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Length-frequency distributions of *Etrumeus golanii* sampled in Crete

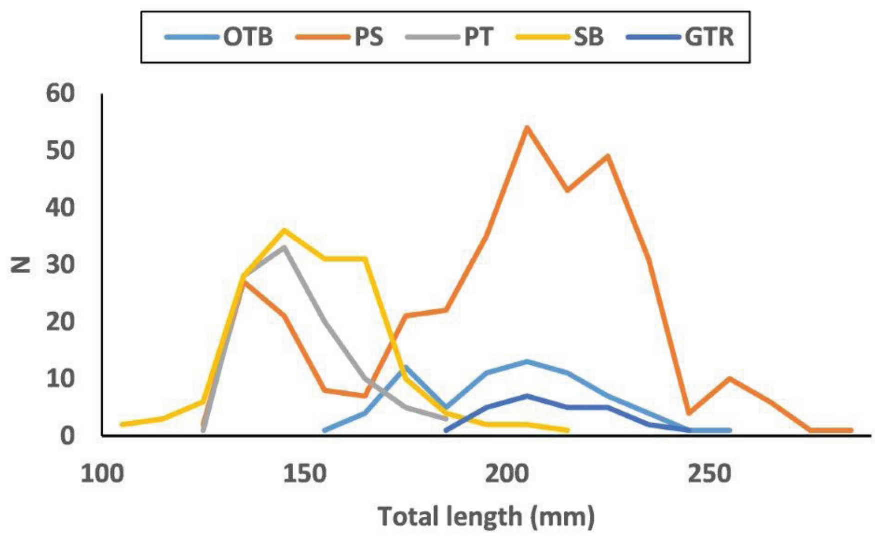

Fig. S1: Length frequency distributions of fish collected by the different gears. OTB: bottom trawl. PS: purse seine. PT: pelagic trawl. SB: beach seine. GTR: trammel net.

Macroscopic maturity stages

Table S1. *Etrumeus golanii*. Descriptions of macroscopic maturity stages adopted for *Etrumeus golanni*.

Macroscopic maturity stage	Females	Males
M1: Resting/virgin	Ovary pinkish/translucent; no opaque oocytes visible to naked eye; size ≤1/3 of body cavity.	Thin and whitish/pinkish testis; size ≤1/3 of body cavity.
M2: Recovering	Ovary pinkish-reddish/translucent; no opaque oocytes visible to naked eye; size 1/3 – 1/2 of body cavity.	Whitish/pinkish testis; size 1/3 – 1/2 of body cavity.
M3: Developing	Ovary yellowish and firm; visible opaque oocytes; size about 2/3 of body cavity.	Whitish to creamy testis; size about 2/3 of body cavity.
M4: Ripe	Ovary with hyaline appearance, reddish with high vascularization. Hyaline oocytes visible; size: 2/3 to full length of body cavity.	Whitish-creamy and soft testis; size: 2/3 to full length of body cavity.
M5: Spent	Flaccid ovary and with blood; small size (about 1/2); remnants of opaque oocytes still visible.	Bloodshot and flabby testis; small size (about 1/2).

Simulation of the hydrodynamic-biogeochemical model

In order to obtain more insights into the annual cycle of mesozooplankton in the study area (main food of small pelagic fish) and its relation to the spawning period and the monthly changes in fecundity and somatic condition of Golani's herring, a basin-scale Mediterranean coupled hydrodynamic-biogeochemical model, building on the currently operational model within the POSEIDON forecasting system (www.poseidon.hcmr.gr; Korres *et al.*, 2007; Kalaroni *et al.*, 2020a, b), has been setup and implemented over the 2016-2019 period, forced by the POSEIDON operational atmospheric model output (Papadopoulos *et al.*, 2008).

The POSEIDON hydrodynamic model is based on the Princeton Ocean Model (POM, Blumberg & Mellor, 1983), which is a three-dimensional, sigma-coordinate, free surface and primitive equation model. The vertical eddy viscosity/diffusivity coefficients are computed us-

