Science of the Total Environment 484 (2014) 196–205

Contents lists available at ScienceDirect

Science of the Total Environment

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

An assessment of contaminant concentrations in toothed whale species of the NW Iberian Peninsula: Part I. Persistent organic pollutants

Paula Méndez-Fernandez [a,b,c,*], Lynda Webster [d], Tiphaine Chouvelon [a], Paco Bustamante [a], Marisa Ferreira [c], Angel F. González [e], Alfredo López [b], Colin F. Moffat [d], Graham J. Pierce [f,g], Fiona L. Read [e], Marie Russell [d], Maria B. Santos [h], Jérôme Spitz [i], José V. Vingada [c,g], Florence Caurant [a]

[a] Littoral Environment et Sociétes (LIENSs), UMRi 7266 CNRS-Université de La Rochelle, 2 Rue Olympe de Gouges, 17042 La Rochelle Cedex 01, France
[b] Coordinadora para o Estudo dos Mamiferos Mariños (CEMMA), Apdo. 15, Pontevedra 36380, Spain
[c] Centro de Biologia Molecuar e Ambiental (CBMA)/Sociedade Portuguesa de Vida Selvagem (SPVS), Dep. de Biologia, Universidade do Minho, Campus de Gualtar, Braga 4710-057, Portugal
[d] Marine Scotland, Marine Laboratory, Victoria Road, Aberdeen AB11 9DB, United Kingdom
[e] Instituto de Investigaciones Marinas (C.S.I.C), Eduardo Cabello 6, 36208 Vigo, Spain
[f] Oceanlab, University of Aberdeen Main Street, Newburgh, Aberdeenshire AB41 6AA, United Kingdom
[g] Centre for Environmental and Marine Studies (CESAM), Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[h] Instituto Español de Oceanografía, Centro Oceanográfico de Vigo, P.O. Box 1552, Vigo 36200, Spain
[i] Marine Mammal Research Unit, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada

HIGHLIGHTS

- POPs were measured in toothed whales from the NW Iberian Peninsula.
- Bottlenose dolphin and harbour porpoise showed the greatest PCB concentrations.
- The POP levels were higher than in the South Atlantic and Pacific Oceans.

ARTICLE INFO

Article history:
Received 26 July 2013
Received in revised form 11 February 2014
Accepted 13 February 2014

Keywords:
PCBs
PBDEs
Bioaccumulation
Patterns
Toothed whales
Northwest Iberian Peninsula

ABSTRACT

Concentrations and patterns of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in the blubber of the five most common toothed whales off the Northwest Iberian Peninsula (NWIP), specifically common dolphin, long-finned pilot whale, harbour porpoise, striped dolphin and bottlenose dolphin, were investigated. The study revealed that differences in PCB and PBDE concentrations among the species are highly dependent on age and sex but also on ecological factors such as trophic level, prey type and habitat. Of the five species studied, bottlenose dolphin and harbour porpoise showed the greatest concentrations of PCBs. Both species exceed the toxic threshold of 17 μg g^{-1} lipid weight (PCB Aroclor equivalent) for health effects on marine mammals, for 100% and 75% of the individuals tested, respectively. Overall, the PCB and PBDE levels observed in the NWIP toothed whales were of the same order of magnitude or lower than those reported by previous studies in areas of the NE Atlantic. However, they are often higher than those for toothed whales from the southern Atlantic and Pacific Ocean.

