NM835/NM529

Ship Operability and Control

Coursework tutorial

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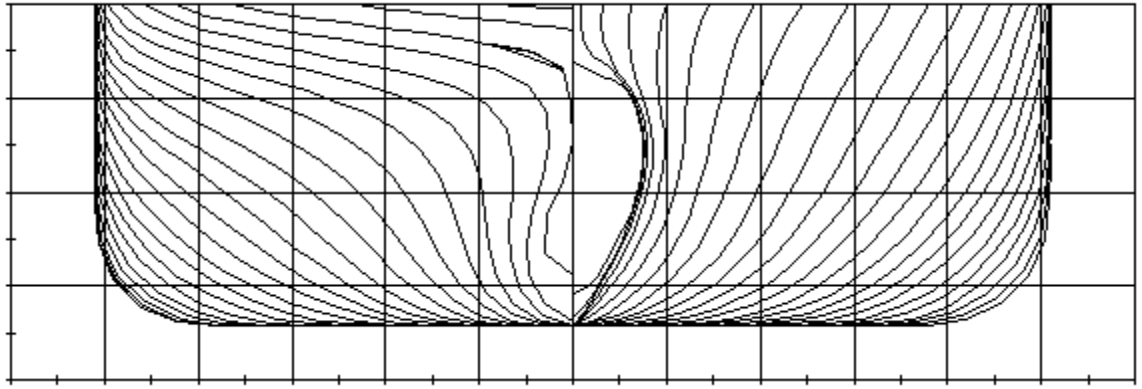
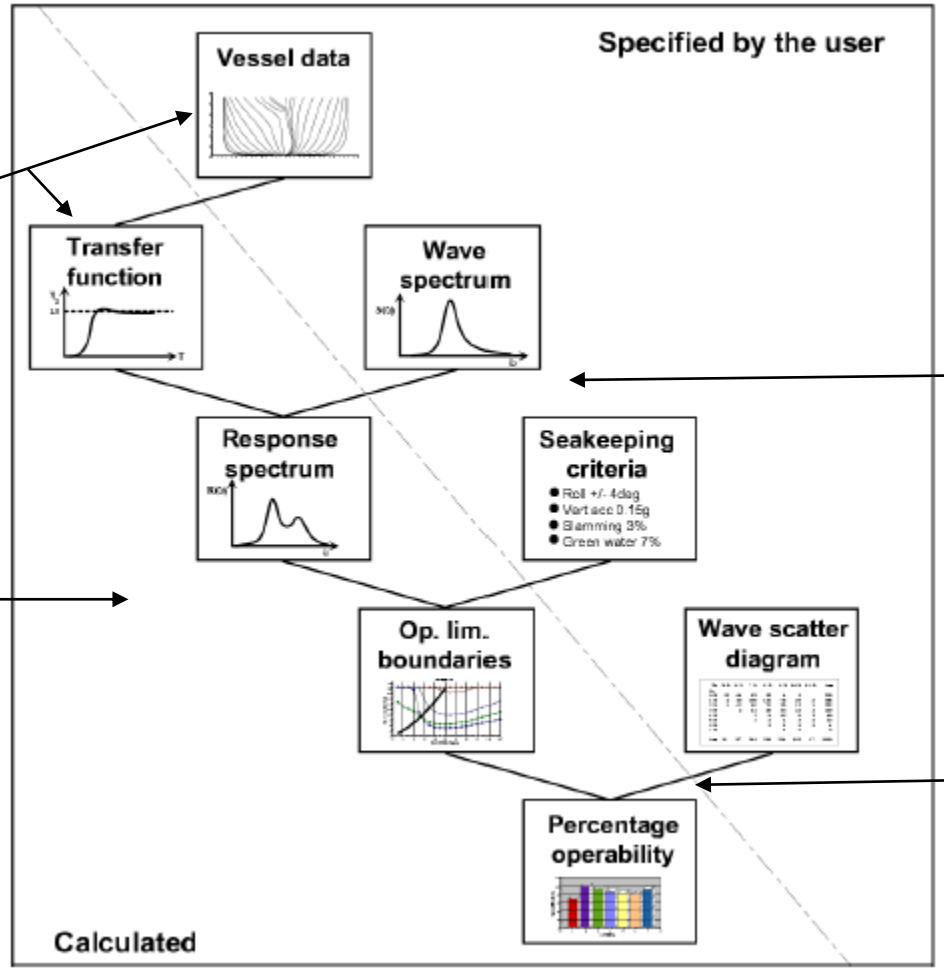


Introduction to operability

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



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

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

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

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

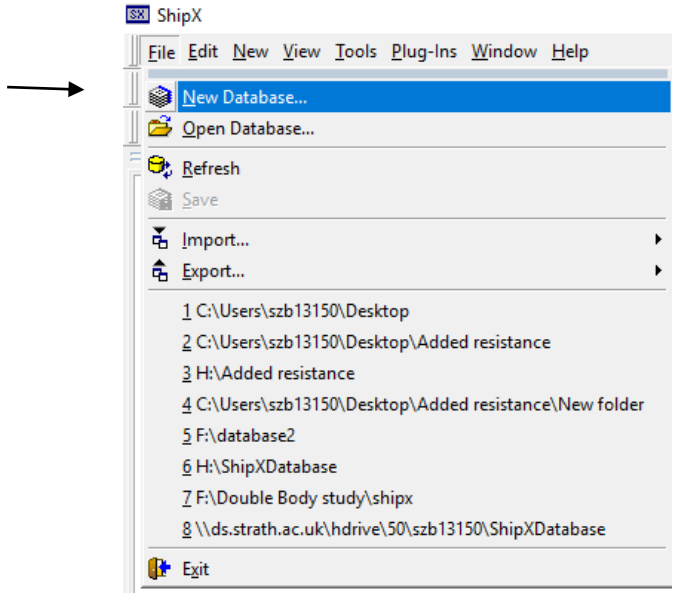
Response spectrum

Sea spectrum

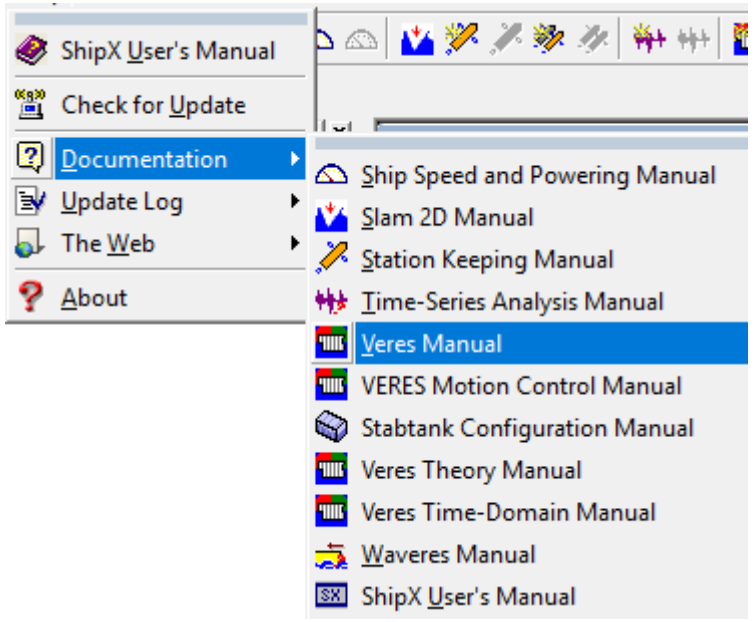
Taken from Fathi (2015) ShipX Vessel Responses (VERES)- User's Manual

Step 1: Preliminaries

- First, create a new database.

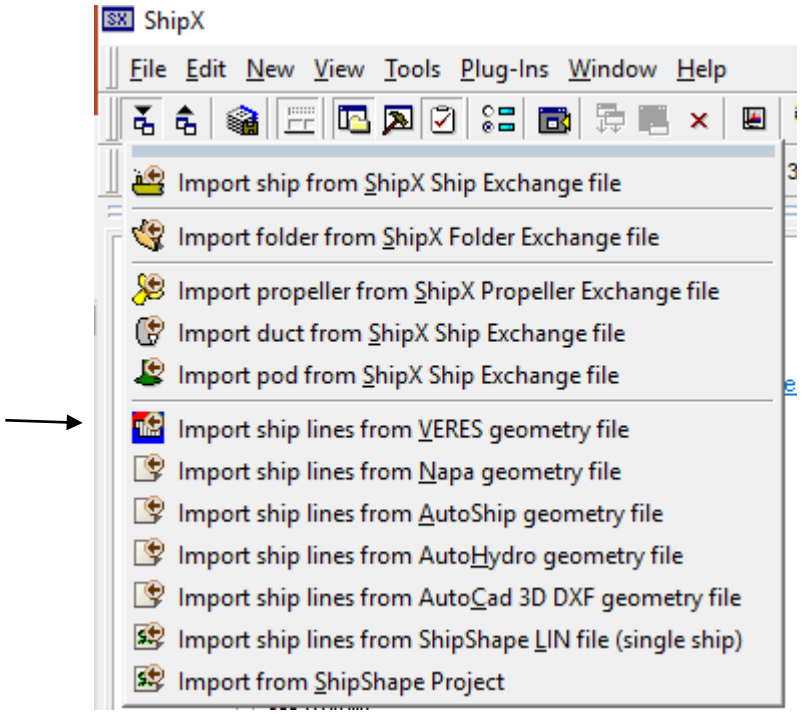


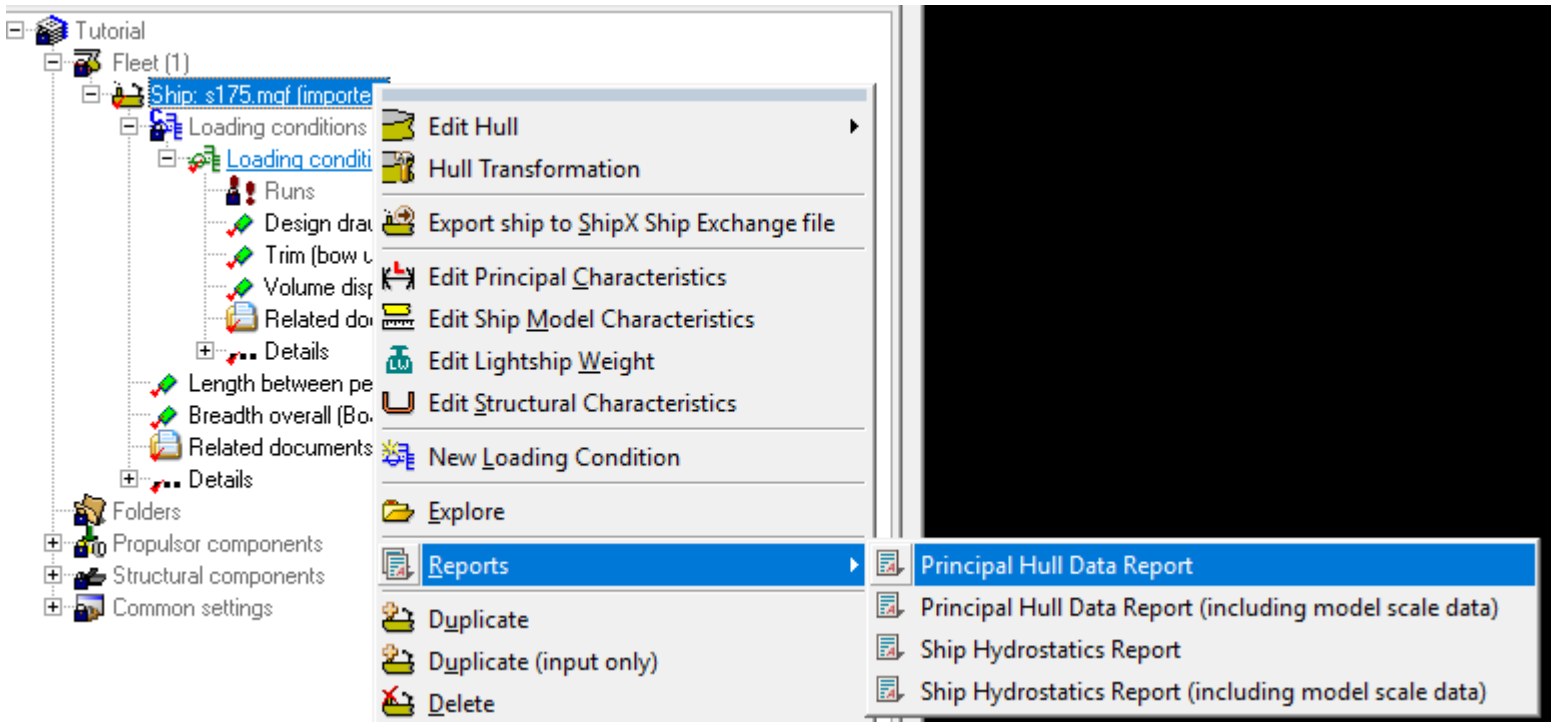
- Consulting the user manual is always a good idea!



Step 2: Ship geometry

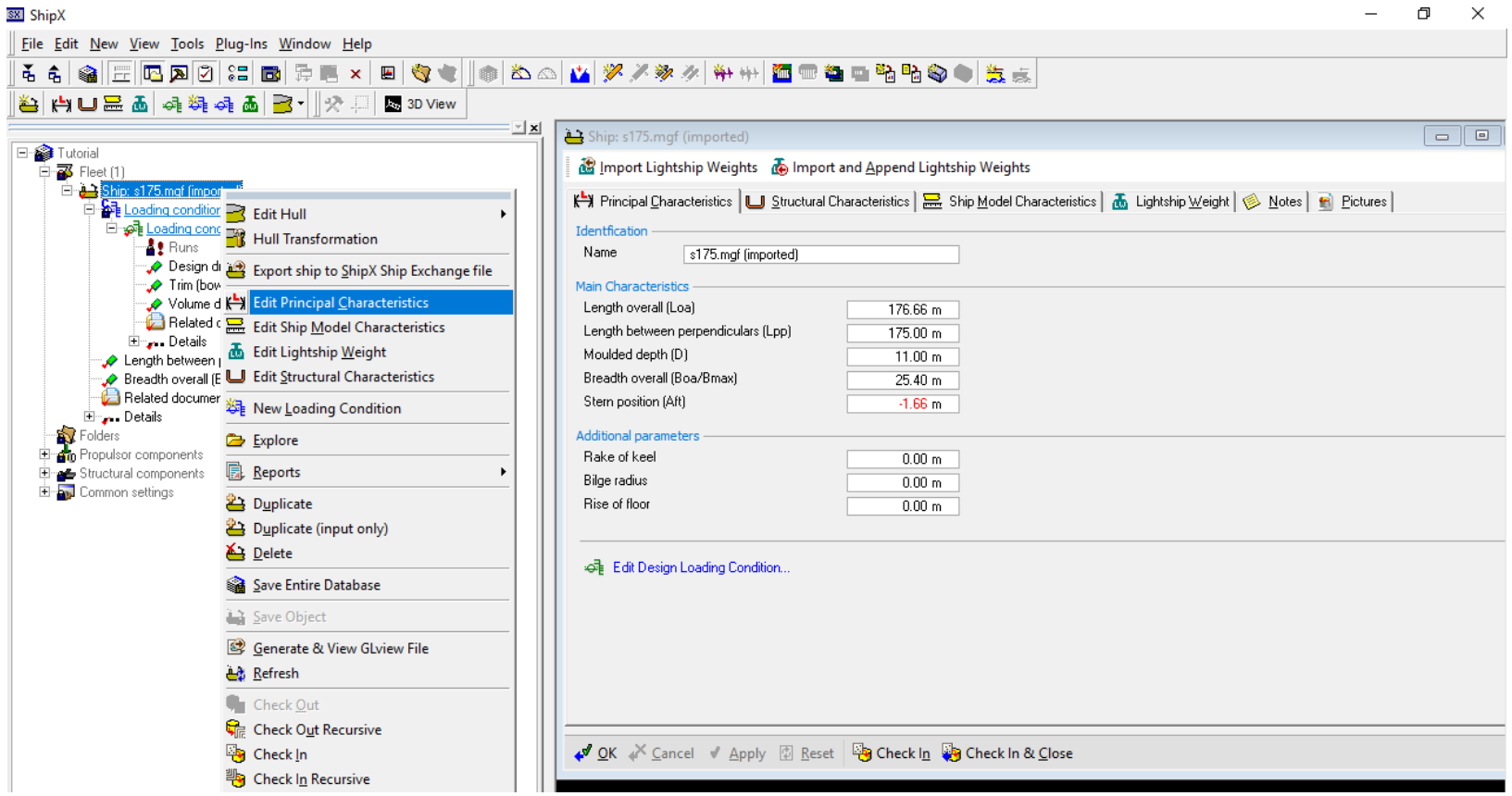
- Import the required ship hull.
- Check that your imported file matches the requirements.



