Distribution of *Parapenaeus longirostris* (Lucas, 1846) populations along the Spanish Mediterranean coast: A collapse and rebuilding episode.

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ABSTRACT: The deep-water rose shrimp, *Parapenaeus longirostris*, is a demersal species found in the Mediterranean and Atlantic Seas. The study area comprises three Spanish CGPM-FAO Geographic Sub-Areas (GSA's): Alboran Sea (GSA 1), the Balearic Islands (GSA 5) and Northern Spain (GSA 6). Data from annual commercial landings and MEDITS_ES surveys biomass index per haul (kg/km2) were analyzed for the 1994–2016 period. Mapping the spatial distribution of biomass makes evident its occurrence in all the areas, particularly in GSA 1 and also in the South of GSA 6. Depth distribution shows that presence ranged from 55 to 741 m, being mainly located between 200 to 300 m depth. Biomass index average shows large yearly oscillations, particularly in GSA 1 decreasing beyond 2009. In contrast biomass indices in GSA 6 (South and North) and in GSA 5 increased steeply and synchronously from 2006 onwards, rebuilding the populations to similar levels of a previously observed maximum.

INTRODUCTION: The deep-water rose shrimp *Parapenaeus longirostris* (Lucas, 1846) is a demersal species found on sandy and muddy bottoms in the Mediterranean Sea and South Atlantic Ocean, where is more abundant at depths of between 150 to 400 m**.**. In the Mediterranean is one of the trawl target species with average landings around 15,000 t/year. In the Spanish Mediterranean, it is considered a by-catch species of the trawl fishery, except in years of high abundance when it becomes a target species of the trawl fleet. The species show high inter-annual fluctuations in landings.

MATERIALS AND METHODS: The study area comprises three Spanish CGPM-FAO Geographic Sub-Areas (GSA's): Alboran Sea (GSA 1), the Balearic Islands (GSA 5) and Northern Spain (GSA 6); the last one was split into two equivalent areas, South and North. (Fig. 1). Data from annual commercial landings by port and MEDITS_ES international spring surveys, performed according to a standard methodology [1], were collected. Landings (t) and biomass index per haul (kg/km^2) were analyzed for the 1994–2016 period.

RESULTS AND DISCUSSION: I. Considering the whole area, total annual landings ranges from 17.8 t in 1994 to 643 t in 2016, but the contribution of each individual zone differs. Landings in GSA 1 are greater than in GSA 6 , and much greater than in GSA 5. Total annual landings follow an increasing trend since 1994 to 2000, and boosted from 97.1 t in 1998 to 568.4 t in 2000. From 2000 to 2006, the total annual landings wane to 66.0 t, what led to consider that the resource was almost depleted in GSA 6 [2]. Since then, annual landing value increases continuously to its maximum in GSA 6, whereas stayed low and constant in GSA 5, and waxed and waned over time in GSA 1 (Fig. 2).
In MEDITS data, a total of 3,268 hauls were registered, with *P. longirostris* being present in 773 (23.6%) of them. Positive hauls were used to calculate biomass index per haul, with values ranging from 0.01 to 57.3 kg/km^2 and an average of 3.9 kg/km^2.

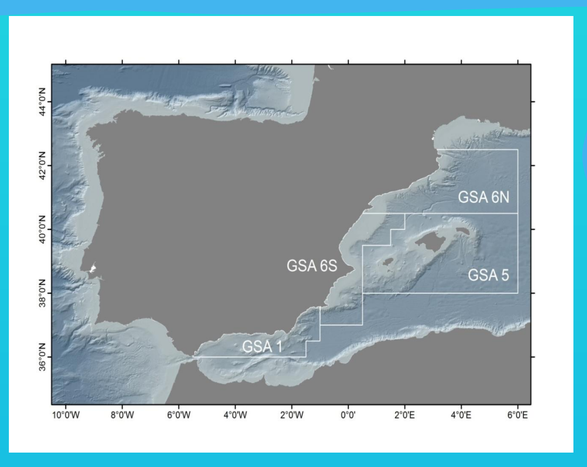

Figure 1.- Location of the three different Geographic Sub-Areas (GSA) present in the Spanish Mediterranean studied area.

