frontiers | Frontiers in Marine Science

DATA REPORT
published: 06 July 2022
doi: 10.3389/fmars.2022.910887

ClimateFish: A Collaborative Database to Track the Abundance of Selected Coastal Fish Species as Candidate Indicators of Climate Change in the Mediterranean Sea

Ernesto Azzurro[1,2*], *Tosca Ballerini*[1,3], *Chryssanthi Antoniadou*[4], *Giulia Domizia Aversa*[5], *Jamila Ben Souissi*[6,7], *Andrea Blašković*[8], *Valentina Cappanera*[9], *Marina Chiappi*[10,11], *Maria-Francesca Cinti*[12], *Francesco Colloca*[13], *Ivan Cvitković*[14], *Manuela D'Amen*[1,3], *Marija Despalatović*[14], *Antonio Di Franco*[15], *Charalampos Dimitriadis*[16], *Branko Dragičević*[14], *Emanuela Fanelli*[10], *Laura Figuerola*[17], *Tomaso Fortibuoni*[18], *Giulio Franzitta*[19], *Joaquim Garrabou*[20], *Tatiana Geloso*[21], *Raouia Ghanem*[7], *Andrea Gori*[17], *Martina Hervat*[8], *Andres Izquierdo-Muñoz*[22], *Cristina Linares*[17], *Gabriele La Mesa*[23], *Lorenzo Merotto*[9], *Reno Micallef*[24], *Anastasia Miliou*[25], *Annalisa Minelli*[23], *Paula Moschella*[26], *Federica Pannacciulli*[27], *Pieraugusto Panzalis*[12], *Mišo Pavičić*[14], *Antonis Petrou*[28], *Alfonso A. Ramos-Esplá*[7], *Luca Saponari*[29], *Giuseppe Scarcella*[1], *Marco Spoto*[30], *Nika Stagličić*[14], *Dario Vrdoljak*[14], *Boris Weitzmann*[31] and *Patrick Joseph Schembri*[24]

[1] National Research Council, Institute of Biological Resources and Marine Biotechnologies (CNR-IRBIM), Ancona, Italy, [2] Integrative Marine Ecology Department, Stazione Zoologica Anton Dohrn,Naples, Italy, [3] Integrative Marine Ecology Department, Stazione Zoologica Anton Dohrn, Fano Marine Centre, Fano (PU), Italy, [4] School of Biology, Aristotle University of Thessaloniki, Thessaloniki, Greece, [5] Department of Environmental Biology, The Sapienza University of Rome, Rome, Italy, [6] National Institute of Agronomy of Tunisia (INAT), University of Carthage, Carthage, Tunisia, [7] Biodiversity, Biotechnology and Climate Change Laboratory-LR11ES09, University of Tunisia El Manar, Tunis, Tunisia, [8] Brijuni National Park, Brijuni, Pula, Croatia, [9] Department of Life and Environmental Sciences, Polytechnic University of Marche, Ancona, Italy, [10] Portofino Marine Protected Area - Consortium of Management, Portofino, Italy, [11] AP Marine Environmental Consultancy Ltd, Nicosia, Cyprus, [12] Tavolara Punta Coda Cavallo Marine Protected Area, Tavolara, Olbia, Sassari, Italy, [13] Institute of Oceanography and Fisheries (IOF), Split, Croatia, [14] Integrative Marine Ecology Department, Stazione Zoologica Anton Dorhn, Rome, Italy, [15] National Marine Park of Zakynthos, Zakynthos Island, Greece, [16] Department of Evolutionary Biology, Ecology and Environmental Sciences, University of Barcelona, Barcelona, Spain, [17] Department of Evolutionary Biology, Ecology and Environmental Sciences, IRBio, University of Barcelona, Barcelona, Spain, [18] Italian Institute for Environmental Protection and Research (ISPRA), Ozzano dell'Emilia, Italy, [19] Research Infrastructures for Marine Resources (RIMAR) Department, Stazione Zoologica Anton Dohrn, Naples, Italy, [20] Institute of Marine Sciences, Spanish Research Council (ICM-CSIC), Barcelona, Spain, [21] Mare Nostrum Diving, Palermo, Italy, [22] Department of Marine Sciences, University of Alicante,Alicante, Spain, [23] Italian Institute for Environmental Protection and Research (ISPRA), Roma, Italy, [24] Department of Biology, University of Malta, Msida, Malta, [25] Archipelagos Institute of Marine Conservation, Samos, Greece, [26] Mediterranean Science Commission, The Mediterranean Science Commission (CIESM), Monaco, [27] Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Marine Environment Research Centre - S. Teresa, La Spezia, Italy, [28] Enalia Physis Environmental Research Centre, Nicosia, Cyprus, [29] Nature Seychelles, The Centre for Environment and Education, Mahe, Seychelles, [30] National Research Council, Institute of Biological Resources and Marine Biotechnologies (CNR-IRBIM), Palermo, Italy, [31] Parc Natural del Montgrií, Estartit, Spain

