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Nephrops (FU 30) UWTV Exploratory Survey on the Gulf of Cadiz Grounds

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INTRODUCTION

The Norway lobster, *Nephrops norvegicus* is a one of the main commercial crustaceans exploited by a unique and highly multispecific bottom trawl fleet in the Gulf of Cadiz (Jiménez et al, 2004; Silva et al., 2007). Despite annual catches of *Nephrops* are small compared with other Atlantic *Nephrops* stock (≈100 t annually in 2009-2013 periods), this species gives valuable revenues for the trawl fleet. This species occurs in sandy-muddy bottoms from 200 m to 700 m of depth (Sobrino, 1994), where sediment is suitable for them to construct their burrows.

Nowadays, the ICES advice for the *Nephrops* stock in the Gulf of Cadiz (FU 30) is on the basis of a data-limited approach, meaning that no analytical stock assessment is conducted in this FU. According to this approach, FU 30 is considered as category 3.1.4 (ICES, 2012a) and it is assessed mainly by the analysis of the LPUE series trend. Thus, the catch recommendation is set at a long-term average, with and "uncertainty cap" or "change limit" of ± 20% comparing with recent catches.

In the past, the assessment and management advice for *Nephrops* stocks in ICES framework were based on the Length Cohort Analysis (LCA) or Extended Survivors Analysis (XSA), where annual length distribution were sliced into pseudo-age groups. However, the analytical assessment of *Nephrops* is problematic. *Nephrops* lack hard structures bearing marks indicative of age and shows variability in growth and sexual dimorphic growth rates making difficult to apply age-based assessment models. In addition, problems associated with misreporting of catches and unreliable measurements of effort have indicated that the assessment based on dependent fishery data is not realistic in some *Nephrops* stocks. Finally, the variability in emergence patterns associated with, among other factors, time day, tidal, season, sex, reproductive state result in trawl catch rates that are thought to be poorly representative of the *Nephrops* populations. All these issues have encouraged the search for alternatives.

Underwater television surveys to monitor the abundance of *Nephrops* populations were pioneered in Scotland in early 90's. The estimation of Norway lobster abundances using UWTV systems involves identification and quantification of burrow density over the known area of *Nephrops* distribution. This can be used to produce a raised abundance estimate for the stock. In last decade, this technique has received detailed attention in a series of ICES workshops aimed at standardising methodologies and quantifying the uncertainties associated with the

method (Campbell et al., 2008; ICES, 2010). Currently, ICES considers this methodology as the most appropriate, and suggests that, the so-called UWTV surveys can be used in order to obtain an absolute estimate of the biomass of Norway lobster and can be use as the basis of the scientific advice. Thus, UWTV surveys have been extended to many stocks in Atlantic waters and Mediterranean Sea resulting in about 18 stocks prospected with these surveys in 2014. Beside, these UWTV surveys are an excellent platform for obtain information on the benthic habitats and the monitoring of benthic macro fauna of the sedimentary areas in the circa littoral zone deep, such as the communities of pennatulaceans mega fauna and the burrowers fauna that have been included in the OSPAR List (OSPAR, 2010), on the impact of fishing activity on the bottom, as well as information of environmental variables. This information could be useful in the monitoring programs within the Marine Strategy Framework Directive.

In this sense, the Spanish Oceanographic Institute (IEO) carried out an exploratory *Nephrops* UWTV survey on the Gulf of Cadiz fishing grounds in 2014 within the framework of a project supported by Fundación Biodiversidad (Agricultura, Alimentación y Medio Ambiente Ministry) and European Fisheries Funds (EFF). The survey was designed from a multidisciplinary approach. The specific objectives are listed below:

1. To set up the equipment and the UWTV survey methodology in the Gulf of Cadiz
2. To obtain estimates of *Nephrops* burrows densities from a randomized isometric grid of UWTV stations spacing 5 nautical miles
3. To obtain density estimates of macro benthos species and the occurrence of trawl marks on the sea bed
4. To collect sediment samples using a meso Box-Corer
5. To collect oceanographic data using a sledge mounted CTD

MATERIAL AND METHODS

The exploratory ISUNEPCA UWTV survey was carried out from 22nd August to 1st September 2014 in the Spanish Gulf of Cadiz waters (FU 30) onboard RV Angeles Alvariño. The UWTV designs followed a randomized isometric grid of stations at 5 nm spacing. The grid spacing was determinate based on a time constraints of getting the survey completed within a time window of around 11 days with a work schedule about 14 hours per day. This resulted in 35 planned stations. The stations ranged from 130-640 m depth with an average depth around 410 m (Table 1). Additionally, 7 stations located on the shallower edge of the study area were considered as reserve.