Species biomass per haul was calculated as the catch in weight by sweep area and expressed in kg/km^2. G.I.S. was used to represent the triennial biomass distribution maps.

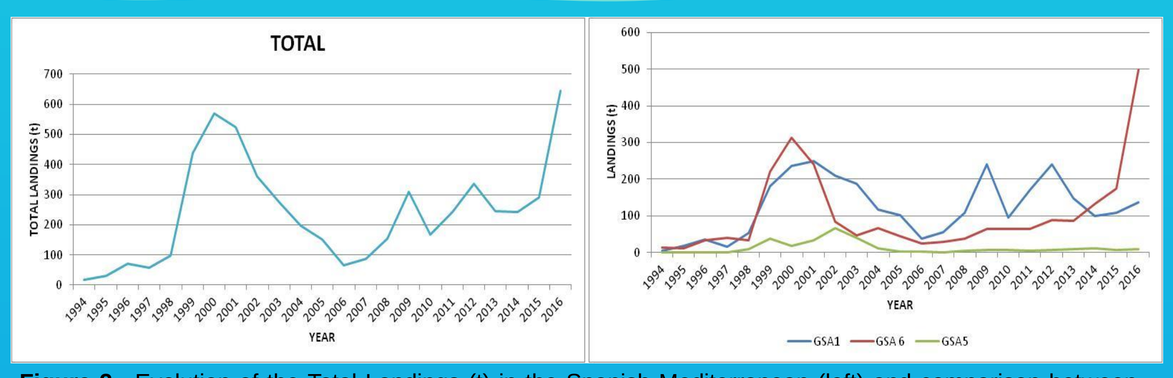

Figure 2.- Evolution of the Total Landings (t) in the Spanish Mediterranean (left) and comparison between GSA 1 and GSAs 5 and 6 (right).

II. Mapping the spatial distribution of biomass index per haul makes evident the occurrence of *P. longirostris* in all areas (Fig. 3). Particularly in GSA I and in the South of GSA 6, but it does also show an increasing latitudinal trend in the North part of GSA 6 during the last years, especially in 2016 (Fig. 4). Depth distribution indicates that the presence of *P. longirostris* ranged from 55 to 741 m depth, being more frequent between 200 and 300 m depth in concordance with a previous study [3]. In GSA 5 results indicates that *P. longirostris* populations are located at deeper grounds (Fig. 5).

