

# EMODnet Thematic Lot n°0 - Bathymetry – High Resolution Seabed Mapping (HRSM2)

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Start date of the project: 18/12/2018 - (24 months)

### **EMODnet Phase III – Interim/Final Report**

**Reporting Period: 18/12/2018 – 17/12/2020** 





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### Disclaimer

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### **Executive summary**

This report describes the activities and results of the **EMODnet Bathymetry - High Resolution Seabed Mapping – Bathymetry** contract (HRSM2) which ran for 2 years from 18<sup>th</sup> December 2018. It is a follow-up of the earlier projects which took off in June 2009 and that resulted in the EMODnet Bathymetry portal<sup>1</sup> with several services and products.

One part of the project was dedicated to training and supporting data providers in further populating data collections in the SeaDataNet CDI data discovery and access service and the SeaDataNet Sextant catalogue. These data collections served as input for generating regional DTMs (Digital Terrain Model) for 11 European sea basins.



Image: Workflow for EMODnet HRSM2

The methodology, software tools, and guidelines for gathering and processing bathymetric survey and composite DTM data sets from data providers into regional DTMs were improved. The Globe software for generation of the Regional DTMs was upgraded and now supports NetCDF V4, facilitating to handle larger data files. Not only regional coordinators used Globe, but also all data providers for pre-processing and pre-gridding their data inputs to regional coordinators. This way there was a harmonized process in all steps, fully supported by metadata from CDI and Sextant references. As a next step, the regional DTMs were validated and integrated into the full EMODnet DTM.

13<sup>th</sup> January 2021 a new 2020 version of the EMODnet DTM was officially released in sync with the GEBCO conference, hosted by Shom, coordinator of EMODnet Bathymetry. Compared to the 2018 release, grid resolution has continued at 1/16 \* 1/16 arc minutes (circa 115 \* 115 m<sup>2</sup>). This way, it contains approx. 12.3 billion grid nodes, organized in 113892 columns and 108132 rows (seabed and terrestrial coverage included) (for comparison: GEBCO has 933 million grid nodes for worldwide coverage). From all the data sources gathered, a total of 16.260 unique CDI references and CDTM references are used in the 2020 DTM (9.456 in 2018 version).

Special features of the new 2020 DTM release are:

- Covering all European seas including part of the Arctic Ocean and Barents Sea;
- Freely available in a versatile Viewer and Download service and by OGC web services (WMS, WFS, WECS, WMTS)
- A powerful 3D bathymetry visualisation functionality in the viewer without plugins;

<sup>&</sup>lt;sup>1</sup> <u>https://www.emodnet-bathymetry.eu</u>



- Inclusion of Satellite Derived Bathymetry data products, in particular for coastal stretches of Spain, Greece, Croatia, Italy, and Cyprus;
- Updated source reference layer with quality indication sublayers: the source reference layer gives a map with polygons which correspond to contributing surveys and composite DTMs for which related metadata can be retrieved. Quality index gives classifications for vertical, horizontal and temporal indicators, purpose of the survey, and information about commonly adopted standards;

In addition, several other updated product releases were generated and published:

- An updated inventory and report presenting baseline and coastline data as collected from 26 national authorities (versus 21 previously), downloadable from the portal together with shapefiles of the baselines and coastlines;
- An updated set of best-estimate coastlines, determined from satellite data (typically Sentinel-2 and Landsat-8) and in combination with an upgraded Global Tide Surge Model (GTSM) processed into digital coastlines for the European seas at LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water), integrated in the Bathymetry Viewer and Download service;
- Thanks to the GTSM, DTM tiles of the 2020 Version can be downloaded both relative to LAT and MSL reference levels;
- The multi-resolution layer has been expanded consisting of a collection of even higher resolution composite DTMs for selected areas which have been gathered and processed by data providers into High Resolution DTM (HR-DTM) files. The resolution of HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. The HR-DTMs can be viewed, interrogated for metadata and downloaded by an extra HR-DTM layer in the Bathymetry viewer.



Figure: New 2020 EMODnet DTM for European seas



Finally, the range of products and services has been expanded with the first release of the exciting **EMODnet Bathymetry World Base Layer (EBWBL)** service, covering a standard grid resolution for topography and bathymetry for the whole world as a combination of EMODnet DTM, GEBCO 2019, and a satellite derived Digital Terrain Model for landcover. The EBWBL is only published as OGC WMTS service, available for many purposes and in various projections, e.g. nonprojected coordinate system, Web Mercator, Inspire compliant projection and projections adapted to both poles.

EMODnet Bathymetry continued its success with many user groups, which can be underpinned by more than 70.000 DTM tile downloads by circa 7.400 users, more than 50 million OGC service requests, and circa 300 references to EMODnet Bathymetry in papers and books according to Google Scholar in the project period of 2 years.



# **1. Introduction**

This report will describe the activities and results of the **EMODnet Bathymetry - High Resolution Seabed Mapping contract (HRSM2)** project which ran for 2 years from 18<sup>th</sup> December 2018.

EMODnet Bathymetry is being developed in the framework of the European Marine Observation and Data Network (EMODnet) as initiated by the European Commission. This is done in a series of EMODnet Bathymetry contracts, assigned by EASME since June 2009.

The main objective of EMODnet Bathymetry is to create and maintain an operational service providing free and open access to digital maps of the seabed topography and the coastline of European seas at the highest resolution possible and to the survey data underlying them.

In order to do so, the EMODnet Bathymetry portal<sup>2</sup> provides open and free access to the bathymetry of the European seas by means of the EMODnet Digital Terrain Model (DTM) at a grid resolution of 1/16 arc minute  $\times$  1/16 arc minute (approximately 115 m width and 60 to 90 m height, depending on latitude), covering all the European seas, along with metadata of bathymetric surveys and pre-gridded products which are held by multiple organisations such as Hydrographic Offices, research organisations and private companies.

The viewing and downloading services at the portal give users wide functionalities to interact with the **EMODnet DTM** and all its constituents, including free downloading of the DTM in tiles in various formats. They are also made available by means of OGC (Open Geospatial consortium) web services (WMS, WFS, WCS, WMTS).

Moreover, the portal services give access for viewing and downloading of a **best-estimate digital European coastline**, and selected areas that are covered with **higher resolution DTMs** (**HR-DTMs**), with resolutions of 1/32 to 1/512 arc minute, depending on the data policy of the data provider or prevailing national policy. These HR-DTMs are covering areas of particular interests such as, for example, canyons, sea mounts, hydraulic sand dunes and coastal areas. In addition, the portal gives access to **an inventory of European baselines**.

The focus in the latest project has been on improving and optimizing existing services and products and expanding the data collections, which serve as underlying basis. This has resulted in new releases of the EMODnet DTM and the best-estimate coastlines, expansion of the series of HR-DTMs, and an updated inventory of national baselines.

On top of this, EMODnet Bathymetry has generated and released the EMODnet World Base Layer (EBWBL) service, covering both water and land at a global scale, and published only as an OGC WMTS service to serve as basemap for various applications.

The latest project has been a seamless continuation of the previous EMODnet High Resolution Seabed Mapping (HRSM) project which was undertaken by the same consortium. It was coordinated by Shom (France), while MARIS (Netherlands) acted as technical coordinator. The project consortium brought together 41 participants from 20 countries (18 EU member states) along European seas, mostly major marine research institutes (17) and national hydrographic services (16), complemented with experts in portal and services development, data management, system architecture analysis, INSPIRE, ISO, OGC, product visualisation, Satellite Derived Bathymetry and tidal modelling. Furthermore, the consortium included representatives of GEBCO (General Bathymetric Chart of the Oceans), BSBD (Baltic Sea Bathymetric Database), NSBD (North Sea Bathymetric Database), and IBCAO (International Bathymetric Chart of the Arctic Ocean) for close cooperation and cross-fertilisation. This way the project has been implemented by a group that not only brought together bathymetric and coastal data resources from most coastal countries in Europe, but also combined a wealth of national expertise and local knowledge about their data and their marine and coastal domains, which is essential for producing and validating high quality pan-European data products which will then meet acceptance by a large user community. Moreover, there are established relations with the international hydrographic community which contributed to international interoperability and synergies.

<sup>&</sup>lt;sup>2</sup> <u>https://www.emodnet-bathymetry.eu</u>



The report will describe the overall approach and methodology, the roles and activities undertaken by the consortium, and the achieved results in the contract period of 2 years until 18 December 2020. In addition, it will provide a set of indicators about the coverage and use of the EMODnet Bathymetry services and products, which are included in a separate Excel file with multiple spreadsheets.



## 2. Highlights

#### Number of bathymetry data sets gathered:

Data providers have further populated the EMODnet Bathymetry catalogue services and made bathymetric data sets ready for use by the basin coordinators. The total number of **CDI records** for survey data sets has increased from **27.168 to 30.560** records by multiple data providers. The number of **Composite DTM entries** has increased from **147 to 207** and the number of **High Resolution DTMs** went from **196 to 244.** The latter have been added to the HR-DTM layer in the Bathymetry Viewing and Download service. The overall number of data providers for the CDI and both Sextant catalogues increased from **51 to 70** organisations. In comparison to the start situation, much more data has become available also for the Arctic and Baltic regions, while increasing the coverage for all other European sea areas. Furthermore, EOMAP generated **16** composite DTMs from Sentinel-2 satellite data for coastal and near shore zones, covering Cyprus, Northern Denmark, Croatia and Southern Sicily and Puglia, Italy.

#### Release of new 2020 EMODnet multiresolution DTM:

A new **2020 version of the EMODnet DTM** has been officially released on 13th January 2021 in sync with the GEBCO week and Map the Gaps symposium. Compared to the 2018 release, a total of **16.260** unique references to CDI entries and Composite DTMs entries are used in the overall DTM versus **9.456** in the 2018 version. The DTM is an integration of eleven regional DTMs which were prepared by regional basin coordinators, after selecting and merging pre-gridded and pre-processed datasets as received from data providers. The 2020 DTM is also available with 3D visualisation, while 2020 DTM tiles can be downloaded in several formats, and including a version with MSL vertical reference next to LAT. The **High Resolution DTM layer** has been expanded with an additional **48** HR-DTMs, now covering **244** HR-DTMs which can be viewed and dowenloaded. Related metadata has been populated in a special section of the the Sextant Products Catalogue. The resolution of HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. The **Quality Index layer** has been updated for the new 2020 DTM. It gives quality indication by means of maps for 'age', 'vertical precision', 'horizontal precision', 'purpose', and 'combined' whereby the last one is resulting from an algorithm combining the earlier four indicators.

#### Release of EMODnet World Base Layer Service (EBWBL)

A new exciting service has been added by way of the **EMODnet World Base Layer Service (EBWBL)** which provides a fast and easy access to **worldwide** bathymetric and topographic information. It is published as OGC WMTS service along with a demo viewer<sup>3</sup> to zoom in on every detail. It is available in various projections, e.g., non-projected coordinate system, Web Mercator, Inspire-compliant projection and projections adapted to both poles.

#### Release of best-estimate European digital coastlines and legal baselines:

A new set of the **best-estimate coastlines** has been released. These have been determined from satellite data (typically Sentinel-2 and Landsat-8) and combined with the Global Tide Surge Model (GTSM) to provide digital coastlines for the European seas at LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water), covering all European coastlines. The satellite derived coastlines can be viewed as extra layer in the Bathymetry Viewer and downloaded with documentation at the EMODnet Bathymetry portal. In addition, a new **inventory and report of baseline and coastline data** have been released, now including input as collected from **26** national authorities in Europe versus **21** countries previously. It gives information available per country, the resolution, the source of the data and the institute providing/ hosting the data. This can be downloaded from the portal together with shapefiles of the baselines and coastlines;

#### International interoperability and INSPIRE-compliance:

EMODnet Bathymetry is well embedded in the international bathymetry community and has continued its cooperation and synergies with GEBCO, NOAA, IHO, BSHC, NSHC, IBCAO, and the Seabed 2030 initiative. The EMODnet DTM is integrated in the GEBCO digital bathymetry product to cover European seas, while GEBCO is integrated in EMODnet DTM to complete areas without survey coverage. International exchanges of data and metadata take place in the framework of the Seabed 2030 initiave whereby EMODnet Bathymetry represents the European contribution. EMODnet Bathymetry provides a range of services which are INSPIRE compliant.

#### **Performance and citations**:

<sup>&</sup>lt;sup>3</sup><u>https://tiles.emodnet-bathymetry.eu/preview.html</u>



The EMODnet Bathymetry portal with its products and services continue to be very popular among researchers, governments, industry, university and public users, giving great statistics. In the contract period more than **71.000 DTM tiles** were downloaded in circa by more than **7.400 unique users** from circa **2.200 unique organisations** and more than **115 countries** during more than **23.000 transactions**. This represents circa **6.45 TB** in data volumes. Also the OGC web services (machine-to-machine) are very popular with more than **50 million OGC service requests** in the reporting period by circa **430.000 visitors**. There are several known use cases, including oceanographic modellers adopting the EMODnet DTM grid, giving improved model calculation results. Moreover, using Google Scholar more than **300 references** to EMODnet Bathymetry can be found for accepted papers and edited books during the reporting period from January 2019 to December 2020, which also underpins the extensive use being made of the EMODnet Bathymetry products, whereby the DTM serves as a major reference.



# 3. Summary of the work done

The summary of activities and results is given, considering each of the contractual tasks:

#### Task 1 - Gather and give common access to bathymetric survey data held in repositories:

- Data providers were instructed and trained in using the EMODnet Bathymetry metadata and data standards and dedicated software tools for populating the two catalogue services: 1) CDI Data Discovery and Access service for survey data sets and 2) the Sextant catalogue for Composite DTMs. Globe software was used for processing and pre-gridding of the data sets for further use by the regional basin coordinators. Data providers have gathered and populated the catalogues and made bathymetric data sets ready for use by the basin coordinators. During the process support was given by the helpdesks of MARIS (CDI) and IFREMER (Sextant and Globe) and user manuals, existing [1], [2], [3], [4], and new [5], [6], were provided as well as CDI upgrading training material. The total number of CDI records increased over the project duration from **27.168 to 30.560** CDIs. The number of Composite DTM entries has increased from **147 to 207**.
- Partner EOMAP generated 16 composite DTMs from Sentinel-2 satellite data for coastal and near shore zones, covering Cyprus, Northern Denmark, Croatia and Southern Sicily and Puglia, Italy, while related metadata have been populated in the Sextant Products Catalogue.

#### Task 2 - Compile a multi-resolution digital terrain model of European seas:

- The regional basin coordinators have selected and merged the pre-gridded and pre-processed datasets as received from data providers and have build the regional DTMs for the **11** specified regions. The RDTMs were forwarded to the integrator for building the new 2020 version of the EMODnet DTM;
- The integration started after summer 2020 and was finalised early December 2020. Several quality issues were identified during the integration process which required solving in cooperation with regional coordinators. Also, presence of all CDI/CPRD references was checked and quality assessment (visual checks of remaining artefacts);
- The **EMODnet DTM 2020** has been officially released on 13th January 2021 in sync with the GEBCO week and Map the Gaps symposium, hosted by Shom.
- Data providers have prepared and provided an additional **50** High Resolution DTMs (HR-DTMs), using Globe software, bringing the current total on **244** HR-DTMs. Related metadata has been populated in a special section of the the Sextant Products Catalogue.
- The Quality Index has been updated for the new 2020 DTM, as layers in the Viewing service and as report [7].
- The new **EMODnet World Base Layer Service (EBWBL)** has been developed by GGSGC, combining EMODnet Bathymetry DTM, GEBCO 2019, and a satellite derived Digital Terrain Model in order to provide a global seamless topography and bathymetry which can serve as base layer for many applications. It was launched in June 2020 and is served out as OGC WMTS service.

#### Task 3 - Establish best-estimate European digital coastlines and compile overview of legal baselines:

- Deltares has updated and expanded the best-estimate coastlines data set. These are determined from satellite data (typically Sentinel-2 and Landsat-8) and in combination with the Global Tide Surge Model (GTSM) processed into digital coastlines for the European seas, now covers all European coastlines. The GTSM was updated by adopting the EMODnet DTM and GEBCO 2019 bathymetry grid, which gave clearly improved model calculation results for the tidal parameters. The coastlines data set was added to the Bathymetry Viewer for viewing and downloading and a report [11] was added to the portal.
- The existing inventory and report of baseline and coastline data have been updated and expanded, now including input as collected from **26** national authorities in Europe versus **21** countries previously. The inventor and report [12] have been published at the portal.

#### Task 4 - Establish machine-to-machine connections to data and data products:

- The new 2020 EMODnet DTM and associated layers have been integrated in the Bathymetry Viewing and Download service for viewing and downloading;
- The OGC web services (WMS, WFS, WCS, and WMTS) from the Bathymetry viewer have also been updated by including the new 2020 DTM version, while continuing to publish the older 2016 and 2018 versions;
- The Globe software has been upgraded, among others by making it fit for handling the NetCDF V4 data format, allowing much larger data files and thus improving the efficiency of the workflows. Also, new interpolation algorithms were developed by Coronis [16], and included in the Globe software;





- The existing 3D visualisation as extra functionality in the Bathymetry viewer has been updated for the 2020 EMODnet DTM by Coronis, using the method and software [8] that they earlier developed for generating a TIN model from the EMODnet DTM which is instrumental for supporting stable 3D viewing;
- Further developments of Ifremer resulted in a working and tested prototype for the Collaborative Virtual Environment (CVE) [14] [15]. The prototype allows different regional coordinators to collaborate with Globe online in the same session. They can produce and finalize the Regional DTM for a specific geographic region, while sharing datasets and information with the neighboring areas. It allows the regional coordinators to work remotely and to benefit from powerful computing and storage capabilities of the dedicated virtual machine at the IFREMER DATARMOR HPC computing facility. WPS (Web Processing Service) accessible through the CVE are instrumental for using the tools and pre-defined processing workflows which are set up to follow EMODnet's established methodology. The working prototype has been tested by selected basin coordinators, using a subset centered on Sardinia island. The results are promising, but still further developments are needed for operational use.

#### Task 5 - Maintain a web portal:

- The EMODnet Bathymetry portal has been upgraded to comply with the new GDPR Directive. The domain has been upgraded to https://;
- The web portal was operated and maintained with adding news, promotion items and information about new products and services as they became available;
- The Bathymetry Viewing and Download service of the Bathymetry portal were updated to include the latest versions of the EMODnet DTM, the Satellite Derived Coastlines, the expanded HR-DTM files and layer, and the Quality Index layer. The downloading of 2016 and 2018 DTM tiles was expanded with tiles from the new 2020 DTM version in various formats, including DTM files with MSL reference next to LAT reference, 2020 HR-DTMs, and 2020 Satellite Derived Coastlines.

#### Task 6 - Operate a help-desk:

• The help desk is integrated in the portal and frequently used. In the reporting period **95** questions from users were received and answered by the helpdesk.

#### Task 7 - Achieve international interoperability:

- A 'Report on Interoperability and International Collaboration' [10] was drafted, submitted to the EU and accepted together with the 1st Annual Progress report early 2020;
- Follow-up was given to the cooperation as mentioned in the given report with GEBCO, NOAA, IHO, BSHC, NSHC, IBCAO, and the Seabed 2030 initiative.

#### Task 8 - Achieve INSPIRE compliance:

- The 'Report on Interoperability and International Collaboration' [10] from early 2020 also describes how EMODnet Bathymetry is seeking INSPIRE compliance for its range of services;
- Upon request of the EMODnet Secretariate metadata were added to several EMODnet Bathymetry OGC web services to achieve full INSPIRE compliance for these services.

#### Task 9 - Monitoring of performance:

• The overall performance of the portal and its services is continuously measured and reported at a quarterly basis by a series of indicators. These are based upon Matomo and other stats for web traffic, while downloads are registered in registers. Moreover, Google Scholar is used to determine which publications make reference to EMODnet Bathymetry.

The indicated reports are listed in Chapter 15 – References - and can be downloaded from the portal.<sup>4</sup>

<sup>&</sup>lt;sup>4</sup> <u>https://www.emodnet-bathymetry.eu/approach/technical-documentation</u>



## 4. Challenges encountered

List of all challenges encountered since the start of the project phase				
Main challenge	Measures taken			
Difficulties related to the home confinement in relation to COVID-19. Data producers and basin coordinators might not be able to get access to dedicated computer resources from their organisation.	Most of the organisations, members of the consortium have enabled their collaborators with connections to their network and resources using dedicated VPN. However, 3D visualisation of the data and data transfer through these VPN are often slow and inefficient for the volume of data considered. In the near future relief might be provided by the Collaborative Virtual Environment (CVE) for which a working prototype has been established and tested. This should make it possible to work together on a regional DTM with sufficient processing power and performance. (see also Task 4).			
A major challenge has been the uptake of the upgraded CDI service and its new methodology for populating the CDI service by data providers. For multiple EMODnet Bathymetry data providers it included deploying the new Replication Manager (RM) software, while all data providers had to adapt to the new CDI Import Manager service steps which give each data provider more self- control for submitting and checking updated and new CDI entries. Moreover, all data providers had to pre- process data sets using GLOBE for transfer of new and updated data sets to the Regional Coordinators for inclusion in the new Regional DTMs.	The challenge was overcome by informing the data providers about the CDI service upgrading development, while also several joined the Training Workshops in summer 2019 which were organised and funded by the EU SeaDataCloud project for transfer and hands-on training with the new methodologies and associated software and services. This was followed by releasing the new RM software and sending new manuals and instructions to all data providers. As follow-up, bilateral guidance and support was given to each data provider for deploying software, where applicable, testing it's functioning, and adopting the new approach to population of the CDI service. This was an intensive process between the data providers and MARIS as cdi-support helpdesk and is still not fully completed, but very good progress is made whereby the upgraded CDI services function as planned. As described earlier under Task 1 this has resulted in the desired results. Furthermore, training and support was given to data providers concerning the use of the Globe software.			



## 5. Identified issues: status and actions taken

A. Priority issue(s) id	A. Priority issue(s) identified and communicated by EASME/ DG MARE/ SECRETARIAT					
Priority issue(s)	Status (Pending/Resolved)	Action(s) taken / remaining actions planned	Date due			
Representation of UK considering Brexit status	Resolved	The EMODnet Bathymetry portal presents only physical geography elements (water depth, topography), without any reference to aggregated statistics. Therefore it appears that no action is needed in views of this issue.	Begin 2020			
JIRA Issue 33: Implement Web Services MetadataUrl and DataUrl fields	Resolved	Tuning with other lots and the Secretariat actions were undertaken for including MetadataUrls and DataUrls in the OGC web services of the CDI data discovery and access service respectively the Bathymetry Viewing and Download service. INSPIRE compliant landing pages have been incorporated in Sextant to serve as MetadataUrls, which have been included in the GeoServer instances. The Secretariat has made a final validation, which indicated that the issue is fully resolved.	Mid 2020			
EM-126 Bathymetry to report on number and volume of downloaded data and data products by 6th of January	Resolved	Report as requested	5/1/2021			
EM-120 Bathymetry to provide an email contact that will be notified in case of downtime of their OGC services	Resolved	Provided a list of names (project management and technical contact)	18/12/2020			
EM-100 Bathymetry - Removal of Brexit content disclaimer	Resolved	Previously removed	27/11/2020			
EM-82 Bathymetry - Web Services MetadataUrl and DataUrl fields	Resolved	Updated the DataURL field with respect of capabilities and INSPIRE guidelines	05/01/2021			

B. Other priority issue(s) identified by the thematic assembly group itself							
Priority issue(s)	Status	Action(s) taken / remaining	Date due				
	(Pending/Resolved)	actions planned					
During generation of the RDTM for the Celtic and Irish seas and Atlantic Ocean it appeared that there was a horizontal shift compared to the 2018 version	Resolved	Communication between Shom, GGSGC, and GSI to explain the shift and to decide which is correct, has led to a solution.	End Oct 2020				



# 6. Allocation of project resources

Information on the allocation of project resources				
Categories	Resource usage (%)			
Task 1: a common method of access to data from surveys held in repositories	24%			
Task 2: a multi-resolution digital terrain model of the sea bottom of European seas with common standards, baseline and formats	23%			
Task 3: standard coastline data	16%			
Task 4: procedures for machine-to-machine connections to data and data products	4%			
Task 5: a web portal allowing users to find, visualise and download data	12%			
Task 6: a help desk offering support to users	2%			
Task 7: interoperability with digital terrain models developed by organisations from outside the EU	2%			
Task 8: a process to become compliant with the INSPIRE Directive	2%			
Task 9: a process to monitor performance and deal with user feedback	15%			



# 7. Work Package updates

Status of the Milestones and Deliverables listed in the workplan						
Milestone/Deliverable	WP	Date due	Status (Pending/Resolved)			
D0.1.1: Quarterly concise	WP0	15-04-2019	Resolved			
D0.1.2: Quarterly concise	WP0	15-07-2019	Resolved			
progress report 2						
D0.1.3: Quarterly concise progress report 3	WP0	15-10-2019	Resolved			
D0.1.4: Quarterly concise	WP0	15-01-2020	Resolved			
D0.1.5: Quarterly concise	WP0	15-04-2020	Resolved			
progress report 5						
D0.1.6: Quarterly concise	WP0	15-07-2020	Resolved			
D0.1.7: Quarterly concise	WP0	15-10-2020	Resolved			
progress report 7						
D0.1.8: Quarterly concise	WP0	15-01-2021	Resolved			
D0 2: Annual Interim report	WP0	31-01-2020	Resolved			
D0 3: Final report	WP0	28-02-2021	Resolved			
D0.4: Plan for service continuity, incl. Docs and sources	WP0	28-02-2021	Resolved			
D1.1: Upgraded guidelines for data pre- processing and population of metadata	WP1	31-03-2019	Resolved			
D1.3: Pre-processed survey data sets and included in CDI Service	WP1	31-10-2019	Resolved			
D1.4: Pre-processed composite DTMs and included in Sextant service	WP1	31-10-2019	Resolved			
D1.5: Satellite Derived Bathymetry data sets and included in Sextant service	WP1	31-10-2019	Resolved			
D2.1: Upgraded guideline of EMODnet methodology for DTM production, including using pilot CVE	WP2	31-08-2019	Resolved			
D3.1: New EMODnet DTM incl Quality Index and loaded in EMODnet portal for viewing and downloading	WP3	30-06-2020	Resolved			



D3.2: HR DTMs loaded as separate layer in EMODnet portal for viewing and downloading	WP3	30-08-2020	Resolved
D3.3: Source reference layer to link to CDI and Sextant Catalogue services	WP3	30-04-2020	Resolved
D4.1: Updated web portal for new contract	WP4	30-06-2019	Resolved
D5.1: Refined best-estimate European digital coastlines for a range of vertical levels at the portal	WP5	30-10-2020	Resolved
D5.2: Updated Inventory of existing and ratified baselines and registered claims / disputes under UNCLOS, for European countries at the portal	WP5	31-12-2019	Resolved
D6.1: Operational helpdesk	WP6	Continuously	Resolved
D6.2: Promotional material and up-to- date website	WP6	Continuously	Resolved
D6.3: Presentations at relevant conferences	WP6	Regularly	Resolved
D6.4: Report on international cooperation and interoperability	WP6	31-01-2020	Resolved
MS1: Gathered survey, composite DTM and SDB data sets, included in CDI and Sextant services	WP1	31-10-2019	Resolved
MS2: Prototype CVE system ready for RDTM support	WP4	31-10-2019	Resolved
MS3: 1st Interim report	WP0	31-01-2020	Resolved
MS4: Report on international cooperation and interoperability	WP6	31-01-2020	Resolved
MS5: Updated inventory of legal baselines at portal	WP5	31-12-2019	Resolved
MS6: New EMODnet DTM loaded in EMODnet portal for viewing and downloading	WP3	30-04-2020	Resolved
MS7: High Resolution hotspots layer added to viewer	WP3	31-08-2020	Resolved
MS8: Prototype CVE system further developed	WP4	31-10-2020	Resolved

In the reporting belowe, references are made to reports by [n] which are listed in Chapter 15 - References - and which can be downloaded from the portal in the sections on technical documentation<sup>5</sup> and reports to EU<sup>6</sup>.

