NEW PROPOSED AREA FOR THE ISUNEPCA UWTV SURVEY IN THE GULF OF CADIZ (FU 30)

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Abstract

ISUNEPCA UWTV survey is carried out in the Gulf of Cadiz (UF 30) yearly in spring-summer since 2014, although the first survey is considered as exploratory. The main objective is to estimate a *Nephrops* abundance index to be use as base of the assessment and advice of this stock. The *Nephrops* area distribution and coverage of the survey was accepted by the Benchmark Workshop WKNEP in 2016 and this survey was considered as appropriated to providing scientific advice on the abundance of this stock. However, experience acquired during ISUNEPCA survey time series suggests the survey area should be smaller than the current coverage area for this UWTV survey. Therefore, the *Nephrops* abundance estimate and as consequence the advice of this stock could be affected. A new survey area is proposed based on the analysis of updated and available data.

INTRODUCTION

Nephrops FU30 (Gulf of Cadiz, ICES Division 9a) is a category 3 stock. The scientific advice is based on the ratio of the mean of the last two abundance index values (index A) and the mean of the preceding values (Index B) multiplied by the recent advised catch using the *Nephrops* abundance, estimated by UWTV surveys as the stock size index.

ISUNEPCA UWTV survey (U9111) is carried out in the Gulf of Cadiz (UF 30) yearly in spring-summer since 2014, although the first survey is considered as exploratory. ISUNEPCA is a multi-disciplinary survey and different specific objectives are established:

1. To obtain estimates of *Nephrops* burrows densities

2. To confirm the boundaries of the *Nephrops* area distribution

2. To obtain estimates of macro benthos species and the occurrence of trawl marks and litter on the sea bed

3. To collect oceanographic data using a CTD coupled to the sledge

4. To collect sediment samples

5. To collect sea bed morphological and backscatter data

The current survey area used to obtain the *Nephrops* abundance estimate in the Gulf of Cadiz (FU30) was established in the Benchmark Workshop on *Nephrops* Stocks (WKNEP) in 2016 (ICES, 2016; Vila et al., 2016). It was delimited mainly based on the combination of VMS and

logbook data analysis (2011-2012) and the *Nephrops* abundance from ARSA IBTS surveys (G7511 and G4309) time series (1994-2014). Additional information obtained from sediment samples (Vila et al., 2015) and the bathymetric and morphologic information (Díaz del Río et al., 2014) was also used. The design of the survey follows a randomized isometric grid at 4 nm spacing. Since 2016, stations are allocated in the grid in a rhomboidal way. The grid was extended in an adaptive way until boundaries was established. The sampling effort by year is around 65 stations covering the *Nephrops* area distribution. This area corresponds to 3000 Km^2 and covers depths ranging between 90 m to 700 m, approximately.

However, data compiled and the experience acquired during ISUNEPCA UWTV survey time series suggests that the presence of *Nephrops* is very low or null in the shallowest and the southern border of the current survey area. Besides, visibility at those depths is very poor and the presence of other species with a burrowing behavior generates a high uncertainty in the *Nephrops* burrows identification. For that reason, the stations located in the shallowest limit of the area have been considered stations with zero *Nephrops* density in the 2017-2019 period (ICES, 2018a; 2018b; 2020). That assumption was considered on the basis of results obtained in ARSA IBTS surveys and beam trawls hauls carried out in those years during ISUNEPCA UWTV surveys (ICES, 2018a; 2018b; 2020). So the *Nephrops* distribution limits could be different and, as a consequence, the survey area should be probably smaller than the current area. These facts could directly affect the *Nephrops* abundance estimate and as consequence to the scientific advice.

SGNEPS recommends that the boundary definition of the survey area should be assessed on a regular basis (ICES, 2012). In this sense, a new ISUNEPCA UWTV survey area was proposed during WGNEPS 2021 (ICES, 2022) since nowadays new and more accurate information is available. WGNEPS agreed that a working document explaining details about the re-definition of the survey area must be presented in advance to WGBIE in order to can be reviewed by experts and it can be used from the ISUNEPCA UWTV survey in 2022.

METHODOLOGY

Different sources of information have been considered to re-define the ISUNEPCA survey area: fishing activity, fishery independent indices and seafloor and habitats information.

Nephrops fishing activity

Under the European common fisheries policy, satellite-based Vessel Monitoring Systems (VMS) were adopted, and electronic devices (called blue boxes) were installed on board vessels longer than 15 m to monitoring fishing activities (EC commission regulation No. 2244/2003 of 18 December 2003, laying down detailed provisions regarding satellite-based Vessel Monitoring Systems). VMS provide information about the spatial-temporal distribution of different fishing fleets. Nevertheless, since 2004, the Andalusian Regional Government started installing its own monitoring system (called “green boxes” to differentiate them from the EU VMS), SLSEPA (*“Sistema de Localización y Seguimiento de Embarcaciones Pesqueras Andaluzas*”), on the fishing fleet. Most vessels are now equipped with these systems, including the bottom trawl fleet. SLSEPA devices aim to ensure the safety at sea, control fishing activity,

and improve the monitoring and assessment of fisheries resources (Burgos et al 2013). Additionally, landings geographical distributions could be drawn, linking VMS data with their respective sales at landing port.