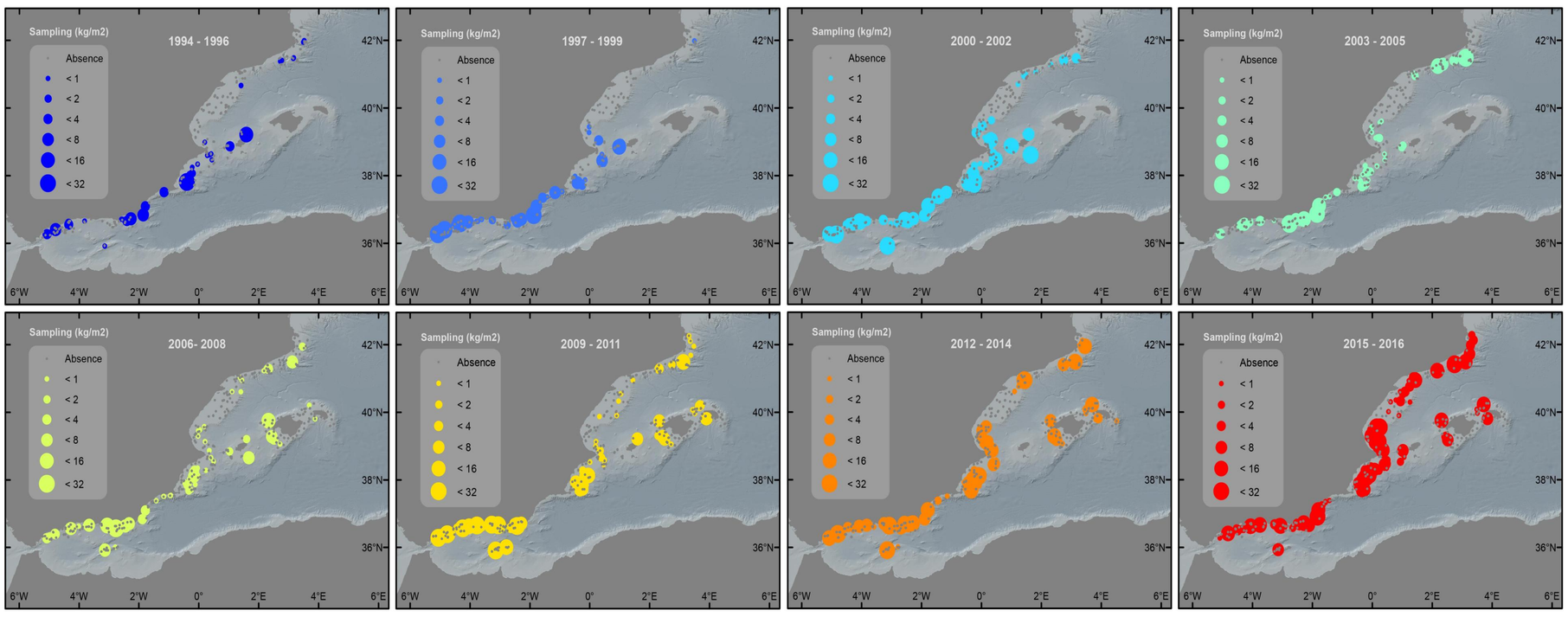

Figure 3.- Spatial distribution of biomass, with data grouped by triennials, showing the evolution, fluctuations and recovery of the biomass values along the Spanish Mediterranean coast.

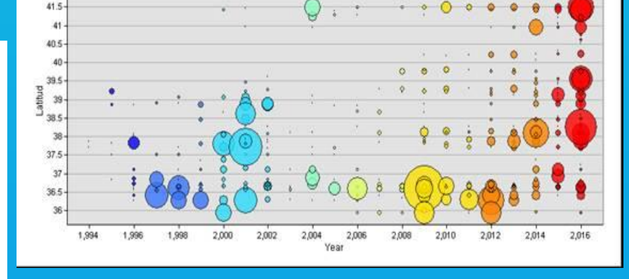

Figure 4.- Representation of the latitudinal evolution in the Spanish Mediterranean studied area. Bubbles area are proportional to the biomass values. Bubbles colour matches the triennial mapping.

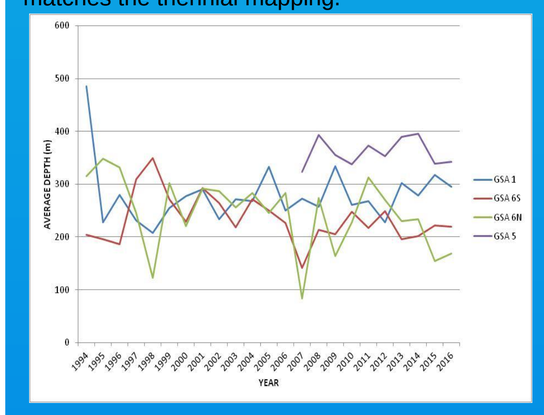

Figure 5. Average deep biomass distribution, by GSA, along the studied period in the Spanish Mediterranean.

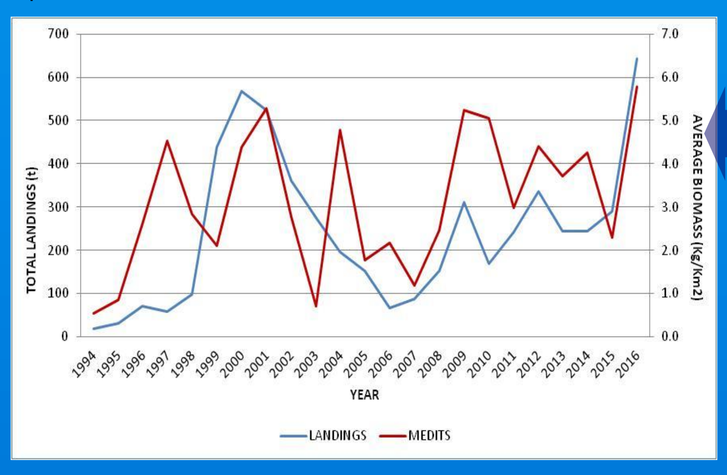

Figure 6.- Comparison between total landings and MEDITS biomass index showing the evolution along the studied period.

