

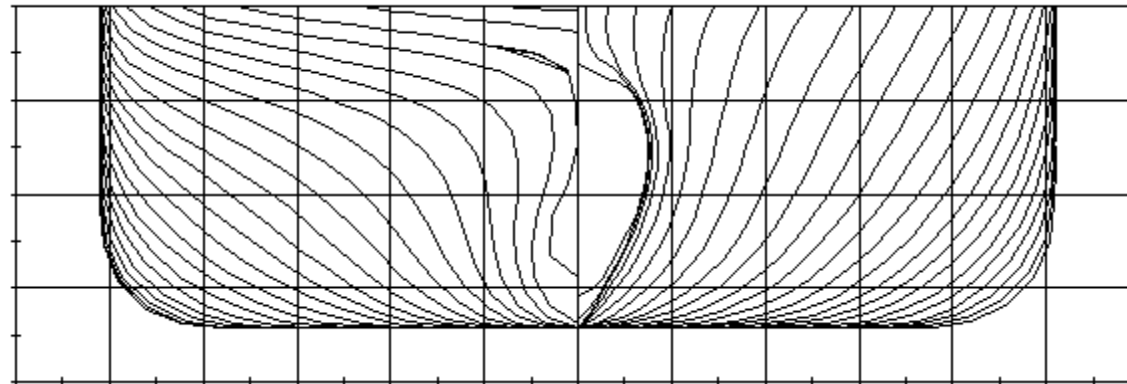
# NM835/NM529

## Ship Operability and Control

Coursework tutorial

Dr Momchil Terziev

[momchil.terziev@strath.ac.uk](mailto:momchil.terziev@strath.ac.uk)



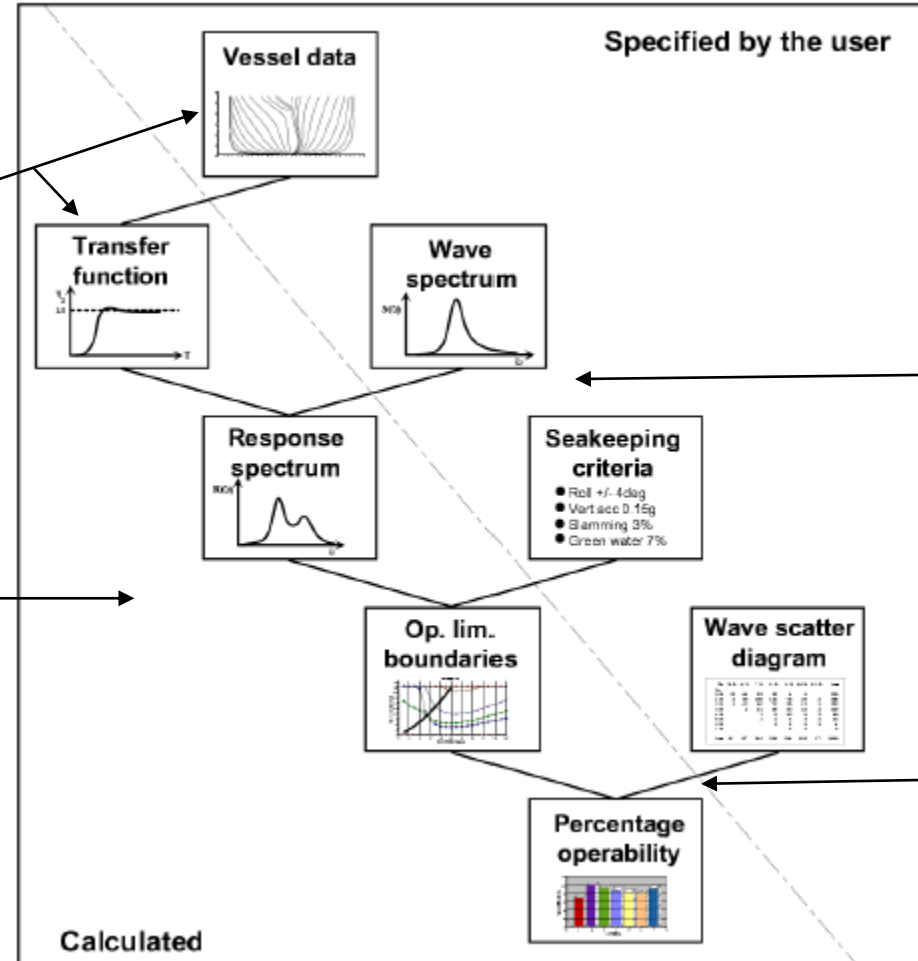
# Introduction to operability

1. ShipX calculates the motion transfer functions in six degrees of freedom for your ship at the specified speeds and headings.

3. The response spectra are combined with the specified seakeeping criteria to obtain operability limiting boundaries.

2. The Postprocessor combines the RAOs with the specified wave spectra to obtain the response spectra (short term statistics).

4. The operability limiting boundaries combined with the specified wave scatter diagram are summed up over the sea states to obtain the percentage operability.



Note:

Response amplitude  
operator

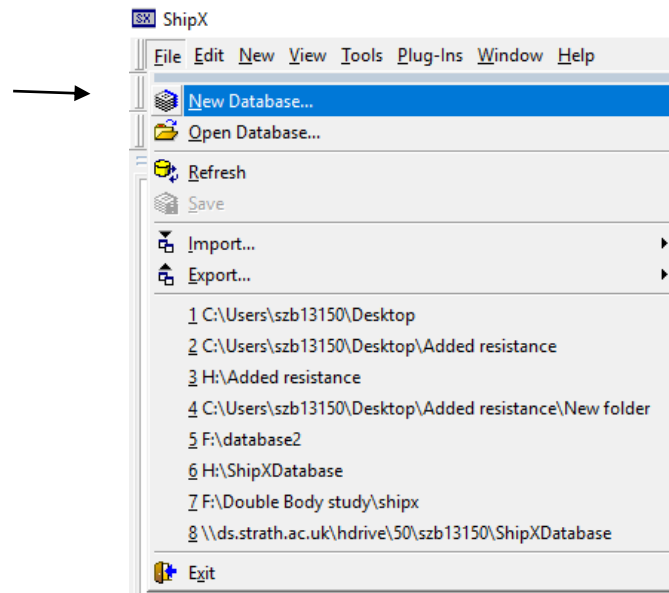
$$S_{\zeta}(\omega) = |RAO(\omega)|^2 \times S(\omega)$$

Response spectrum

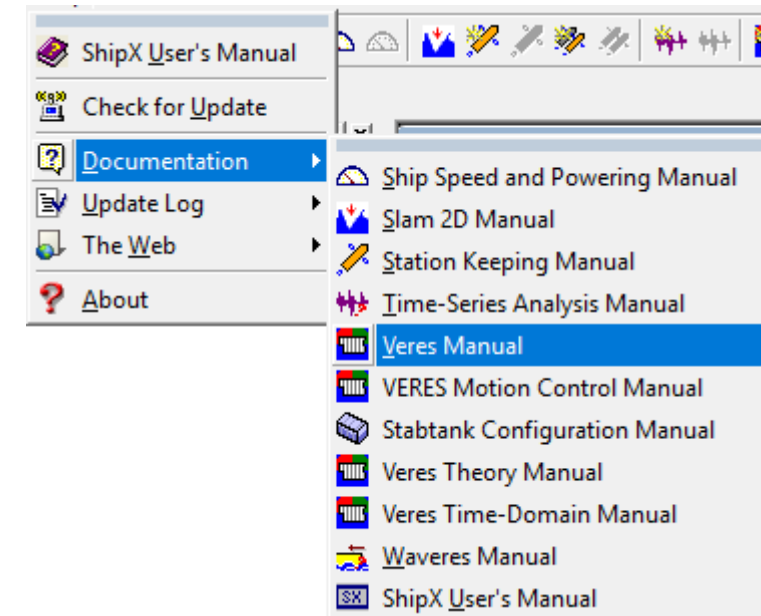
Sea spectrum

# Step 1: Preliminaries

- First, create a new database.

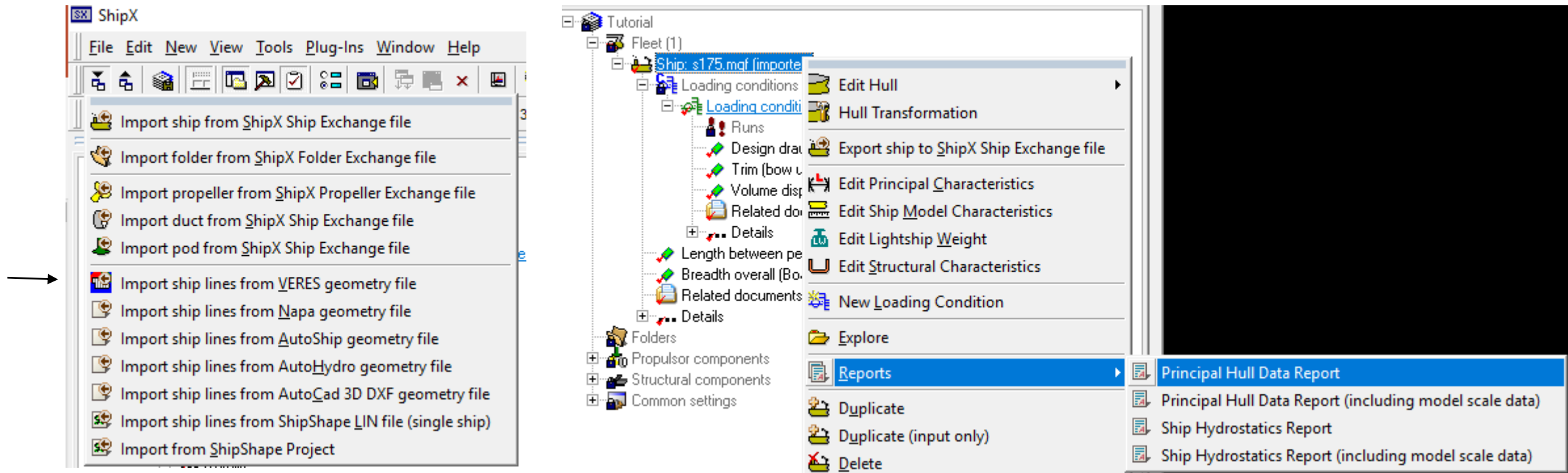


- Consulting the user manual is always a good idea!



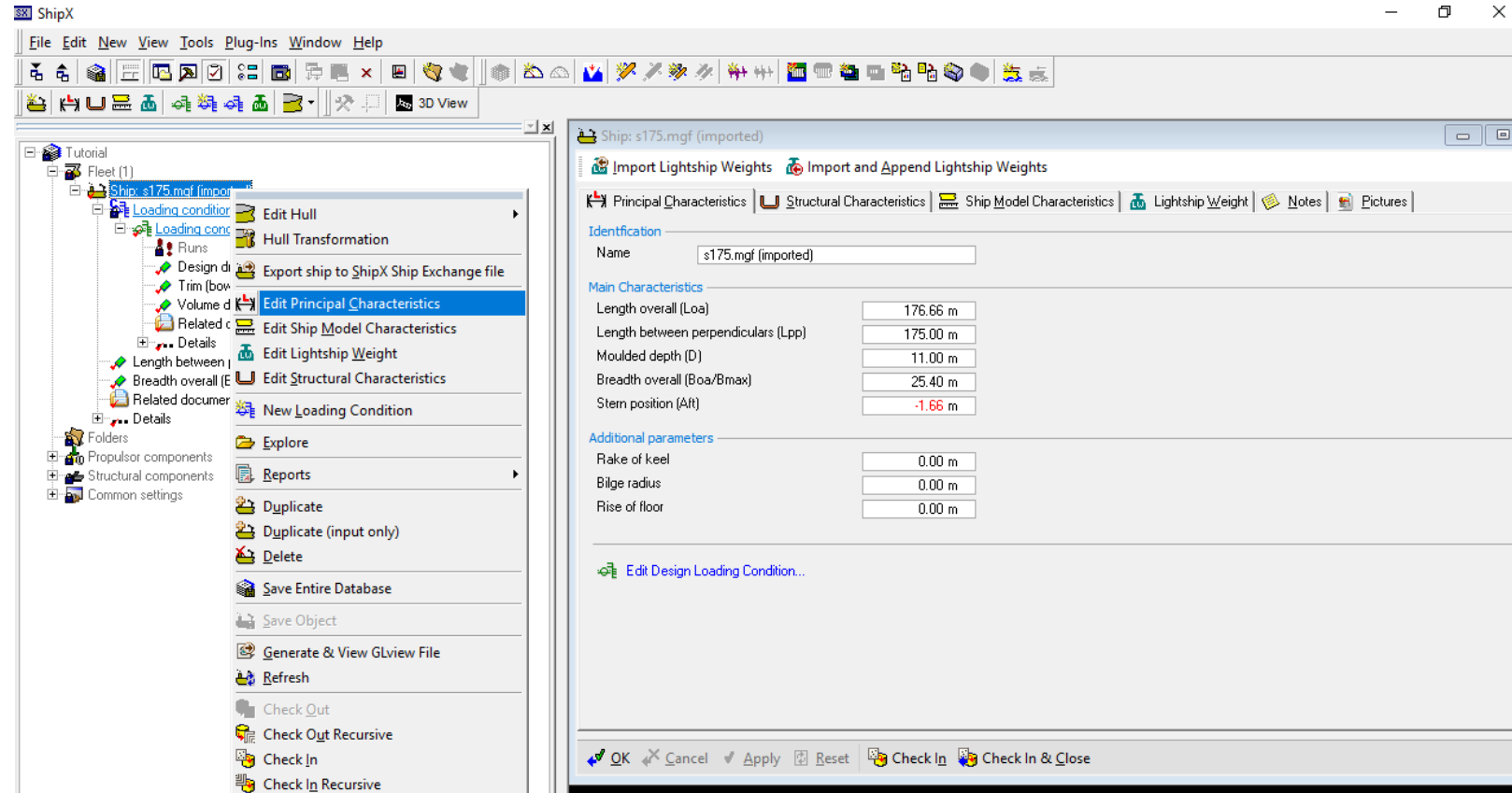
# Step 2: Ship geometry

- Import the required ship hull.
- Check that your imported file matches the requirements.




# Step 3: Editing the ship particulars

- If the input does not match the requirements, you may edit the design loading condition as shown.