1. Introduction

Human activities in marine and coastal environments have intensified since the 1950s. Furthermore, reliance of human populations on coastal areas for urban development and exploitation of marine resources is predicted to keep increasing in the near future. The Northwest Iberian Peninsula (NWIP), situated at the northern limit of the NW African upwelling system (Figueiras et al., 2002), is a good example of such processes. Over the last fifty to sixty years, industrial development and an increase in other human activities in the area have increased the pressures on the marine environment. In this context, and to realise the ambition of clean, productive and biologically diverse seas, the European Community developed the Marine Strategy Framework Directive (MSFD, Directive, 2008/56/EC of the European Parliament and of the Council of 17 June 2008) the main objective of which is to

* Corresponding author at: Littoral Environment et Sociétes (LIENSs), UMRi 7266 CNRS-Université de La Rochelle, 2 Rue Olympe de Gouges, 17042 La Rochelle Cedex 01, France. Tel.: +33 5 46458388; fax: +33 5 46496711.
E-mail address: paula.mendez_fernandez@univ-lr.fr (P. Méndez-Fernandez).

http://dx.doi.org/10.1016/j.scitotenv.2014.02.045
0048-9697/

deliver “Good Environmental Status” of European marine ecosystems by 2020. To achieve this, better knowledge of the contamination status of marine populations is needed, specifically in connection with both Descriptor 8 and Descriptor 9 of the MSFD.

The persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs) and pesticides (e.g. dichlorodiphenyltrichloroethane, DDT) are among the primary pollutants of concern in marine ecosystems cited on the OSPAR list of Chemicals for Priority Action (OSPAR, 2010); they are lipophilic synthetic organic compounds that have been produced for industrial and agricultural purposes since the 1940s, or are by-products of other industrial processes developed over a similar period of time. Although their production has been banned since the end of the 1970s, PCBs can still be found in wildlife and other environmental components e.g. sediments (OSPAR, 2010). Other classes of organic chemicals are also of concern nowadays, notably the brominated diphenyl ether formulations (PBDEs) (de Boer et al., 1998) and the hexabromocyclododecanes (HBCDs) another brominated flame retardant (e.g. Zegers et al., 2005). Marine mammals, as long-lived apex predators, are at risk from these toxic compounds, since they have a high bioaccumulation potential and biomagnify through food webs (Aguilar et al., 1999). Due to their lipophilic nature, POPs reach their highest concentrations in fatty tissues and, particularly, in the hypodermic fat or blubber. Compared to most terrestrial mammals, marine mammals appear to have a lower capacity to metabolize and excrete lipophilic organochlorine compounds (Boon et al., 1992; Duinker et al., 1989; Tanabe et al., 1988). This capacity is lower in toothed whales than in pinnipeds (seals and sea lions) (Tanabe et al., 1988), which makes them especially vulnerable to POPs. Although information on the actual effect of POPs on the health of marine mammals is scarce (Reijinders et al., 1999), results from laboratory feeding studies and field investigations have allowed the determination of several threshold values for adverse effects (e.g. Kannan et al., 2000). The concentration of contaminants in marine mammal tissues primarily varies in relation to prey consumption, but there is also a function of their specific capacity to transform these compounds to metabolised forms and/or ultimately excrete the native form or the associated metabolites (Aguilar et al., 1999). Other biological factors have also been found to be responsible for variation in POP concentrations in marine mammals. These include body size and composition, nutritive condition, age, sex, health status, duration of lactation, transfer from mother to offspring during both pregnancy and lactation (Aguilar et al., 1999). Thus, since the uptake of contaminants in marine mammals depends on the diet, feeding habitat and biological factors, any interpretation of concentrations or comparison between species would be incomplete without considering as many of the factors as possible.

For many years, the concentration of contaminants in the NWIP has been routinely monitored through the analysis of samples of sediments, seawater and commercial species such as shellfish (e.g. Carro et al., 2002; Prego and Cobelo-García, 2003). Potentially toxic substances have also occasionally been investigated in marine mammals since the 1980s, as part of the European funded BIOCET project (Murphy et al., 2010; Pierce et al., 2008; Zegers et al., 2005) among others (Borrell et al., 2001, 2006; Tornero et al., 2006), although to a lesser extent than in other marine organisms from this area.