<sup>&</sup>lt;sup>5</sup> <u>https://www.emodnet-bathymetry.eu/approach/technical-documentation</u> <sup>6</sup> <u>https://www.emodnet-bathymetry.eu/approach/reports-to-eu</u>



### 7.1 WP0 - Project Management

The EMODnet Bathymetry – High Resolution Seabed Mapping project, internally known as HRSM2, is successor to the EMODnet High Resolution Seabed Mapping project, and has been awarded by EASME on 22 November 2018 to the consortium, led by Shom. The contract was signed by both parties on the 21 December 2018 after arranging requested evidences. A consortium agreement (for full partners) and subcontractor agreements (for subcontractors) were drafted, introduced, following feedback amended, and signed by all in the 2<sup>nd</sup> project quarter of 2019. The Core Group, composed of Coordinators and Work package leaders, met 5 April 2019 in Paris - France, hosted by Shom, to prepare the project kick-off meeting and to discuss updating, where needed, of the methodology, technology and production processes as used in the predecessor EMODnet HRSM project. The HRSM2 kick-off meeting including all consortium members took place 11-12 June 2019, in Brest, France, hosted by Shom. All consortium members were present to discuss the project implementation and activities of each member. Also, instructions and training and updated guidance documents were given concerning the methodology and use of the preferred software tools (Mikado, Nemo, CDI service, Sextant service, Globe). A technical sub group met 29 November 2019 in Brest – France, hosted by IFREMER, to discuss progress on upgrading the Globe software, making it fit for handling NetCDF V4 in order to overcome earlier filesize limitations, and reviewing the overall planning. A further meeting was held 15 - 16 April 2020 with core partners and regional coordinators to monitor project progress and in particular, finetune the activities for generating updated regional DTMs, applying the upgraded Globe software and its new features. On 28th May 2020 another meeting was held with core partners and regional coordinators to monitor progress and targeting an expected delivery of the Regional DTMs around summer 2020. However, there was some delay in this schedule for a few regions as issues were found during the integration process for compiling the EMODnet DTM. Therefore, in September - October 2020 a few smaller meetings were held with selected regional coordinators to solve the issues, which was done successfully.

The coordinator (Shom) and technical coordinator (MARIS) prepared 8 quarterly progress reports which have been accepted by the EU (EASME and DG MARE). Shom and MARIS have also drafted and submitted the 1st Annual Report [13] and the separate report on Interoperability and International Cooperation [10]. Both were accepted by the EU (EASME and DG MARE) and as follow-up Shom processed the invoices as collected from consortium members for their share of the first payment (50% total budget).

Shom and MARIS have participated in EMODnet Steering Committee meetings, presenting the project progress and contributing to discussions, and EMODnet Technical Working Group meetings, discussing technical interaction between the thematic and central portals.

Also, a technical meeting took place on 20 March 2020 between the technical team of EMODnet Bathymetry, coordinators of other EMODnet thematic projects, and representatives of the Central Portal team (VLIZ, EMODnet Secretariat), DG MARE and EASME to brainstorm about the planned migration from thematic to central portal that will be undertaken as part of a new series of EMODnet tenders and contracts.

In the meantime, the current EMODnet Bathymetry consortium has made a successful bid for the new EMODnet Bathymetry tender and a contract has been signed with EASME for a seamless continuation per 19 December 2020.

For all project meetings internal minutes and actions lists were made and included in the project extranet together with all presentations and all consortium members were informed about these. Moreover, regularly emails were sent by the coordinator and the technical coordinator to the full consortium to keep them informed about the overall project progress and expected activities.

Unfortunately, due to COVID, only a few face-to-face meetings were possible in the first part of the project, while all other meetings have been done by web conferences and emails. This has worked, mostly because EMODnet Bathymetry has a team that already has worked together over many years, while the project workplan was mostly a continuation and refinement of earlier contracts. But generally, in a European project with so many partners and different nationalities, face-to-face meetings and socialising are instrumental and cannot be missed. For that reason, there is hope that the COVID situation will improve as the new contract has a major challenge in the planned migration from thematic portal to central portal. This will require extensive brainstorming with all involved, which is helped considerably by face-to-face meetings.



# 7.2 WP1 – Bathymetric data collection and metadata compilation for all maritime basins

At the project kick-off meeting, all data providers have been informed about the proven approach and software tools and services that are used in EMODnet HRSM2 for gathering source data sets such as bathymetric survey data sets and composite DTMs and populating these into the two major catalogues: the CDI Data Discovery and Access service for describing survey data sets and the Sextant data products catalogue service for describing composite DTMs. Where needed, data providers were encouraged to familiarize themselves again with the software tools and services and to start the process of preparing their datasets and related metadata entries for the CDI and Sextant catalogue services.

Also, data providers have been asked to review their existing entries in both catalogues for improving and completing the Quality Index information. Next to populating the two catalogues, data providers have also been instructed and trained to pre-process and pre-grid their data input using the Globe software and following the EMODnet Bathymetry method and grid. This way their data input is made fit for the Regional Coordinators and their planned WP2 activities for updating and upgrading the existing regional DTMs with new and improved data contributions. A review took place of the various guidelines that have been produced and made available over the years for giving guidance on the methodologies for populating the catalogues and pre-processing the data sources. This has resulted in a set of up-to-date guidelines in a dedicated folder on the extranet, see [1], [2], [3], [4] and training material.

Where needed, support was given by MARIS for the CDI population and by IFREMER for the Sextant population and consecutive pre-processing with the Globe software. During the population, there has been a major upgrading of the CDI service as part of the EU SeaDataCloud project. This had some implications for data providers with a direct connection, because they have been asked to replace the existing local Download Manager component with the new Replication Manager component. As part of this migration to the upgraded CDI service, data providers have been informed by the CDI support desk at MARIS and also, they have been invited to participate in the SeaDataCloud Training Workshop which was held in June 2019 in Ostend – Belgium. This was followed up by several data providers. However, the migration has delayed somewhat the progress of CDI population in the first year and therefore, the original deadline of finalising CDI and Sextant population has been extended from end January 2020 to end February 2020.

This has worked out in practice and the total number of CDIs overall has increased in the project from **27.168 to 30.560** records by 45 CDI data providers from 23 countries. A major contribution came from OceanWise which populated more than 2000 new CDIs for the Greater North Sea region. Moreover, new CDIs were populated for the Black Sea. In addition, as part of the CDI upgrading process, existing CDI data sets have been validated for their formats which has led to some data sets that needed correction.

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Figure: New CDI service user interface for EMODnet Bathymetry



The number of Composite DTM entries has increased from 147 to 207 from 64 data providers from 25 countries. This included also several CDTM contributions from hydrographic services in the Baltic from Lithuania, Finland, Poland, and Russian Federation, bringing in extra geo-coverage as part of their cooperation in the BSHC and mobilised by SMA as regional Baltic coordinator.

The CDTM catalogue expansion also include 16 Satellite Derived Bathymetry (SDB) DTMs for five sites, covering Cyprus, Northern Denmark, Croatia and Southern Sicily and Puglia, Italy, which have been generated by partner EOMAP. A total of 8,759 sq km was mapped using Sentinel – 2 data covering shallow waters down to approx. 10-13m (Denmark) and 17-20m (Mediterranean Sea areas). The methodology used by EOMAP for SDB is described in Chapter 13 Annex: Other documentation attached – Annex 1.



#### Sextant Catalogue service

Figure: Sextant Composite DTM catalogue user interface for EMODnet Bathymetry

After population, the data providers have made their bathymetric data sets ready for use by the regional coordinators by undertaking pre-processing and pre-gridding of their data into single DTMs with EMODnet grid and format, using the Globe software.

In the last months of the project, data providers have worked on preparing and contributing more High Resolution DTMs for which the number went up from 196 to 244. These were described with metadata in the special HR-DTM Sextant catalogue, using the online CMS, which has been upgraded by IFREMER. Sextant now has a staging process, whereby providers can enter new records, but these can only be published by IFREMER as master, this way controlling better the consistency and quality. IFREMER gave support, where needed, and also prepared new manuals for the upgraded Sextant system [5], [6]. The HR-DTM data files were collated by IFREMER from their providers and bundled for transfer to GGSGC for integration in the Bathymetry Viewer and Download service as part of WP3.

In the project period, the overall number of data providers for the CDI and both Sextant catalogues has increased from **51 to 70** organisations, comprising the data providers in the consortium and several other providers through the existing community networks, run by regional coordinators. Also, bathymetry data sets came available through EMODnet Ingestion activities.

WP1 contributes to the following tasks as shared with WP2:

- Task 1: Bathymetric surveys
- WP1 also contributes to the following tasks as shared with WP2 and WP5:

#### • Task 3: Coastline data

WP1 also contributes to the following tasks as shared with WP6:

• Task 7: International interoperability



WP1 also contributes to the following tasks as shared with WP3 and WP4:

#### • Task 8: INSPIRE compliance

Task 1 and 3 have been completed as described in the progress of WP1 and WP5. Task 7 and 8 have also been completed. This is described in the progress of WP4 and documented in detail in the separate report on interoperability and international collaboration [10].

# 7.3 WP2 – QA-QC, data processing and producing Digital Terrain Models for the basins

The latest version of the EMODnet DTM (Digital Terrain Model) was released 24th September 2018 with its improved resolution of 1/16 \* 1/16 arc minutes (circa 115 \* 115 m2). The overall methodology for the generation of the new EMODnet DTM has remained the same as in the previous phase. Following the usual approach, the new DTM has been compiled by an integration of new versions of regional DTMs that were generated by regional coordinators.

For improving the methods, activities were undertaken in WP4 for upgrading the Globe software, e.g. with a spike identification detector and removal. Also, use is to be made of GEBCO 2019 for filling gaps. That latest GEBCO bathymetry includes the EMODnet Bathymetry 2018 version. In November 2019, a technical tuning meeting took place between core partners to discuss and refine the actions and planning for the compilation of the new version of the EMODnet Digital Terrain Model (DTM).

The upgraded Globe was released by end of February 2020. The new version facilitates handling of large files by adopting the NetCDF V4 data format for input and output, which also optimises compliance with international standards compared to the earlier used 'native' NetCDF v3.

As follow-up to the population of the catalogues in WP1, data providers used Globe to prepare their data sets and delivered their single DTMs to the regional coordinators. The following regional coordinators were tasked with generating and providing regional DTMs:

- The Greater North Sea region task coordinated by BSH, also cooperating with NSHC and NSBD project
- The Celtic Seas region task coordinated by UKRI-NOC
- <u>Iberian Coast North East Atlantic Ocean north of Equator Macaronesia region</u> task coordinated by IPMA with IHPT
- The <u>Channel North East Atlantic Ocean Bay of Biscay region</u>: task coordinated by Shom
- The Baltic Sea region task coordinated by SMA, who also brings in the BSBD DTM and related data
- The <u>Norwegian Icelandic Sea region</u> task coordinated by GRID
- The <u>Western Mediterranean Sea region</u> task coordinated by IFREMER
- The Adriatic Ionian Sea region Central Mediterranean task coordinated by CNR-ISMAR
- The Eastern Mediterranean Sea region task coordinated by HCMR
- The <u>Black Sea Sea region</u> task coordinated by IFREMER
- The <u>European Arctic waters and Barents Sea</u> task coordinated by SU who also brings in part of the IBCAO DTM and related data

Previously, for the 2018 release all regional coordinators were provided by GGSGC with an up-sampled 2016 data set divided in the 64 product tiles of the 2016 release. For the 2020 release it was decided this time to have everybody start from scratch as using old data also introduces old problems again. This turned out to be a good decision. Certain errors and anomalies that were introduced in earlier versions are now gone.

From March to Summer 2020, regional basin coordinators analysed, processed and merged selected contributions using the new Globe version into regional DTMs. A meeting with all basin coordinators and core technical partners was held 15 - 16 April 2020 as a web conference, aimed at monitoring progress, and gaining feedback on the new Globe version and the common methodology. Following the meeting, further improvements were made to the Globe software. Also, new developments from Coronis related to the interpolation of sparse data were included. First, for testing purposes as the algorithms were still in development phase, later for use in production, although regional coordinators always must be careful when using interpolations.

As follow-up, each of the regional coordinators has been working on their Regional DTMs, and several were delivered to the integrator, GGSGC, around summertime together with a QA-QC report for their RDTM following the agreed EMODnet Bathymetry template. This contributes to the assessment of the quality of the overall EMODnet DTM. While, the last



regional DTMs were delivered after summer, reducing the available time earlier reserved for the integration, thus in practice shifting the original delivery date of the new 2020 DTM to end 2020.



Figure: Division of EMODnet DTM coverage over Regional DTMs

The figure below give an example from the new regional DTM for the Black Sea - a 3D view off the Bosporus.

WP2 concerns the following task as formulated in the tender and as shared with WP1:

• Task 1: Bathymetric surveys

WP2 also concerns the following tasks as shared with WP1 and WP5:

- Task 2: Digital Terrain Model
- Task 3: Coastline data

All tasks have been completed as can be derived from the WP1, WP2 and WP5 progress reporting.

### 7.4 WP3 – Integration and inclusion of the DTMs into the portal

After delivery by each of the basin coordinators of their regional DTM, the integrator, GGSGC, could start with the integration. This step included a detailed second quality assessment of the regional DTM products. The integration of the Regional DTMs into the overall EMODnet DTM has taken place in the last 5 months of the project. GGSGC has led the work with support from regional coordinators and MARIS. A number of actions, illustrated in the figure below, describe the actions being done for each RDTM. Most of the processing steps have been automated, while a few of them still need human interventions.



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#### Figure: Actions undertaken for individual RDTM before integration in the final EMODnet HRSM2 DTM product.

Based on experiences gained from the production of the EMODnet Bathymetry World Base Layer (EBWBL), GGSGC has improved its Software Bench. Processing is now much quicker due to the introduction of a 1 x 1 degree tile cache. This also makes it possible to apply updates to smaller regions instead of reprocessing the complete DTM. A major change was the introduction of the new Globe NetCDF format based on NetCDF version 4. The GGSGC software bench is now completely in line with this new version.

The quality of each RDTM has been reviewed through quality checks such as presence of all the requested statistics and CDI/CPRD reference, coherence with previous release of EMODnet DTM and quality assessment (visual checks of remaining artefacts). Identified issues then had to be solved between the basin coordinators and GGSGC. As part of the quality checking, GGSGc noticed an inconsistent lateral gridding shift of one cell for only one of the major contributors (GSI) which raised interrogations on the overall processes. All the stakeholders have investigated the potential source of this problem with their own expertise either directly on the source data, or in the implementation of the algorithms used as part of the gridding processes in Globe, or on the steps undertaken for the merging of the data sources for this area. This has led to a solution and suggestions for further upgrading of Globe in a next round to prevent the same issue later again. The contribution of partner GSI has been key in solving the issue at hand by regenerating and re-integrating their contribution.

The new version of the OpenStreetMap Coastline (version 2020) was used for the delimitation of land and sea. The overall quality and accuracy of the 2020 version of the coastline is greatly improved. Unfortunately, OpenStreetMap contributors more and more use baselines to close off rivers and estuary along the coast. As a result, GGSGC had to edit manually the OpenStreetMap coastline to remove these "closing baselines" and to add a more topographically correct coastline respecting larger rivers and estuary.

Finally, all regional DTMs have been integrated into the final DTM product, which was made available for final checks and testing to the members of the consortium early December 2020 as part of a test portal.

Associated to the full gridded DTM, the source reference layer (providing the origin of each data sets contributing to the grid) and the Quality layer (providing the qualitative descriptions of the gridded product) have been fully updated. A separate report documents the new Quality Index and is available for users of the portal [7]. These layers of information



are also displayed on the EMODnet portal and available as OGC web services. The number of CDI and Sextant references in the new DTM has increased to 16.260 for which MARIS and GGSGC have done consistency checks, ensuring that every reference exists and resolves in the CDI and Sextant catalogues. The image below gives a part of the source reference layer for the Baltic Sea which clearly shows the improvement with respect to the previous 2018 DTM where there were sparse references and most area only covered by the Baltic Sea DTM (BSBD).



Figure: detailed source reference map in the Baltic Sea in the 2020 DTM version. Each colour represents an individual data source for which metadata can be retrieved in a pop-up.

The High-Resolution DTM files have also been processed by GGSGC to expand the existing High Resolution layer. A total of 53 new or updated HR-DTM data sets have been made available for the 2020 release. These have been added to the HR-DTM data sets already available from the 2018 release. It is noticeable that there is an increase in resolution. A large area in the German Wadden Sea is now available in a 1 meter (1/1024 arc minute) resolution (see image).



Figure: HR-DTM with 1 meter resolution data in the Jade region in the German Wadden sea





Figure: New HR-DTM layer with 2018 HR-DTMs in orange and 2020 HR-DTMs in light green demarcation

CORONIS created a new data set for use in the 3D Cesium viewer available in the Portal. The n3D data set is based on the EMODnet 2020 release. New is the reduced exaggeration for the land data. The overall result is now more realistic.



Figure: 3D visualisation of the Spanish Balearan islands in the Mediterranean sea

GGSGC and MARIS have integrated the new DTM in the Bathymetry Viewing and Download service and MARIS has updated all related text and documents at the portal. The new common DTM (2020) has replaced the existing common DTM (2018) in the layer menu of the Bathymetry Viewing and Download service for the mean depth layers with 3 colour palettes. Also the source references layer has been replaced to fit the new DTM release. However, in the OGC web services (WMS, WFS, WCS, and WMTS) and the DTM download service the new DTM has been added next to the old 2016 and 2018 DTMs. Also a new DOI (https://doi.org/10.12770/bb6a87dd-e579-4036-abe1-e649cea9881a) has been minted and a new landing page has been completed and launched for the new DTM so that users can cite this DOI as a persistent



reference, while the DOI and landing pages of the 2016 and 2018 DTM versions have been sustained. This is done to have a persistent version management and because a lot of users have made use and are referencing to earlier versions of the EMODnet DTMs.

Finally, it was decided to launch the new 2020 DTM release at 13th January 2021 in order to announce it at the GEBCO conference 'Mapping the gaps' that was hosted by Shom. The publication was accompanied by a press release which was drafted together with the EMODnet secretariate and disseminated making full use of the EMODnet channels.

WP3 contributes to the following task as formulated in the tender and as shared with WP2 and WP5:

• Task 2: Digital Terrain Model

WP3 also contributes to the following task as shared with WP4:

• Task 4: Machine-to-machine connections to data and data products

WP3 also contributes to the following task as shared with WP1 and WP4:

• Task 8: INSPIRE compliance (see

All tasks have been completed as can be derived from the WP1, WP2, WP3, and WP4 progress reporting and the separate report on international interoperability [10].

### 7.5 WP4 – Technical Development & Operation of portal, tools and services:

The EMODnet Bathymetry portal is operational at the domain <u>https://www.emodnet-bathymetry.eu</u>. Following the GDPR Directive and upon request of the EU, activities were undertaken together with the EMODnet Secretariate and EU services to improve the GDPR compliance of the EMODnet Bathymetry website and related services. For instance, https:// certificates were acquired and implemented for the main domain and for all the services, such as for the dedicated CDI and Sextant catalogues and the Bathymetry Viewing and Download service. And sections were formulated and added for 'privacy policy' and 'cookies'. This was undertaken in tune with the other EMODnet portals for further establishing harmony.

IFREMER worked on upgrading the Globe software. A major improvement is the moving of support for NetCDF V3 to NetCDF V4 file format in all relevant functions (import xyz, reduce, merge, export). This has two major advantages: 1) overcomes the 2Gb size limit of NetCDF V3 files, which will implicate that data providers and regional coordinators no longer have to chop up areas in smaller pieces, and 2) overcomes the use of the scale factor. Earlier this scale factor raised concerns, as cumulative effects seemed to affect individual surveys during the compilation, and generate discontinuities between contiguous datasets. The new Globe software avoids that effect. However, it implicated as part of WP2 that regional coordinators needed to reprocess with the upgraded Globe software the data sources as received from data providers because they could not use the earlier provided data sources. Internal tests were included within the Globe code to prevent regional coordinators to use previous NetCDF V3 contributions in their new compilation. The new Globe release was ready by end of February 2020 for use by the regional coordinators.

CORONIS developed a smart solution for interpolation issues. A literature analysis was done gaining insight in state-ofthe-art interpolation methods. As follow-up, they implemented a Matlab version of the main interpolation methods, and prototyped their methods, followed by comparisons. The toolbox and documentation have been made available with an open-source GPLv3 license on github<sup>7</sup>. After reviewing and testing, Coronis found the most versatile to be the Radial Basis Function (RBF) interpolator. They undertook a lot of effort to refine the method and make it fit for purpose. The interpolants were first implemented in Matlab, and then ported to Python, to ease their implementation within the Globe software by Ifremer. The Python implementation was also released under LGPLv3 license at github<sup>8</sup>. The investigations and final results are documented by Coronis in a technical report [16]. The interpolation components have been integrated by Ifremer in Globe in two steps. First by a test version, whereby regional coordinators evaluated the performance with various configurations (density of soundings, relative distribution of the information, type of seabed morphology, computer resources, ....) and gave feedback. This was used by Coronis for further refinement and upgraded software, which is now included in Globe. However, users must be careful with interpolations as unwanted side-effects might occur.

Further down the EMODnet HRSM 2 project, Coronis has continued the work on converting raster DTMs, as the ones generated within this project, into triangulated irregular networks (TINs) optimized for web-based visualization. Earlier code of the software was refactored and some bugs solved. Finally in December 2020, the updated code was applied by

<sup>&</sup>lt;sup>7</sup> https://github.com/coronis-computing/heightmap interpolation toolbox

<sup>&</sup>lt;sup>8</sup> <u>https://github.com/coronis-computing/heightmap\_interpolation</u>



Coronis to generate the 3D visualization of the new 2020 DTM, which has been added to the Bathymetry Viewing and Download service.

A major upgrade has taken place of the CDI Data Discovery & Access service which gives overview and access to the gathered bathymetric surveys. As part of the EU SeaDataCloud project, the CDI service has been improved in functionality and performance by adopting the cloud and completely renewing the user interface and the data shopping experience. Following the upgrade of the SeaDataNet CDI user interface, also efforts were undertaken by MARIS for upgrading the CDI service user interface of EMODnet Bathymetry. And upgrading took place of the CDI OGC WMS – WFS services, which are integrated in the Bathymetry Viewing and Download service. As a consequence, data providers had to adopt the new procedure for submitting CDI entries and configure and get acquainted with upgraded tools and services. A lot of support and training was given and the deployment went well as has been described in WP1. More details about the upgrading can be found in Chapter 13 Annex 3.

Changes by the INSPIRE team at EU-JRC, both on the INSPIRE ISO19139 metadata schema and the introduction of a new official (beta) validator service, required renewed action for making the CDI XML schema INSPIRE compliant. This gave reason for a dialogue with the INSPIRE team for overcoming the issues on both sides as it was clear that the functioning of the new validator was one of the reasons for concern. After quite some communication and efforts, the issues have been solved by updating the CDI XML coding (published on SeaDataNet portal) which can be validated using the latest version of the amended ETF validator of INSPIRE: <u>http://inspire.ec.europa.eu/validator/</u>, whereby one has to select metadata for interoperability as the target conformance class. More details can be found in the separate report on international interoperability [10].

Ifremer has upgraded the Sextant catalogue Content Management System (CMS) and associated manual in such a way, that there is now a staging process. Data providers can make new entries or update existing entries in the CPRD and HR-DTM catalogues, while Ifremer as master can validate these before actual publishing. This improves the overall quality and consistency of these two catalogues [5], [6].

The bathymetric survey data sets are really massive, and processing them to produce a Digital Terrain Model, in particular on regional and pan-European scales, is very challenging. The grid resolution of the new EMODnet DTM is 1/16 \* 1/16 arc minutes (circa 115 \* 115 m2) and it contains approximately 12.3 billion grid nodes, organized in 113892 columns and 108132 rows (seabed and terrestrial coverage included). To handle the integration the overall DTM was split over 64 tiles. Also the regional coordinators (11) had to split their regional DTMs in tiles during production, because their desktop PC's could not handle the number of data points, while production runs took considerable time in practice. Not only is this time consuming, but it also increases chances for anomalies at the edges of tiles, which need to be corrected. Furthermore, regional coordinators work independently of each other, albeit with agreed overlap zones between the regional DTM areas in order to minimise possible edge effects. For sure one can speak of big data and a high challenge for the regional coordinators and integrated Collaborative Virtual Environment (CVE), to be hosted in the cloud and with strong computing power. The CVE should facilitate the data provision from data providers and the collaborative processing of regional DTMs between regional coordinators and their interaction with the integrator. The CVE should make it more efficient for regional coordinators and integrator to perform their workflows for generating the DTM, also in closer interaction and with additional functions to optimize results.