The boundary used to delineate the limits of the *Nephrops* ground was based on VMS data of fishing activity in the years2012 and 2013. The VMS positional data were selected from fishing vessels targeting *Nephrops* using the logbooks. Geographical positions are available at least every two hours and the speed when the vessels are fishing ranges between 3 and 4 knots but speeds up to 5 knots can be achieved according to the knowledge from onboard fisheries observers. Therefore, speed values lower 5 knots were selected for the analysis. Records at entries and exits from main ports and from distances to the coast lower 6 mn, where is forbidden trawling, were removed. Additionally, records allocated lower 200 m isobath were

removed too since *Nephrops* catches were near zero. The surveyed area was calculated on the base on the VMS analysis defining squares of 5x5 mn. The grid was established from the vertices of these squares covering the most of the *Nephrops* fishing ground (Figure 2).

The sledge and the main equipment were developed and made by a small company, which performed the sledge operations during the survey (Figure 1). The UWTV equipment is composed of:

- *Image system:* 2 FullHD (1080x1920 pixels) video cameras which are placed in 2 reduced size CPUs with a processor of 700 MHz, 512 Mb RAM and 16 Gb for the storage memory
- *Lighting system:* 1 high power LED made according to the model of this company
- *Lasers system*: 2 lasers of 200 mW
- *Navigation system*: accelerometer and magnetometer both tri-axial with internal data processor, offering offset data of heading, pitch and roll with precision of 1º
- *Communication system:* 1 multiplexor and an IBERCISA MCS-E/30/1500-11 (1500 m and 11 mm diameter coaxial cable)
- *Auxiliary system*: 1 high capacity lithium battery
- *Deck system*: a control unit

The sledge was deployed and towed at the side of the vessel using an 11 mm diameter coaxial cable. The malfunction of the stern portico and the allocation of the winch on the deck, which is to starboard, and not center on the deck were the reasons to decide using the side. This option results in a continuous and without jumpy displacement of the sledge. The sledge was deployed with vessel stopped and when the sledge went down up to half of depth, the vessel was about 1-1.5 knots. Once stable on the seabed the sledge was towed at between 0.5-0.6 knots in order to obtain the best possible conditions for counting burrows and 13 good minutes were recorded. This time corresponds to 200 m swept, approximately. The footages were recorded onto internal memory of the image system and were downloaded after each station onto to computer. Footages files were converted from H264 to MPEG4 format and recorded on DVD disc. Vessel position (DGPS) was logged to text file via Hyperterminal and a HiPAP transponder on the sledge was used to obtain the sledge position. The distance over ground estimate (DOG) was calculated using the sledge position for all stations and the field of view of the video footages was 75 cm (FOV), which was confirmed using lasers.

According to the SGNEPS recommendations all scientists were trained and familiarized with the identification of *Nephrops* burrows (ICES, 2008) using training material and validated using reference footages from Porcupine Bank since the burrow density could be the most similar to the Gulf of Cadiz. Linn's concordance correlation coefficient (CCC) was used to analyze the individual's counting against the reference counts. SGNEPS (ICES, 2009) suggests that individual's counts should be higher 0.8 but a lower threshold might be considered acceptable establishing a CCC value limit of 0.5. In this survey a threshold ≥ 0.5 was accepted for considering a reader as valid. Two trained "burrow identified" scientists independent of each other in the lab conducted all recounts after the survey. The number of *Nephrops* burrows systems and *Nephrops* in and out of burrows were counted for each one-minute interval

according to WKNEPHBID (ICES, 2008). Visibility was subjectively classified using the follow classification key: excellent, good, ok, ok-poor, poor and nil.

Estimates of density at each station were calculated from standardized *Nephrops* burrows recounts divided by the area observed. This area was calculated multiplying the DOG by the FOV. Then, *Nephrops* burrows density was raised to the total area surveyed. In addition, a geostatistic analysis was carried out applying an ordinary kriging. The result of kriging was used to obtain a second *Nephrops* burrows abundance estimate, dividing the area in polygons with the some density range and raising this density to the surface of the each polygon.

A number of factors are suspected to contribute bias to UWTV surveys. In order to use the survey abundance estimate as absolute it is necessary to correct for these potential biases. The main bias is the "edge effect" which is a moderate source of overestimation when deriving *Nephrops population* size from underwater TV surveys. This bias is related to the counting of burrow complexes which lie mainly outside the viewed track. Other bias identify are the "burrow detection" and "burrow identification regarding to visibility quality and the the presence of other burrowing macro benthic species. This correction factors were not applied but must be obtained for further surveys.

Moreover, the footages were used to identify macro benthos species, the type of habitat present in the study area and obtain information about trawl marks on the seabed. The abundance was estimated using a range system. Dominance, frequency, species richness, mean abundance by species and Shannon-Wiener index were estimated by each tow.

At each station, CTD profile was logged for the duration of the tow using a SBE 37. Finally, samples of seabed sediment were collected at each of 35 planned UWTV stations using a meso Box-Corer for granulometric and organic material analysis during the survey. All the samples were frozen for further analysis in the lab.