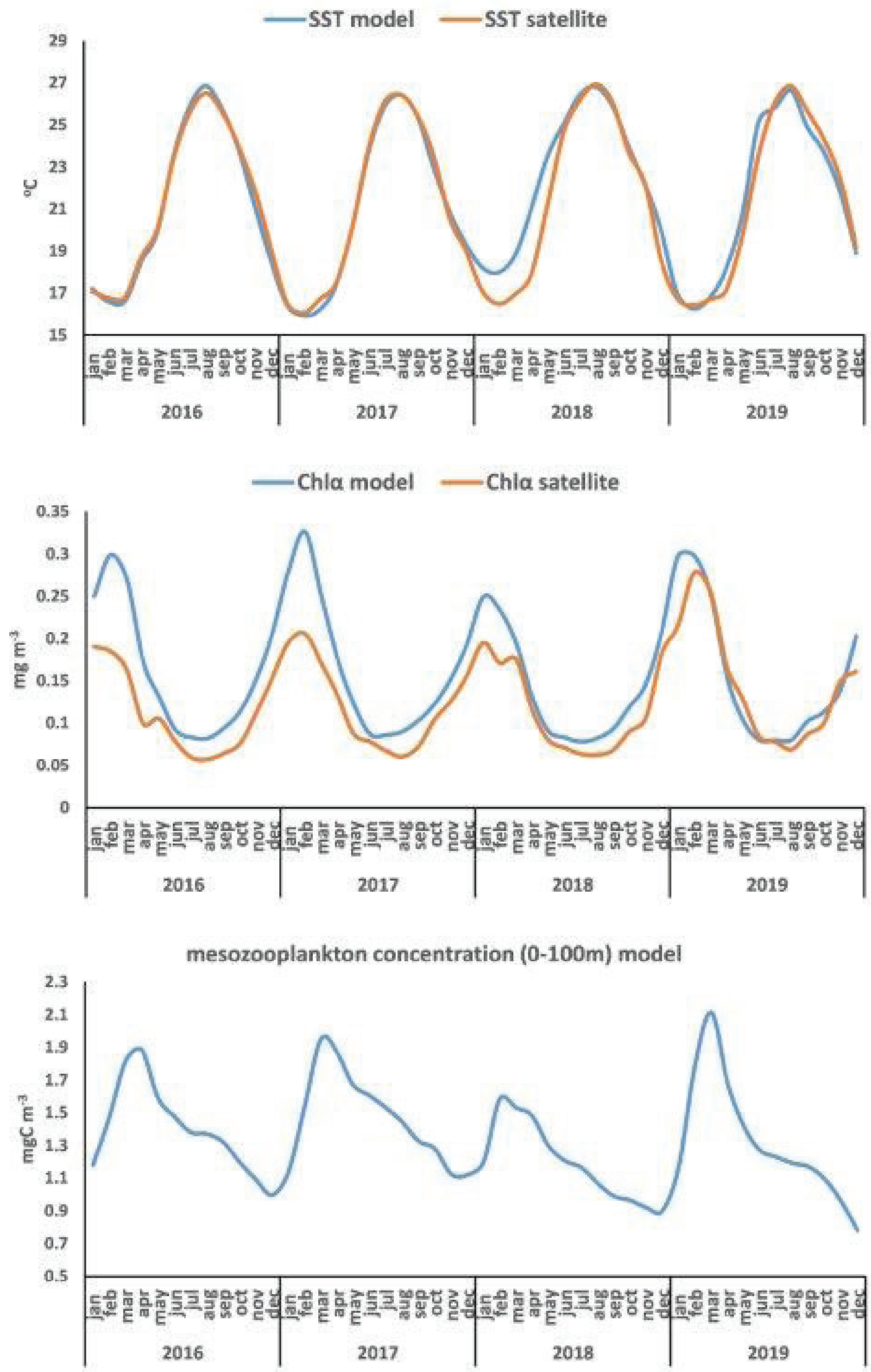

Fig. S2: Time series (2016-2019) of monthly mean SST and Chl-α (satellite and model-simulated). The lower panel shows the model simulated mesozooplankton concentration.

ing the Mellor-Yamada 2.5 turbulence closure scheme (Mellor & Yamada, 1982). In the vertical, 24 sigma-layers are resolved.

The biogeochemical model is based on the European Regional Seas Ecosystem Model (ERSEM, Baretta *et al.*, 1995) that follows a "functional" group approach in which the ecosystem is described in terms of functional roles (producers, consumers, decomposers). The pelagic plankton food web is described with four phytoplankton groups (diatoms, nanoplankton, picoplankton, dinoflagellates), three zooplankton groups (heterotrophic nanoflagellates, microzooplankton, mesozooplankton) and bacteria. Additionally, the pelagic model variables include particulate and dissolved organic matter, along with dissolved inorganic nutrients (nitrate, ammonium, phosphate, silicate). Carbon dynamics are loosely coupled to the chemical dynamics of nitrogen, phosphate and silicate through a variable organic matter C:N:P:Si ratio scheme.

