STOCA: THE MONITORING PROGRAM IN THE GULF OF CÁDIZ. PHYTOPLANKTON POPULATIONS AND DISTRIBUTION

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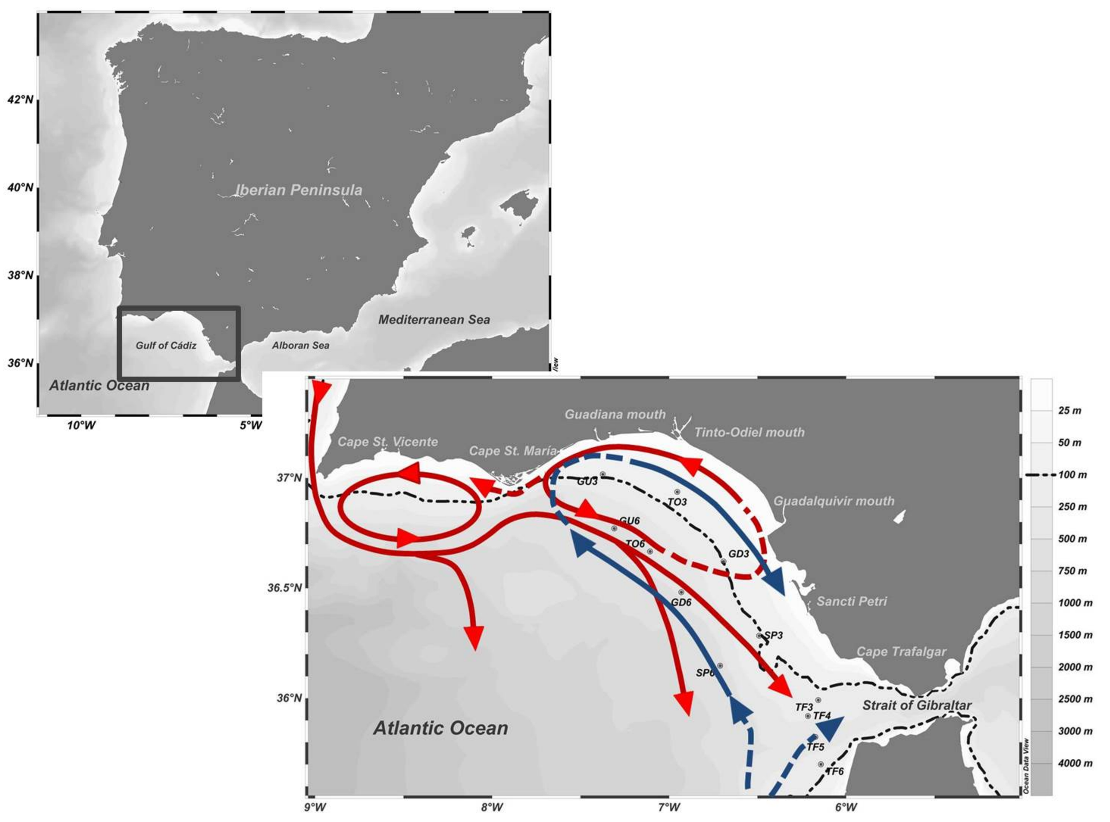

Figure 1. Map of Gulf of Cadiz showing the main circulation pattern (in red surface circulation, in blue the depth one) and the stations samples during STOCA cruises

INTRODUCTION

To understand the functioning of the seas, it is necessary to have enough data of a very diverse type (physical, chemical, biological, atmospheric) and with an appropriate temporal and spatial resolution. Marine dynamics affects the distribution of the different physico-chemical-biological variables that determine the trophic characteristics of a particular area. Since 1992, the Spanish Institute of Oceanography (IEO) has funded marine observation projects (López-Jurado, et al., 205; Tel et al., 2016), which pretend to be able to describe in the best possible way the average characteristics of the different areas sampled in addition to trying to detect trends and changes.

The specific monitoring program in the Gulf of Cadiz (Southwest of the Iberian Peninsula), is called STOCA (Oceanographic Time Series of the Gulf of Cadiz) and was initiated in 2009, with a quarterly periodicity (Sánchez-Leal, 2018). During the STOCA cruises, 5 transects are monitored in which CTD-LADCP data and water samples are taken for different chemical and biological variables (Fig.1). Until 2014 the sampling of the different phytoplankton fractions (micro, pico and nanophytoplankton) was not routinely included. In this work, all available phytoplankton information from STOCA, from 2014 to March 2020 is analyzed, (a total of 25 cruises), showing the different products that can be obtained from a monitoring program like STOCA. The phytoplankton communities are determined both by microscopy and flow cytometry depending on the cell size. This is the longest time series of data of the different phytoplankton populations in the area, which allows the description of both spatial and temporal phytoplankton communities, as well as their relationship with oceanographic variables.

