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Seasonal changes in coastal fish assemblages by multiparametric video-observatory monitoring

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***Abstract* – Multiparametric cable video-observatories can offer a great opportunity for the simultaneous monitoring of biotic and abiotic components of an ecosystem, responding to the monitoring strategic needs of the EU Marine Strategy Framework Directive (MSFD). Here, we used images and oceanographic/atmospheric data provided by North-western Mediterranean OBSEA cabled observatory as EMSO shallow water (i.e. 20 m depth) testing-site to highlight seasonal variations in coastal fish assemblages and identify the key environmental drivers. Significant variation was observed in fish composition across the seasons of 2014 in response to wind direction, sun azimuth, air temperature, and chlorophyll *a* (i.e. recorded *in situ* and by satellite one month before the real observation). Our results highlight the importance and power of multiparametric biological and environmental monitoring on the benthopelagic coupling to rule temporal changes in coastal fish communities.**

I. INTRODUCTION

Fishes have been used as indicators of environmental changes, in short and large temporal and spatial scale, due to their capacity of being very mobile and able to search better conditions [1, 2]. Therefore, long-term monitoring of fish communities is receiving increasing attention to assess anthropogenic impacts on marine ecosystems such as pollution [3], marine bioinvasion [4] or temperature increase [5], among others. However, consistent difficulties in sampling is biasing our understanding of species composition and abundance changes at seasonal level. Traditional methods (e.g. trawling or other fishing gears, visual census, or AUVs and ROVs), present different frequency shortcomings. For example, trawling is highly destructive for habitats, but also for accessory by-catch, benthic communities and the seabed [6]. Secondly, the quantity and frequency of collected oceanographic data is often insufficient to describe how species behavioural reaction affects animal presence into our sampling areas, in turn constraining our perception of local biodiversity [7]. Fish behaviour should be tracked with non-invasive and long-term monitoring tools at high time frequency (i.e. minutes to hours), in order to link the variability in perceived fish assemblage with concomitant environmental changes [8]. The recent development of multiparametric cabled video observatory technology is allowing the long-term monitoring of fish communities with the great advantage in eliminating the inevitable disturbance of sampling activity [9, 8], being capable of record and transmit data in real-time through fibre optic cabled connected to shore [10].

Within this context, we used image data provided by the North-western Mediterranean coastal-cabled video-observatory OBSEA of the EMSO network (European Multidisciplinary Seafloor and water-column Observatory, http://www.emso-eu.org/), to analyse seasonal variations in a coastal (20 m depth) fish assemblage. Fish counts recorded continuously every 30 min for the year 2014) were integrated with oceanographic and meteorological data acquired simultaneously. Thus, our main aims are *i.* to identify seasonal patterns in fish assemblage structure and *ii.* to determine which environmental factors are mostly responsible of such changes.

II. MATERIALS AND METHODS

A. Experimental setting

The Western Mediterranean Expandable SEAfloor OBservatory (OBSEA; www.obsea.es) is a cabled video platform located at 20 m depth within the Colls i Miralpeix Natural Interest Region, 4 km off Vilanova i la

Geltrú (Catalonia, Spain) (Fig. 1) [8]. Images were recorded automatically at 30 min frequency during continuously the 24-h, throughout 12 months (from the 1st of January to the 31st of December) of 2014. Detailed methodology was presented in [11].

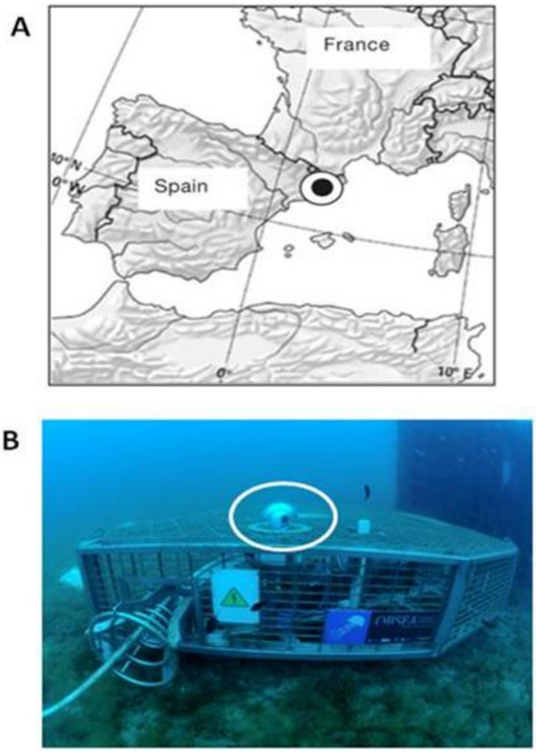

Fig. 1. Map of the location of OBSEA and a picture of the structure with focus (white circle) on the videocamera.