The source of data was SLSEPA data from the Gulf of Cadiz bottom trawl fleet (OTB_MCD≥55_0_0 *metier*) for the year 2019 and the corresponding daily landings provided by the Junta de Andalucía landings statistics database. Boats carry a device, that transmit hour and positions (provided by GPS), course and speed to the control center every three minutes. Data transmission uses technology of the cellular networks General Packet Radio Service/Global System for Mobile Communications (GPRS/GSM) instead of a satellite system to send data (Del Olmo, 2006). In case of loss of coverage, data are kept in an internal queue and are dumped to the data control center once the coverage is recovered.

The data received from SLSEPA devices were preprocessed by the control center of the Department of Agriculture and Fisheries of the Andalucía Regional Government. Transmission errors and records on landings were excluded. This preprocessing allows the transmission of smaller data to IEO-CSIC without losing data of interest for this study. Later, at the IEO-CSIC Oceanographic Centre of Cadiz, SLSEPA data were integrated into an MS Access database for management and subsequent incorporation into a Geographic Information System (GIS) using the ArcGIS (ESRI) software for processing and mapping.

Records with speed value less or equal than 5 knots were selected, based on the assumption (corroborate by captains and observers on board) that this is the maximum speed during fishing operations for this fleet. Methods to discriminate fishing and non-fishing activities from VMS data have been studied in several fisheries (see review in Lee et al., 2010). Additionally, records located in shallow waters (less than 100 m deep where *Nephrops* is not targeted) were excluded using spatial statistics tools. For depth criteria, GEBCO bathymetry was used. Although the resolution and accuracy of GEBCO is low, it was considered sufficient for the purpose of this analysis.

Sales at port of *Nephrops* from landings statistics database, which includes quantities sold by species per vessel and per day, were associated to SLSEPA locations. Data could be reliably linked to sales information because trips never last more than one day (although sometimes the sale may occur the next day). Apportioning landings data to fishing points permits the spatial distribution of the catch to be mapped. However, allocating boat daily catches equally to fishing points assumes that the catch rate is the same in all points for a given boat and day (Gerritsen and Lordan, 2011).

The spatial distribution of the catches was estimated by summing the catch of points within 0,5 square nautical mile (nm^2) grid cells, a sufficient resolution based on the total size of study area (around 870 nm^2).

Bottom trawl surveys

The ARSA IBTS surveys are conducted in spring and autumn in the Southern part of ICES Division 9a, in the Gulf of Cadiz (SpSGFS-cspr-WIBTS-Q1 (G7511) and SpGFS-caut-WIBTS-Q4 (G4309)). The area covers 7 224 Km^2 and extends from 15 to 800 m depth. Sampling design follows a random stratified scheme with 5 depth strata (15-30 m, 31-100 m, 101-200 m, 201-

500 m and 501-800 m) (Figure 1). The number of hauls in each depth stratum is proportional to the stratum surface and the haul takes 60 minutes. All hauls are carried out during daylight hours using Baka 40/60 trawl fear with a 43.6 m footrope and 60.1 m headline. An inner 20 mm mesh codend liner is used to prevent the escape of small individuals. This survey collects data on the distribution, relative abundance and biology of commercial fish such as hake, wedge sole, sea breams, mackerel and horse mackerel. Abundance indices are also estimated for crustaceans (mainly rose shrimp and *Nephrops*), cephalopods species and other invertebrates. *Nephrops* abundance spatial distribution time series (1994-2020) has been used as additional information to define the UWTV survey area. No survey was conducted in 2021 and data in spring 2022 are not available yet.

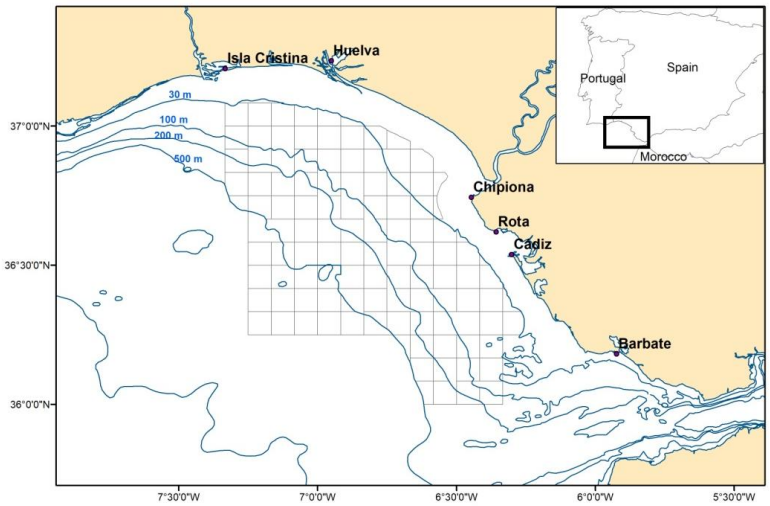

Figure 1. ARSA IBTS survey area (grey grid 5x5 nm).

Beam trawl hauls

Beam trawl hauls have been carried out during ISUNEPCA UWTV survey for the 2017-2019 period in order to know the presence of other burrowing megafauna which co-occurring with *Nephrops* and that could be source of confusion in the identification of *Nephrops* burrows.

Gear used in this survey has a 50 mm mesh size and 10 mm mesh codend. It is mounted on a structure with a horizontal opening of 1,9 m wide supported by a steel bar and a vertical height of 0,6 m provided by the steel skids. Hauls were carried out at towing speed between 1,7 and 2 knot and the effective duration was 15 minutes.

