# 5. CONCLUSIONS

The work developed during this Ph.D. covered different topics related to wave data modeling and analysis. In first instance, a wave hindcast for the Pacific Region of Central America was developed and validated, providing the first long term dataset of wave parameters in the area. Starting from these data, the wave energy potential was assessed according to different wave energy converters, detecting the optimal choice for different sites and computing the respective performances.

The analysis was next replicated along the Ligurian coastline, taking advantage of a hindcast previously developed by the MeteOcean Research Group of the Department of Civil, Chemical, and Environmental Engineering of the University of Genoa. The same data were employed to develop and test a methodology for the automatic detection of directional wave systems which leverage image processing algorithms.

The main findings for each of the above topics are split and summarized below for the sake of clarity.

## 5.1. Wave hindcast implementation

- After evaluating several run tests by tuning the WWIII parametrizations it is concluded that the ST4 and ST6 produces similar results of $H_{m0}$ among the run tests, where the ST4 offers a better adjustment to the satellite records for the bulk correction procedure of $H_{m0}$.
- The employed 2-step $H_{m0}$ correction process (bias adjustment of the cumulative $H_{m0}$ distribution followed by the adjustment method published by Albuquerque et al. [2018]), has produced satisfactory, even if three swell partitions were considered in this correction method.
- In general, the bulk correction, i.e. without spectral partitioning, provided better $H_{m0}$ adjustments than the partitioned correction, according to Taylor diagrams for all parametrizations (Figure 2.7).
- The input wind information in the model affects significantly the results of $H_{m0}$, as demonstrated in Test run 12 which utilises a different wind input database (CFSR, CFSRv2 [Saha et al., 2010, 2014]).
- The comparison of different fitting parameters for the assessment of seabed friction as well as the consideration of the turbulent regime at the water surface did not improve significantly the results.
- In the model optimization for the Central American Pacific, it is concluded that the model parametrizations improved, particularly for $H_{m0}$, according to the depth criterion, either

deep or shallow water. This was evidenced by the results of the Taylor diagrams in Figure 2.7.

- It is concluded that an optimal model parametrization corresponds to the WWIII model configuration of run 10 (Table 2.3). This model configuration has been used to produce the entire wave hindcast. According to the $H_{m0}$ adjustments shown through the Figure 2.7(D), the run 10 reached a $\rho$ of 0.7729 at all the nodes in the studied region.

- The wave database generated in this work can be used openly for wave climate understanding as well as for the development of future research in this coastal-marine environment.

- The generated wave hindcasting information represents a proper database to feed wave models locally, study the wave conditions for different approaches, and the model configuration reached in this study can be used to predict the wave conditions through a the generation of wave forecasting.

## 5.2. Wave energy assessment

**• Central American Pacific region**

- A low variability of the wave energy potential was found in Pacific region of Central America, which differs insignificantly from the seasonal analysis with respect to the monthly analysis (see Figure 3.11). Thus, it confirms the assessment that low latitude regions are attractive for the continued exploitation of wave energy [Portilla-Yandun and Guachamin-Acero, 2023].

- Mean $P_w$ values in nearshore can reach values between 5 to 14 kW/m, whereas over the deep waters can reach values over 10 kW/m up to 26 kW/m.

- Wave with mean $T_P$ values over 14 seconds have been found over the assessed nodes, indicating the high presence of swells, which wave directions are coming predominantly from the South-Southwest and Southwest.

- WEC sizing can extract the wave energy more efficiently. The optimal operating point of the converter device is adapted as closely as possible to the wave conditions typical of a given marine location.

- It is concluded that the best converter for all the 16 assessed locations, based on the WEDI and $SIWED_{30}$ indexes, corresponds to the Pelamis as first choice, but also the F-2HB converter, both at reduced scales. The Pelamis must be positioned in a way that longitudinal body must be positioned parallel to the direction of wave propagation to function properly. Pelamis, as attenuator type converter, coincidentally suits for marine environments where there presence of swells with high wave periods arrive.

- SIWED$_{30\,scaled}$ values above 0.1 are reached for the different evaluated WEC, exceeding even potential energy converter values evaluated in the North Sea (see Figure 3.15), thus the WEC survival results higher than the North Sea environment and it could provide more exploitable wave energy throughout the time.

- The lack in the legal framework related to the marine energy exploitation precludes the proper feasibility studies on wave energy, as occurs in the Central American region.

• **Ligurian Sea**

- Mean values of $H_{m0}$ over the 36 assessed locations oscillates in between 0.1 m to 0.8 m, where maximum values between of 4 m to even 6 m can be reached.

- Mean values of $T_P$ over the 36 assessed locations oscillates in between 4.5 s to 8.2 s, where maximum values can reach $T_P$ up to 25 s.

- Ligurian Sea present several wave systems which conditions the wave characteristics that affects the wave energy exploitability, one of this characteristics is the wave direction which presents a high variability (see Figure 3.2).

- $P_w$ values over the assessed locations vary monthly and seasonally, in which the highest energetic period (winter) present values between 3 kW/m and 5 kW/m.

- Maritime planning and mapping increase the feasibility and a better detection of wave energy deployment locations.

- Wave energy exploitation at the Ligurian Sea becomes interesting once the WECs have been resized, adapting them to the local wave conditions. In particular at the Ligurian Sea the WECs increase its efficiency by downsizing them, based on the assessed WEC performance indexes CF and SIWED$_{TR}$.

- An assessment from a technical and economic point of view clearly demonstrates the feasibility of energy harvesting through several WECs.

- It is concluded that indexes as SIWED$_{TR}$ and WEDI demonstrate to be reliable indicators for determining the best WEC and the location to deploy the wave energy.

- Regarding the economic assessment, it is concluded that the most expensive WEC deployment corresponds to the COE and LCOE of Langlee converter, in all the 36 locations except the location 27.

- In average, the most feasible WEC in economic terms in the 36 assessed locations corresponds to the AWS converter.

- The PBP associated to the Langlee converter exceeds the threshold of 20 years, i.e. maximum feasibility threshold, at locations 8, 19, and 23, thus exceeding the non-feasibility threshold (Figure 3.31).

- According to the economic analysis shown in Figures 3.31 and 3.30, it is concluded that depending on the converter evaluated the costs can be very high, a clear indicator is the fact that converters such as Langlee and Pontoon reach CapEx that exceed 500 € in some locations; or the AquaBUOY or Pelamis reaching LCOE values of over 1000 € per MWh in some locations.

- According to the findings related to the technical benefit and WECs costs (Figure 3.32), it is concluded that LCOE increase the converters' efficiency tends to decrease based on the $SIWED_{30,scaled}$. The extension of this finding could optimise a WEC deployment in terms of acceptable ranges relative to the costs of such deployment.

- Based on the technical-economic assessment (Figure 3.33) it is concluded that the best converter for most of the 36 locations evaluated corresponds to Pontoon, while AWS can be feasible at locations 2, 8, 19, 22, 33, 34 and 35; and OEBuoy at location 36.

## 5.3. Wave systems in the Mediterranean Sea

- The wave systems analysis represents an innovative approach for identifying significant directional wave patterns at a specified location.

- Wave climate modes linked to specific directions of wave propagation can be accurately extracted by applying an image processing algorithm to images made of the spectral parameters $T_m$ and $\theta_m$ belonging to different spectral partitions.

- The wave systems analysis has demonstrated the robustness of the methodology, especially in regions experiencing multi-modal wave climates originating from various fetches. The wave systems extracted have provided valuable insights into the frequency of complex wave occurrences, such as crossing seas characterized by simultaneous waves pertaining to different directions.

- By leveraging this methodology, the most frequent directional wave systems in the Mediterranean Sea have been successfully identified, using hindcast data spanning the entire basin.

- In the southeast of the Levantine Basin, specifically in the Nile's Delta area, there is a high occurrence of crossing seas, with occurrences of up to 14 days per year (see Figure 4.10), a similar situation occurs in the eastern part of the Strait of Gibraltar basin. Crossing seas occur with less intensity in the Gulf of Sidra in Libya, where the occurrence can vary between 6 to 10 days per year.

- The developed analysis can be reuse for future applications in offshore and coastal engineering design, catering to navigation safety and coastal protection requirements

## REFERENCES

Gunnar Mork, Stephen Barstow, Alina Kabuth, and M Teresa Pontes. Assessing the global wave energy potential. In *International Conference on Offshore Mechanics and Arctic Engineering*, volume 49118, pages 447–454, 2010. URL `https://doi.org/10.1115/OMAE2010-20473`.

Erwin WJ Bergsma, Rafael Almar, Edward J Anthony, Thierry Garlan, and Elodie Kestenare. Wave variability along the world's continental shelves and coasts: Monitoring opportunities from satellite earth observation. *Advances in Space Research*, 69(9):3236–3244, 2022. URL `https://doi.org/10.1016/j.asr.2022.02.047`.

WW3DG WAVEWATCH III Development Group. *User manual and system documentation of WAVEWATCH III version 6.07. NOAA/NWS/NCEP/MMAB Tech. Note 333*. NOAA-EMC, 2019. URL `https://github.com/NOAA-EMC/WW3/releases/tag/6.07`.

Lorenzo Mentaschi, Georgia Kakoulaki, Michalis Vousdoukas, Evangelos Voukouvalas, Luc Feyen, and Giovanni Besio. Parameterizing unresolved obstacles with source terms in wave modeling: a real-world application. *Ocean Modelling*, 126:77–84, 2018. URL `https://doi.org/10.1016/j.ocemod.2018.04.003`.

George Lavidas. Selection index for wave energy deployments (siwed): A near-deterministic index for wave energy converters. *Energy*, 196:117131, 2020. doi: 10.1016/j.energy.2020.117131. URL `https://doi.org/10.1016/j.energy.2020.117131`.