This CVE development was started in the previous project and has continued in the current project as follows. A recent version of the Globe Software has been installed and configured on the shared DATARMOR high performance computing infrastructure to provide a Globe online workbench. This allows different users to share a same session, which is ideal for regional coordinators who are generally skilled in using the full potential of Globe. The regional coordinators produce and finalize the Regional DTM for a specific geographic region and need to share data and information with the neighboring areas. Furthermore, Globe online allows the regional coordinators to work remotely and to benefit from computing and storage capabilities of the dedicated virtual machine.

Furthermore, Web Processing Services (OGC WPS) have been developed and deployed. A WPS is very useful for promoting tools and pre-defined processing workflows following EMODnet's established methodology. For regional coordinators, the WPSs can promote a standard "merging" workflow, based on single and harmonized DTMs stored on a common data infrastructure. It can also provide specific tools for validating DTMs.

On the server side, the WPS programming interface and service provider are implemented by QGIS Server and a customized version of PyWPS. One can execute R or Python scripts with a few additional headers and QGIS Server/PyWPS handle the dispatch of input and output datas in WPS format. This allowed to build a DTM merge WPS with Python, calling a command-line derivate of Globe for core data processing.



On the client side, the Sextant Web UI is able to build ad-hoc data entry fields from WPS embedded inputs/outputs description and send the appropriate WPS Execute requests. Although from a theorical point of view WMS and WPS available on a same server are completely separate, for this application, both services use the same data. Therefore, the Sextant Web UI is now able to use the checkboxes' state on the map layer list (coming from WMS) to build a layer list as an input for a WPS, thus giving a more streamlined experience to the user who can now directly call the merge WPS after selecting the displayed DTMs, without having to select them a second time from the drop-down lists.

This way, a CVE prototype has been developed whereby regional data sets (single DTMs and resulting Composite DTMs) are stored and accessible from the DATAWORK disk space. The WPS allows one to select DTMs stored on the "DATAWORK" space and merge them. Behind the scenes, a Python script managed by QGIS server+PyWPS calls the "EmodnetProcesses" command-line tool derived from Globe to perform the merge operation and stores the generated file in-place. Furthermore, the web application can query Sextant, SeaDataNet CDI and EMODnet databases in order to display metadata and to query Quality Indicators, based on the CDI or CPRD identifier of the file.

The main functionalities developed for the prototype are:

- Data selection tools
  - Exploring and retrieving of available data sets from the "DATAWORK" DTMs pool,
    - 2D mapping and visualization services,
    - Interaction with the SeaDatanet CDI and Sextant services.
- Data processing tools
  - Spike detector
  - DTM annotation
  - o Slope, hillshade

The CVE prototype is online available for regional coordinators and members of the technical team.9



Figure: screen from the CVE Prototype

The development and set-up of the CVE Prototype are documented in a technical report [17], while there is also a user manual [14] for the CVE Prototype.

<sup>&</sup>lt;sup>9</sup> <u>https://www.ifremer.fr/sextant\_doc/emodnet\_bathymetry/api/sardinia.html#/map</u>



Three regional coordinators, CNR (Italy), HCMR (Greece), Ifremer (France), together covering the Mediterranean Sea area, have been involved in testing the CVE Prototype in order to gain experience and to try out the performance and ways of working collaboratively.

The CVE Prototype tests included:

- Access to the software (and associated resources of the infrastructure) and associated data, per individual and shared projects;
- Test that thematic actions are feasible (data import, sorting of the data per quality Index, merging of datasets, interpolation between dataset
- Share results / projects remotely held on DATARMOR

In principle, functional tests have been undertaken successfully, with the main comment that further improvement could be envisioned regarding user friendliness. However, there is a serious problem with performance, which is also due to issues with connectivity of remote users to the CVE Prototype. A preliminary conclusion is that the CVE solution is promising but still has performance limitations which prevent currently an wider adoption of this cloud-based solution at full scale by the basin coordinators. Further work will be undertaken towards this aim in the future. The test report is available at the portal [15].

WP4 contributes to the following task as formulated in the tender and as shared with WP3:

• Task 4: Machine-to-machine connections to data and data products

WP4 also contributes to the following task as shared with WP6:

- Task 5: Web portal
- WP4 also contributes to the following task as shared with WP1 and WP3:
  - Task 8: INSPIRE compliance

WP4 also contributes to the following task as shared with WP0 and WP6:

• Task 9: Monitoring of performance

All tasks have been completed as can be derived from the WP0, WP1, WP3, WP4 and WP6 progress reporting and the separate reports on upgrading Sextant catalogue service [5], [6], international interoperability [10], interpolation methods [16], and Collaborative Virtual Environment [14], [15], and [17] as well as Annex 3 for CDI service upgrading.

### 7.6 WP5 – Coastlines, legal baselines and vertical reference levels:

With the increase of the resolution of the EMODnet DTM, the EMODnet Bathymetry team has strongly focused on the land-sea interface. Two main tasks have been pursued along the duration of the contract. The first one concerns the location of the coastline, while the second concerns the conversion between vertical references. These have been essentially managed by consortium member Deltares.

#### Official coastline and legal baselines:

The existing inventories of official coastline and legal baselines have been updated. The information has been collected by Deltares together with EMODnet Bathymetry consortium members and where possible, also from other EU member states, from the officially recognised national sources. The information is now available from 26 countries versus 21 in the previous version. The result of the updated inventory has been documented in a public report [12] which provides a snapshot of the inventory of existing coastlines and baselines without any attempt to resolve existing legal disputes as this is out of scope and capability of EMODnet.

Nr	Country	Baseline	Coastline
1	Albania	Available	N/A
2	Belgium	Available	Available
3	Bulgaria	N/A	Available
4	Croatia	N/A	Available
5	Cyprus	N/A	N/A
6	Denmark	Available	Available



7	Estonia	Available	N/A
8	Finland	Available	N/A
9	France	Available	Available
10	Georgia	N/A	N/A
11	Germany	Available	Available
12	Greece	Available	Available
13	Iceland	Available	N/A
14	Ireland	Available	Available
15	Israel	N/A	Available
16	Italy	Available	Available
17	Latvia	Available	Available
18	Lithuania	Available	N/A
19	Malta	Available	Available
20	Monaco	N/A	N/A
21	Montenegro	N/A	N/A
22	Netherlands	Available	Available
23	Norway	Available	Available
24	Poland	Available	N/A
25	Portugal	Available	Available
26	Romania	Available	Available
27	Russia	N/A	N/A
28	Slovenia	Available	Available
29	Spain	Available	Available
30	Sweden	N/A	Available
31	Turkey	N/A	N/A
32	Ukraine	N/A	N/A
33	United Kingdom	Available	Available

Table: Status of collected national legal baseline data-sets and coastline data-sets (12/2020)

The information provided as part of the coastline and baseline inventory has been collected with the utmost care from authorities responsible for the definition and maintenance of official coastline and baseline in their national jurisdiction in Europe. Information made available in this inventory has been verified in December 2020, but might have been subject to changes since then. When available, a national disclaimer specific to each coastal state specifies its use and its legal scope. This national disclaimer must be used complementary to the document [12]. Therefore, EMODnet Bathymetry is by no means responsible for the production, the maintenance, the completeness, the accuracy, the reliability, the suitability and/or the availability of this information (all or parts). The inventory report [12] and the digital files of the coastlines and baselines can be downloaded from the EMODnet Bathymetry portal.

#### Satellite Derived Coastlines at different reference levels:

Deltares has undertaken activities for updating and refining the best-estimate European digital coastlines for a range of vertical levels. First of all, it has identified and analysed the difficulties that were earlier experienced with estimating the



digital coastlines from satellite views. Several steps have been performed in making the land-water-detection more robust and considering the dynamics of the seabed for very dynamic areas

While a single satellite image can be used to detect coastline geometry, a much more robust approach is to combine multiple satellites. This allows capturing not only coastline geometry, but also variations in the coastline geometry due to tidal water level changes. Processing of satellite images at large spatio-temporal scales is a challenging task, due to large volumes of satellite data to be processed, but also, due to variety in the satellite data radiometric properties and formats. Deltares has used Google Earth Engine platform to overcome some of these challenges. The platform allows parallel processing of huge volumes of satellite data in reasonable time and also harmonizes satellite data acquired by different satellite missions performed by NASA and ESA. A mixture of top-of-atmosphere reflectance satellite images have been used from NASA/USGS Landsat 8 and ESA Sentinel-2 satellite missions, acquired during 2013-2020.

Existing methods for surface water detection from multispectral satellite data use the fact that water significantly absorbs most radiation at near-infrared wavelengths and beyond. This fact makes it easy to detect clear water employing spectral indices, such as the Normalized Difference Water Index (NDWI). The NDWI has been used to distinguish between land and water and, hence, detect the coastline.

There are several sources of noise for optical images that had to be overcome such as Clouds and cloud shadows, Snow and ice, Georeferencing, Spectral and radiometer resolution, and others. To address most of these challenges, Deltares has used statistical methods to process and combine a large number of satellite images. In particular, instead of detecting surface water from satellite images using fixed NDWI threshold, the images were processed to represent a probability of land/water boundary, a values close to 1 indicates that a particular pixel is always "wet", therefore almost sure that location is water. The NDWI algorithm was applied to process most images from Landsat 8 and Sentinel-2 missions covering the EMODnet Bathymetry area.

The availability of Landsat satellite imagery allows us to study these coastlines from 1984 until now with a pixel resolution down to 15m. The recent Sentinel-2 satellite mission (ESA, 2016) even go up to a pixel resolution of 10m. Based on these images historic trends in coastal erosion can be detected. Recent work to assess the accuracy of satellite derived coastline trends compared to survey data has shown very promising results for a case study of the Sand Engine mega nourishment in the Netherlands. Similar analysis can be made to derive other coastal parameters such as vegetation, sand and human infrastructure. In EMODnet-HRSM2 the NDWI algorithm is used to derive coastlines for the European waters. This in combination with a tidal model allows then to retrieve coastlines at different vertical datum (e.g. MSL, MHW, LAT).



Figure: Water occurrence computed as expected value from all NDWI values, using per-pixel cloudiness values as weights (dark blue = permanent water, red = land).

For tidal referencing, Deltares has refined and recalibrated their Global Tide and Surge Model (GTSM) at 5 km and 1.25 km grids. New runs were generated integrating updated tide gauge control points and GTSM adopted the EMODnet 2018 DTM and GEBCO 2019 bathymetry. This has resulted in a significant improvement of the accuracy, e.g. from 8.0 to 5.6 cm RMSE in the North Atlantic and from 6.3 to 4.9 cm RMSE globally. An extensive calibration of the model has been performed in cooperation with the TU Delft. The current version now has an accuracy of 3.5 cm RMSE in the North Atlantic and 3.3 cm on average globally.



Bathymetry difference after estimation in Approach 2



DMCE	GTSM with fine grid				
RMSE	Initial	Approach 1	Approach 2		
Arctic	5.22	3.85	4.33		
Indian Ocean	5.43	3.99	3.54		
north atlantic	5.58	3.39	3.48		
south atlantic	4.98	3.77	3.44		
north pacific	3.93	3.19	3.09		
south pacific	4.91	3.34	3.17		
southern ocean	3.95	2.94	2.90		
Total	4.85	3.47	3.30		

Image: Bathymetry adjustments during calibration of GTSM and Table: Accuracy of GTSM in deep water compared to satellite

Such improvement is double sided as it shows clearly that efforts improving the EMODnet Bathymetry product are generating benefits to the hydrodynamic modelling community. While locations with less good tidal model results indicate where the bathymetry still might need to be improved further. This concerns mostly estuaries and tidal areas where we require additional bathymetry data sets.

On the other side, benefits from these results have been directly integrated in the automated coastline delineation production algorithm along with the conversion surfaces used to vertically transform the gridded bathymetry, natively generated at the LAT (Lowest Astronomical Tide) to the Mean Sea Level (MSL).

The GTSM tidal information allowed to retrieve water level at any time and location and compute satellite derived coastline to a coordinated tide level. The availability of the conversion between these vertical reference frames makes it possible to connect data-sets using different vertical reference frames, and conversion to a reference frame of choice for the user. The schematization of the vertical datum referencing process is shown in the figure below.



Figure: schematization of the vertical datum referencing of satellite derived coastline

Finally, Deltares has generated a new release of the best-estimate digital coastlines for different tidal reference levels (LAT, MSL, MHW) was generated. These satellite derived coastlines can be viewed as an extra layer in the Bathymetry Viewing service which also allows downloading them as vector shapefiles. The latest December 2020 version now covers the entire coastline of Europe. The production process has been documented in a report [11] which can be retrieved from the EMODnet Bathymetry portal.

WP5 contributes to the following task as formulated in the tender and as shared with WP2 and WP3:

• Task 2: Digital terrain model



WP5 also contributes to the following task as formulated in the tender and as shared with WP1 and WP2:

• Task 3: Coastline data

All tasks have been completed as can be derived from the WP1, WP2, WP3 and WP5 progress reporting and the public reports on national coastlines and baselines [12] and satellite derived coastlines [11] which have been published at the portal.

### 7.7 WP6 – Outreach, helpdesk and evaluation

The earlier success of the EMODnet Bathymetry portal and services is continued and also in the reporting period there are lots of interest and users registered. Chapter 10 gives a list of participations of consortium members in conferences, papers and other outreaching activities. For instance, an official Memorandum of Understanding was established between EMODnet Bathymetry, IHO-IOC General Bathymetric Chart of the Ocean / Seabed 2030 and the Seabed 2030 initiative<sup>10</sup>, led by the IHO-IOC GEBCO, under the financial sponsorships of the Nippon Foundation. EMODnet Bathymetry is recognized as a worldwide key actor of bathymetric data production and important partner for the Seabed 2030 initiative.

The web portal was maintained, statistics about use of portal and services were collected and several questions were received and answered by the helpdesk. The monitoring indicators are summarised in chapter 11 and detailed in a separate excel file. Overall, these indicators are very good, showing the major interest of users above all in the EMODnet DTM by views, downloads, and OGC web service requests. Ninety five (95) user questions were received and answered through the helpdesk which are listed in chapter 8. More than three hundred (300) references to EMODnet Bathymetry can be found in scientific articles, books, and thesis documents. These have been identified using Google Scholar and these listings are given in Chapter 10.

The following articles were written by members of EMODnet Bathymetry and together with other international bathymetry experts:

- Seafloor Mapping The Challenge of a Truly Global Ocean Bathymetry; Anne-Cathrin Wölfl, Helen Snaith, Sam Amirebrahimi, Colin W. Devey, Boris Dorschel, Vicki Ferrini, Veerle A. I. Huvenne, Martin Jakobsson, Jennifer Jencks, Gordon Johnston, Geoffroy Lamarche, Larry Mayer, David Millar, Terje Haga Pedersen, Kim Picard, Anja Reitz, Thierry Schmitt, Martin Visbeck, Pauline Weatherall and Rochelle Wigley; 2019; article in Frontiers;<sup>11</sup>
- 3D Simplification Methods and Large-Scale Terrain Tiling; Ricard Campos, Josep Quintana, Rafael Garcia, Thierry Schmitt, George Spoelstra, Dick M. A. Schaap; 2020; Article in Remote Sensing magazine. 2020, *12*(3), 437;<sup>12</sup>
- The European harmonised bathymetry grid EMODnet Bathymetry; Thierry Schmitt, Dick Schaap, George Spoelstra, Patricia Slabon, Paul Wintersteller, and Knut Hartmann; 2020; Article in Hydrographische Nachrichten HN 117, October 2020, ISSN: 1866-9204;<sup>13</sup>

International interoperability is ensured in a number of ways. First of all, the EMODnet HRSM2 consortium consists of organisations that have international networks and are well acquainted with international cooperation also aiming at international interoperability. This includes relationships concerning standards such as: ISO, OGC, INSPIRE, SeaDataNet, IHO, IOC, and ODIP. It also includes collection and sharing of metadata, data and DTMs such as GEBCO, IBCAO, BSBD, NSBD, and NOAA/NCEI. Both levels results in formats and controlled terms that are applied to the metadata and datasets in EMODnet HRSM2 and which are therefore interoperable with international practices. It also comes back in the web services that are based upon OGC standards and tools which are broadly used by international communities. Another element ensuring coherence and interoperability is the fact that bathymetry data are collected in-situ by remote sensing techniques and instruments which are used by the global community of hydrographers and bathymetric researchers, with relatively similar principles, methodologies and practices. This implicates that the original collected data sets are comparable in formats. Finally there is a long tradition on a global scale, such as through IHO and the GEBCO project, to share bathymetry methods and resulting datasets which also results in international interoperability. Benefiting from the previous EMODnet Bathymetry activities, EMODnet HRSM2 is well engaged in multiple active international

<sup>&</sup>lt;sup>10</sup> https://seabed2030.gebco.net/

<sup>&</sup>lt;sup>11</sup> <u>https://doi.org/10.3389/fmars.2019.00283</u>

<sup>&</sup>lt;sup>12</sup> https://doi.org/10.3390/rs12030437

<sup>&</sup>lt;sup>13</sup> <u>https://www.emodnet-bathymetry.eu/media/emodnet\_bathymetry/org/documents/hn117.pdf</u>



collaborations (International Hydrographic Organisation (IHO), General Bathymetric Chart of the Ocean (GEBCO), US National Oceanographic and Atmospheric Agency (NOAA) through the Atlanctic Ocean Research Aliance (AORA)), and the International Bathymetric Chart of the Arctic Ocean (IBCAO). Further details about international cooperation are detailed as part of the separate report on interoperability and international collaboration [10].

The web portal was regularly updated to reflect events and releases of new and updated products and services. Promotion of the new\_EMODnet Bathymetry World Base Layer (EBWBL) has been undertaken together by the EMODnet Secretariat, EMODnet Bathymetry and the SEABED 2030 / GEBCO participants, and with help from DG-MARE. This pre-tiled representation service (OGC-WMTS) of the world provides the most up-to-date compilation of bathymetric data and topographic data available. This work is presented to the user and the international community as a contribution from EMODnet Bathymetry and the European Commission in the global effort of sharing broadly ocean data knowledge. The release has been made public on the 30 June 2020. Also in communication with the EMODnet Secretariate, a press release was prepared for the new 2020 EMODnet DTM release, which officially was launched on 13<sup>th</sup> January 2021.

EMODnet Bathymetry members are regularly discussing technical matters with GEBCO / Seabed 2030 counterparts. Since early 2020 a monthly technical remote meeting is organised. Also, as part of the "EMODnet 10 years webinar", contributions were given to the drafting of the presentation by IHO General Secretariat. This presentation describes the EMODnet Bathymetry data management / distribution model (leaving data provider at the center of all decisions concerning their datasets), and promotes EMODnet Data Ingestion as a "trusted node" in the IHO concept of collecting Crowd Source Bathymetry. Both of these actions are part of long-term actions to ensure that actions and contributions from the EMODnet Bathymetry members are fully interoperable with global initiatives.

As before done for the previous grid, the 2020 EMODnet DTM will be included in the next release of the GEBCO grid to be generated around the middle of 2021. Thanks to the delivery of web services, the inventory and viewer service of worldwide bathymetric data<sup>14</sup> held by the IHO Data Centre for Digital Bathymetry, has been automatically updated with new datasets from EMODnet Bathymetry. Also, the IHO - Europe Networking Working Group (IENWG) meeting, in December 2020, allowed the promotion of EMODnet Bathymetry activities to the IHO and to hydrographic offices which are not yet members of the consortium. Success in the strategy of the European Commission and its implementation from the EMODnet Bathymetry group has been acknowledged by the participants and more especially by representatives from the IHO.

Also, as part of the EMOD-PACE project, experts from EMODnet Bathymetry have provided elements on the EMODnet bathymetry methodology on data and metadata formatting and delivery to Chinese counterparts for them to adapt and undertake the European model.

WP6 combines the following task as formulated in the tender:

• Task 6: Helpdesk

WP6 contributes to the following task as formulated in the tender and as shared with WP4:

• Task 5: Web portal

WP6 also contributes to the following task as formulated in the tender and as shared with WP1:

• Task 7: International interoperability

- WP6 also contributes to the following task as formulated in the tender and as shared with WP4:
  - Task 9: Monitoring of performance

All tasks have been completed as can be derived from the WP1, WP4, and WP6 progress reporting and the separate report on interoperability and international collaboration [10].

<sup>&</sup>lt;sup>14</sup> <u>https://maps.ngdc.noaa.gov/viewers/iho\_dcdb/</u>



## 8. User feedback

	User feedback and/or requests received							
Date	Organisation	Type of user feedback (e.g. technical, case study, etc.) and short description of the feedback received	Response time	Status of user query: resolved/pending	Measures ta resolve the c	ken to Juery	Status: if not (yet) resolved/pending, explain reason why and expected timeline	
7 Jan 2019	IFREMER, France	Problem with response mail with download URLs	Same day	Resolved	Given feedback	satisfactory		
18 Jan 201	9 ?, Netherlands	Problem with downloading files	Same day	Resolved	Given feedback	satisfactory		
23 Jan 201	9 ?, France	Problem with downloading files	Two days later	Resolved	Given feedback	satisfactory		
25 Jan 201	9 IFREMER, France	Looking for geology maps	Same day	Resolved	Given feedback	satisfactory		
2 Feb 2019	?, Spain	Problem with coastline of Menorca	Two days later	Resolved	Given feedback	satisfactory		
18 Fe 2019	DEFRA, United Kingdom	Question about download options	Next day	Resolved	Given feedback	satisfactory		
22 Fe 2019	JRC, Italy	Question about overlap between tiles	Same day	Resolved	Given feedback	satisfactory		
25 Fe 2019	o GTK, Finland	Question about MSL - LAT	Next day	Resolved	Given feedback	satisfactory		
28 Fe 2019	GMZ, Switzerland	Question about metadata and acknowledgement	Same day	Resolved	Given feedback	satisfactory		
11 Ma 2019	r ?,?	Question about CDI service	Same day	Resolved	Given feedback	satisfactory		
13 Ma 2019	r ?,?	Compliments about the service	Same day	Resolved	Given feedback	satisfactory		



13 Mar 2019	CNR-ISMAR, Italy	Question about wrecks layer	Same day	Resolved	Given feedback	satisfactory	
19 Mar 2019	HAFOK, Sweden	Question about shift in land cover	Few days later	Resolved	Given feedback	satisfactory	
2 Apr 2019	HAFOK, Sweden	Continued communication about shift in land cover	Few days later	Resolved	Given feedback	satisfactory	
3 Apr 2019	Noveltis, France	Question about .emo format	Same day	Resolved	Given feedback	satisfactory	
8 Apr 2019	Noveltis, France	Question about metadata for HR- DTMs	Same day	Resolved	Given feedback	satisfactory	
17 Apr 2019	Global Maritime Services, UK	Question whether a tile for MSL is correct	Same day	Resolved	Given feedback	satisfactory	
17 Apr 2019	Svasek, The Netherlands	Question about a tile with issues	Same day	Resolved	Given feedback	satisfactory	
25 Apr 2019	?,?	Question about wrecks layer	Same day	Resolved	Given feedback	satisfactory	
25 Apr 2019	Institute of Marine Research, Norway	Question about 2D – 3D and about ESRI ASCII format of tiles	Same day	Resolved	Given feedback	satisfactory	
25 Apr 2019	?,?	Question about Help page	Few days later	Resolved	Given feedback	satisfactory	
9 May 2019	University of Louvain, Belgium	Question about problem with downloading	Same day	Resolved	Given feedback	satisfactory	
9 May 2019	Grizzly Geosciences Inc, USA	Question about problem with GMT software	Next day	Resolved	Given feedback	satisfactory	
10 May 2019	Grizzly Geosciences Inc, USA	Question about GeoTiffs	Same day	Resolved	Given feedback	satisfactory	
14 May 2019	?,?	Question about possible job positions	Few days later	Resolved	Given feedback	satisfactory	
16 May 2019	Wsense, Italy	Question about maximum zoom level	Few days later	Resolved	Given feedback	satisfactory	
20 May 2019	University of Salento, Italy	Question about NetCDF	Next day	Resolved	Given feedback	satisfactory	



21 May 2019	?,?	Question about WMS in Arc	Few days later	Resolved	Given feedback	satisfactory	
5 Jun 2019	?, France	Question about resolution	Next day	Resolved	Given feedback	satisfactory	
11 Jun 2017	?,?	Question about coordinate system	Few days later	Resolved	Given feedback	satisfactory	
19 Jun 2019	US Navy, USA	Question about emo file format	Same day	Resolved	Given feedback	satisfactory	
20 Jun 2019	AWI, Germany	Question about emo format documentation	Same day	Resolved	Given feedback	satisfactory	
20 Jun 2019	?,?	Question about LAT - MSL	Next day	Resolved	Given feedback	satisfactory	
27 Jun 2019	?,?	Question about meaning of positive values in DTM	Same day	Resolved	Given feedback	satisfactory	
2 Jul 2019	UK HO, UK	Question about emo format	Next day	Resolved	Given feedback	satisfactory	
7 Aug 2019	Gavin and Doherty Geosolutions Ltd, Ireland	Question about MSL DTM tiles	Same day	Resolved	Given feedback	satisfactory	
9 Aug 2019	Scotland government, Scotland	Noted a spelling mistake in map	Same day	Resolved	Given feedback	satisfactory	
14 Aug 2019	Grupo Gimeno, Spain	Question about river bathymetry	Same day	Resolved	Given feedback	satisfactory	
14 Aug 2019	Unknown	Question about bathymetry survey time series	Next day	Resolved	Given feedback	satisfactory	
15 Aug 2019	National University of Ireland, Ireland	Question about downloading of isolines	Same day	Resolved	Given feedback	satisfactory	
25 Aug 2019	University of York, UK	Question about referencing EMODnet Bathymetry	Next day	Resolved	Given feedback	satisfactory	
2 Sep 2019	Aarhus University, Dep of Bioscience, Denmark	Remark about anomalies in Danish bathymetry	Next day	Resolved	Given feedback	satisfactory	


