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Towed underwater television towards the quantification of Norway lobster, squat lobsters and sea pens in the Adriatic Sea

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Norway lobster, *Nephrops norvegicus*, is of great commercial importance throughout the NE Atlantic and Mediterranean, where it lives in burrows within muddy sediments.

In the Adriatic Sea, the Norway lobster, *Nephrops norvegicus,* ranks first of all crustacean species exploited in terms of value, and second in terms of weight, with a decreasing trend in catches since 1993 (Vrgoć et al., 2004). It inhabits muddy substrates at depths between *ca.* 50 m and 400 m depth (Artegiani et al., 1979), making the Pomo (Jabuka) pits (200 – 270 m) very important fishing grounds in the Adriatic Sea (Froglia and Gramitto, 1988; Froglia et al., 1997; Morello et al., 2007). The western Adriatic Sea trawling grounds have been classified as fully exploited to overexploited with respect to *Nephrops* (Sardà, 1998). Furthermore, the Pomo pits, with their particular topography, bottom-sediment composition (fine muddy sloping down to 270m) and oceanography also comprise the main nursery grounds of the commercially important European hake (*Merluccius merluccius*) (Zupanovic and Jardas, 1986). The presence of significant quantities of juvenile hake coincides with the maximum trawling effort for *Nephrops*. For these reasons, the Pomo pits have been the subject of many discussions aimed at establishing them as areas closed to bottom trawling. In this context, careful management of these grounds and their main resources is vital, especially because two mixed-species trawling fleets from two different countries (Italy and Croatia) fish there regularly. Furthermore, the Italian and Croatian grounds share important common characteristics and the *Nephrops* populations are, to some extent, interdependent because of larval exchange.
In several European countries *Nephrops* is assessed by means of towed underwater cameras (UWTV) techniques. This technique is particularly suited to *Nephrops* because, for a number of reasons, normal fishery-dependent stock-assessment methods are not applicable to this species. The UWTV methodology relies on the fact that a known surface area of seabed is visually assessed and the number of *Nephrops* burrows, whose features are distinct, can be counted and their inhabitants quantified.

The Adriatic Pomo pit grounds have been the subject of detailed *Nephrops*-centric studies throughout the years (see Morello et al. (2007) for a summary). Pioneering research on *Nephrops* burrows derives

from the former Yugoslavia (Crnkovic 1968), but the stocks have never been subject to systematic assessment before the present study.

In May 2009, the Istituto di Scienze Marine (CNR – ISMAR) of Ancona (Italy) and the Institute of Oceanography and Fisheries (IOF) of Split (Croatia) joined forces, under the auspices of the FAO – ADRIAMED project, in order to carry out an evaluation of the *Nephrops* stock in the Pomo pits using the towed UWTV methodology. This survey was exceptional in that it was extended for the first time to both Croatian and Italian waters. The same effort was repeated in August 2010 with the aim of making this approach the standard method of *Nephrops* abundance estimation in the Adriatic Sea, as it is in the NE Atlantic and the North Sea.

The recording of underwater footage using a system set up for the quantification of anything included within the field of view of the camera, lends itself nicely to the collection of corollary ecological data, potentially producing datasets which could be used in the context of an ecosystem approach to fisheries management.

In this case, the UWTV methodology was used not only to determine *Nephrops* burrow densities but also to gain estimates of:

- The abundance of squat lobsters, *Munida* spp: this group is important because since 2000, a new-comer, *Munida rutllanti*, made it's first appearance in the Pomo pits and in just a few years completely replaced the native, dominant, *M. intermedia*;
- The abundance of the sea pen, *Funiculina quadrangularis*, whose assessment by means of UWTV has recently been the object of OSPAR attention;
- The numbers of trawl tracks in the area towards developing a proxy for fishing effort which could be incorporated into future *Nephrops* assessments.

The UWTV stations were assigned to the study area following a stratified random sampling design with strata defined according to:

(i) depth: shallow (< 200 m) and deep (> 200 m);
(ii) fishing intensity (this is defined indirectly using the 12 nmi line delimiting Croatian territorial waters as a proxy based on the hypothesis that less boats operate within the Croatian territory).

This subdivision resulted in 4 distinct substrata:

1. DC: deep Croatian territorial waters
2. DI: deep international waters;
3. SC: shallow Croatian territorial waters; and
4. SI: shallow international waters.

