SEA Wave: Strategic Environmental Assessment of Wave energy technologies

Deliverable Report D4.5

Guidelines on secondary data and model dissemination

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Revision

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Project Information

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1 Introduction

The Deliverable Report 3.5 detailed how the data measured by project partners is to be organized and prepared (metadata) for dissemination purposes, ensuring transferability with existing data platforms, including EMODNet, SeaDataNet and Copernicus Marine Services. Hidromod is responsible for developing the Data Platform where project information and data will be manipulated, where validation of project metadata information will occur and which will generate post-processed primary data and information. Post-processed data is considered the secondary data. The platform will enable processing of numerical results obtained from hindcast wave simulations, to be made available as secondary data.

Given the variety of the data likely to be managed by the platform and the different forms of outputs likely to be produced, a framework for secondary data generation is required to deliver a simple and useful Data Platform. This report provides a detailed description of the proposed secondary data generation framework and the processing steps needed in the Data Platform considering the type of secondary data requirements (format and size) to be met, including conformity with primary metadata information, data storage, access and dissemination methodologies.

2 Secondary Data Produced within SEA Wave

2.1 Data Type, Models, Methodologies and Dissemination

2.1.1 Environmental data

During each period of fieldwork a set of primary data are generated from the measurements taken by the different instruments (Table 1). Different types of secondary data can be generated as:

- Campaign analysis reports;
- Graphs/tables of datasets and/or subsets (identical for all .csv data);
- Post-processed videos highlighting relevant information of the campaigns.

Each secondary data type is aimed at different users. Therefore, this may change in latter stages of the project as partners may want to disseminate different/additional types of secondary data (eventually driven by users of the Data Platform).

A first iteration of secondary data to be made available in the Data Platform is described in Table 1.

Device	Equipment Type	Data description	Primary Data Format	Processing	Secondary Data
Towed camera	Bowtech Camera	Species abundance & diversity	.csv	Expert makes a report	.pdf report containing graphical outputs and interpretation
Baited camera	BRUV systems	Species abundance & diversity	.csv	Expert makes a report	.pdf report containing

Device	Equipment Type	Data description	Primary Data Format	Processing	Secondary Data
				Specific algorithm	graphical outputs and interpretation
Fisheries acoustics	Simrad EK80	NASC	.raw (size prohibits direct sharing)	Expert makes a report.	.pdf report;
Ambient acoustics	Jasco AMAR-G3	Third Octave Band	.wav (size prohibits direct sharing)	Expert makes a report.	.pdf report;

Table 1: Summary of devices from survey campaigns, primary and secondary data including processing steps.

2.1.2 Wave Energy Data

From the hindcast wave data a set of post-processed analysis and data representation are proposed following the standards of the technical specifications (TS) for wave energy resource assessment provided by the International Electrotechnical Commission (IEC), IEC TS 63600-101, hereafter TS101. Given the large amount and variety of primary data available, different data combinations and processing procedures are possible. Therefore, in order to create a platform development strategy it is important to rank, with partners and users, the relevance of each possible secondary data for their progressive implementation in the platform.

Below a set of post-processed products are presented considering the information in TS101:

- Characteristic wave height
- Characteristic wave period
- Omni-directional wave power
- Maximum directionally resolved wave power
- Maximum directionally resolved wave power
- Direction of maximum directionally resolved power

For each parameter the following statistics with different time intervals (i.e. annual, seasonal, monthly) are suggested:

- Mean
- Standard deviation
- Median for 50th percentile
- 10th percentile
- 90th percentile
- Maximum

- Minimum

The results can be displayed for spatial maps (mainly to evaluate spatial variabilities) and at discrete point locations (to identify temporal properties). Table 2 describes the steps to secondary data generation (respective primary data and processing) considering the parameters indicated above.

Primary Data	Data and Processing	Secondary Data
Spatial maps and discrete point analysis		
H_s	NA	Significant wave height (Figure 1)
T_p	NA	Peak period. (Figure 2)
T_p	$T_e = 0.857T_p$ (bulk parameters only) $T_e = T_{-10} = \frac{m_{-1}}{m_0}$	Energy period, T_e
H_s, $T_p$and Wave number *k* from T_e.	$C_gE = C_g\frac{1}{16}\rho_w g H_s^2$ $C_g = \frac{2\pi}{k}\left(1+\frac{2kh}{\sinh(2kh)}\right)$	Wave power/ Energy Flux. **(**Figure 3, Figure 4 and Figure 5**)**
H_s, T_{01} (mean wave period) and T_{02}(zero-crossing wave period)	$\epsilon_0 = \sqrt{\frac{m_0m_2-1}{m_1^2}}$ $m_0 = \frac{H_s^2}{16}$ $m_1 = m_0T_{01}^{-1}$ $m_2 = m_0T_{02}^{-3}$	Spectral width, ϵ_0**.** **(**Figure 2 and Figure 3**)**
H_s, T_p and θ (mean wave direction). For each sea partition	$\Theta_M = argmax(J_{\Theta_i})$ $\Theta_{j\epsilon}(0,\dots.,2\pi)$	Direction of maximum directional resolved wave power, Θ_M**.**
H_s, T_p and θ (mean wave direction). For each sea partition	$J_\Theta = \rho_w g\sum_{j=1}^{n} c_{gj}(T_{pj},d)\frac{H_{sj}^2}{16}max\{($ $-\Theta)\}$ n=number of sea partitions $J_M = maxJ_{\Theta_i}$ $\Theta_{j\epsilon}(0,\dots.,2\pi)$	Maximum directionally resolved wave power, JM
H_s, T_p and θ (mean wave direction). For each sea partition	$d_\Theta = \frac{J_M}{C_gE}$	Directionality coefficient, d_Θ**.** **(**Figure 3 and Figure 4**)**
H_s *and* T_p.	Univariate and bivariate histogram visualization under implementation in the platform.	Joint probability distribution of sea states (Figure 6 and Figure 7)

Primary Data	Data and Processing	Secondary Data
H_s *and* T_p.	Visualization under implementation in the platform.	Cumulative distribution (Figure 8 and Figure 9)
Operational and planning logistics		
H_s , T_p, wind intensity …	Under implementation in the platform.	Weather windows (Figure 10)
Design and Development		
H_s *and* T_p.	Based on WEC Design Response Toolbox (WDRT) methodology developed by Sandia National Laboratories. Under implementation in the platform.	Extreme wave analysis (Figure 11)

Table 2: Types of wave primary and secondary data including processing steps.

The figures below show examples of graphical representation of different post-processed wave information.

