Journal of Sea Research 76 (2013) 22–30

Contents lists available at SciVerse ScienceDirect

Journal of Sea Research

journal homepage: www.elsevier.com/locate/seares

PCBs in the fish assemblage of a southern European estuary

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ARTICLE INFO

Article history:
Received 12 December 2011
Received in revised form 7 August 2012
Accepted 29 September 2012
Available online 21 November 2012

Keywords:
PCBs
Mondego Estuary
Fish Assemblage
Accumulation

ABSTRACT

The Mondego estuary fish assemblage was studied for the accumulation of PCBs. Three sampling stations were visited along an estuarine salinity gradient, and, in total, 15 species were collected. Analysis of PCBs revealed no significant differences among the sampling stations, although differences were observed among the fish assemblages. Fish assemblages could be divided into three groups. The first group comprised those with higher concentration (more than 10 ng g^{-1}, dw), included the species *Gobius niger*, *Sardina pilchardus*, *Anguilla anguilla*, *Pomatoschistus microps*, *Chelidonichthys lucerna* and *Liza ramada*; the second group with medium concentration (5–10 ng g^{-1}, dw), included the species *Pomatoschistus minutus*, *Dicentrarchus labrax*, *Atherina presbyter*, *Chelon labrosus*, *Diplodus vulgaris*, *Platichthys flesus* and *Cilata mustela*; and a third group with low concentration (less than 5 ng g^{-1}, dw), included the species *Solea solea* and *Callionymus lyra*. A positive correlation was found between lipid content and PCB concentrations. To evaluate the influence of the residence time of species on the accumulation of PCBs, species were divided into two groups: species that spend more than 3 years in the estuary, and species that spend less than 3 years in the estuary. Species that spend more than 3 years in the estuary presented higher concentrations than species that spend less than 3 years in the estuary. CBs 138 and 153 had higher concentration, and tended to increase with time spent in the estuary.

1. Introduction

Estuaries are transitional areas that have strong environmental gradients, mainly due to salinity (Elliot and McLusky, 2002). Transitional areas have a very important role for fish fauna, since they provide nursery habitats, reproduction grounds, refuge against predators, and migratory routes (Cabral et al., 2007; Martinho et al., 2008). Many marine species with commercial value use transitional areas in parts of their life-cycles, and estuaries are important for the renewal of fish resources (Nicolas et al., 2007). In general, estuaries are exposed to high degrees of anthropogenic stress (Elliot and Quintino, 2007), such as agricultural activities, industrial outflow and urban runoff, overfishing, bank reclamation, and general environmental degradation (Nicolas et al., 2007).

Polychlorinated biphenyls (PCBs) are a class of environmental contaminants which tend to accumulate in fish. Their persistence in marine ecosystems can be due to their relatively long environmental half-live, low metabolic transformation and hydrophobicity (Stapleton et al., 2001).

In the estuarine environment, the study of organic pollutants is important. Estuaries with persistent organic pollutants present low quality habitats and habitat losses, which can have consequences for fish growth, survival and population renewal (Courrat et al., 2009). Fishes can be important in monitoring ecosystems, although the bioaccumulation patterns vary among species. Fishes can concentrate pollutants directly from water (bioconcentration) (Costa et al., 2008) and through their diet (biomagnification) (Borga et al., 2001), allowing the transfer of pollutants through the trophic web. Furthermore, they accumulate according to their trophic level, different assimilation efficiencies, depuration rates, and lipid content (Stapleton et al., 2001). Fishes are considered to be useful tools to assess anthropogenic impact, because they have low congener metabolism rates (Muir et al., 1988) reflecting the levels of pollution in the aquatic environment. Different species of fish occupy different habitats in the same ecosystem and have different feeding behaviours. As a result, they are used as a good proxy to assess the influence of the environment and biological factors on the bioaccumulation of pollutants (Pastor et al., 1996).

Both commercial and non-commercial species are important for the function of the estuarine environment. So it is important to determine and compare PCB concentrations in commercial and non-commercial species. Many studies performed in estuaries have only compared the contamination among different estuaries (Courrat et al., 2009; Harvey et al., 2008) and in commercial species, like *Anguilla anguilla* (Ashley et al., 2003), *Solea senegalensis* (Costa et al., 2008), or *Dicentrarchus labrax* (Pastor et al., 1996). Only a few studies have been made regarding the entire estuarine fish assemblage (Veltman et al., 2005) including the non-commercial estuarine species. The present study aimed to

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1385-1101/$ – see front matter
http://dx.doi.org/10.1016/j.seares.2012.09.011

detect PCBs in the estuarine fish assemblage of the Mondego estuary, including many species with commercial and non-commercial value. From a study of a wide fish assemblage, certain questions can be addressed, especially: a) are there differences among the fishes' with respect to their PCB concentrations from different areas of the estuarine system; b) are there differences among different species of the estuarine fish community, regarding PCB accumulation; and c) what are the main factors influencing interspecies trends in PCB accumulation?