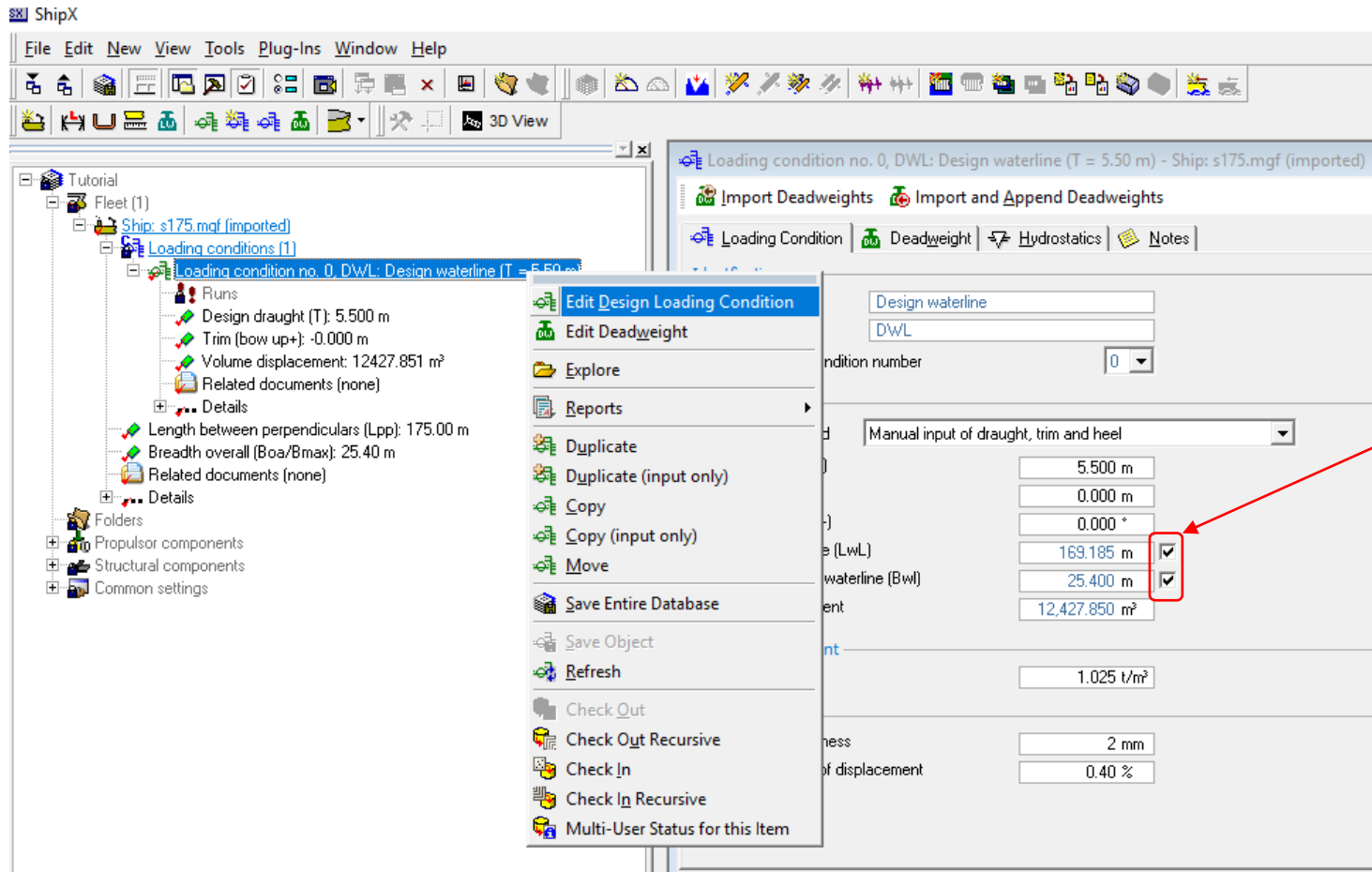


# Step 4: Ship principal characteristics

<div> <div>  <b>PRINCIPAL HULL DATA</b> </div> <div> ENCL. A.520  REPORT  DATE 23/01/2020  REF. </div> </div>			
SHIP: s175.mgf (imported) Loading condition: Design WL Draught AP/FP: 5.500 / 5.500 [m]			
	Symbol	Unit	
Length overall	Loa	[m]	176.663
Length on designed waterline	LWL	[m]	169.185
Length betw. perp.	LPP	[m]	175.000
Breadth moulded	B	[m]	25.400
Breadth waterline	BWL	[m]	25.400
Depth to 1 <sup>st</sup> deck	D	[m]	11.000
Draught at LPP/2	T	[m]	5.500
Draught at FP	TFP	[m]	5.500
Draught at AP	TAP	[m]	5.500
Trim (pos. aft)	t	[m]	-0.000
Rake of keel		[m]	0.000
Rise of floor		[m]	0.000
Bilge radius		[m]	0.000
Sea water density	$\rho_s$	[kg/m <sup>3</sup> ]	1025.00
Shell plating thickness		[mm]	2
Shell plating in % of displ.		[%]	0.40
Volume displacement	V	[m <sup>3</sup> ]	12427.9
Displacement	$\Delta$	[t]	12789.5
Prismatic coefficient*	C <sub>P</sub>	[-]	0.5395
Block coefficient*	C <sub>B</sub>	[-]	0.5083
Midship section coefficient	C <sub>M</sub>	[-]	0.9422
Longitudinal C.B. from LPP/2	LCB	[m]	-0.742
Longitudinal C.B. from LPP/2*	LCB	[% LPP]	-0.424
Longitudinal C.B. from AP	LCB	[m]	86.758
Wetted surface	S	[m <sup>2</sup> ]	3828.05
Wetted surface of transom stern	A <sub>r</sub>	[m <sup>2</sup> ]	0.00
Remarks: *Refers to LPP Hydrostatic corrections not included			

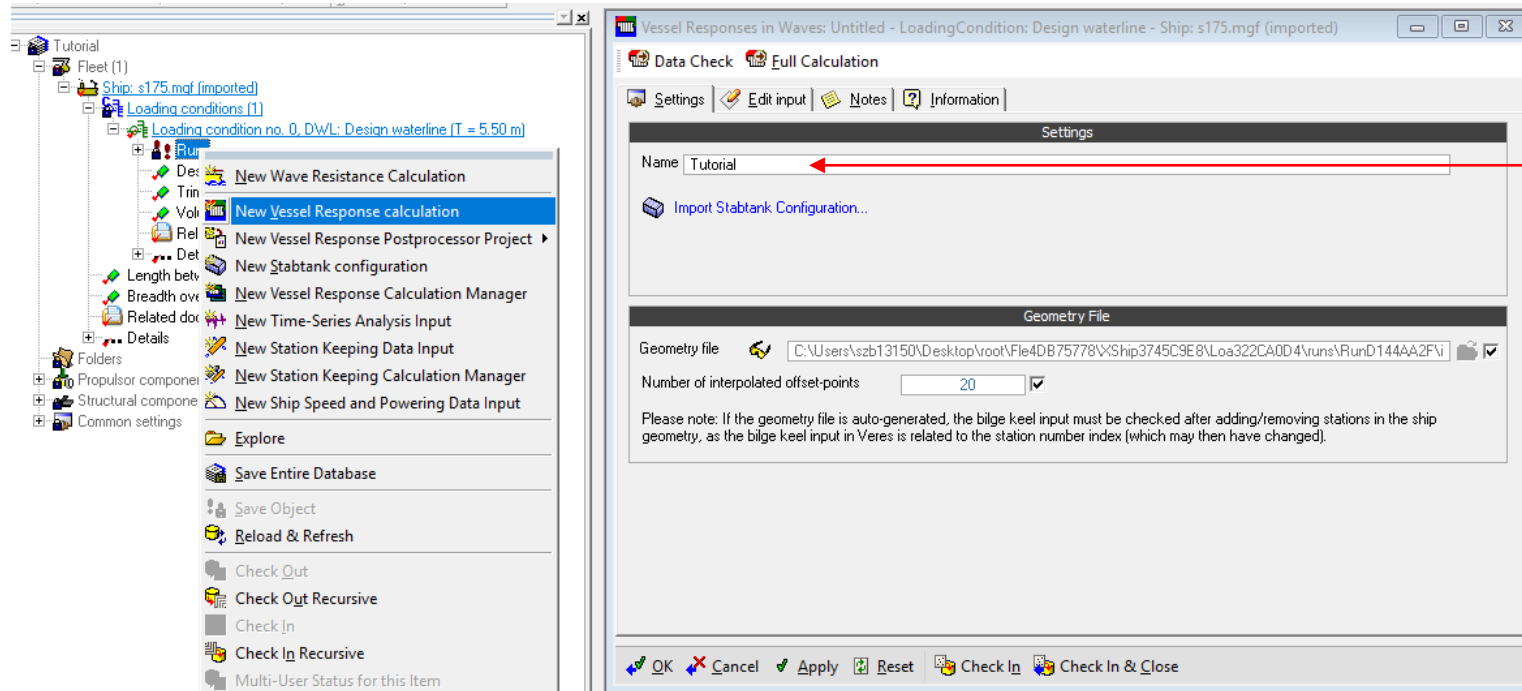
- ShipX's plot program may require several attempts to open.
- Check that all parameters match your required input.

# Step 5: Loading condition



- Ensure that you design loading condition matches the requirements, set out in the coursework.
- Indicates an automatically calculated value
- **For catamarans, the Breadth must be entered as twice that of a demihull.**

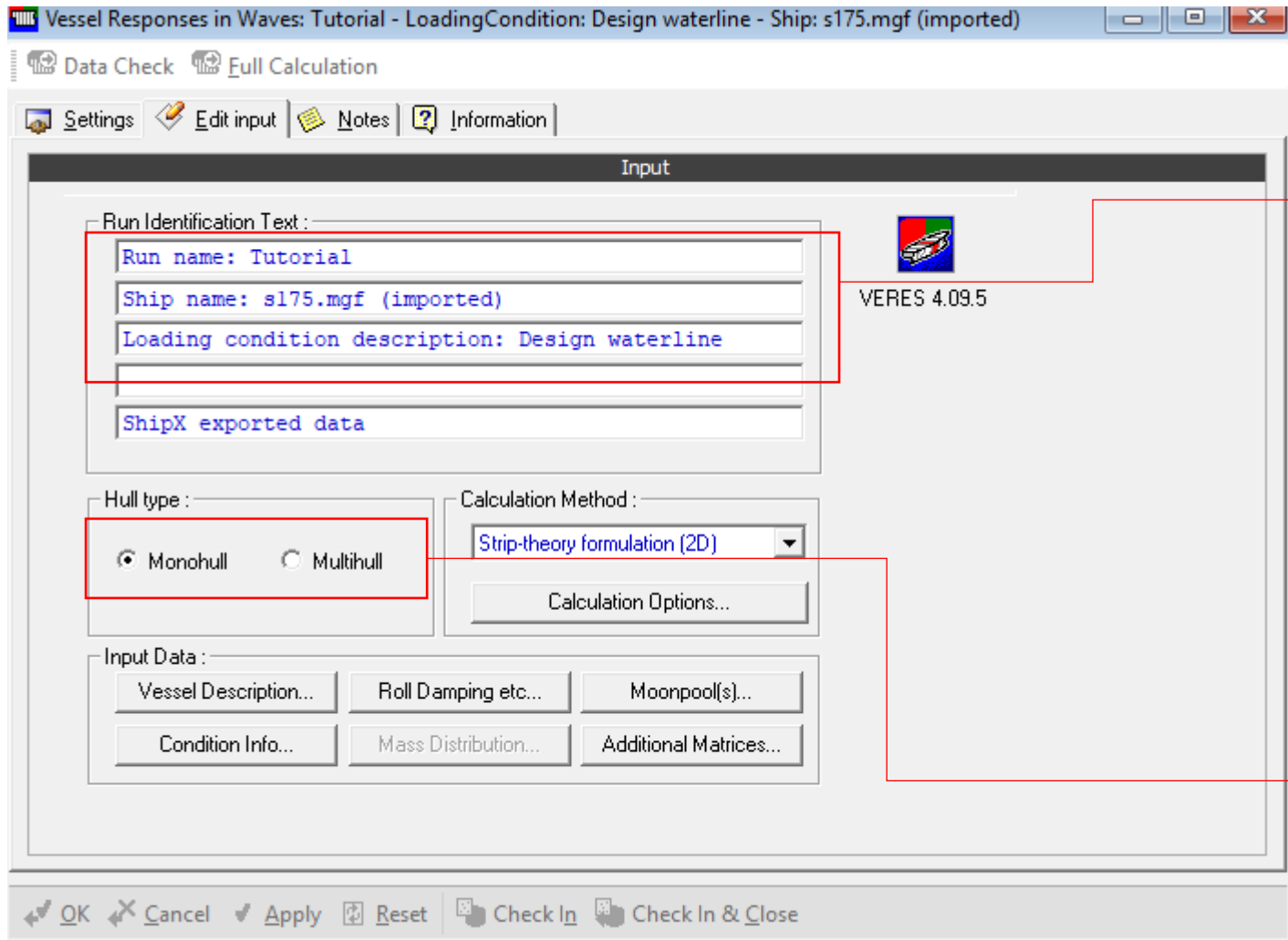
# Step 6: Define a response calculation



- Create a new vessel response calculation.
- Name your case suitably.
- Select Edit Input – this may require multiple attempts.