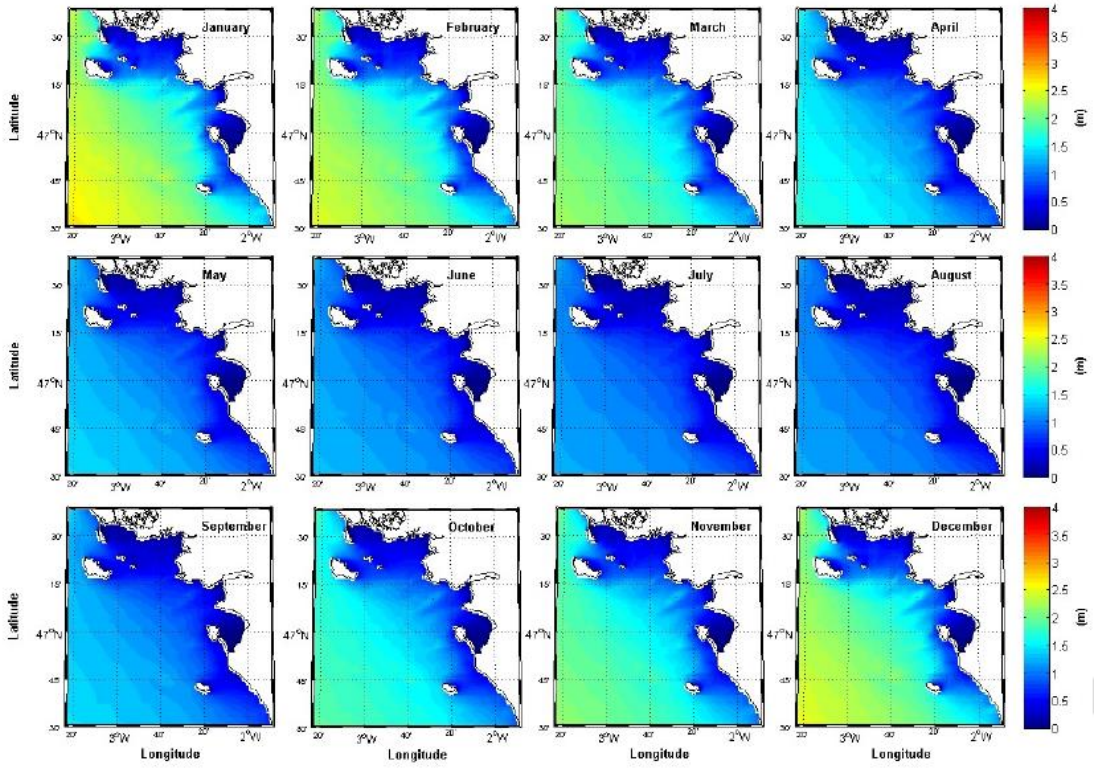

Figure 1: Significant wave height, monthly mean. From Gonçalves el al 2018.

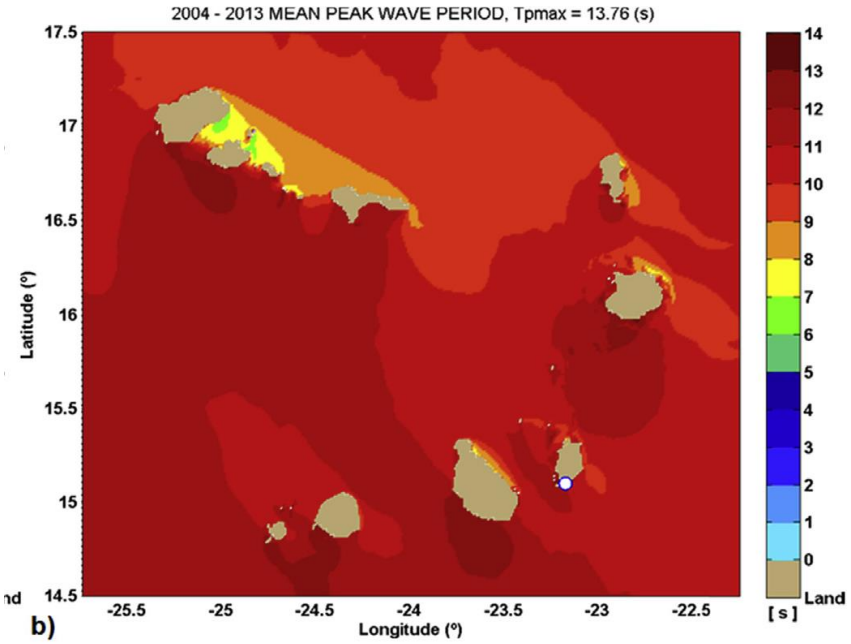

Figure 2: Mean peak period, from 2004-2013. From Bernardino et al. 2017.

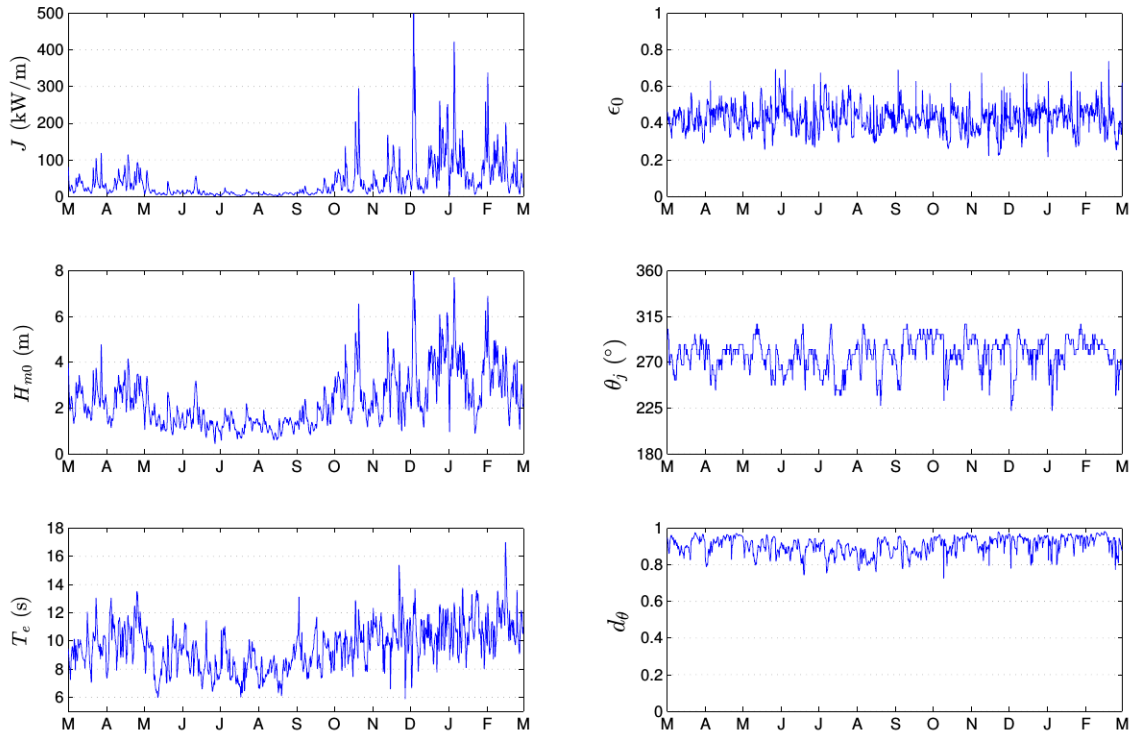

Figure 3: Annual record of the six parameters described above. From Dallman and Neary (2015).