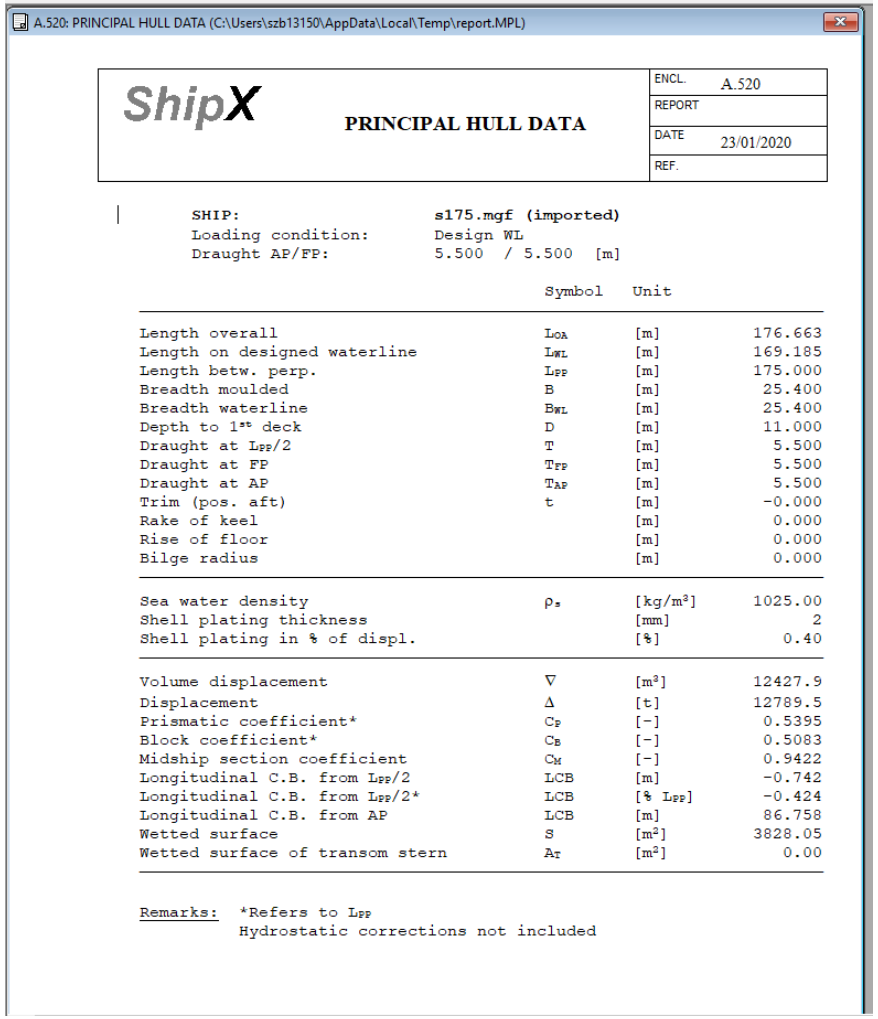


Step 3: Editing the ship particulars

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



Step 4: Ship principal characteristics



A.520: PRINCIPAL HULL DATA (C:\Users\szb13150\AppData\Local\Temp\report.MPL)

ShipX

PRINCIPAL HULL DATA

ENCL.	A.520
REPORT	
DATE	23/01/2020
REF.	

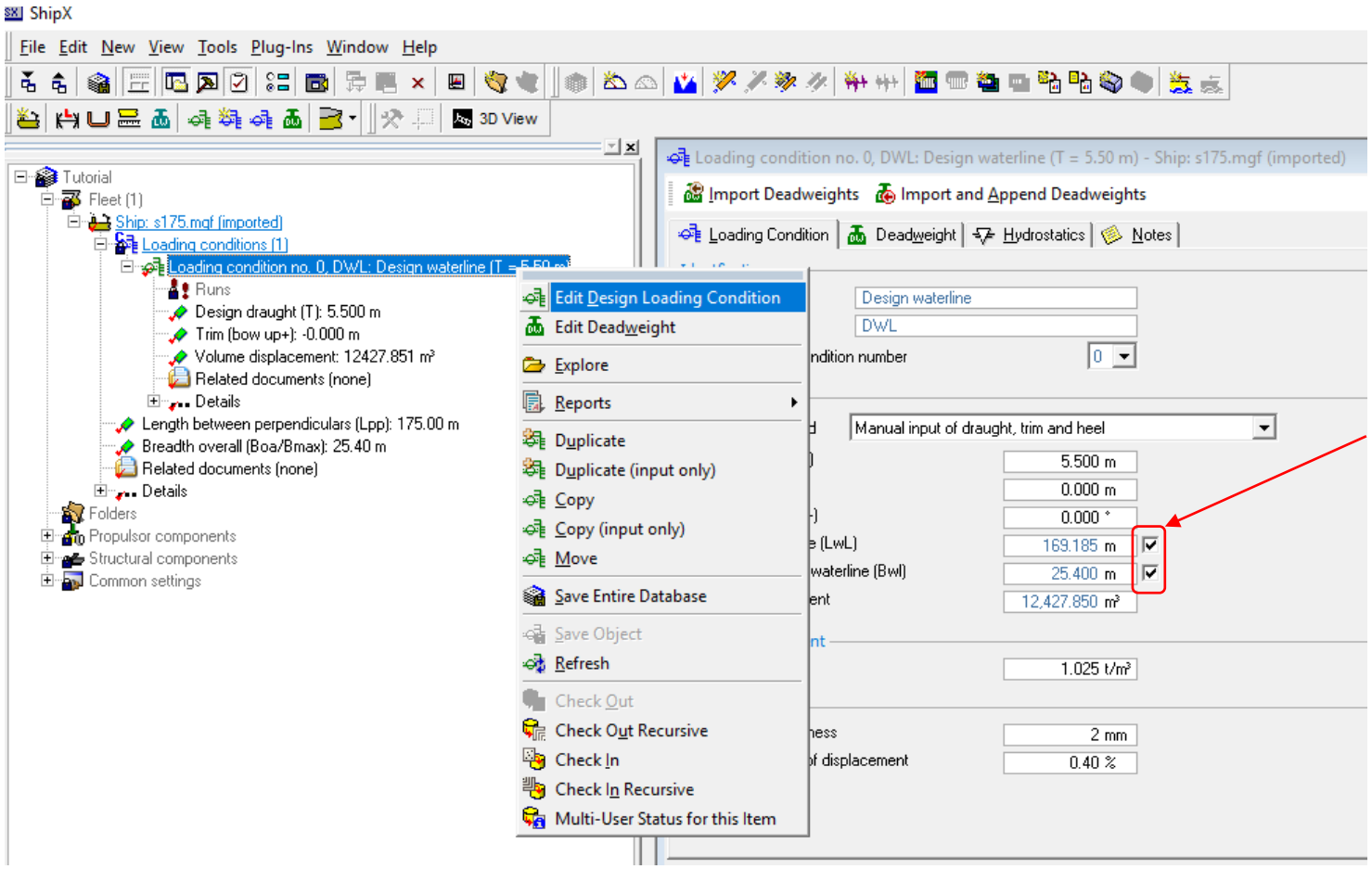
SHIP: s175.mgf (imported)
Loading condition: Design WL
Draught AP/FP: 5.500 / 5.500 [m]

	Symbol	Unit	
Length overall	L_{OA}	[m]	176.663
Length on designed waterline	L_{WL}	[m]	169.185
Length betw. perp.	L_{PP}	[m]	175.000
Breadth moulded	B	[m]	25.400
Breadth waterline	B_{WL}	[m]	25.400
Depth to 1st deck	D	[m]	11.000
Draught at $L_{PP}/2$	T	[m]	5.500
Draught at FP	T_{FP}	[m]	5.500
Draught at AP	T_{AP}	[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	ρ_s	[kg/m³]	1025.00
Shell plating thickness		[mm]	2
Shell plating in % of displ.		[%]	0.40
Volume displacement	∇	[m³]	12427.9
Displacement	Δ	[t]	12789.5
Prismatic coefficient*	C_P	[-]	0.5395
Block coefficient*	C_B	[-]	0.5083
Midship section coefficient	C_M	[-]	0.9422
Longitudinal C.B. from $L_{PP}/2$	LCB	[m]	-0.742
Longitudinal C.B. from $L_{PP}/2$*	LCB	[% L_{PP}]	-0.424
Longitudinal C.B. from AP	LCB	[m]	86.758
Wetted surface	S	[m²]	3828.05
Wetted surface of transom stern	A_T	[m²]	0.00

Remarks: *Refers to L_{PP}
Hydrostatic corrections not included

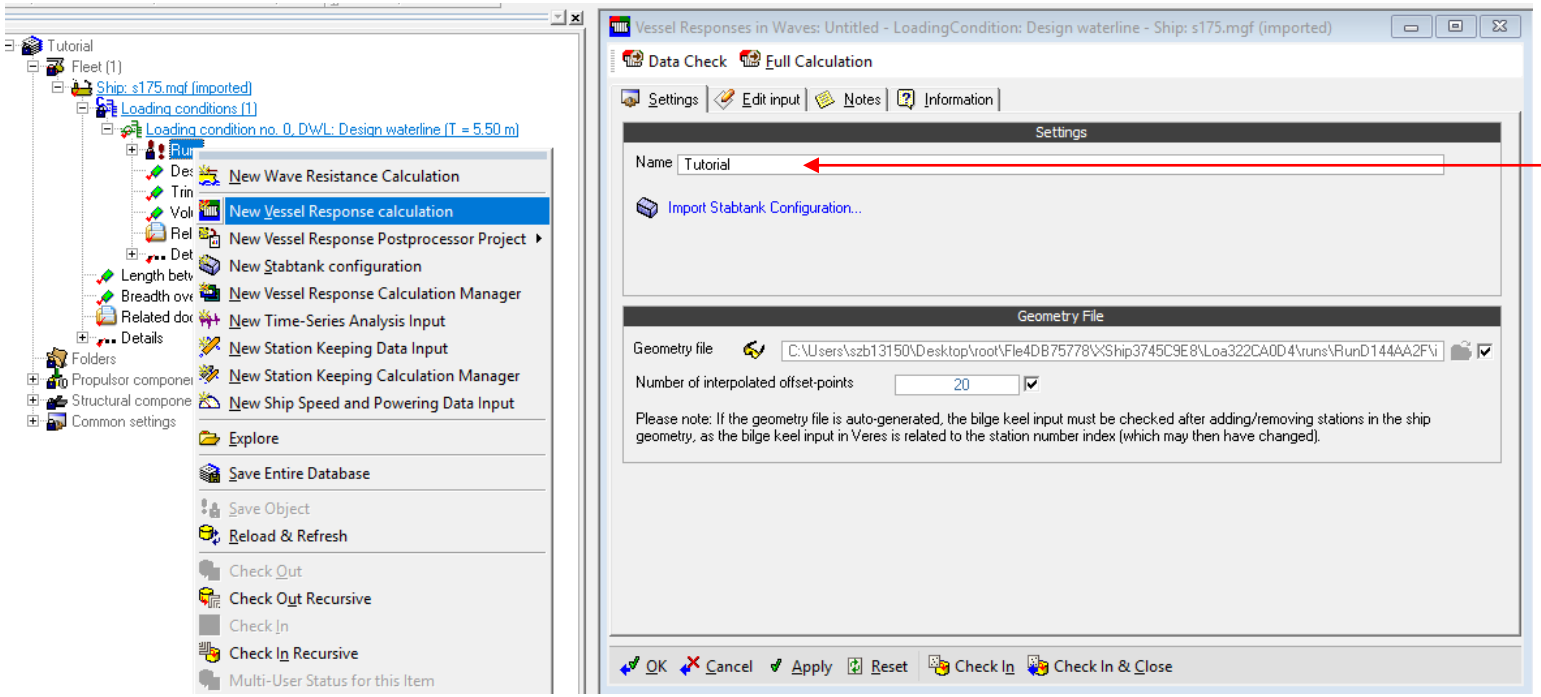
- ShipX's plot program may require several attempts to open.
- Check that all parameters match your required input.

