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The occurrence of chemical elements and POPs in loggerhead turtles (*Caretta caretta*): An overview

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ABSTRACT

Chemical elements and persistent organic pollutants (POPs) are globally present in aquatic systems and their potential transfer to loggerhead marine turtles (*Caretta caretta*) has become a serious threat for their health status. The environmental fate of these xenobiotics may be traced by the analysis of turtles' tissues and blood. Generally, loggerhead turtles exhibited a higher metal load than other turtle species, this could be explained by differences in diet habits being food the main source of exposure. Literature shows that muscle, liver and kidney are most considered for the quantification of chemical elements, while, organic compounds are typically investigated in liver and fat.

This paper is an overview of the international studies carried out on the quantification of chemical elements, polychlorinated biphenyls (PCBs), organochlorines (OCs) and perfluorinated compounds (PFCs), in tissues, organs and fluids of *C. caretta* from the Mediterranean Sea, the Atlantic and the Pacific Oceans.

Contents

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1. Introduction

Inorganic contaminants and persistent organic pollutants (POPs) are present in aquatic systems worldwide as a consequence of their wide-spread usage and long-range transport. Coastal and marine pollution is increasing throughout the world and a critical threshold for many pollutants is almost unknown (Domingo and Bocio, 2007; Hamann et al., 2010; Sobek et al., 2010). The bioaccumulation of these toxic substances has become a matter of concern for its possible transfer to food chain and impact on several wildlife species of the marine environment, including loggerhead sea turtles (*Caretta caretta*) (Marcotrigiano and Storelli, 2003; Keller et al., 2005; Moon et al., 2010; Ogata et al., 2009; Roose and Brinkman, 2005). Contamination of marine system is one of the key research priorities highlighted by 35 sea turtle researchers from 13 nations working in fields related to turtle biology and/or conservation (Hamann et al., 2010).

Heavy metals in marine mammals (cetaceans, like dolphins and beluga) may produce alterations in the immune function and increase the incidence of infectious diseases (Cámara Pellissó et al., 2008). Different authors assessed trace element body burden in dolphins, all of them agreed on the need of establishing toxicological consequence of this metal accumulation (Lavery et al., 2008; Stavros et al., 2011) and spatial or temporal variations of stable inorganic and organic pollutant levels (Holsbeek et al., 1998; Raach et al., 2011; Yordy et al., 2010). Concentration of trace elements in tissues of seals revealed difference in species accumulation providing possible basis for the evaluation of species susceptibility (Ikemoto et al., 2004).

Sea turtles are long-living vertebrates that may bioaccumulate these contaminants from food, sediment and water. In this regard, sea turtles are considered of increasing interest as potential bioindicators for pollution in marine ecosystems (Andreani et al., 2008; Godley et al., 1999; Keller et al., 2004b; Sakai et al., 2000). The concentrations of chlorobiphenyls (CBs) and organochlorine pesticides (OCPs) in tissues of three marine turtle species from Mediterranean and European Atlantic waters revealed that the level of these organic contaminants decreases in the order: loggerhead > green = leatherback. These differences may be related to the diet habits of loggerhead turtle and its higher position in the marine food chain. This may lead to a greater exposure to contaminants than the other two species (Mckenzie et al., 1999). Loggerhead sea turtles were tracked by satellite in combination with the analysis of stable isotope in order to provide a means of linking different phases of the migration cycle of these marine vertebrates. The authors recommended the analysis of stable isotope and other chemical markers as a standard procedure integrated with all studies of migratory vertebrates equipped with satellite transmitters. This would open new perspectives in forensic tracking methodologies to increase proportionally the knowledge from a limited number of individuals to sample sizes that are more significant from a population point of view (Zbinden et al., 2011). The loggerhead *C. caretta* is the most abundant marine turtle species present in the Mediterranean Sea and it can be also found in the Atlantic, the Pacific and the Indian Oceans and other parts of the world (Day et al., 2005; Nagelkerken et al., 2003; Caurant et al., 1999; Mingozzi et al., 2007). Since 1975, *C. caretta* was included in Red List of threatened species of the International Union for Conservation of Nature (IUCN, 2009).