Vincent Mazet. Basics of image processing. `https://vincmazet.github.io/bip/segmentation/histogram.html`, 2023. Accessed: 2023-07-28.

Mark A Donelan, William M Drennan, and Kristina B Katsaros. The air–sea momentum flux in conditions of wind sea and swell. *Journal of physical oceanography*, 27(10):2087–2099, 1997. URL `https://doi.org/10.1175/1520-0485(1997)027%3C2087:TASMFI%3E2.0.CO;2`.

Y Goda. Random seas and design of maritime structures. *World Scientific google schola*, 2:1665–1678, 2010.

Qingxiang Liu, Alexander V Babanin, W Erick Rogers, Stefan Zieger, Ian R Young, Jean-Raymond Bidlot, Tom Durrant, Kevin Ewans, Changlong Guan, Cagil Kirezci, et al. Global wave hindcasts using the observation-based source terms: Description and validation. *Journal of Advances in Modeling Earth Systems*, 13(8):e2021MS002493, 2021.

MH Moeini and A Etemad-Shahidi. Application of two numerical models for wave hindcasting in lake erie. *Applied Ocean Research*, 29(3):137–145, 2007. URL `https://doi.org/10.1016/j.apor.2007.10.001`.

W Erick Rogers and Paul A Wittmann. Quantifying the role of wind field accuracy in the us navy's global ocean wave nowcast/forecast system. In *CD-ROM 7th Int. Workshop on Wave Hindcasting and Forecasting*, pages 21–26, 2002.

Klaus Hasselmann, Tim P Barnett, E Bouws, H Carlson, David E Cartwright, K Enke, JA Ewing, A Gienapp, DE Hasselmann, P Kruseman, et al. Measurements of wind-wave growth and swell decay during the joint north sea wave project (jonswap). *Ergaenzungsheft zur Deutschen Hydrographischen Zeitschrift, Reihe A*, 1973.

Tarmo Soomere. Numerical simulations of wave climate in the baltic sea: A review. *Oceanologia*, 65(1):117–140, 2023. URL `https://doi.org/10.1016/j.oceano.2022.01.004`.

Leo H Holthuijsen. *Waves in oceanic and coastal waters*. Cambridge university press, 2007.

LH Holthuijsen. Observations of the directional distribution of ocean-wave energy in fetch-limited conditions. *Journal of Physical Oceanography*, 13(2):191–207, 1983.

Arun Chawla, Hendrik L Tolman, Jeffrey L Hanson, Eve-Marie Devaliere, and Vera M Gerald. Validation of a multi-grid wavewatch iii modeling system. *NOAA/MMAB Contribution*, 281 (15), 2009.

Suranjana Saha, Shrinivas Moorthi, Xingren Wu, Jiande Wang, Sudhir Nadiga, Patrick Tripp, David Behringer, Yu-Tai Hou, Hui-ya Chuang, Mark Iredell, et al. The ncep climate forecast system version 2. *Journal of climate*, 27(6):2185–2208, 2014.

Jorge Perez, Melisa Menendez, and Inigo J Losada. Gow2: A global wave hindcast for coastal applications. *Coastal Engineering*, 124:1–11, 2017.

José Beyá, Marco Álvarez, Ariel Gallardo, Héctor Hidalgo, and Patricio Winckler. Generation and validation of the chilean wave atlas database. *Ocean Modelling*, 116:16–32, 2017. doi: 10.1016/j.ocemod.2017.06.004. URL `https://doi.org/10.1016/j.ocemod.2017.06.004`.

Nicolas Rascle and Fabrice Ardhuin. A global wave parameter database for geophysical applications. part 2: Model validation with improved source term parameterization. *Ocean Modelling*, 70:174–188, 2013. URL `https://doi.org/10.1016/j.ocemod.2012.12.001`.

Stéphane Law-Chune, Lotfi Aouf, Alice Dalphinet, Bruno Levier, Yann Drillet, and Marie Drevillon. Waverys: a cmems global wave reanalysis during the altimetry period. *Ocean Dynamics*, 71:357–378, 2021. URL `https://doi.org/10.1007/s10236-020-01433-w`.

H Hersbach, B Bell, P Berrisford, G Biavati, A Horányi, J Muñoz Sabater, J Nicolas, C Peubey, R Radu, I Rozum, et al. Era5 hourly data on single levels from 1979 to present. *Copernicus Climate Change Service (C3S) Climate Data Store (CDS)*, 10, 2018. doi: 10.24381/cds.adbb2d47. URL `https:\protect/\penalty\exhyphenpenalty\protect/\penalty\exhyphenpenaltycds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview`.

The Wamdi Group. The wam model—a third generation ocean wave prediction model. *Journal of Physical Oceanography*, 18(12):1775–1810, 1988. URL https://doi.org/10.1175/1520-0485(1988)018<1775:TWMTGO>2.0.CO;2.

N Booij, LH Holthuijsen, and RC Ris. The" swan" wave model for shallow water. In *Coastal engineering 1996*, pages 668–676. 1996. URL https://doi.org/10.1061/9780784402429.053.

Hendrik L Tolman et al. User manual and system documentation of wavewatch iii tm version 3.14. *Technical note, MMAB Contribution*, 276(220), 2009.

PA Umesh and J Swain. Inter-comparisons of swan hindcasts using boundary conditions from wam and wwiii for northwest and northeast coasts of india. *Ocean Engineering*, 156:523–549, 2018. URL https://doi.org/10.1016/j.oceaneng.2018.03.029.

Khalid Amarouche, Adem Akpınar, Aleksandra Rybalko, and Stanislav Myslenkov. Assessment of swan and wavewatch-iii models regarding the directional wave spectra estimates based on eastern black sea measurements. *Ocean Engineering*, 272:113944, 2023. URL https://doi.org/10.1016/j.oceaneng.2023.113944.

NRRC Booij, Roeland C Ris, and Leo H Holthuijsen. A third-generation wave model for coastal regions: 1. model description and validation. *Journal of geophysical research: Oceans*, 104 (C4):7649–7666, 1999.

L Cavaleri, J-HGM Alves, F Ardhuin, A Babanin, M Banner, K Belibassakis, M Benoit, M Donelan, J Groeneweg, THC Herbers, et al. Wave modelling–the state of the art. *Progress in oceanography*, 75(4):603–674, 2007. URL https://doi.org/10.1016/j.pocean.2007.05.005.

AJ Kuik, G Ph Van Vledder, and LH Holthuijsen. A method for the routine analysis of pitch-and-roll buoy wave data. *Journal of physical oceanography*, 18(7):1020–1034, 1988. URL https://doi.org/10.1175/1520-0485(1988)018<1020:AMFTRA>2.0.CO;2.

COCATRAM. Summary of maritime port statistics. english version 2021, 2021. URL https://www.cocatram.org.ni/en/publications/. Accessed: 2023-02-17.

Panama Canal Authority. Transit statistics, panama canal, 2021. URL https://pancanal.com/en/statistics/. Accessed: 2023-01-07.

Gabriel Díaz Hernández, Antonio Tomás Sampedro, Javier López Lara, Beatriz Rodriguez Fernandez, R Molina, P Rodríguez-Rubio, F De los Santos, et al. Herramientas para el diagnóstico y gestión de la agitación producida por el paso de embarcaciones en áreas portuarias. 2017.

Sudong Xu, Mengdi Ma, Kai Yin, and Shuang Tang. Risk evaluation system of navigation security based on coupled wind and wave model: a case of study of qiongzhou strait. *IET Intelligent Transport Systems*, 14(10):1311–1318, 2020. URL https://doi.org/10.1049/iet-its.2019.0418.

SITCA. Compendium of tourism statistics of SICA region in 2019, 2020. URL https://sitca.info/wp-content/uploads/2021/07/Compendium-of-Tourism-Statistics-of-the-SICA-region-2019-1-compressed.pdf. Accessed: 2023-02-20.

Diego Vicinanza, P Contestabile, and V Ferrante. Wave energy potential in the north-west of sardinia (italy). *Renewable Energy*, 50:506–521, 2013. URL https://doi.org/10.3390/en81212423.

Liliana Rusu and Florin Onea. Assessment of the performances of various wave energy converters along the european continental coasts. *Energy*, 82:889–904, 2015. URL https://doi.org/10.1016/j.energy.2015.01.099.

Luca Martinelli and Barbara Zanuttigh. Effects of mooring compliancy on the mooring forces, power production, and dynamics of a floating wave activated body energy converter. *Energies*, 11(12):3535, 2018. URL https://doi.org/10.3390/en11123535.

Edgar Mendoza, Rodolfo Silva, Barbara Zanuttigh, Elisa Angelelli, Thomas Lykke Andersen, Luca Martinelli, Jørgen Quvang Harck Nørgaard, and Piero Ruol. Beach response to wave energy converter farms acting as coastal defence. *Coastal Engineering*, 87:97–111, 2014. URL https://doi.org/10.1016/j.coastaleng.2013.10.018.

Pasquale Contestabile, Gaetano Crispino, Enrico Di Lauro, Vincenzo Ferrante, Corrado Gisonni, and Diego Vicinanza. Overtopping breakwater for wave energy conversion: Review of state of art, recent advancements and what lies ahead. *Renewable Energy*, 147:705–718, 2020. URL https://doi.org/10.1016/j.renene.2019.08.115.

Raúl Cascajo, Emilio García, Eduardo Quiles, Antonio Correcher, and Francisco Morant. Integration of marine wave energy converters into seaports: A case study in the port of valencia. *Energies*, 12(5):787, 2019.

