

## SUPPLEMENTARY TABLES

Table S1. Number of occurrences of eggs and larvae of *Sardina pilchardus* available in each database. ICES: International Council for the Exploration of the Sea, OBIS: Ocean Biogeographic Information System, CCMA: Centre of Marine Sciences of the University of Algarve, IPMA: Portuguese Institute for the Sea and the Atmosphere, IEO: Spanish Institute of Oceanography, MARE: Marine and Environmental Sciences Centre.

| Database         | Occurrences  |              |           |              | References  |
|------------------|--------------|--------------|-----------|--------------|-------------|
|                  | Eggs         | Larvae       | Years     | Campaigns    |             |
| <b>IPMA</b>      | 6116         | 446          | 2005-2010 | SAR, PELAGOS |             |
| <b>ICES</b>      | 95           | 27           | 2004      | -            | ICES, 2020* |
| <b>OBIS</b>      | 824          | 5026         | 1905-2010 | -            | OBIS, 2020* |
| <b>IEO</b>       | 3121         | -            | 1988-2019 | PELACUS      |             |
| <b>MARE</b>      | -            | 171          | 2011-2012 | BIOMARES     |             |
| <b>CCMAR</b>     | -            | 31           | 2000      | SURVIVAL     |             |
|                  | -            | 11           | 2010-2011 | GUADIANA     |             |
| <b>Sub-total</b> | <b>10156</b> | <b>5712</b>  |           |              |             |
| <b>Total</b>     |              | <b>15868</b> |           |              |             |

\*Several campaigns worldwide

## References

- ICES. (2020). The International Council for the Exploration of the Sea, Copenhagen. 2010. ICES Database of trawl and acoustic surveys. Online source: <http://ecosystemdata.ices.dk>. (Accessed: 18 January 2020)
- OBIS. (2020). Ocean Biodiversity Information System. Distribution records of *Sardina pilchardus* (Walbaum, 1792) (Available: Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. [www.obis.org](http://www.obis.org). (<https://obis.org/taxon/126421>) (Accessed: 12 September 2020)

Table S2. Description of environmental satellite parameters.

| Parameters                        | Abbreviation | Units               | Resolution | Present-day                                                   | References             | Resolution | 2050-2099 - RCP 8.5                           | References         |
|-----------------------------------|--------------|---------------------|------------|---------------------------------------------------------------|------------------------|------------|-----------------------------------------------|--------------------|
| Sea surface temperature           | SST          | °C                  | 0.25°      | NOAA's WOA 2018 Data                                          | Locarnini et al., 2018 | 1°         | Coupled Model Intercomparison Project (CMIP5) | Scott et al., 2016 |
| Sea surface salinity              | SSS          | PSU                 | 0.25°      |                                                               | Zweng et al., 2018     | 1°         |                                               |                    |
| Dissolved oxygen                  | DO           | mol m <sup>-3</sup> | 0.25°      |                                                               | Garcia et al., 2018    | 1°         |                                               |                    |
| Chlorophyll <i>a</i>              | Chl-a        | mg m <sup>-3</sup>  | 0.25°      | Copernicus-Global Ocean Biogeochemistry Analysis and Forecast | Perruche, 2019         | 1°         |                                               |                    |
| Northward near-surface wind speed | NWS          | m s <sup>-1</sup>   | 0.25°      | Copernicus-Global Ocean Wind L4                               | Bentamy, 2020          | 1°         |                                               |                    |
| Eastward near-surface wind speed  | EWS          | m s <sup>-1</sup>   | 0.25°      |                                                               |                        | 1°         |                                               |                    |
| Distance to the nearest coast     | DIST         | km                  | 0.01°      | NASA's Goddard Space Flight Center                            | NASA, 2009             | 0.01°      | NASA's Goddard Space Flight Center            | NASA, 2009         |

