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Effects of coastal fish farms on body size and isotope composition of wild penaeid prawn

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ABSTRACT

Penaeid prawn are highly valued throughout the Mediterranean Sea where they support artisanal fisheries that may be affected by coastal fish farming. We examined the effects of proximity to costal fish farms on body size and stable isotope composition of the caramote prawn *Melicertus kerathurus*, a species that supports a valuable artisanal fishery. Prawn sampled near fish cages were significantly larger, heavier and more depleted in ^{13}C than those sampled further away, while laboratory trials confirmed that prawn can readily feed on fish food pellets. Proximity to fish farms had no effect on ^{15}N isotope values, which became depleted with increasing body size, possibly as a result of organ differentiation during ontogeny. Our results indicate that fish farms can have a positive effect on the size of prawn in the vicinity of floating cages, possibly by facilitating their growth or by protecting them from the fishery. However, fish farms can also affect the isotope composition of wild prawn, and thus likely their nutritional value. These findings highlight the need to examine the potential effects of fish farms on prawn fisheries in the Mediterranean region, an area where artisanal fisheries and coastal aquaculture need to coexist in the same locations.

1. Introduction

Coastal fish farming using open-net cages is expanding around the world (Soto, 2009), including the Mediterranean Sea (Trujillo et al., 2012), where it can compete for space and resources with artisanal fisheries (Machias et al., 2006; Fernandez-Jover et al., 2008). One of the most common impacts of cage aquaculture in coastal waters is the organic enrichment of marine sediments (Holmer, 2010). Organic matter, in the form of uneaten fish feeds and faeces from cultured fish, sink to the bottom underneath the cages or are spread by the currents. Thus, the effects of coastal fish farming extends to both the benthic and pelagic levels, over scales ranging from tens to hundreds of metres in the case of benthic ecosystems, to kilometres in the case of pelagic resources (Kalantzi and Karakassis, 2006; Giles, 2008).

The effects of coastal fish farming on wild fish assemblages are reasonably well understood, but very little is known about effects on other taxa. Wild fish assemble around fish cages (Dempster et al., 2004; Bacher et al., 2012; Ozgul and Angel, 2013) where they consume particulate organic matter drifting off the farms, increase their body condition and help to decrease sediment enrichment (Fernandez-Jover et al., 2008; Dempster et al., 2011). Fish feeding on nutrients originating from fish farms may remain near sea-cages (Akyol and Ertosluk, 2010; Bagdonas et al., 2012) or move off the farms, where they can be landed by artisanal fisheries, potentially entering the food supply and reaching the consumers (Arechavala-Lopez et al., 2011). However, studies on the trophic subsidy of fish farms to crustaceans and other invertebrate fishery resources are very scant

The penaeid prawn *Melicertus kerathurus* (Forsköl, 1775) is a highly valued decapod crustacean that is fished throughout the Mediterranean and the West Atlantic Coasts, from Angola to Britain (Rodriguez, 1977; Holthius, 1980; Palomares and Pauly, 2013). This species can command a high market price and the correct management of the stock is important for the sustainability of the local fisheries and the communities who rely on them. Despite its wide distribution, it has been suggested that the management of the species needs to carried out at a local scale (Pellerito et al., 2009), depending on the geographical areas where it is exploited. Studies conducted over the last few years have identified several

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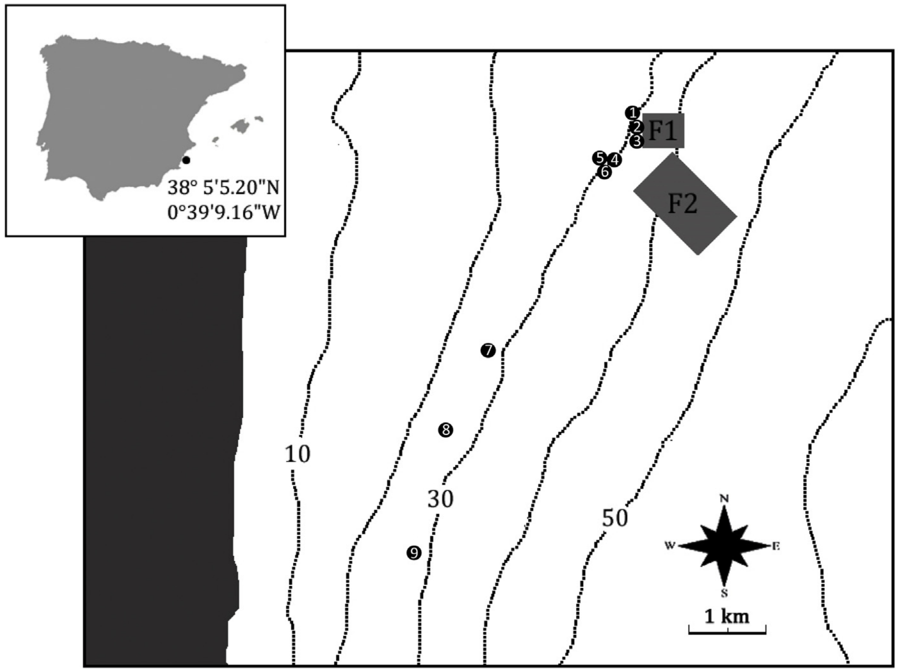