Silvia Bozzi, Giovanni Besio, and Giuseppe Passoni. Wave power technologies for the mediterranean offshore: Scaling and performance analysis. *Coastal Engineering*, 136:130–146, 2018. URL https://doi.org/10.1016/j.coastaleng.2018.03.001.

Aurélien Babarit, Jorgen Hals, Made Jaya Muliawan, Adi Kurniawan, Torgeir Moan, and Jorgen Krokstad. Numerical benchmarking study of a selection of wave energy converters. *Renewable energy*, 41:44–63, 2012. doi: 10.1016/j.renene.2011.10.002. URL https://doi.org/10.1016/j.renene.2011.10.002.

Yago Torre-Enciso, I Ortubia, LI López De Aguileta, and J Marqués. Mutriku wave power plant: from the thinking out to the reality. In *Proceedings of the 8th European wave and tidal energy conference, Uppsala, Sweden*, volume 710, pages 319–329, 2009. URL https://tethys.pnnl.gov/sites/default/files/publications/Torre-Enciso_et_al_2009.pdf.

F Arena, G Malara, and A Romolo. A u-owc wave energy converter in the mediterranean sea: Preliminary results on the monitoring system of the first prototype. *Renewable Energy*

*Offshore; Guedes Soares, C., Ed.; Taylor & Francis Group: London, UK*, pages 417–421, 2015.

Iain Fairley, Matthew Lewis, Bryson Robertson, Mark Hemer, Ian Masters, Jose Horrillo-Caraballo, Harshinie Karunarathna, and Dominic E Reeve. A classification system for global wave energy resources based on multivariate clustering. *Applied Energy*, 262:114515, 2020. URL `https://doi.org/10.1016/j.apenergy.2020.114515`.

Barbara Zanuttigh, Elisa Angelelli, Andreas Kortenhaus, Kaan Koca, Yukiko Krontira, and Phoebe Koundouri. A methodology for multi-criteria design of multi-use offshore platforms for marine renewable energy harvesting. *Renewable Energy*, 85:1271–1289, 2016. doi: 10.1016/j.renene.2015.07.080. URL `https://doi.org/10.1016/j.renene.2015.07.080`.

Silvia Bozzi, Renata Archetti, and Giuseppe Passoni. Wave electricity production in italian offshore: A preliminary investigation. *Renewable Energy*, 62:407–416, 2014. doi: 10.1016/j.renene.2013.07.030. URL `https://doi.org/10.1016/j.renene.2013.07.030`.

M O'Connor, T Lewis, and G Dalton. Techno-economic performance of the pelamis p1 and wavestar at different ratings and various locations in europe. *Renewable energy*, 50:889–900, 2013. doi: 10.1016/j.renene.2012.08.009. URL `https://doi.org/10.1016/j.renene.2012.08.009`.

Nicolás Faedo, Yerai Peña-Sanchez, Edoardo Pasta, Guglielmo Papini, Facundo D Mosquera, and Francesco Ferri. Swell: An open-access experimental dataset for arrays of wave energy conversion systems. *Renewable Energy*, 212:699–716, 2023. URL `https://doi.org/10.1016/j.renene.2023.05.069`.

RN Silva, MM Nunes, FL Oliveira, TF Oliveira, ACP Brasil Junior, and MSS Pinto. Dynamical analysis of a novel hybrid oceanic tidal-wave energy converter system. *Energy*, 263:125933, 2023. URL `https://doi.org/10.1016/j.energy.2022.125933`.

Siya Jin, Siming Zheng, and Deborah Greaves. On the scalability of wave energy converters. *Ocean Engineering*, 243:110212, 2022. URL `https://doi.org/10.1016/j.oceaneng.2021.110212`.

Robert Mayon, Dezhi Ning, Boyin Ding, and Nataliia Y Sergiienko. Wave energy converter systems–status and perspectives. In *Modelling and Optimization of Wave Energy Converters*, pages 3–58. CRC Press, 2022. URL `https://api.taylorfrancis.com/content/chapters/oa-edit/download?identifierName=doi&identifierValue=10.1201/9781003198956-1&type=chapterpdf`.

Edward BL Mackay, AbuBakr S Bahaj, and Peter G Challenor. Uncertainty in wave energy resource assessment. part 2: Variability and predictability. *Renewable energy*, 35(8):1809–1819, 2010. URL `https://doi.org/10.1016/j.renene.2009.10.027`.

Charlotte Beels, JCC Henriques, Julien De Rouck, MT Pontes, Griet De Backer, and Hadewych Verhaeghe. Wave energy resource in the north sea. In *EWTEC 2007-7th European Wave and Tidal Energy Conference*, 2007. URL https://repositorio.lneg.pt/bitstream/10400.9/404/1/1004.pdf.

Jin Liu, Alberto Meucci, Qingxiang Liu, Alexander V Babanin, Daniel Ierodiaconou, Xingkun Xu, and Ian R Young. A high-resolution wave energy assessment of south-east australia based on a 40-year hindcast. *Renewable Energy*, page 118943, 2023. URL https://doi.org/10.1016/j.renene.2023.118943.

Felipe Lucero, Patricio A Catalán, Álvaro Ossandón, José Beyá, Andrés Puelma, and Luis Zamorano. Wave energy assessment in the central-south coast of chile. *Renewable Energy*, 114:120–131, 2017. URL https://doi.org/10.1016/j.renene.2017.03.076.

Paul T Jacobson, George Hagerman, and George Scott. Mapping and assessment of the united states ocean wave energy resource. Technical report, Electric Power Research Institute, 2011. URL https://doi.org/10.2172/1060943.

AM Rizal and NS Ningsih. Description and variation of ocean wave energy in indonesian seas and adjacent waters. *Ocean Engineering*, 251:111086, 2022. URL https://doi.org/10.1016/j.oceaneng.2022.111086.

A Martinez and G Iglesias. Wave exploitability index and wave resource classification. *Renewable and Sustainable Energy Reviews*, 134:110393, 2020. URL https://doi.org/10.1016/j.rser.2020.110393.

G Besio, L Mentaschi, and A Mazzino. Wave energy resource assessment in the mediterranean sea on the basis of a 35-year hindcast. *Energy*, 94:50–63, 2016. URL https://doi.org/10.1016/j.energy.2015.10.044.

George Lavidas, Vengatesan Venugopal, and Atul Agarwal. Long-term evaluation of the wave climate and energy potential in the mediterranean sea. In *Proc., 4th IAHR European Congress, edited by S. Erpicum, B. Dewals, P. Archambeau, and M. Pirotton*, pages 247–253, 2016.

Tommaso Caloiero, Francesco Aristodemo, and Danilo Algieri Ferraro. Annual and seasonal trend detection of significant wave height, energy period and wave power in the mediterranean sea. *Ocean Engineering*, 243:110322, 2022. URL https://doi.org/10.1016/j.oceaneng.2021.110322.

Khalid Amarouche, Adem Akpınar, Nour El Islam Bachari, and Fouzia Houma. Wave energy resource assessment along the algerian coast based on 39-year wave hindcast. *Renewable Energy*, 153:840–860, 2020. URL https://doi.org/10.1016/j.renene.2020.02.040.

Luca Liberti, Adriana Carillo, and Gianmaria Sannino. Wave energy resource assessment in the mediterranean, the italian perspective. *Renewable Energy*, 50:938–949, 2013. URL https://doi.org/10.1016/j.renene.2012.08.023.

Joan Pau Sierra, Ricard Castrillo, Marc Mestres, César Mösso, Piero Lionello, and Luigi Marzo. Impact of climate change on wave energy resource in the mediterranean coast of morocco. *Energies*, 13(11):2993, 2020. URL https://doi.org/10.3390/en13112993.

Renata Archetti, Silvia Bozzi, and Giuseppe Passoni. Feasibility study of a wave energy farm in the western mediterranean sea: comparison among different technologies. In *International Conference on Offshore Mechanics and Arctic Engineering*, volume 44373, pages 447–452, 2011. URL https://doi.org/10.1115/OMAE2011-49372.

A De Andres, R Guanche, C Vidal, and IJ Losada. Adaptability of a generic wave energy converter to different climate conditions. *Renewable Energy*, 78:322–333, 2015.

George Lavidas, Francesco De Leo, and Giovanni Besio. Blue growth development in the mediterranean sea: Quantifying the benefits of an integrated wave energy converter at genoa harbour. *Energies*, 13(16):4201, 2020. doi: 10.3390/en13164201. URL https://doi.org/10.3390/en13164201.

Irene Simonetti and Lorenzo Cappietti. Mediterranean coastal wave-climate long-term trend in climate change scenarios and effects on the optimal sizing of owc wave energy converters. *Coastal Engineering*, 179:104247, 2023. doi: 10.1016/j.coastaleng.2022.104247. URL https://doi.org/10.1016/j.coastaleng.2022.104247.

Carlo Lo Re, Giorgio Manno, Mirko Basile, and Giuseppe Ciraolo. The opportunity of using wave energy converters in a mediterranean hot spot. *Renewable Energy*, 196:1095–1114, 2022. URL https://doi.org/10.1016/j.renene.2022.07.010.

Spyros Foteinis. Wave energy converters in low energy seas: Current state and opportunities. *Renewable and Sustainable Energy Reviews*, 162:112448, 2022. URL https://doi.org/10.1016/j.rser.2022.112448.

Fabio Carapellese, Edoardo Pasta, Nicolás Faedo, and Giuseppe Giorgi. Dynamic analysis and performance assessment of the inertial sea wave energy converter (iswec) device via harmonic balance. *IFAC-PapersOnLine*, 55(31):439–444, 2022. URL https://doi.org/10.1016/j.ifacol.2022.10.467.