Seafloor morphological, sediment and habitats information

The mapping of seafloor morphologies, substrate types and habitats in the shallow part of the Site of Community Importance (SCI) denominated "Volcanes de fango del Golfo de Cádiz" (Mud volcanoes of the Gulf of Cadiz) has been recently published by Lozano et al. (2020a; 2020b). This SCI is part of the *Nephrops* ground in FU 30 and results of that work can be very useful information to re-define the ISUNEPCA survey area. The mapping was based on a semi-automatic approximation from geophysical data (derived from multibeam echosounder maps and sub bottom profiles). Rock and sediment samples, as well as, a visual interpretation of the submarine images were used in order to validate the geophysical results. In addition, benthic

megafauna were identified in samples obtained by beam trawl and videos taken using sledges and remotely operated vehicles (VORs) to determinate different habitats in the SCI. Additionally, sediment samples using a box-corer and shipek dredges collected in the ISUNEPCA UWTV surveys in 2014, 2018 and 2019 will be considered.

RESULTS AND DISCUSION

The *Nephrops* stock from FU30 is allocated on the Spanish waters of the Gulf of Cadiz, defined as the Spanish Suratlantic Region. The western limit of the stock is at the Portuguese border, on the Guadiana River estuary, whereas the eastern border is at the Gibraltar Strait. The Gibraltar Strait separates the Gulf of Cadiz from the Mediterranean Sea and is considered a natural border. On the other hand, the Guadiana River does not seem to be a real boundary for splitting possibly different populations (FUs 29 and 30). This stock limit was decided mainly on management considerations, without any clear biological basis.

The Gulf of Cadiz is characterized by a strong and complex bottom-current dynamics due the exchange of water masses between Atlantic Ocean and Mediterranean Sea, which configure the seafloor topography and substrate types (Fernández-Salas et al., 2012; Sánchez et al., 2017). Both geological and oceanographic processes determine the distribution of a wide variety of geomorphic features, habitats and species (Rueda et al., 2012). The study area has a wide and flat continental shelf but the seafloor topography increase in complexity in the continental slope (Figure 2A). Lozano et al. (2020a, 2020b) mapped and characterized the area between 400 m and 800 m depth included in the shallow part of the Site of Community Importance denominated “Volcanes de fango del Golfo de Cadiz” (Mud volcanoes (MVs) of the GoC) and established four different geomorphic features (diapiric structures, mud volcanoes, channels and depressions, and flat areas) with seven different substrate types that harbor 11 main habitat types (Figure 2B and 2C). Results obtained from the sediment samples collected in the ISUNEPCA UWTV surveys in 2014, 2018 and 2019 are shown in Figure 3.

Traditionally, soft bottoms of the Gulf of Cadiz are exploited by a highly multiespecific bottom otter trawl *métier* (OTB_MCD≥55_0_0) targeting to a variety of species of crustaceans, cephalopods and demersal fish (Castro et al., 2000; Jimenez, 2004; Silva et al., 2007). One of the main target species is the Norway lobster *Nephrops norvegicus*, which is distributed in mud and muddy-sand areas, where the sediment is suitable for them to build their burrows (Vila et al., 2015; Vila et al., 2016).

Nephrops stock in FU 30 is exploited mainly by the Spanish fleet and in a small proportion by the Portuguese fleet (ICES, 2021). *Nephrops* grounds are located far away from ports and the fleet decides when they want to go fishing *Nephrops*. The fleet operates mainly from Ayamonte and Isla Cristina ports fishing at the western *Nephrops* grounds while Sanlúcar de Barrameda fleet fish mainly in the eastern ground (ICES, 2009). It should be noted that the bottom trawl *métier* operating in the Gulf of Cadiz is composed of 123 vessels, developing more than 19 700 trips by year (mean 2018-2021 period). Moreover, the management of the FU 30 follows a system of individual quotas in which any of those 123 trawlers is allowed to catch a small share of the TAC.