Materials and methods

For the analysis of the phytoplankton communities, samples are obtained using two different metodologies. In the case of pico- and nanophytoplankton samples are taken from platform and slope stations (numbers 3 and 6 respectively in figure 1) and are fixed on board with glutaraldehid and preserved at -80ª until its analysis in laboratory by flow citometry (Gasol et al, 1999). Four main groups are detected: Prochlorococcus, Synecochoccus, picoplankton and nanoplankton. For the anlysis of the biggest fraction, the microplankton samples are only taken at stations 3,platform, preserved with lugol-iodine solution and analyzed by inverted microscope using Uthermohl tecnnique (Uterrmohl,1958). The study by microscope include the taxonomic determination of the communities present in the sample trying to reach the level of species,. When it's not possible, individuals are clasified by the genera.

Once the samples are analyzed the results are grouped in: diatoms, dinoflagellata and small flagelata.

In all cases, both micro- and pico- and nanophytoplankton, mean seasonal values are calculated.

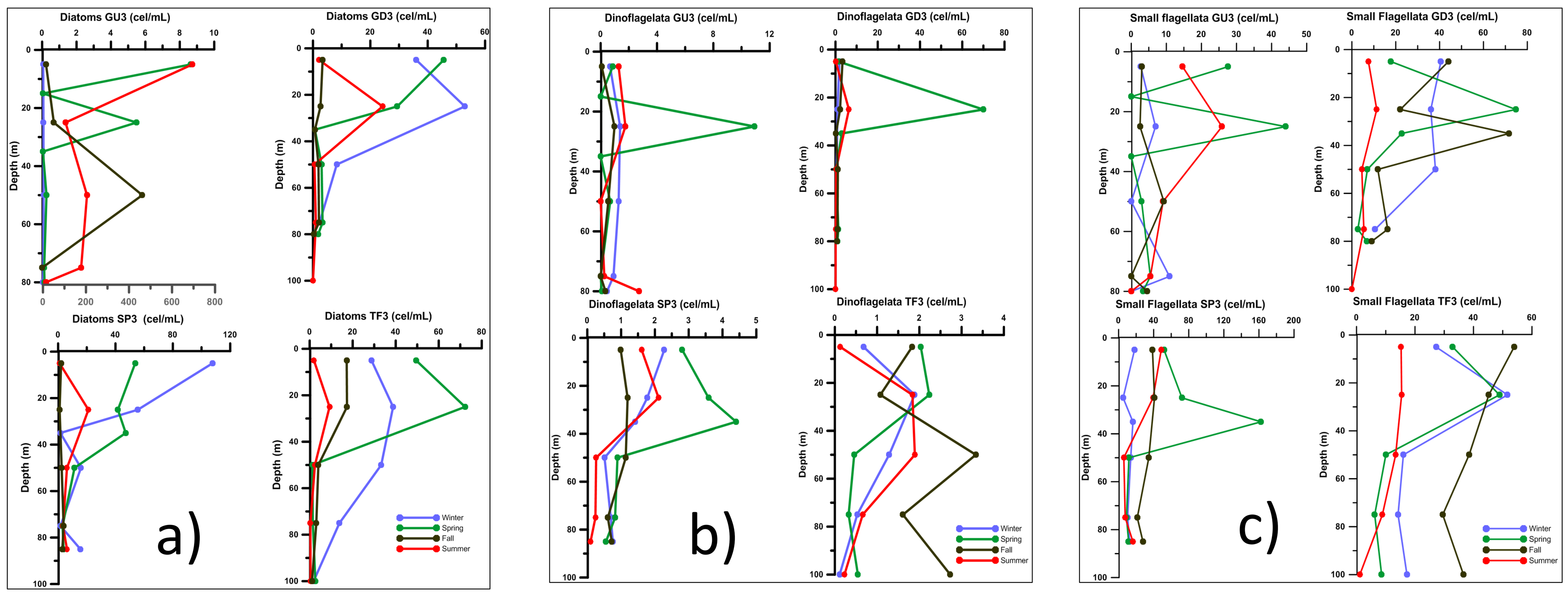

Figure 2. Mean concentration (cel/mL): a) Diatoms, b) Dinoflagelata and c) Small flagelata, for winter (blue), spring (green), fall (brown) and summer (red) at: Guadiana(GU3) , Guadalquivir (GD3), Sancti Petri (SP3) and Trafalgar (TF3) platform stations. Notice that in a) the upper axis is for summer and fall, the lower one for winter and summer),

