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Addition of dissolved nitrogen and dissolved organic carbon from wild fish faeces and food around Mediterranean fish farms: Implications for waste-dispersal models

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Abstract

Leaching of ammonium (NH_4^+) and dissolved organic carbon (DOC) from food pellets used at three fish farms in the Mediterranean Sea and the faeces of four different species of farm-associated wild fish (*Trachurus mediterraneus*, *Mugil cephalus*, *Trachinotus ovatus* and *Boops boops*) were determined. They were placed in seawater and agitated slowly (5 cm s^{-1}) to reflect natural conditions during their fall to the sediment. Two temperatures were tested, 25 °C and 15 °C, to assess the influence of seasons on leaching rates. Leaching from fish faeces was generally higher compared to food pellets. *T. mediterraneus* faeces leached more NH_4^+ and DOC than *M. cephalus*, *T. ovatus* and *B. boops*. The results showed that there is an important addition of NH_4^+ and DOC to the water column during sinking of the faeces and that this is species-dependent. Water turbulence and faeces composition seemed to have a higher influence than temperature on the leaching process. Due to the high abundance and biomass of farm-associated fish in the Mediterranean and their capacity to remove waste, they appear to be an important component for models that predict the impact of aquaculture. Large biomasses of wild fish at fish farms may reduce the impact on benthic systems but increase the nitrogen and carbon loads into the water column, affecting the pelagic system and modifying the spatial dispersion of wastes.

Keywords: Ammonium; Aquaculture; Dissolved organic matter; Farm-waste dispersal; Leaching; Wild fish

1. Introduction

As sea-cage aquaculture continues expanding rapidly along the Mediterranean coast both in the number of farms and production (FAO, 2003), it is necessary to be more accurate when predicting potential impacts of this practice. Consequently, much research has focused on modelling the dispersal of sea-cage farm wastes to infer the impact of aquaculture more precisely and thus improve management actions and find the most suitable places to locate farms (see Cromey and Black, 2005 for review).

The environmental modifications that sea-cage aquaculture produces on the benthos (Karakassis et al., 2000) and water column (Pitta et al., 1999) are quite well

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known. Moreover, some works have detected the effect of aggregated wild fish in reducing the impact on the benthos (e.g. Katz et al., 2002; Vita et al., 2004). There are models that include wild fish as removers of feed wastes (http://www.meramed.com) but they are only considered as a sink of organic matter. However, the associated ichthyofauna continues the process of transformation of wastes through excretion and defecation, projecting the nitrogen and carbon from the food pellets to the pelagic environment. However, even though it is possible to infer the quantity of waste material removed by wild fish, the effect of their defecation on the nutrient fluxes is more difficult to assess (Cromey and Black, 2005).

Leaching of nutrients from fish faeces during sinking has not been studied except for some cultivated species like salmon (Phillips et al., 1993; Tlusty et al., 2000; Chen et al., 2003), sea bass and sea bream (Magill et al., 2006). Due to the high abundance and biomass of farm-associated wild fish in the Mediterranean (Dempster et al., 2002, 2004) we hypothesized that they may have an important role by changing the pattern of addition of nutrients to the environment, reducing the impact on the benthos by feeding on the lost pellets and increasing nutrient levels in the water column. Also, we considered that water temperature should be an important factor that affects leaching rates. Therefore, we compared the NH_4^+ and DOC leaching from the faeces of four important species (*Trachurus mediterraneus*, *Trachinotus ovatus*, *Boops boops* and *Mugil cephalus*) to that of food pellets at two temperatures; 25 °C and 15 °C (summer and winter conditions respectively). Since the aggregation of these species of wild fish around Mediterranean fish farms seems to be a general phenomenon (Dempster et al., 2002, 2005; Smith et al., 2003; Thetmeyer et al., 2003), the data obtained here may help to develop more accurate models to predict the effect of aquaculture on coastal environments.

2. Materials and methods

Wild fish aggregated around three fish farms separated by 50 km along the south-east coast of Spain (Fig. 1) were captured. The farm at Campello was 3.2 km off the coast at an average depth of 28.6 m; the farm at Guardamar was 3.7 km from shore at a depth of 22.6 m; and the farm at Altea was 2.8 km offshore at an average depth of 34 m. Mean current speed at farms were measured at every site at 15 m depth. Current speeds were 5.2 cm/s at Campello (40 days of record), 3.5 cm/s at Guardamar (44 days of record) and 3.4 cm/s at Altea farm (51 days of record, Workhorse Sentinel Acoustic Doppler Current Meter). The maximum temperature in summer is 27 °C and 13 °C is the minimum temperature of water during winter season. All farms reared sea-bass (*Dicentrarchus labrax*) and sea-bream (*Sparus aurata*). Fish were caught during December 2004 and January 2005; the target species were the mugilid *M. cephalus*, the carangids *T. mediterraneus* and *T. ovatus* and the sparid *B. boops*. Due to the different abundance of the species around each farm, every species was captured in a single farm; *M. cephalus* was captured in Guardamar, *T. ovatus* in Altea, and *T. mediterraneus* and *B. boops* were fished in Campello farm. Food pellets used to feed cultivated fish were collected from the three

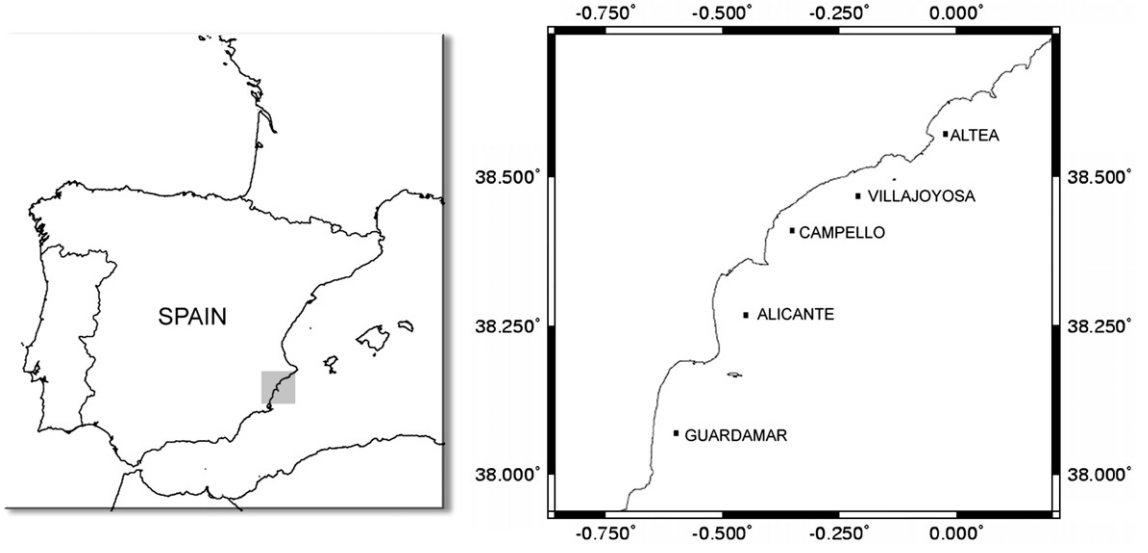

Fig. 1. Map of the three Sea Bream and Sea Bass farms on the SE coast of Spain where farm-associated wild fish were collected from.