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Experimental beam-trawling in *Lanice conchilega* reefs: Impact on the associated fauna

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Abstract

To study fisheries impact at the species level in temperate sandy bottom areas, a controlled field manipulation experiment was designed focusing on areas with high densities of the habitat-structuring, tube-dwelling polychaete *Lanice conchilega* (i.e. *L. conchilega* reefs). The hypothesis was that the impact on *L. conchilega* would be minimal, but that the fauna benefiting from the biogenically structured habitat would be impacted by beam-trawling. In this study, the impact of beam-trawl passage on intertidal *L. conchilega* reefs and its associated fauna was quantified. A treatment zone was exposed to a one-off experimental trawling. Subsequently, the impact on and recovery of the associated fauna was investigated for a period of 9 days post-impact. Community analysis showed a clear impact followed by a relatively quick recovery as apparent through MDS analysis (stress 0.06), a significant ($p < 0.001$) IMS of 0.61, through ANOSIM analysis: significant ($p = 0.001$) dissimilarities between treatment and control and through SIMPER analysis (decreasing dissimilarities over time). This impact and subsequent recovery was largely explained by two species: *Eumida sanguinea* and *Urothoe poseidonis*. Species analysis confirmed the beam-trawl passage significantly ($p = 0.001$) impacted *E. sanguinea* for the whole period of the experiment. The experiment confirmed that closely associated species of *L. conchilega* reefs are impacted by beam-trawl fisheries. This small-scale intertidal study provides some pointers which indicate that the tightly associated species will be impacted significantly when beam-trawling *L. conchilega* reefs in subtidal areas.

Keywords: Beam-trawl disturbance; Associated fauna; *Lanice conchilega*; *Eumida sanguinea*; GLMM

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1. Introduction

1.1. Fisheries impact on soft bottoms

Impact of fisheries on benthic ecosystems has been reported to vary substantially depending both on the type of gear used and on the nature of the impacted habitats (e.g. Brylinski et al., 1994; Kaiser et al., 2006). The impact of beam-trawling on soft-sediment systems has already triggered considerable attention (e.g. Bergman and Hup, 1992; Kaiser and Spencer, 1996; Sparks-McConkey and Watling, 2001). However, the former studies did not focus on specific habitats or niches within these soft-sediment systems. Kaiser et al. (2002) mention that biogenically structured habitats are more adversely affected by fishing than unconsolidated sediment habitats. Moreover, biogenically structured habitats have the longest recovery trajectory in terms of recolonisation of the habitat by the associated fauna. Yet, soft-sediment organisms that create structures reaching only a few centimetres into the water column have been described as an important habitat supporting a diversity of taxa (cf. ecosystem engineers: Jones et al., 1997; Coleman and Williams, 2002), including post-settlement juveniles of commercially important fish (Watling and Norse, 1998). Quantifying the resilience of biogenically created habitats towards fisheries in soft sediments is therefore considered to be a key factor in assessing fisheries impact in the soft sediment environment.

1.2. Lanice conchilega

This study focuses on the habitat engineer (Rabaut et al., 2007) *Lanice conchilega* (Polychaeta). This tubeworm can be found in elevated patches of high densities (Ropert and Dauvin,

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2000), in which suspended material is trapped. The availability of habitat structures and their effect on the local hydrodynamic regime are important causal factors for polychaete larvae settling (Callaway, 2003). As such, patches of high abundances trap sediment and evolve towards biogenic emergent structures. They are referred to as "*L. conchilega* reefs" and create a heterogeneous habitat, which attracts species from the surrounding unconsolidated environment, thus enhancing biodiversity (Dittmann, 1999; Zühlke, 2001; Ager, 2002). The fauna associated with *L. conchilega* reefs depends to some extent on the nature of the habitat and the species community but *L. conchilega* always has an effect on the benthos (Zühlke et al., 1998; Dittmann, 1999; Rabaut et al., 2007). Some of these species live in commensal relationship with *L. conchilega*, such as *Eumida sanguinea* (Callaway, 2006), a predatory polychaete living between the fringes of the tubes. Besides the increased diversity, intertidal *L. conchilega* reefs harbour high benthic standing stocks and are considered to be highly productive (Zühlke et al., 1998; Zühlke, 2001; Callaway, 2006). Also in subtidal areas, *L. conchilega* acts as a bio-engineer (Rabaut et al., 2007). As enhanced standing stocks and productivity attract opportunistic demersal predators such as sole and plaice, the multitude of target species makes these reefs attractive for fisheries (Rijnsdorp et al., 2000).

1.3. Aims of the study

This experimental study was designed to quantify beam-trawl impact on the associated fauna community of *L. conchilega* reefs. Since *L. conchilega* has high chances to survive beam-trawling, avoiding damage by quickly retreating into its tube (Bergman and Hup, 1992), it was expected that experimental fishing would not harm *L. conchilega* individuals. The hypothesis was that species most associated with *L. conchilega* and occurring in high abundances would be mostly impacted by the disturbance. As these species shape the community structure in the reef systems, a community shift was expected after disturbance, followed by a rapid recovery. The final aim was to investigate the response mechanism to have some pointers of how similar *L. conchilega* reef systems in subtidal areas respond to beam-trawl fisheries.

2. Methods

2.1. Intertidal study area

This impact study was carried out in the intertidal zone, which offered several advantages for a controlled field experiment. Firstly, there was no interference with commercial fisheries. This was related to the limited depth and the location in a protected zone where fishermen are not allowed. Secondly, the substantial tidal range made it possible to disturb the plots at high water spring tide (HWST) and to look for evidence of gear passage at low water spring tide (LWST). Thirdly, it was possible to sample manually and to visually follow up the recovery. The experimental area was situated in the intertidal zone of the seashore of Boulogne-sur-mer, France (50°44.10′N, 1°35.25′E; Fig. 1), a pocket-beach sheltered by two harbour walls. The largest zone covers an area of about 45,000 m^2 and is situated below the mean low waterline at spring tide. These lower reefs are only visible with extreme LWST conditions. The reef zones located higher on the beach were exposed at every low water: patches of the higher western zone occupied an area of about 4000 m^2, while the higher eastern zone has patches with a total area of 2500 m^2. The experiment was performed in the latter areas in which a treatment and control zone was delineated prior to disturbance (Fig. 1). *Lanice conchilega* patches in this study area reach on average densities of 3259 ± 269.1 individuals/m^2 (±SE) and the maximum density observed was 8262 individuals/m^2. These densities however, differed at a small scale (i.e. within the same reefs). This is an inherent characteristic of the investigated system as has been recorded by Carey (1987) and Heuers et al. (1998). Novel statistical modelling techniques allowed inclusion of the *L. conchilega* densities and modelling of the error structure as such (cf. *infra*).

2.2. Disturbance and sampling

On 13 February 2006, during HWST, a one-off disturbance event was simulated with the RV Sepia 2. A beam-trawl of 2.9 m width trawled the previously delineated treatment zone nine times. At the low tide (T0) following the experimental fishing, *L. conchilega* patches with evidence of beam-trawl passage were traced. Three treatment plots were defined (TR1–3) and four control sites (C1–4) were selected randomly and marked with star pickets to facilitate future tracing. Macrofauna samples were collected with an inox macrocorer of 15 cm diameter (i.e. 0.017 m^2), sampling to a depth of 40 cm. Each set of replicate samples was accompanied by an additional sample collected for sediment (diameter 3.6 cm; penetration depth 5 cm).

To estimate the recovery of associated fauna, the site was subsequently sampled at every low tide during 3 days (T1–T4) (Table 1). At every sampling event, all treatment and control plots were sampled. Each sampling event took place around the moment of lowest water level to be able to reach the study area. The last sampling event (T5) was carried out 200 h after disturbance. Macrofauna was sieved alive on a 1 mm mesh size, fixed in 4% formalin–seawater solution and stained with Rose Bengal.

Table 1
Disturbance (D) and sampling times of the experiment

Sampling time	Hours after D
D	0
T0	6
T1	18
T2	30
T3	42
T4	54
T5	200

The hours are indicative and coincide in reality with the moment of lowest water level to be able to reach the study area.