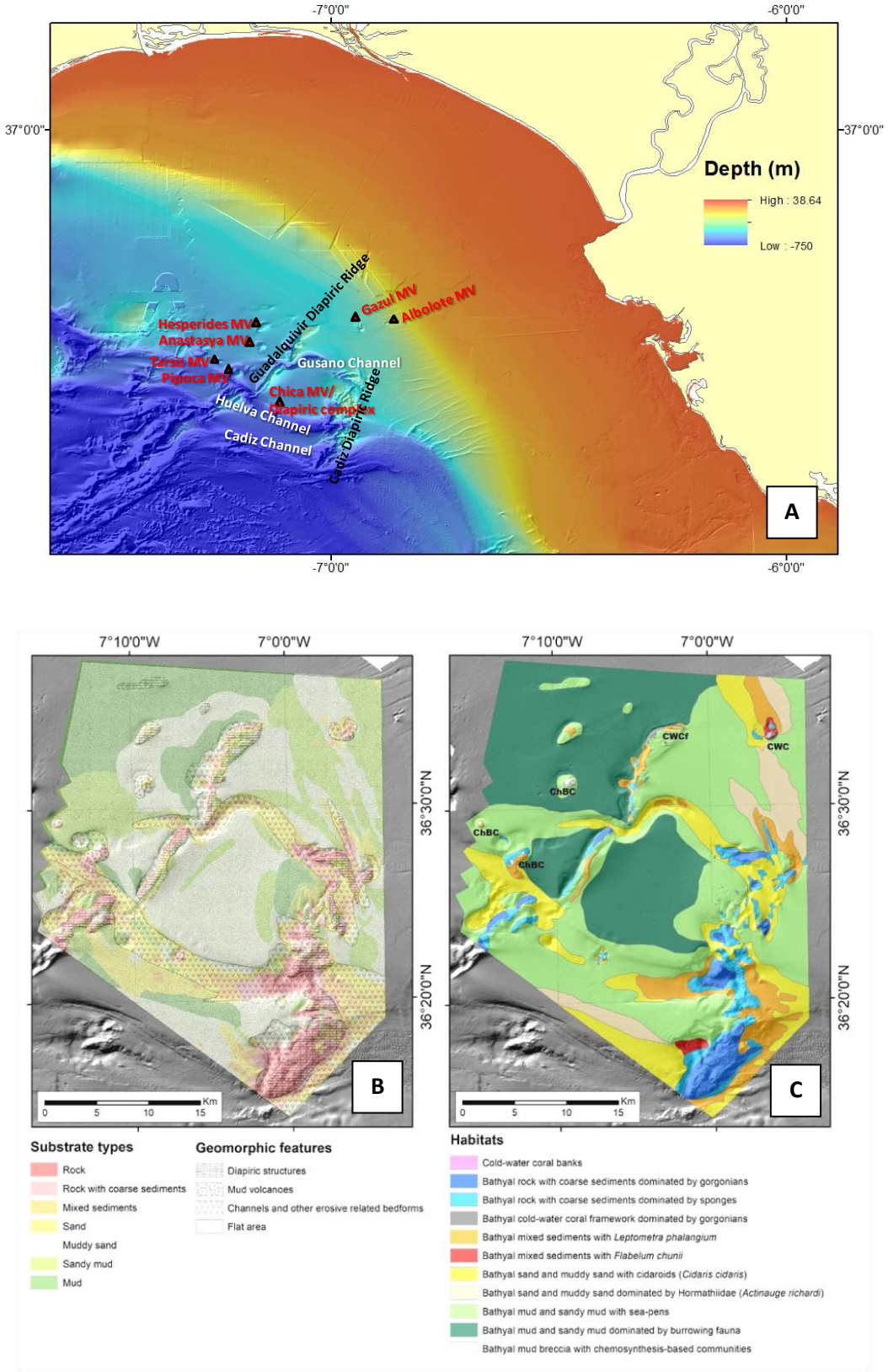

Figure 2. (A) Geomorphic features in the Gulf of Cadiz (In INDEMARE-Project). (B) Morphosedimentary map showing the main substrate types and geomorphic features in the shallow part of the SIT Mud volcanoes of the Gulf of Cadiz. (C) Habitat map based on multibeam echosounder data, imagery and samples. (In: Lozano et al., 2020a).

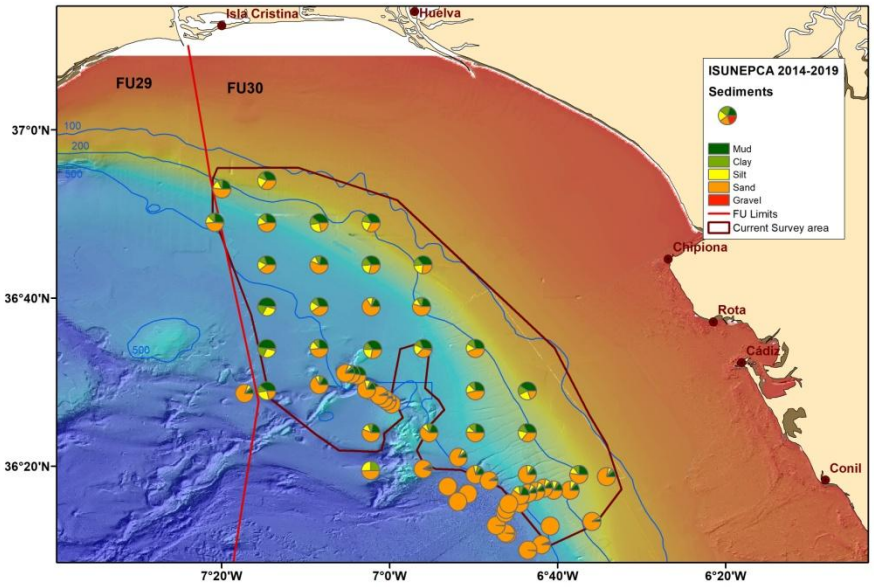

Figure 3. Sediment types from dredge sampling carried out in 2014, 2018 and 2019 ISUNEPCA UWTV surveys.

The SLSEPA information linked to sales notes analysis for this *metier* in the Gulf of Cadiz shows the highest *Nephrops* catches in the western half of the area, mainly between 400 m and 600 m depth and about 300 m depth (Figure 4). Unlike, the eastern part shows lower *Nephrops* catches.

The most of catches located in the 100-200 m stratum of the eastern of the area correspond to vessels having also worked at more than (or near) 200 m depth the same day, and these catches have been assigned to deeper locations. Figure 5 shows (highlighted blue dots) an example of two hauls same vessel same day, one of them near the 100 m isobaths and the other one near the 200 m isobaths.

An analysis of catches by ranges evidenced that in the shallower area in front of Cadiz Bay they never exceeded 5 Kg/day, and higher values corresponded to vessels having worked close to the 200 m isobaths. Vessels positions in the 100-200 m stratum with catches lower than 5Kg/day were excluded (Figure 6).

No fishing activity is observed in some parts of the study area, which match mainly with the Guadalquivir and Cadiz diapiric ridge and mud volcanoes as Tarsis and Pipoca at 600-700 m depth or Gazul at about 300 m depth. These geomorphic features are mainly composed of rocks and coarse sediments (Lozano et al., 2020a; 2020b).