Step 5: Loading condition



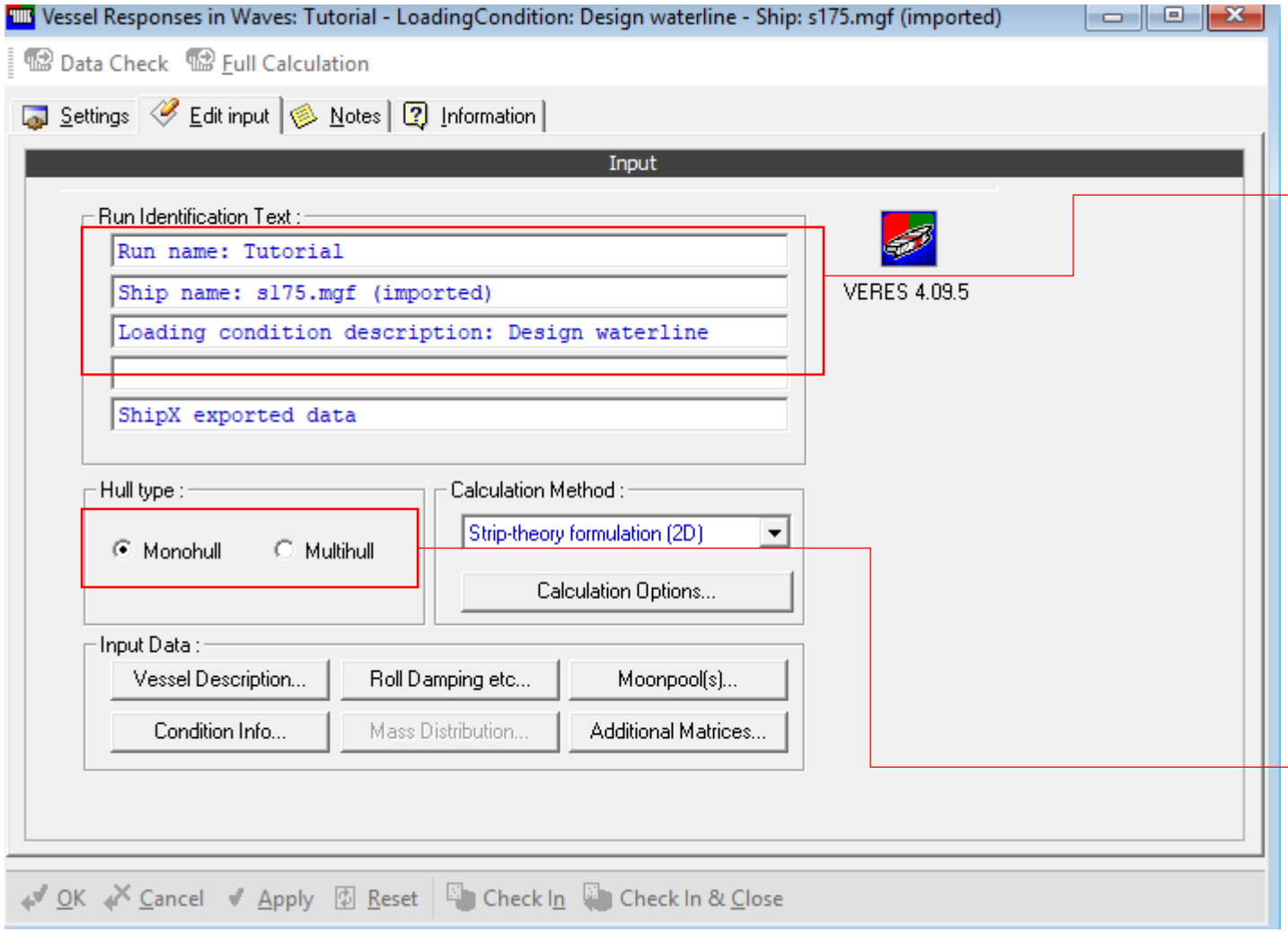
- Ensure that you design loading condition matches the requirements, set out in the coursework.
- Indicates an automatically calculated value
- **For catamarans, the Breadth must be entered as twice that of a demihull.**

Step 6: Define a response calculation



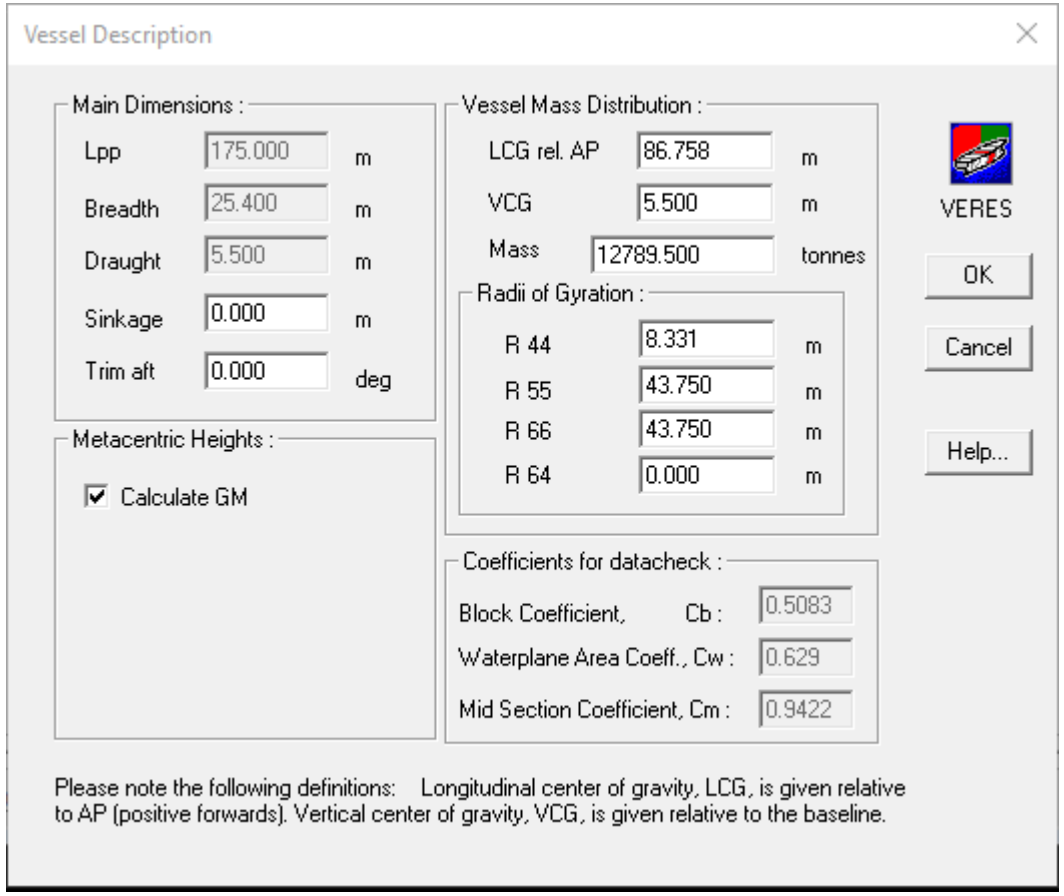
- Create a new vessel response calculation.
- Name your case suitably.
- Select Edit Input – this may require multiple attempts.

Step 7: Edit the response calculation



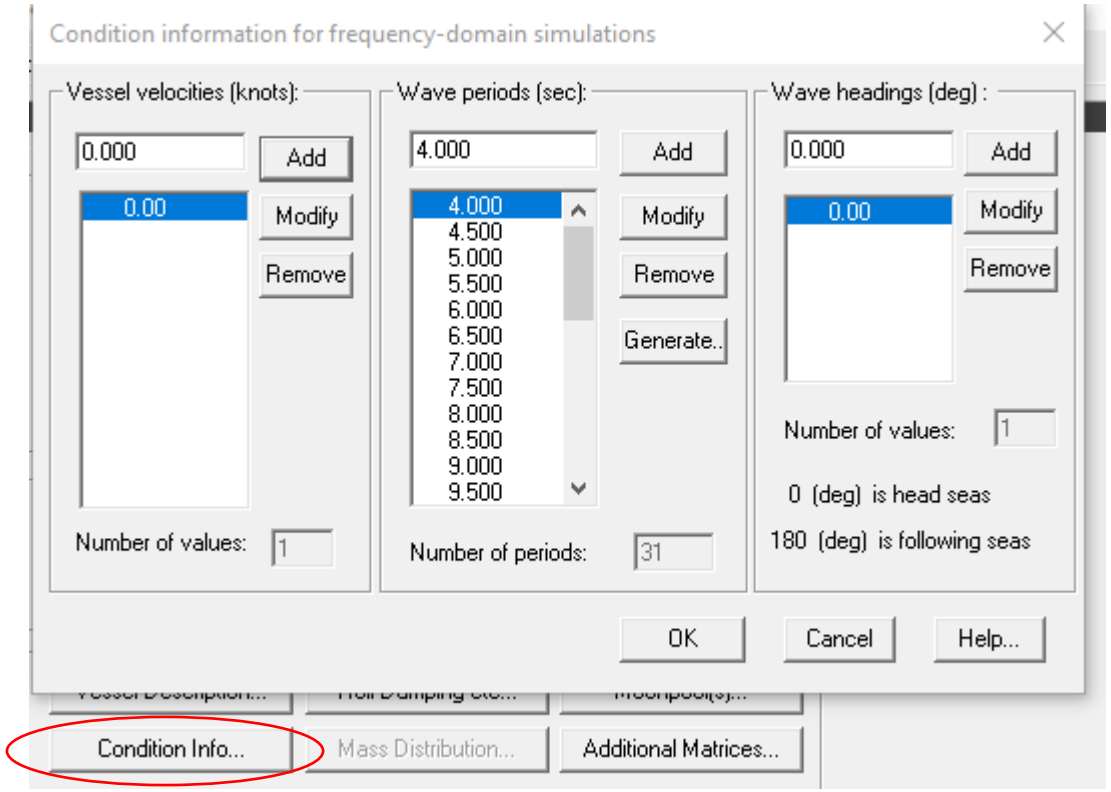
- Name you case.
- The default theory for seakeeping calculations is of 2D strip theory of Tuck and Faltinsen (referenced in the manual and lecture notes).
- Select Vessel Description.
- Change the radial button accordingly.

Step 8: Edit the vessel description



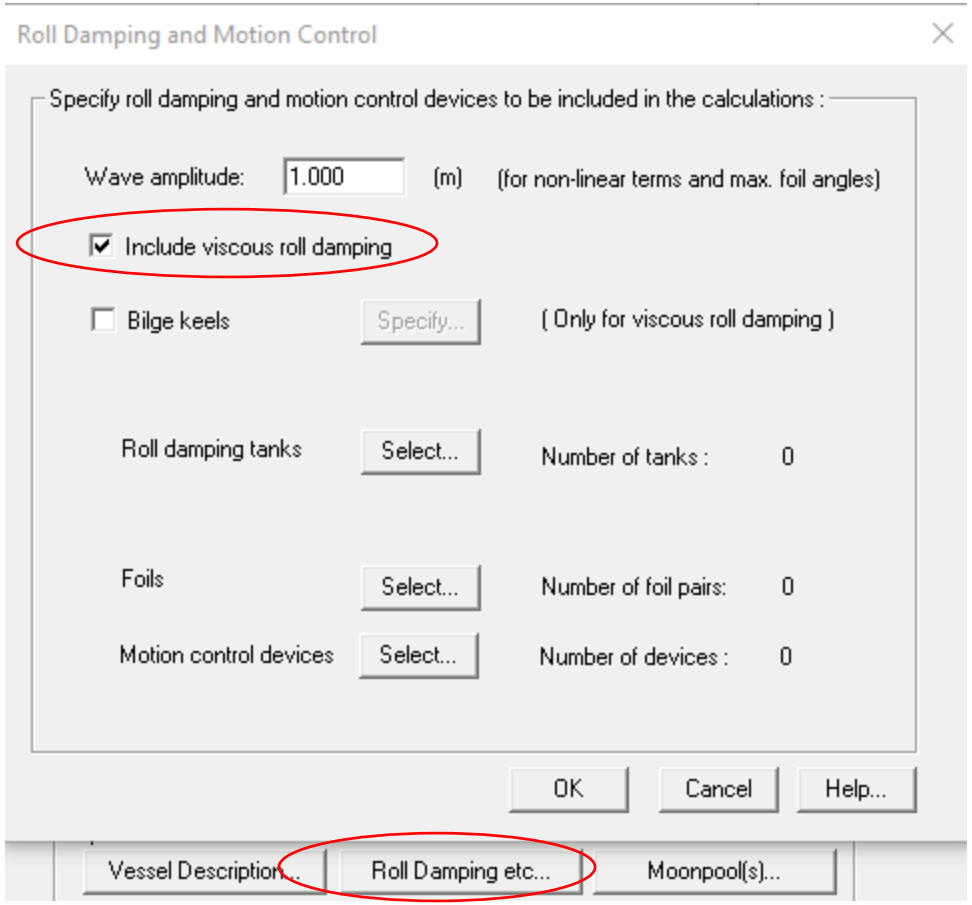
- Input the radii of gyration as required by the coursework.
- Edit the VCG and LCG if necessary.
- If you do not complete this step, the analysis will not run.
- Ensure that R_{44} is correctly specified depending on your ship.
- Select Ok to return to the pre-processor window.

Step 9: Set the conditions



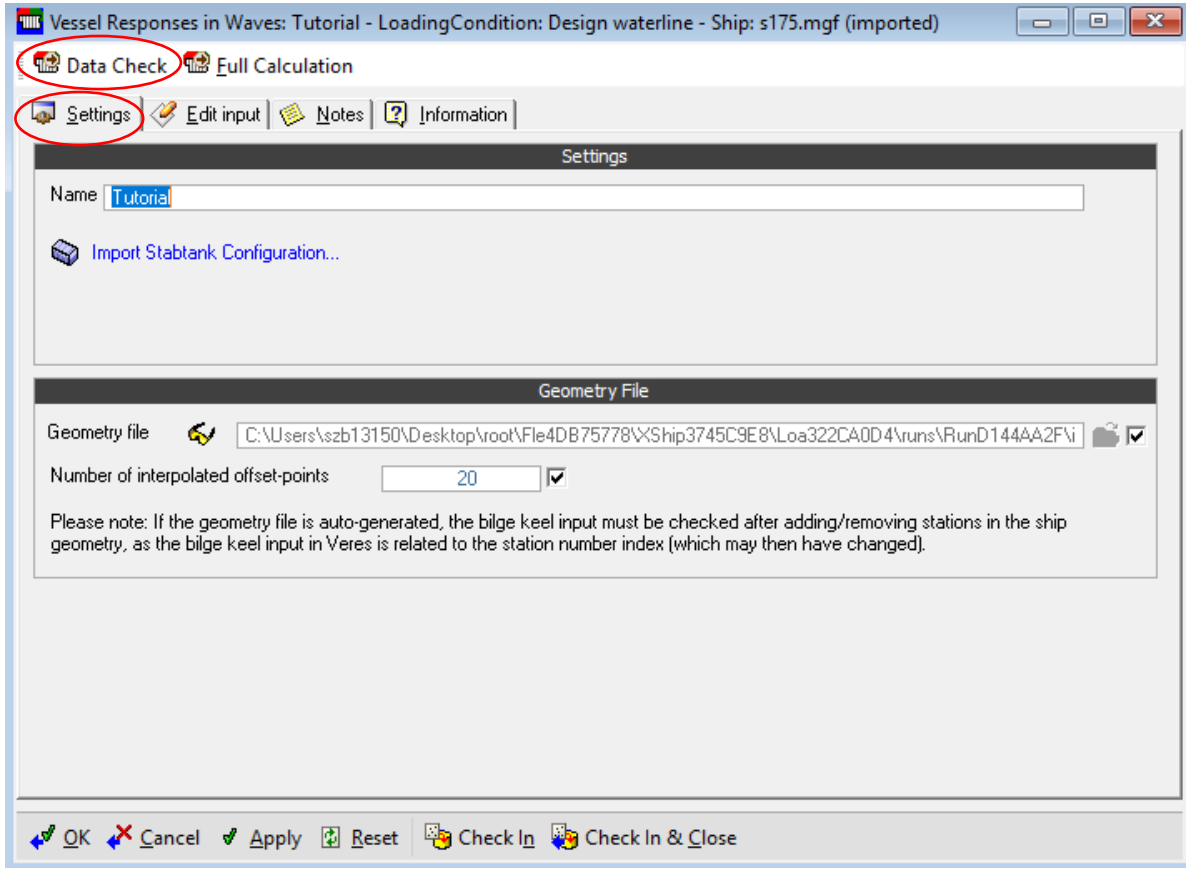
- Select Condition Info.
- Set the ship speeds depending on the requirements.
- You may specify the wave periods individually, or generate them all at once.
- The limit is <100 wave periods.
- Ensure that your curves have a sufficient number of periods near the resonant frequency.
- Remember to check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

Step 10: Check that roll damping is enabled

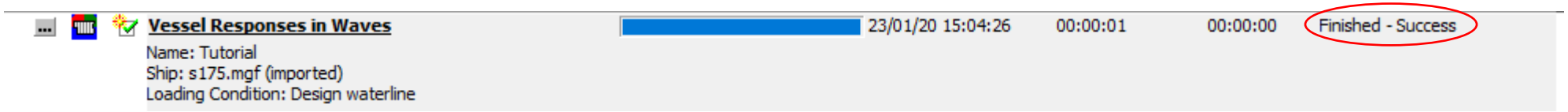


- Although this is enabled by default, it is a good idea to check that the viscous roll damping correction has been applied.
- Go to Roll Damping etc.
- Leave the wave amplitude as 1m.
- This is used in making the RAOs non-dimensional.
- Return to the pre-processor window.

