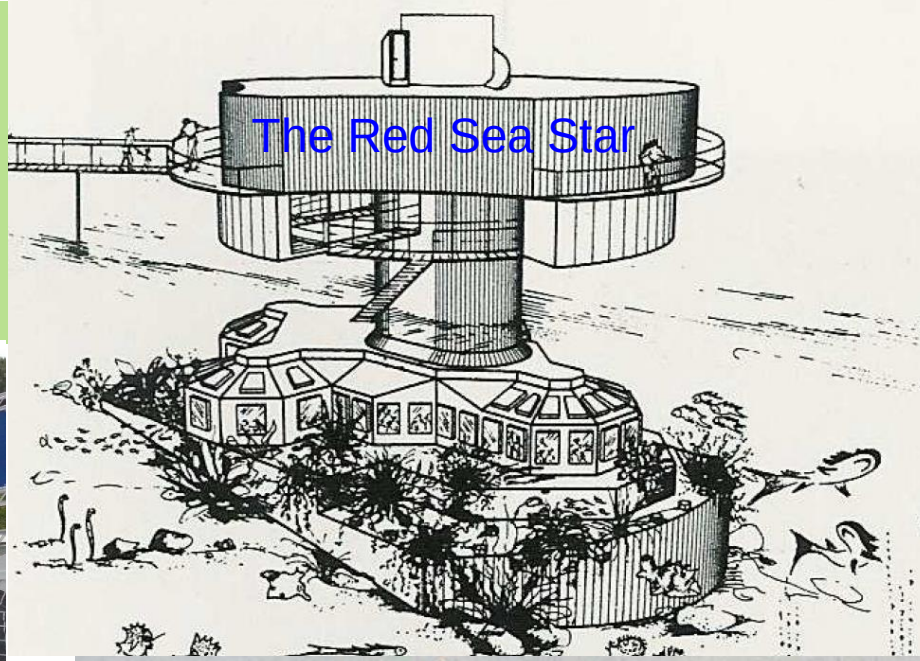


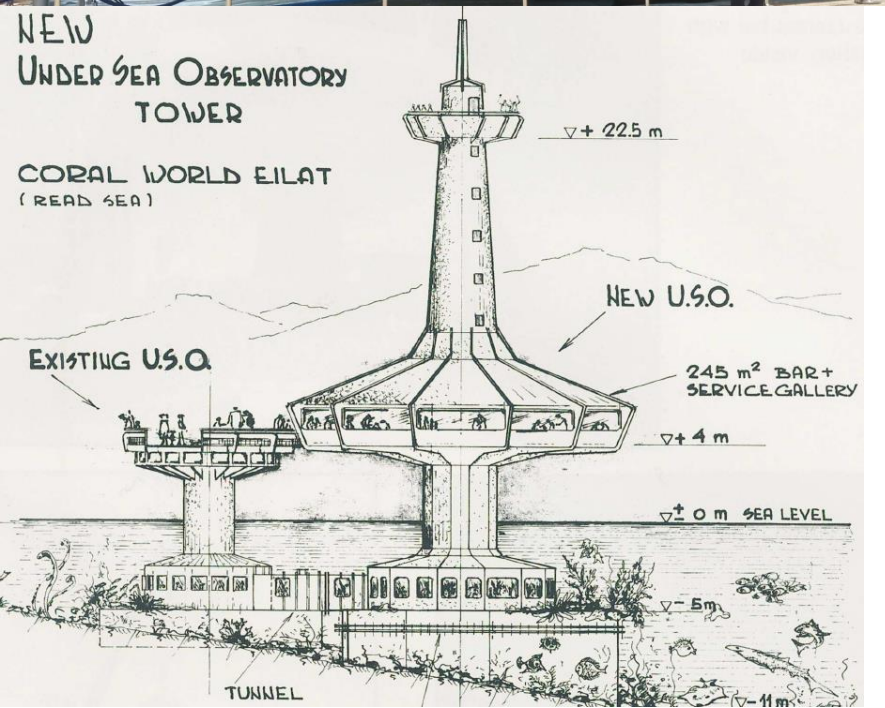
Rational analysis of the Boat-Water interaction applying ABAQUS

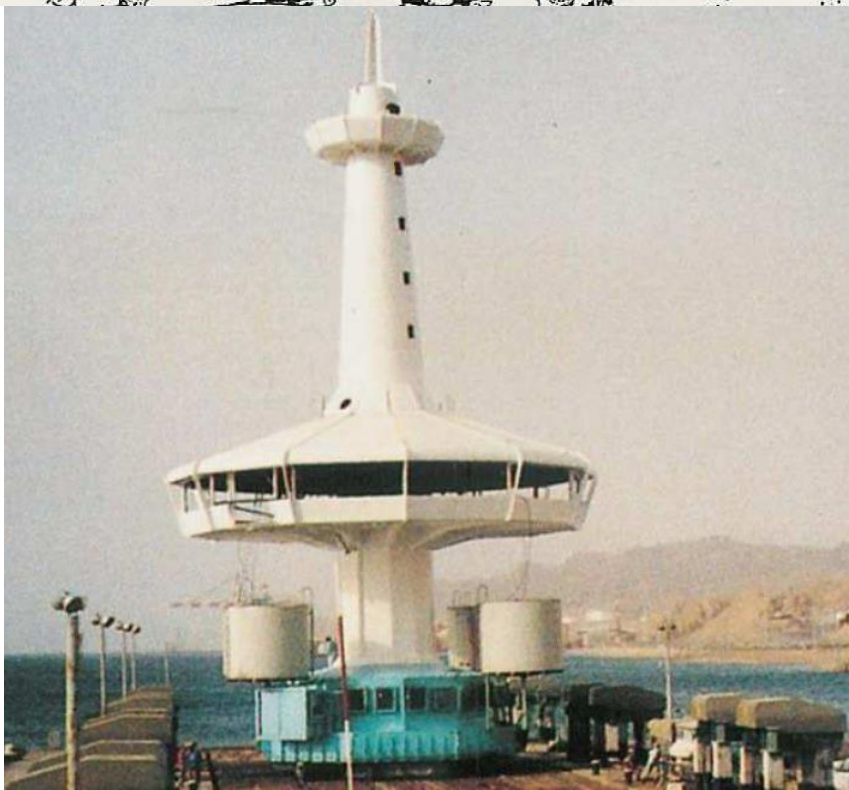
NAMCO – Naval & Mechanical Engineering Company
Designer 1984-2014, director and owner 1998-2014

CAMERI – Coastal & Marine Engineering Research Institute
Research Engineer 1994-1999, Director 2000-2012