The OM content in the sediment was obtained as the difference between dry and burnt weights (4 h and 550°). Samples for the grain size analysis were treated with hydrogen peroxide and separated in two fractions with a sieve of 63 µm mesh size. The coarse fraction (>63 µm, sand and gravel) was analyzed through sieve column with size mesh decreasing (>2, 1, 0.5, 0.25, 0.125 and 0.063 µm). The weight of the different fractions retained in each sieve was recorded for calculate the percentages of sediment in weight. Fine fraction (<63 µm, silt and clay) was analyzed using an analyzer of particle size by laser diffraction (Mastersizer 3000 Malvern®). Grain size distribution was classified according to Wentworth (1922): gravel (>2 mm), sand (2 mm-63 µm), silt (63-4 µm), and clay (<4 µm). The textural classification of the sediment was analyzed using the ternary plots proposed by Folk (1954) and Shepard (1954) in order to describe the different types of sediment in relation to the sand, silt and clay content. The software GRADISTAT (Boltt & Pye, 2001) was used for the estimation of the mode, median and sorting.

RESULTS

ISUNEPCA_0814 is the first *Nephrops* UWTV survey in the Gulf of Cadiz and it must be considered as an exploratory survey. This survey offered the opportunity to set up the

equipment and the methodology in this area. In addition, it was an important training both for the scientists and the crew of the vessel. Thus, scientists were able to get to know the survey protocol, the use of the UWTV equipment and *Nephrops* burrow identification.

Figure 3 shows the results of the VMS analysis and the abundance of *Nephrops* obtained during the ARSA bottom trawl spring survey series (SpSGFS-cspr-WIBTS-Q1_1993-2014). The *Nephrops* ARSA distribution is in concordance with the spatial distribution of the fishing activity on the ground in the Gulf of Cadiz (200-600 m depth). Nevertheless, small quantities of *Nephrops* occur below 200 m isobath and on the deepest area (about 600-700 m) although none bottom trawl fleet activity targeting to *Nephrops* is observed in the VMS. Within this area, there are zones where the *Nephrops* fishing activity is scarce or absent that can be explained by the composition of the substrate, as it was confirmed after the analysis of the sediments, since this species needs bottoms of muddy nature to be able to construct its burrows. The UWTV stations covered relatively well the entire distribution of the *Nephrops* ground corresponding to a 2816 Km^2 (Figure 4).

Some difficulties were found when the UWTV stations were allocated on the ground. Firstly, *Nephrops* fishing ground (FU 30) borders on Portuguese waters, therefore none station could be added in an adaptive way to ensure that the boundaries of the ground were surveyed. On the other hand, the bathymetry on the Gulf of Cadiz shows a rugged bottom with deep channels and some mud volcanoes located on the southwestern area. To avoid these submarines structures 4 stations were slightly moved (20, 25, 33 and 37).

All planned UWTV stations were completed but the UWTV stations considered as reserve could not carry out within of the time window of the survey. 10 of the 35 planned stations were visited again because the visibility was very poor or nil. The mainly reason was the fishing activity which causes considerable amounts of suspended material in the water near the seabed making difficult the identification of *Nephrops* burrows. Most of these stations were revisited during the weekend when the fleet is docked in accordance with the regulation. However, the bad visibility conditions remained in 3 of them that were considered null stations. All stations were classified according to the visual clarity (Table 2). Most of them showed clear waters and were classified as excellent and good visibility (46% and 31%, respectively). The visual clarity was acceptable in a number of stations corresponding to 11% as Ok and 3% as OK-poor. Finally, a low percentage of the stations showed a visibility classified as poor (3%) and nil (6%). Only in 2 footages some one-minute intervals had more than 30 uncountable seconds. These minutes were eliminated in the further analysis.

The two counters obtained a CCC value higher than 0.5 but independent recounts showed a bias (Figure 5). Differences between counters were found in footages in poor-ok conditions of visibility, with small *Nephrops* burrows and with high density of other burrowing species. Moreover, all recounts were carried out in the lab after de survey and during a wide period, which could influence in the *Nephrops* quantification.

The distribution of burrows density (within correction factor applied) from these recounts on the footages indicates a modal distribution around 0-0.3 burrows/m^2 with a range of observations relatively low. Figure 6 shows the burrows density by UWTV station. The *Nephrops* density in the border of the area was relatively high but it was not possible to add

UWTV stations in an adaptive way in order to ensure the boundaries of the ground in this first survey. Nevertheless, it will be difficult to extend UWTV stations in the west of the area since it limits with Portuguese waters. The mean burrow density was 0.102 burrows/m^2. The total numbers of burrows counted during the survey was raised to the area surveyed (2816 Km^2) to give a preliminary and not corrected estimate of the number of burrows system in the Gulf of Cadiz. Assuming 100% occupancy the total number of *Nephrops* in the Gulf of Cadiz was estimated to be around 294 millions of individuals.