11 Se 2019	o ?,Spain	Question about referencing EMODnet Bathymetry and about vessel traffic density maps	Next day	Resolved	Given feedback	satisfactory	
17 Se 2019	GeoData Agency, Denmark	Problem with order processing	Next day	Resolved	Given feedback	satisfactory	
18 Se 2019	Geology Service, Sweden	Question about identification of low and high resolution DTM parts	A week later	Resolved	Given feedback	satisfactory	
18 Se 2019	D University of Nantes, France	Question about using the DTM	Same day	Resolved	Given feedback	satisfactory	
20 Se 2019	GeoData Agency, Denmark	Signals a displacement of one grid cell	A week later	Resolved	Given feedback	satisfactory	
27 Se 2019	NoLogin, Spain	Question about LAT – MSL references	Two days later	Resolved	Given feedback	satisfactory	
3 Oct 2019	ThinkRCG, United Kingdom	Question about difference between DTM and nautical chart depths near Ireland	Three days later	Resolved	Given feedback	satisfactory	
6 Oct 2019	UMA, Spain	Question about losing information when joining DTM data	Two days later	Resolved	Given feedback	satisfactory	
10 Oc 2019	t UIS, Norway	How to download High Resolution DTMs near Greece	2 weeks later	Resolved	Given feedback	satisfactory	
28 Oo 2019	t Vattenfall, Germany	Question about vertical reference used in DTM	Same day	Resolved	Given feedback	satisfactory	
31 Oc 2019	t ??	Whether the DTM can be downloaded with negative values	One week later	Resolved	Given feedback	satisfactory	
15 Nov 2019	FMI, Finland	Warning that the WMS service was not functioning	Same day	Resolved	Given feedback	satisfactory	
29 No 2019	UniCT, Italy	How to acknowledge EMODnet DTM in scientific abstracts	Three days later	Resolved	Given feedback	satisfactory	
3 Dec 201	University of Colorado, USA	Question about geographical coverage of EMODnet DTM	Same day	Resolved	Given feedback	satisfactory	
15 De 2019	??	Whether EMODnet Bathymetry performs environmental studies	Next day	Resolved	Given feedback	satisfactory	



17 Dec 2019	Tinopolis, United Kingdom	Asking permission to use EMODnet Bathymetry maps in a tv documentary	Same day	Resolved	Given satis feedback	factory
17 Dec 2019	HZG, Germany	Question about including land cover in downloads	Next day	Resolved	Given satis feedback	factory
3 Jan 2020	JNCC, UK	Question about date ranges of input data sets	Three days later	Resolved	Given satis feedback	factory
8 Jan 2020	Exeter University, UK	Question about uncertainty associated with the EMODnet Bathymetry DTM	Same day	Resolved	Given satis feedback	factory
8 Jan 2020	Intertek, Netherlands	Question about about the vertical datums	Next day	Resolved	Given satis feedback	factory
15 Jan 2020	DTU, Denmark	Question about acknowledgements to images in thesis	Same day	Resolved	Given satis feedback	factory
16 Jan 2020	TU Delft, The Netherlands	Question about DTM formats	Same day	Resolved	Given satis feedback	factory
7 Feb 2020	??	Question about about the vertical datums	Two day later	Resolved	Given satis feedback	factory
6 Feb 2020	University of Aberdeen, UK	Question about .emo file format for DTM tiles	Two days later	Resolved	Given satis feedback	factory
18 Feb 2020	UNICA, Italy	Issue with downloading	Same day	Resolved	Given satis feedback	factory
24 Feb 2020	??, Greece	Question about coordinates on the map	Same day	Resolved	Given satis feedback	factory
24 Feb 2020	University of Texas, USA	Question about desirability of csv files for depth profiles	Same day	Resolved	Given satis feedback	factory
24 Feb 2020	??	Question if we can provide bathymetry of Mozambique	Two days later	Resolved	Given satis feedback	factory
17 March 2020	??	Question how to solve inverted relief.	Same day	Resolved	Given satis feedback	factory
4 April 2020	??	Question about the EMO format for the DTM	Same day and number of messages	Resolved	Format docume provided and expla	anation



			following days		given how to use it with GLOBE	
12 April 2020	??	Issue with using GeoTiff files	Two days later	Resolved	Tested it without issues ourselves and given feedback	
15 April 2020	Sympatico, Canada	Issue with WCS	Next day a number of messages	Resolved	Tested that WCS was working properly and informed user.	
1 May 2020	??	Question about colour bands of GeoTiffs	Three days later	Resolved	Explanation given.	
11 May 2020	Manxgeo, UK	Issue with registration	Next day	Resolved	Tested ourselves and explained. Confirmation received from user.	
15 May 2020	??	Question about coverage of WMS	Two days later	Resolved	Information provided about new global coverage (EBWBL service).	
14 June 2020	Onplotsolutions, UK	Question about having land in downloadable DTM tiles	Next day	Resolved	Explanation given.	
15 June 2020	??	Spotted an error in the DTM	Next day	Resolved	Reported to regional coordinator. Has been solved in the new 2020 DTM release	
22 June 2020	University of Rhode Island, USA	Question about Quality Index	Two days later	Resolved	Explanation given how the QI can be used.	
7 July 2020	IOPAN, Poland	Question about sediment accumulation rates for the Baltic sea	Same day	Resolved	Referred to EMODnet Geology	
14 July 2020	Red Rock Power, UK	Question about Geotiffs	Two days later	Resolved	Explanation given about Geotiffs and alternative solution given	
22 July 2020	Naval Group, France	Question about EMODnet Bathymetry World Base Layer Service (EBWBL)	1 week later	Resolved	Explanation given about WMTS service	



30 July 2020	Leibniz University, Germany	Problem with downloading tiles.	Same day	Resolved	Error in DTM list in shop. Corrected.	
10 August 2020	Dagbladet Information, Denmark	Question about map used in article.	Same day	Resolved	Explanation given about background map and reference	
21 August 2020	NCIA – NATO, Belgium	Question about use of DTM and EBWBL for NATO purposes	One day later	Resolved	Explanations given and invitation for web conference	
5 October 2020	Map Media, ?	Question about downloading of HR-DTMs	One day later	Resolved	Explained how downloading works.	
5 October 2020	Company; Map Media, ?	Question about downloading of HR-DTMs	One day later	Resolved	Explanation given	
13 November 2020	Company; Navico, Mexico	Question about commercial use of HR-DTMs	Two days later	Resolved	Referred to Terms of Use	
18 November 2020	Company; Fiskher, Norway	Question about commercial use of DTM	Same day	Resolved	Referred to Terms of Use	
18 November 2020	Research Institute; SYKE, Finland	Question about Terms of Use of EMODnet Bathymetry products	Same day	Resolved	Explanation given	
18 November 2020	Research Institute; SYKE, Finland	Question about option for downloading all 64 DTM tiles via FTP	Same day	Resolved	Explanation given	
25 November 2020	Company; Fishker, Norway	Additional questions about commercial usage of DTM	Same day	Resolved	Referred to Terms of Use	
18 December 2020	University; Technical University Hamburg, Germany	Question about conversion of coordinates between Mercator and UTM	Same day	Resolved	Explanation given which software to use	



## 9. Meetings held/attended

	Meetings organised and attended					
Date	Location	Type event (meeting, training (workshop), etc.)	Attended (A) / Organised (O)	Short description and main results (# participants, agreements made, etc.)		
5 Apr 2019	Paris - France	Project core group meeting	0	11 Representatives of the consortium, all leading one or more work package met in Paris to discuss the organisation of the Kick-Off Meeting.		
11- 12 Jun 2019	Brest - France	Project kick off meeting	0	All Representatives of the consortium met in Brest to implement the production agenda and refresh their skills related to the use of the software		
2 – 3 Sept 2019	Ghent - Belgium	EMODnet Steering Committee meeting	А	Progress presented		
3 – 4 Sept 2019	Ghent - Belgium	EMODnet Technical Working Group	А	Various topics discussed		
29 Oct 2019	Brest - France	Project technical meeting	0	Discuss GLOBE upgrading and QA-QC methods, and possible implications for the overall planning		
20 March 2020	Web Conf	External technical meeting with Shom, MARIS and GGSGC for EU DG MARE, Secretariat, VLIZ, and EMODnet Thematic	Ο	Providing insights and visions on the integration within the EMODnet Central portal.		
				Discussed about EMODnet Bathymetry technical and organisational set-up as part of process for planning approach new vision of an integrated EMODnet Central portal		
15-16 April 2020	Remote	Project progress meeting with core group	0	Progress meeting with core technical team and basin coordinators (30 persons)		
23-24 April 2020	Remote	EMODnet Technical Working Group	А	Various topics discussed (approx. 15 persons)		
28 May 2020	Remote	Project progress meeting with core group	0	Progress meeting with core team and basin coordinators (30 persons)		
11 Sept 2020	remote	Progress meeting with regional coordinators	0	Progress and delivery of the basin compilation.		
21 Sept 2020	remote	Progress meeting with regional coordinators	0	Progress and delivery of the basin compilation.		
6 Oct 2020	remote	Progress meeting with regional coordinators	0	Progress and delivery of the basin compilation.		
9-13 Nov 2020	Remote	13th EMODnet Steering Committee and 8th Technical Working group	А	EMODnet bathymetry progress and reports given		
SUM			O = 9	Total # of meetings organised =		



SUM

EASME/EMFF/2017/1.3.1.2/01/SI2.79126-EMODnet Lot n°0 – Bathymetry Final Report

A = 4 7

Total # of meetings attended =



## **10.** Outreach and communication activities

	Outreach and communication activities						
Date	Communication action/material	Short description (of the material, title,) and/or link to the activity	Main results (# participants, # views, # press clippings, etc.)				
18 Feb 2019	News item on portal	New releases of DTM, coastlines, HR-DTMs and others	For portal visitors				
05 Jun 2019	Scientific paper	"Seafloor Mapping – The Challenge of a Truly Global Ocean Bathymetry"	https://www.frontiersin.org/articles/ 10.3389/fmars.2019.00283/full				
20 Jun 2019	Conference paper and associated presentation	EMODnet Bathymetry - a compilation of bathymetric data in the European waters Presented at IEEE Oceans 2019	2000 attendees at the conference				
29 Jun 2019 – 10 Jul 2019	Presentation / small group conferences	La Mer XXL	Over 3000 visitors				
16 – 20 Sept 2019	Conference	Honolulu - USA; Ocean Obs 2019 Conference	Participant in Data Interoperability forum and presented one EMODnet Bathymetry poster				
27 Sep 2019	Movies (fly-through) and 3D views	"Nuit européenne des Chercheurs"	>5000 visitors				
30 Sept 2019	News item on portal	MOU established between Seabed 2030 and EMODnet Bathymetry	For portal visitors				
22-23 Oct 2019	Conference UK	London – UK; Seabed 2030 meeting	GEBCO Meeting - The Nippon Foundation- GEBCO Seabed 2030 Project: From Vision to Action. Drafting a Memorandum of understanding.				
3 Nov 2019	Poster	EMODnet poster presented for the "Journée de l'information scientifique du Shom"	Approx. 70 participants				
4-9 Nov 2019	Symposium	Portsmouth – USA; GEBCO Symposium	Various topics discussed				
16 Dec 2019	News item on portal	More than 200.000 DTM tiles downloaded	For portal visitors				
Dec 2019	Article in magazine	3D Simplification Methods and Large-Scale Terrain Tiling by Ricard Campos, Josep Quintana, Rafael Garcia, Thierry Schmitt, George Spoelstra, Dick M. A. Schaap	Remote Sensing magazine. 2020, 12(3), 437; ttps://doi.org/10.3390/rs12030437				
30 Jan 2020	News item on portal	Paper in Remote Sensing magazine about 3D visualisation	For portal visitors				
17-19 March 2020	Exhibition	London, United Kingdom; Oceanology International 2020, stand with poster	CANCELLED DUE TO COVID				
16 April 2020	News item on portal	Poster released Oceanology International 2020	For portal visitors				
10 June 2020	Conference	Remote; Conference: "INSPIRE Conference"	Presenting "EMODnet Bathymetry – INSPIRE compliance for bathymetric data" (100+ attendees)				
16 June 2020	Workshop	Remote; Workshop; "Coastal workshop: EMODnet and CMEMS"	Presenting EMODnet Bathymetry products and active collaboration on Satellite Derived Bathymetry and coastline delineation (15+ attendees)				



30 Jun 2020	News item on portal	Release of EMODnet Bathymetry World Base Lasyer service	For portal visitors
30 June – 2 July 2020	Workshop	Remote; Crowd Source Bathymetry Working Group	Status report on EMODnet bathymetry and EMODnet Ingestion to this group (15+ attendees)
10 Jul 2020	News item on portal	More than 30.000 survey data sets indexed	For portal visitors
28 July 2020	Workshop	Remote; SEABED 2030 technical meeting	Monthly meeting dealing with data gathering and data compilation in the GEBCO / SEABED 2030 grid. Strengthening collaboration between EMODnet and this group
22 Sept 2020	Conference	Remote; EMODNET: A decade of achievements connecting marine data to knowledge	Helping IHO better understanding the EMODnet Bathymetry and Ingestion projects
Oct 2020	Article in magazine	The European harmonised bathymetry grid EMODnet Bathymetry by THIERRY SCHMITT, DICK SCHAAP, GEORGE SPOELSTRA, PATRICIA SLABON, PAUL WINTERSTELLER and KNUT HARTMANN	Published October 2020, Hydrographische Nachrichten HN 117, ISSN: 1866-9204
10-11 Oct 2020	Hackaton	Brest France; Ocean Hackaton	Acting as a data coach – sharing coverage of the EMODnet presence on the event with Secretariat GIS support officer
1 Nov 2020	News item on portal	PaperonEMODnetBathymetryinHydrographischeNachrichten	For portal visitors
4 Nov 2020	Meeting	Remote; NATO: Introduction to EMODnet Bathymetry data and products	Introducing EMODnet Bathymetry and potentially other EMODnet Thematic data content to the NATO Geospatial unit
24-26 Nov 2020	Conference	Remote; MERIGEO	Shared presentation of mutual collaboration of Seabed Habitats and Bathymetry (50+ attendees)
2 Dec 2020	Workshop	Remote; IHO – European Network working group	Report and promote on the recent progress made by the EMODnet Bathymetry Consortium
18 Dec 2020	News item on portal	Release of updated inventory of baselines and national coastlines	For portal visitors
			Total # of 29

## **References in papers and books:**

EMODnet Bathymetry is also referred many times in accepted papers and edited books. Using Google Scholar more than **300 references** to EMODnet Bathymetry can be found during the reporting period from January 2019 to December 2020, which also underpins the extensive use being made of the EMODnet Bathymetry products, whereby the DTM serves as a major reference.



Date	Name of journal, conference,	Publication title	Authors	Organisation(s)
01/19	Peer Reviewed Journal: Natural hazards and earth system sciences	Tsunami run-up estimation based on a hybrid numerical flume and a parameterization of real topobathymetric profiles.	Aniel-Quiroga, I.; Quetzalcóatl, O.; González, M.; Guillou L.	Universidad de Cantabria, SP
01/19	Peer Reviewed Journal: Progress in Oceanography	Vertical distribution of Microbial Communities abundance and biomass in two NW Mediterranean Sea submarine canyons.	DIOCIAIUTI, T., AUBRY, F. B, et UMANI, S	Oceanography Division-Istituto Nazionale di Oceanografia e Geofisica Sperimental, IT
02/19	Peer Reviewed Journal: Geomorphology	Regional scale morphological pattern of the Tyrrhenian Sea: New insights from EMODnet bathymetry	Palmiotto, C., Loreto, M. F.	CNR, Bologna IT
02/19	6th Mediterranean Symposium on Marine Vegetation	STRATEGY TO STUDY BLUE CARBON ECOSYSTEMS IN CORSICA.	VALETTE-SANSEVIN, A.	University of Corsica, FR
02/19	Report	Stakeholder Engagement 'Support Facility' Test Exercise (Demonstrator)	Miguez, B. M.; Calewaert, J. B.	Seascape consultant, BE
02/19	Peer reviewed journal Journal of Maps	Seabed classification around Lampione islet, Pelagie Islands Marine Protected area, Sicily Channel, Mediterranean Sea.	INNANGI, S.; DI MARTINO, G.; ROMAGNOLI, C.; <i>et al.</i>	CNR ISMAR, IT
02/19	BSc grade report	Viabilidade dun parque eólico mariño en Cantabria considerando plataformas flotantes de tipo semisumerxible	Feijoo Díaz, L.	Universidade de Coruna, SP
02/19	Peer reviewed journal Ecological Indicators	Assessing the environmental status of temperate mesophotic reefs: A new, integrated methodological approach	ENRICHETTI, F. ; BO, M. ; MORRI, C. et al.	Università di Genova, IT
02/19	Journal Geomedia	Le Carte Nautiche: dalla carta ai BIT	Aldo Caterino	Istituto Idrografico della Marina, IT
02/19	Peer reviewed Journal Quaternary International	Late Holocene sea-level evolution of Paros Island (Cyclades, Greece).	KARKANI, A., EVELPIDOU, N., GIAIME, M., <i>et al.</i>	University of Athens, GR
02/19	Peer Reviewed Journal: Energies,	Characterization of Wave Energy Potential for the Baltic Sea with Focus on the Swedish Exclusive Economic Zone.	Nilsson, E., Rutgersson, A., Dingwell, A., Björkqvist, J. V., Pettersson, H., Axell, et al	Department of Earth Sciences, Uppsala University, SE



02/19	Peer Reviewed Journal: Progress in Oceanography,	Living foraminiferal assemblages in two submarine canyons (Polcevera and Bisagno) of the Ligurian basin (Mediterranean Sea).	Di Bella, L., Sabbatini, A., Carugati, L., Martire, M. L., Luna, G. M., Pierdomenico, M., et al.	Dipartimento di Scienze della Terra, "Sapienza" Università di Roma, IT
02/19	Data acquisition report	RV MARIA S. MERIAN Fahrtbericht/Cruise Report MSM78- PERMO 2, Edinburgh–Edinburgh (UK), 16.10.–25.10. 2018.	Karstens, J., Böttner, C., Edwards, M., Falcon- Suarez, I., Flohr, A., James, R., et al.	Geomar Helmoltz-Zentrum für Ozeanforschung Kiel DE
02/19	Peer Reviewed Journal: Mitigation and Adaptation Strategies for Global Change	Carbon dioxide submarine storage in glass containers: Life Cycle Assessment and cost analysis of four case studies in the cement sector.	BARRETO, B. B., CASERINI, S., DOLCI, G., <i>et al.</i>	Dipartimento di Ingegneria Civile e AmbientalePolitecnico di MilanoMilan IT
02/19	Peer review journal Nature Scientific report	A unique and threatened deep water coral-bivalve biotope new to the Mediterranean Sea offshore the Naples megalopolis.	TAVIANI, M., ANGELETTI, L., CARDONE, F., <i>et al.</i>	CNR, IT
02/19	MsC Thesis	Positioning of Danish offshore wind farms until 2030-using Levelized Cost of Energy.	OHLSEN, G. L, CLAUSEN, N-E, et ABRAHAMSEN, A. B.	Technical University of Denmark, DK
02/19	Peer review journal Natural Hazards and Earth System and Sciences	From regional to local SPTHA: efficient computation of probabilistic tsunami inundation maps addressing near-field sources	Volpe, M.; Lorito, S; Selva, J; Tonini, R.; Romano, F. Brizuela <sup>,</sup> B	Istituto Nazionale di Geofisica e Vulcanologia, IT
02/19	Conference proceedings: 2018 IEEE International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters (MetroSea)	Monitoring for Coastal Resilience: A Project for Five Italian Beaches.	Melito, L., Parlagreco, L., Perugini, E., Postacchini, M., Zitti, G., Brocchini, M.	Università Politecnica delle Marche, IT
02/19	Conference proceedings: 2018 IEEE International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters (MetroSea)	Seafloor habitat mapping on the" Pelagie Islands" MPA (Sicily Channel) using Remote Sensing Object Image Analysis supported by multibeam bathymetry and ground-truth data	Innangi, S., Tonielli, R., Romagnoli, C., Innangi, M	Istituto per l'Ambiente Marino Costiero, IT
03/19	Conference:8thInternationalWorkshop onMarineTechnology:MARTECH2018."InstrumentationViewpoint".	EMODnet physics: towards an European impulsive noise register	Novellino, A.; Alba, M.	ETT Spa, IT



03/19	Peer Reviewed Journal: Natural Hazards and Earth System Sciences	Tsunamigenic potential of a Holocene submarine landslide along the North Anatolian Fault (northern Aegean Sea, off Thasos island): insights from numerical modelling	Janin, A; Rodriguez M.; Sakellariou D.; Lykousis V.; Gorini <b>C.</b>	Laboratoire de Géologie de l'Ecole normale supérieure de Paris, FR
03/19	Msc Thesis	Modelling shelf morphodynamics and shoreline change: free behaviour and response to the construction of artificial islands	Wolf T.	Utrecht University, NL
03/19	Book section In: Maritime Spatial Planning.	Challenges and Opportunities for Ecosystem-Based Management and Marine Spatial Planning in the Irish Sea.	O'HIGGINS, T.; O'HIGGINS, L.; O'HAGAN, A-M, <i>et al.</i>	University College Cork, IE
03/19	Book section In: Coasts and Estuaries	The Black Sea—The Past, Present, and Future Status.	GÜNEROĞLU, A.; SAMSUN, O.; FEYZIOĞLU, M.; <i>et al.</i>	Faculty of Marine Sciences, Karadeniz Technical University, Çamburnu, Trabzon, TK
03/19	Peer reviewed journal Energy Procedia,	Marine Currents Energy Resource Characterization for Morocco.	HAZIM, S.; EL OUATOUATI, A.; JANAN, M. T.; <i>et al.</i>	Mohammed V University of Rabat, Morocco
03/19	Peer reviewed journal Irish Geography	Temporal variability in winter wave conditions and storminess in the northwest of Ireland	LOUREIRO, C.; COOPER, A.	University of Stirling UK
03/19	Peer Reviewed Journal: Miscellanea Malacologica	A unique and diverse amalgamated mollusk assemblage from the Coral Patch Seamount, eastern Atlantic.	HOFFMAN, L.; FREIWALD, A.	Senckenberg am Meer, Abteilung Meeresforschung DE
04/19	Peer Reviewed Journal: Science advances.	Ice-stream demise dynamically conditioned by trough shape and bed strength.	BRADWELL, T., SMALL, D., FABEL, D., et al.	University of Stirling, UK
04/19	Peer Reviewed Journal: Geosciences.	Legacy Data: How Decades of Seabed Sampling can Produce Robust Predictions and Versatile Products.	MITCHELL, P J., ALDRIDGE, J, et DIESING, M.	CEFAS, UK
04/19	Peer Reviewed Journal: Tectonophysics.	Fault pattern and seismotectonic potential at the south-western edge of the Ionian Subduction system (southern Italy): New field and geophysical constraints.	BARRECA, G., SCARFÌ, L., GROSS, F., et al.	University of Catania, Italy
04/19	Peer Reviewed Journal: European Harbour Data Repository.	Medieval Bruges and its outports. A landscape-archaeological contribution to the Zwin-debate. 2019.	TRACHET, J. et DE RUIJSSCHER, D.	University Gent, BE
04/19	Peer Reviewed Journal: European Harbour Data Repository.	The Thracian harbour city Ainos.	SCHMIDTS, T.	University of Tuebingen, Germany
04/19	Peer Reviewed Journal: Nature Scientific data.	Nutrient, pigment, suspended matter and turbidity measurements in the Belgian part of the North Sea.	MORTELMANS, J., DENEUDT, K., CATTRIJSSE, A., et al.	VLIZ, Oostende, Belgium



04/19	Peer Reviewed Journal: Wind Energy.	Estimation of offshore extreme wind from wind-wave coupled modeling.	LARSÉN, X. G., DU, J., BOLAÑOS, R., et al.	Technical University of Denmark, Denmark
04/19	Peer Reviewed Journal: Marine and Petroleum Geology.	Active degassing across the Maltese Islands (Mediterranean Sea) and implications for its neotectonics.	MICALLEF, A., SPATOLA, D., CARACAUSI, A., et al.	University of Malta, MT
04/19	Peer Reviewed Journal: Scientia Marina.	Spatiotemporal abundance pattern of deep-water rose shrimp, Parapenaeus longirostris, and Norway lobster, Nephrops norvegicus, in European Mediterranean waters.	SBRANA, M., ZUPA, W., LIGAS, A., et al.	Centro Interuniversitario di Biologia Marina ed Ecologia Applicata "G. Bacci" (CIBM), Italy
04/19	Peer Reviewed Journal: Heliyon.	Endobiotic communities of Marine Sponges in Cyprus (Levantine Sea).	PAPATHEODOULOU, M., JIMENEZ, C., PETROU, A., et al.	University of Glasgow,
04/19	Peer Reviewed Journal: Progress in Oceanography.	Vertical distribution of Microbial Communities abundance and biomass in two NW Mediterranean Sea submarine canyons.	DIOCIAIUTI, T., AUBRY, F. B., et UMANI, S. F.	OGS, Trieste, IT
04/19	Peer Reviewed Journal: Geochemistry, Geophysics, Geosystems.	Pockmarks in the Witch Ground Basin, central North Sea.	BÖTTNER, C., BERNDT, C., REINARDY, B, et al.	GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
04/19	Peer Reviewed Journal: Sensors	Monitoring for Coastal Resilience: A Project for Five Italian Beaches.	MELITO, L., PARLAGRECO, L., PERUGINI, E., et al.	Istituto Superiore per la Protezione e la Ricerca Ambientale, Rome, Italy
05/19	Peer Reviewed Journal: Seismological Research Letters.	Seismicity and Noise Recorded by Passive Seismic Monitoring of Drilling Operations Offshore the Eastern Canary Islands.	UGALDE, A., GAITE, B., RUIZ, M., et al.	CSIC, Barecelona, SP
05/19	Thesis (MSc)	Hydrodynamics and sand transport on the lower shoreface of the Ameland tidel inlet.	Leummens, M. (2018)	University Twente, NL
05/19	Peer Reviewed Journal: Frontiers in Marine Science.	Seafloor Mapping-the challenge of a truly global ocean bathymetry.	WÖLFL, A., SNAITH, H., AMIREBRAHIMI, S., et al.	GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
05/19	Peer Reviewed Journal: Tectonophysics.	Multi-temporal tectonic evolution of Capo Granitola and Sciacca foreland transcurrent faults (Sicily channel).	FERRANTI, L., PEPE, F., BARRECA, G., et al.	Università di Napoli, IT
05/19	Conference Proceedings: MARID VI, 2019, p. 127.	Evolution of offshore sand ridges in tideless continental shelves (Western Mediterranean)	Durán , R., Guillén J., Ribó, M., Puig, P, Muñoz, A.	CSIC, Barcelona
05/19	Conference Proceedings: MARID VI, 2019, p. 127.	Multi-scale analysis of sandbank features optimising geomorpho-logical mapping of sandy shelf environments: Belgian part of the North Sea.	KINT, Lars.	Royal Belgian Institute of Natural Sciences, BE
05/19	Peer Reviewed Journal: PlatForum.	Marine Shell Ornaments in Atlantic Europe: Standardization of Form in the Gravettian.	ROGERS, Lisa.	
05/19	Peer Reviewed Journal: Marine Geology.	Morphological evidence for marine ice stream shutdown, central Barents Sea.	KURJANSKI, B., REA, B. R., SPAGNOLO, M., et al.	University of Aberdeen, UK