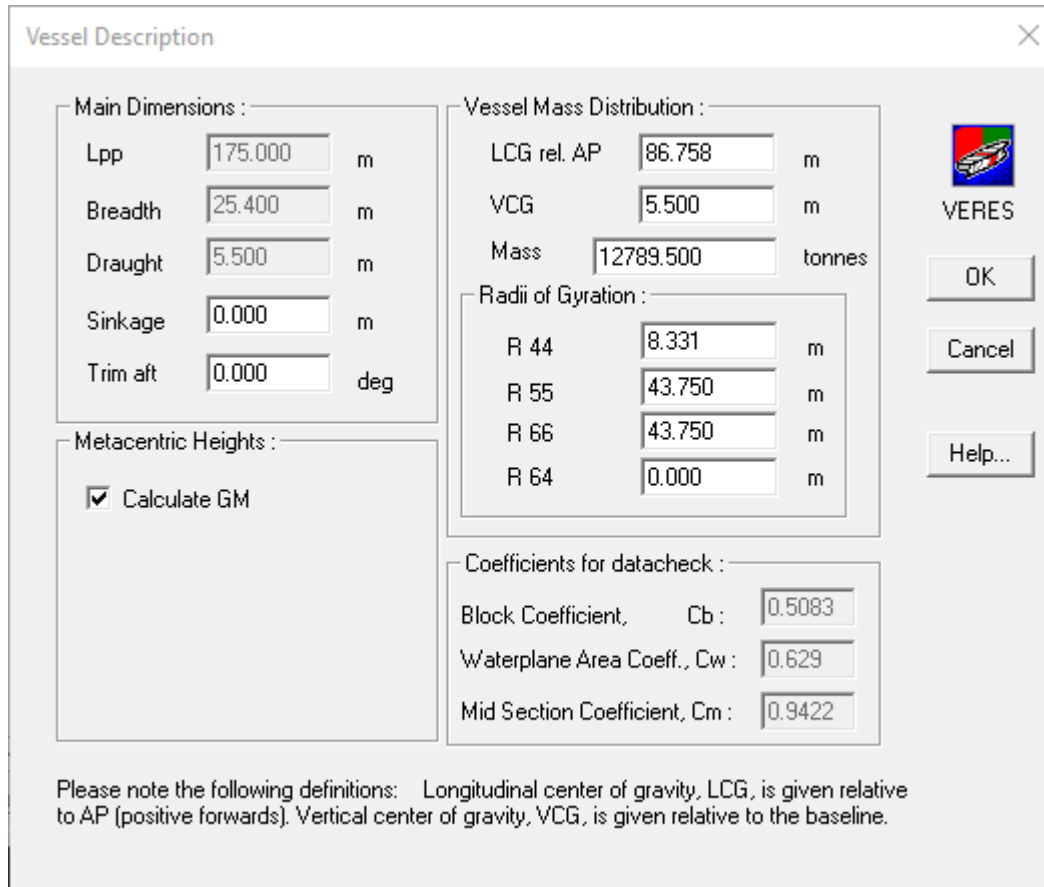


# Step 7: Edit the response calculation



- Name you case.
- The default theory for seakeeping calculations is of 2D strip theory of Tuck and Faltinsen (referenced in the manual and lecture notes).
- Select Vessel Description.
- Change the radial button accordingly.

# Step 8: Edit the vessel description



**Vessel Description**

**Main Dimensions :**

Lpp	175.000	m
Breadth	25.400	m
Draught	5.500	m
Sinkage	0.000	m
Trim aft	0.000	deg

**Metacentric Heights :**

☒ Calculate GM

**Vessel Mass Distribution :**

LCG rel. AP	86.758	m
VCG	5.500	m
Mass	12789.500	tonnes

**Radii of Gyration :**

R 44	8.331	m
R 55	43.750	m
R 66	43.750	m
R 64	0.000	m

**Coefficients for datacheck :**

Block Coefficient, Cb :	0.5083
Waterplane Area Coeff., Cw :	0.629
Mid Section Coefficient, Cm :	0.9422

Please note the following definitions: Longitudinal center of gravity, LCG, is given relative to AP (positive forwards). Vertical center of gravity, VCG, is given relative to the baseline.

VERES

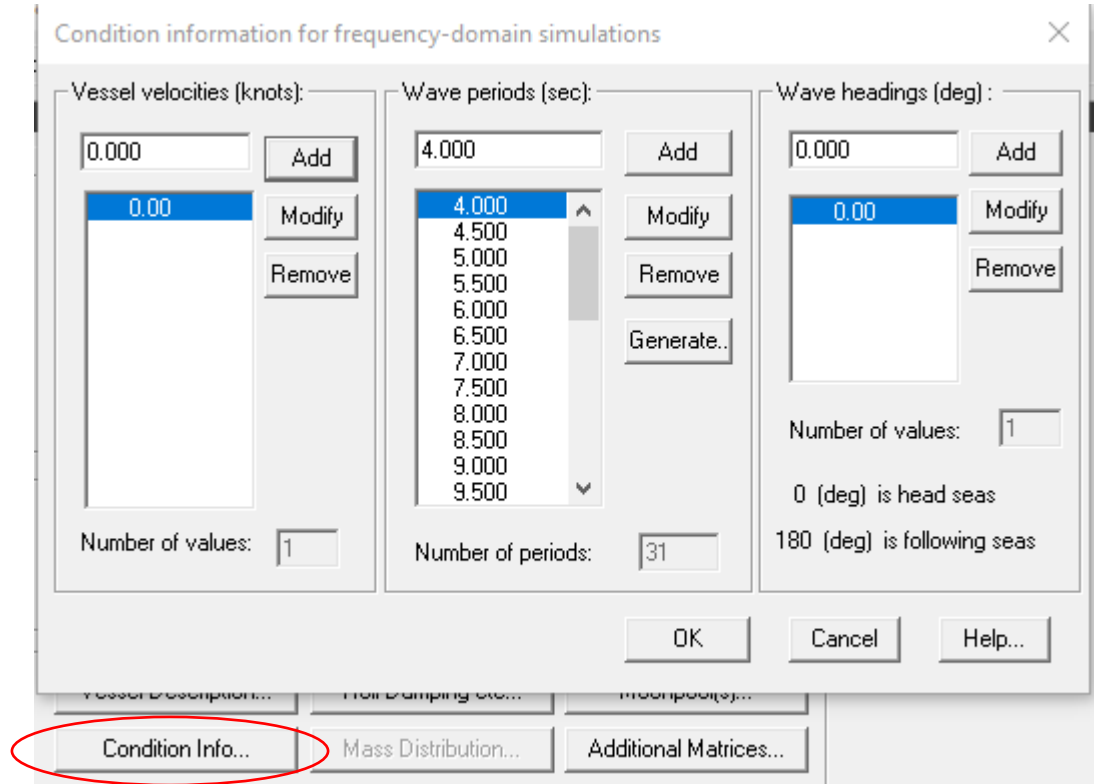
OK

Cancel

Help...

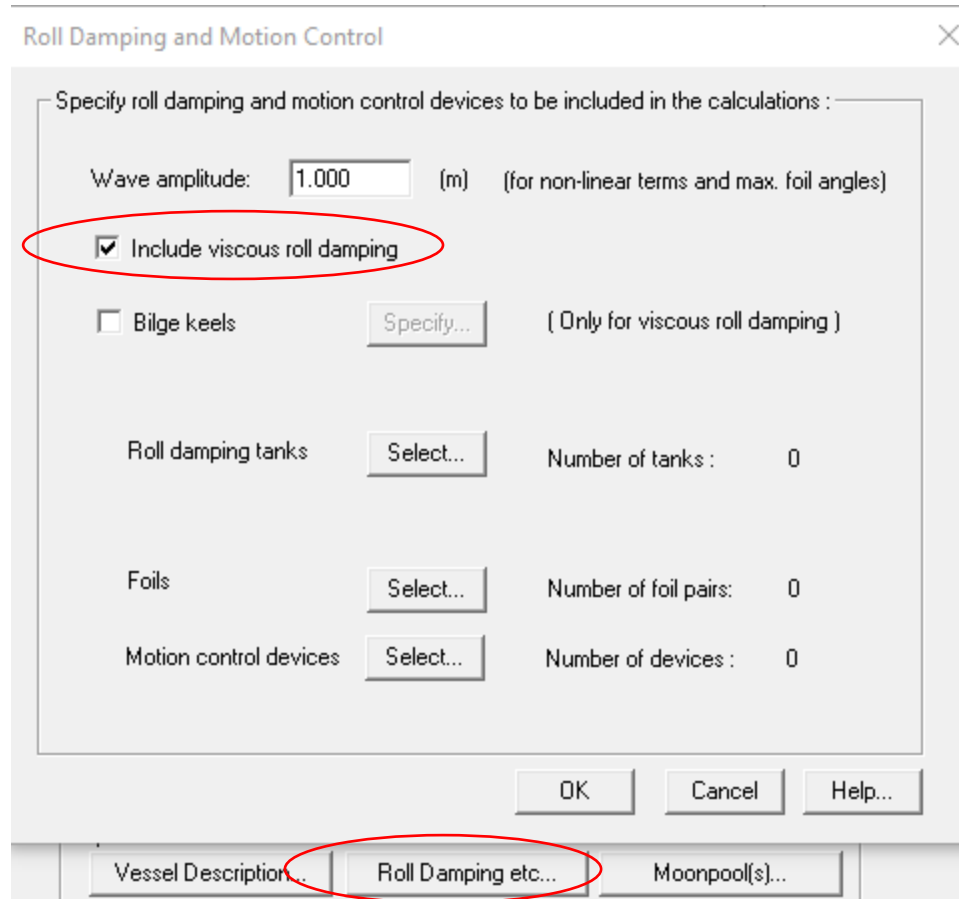
- Input the radii of gyration as required by the coursework.
- Edit the VCG and LCG if necessary.
- If you do not complete this step, the analysis will not run.
- Ensure that  $R_{44}$  is correctly specified depending on your ship.
- Select Ok to return to the pre-processor window.

# Step 9: Set the conditions



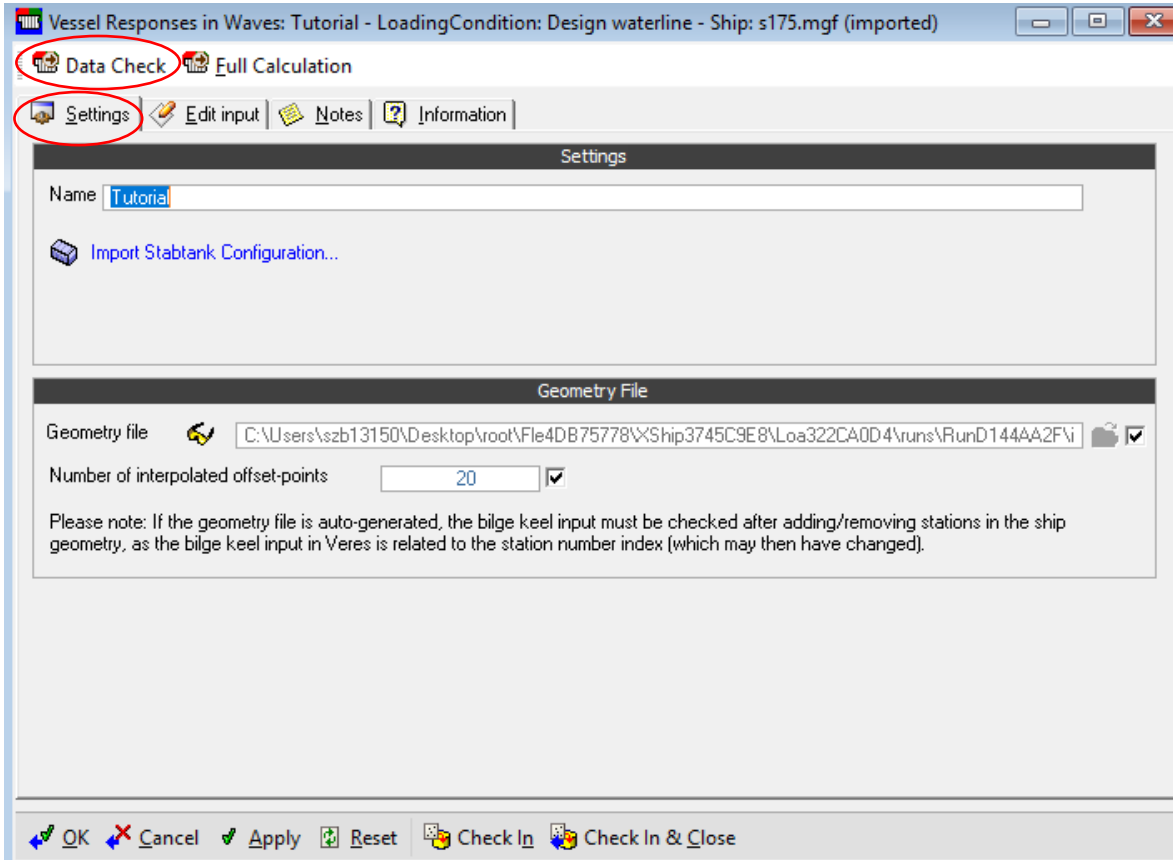
- Select Condition Info.
- Set the ship speeds depending on the requirements.
- You may specify the wave periods individually, or generate them all at once.
- The limit is  $<100$  wave periods.
- Ensure that your curves have a sufficient number of periods near the resonant frequency.
- Remember to check the headings:  $0^\circ$  is head seas.

# Step 10: Check that roll damping is enabled

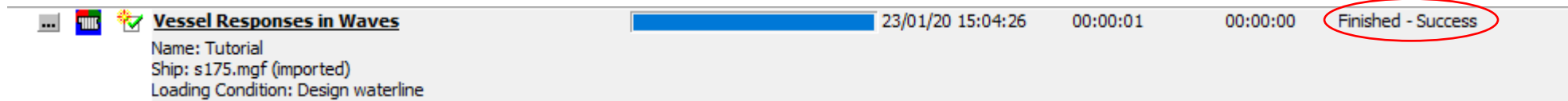


- Although this is enabled by default, it is a good idea to check that the viscous roll damping correction has been applied.
- Go to Roll Damping etc.
- Leave the wave amplitude as 1m.
- This is used in making the RAOs non-dimensional.
- Return to the pre-processor window.

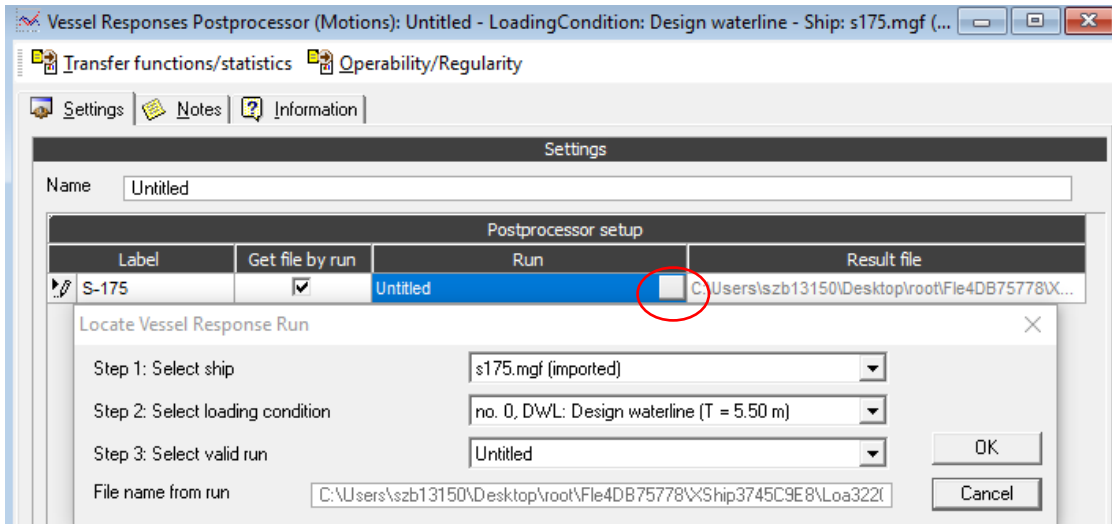
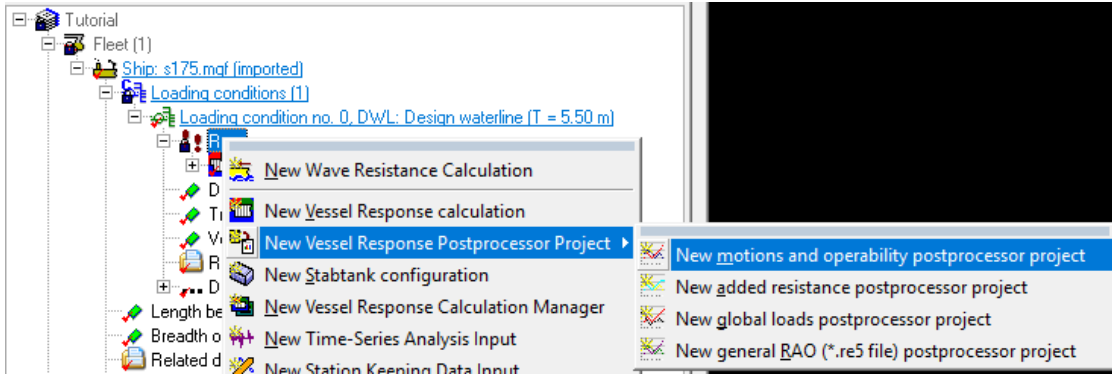
# Step 11: Run a data check



- Run a “Data Check”.
- If successful, ShipX’s plot program will open and display the ship particulars and sections (remember this might not work well and could require multiple attempts).
- You can now run the full calculation.