The spatial co-variance and other spatial structuring Geo-statistical analysis were conducted using ARCGIS software. However, some difficulties were identified as the low number of observations and no observations with zero densities on the boundary ground. A number of assumptions were considered and explored. *Nephrops* density estimate base on the geostatistic analysis was similar (282 millions of individuals). The map of the density surface is showed in Figure 7. The CV estimation on the abundance was around 80%, suggesting that the variability between adjacent stations is very high. Therefore in future UWTV surveys the distance between stations will be reduced. A summary of the univariate statistic and geostatistics on the burrow density estimates are given in table 3.

Regarding to the fauna associated, the especies dominant in the footages were mainly the polychaete worm *Lanice cf. conchilega*, sea-pens *Kophobelemnon stelliferum* and *funiculina quadrangularis, and* anemone *Actinauge richardi* (Figura 8). In less proportion, dominated *Thenea muricata*, sea-pens *Pennatula aculeta*, *Cerianthus cf. membranaceus* and *Virgularia mirabilis*, the crustacean *Meganyctiphanes norvegica* and sea urchin *Cidaris cidaris* and *Leptometra phalangium* (see Figure 8). The species with high values of frequency of occurrence were similar. 7 species with fishing interest were observed, being the most dominant and frequent shrimp (*Parapenaeus longirostris*), Norway lobster (*Nephrops norvegicus*) and some cephalopods especies (*Eledone cirrhosa*, *Loligo* sp., *Sepietta* sp., *Sepiola* sp.). On the other hand, it was found a total of 11 species that form deep and batial circalitoral hábitats like *K. stelliferum*, *F. quadrangularis*, *A. richardi* or the bamboo coral *Isidella elongata*.

On the basis of predominat species and its density 7 habitats types were recorded. According to the Marine Habitats Spanish Checklist are Bathyal muds (040202), Bathyal muds with Cerianthids (040202), Sands and muddy sands with *A. richardi* (04020401), Bathyal muds with pennatulacea (04020202), Bathyal muds with *L. conchilega* (04020211), Bathyal muds with crinoids (04020214) and bathyal muds with *T. muricata* (0402020401) (Figure 9).

The analysis of the environmental variables shows low variations in temperature and salinity with a gradient depending on the depth. The mean values observed were 13.4° y 36.3 psu. Regarding to the granulometry analysis, the sediment in the *Nephrops* ground is very little sorting and shows small size grain belonging to the textural group of sand and mud (Figure 10). In general, the sand fraction dominant are very fine sand and fine sand (Figura 11a). The area with the highest percentage of mud is located closet o the Portuguese border, with a similar proportion of silt and clay (Figure 11b). Organic material range 2.4% y 10.8% and the highest values were observed to the southwest area surveyed while the lowest values were observed in the northeast closet o the border with Portugal.

CONCLUSIONS

It is the first *Nephrops* UWTV survey in the Gulf of Cadiz and it must be considered as an exploratory survey. This survey offered the opportunity to set up the equipment and the methodology in this area. In addition, it was an important training both for the scientists and the crew of the vessel. Thus, scientists were able to get to know the survey protocol, the use of the UWTV equipment and *Nephrops* burrow identification. However, some questions must be improved:

1. The boundaries of the *Nephrops* ground have to be better defined
2. Increase the intensity of UWTV stations and decrease the distance between them in order to reduce the CV
3. Bathymetry must be taken to account when the UWTV stations are allocated on the grid
4. Higher training of readers and good knowledge of the burrows of other species is needed
5. The *Nephrops* identification and quantification must be carried out during the survey
6. To calculate the conversion factors in order to use the UWTV abundance estimate as an absolute index (edge effect, burrow detection rates, burrow identification)

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Table 1. Characteristics of the UWTV stations.