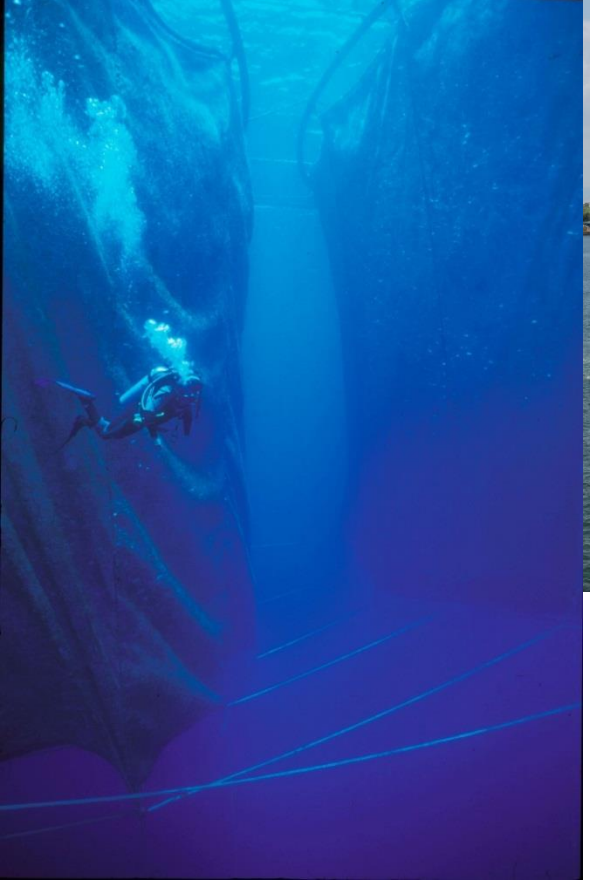
Technion – Israel Institute of Technology, Mechanical Eng.
Since 2012, Head Naval Architecture and Ocean Eng. Major







Semi-Rigid Fish Farm
ARDAG The Red Sea
1986 - 2008



Air Vent

Dive Control Pipes

Cage

Grid Lines

Chains

Main Hawser

Front Frame

Water Inlet

SUBFLEX Open Sea Aquaculture System operated since 2006

Wave Rider
CAMERI
Haifa
Ashdod

http://www.israports.co.il/_layouts/IsraelPorts/WaveHeight/Haifaw-ipa.html

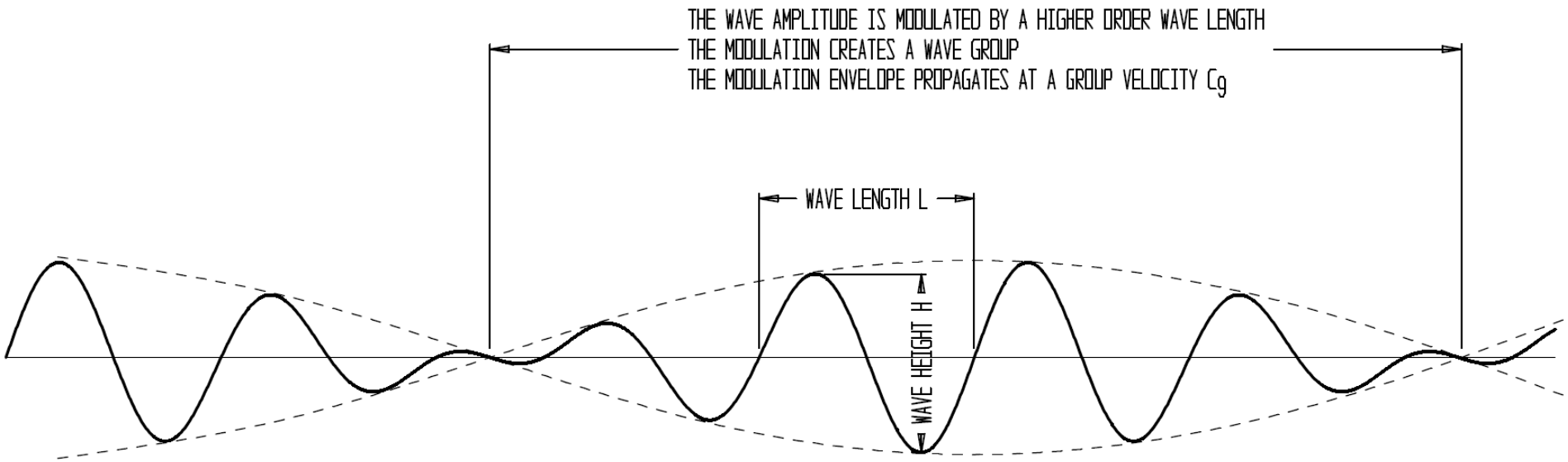
Time GMT	Hmax meter	Hs meter	H1/3 meter	Direction deg	Tav sec	Tz sec	Tp sec	Temperature ^{o}C
03:00	0.56	0.42	0.35	256	4.3	4.0	9.1	29.45
03:30	**0.76**	**0.44**	**0.37**	**269**	**4.2**	**4.0**	**10.0**	**29.40**
04:00	0.66	0.42	0.35	256	4.2	4.0	8.3	29.40
04:30	0.62	0.39	0.34	262	4.3	3.9	9.1	29.45
05:00	0.58	0.40	0.34	257	4.3	3.9	10.0	29.45
05:30	0.58	0.39	0.33	263	4.2	3.9	9.1	29.40
06:00	0.61	0.41	0.35	259	4.3	4.1	8.3	29.45
06:30	0.57	0.41	0.35	259	4.1	3.9	10.0	29.50
07:00	0.63	0.41	0.36	255	4.1	3.8	9.1	29.55