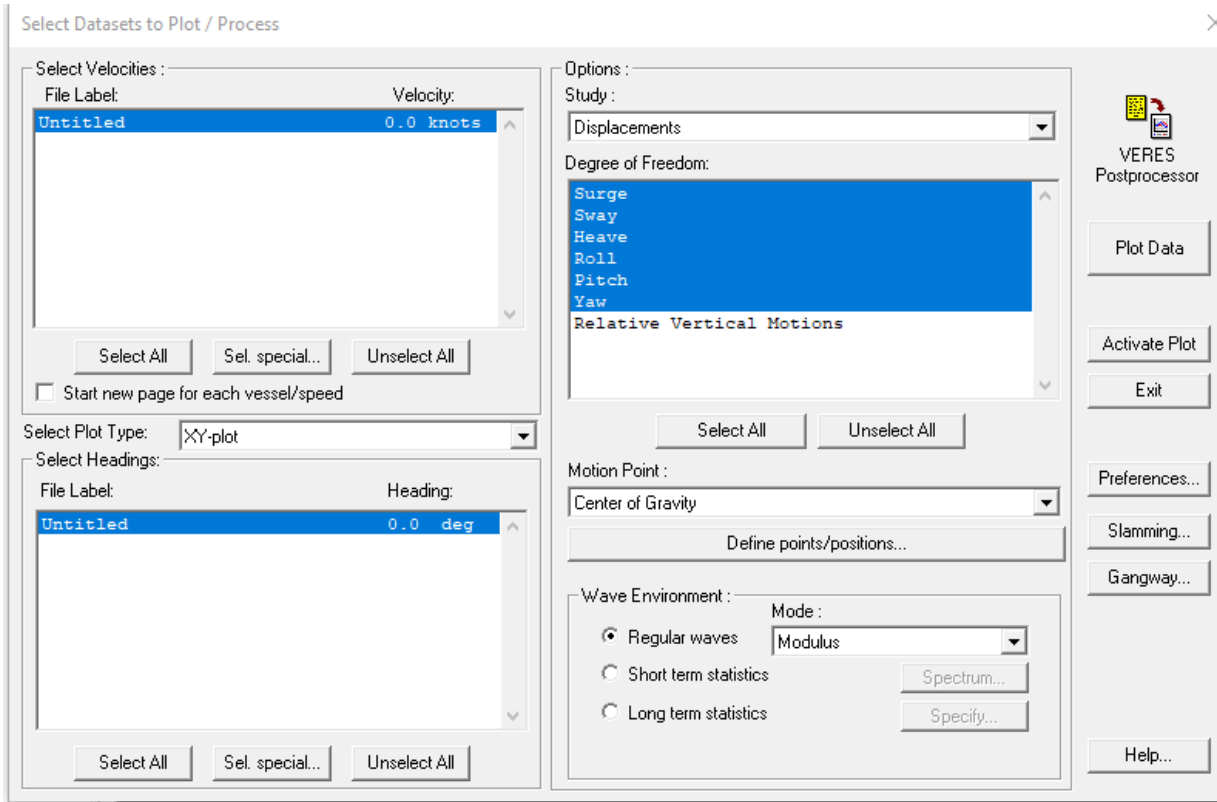


# Step 12: Set-up a post processor

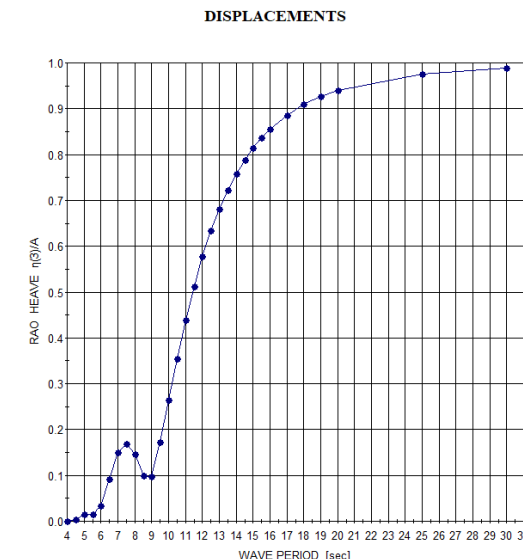


- You are now ready to perform the operability analysis.
- The first step is to create a post-processor for your calculation.
- Then, select your calculation and press Ok.
- Once ready, progress to Transfer functions/statistics

# Step 13: Plot the RAOs



- Highlight the required degrees of freedom, speeds and headings, and select Plot Data
- Sample result shown below (heave displacement RAO for 0° heading and 0 kn speed):



# Step 14: Edit and export data

VERES Postprocessor Preferences

Standard units :

Lengths/Forces: ☒ SI ☐ US Customary

Angles: ☒ [degrees] ☐ [radians]

Periods: ☒ [seconds] ☐ Non-dimensional

Frequencies: ☒ [rad/sec] ☐ [Hz]

Short-term probabilities: ☒ [%] ☐ per hour

Regular waves:

Rotational motions - RAD's:

Abscissa values:

Short term statistics:

Response:

Abscissa values:

Output destination :

☒ To Plot Program ☒ To plot file (\*.MPL)

Exposure time for MSI short-term statistics:  hours

Motion sickness factor Km for MSI by ISO 2631-1:1997 short-term statistics:

Typically, a Km value of 1/3 represents a mixed population of unadapted male and female adults.

☒ Translatory accelerations divided by acceleration of gravity

☒ Non-dimensional added resistance based on vessel dimensions

Program settings:

Default scatter data directory:

VERES Postprocessor

OK

Set as default

Cancel

Plot Data

Activate Plot

Exit

Preferences...

Slamming...

Gangway...

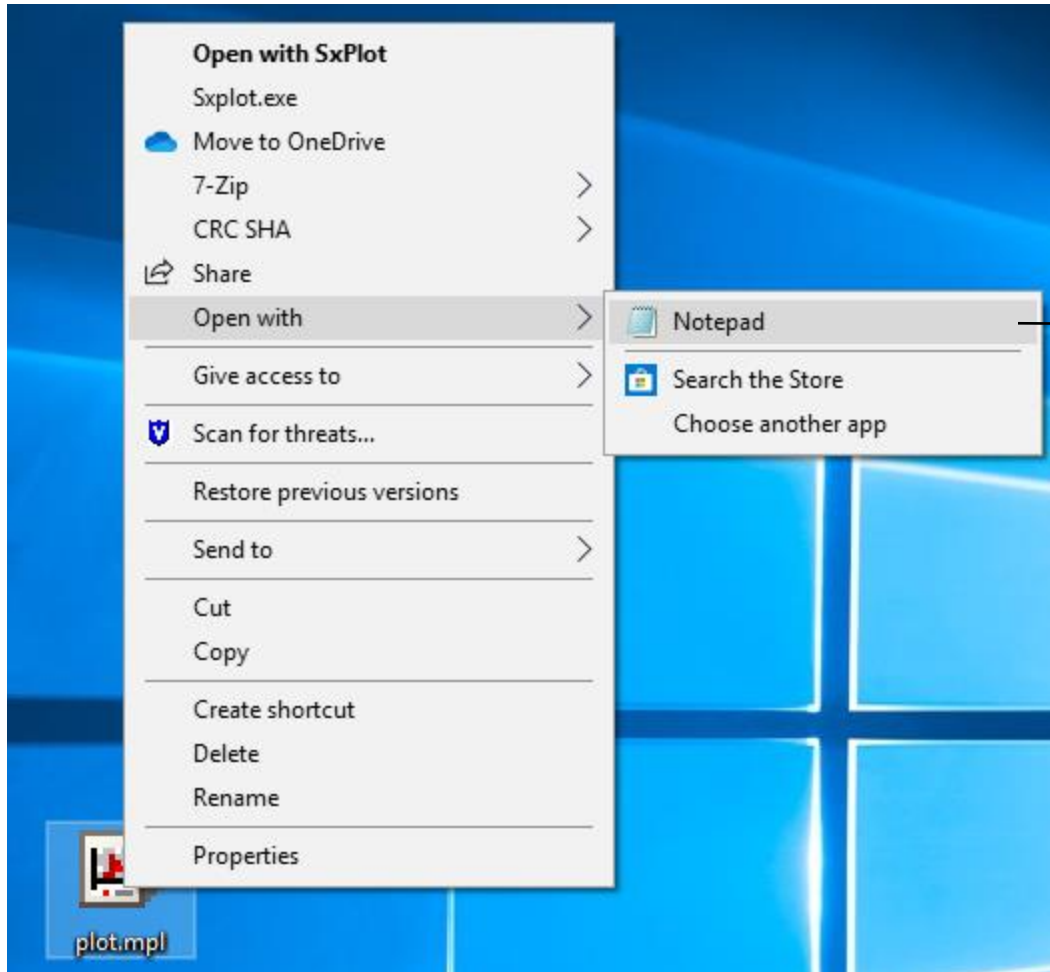
Help...

- If necessary, you can edit the  $x$  and  $y$  axes of the plot by selecting Preferences.
- To export the information used to produce the data, ensure that the “To plot file” box is ticked as shown.



# Step 15: Interpret exported data

- Open the .mpl file as shown



```

plot.mpl - Notepad
File Edit Format View Help
1
RESPONSE AMPLITUDE OPERATORS
DISPLACEMENTS
Project: Untitled
WAVE PERIOD [sec]
RAO HEAVE \eta(3)/A
1
Tutorial ; 0.00kn 0.0°
31
30.000002 9.887936e-001
25.000002 9.762343e-001
20.000004 9.407691e-001
18.999998 9.270822e-001
18.000002 9.093360e-001
17.000002 8.860575e-001
16.000000 8.551793e-001
15.500000 8.360195e-001
15.000001 8.137668e-001
14.500002 7.878742e-001
14.000002 7.576900e-001
13.500001 7.224308e-001
13.000002 6.812906e-001
12.499998 6.332754e-001
12.000003 5.773999e-001
11.500001 5.127429e-001
11.000002 4.386987e-001
10.500000 3.553279e-001
10.000001 2.644318e-001
9.500000 1.717923e-001
9.000001 9.824925e-002
8.500000 9.953062e-002
8.000001 1.463345e-001
7.500000 1.697475e-001
7.000001 1.492854e-001
6.500000 9.262825e-002
  
```

Units of 1<sup>st</sup> column

Units of 2<sup>nd</sup> column

Identifying information

Number of data points. If you have exported more than one parameter, these will be listed sequentially and grouped by the number of data points for each parameter.