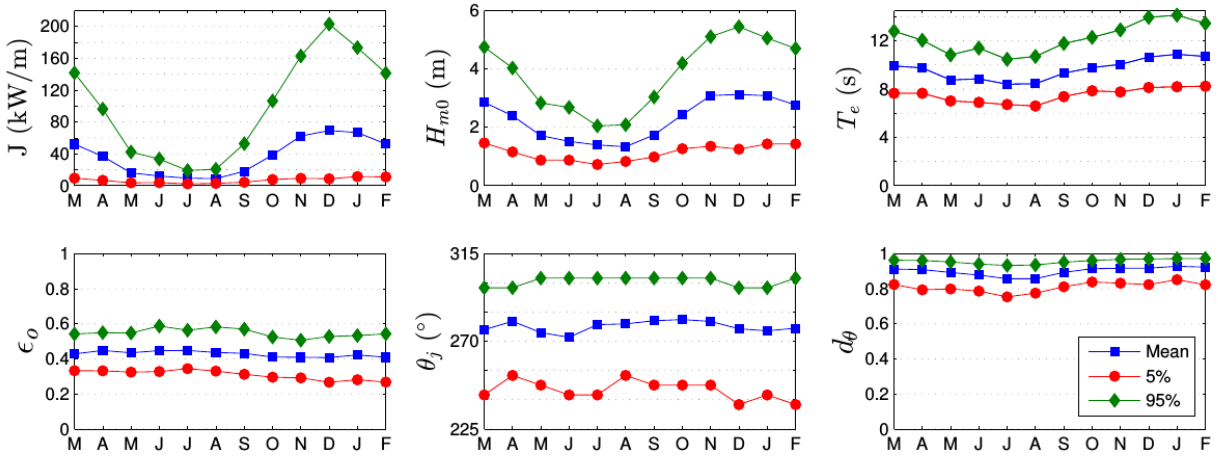

Figure 4: The average, 5th and 95th percentiles of the six parameters defined above. From Dallman and Neary (2015).

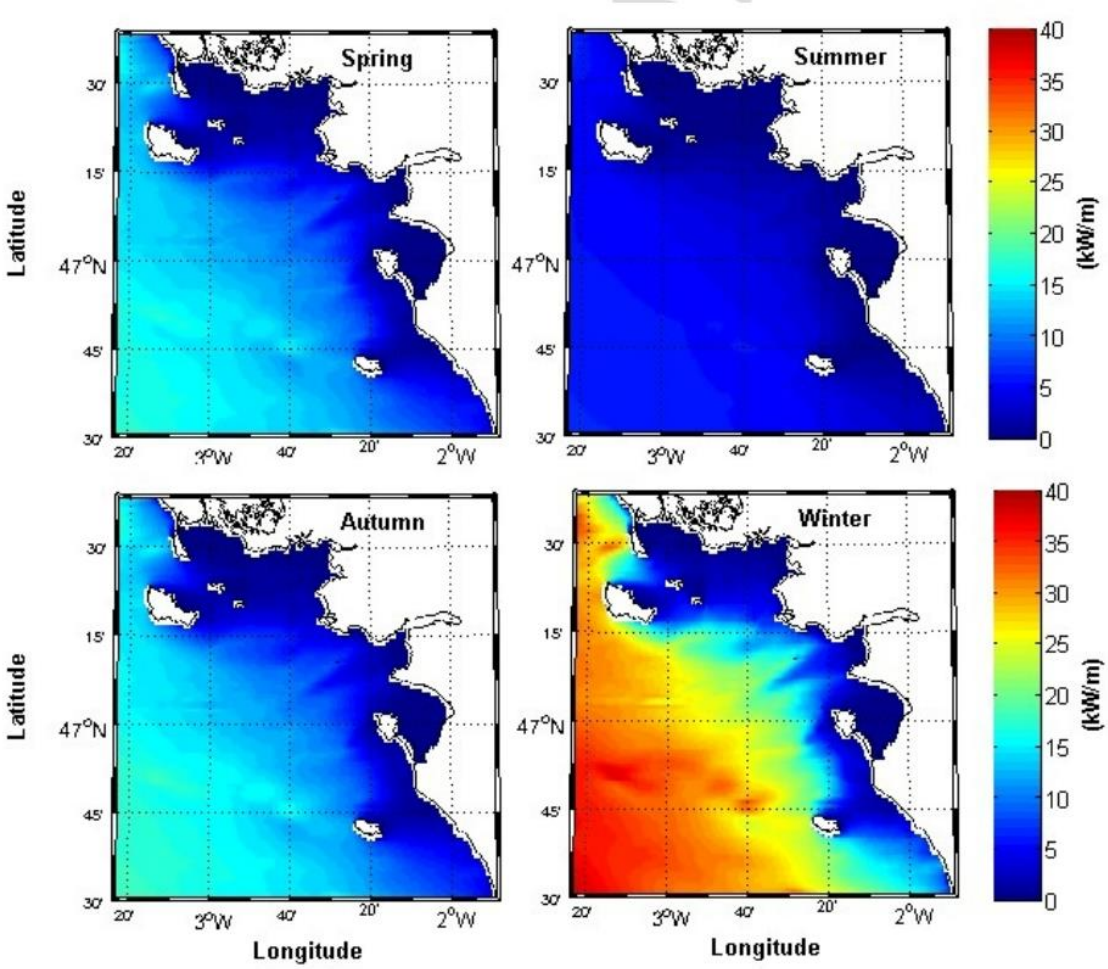

Figure 5: Seasonal mean wave power. From Gonçalves et al. 2018.

