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Life history as a source of variation for persistent organic pollutant (POP) patterns in a community of common bottlenose dolphins (*Tursiops truncatus*) resident to Sarasota Bay, FL

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ABSTRACT

As apex predators within coastal ecosystems, bottlenose dolphins (*Tursiops truncatus*) are prone to accumulate complex mixtures of persistent organic pollutants (POPs). While substantial variations in POP patterns have been previously observed in dolphin populations separated across regional- and fine-scale geographic ranges, less is known regarding the factors influencing contaminant patterns within localized populations. To assess the variation of POP mixtures that occurs among individuals of a population, polychlorinated biphenyl (PCB), organochlorine pesticide (OCP) and polybrominated diphenyl ether (PBDE) concentrations were measured in blubber and milk of bottlenose dolphins resident to Sarasota Bay, FL, and principal components analysis (PCA) was used to explain mixture variations in relation to age, sex and reproductive maturity. PCA demonstrated significant variations in contaminant mixtures within the resident dolphin community. POP patterns in juvenile dolphins resembled patterns in milk, the primary diet source, and were dominated by lower-halogenated PCBs and PBDEs. A significant correlation between principal component 2 (PC2) and age in male dolphins indicated that juvenile contaminant patterns gradually shifted away from the milk-like pattern over time. Metabolically-refractory PCBs significantly increased with age in male dolphins, whereas PCBs subject to cytochrome p450 1A1 metabolism did not, suggesting that changes in male POP patterns likely resulted from the selective accumulation of persistent POP congeners. Changes to POP patterns were gradual for juvenile females, but changed dramatically at reproductive maturity and gradually shifted back towards pre-parturient profiles thereafter. Congener-specific blubber/milk partition coefficients indicated that lower-halogenated POPs were selectively offloaded into milk and changes in adult female contaminant profiles likely resulted from the offloading of these compounds during the first reproductive event and their gradual re-accumulation thereafter. Overall, these results indicate that significant variations in contaminant mixtures can exist within localized populations of bottlenose dolphins, with life history factors such as age and sex driving individual differences.

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1. Introduction

Wildlife species that feed within top trophic levels of aquatic food webs are prone to accumulating high concentrations and complex mixtures of persistent organic pollutants (POPs). Cetaceans (whales, dolphins and porpoises) are amongst those species most susceptible to POP exposure. Historically, human activities such as commercial harvesting, fishery interactions and habitat degradation, have threatened cetacean populations, leading to their current status as federally protected species (Reeves et al., 2003). Compounding these direct threats, exposure to anthropogenic contaminants may also affect the sustainability of wild populations. Risk assessments suggest that cetaceans may experience impaired reproduction and reduced population growth rates at their current level of exposure (Hall et al., 2006; Schwacke et al., 2002). Furthermore, the frequency of large-scale marine mammal mortalities appears to have increased in recent decades (Gulland and Hall, 2007). Although the role of contaminants in these die-offs is unclear, there is evidence to suggest that POPs may compromise marine mammal immune function, thus heightening their disease susceptibility (de Swart et al., 1996; Lahvis et al., 1995).

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Despite these concerns, direct assessments of health and contaminant exposure in wild populations remain difficult. The collection of samples from free-ranging, pelagic cetaceans is logistically-difficult, and when feasible, accompanying information regarding movement patterns, dietary history and life history is generally unknown, impairing efforts to identify the factors responsible for individual variations in POP exposure and resulting health effects. Consequently, it has been suggested that a well-studied cetacean species, such as the bottlenose dolphin, be used as a model cetacean species for assessing risks to larger and/or less-accessible species (Marine Mammal Commission, 1999).

Common bottlenose dolphins (*Tursiops truncatus*) are non-endangered, medium-sized odontocetes (generally <3 m) that are common inhabitants of coastal waters throughout temperate and tropical regions (Wells and Scott, 1999, 2009). Such characteristics make bottlenose dolphins relatively easy to observe and study. Moreover, coastal dolphin populations within the U.S. have been the focus of long-term efforts to assess health, population dynamics and stock structure (Reif et al., 2008; Wells et al., 2004), thus considerable knowledge exists regarding this species.