OPEN ACCESS

Edited by:
Roberto Sandulli,
University of Naples Parthenope, Italy

Reviewed by:
Francesco Tiralongo,
University of Catania, Italy
Lucia Fanini,
Hellenic Center for Marine Research, Greece

****Correspondence:***
Ernesto Azzurro
ernesto.azzurro@cnr.it

Specialty section:
This article was submitted to Global Change and the Future Ocean, a section of the journal Frontiers in Marine Science

Received: *01 April 2022*
Accepted: *30 May 2022*
Published: *06 July 2022*

Citation:
Azzurro E, Ballerini T, Antoniadou C, Aversa GD, Souissi JB, Blašković A, Cappanera V, Chiappi M, Cinti M-F, Colloca F, Cvitković I, D'Amen M, Despalatović M, Di Franco A, Dimitriadis C, Dragičević B, Fanelli E, Figuerola L, Fortibuoni T, Franzitta G, Garrabou J, Geloso T, Ghanem R, Gori A, Hervat M, Izquierdo-Muñoz A, Linares C, La Mesa G, Merotto L, Micallef R, Miliou A, Minelli A, Moschella P, Pannacciulli F, Panzalis P, Pavičić M, Petrou A, Ramos-Esplá AA, Saponari L, Scarcella G, Spoto M, Stagličić N, Vrdoljak D, Weitzmann B and Schembri PJ (2022) ClimateFish: A Collaborative Database to Track the Abundance of Selected Coastal Fish Species as Candidate Indicators of Climate Change in the Mediterranean Sea. Front. Mar. Sci. 9:910887. doi: 10.3389/fmars.2022.910887

Keywords: climate change indicators, coastal fishes, monitoring, global warming, visual census

BACKGROUND

Under the effects of global warming, many animals and plants are undergoing rapid distribution shifts. These changes can be particularly rapid in marine fishes, and many species have responded markedly to recent increases in sea temperature. ClimateFish is an open-access database, which collates abundance data for 7 Mediterranean indigenous and 8 non-indigenous fishes, proposed as candidate indicators of climate change. These species have been selected by a network of Mediterranean scientists based on their wide distribution, responsiveness to temperature conditions and easy identification. Data are periodically collected according to a standard visual census protocol in four different depth layers. At present, the database collates data on a total number of 101'771 observed individuals belonging to the 15 target species. Counts were realized along 3142 transects carried out in 7 Mediterranean countries between 2009 and 2021. This database, associated with climate data, offers new opportunities to investigate spatiotemporal effects of climate change and to test the effectiveness of each selected indicator. Data are available at https://doi.org/10.17882/86784.

The Mediterranean Sea is warming faster than any other marine region in the world (Pastor et al., 2020; Pisano et al., 2020), with increasingly drastic consequences on marine ecosystems (Albano et al., 2021; Garrabou et al., 2021) and on the services they provide to our societies. These changes can be particularly rapid in fish species, which are globally responding with marked shifts in latitude or depth or both (Perry et al., 2005; Chaikin et al., 2022). Climate change is indeed driving species ranges toward the poles and increasing the risks of extinction when dispersal capabilities are limited, such as in the semi-enclosed Mediterranean basin (Ben Rais Lasram et al., 2010). During the last decades, several warm water species have expanded their geographical distribution and increased their abundance in the Mediterranean Sea. This phenomenon, often indicated as "meridionalization" - i.e., meridional, or southern, species moving northward - (Bianchi and Morri, 1993; Riera et al., 1995) involves several warm-adapted coastal fishes (Azzurro, 2008; Azzurro et al., 2019), such as *Sparisoma cretense* (Ventura et al., 2019), and *Thalassoma pavo* (Vacchi et al., 2001), that have been recorded northward with respect to their original geographical distribution. Other visible changes are related to non-indigenous fishes of tropical origin, which are predicted to become increasingly successful and widely distributed under warming conditions (D'Amen and Azzurro, 2020; Golani et al., 2021). This phenomenon is often cited under the name of "tropicalization" (Bianchi and Morri, 2003).

