Marine Pollution Bulletin 128 (2018) 208–213

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Organochlorine pesticide accumulation in seabirds and marine mammals from the Northwest Pacific

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ARTICLE INFO

Keywords:
Organochlorines
GC–MS
Seabirds
Marine mammals
Northwest Pacific

ABSTRACT

Bioaccumulation of organochlorine pesticides by marine organisms is one of the methods of environmental quality. Concentrations of organochlorine pesticides (HCH isomers (α-, β-, γ-HCH), *p,p′*-DDT and its metabolites (*p,p′*-DDD, *p,p′*-DDE)) in samples of seabirds (Northern fulmar *Fulmarus glacialis*, Crested auklet *Aethia cristatella*, Auklet-crumb *Aethia pusilla*, Pacific gull *Larus schistisagus*, and Gray petrel *Oceanodroma furcate*) and marine mammals (Gray whales *Eschrichtius robustus* and Pacific walrus *Odobenus rosmarus divergens*) were measured by a GC–MS. The total concentration of OCPs in mammals was higher than in seabirds. Environmental biomonitoring with the use of seabirds and marine mammals, as a long-lived species, is used for global monitoring, since bioaccumulation in these organisms occurs throughout life. The environmental assessment of the Northwest Pacific marine ecosystems revealed that the levels of OCP contamination in this area are similar to the other subarctic regions of the World Ocean.

1. Introduction

Organochlorine pesticides were widely used as insecticides and herbicides in the 20th century due to their high toxicity and resistance to photolytic, chemical and biological degradation. Among OCPs, hexachlorocyclohexane (HCHs) and DDTs were used mostly all over the world. In 2001, several hazardous substances including DDT and its metabolites (DDD and DDE) were listed to the "Dirty dozen" recognized by The Stockholm Convention (UNEP, 2005). In 2009, HCH was added to this list. Pesticides are able to transport for a long distance via atmosphere, oceanic currents, runoff, and transfer with migrating organisms (Iwata et al., 1993; Tanabe et al., 1994; Rolland et al., 1995; Wania and MacKay, 1996; Tanabe and Subramanian, 2006). DDT, HCH, and their metabolites as lipophilic compounds have the ability for biomagnifications in food web. Marine ecosystems often become the final "sink" for many pollutants, including OCPs. Hence, marine mammals and predatory seabirds often have the high pesticide concentrations in organs.

Species that correspond to the basic parameters of bioindicators are used in biodiagnostics of environment conditions. Bioindicators are considered as biological processes, species, or communities and may be used to assess the environmental quality and its changes over the time (Holt and Miller, 2010). For example, fish are currently among the best organisms to study bioaccumulation characteristics and effects of pollutants in the ecosystem, being short-lived organisms (Lukyanova et al., 2016). Marine mammals and some seabird species are long-lived organisms, therefore are suitable for a global and long-term monitoring of the environment. Seabirds that migrate short distances can exhibit the background level of contamination in their habitat. If local pollution impact is negligible, seabirds reflect the global pollution as a result of the transboundary transfer of pollutants (Kunisue et al., 2003; Tsygankov et al., 2016a). Marine mammals are considered as bioindicators of global pesticide pollution and reflect modern trends of marine ecosystems contamination (Tanabe and Subramanian, 2006; Tsygankov et al., 2015).

The purpose of this research is assessment of marine ecosystems in the Northwest Pacific region based on bioaccumulation of organochlorines in seabirds and marine mammals.

2. Materials and methods

2.1. Study sites and samples

Marine organisms (Table 1) were collected in various areas of the Sea of Okhotsk and the Bering Sea over the period of 2010–2013 (Fig. 1). Seabirds, such as Northern fulmar *Fulmarus glacialis*, Crested

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https://doi.org/10.1016/j.marpolbul.2018.01.027
Received 24 December 2017; Received in revised form 10 January 2018; Accepted 14 January 2018

Table 1
Characteristics of studied species.

