



Persistent organic pollutant concentrations in blubber of 16 species of cetaceans stranded in the Pacific Islands from 1997 through 2011



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HIGHLIGHTS

- DDTs, PCBs and chlordanes were predominant in Pacific cetaceans.
- POP classes are stable in cetaceans stranded over the last 15 years for this region.
- Contaminants are compared among cetacean species and to other populations globally.

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ABSTRACT

Persistent organic pollutants (POPs) are toxic man-made chemicals that bioaccumulate and biomagnify in food webs, making them a ubiquitous threat to the marine environment. Although many studies have determined concentrations of POPs in top predators, no studies have quantified POPs in stranded cetaceans within the last 30 years around the Hawaiian Islands. A suite of POPs was measured in the blubber of 16 cetacean species that stranded in the tropical Pacific, including Hawai'i from 1997 to 2011. The sample set includes odontocetes ($n = 39$) and mysticetes ($n = 3$). Median (range) contaminant concentrations in ng/g lipid for the most representative species category (delphinids excluding killer whales [$n = 27$]) are: 9650 (44.4–99,100) for \sum DDTs, 6240 (40.8–50,200) for \sum PCBs, 1380 (6.73–9520) for \sum chlordanes, 1230 (13.4–5510) for \sum toxaphenes, 269 (1.99–10,100) for \sum PBDEs, 280 (2.14–4190) for mirex, 176 (5.43–857) for HCB, 48.1 (<5.42–566) for \sum HCHs, 33.9 (<2.42–990) for \sum HBCDs, 1.65 (<0.435–11.7) for octachlorostyrene and 1.49 (<2.07–13.1) for pentachlorobenzene. \sum PCB concentrations in these Pacific Island cetaceans approach and sometimes exceed proposed toxic threshold values. Backward stepwise multiple regressions indicated the influence of life history parameters on contaminant concentrations when performed with three independent variables (species category, year of stranding, and sex/age class). No temporal trends were noted ($p > 0.063$), but sex/age class influences were evident with adult males exhibiting greater contaminant loads than adult females and juveniles for \sum DDT, \sum PCBs, \sum CHLs, and mirex ($p \leq 0.036$). POP concentrations were lower in mysticetes than odontocetes for many compound classes ($p \leq 0.003$). p,p' -DDE/ \sum DDTs ratios were greater than 0.6 for all species except humpback whales, suggesting exposure to an old DDT source. These POP levels are high enough to warrant concern and continued monitoring.

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1. Introduction

Persistent organic pollutants (POPs) are a ubiquitous threat to the marine environment and include polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and organochlorine pesticides (OCPs). These organic pollutants originate from a variety of sources including electrical transformers, pesticides, flame retardants and various

other household and industrial items. Transport of organic contaminants through the environment occurs via agricultural runoff (Ross and Birnbaum, 2003), atmospheric transport (Gouin et al., 2004), combustion (Jones and de Voogt, 1999) and ocean circulation (Wania and Mackay, 1995). These persistent, lipophilic, and biomagnifying organic compounds in the environment are extremely stable and resistant to degradation (Godduhn and Duffy, 2003).

In the Hawaiian Islands region, high POP concentrations in fish, Hawaiian monk seals (*Monachus schauinslandi*) and false killer whales (*Pseudorca crassidens*) have raised concerns regarding health impacts of these chemicals on cetacean populations (Brasher and Wolff, 2004; Willcox et al., 2004; