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Influence of sex, maturity and reproduction on PCB and p,p′DDE concentrations and repartitions in the European hake (*Merluccius merluccius*, L.) from the Gulf of Lions (N.W. Mediterranean)

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ABSTRACT

The main objective of this work was to establish the influence of sex, maturity and reproduction on the contamination of the demersal fish *Merluccius merluccius* by organochlorine compounds. Polychlorinated biphenyls (PCBs) and p,p′DDE were quantified in muscle, liver and gonads of female and male hakes collected in the Gulf of Lions in 2004 and 2005. Observed levels appeared higher than the population of the Bay of Biscay and lower than the population of the Thyrrenian Sea. Contaminant fingerprints were roughly constant whatever the studied organ and the hake biological condition. Concentrations varied significantly according to the sex and maturity of hakes. Mature specimens were more contaminated than immature, and males presented higher levels than females. This sex effect can be linked to a lower growth rate of males, and a contaminant elimination during female spawning. Gonadal contamination depends on the importance of lipid content and increases with the maturation degree. Although the main organ of energy and PCB storage is the liver, muscle appears as the main contributor to the gonad contamination.

1. Introduction

Organochlorine compounds such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) are synthetic chemicals that have been introduced into the environment since the 1920s. DDT was used as an insecticide, and PCBs, as a thermal stabilizer in a wide scale of applications, such as coatings, inks, flame retardants and paints, but their major applications were in electric appliances, heat transfer systems and hydraulic fluids. PCB open applications were banned in many countries in the 1970s (Stockholm Convention Anonymous, 2003) and their use in close systems (such as capacitors and transformers) was limited since the 1990s. However, their high lipophilicity and environmental stability make them persist in the environment for long periods, involving a wide geographical distribution. These compounds are considered among the most dangerous pollutants. They exhibit a broad spectrum of toxicological responses, including immunotoxicity, teratogenicity, endocrine disruption, reproductive deficits, and contribute to tumor and carcinoma development (Ahlborg and Hanberg, 1994). Because of their stability, long biological half-life, and high liposolubility, they may be bioaccumulated and biomagnified along food chains involving a wide range of trophic levels, with a potential risk for high trophic level predators (Borgå et al., 2001; Fisk et al., 2001; Nfon and Cousins, 2006). The dietary intake, especially the consumption of marine organisms, is considered as one of the most important exposure source of PCBs for human population (Johansen et al., 1996; Pompa et al., 2003).

The European hake (*Merluccius Merluccius*) is an important ecological and commercial species in the ecosystem of the Gulf of Lions (N.W. Mediterranean). With a large spatial distribution from the coast to the continental slope, this species plays a fundamental ecological role in this area. This is a major focus for stock assessment on account that hake is the main commercial demersal species (Oliver and Massuti, 1995; Aldebert and Recasens, 1996) with catches principally taken on juveniles. Its bathymetric distribution, between 30 and 600 m depth, depends on its length (Campillo et al., 1991). Hake goes up to the water column to eat, and its food is mainly made up of crustaceans and pelagic fishes depending on hake size (Bozzano et al., 1997; Cartes et al., 2004, Ferraton et al., 2007). In the Gulf of Lions, the spawning season runs throughout the year, peaking in autumn–early winter (Recasens et al., 1998). Although growth has been studied over a number of decades, age determination from recently tagged otolith readings in Atlantic (De Pontual et al., 2003, 2006) and from otolith microstructure readings in the Mediterranean

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Sea (Arneri and Morales-Nin, 2000; Morales-Nin and Moranta, 2004; Belcari et al., 2006) has called into question the previous results.

Due to a high trophic level, hake is potentially exposed to the bioaccumulation of organic compounds, especially in the Gulf of Lions. After, Bodiguel et al. (2008), the high levels of persistent halogenated compounds in Mediterranean hakes might be related to the Rhône River loads coming from urbanised and industrialised watershed in southern France. In fact, this river is polluted by extensive anthropogenic activities and is particularly exposed to PCBs (Babut and Miège, 2007). The bioaccumulation of organochlorine compounds is however a complex phenomenon ruled by both physico-chemical properties of compounds and ecological and biological factors such as feeding behaviors, habitat, age, sex or state of health of the animals (Paterson et al., 2003; Bodin et al., 2007a; Di Bella et al., 2006). Nevertheless few studies describe organ-specific bioaccumulation (Filmann et al., 2007), and especially in relation to the reproduction process. The aim of this study was to understand the influence of sex, maturation degree and reproduction on PCB and p,p′DDE concentrations and distributions in muscle, liver and gonads of hake from the Gulf of Lions.

2. Materials and methods

2.1. Sampling

The study area is the Gulf of Lions, situated in the North Western Mediterranean Sea (Fig. 1). This large continental shelf is exposed to important contaminant discharges from the Rhone River. The Rhone watershed represents about 130 000 km^2 and a quarter of France's population. Moreover, 20% of French industrial activities are located in this catchment area, as well as some other agricultural and tourist activities (Anon., 2000). Hake cannot be considered as a sedentary fish since it reaches increasingly deeper waters as it gets older, fish samples were caught on the continental shelf (between 30 and 120 m depth) during three bottom-trawl cruises (May 2004–2005; October 2004) and at the edge of canyons (>150 m depth) during gillnets cruise in October 2006. Moreover, a complementary sampling was carried out in 2006 by IFREMER at the Sète Auction market. A total of 104 hakes or hake pools, from 6 to 70 cm total length (TL), were collected for organic contaminant analysis.

2.2. Sample preparation

Preliminary sample pre-treatment steps were performed as soon as possible on receipt of the fish. Specimens larger than 25 cm TL were primarily pre-treated on board whereas the smallest individuals were processed in the laboratory. Pre-treatment included total body weight, fish gutted weight, total length, macroscopic sex determination and dissection of tissues to cut off organs (muscle, liver and gonads). Only specimens ≥25 cm TL were sexually identifiable. Muscle, liver, as well as gonads were weighed and stored in pre-cleaned glass jars at −20 °C. In the laboratory, all sampled tissues were freeze dried, and grounded to obtain a fine homogeneous powder. Their water content was estimated from the weight lost during freeze drying. Finally, to obtain sufficient quantity of tissue powder to carry out contaminant analysis, each tissue, livers and muscles, of the smallest individuals (<25 cm TL) were pooled at each season per centimetric class.

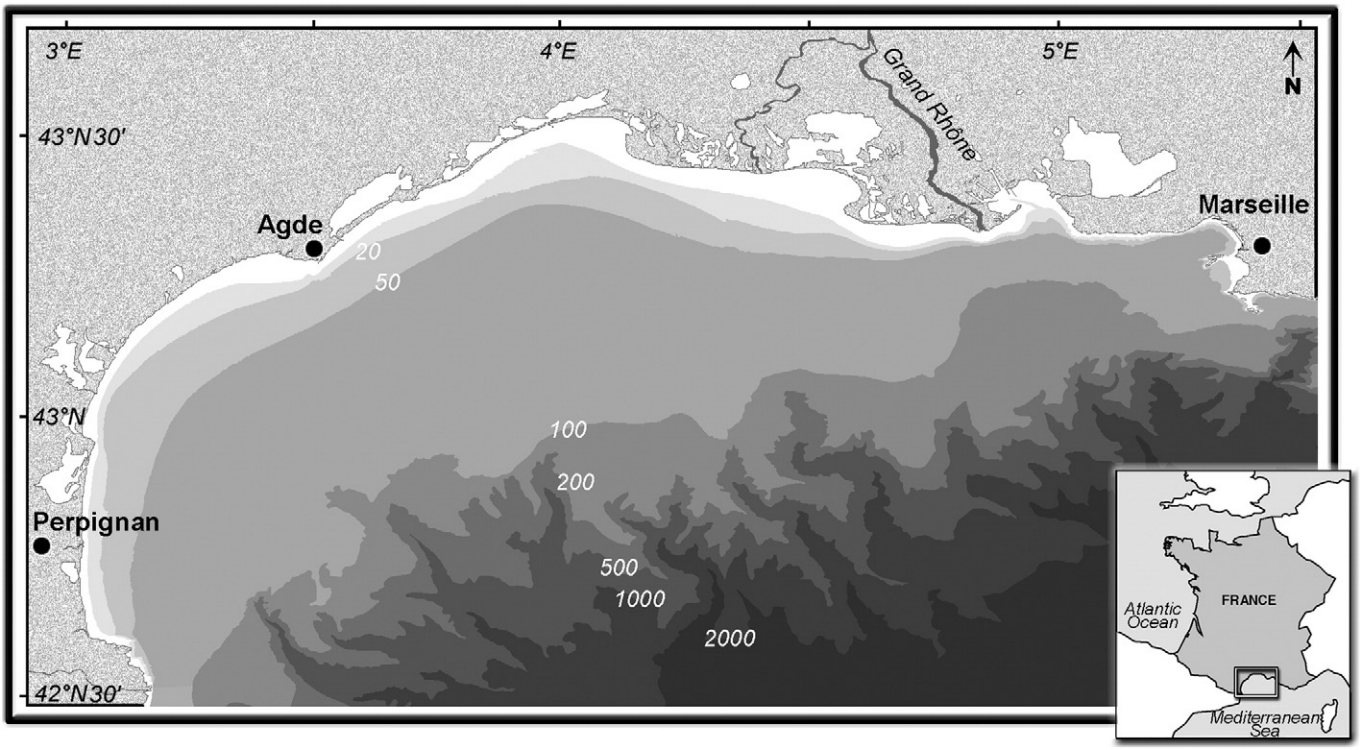

Fig. 1. Map of the study area: the Gulf of Lions.