05 September 2014

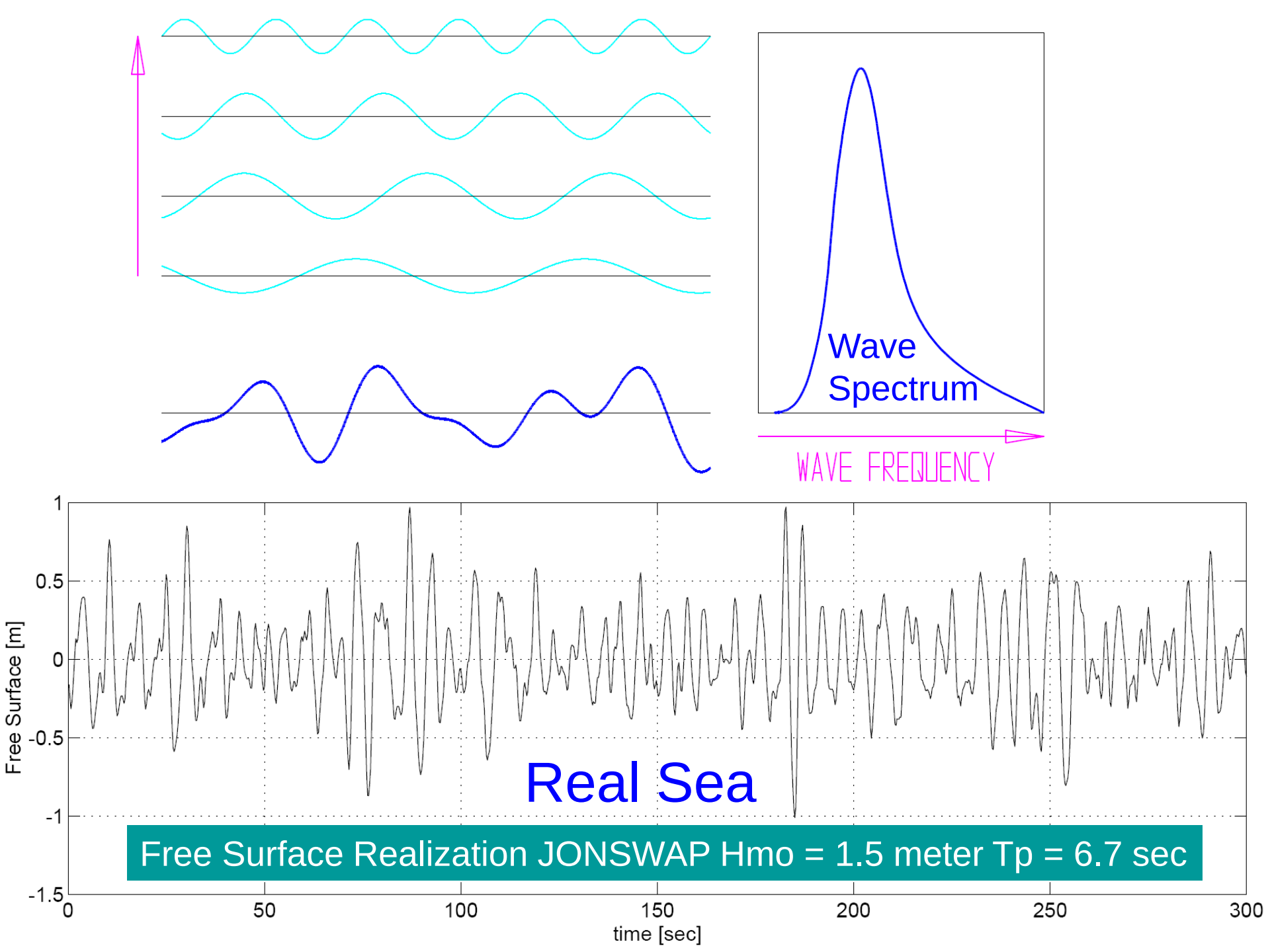
- Time GMT - Greenwich Mean Time:
  in Summer - Local Israeli time = GMT + 3 hours
  in Winter - Local Israeli time = GMT + 2 hours
- Hmax - maximum wave height in the wave record
- Hs - spectral significant wave height (spectral parameter)
- $H_{1/3}$ - average height of highest one-third waves in the wave record
- Direction - the angle between true North and the spectral peak wave direction
- Tav - average period of all waves in the wave record
- Tz - mean wave period (spectral parameter)
- Tp - period of the spectral peak wave

Wave Group

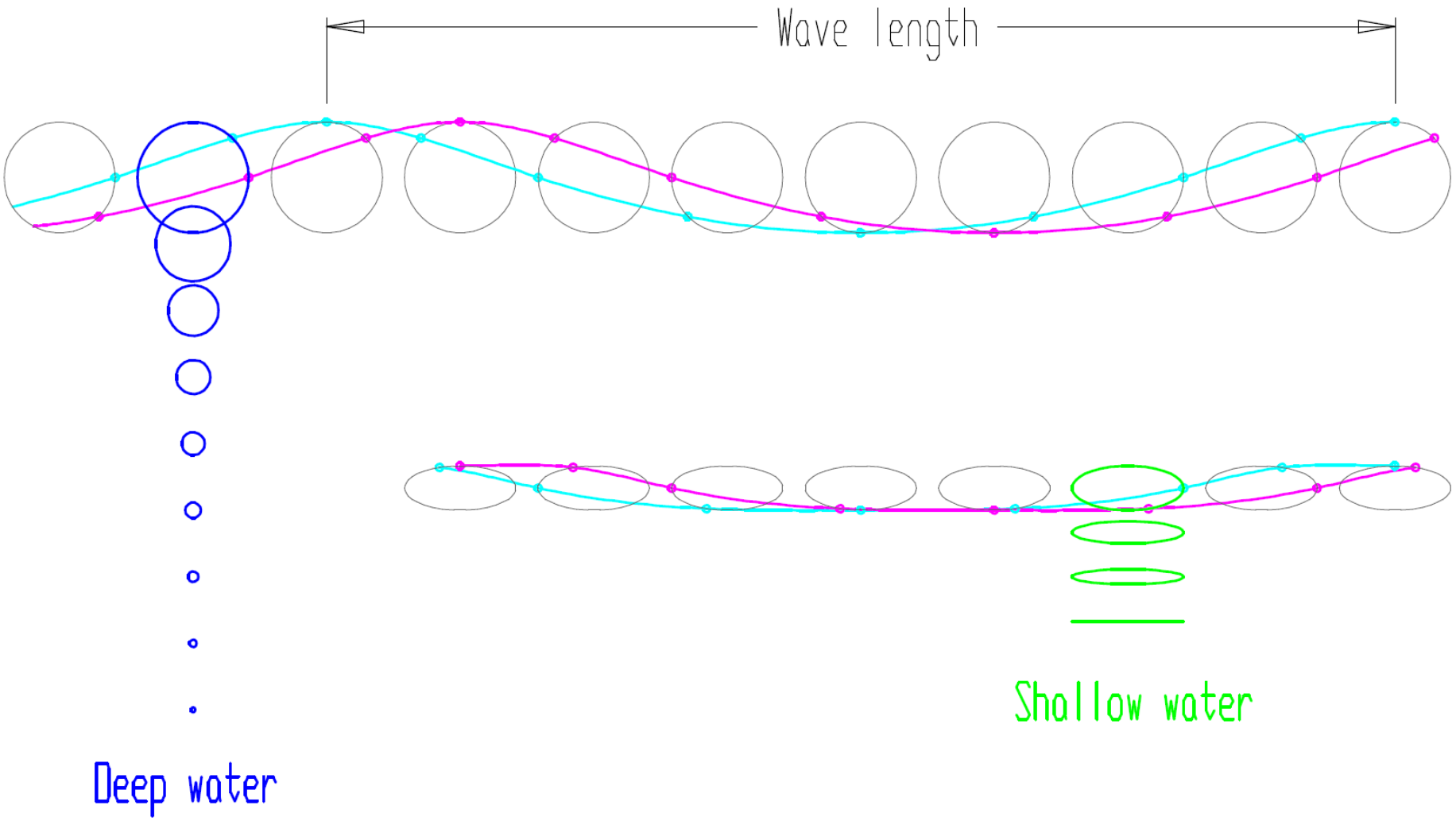
$$\sin(\omega_1 t)+\sin(\omega_2 t)=2\sin\left(\frac{\omega_1+\omega_2}{2}t\right)\cos\left(\frac{\omega_1-\omega_2}{2}t\right)$$