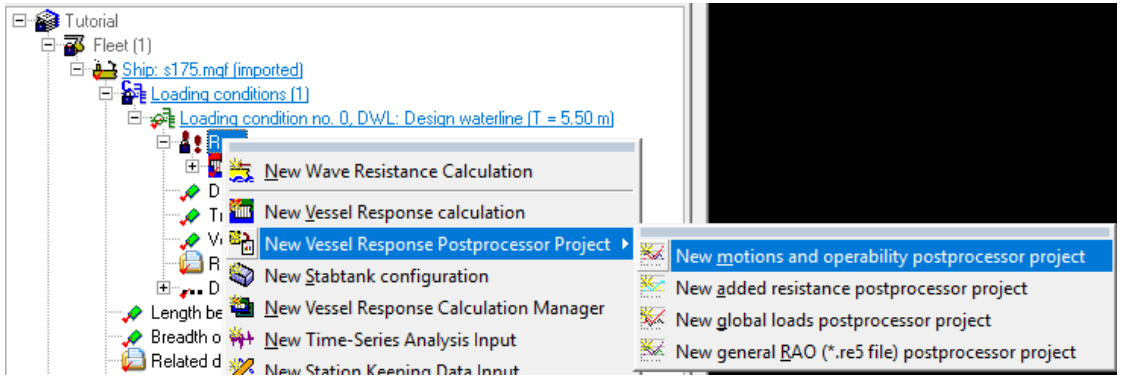
Step 11: Run a data check

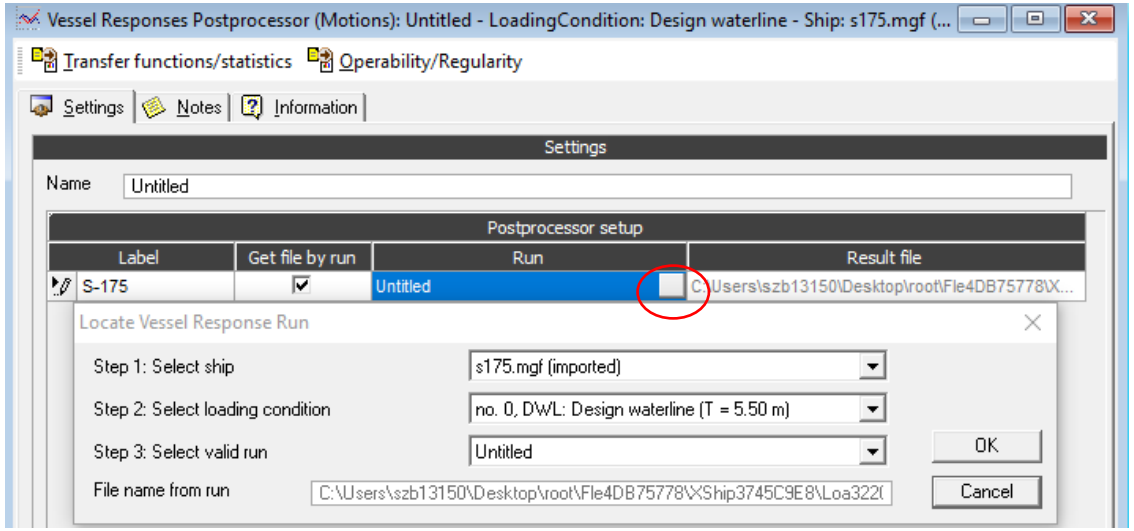


- Run a "Data Check".
- If successful, ShipX's plot program will open and display the ship particulars and sections (remember this might not work well and could require multiple attempts).
- You can now run the full calculation.



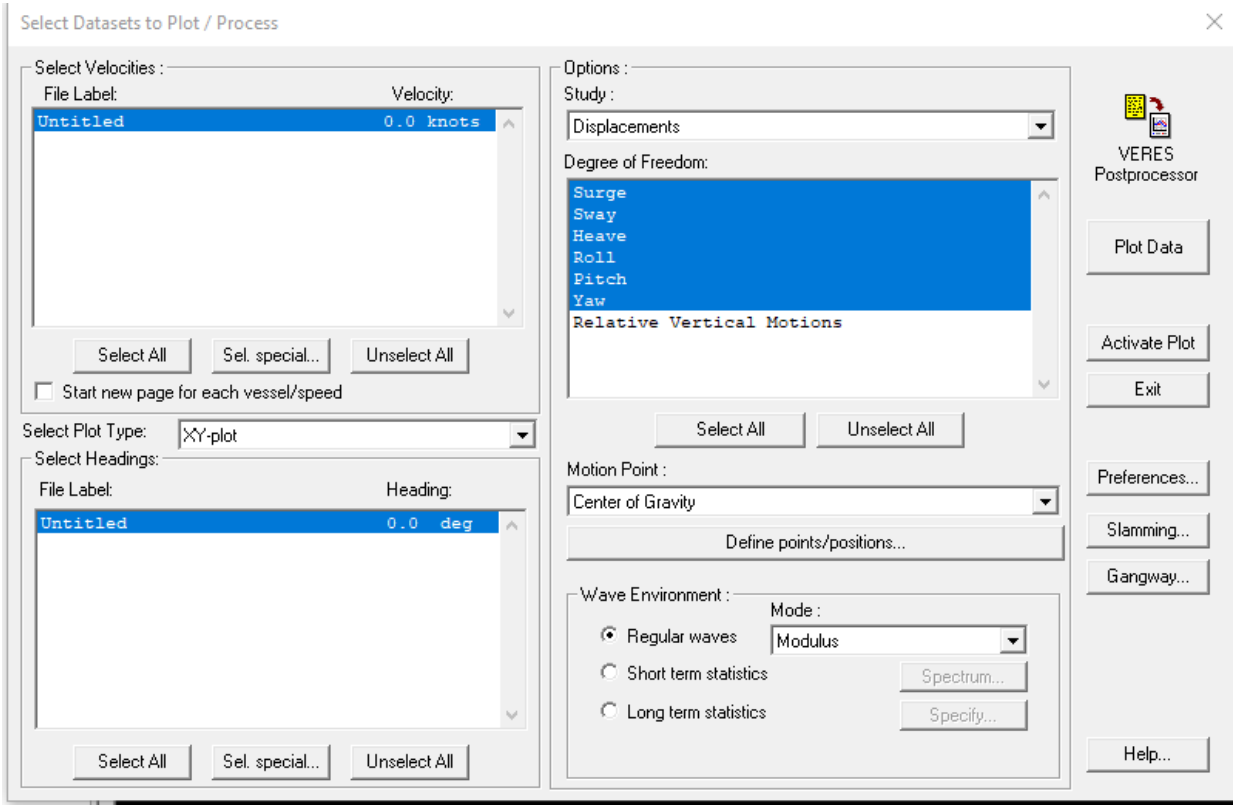
Step 12: Set-up a post processor



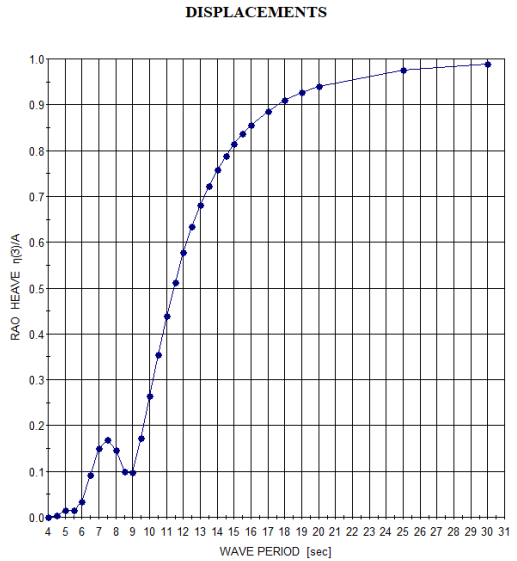


- You are now ready to perform the operability analysis.
- The first step is to create a post-processor for your calculation.
- Then, select your calculation and press Ok.
- Once ready, progress to Transfer functions/statistics

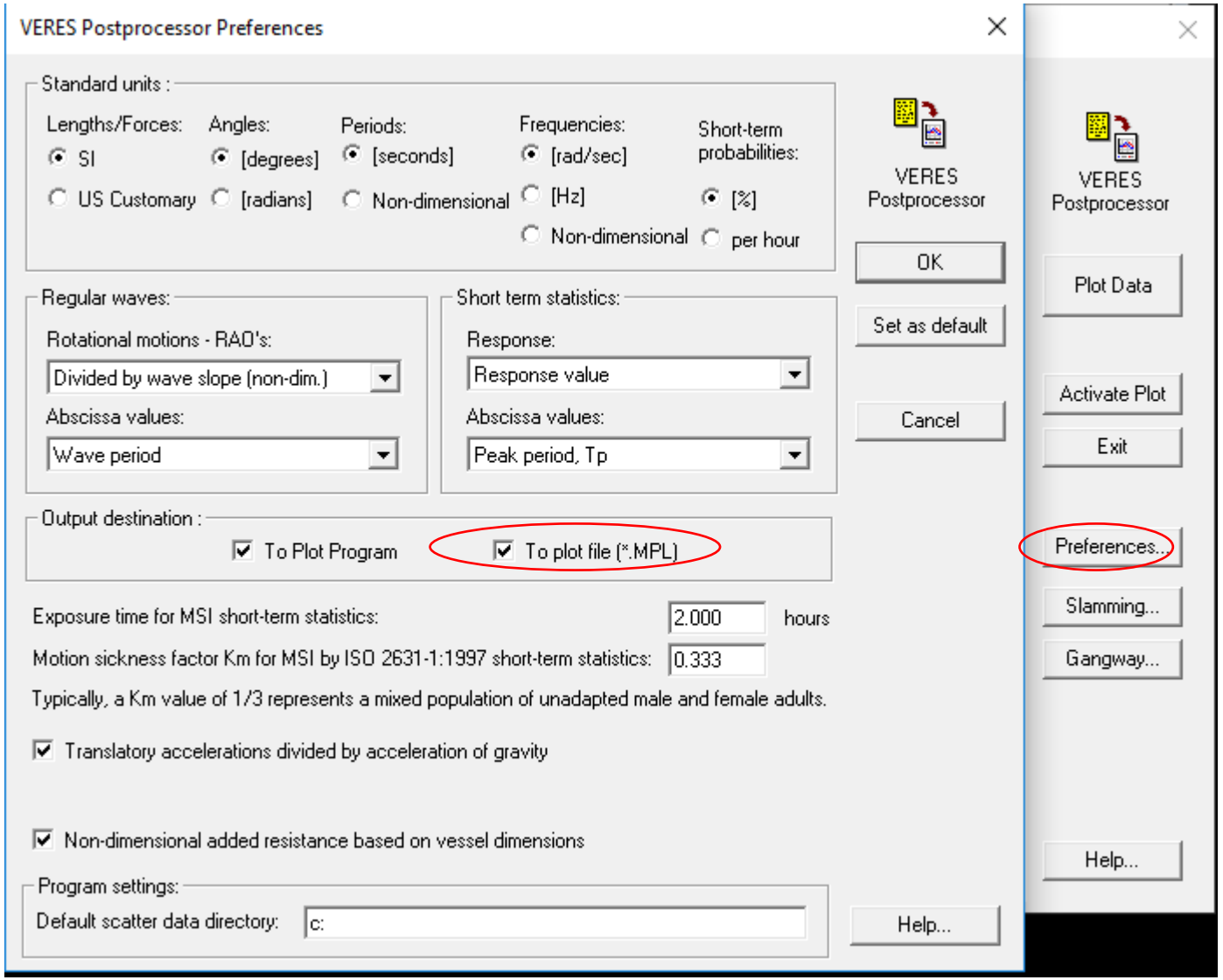
Step 13: Plot the RAOs



- 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):



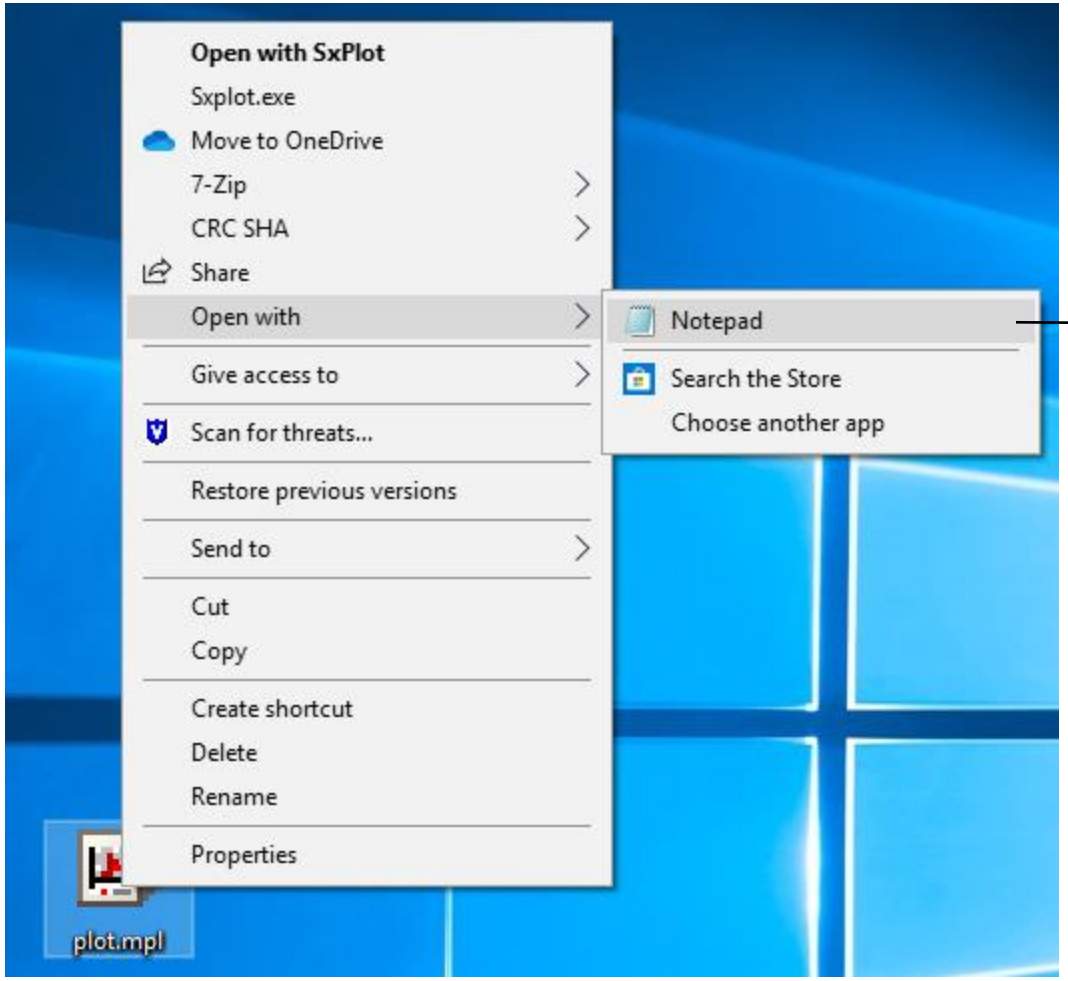
Step 14: Edit and export data



- 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 1st column

Units of 2nd 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.