Table 1. Average abundance expressed in cells per mililitre (cel/mL) along the water column for the station GD3 for the *Prochlorococcus* bacteria. For each season and depth level five columns are presented: seasonal mean value, standard deviation, number of data used and minimum and maximum values recorded along the complete time series

GD3 station. *Prochlorococcus (cel/mL)*																				
	Winter					Spring					Summer					Fall				
Depth	Mean	s	n	Min.	Max.	Mean	s	n	Min.	Max.	Mean	s	n	Min.	Max.	Mean	s	n	Min.	Max.
5	2364	1108	3	1282	3887	7037	10767	5	0	27797	22691	23295	4	1410	58177	31675	26665	6	1838	77878
25	1879	873	3	804	2942	18091	22637	5	0	52559	4809	3970	4	2016	11642	40679	47680	6	3531	139617
50	587	369	3	70	902	7004	9805	5	0	25020	1409	971	4	0	2711	16816	16900	6	812	43934
75	446	267	3	69	659	735	1273	4	0	2940	334	345	4	0	794	12248	18007	6	482	51837
80						2249	2249	2	0	4497										
GD6 station. *Prochlorococcus (cel/mL)*																				
5	2476	95	2	2381	2571	3452	2004	3	863	5746	15724	6226	3	9354	24173	39152	20584	5	952	60011
25	4676	2603	2	2073	7280	3737	2481	3	256	5857	14467	9363	3	3644	26484	49484	32420	5	1756	95549
50	3058	1831	2	1227	4889	5532	1790	3	3742	7977	51412	47791	3	958	115584	33163	33841	5	6159	99961
75	1837	1418	2	418	3255	20402	13582	3	8908	39477	21876	26191	3	343	58741	13822	16272	5	2243	45551
100	1353	1353	2	0	2706	2250		1			316	261	2	55	576	19134	32043	4	0	74629
125						2768	2723	2	45	5491										
200	339	339	2	0	677	0		1			51	42	2	9	93	4205	6843	4	100	16054
300	46	38	2	8	84	1902	2676	3	0	5686	110	95	2	15	205	13074	25826	5	15	64724
400	65		1			1016	1016	2	0	2033	185		1			6782	10781	4	156	25450
450	125	69	2	56	195	201	162	2	38	363	381	122	2	259	503	132	132	2	0	264

RESULTS.

The main benefit of a monitoring program like STOCA is the determination of mean parameters that allow the description of the at least the seasonal values of certain variables. In the case of biological ones, the time series should be long enough in order to describe the natural variability of these parameters. Once the general picture is stablished, the natural status of a certain area, in this case the Gulf of Cadiz, can be described.

In this work some products obtained from the analysis of 25 STOCA cruises are shown as follows.

Figure 2 shows the seasonal mean concentration at different depths of the groups of microphytoplanton at Guadiana (GU3), Guadalquivir (GD3), Sancti Petri (SP3) and Trafalgar (TF3)platform stations, showing the differences found depending on the transect analyzed.

Table 1 is a very good example of how the information collected can be presented. The table shows the seasonal concentration of Prochlorococcus (Cel/mL) at at different depths, including the mean value, with its standard deviation, the number of data used for the calculations and the minimum and maxima concentration obtained in all the cruises. This type of table is very useful for the description of climatological values and to set the good environmental status of the area. Any deviation from these values should be studied in order to determine if it is due to natural variability or if it is the consequence of induced changes