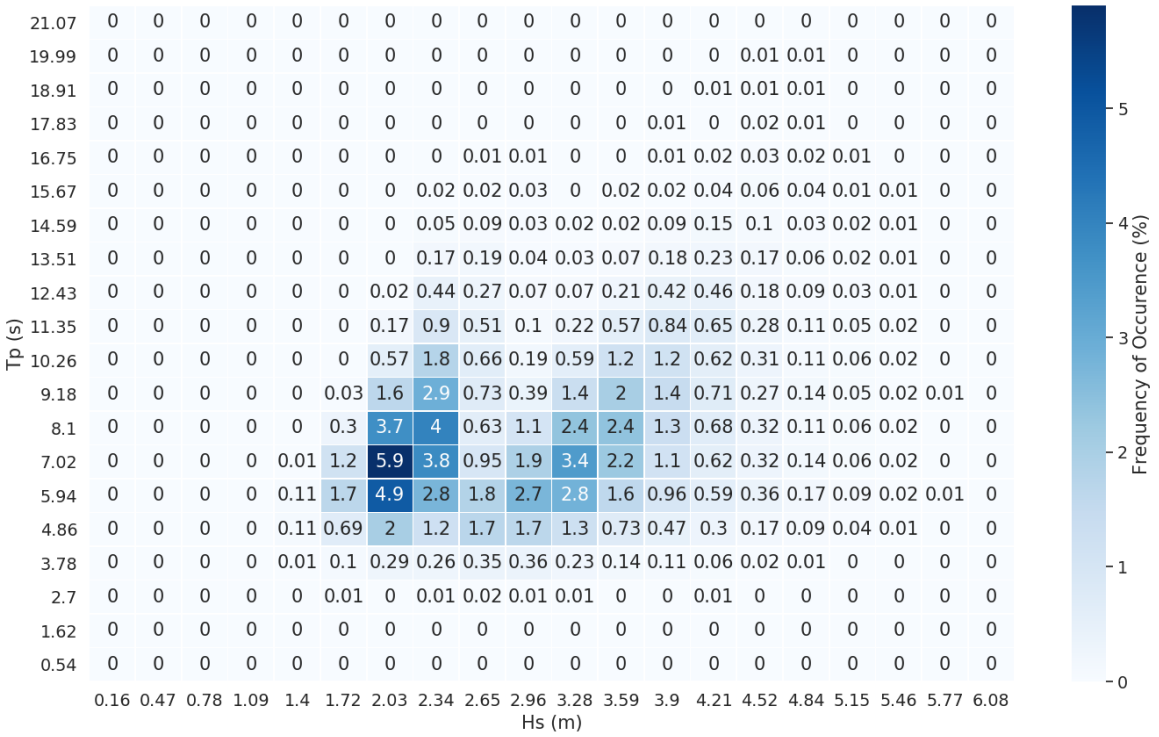

Figure 6: Joint probability distribution of sea states.

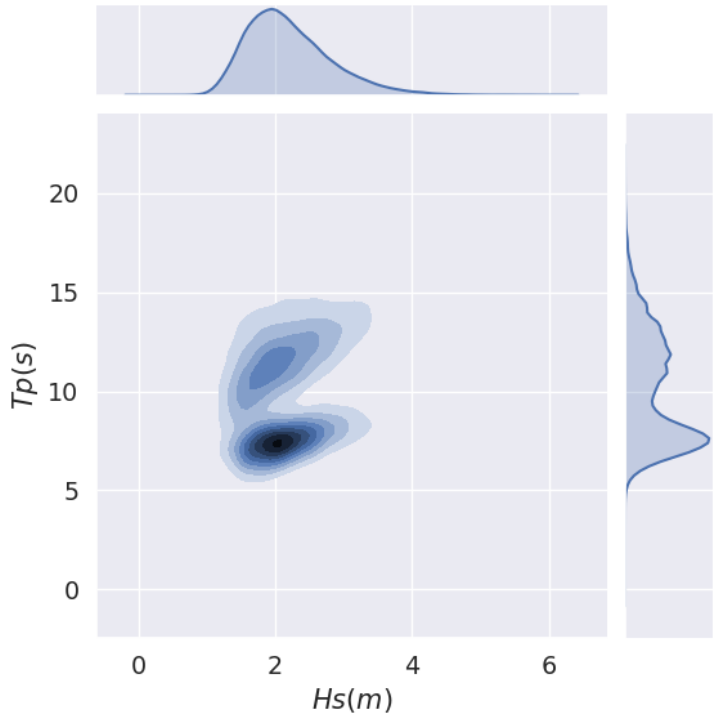

Figure 7: Scatter plot of *Tp* and *Hs* with their respective histogram.

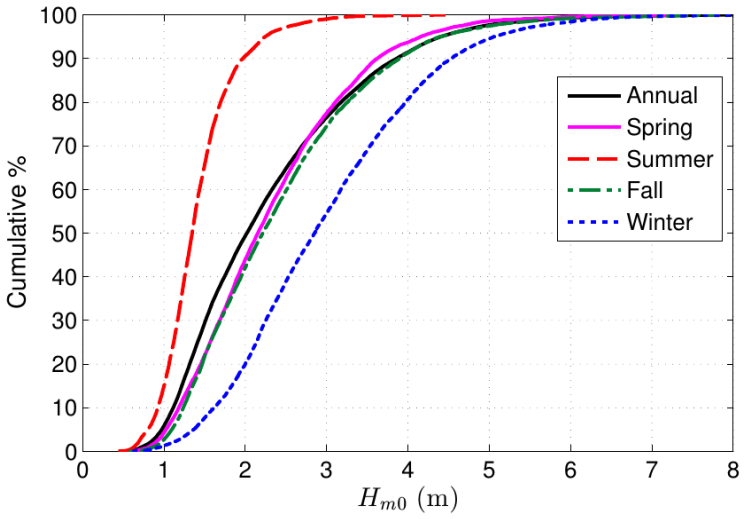

Figure 8: Annual and seasonal cumulative distributions of significant wave height. From Dallman and Neary (2015).

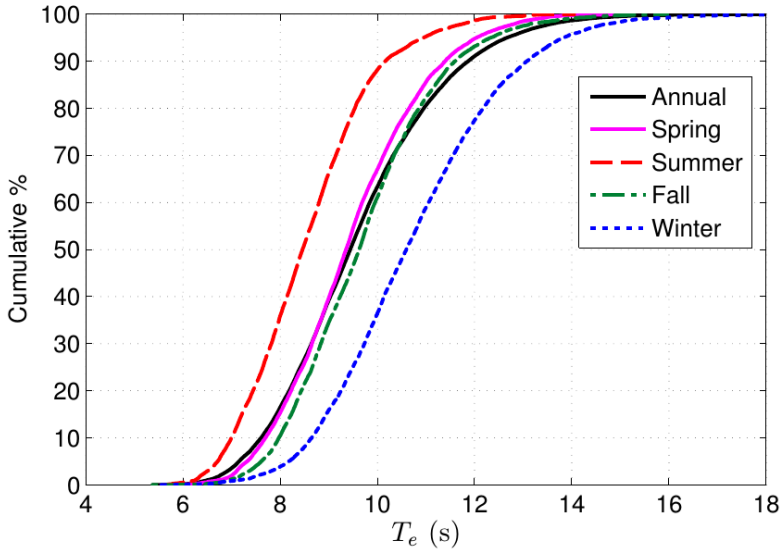

Figure 9: Annual and seasonal cumulative distributions of energy period. From Dallman and Neary (2015).