05/19	Peer Reviewed Journal: Journal of Marine Science and Engineering.	Weather-routing system based on METOC navigation risk assessment.	FABBRI, T. et VICEN-BUENO, R.	NATO STO, La Spezia, IT
05/19	Peer Reviewed Journal: Natural Hazards and Earth System Sciences	Tsunami run-up estimation based on a hybrid numerical flume and a parameterization of real topobathymetric profiles. 2018.	ANIEL-QUIROGA ZORRILLA, I., GUTIÉRREZ GUTIÉRREZ, O. Q., GONZÁLEZ RODRÍGUEZ, E. M., et al.	Universidad de Cantabria
06/19	Peer Reviewed Journal: Pure and Applied Geophysics.	Tsunami Potential of Moderate Earthquakes: The July 1, 2009 Earthquake (Mw 6.45) and its Associated Local Tsunami in the Hellenic Arc.	BOCCHINI, G. M., NOVIKOVA, T., PAPADOPOULOS, G. A., et al.	Natioanl Observatory Athens, GR
06/19	Conference Proceedings: Proceedings of the 2018 International Conference on Computational Science and Computational Intelligence (CSCI'18).	Multi-criteria weather routing optimization based on ship navigation resistance, risk and travel time.	Fabbri, T., Vicen Bueno, R., Hunter, A.	NATO CMRE, IT
06/19	Peer Reviewed Journal: Tectonics, 2019.	Spatial and temporal evolution of rifting and continental breakup in the Eastern Black Sea Basin revealed by long-offset seismic reflection data.	MONTELEONE, V., MINSHULL, T. A., et MARIN-MORENO, H.	National Oceanography Centre,
06/19	MSc Report	Estudio de áreas de implementación de sistemas undimotrices en la costa gallega.	RODRÍGUEZ ABAL, D. et al.	UNIVERSIDAD POLITÉCNICA DE CARTAGENA, SP
06/19	Conference Proceedings: International Conference on Computational Science. Springer, Cham, 2019. p. 265-278.	Implementation of a 3-Dimensional Hydrodynamic Model to a Fish Aquaculture Area in Sines, Portugal-A Down-Scaling Approach.	CORREIA, A., PINTO, L., et MATEUS, M.	Universidade de LisboaLisbonPortugal
06/19	Peer Reviewed Journal: Geologia Croatica, 2019, vol. 72, no 2, p. 137-144.	In search of the seismogenic fault of the March 23rd 2018 earthquake (Mw 3.7) near Brindisi (Puglia, Southern Italy).	FESTA, V., DE GIOSA, F., MORETTI, M., et al.	Università degli Studi di Bari "Aldo Moro", IT
06/19	Peer Reviewed Journal: Heritage, 2019, vol. 2, no 2, p. 1588-1613.	Sustainable Management of Underwater Cultural Heritage: The Route from Discovery to Engagement—Open Issues in the Mediterranean.	ARGYROPOULOS, V. STRATIGEA, A.	Ag. Spyridonos,, GR
06/19	Peer Reviewed Journal: Paleoceanography and Paleoclimatology.	Millennial-scale climate variability and dinoflagellate-cyst- based seasonality changes over the last~ 150 kyrs at 'Shackleton Site'U1385.	DATEMA, M., SANGIORGI, F., DE VERNAL, A., et al.	University Utrecht, NL
07/19	Journal of Operational Oceanography	Developing community marine data service for Blue Growth sectors.	She, J., & Murawski, J. (2019)	Danish Meteorological Institute, Denmark
07/19	Remote Sensing, 11(16), 1848.	(2019). On the Segmentation of the Cephalonia–Lefkada Transform Fault Zone (Greece) from an InSAR Multi-Mode Dataset of the Lefkada 2015 Sequence.	Svigkas, N., Atzori, S., Kiratzi, A., Tolomei, C., Antonioli, A., Papoutsis, I., & Kontoes, C. H.	Aristotle University of Thessaloniki, Greece
07/19	Geo-Marine Letters, 1-14.	Geostatistical mapping of marine surficial sediment types in the Northern Aegean Sea using indicator kriging.	Zananiri, I., & Vakalas, I.	Hellenic Survey of Geology & Mineral Exploration, Greece



07/19	Thesis	Estudi tècnic - econòmic d'un parc eòlic offshore	Victor Luid Pinol	UPC Barcelona, Spain
07/19	Journal of Quaternary Science	ICE MARGIN OSCILLATIONS DURING DEGLACIATION OF THE NORTHERN IRISH SEA BASIN.	R.C. Chiverrell, et al.	University of Liverpool
07/19	Marine Geology, 416, 105999	A series of volcanic edifices discovered a few kilometers off the coast of SW Sicily.	Lodolo, E., Civile, D., Zecchin, M., Zampa, L. S., & Accaino, F. (2019)	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Italy
07/19	Data in brief, 25, 104286.	Seagrass and hydrographic data for the Mediterranean Sea.	Effrosynidis, D., Arampatzis, A., & Sylaios, G. (2019).	Democritus University of Thrace, Greece
07/19	IEEE Transactions on Geoscience and Remote Sensing	Measurements of Sea Surface Currents in the Baltic Sea Region Using Spaceborne Along-Track InSAR.	Elyouncha, A., Eriksson, L. E., Romeiser, R., & Ulander, L. M. (2019).	Chalmers University of Technology, Sweden
07/19	Deep Sea Research Part II: Topical Studies in Oceanography.	Current structures and topographic Rossby waves in the Levantine basin south of Crete revealed by snapshot and time series current measurements.	Kontoyiannis, H., Velaoras, D., Papadopoulos, V., & Kioroglou, S. (2019).	Hellenic Center for Marine Research, Greece
07/19	Ocean Science, 15(4), 905- 924.	(2019). Bathymetric properties of the Baltic Sea.	Jakobsson, M., Stranne, C., O'Regan, M., Greenwood, S. L., Gustafsson, B., Humborg, C., & Weidner, E.	Stockholm University, Sweden
07/19	Frontiers in Marine Science, 6, 493.	High emissions of carbon dioxide and methane from the coastal Baltic Sea at the end of a summer heat wave	Humborg, C., Geibel, M. C., Sun, X., McCrackin, M., Mörth, C. M., Stranne, C., & Norkko, J. (2019).	Stockholm University, Sweden
07/19	Aquatic Conservation: Marine and Freshwater Ecosystems.	Modelling dolphin distribution within an Important Marine Mammal Area in Greece to support spatial management planning.	Bonizzoni, S., Furey, N. B., Santostasi, N. L., Eddy, L., Valavanis, V. D., & Bearzi, G.	Dolphin Biology and Conservation, Italy
07/19	Thesis	Island shelf and slope geomorphology of La Palma island (Southern sector).	Velasco Martínez, A.	Universidad de Las Palmas de Gran Canaria
07/19	In Mediterranean Cold- Water Corals: Past, Present and Future	Review of the Circulation and Characteristics of Intermediate Water Masses of the Mediterranean: Implications for Cold- Water Coral Habitats.	Hayes, D. R., Schroeder, K., Poulain, P. M., Testor, P., Mortier, L., Bosse, A., & du Madron, X.	CNR-ISMAR, Italy
07/19	Data in brief, 25, 104186.	Biodiversity of gelatinous macrozooplankton: Quantitative assessment of data and distribution patterns in the southern and central North Sea during August 2018.	Gawinski, C., Huwer, B., Munk, P., & Jaspers, C.	Technical University of Denmark, Denmark
07/19	Tectonics.	Magmatism along lateral slab edges: Insights from the Diamante-Enotrio-Ovidio volcanic-intrusive complex (Southern Tyrrhenian Sea).	De Ritis, R., Pepe, F., Orecchio, B., Casalbore, D., Bosman, A., Chiappini, M., & Monaco, C.	Istituto Nazionale di Geofisica e Vulcanologi, Italy



07/19		Influence of the summer deep-sea circulations on passive drifts among the submarine canyons in the northwestern Mediterranean Sea.	Clavel-Henry, M., Solé, J., Ahumada- Sempoal, M. Á., Bahamon, N., & Briton, F.	Consejo Superior de Investigaciones Científicas, Spain
07/19	Data in brief, 25, 104188.	Database of historic ports and coastal sailing routes in England and Wales.	Alvarez-Palau, E. J., & Dunn, O.	Universitat Oberta de Catalunya, Spain
07/19	Natural Hazards and Earth System Sciences, 19(8), 1585-1600.	Assessment of the 1783 Scilla landslide–tsunami's effects on the Calabrian and Sicilian coasts through numerical modeling.	Zaniboni, F., Pagnoni, G., Gallotti, G., Paparo, M. A., Armigliato, A., & Tinti, S.	Università di Bologna, Italy
07/19	PloS one, 14(6), e0219015.	Effects of sampling site, season, and substrate on foraminiferal assemblages grown from propagule banks from lagoon sediments of Corfu Island (Greece, Ionian Sea).	Weinmann, A. E., Goldstein, S. T., Triantaphyllou, M. V., & Langer, M. R.	Rheinische Friedrich-Wilhelms- Universität Bonn, Germany
07/19	Journal of Geophysical Research: Oceans.	The Impact of Waves and Tides on Residual Sand Transport on a Sediment-poor, Energetic and Macrotidal Continental Shelf.	King, E. V., Conley, D. C., Masselink, G., Leonardi, N., McCarroll, R. J., & Scott, T.	Plymouth University
08/19	International Journal of Greenhouse Gas Control, 90, 102820.	Application of three-dimensional fault stress models for assessment of fault stability for CO2 storage sites	Gamboa, D., Williams, J. D., Bentham, M., Schofield, D. I., & Mitchell, A. C.	British Geological Survey, United Kingdom
08/19	PhD Thesis	Marine gravity and bathymetry modelling from recent satellite altimetry.	Abulaitijiang, A.	Technical University of Denamrk, Denmark
08/19	Nature communications,	2019). Earthquake crisis unveils the growth of an incipient continental fault system	Gracia, E., Grevemeyer, I., Bartolome, R., Perea, H., Martinez-Loriente, S., de la Peña, L. G., & Calahorrano, A.	CSIC, Spain
08/19	Tectonophysics, 768, 228179	Tectonics controls on fluvial landscapes and drainage development in the westernmost part of Switzerland: Insights from DEM-derived geomorphic indices.	Radaideh, O. M., & Mosar, J.	University of Fribourg, Switzerland
08/19	Scientific reports, 9(1), 1- 15.	Time and space scattered volcanism of Mt. Etna driven by strike-slip tectonics.	Carlino, M. F., Cavallaro, D., Coltelli, M., Cocchi, L., Zgur, F., & Patanè, D.	Istituto Nazionale di Geofisica e Vulcanologi, Italy
08/19	Journal of Geodynamics, 132, 101653.	Recent deformational state from morphological analysis of mud volcanoes in the Gulf of Cadiz (southwestern part of the Iberian Atlantic Margin).	Maestro, A., Bohoyo, F., & Corral, R.	Instituto Geológico y Minero de España, Spain
08/19	Marine and Petroleum Geology.	Hydrate occurrence in Europe: A review of available evidence.	Minshull, T. A., Marín-Moreno, H., Betlem, P., Bialas, J., Buenz, S., Burwicz, E., & Hölz, S.	University of Southampton, United Kingdom



08/19	Морской гидрофизический журнал	Оценка точности результатов моделирования циркуляции Черного моря при использовании различных данных о топографии дна.	Дымова, О. А., & Миклашевская, Н. А.	Russian Academy of Sciences, Russia
08/19	Sensors	Evaluation of Sentinel-3A OLCI Products Derived Using the Case-2 Regional CoastColour Processor over the Baltic Sea.	Kyryliuk, D., & Kratzer, S.	Stockholm University, Sweden
09/19	Marine Policy,	Discard ban: A simulation-based approach combining hierarchical Bayesian and food web spatial models.	Pennino, M. G., Bevilacqua, A. H., Torres, M. A., Bellido, J. M., Sole, J., Steenbeek, J., & Coll, M.	Instituto Español de Oceanografía (IEO) Spain
09/19	Thesis	Sedimentary evidences of paleotsunamis in the Mediterranean Sea: accumulation of large boulders along the coastline and mass transport deposits.	Canals Artigas, M.,	UPC Barcelona, Spain
09/19	Journal of Maps, 15(2), 759- 772	Shallow geophysics of the Asinara Island Marine Reserve Area (NW Sardinia, Italy).	Romeo, R., Baradello, L., Blanos, R., Congiatu, P. P., Cotterle, D., Ciriaco, S., & Lodolo, E.	Instituto Nazionale di Oceanografia e di Geofisica Sperimentale, Italy
09/19	Revista Brasileira de Cartografia	Desenvolvimento e Perspectivas da Infraestrutura de Dados Espaciais Marinhos Brasileira	Florentino, C., Pimentel, V. B., & Neto, A. A.	Diretoria de Hidrografia e Navegação, Brasil
09/19	Deep Sea Research Part I: Oceanographic Research Papers	Analysis of the population structure of a gorgonian forest (Placogorgia sp.) using a photogrammetric 3D modeling approach at Le Danois Bank, Cantabrian Sea.	Prado, E., Sanchez, F., Basalo, A. R., Altuna, Á., & Cobo, A.	Instituto Español de Oceanografía (IEO), Spain
09/19	(Master's thesis).	Habitat suitability mapping for Tursiops truncatus in the Aegean Sea	van der Roest, R. A.	Supervisor Wageningen University:, Netherlands
09/19	Minerals, 9(10), 577.	Potential for the Geological Storage of CO2 in the Croatian Part of the Adriatic Offshore.	Saftić, B., Kolenković Močilac, I., Cvetković, M., Vulin, D., Velić, J., & Tomljenović, B.	Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Croatia
09/19	In The Geology of Egypt (pp. 295-342). Springer, Cham.	Structural Setting and Tectonic Evolution of the Gulf of Suez, NW Red Sea and Gulf of Aqaba Rift Systems.	Moustafa, A. R., & Khalil, S. M.	Ain Shams University, Egypt
09/19	Marine Geodesy, (just- accepted), 1-26.	Development of a User-Centred Web-Mapping Application for Ocean Modellers.	Padilla Ruiz, M., Stefanakis, E., & Church, I.	University of New Brunswick, Canada
10/19	Morskoy Gidrofizicheskiy Zhurnal. 2019;35(5):496- 510. (In Russ.)	Long-Term Variability of Thermohaline Characteristics of the Azov Sea Based on the Numerical Eddy-Resolving Model.	Mizyuk A.I., Korotaev G.K., Grigoriev A.V., Puzina O.S., Lishaev P.N.	Marine Hydrophysical Institute of RAS, Sevastopol, Russian Federation
10/19	Deep Sea Research Part I: Oceanographic Research Papers, 154, 103144.	Estimating vertical mixing in the deep north Aegean Sea using argo data corrected for conductivity sensor drift.	Zervakis, V., Krauzig, N., Tragou, E., & Kunze, E.	Department of Marine Sciences, School of the Environment,



				University of the Aegean, Mytilene, Greece
10/19	Scientific reports, 9(1), 1- 10.	Recreational vessels without Automatic Identification System (AIS) dominate anthropogenic noise contributions to a shallow water soundscape.	Hermannsen, L., Mikkelsen, L., Tougaard, J., Beedholm, K., Johnson, M., & Madsen, P. T.	Zoophysiology, Department of Bioscience, Aarhus University, Aarhus, Denmark
10/19	Journal of environmental management, 253, 109749.	Are FADs a significant source of marine litter? Assessment of released debris and mitigation strategy in the Mediterranean sea.	Mauro, S., Tiziana, C., Franco, A., Claudio, B., Pierpaolo, C., Francois, G., & Teresa, R.	Centro Interdipartimentale Della Sicilia, Integrative Marine Ecology, Palermo, Italy
10/19	Journal of Applied Ecology.	Distribution maps of cetacean and seabird populations in the North-East Atlantic	Waggitt, J. J., Evans, P. G., Andrade, J., Banks, A. N., Boisseau, O., Bolton, M., et al.	School of Ocean Sciences, Bangor University, Menai Bridge, UK
10/19	Physical Oceanography, 26(4), 304-315.	Accuracy Estimation of the Black Sea Circulation Modeling Results Obtained at Different Bottom Topography.	Dymova, O. A., & Miklashevskaya, N. A.	Marine Hydrophysical Institute of RAS, Sevastopol, Russian Federation
10/19	International conference computational science ICCS 2019	Implementation of a 3-dimentional hydrodynamic model to a fish aquaculture area in Sines, Portugal-A down-scaling approach.	Corre, A., Pinto, L., Mateus M.	Universidade de Lisboa, Lisbon
10/19	Marine Geology, 419, 106061.	Linking the high-resolution acoustic and sedimentary facies of a transgressed Late Quaternary alluvial plain (Gulf of Trieste, northern Adriatic).	Novak, A., Šmuc, A., Poglajen, S., & Vrabec, M.	University of Ljubljana, Slovenia
10/19	Geochemistry, Geophysics, Geosystems.	Progressive changes in magma transport at the active Serreta Ridge, Azores	Romer, R. H. W., Beier, C., Haase, K. M., Klügel, A., & Hamelin, C.	Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
10/19	PloS one, 14(10).	Megabenthic communities of the Ligurian deep continental shelf and shelf break (NW Mediterranean Sea).	Enrichetti, F., Dominguez-Carrió, C., Toma, M., Bavestrello, G., Betti, F., Canese, S., & Bo, M.	Università degli Studi di Genova, Italy
10/19	Geophysical Journal International, 220(1), 461- 489.	Tectonic deformation in the Santorini volcanic complex (Greece) as inferred by joint analysis of gravity, magnetotelluric and DGPS observations.	Tzanis, A., Chailas, S., Sakkas, V., & Lagios, E.	University of Athens, Greece
10/19	Doctoral dissertation	Beach carrying capacity assessment: case study for sustainable use of kusadasi beaches	Khodkar, G.	Middle East Technical University), Turkey
10/19	Doctoral dissertation	Historical Development of Heavy Metal Input into Near-Coastal Areas.	Boehnert, S.	Universität Bremen, Germany



10/19	Journal of Maps, 15(2), 759- 772.	Shallow geophysics of the Asinara Island Marine Reserve Area (NW Sardinia, Italy).	Romeo, R., Baradello, L., Blanos, R., Congiatu, P. P., Cotterle, D., Ciriaco, S., & Lodolo, E.	OGS, Trieste, Italy
10/19	15th Internat ional Congress of the Geological Society of Greece	Post-Miocene Deformation in the South Aegean: Insights from Seafloor Morphology and Seismic Profiling Data	Tsampouraki-Kraounaki, K., & Sakellariou, D	Hellenic Centre for Marine Research, Greece
10/19	Master dissertation	MILDwave modelling of impact of WEC farms along a realistic coastline configuration	De Neve, M	Ghent University, Belgium
10/19	In Proceedings of the 5th International Conference on Geographical Information Systems Theory, Applications and Management (GISTAM 2019), pages 297-304	Workflows for Virtual Reality Visualisation and Navigation Scenarios in Earth Sciences.	Mel, K., Luca, B. F., Fabio, V., Varvara, A., Ugo, B., Elena, R., & Eva, S.	University of Portsmouth, United Kingdom
11/19	Briefing notes	Arctic connections-Mapping an Arctic policy framework for the Scottish government.	Jafry, T., Mikulewicz, M., & Mattar, S.	Centre for Climate Justice, Glasgow Caledonian University, Scotland, UK.
11/19	Deep Sea Research Part II: Topical Studies in Oceanography, 104701.	Assessment of the eruptive activity and identification of the mud breccia's source in the Olimpi mud volcano field, Eastern Mediterranean.	Panagiotopoulos, I. P., Paraschos, F., Rousakis, G., Hatzianestis, I., Parinos, C., Morfis, I., & Gogou, A.	Institute of Oceanography, Hellenic Centre for Marine Research, 46.7 km Athens-Sounio Av., Anavyssos, 19013, Attica, Greece
11/19	Doctoral dissertation	Estudo geoquímico e mineralógico das crostas de Fe-Mn no Atlântico Norte	Pereira, A. R. C.	Universidade de Lisboa, Portugal
11/19	Scientific reports, 9(1), 1- 14.	fault-controlled deep hydrothermal flow in a back-arc tectonic setting, SE Tyrrhenian Sea.	Loreto, M. F., Düşünür-Doğan, D., Üner, S., İşcan-Alp, Y., Ocakoğlu, N., Cocchi, L., et al.	Istituto di Scienze Marine, CNR, Via P. Gobetti 101, 40129, Bologna, Italy
11/19	Geology.	Recent inversion of the Tyrrhenian Basin.	Zitellini, N., Ranero, C. R., Loreto, M. F., Ligi, M., Pastore, M., D'Oriano, F., et al.	Istituto di Scienze Marine, CNR, Via P. Gobetti 101, 40129, Bologna, Italy
11/19	Journal of Quaternary Science.	Pattern, style and timing of British–Irish Ice Sheet retreat: Shetland and northern North Sea sector	Bradwell, T., Small, D., Fabel, D., Clark, C. D., Chiverrell, R. C., Saher, M. H., et al.	British Geological Survey, Edinburgh, UK



11/19	In Journal of Physics: Conference Series (Vol. 1359, No. 1, p. 012083). IOP Publishing	Dynamics of the Azov-Black Sea basin by means of parallel ocean circulation modeling	Mizyuk, A. I., & Puzina, O. S.	Marine Hydrophysical Institute of RAS, Sevastopol, Russian Federation
11/19	Master Thesis	Caracterización met-oceánica en el PN Marítimo-Terrestre del archipiélago de Cabrera e implicaciones en la navegación.	Megías Baños, C.	Universidad de Cantabria, Spain
11/19	Geomorphology, 351, 106894.	Morphology of retrogressive failures in the Eastern Rhone interfluve during the last glacial maximum (Gulf of Lions, Western Mediterranean).	Badhani, S., Cattaneo, A., Dennielou, B., Leroux, E., Colin, F., Thomas, Y., et al.	Ifremer, France
11/19	Biogeosciences Discussion	Benthic foraminifera as tracers of brine production in Storfjorden "sea ice factory".	Fossile, E., Nardelli, M. P., Jouini, A., Lansard, B., Pusceddu, A., Moccia, D., et al.	Université d'Angers, France
11/19	Recursos marins en el passat. IV Jornades d'arqueozoologia. Museu de Prehistòria de València (2019): 15-45.	Areas litorales y recursos marinos durante el paleolítico- mesolítico de la región mediterránea ibérica. Sesgos y evidencias.	Tortosa, J. E. A.	Universitàt Valencia; Spain
11/19	Remote Sensing, 11(22), 2636.	Synergy of Satellite Remote Sensing and Numerical Ocean Modelling for Coastal Geomorphology Diagnosis.	Benincasa, M., Falcini, F., Adduce, C., Sannino, G., & Santoleri, R.	CNR-ISMAR, Institute of Marine Sciences, National Research Council, 00133 Rome, Italy
11/19	Pure and Applied Geophysics, 1-25	Spatio-Seasonal Variations in Long-Term Trends of Offshore Wind Speeds Over the Black Sea; an Inter-Comparison of Two Reanalysis Data.	Çarpar, T., Ayat, B., & Aydoğan, B.	Istanbul Water and Sewerage Administration (ISKI)Eyüp/IstanbulTurkey
11/19	Human Adaptations to the Last Glacial Maximum: The Solutrean and its Neighbors, 372.	Fishes from solutrean sites of the iberian mediterranean region: palaeogeographical, palaeoecological.	Tortosa, J. E. A.	Universitàt Valencia, Spain
11/19	Mediterranean demersal resources and ecosystems: 25 years of MEDITS trawl surveys M.T. Spedicato, G. Tserpes, B. Mérigot and E. Massutí (eds)	Spatial distribution pattern of European hake, Merluccius merluccius (Pisces: Merlucciidae), in the Mediterranean Sea.	Spedicato, M. T., Tserpes, G., & Mérigot, B.	Department of Biology, University of Bari, Italy.