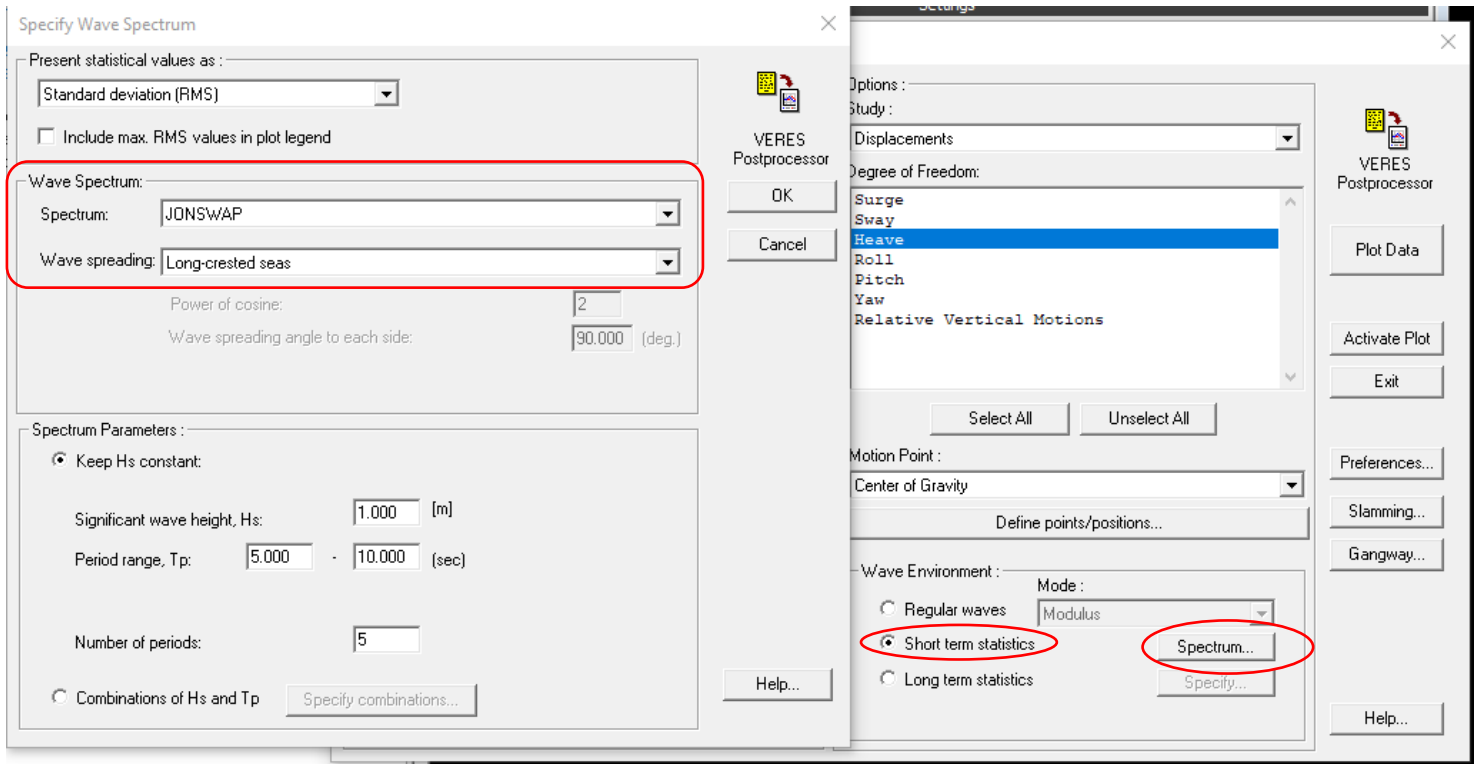
Data

x data

y data

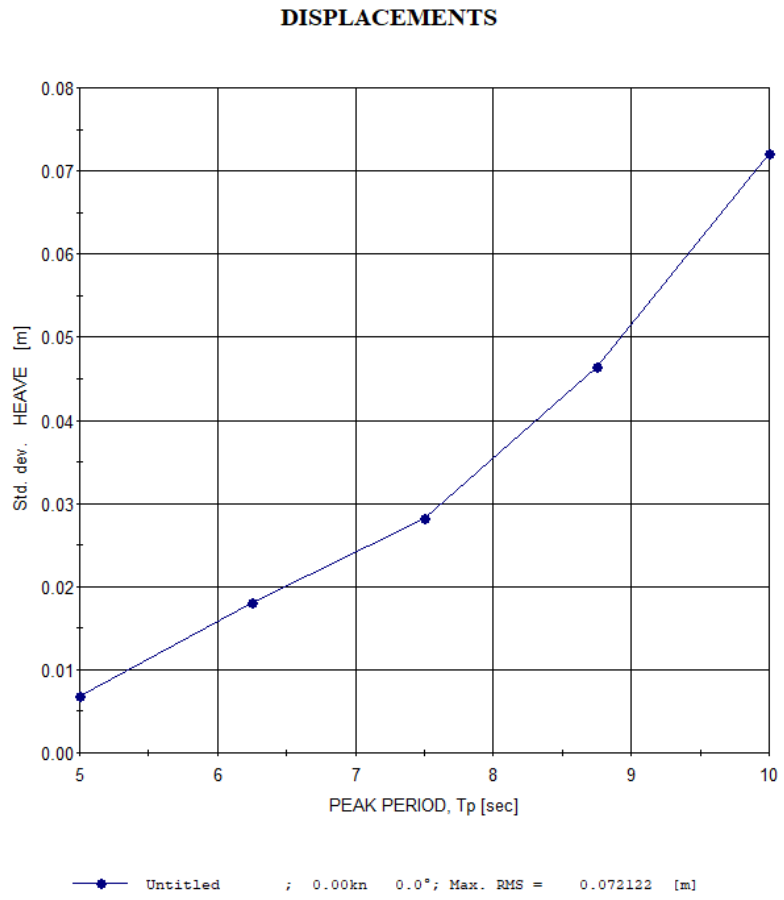
Step 16: Short term statistics

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



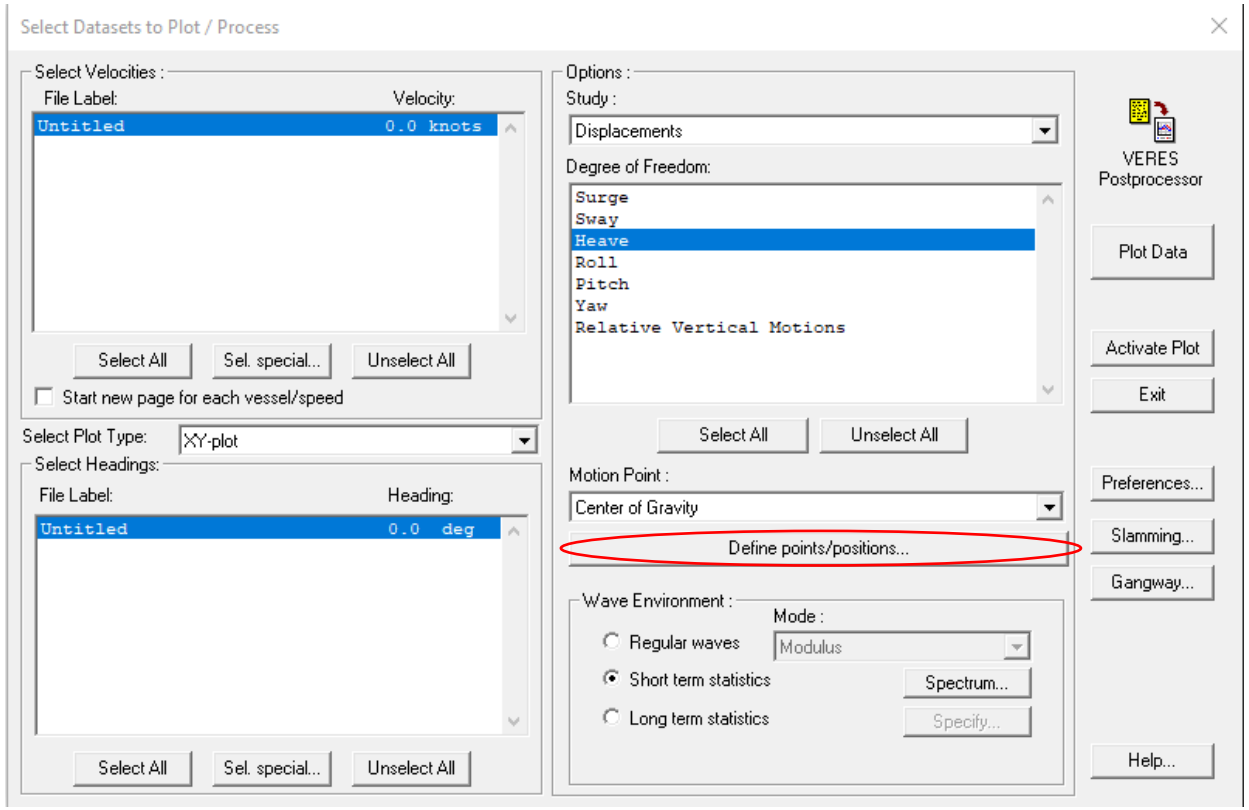
- Define the spectrum as directed by the coursework. In this example, the long-crested version of the JONSWAP spectrum is used.
- You may set specific combinations of Hs and Tp if necessary.

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.

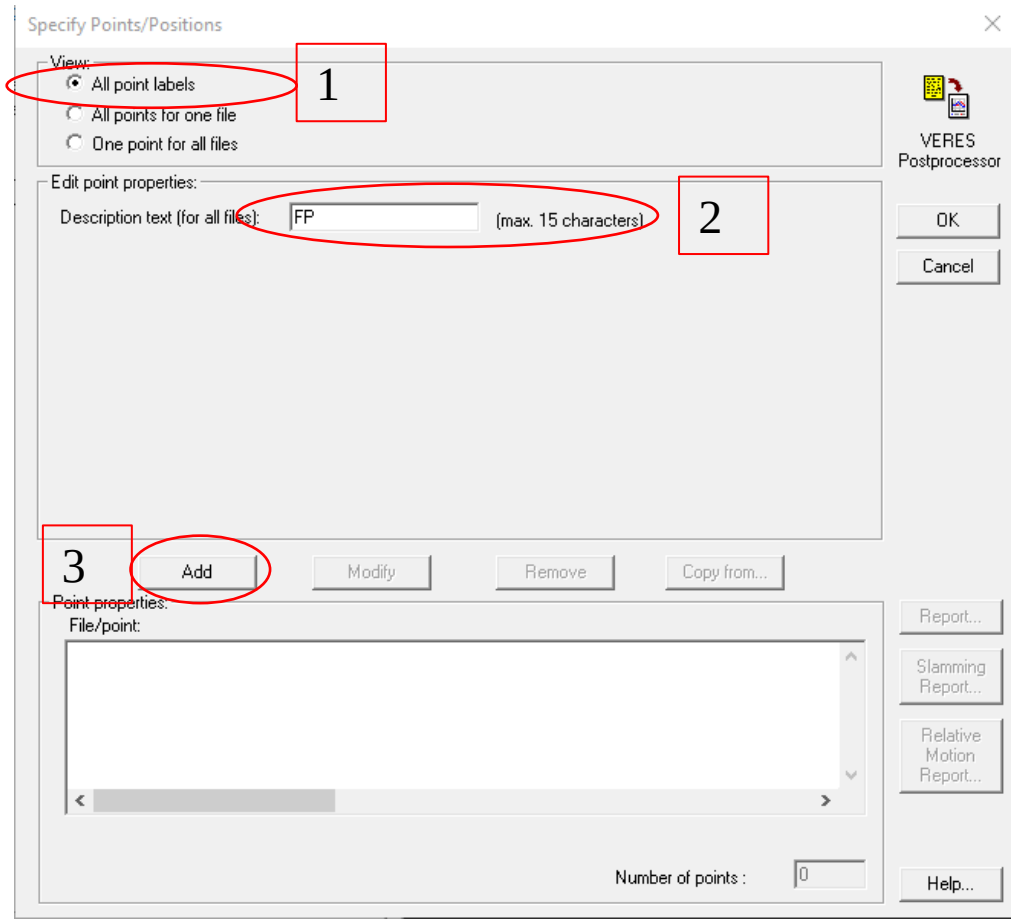
Step 18: Define points for analysis

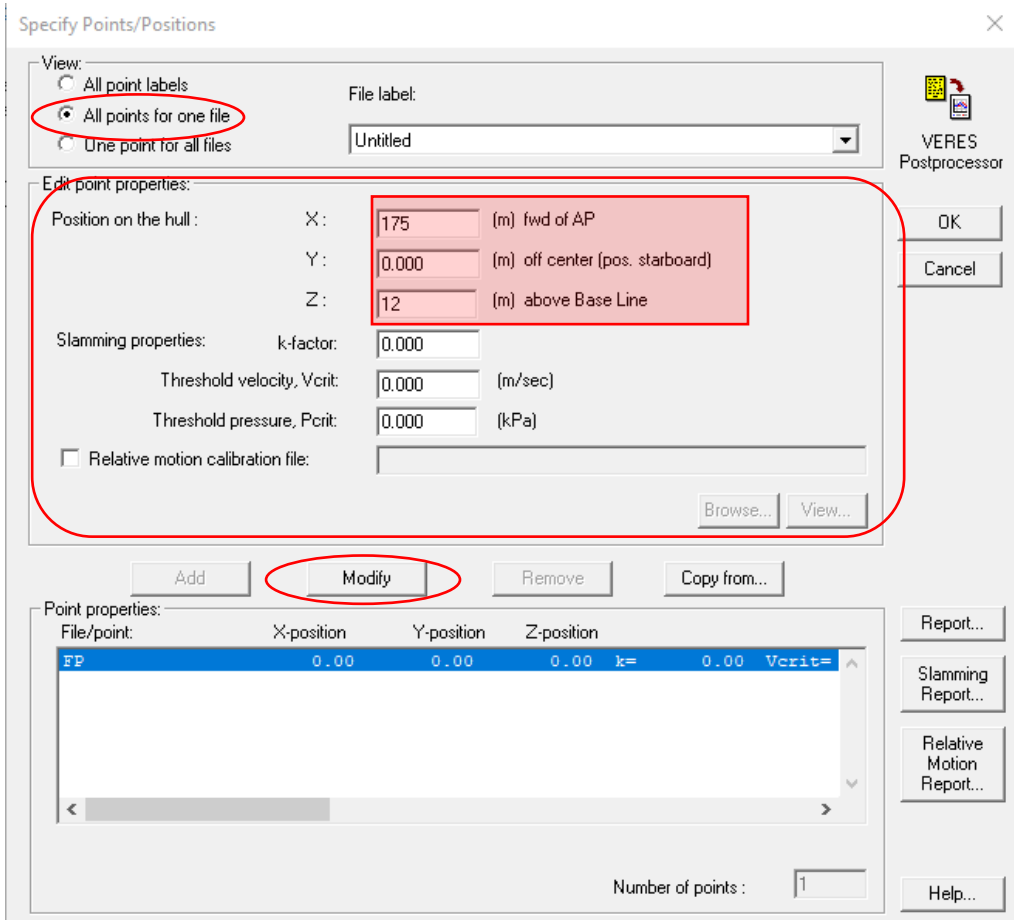


- As the ship experiences motions resulting from the seaway, different parts of the ship will be characterised by different motions.
- For example consider the motions experienced by a person located at the CoG versus the motions experienced by someone on the deck above the AP.
- Points are defined selecting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

Step 19: Define points for analysis #2

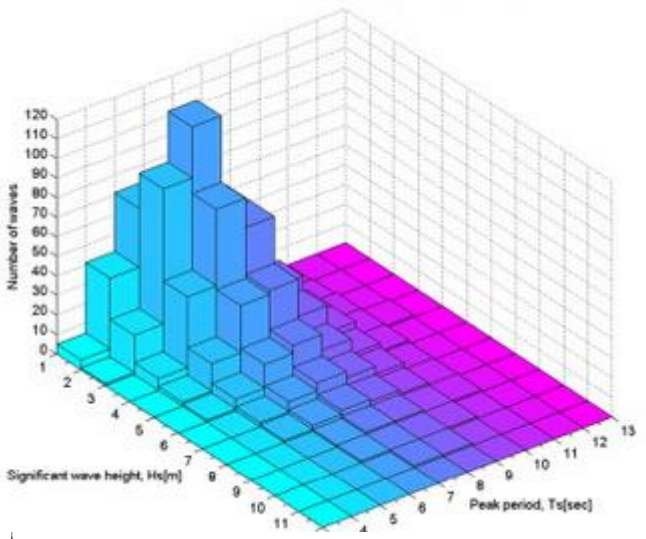
- Points for analysis are defined in two steps. First, name the point as shown below. Then, switch the radial button to "All points for one file", and define its [*x*, *y*, *z*] coordinates.