According to these authors, sandy and muddy bottoms with different habitats can be found between Cadiz diapiric ridge and Gazul volcano, such as bathyal sand and muddy-sand with *Cidaris cidaris,* bathyal mixed sediments with *Leptometra phalangium*, bathyal sand and muddy-sand dominated by *Actinauge richardii* and bathyal mud and sandy-mud with sea-pens. On the other hand, Urra et al. (2021) observed different habitats around the Gazul volcano as sandy ripples bottoms typified by *A. richardi*, sandy-muddy-coarse-sand and bioclastic bottoms dominated by the solitary coral *Flabellum chunii* and coarse-sand and bioclastic bottoms and

mixed bottoms characterized by the echinoid *C. cidaris*. These bottoms are not suitable for *Nephrops* and therefore, the fleet does not exploit this part of the area (Figure 6).

Others geomorphic features as Gusano channel and Tofiño channel are also located into the area without signs of fishing activity (Figure 6). The fleet avoids fishing on these channels probably because of their great depth and the high speed current inside (Sánchez et al., 2017).

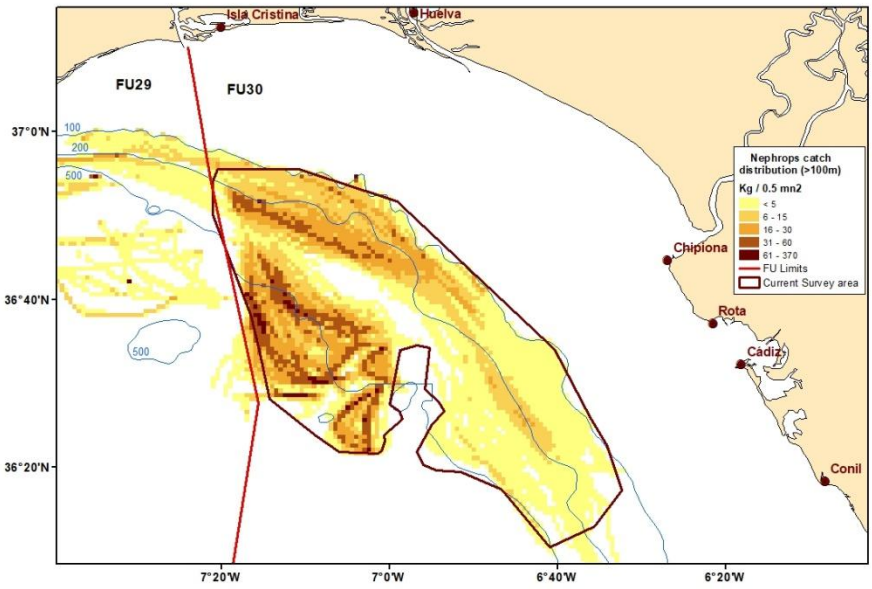

Figure 4. Spatial distribution of *Nephrops* catches provided by SLSEPA information linked to sales notes in 2019 for the bottom trawl fleet in the Gulf of Cadiz (FU30).

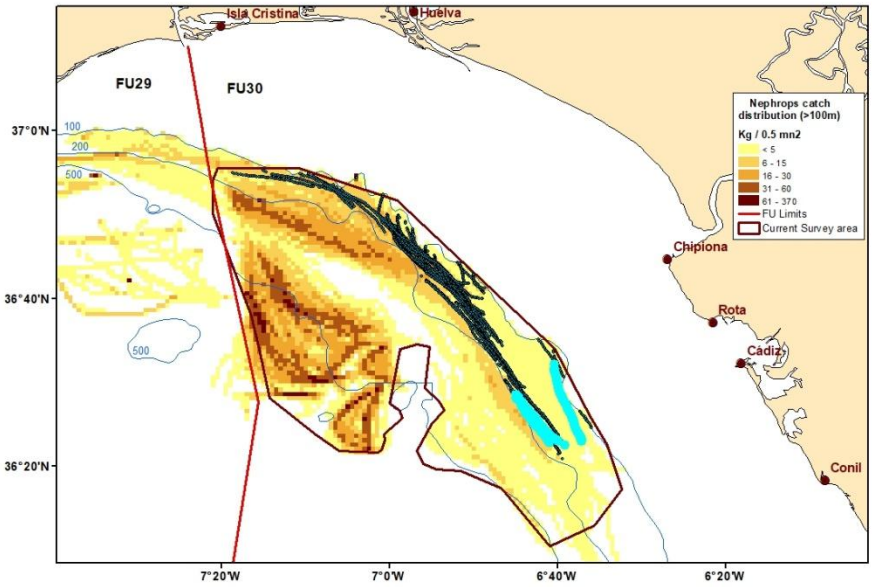

Figure 5. Hauls carried out in the 100-200 m strata (black dots). Example of two hauls conducted by the same vessel same day (highlighted blue dots).