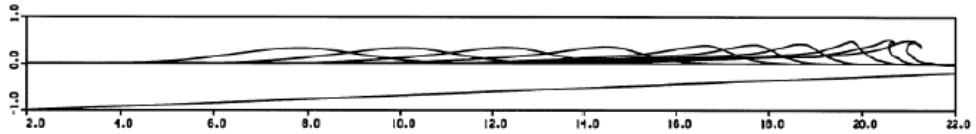
THE WAVE PHASE IS PROPAGATING AT THE PHASE VELOCITY C (CELARITY).
THE WAVE ENERGY IS PROPAGATING AT THE GROUP VELOCITY Cg.
AT DEEP WATER Cg = C / 2. AT SHALLOW WATER Cg = C.
THE WAVE PHASE PROPAGATES ONE WAVE LENGTH, L, AT A WAVE PERIOD, T. C = L / T.
THE WAVE AMPLITUDE, a, EQUALS HALF OF THE WAVE HEIGHT. a = H / 2.
AT A GIVEN SEA STATE THE VAVE HEIGHT, H, VARIATES. THE SIGNIFICANT WAVE HEIGHT,
Hs, IS THE AVERAGE HEIGHT OF THE HIGHEST ONE THIRD OF THE WAVES IN A SAMPLE.

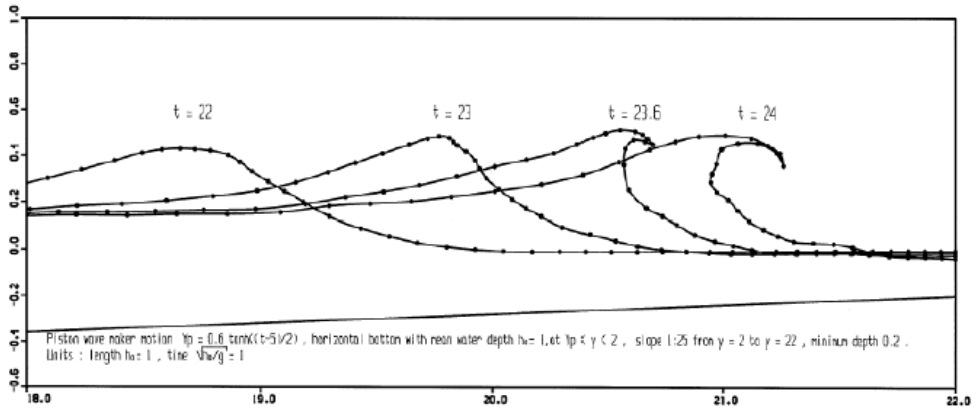

Wave
Spectrum
WAVE FREQUENCY
Free Surface [m]
time [sec]
1
0.5
0
-0.5
-1
-1.5
0
50
100
150
200
250
300
Real Sea
Free Surface Realization JONSWAP Hmo = 1.5 meter Tp = 6.7 sec

Orbital Velocities by Linear Wave Theory



Shoaling



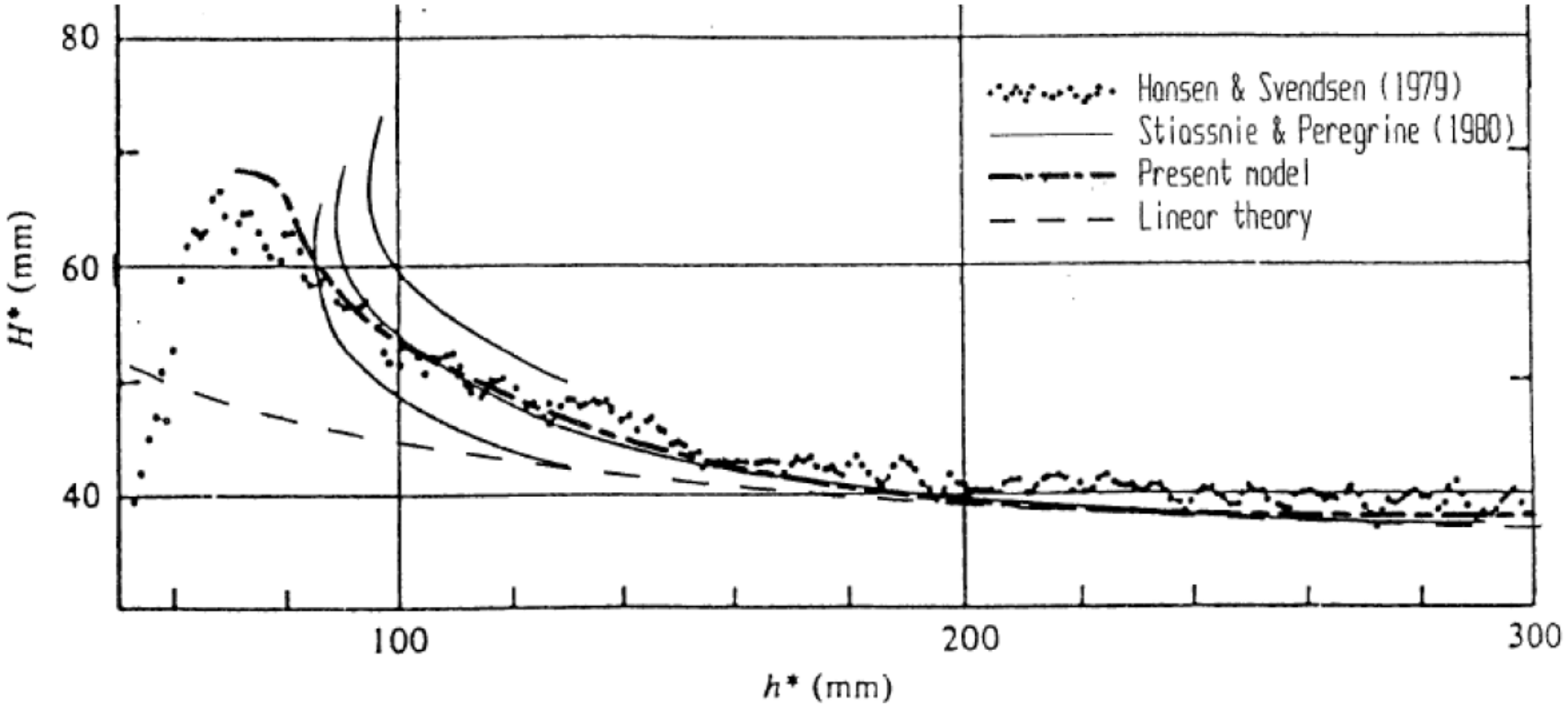


$$\overline{E} = \frac{1}{2}\rho\, g\, a^2$$

$$\omega^2 = g\, k \tanh(kh)$$

$$C = \frac{\omega}{k},\ C_g = \frac{\partial \omega}{\partial k} = \frac{C}{2}\left(1 + \frac{2kh}{\sinh(2kh)}\right)$$