Pasquale Contestabile, Sara Russo, Arianna Azzellino, Furio Cascetta, and Diego Vicinanza. Combination of local sea winds/land breezes and nearshore wave energy resource: Case study at marelab (naples, italy). *Energy Conversion and Management*, 257:115356, 2022. URL https://doi.org/10.1016/j.enconman.2022.115356.

Felice Arena, Alessandra Romolo, Giovanni Malara, Vincenzo Fiamma, and Valentina Laface. Response of the u-owc prototype installed in the civitavecchia harbour. In *International Conference on Offshore Mechanics and Arctic Engineering*, volume 51319, page V010T09A034.

American Society of Mechanical Engineers, 2018. URL https://doi.org/10.1115/OMAE2018-78762.

Rene Castro. *Assessing Wave Power for Sustainable Development in Costa Rica: Potential Role within Energy Mix and Comparative Analysis of National Energy Sources through Triple I Index*. PhD thesis, The University of Tokyo, 2016.

T Hernandez-Madrigal, Samuel Wright-Green, Allan Mason-Jones, Timothy O'Doherty, DM O'Doherty, and C Johnstone. Marine energy in costa rica: Development procedures compared to the uk. 2016. URL https://orca.cardiff.ac.uk/id/eprint/97395/.

Maris Eelsalu, RubénD Montoya, Darwin Aramburo, AndrésF Osorio, and Tarmo Soomere. Spatial and temporal variability of wave energy resource in eastern pacific from panama to the drake passage. *Renewable Energy*, page 120180, 2024. URL https://doi.org/10.1016/j.renene.2024.120180.

Yudisleyvis Ventura, Yandy Rodriguez, Itxaso Odériz, Valeria Chavez, Nobuhito Mori, Angelica Felix, Sergio Cerdeira-Estrada, and Rodolfo Silva. New assessment of wave energy in relation to geomorphological and demographic characteristics on the pacific coast of baja california, mexico. *Frontiers in Marine Science*, 9:872707, 2022. doi: 10.3389/fmars.2022.872707. URL https://doi.org/10.3389/fmars.2022.872707.

Emiliano Gorr-Pozzi, Héctor García-Nava, Marco Larrañaga, Melissa G Jaramillo-Torres, and Manuel G Verduzco-Zapata. Wave energy resource harnessing assessment in a subtropical coastal region of the pacific. *Journal of Marine Science and Engineering*, 9(11):1264, 2021. URL https://doi.org/10.3390/jmse9111264.

Ottavio Mattia Mazzaretto, Felipe Lucero, Giovanni Besio, and Rodrigo Cienfuegos. Perspectives for harnessing the energetic persistent high swells reaching the coast of chile. *Renewable Energy*, 159:494–505, 2020. URL https://doi.org/10.1016/j.renene.2020.05.031.

Liliana Rusu and Florin Onea. The performance of some state-of-the-art wave energy converters in locations with the worldwide highest wave power. *Renewable and Sustainable Energy Reviews*, 75:1348–1362, 2017. URL https://doi.org/10.1016/j.rser.2016.11.123.

Dernis G Mediavilla and Héctor H Sepúlveda. Nearshore assessment of wave energy resources in central chile (2009–2010). *Renewable energy*, 90:136–144, 2016. doi: 10.1016/j.renene.2017.03.076. URL https://doi.org/10.1016/j.renene.2017.03.076.

Pasquale Contestabile, Vicenzo Ferrante, and Vicinanza Diego. Wave energy resource along the coast of santa catarina (brazil). *Energies*, 8-12:14219–14243, 2015. URL https://doi.org/10.3390/en81212423.

Monique Maria Hoogwijk. *On the global and regional potential of renewable energy sources*. PhD thesis, 2004. URL https://dspace.library.uu.nl/bitstream/handle/1874/782/full.pdf?sequence=1&isAllowed=y.

Hussein Sharadga, Shima Hajimirza, and Robert S Balog. Time series forecasting of solar power generation for large-scale photovoltaic plants. *Renewable Energy*, 150:797–807, 2020. doi: 10.1016/j.renene.2019.12.131. URL https://doi.org/10.1016/j.renene.2019.12.131.

Jianyue Ji and Dongfang Wang. Regional differences, dynamic evolution, and driving factors of tourism development in chinese coastal cities. *Ocean & Coastal Management*, 226:106262, 2022.

Zihao Zheng, Zhifeng Wu, Yingbiao Chen, Zhiwei Yang, and Francesco Marinello. Exploration of eco-environment and urbanization changes in coastal zones: A case study in china over the past 20 years. *Ecological Indicators*, 119:106847, 2020.

Gregorio Iglesias, Mario López, Rodrigo Carballo, Alberte Castro, José A Fraguela, and Peter Frigaard. Wave energy potential in galicia (nw spain). *Renewable Energy*, 34(11):2323–2333, 2009. URL https://doi.org/10.1016/j.renene.2009.03.030.

C Iuppa, L Cavallaro, Diego Vicinanza, and Enrico Foti. Investigation of suitable sites for wave energy converters around sicily (italy). *Ocean Science*, 11(4):543–557, 2015. URL https://doi.org/10.5194/os-11-543-2015.

Beatrice Battisti, Giuseppe Giorgi, and Gael Verao Fernandez. Balancing power production and coastal protection: A bi-objective analysis of wave energy converters. *Renewable Energy*, 220:119702, 2024. URL https://doi.org/10.1016/j.renene.2023.119702.

IPCC. Ar6 climate change 2021: the physical science basis—ipcc, 2017.

Tunde Aderinto and Hua Li. Review on power performance and efficiency of wave energy converters. *Energies*, 12(22):4329, 2019. doi: 10.3390/en12224329. URL https://doi.org/10.3390/en12224329.

Marco Balsamo, Fabio Montagnaro, and Edward J Anthony. Socio-economic parameters affect co2 emissions and energy consumption–an analysis over the united nations countries. *Current Opinion in Green and Sustainable Chemistry*, 40:100740, 2023.

George Hadley. Vi. concerning the cause of the general trade-winds. *Philosophical Transactions of the Royal Society of London*, 39(437):58–62, 1735.

Jesús Portilla, Ana Lucía Caicedo, Roberto Padilla-Hernández, and Luigi Cavaleri. Spectral wave conditions in the colombian pacific ocean. *Ocean Modelling*, 92:149–168, 2015.

Hugo G Hidalgo, Eric J Alfaro, Franklin HernÃandez-Castro, and Paula M Pérez-Briceño. Identification of tropical cyclones' critical positions associated with extreme precipitation events in central america. *Atmosphere*, 11(10):1123, 2020. URL https://doi.org/10.3390/atmos11101123.

Elisa Canepa, Sara Pensieri, Roberto Bozzano, Marco Faimali, Pierluigi Traverso, and Luigi Cavaleri. The odas italia 1 buoy: More than forty years of activity in the ligurian sea. *Progress in Oceanography*, 135:48–63, 2015. URL https://doi.org/10.1016/j.pocean.2015.04.005.

Giovanni Besio, Riccardo Briganti, Alessandro Romano, Lorenzo Mentaschi, and Paolo De Girolamo. Time clustering of wave storms in the mediterranean sea. *Natural Hazards and Earth System Sciences*, 17(3):505–514, 2017. URL https://doi.org/10.5194/nhess-17-505-2017.

Andrea Lira-Loarca, Alejandro Caceres-Euse, Francesco De-Leo, and Giovanni Besio. Wave modeling with unstructured mesh for hindcast, forecast and wave hazard applications in the mediterranean sea. *Applied Ocean Research*, 122:103118, 2022. URL https://doi.org/10.1016/j.apor.2022.103118.

Adrian De Andres, Encarnacion Medina-Lopez, David Crooks, Owain Roberts, and Henry Jeffrey. On the reversed lcoe calculation: Design constraints for wave energy commercialization. *International journal of marine energy*, 18:88–108, 2017. doi: 10.1016/j.ijome.2017.03.008. URL https://doi.org/10.1016/j.ijome.2017.03.008.

Jesus Portilla-Yandun and Wilson Guachamin-Acero. Wave spectral analysis for designing wave energy converters. In *Proceedings of the European Wave and Tidal Energy Conference*, volume 15, 2023. URL https://doi.org/10.36688/ewtec-2023-175.

Steven A Hughes. *Physical models and laboratory techniques in coastal engineering*, volume 7. World Scientific, 1993.

Ivana Martić, Nastia Degiuli, and Carlo Giorgio Grlj. Scaling of wave energy converters for optimum performance in the adriatic sea. *Energy*, page 130922, 2024. URL https://doi.org/10.1016/j.energy.2024.130922.

Jarrah Orphin, Jean-Roch Nader, and Irene Penesis. Size matters: Scale effects of an owc wave energy converter. *Renewable Energy*, 185:111–122, 2022. URL https://doi.org/10.1016/j.renene.2021.11.121.

Scott Beatty, Francesco Ferri, Bryce Bocking, Jens Peter Kofoed, and Bradley Buckham. Power take-off simulation for scale model testing of wave energy converters. *Energies*, 10(7):973, 2017. URL https://doi.org/10.3390/en10070973.

G Sinden. Variability of uk marine resources. *The Carbon Trust, London*, 2005. URL https://tethys.pnnl.gov/sites/default/files/publications/Carbon_Trust_2005.pdf.

António FO Falcão and João CC Henriques. Model-prototype similarity of oscillating-water-column wave energy converters. *International Journal of Marine Energy*, 6:18–34, 2014. URL https://doi.org/10.1016/j.ijome.2014.05.002.

Wanan Sheng, Raymond Alcorn, and Anthony Lewis. Assessment of primary energy conversions of oscillating water columns. i. hydrodynamic analysis. *Journal of Renewable and Sustainable Energy*, 6(5), 2014.