At the same time, cold adapted and temperate native species, such as *Sarpa salpa* are rapidly losing their preferred climatic habitats and shrinking their distribution and abundance (Marras et al., 2015). Documenting climate-related changes is a key task to support current adaptation policies (O'Regan et al., 2021) and to evaluate the impact of such policies toward international biodiversity goals. However, in marine ecosystems, this goal is often challenged by the complexity of ecological transformation along with the pragmatic challenge of performing large scale studies with limited financial resources (Tiralongo et al., 2020). This stimulates efforts to identify and test essential biodiversity components and appropriate indicators (Jetz et al., 2019) to enable effective biodiversity monitoring, under a common and unified framework. Thus, the aim of this database is to collate information on a selected number of coastal fish species, which could serve as effective indicators of climate change effects in the Mediterranean Sea.

METHODS

Data gathering for this database began in 2009, within a network of Mediterranean scientists engaged in the monitoring of *meridionalization* and *tropicalization* dynamics (*sensu* Bianchi and Morri, 1993; > Bianchi and Morri, 2003; Riera et al., 1995; Azzurro et al., 2008). This international team, organised within the CIESM Programme 'Tropical Signals' https://www.ciesm.org/marine/programs/tropicalization.htm (Azzurro et al., 2011), originally aimed to track and evaluate the biotic responses to climate change in the Mediterranean Sea using reliable and representative biological macro-descriptors. To achieve this goal, a simplified visual census protocol was conceived to be applied over large temporal and geographical scales and across the different Mediterranean countries.

The protocol, later described in Garrabou et al. (2018), is currently available from the MPA Engage website https://mpa-engage.interreg-med.eu. Its sampling units are linear transects of 5 minutes, approximatively corresponding to a surface of 5x50m, to be performed over rocky bottoms with a moderate slope. It is suggested to identify at least three permanent monitoring locations (separated by a minimum distance of 0.5 km) nested in each study area. Four depth ranges can be considered: 1-3 m, 5-10 m, 11-20 m, 21-30 m. At each location and for each depth layer, each diver is invited to perform 4 consecutive replicate transects.

The protocol focuses on a group of target species chosen on the basis of their responsiveness to temperature conditions, widespread distribution and easy identification. These criteria were discussed within a large network of Mediterranean scientists. We originally included shallow and easy to recognize indigenous species, widely distributed along the Mediterranean coasts and characterized by a different thermal affinity: *Epinephelus marginatus*, *Thalassoma pavo, Sparisoma cretense* - warm affinity species with documented northward expansions (CIESM, 2008; Milazzo et al., 2016); *Coris julis* and *Sarpa salpa* - temperate species, for which there is evidence of shrinking of their preferred habitat (Milazzo et al., 2016). We also included the native *Serranus scriba* and *S. cabrilla*, because of their ecological similarity and taxonomic relatedness, associated with a different thermal affinity (Froese & Pauly, 2002). Later on, and thanks to the feedback received from several Marine Protected Areas that implemented the protocol within the framework of the EU funded projects, MPA-ADAPT https://mpa-adapt.interreg-med.eu, and MPA Engage https://mpa-engage.interreg-med.eu, we included eight Lessepsian fishes (which entered the Mediterranean through the Suez Canal) namely: *Fistularia commersonii, Siganus luridus, Siganus rivulatus, Pterois miles, Stephanolopis diaspros, Parupeneus forskali, Pempheris rhomboidea and Torquigener flavimaculosus*. Considering the trend of an increase of these species in the Mediterranean Sea (Golani et al., 2021) and their climate affinity (D'Amen and Azzurro, 2020), more data on these tropical invaders are expected to come in the future implementation of the study, especially in the eastern sectors of the Mediterranean.