$$E\, C_g = Const$$



Dispersion Relation

$$\omega^2 = gk\tanh(kh), \omega = \frac{2\pi}{T}, k = \frac{2\pi}{\lambda}$$

Deep Water

$$\omega^2 = gk, \lambda = \frac{2\pi}{k} = \frac{g}{2\pi}T^2 = 1.56T^2$$

Shallow Water

$$\omega^2 = gk^2h, c = \frac{\omega}{k} = \sqrt{gh}$$

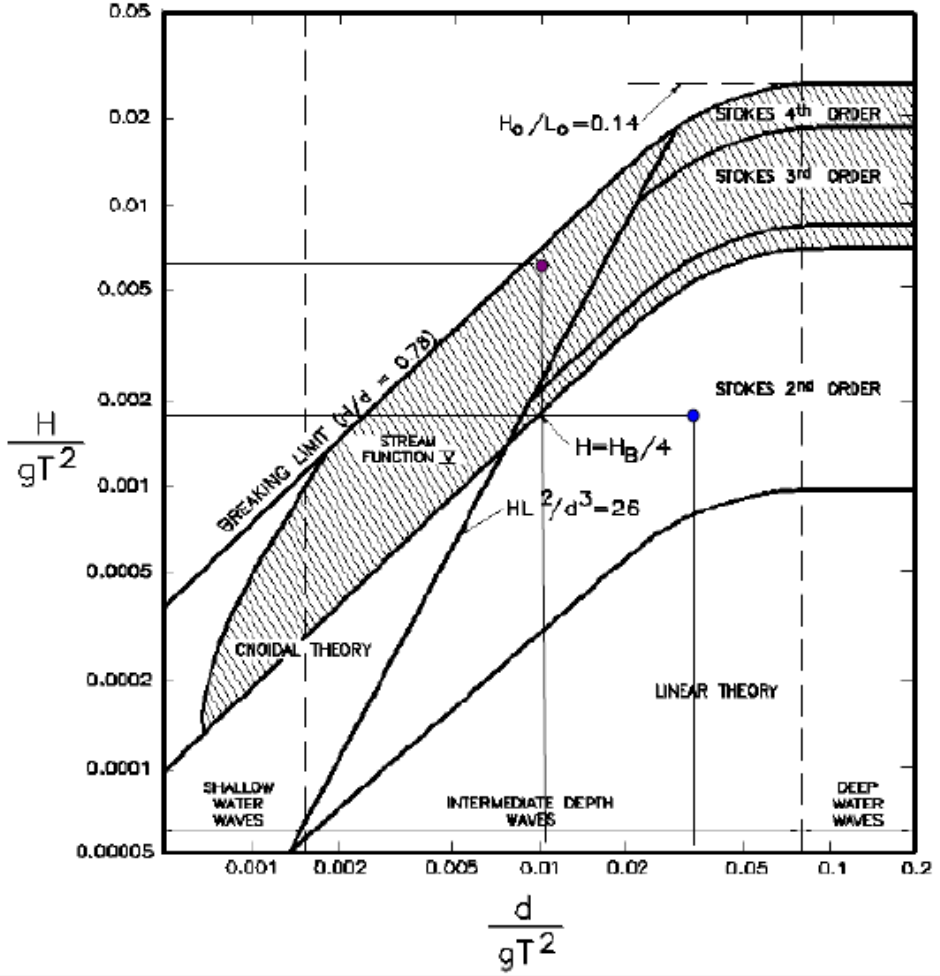
Spilling

Plunging

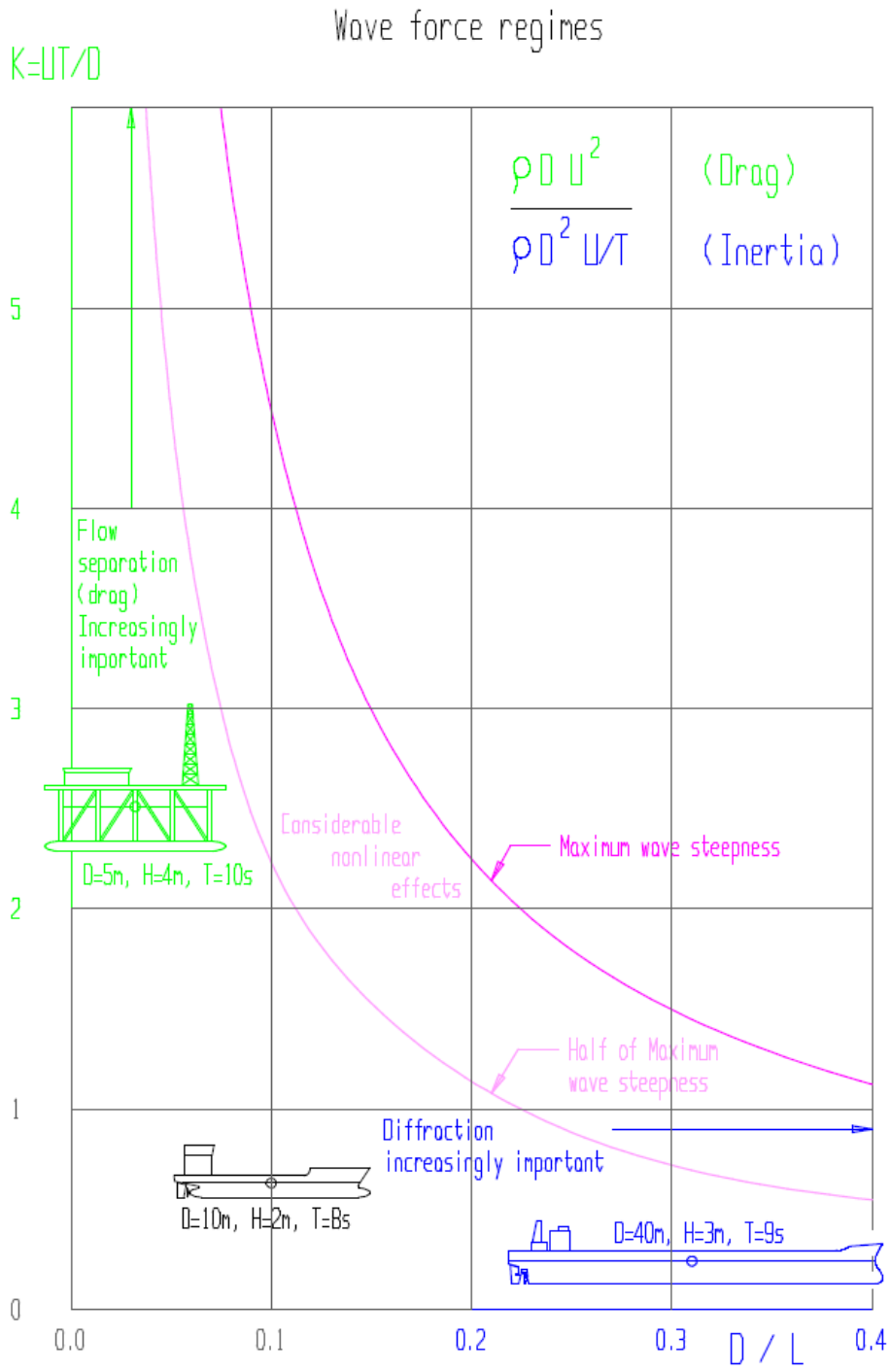
Collapsing

Surging