2. Materials and methods

2.1. Study site and fish community

The Mondego estuary (Fig. 1) is a small estuary of 8.6 km^2 located in the western coast of Portugal (40°08′N, 8°50′W). It comprises two arms, the north and the south arm, with distinct hydrologic characteristics. The north and the south arm are separated for about 7 km inland of the coast, joining again near the mouth of the estuary. The north arm is deeper, being 5–10 m in depth at high tide with 2–3 m of tidal range. It is dredged frequently to maintain its depth, because it is the main navigation channel of the Figueira da Foz harbour. The south arm is shallower, being 2–4 m at high tide, and with 1–3 m of tidal range, presenting about 75% of the intertidal mudflats. The south arm is largely silted up in the upstream areas, causing the water to flow mainly through the north arm. The water circulation in the south arm mainly depends on the tides and on small freshwater inputs from the Pranto River, which is controlled by a sluice, according to the needs in the rice fields from the Mondego agricultural valley.

2.2. Sampling and laboratory work

Fishing was carried out at three sampling stations (M, N and S in Fig. 1) following a typical salinity gradient; M station is the most downstream station presenting higher salinity values, whereas N and S stations are located more upstream, and with lower salinity values. N and S stations have distinct hydrologic characteristics. N station is located in the north arm, where the runoff is higher, while S station is located in the south arm, where the runoff depends on inputs from the Pranto River. Since the three sampling stations have different environments, the fish populations within these stations are also different. Fishing to collect samples took place at these three stations, in order to obtain a sufficient number of fish species of the Mondego estuary.

The fishes were collected between November and December 2009. Fishing was carried out during the night, using a 2 m beam trawl, with 5 mm stretched mesh size in the cod end. Each survey consisted of three hauls of 5 min at each sampling station, covering at least an area of 500 m^2. The fishes were taken to the laboratory where they were identified to the species level and muscle tissues were removed. For each species and each sampling station, 3 samples were analysed for PCBs, given a total of 81 samples analysed. Due to their lack of mass, small fishes were analysed as a composite sample, using 2 to 8 individuals in each sample. After laboratory processing, samples were freeze-dried (Snijders scientific), homogenised and stored at −20 °C, until analysis. Sediments were collected between November and December 2009, at two sampling stations (M and S in Fig. 1).

2.3. PCB analysis

Sediment samples were freeze-dried, sieved to <1 mm, homogenized and frozen (−20 °C) and wrapped in aluminium foil. Representative aliquots were Soxhlet-extracted with a hexane/acetone mixture (2:1) for 6 h at a rate of 4–6 cycles/h, in a pre-washed glass fibre thimble (Folch et al., 1996). Activated copper granules were added to remove elemental sulphur. The resultant extract was concentrated using a rotavapor and submitted to an alumina cleanup (Supelclean® neutral-alumina and anhydrous sodium sulphate at the top) using a solid phase extraction (SPE) system. The column was eluted with hexane:DCM (9:1) and hexane:DCM (2:1). The eluate was then concentrated down to 1 mL using a rotavapor, dried under a gentle stream of nitrogen and solvent changed to hexane. The extract was further submitted to an acid silica gel (Supelclean® silica gel with 44% w/w concentrated sulphuric acid) cleanup and PCBs were eluted with hexane. The eluate was concentrated down to 1 mL using a rotavapor, dried under a gentle stream of nitrogen and the solvent changed to isooctane for further processing by gas chromatography coupled to mass spectrometry (GC–MS).

For biota analysis, 3 g of muscles was accurately weighted and extracted by sonication (Branson 3510) with a *n*-hexane:acetone (1:1) mixture. The extract was decanted and the process repeated three times. The extract volume was reduced by solvent evaporation using a rotavapor.

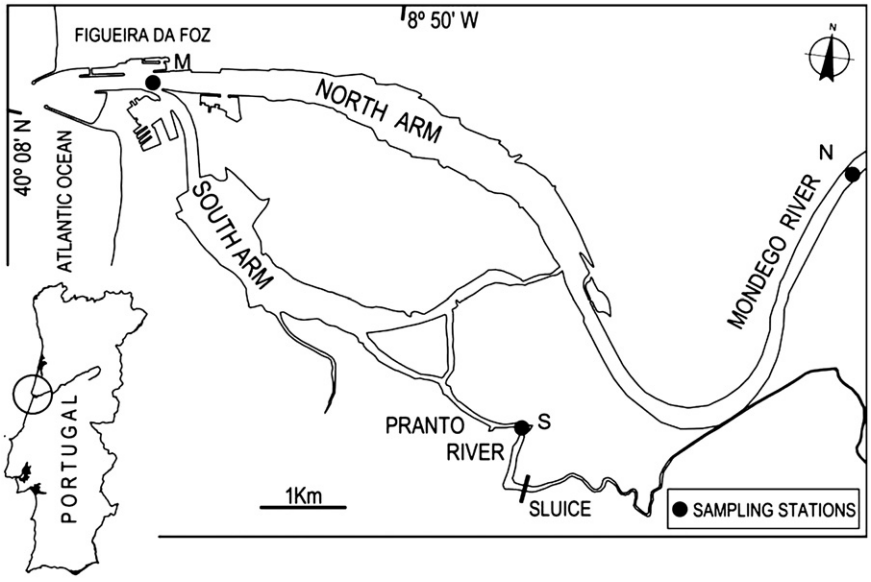

Fig. 1. Mondego estuary and location of the sampling stations.