Station	Date	Start				Finish				Validity
		Time (UTM)	Latitude	Longitude	Deep	Time (UTM)	Latitude	Longitude	Deep	
1	29/08/2014	8:54	36° 53.9'	7° 20.5'	255	9:08	36° 53.9'	7° 20.7'	252	SI
2	29/08/2014	10:26	36° 54.1'	7° 14.8'	136	10:39	36° 54'	7° 14.7'	137	SI
4	28/08/2014	8:19	36° 48.9'	7° 20.7'	490	8:31	36° 49'	7° 20.8'	490	SI
5	28/08/2014	19:14	36° 49.1'	7° 14.9'	433	19:28	36° 49'	7° 14.8'	433	SI
6	28/08/2014	17:49	36° 49.1'	7° 8.5'	287	18:02	36° 49'	7° 8.4'	288	NO
7	28/08/2014	16:29	36° 49.1'	7° 2.3'	132	16:42	36° 49'	7° 2.2'	131	SI
9	28/08/2014	6:34	36° 43.9'	7° 14.5'	509	6:47	36° 44'	7° 14.6'	508	SI
10	31/08/2014	7:55	36° 43.9'	7° 8.2'	480	8:08	36° 44'	7° 8.3'	480	SI
11	31/08/2014	9:35	36° 43.9'	7° 2.1'	350	9:49	36° 44'	7° 2.2'	350	SI
12	27/08/2014	11:52	36° 43.9'	6° 55.9'	131	12:05	36° 44'	6° 56'	131	NO
13	30/08/2014	16:16	36° 39.1'	7° 14.8'	552	16:30	36° 39'	7° 14.7'	552	SI
14	31/08/2014	6:24	36° 38.9'	7° 8.3'	512	6:37	36° 39'	7° 8.4'	512	SI
15	31/08/2014	11:14	36° 38.9'	7° 2'	501	11:27	36° 38.9'	7° 2.1'	501	SI
16	31/08/2014	12:44	36° 38.8'	6° 55.8'	366	12:57	36° 38.9'	6° 55.9'	369	SI
18	26/08/2014	11:50	36° 33.9'	7° 14.4'	568	12:03	36° 34'	7° 14.6'	568	SI
19	26/08/2014	10:17	36° 33.9'	7° 8.2'	504	10:30	36° 34'	7° 8.3'	490	SI
20	29/08/2014	15:22	36° 34.2'	7° 01'	494	15:35	36° 34.1'	7° 0.9'	494	SI
21	26/08/2014	6:28	36° 34'	6° 55.9'	451	6:30	36° 34'	6° 55.9'	445	NO
22	25/08/2014	17:07	36° 34'	6° 49.7'	254	17:20	36° 34'	6° 49.8'	259	SI
24	24/08/2014	18:59	36° 29'	7° 14.7'	617	19:12	36° 29'	7° 14.6'	617	SI
25	25/08/2014	7:29	36° 29.7'	7° 8.4'	566	7:41	36° 29.7'	7° 8.5'	573	SI
26	25/08/2014	9:05	36° 28.8'	7° 2'	568	9:18	36° 28.9'	7° 2.1'	570	SI
27	25/08/2014	11:51	36° 29.1'	6° 56.1'	468	12:05	36° 29'	6° 56'	468	SI
28	25/08/2014	13:37	36° 29.1'	6° 49.9'	399	13:50	36° 29'	6° 49.8'	399	SI
29	25/08/2014	15:50	36° 29'	6° 43.6'	173		36° 29'	6° 43.6'		NO
30	30/08/2014	12:25	36° 19.4'	7° 2.1'	640	12:39	36° 19.5'	7° 2.2'	649	SI
31	24/08/2014	17:18	36° 24.1'	7° 8.5'	617	17:32	36° 24'	7° 8.4'	612	SI
32	24/08/2014	14:25	36° 24'	7° 2.3'	563	14:37	36° 24'	7° 2.2'		SI
33	24/08/2014	11:13	36° 24.1'	6° 55.3'	497	11:26	36° 23.9'	6° 55.3'	499	SI
34	24/08/2014	8:09	36° 24.1'	6° 49.8'	421	8:25	36° 23.9'	6° 49.8'	423	SI
35	30/08/2014	6:31	36° 23.9'	6° 43.4'	295	6:44	36° 23.9'	6° 43.5'	291	SI
37	24/08/2014	12:39	36° 19.7'	6° 56'	544	12:51	36° 19.6'	6° 56'	544	SI
38	23/08/2014	14:05	36° 19.1'	6° 49.7'	621	14:18	36° 19'	6° 49.9'	478	SI
39	30/08/2014	9:44	36° 18.9'	6° 43.3'	378	9:57	36° 18.9'	6° 43.4'	380	SI
40	30/08/2014	8:11	36° 18.9'	6° 37.3'	197	8:24	36° 19'	6° 37.4'	199	SI

Table 2. Visual clarity by UWTV stations in number and percentage.

	UWTV Stations	
	Nº	%
Excellent	16	46
Good	11	31
Ok	4	11
Ok-poor	1	3
Poor	1	3
Nil	2	6

Table 3. Univariate results for the *Nephrops* density.

	Nº madrigueras/m^2
Nº Observaciones	31
Mínimo	0
1er cuartil	0.0325
Mediana	0.08
3er cuartil	0.1675
Máximo	0.3
Media	0.10194
Desviación standard	0.083283
Coef. De sesgo	0.74563
Curtosis	2.7472
CV	0.8170

Figure 1. Sledge used during ISUNEPCA_0814 UWTV Survey in the Gulf of Cadiz (*Nephrops* FU30).