Case	Depth [m]	Hmo [m]	Tpeak [s]	Hmax H [m]	$\frac{d}{gT^2}$	$\frac{H}{gT^2}$	$\frac{H}{d}$	H Breaking
1	12.00	4.0	10.90	7.20	0.0103	0.0062	0.60	9.36
2	30.00	1.0	10.00	1.80	0.0306	0.0018	0.06	23.40

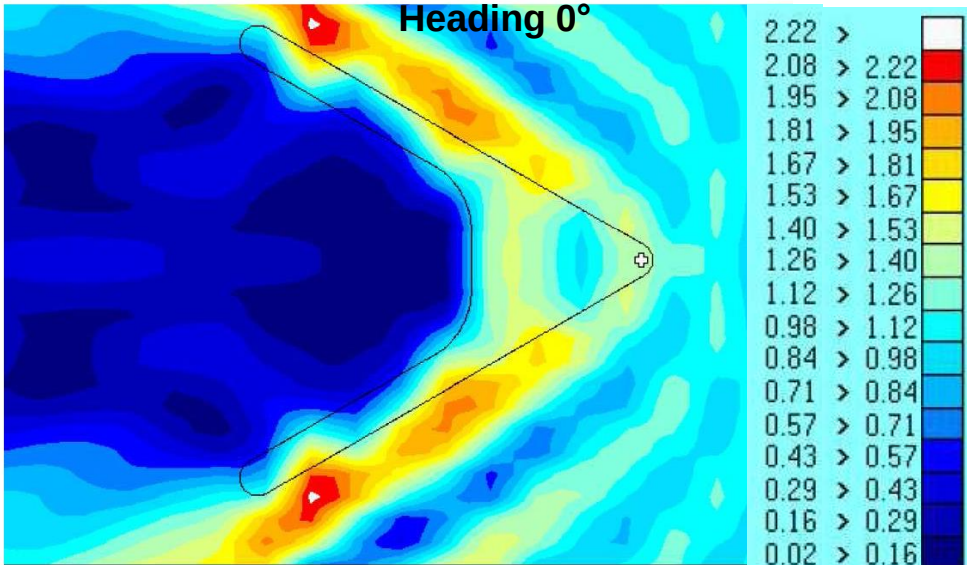


Ranges of suitability various wave theories (Le Mehaute 1976)
Coastal Engineering Manual Part II - Chapter 1- Page 58

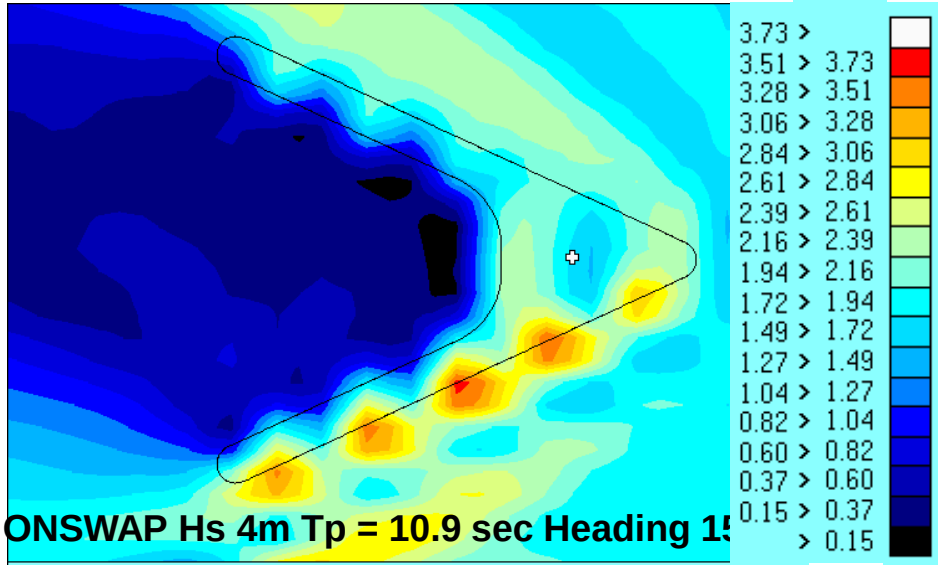


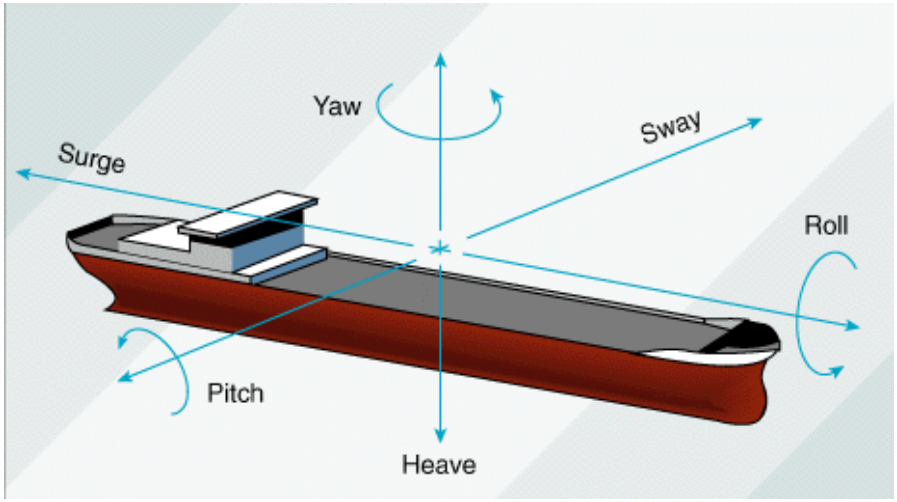
Hydrodynamic Aspects of Wave-Structure Interaction