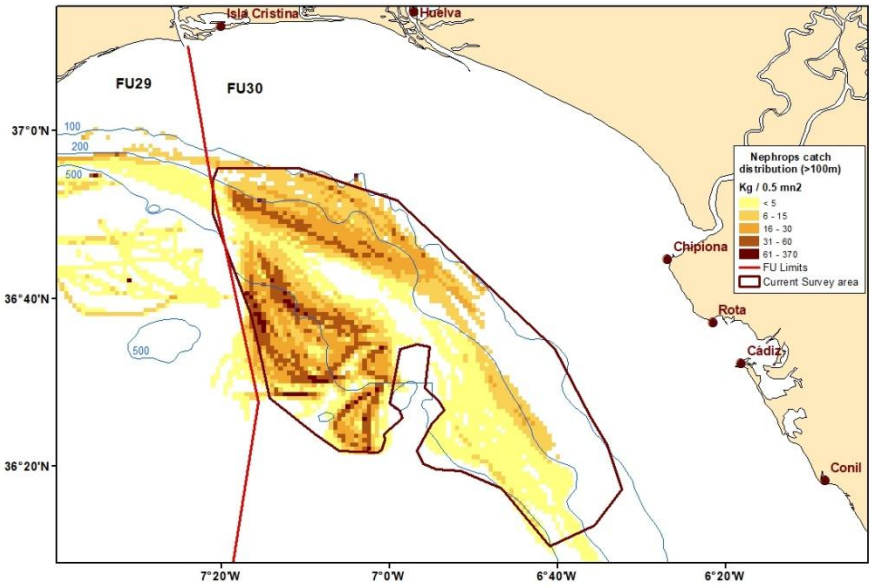

Figure 6. Spatial distribution of *Nephrops* catches excluding vessel positions in the 100-200 m stratum with catches lower than 5Kg/day.

The spatial *Nephrops* density from the ARSA IBTS surveys (G7511 and G4309) time series is in general, according to the spatial distribution of *Nephrops* catches from SLSEPA and sales notes analysis. Nevertheless, very low quantities of *Nephrops* in the 100-200 m stratum have been recorded during the ARSA IBTS time series (1993-2020; no surveys in 2021), as well as, in the southern border of the current UWTV survey area (Figure 7). These differences between both sources of information could be caused by the fact that in SLSEPA analysis it is assumed that the catch rate is the same in all points for a given vessel and day. Information provided by observers on board program confirms that this fleet can target, in the same trip, species with different depth distribution. Therefore, the *Nephrops* catch per 0.5 nm^2 in the 100-200 m stratum could be lower.

Nephrops was also catch in some hauls in the south at more than 700 m depth while the SLSEPA analysis shows no fishing activity. Huelva channel limits the deepest area exploited by the bottom trawl fleet (see Figure 2A, Figure 6 and Figure 7) where the Mediterranean overflow to the Atlantic Ocean is very strong (Sánchez-Leal, 2017). This part of the Gulf of Cadiz is far away to the main ports and probably, it is not profitable for the fisheries industry because the yields are excessively low and the gas consumption outweighs the benefits of fishing. For this reason, during the benchmark workshop WKNEP in 2016 was agreed not to take into account the area beyond the Huelva channel which it is not exploited by the fleet and the *Nephrops* abundance is negligible (ICES, 2016).

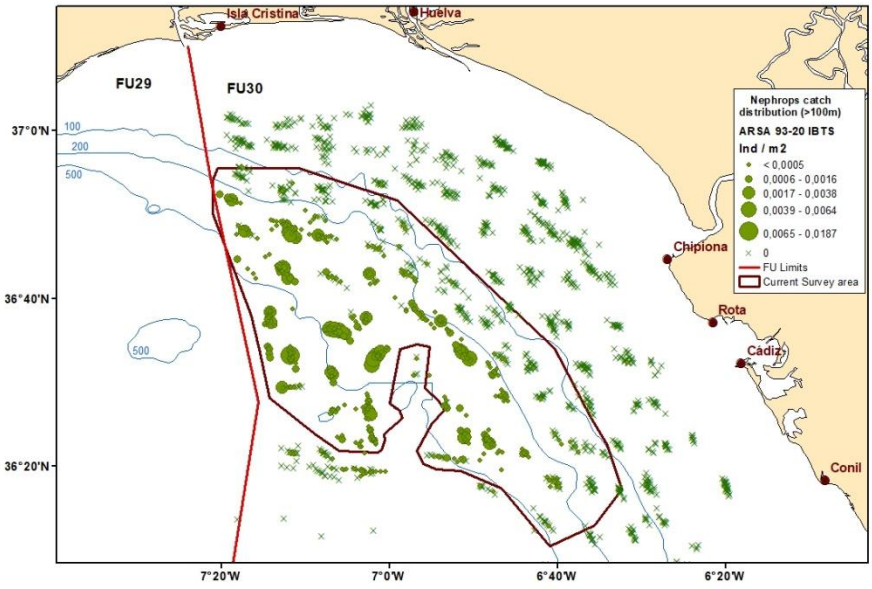

Figure 7. *Nephrops* density from the bottom trawl IBTS surveys time series (1994-2020; no survey in 2021).

The results obtained from the beam trawl hauls conducted during ISUNEPCA UWTV surveys in the 2017-2019 period showed presence of burrowing crustaceans as *Goneplax rhomboids, Alpheus glaber, Munida spp. or Monodaeus coichii* in the 100-200 m stratum but no individuals of *Nephrops* were caught in them (Figure 8). *Nephrops* catches were recorded from 200 m depth and mainly in the deepest waters at more than 500 m depth.