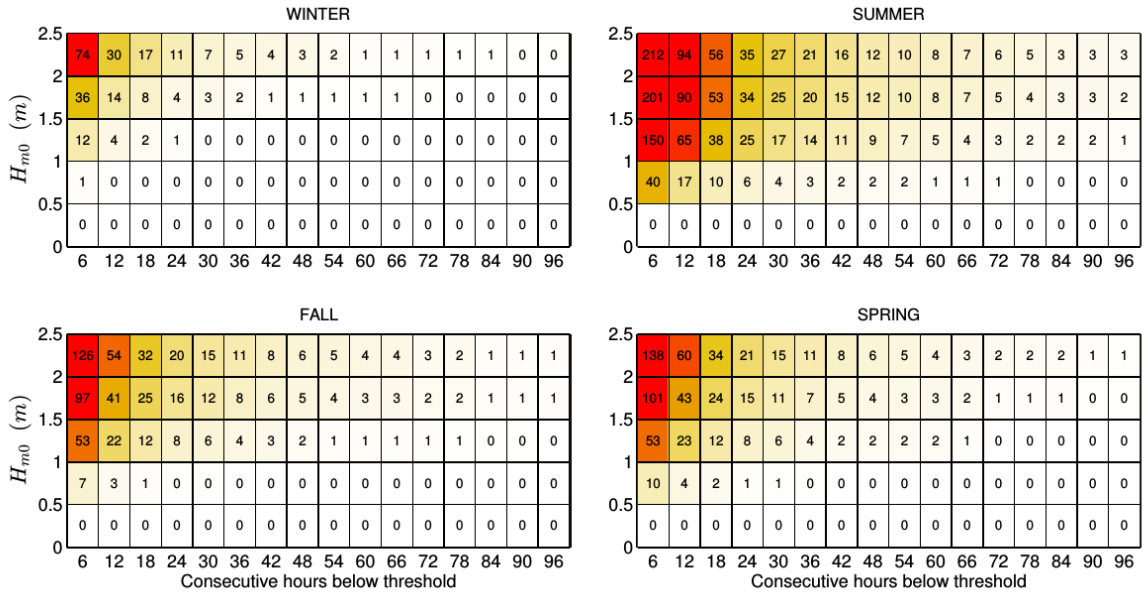

Figure 10: Average cumulative occurrences of wave height thresholds (weather windows). With an additional restriction of U≤ 15 mph. From Dallman and Neary (2015).

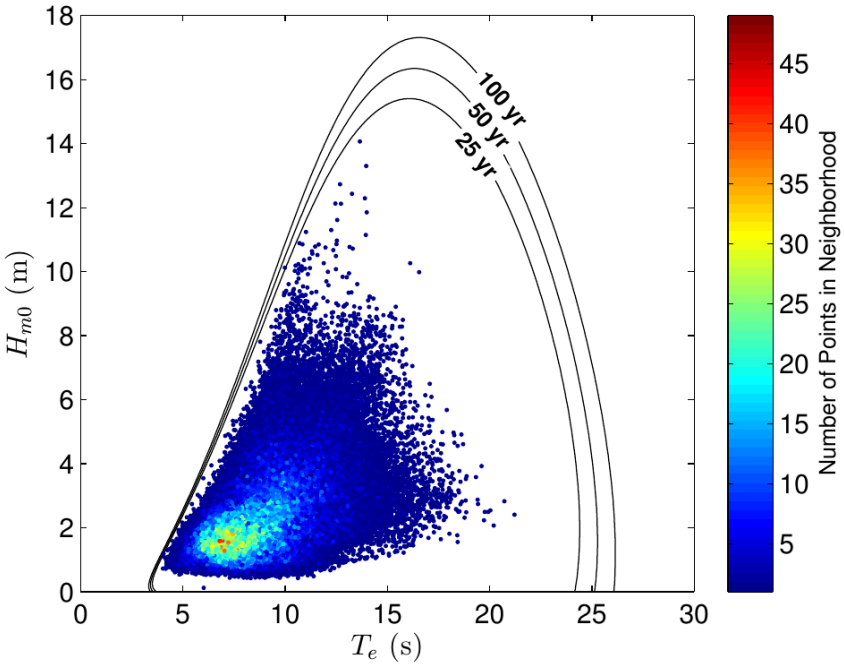

Figure 11: 100-year contour for NDBC 46050 (1996-2014). From Dallman and Neary (2015).

2.2 Metadata Information

Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. In the Deliverable Report 3.5 detailed information regarding primary metadata standards have been provided. It is important to create procedures to ensure secondary data conformity with primary data metadata. Figure

14 shows an example of metadata information generated for the technical report of monthly observations of seabirds near the wave energy converter at Wave Hub (Figure 13).

2.3 Data Storage, Access and Delivery

Data storage and access are two important aspects that will guide the platform´s interaction with the user. The information displayed in the platform will have datasets stored in a dedicated and third-party server (i.e. EMODNet, SeaDataNet and Copernicus Marine Services). For the data stored in the dedicated server predefined steps to data storage will be designed considering the characteristics of each data type. For instance, the integral wave parameters obtained from the hindcast simulations are stored in NetCDF files with the metadata complying with the Climate and Forecasts (CF) Convention.

Regarding data access and delivery, the platform is designed to work with distinct set of operations depending on the data location, data access (authentications) and data size:

2.3.1 Data stored in a dedicated server

Depending on the size of the data and computational processing demand two forms of data delivery are possible:

- on the fly: via immediate access to the information with direct download and/or processing, by the user's choice as:
  - Time series of integral wave parameters (Figure 3).
  - Scatterplots of wave integral parameters (Figure 6 and Figure 7).
  - Pdf reports (example in Appendix, Figure 13).
  - Spectrograms (example in Appendix, Figure 15).
- via request: for large amounts of data a request is sent to a queue and made available to the user when ready. Information or a notification can be sent via email.
  - Large datasets (time and space) of significant wave height, wave peak period and wave direction.