Data gathering was carried by technical personnel of Marine Protected Areas (MPA staff), individual researchers and research groups. The process followed a precise workflow, which started with the training on monitoring protocols, developed in periodical training sessions funded by several national and international projects and based on a series of training tools, now freely available from the project website https://mpa-engage.interreg-med.eu.

Data collected by trained scientific divers were gathered through individual excel files and underwent four different quality checks before reaching the final database (**Figure 1**). A first control was requested to the data providers before data submission. Then, a restricted team of researchers checked the occurrence of species and their numerical counts to spot possible errors or misidentifications and contacted the data provider in case of doubts, inconsistencies, empty cells or missing data (e.g. coordinates, date etc.). A third control was performed on the assembled database, outliers were manually removed and data formatted. Finally, the data were manually examined again after the technical validation process for quality to detect any remaining errors, such as inconsistencies in geolocation.

The ClimateFish database is composed by 25 fields that include a unique record identification number (record ID), three fields for the date of the census (year, month, day), two fields for the geographical coordinates (decimal latitude and longitude), one field for the country where the record occurred, one for the depth at which the census was carried out, one field that indicates the replicate transect at each census event, the source and finally 15 fields for the scientific name of fish species.

THE CLIMATEFISH DATABASE

The ClimateFish database currently consists of 3142 underwater observations, where fish counts were performed along standard visual census transects of 5 minutes at a standard speed of 10m/min (corresponding to an approximate area of 5 x 50 m). The geographical distribution of these surveys is illustrated in **Figure 1** and it covers a time period of 13 years. Censuses were carried out for 9 consecutive years in the three locations Cirkewa, Dwejra and Gnejna in Malta, and in the three locations Ciovo Jug, Ciovo Punta, and Marjan in Split (Croatia); for 9 non-consecutive years in the three locations Faraglioni, Mannarazza, and Pozzolana in Linosa (Pelagie islands, Sicily, Italy); for 6 years in the locations Les Cliques, Punta Tees Frares, and Sarnella, at Cap de Creus (Spain); 5 years at Capu di Fora, La Vardiola, and Punta Arasu in SE Corse; and for a fewer number of years in the several Mediterranean locations, as reported in **Figure 1.** The majority (44.68%) of the transects were carried out at the depth layer of 1-3 m, followed by the depths 5-10 m depth (20.31%), 11-20 m depth (18.56%), and 21-30 m depth (16.45%) (**Figure 2**).

Overall, 101'771 individuals belonging to the 15 target species were counted. The most represented species were *S. salpa* (38'201), *C. julis* (26'620), and *T. pavo* (12'718) (**Figure 2**). The database also contains observations on 8 non indigenous species (NIS). These species, mostly distributed in the eastern sectors of the Mediterranean, are currently underrepresented in the database, but counts of NIS are expected to grow along with