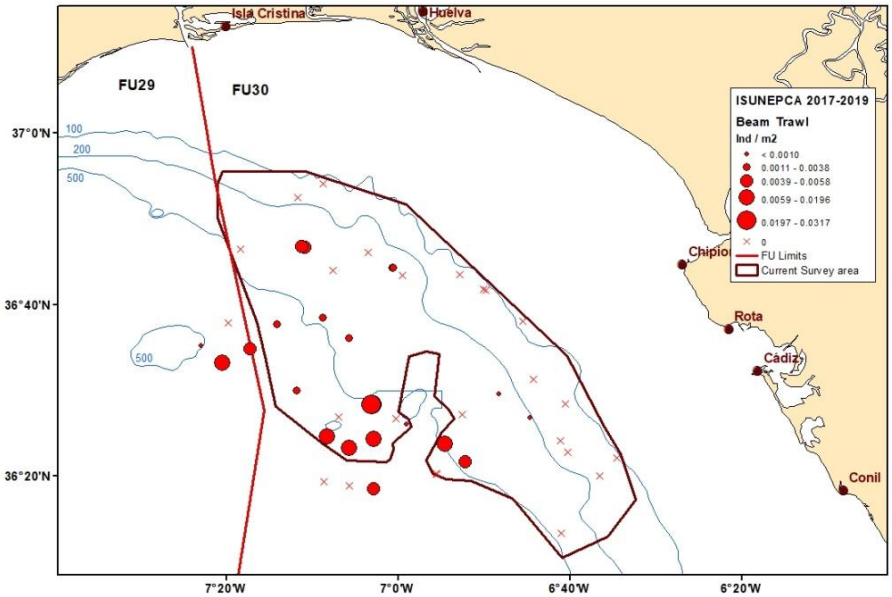

Figure 8. Beam trawls from ISUNEPCA UWTV surveys (2017-2019). Bubbles out of the current survey area on the west part correspond to stations conducted in FU 29 (Algarve Portugal).

Nephrops burrow density obtained during ISUNEPCA UWTV survey time series (2015-2021; no survey in 2020) is shown in Figure 9. Results show that the presence of *Nephrops* is very low in the shallowest limit of the current area, close to 100 m isobaths according to ARSAs IBTS surveys. Since 2018, zero *Nephrops* burrow density was assumed in some stations located around 100 m depth because of the high uncertainty generated by the very poor visibility and the presence of other burrowing species (ICES, 2017; 2018; 2020). Nevertheless, *Nephrops* burrows were identified in video stations located in the southeast border between 100 m and 200 m depth, while the information derived of the ARSAs IBTS and the SLSEPA analysis does not show a significant presence of *Nephrops*, (see Figure 6 and Figure 7).

Video stations conducted in soft bottoms between Cadiz diapiric ridge and Gazul volcano, as well as in the central part of the area between 200 m and 400 m depth, show bottoms with very low bioturbation. Species as *A. richardii*, *C. cidaris*, L. *phalangium* or sea-pens on sandy with bioclastic bottoms or ripples bottoms are usually found in that zone. However, no *Nephrops* burrow systems were observed. Our observations are agreed with the results of other authors (Lozano et al., 2020a; 2020b; Urra et al., 2021).

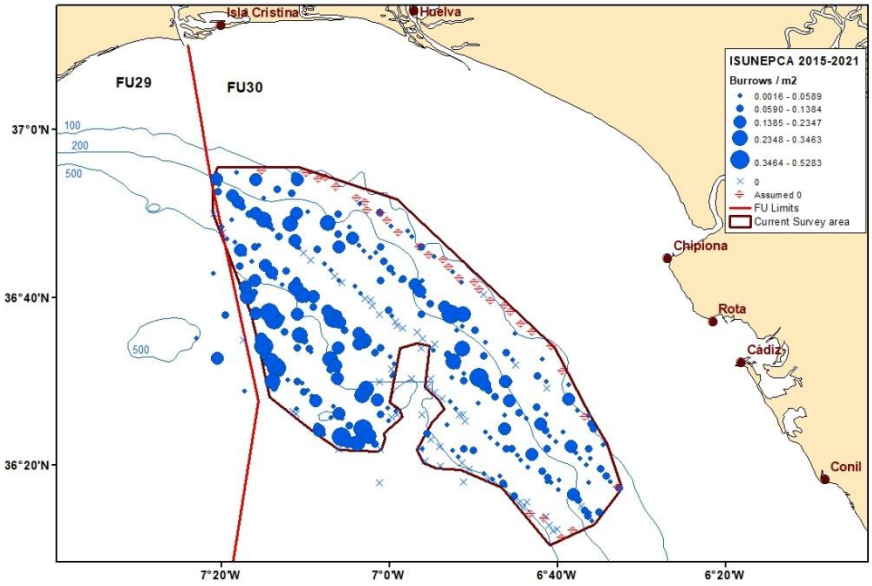

Figure 9. *Nephrops* burrow density from ISUNEPCA UWTV surveys time series (2015-2021; no survey in 2020). Bubbles out of the current survey area on the west part correspond to stations conducted in FU 29 (Algarve Portugal).

CONCLUSION AND PROPOSAL

The new area proposed for the ISUNEPCA UWTV survey in FU 30 taking into account the whole set of information presented in this working document is shown in Figure 10. The WGNEPS in 2021 considered appropriated to adopt this new area as the working area for future ISUNEPCA UWTV surveys (ICES, 2022). The new area coverage is 2332,13 Km^2 (approximately 22% less than the current area).