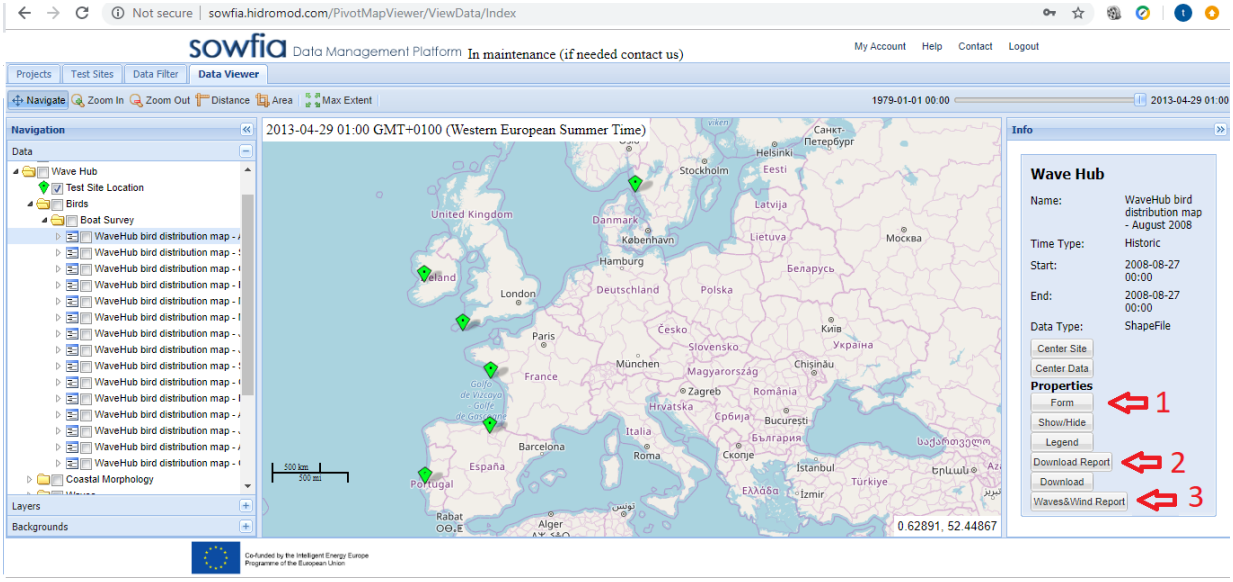

Figure 12: SOWFIA's data platform interface. Left panel shows the data available in the folder, mid panel geo-data visualisation. Right panel displays the data information and options for secondary data download. Red arrow 1 – metadata form (Figure 14), red arrow 2 – fieldwork technical report (Figure 13) and red arrow 3 – option to download wave information related to the period of the field campaign.

2.3.2 Data stored in third-party servers

Data delivery and/or processing in the platform will work similar to the data stored in the dedicated server except when further authentications are needed, therefore the following two procedures are possible:

- request and download the information from the platform.
- the platform will redirect the user to the specific location where the information is stored.

Appendix

Figures below show examples of metadata information and secondary data types made available to the user via SOWFIA's Data Platform.

This project has been co-funded by the European Maritime and Fisheries Fund (EMFF) of the European Union

Analysis of observed seabirds during monthly surveys at Wave Hub

August 2008 to March 2013

A refined data product for SOWFIA

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University of Exeter, UK
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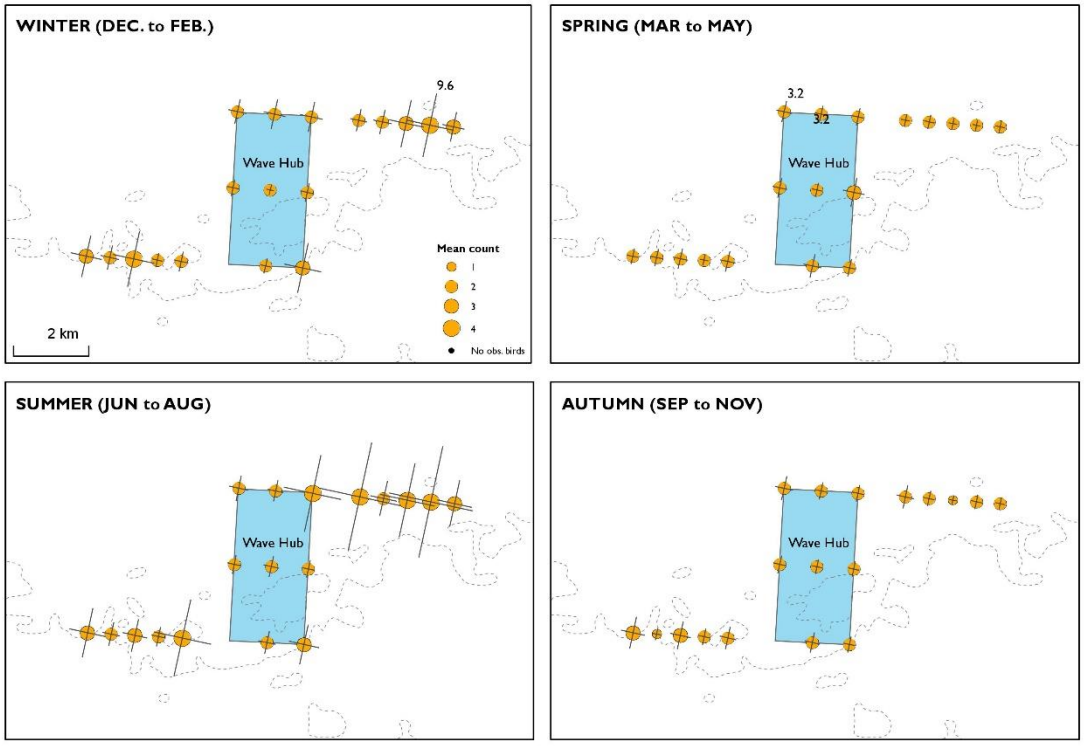
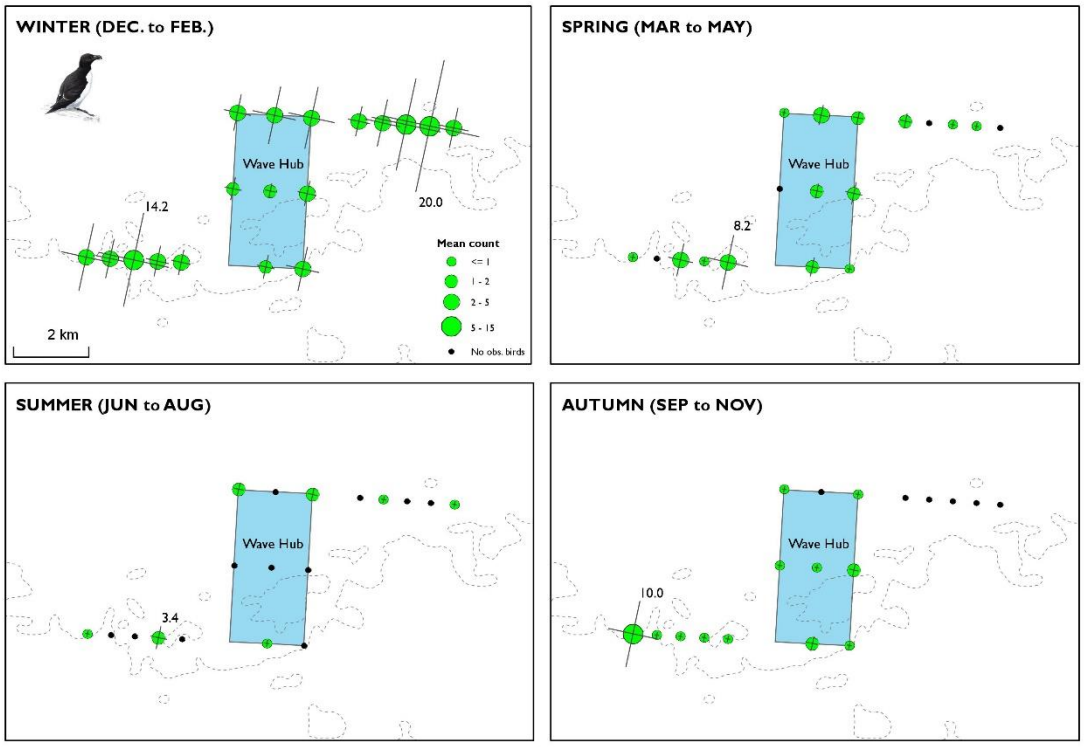
18th April 2013