Monochromatic Amplification Factors T = 12 sec Heading 0°

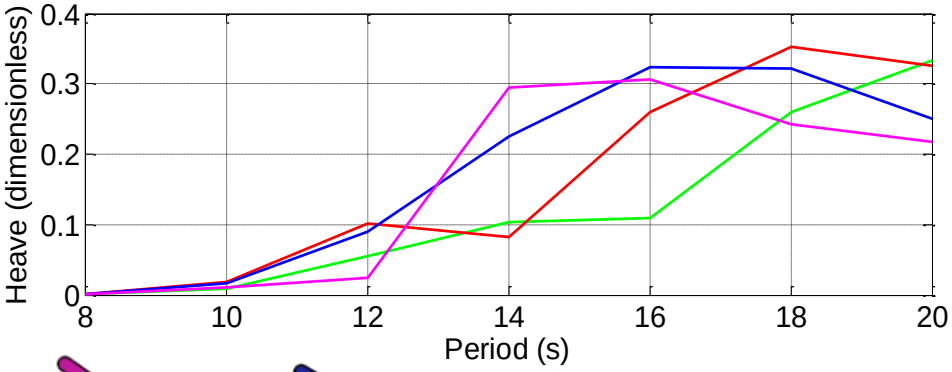


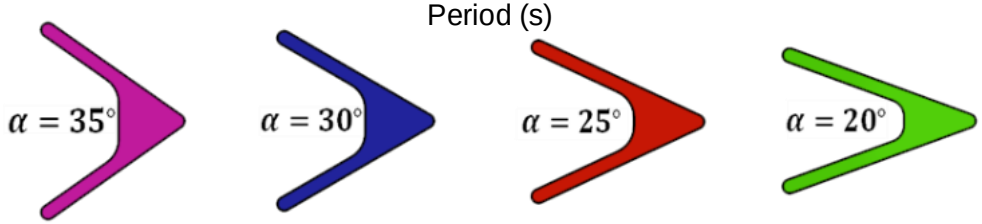
Real Sea Spectra Significant Amplitude



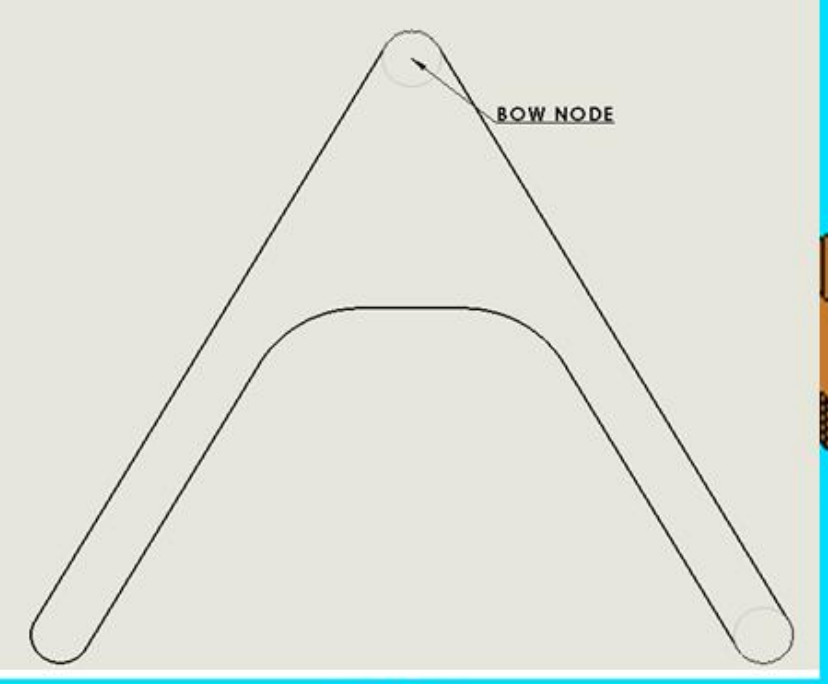


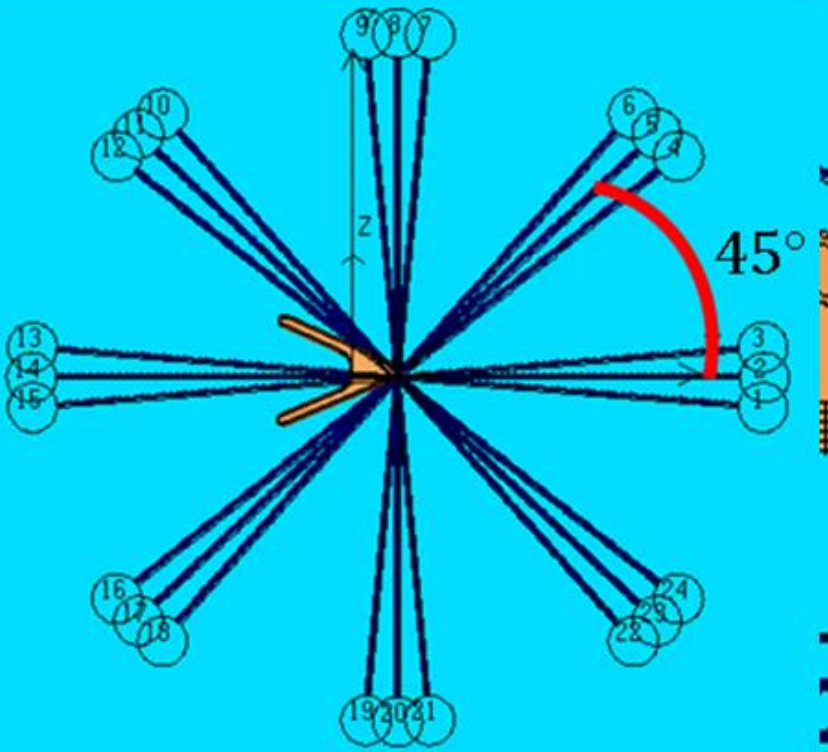
Response Amplitude Operators (RAOs)