B. Environmental parameters recordings

Several environmental parameters have been monitored: *i.* oceanographic measures by CTD; *ii.* Chlorophyll-*a* plus turbidity levels by a fluorimeter and a turbidimeter, respectively; *iii.* atmospheric records (temperature, irradiation, quantity of rain, wind speed, sun elevation, azimuth and the photophase duration) by the meteorological central placed nearby. Additionally, satellite data on Chlorophyll-*a* concentration recorded from three to one month before and simultaneously to actual data and Sea Surface Temperature (SST) were also downloaded from http://giovanni.gsfc.nasa.gov/giovanni/.

C. Data analysis

A preliminary check for differences between day vs. night assemblages was carried out by ANOSIM analysis and as the day assemblages resulted significantly different from night assemblages, with greater abundance and diversity, the analyses were focused on daylight assemblage. The original matrix was first averaged to periods of five days each, in order to reduce the number of zeros in the matrix and to minimize the presence of very rare fishes. Bray-Curtis similarity indices were calculated on log-transformed species abundance data to define relationships of the faunal composition across months [12]. On this multivariate matrix, a PERMANOVA (Permutational Multivariate Analysis of Variance, [13]) was performed. Then, DIVERSE and SIMPER analyses were carried out on factor month in order to highlight species richness for each month and the most typifying species, respectively. Finally, a PCO was carried out to visualize the separation among months.

In order to identify which environmental variables drive monthly changes, a DISTLM model [14] was run on abiotic data. Before the analysis a Draftsman plot was run and only those variables which were not not auto-correlated (Pearson's correlation, r< 0.70) were retained for the analysis. All statistical analyses were carried out with PRIMER6&PERMANOVA+ [12, 13].

III. RESULTS

D. Changes in community composition and environmental control

Overall, the fish daylight assemblage significantly differed among months (*pseudo*-$F_{11,70}$=9.92, p<0.001 and Table 1 for pairwise comparisons).

Table 1. PERMANOVA pairwise comparisons.

Groups	t	Groups	t
Jan-Feb	1.54*	Jul-Aug	2.12**
Feb-March	2.18**	Aug-Sep	1.58^{ns}
Mar-Apr	0.94^{ns}	Sep-Oct	1.70^{ns}
Apr-May	2.30**	Oct-Nov	2.35**
May-Jun	2.01*	Nov-Dec	2.33**
Jun-Jul	2.09**	Dec-Jan	2.65**

ns=not significant; *=p<0.05; **=p<0.01

July was the month which showed the highest diversity in terms of species richness (S= 20) and *H'* index (*H'*=2.1), while from January to April richness varied aorund 14-15. According to SIMPER analyses (Table 2), few fishes typified each month assemblage with *Oblada melanura*, *Diplodus vulgaris*, *D. sargus*, *Spicara maena*, *Scorpaena* sp., *Spicara maena* and *Coris julis* being the dominant throughout the year. *O. melanura* was the most typifying species in winter months, The apogonid *Apogon imberbis* was dominant only in November fish assemblage.

Consistently, PCO results showed the separation of species according to months, with *Scorpaena* sp. mostly linked to January and February and *D. vulgaris* to late summer-early autumn months (Fig. 2).

Table 2. Typifying species for each month with relative abundance (Av. Ab.) and cumulative contribution (Cum%) to the similarity according to SIMPER results the Average similarity 8Av. Sim.)for each month is also reported..