Pál Schmitt and Björn Elsäßer. The application of froude scaling to model tests of oscillating wave surge converters. *Ocean Engineering*, 141:108–115, 2017. URL https://doi.org/10.1016/j.oceaneng.2017.06.003.

I Zabala, JCC Henriques, JM Blanco, A Gomez, LMC Gato, I Bidaguren, AFO Falcão, A Amezaga, and RPF Gomes. Wave-induced real-fluid effects in marine energy converters: Review and application to owc devices. *Renewable and Sustainable Energy Reviews*, 111:535–549, 2019. URL https://doi.org/10.1016/j.rser.2019.05.025.

Saishuai Dai, Sandy Day, Zhiming Yuan, and Haibin Wang. Investigation on the hydrodynamic scaling effect of an owc type wave energy device using experiment and cfd simulation. *Renewable energy*, 142:184–194, 2019. URL https://doi.org/10.1016/j.renene.2019.04.066.

Antonino Viviano, Stefania Naty, and Enrico Foti. Scale effects in physical modelling of a generalized owc. *Ocean Engineering*, 162:248–258, 2018. URL https://doi.org/10.1016/j.oceaneng.2018.05.019.

M Isaacson and OU Nwogu. Wave loads and motions of long structures in directional seas. 1987. URL https://doi.org/10.1115/1.3257000.

João Cruz, Rebecca Sykes, Philip Siddorn, and R Eatock Taylor. Estimating the loads and energy yield of arrays of wave energy converters under realistic seas. *IET Renewable Power Generation*, 4(6):488–497, 2010. URL https://doi.org/10.1049/iet-rpg.2009.0174.

Kjell Budal and Johannes Falnes. Wave power conversion by point absorbers: A norwegian project. *International Journal of Ambient Energy*, 3(2):59–67, 1982. URL https://doi.org/10.1080/01430750.1982.9675829.

George Lavidas. Developments of energy in eu–unlocking the wave energy potential. *International Journal of Sustainable Energy*, 38(3):208–226, 2019. doi: 10.1080/14786451.2018.1492578. URL https://doi.org/10.1080/14786451.2018.1492578.

Ali Trueworthy and Bryony DuPont. The wave energy converter design process: Methods applied in industry and shortcomings of current practices. *Journal of Marine Science and Engineering*, 8(11):932, 2020. URL https://doi.org/10.3390/jmse8110932.

Sharay Astariz and Gregório Iglesias. The economics of wave energy: A review. *Renewable and Sustainable Energy Reviews*, 45:397–408, 2015. doi: 10.1016/j.rser.2015.01.061. URL https://doi.org/10.1016/j.rser.2015.01.061.

Am O'hagan, C Huertas, J O'callaghan, and Deborah Greaves. Wave energy in europe: Views on experiences and progress to date. *International Journal of Marine Energy*, 14:180–197, 2016. URL https://doi.org/10.1016/j.ijome.2015.09.001.

Jannis Langer, Aida Astuti Cahyaningwidi, Charis Chalkiadakis, Jaco Quist, Olivier Hoes, and Kornelis Blok. Plant siting and economic potential of ocean thermal energy conversion in indonesia a novel gis-based methodology. *Energy*, 224:120121, 2021. doi: 10.1016/j.energy.2021.120121. URL https://doi.org/10.1016/j.energy.2021.120121.

George Lavidas and Kornelis Blok. Shifting wave energy perceptions: The case for wave energy converter (wec) feasibility at milder resources. *Renewable Energy*, 170:1143–1155, 2021. doi: 10.1016/j.renene.2021.02.041. URL https://doi.org/10.1016/j.renene.2021.02.041.

United Nations. Sustainable development goals, 2022. URL https://sdgs.un.org/goals.

EMEC. Emec standards, 2009. URL https://www.emec.org.uk/standards/.

IEC. Marine energy—wave, tidal and other water current converters tc-114. *IEC Geneva, Switzerland*, 2023. URL https://iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1316,25.

Pacific Northwest National Laboratory. Regulatory frameworks for marine renewable energy, 2021. URL https://tethys.pnnl.gov/regulatory-frameworks-marine-renewable-energy.

Shuiqing Li and Dongliang Zhao. Comparison of spectral partitioning techniques for wind wave and swell. 2012. URL https://aquadocs.org/handle/1834/5846.

Jesús Portilla-Yandún, Luigi Cavaleri, and Gerbrant Ph Van Vledder. Wave spectra partitioning and long term statistical distribution. *Ocean Modelling*, 96:148–160, 2015.

Susanne Hasselmann, C Brüning, Klaus Hasselmann, and Patrick Heimbach. An improved algorithm for the retrieval of ocean wave spectra from synthetic aperture radar image spectra. *Journal of Geophysical Research: Oceans*, 101(C7):16615–16629, 1996.

Walter Heinrich Munk. *Origin and generation of waves*. Scripps Institution of Oceanography La Jolla, California, 1951.

Ke Wu, Qinglai Fan, and Jing Zheng. Effect of strength anisotropy on failure envelope of offshore shallow foundations under combined loading. *Journal of Coastal Research*, (73): 521–526, 2015. URL https://doi.org/10.2112/SI73-091.1.

Thomas Bruns, Susanne Lehner, Xiao-Ming Li, Katrin Hessner, and Wolfgang Rosenthal. Analysis of an event of "parametric rolling" onboard rv "polarstern" based on shipborne wave radar and satellite data. *IEEE Journal of Oceanic Engineering*, 36(2):364–372, 2011.

Elzbieta M Bitner-Gregersen and Alessandro Toffoli. Occurrence of rogue sea states and consequences for marine structures. *Ocean Dynamics*, 64:1457–1468, 2014. URL https://doi.org/10.1007/s10236-014-0753-2.

JP Sierra and M Casas-Prat. Analysis of potential impacts on coastal areas due to changes in wave conditions. *Climatic change*, 124:861–876, 2014. URL https://doi.org/10.1007/s10584-014-1120-5.

Bryson Robertson, Clayton Hiles, Ewelina Luczko, and Bradley Buckham. Quantifying wave power and wave energy converter array production potential. *International Journal of Marine Energy*, 14:143–160, 2016. URL https://doi.org/10.1016/j.ijome.2015.10.001.

Larry Mayer, Martin Jakobsson, Graham Allen, Boris Dorschel, Robin Falconer, Vicki Ferrini, Geoffroy Lamarche, Helen Snaith, and Pauline Weatherall. The nippon foundation—gebco seabed 2030 project: The quest to see the world's oceans completely mapped by 2030. *Geosciences*, 8(2):63, 2018. URL https://doi.org/10.3390/geosciences8020063.

G Leone. Mediterranean quality status report. *UN Environment Programme*, 2017.

EMSA. Emsa route density map, 2023. URL https://ows.emodnet-humanactivities.eu/geonetwork/srv/api/records/74eef9c6-13fe-4630-b935-f26871c8b661.

Alessandro Toffoli, Jean Michel Lefevre, E Bitner-Gregersen, and Jaak Monbaliu. Towards the identification of warning criteria: analysis of a ship accident database. *Applied Ocean Research*, 27(6):281–291, 2005.

Zhiwei Zhang and Xiao-Ming Li. Global ship accidents and ocean swell-related sea states. *Natural Hazards and Earth System Sciences*, 17(11):2041–2051, 2017. URL https://doi.org/10.5194/nhess-17-2041-2017,2017.

Alvaro Semedo, Kay Sušelj, Anna Rutgersson, and Andreas Sterl. A global view on the wind sea and swell climate and variability from era-40. *Journal of Climate*, 24(5):1461–1479, 2011. URL https://doi.org/10.1175/2010JCLI3718.1.

Alessandro Toffoli, EM Bitner-Gregersen, Alfred Richard Osborne, Marina Serio, Jaak Monbaliu, and Miguel Onorato. Extreme waves in random crossing seas: Laboratory experiments and numerical simulations. *Geophysical Research Letters*, 38(6), 2011. URL https://doi.org/10.1029/2011GL046827.

PG Petrova and C Guedes Soares. Distributions of nonlinear wave amplitudes and heights from laboratory generated following and crossing bimodal seas. *Natural hazards and earth system sciences*, 14(5):1207–1222, 2014. URL https://doi.org/10.5194/nhess-14-1207-2014.

Roberto Vettor and C Guedes Soares. A global view on bimodal wave spectra and crossing seas from era-interim. *Ocean Engineering*, 210:107439, 2020. URL https://doi.org/10.1016/j.oceaneng.2020.107439.

Silvio Davison, Alvise Benetazzo, Francesco Barbariol, Guillaume Ducrozet, Jeseon Yoo, and Marco Marani. Space-time statistics of extreme ocean waves in crossing sea states. *Frontiers in Marine Science*, 9:1002806, 2022. URL https://doi.org/10.3389/fmars.2022.1002806.

Geoff Busswell, Ellis Ash, Jean-Francois Piolle, D Poulter, Helen Snaith, Fabrice Collard, Harjit Sheera, and Simon Pinnock. Project globwave. In *Proceedings of the Third International Workshop SeaSAR 2010, held at ESA ESRIN (Frascati, Italy), 25–29 January 2010*, 2010. URL https://earth.esa.int/eogateway/documents/20142/37627/1-GLOBWAVE-project.pdf.

João Albuquerque, Jose AA Antolínez, Ana Rueda, Fernando J Méndez, and Giovanni Coco. Directional correction of modeled sea and swell wave heights using satellite altimeter data. *Ocean Modelling*, 131:103–114, 2018. doi: 10.1016/j.ocemod.2018.09.001. URL https://doi.org/10.1016/j.ocemod.2018.09.001.