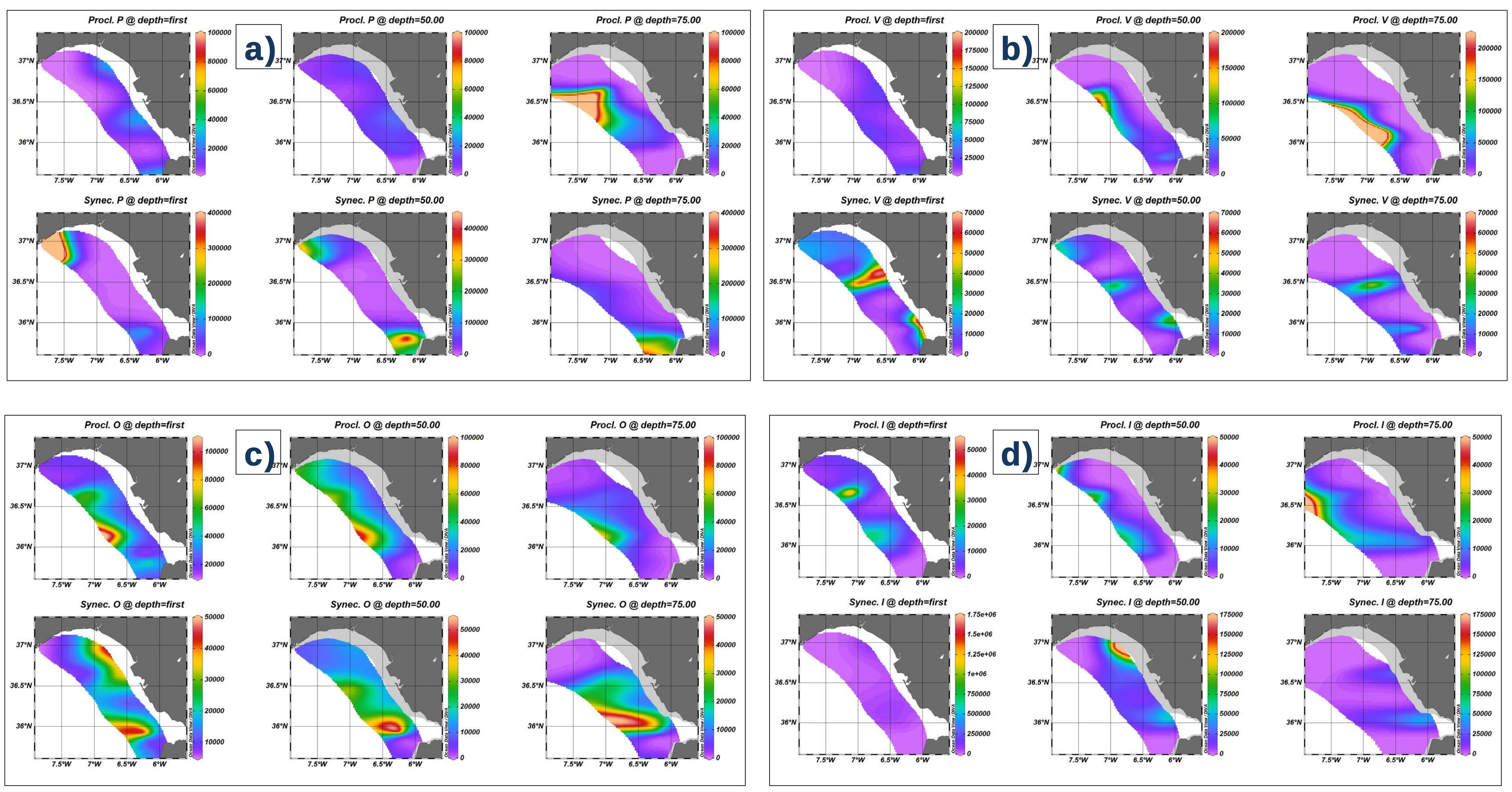

Figure 3. In this figure the spatial distribution of the seasonal mean abundance of the photoautotroph bacteria Prochlorococcus and Synecoccocus at different depths (surface, 50m and 75m) are presented showing the differences in the distribution patterns of these two groups

Figure 2. Seasonal spatial distribution of mean *synechococcus* and *prochlorococcus* bacteria at different depths: surface, 50m and 75 m. a) Spring b) Summer, c) Autumn and d) Winter. Data of all the stations sampled are included, both platform (stations 3) and slope (stations 6) for the complete period.

References.

Gasol,J.M.1999. Gasol, J.M. How to Count Picoalgae and Bacteria with the FACScslibur Flow Cytometer. http://www.cmima.csic.es/pub/gasol/Manuals/FACS/Citometry.html

López-Jurado, et al., 2015 The RADMED monitoring programme as a tool for MSFD implementation: towards an ecosystem-based approach. https://doi.org/10.5194/os-11-897-2015

Sánchez-Leal, 2018 STOCA: El Sistema de Observación del Océano del Golfo de Cádiz. IX Symposium sobre el Margen Ibérico Atlántico. COIMBRA (PORTUGAL)

Tel et al., 2016. IEOOS: the Spanish Institute of Oceanography Observing System. Ocean Science. 12, pp. 345-353.

Utermöhl, H. Zur Vervollkommung der quantitativen Phytoplankton-Methodik. [On the perfection of quantitative phytoplankton methods]. Int. Ver. Angew. Limnol. Mitt. [Commun. Int. Assoc. Appl. Limnol.] 1958, 9, 1–38

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