Fig. 1. Location of fish farms (F1, F2) at Bay of Santa Pola (Alicante, SE Spain) showing 9 sampling locations where caramote prawn were sampled at increasing distances from fish farms.

abundance 'hotspots' along the Mediterranean coast and clarified aspects of the fishery and the species' ecology (Turkmen and Yilmazyerli, 2006; Lumare et al., 2011; Kevrekidis and Thessalou-Legaki, 2011), but little is known about the potential impacts of coastal fish farms on this and other crustaceans (Holmer, 2010).

Stable isotopes can be used as ecological tracers to detect the influence of organic matter originating from fish farms, both in the surrounding environment (Holmer et al., 2007) and in the organisms that live around fish cages (Dolenec et al., 2007; Redmond et al., 2010), or escape from fish cages (Schröder and Garcia de Leaniz, 2010). Although much is known about the effects of coastal farms on fish assemblages, comparatively little is known about their effects on invertebrates, some of which such as the penaeid prawns are highly valued and may be endangered (Olsen et al., 2009; Olsen et al., 2012).

Our aim was to examine the potential trophic impacts of fish farming on the penaeid prawn *M. kerathurus*, given its high importance to local fisheries. To do so, we employed stable isotopes analysis of carbon and nitrogen (δ^{13}C and δ^{15}N) and a combination of laboratory feeding trials and field sampling around fish cages. As fish food pellets tend to be high in lipids and typically depleted in both δ^{13}C and δ^{15}N relative to aquatic organisms (Molkentin et al., 2007; Vollaire et al., 2007), our hypothesis was that trophic influences, detected by corresponding shifts in isotopic values, would increase with duration of feeding on fish pellets and also with proximity to fish farms. We also predicted that if prawn were feeding on excess fish food around fish cages they might grow faster and accumulate more fat reserves, which could perhaps be detected by an increase in body size and a higher C:N ratio compared to prawn unaffected by fish farming.

2. Material and Methods

2.1. Study site and field sampling method

The field study was carried out in the Bay of Santa Pola (Alicante, SE Spain, Fig. 1), an area with two large fish farms located on sandy and muddy bottoms (average depth 35 m) that produce c. 2000 t. of fish annually each, mostly of gilthead sea-bream (*Sparus aurata* L.) and sea-bass (*Dicentrarchus labrax*; (Izquierdo-Gómez et al., 2014)).

Penaeid prawn *M. kerathurus* were sampled from fishing vessels operating in the study area on six occasions from 18th July to 14th August 2012. Between 8 and 12 individuals were randomly collected at each of nine sites located between 44 and 6900 m from the fish farms and along the same 25–30 m depth isopleths (Figure 1). Prawn were measured (carapace length, mm), weighed (wet weight, 0.1 g) and stored at −80 °C until analysis. Fulton's condition factor *K* (Araneda et al., 2008) was calculated to assess changes in body biomass and length that might be related to food availability and growth in relation to the addition of organic matter from fish farms.

2.2. Feeding trial in captivity

A small pilot feeding trial was carried out in captivity in order to obtain baseline isotopic values of prawn fed exclusively on fish feed. A total of 20 prawn were taken alive from the fishing boats to the laboratory at University of Alicante on three occasions, where they were distributed equally between two 100 L. glass aquaria filled with artificial seawater (37 ppm) and kept at 20 °C with continuous aeration. Prawn were fed four food pellets/day/individual, being the same type (Skretting L-Alterna) as that used in the commercial fish farms. Uneaten food pellets were siphoned daily before each feeding and approximately half of the water was replaced once a week to maintain water quality. Any dead prawn were removed within the next 12 h but these were not replaced during the experiment. Individuals were measured, weighed and stored at −80 °C until analysis, and those individuals which could be individually identified and survived for 4–55 days were used for the analysis of the effects of feeding duration on isotopic values ($n = 10$). Feeding was ascertained by visual observation and presence of digested fish food in the digestive tract following dissection. To estimate the likely isotope values of prawn feeding on fish pellets in the wild, we employed a trophic discrimination factor (TDF) of 2.25‰ for δ^{15}N and 0.25‰ for δ^{13}C based on equations for invertebrate tissue (Caut