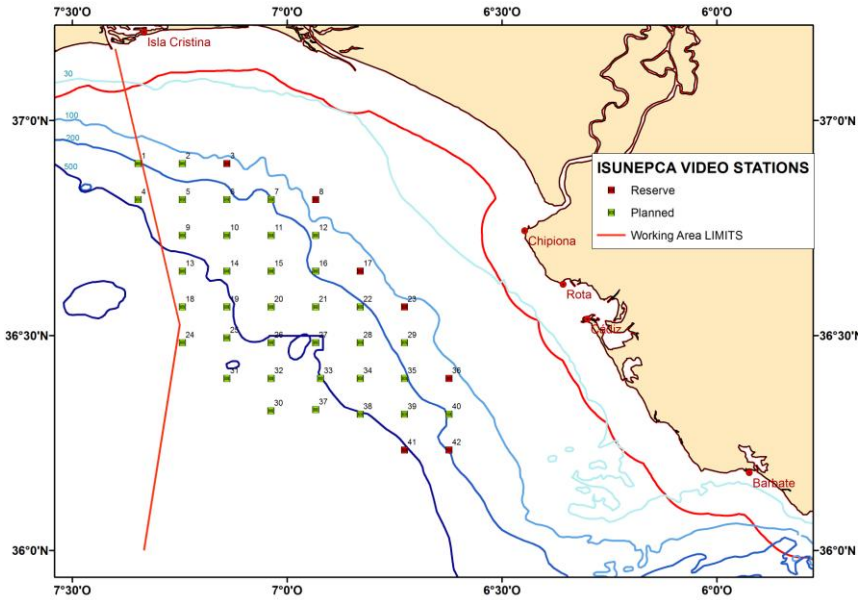

Figure 2. Distribution of the UWTV and Box-Corer stations in the ISUNEPCA_0814 Survey in the Gulf of Cadiz (*Nephrops* FU30).

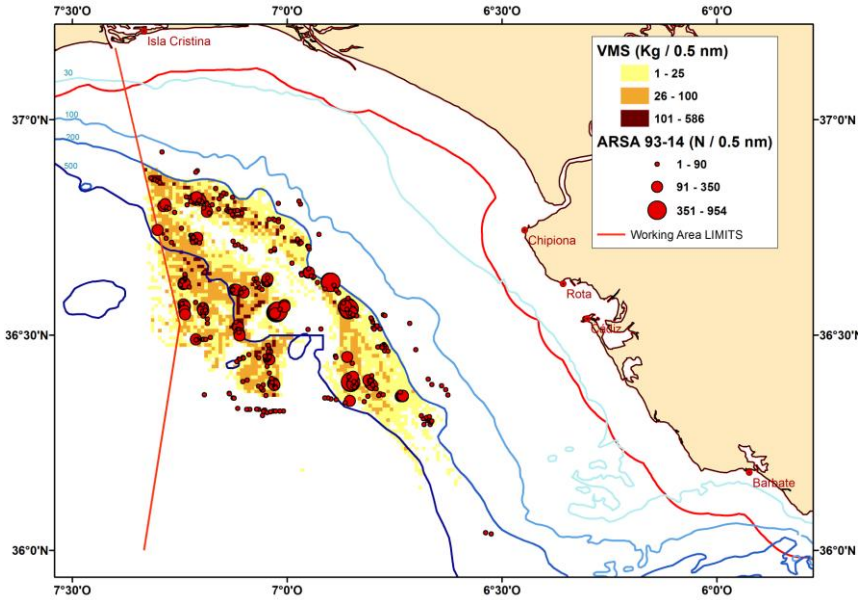

Figure 3. Fishing activity targeting *Nephrops* based on VMS (2012-2013) and *Nephrops* abundance obtained in the ARSA bottom trawl spring survey series (SpSGFS-cspr-WIBTS-Q1_1993-2014) in the Gulf of Cadiz.

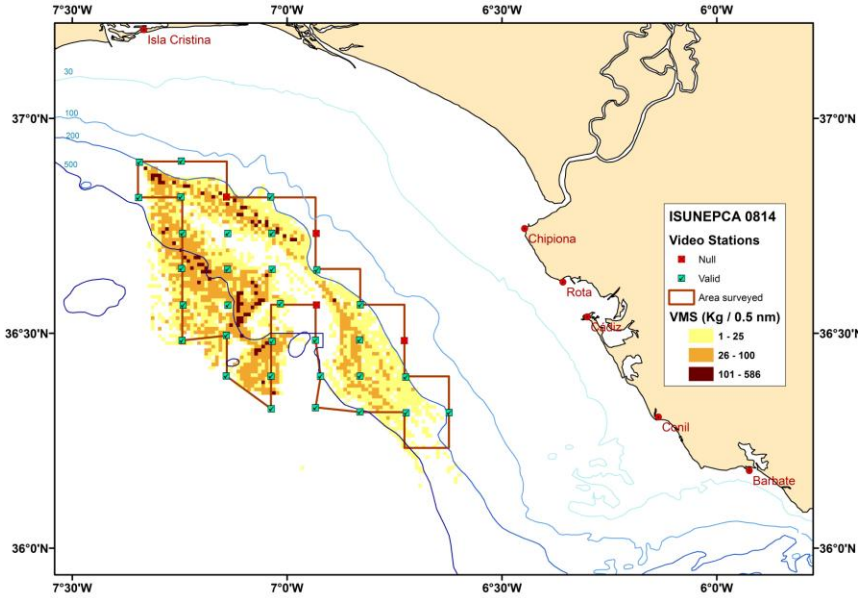

Figure 4. ISUNEPCA_0814 UWTV stations map and area surveyed overlaid on *Nephrops* fishing activity based on the VMS.