The overall objective of this study is to assess the contamination status of the five most common marine mammals in the NWIP: the common dolphin (*Delphinus delphis*), the long-finned pilot whale (*Globicephala melas*), the harbour porpoise (*Phocoena phocoena*), the striped dolphin (*Stenella coeruleoalba*) and the bottlenose dolphin (*Tursiops truncatus*). This paper constitutes the first of a two part study. In this first part we report on the PCB and PBDE concentrations and patterns in these species, and evaluate their contamination status in comparison with threshold values for health effects on marine mammals as well as making comparisons with concentrations found in other geographical areas. In Part II of this study, that will be subsequently reported (Méndez-Fernandez et al., in press), we investigate the concentrations of trace elements, which is another group of potential contaminants in the NWIP, in the context of biological and ecological factors.

2. Materials and methods

2.1. Sampling and study area

Sampling was carried out in the NWIP, from the northern limit of the Galician coast in Spain (43°3′N,7°2′W) to Nazaré on the Portuguese coast (39°36′N, 9°3′W) (Fig. 1). Experienced members of the Spanish (*Coordinadora para o Estudo dos Mamiferos Mariños*, CEMMA) and Portuguese (*Sociedade Portuguesa de Vida Salvagem*, SPVS) stranding networks have been attending stranded and by-caught cetaceans for over twenty years and over ten years, respectively. Animals were identified to species, measured, sexed and, if the decomposition state of the carcass allowed, full necropsies were performed and samples collected whenever possible. All procedures followed the standard protocol defined by the European Cetacean Society (ECS), as did the coding of decomposition state and condition (Kuiken and García Hartmann, 1991).

A total of 172 stranded and by-caught individuals was selected for this study, covering five toothed whale species (common dolphin, n = 114; long-finned pilot whale, n = 9; harbour porpoise, n = 19; striped dolphin, n = 21 and bottlenose dolphin, n = 9) over the period 2004 to 2008. The common dolphin is the cetacean species stranded in the greatest numbers; this is believed to reflect the relatively high abundance in the area (Santos et al., 2013c) and the large number of individuals being by-caught in NWIP fisheries (López et al., 2002, 2003). The animals recovered in a “fresh” state (a score of 1 to 3 from the ECS protocol, i.e. originally stranded alive, freshly dead or mildly decomposed) were selected. Teeth were extracted for age determination, gonads collected for determination of reproductive status and blubber samples for POP analyses. All blubber samples were taken from the left side in front of the dorsal fin. Samples were entire vertical cross-sections of the blubber so as to prevent any possible effects of stratification of the blubber. The samples were wrapped separately in aluminium foil and after the necropsies, all samples were stored frozen at −20 °C until required for analysis.

Analysis of POPs is costly and the present study was budget-limited. As such, effort was focused on the best sample sets (i.e. individuals for which most data on other variables were available). Thus, in this part of the study 120 blubber samples, out of a possible 172, were analysed for PCBs (common dolphin, n = 81; long-finned pilot whale, n = 3; harbour porpoise, n = 12; striped dolphin, n = 15 and bottlenose dolphin, n = 7) and 20 for PBDEs (common dolphin, n = 19; harbour porpoise, n = 1).

2.2. Age estimation and reproductive status

Age was estimated by analysing growth layer groups (GLGs) in the dentine and cementum of teeth, following adapted methods based on Lockyer (1993) and Hohn and Lockyer (1995). Teeth were decalcified and sectioned at 25 µm using a cryostat. The most central and complete sections (including the whole pulp cavity) were selected from each tooth, stained with Mayer's haematoxylin (modified by Grue) and ‘blued’ in a weak ammonia solution, mounted on glass slides and allowed to dry. GLGs were counted under a binocular microscope. All readings were made blind (without access to individual biological data), and replicate counts were made by two readers. If the age estimates obtained by the two readers differed by more than 1 year, readings were repeated. If the increments were difficult to count, both readers discussed the interpretation and either reached an agreed age or judged the tooth to be unreadable.