III. Total landings and MEDITS_ES biomass indices show a positive covariance and correlation index (r = 0.55) (Fig. 6), reinforcing the validity and robustness of the comparison of results.

Biomass index average show large yearly oscillations. Particularly in GSA 1, where it increases from a minimum in 2003 to a maximum in 2009, decreasing steeply thereafter (Fig. 7 top). On the other hand, in GSA 6 (N and S) and in GSA 5, starting from the minimum of 2003, biomass indices increased steeply and synchronously, especially from 2007 onwards, showing positive covariance and correlation (GSA5-GSA6 r=0.51), rebuilding the populations to similar levels of the previously observed maximum (Fig. 7 bottom). This dissimilar pattern between GSAs (Alborán Sea VS Balearic Sea) shows negative covariance and correlation (GSA 1-GSAs 5&6; r = - 0.11), allowing us to consider the existence of two different areas in the Spanish Mediterranean in relation with *P. longirostris* populations behavior. This different response can be attributed to the interaction of diverse mesoscale drivers in each area.

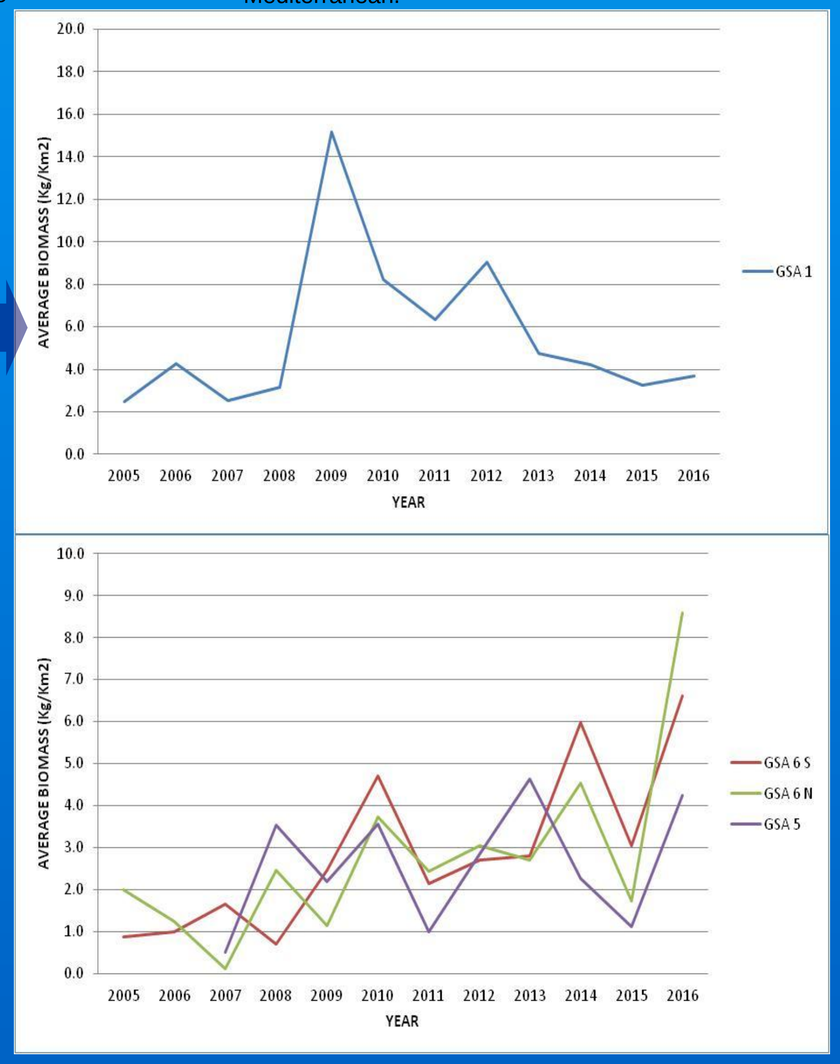

Figure 7.- Comparison between MEDITS biomass index evolution in GSA 1 (up) and in GSA 6 (N and S) and GSA 5 (down) along the studied period.

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