Nobuyuki Otsu. A threshold selection method from gray-level histograms. *IEEE transactions on systems, man, and cybernetics*, 9(1):62–66, 1979.

Hendrik L Tolman and Dmitry Chalikov. Source terms in a third-generation wind wave model. *Journal of Physical Oceanography*, 26(11):2497–2518, 1996. URL https://doi.org/10.1175/1520-0485(1996)026<2497:STIATG>2.0.CO;2.

Gerbrand J Komen, Luigi Cavaleri, Mark Donelan, Klaus Hasselmann, S Hasselmann, and PAEM Janssen. *Dynamics and modelling of ocean waves*. 1994.

Robert G Dean and Robert A Dalrymple. *Water wave mechanics for engineers and scientists*, volume 2. world scientific publishing company, 1991.

Darren Engwirda. Locally optimal delaunay-refinement and optimisation-based mesh generation. 2014. URL https://ses.library.usyd.edu.au/handle/2123/13148.

Michel Benoit, Frederic Marcos, and Francoise Becq. Development of a third generation shallow-water wave model with unstructured spatial meshing. In *Coastal Engineering 1996*, pages 465–478. 1997. URL https://doi.org/10.1061/9780784402429.037.

RL Snyder, FW Dobson, JA Elliott, and RB Long. Array measurements of atmospheric pressure fluctuations above surface gravity waves. *Journal of Fluid mechanics*, 102:1–59, 1981. URL https://doi.org/10.1017/S0022112081002528.

GJ Komen, Susanne Hasselmann, and Klaus Hasselmann. On the existence of a fully developed wind-sea spectrum. *Journal of physical oceanography*, 14(8):1271–1285, 1984. URL https://doi.org/10.1175/1520-0485(1984)014<1271:OTEOAF>2.0.CO;2.

S Abdalla and J Bidlot. Wind gustiness and air density effects and other key changes to wave model in cy25r1. *Tech. Rep. Memomrandum R60. 9/SA/0273, Research Department, ECMWF, Reading, U. K*, 2002.

John W Miles. On the generation of surface waves by shear flows. *Journal of Fluid Mechanics*, 3(2):185–204, 1957. URL https://doi.org/10.1017/S0022112057000567.

Peter AEM Janssen. Quasilinear approximation for the spectrum of wind-generated water waves. *Journal of Fluid Mechanics*, 117:493–506, 1982. URL https://doi.org/10.1017/S0022112082001736.

Peter AEM Janssen. Quasi-linear theory of wind-wave generation applied to wave forecasting. *Journal of physical oceanography*, 21(11):1631–1642, 1991. URL https://doi.org/10.1175/1520-0485(1991)021<1631:QLTOWW>2.0.CO;2.

Fabrice Ardhuin, Erick Rogers, Alexander V Babanin, Jean-François Filipot, Rudy Magne, Aaron Roland, Andre Van Der Westhuysen, Pierre Queffeulou, Jean-Michel Lefevre, Lotfi Aouf, et al. Semiempirical dissipation source functions for ocean waves. part i: Definition, calibration, and validation. *Journal of Physical Oceanography*, 40(9):1917–1941, 2010. URL https://doi.org/10.1175/2010JPO4324.1.

OM Phillips. On the response of short ocean wave components at a fixed wavenumber to ocean current variations. *Journal of Physical Oceanography*, 14(9):1425–1433, 1984. URL https://doi.org/10.1175/1520-0485(1984)014<1425:OTROSO>2.0.CO;2.

Fabrice Ardhuin, Bertrand Chapron, and Fabrice Collard. Observation of swell dissipation across oceans. *Geophysical Research Letters*, 36(6), 2009. URL https://doi.org/10.1029/2008GL037030.

Fabrice Collard, Fabrice Ardhuin, and Bertrand Chapron. Monitoring and analysis of ocean swell fields from space: New methods for routine observations. *Journal of Geophysical Research: Oceans*, 114(C7), 2009. URL https://doi.org/10.1029/2008JC005215.

MAC Teixeira and SE Belcher. On the distortion of turbulence by a progressive surface wave. *Journal of Fluid Mechanics*, 458:229–267, 2002. URL https://doi.org/10.1017/S0022112002007838.

Fabrice Ardhuin and Alastair D Jenkins. On the interaction of surface waves and upper ocean turbulence. *Journal of physical oceanography*, 36(3):551–557, 2006. URL https://doi.org/10.1175/JPO2862.1.

W Erick Rogers, Alexander V Babanin, and David W Wang. Observation-consistent input and whitecapping dissipation in a model for wind-generated surface waves: Description and simple calculations. *Journal of Atmospheric and Oceanic Technology*, 29(9):1329–1346, 2012. URL https://doi.org/10.1175/JTECH-D-11-00092.1.

Alexander V Babanin, Michael L Banner, Ian R Young, and Mark A Donelan. Wave-follower field measurements of the wind-input spectral function. part iii: Parameterization of the wind-input enhancement due to wave breaking. *Journal of Physical Oceanography*, 37(11):2764–2775, 2007. URL https://doi.org/10.1175/2007JPO3757.1.

Stefan Zieger, Alexander V Babanin, W Erick Rogers, and Ian R Young. Observation-based source terms in the third-generation wave model wavewatch. *Ocean Modelling*, 96:2–25, 2015. URL https://doi.org/10.1016/j.ocemod.2015.07.014.

Ian R Young and Alexander V Babanin. Spectral distribution of energy dissipation of wind-generated waves due to dominant wave breaking. *Journal of Physical Oceanography*, 36(3): 376–394, 2006. URL https://doi.org/10.1175/JPO2859.1.

PA Umesh and Manasa R Behera. Performance evaluation of input-dissipation parameterizations in wavewatch iii and comparison of wave hindcast with nested wavewatch iii-swan in the indian seas. *Ocean Engineering*, 202:106959, 2020. URL https://doi.org/10.1016/j.oceaneng.2020.106959.

Sachini Pathirana, Ian Young, and Alberto Meucci. Modelling swell propagation across the pacific. *Frontiers in Marine Science*, 10:1187473, 2023. URL https://doi.org/10.3389/fmars.2023.1187473.

Fan Bi, Jinbao Song, Kejian Wu, and Yao Xu. Evaluation of the simulation capability of the wavewatch iii model for pacific ocean wave. *Acta Oceanologica Sinica*, 34:43–57, 2015. URL https://doi.org/10.1007/s13131-015-0737-1.

HL Tolman. Optimum discrete interaction approximations for wind waves. part 1: Mapping using inverse modeling. tech. Technical report, Note 227, NOAA/NWS/NCEP/MMAB, 57 pp.+ Appendices, 2003.

British Oceanographic Data Centre. Gebco bathymetric compilation group 2019. gebco web map service, 2020. URL http://gebco.net/data_and_products/gebco_web_services/web_map_service/.

Pål Wessel and Walter HF Smith. A global, self-consistent, hierarchical, high-resolution shoreline database. *Journal of Geophysical Research: Solid Earth*, 101(B4):8741–8743, 1996.

Hans Hersbach, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, Carole Peubey, Raluca Radu, Dinand Schepers, et al. The era5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society*, 146(730):1999–2049, 2020. doi: 10.1002/qj.3803.

Suranjana Saha, Shrinivas Moorthi, Hua-Lu Pan, Xingren Wu, Jiande Wang, Sudhir Nadiga, Patrick Tripp, Robert Kistler, John Woollen, David Behringer, et al. The ncep climate forecast system reanalysis. *Bulletin of the American Meteorological Society*, 91(8):1015–1058, 2010.

Agung Setianto and Tamia Triandini. Comparison of kriging and inverse distance weighted (idw) interpolation methods in lineament extraction and analysis. *Journal of Applied Geology*, 5(1), 2013. URL https://doi.org/10.22146/jag.7204.

UAIP-MARN. Unidad de acceso a la informacion publica, 2021. URL https://oir.ambiente.gob.sv/. Accessed on: 02/03/2021.

IMARES-UCR. Data access consultancy, 2021. URL https://imares.ucr.ac.cr/index.php/contacto/. Accessed on: 03/17/2021.

NOAA. National data buoy center, 2021. URL https://www.ndbc.noaa.gov/. Accessed on: 01/14/2021.

INOCAR. Instituto oceanografico y antartico de la armada de ecuador, 2021. URL https://www.inocar.mil.ec/web/index.php. Accessed on: 01/19/2021.

Chong-wei Zheng, Di Wu, Hai-lang Wu, Jing Guo, Chong Shen, Chuan Tian, Xin-long Tian, Zi-niu Xiao, Wen Zhou, and Chong-yin Li. Propagation and attenuation of swell energy in the pacific ocean. *Renewable Energy*, 188:750–764, 2022. doi: 10.1016/j.renene.2022.02.071. URL https://doi.org/10.1016/j.renene.2022.02.071.

Atul K Jain et al. Global carbon budget 2022. *Earth System Science Data*, 14(11):4811–4900, 2022. URL https://essd.copernicus.org/articles/14/4811/2022/.

Carlo Lo Re, Giorgio Manno, Giuseppe Ciraolo, and Giovanni Besio. Wave energy assessment around the aegadian islands (sicily). *Energies*, 12(3):333, 2019. URL https://doi.org/10.3390/en12030333.

A Rute Bento, Paulo Martinho, and C Guedes Soares. Wave energy assessement for northern spain from a 33-year hindcast. *Renewable Energy*, 127:322–333, 2018.

Dogan Kisacik, Vasiliki Stratigaki, Minghao Wu, Lorenzo Cappietti, Irene Simonetti, Peter Troch, Alejandro Crespo, Corrado Altomare, José Domínguez, Matthew Hall, et al. Efficiency and survivability of a floating oscillating water column wave energy converter moored to the seabed: an overview of the esflowc marinet2 database. *Water*, 12(4):992, 2020.