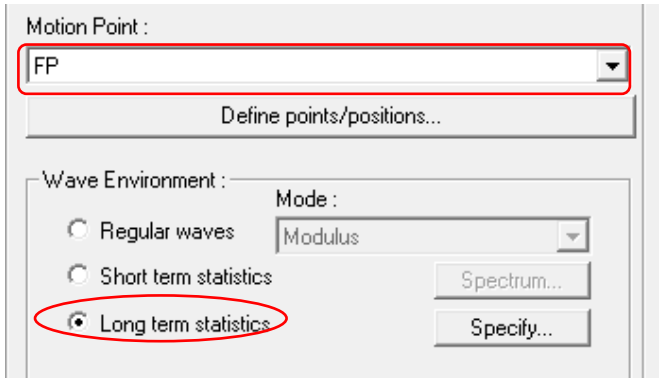


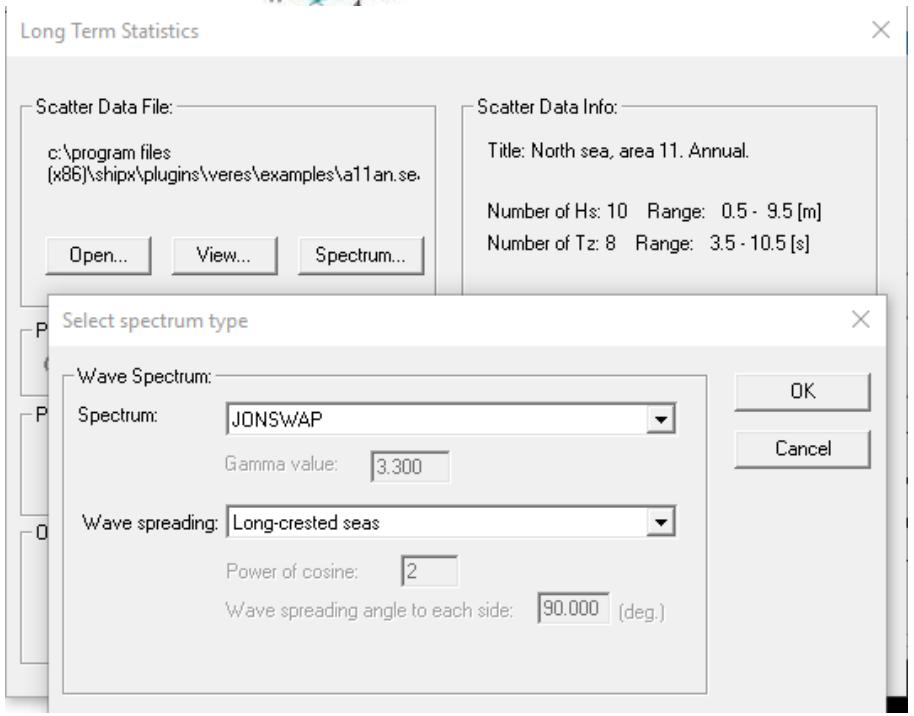


Step 20: Long term analysis

- 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\PlugIns\Veres\Examples** and open “a11an.sea”.
- A typical wave scatter diagram is shown above.

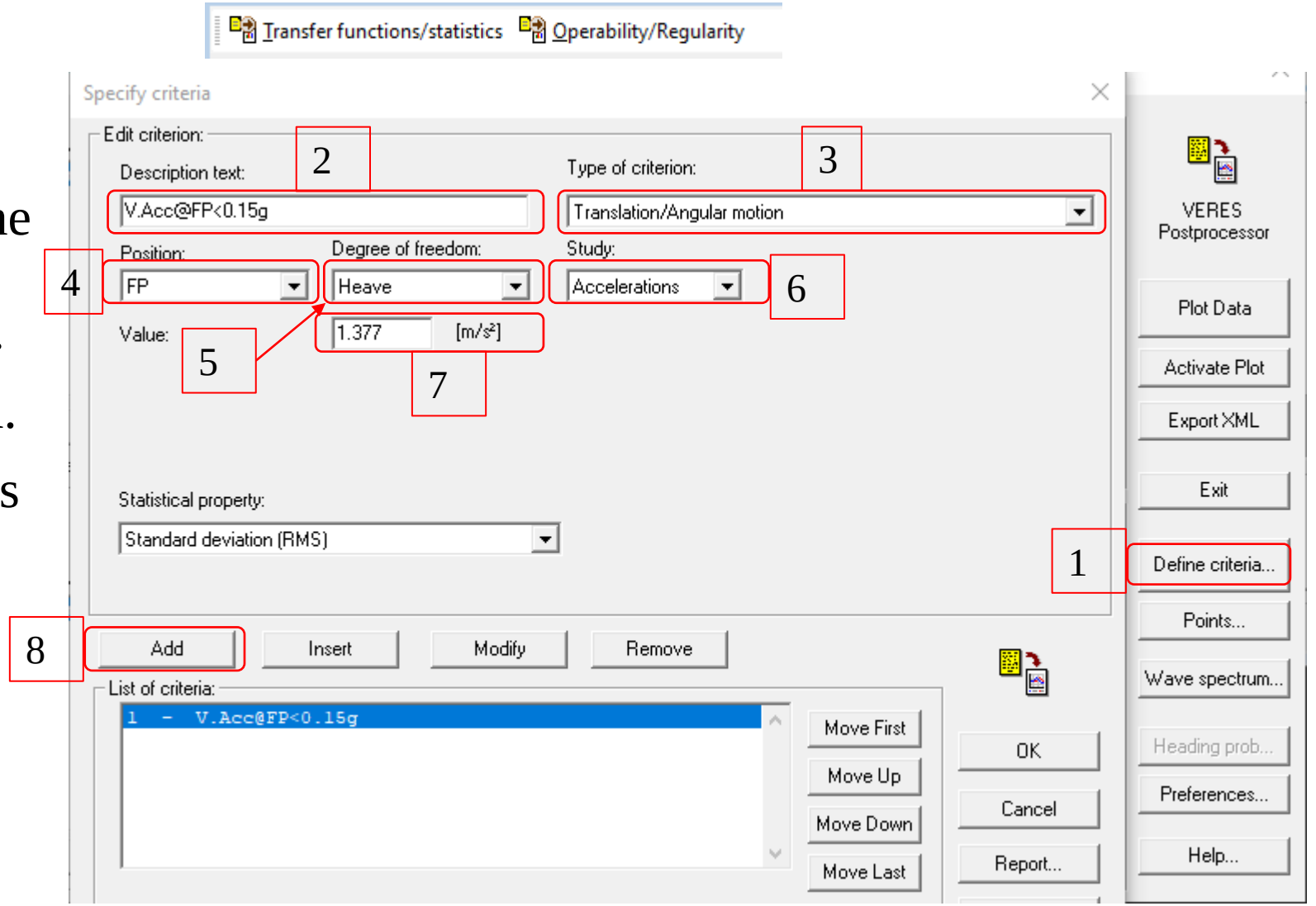






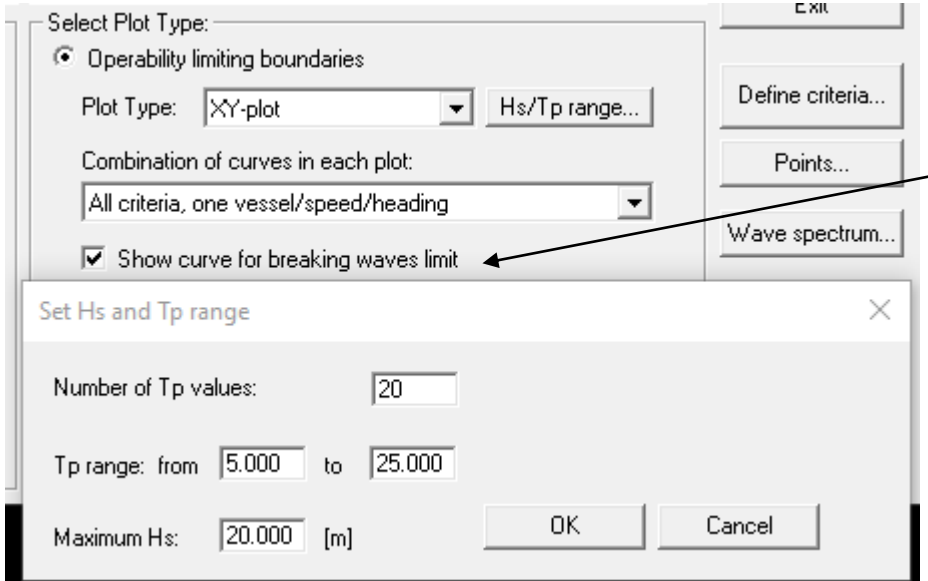
Step 21: Long term analysis #2

- 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.

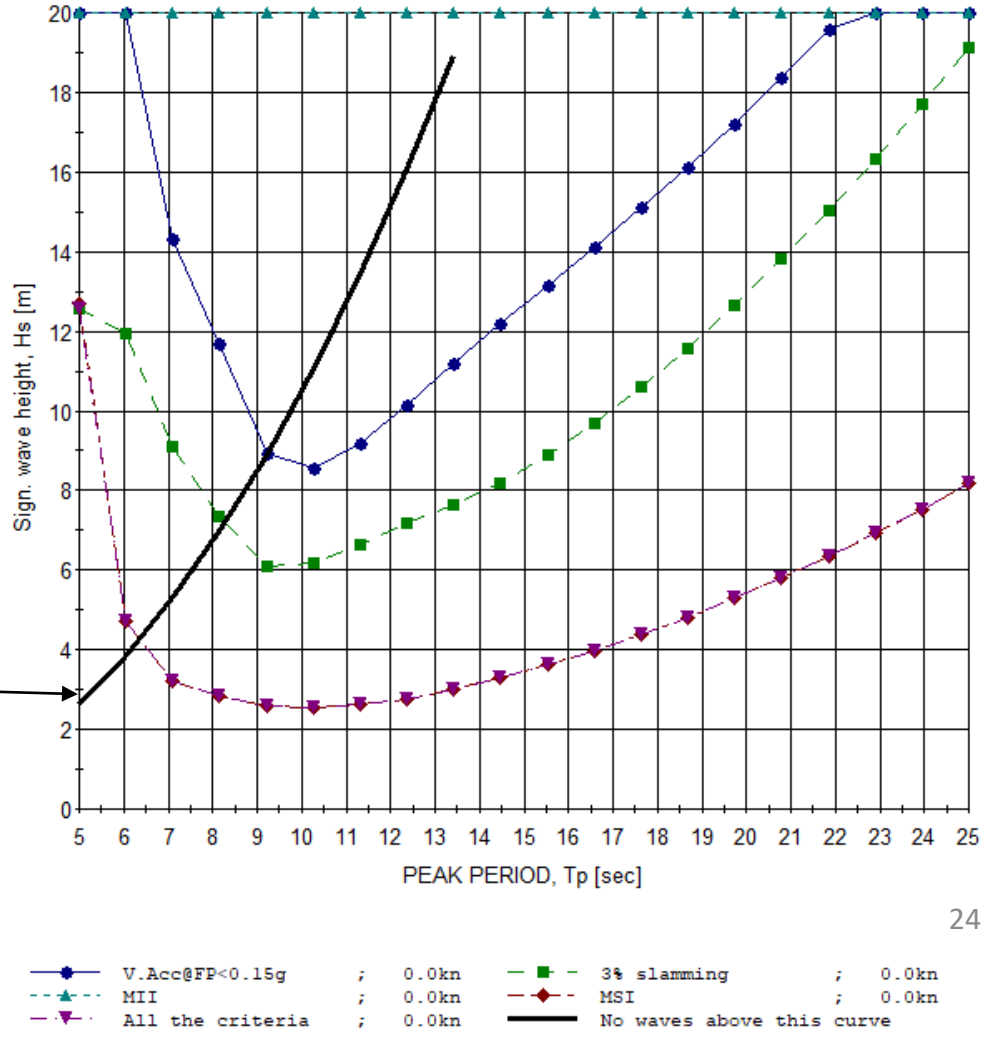


Step 22: Long term analysis #3

- 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.