Observed seabirds [ALL SEABIRDS] at Wave Hub derived from monthly boat-based surveys (2008 to 2013; n = 28 surveys)
Standard deviation for counts indicated by error bars (cross hairs), arabic numbers provide indication of error. Five minute counts at each location. Birds with 300 m of survey vessel only.



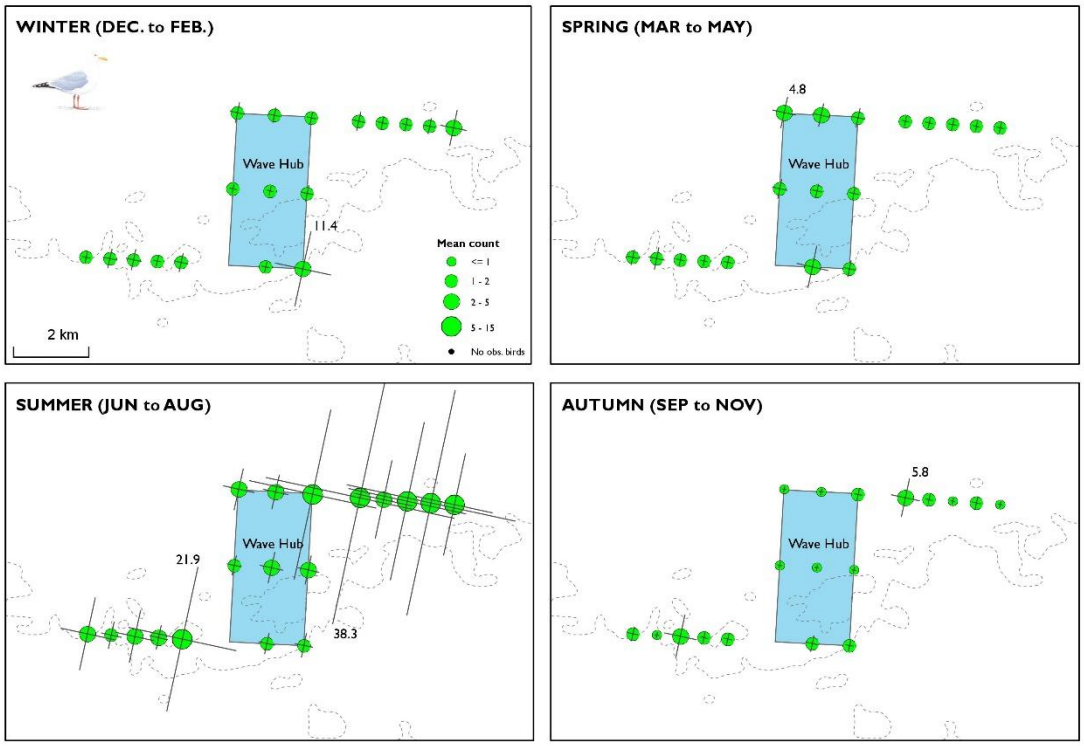
Observed seabirds [ALCIDAE; Auks] at Wave Hub derived from monthly boat-based surveys (2008 to 2013; n = 28 surveys)

Standard deviation for counts indicated by error bars (cross hairs), arabic numbers provide indication of error. Five minute counts at each location. Birds with 300 m of survey vessel only.



Observed seabirds [LARIDAE; Gulls] at Wave Hub derived from monthly boat-based surveys (2008 to 2013; n = 28 surveys)

Standard deviation for counts indicated by error bars (cross hairs), arabic numbers provide indication of error. Five minute counts at each location. Birds with 300 m of survey vessel only.