Jan	Av. sim.: 60.67		July	Av. sim.: 61.87	
Species	Av.Ab.	Cum.%	Species	Av.Ab.	Cum.%
Omel	0.7	40.55	*Dvul*	0.97	25.92
Scorp	0.34	61.11	*Cjul*	0.47	42.31
			Cchr	0.45	53.8
			Dsar	0.36	64.97
Feb	Av. sim.: 72.36		August	Av. sim.: 74.85	
Scorp.	0.87	36.76	*Dvul*	1.5	38.7
Omel	0.77	70.78	*Dsar*	0.79	54.71
			Cchr	0.49	65.27
March	Av. sim.: 62.86		Sep	Av. sim.: 67.81	
Dvul	1.25	39.02	*Dvul*	2.04	44.57
Omel	1	63.64	*Dsar*	0.84	63.96
April	Av. sim.: 74.42		Oct	Av. sim.: 78.41	
Omel	1	33.53	*Dvul*	2.76	49.44
Dvul	1.06	62.8	*Dsar*	0.77	60.79
May	Av. sim.: 73.98		Nov	Av. sim.: 54.71	
Dvul	1.72	46.11	*Dvul*	1.05	23.58
Omel	0.52	58.75	*Omel*	0.67	38.5
Cjul	0.38	68.7	*Aimb*	0.42	52.38
			Smae	0.69	65.09
June	[illegible]8.77		Dec	Av. sim.: 49.77	
Dvul	1.17	26.15	*Smae*	1.23	29.97
Smae	1.27	48.46	*Cchr*	0.91	58.75
Cchr	0.76	64.78	*Omel*	1.39	80.06

Species legend: Aimb= Apogono imberbis; Cjul= Coris julis; Cchr= Chromis chromis; Dvul=Diplodus vulgaris; Dsar= D. sargus; Omel=Oblada melanura; Scorp= Scorpaena sp.; *Smae=Spicara maena.*

Month legend: Jan=January; Feb=February; Sep=September; Oct=October; Nov=November; Dec= December

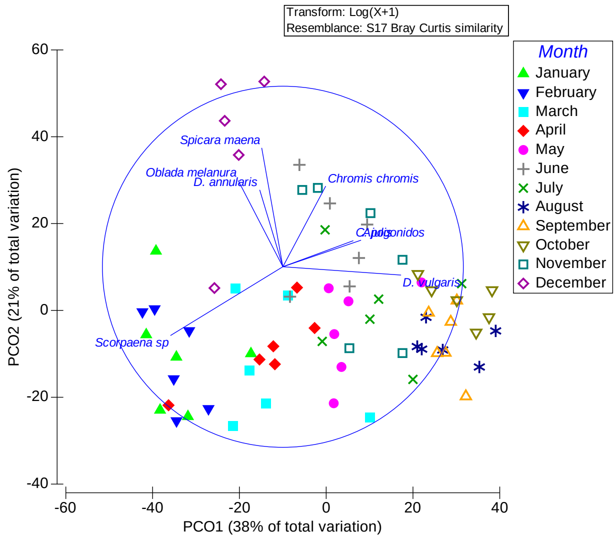

Fig. 2. PCO by month of the fish assemblage in 2014, with overlaid vectors of most typifying fishes according to SIMPER analysis.

Finally, the DISTLM highlighted six variables (Chlorophyll-*a* recorded one month before the real observation - Chla_1mo; air temperature - airT; azimuth; solar irradiance; chlorophyll *a* recorded by the OBSEA sensor - Chla-ob and wind direction - wind dir), as the main drivers of fish assemblage structure throughout the year (Table 3). Overall those six variables explained 42% of the total variance.

Table 3. Results of DISTLM model.

Variable	R^2	Pseudo-F
Chla_1mo	0.24	21.67***
air T	0.32	7.81***
azimuth	0.35	3.25**
solar irradiance	0.38	2.79*
Chla ob	0.4	2.57*
wind dir	0.42	2.20*

IV. DISCUSSION

An important goal of underwater faunistic surveys is to know which species could be present in long-term and continuous video-observations [15]. Here, we highlighted dominant species, their pattern pf seasonal variation and key controlling environmental drivers. The environmental drivers here found to structure changes in fish communities were surprisingly more related to variation in the atmosphere than in the water column (i.e. wind direction, azimuth, air temperature). As far as concerns the wind forcing, it causes by interplaying with temperature, water stratification, which influence the depth of the thermocline and in turn the composition of fish assemblages. Finally, the link between surface production and fish production has been widely demonstrated [16], but reasonably changes in fish assemblages were delayed (one month in our case) with respect to variation in primary production at surface [17]. Our data and ecological monitoring protocols are essential for the sampling strategies within the framework of the MSFD (EU 46/2008). The simultaneous recording of environmental variables offered by cabled observatories such as the OBSEA, fully fit within the Ecosystem-based management approach for marine biological resources proposed by the MSFD.

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