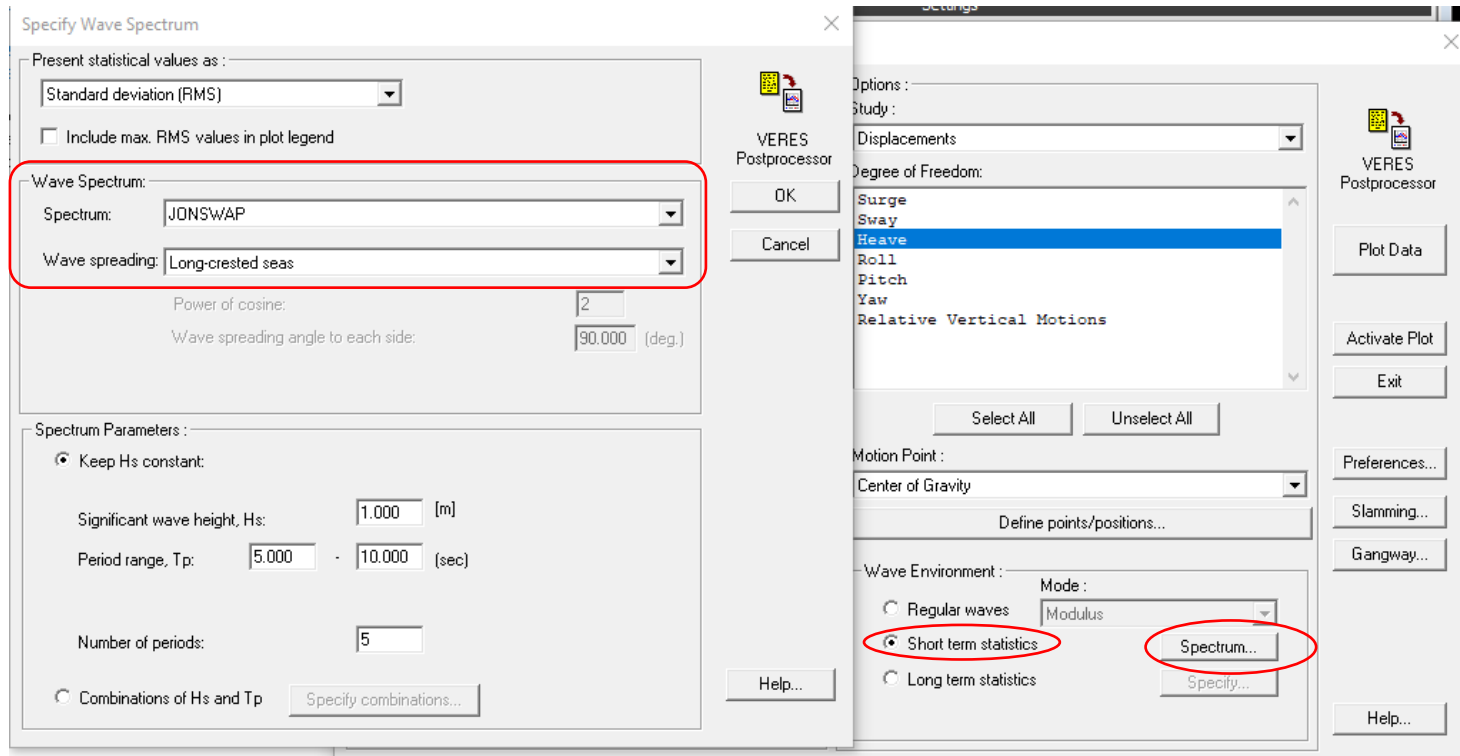
Data

x data

y data

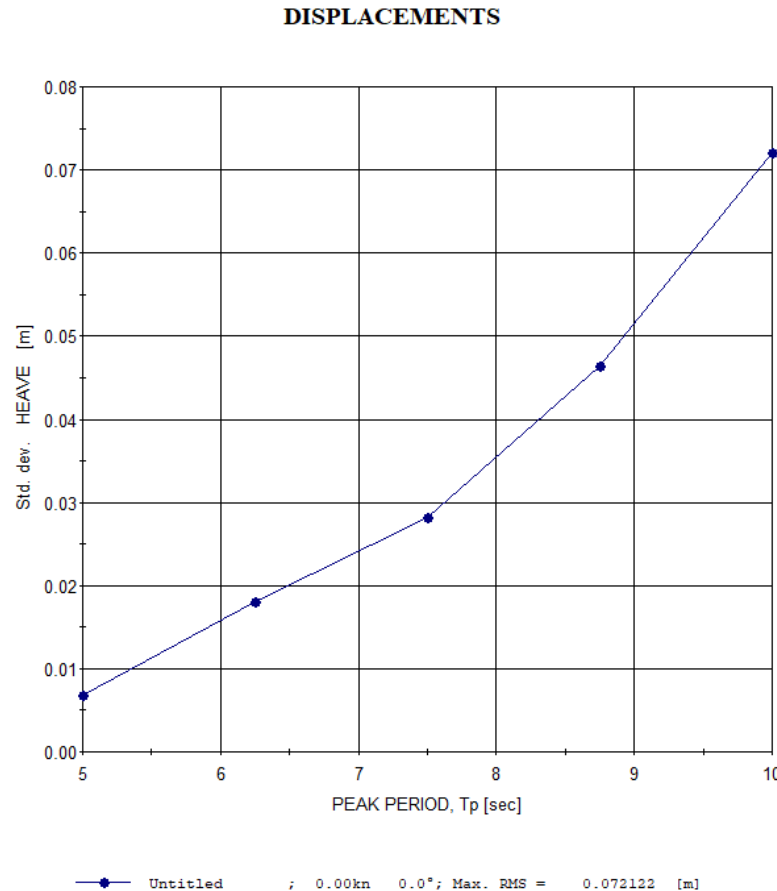
# Step 16: Short term statistics

- Set the radial button to Short term statistics and select Spectrum



- Define the spectrum as directed by the coursework. In this example, the long-crested version of the JONSWAP spectrum is used.
- You may set specific combinations of  $H_s$  and  $T_p$  if necessary.

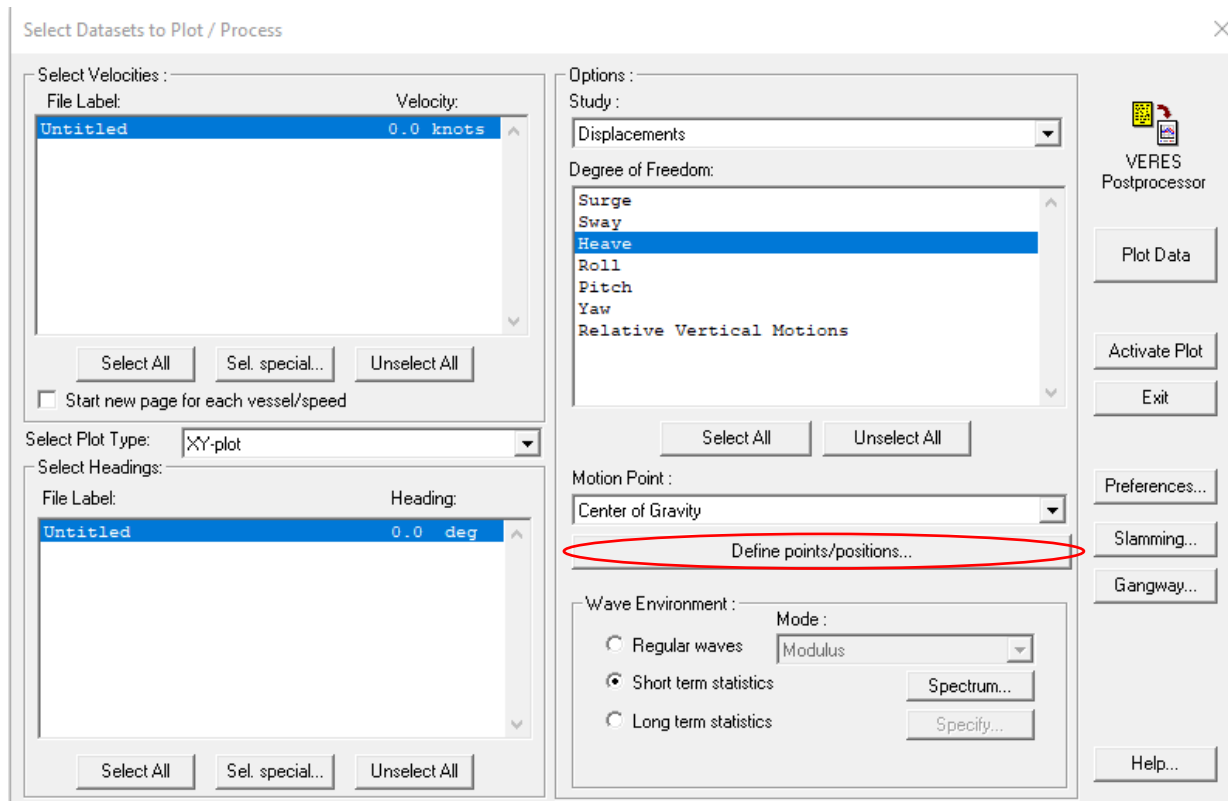
# Step 17: Short term statistics #2



- You may notice that standard deviation and RMS values are used interchangeably.
- This is the case because in linear frequency-domain calculations, the mean value of the response is zero, while the standard deviation is equivalent to the RMS value.

# Step 18: Define points for analysis

- As the ship experiences motions resulting from the seaway, different parts of the ship will be characterised by different motions.
- For example consider the motions experienced by a person located at the CoG versus the motions experienced by someone on the deck above the AP.
- Points are defined selecting Define points/positions.



# Step 19: Define points for analysis #2

- Points for analysis are defined in two steps. First, name the point as shown below. Then, switch the radial button to “All points for one file”, and define its [x, y, z] coordinates.

Specify Points/Positions

View:

☒ All point labels **1**

☐ All points for one file

☐ One point for all files

Edit point properties:

Description text (for all files):  (max. 15 characters) **2**

OK Cancel

**3** Add Modify Remove Copy from...

Point properties:

File/point:

Number of points : 0

VERES Postprocessor

Report... Slamming Report... Relative Motion Report... Help...

Specify Points/Positions

View:

☒ All point labels **4**

☒ All points for one file **5**

☐ One point for all files

File label:

Edit point properties:

Position on the hull :

X :  (m) fwd of AP

Y :  (m) off center (pos. starboard)

Z :  (m) above Base Line

Slamming properties:

k-factor:

Threshold velocity, Vcrit:  (m/sec)

Threshold pressure, Pcrit:  (kPa)

☐ Relative motion calibration file:

Browse... View...

OK Cancel

**6** Add Modify Remove Copy from...

Point properties:

File/point:	X-position	Y-position	Z-position	k=	Vcrit=
FP	0.00	0.00	0.00	0.00	0.00

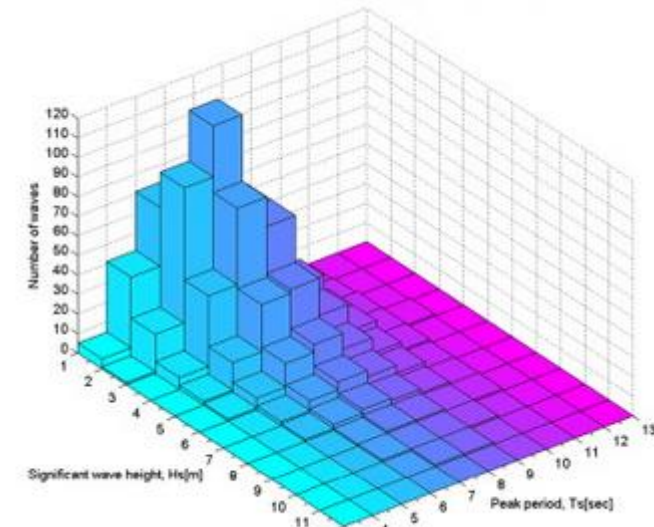
Number of points : 1

VERES Postprocessor

Report... Slamming Report... Relative Motion Report... Help...

# Step 20: Long term analysis

- ShipX enables the user to specify the waves observed at a particular area as input for the long term analysis. First, change the radial button to “Long term statistics” and set the required motion point as shown below.
- You must then specify the specific waves observed at the location where the ship will be located (this is known as a wave scatter diagram). The wave scatter data is coupled with the spectrum used to define the waves. To find the example wave scatter data, navigate to **C:\Program Files (x86)\ShipX\Plugin\Veres\Examples** and open “a11an.sea”.
- A typical wave scatter diagram is shown above.



Motion Point :

Define points/positions...

Wave Environment :  
 Mode :  
☐ Regular waves   
☐ Short term statistics  
☒ Long term statistics

Long Term Statistics

Scatter Data File:  
 c:\program files (x86)\shipx\plugins\veres\examples\allan.sea

Scatter Data Info:  
 Title: North sea, area 11. Annual.  
 Number of Hs: 10 Range: 0.5 - 9.5 [m]  
 Number of Ts: 8 Range: 3.5 - 10.5 [s]

Select spectrum type

Wave Spectrum:  
 Spectrum:   
 Gamma value:

Wave spreading:   
 Power of cosine:   
 Wave spreading angle to each side:  (deg.)

# Step 21: Long term analysis #2

- You are now ready to define the criteria against which the operability assessment is to be conducted. To do this, return to the vessel response post-processor and select Operability/Regularity.
- Here, define the criteria as shown.
- You can define multiple criteria as required at multiple locations.

Transfer functions/statistics Operability/Regularity

Specify criteria

Edit criterion:

Description text: 2 V.Acc@FP<0.15g

Type of criterion: 3 Translation/Angular motion

Position: 4 FP

Degree of freedom: Heave

Study: 6 Accelerations

Value: 5 1.377 [m/s<sup>2</sup>] 7

Statistical property: Standard deviation (RMS)

1 Define criteria...

8 Add Insert Modify Remove

List of criteria:

1 - V.Acc@FP<0.15g

Move First Move Up Move Down Move Last OK Cancel Report...

VERES Postprocessor

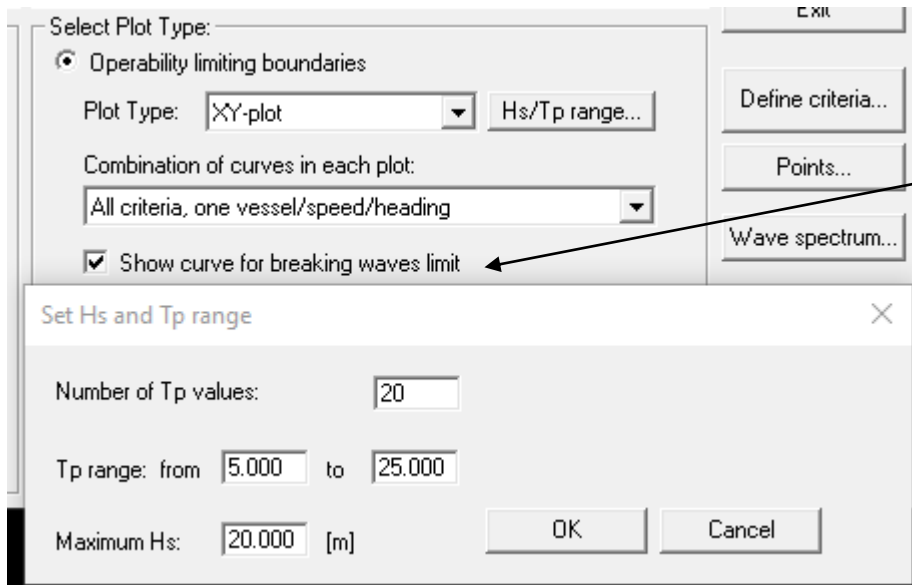
Plot Data Activate Plot Export XML Exit

Points... Wave spectrum... Heading prob... Preferences... Help...