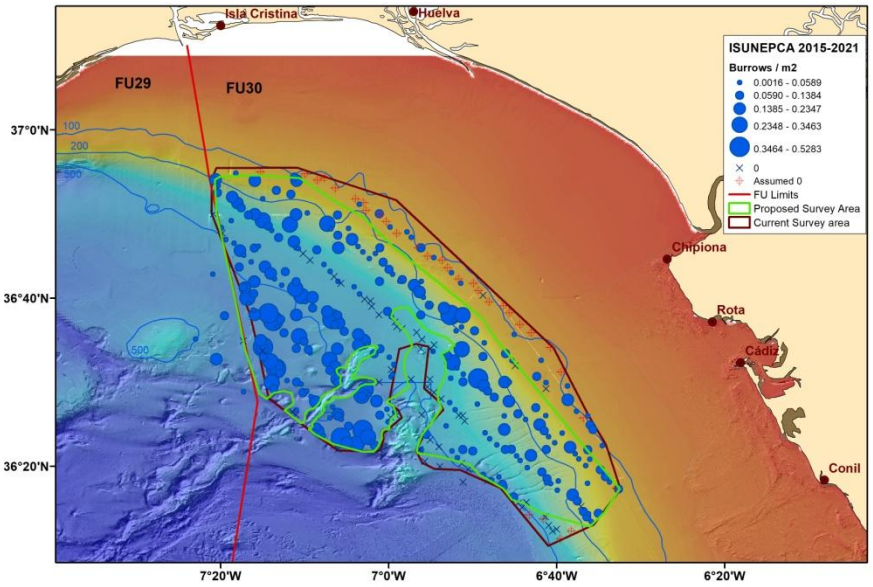

Figure 10. *Nephrops* burrow density from ISUNEPCA UWTV surveys time series (2015-2021; no survey in 2020) overlapped on the seafloor topography, as well as, the current (red) and new proposed (green) ISUNEPCA UWTV survey area.

However, some stations carried out during the ISUNEPCA UWTV survey time series, where *Nephrops* burrows systems were identified, stay out of the new area proposed. This time series is relatively new, as it started in 2015. The low experience in the identification and quantification of the *Nephrops* burrows when the time series started could be the explanation for the presence of *Nephrops* in this part of the area. The WKNEPS in 2021 recommended reviewing those stations in order to check them. Nevertheless, it has not been possible to complete it before the deadline for this working document (1^{ft} April). Results will be presented in the WGBIE in May.

A reduction the grid size for future surveys (more stations and less distance between them) is also proposed. The new proposed area has a surface smaller than the current area, so the number of stations for a survey will be lower. In the time series, the number of stations by survey used for the statistical analysis ranged between 65 and 58. This number is the minimum number of stations needed to carry out a robust geostatistical analysis. The days for the surveys will be the same; therefore, the number of video stations could be increased.

On the other hand, SGNEPS recommended that a coefficient of variation (CV - relative standard error) of less than 20% is an acceptable precision level for UWTV surveys estimates of abundance (ICES, 2012). Up to date the surveys using geo-statistical methods, the CVs obtained are less than 5% (ICES, 2012). The CV of the estimates of *Nephrops* abundance for the ISUNEPCA UWTV time series ranged between 6% and 11% with higher values in the last years (ICES, 2021). Sampling intensity is dependent on burrow densities and the distribution of these densities over the survey area (ICES, 2021). The *Nephrops* mean density in the Gulf of Cadiz can be considerate low in relation to others NE Atlantic FUs (0.08 burrows/m^2, mean value for the whole time series). Moreover, in last two years the differences between close stations increased in some parts of the survey area, probably because of the decreases of the *Nephrops*

abundance. Therefore, a new sampling grid with stations spacing 3.5 nm, instead 4 nm used currently, is also proposed to ensure good coverage and accurate burrow surfaces (Figure 11).

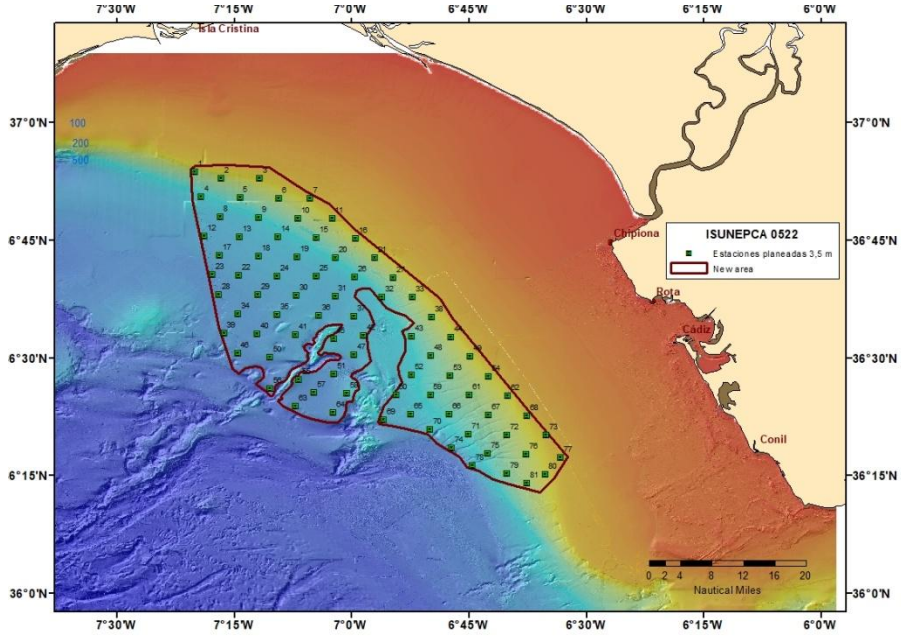

Figure 11. New ISUNEPCA UWTV survey area proposed and sampling grid with equidistant stations spacing 3.5 nm[2].

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