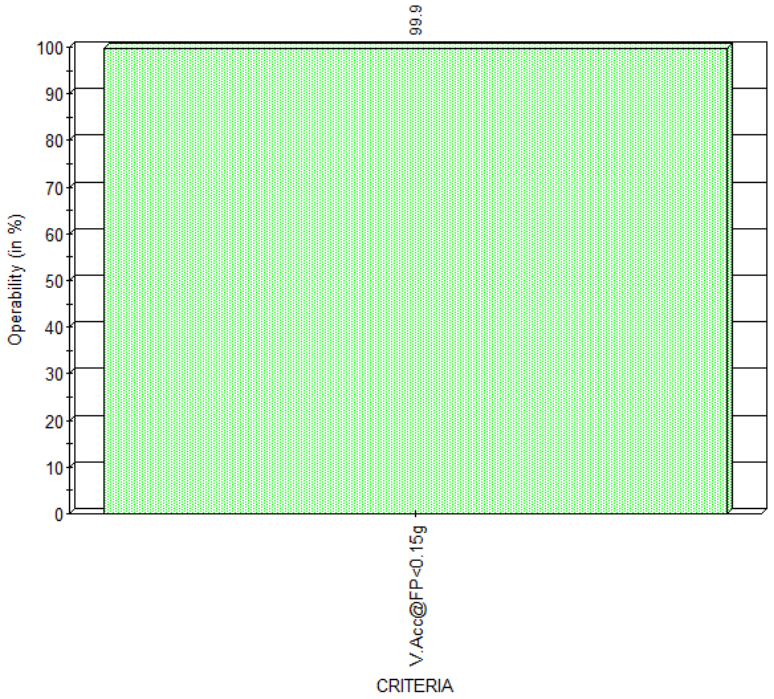


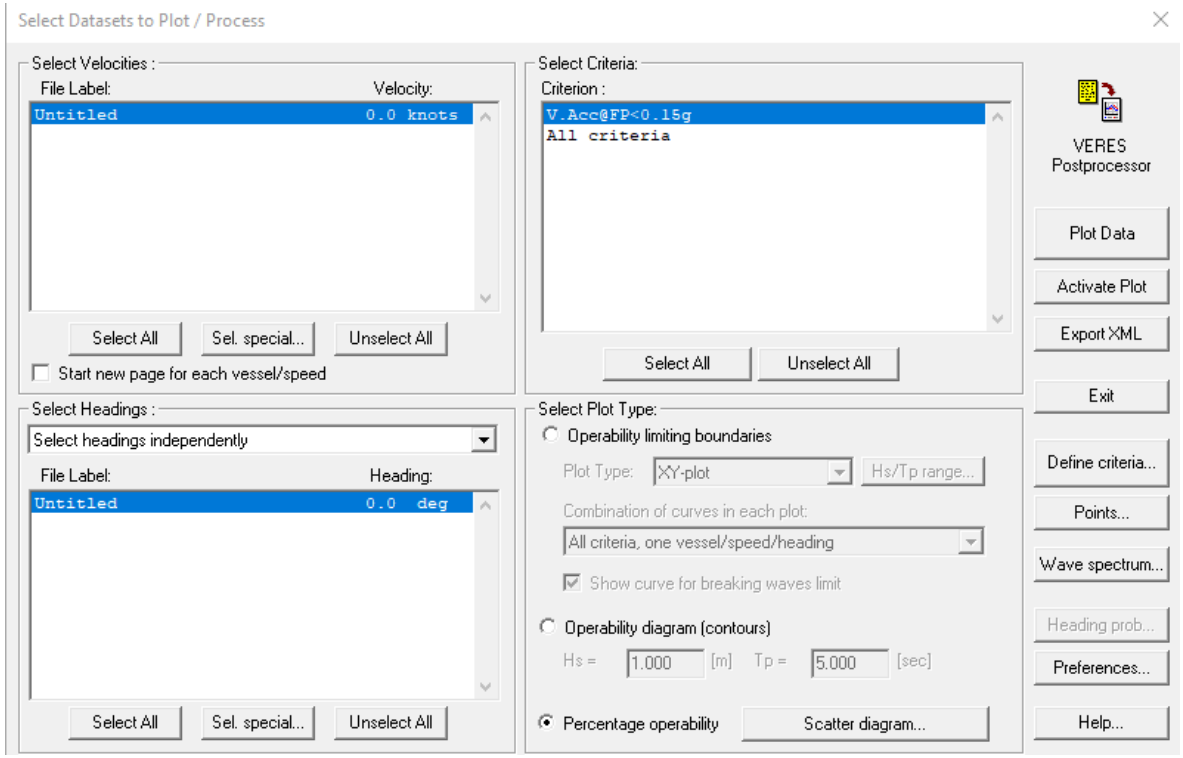
Waves cannot exist above this curve (because they break).



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.

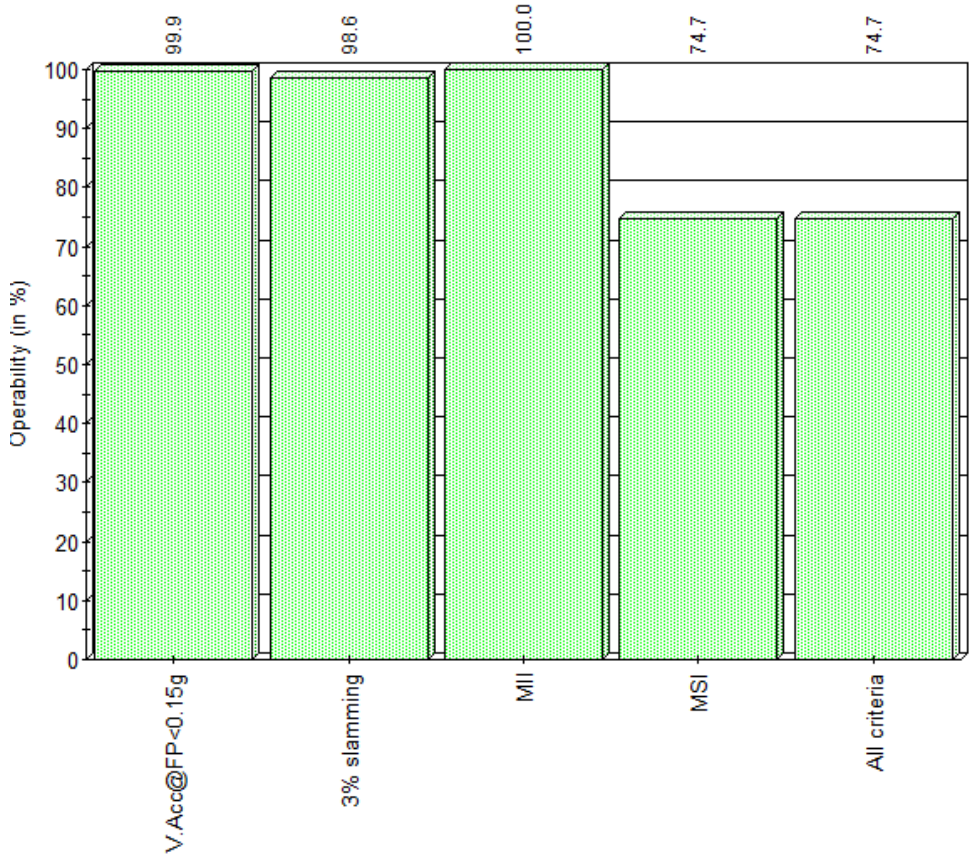




- Exporting the data used to create the operability diagram is done in the same way as was demonstrated previously: Preferences > To plot file .mpl

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

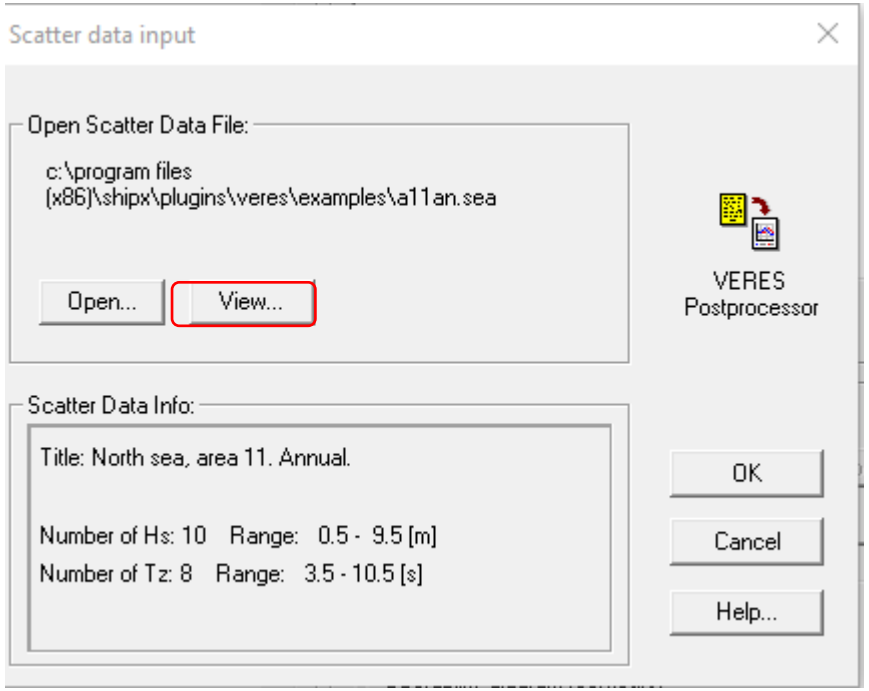
- Open the wave scatter diagram, given as an example by ShipX.
- You can find this by navigating to: **C:\Program Files (x86)\ShipX\PlugIns\Veres\Examples**
- It is advisable you make a copy of the original file, "a11an.sea", to work on. *Note*: *you may not be able to work in the same directory – make 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    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
```

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 occurences

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

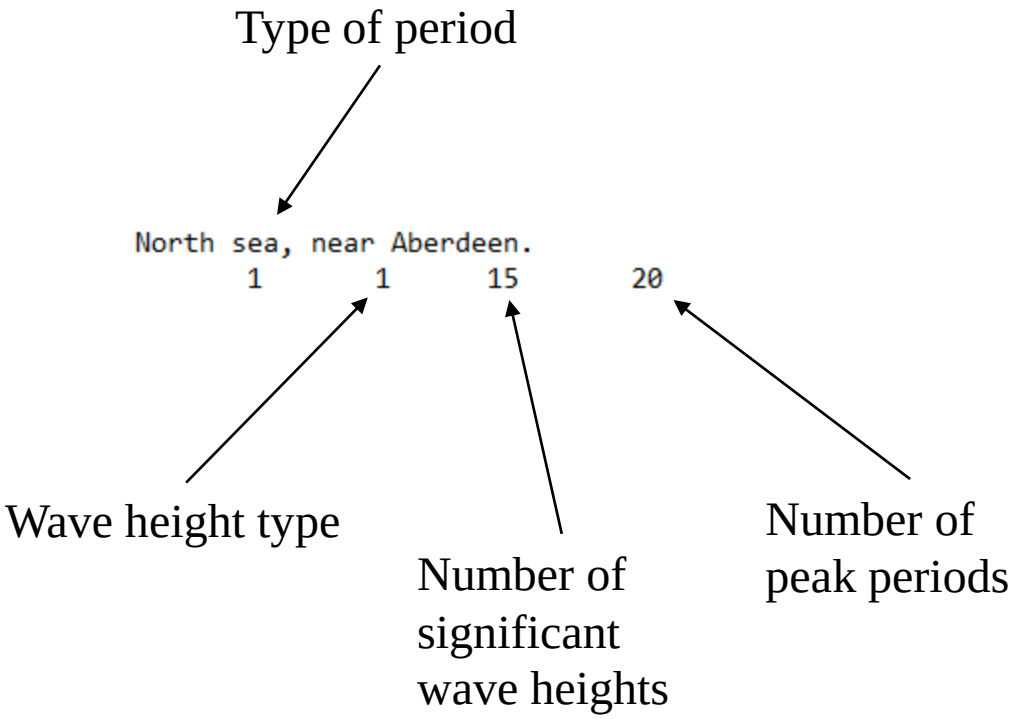
- The type of period is controlled by changing the first number on the second row.
- By default, this is set to (2), which the software interprets as zero crossing period.
- To tell the software that we are working in peak periods, modify this to (1).
- Save your copy of the wave scatter and view it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

```
North sea, near Aberdeen.
   1      1     10      8
 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 occurences

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 occurence of a sea state	R(I,I)	–

Table 9: Definition of variables

Taken from Fathi (2015) ShipX Vessel Responses (VERES)- User's Manual

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

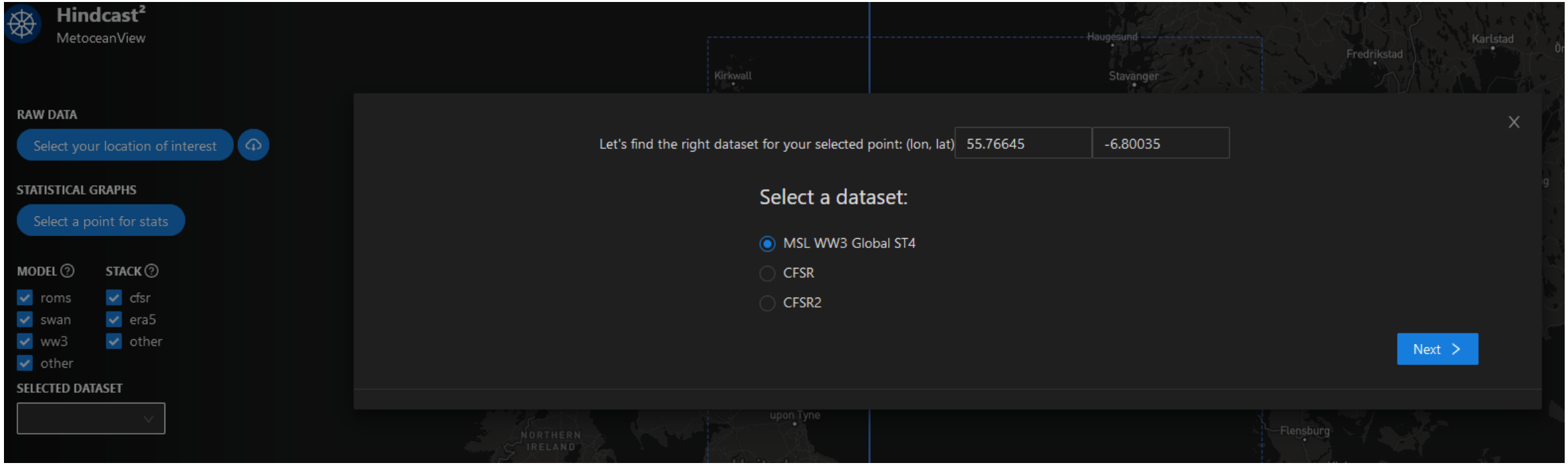
```
North sea, area 11 in Global Wave Statistics. Annual.
2  1  10  7
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5
3.5 4.5 5.5 6.5 7.5 8.5 10
 19  86  94  41  10   2   0
  3  49 121  99  40  10   2
  1  17  63  73  40  13   4
  0   6  27  39  26  10   4
  0   2  11  19  14   6   3
  0   1   4   9   7   4   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
```

Taken from Fathi (2015) ShipX Vessel Responses (VERES)- User's Manual

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

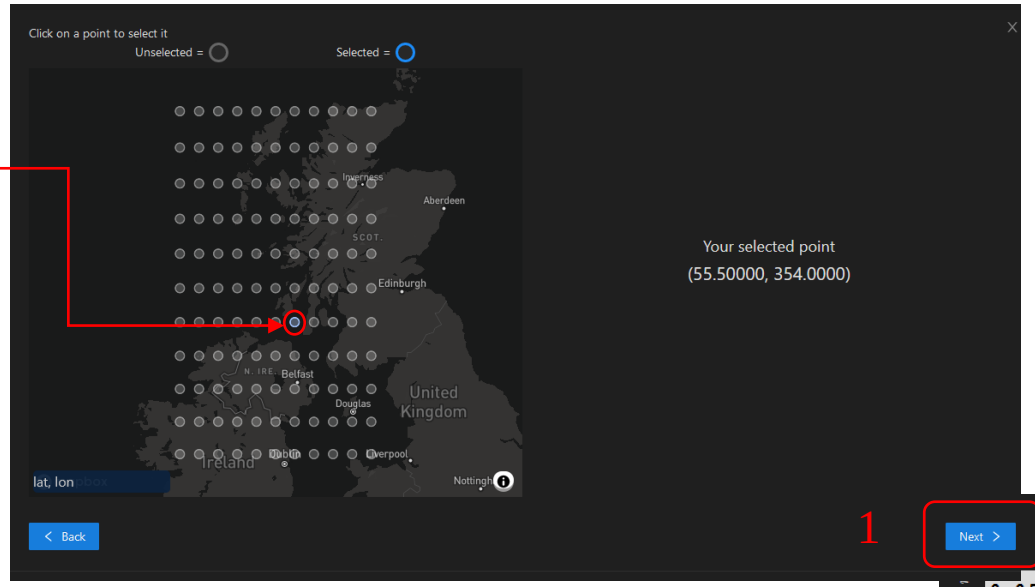


- Go to your area of interest
- Click on “Select a point for stats”
- Click on the location of interest