The number of stations per stratum was determined proportionally to the surface area of the stratum for a total of 60 stations. Each UWTV station entailed an effective towing time of *ca.* 20 minutes. The UWTV tows were carried out during the day time on board RV Dallaporta, on 5-27 May in 2009 and on 6-28 August in 2010.

The methodology used to count *Nephrops* burrows (with the exception of the application of edge effects) was applied to *Munida* spp and *F. quandrangularis*, resulting in data regarding absolute numbers per tow and average densities per tow and sub-stratum. Trawling activity was quantified by counting the number of trawl tracks (visible as deep furrows caused by the dragging of otter doors) in the footage and using them as a proxy of fishing intensity. These counts were divided by two to account for the fact that there are two otter doors per net.

The densities obtained from the footage are summarised in Table 1. On a semi-quantitative scale of abundance (ICES, 2010), *Munida* spp could be classified as abundant (found in almost all frames, in multiples) in 2009, whilst in 2010 it was abundant in some areas but only occasional (*ca.* 12 individuals per 10 minute run) in others. *Funiculina quadrangularis*, on the other hand, was rare (1-5 individuals per 10 minute run) everywhere. There were no significant differences in the densities of *Nephrops* burrows and trawl tracks in 2009 and 2010, both overall and in the different sub-strata. *Munida* spp decreased significantly in all sub-strata in 2010, particularly in international waters. This result should be treated with caution because sampling was carried out in different months in 2009 and 2010. There were no significant correlations between the density of trawl tracks and that of *Nephrops* burrows or *Munida* spp. The numbers of *Funiculina quadrangularis* were very low in both years and performed poorly in any comparative or correlative analyses.

Table 1. Mean density (and standard deviation) of *Nephrops* burrows, *Munida* spp., *Funiculina quandrangularis* and trawl tracks counted for each of the four substrata of the Nephrops 2009 and 2010 surveys of the Pomo (Jaubuka) pits, Adriatic Sea. Notes: DC = deep Croatian territorial waters, DI = deep international waters, SC = shallow Croatian territorial waters, SI = shallow international waters.

Sub-stratum	***Nephrops* burrows·m^{-2}**	***Munida* spp·m^{-2}**	***Funiculina quadrangularis*·m^{-2}**	**Trawl tracks·m^{-2}**	**Tot. SA viewed (m^2)**	**No. stations**
			2009			
DC	1.247 (0.457)	0.335 (0.108)	0.001 (0.002)	0.017 (0.015)	1621.30	7
DI	0.886 (0.258)	0.147 (0.084)	0.001 (0.001)	0.021 (0.006)	5385.21	21
SC	1.236 (0.298)	0.169 (0.139)	0.001 (0.003)	0.021 (0.015)	3040.51	12
SI	0.942 (0.260)	0.156 (0.126)	0.016 (0.031)	0.019 (0.010)	2529.49	9
			2010			
DC	1.139 (0.438)	0.147 (0.136)	0.001 (0.001)	0.012 (0.009)	1677.12	7
DI	1.027 (0.271)	0.084 (0.181)	0.001 (0.002)	0.016 (0.010)	4853.16	20
SC	1.351 (0.426)	0.003 (0.006)	0.003 (0.010)	0.022 (0.0124)	3117.53	13
SI	1.201 (0.320)	0.004 (0.009)	0.004 (0.011)	0.014 (0.011)	3008.40	12

The footage produced by the *Nephrops* UWTV assessment survey of the Pomo (Jabuka) pits (Adriatic Sea) in 2009 and 2010 allowed the quantification of two organisms (*Munida* spp. and *Funiculina quadrangularis*) and topographic features (trawl tracks) other than the target *Nephrops* burrows, even under poor visibility conditions. In this particular case, the reason why these identifications were possible was related to the uniqueness of the squat lobster shape and their relatively large size, the prior knowledge of the distribution of *Funiculina quadrangularis* compared to other sea pens in the area and the distinctiveness of otter door furrows on the seabed. The extent to which footage from UWTV surveys for *Nephrops* will be suitable for other ecological purposes greatly depends on the organisms/features to be quantified (i.e. their distinctiveness, their relative size and their habits), the quality of footage and the degree of expertise of the viewer. If these conditions were all met simultaneously, this would allow for the assessment of these accessory species of choice along with the production of quantitative distribution maps even in a historic context, where footage was to be available (ICES, 2010).

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