Contaminant data collected from captive and wild bottlenose dolphin populations have helped to establish how biological and ecological factors can influence contaminant bioaccumulation in cetaceans (Houde et al., 2005). These data have contributed to the widely accepted notion that the level of contaminant exposure can vary between individuals as a result of differences in age, sex, reproductive history, diet and habitat (Aguilar et al., 1999). More recently, there has been a renewed interest in understanding the factors that influence exposure to specific POP mixtures, which are proving to be important in modulating contaminant-related health effects (Mori et al., 2008, 2006). Substantial variations in POP patterns have been observed in bottlenose dolphin populations separated across regional and fine-scale geographic ranges (Hansen et al., 2004; Litz et al., 2007; Pulster and Maruya, 2008), suggesting that spatial variations in habitat contamination and individual habitat usage patterns strongly affect POP profiles. Although not documented for bottlenose dolphins specifically, contaminant mixtures may also vary in accordance with age, sex and reproductive history. Among a group of 22 stranded Atlantic white sided dolphins (*Lagenorhychus actus*), it was noted that POP patterns varied between juveniles, adult males, lactating and non-lactating adult females (McKenzie et al., 1997). Although based on a small sample size, the results of this study suggest that in the absence of geographic variations, individual differences in contaminant patterns are still apparent and likely associated with biological processes such as biotransformation, parturition, and lactation. With the exception of this study, the influence of life history on cetacean contaminant patterns has not been investigated in detail, likely because individual-specific data on age, sex, reproductive status, habitat quality, site fidelity and movement patterns are needed in order to make such detailed comparisons, but are difficult to ascertain for wild populations. A better understanding of the factors driving variability in contaminant mixtures within a population may be important for identifying individuals at disproportionate risk for exposure-related health effects.

Although the majority of biomonitoring studies for cetaceans are limited by a lack of biological data, the bottlenose dolphin community resident to Sarasota Bay, Florida, has been extensively studied and represents an ideal population with which to assess the influence of life history on contaminant mixtures. Located on the central west coast of Florida, Sarasota Bay and the associated waters comprise a system of shallow, high salinity embayments that are separated from the Gulf of Mexico by a series of barrier islands. Extended longitudinal studies (nearly 40 years) indicate that bottlenose dolphins are long-term, year round residents to Sarasota Bay (Scott et al., 1990). The community of about 160 individuals is not reproductively isolated from adjacent populations, however, movement patterns indicate that residents remain primarily within a 125 km^2 home range encompassing Sarasota Bay and adjacent Gulf of Mexico waters (Duffield and Wells, 2002; Wells, 2003; Wells and Scott, 1999). The immigration of outside individuals into the Sarasota Bay dolphin community is relatively low, with the population experiencing maximum immigration rates of less than 3% per year (Wells and Scott, 1990). Furthermore, life history information, including age, sex, reproductive status and birth order is known for most of the resident animals.

The attributes of Sarasota Bay and resident dolphins provide a relatively 'closed' community with which to assess the influence of life history on POP concentrations and patterns in detail. Specifically, the objectives of this study were to 1) assess the intra-population variability of POP levels and patterns of Sarasota Bay dolphins and 2) evaluate the influence of life history parameters on POP patterns. Based on a previous study (McKenzie et al., 1997), it is expected that biological processes such as metabolism, parturition and lactation may contribute to variations in POP patterns among individuals. Therefore, relating aspects of dolphin life history to changes in POP profiles should provide novel insight into mechanisms governing accumulation, biotransformation and reproductive transfer of POPs in cetaceans and may aid in identifying subsets of the population most at risk from contaminant-related health effects.

2. Materials and methods

2.1. Study area

Sarasota Bay, FL is characterized as a high salinity estuary that receives limited fresh water inflow. Land use around Sarasota Bay consists mainly of medium to high density suburban development (Fig. 1).

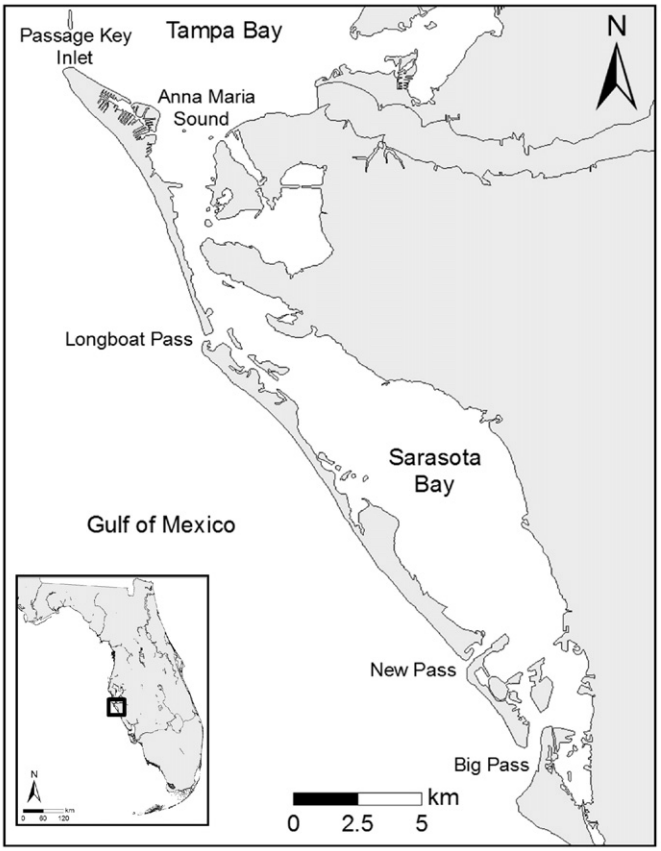

Fig. 1. Location of study area, Sarasota Bay, FL.