Recently, it has been shown that, despite some deviations (e.g. more intense model-simulated winter vertical mixing in the eastern Mediterranean resulting in overestimated nutrients and the Chl-α bloom), this generic ecosystem model present a reasonable skill in reproducing the spatial gradient and the seasonal variability of the main biogeochemical and plankton features of the Mediterranean ecosystem, influenced by the seasonal variability of the thermocline and vertical mixing in the water column (Kalaroni *et al.*, 2020a, b).

In this study, the model was implemented with 1/20^o (5 Km) horizontal resolution and its outputs were averaged on a monthly basis for the period January 2016 - December 2019 (period of fish sampling) over an area surrounding the island of Crete (a rectangle defined by the coordinates 35.66667° N, 23.50000° E and 34.83333° N, 26.50000° E). Furthermore, monthly standard mapped image (SMI) products for MODISA SST and Chl-α were downloaded from NASA's Level-3 data viewer (NASA-GSFC-OBPG, 2014) and the satellite data were compared with model SST and Chl-α outputs for the same period and area in order to assess the model skill in reproducing the seasonal variability.

The times series of SST, near-surface Chl-α and simulated mesozooplankton concentration are shown in Fig. S2. Despite the aforementioned overestimation of Chl-α (especially its winter bloom) the generic POSEIDON model reproduced well the seasonal variability in SST and Chl-α. The Chl-α bloom was generally centered in February/March and, according to the simulation, it is followed by a mesozooplankton maximum, with approximately one month time lag. This is in agreement with available time series of *in situ* data in the Mediterranean showing that the seasonal mesozooplankton and copepod peak succeeds the Chl-α maximum with a lag of approximately 1 - 2 month (Berline *et al.*, 2012; Fullgrabe *et al.*, 2020).

References

Baretta, J.W., Ebenhoh, W., Ruardij, P., 1995. The European regional seas ecosystem model, a complex marine ecosystem model. *Netherlands Journal of Sea Research*, 33 (3-4), 233-246.

Berline, L., Siokou-Frangou, I., Marasovic, I., Vidjak, O., Fernandez de Puelles, M., *et al.*, 2012. Intercomparison of six Mediterranean zooplankton time series. *Progress in Oceanography*, 97-100, 76-91.

Blumberg, A.F., Mellor, G.L., 1983. Diagnostic and prognostic numerical circulation studies of the South Atlantic Bight. *Journal of Geophysical Research*, 88 (C8), 4579-4592.

Fullgrabe, L., Grosjean, P., Gobert, S., Lejeune, P., Leduc, M., *et al.*, 2020. Zooplankton dynamics in a changing environment: A 13-year survey in the northwestern Mediterranean Sea. *Marine Environmental Research*, 159, 104962.

Kalaroni, S., Tsiaras, K., Petihakis, G., Economou-Amilli, A., Triantafyllou, G., 2020(a). Modelling the Mediterranean pelagic ecosystem using the POSEIDON ecological model. Part I: Nutrients and chlorophyll-a dynamics. *Deep Sea Research Part II: Topical Studies in Oceanography*, 171, 104647.

Kalaroni, S., Tsiaras, K., Petihakis, G., Economou-Amilli, A., Triantafyllou, G., 2020(b). Modelling the Mediterranean pelagic ecosystem using the POSEIDON ecological model. Part II: Biological dynamics. *Deep Sea Research Part II: Topical Studies in Oceanography*, 171, 104711.

Korres, G., Hoteit, I., Triantafyllou, G., 2007. Data assimilation into a Princeton Ocean Model of the Mediterranean Sea using advanced Kalman filters. *Journal of Marine Systems*, 65 (1-4), 84-104.

Mellor, G.L., Yamada, T., 1982. Development of a turbulence closure model for geophysical fluid problems. *Reviews of Geophysics*, 20 (4), 851.

NASA Goddard Space Flight Center, Ocean Biology Processing Group; (2014): Moderate Resolution Imaging Spectroradiometer Aqua (MODISA) Ocean Color Data, NASA OB.DAAC, Greenbelt, MD, USA. https://oceancolor.gsfc.nasa.gov/ Accessed 2020/11/28. Maintained by NASA Ocean Biology Distributed Active Archive Center (OB.DAAC), Goddard Space Flight Center, Greenbelt MD.

Papadopoulos, A., Katsafados, P., Mavromatidis, E., Kallos, G., 2008. Assessing the skill of the POSEIDON-II weather forecasting system. *Abstracts book of the EuroGOOS 2008 conference*.