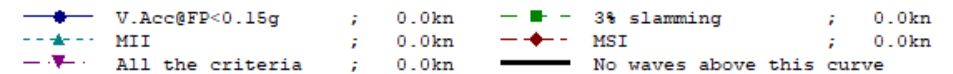
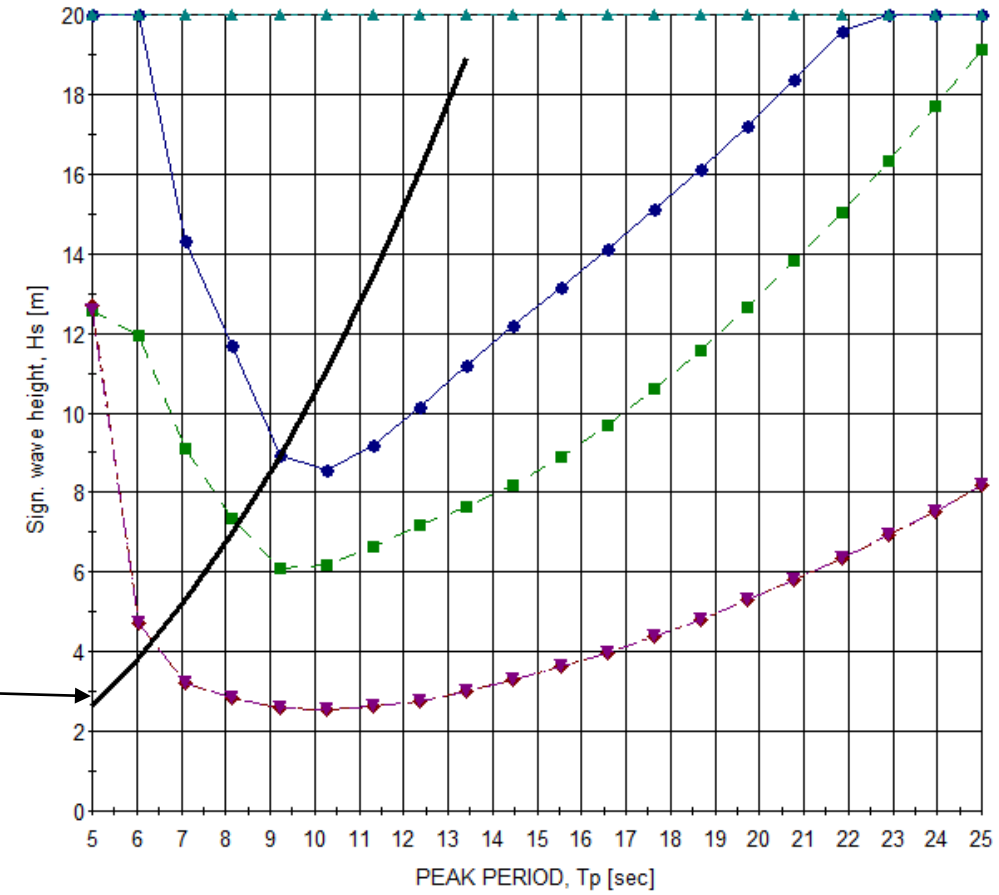


# Step 22: Long term analysis #3

- In some cases, you may be interested in information relating to the sea state and the ship's performance from a statistical point of view. This can be extracted by plotting the operability limiting boundaries. This can be achieved by setting the radial button to Operability limiting boundaries, specifying the Hs/Tp range suitably and plotting.



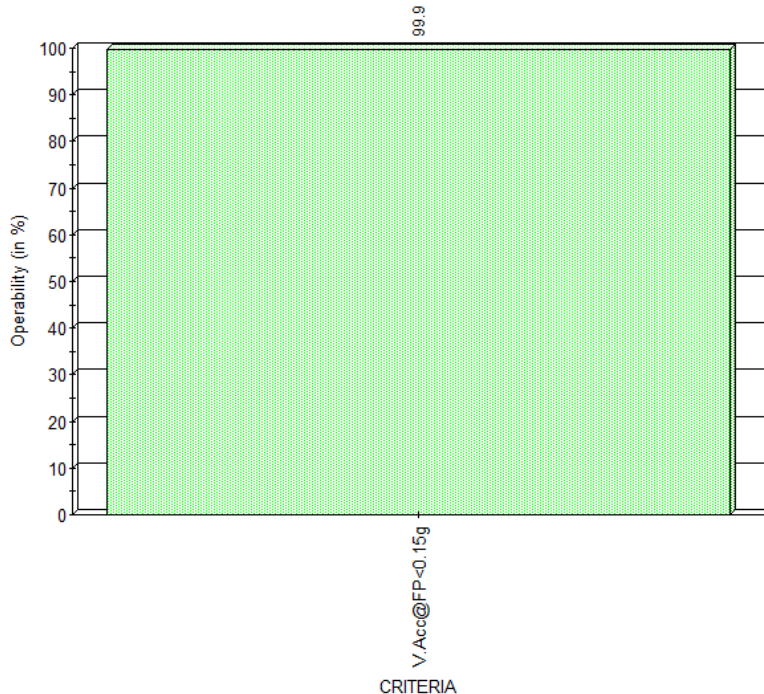
Waves cannot exist above this curve (because they break).





# Step 23: Long term analysis #4

- It is convenient to present operability data in terms of percentages. To do this, set the radial button to “Percentage operability”, highlight the criteria, speeds and headings.
- Plot your result.



Select Datasets to Plot / Process

Select Velocities :

File Label: Velocity:

Untitled 0.0 knots

Select All Sel. special... Unselect All

☐ Start new page for each vessel/speed

Select Headings :

Select headings independently

File Label: Heading:

Untitled 0.0 deg

Select All Sel. special... Unselect All

Select Criteria:

Criterion :

V.Acc@FP<0.15g

All criteria

Select All Unselect All

Select Plot Type:

☐ Operability limiting boundaries

Plot Type: XY-plot Hs/Tp range...

Combination of curves in each plot:

All criteria, one vessel/speed/heading

☒ Show curve for breaking waves limit

☐ Operability diagram (contours)

Hs = 1.000 [m] Tp = 5.000 [sec]

☒ Percentage operability Scatter diagram...

VERES Postprocessor

Plot Data

Activate Plot

Export XML

Exit

Define criteria...

Points...

Wave spectrum...

Heading prob...

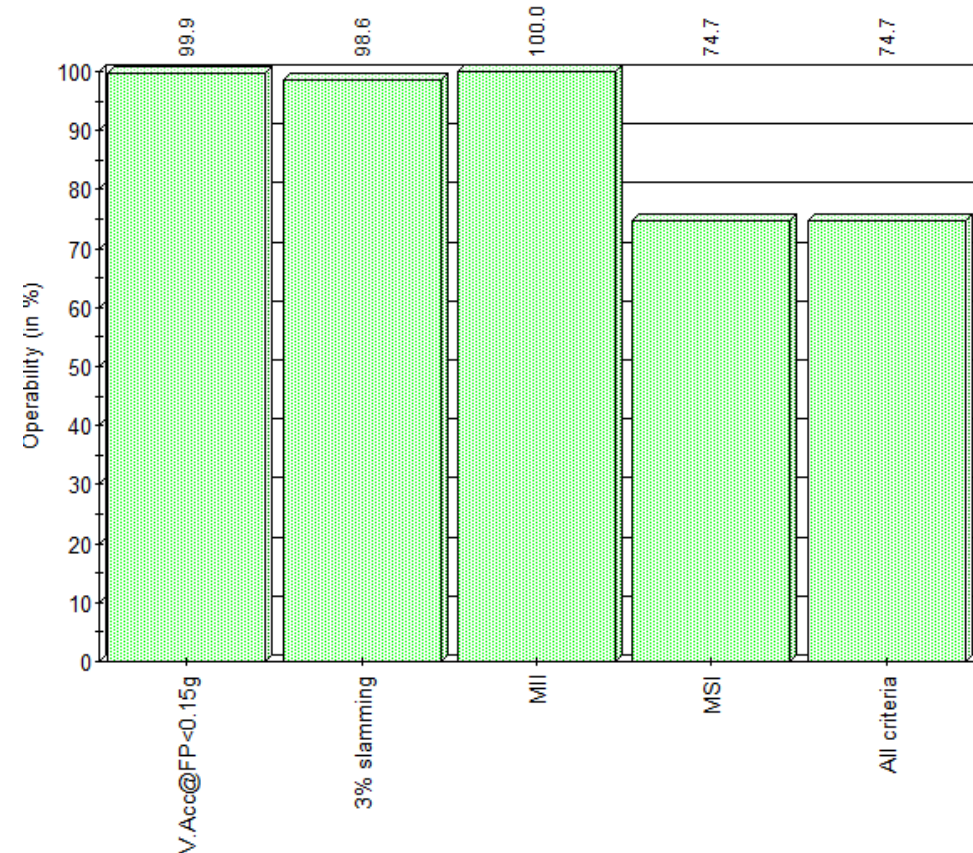
Preferences...

Help...

- Exporting the data used to create the operability diagram is done in the same way as was demonstrated previously: Preferences > To plot file .mpl

# Step 24: Long term analysis #5

- Add more criteria, depending on the specific requirements of your ship.
- Each condition will produce its own percentage operability.
- The total operability corresponds to the lowest operability across all criteria.
- For example, consider the following as applied to the FP:
  - Vertical accelerations  $<0.15g$ .
  - Maximum 3% slamming probability.
  - Motion induced interruptions  $<2$  per min.
  - Motion induced sickness  $<3\%$  per 2 hours.
- Criteria vary depending on ship type, function, etc.



# Wave scatter data

May differ on your PC

- Open the wave scatter diagram, given as an example by ShipX.
- You can find this by navigating to: C:\Program Files (x86)\ShipX\PlugIns\Veres\Examples
- It is advisable you make a copy of the original file, “allan.sea”, to work on. *Note: you may not be able to work in the same directory – make a copy in your H drive.*
- Open the file via the Notepad.
- Notice that **significant wave heights** are given as in a row above the **period data**

North sea, area 11. Annual.

	2	1	10	8					
0.5	19	86	94	41	10	2	0	0	
1.5	3	49	121	99	40	10	2	0	
2.5	1	17	63	73	40	13	3	1	
3.5	0	6	27	39	26	10	3	1	
4.5	0	2	11	19	14	6	2	1	
5.5	0	1	4	9	7	4	1	0	
6.5	0	0	2	4	4	2	1	0	
7.5	0	0	1	2	2	1	1	0	
8.5	0	0	0	1	1	1	0	0	
9.5	0	0	0	1	1	0	0	0	

END

A matrix showing the number of occurrences of each height/period combination given above.

8 columns → represent the periods

10 rows → represent the wave heights

# Wave scatter data: Definitions in ShipX

- The first row in your Notepad contains the description of the file – you can modify this as you wish. This displays if you select “View...”

| North sea, area 11. Annual.

Number of occurrences

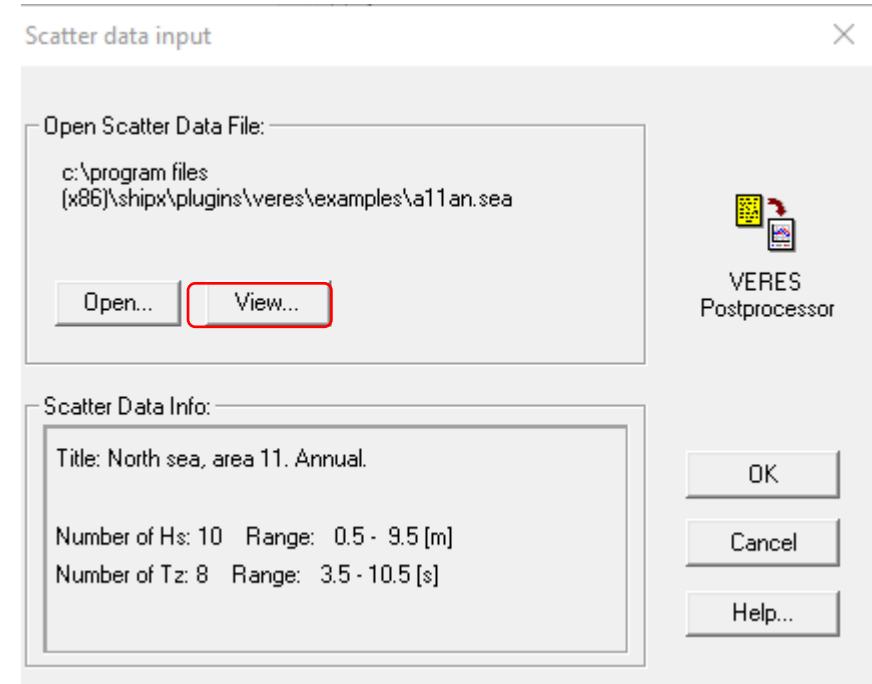
Total 23 161 323 288 145 49 13 3 1005

Hs

9.5				1	1				2
8.5				1	1	1			3
7.5			1	2	2	1	1		7
6.5			2	4	4	2	1		13
5.5		1	4	9	7	4	1		26
4.5		2	11	19	14	6	2	1	55
3.5		6	27	39	26	10	3	1	112
2.5	1	17	63	73	40	13	3	1	211
1.5	3	49	121	99	40	10	2		324
0.5	19	86	94	41	10	2			252

Tz 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 Total

Hs and Tz values are the middle values in each interval



- You will notice that the wave scatter diagram is not in given in peak wave periods, rather, in zero crossing periods.

# Wave scatter data: Definitions in ShipX #2

- The type of period is controlled by changing the first number on the second row.
- By default, this is set to (2), which the software interprets as zero crossing period.
- To tell the software that we are working in peak periods, modify this to (1).
- Save your copy of the wave scatter and view it in ShipX (see previous step) to confirm the change.

North sea, near Aberdeen.

→ 1

0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5
3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5		
19	86	94	41	10	2	0	0		
3	49	121	99	40	10	2	0		
1	17	63	73	40	13	3	1		
0	6	27	39	26	10	3	1		
0	2	11	19	14	6	2	1		
0	1	4	9	7	4	1	0		
0	0	2	4	4	2	1	0		
0	0	1	2	2	1	1	0		
0	0	0	1	1	1	0	0		
0	0	0	1	1	0	0	0		

END

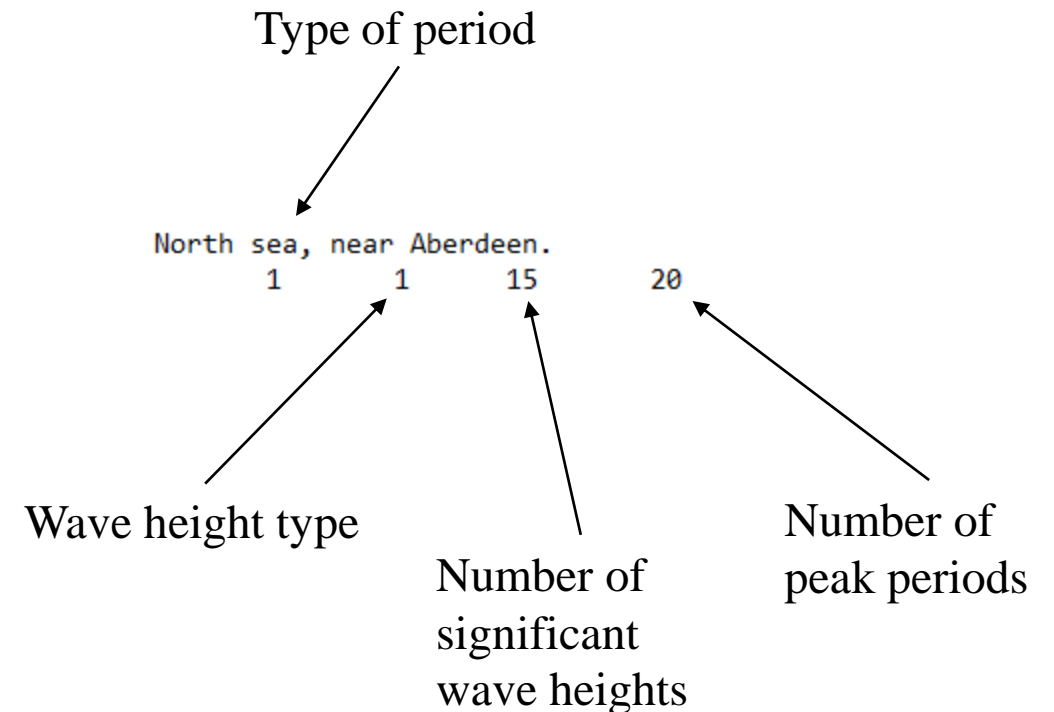
North sea, near Aberdeen.