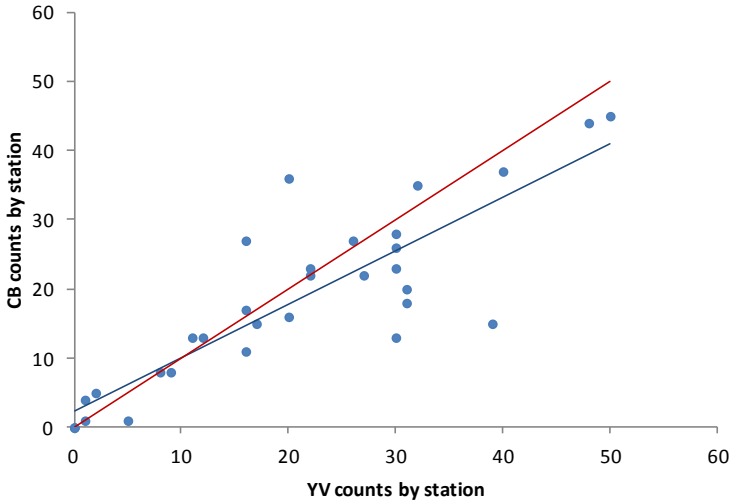

Figure 5. A scatterplot of the recounts made for each station by two counters independently. The blue line is the linear regression (r^2=0.74) and the red line indicates a 1-1 relationship.

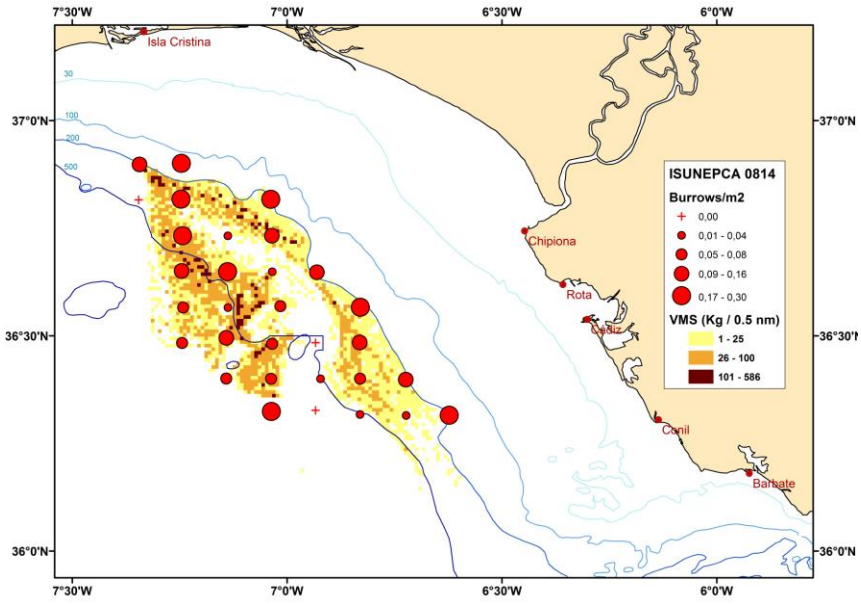

Figure 6. Results of *Nephrops* density distribution (within corrector factors applied) overlaid on *Nephrops* fishing activity based on the VMS in the Gulf of Cadiz (*Nephrops* FU 30).

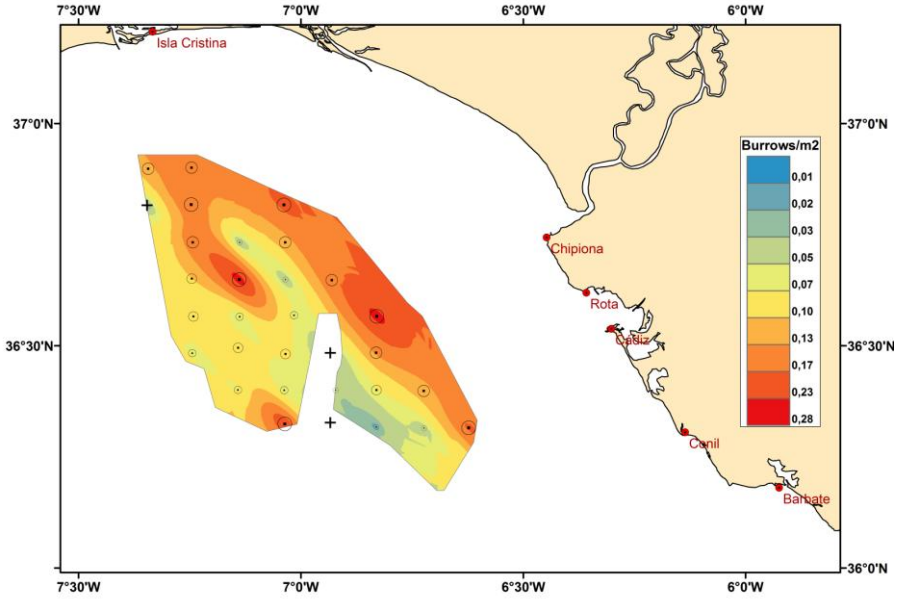

Figure 7. *Nephrops* density surface map.