11/19	Doctoral dissertation	The coastal circulation model of büyük menderes river mouth and adjacent coastal areas	Gözlet, M. S.	Middle East Technical University), Turkey
11/19	Romanian Reports in Physics	Sound speed characteristics and impulsive noise hotspots assessment in the north-western black sea.	Mihailov, M. E.	National Institute for Marine Research and Development "Grigore Antipa" Constanta - Romania
11/19	Geophysical Journal International, 220(2), 1128- 1148.	Mantle thermal structure at northern Mid-Atlantic Ridge from improved numerical methods and boundary conditions.	Cuffaro, M., Miglio, E., Penati, M., & Viganò, M.	Istituto di Geologia Ambientale e Geoingegneria Italy
12/19	Rapp. Comm. int. Mer Médit., 42, 2019	Morphogenetic processes on the continental slope of the galicia bank (west iberia margin).	Simões, M., Roque, C., Riberio, C., Madureira, P., & Somoza, L.	EMEPC, Portugal
12/19	Master's thesis,	High-resolution modeling of spread of anthropogenic contaminants in marine waters, influencing aquaculture	Perepelytsya, M.	Universitat Politècnica de Catalunya
12/19	Doctoral dissertation,	Développement d'un indice biotique basé sur les foraminifères benthiques: application sur la façade méditerranéenne française	Parent, B.	Université d'Angers, France
12/19	Pure and Applied Geophysics, 1-22.	The Tsunami Inundation Hazard of the Maltese Islands (Central Mediterranean Sea): A Submarine Landslide and Earthquake Tsunami Scenario Study.	Mueller, C., Micallef, A., Spatola, D., & Wang, X.	GNS Science, Lower Hutt, New Zealand
12/19	Marine and Petroleum Geology, 104174.	The Catalan magnetic anomaly: Its significance for the crustal structure of the Gulf of Lion passive margin and relationship to the Catalan transfer zone.	Canva, A., Thinon, I., Peyrefitte, A., Couëffé, R., Maillard, A., Jolivet, L., et al.	BRGM, GeoResources Division, Orleans, France
12/19	Physical Oceanography, 26(5), 438.	Long-Term Variability of Thermohaline Characteristics of the Azov Sea Based on the Numerical Eddy-Resolving Model.	Mizyuk, A. I., Korotaev, G. K., Grigoriev, A. V., Puzina, O. S., et al.	Marine Hydrophysical Institute of RAS, Sevastopol, Russian Federation
12/19	Geophysical Journal International.	A new 3-D P-wave velocity model for the Gulf of Cadiz and adjacent areas derived from controlled-source seismic data: application to non-linear probabilistic relocation of moderate earthquakes.	Lozano, L., Cantavella, J. V., & Barco, J.	Spanish Seismic Network, Instituto Geográfico Nacional, Madrid, Spain
12/19	Conference Series: Earth and Environmental Science (Vol. 386, No. 1, p. 012024). IOP Publishing.	The impact of various types of open boundary conditions in numerical simulation of the Black Sea coastal circulation. In IOP	Senderov, M. V.	Marine Hydrophysical Institute, RAS, Kapitanskaya str. 4, Sevastopol, 299011, Russia



12/19	Conference Series: Earth and Environmental Science (Vol. 386, No. 1, p. 012023). IOP Publishing.	Sea ice modeling in the Sea of Azov for a study of long-term variability	Mizyuk, A. I., & Puzina, O. S.	Marine Hydrophysical Institute, RAS, Kapitanskaya str. 4, Sevastopol, 299011, Russia
12/19	In Australasian Coasts and Ports 2019 Conference: Future directions from 40 [degrees] S and beyond, Hobart, 10-13 September 2019 (p. 276). Engineers Australia.	Global-to-local scale storm surge modelling: Operational forecasting and model sensitivities.	De Kleermaeker, S., Apecechea, M. I., Verlaan, M., Mortlock, T., & Rego, J. L.	Deltares, Delft, The Netherlands
12/19	Mediterranean demersal resources and ecosystems: 25 years of MEDITS trawl surveys M.T. Spedicato, G. Tserpes, B. Mérigot and E. Massutí (eds)	Spatial variability of Chondrichthyes in the northern Mediterranean.	Follesa, M. C., Marongiu, M. F., Zupa, W., Bellodi, A., Cau, A., Cannas, R., et al.	Department of Life and Environmental Science, University of Cagliari, Via T. Fiorelli 1, Cagliari, Italy.
12/19	Deep Sea Research Part I: Oceanographic Research Papers, 103186.	Unveiling the deep biodiversity of the Janua Seamount (Ligurian Sea): first Mediterranean sighting of the rare Atlantic bamboo coral Chelidonisis aurantiaca Studer, 1890	Bo, M., Coppari, M., Betti, F., Massa, F., Gay, G., Cattaneo-Vietti, R., & Bavestrello, G.	CoNISMa, Roma, Italy
12/19	Ocean Dynamics, 70(1), 57- 75.	The importance of wind forcing in fjord wave modelling.	Christakos, K., Furevik, B. R., Aarnes, O. J., Breivik, Ø., Tuomi, L., & Byrkjedal, Ø.	Norwegian Meteorological Institute, Bergen, Norway
01/20	Quaternary Science Reviews, 229, 106135.	Oceanic versus continental influences over the last 7 kyrs from a mid-shelf record in the northern Bay of Biscay (NE Atlantic).	Penaud, A., Ganne, A., Eynaud, F., Lambert, C., Coste, P. O., Herlédan, M., el al.	University of Brest, France
01/20	Pure and Applied Geophysics. (Peer reviewed)	Topographically Predicted Vertical Gravity Gradient Field and Its Applicability in 3D and 4D Microgravimetry: Etna (Italy) Case Study.	Vajda, P., Zahorec, P., Papčo, J., Carbone, D., Greco, F., & Cantarero, M. (2020).	Slovak Academy of Sciences, Slovakia
01/20	PloS one. (Peer reviewed)	Post-LGM coastline evolution of the NW Sicilian Channel: Comparing high-resolution geophysical data with Glacial Isostatic Adjustment modeling.	Lodolo, E., Galassi, G., Spada, G., Zecchin, M., Civile, D., & Bressoux, M. (2020).	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Italy
01/20	Continental Shelf Research. (Peer reviewed)	Optimal estimations of directional wave conditions for nearshore field studies.	de Swart, R. L., Ribas, F., Calvete, D., Kroon, A., & Orfila, A. (2020).	Universitat Politècnica de Catalunya, Spain



01/20	Remote Sensing. (Peer reviewed)	3D Simplification Methods and Large Scale Terrain Tiling.	Campos, R., Quintana, J., Garcia, R., Schmitt, T., Spoelstra, G., & Schaap, D. (2020).	Coronis, Spain
01/20	Doctoral dissertation	Architecture and kinematics of forearc basins and intra-caldera resurgences: new insight from the Paola Basin (western offshore Calabria region) and the Campi Flegrei caldera (Campania region).	Corradino, M.	Universtia degli Studi di Palermo, Italy
01/20	Vestnik gosudarstvennogo universiteta morskogo i rechnogo flota imeni admirala S.O. Makarova	SEABED RELIEF MAPPING PROBLEMS ON THE RUSSIAN BATHYMETRIC CHART OF THE ARCTIC OCEAN.	Firsov, Y. G.	Admiral Makarov State University of Maritime and Inland Shipping, Russia
	(Peer reviewed)			
01/20	International Journal of Greenhouse Gas Control.	Impact and detectability of hypothetical CCS offshore seep scenarios as an aid to storage assurance and risk assessment.	Blackford, J., Alendal, G., Avlesen, H., Brereton, A., Cazenave, P. W., Chen, B., & Phelps, J. (2020).	Plymouth Marine Laboratory, UK
01/20	Proceedings of the 15th Int. Congress of the Geol. Soc. Greece.	Contemporary kinematics of the South Aegean area detected with differential GNSS measurements. In	Doxa, C., Sakkas, V., Tzanis, A., & Kranis, H. (2019, May).	University of Athens, Greece
01/20	Tectonics (Peer reviewed)	3-D Architecture and Plio-Quaternary Evolution of the Paola Basin: Insights Into the Forearc of the Tyrrhenian-Ionian Subduction System.	Corradino, M., Pepe, F., Bertotti, G., Picotti, V., Monaco, C., & Nicolich, R. (2020).	University of Palermo, Palermo, Italy
01/20	Processes. (Peer reviewed)	Layout Optimization Process to Minimize the Cost of Energy of an Offshore Floating Hybrid Wind–Wave Farm.	Izquierdo-Pérez, J., Brentan, B. M., Izquierdo, J., Clausen, N. E., Pegalajar-Jurado, A., & Ebsen, N	UNEP DTU Partnership, Denmark
01/20	Pure and Applied Geophysics. (Peer reviewed)	Seiches Around the Shetland Islands.	Pugh, D. T., Woodworth, P. L., & Wijeratne, E. M. S.	National Oceanography Centre, UK
01/20	Geological Society, London, Special Publications. (Peer reviewed)	Geological and tectonic controls on morphometrics of submarine landslides of the Spanish margins.	León, R., Urgeles, R., Pérez-López, R., Payo, E., Vázquez-Izquierdo, A., Giménez-Moreno, C. J., & Casas, D.	Geological Surey of Spain, Spain
01/20	MSc. Dissertation (Report)	Redefinition of the circalittoral zone and its assemblages from Azores insular shelves through video survey	Mano, A. L. S. A. T.	Instituto Universario de ciencias psicologicas, sociais e da vida, Portugal
02/20	Marine Pollution Bulletin. (Peer reviewed)	Microplastics in the Bay of Biscay: An overview.	Mendoza, A., Osa, J. L., Basurko, O. C., Rubio, A., Santos, M., Gago, J., & Peña- Rodriguez, C. (2020).	University of the Basque Country, Spain



02/20	Marine Pollution Bulletin. (Peer reviewed)	Polycyclic aromatic hydrocarbons in surface sediments of the Aegean Sea (eastern Mediterranean Sea).	Hatzianestis, I., Parinos, C., Bouloubassi, I., & Gogou, A. (2020).	Institute of Oceanography, Hellenic Centre for Marine Research, Greece
02/20	Geological Society of London Special Publication on Subaqueous Mass Movements and Their onsequences (Peer reviewed)	Integrated geotechnical, sedimentological and geophysical investigation of seafloor instabilities in the Gulf of Lions Western Mediterranean.	Badhani, S., Cattaneo, A., Collico, S., Urgeles, R., Dennielou, B., Leroux, E., & Droz, L. (2020	Ifremer, France
02/20	PeerJ. (Peer reviewed)	Citizen science in the marine environment: estimating common dolphin densities in the north-east Atlantic.	Robbins, J. R., Babey, L., & Embling, C. B. (2020).	ORCA, UK
02/20	Global change biology. (Peer reviewed)	Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic.	Morato, T., González-Irusta, J. M., Dominguez-Carrió, C., Wei, C. L., Davies, A., Sweetman, A. K., & Laffargue, P. (2020).	Okeanos Research Centre, Portugal
02/20	Water. (Peer reviewed)	Sound Velocity in a Thin Shallowly Submerged Terrestrial- Marine Quaternary Succession (Northern Adriatic Sea).	Novak, A., Šmuc, A., Poglajen, S., Celarc, B., & Vrabec, M. (2020).	Geological Survey of Slovenia, Slovenia
02/20	Вестник государственного университета морского и речного флота им. адмирала СО Макарова. (Peer reviewed)	СПЕЦИАЛЬНОЕ НАВИГАЦИОННОЕ ОБЕСПЕЧЕНИЕ И ТОЧНОСТЬ БАТИМЕТРИЧЕСКОЙ СЪЕМКИ ДЛЯ РЕШЕНИЯ ЗАДАЧ ГЛУБОКОВОДНЫХ ГЕОЛОГОРАЗВЕДОЧНЫХ РАБОТ. (SPECIAL NAVIGATIONAL SUPPORT AND ACCURACY OF BATHYMETRIC SURVEYS FOR DEEP- SEA MARINE GEOLOGICAL INVESTIGATIONS)	Firsov Yury G.	Admiral Makarov State University of Maritime and Inland Shipping, Russia
03/20	Marine Ecology Progress Series. (Peer reviewed)	Structure and environmental drivers of phytoplanktonic resting stage assemblages in the central Mediterranean Sea.	Casabianca, S., Capellacci, S., Ricci, F., Andreoni, F., Russo, T., Scardi, M., & Penna, A.	University of Urbino, Italy
03/20	Fisheries Management and Ecology. (Peer reviewed)	Spatial distribution and abundance of the by-catch coastal elasmobranch Raja undulata: Managing a fishery after moratorium.	Figueiredo, I., Maia, C., & Carvalho, L.	Portuguese Institute for the Sea and Atmosphere, Portugal
03/20	ICESWGNEPS Report 2018	New monitoring technologies to produce ancillary data on Nephrops stock assessment.	Aguzzi, J., Navarro, J., Bahamon, N., Rotllant, G., García, J. A., Río, J. D., & Lordan, C. (2019).	ICES, Denmark
03/20	Environmental and Sustainability Indicators (Peer reviewed)	Identifying ecosystem services research hotspots to illustrate the importance of site-specific research: an Atlantic coastal region case study.	Caro, C., Cunha, P. P., Marques, J. C., & Teixeira, Z. (2020).	La Molina National Agrarian University, Peru



03/20	Marine Chemistry (Peer reviewed)	Observations and idealized modelling of microplastic transport in estuaries: The exemplary case of an upwelling system (Ría de Vigo, NW Spain).	Díez-Minguito, M., Bermúdez, M., Gago, J., Carretero, O., & Viñas, L. (2020).	Andalusian Institute for Earth System Research, Spain
03/20	Aquatic Conservation: Marine and Freshwater Ecosystems. (Peer reviewed)	Spatial distribution modelling of striped dolphin (Stenella coeruleoalba) at different geographical scales within the EU Adriatic and Ionian Sea Region, central-eastern Mediterranean Sea.	Azzolin, M., Arcangeli, A., Cipriano, G., Crosti, R., Maglietta, R., Pietroluongo, G., & Carlucci, R.	University of Torino, Italy
03/20	Izvestiya, Atmospheric and Oceanic Physics (Peer reviewed)	Black Sea Intrapycnocline Lenses according to the Results of a Numerical Simulation of Basin Circulation.	Mizyuk, A. I., & Korotaev, G. K. (2020).	Russian Academy of Sciences, Russia
03/20	Diversity (Peer reviewed)	Offshore Neopycnodonte Oyster Reefs in the Mediterranean Sea.	Angeletti, L., & Taviani, M. (2020).	ISMAR-CNR, Italy
04/20	Frontiers in Earth Science. (Peer reviewed)	Insights into microseism sources by array and machine learning techniques: Ionian and Tyrrhenian Sea case of study.	Moschella, S., Cannata, A., Cannavò, F., Di Grazia, G., Nardone, G., Orasi, A., & Gresta, S.	Dipartimento di Scienze Biologiche, Geologiche e Ambientali – Sezione di Scienze della Terra, Università degli Studi di Catania, Catania, Italy,
04/20	Technium: Romanian Journal of Applied Sciences and Technology, 2(2), 25- 38. (Peer reviewed)	Importance of offshore wind farms Marmara Sea for Turkey's renewable energy targets: a case study Marmara Sea.	Karipoğlu, F.	Izmir Institute of Technology
04/20	The Archaeology of Europe's Drowned Landscapes (pp. 371-392). Springer, Cham. (Peer reviewed)	Greece: Unstable Landscapes and Underwater Archaeology. In	Galanidou, N., Dellaporta, K., & Sakellariou, D.	Department of History and Archaeology University of Crete Rethymno Greece
04/20	Ecological Informatics, 101092. (Peer reviewed)	Seafloor geomorphic features as an alternative approach into modelling the distribution of cetaceans.	Claroa, B., Pérez-Jorgeb, S., & Freya, S.	OceanCare, 8820 Wädenswil, Switzerland
04/20	Environmental Pollution, 114567. (Peer reviewed)	A closer look at anthropogenic fiber ingestion in Aristeus antennatus in the NW Mediterranean Sea: Differences among years and locations and impact on health condition.	Carreras-Colom, E., Constenla, M., Soler- Membrives, A., Cartes, J. E., Baeza, M., & Carrassón, M. (2020	Departament de Biologia Animal, de Biologia Vegetal i d'Ecologia, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, 08193, Barcelona, Spain



04/20	BioRxiv. (Peer reviewed)	Impact of removing a concrete gas platform on benthic communities in the North Sea.	Coolen, J. W., Bittner, O., Driessen, F. M., Van Dongen, U., Siahaya, M. S., De Groot, W., & Van Der Weide, B	Wageningen Marine Research Den Helder, The Netherlands
04/20	Remote Sensing, 12(8), 1344. (Peer reviewed)	The autonomous underwater vehicle integrated with the unmanned surface vessel mapping the Southern Ionian Sea. The winning technology solution of the Shell Ocean Discovery XPRIZE.	Zwolak, K., Wigley, R., Bohan, A., Zarayskaya, Y., Bazhenova, E., Dorshow, W., & Wallace, C	Department of Navigation and Marine Hydrography, Faculty of Navigation and Naval Weapon, Polish Naval Academy, 81-127 Gdynia, Poland
04/20	Doctoral dissertation	Natural and anthropogenic fluid migration pathways in marine sediments	Böttner, C.	Christian-Albrechts-Universität).
04/20	Scientific Reports (Nature Publisher Group), 10(1). (Peer reviewed)	Deep sea explosive eruptions may be not so different from subaerial eruptions.	Iezzi, G., Lanzafame, G., Mancini, L., Behrens, H., Tamburrino, S., Vallefuoco, M., & Ventura, G.	National Institute of Geophysics and Volcanology, Rome, Italy
04/20	Journal of Geophysical Research: Oceans, e2019JC015804 (Peer reviewed)	Glider Observations of the Northwestern Iberian Margin During an Exceptional Summer Upwelling Season.	Rollo, C., Heywood, K. J., Hall, R. A., Barton, E. D., & Kaiser, J.	Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom
04/20	Quaternary International. (Peer reviewed)	At the edge of the Cantabrian sea. New data on the Pleistocene and Holocene archaeological open-air site of Bañugues (Gozón, Asturias, Spain): Palaeogeography, geoarchaeology and geochronology.	Álvarez-Alonso, D., Pardo, J. F. J., Carral, P., Flor-Blanco, G., Flor, G., Iriarte-Chiapusso, M. J., & Weniger, G. C. (2020	Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, C/ Profesor Aranguren s/n. Ciudad Universitaria, E-28080 Madrid, Spain
04/20	ICES Scientific Reports.	ICES. 2020. Working Group on Nephrops Surveys (WGNEPS; outputs from 2019).	Aristegui-Ezquibela, M., Burgos, C., Chiarini, M., Cvitanic, R., Río Fernandez, J. D., Doyle, J., & Martinelli, M.	Universitat politecnica de Catalunya – BarcelonaTech
04/20	Frontiers in Marine Science, 7, 263. (Peer reviewed)	. A High-Resolution Global Dataset of Extreme Sea Levels, Tides, and Storm Surges, Including Future Projections.	Muis, S., Apecechea, M. I., Dullaart, J., de Lima Rego, J., Madsen, K. S., Su, J., & Verlaan, M.	Deltares, Delft, Netherlands
04/20	Science, 368(6495), 1140- 1145. (Peer reviewed)	Seafloor microplastic hotspots controlled by deep-sea circulation.	Kane, I. A., Clare, M. A., Miramontes, E., Wogelius, R., Rothwell, J. J., Garreau, P., & Pohl, F	School of Earth and Environmental Sciences, University of Manchester, Manchester M13 9PL, UK.
04/20	Offshore Technology Conference. Offshore Technology Conference.	Supervised Multi-Agent Autonomy for Cost-Effective Subsea Operations. In	Vincent, J., Vannuffelen, S., Ossia, S., Speck, A., Strunk, G., Croux, A., & Grall, S. (2020, May).	Onesubsea



04/20	XVIII Congreso Asociación Española de Teledetección.	Progreso en la estimación de la batimetría en regiones costeras turbias de EEUU con los satélites Sentinel-2A/B.	Caballero, I., & Stumpf, R. P.	NOAA, USA
05/20	OCEAN DYNAMICS.	Short-term, linear, and non-linear local effects of the tides on the surface dynamics in a new, high-resolution model of the Mediterranean Sea circulation.	Palma, M., Iacono, R., Sannino, G., Bargagli, A., Carillo, A., Fekete, B. M., & Struglia, M. V.	ENEA - CR Casaccia, Via Anguillarese 301, 00123, Rome, Italy
05/20	Bulletin of Volcanology, 82(6).	The evolution of Santa Maria Island in the context of the Azores Triple Junction.	Marques, F. O., Hildenbrand, A., Costa, A. C. G., & Sibrant, A. L. R.	Universidade de Lisboa, Lisbon, Portugal
	(Peer reviewed)			
05/20	Master Thesis	Desarrollo de una herramienta de optimización del" LCOE"(Costo Nivelado Eléctrico) utilizada para la ubicación y planificación de parques flotantes híbridos de energía eólica y marina	Izquierdo Pérez, J.	Universitat Politècnica de València. Escuela Técnica Superior de Ingenieros Industriales - Escola Tècnica Superior d'Enginyers Industrials
05/20	Water, 12(5), 1412. (Peer reviewed)	Evaluation and Application of Newly Designed Finite Volume Coastal Model FESOM-C, Effect of Variable Resolution in the Southeastern North Sea.	Kuznetsov, I., Androsov, A., Fofonova, V., Danilov, S., Rakowsky, N., Harig, S., & Wiltshire, K. H.	Helmholtz Centre for Polar and Marine Research, Alfred Wegener Institute, Klußmannstr. 3d, 27570 Bremerhaven, Germany
05/20	Journal of Marine Systems, 103372. (Peer reviewed)	Modeling the spatiotemporal distribution of the deep-sea shrimp Aristeus antennatus (Crustacea: Decapoda) on the northwestern Mediterranean continental margin crossed by submarine canyons.	Clavel-Henry, M., Bahamon, N., Solé, J., Gorelli, G., del Arco, J. G., Carretón, M., & Company, J. B.	Instituto de Ciencias del Mar (CSIC), Passeig maritim de la Barceloneta, 37-49, 08003 Barcelona, Spain
05/20	Frontiers in Marine Science. (Peer reviewed)	Drivers of megabenthic community structure in one of the world's deepest silled-fjords, Sognefjord (Western Norway).	Meyer, H. K., Roberts, E. M., Mienis, F., & Rapp, H. T.	Department of Biological Sciences and K.G. Jebsen Centre for Deep- Sea Research, University of Bergen, Bergen, Norway,
05/20	Sensors, 20(10), 2911. (Peer reviewed)	Towards Naples Ecological REsearch for Augmented Observatories (NEREA): The NEREA-Fix Module, a Stand- Alone Platform for Long-Term Deep-Sea Ecosystem Monitoring.	Fanelli, E., Aguzzi, J., Marini, S., del Rio, J. D., Nogueras, M., Canese, S., & Conversano, F.	Department of Life and Environmental Science, Polytechnic University of Marche, 60131 Ancona, Italy
05/20	Physical Geography, 1-37. (Peer reviewed)	. Physio-geographical characteristics of the marine regions and their catchment areas of the Mediterranean Sea and Black Sea marine system.	Poulos, S., & Kotinas, V.	National and Kapodistrian University of Athens, Greece
05/20	PeerJ, 8, e9260. (Peer reviewed)	Here are the polyps: in situ observations of jellyfish polyps and podocysts on bivalve shells.	van Walraven, L., van Bleijswijk, J., & van der Veer, H. W.	Department of Coastal Systems, and Utrecht University, NIOZ Royal Netherlands Institute for Sea Research, Den Burg, Netherlands



05/20	Frontiers in Marine Science. (Peer reviewed)	Ecosystem Functioning Under the Influence of Bottom- Trawling Disturbance: An Experimental Approach and Field Observations From a Continental Slope Area in the West Iberian Margin.	Ramalho, S. P., Lins Pereira, L., Soetaert, K., Lampadariou, N., Cunha, M. R., Vanreusel, A., & Pape, E.	Centre for Environmental and Marine Studies, Department of Biology, Universidade de Aveiro, Aveiro, Portugal
05/20	Journal of Coastal Research, 95(sp1), 695-700. (Peer reviewed)	What Happens to a Mediterranean Microtidal Wave- dominated Beach During Significant Storm Events? The Morphological Response of a Natural Sardinian Beach (Western Mediterranean).	Trogu, D., Buosi, C., Ruju, A., Porta, M., Ibba, A., & De Muro, S.	Department of Chemical and Geological Sciences University of Cagliari Cagliari, Italy
05/20	Frontiers of Biogeography. (Peer reviewed)	(2019). Recent geospatial dynamics of Terceira (Azores, Portugal) and the theoretical implications for the biogeography of active volcanic islands.	Rijsdijk, K. F., Buijs, S., Quartau, R., Aguilée, R., Norder, S. J., Ávila, S. P., & Stocchi, P.	Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam,
05/20	Report:	7097 Rapid Coastal Zone Assessment Survey: Phase One Desk-based Assessment for South-West England: South Coast Cornwall.	Johns, C., Dudley, P., & Grant, M.	Cornwall archeological Unit
05/20	Bachelor's thesis	Estudio numérico-experimental del oleaje en las proximidades del puerto de Bilbao, como herramienta de gestión portuaria	Botella Langa, A.	Universitat Politècnica de Catalunya).
05/20	Geosciences, 10(6), 210. (Peer reviewed)	. Ground Deformation and Seismic Fault Model of the M6. 4 Durres (Albania) Nov. 26, 2019 Earthquake, Based on GNSS/INSAR Observations.	Ganas, A., Elias, P., Briole, P., Cannavo, F., Valkaniotis, S., Tsironi, V., & Partheniou, E. I.	National Observatory of Athens, Institute of Geodynamics, Lofos Nymfon, Thission, 11810 Athens, Greece
05/20	Quaternary International. (Peer reviewed)	Lower Palaeolithic archaeology and submerged landscapes in Greece: The current state of the art.	Tsakanikou, P., Galanidou, N., & Sakellariou, D	Centre for the Archaeology of Human Origins, University of Southampton, Avenue Campus, SO17 1BJ, United Kingdom
05/20	Archaeological and Anthropological Sciences, 1-13. (Peer reviewed)	Residual relief modelling: digital elevation enhancement for shipwreck site characterisation.	Majcher, J., Plets, R., & Quinn, R.	School of Geography and Environmental Sciences, University of Ulster, Coleraine, Northern Ireland BT52 1SA, UK
06/20	Journal of Sea Research, 101914. (Peer reviewed)	Spatial dynamics of eukaryotic microbial communities in the German Bight.	Sprong, P. A. A., Fofonova, V., Wiltshire, K. H., Neuhaus, S., Ludwichowski, K. U., Käse, L., & Metfies, K.	Alfred-Wegener-Institute, Helmholtz-Zentrum für Polar- und



				Meeresforschung, 27570 Bremerhaven, Germany
06/20	Marine Biology, 167(91), 91. (Peer reviewed)	The historical ecology and demise of the iconic Angelshark Squatina squatina in the southern North Sea.	Bom, R. A., van de Water, M., Camphuysen, K. C., van der Veer, H. W., & van Leeuwen, A.	Department of Coastal Systems, NIOZ Royal Netherlands Institute for Sea Research, and Utrecht University, P.O. Box 59, 1790 AB, Den Burg, Texel, The Netherlands
06/20	Geophysical Research Letters, e2019GL086604 (Peer reviewed)	Elastic fault interactions and earthquake-rupture along the southern Hellenic subduction plate-interface zone in Greece	Saltogianni, V., Mouslopoulou, V., Oncken, O., Nicol, A., Gianniou, M., & Mertikas, S.	Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany
06/20	Geological Society, London, Special Publications, 505. (Peer reviewed)	Mapping Ireland's coastal, shelf and deep water environments using illustrative case studies to highlight the impact of seabed mapping on the generation of blue knowledge.	O'Toole, R., Judge, M., Sachetti, F., Furey, T., Mac Craith, E., Sheehan, K., & Monteys, X	Geological Survey IrelandBeggars Bush, Haddington Rd. Dublin, Ireland
06/20	Tectonics, e2020TC006116. (Peer reviewed)	Active extension in a foreland trapped between two contractional chains: The South Apulia Fault System (SAFS).	Maesano, F. E., Volpi, V., Civile, D., Basili, R., Conti, A., Tiberti, M. M., & Rossi, G.	Istituto Nazionale di Geofisica e Vulcanologia, Rome, ITALY
06/20	Journal of the Acoustical Society of America, 147(6), 3948-3958 (Peer reviewed)	Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities. <i>The</i>	Whyte, K. F., Russell, D. J., Sparling, C. E., Binnerts, B., & Hastie, G. D	Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife, KY16 8LB, United
06/20	Palaeogeography, Palaeoclimatology, Palaeoecology, 109878.	Medieval versus recent environmental conditions in the Baltic Proper, what was different a thousand years ago?.	Andrén, E., van Wirdum, F., Ivarsson, L. N., Lönn, M., Moros, M., & Andrén, T. (	Södertörn University, SU
06/20	Ecological Informatics, 101130. (Peer reviewed)	. An open-source framework to model present and future marine species distributions at local scale.	Lasram, F. B. R., Hattab, T., Nogues, Q., Beaugrand, G., Dauvin, J. C., Halouani, G., & Leroy, B.	Univ. Littoral Côte d'Opale, Univ. Lille,
06/20	EGU, Earth Surface Dynamics	Links between Baltic Sea submarine terraces and groundwater sapping.	Jakobsson, M., O'Regan, M., Mörth, C. M., Stranne, C., Weidner, E., Hansson, J., & Norkko, J.	Stockholm University,
06/20	Desalination, 491, 114570. (Peer reviewed)	Screening the hurdles to sea disposal of desalination brine around the Mediterranean.	Pistocchi, A., Bleninger, T., & Dorati, C.	European Commission JRC, Ispra, Italy
06/20	Book	Maritime Spatial Planning.	Zaucha, J., & Gee, K	University of Gdańsk