The present paper presents an overview on data of international literature on the occurrence of trace elements and POPs in different tissues, organs and fluids of loggerhead sea turtles (*C. caretta*) from the Mediterranean Sea, the Atlantic and the Pacific Oceans, as a contribution to the knowledge of the contamination levels of the species and, more in general, of the marine environments.

2. Geographical distribution, habitat and biology

Loggerhead sea turtles (*C. caretta*) are fairly widely distributed across subtropical and temperate latitudes (Márquez, 1990). In the Atlantic Ocean, the greatest concentration is along the South eastern coast of North America and in the Gulf of Mexico (Spotila, 2004). Nesting extends as far North as Virginia, as far South as Brazil, and as far East as the Cape Verde Islands. Along the African coastline, loggerheads nest from Mozambique's Bazaruto Archipelago to South Africa's St. Lucia estuary. Eastern Australia and Japan are the major nesting areas. In the Mediterranean Sea, turtles nest on eastern basin shores, mainly in Greece, Turkey and Cyprus (Groombridge, 1994; Pritchard and Mortimer, 1999). *C. caretta* is the most frequent chelonian in the Italian waters, with egg-laying sites localized in southern Italy, Sardinia, Sicily and in its smaller islands (Di Palma, 1978).

Migratory flux of loggerhead turtles near and through the Strait of Gibraltar has been reported in both directions. Thanks to this connection, Atlantic and Mediterranean loggerhead populations share developmental habitats in western Mediterranean and in North eastern Atlantic (Margaritoulis et al., 2003; Camiñas and De La Serna, 1995). Loggerheads spend most of their life cycle in marine environments, they are carnivorous, foraging primarily on benthic invertebrates throughout their distribution range. The great availability of food and warm shallow waters seem to be ideal for foraging and as over-wintering environment.

Like other species, loggerhead sea turtles are migratory, and the life cycle period influences the distance of their travel (Meylan, 1982; Meylan et al., 1983; Hughes, 1989; Limpus et al., 1992). From nesting sites, hatchlings move to the open ocean foraging on the surface, then they start a developmental migration towards near-shore and continental shelf waters, foraging at the bottom in the shallow fringes of the sea. Oceanic juveniles from this population are distributed along the Mediterranean basin (Margaritoulis et al., 2003). Juveniles and subadults feed in coastal areas, usually far from their hatching ground (Carr, 1987; Bowen et al., 1993, 1995; Bolten et al., 1998). Sexually mature turtles move to specific mating and nesting sites during the breeding season, they return thereafter to the foraging and wintering areas where they spend much of their life (Miller, 1997).

3. Major and trace elements in tissues, organs and fluids

Aluminum, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Se and Zn are the elements most investigated in specimens of *C. caretta*. The collection of papers has revealed that the 13 elements are analyzed according to the following decreasing percentages: Cd (14.8), Cu (13.1), Pb (12.5), Zn (12.1), total Hg (11.5), Fe (10.4), Ni (6.9), Mn (6.7), Al, As, B, Ba, Cr, Mg, Sb and Se (<5). Chromium, Cu, Fe, Mn, Ni, Se and Zn play an essential role in animal metabolism and growth (Alam and Brim, 2000), in particular, Cu and Fe have a crucial function in oxygen transport, energy production and enzyme activity. Some essential (Cu, Fe, Mn and Zn) and a limited number of toxic elements (As, Cd and Pb) can be also transferred from the mother to turtle eggs (Kaska et al., 2004). Cadmium is typically long-term accumulated in kidney, this is principally due to its binding by metallothionein, while Cu and Zn tend to accumulate in liver (Andreani et al., 2008). Mercury has been recognized to induce toxic effects in fish, including neurotoxicity, impaired growth and development, reduced reproductive success, liver and kidney damage and immunomodulation. In the aquatic systems, the inorganic Hg is microbially transformed to the more toxic and bioavailable methylmercury (MeHg), a potent neurotoxin with a strong tendency to biomagnify in aquatic food webs (Day et al., 2005, 2007; Kampalath et al., 2006).