Sadaf Nasrollahi, Aliyeh Kazemi, Mohammad-Hossein Jahangir, and Sara Aryaee. Selecting suitable wave energy technology for sustainable development, an mcdm approach. *Renewable Energy*, 202:756–772, 2023.

Ahmed Jabrali, Rabha Khatyr, and Jaafar Khalid Naciri. Wave conditions variation effects on energy recovery for a dexa wave energy converter. In *IOP Conference Series: Earth and Environmental Science*, volume 1050, page 012006. IOP Publishing, 2022.

EMEC. Technology readiness levels, 2022. URL https://www.emec.org.uk/services/provision-of-wave-and-tidal-testing/pathway-to-emec/technology-readiness-levels/.

D.D. Forbush, J.A. Colby, and N. Mendoza. A comprehensive assessment tool for low-trl current energy converters: Preprint. *Golden, CO: National Renewable Energy Laboratory*, NREL/CP-5000-87075, 2023. URL https://www.nrel.gov/docs/fy23osti/87075.pdf.

Easton R White, Mark C Myers, Joanna Mills Flemming, and Julia K Baum. Shifting elasmobranch community assemblage at cocos island—an isolated marine protected area. *Conservation Biology*, 29(4):1186–1197, 2015. URL https://doi.org/10.1111/cobi.12478.

Tito Maldonado, Eric J Alfaro, and Hugo G Hidalgo. A review of the main drivers and variability of central america's climate and seasonal forecast systems. *Revista de Biología Tropical*, 66(S1):S153–S175, 2018. doi: 10.15517/rbt.v66i1.33294. URL https://doi.org/10.15517/rbt.v66i1.33294.

Zijie Zhao, Neil J Holbrook, Eric CJ Oliver, Daniel Ballestero, and J Mauro Vargas-Hernandez. Characteristic atmospheric states during mid-summer droughts over central america and mexico. *Climate Dynamics*, 55:681–701, 2020. URL https://doi.org/10.1007/s00382-020-05283-6.

BG Reguero, FJ Méndez, and IJ Losada. Variability of multivariate wave climate in latin america and the caribbean. *Global and Planetary Change*, 100:70–84, 2013. URL https://doi.org/10.1016/j.gloplacha.2012.09.005.

Isabelle Gouirand, Vincent Moron, and Bernd Sing. Seasonal atmospheric transitions in the caribbean basin and central america. *Climate Dynamics*, 55(7-8):1809–1828, 2020. URL https://doi.org/10.1007/s00382-020-05356-6.

David Dunnett and James S Wallace. Electricity generation from wave power in canada. *Renewable Energy*, 34(1):179–195, 2009. doi: 10.1016/j.renene.2008.04.034. URL https://doi.org/10.1016/j.renene.2008.04.034.

R Camilla Thomson, John P Chick, and Gareth P Harrison. An lca of the pelamis wave energy converter. *The international journal of life cycle assessment*, 24:51–63, 2019. URL https://doi.org/10.1007/s11367-018-1504-2.

SeaPower Ltd. Power matrix of seapower platform, n.d. URL http://www.seapower.ie/wp-content/uploads/Seapower-Powermatrix1.png. Accessed on January 11, 2023.

De Zhi Ning, Xuan Lie Zhao, Li Fen Chen, and Ming Zhao. Hydrodynamic performance of an array of wave energy converters integrated with a pontoon-type breakwater. *Energies*, 11(3):685, 2018. URL https://doi.org/10.3390/en11030685.

G Rinaldi, JCC Portillo, F Khalid, JCC Henriques, PR Thies, LMC Gato, and L Johanning. Multivariate analysis of the reliability, availability, and maintainability characterizations of a spar–buoy wave energy converter farm. *Journal of Ocean Engineering and Marine Energy*, 4:199–215, 2018. doi: 10.1007/s40722-018-0116-z. URL https://doi.org/10.1007/s40722-018-0116-z.

Julia Fernandez Chozas, Jens Peter Kofoed, and Niels Ejner Helstrup Jensen. User guide–coe calculation tool for wave energy converters: ver. 1.6-april 2014. 2014. URL https://vbn.aau.dk/en/publications/user-guide-coe-calculation-tool-for-wave-energy-converters-ver-16.

Daniel Clemente, P Rosa-Santos, and F Taveira-Pinto. On the potential synergies and applications of wave energy converters: A review. *Renewable and Sustainable Energy Reviews*, 135: 110162, 2021. URL https://doi.org/10.1016/j.rser.2020.110162.

Anika Obermann, Sophie Bastin, Sophie Belamari, Dario Conte, Miguel Angel Gaertner, Laurent Li, and Bodo Ahrens. Mistral and tramontane wind speed and wind direction patterns in regional climate simulations. *Climate Dynamics*, 51:1059–1076, 2018. URL https://doi.org/10.1007/s00382-016-3053-3.

Chenglong Guo, Wanan Sheng, Dakshina G De Silva, and George Aggidis. A review of the levelized cost of wave energy based on a techno-economic model. *Energies*, 16(5):2144, 2023. doi: 10.3390/en16052144. URL https://doi.org/10.3390/en16052144.

María M Vanegas-Cantarero, Shona Pennock, Tianna Bloise-Thomaz, Henry Jeffrey, and Matthew J Dickson. Beyond lcoe: A multi-criteria evaluation framework for offshore renewable energy projects. *Renewable and Sustainable Energy Reviews*, 161:112307, 2022. doi: 10.1016/j.rser.2022.112307. URL https://doi.org/10.1016/j.rser.2022.112307.

Linus Mofor, Jarett Goldsmith, and Fliss Jones. Ocean energy: Technology readiness, patents, deployment status and outlook. *Abu Dhabi*, 27, 2014. URL https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Ocean_Energy_report_2014.pdf.

Manuel Corrales-Gonzalez, George Lavidas, and Giovanni Besio. Feasibility of wave energy harvesting in the ligurian sea, italy. *Sustainability*, 15(11):9113, 2023. doi: 10.3390/su15119113. URL https://doi.org/10.3390/su15119113.

Pauline Weatherall, Karen M Marks, Martin Jakobsson, Thierry Schmitt, Shin Tani, Jan Erik Arndt, Marzia Rovere, Dale Chayes, Vicki Ferrini, and Rochelle Wigley. A new digital bathymetric model of the world's oceans. *Earth and space Science*, 2(8):331–345, 2015. doi: 10.1002/2015EA000107. URL https://doi.org/10.1002/2015EA000107.

Francesco De Leo, Giulia Cremonini, Manuel Corrales-González, and Giovanni Besio. Climate analysis of wave systems for multimodal sea states in the mediterranean sea. *Applied Ocean Research*, 142:103813, 2024. URL https://doi.org/10.1016/j.apor.2023.103813.

Giulia Cremonini, Francesco De Leo, Alessandro Stocchino, and Giovanni Besio. On the selection of time-varying scenarios of wind and ocean waves: Methodologies and applications in the north tyrrhenian sea. *Ocean Modelling*, 163:101819, 2021. doi: 10.1016/j.ocemod.2021.101819. URL https://doi.org/10.1016/j.ocemod.2021.101819.

Jochem Weber. Wec technology readiness and performance matrix–finding the best research technology development trajectory. In *Proceedings of the 4th International Conference on Ocean Energy, Dublin, Ireland*, volume 17, 2012.

C Bosserelle, S Reddy, and J Krüger. Cost analysis of wave energy in the pacific. *Waves and Coasts in the Pacific*, 2015. URL https://prdrse4all.spc.int/data/waves-and-coasts-pacific-cost-analysis-wave-energy-pacific.

Julia Fernandez Chozas, Amélie Têtu, and Abel Arredondo-Galeana. A parametric cost model for the initial techno-economic assessment of lift-force based wave energy converters. In *The 14th European Wave and Tidal Energy Conference*, 2021. URL https://pureportal.strath.ac.uk/en/publications/a-parametric-cost-model-for-the-initial-techno-economic-assessmen.

Irena. Renewable power generation costs in 2022. report. *International Renewable Energy Agency, Abu Dhabi*, 2022. URL https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022.

Pierpaolo Ricci. *Economic Performance Analysis of Wave Energy Farms: A Global Assessment Procedure*. 2012.

Robert E Harris, Lars Johanning, and Julian Wolfram. Mooring systems for wave energy converters: A review of design issues and choices. *Marec2004*, 2004. URL https://www.energiatalgud.ee/sites/default/files/images_sala/5/59/Harris%2C_R.E.%2C_Johanning%2C_L.%2C_Wolfram%2C_J._Mooring_systems_for_wave_energy_converters_-_A_review_of_design_issues_and_choices..pdf.

Anders Myhr, Catho Bjerkseter, Anders Ågotnes, and Tor A Nygaard. Levelised cost of energy for offshore floating wind turbines in a life cycle perspective. *Renewable energy*, 66:714–728, 2014. doi: 10.1016/j.renene.2014.01.017. URL https://doi.org/10.1016/j.renene.2014.01.017.

Catho Bjerkseter and Anders Ågotnes. Levelised costs of energy for offshore floating wind turbine concepts. Master's thesis, Norwegian University of Life Sciences, Ås, 2013.

SI Ocean. Ocean energy: cost of energy and cost reduction opportunities. *SI OCEAN*, 2013.