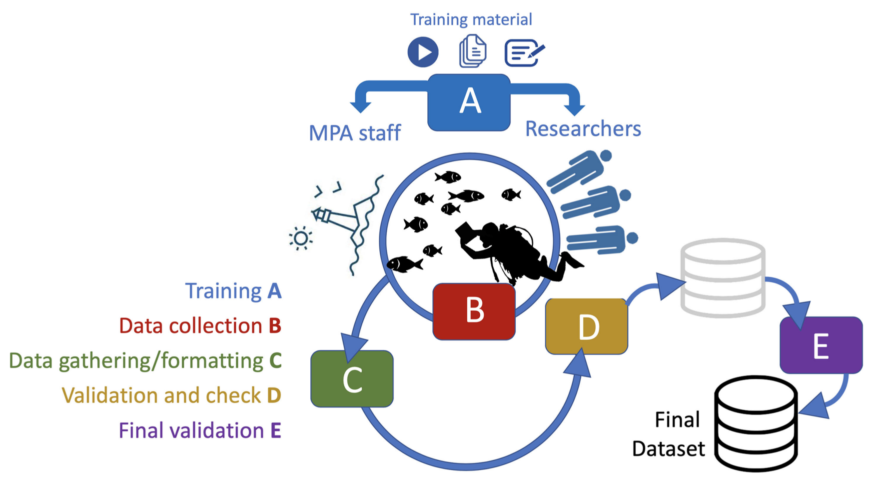

FIGURE 1 | ClimateFish workflow. Visual representation of the data curation, formatting, technical validation, and quality control process of the database: **(A)** Training sessions/materials were delivered to both MPA staff and collaborating researchers; **(B)** Data were collected by trained scientists and technicians, according to the protocol described in Garrabou et al. (2018) and checked before submission; **(D)** Formatted data were then examined for possible errors and underwent the technical validation process. The data providers were contacted in case of doubts or errors; **(C)** Data were gathered and formatted to meet Darwin Core archive standards (https://www.tdwg.org/standards/dwc/) and reports which did not meet inclusion criteria were removed (see Technical Validation section); **(E)** After the technical validation process, data were manually examined to detect any remaining error. The final database was published at the end of this repeated validation and quality check process and is freely accessible at: https://doi.org/10.17882/86784.

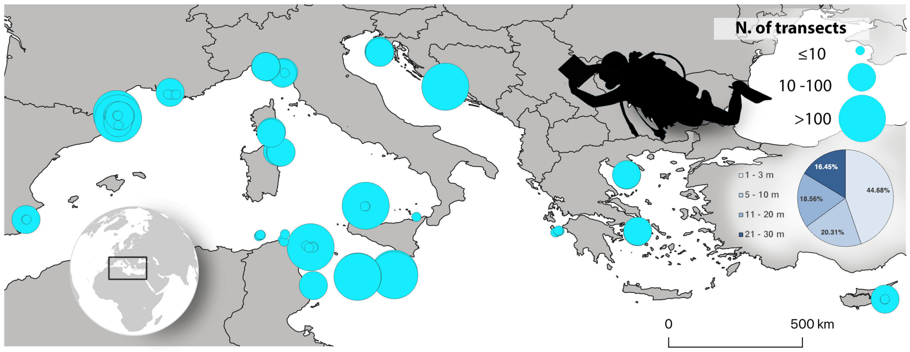

FIGURE 2 | ClimateFish study areas. The total number of transects carried out in each permanent location is illustrated by the size of the circles. The percentage distribution of the number of transects per depth is indicated.

the future implementation of the ClimateFish protocol in the eastern sector of the Mediterranean.

REFERENCE TO DIGITAL REPOSITORY OF THE DATABASE

The final database is available, under CC-BY license (v. 4.0), on the SEANOE data repository as a.csv file. https://doi.org/10.17882/86784.

USAGE NOTES

The ClimateFish database includes spatio-temporal information on the abundance of 15 coastal fishes, proposed as candidate indicators of climate change in the Mediterranean Sea. This information could be coupled with temperature data to better understand how the abundance and distribution of these species is linked to climate change. This would allow testing the effectiveness of selected taxa to track the variation of temperature and other geophysical, biotic and climate layers, which can be easily downloaded from public sources such as the open-access BIO-ORACLE database https://www.bio-oracle.org. Other potential applications of the ClimateFish data include setting a baseline against which to evaluate future changes. The resulting outputs could have several benefits for single MPAs, with possible integrations at the level of both IMAP (UNEP/MAP, 2006) and MSFD (MSFD; Directive 2008/56/EC) (EC 2008), since these initiatives do not specifically consider climate change impacts. Finally, ClimateFish should be considered as a living database, which will keep being updated in the future, also with the support of the T-Mednet platform https://t-mednet.org, which is devoted to track climate change effects in the Mediterranean Sea. T-Mednet is currently being implemented to return the information to users, in the form of simple and interactive data visualization and exploration. We also foresee possible integrations with data provided by trained recreational divers under the framework of existing citizen science initiatives. These data are currently not included in the 'ClimateFish' database but are presently stored on the online platform www.observadoresdelmar.es under the homonym project 'ClimateFish' that includes training materials and tools for data reporting. We believe that this beneficial partnership between research bodies and MPA managers, with the potential inclusion of the recreational diving industry, could increase our potential for integrated monitoring and conservation planning and contribute to set an effective strategy to monitor climate related impacts in the Mediterranean region.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found on online repositories. The names of the repository/repositories and accession number(s) can be found below: https://doi.org/10.17882/86784.