Species	Location	Organs	N	% lipid, range
Seabirds				
Northern fulmar (*Fulmarus glacialis*)	The south-eastern coast of the Sea of Okhotsk (western coast of Kamchtka and the Kuril Islands), in June 2012	Feather	5	1.1–3.2
		Feather with skin	5	1.1–21.0
		Whole body (organs and tissues)	5	0.2–12.2
Crested auklet (*Aethia cristatella*)		Feather	2	1.5–2.9
		Feather with skin	2	8.6–19.0
		Whole body (organs and tissues)	2	7.5–11.5
Auklet-crumb (*Aethia pusilla*)		Whole body (organs and tissues)	3	6.5–12.7
Pacific gull (*Larus schistisagus*)		Feather	2	1.6–3.3
		Feather with skin	2	9.9–17.2
		Muscle	2	7.3–8.5
		Liver	2	10.1–13.6
Gray petrel (*Oceanodroma furcate*)		Feather with skin	1	14.4
		Whole body (organs and tissues)	1	11.9
Marine mammals				
Gray whales (*Eschrichtius robustus*)	The coast waters (Mechigmensky Bay) of the Bering Sea, summer 2010–2011	Muscle	7	0.5–4.1
		Liver	7	1.1–8.0
Pacific walrus (*Odobenus rosmarus divergens*)		Muscle	8	1.3–6.4
		Liver	8	2.6–10.2

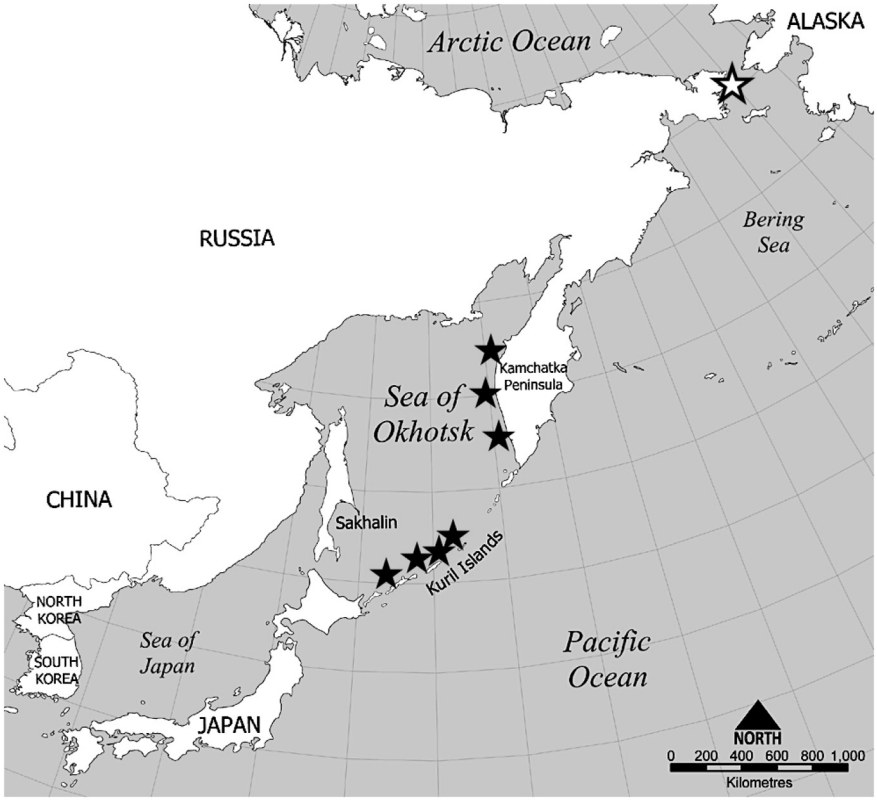

Fig. 1. Map of sampling: black star – seabirds; white star – marine mammals.

auklet *Aethia cristatella*, Auklet-crumb *Aethia pusilla*, Pacific gull *Larus schistisagus*, and Gray petrel *Oceanodroma furcate*, were collected in June and October 2012 in the Sea of Okhotsk. Various organs of seabirds were analyzed: feathers, feathers with skin, liver, muscle, and whole bird. The liver and muscle of Gray whales *Eschrichtius robustus* and Pacific walrus *Odobenus rosmarus divergens*, caught by the indigenous people in summer 2010–2011 from the coastal area (in Chukotka, near Lorino village) of the Bering Sea, were sampled.

2.2. Chemical analysis

Frozen samples (−20 °C) were transported to laboratory. Before chemical analysis, separate organs and tissues were homogenized. Lipids were extracted from homogenate (10–20 g) using *n*-hexane, with subsequent disintegration of the fat components by concentrated sulphuric acid (Tsygankov and Boyarova, 2015). Concentrations of organochlorine pesticides (HCH isomers (α-, β-, γ-HCH), *p,p′*-DDT and its metabolites (*p,p′*-DDD, *p,p′*-DDE)) in samples were measured by gas chromatography–mass spectrometry (GC–MS). A Shimadzu gas