Figure 8. Especies dominant in the footages: K) *Kophobelemnon stelliferum*; C) *Cerianthus cf. membranaceus*; L) *Leptometra phalangium*; A) *Actinauge richardi*; F) *Funiculina quadrangularis*; Cd) *Cidaris cidaris*.

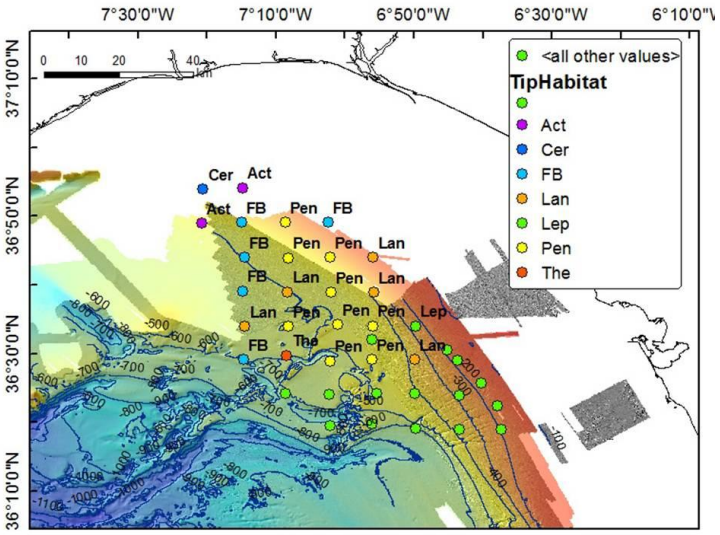

Figure 9. Habitat types identify on the *Nephrops* grounds. Bathyal muds (040202), Bathyal muds with Cerianthids (040202), Sands and muddy sands with *A. richardi* (04020401), Bathyal muds with pennatulacea (04020202), Bathyal muds with *L. conchilega* (04020211), Bathyal muds with crinoids (04020214) and bathyal muds with *T. muricata* (0402020401).

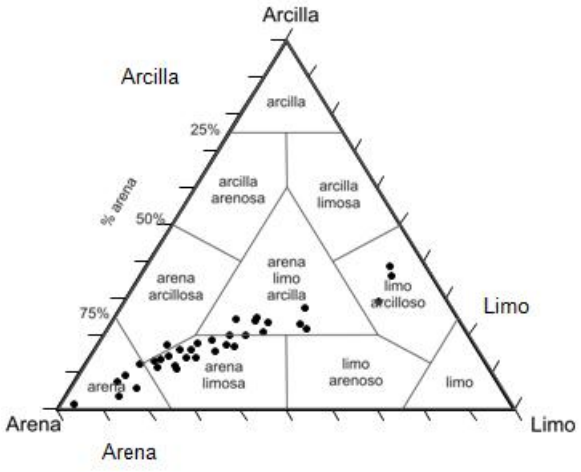

Figure 10. Ternary plot for the granulometry analysis results.

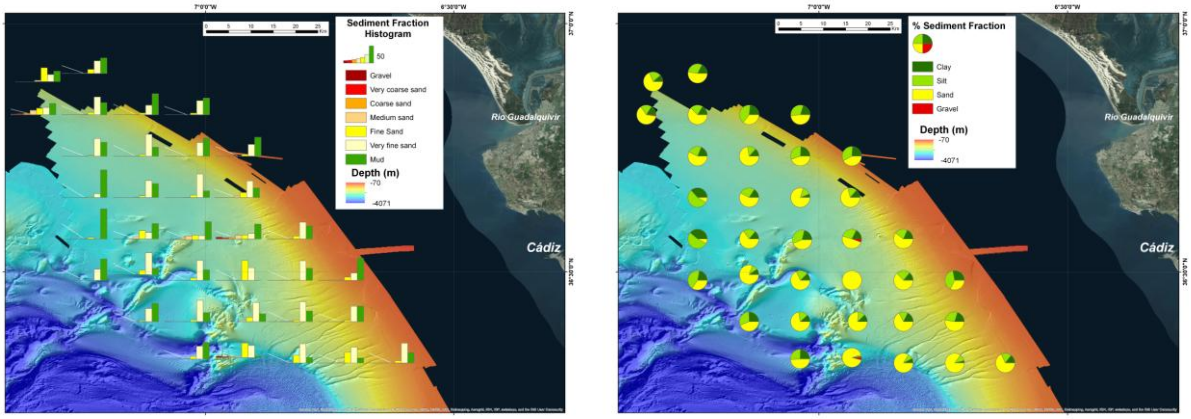

Figure 11. Spatial distribution of the a) grain size and b) organic material on the *Nephrops* ground.