AUTHOR CONTRIBUTIONS

EA conceived the monitoring protocol and FP, JS, JG, PM, PJS participated in the design of it; AB, AF, AMil, AP, AR, BW, CD, EA, FP, GM, JB, JG, LM, MD, M-FC, MH, PM, PJS, and VC organized or coordinated filed work; AG, AI-M, AMil, BD, BW, CA, CD, CLP, DV, EA, EF, FC, FP, GD, GF, GS, IC, JB, JG, LF, LM, LS, MC, M-FC, MP, MS, NS, PM, PP, RG, RM, and TG carried out field work; EA and TB did data management and wrote the first version of the paper with the support of AMin, MD'A, and TF. All authors approved the submitted manuscript.

FUNDING

The Mediterranean ClimateFish initiative was initially conceived by the international basin wide monitoring program CIESM Tropical Signals (funded by the Albert II of Monaco Foundation) and subsequently supported by the Interreg Med Programme (Projects: MPA-ADAPT, grant number 1MED15_3.2_M2_337 and MPA Engage, grant number 5MED18_3.2_M23_007), 85% co funded by the European Regional Development Fund.

REFERENCES

Albano, P. G., Steger, J.., Bošnjak, M., Dunne, B., Guifarro, Z.., Turapova, E., et al. (2021). Native Biodiversity Collapse in the Eastern Mediterranean. *Proc. R. Soc B*, 288(1942)20202469. doi: 10.1098/rspb.2020.2469

Azzurro, E. (2008). The Advance of Thermophilic Fishes in the Mediterranean Sea: Overview and Methodological Questions. *In CIESM Workshop Monographs* (Vol. 35, pp. 39–45). *CIESM, Monaco*.

Azzurro, E., Sbragagli, V., Cerri, J., Bariche, M., Bolognini, L., Ben Souissi, J., et al. (2019). Climate Change, Biological Invasions, and the Shifting Distribution of Mediterranean Fishes: A Large-Scale Census Based on Local Ecological Knowledge. *Glob. Change Biol* 25(8), 2779–2792. doi: 10.1111/gcb.14670

Azzurro, E., Moschella, P., and Maynou, F. (2011). Tracking Signals of Change in Mediterranean Fish Diversity Based on Local Ecological Knowledge. *PLoS One* 6 (9), e24885. doi: 10.1371/journal.pone.0024885

Ben Rais Lasram, B., Guilhaumon, F., Albouy, C., Somot, S., Thuiller, W., and Mouillot, D. (2010). The Mediterranean Sea as a 'Cul De Sac' for Endemic Fishes Facing Climate Change. *Glob. Change Biol.* 16 (12), 3233–3245. doi: 10.1111/j.1365-2486.2010.02224.x

Bianchi, C. N., and Morri, C. (1993). Range Extension of Warmwater Species in the Northern Mediterranean: Evidence for Climatic Fluctuations? *Porcup. Newslett.* 5 (7), 156–159. doi: 10.21426/B6110129

Bianchi, C. N., and Morri, C. (2003). Global Sea Warming and "Tropicalization" of the Mediterranean Sea: Biogeographic and Ecological Aspects. *Biogeographia–The J. Integr. Biogeography* 24 (1).

Chaikin, S., Dubiner, S., and Belmaker, J. (2022). Cold-Water Species Deepen to Escape Warm Water Temperatures. *Global Ecol. Biogeography* 31 (1), 75–88. doi: 10.1111/geb.13414

D'Amen, M., and Azzurro, E. (2020). Lessepsian Fish Invasion in Mediterranean Marine Protected Areas: A Risk Assessment Under Climate Change Scenarios. *ICES J. Mar. Sci.* 77 (1), 388–397. doi: 10.1093/icesjms/fsz207

Garrabou, J., Bensoussan, N., and Azzurro, E. (2018). *Monitoring Climate-Related Responses in Mediterranean Marine Protected Areas and Beyond: Five Standard Protocols* (Barcelona, Spain:Institute of Marine Sciences, Spainsh Research Council ICM-CSIC, Passeig Marítim de la Barceloneta).

