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A novel underwater visual census: Seahorse population survey as a case study

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HIGHLIGHTS

- UVC2 was more effective in finding seahorses, particularly at low density.
- UVC2 might be used to survey other seahorse species populations.
- UVC2 can be used to survey other benthic species.

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ABSTRACT

Two different Underwater Visual Census (UVC1 and UVC2) were performed at three sites in the Ria Formosa, using 30 meter transect belts, and compared for differences in seahorse density and holdfast availability. Each UVC differed in transect placement and total survey area coverage. The observed *Hippocampus guttulatus* density was significantly higher ($P < 0.05$) using UVC2 for Site 1 and Site 2, but not in Site 3. No statistically significant differences were found in holdfast availability ($P > 0.05$) between the two UVC methods. We conclude that the UVC2 method is more effective in quantifying abundance of seahorses compared with UVC1, particularly in low population density scenarios. This method can also be used in assessing other seahorse species' populations, in similar habitats.

1. Introduction

The first underwater visual census (UVC) were performed by Brock (1954) and set the basis for most studies on fish ecology using visual techniques. UVCs have since been used to study a wide variety of marine fish species, especially those exploited in fisheries (Russ, 1984; Kulbicki, 1998; Ferreira et al., 2004; Mayo and Jackson, 2006; McClanahan et al., 2009). The non-destructive nature of this technique makes it appealing for fish monitoring as it is fisheries-independent, quick and relatively inexpensive (Watson and Quinn, 1997). UVCs have also been reported to be an appropriate technique for estimating the abundance of shallow-water reef fish and are used worldwide (García-Charton et al., 2004; Floeter et al., 2007; Stobart et al., 2007; Evans et al., 2008; Leopold et al., 2009; Andrefouet and Wantiez, 2010). This method involves systematic data collection in the surveyed area, enumerating the animals and collecting environmental information (Curtis et al., 2004) and it can be used for the estimation of relative abundances, biomass, and distribution of fish populations (Andaloro et al., 2011; Cenci et al., 2011; Pelletier et al., 2011).

However, underwater visual surveys present specific challenges, including restricted surveying time spent underwater, observer mobility and underwater visibility (Charton et al., 2000; Williams et al., 2006). Thus, UVC methodology has been adapted to monitor fish populations depending on the target fishes' biology, behaviour and surveyed area (Mapstone and Ayling, 1998; Samoilys and Carlos, 2000; Ordines et al., 2005).

UVC has been widely used for surveys of particular fish families and species (De Raedemaecker et al., 2010; Kulbicki et al., 2010), including seahorses (Bell et al., 2003; Curtis et al., 2004; Curtis and Vincent, 2005; Freret-Meurer and Andreata, 2008; Caldwell and Vincent, 2012). Although several UVC techniques have been used to monitor Syngnathid species, from timed swims (Martin-Smith, 2011; Harasti et al., 2014) to permanent transects (Sanchez-Camara and Booth, 2004), none have been tested for the two seahorse species that inhabit the Ria Formosa lagoon. In the early 2000's, Curtis and Vincent (2005) used UVC to describe the highest seahorse densities ever recorded in the Ria Formosa lagoon or anywhere elsewhere in the world. The protocol used in the latter study

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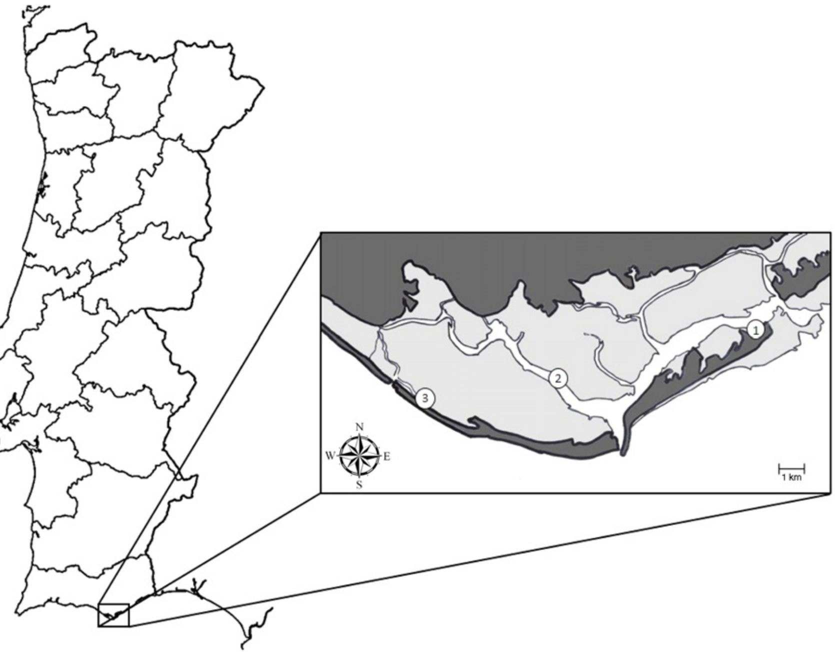