				Gdańsk, Poland
06/20	Marine Chemistry (Peer reviewed)	Manganese dynamics in tidal basins of the Wadden Sea: Spatial/seasonal patterns and budget estimates.	Beck, M., Dellwig, O., Schnetger, B., Riedel, T., & Brumsack, H. J	Institute for Chemistry and Biology of the Marine Environment (DE)
07/20	Tectonics (Peer reviewed)	Slab Detachment, Mantle Flow, and Crustal Collision in Eastern Sicily (Southern Italy): Implications on Mount Etna Volcanism.	Barreca, G., Branca, S., Corsaro, R. A., Scarfì, L., Cannavò, F., Aloisi, M., & Faccenna, C.	University of Catania (IT)
07/20	Natural Hazards and Earth System Sciences Discussions (Peer reviewed)	Assessing the impact of explosive eruptions of Fogo volcano (São Miguel, Azores) on the tourism economy.	Medeiros, J., Carmo, R., Pimentel, A., Vieira, J. C., & Queiroz, G.	Centro de Informação e Vigilância Sismovulcânica dos Açores (PT)
07/20	. Continental Shelf Research (Peer reviewed)	Impact of storms on residence times and export of coastal waters during a mild autumn/winter period in the Gulf of Lion	Mikolajczak, G., Estournel, C., Ulses, C., Marsaleix, P., Bourrin, F., Martín, J., & Seyfried, L.	University of Toulouse (FR)
07/20	Water (Peer reviewed)	Relative Sea-Level Rise and Potential Submersion Risk for 2100 on 16 Coastal Plains of the Mediterranean Sea.	Antonioli, F., Falco, G. D., Presti, V. L., Moretti, L., Scardino, G., Anzidei, M., & Marsico, A.	Istituto Nazionale di Geofisica e Vulcanologia (IT)
07/20	International Journal of Greenhouse Gas Control (Peer reviewed)	Greenhouse gas emissions from marine decommissioned hydrocarbon wells: leakage detection, monitoring and mitigation strategies	Böttner, C., Haeckel, M., Schmidt, M., Berndt, C., Vielstädte, L., Kutsch, J. A., & Weiß, T.	GEOMAR Helmholtz Centre for Ocean Research Kiel (GE)
07/20	Okeanos. (Peer reviewed)	Energía eólica marina: Un nuevo sector marítimo y su encaje en las propuestas de ordenación espacial marina en las Islas Canarias.	Abramic Petkovic, A., García Mendoza, A., Fernández-Palacios Vallejo, M. Y., & Haroun Tabraue, R. J. (2020).	Univ. de Las Palmas de Gran Canaria (SP)
07/20	Quarterly Journal of Engineering Geology and Hydrogeology. (Peer reviewed)	INFOMAR data in the EMODnet Geology data portal supports marine spatial planning and offshore energy development in the Irish offshore.	Guinan, J., McKeon, C., O'Keeffe, E., Monteys, X., Sacchetti, F., Coughlan, M., & Aonghusa, C. N.	Geological Survey Ireland (IE)
07/20	Frontiers in Marine Science (Peer reviewed)	The" Corsica Channel Cold-Water Coral Province"(Mediterranean Sea).	Angeletti, L., Castellan, G., Montagna, P., Remia, A., & Taviani, M.	ISMAR-CNR (IT)
07/20	Journal of Marine Systems (Peer reviewed)	New production across the shelf-edge in the northeastern North Sea during the stratified summer period.	Bendtsen, J., & Richardson, K.	Norwegian Institute for Water Research (DK)
07/20	Geomorphology (Peer reviewed)	Formation and widening of a North Sea tunnel valley-The impact of slope processes on valley morphology.	Prins, L. T., Andresen, K. J., Clausen, O. R., & Piotrowski, J. A.	Aarhus Universit (DK)



07/20	Natural Hazards and Earth System Sciences (Peer reviewed)	Coastal impacts of Storm Gloria (January 2020) over the north-western Mediterranean.	Amores, A., Marcos, M., Carrió, D. S., & Gómez-Pujol, L.	Mediterranean Institute for Advanced Studies (SP)
07/20	Nature Scientific data (Peer reviewed)	The International Bathymetric Chart of the Arctic Ocean Version 4.0.	Jakobsson, M., Mayer, L. A., Bringensparr, C., Castro, C. F., Mohammad, R., Johnson, P., & Arndt, J. E. (2020).	Stockholm University (SE)
07/20	Journal of Quaternary Science. (Peer reviewed)	The evolution of the terrestrial-terminating Irish Sea glacier during the last glaciation.	Chiverrell, R. C., Thomas, G. S. P., Burke, M., Medialdea, A., Smedley, R., Bateman, M., & Ou, X.	University of Liverpool (UK)
07/20	Continental Shelf Research (Peer reviewed)	Tidal sand ridges on the shelf: A numerical study of their natural morphodynamic evolution and response to interventions.	Nnafie, A., Wolf, T. B. J., & de Swart, H. E.	Utrecht University (NL)
07/20	Geosciences (Peer reviewed)	A Review of Data Cleaning Approaches in a Hydrographic Framework with a Focus on Bathymetric Multibeam Echosounder Datasets.	Le Deunf, J., Debese, N., Schmitt, T., & Billot, R.	Shom (FR)
07/20	Ecology and Evolution (Peer reviewed)	Movement patterns of large juvenile loggerhead turtles in the Mediterranean Sea: Ontogenetic space use in a small ocean basin.	Chimienti, M., Blasi, M. F., & Hochscheid, S.	Aarhus University (DK)
07/20	Aquatic Conservation: Marine and Freshwater Ecosystems (Peer reviewed)	Species-specific distribution model may be not enough: The case study of bottlenose dolphin (Tursiops truncatus) habitat distribution in Pelagos Sanctuary.	Vassallo, P., Marini, C., Paoli, C., Bellingeri, M., Dhermain, F., Nuti, S., & Gnone, G.	Università degli Studi di Genova (IT)
07/20	Report	Description de la configuration régionale BOB400 du modèle CROCO (Bay Of Biscay 400 mètres de résolution spatiale horizontale).	Theetten, S., & Charria, G. (2020).	Ifremer (FR)
07/20	21st IEEE International Conference on Mobile Data Management (MDM)	Sea Area Monitoring and Analysis of Fishing Vessels Activity: The i4sea Big Data Platform.	Tampakis, P., Chondrodima, E., Pikrakis, A., Theodoridis, Y., Pristouris, K., Nakos, H., & Maina, I. (2020, June).	University of Piraeus (GR)
08/20	Journal of Quaternary Science. (Peer reviewed)	Formational history of the Wicklow Trough: a marine- transgressed tunnel valley revealing ice flow velocity and retreat rates for the largest ice stream draining the late- Devensian British–Irish Ice Sheet.	Coughlan, M., TÓth, Z., Van Landeghem, K. J., Mccarron, S., & Wheeler, A. J.	University College Dublin (IE)
08/20	The Journal of the Acoustical Society of America (Peer reviewed)	Predicting the exposure of diving grey seals to shipping noise.	Trigg, L. E., Chen, F., Shapiro, G. I., Ingram, S. N., Vincent, C., Thompson, D., & Embling, C. B.	University of Plymouth (UK)



08/20	In European Harbour data repository	Trading terps and Geest boundary harbours – medieval trading ports on the German	Majchczack, B.	University Kiel (GE)
08/20	Geogaceta	Los volcanes de las islas Columbretes (Mediterráneo occidental) I: el volcán de Columbrete Grande y el volcán de Navarrete.	Ancochea, E., & Huertas, M. J.	Universidad Complutense de Madrid (SP)
08/20	Thesis	The impact of sea level rise on tides, waves and tidal sand ridges in the North Sea	Bindels, M.	Utrecht University (NL)
08/20	Journal of Environmental Radioactivity (Peer reviewed)	Validation of a database of mean uranium, thorium and potassium concentrations in rock samples of Portuguese geological units, generated of literature data.	Domingos, F., Cinelli, G., Neves, L., Pereira, A., Braga, R., Bossew, P., & Tollefsen, T.	University of Coimbra (PT)
08/20	Journal of Volcanology and Geothermal Research (Peer reviewed)	Potential mass movements on the Palinuro volcanic chain (southern Tyrrhenian Sea, Italy) and consequent tsunami generation	Gallotti, G., Passaro, S., Armigliato, A., Zaniboni, F., Pagnoni, G., Wang, L., & Ventura, G.	Department of Physics and Astronomy (DIFA), Bologna, Italy
08/20	Marine Ecology Progress Series (Peer reviewed)	Climate change in the Bay of Biscay: Changes in spatial biodiversity patterns could be driven by the arrivals of southern species.	Le Marchand, M., Hattab, T., Niquil, N., Albouy, C., & Lasram, F. B. R. (2020).	France Enérgies Marines (FR)
08/20	Journal of Marine Systems (Peer reviewed)	Seafloor features and benthic foraminifera off Linosa Island (Sicily Channel, southern Mediterranean).	Ferraro, L., Innangi, S., Di Martino, G., Russo, B., Tonielli, R., & Innangi, M.	CNR-ISMAR (IT)
08/20	The Journal of the Acoustical Society of America (Peer reviewed)	Exclusion of tidal influence on ambient sound measurements	van Geel, N. C., Merchant, N. D., Culloch, R. M., Edwards, E. W., Davies, I. M., O'Hara Murray, R. B., & Brookes, K. L.	Scottish Marine Institute (UK)
08/20	Coral Reefs (Peer reviewed)	Feeding biology of a habitat-forming antipatharian in the Azores Archipelago.	Rakka, M., Orejas, C., Maier, S. R., Van Oevelen, D., Godinho, A., Bilan, M., & Carreiro-Silva, M.	University of the Azores (PT)
08/20	Water (Peer reviewed)	Seven Good Reasons for Integrating Terrestrial and Marine Spatial Datasets in Changing Environments	Prampolini, M., Savini, A., Foglini, F., & Soldati, M.	ISMAR (IT)
09/20	Thesis	A seismological and remote sensing approach of geodynamic phenomena	Nikos A Svigkas	Aristotle University of Thessaloniki (GR)
09/20	Thesis	Do cold-water corals spatially correlate with submarine canyons in the Bay of Biscay?: A GIS study analysing the	Asdal, Kaya	University of Agder (NO)



		spatial distribution of cold-water corals along the seascape of the Bay of Biscay		
09/20	Journal of Geophysical Research: Oceans (Peer reviewed)	Revisiting the Role of Convective Deep Water Formation in Northern Baltic Sea Bottom Water Renewal.	Gieße, C., Meier, H. M., Neumann, T., & Moros, M.	Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Rostock, Germany
09/20	Presentation: 1 <sup>st</sup> virtual EXCELSIOR International Technical Workshop	Offshore wind power assessment around Cyprus using Sentinel-1 data.	Kyriakidis, P	Cyprus University of Technology (CY)
09/20	Quarterly Journal of Engineering Geology and Hydrogeology. (Peer reviewed)	Submarine landslide: mapping the susceptibility in European seas	Innocenti, C., Battaglini, L., D'Angelo, S., & Fiorentino, A.	ISPRA (IT)
09/20	Quarterly Journal of Engineering Geology and Hydrogeology.	Mapping the Geology and Topography of the European Seas (European Marine Observation Data Network, EMODnet).	Moses, C. A., & Vallius, H.	Edge Hill University (UK)
	(Peer reviewed)			
09/20	Energy (Peer reviewed)	A new directional wave spectra characterization for offshore renewable energy applications	Ribeiro, P. J. C., Henriques, J. C. C., Campuzano, F. J., Gato, L. M. C., & Falcão, A. F. O.	Universidade de Lisboa (PT)
09/20	Nature Communications (Peer reviewed)	Climate action requires new accounting guidance and governance frameworks to manage carbon in shelf seas.	Luisetti, T., Ferrini, S., Grilli, G., Jickells, T. D., Kennedy, H., Kröger, S., & Pryce, T.	Centre for Environment, Fisheries, and Aquaculture Science (UK)
09/20	Journal of Structural Geology	Ongoing shortening in the Dinarides fold-and-thrust belt: A new structural model of the 1979 (Mw 7.1) Montenegro	Schmitz, B., Biermanns, P., Hinsch, R., Đaković, M., Onuzi, K., Reicherter, K., &	Friedrich-Schiller-Universität Jena
	(Peer reviewed)	earthquake epicentral region.	Ustaszewski, K.	
09/20	(Peer reviewed) Journal of Geophysical Research: Solid Earth (Peer reviewed)	earthquake epicentral region. Temporal modulation of the local microseism in the North Sea.	Ustaszewski, K. Becker, D., Cristiano, L., Peikert, J., Kruse, T., Dethof, F., Hadziioannou, C., & Meier, T.	Universität Hamburg (GE)
09/20	(Peer reviewed) Journal of Geophysical Research: Solid Earth (Peer reviewed) Master Thesis	earthquake epicentral region. Temporal modulation of the local microseism in the North Sea. Análisis del impacto en la inundación costera ocasionado por el temporal marítimo Gloria.	Ustaszewski, K. Becker, D., Cristiano, L., Peikert, J., Kruse, T., Dethof, F., Hadziioannou, C., & Meier, T. López Muñoz, M.	Universität Hamburg (GE) UNIVERSIDAD DE CANTABRIA, Spain
09/20 10/20 10/20	(Peer reviewed) Journal of Geophysical Research: Solid Earth (Peer reviewed) Master Thesis Biogeosciences Discussions (Peer reviewed)	earthquake epicentral region. Temporal modulation of the local microseism in the North Sea. Análisis del impacto en la inundación costera ocasionado por el temporal marítimo Gloria. Microbial activity, methane production, and carbon storage in Early Holocene North Sea peats.	Ustaszewski, K. Becker, D., Cristiano, L., Peikert, J., Kruse, T., Dethof, F., Hadziioannou, C., & Meier, T. López Muñoz, M. Lippmann, T. J., Van der Putten, N. N., Busschers, F. S., Hijma, M. P., van der Velden, P., de Groot, T., & Welte, C. U.	Universität Hamburg (GE) UNIVERSIDAD DE CANTABRIA, Spain Vrije Universiteit Amsterdam, The Netehrlands



10/20	Deep Sea Research Part I: Oceanographic Research Papers (Peer reviewed)	Spatial distribution and habitat characterization of marine animal forest assemblages along nine submarine canyons of Eastern Sardinia (central Mediterranean Sea).	Moccia, D., Cau, A., Bramanti, L., Carugati, L., Canese, S., Follesa, M. C., & Cannas, R.	Università di Cagliari,, Italy
10/20	ICES Journal of Marine Science	Tracking the spatiotemporal variability of the oxic–anoxic interface in the Baltic Sea with broadband acoustics	Weidner, E., Stranne, C., Sundberg, J. H., Weber, T. C., Mayer, L., & Jakobsson, M.	University of New Hampshire, USA
	(Peer reviewed)			
10/20	Geoscientific Model Development Discussions (Peer reviewed)	HIDRA 1.0: Deep-Learning-Based Ensemble Sea Level Forecasting in the Northern Adriatic	Žust, L., Fettich, A., Kristan, M., & Ličer, M.	University of Ljubljana,, Slovenia
10/20	Marine Geology (Peer reviewed)	Late Quaternary tectono-sedimentary processes on an isolated offshore high marginal platform (NW Iberian Continental Margin).	López-Pérez, A. E., Rubio, B., Rey, D., Plaza-Morlote, M., & Pinheiro, L. M.	Universidade de Vigo, Spain
10/20	Heritage (Peer reviewed)	Atlas of shipwrecks in Inner Ionian Sea (Greece): A remote sensing approach.	Geraga, M., Christodoulou, D., Eleftherakis, D., Papatheodorou, G., Fakiris, E., Dimas, X., & Ferentinos, G.	University of Patras, Greece
10/20	Marine Ecology (Peer reviewed)	Keratose-dominated sponge grounds from temperate mesophotic ecosystems (NW Mediterranean Sea	Enrichetti, F., Bavestrello, G., Betti, F., Coppari, M., Toma, M., Pronzato, R., & Bo, M.	University of Genoa, Italy
10/20	Geosciences (Peer reviewed)	Identifying Trawl Marks in North Sea Sediments	Bruns, I., Holler, P., Capperucci, R. M., Papenmeier, S., & Bartholomä, A.	University of Bremen, Germany
10/20	Water (Peer reviewed)	Assessment of Wave Storm-Induced Flood Vulnerability in Rhodes Island, Greece.	Gad, F. K., Chatzinaki, M., Vandarakis, D., Kyriakidou, C., & Kapsimalis, V.	Hellenic Centre for Marine Research, Greece
10/20	BOOK	Governing Future Challenges in Mediterranean Protected Areas.	Alfarè, L. T., & Ruoss, E.	Consiglio Nazionale delle Ricerche, Italy
10/20	Marine and Petroleum Geology (Peer reviewed)	Factors controlling margin instability during the Plio- Quaternary in the Gela Basin (Strait of Sicily, Mediterranean Sea).	Gauchery, T., Rovere, M., Pellegrini, C., Cattaneo, A., Campiani, E., & Trincardi, F.	National Research Council, Italy
10/20	Aquaculture	Functional trait-based layers-an aquaculture siting tool for the Mediterranean Sea	Giacoletti, A., Lucido, G. D., Mangano, M. C., & Sarà, G.	University of Palermo, Italy
10/20	(Peer reviewed) Journal of Marine Science and Engineering (Peer reviewed)	Platform Optimization and Cost Analysis in a Floating Offshore Wind Farm.	Ghigo, A., Cottura, L., Caradonna, R., Bracco, G., & Mattiazzo, G.	Politecnico di Torino, Italy
10/20	Open report	A two-part seabed geomorphology classification scheme:(v. 2). Part 1: morphology features glossary.	Dove, D., Nanson, R., Bjarnadóttir, L. R., Guinan, J., Gafeira, J., Post, A., & Scott, G.	British Geological Survey, UK



10/20	Deep Sea Research Part I: Oceanographic Research Papers (Peer reviewed)	Exploring a deep-sea vulnerable marine ecosystem: Isidella elongata (Esper, 1788) species assemblages in the Western and Central Mediterranean	Carbonara, P., Zupa, W., Follesa, M. C., Cau, A., Capezzuto, F., Chimienti, G., & Maiorano, P.	COISPA Tecnologia & Ricerca - Stazione Sperimentale per lo Studio delle Risorse del Mare, Italy
10/20	Aquatic Conservation: Marine and Freshwater Ecosystems. (Peer reviewed)	The high biodiversity and vulnerability of two Mediterranean bathyal seamounts support the need for creating offshore protected areas.	Bo, M., Coppari, M., Betti, F., Enrichetti, F., Bertolino, M., Massa, F., & Bavestrello, G.	Università degli Studi di Genova, Italy
10/20	Ocean Modelling (Peer reviewed)	Implementation and assessment of a flux limiter based wetting and drying scheme in NEMO.	O'Dea, E., Bell, M. J., Coward, A., & Holt, J.	Met Office, UK
10/20	Biogeosciences Discussions (Peer reviewed)	Organic carbon in surface sediments of the North Sea and Skagerrak.	Diesing, M., Thorsnes, T., & Bjarnadóttir, L. R.	Geological Survey of Norway, Norway
10/20	Natural Hazards (Peer reviewed)	The 6–7 July 2010 meteotsunami along the coast of Portugal: insights from data analysis and numerical modelling	Kim, J., & Omira, R.	Instituto Português Do Mar E da Atmosfera, Portugal
11/20	Quarterly Journal of Engineering Geology and Hydrogeology. (Peer reviewed)	EMODnet collation of geological events data provides evidences of their mutual relationships and connections with underlying geology: a few examples from Italian seas.	Fiorentino, A., Battaglini, L., & D'Angelo, S.	Geological survey of Italy, Italy
11/20	Future Science Brief 6 of the European Marine Board Report	Big Data in Marine Science. Alexander, B., Heymans, J. J., Muñiz Piniella, A., Kellett, P., Coopman, J. [Eds.],.	Guidi, L., Fernandez Guerra, A., Canchaya, C., Curry, E., Foglini, F., Irisson, JO., Malde, K., Marshall, C. T., Obst, M., Ribeiro, R. P., Tjiputra, J., Bakker, D. C. E.	The European Marine Board Ostend, Belgium
11/20	Ocean Modelling (Peer reviewed)	Modelling wave growth in narrow fetch geometries: The white-capping and wind input formulations.	Christakos, K., Björkqvist, J. V., Tuomi, L., Furevik, B. R., & Breivik, Ø.	Norwegian Meteorological Institute, Norway
11/20	Geophysical Journal International (Peer reviewed)	Clusty, the waveform-based network similarity clustering toolbox: concept and application to image complex faulting offshore Zakynthos (Greece).	Petersen, G. M., Niemz, P., Cesca, S., Mouslopoulou, V., & Bocchini, G. M.	GFZ German Research Centre for Geosciences, Germany
11/20	In Varna Medical Forum	Modelling Study With MIKE 21 And Analysis Of Data On Non-Fish Marine Resources.	Penchev, F., Petrova, E., & Mihneva, V.	Institute of Fish Resources – Varna, Bulgary
11/20	Frontiers in Marine Science. (Peer reviewed)	Modeling the Distribution of Habitat-Forming, Deep-Sea Sponges in the Barents Sea: The Value of Data.	Gonzalez-Mirelis, G., Ross, R. E., Albretsen, J., & Buhl-Mortensen, P.	Institute of Marine Research, Bergen, Norway



11/20	6.as Jornadas de Engenharia Hidrográfica / 1.as Jornadas Luso- Espanholas de Hidrografia	Evolução morfo-sedimentar da plataforma adjacente ao sistema fluvial do Tejo desde o Último Máximo Glaciário	Vinhas, A., & Rodrigues, A.	Portuguese Hydrographic Service, Portugal
	Conference proceedings	Using GMT for 2D and 2D Modeling of the Dunkun Transh		
11/20	Miscellanea Geographica	Topography, Pacific Ocean.	Lemenkova, P.	Ocean University of China, China
	(Peer reviewed)	Historical Forthqueles Secondrice for the Middle Strand of the		
11/20	Seismological Society of America	North Anatolian Fault Deduced from Archeo-Damage Inventory and Building Deformation Modeling.	Benjelloun, Y., de Sigoyer, J., Dessales, H., Baillet, L., Guéguen, P., & Sahin, M.	Institut de Physique du Globe de Paris, Paris
	(Peer reviewed)			
12/20	Marine Environmental Research (Peer reviewed)	Main drivers of spatial change in the biomass of commercial species between summer and winter in the NW Mediterranean Sea	Lloret-Lloret, E., Pennino, M. G., Vilas, D., Bellido, J. M., Navarro, J., & Coll, M.	Institut de Ciències del Mar (ICM- CSIC), Spain
12/20	Journal of Physics: Conference Series (Peer reviewed)	The structure of the Black Sea mesoscale eddies from the numerical modeling with various spatial resolution	Puzina, O. S., & Mizyuk, A. I.	Marine Hydrophysical Institute RAS, Sevastopol, Russia
12/20	Journal of Physics: Conference Series	Estimation of the Azov Sea state based on the Black Sea hydrography	Mizyuk, A. I., Lishaev, P. N., & Puzina, O. S.	Marine Hydrophysical Institute RAS, Sevastopol, Russia
	(Peer reviewed)			
12/20	Türk Denizcilik ve Deniz Bilimleri Dergisi	Submarine earthquakes in South-West Anatolia until the 18th century and their probable seismic sources.	AKSOY, M. E.	MUĞLA SITKI KOÇMAN ÜNİVERSİTESİ, Turkey
12/20	Journal of Marine Science and Engineering, 9(1), 31. (Peer reviewed)	Offshore Wind Energy Resource in the Kingdom of Morocco: Assessment of the Seasonal Potential Variability Based on Satellite Data.	Benazzouz, A., Mabchour, H., El Had, K., Zourarah, B., & Mordane, S.	Institut Supérieur d'Etudes Maritimes, Morocco
12/20	Geosciences, 10(12), 505.	Revisiting the Paleo Elbe Valley: Reconstruction of the Holocene, Sedimentary Development on Basis of High-	Papenmeier, S., & Hass, H. C.	Leibniz Institute for Baltic Sea Research
	(Peer reviewed)	Resolution Grain Size Data and Shallow Seismics.		, Germany
12/20	Ocean Dynamics. (Peer reviewed)	Variational interpolation of high-frequency radar surface currents using DIVAnd	Barth, A., Troupin, C., Emma, R., Alvera Azcarate, A., Beckers, J. M., & Joaquín, T.	Université de Liège, Belgium
12/20	Earth and Space Science Open Archive ESSOAr. (Peer reviewed)	Wave, Tide and Topographical Controls on Headland Sand Bypassing.	King, E. V., Conley, D. C., Masselink, G., Leonardi, N., McCarroll, R. J., Scott, T., & Valiente, N. G.	Plymouth University, UK



12/20	Thesis	Cálculo del campo teórico de la zona de estabilidad de los hidratos de gas natural biogénico en los márgenes continentales europeos.	Núñez Varela, E.	Universidad Politécnica de Madrid, Spain
12/20	Bulletin of Volcanology (Peer reviewed)	Tsunamis from prospected mass failure on the Marsili submarine volcano flanks and hints for tsunami hazard evaluation.	Gallotti, G., Zaniboni, F., Pagnoni, G., Romagnoli, C., Gamberi, F., Marani, M., & Tinti, S.	University Bologna, Italy
12/20	Journal of Geophysical Research: Oceans (Peer reviewed)	Breaking location of Internal Solitary Waves over a sloping seabed.	Cavaliere, D., la Forgia, G., Adduce, C., Alpers, W., Martorelli, E., & Falcini, F.	Roma Tre University, Rome, Italy