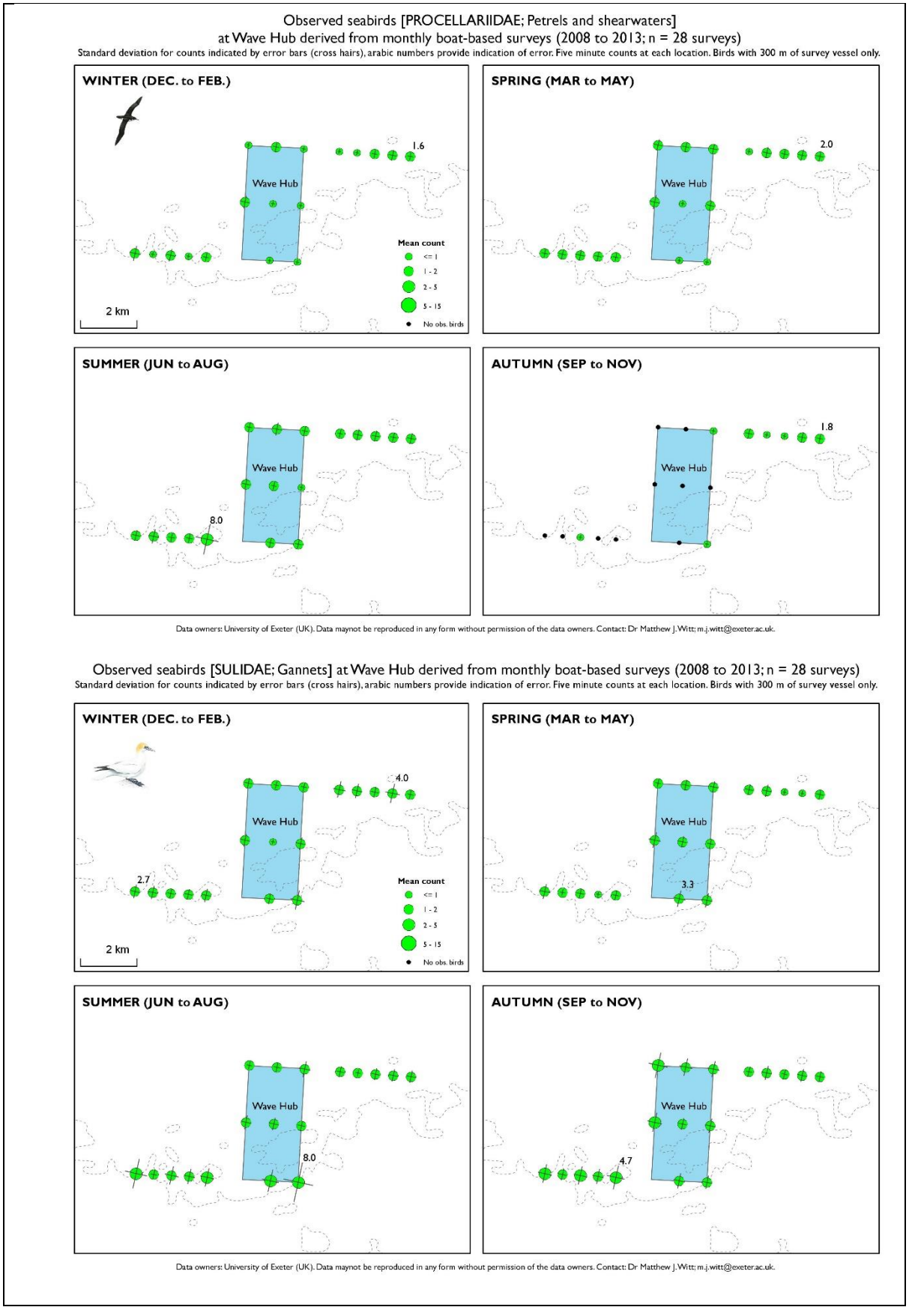


Figure 13: Example of secondary data download directly from the Data Platform (Red arrow 2, Figure 12).

Common Data Designation: WaveHub bird distribution map - August 2008
Name of Institution That Has Colected Data: University of Exeter
Test Site: Wave Hub
Why Monitorizing Data: Baseline bird distribution data at WaveHub prior to installation of wave energy devices
Environmental Parameters - Methods: Birds - Boat Survey
Data Type: ShapeFile
Classification: biota
Conformities Date: 2012-09-27 00:00
Conformities Type: revision
Conformities Degree: Not conformant
Conditions Access Use: Conditions unknown
Limitations Public Access: (e) intellectual property rights
Lower Left X: -5.6738
Lower Left Y: 50.3396
Upper Right X: -5.54827
Upper Right Y: 50.3878
Resource Title: WaveHub bird distribution map
Resource Locator: http://www.primare.org/?p=104_3
Resource Locator:
Identifier Code: WaveHub bird distribution map
Identifier Namespace:
Keyword: Species distribution
Keyword Title: GEMET - INSPIRE themes, version 1.0
Keyword Date: 2012-07-20 00:00
Keyword Type: revision
Keyword: ANIMALS/VERTEBRATES
Keyword Title: GEOSS - Earth Observation Vocabulary, version 1.0
Keyword Date: 2011-05-01 00:00
Keyword Type: publication
MetaData Language: eng
MetaData Institution: University of Exeter
MetaData Date: 2012-09-27 00:00
Quality Lineage: Data validated.
Responsible Role: 5
Responsible Institution: University of Exeter
Date Of Publication: 2011-05-01 00:00
Date Last Revision: 2012-09-27 00:00
Date Of Creation: 2012-09-27 00:00
Start Date: 2008-08-27 00:00

Figure 14: Metadata form generated for the report in Figure 13.

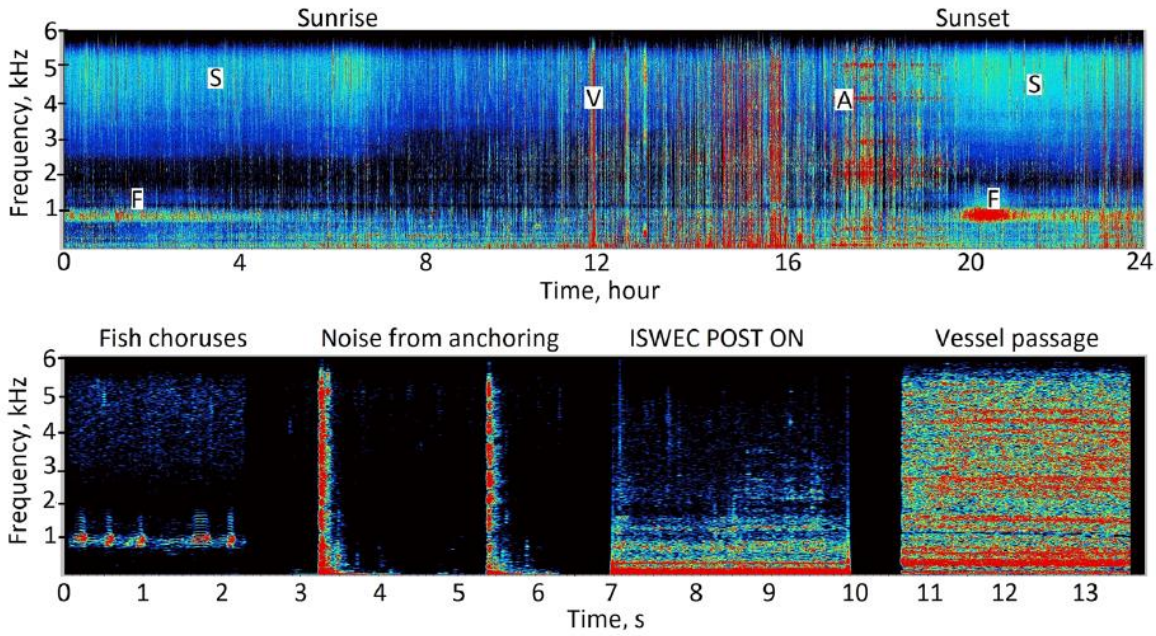


Figure 15: Top: One-day continuous spectrogram (6 September 2015) showing the snapping shrimp sound (S), fish choruses (F), anthropogenic noise caused by the passage of vessels (V), and the noise due to the (A) anchoring system of the ISWEC. Below: Fish choruses, noise from the anchoring system (POST), noise from the ISWEC activated for energy conversion (Post ON) and noise from vessel passage (Buscaino et al. 2019).

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