Fig. 1. Sites location in the Ria Formosa lagoon. Site 1 (1), Site 2 (2) and Site 3 (3).

was designed based on this high seahorse density and the wide distribution of the focal species throughout the lagoon. However, a more recent study of the same seahorse populations using Curtis and Vincent (2005) UVC methodology showed a significant decrease in seahorse density: 94% and 57% for *Hippocampus guttulatus* Cuvier 1829 and *Hippocampus hippocampus* Linnaeus 1758, respectively (Caldwell and Vincent, 2012). Most seahorse species are found at low densities and are patchily distributed (Perante et al., 2002; Bell et al., 2003; Martin-Smith and Vincent, 2005; Freret-Meurer and Andreata, 2008; Harasti et al., 2012) which highlights the importance of a proper UVC method to accurately assess the populations. This study aimed to compare a modified UVC technique designed to survey sedentary fish populations at low densities, with a previously used one, in order to assess seahorse populations in the Ria Formosa lagoon.

2. Material and methods

Two seahorse species occur in the Ria Formosa lagoon (South Portugal), the long snouted seahorse (*H. guttulatus*) and the short snouted seahorse (*H. hippocampus*). These species are easily distinguishable by their size and morphological traits, including coronet shape, number of trunk rings (Lourie et al., 2004) and skin colour patterns. The two species share a similar distribution in shallow, coastal waters of the north-eastern Atlantic Ocean and Mediterranean Sea (Lourie et al., 2004). However, they have distinct habitat preferences: while *H. guttulatus* has been reported to prefer habitat with greater complexity such as seagrass meadows, *H. hippocampus* is mostly found in low complexity sandy habitats (Curtis and Vincent, 2005).

Underwater surveys were carried out in the Ria Formosa lagoon (36° 59′N, 7° 51′W) and three locations were selected and surveyed on 3 occasions (Fig. 1). Surveys were performed in May and June 2012.

The surveyed sites were chosen due to their differences in habitat characteristics (Table 1). A GPS unit (Garmin® GPSMap 78s) was used to accurately determine the location of each study area and during the site delineation. The same bearing was taken while laying each transect so that the same area could be consistently covered on each sampling occasion.

On each sampling occasion, the two survey techniques were performed by SCUBA simultaneously in order to minimize bias derived from individual seahorse's daily movement. First, the UVC method (Caldwell and Vincent, 2012) was used and hereafter described as UVC1. In this methodology, three 30 m belt transects were randomly placed >5 m apart, and a 1 m wide strip on each side for each transect was covered by two divers (Fig. 2(a)), for a total area of 180 m^{-2} per site. The second UVC method (specifically designed for this study) was then performed after the completion of UVC1, hereafter described as UVC2. UVC2 consisted of placing two 30 m belt transects in parallel and 2 m wide strips on each side were surveyed, covering a total area of 240 m^{-2} (Fig. 2(b)). Surveys were carried out by 2 divers in each UVC method. Both divers performed the two UVC methods in order to minimize observational bias. All surveys were carried out at slack high tide when turbidity is lowest, visibility greatest and to minimize effects of the water current. At each sampling site, the two methodologies were performed over a 2 h period. Whenever a seahorse was found, information on species, sex, substrate type, holdfast type and overall bottom coverage (in a 1 m^2 diameter area at each seahorse location) was recorded. Habitat complexity was considered low if bottom coverage (i.e. number of holdfasts available), was less than two holdfasts m^{-2}; medium for 2–10 holdfasts m^{-2}; and high for more than 10 holdfasts m^{-2}. Holdfast distribution was considered patchy when the distance between holdfasts was greater than a 3-m radius. In each sampling, human related activities were recorded to determine their impact in each site. Sites were considered as highly impacted by human activities when two or more activities were observed during all the sampling occasions (i.e., fishing, boat traffic and anchoring); medium impact when at least two of the activities were observed in at least half of the sampling occasions; and low impact when less than two activities were observed in less than half of the sampling occasions. Seahorse abundance was calculated for each UVC at each site, and the Student *t*-test was used to test for differences in abundance (Zar, 1999). For each site, the 3 surveys were pooled together for the statistical analysis.

3. Results

The observed overall mean ± S.D. seahorse abundances (both species pooled together) using UVC1 was 12.0 ± 4.0, 3.0 ± 1.0 and

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