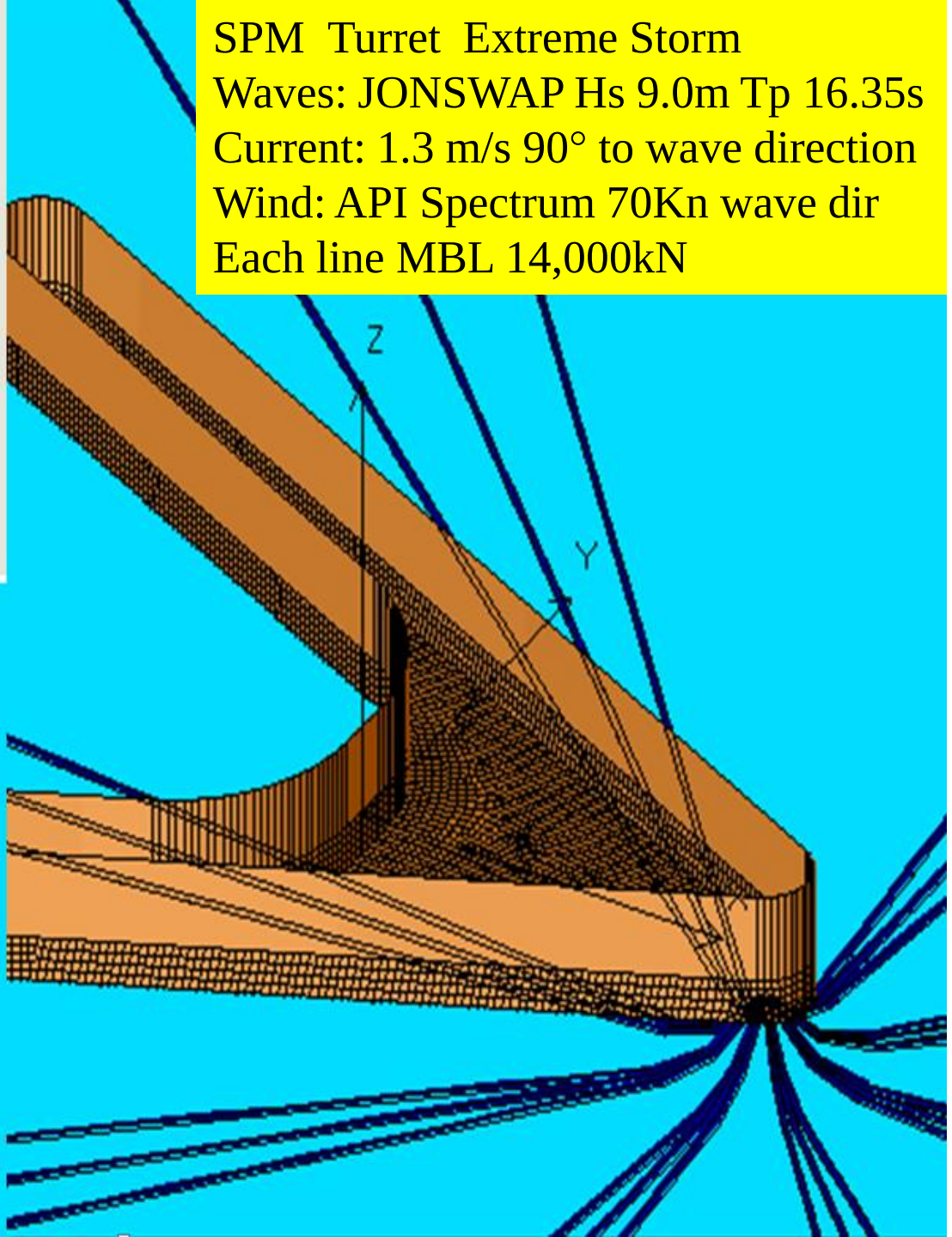




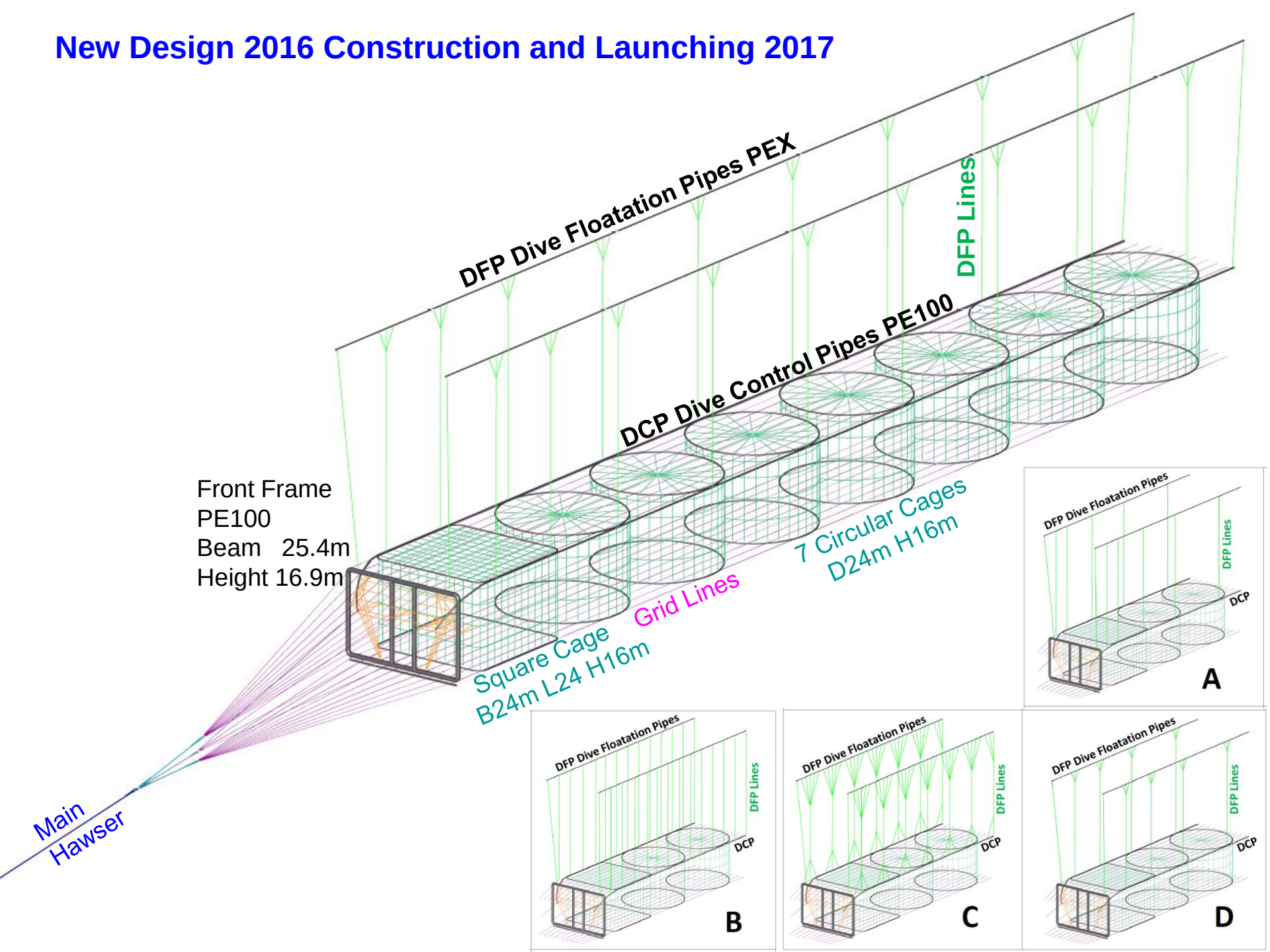
SPM Turret Extreme Storm
Waves: JONSWAP Hs 9.0m Tp 16.35s
Current: 1.3 m/s 90° to wave direction
Wind: API Spectrum 70Kn wave dir
Each line MBL 14,000kN







New Design 2016 Construction and Launching 2017



Simulations for SUBFLEX new Open Sea Aquaculture System Ashdod 2016

by

Naval Architecture and Ocean Engineering Research Group
Mechanical Engineering Faculty
Technion – Israel Institute of Technology

applying **AQUASIM**

aquastructures