## References

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- Garcia, H. E., Weathers, K., Paver, C. R., Smolyar, I., Boyer, T. P., Locarnini, R. A., Zweng, M. M., Mishonov, A. V., Baranova, O. K., Seidov, D., Reagan, J. R. (2018). World Ocean Atlas 2018, Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, and Oxygen Saturation. A. Mishonov Technical Ed.; NOAA Atlas NESDIS 83, 38pp.
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- NASA Goddard Space Flight Center, Ocean Biology Processing Group (2009): Distance to the Nearest Coast. <https://oceancolor.gsfc.nasa.gov/docs/distfromcoast/>. Maintained by NASA Ocean Biology Distributed Active Archive Center (OB.DAAC), Goddard Space Flight Center, Greenbelt MD.
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- Scott, J.D., Alexander, M.A., Murray, D.R., Swales, D., Eischeid, J. (2016). THE CLIMATE CHANGE WEB PORTAL: A System to Access and Display Climate and Earth System Model Output from the CMIP5 Archive. Bulletin of the American Meteorological Society. 523 - 530. DOI 10.1175/BAMS-D-15-00035.1
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Table S3. Modelling algorithms considered in the ensemble modelling.

| Models                         | Non-linear response | Methods                                                                                | References                  |
|--------------------------------|---------------------|----------------------------------------------------------------------------------------|-----------------------------|
| Generalised Linear Models      | no                  | Polynomial regression-based; use of a link function between model and predicted values | McCullagh and Nelder, 1989  |
| Generalised Additive Models    | yes                 | Regression-based; a gathering of smooth functions according to the predictors          | Hastie and Tibshirani, 1990 |
| Artificial Neural Network      | yes                 | Machine learning; stepwise and self-learning method                                    | Lawrence, 1994              |
| Flexible Discriminant Analysis | yes                 | Machine learning; mixes linear regression and multivariate adaptive regression splines | Hastie et al., 1994         |
| General Boosting Models        | yes                 | Machine learning; uses negative gradient method to estimate a function                 | Friedman, 1999              |
| Random Forest                  | yes                 | Machine learning; a gathering of classification trees                                  | Breiman, 2001               |
| Classification Tree Analysis   | yes                 | Classification; binary decision tree to identify combination of factors                | Breiman, 1984               |

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Hastie, T., Tibshirani, R., Buja, A. (1994) Flexible discriminant analysis by optimal scoring. *Journal of the American Statistical Association*, 89:1255-1270.

Hastie, T.J., Tibshirani, R.J. (1990). *Generalized Additive Models*, 1st ed. Chapman and Hall, London.

Lawrence, J. (1994). *Introduction to Neural Network*. Nevada: California Sceintific Software.

McCullagh, P., Nelder, J.A. (1989). *Generalized Linear Models*, second ed. Chapman & Hall, London, pp. 509.

Table S4. Total catches of the European sardine by important fish stocks.

| Models                                     | Year | Catches     | References            |
|--------------------------------------------|------|-------------|-----------------------|
| Southern Celtic Seas and English Channel   | 2020 | 13 553 t    | ICES, 2021            |
| Bay of Biscay                              | 2018 | 32 299 t    | ICES, 2019            |
| Cantabrian Sea and Atlantic Iberian Waters | 2015 | 20 595 t    | ICES, 2020            |
| Adriatic Sea                               | 2010 | 32 860 t    | SFP, 2022             |
| Northern Alboran Sea                       | 2013 | 11 000 t    | GFCM, 2014; SFP, 2022 |
| NW Afria                                   | 2017 | 1 220 500 t | FAO, 2019             |

FAO (2019). Report of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa. Banjul, the Gambia, 26 June–1 July 2018. FAO Fisheries and Aquaculture Report/FAO No. 1247. Rome. 336 pp.

GFCM (2014). General Fisheries Commission For The Mediterranean. Report of the Working Group on Stock Assessment of Small Pelagic Species (WGSASP). 24–27 November 2014. Rome, Italy. 39 pp.

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