Abbie Badcock-Broe, Rob Flynn, Sian George, Remi Gruet, and Nick Medic. Wave and tidal energy market deployment strategy for europe, 2014. URL https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjThJmgg6n-AhUjSfEDHTTUDzkQFnoECAkQAQ&url=https%3A%2F%2Fpublications.jrc.ec.europa.eu%2Frepository%2Fbitstream%2FJRC118296%2Fjrc118296_1.pdf&usg=AOvVaw0fdMTcd_Rx0ru8b_cAK9gU.

Davide Magagna, Riccardo Monfardini, and Andreas Uihlein. Jrc ocean energy status report 2016 edition. *Publications Office of the European Union: Luxembourg*, 2016.

Davide Magagna, Andreas Uihlein, Marta Silva, and Alex Raventos. Wave and tidal energy in europe: Assessing present technologies. 2015. URL https://publications.jrc.ec.europa.eu/repository/handle/JRC96528.

Adrián De Andres, Andrew MacGillivray, Raúl Guanche, and Henry Jeffrey. Factors affecting lcoe of ocean energy technologies: A study of technology and deployment attractiveness. In *Proceedings of the International Conference on Ocean Energy, Halifax, NS, Canada*, pages 4–6, 2014. URL https://tethys-engineering.pnnl.gov/sites/default/files/publications/andresetal.pdf.

Davide Magagna and Andreas Uihlein. Ocean energy development in europe: Current status and future perspectives. *International Journal of Marine Energy*, 11:84–104, 2015. doi: 10.1016/j.ijome.2015.05.001. URL https://doi.org/10.1016/j.ijome.2015.05.001.

Kornelis Blok and Evert Nieuwlaar. *Introduction to energy analysis*. Routledge, 2020.

Chunbo Zhang, Mingming Hu, Benjamin Laclau, Thomas Garnesson, Xining Yang, and Arnold Tukker. Energy-carbon-investment payback analysis of prefabricated envelope-cladding system for building energy renovation: Cases in spain, the netherlands, and sweden. *Renewable and Sustainable Energy Reviews*, 145:111077, 2021. URL https://doi.org/10.1016/j.rser.2021.111077.

Giovanna Pisacane, Gianmaria Sannino, et al. *Ocean energy exploitation in Italy: ongoing R&D activities. Position paper/September 2017.* Enea, 2017. ISBN 978-88-8286-355-5.

Luigi Cavaleri, Francesco Barbariol, Luciana Bertotti, Giovanni Besio, and Francesco Ferrari. The 29 october 2018 storm in northern italy: Its multiple actions in the ligurian sea. *Progress in Oceanography*, 201:102715, 2022.

Pablo Ruiz-Minguela, Donald R Noble, Vincenzo Nava, Shona Pennock, Jesus M Blanco, and Henry Jeffrey. Estimating future costs of emerging wave energy technologies. *Sustainability*, 15(1):215, 2022. URL https://doi.org/10.3390/su15010215.

Andrew MacGillivray, Henry Jeffrey, Mark Winskel, and Ian Bryden. Innovation and cost reduction for marine renewable energy: A learning investment sensitivity analysis. *Technological Forecasting and Social Change*, 87:108–124, 2014. doi: 10.1016/j.techfore.2013.11.005. URL https://doi.org/10.1016/j.techfore.2013.11.005.

LiGuo Wang, Tao Zhao, MaoFeng Lin, and Hui Li. Towards realistic power performance and techno-economic performance of wave power farms: The impact of control strategies and wave climates. *Ocean Engineering*, 248:110754, 2022. doi: 10.1016/j.oceaneng.2022.110754. URL https://doi.org/10.1016/j.oceaneng.2022.110754.

Carmela Maienza, Alberto Maria Avossa, Vincenzo Picozzi, and Francesco Ricciardelli. Feasibility analysis for floating offshore wind energy. *The International Journal of Life Cycle Assessment*, 27(6):796–812, 2022. doi: 10.1007/s11367-022-02055-8. URL https://doi.org/10.1007/s11367-022-02055-8.

Stocker Klaus. Financial and economic assessment of tidal stream energy—a case study. *International Journal of Financial Studies*, 8(3):48, 2020. doi: 10.3390/ijfs8030048. URL https://doi.org/10.3390/ijfs8030048.

Vincenzo Piscopo, Guido Benassai, Renata Della Morte, and Antonio Scamardella. Cost-based design and selection of point absorber devices for the mediterranean sea. *Energies*, 11(4): 946, 2018.

Marianna Giassi, Valeria Castellucci, and Malin Göteman. Economical layout optimization of wave energy parks clustered in electrical subsystems. *Applied Ocean Research*, 101:102274, 2020. doi: 10.1016/j.apor.2020.102274. URL `https://doi.org/10.1016/j.apor.2020.102274`.

Lorenzo Mentaschi, Giovanni Besio, Federico Cassola, and Andrea Mazzino. Developing and validating a forecast/hindcast system for the mediterranean sea. *Journal of Coastal Research*, (65):1551–1556, 2013. URL `https://doi.org/10.2112/SI65-262.1`.

Josef Kittler and John Illingworth. Minimum error thresholding. *Pattern recognition*, 19(1): 41–47, 1986. URL `https://doi.org/10.1016/0031-3203(86)90030-0`.

Jesús Portilla-Yandún. The global signature of ocean wave spectra. *Geophysical Research Letters*, 45(1):267–276, 2018.

Miguel Onorato, Davide Proment, and Alessandro Toffoli. Freak waves in crossing seas. *The European Physical Journal Special Topics*, 185(1):45–55, 2010. URL `http://dx.doi.org/10.1140/epjst/e2010-01237-8`.

Tim Toomey, Angel Amores, Marta Marcos, and Alejandro Orfila. Coastal sea levels and wind-waves in the mediterranean sea since 1950 from a high-resolution ocean reanalysis. *Frontiers in Marine Science*, 9:991504, 2022. URL `https://doi.org/10.3389/fmars.2022.991504`.

Piero Lionello and A Sanna. Mediterranean wave climate variability and its links with nao and indian monsoon. *Climate Dynamics*, 25(6):611–623, 2005. URL `https://doi.org/10.1007/s00382-005-0025-4`.

A Sánchez-Arcilla, D González-Marco, and R Bolaños. A review of wave climate and prediction along the spanish mediterranean coast. *Natural hazards and earth system sciences*, 8(6): 1217–1228, 2008. URL `https://doi.org/10.5194/nhess-8-1217-2008`.

Mercè Casas-Prat and JP Sierra. Trend analysis of wave storminess: wave direction and its impact on harbour agitation. *Natural Hazards and Earth System Sciences*, 10(11):2327–2340, 2010. URL `https://doi.org/10.5194/nhess-10-2327-2010`.

Asmaa A Abu Zed, Rawya M Kansoh, Moheb M Iskander, and Mohamed Elkholy. Wind and wave climate southeastern of the mediterranean sea based on a high-resolution swan model. *Dynamics of Atmospheres and Oceans*, 99:101311, 2022. URL `https://doi.org/10.1016/j.dynatmoce.2022.101311`.

I Koletsis, K Lagouvardos, V Kotroni, and A Bartzokas. The interaction of northern wind flow with the complex topography of crete island–part 1: Observational study. *Natural Hazards and Earth System Sciences*, 9(6):1845–1855, 2009. URL `https://doi.org/10.5194/nhess-9-1845-2009`.

Alvise Benetazzo, Silvio Davison, Francesco Barbariol, Paola Mercogliano, Chiara Favaretto, and Mauro Sclavo. Correction of era5 wind for regional climate projections of sea waves. *Water*, 14(10):1590, 2022. URL https://doi.org/10.3390/w14101590.

Simona Saviano, Daniela Cianelli, Enrico Zambianchi, Fabio Conversano, and Marco Uttieri. An integrated reconstruction of the multiannual wave pattern in the gulf of naples (south-eastern tyrrhenian sea, western mediterranean sea). *Journal of Marine Science and Engineering*, 8(5):372, 2020. URL https://doi.org/10.3390/jmse8050372.

Sara Morucci, Marco Picone, Gabriele Nardone, and Giovanni Arena. Tides and waves in the central mediterranean sea. *Journal of Operational Oceanography*, 9(sup1):s10–s17, 2016. URL https://doi.org/10.1080/1755876X.2015.1120960.

Francesco De Leo, Sebastián Solari, and Giovanni Besio. Extreme wave analysis based on atmospheric pattern classification: an application along the italian coast. *Natural Hazards and Earth System Sciences*, 20(5):1233–1246, 2020. URL https://doi.org/10.5194/nhess-20-1233-2020.

S Federico, T Lo Feudo, C Bellecci, and F Arena. Impact of wind field horizontal resolution on sea waves hindcast around calabrian coasts. *Il nuovo cimento C*, 29(2):147–165, 2006. URL https://doi.org/10.1393/ncc/i2005-10023-7.

Francesco Barbariol, Silvio Davison, Francesco Marcello Falcieri, Rossella Ferretti, Antonio Ricchi, Mauro Sclavo, and Alvise Benetazzo. Wind waves in the mediterranean sea: An era5 reanalysis wind-based climatology. *Frontiers in Marine Science*, 8:760614, 2021. URL https://doi.org/10.3389/fmars.2021.760614.

George Zodiatis, George Galanis, Andreas Nikolaidis, Christina Kalogeri, Dan Hayes, Georgios C Georgiou, Peter C Chu, and George Kallos. Wave energy potential in the eastern mediterranean levantine basin. an integrated 10-year study. *Renewable energy*, 69:311–323, 2014. URL https://doi.org/10.1016/j.renene.2014.03.051.

Ahmed I Elshinnawy and Jose AÁ Antolínez. A changing wave climate in the mediterranean sea during 58-years using uerra-mescan-surfex high-resolution wind fields. *Ocean Engineering*, 271:113689, 2023. URL https://doi.org/10.1016/j.oceaneng.2023.113689.