Number of occurrences

Total	23	161	323	288	145	49	13	3	1005
Hs									
9.5				1	1				2
8.5				1	1	1			3
7.5			1	2	2	1	1		7
6.5			2	4	4	2	1		13
5.5		1	4	9	7	4	1		26
4.5		2	11	19	14	6	2	1	55
3.5		6	27	39	26	10	3	1	112
2.5	1	17	63	73	40	13	3	1	211
1.5	3	49	121	99	40	10	2		324
0.5	19	86	94	41	10	2			252
→ Tp	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	Total

# Wave scatter data: Definitions in ShipX #3

- Next, we must ensure that the software reads the significant wave heights.
- This is controlled by the second number on the second row.
- By default, this is (1), which tells the software to interpret the wave heights as the middle value of the highest one third of the waves.
- Thus, no change is necessary.
- The next two entries indicate the number of significant wave heights, and peak periods. You must modify these based on your data.
- The case used here contains 15 peak periods and 20 significant wave heights.





### A.2.2 Wave scatter diagram files (\*.sea)

This section describes the file format of the scatter diagram input file, which enables the user to specify any chosen wave scatter diagram for use in the long term statistics of the VERES Postprocessor.

The file format is:

```
DESCRTEXT
IFORM      HSTXTYPE      NUMHS      NUMTX
HS(IHs), IHs = 1, NUMHS
TX(ITx), ITx = 1 NUMTX
do IHs = 1, NUMHS
    (PROB(IHs,ITx), ITx = 1, NUMTX)
enddo
```

The definitions of the variables are given in Table 9.

Variable	Description	Type	Unit
DESCRTEXT	Text describing the scatter diagram	Char	–
IFORM	Identifies type of wave period 1 – $T_p$ 2 – $T_z$ 3 – $T_1$	I	–
HSTXTYPE	Identifies if the $H_s$ and $T_x$ –values are given as: 1 – the middle value of the range 2 – the highest value of the range 3 – the lowest value of the range	I	–
NUMHS	Number of significant wave heights	I	–
NUMTX	Number of wave periods	I	–
HS	Significant wave height	R(I)	m
TX	Wave period	R(I)	s
NPROB	Number of occurrence of a sea state	R(I,I)	–

Table 9: Definition of variables

An example of a wave scatter diagram input file is given below:

North sea, area 11 in Global Wave Statistics. Annual.

2 1 10 7

0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5

3.5 4.5 5.5 6.5 7.5 8.5 10

19 86 94 41 10 2 0

3 49 121 99 40 10 2

1 17 63 73 40 13 4

0 6 27 39 26 10 4

0 2 11 19 14 6 3

0 1 4 9 7 4 1

0 0 2 4 4 2 1

0 0 1 2 2 1 1

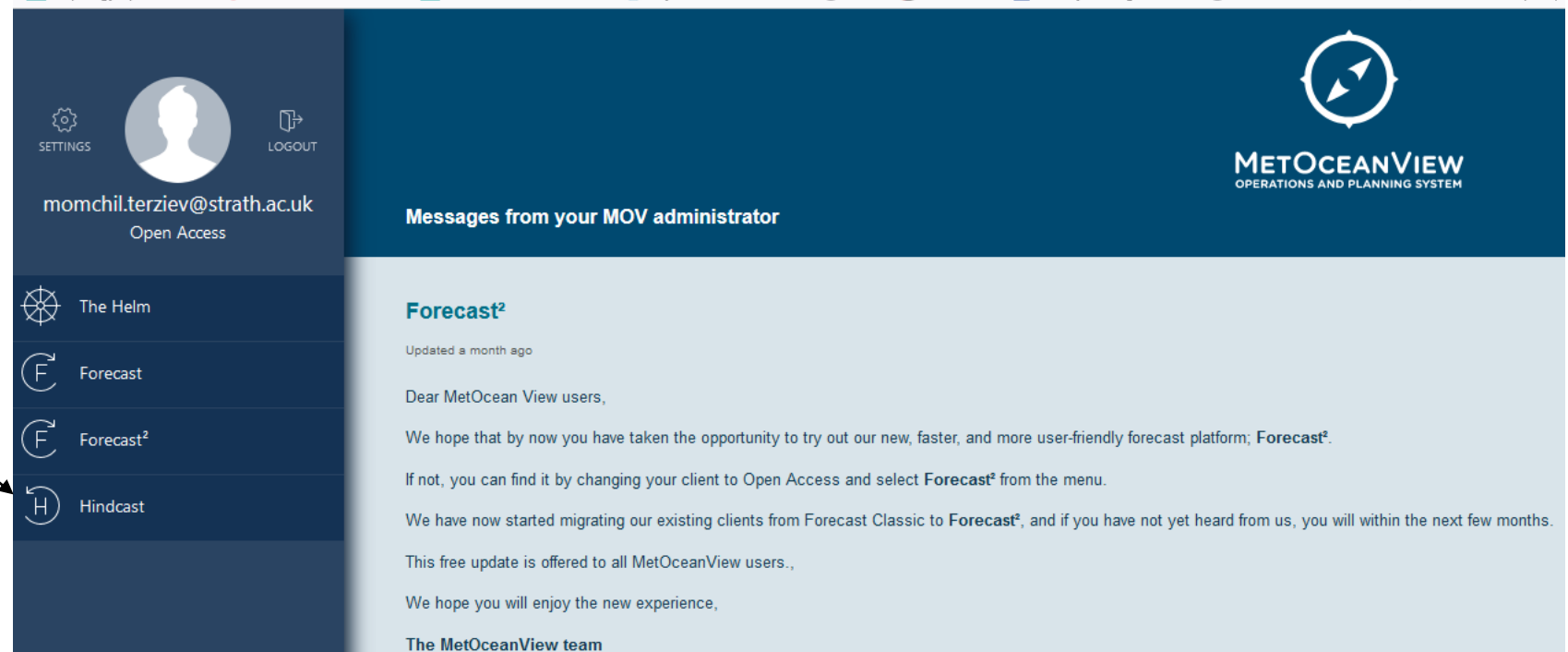
0 0 0 1 1 1 0

0 0 0 1 1 0 0



# Wave scatter data

- Navigate to the following website:  
<https://app.metoceanview.com/helm/#/>
- Create an account or log in.
- Click on Hindcast.
- For this tutorial, assume we are asked to look at the North Sea.



# Wave scatter data

**Hindcast<sup>2</sup>**  
MetoceanView

RAW DATA  
Select your location of interest

STATISTICAL GRAPHS  
Select a point for stats

MODEL <sup>?</sup> STACK <sup>?</sup>

<input checked="" type="checkbox"/> roms	<input checked="" type="checkbox"/> cfsr
<input checked="" type="checkbox"/> swan	<input checked="" type="checkbox"/> era5
<input checked="" type="checkbox"/> ww3	<input checked="" type="checkbox"/> other
<input checked="" type="checkbox"/> other	

SELECTED DATASET

Let's find the right dataset for your selected point: (lon, lat) 55.76645 -6.80035

Select a dataset:

☒ MSL WW3 Global ST4

☐ CFSR

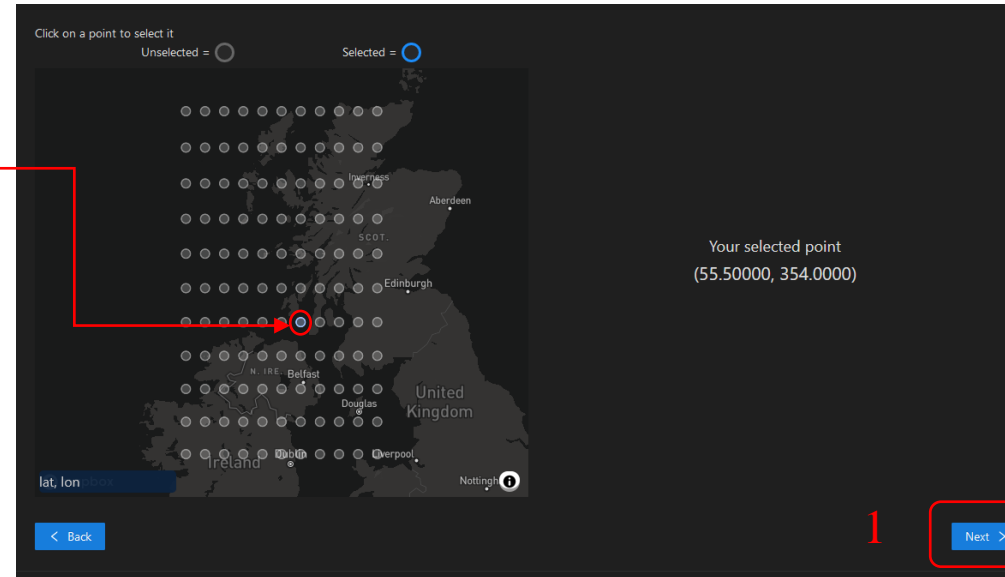
☐ CFSR2

Next >

- Go to your area of interest
- Click on “Select a point for stats”
- Click on the location of interest
- Set the dataset to MSL WW3 Global ST4
- Click next
- **Do not click on any of the boxes or lines in the map**

# Wave scatter data

- Select the point you are interested in.
- Click Next.
- On the following screen, select Data Matrices.
- Navigate to Significant wave height vs Peak period and download the data as a CSV (Comma Separated Value) file.



- 4 Save the file and open it with MS Excel

1

Next >

	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13
0 - 0.5	0%	0%	0.6%	1.3%	0.3%	0.2%	0.6%	1.5%	3.6%	4.4%	3.2%	2%	1.2%
0.5 - 1	0%	0%	0.3%	5.4%	5.4%	0.4%	0.2%	0.5%	1.8%	4.4%	5.2%	4.5%	3.4%
1 - 1.5	0%	0%	0%	<0.1%	5.7%	4.2%	0.3%	<0.1%	0.2%	0.8%	1.6%	2.1%	2.3%
1.5 - 2	0%	0%	0%	0%	0.3%	6.1%	1.8%	<0.1%	<0.1%	<0.1%	0.3%	0.6%	0.5%
2 - 2.5	0%	0%	0%	0%	<0.1%	0.9%	3.8%	0.3%	<0.1%	<0.1%	<0.1%	<0.1%	0.1%
2.5 - 3	0%	0%	0%	0%	0%	<0.1%	1.3%	1.4%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
3 - 3.5	0%	0%	0%	0%	0%	0%	0.1%	0.9%	0.3%	<0.1%	0%	0%	0%
3.5 - 4	0%	0%	0%	0%	0%	0%	<0.1%	0.2%	0.5%	<0.1%	0%	0%	0%
4 - 4.5	0%	0%	0%	0%	0%	0%	0%	<0.1%	0.3%	<0.1%	0%	0%	0%
4.5 - 5	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0.1%	0%	0%	0%
5 - 5.5	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%
5.5 - 6	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	<0.1%	0%	0%
6 - 6.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%
6.5 - 7	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%
7 - 7.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	0%	0%	0%

3

Download CSV

# Wave scatter data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	significant	0 - 1	01-Feb	02-Mar	03-Apr	04-May	05-Jun	06-Jul	07-Aug	08-Sep	09-Oct	10-Nov	11-Dec	Dec-13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18
2	0 - 0.5	0%	0%	0.60%	1.30%	0.30%	0.20%	0.60%	1.50%	3.60%	4.40%	3.20%	2%	1.20%	0.50%	0.20%	0.10%	<0.1%	<0.1%
3	0.5 - 1	0%	0%	0.30%	5.40%	5.40%	0.40%	0.20%	0.50%	1.80%	4.40%	5.20%	4.50%	3.40%	2%	0.80%	0.30%	0.20%	<0.1%
4	1 - 1.5	0%	0%	0%	<0.1%	5.70%	4.20%	0.30%	<0.1%	0.20%	0.80%	1.60%	2.10%	2.30%	1.90%	0.90%	0.40%	0.30%	0.10%
5	1.5 - 2	0%	0%	0%	0%	0.30%	6.10%	1.80%	<0.1%	<0.1%	<0.1%	0.30%	0.60%	0.90%	0.90%	0.60%	0.20%	0.20%	<0.1%
6	2 - 2.5	0%	0%	0%	0%	<0.1%	0.90%	3.80%	0.30%	<0.1%	<0.1%	<0.1%	<0.1%	0.20%	0.30%	0.20%	<0.1%	0.10%	<0.1%
7	2.5 - 3	0%	0%	0%	0%	0%	<0.1%	1.30%	1.40%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
8	3 - 3.5	0%	0%	0%	0%	0%	0%	0.10%	0.90%	0.30%	<0.1%	0%	0%	0%	0%	<0.1%	0%	<0.1%	<0.1%
9	3.5 - 4	0%	0%	0%	0%	0%	0%	<0.1%	0.20%	0.50%	<0.1%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%
10	4 - 4.5	0%	0%	0%	0%	0%	0%	0%	<0.1%	0.30%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%
11	4.5 - 5	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0.10%	0%	0%	0%	0%	0%	0%	0%	0%
12	5 - 5.5	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%
13	5.5 - 6	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%
14	6 - 6.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%
15	6.5 - 7	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%
16	7 - 7.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%

- Excel interprets part of the data as dates – go to the webpage and replace the ranges with the relevant data.
- Average the interval. →
- Repeat for peak period values.