Garrabou, J., Ledoux, J. B., Bensoussan, N., Gómez-Gras, D., and Linares, C. (2021). "Sliding Toward the Collapse of Mediterranean Coastal Marine Rocky Ecosystems. in: Ecosystem Collapse and Climate Change," in *Ecological Studies (Analysis and Synthesis)*, vol. 241 . Eds. J. G. Canadell and R. B. Jackson (Springer, Cham). doi: 10.1007/978-3-030-71330-0_11

Golani, D., Azzurro, E., Dulčić, J., Massutí, E., and Orsi-Relini, L. (2021). *Atlas of Exotic Fishes in the Mediterranean Sea. 2nd Edition*. Ed. F. Briand (Paris, Monaco: CIESM Publishers), 365, ISBN: .

Jetz, W., McGeoch, M. A., Guralnick, R., Ferrier, S., Beck, J., Costello, M. J., et al. (2019). Essential Biodiversity Variables for Mapping and Monitoring Species Populations. *Nat. Ecol. Evol.* 3 (4), 539–551. doi: 10.1038/s41559-019-0826-1

Marras, S., Cucco, A., Antognarelli, F., Azzurro, E., Milazzo, M., Bariche, M., et al. (2015). Predicting Future Thermal Habitat Suitability of Competing Native and Invasive Fish Species: From Metabolic Scope to Oceanographic Modelling. *Conserv. Physiol.* 3 (1), cou059. doi: 10.1093/conphys/cou059

Milazzo, M., Quattrocchi, F., Azzurro, E., Palmeri, A., Chemello, R., Di, F., et al. (2016). Warming-related shifts in the distribution of two competing coastal wrasses. *Marine Environmental Research* 120, 55–67.

O'Regan, S. M., Archer, S. K., Friesen, S. K., and Hunter, K. L. (2021). A Global Assessment of Climate Change Adaptation in Marine Protected Areas Management Plans. *Front. Mar. Sci* 8. doi: 10.3389/fmars.2021.711085

Pastor, F., Valiente, J. A., and Khodayar, S. (2020). A Warming Mediterranean: 38 Years of Increasing Sea Surface Temperature. *Remote Sens.* 12 (17), 2687. doi: 10.3390/rs12172687

Perry, A. L., Low, P. J., Ellis, J. R., and Reynolds, J. D. (2005). Climate Change and Distribution Shifts in Marine Fishes. *Science* 308 (5730), 1912–1915. doi: 10.1126/science.1111322

Pisano, A., Marullo, S., Artale, V., Falcini, F., Yang, C., Leonelli, F. E., et al. (2020). New Evidence of Mediterranean Climate Change and Variability From Sea Surface Temperature Observations. *Remote Sens.* 12, 132. doi: 10.3390/rs12010132

Riera, F., Grau, A. M., Pastor, E., and Pou, S. (1995). "Faunistical and Demographical Observations in Balearic Ichthyofauna," in *La Méditerranée: Variabilités Climatiques, Environnement Et Biodiversité* (Montpellier, France: Actes Colloque scientifique OKEANOS Montpellier), 213–220.

Tiralongo, F., Crocetta, F., Riginella, E., Lillo, A. O., Tondo, E., Macali, A., et al. (2020). Snapshot of Rare, Exotic and Overlooked Fish Species in the Italian Seas: A Citizen Science Survey. *J. Sea Res.* 164, 101930. doi: 10.1016/j.seares.2020.101930

Vacchi, M., Morri, C., Modena, M., La Mesa, G., and Bianchi, C. N. (2001). Temperature Changes and Warm-Water Species in the Ligurian Sea: The Case of the Ornate Wrasse Thalassoma Pavo (Linnaeus 1758). *Archo. Oceanogr. Limnol.* 22, 149–154.

Ventura, D., Colloca, F., and Ardizzone, G. (2019). Settlement Evidence of the Mediterranean Parrotfish Sparisoma Cretense (Teleostei: Scaridae) in the Central Tyrrhenian Sea (Giglio Island, Italy). *BioInvasions Rec.* 8 (2), 413–418. doi: 10.3391/bir.2019.8.2.23

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.