# **11. Monitoring indicators**

Comments on the progress	indicators in the excel template
Progress indicator	Comment
<ol> <li>Current status and coverage of total available thematic data A) Volume and coverage of available data</li> </ol>	There has been a great increase of bathymetry data sets gathered in the SeaDataNet CDI Data Discovery and Access service: CDI entries for survey data sets went from 27.168 to 30.560; Most data concern European seas while also many surveys from scientific cruises on the global oceans are included. During this contract, in particular many data sets were added for the Baltic Sea and Arctic waters. The number of CDI data providers is 45 from 23 countries.
B) Usage of data	Steady use of data sets from the CDI Data Discovery and Access service: 306 CDI survey data requests from 203 users for 19514 data sets
2. Current status and coverage of total number of data products A) Volume and coverage of available data products	<ul> <li>There has been a 20 – 25% increase of bathymetry data products gathered in the SeaDataNet Sextant catalogue services:</li> <li>CPRD entries for composite DTMs went from 147 to 207;</li> <li>HR-DTM entries for High-Resolution DTMs went from 196 to 244 entries.</li> <li>16 DTM tiles in a range of formats and to LAT for the 2016 EMODnet DTM</li> <li>64 DTM tiles in a range of formats and to LAT and MSL vertical reference for the 2018 EMODnet DTM</li> <li>As part of the release of the new 2020 EMODnet DTM a total of 64 new 2020 DTM tiles in a range of formats and to LAT and to LAT and MSL were produced and added end of the contract to the download mechanism as part of the Bathymetry Viewing and Download service.</li> </ul>
B) Usage of data products	<ul> <li>Excellent use of the data products:</li> <li>71.000 DTM tiles downloaded by more than 7400 unique users from circa 2200 unique organisations and more than 115 countries through more than 23.000 transactions. This represents circa 6.45 TB.</li> <li>The new 2020 DTM tiles are not vet included as their release took</li> </ul>
	place end of the reporting period. Overall, the statistics demonstrate that EMODnet Bathymetry is very popular among researchers, governments, industry, university and public users.
3. Overview of all organisations supplying and approached to supply data and data products since the start of the project phase	The total number of data providers for the CDI and Sextant catalogues has increased this project from 51 to 70 from 28 countries. This includes several new data providers from the Baltic and Arctic regions under influence of the activities of their regional coordinators and the synergy with the IBCAO (Arctic) and BSHC (Baltic).
4. Interfaces to access or view data: update on the current status at time of reporting	OGC web services are provided for the CDI Data Discovery and Access service (WMS, WFS) and for the Bathymetry Viewing and Download service (WMS, WFS, WCS, WMTS), serving out the EMODnet DTM and associated layers. In addition, the new EMODnet Bathymetry World Base Layer (EBWBL) service was released giving a topography and bathymetry of the whole world by means of an OGC WMTS service, which can be used as map base layer for many users and applications.
5. Statistics on information volunteered through download forms	Bathymetry is used by all sectors and for many applications as it provides basis information. A lot of users do not give details about themselves, unless they use Marine-ID in the download forms



6. Published use cases	EMODnet Bathymetry has a steady number of 9 known use cases published at the Central Portal which all receive regular attention from users.
8.1. Technical monitoring	The portal has a very good and stable response time and overall a very good up time (100%).
8.2. Portal user-friendliness (Visual harmonization score)	There were a few items that have been dealt with during the project. The portal now has reached a 100% score.
9. Visibility & Analytics for web pages	As expected and targeted, the pages related to the "EMODnet bathymetry viewing and Download Service" have the highest score and this traffic is very stable, like also other sections and services. This means that users spent the most time browsing and interacting with the viewing service which has many functions and overall is the most interesting product and service that EMODnet Bathymetry has to offer. From there, users also undertake downloading of DTM tiles which has a continuous high score of circa 3000 downloaded DTM files per month. Note: the graphical overview does not cover the full reporting period as Matomo was installed during the project.
10. Visibility & Analytics for web sections	This indicator shows the interest of users for specific sections of the website, excluding the Bathymetry Viewing and Download service. There seems to be an error in coloring as the helpdesk receives most attention, while that should be the CDI pages. Although many feedback forms are received through the helpdesk (see Chapter 8), their numbers are far lower than the reported page views. Note: the graphical overview does not cover the full reporting period as Matomo was installed during the project.
11. Average visit duration for web pages	Average visit duration is erratic, ranging from few seconds to 2:30 minutes. The interpretation of this diagram is complex as it might be interpreted in terms of user's interest but also as difficulty to understand the concept described on the web page. Note: the graphical overview does not cover the full reporting period as Matomo was installed during the project.

The monitoring numbers reported as part of the progress monitoring of EMODnet performance are collected through Matomo. While for the downloading numbers use is made of the shopping registers of the CDI service and the Bathymetry Viewing and Download service.



# 12. Recommendations for follow-up actions by the EU

- Promote the EMODnet Bathymetry infrastructure as a repository for all european bathymetric data and more especially those financed by european funds. This could take the form of citing EMODnet Bathymetry in contractual documents (tenders or calls for proposal) which concern bathymetry data acquisition and/or management.
- Discuss strategies to motivate non EU data providers, especially for north Africa, but also Russian Federation.



# 13. Annex: Other documentation attached

#### 13.1 ANNEX 1: Generating Satellite Derived Bathymetry by EOMAP

As part of the project, use is made of satellite derived bathymetry (SDB) for coastal areas with scarce of no data coverage. This is performed by EOMAP using the following methodology.

EOMAP made use of optical satellite data from European Space Agency's (ESA) Sentinel-2 sensors. Those satellites have a free & open data policy and have a revisit time of 5 days average. Sentinel-2 has three bands in the visible spectral range which are recorded in a spatial resolution of 10m, and a further high-resolution band in the near infrared region. Out of all the archived satellite recordings, EOMAP selected datasets with the following priorities

- cloud and haze free conditions,
- water clarity as good as possible,
- little or no impact on sunglint (mirror-like reflectance of the water surface),
- little or no impact of waves and wave-breaking.

In total 274 Sentinel-2 records were processed by EOMAP to derive bathymetric data for shallow waters following its own physics-based inversion methods. Quantitative information of the shallow water bathymetry can be derived using the reflected sunlight energy in different wavelength of the visible and near infrared region. The core algorithm of this retrieval is embedded in a processing workflow (EWS) which includes the following steps:

- (a) correct the satellite data for effects of **adjacency** of the land (Kisilev et al. 2015<sup>15</sup>);
- (b) correct for **atmospheric** and sea surface impacts using a coupled retrieval of in water optical properties (IOP's) and atmosphere (Heege et al. 2014<sup>16</sup>);
- (c) minimize further effects of **sunglint** of the water surface;
- (d) retrieve spatial resolved information on spectral **absorption** and **scattering** (in physical units) of water constituents in the water column;
- (e) retrieve spatially resolved information on water depth and seafloor albedo.

Following this the water depth will be corrected for further effects:

- (f) water level heights using predicted **tidal information** of nearby stations were used to refer to Mean Sea Level Datum (MSL);
- (g) finally, a **QA/QC** procedure was applied, combining uncertainty products from the error propagation and manual checks for biased pixels (e.g. ships, deep waters, cloud shadow). Furthermore, extreme outliers were removed and data were checked for all logical inconsistencies;
- (h) The final step included the creation of the EMODnet specific **delivery format** using the Sextant catalogue for metadata and Globe software to generate the 1/32 and 1/64 minute DTMs.

<sup>&</sup>lt;sup>15</sup> Kiselev, V., Bulgarelli, B. and Heege, T., 2015. Sensor independent adjacency correction algorithm for coastal and inland water systems. Remote Sensing of Environment, 157: 85-95. ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2014.07.025.

<sup>&</sup>lt;sup>16</sup> Heege, T., Kiselev, V., Wettle, M, Hung, N.N. (2014): Operational multi-sensor monitoring of turbidity for the entire Mekong Delta, International Journal of Remote Sensing, Vol. 35, Issue 8, 2014, p. 2910-2926





Image: Schema of EOMAP's workflow for creating Satellite Derived bathymetry using optical satellite image data.

The applied method and its workflow are described in more detail in scientific articles and publications and is known as Modular Inversion Program (MIP, Cerdeira Estrada et al. 2012<sup>17</sup>, Siermann et al. 2014<sup>18</sup>, Heege et al. 2014<sup>19</sup>). It allows mapping bathymetry and benthic habitats up to approx. 1 to 1.2 times Secchi Disk depth at time of satellite image recording. The current version includes further enhanced cutting-edge processes with improved corrections of atmospheric, adjacency and sunglitter impacts. The system can process also multiple satellite records where available, taking advantage of a patented approach (US Patent 2017<sup>20</sup>) to reduce the uncertainties and indeterminacies of the various environmental variables through simultaneous retrievals. For all sites EOMAP has applied this patented multiple image processing to result in cloud-gap free bathymetric surfaces and lowest vertical uncertainties.

<sup>&</sup>lt;sup>17</sup> Cerdeira-Estrada S., Heege, T., Kolb M., Ohlendorf S., Uribe A., Müller A., Garza R., Ressl R., Aguirre R., Marino I., Silva R., Martell, R. (2012): Benthic habitat and bathymetrry mapping of shallow waters in Puerto Morelos reefs using remote sensing with a physics based data processing, Proc. IGARSS, p. 1-4

<sup>&</sup>lt;sup>18</sup> Siermann, J., Harvey, C., Morgan, G., & Heege, T. (2014, January 19). Satellite derived Bathymetry and Digital Elevation Models (DEM). International Petroleum Technology Conference. doi:10.2523/17346-MS

<sup>&</sup>lt;sup>19</sup> Heege, T., Kiselev, V., Wettle, M, Hung, N.N. (2014): Operational multi-sensor monitoring of turbidity for the entire Mekong Delta, International Journal of Remote Sensing, Vol. 35, Issue 8, 2014, p. 2910-2926

<sup>&</sup>lt;sup>20</sup> US Patent No 9613422 (2017): Using multispectral satellite data to determine littoral water depths despite varying water turbidity. Patent Publication Number 20150310618. Assignee: EOMAP GmbH & Co.KG. Inventor: Thomas Heege





Image: Satellite-Derived Bathymetry results for Northern Denmark



Image: Satellite-Derived Bathymetry results for Northern Denmark





Image: Satellite-Derived Bathymetry results for Cyprus



Image: Satellite-Derived Bathymetry results for North-Cyprus

The generated Satellite Derived Bathymetry DTMs have been compared to nautical charts of various scales and dates, which covered limited areas of all study sites. It is of high importance to understand the characteristics of the nautical charts before reviewing the comparison

1. **Date and methods of the charts**: The charts have been collected at various dates starting in the last decades, parts of those data collections were done prior to GPS era and bathymetric survey methods were often not done with the accurate multibeam sonar systems, which we have today. Thus,



- a. the horizontal accuracy of the depth soundings will have uncertainties of several meters to 10th of meters in extreme cases
- b. A full seafloor coverage (equivalent to modern MBES surveys) was often not done. Data gaps in between the lead line survey points will exist
- c. Vertical uncertainties will be present in all areas where the seabed has changed in the last decades. Those areas are more likely to be sandy bottom and hardbottom/rocky features are less likely to have changed
- 2. Scale of the charts: The scale of the charts is not ideal and much coarser than the native resolution of the Satellite-Derived Bathymetry. Thus, the data have a lower level of details and also focus on the most-shallow features (see next item).
- **3.** Shoal bias of nautical charts: Nautical charts are shoal biased, which describes the fact, that charts represent the shallowest depth sounding of the surrounding. Satellite-Derived Bathymetry data however, represent the mean depth. Depending on the seafloor heterogeneities this can cause issues when comparing the data.

The direct comparison of the charting points with the SDB data set shows an almost ideal 1:1 fit of the data, with the vast majority of the data (81%) being within CAT ZOC C vertical uncertainty category (2m absolute and 5% depth uncertainty). Further statistical measures are: Mean square error = 1.55m, R<sup>2</sup> of the linear regression = 0.76, gain of the linear regression = 0.97, offset of the linear regression = 0.16m, number of charting points = 11,313



Image: Comparison of Satellite-Derived Bathymetry in native 10m spatial resolution against various nautical charting points.

Considering the above-mentioned restrictions of the comparison of SDB data with nautical charts, we can conclude, that the overall comparison shows good agreement. But, based on this comparison it is not possible to validate the SDB data. This procedure would require higher resolution acoustic survey data.

#### **13.2 ANNEX 2: EMODnet Bathymetry World Base Layer (EBWBL) service** by GGSGC

serviceCollaborative Virtual Environment (CVE) by IFREMER



A new exciting service has been added by way of the **EMODnet World Base Layer Service (EBWBL)** which provides a fast and easy access to **worldwide** bathymetric and topographic information. It is published as OGC WMTS service<sup>21</sup> along with a **demo viewer<sup>22</sup>** to zoom in on every detail. It is available in various projections, e.g., non-projected coordinate system, Web Mercator, Inspire compliant projection and projections adapted to both poles.



Image 1: Global map of bathymetry and topography (EBWBL)

The underlying idea is that all EMODnet portals would benefit from having a common worldwide base layer in a common EMODnet look & feel. This suggestion was presented at the EMODnet Steering Committee meeting of November 2018 and welcomed by the EMODnet community. Having a common elevation base layer in all thematic portals will contribute to having a consistent "family" look and it will further promote the EMODnet brand as it can also be shared with external users. The base layer makes use of the EMODnet DTM for European waters and GEBCO\_2019 data for the rest of the world. Next to bathymetry also terrestrial elevation has been included. Source for the land terrain model is a combination of the Shuttle Radar Topography Mission (SRTM) 3 arc seconds data, ASTER 1 arc second and topographic maps. All land data used for this layer is compiled, corrected and resampled by Viewfinderpanorama.<sup>23</sup>

At the start of the work, two major challenges were identified:

- 1. The amount of data for a global dataset at the same zoom level as the EMODnet Bathymetry viewing service
- 2. Mismatch between data sources

#### Data volume

In order to display the entire world at the same zoom level as used for the EMODnet Bathymetry viewing service a total of 9.33120-e10 (more than 93 billion) source data points have to be taken into account. To improve the viewing, the source data has eventually been up sampled to over 135 billion points. The size of the dataset comes with a price. High resolution global elevation viewing services including both land and water have so far only been produced by Google and Esri. Of these two, the only continuous dataset is the Esri Ocean base map as Google basically has photographically blended water

<sup>&</sup>lt;sup>21</sup> <u>https://tiles.emodnet-bathymetry.eu/</u>

<sup>&</sup>lt;sup>22</sup> EMODnet WMTS Preview (emodnet-bathymetry.eu)

<sup>&</sup>lt;sup>23</sup> <u>http://www.viewfinderpanoramas.org</u>



and land. The Esri Ocean Base map however is a proprietary service and only available when Esri technology is used. In order to produce the EMODnet World base layer at an affordable cost GGSGC was facing a huge challenge. By using Amazon Web Services (AWS) and a highly optimized version of the GGSGC workbench software this challenge was successfully managed. The solution was found in dividing the world in tiles of 1 by 1 degree with an overlap of 20 data cells on each side. By analyzing these using the Open Streetmap coastline, it is possible to differentiate between three tile types:

- Just water
- Just land
- Combination

The first two types are easy and need no complex processing to combine land and water (this is explained below). The third type is the problematic one as the various sources do not match nicely.

#### Mismatch between data sources

Global land data is available from different sources (ASTER, SRTM and others). They usually have in common that the data is organized in tiles of 1 by 1 degree and formatted as HGT files. This format was introduced by NASA for use during the SRTM project. The best available global datasets are all in a 3 arc second (~90 meter) resolution. Higher resolutions are usable for local regions but the worldwide data sets contain too much voids. Land elevation source data usually is not filtered for seas and oceans. That is, sea and oceans are set to (or measured at) 0 meter. So, the first preparation step is to mask out all these 0 meter sea elevation. This is not a simple filter process as many areas on land have a valid 0 meter elevation and with a filter, these will also disappear. By using a mask based on the global OpenStreetMap coastline a correct distinction can be made between valid and invalid 0 meter elevation. Using this map also ensures that there is a perfect match between the final dataset and the OpenStreetMap data which is used as an overlay in the viewing service. Global sea elevation are derived from the GEBCO 2019 dataset. The source resolution for GEBCO 2019 is <sup>1</sup>/<sub>4</sub> of an arc minute (~500 meter). Although the dataset resolution has doubled compared to the previous release (GEBCO 2014), most of the 2014 data has been up-sampled. The quality of the dataset in many areas therefore is not better than <sup>1</sup>/<sub>2</sub> arc minutes. This causes a major mismatch between the high-resolution land data and the water. This is called the GEBCO effect and is visualized in the image below.



Image: GEBCO effect

The GEBCO effect causes water areas along the coast to become drying heights (the yellow area in the image outside the coastline). The steeper the coast, the stronger this unwanted effect. Just like with the 0 meter elevations discussed above,



there is no simple way to filter out this GEBCO effect. One could remove all drying heights but this would still cause a discontinuity between the land and the water. The solution earlier developed for the EMODnet Bathymetry dataset is therefore also used for the world base layer. The idea is that somewhere between the land and the water a 0-meter elevation exists. Given the resolution of ~90 meters in most cases it is safe to assume that the 0 meter will be within a single data cell adjacent to the coast. Except for shallow areas that have a large tidal difference this may not be the case but for the purpose of the base layer this will be acceptable as shallow areas show little color nuance in the viewing service anyway. A special algorithm was developed to mark all data cells around the land as coastline data cells which are then given the value 0. An exception has to be made for the Caspian Sea. By many this inland lake is defined as a sea and is therefore incorporated in the world base layer. The Caspian Sea however has an elevation of -28 meter so the shoreline around the Caspian Sea has to be set to -28 meter instead of 0.

Next step is to create a buffer zone around these coastline data cells in the direction of the water. When combining the land and the water this buffer zone is left empty. At a later processing stage, the buffer zone is interpolated which results in a smooth transition between land and water. The width of the buffer zone is set to 12 data cells, causing it to spawn a little bit more than a single GEBCO 2014 data cell. In most cases this is sufficient to remove the GEBCO effect. The width does however cause an issue for narrow channels and fjords. The buffer is applied to both sides of the narrow channel and therefore the channel is sometimes completely masked. This causes the whole channel to be set to zero meter after interpolation. Especially for deep fjords this is an unwanted effect. A solution was found by detecting what is called the channel center line before applying the buffer. The buffer is not applied to the channel center and this results in a correct interpolation of the channel. Channel detection is developed for the World base layer and has so far not been applied to the EMODnet data set. For the EMODnet data set the channel effect is less prominent because buffering is not performed on CDI data. The narrow channel effect is however visible in areas where only GEBCO data is available. For the next release of EMODnet Bathymetry these areas will be processed using channel detection as well.

#### <u>Results</u>

The following images give examples of the EMODnet World base layer. To manage the larger depth and elevation range for the global scale, minor changes have been applied to the color scheme. This new color scheme has also be used for the 2020 release of EMODnet Bathymetry.



Image: Hawaii overview





Image: Hawaii detail



Image: Tierra del Fuego overview





Image: Tierra del Fuego detail



Image: US East coast overview





Image: Mariana Trench (deepest point on earth) Detail



Image: Mount Everest detail

# 13.3 ANNEX 3: Upgraded CDI Data Discovery and Access service by MARIS and IFREMER

As part of the H2020 SeaDataCloud project a major upgrade took place of the SeaDataNet CDI Data Discovery and Access service which is used in EMODnet Bathymetry for gathering and describing bathymetry survey data sets in a common way and facilitating access and downloading. The upgrading comprised a new architecture, adopting cloud technologies, and a complete, new design and implementation of the import, discovery and access mechanisms.





Table and image: components of the new CDI service architecture

The CDI service infrastructure has been expanded with the EUDAT data cloud. This data cloud communicates with an upgraded central CDI Import Manager and the new decentral Replication Managers, replacing the existing Download Managers, to perform the CDI metadata and data import workflow. The CDI Import Manager provides a dashboard to data providers to control the import process while the Replication Manager component provides the data centres a toolbox for local data management and for preparing the batches of metadata and data sets that are to be populated in the CDI service. The CDI Import Manager and data cloud also host and allow to run extra quality control, transformation, metadata enriching, extracting, and versioning services. The data cloud also communicates with an upgraded Request Status Manager, now integrated in the CDI User Interface through MyCDI, to perform the delivery of data sets to users following the processing of their shopping baskets, also considering possible negotiations in case of restricted data requests.

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Image: User Interface of upgraded CDI service

An important element of the new CDI User Interface is that all functions for both users and data providers can be reached from the new MyCDI dashboard, depending on the Marine-ID and associated registered functions and roles. As part of this, also the shopping process is now an integrated dialogue instead of having to jump to separate applications and URLs for example for searching, registering, checking shopping progress, and retrieving data sets. This makes the dialogues for users and providers much more efficient, and easy to understand and perform. Furthermore, several processes and functionalities have been reviewed and optimised, including performances, which again is in favour of the users and data providers. The new CDI User Interface allows to combine search criteria from pull down lists, search by facets, and perform powerfull full text search over all contents. This is supported by SQL server for database queries and Elastic Search for free text search (very fast!). Moreover, the User Interface features a full screen mapping service which is powered by GeoServer in combination with Elastic Search.



Image: Large mapping interface as part of new User Interface of upgraded CDI service



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Image: MyCDI dashboard with multiple functions, including overview of outstanding data requests and options for downloading



## 14. List of abbreviations and acronyms

Acronyms as used in this report are defined in the following list:

BSBD, Baltic Sea Bathymetry Database.

BSHC, Baltic Sea Hydrographic Commission.

**CDI**, Common Data Index, provides a highly detailed description of the survey data, answering to the questions: where, when, how and who collected the data, and how to get them. One CDI describes a survey by means of a polygon or survey track. The CDI service also includes a shopping service for requesting access to selected data sets and for downloading as data files, if access has been granted by the data owners.

**CPRD**, Composite DTM data sets, giving a gridded bathymetry. In practice it was found that Hydrographic Offices (HO's) do not want or can not deliver primary surveys but composite data sets from the Digital Terrain Models that they maintain themselves for producing and maintaining their nautical charts following international IHO procedures. Composite DTM's are DTM's that have been generated by the data provider itself at a specific resolution and making use of survey data sets as managed by that data provider. These Composite DTM's might contain grid cells for which no survey data were available and which are then possibly completed by interpolation or other manipulation. Overall the EMODnet project prefers to get access to survey data sets, where possible, and not the derived Composite DTM's. However in practice this is not (yet) always possible and using the Composite DTM's can then be considered as the next best option. In addition, Composite DTM providers are encouraged to describe anyway their survey data sets in the CDI Data Discovery and Access service in order to give better insight in the real survey coverage. This is followed up by an increasing number of providers, but not always possible for historic reasons.

CVE, Collaborative Virtual Environment, also known as Virtual Research Environment

**DEM**, Digital Elevation Model. It is a digital model or 3D representation of a terrain's surface. In the context of EMODnet HRSM it is used to describe the land elevation, while the bathymetry is described with a Digital Terrain Model (see next).

**DTM**, Digital Terrain Model, is a resulting grid data set with attributes for lat, lon, minimum depth, maximum depth, average water depth, standard deviation, number of values, number of elementary surfaces, smoothed average water depth, depth smoothed offset, CDI reference, and Composite DTM reference / GEBCO\_2014 reference.

**GEBCO**, the General Bathymetric Chart of the Oceans (GEBCO) consists of an international group of experts who work on the development of a range of bathymetric data sets and data products, including gridded bathymetric data sets, the GEBCO Digital Atlas, the GEBCO world map and the GEBCO Gazetteer of Undersea Feature Names. GEBCO operates under the joint auspices of the the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) (of UNESCO). GEBCO 30" gridded data is used by the EMODnet project to complete area coverage in case there are no survey data or Composite DTM data sets available to the partners. GEBCO is represented in the EMODnet HRSM consortium by its editor, NERC-BODC.

#### GTSM, Global Tide Surge Model developed and operated by Deltares.

**IBCAO**, the International Bathymetric Chart of the Arctic Ocean is an initiative to develop a Digital Terrain Model (DTM) based upon all available bathymetric data north of 64° North, for use by mapmakers, researchers, institutions, and others whose work requires a detailed and accurate knowledge of the depth and the shape of the Arctic seabed. Initiated in 1997, this undertaking has been endorsed by the Intergovernmental Oceanographic Commission (IOC), the International Arctic Science Committee (IASC), the International Hydrographic Organization (IHO), the General Bathymetric Chart of the Oceans (GEBCO), and the US National Centers for Environmental Information (NCEI). IBCAO is represented in the EMODnet HRSM consortium by its coordinator, the University of Stockholm.

**Sextant,** catalogue service used to provide details about Composite DTM data sets. It allows to discover any Composite DTM's as available and used for the EMODnet DTM instead of bathymetry survey data sets. The location is given by a Lat-Lon box in a map and descriptions are given of each Composite DTM with information for what, when, how, and who. The Sextant entries are linked as references in the EMODnet DTM grid cells, where appropriate, to indicate the source



data. The Sextant service for EMODnet HRSM does not give a shopping service, but includes contact links for requesting access to the Composite DTM's.

**SeaDataNet**, is the pan-European infrastructure for ocean & marine data management sponsored within FP7 (grant agreement 283607, 1/10/2011-30/9/2015) connecting at present more than 100 national oceanographic data centres and marine data centres from 35 countries riparian to all European seas.

**SeaDataCloud**, is the successor project to SeaDataNet II for further developing the technical basis of the SeaDataNet infrastructure, funded by HORIZON 2020 (grant agreement 730960, 1/11/2016-31/10/2020).

**TIN**, triangulated irregular network, a way to model the EMODnet DTM using triangles in different sizes to support 3D viewing.

VRE, Virtual Research Environment, also known as Collaborative Virtual Environment

**WCS**, Web Coverage Service is an OGC standard defining Web-based retrieval of coverages i.e. digital geospatial information representing space/time-varying phenomena.

**WFS**, Web Feature Service is an OGC standard allowing requests for geographical features across the web using platform-independent calls.

WMS, Web Map Service is a standard OGC protocol for serving geo- referenced map images over the Internet.

**WMST**, Web Map Tile Service is a standard OGC protocol for serving pre-rendered georeferenced map tiles over the Internet.



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These publications can be downloaded from the portal:

See: https://www.emodnet-bathymetry.eu/approach/technical-documentation

See: <u>https://www.emodnet-bathymetry.eu/approach/reports-to-eu</u>