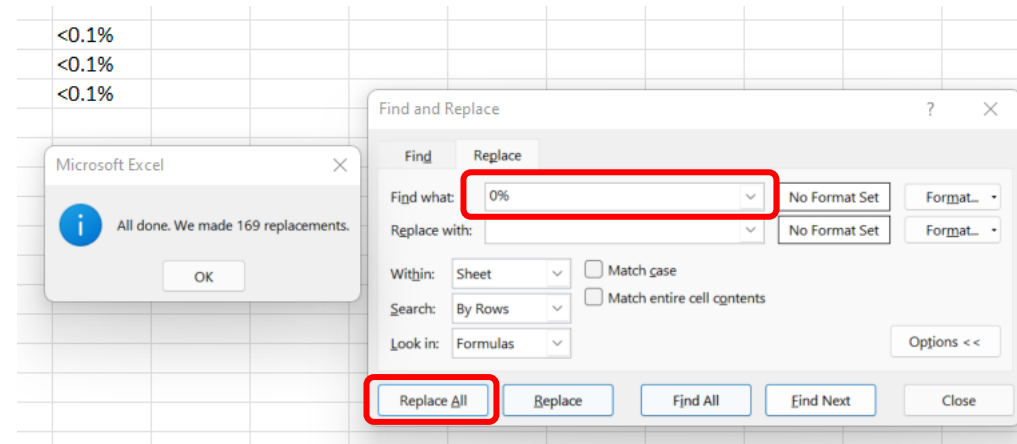
significant height	significant height
0 - 0.5	0.25
0.5 - 1	0.75
1 - 1.5	1.25
1.5 - 2	1.75
2 - 2.5	2.25
2.5 - 3	2.75
3 - 3.5	3.25
3.5 - 4	3.75
4 - 4.5	4.25
4.5 - 5	4.75
5 - 5.5	5.25

0 - 1	01-Feb	02-Mar	03-Apr	04-May	05-Jun
0.5	1.50	2.50	3.5	4.50	5.50

# Wave scatter data

significant height	0.5	1.50	2.50	3.5	4.50	5.50	6.5	7.50	8.50	9.5	10.50	11.50	12.5	13.50	14.50	15.5	16.50	17.50	18.5	19.50
0.25	0%	0%	0.60%	1.30%	0.30%	0.20%	0.60%	1.50%	3.60%	4.40%	3.20%	2%	1.20%	0.50%	0.20%	0.10%	<0.1%	<0.1%	<0.1%	<0.1%
0.75	0%	0%	0.30%	5.40%	5.40%	0.40%	0.20%	0.50%	1.80%	4.40%	5.20%	4.50%	3.40%	2%	0.80%	0.30%	0.20%	<0.1%	<0.1%	<0.1%
1.25	0%	0%	0%	<0.1%	5.70%	4.20%	0.30%	<0.1%	0.20%	0.80%	1.60%	2.10%	2.30%	1.90%	0.90%	0.40%	0.30%	0.10%	<0.1%	<0.1%
1.75	0%	0%	0%	0%	0.30%	6.10%	1.80%	<0.1%	<0.1%	<0.1%	0.30%	0.60%	0.90%	0.90%	0.60%	0.20%	0.20%	<0.1%	<0.1%	<0.1%
2.25	0%	0%	0%	0%	<0.1%	0.90%	3.80%	0.30%	<0.1%	<0.1%	<0.1%	<0.1%	0.20%	0.30%	0.20%	<0.1%	0.10%	<0.1%	<0.1%	<0.1%
2.75	0%	0%	0%	0%	0%	<0.1%	1.30%	1.40%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
3.25	0%	0%	0%	0%	0%	0%	0.10%	0.90%	0.30%	<0.1%	0%	0%	0%	0%	<0.1%	0%	<0.1%	<0.1%	<0.1%	0%
3.75	0%	0%	0%	0%	0%	0%	<0.1%	0.20%	0.50%	<0.1%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	<0.1%	0%
4.25	0%	0%	0%	0%	0%	0%	0%	<0.1%	0.30%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%
4.75	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0.10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5.25	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5.75	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6.25	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6.75	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7.25	0%	0%	0%	0%	0%	0%	0%	0%	0%	<0.1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

- Now we must remove the <0.1% and 0% data.
- Use Ctrl+H to 'find and replace' as shown, or search for 'replace' using the search bar at the top of your screen. Repeat for <0.1%.
- Removing the <0.1% values means we lost 1.9% of the waves – this is acceptable.



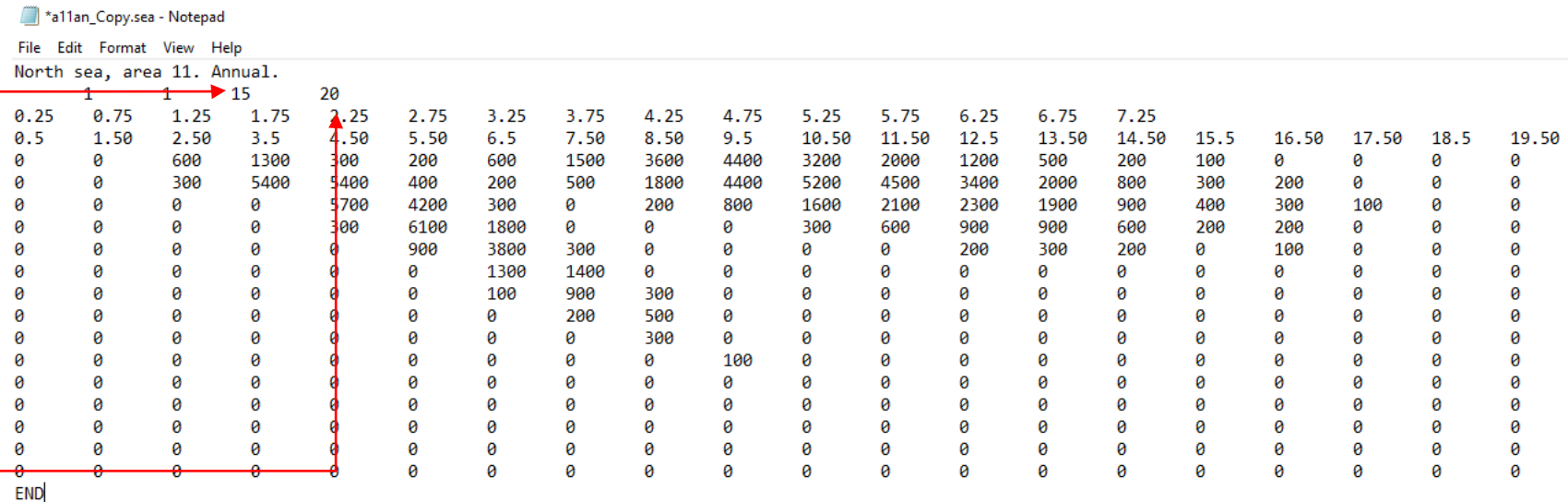
# Wave scatter data

- Copy the height and period data as shown.
- Populate wave occurrences by multiplying the % by some large number. In this example, I used **100000**.
- The number 100000 represents how many waves have occurred.
- As long as the ratio is preserved and all occurrences are **integer numbers**, the actual value (100000) does not matter

Undo		Clipboard		Font		Alignment		Number		Styles		Cells		Editing								
SUM		fx		=B2*100000																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	significant height	0.5	1.50	2.50	3.5	4.50	5.50	6.5	7.50	8.50	9.5	10.50	11.50	12.5	13.50	14.50	15.5	16.50	17.50	18.5	19.50	
2	0.25			0.60%	1.30%	0.30%	0.20%	0.60%	1.50%	3.60%	4.40%	3.20%	2%	1.20%	0.50%	0.20%	0.10%					
3	0.75			0.30%	5.40%	5.40%	0.40%	0.20%	0.50%	1.80%	4.40%	5.20%	4.50%	3.40%	2%	0.80%	0.30%	0.20%				
4	1.25					5.70%	4.20%	0.30%		0.20%	0.80%	1.60%	2.10%	2.30%	1.90%	0.90%	0.40%	0.30%	0.10%			
5	1.75					0.30%	6.10%	1.80%				0.30%	0.60%	0.90%	0.90%	0.60%	0.20%	0.20%				
6	2.25						0.90%	3.80%	0.30%					0.20%	0.30%	0.20%		0.10%				
7	2.75							1.30%	1.40%													
8	3.25							0.10%	0.90%	0.30%												
9	3.75								0.20%	0.50%												
10	4.25									0.30%												
11	4.75										0.10%											
12	5.25																					
13	5.75																					
14	6.25																					
15	6.75																					
16	7.25																					
17																						
18																						
19																						
20																						
21	Wave height	0.5	1.50	2.50	3.5	4.50	5.50	6.5	7.50	8.50	9.5	10.50	11.50	12.5	13.50	14.50	15.5	16.50	17.50	18.5	19.50	
22	0.25	100000	0	600	1300	300	200	600	1500	3600	4400	3200	2000	1200	500	200	100	0	0	0	0	
23	0.75	0	0	300	5400	5400	400	200	500	1800	4400	5200	4500	3400	2000	800	300	200	0	0	0	
24	1.25	0	0	0	0	5700	4200	300	0	200	800	1600	2100	2300	1900	900	400	300	100	0	0	
25	1.75	0	0	0	0	300	6100	1800	0	0	0	300	600	900	900	600	200	200	0	0	0	
26	2.25	0	0	0	0	0	900	3800	300	0	0	0	0	200	300	200	0	100	0	0	0	
27	2.75	0	0	0	0	0	0	1300	1400	0	0	0	0	0	0	0	0	0	0	0	0	
28	3.25	0	0	0	0	0	0	100	900	300	0	0	0	0	0	0	0	0	0	0	0	
29	3.75	0	0	0	0	0	0	0	200	500	0	0	0	0	0	0	0	0	0	0	0	
30	4.25	0	0	0	0	0	0	0	0	300	0	0	0	0	0	0	0	0	0	0	0	
31	4.75	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	
32	5.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
33	5.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
34	6.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
35	6.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
36	7.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
37																						



- [illegible]



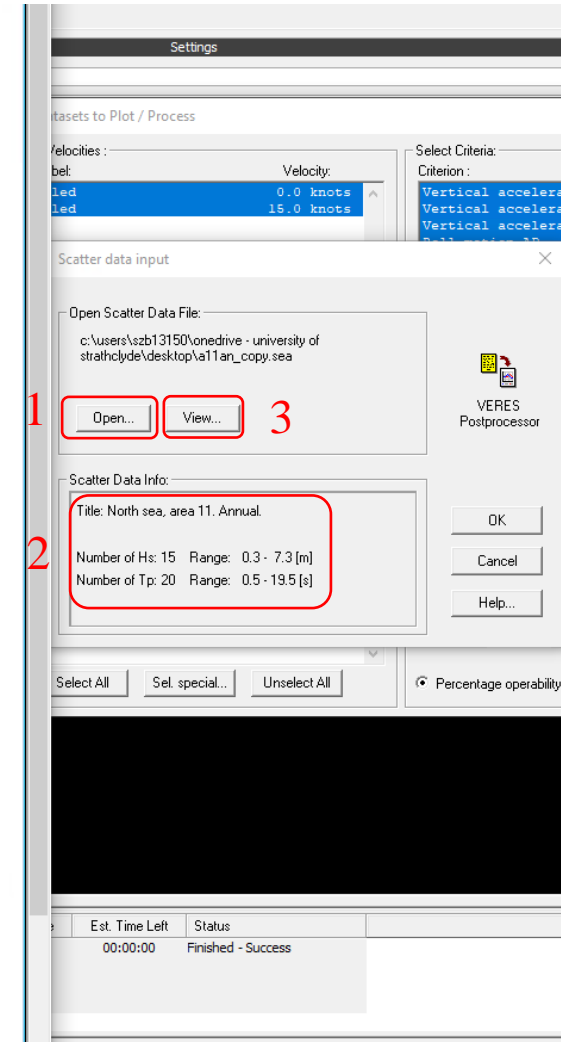
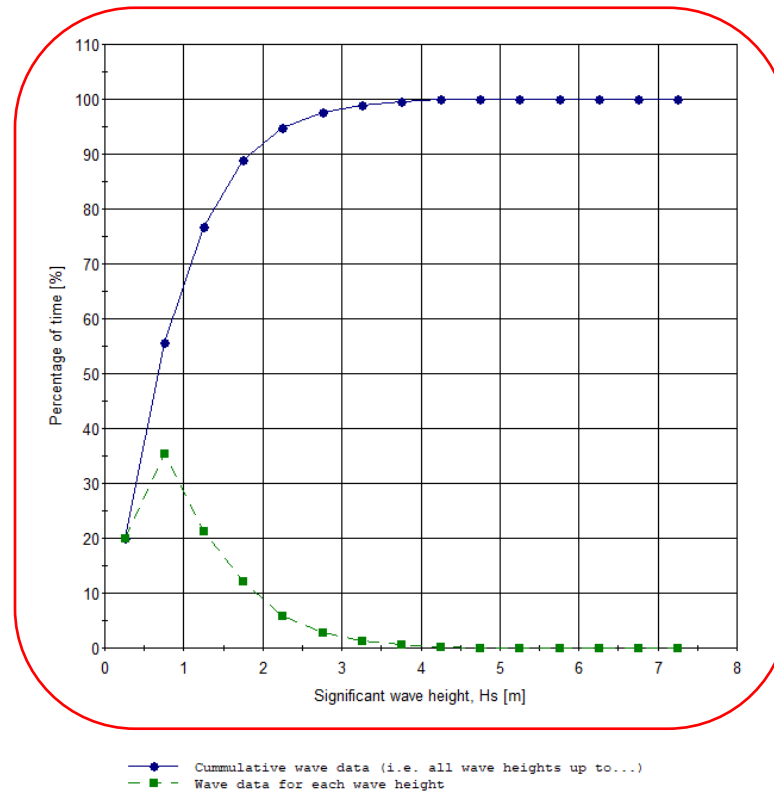
# Wave scatter data: Process data

- Check your data has been interpreted correctly in ShipX.
- Note that ShipX has rounded up values 0.25m→0.3m.
- Open the wave scatter diagram.
- Check the range of  $H_s/T_p$
- Click View
- Check the interpretation.

<b>ShipX</b>	ENCL.	A.868
	REPORT	
	DATE	17/01/2022
	REF.	

## SCATTER DIAGRAM DATA

Project: Tutorial 4





# Tutorial end

- Adapt the techniques above to the specific problem you are tasked with.
  - Change the ship hull and its particulars.
  - Set the required headings, wave periods, and ship speeds.
  - Specify the spectrum as instructed.
  - Create and use the required wave scatter diagram as directed.
  - Define the criteria as required for your ship, and apply them to the points of interest.
  - Export the necessary information.
- If you have problems/questions:
  - Email me: [momchil.terziev@strath.ac.uk](mailto:momchil.terziev@strath.ac.uk)
  - Check the user manual:
    - Help>Documentation>VERES Manual – for general help with the software.
    - Help>Documentation>VERES Theory Manual – a more in-depth explanation of the theory.
- Visit <https://momchil-terziev.github.io/tutorials> if you are using ShipX for your own work.