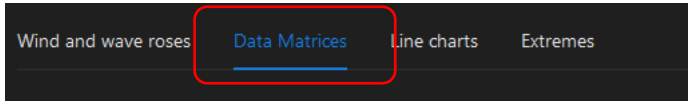
- Set the dataset to MSL WW3 Global ST4
- Click next
- **Do not click on any of the boxes or lines in the map**

Wave scatter data

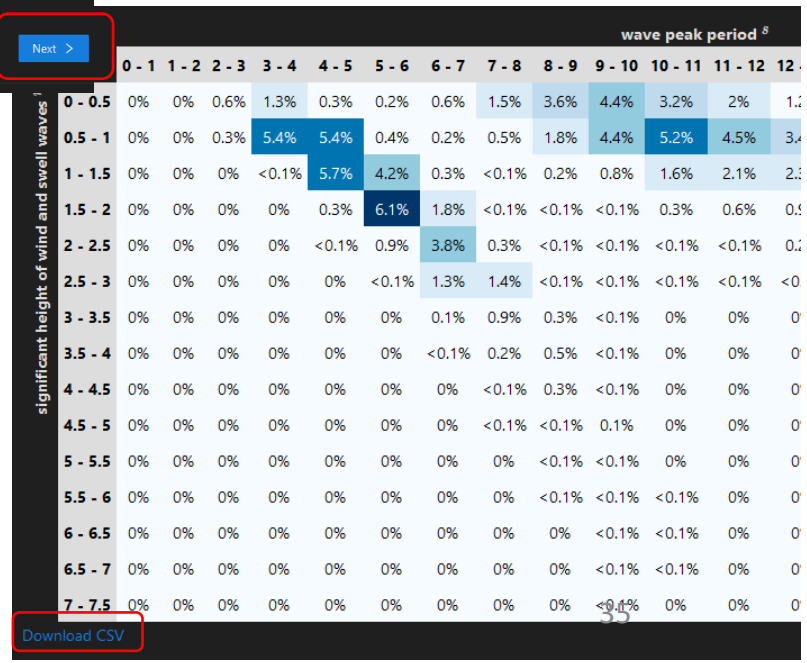
- Select the point you are interested in.
- Click Next.
- On the following screen, select Data Matrices.
- Navigate to Significant wave height vs Peak period and download the data as a CSV (Comma Separated Value) file.



2



4 Save the file and open it with MS Excel



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.

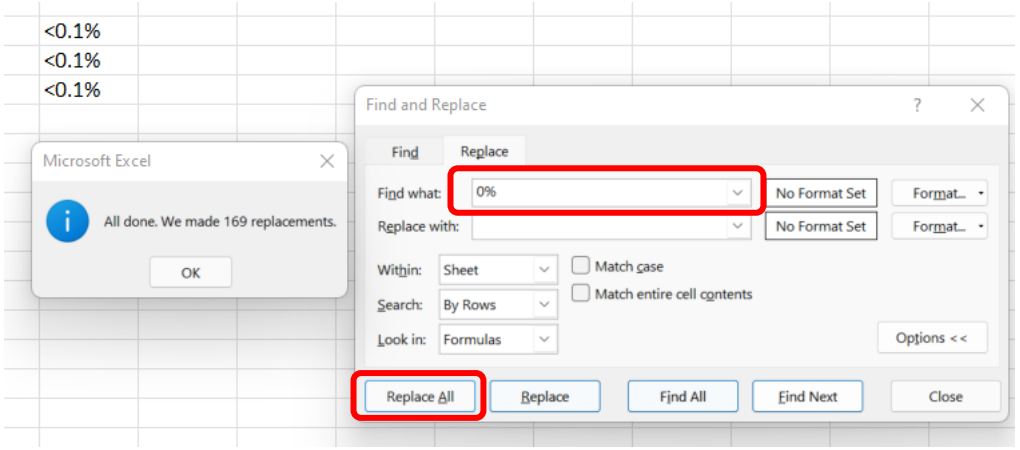
significant height	significant height
0 - 0.5	0.25
0.5 - 1	0.75
1 - 1.5	1.25
1.5 - 2	1.75
2 - 2.5	2.25
2.5 - 3	2.75
3 - 3.5	3.25
3.5 - 4	3.75
4 - 4.5	4.25
4.5 - 5	4.75
5 - 5.5	5.25

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

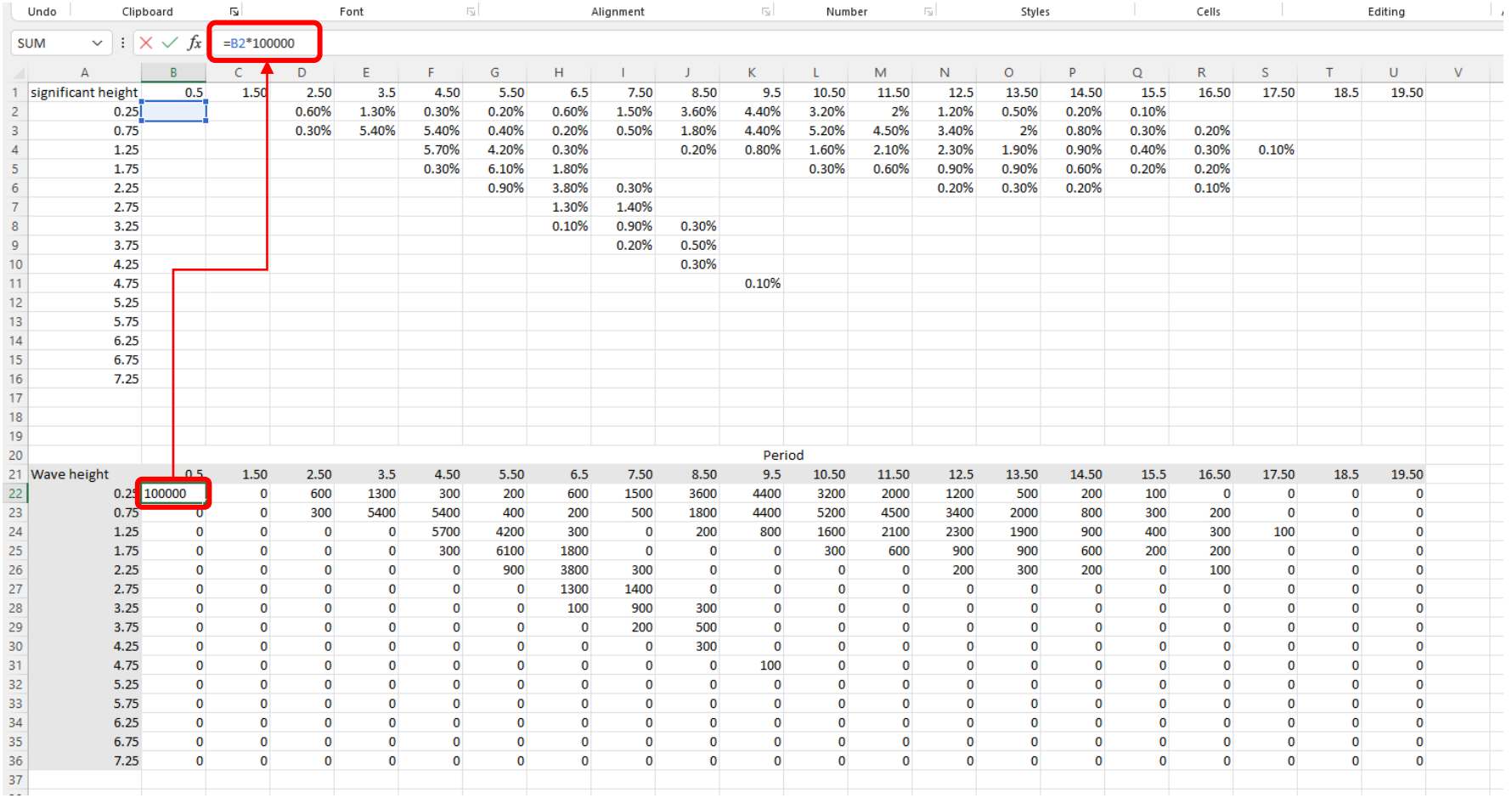
significant height	0.5	1.50	2.50	3.5	4.50	5.50	6.5	7.50	8.50	9.5	10.50	11.50	12.5	13.50	14.50	15.5	16.50	17.50	18.5	19.50
0.25	0%	0%	0.60%	1.30%	0.30%	0.20%	0.60%	1.50%	3.60%	4.40%	3.20%	2%	1.20%	0.50%	0.20%	0.10%	<0.1%	<0.1%	<0.1%	<0.1%
0.75	0%	0%	0.30%	5.40%	5.40%	0.40%	0.20%	0.50%	1.80%	4.40%	5.20%	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%	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



	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											Period											
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																						

Wave scatter data: Process data

- Copy the wave height column.
- Select the cell above the first period.
- Right click, and select "Transpose" under Paste Options.
- Create a copy of your "a11an.sea" and paste your wave occurrences in place of the existing data.
- Edit the number of heights and periods

0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25					
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	0	600	1300	300	200	600	1500	3600	4400	3200	2000	1200	500	200	100	0	0	0	0
0	0	300	5400	5400	400	200	500	1800	4400	5200	4500	3400	2000	800	300	200	0	0	0
0	0	0	0	5700	4200	300	0	200	800	1600	2100	2300	1900	900	400	300	100	0	0
0	0	0	0	300	6100	1800	0	0	0	300	600	900	900	600	200	200	0	0	0
0	0	0	0	0	900	3800	300	0	0	0	0	200	300	200	0	100	0	0	0
0	0	0	0	0	0	1300	1400	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	100	900	300	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	200	500	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	300	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

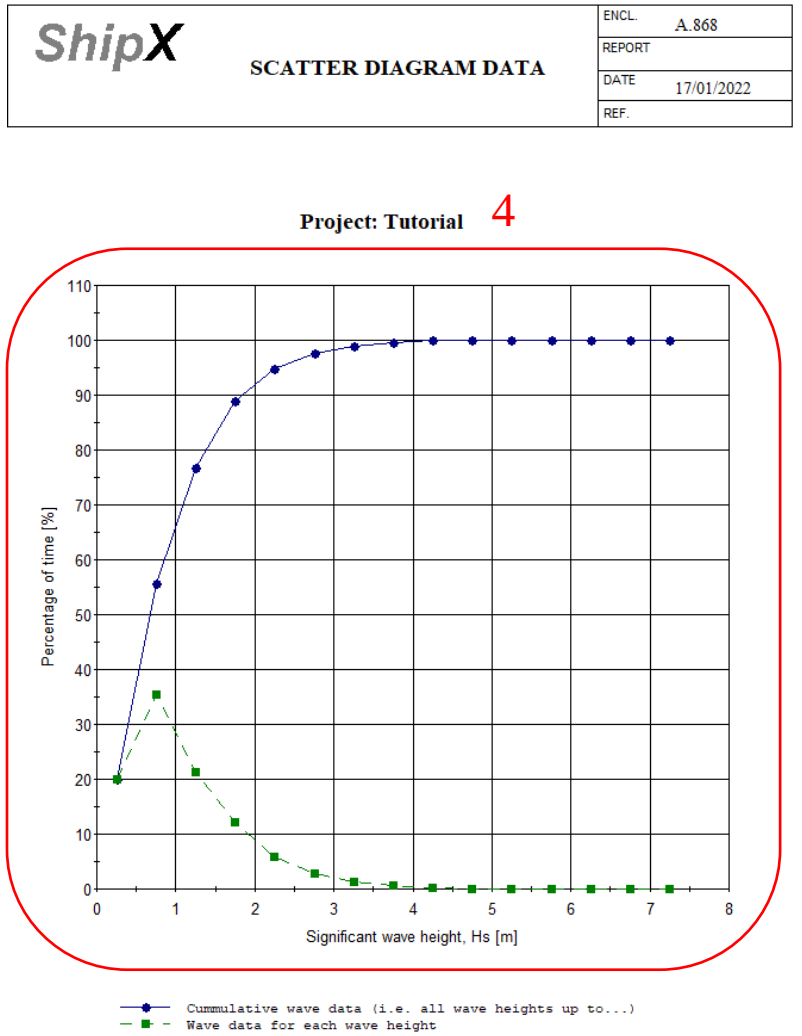
*a11an_Copy.sea - Notepad

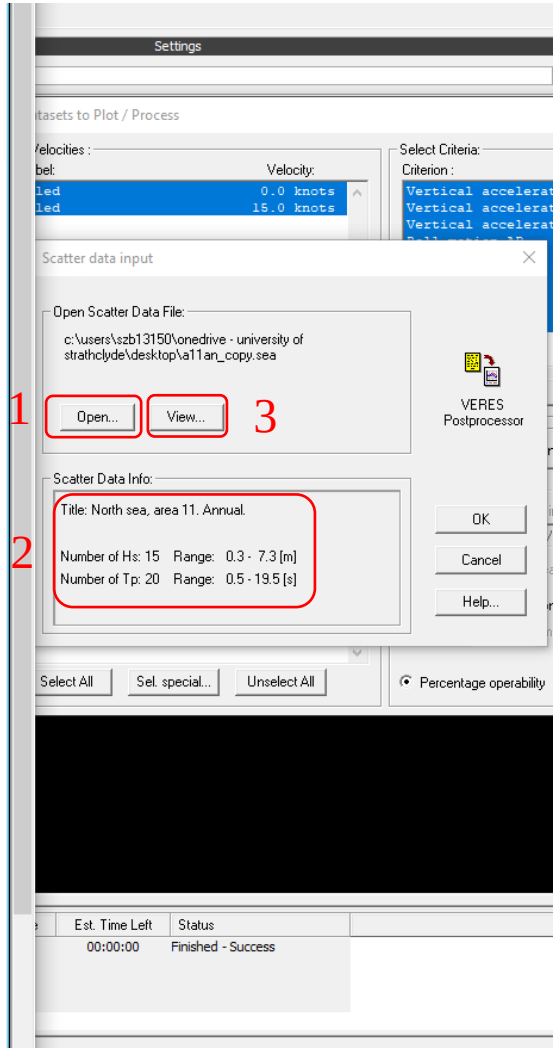
File Edit Format View Help

```
North sea, area 11. Annual.
         1         1        15        20
0.25      0.75      1.25      1.75      2.25      2.75      3.25      3.75      4.25      4.75      5.25      5.75      6.25      6.75      7.25
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         0         600       1300      300       200       600       1500      3600      4400      3200      2000      1200      500       200       100       0         0         0         0
0         0         300       5400      5400      400       200       500       1800      4400      5200      4500      3400      2000      800       300       200       0         0         0
0         0         0         0         5700      4200      300       0         200       800       1600      2100      2300      1900      900       400       300       100       0         0
0         0         0         0         300       6100      1800      0         0         0         300       600       900       900       600       200       200       0         0         0
0         0         0         0         0         900       3800      300       0         0         0         0         200       300       200       0         100       0         0         0
0         0         0         0         0         0         1300      1400      0         0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         100       900       300       0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         200       500       0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         300       0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         100       0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
END
```

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 Hs/Tp
- Click View
- Check the interpretation.





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
  - 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.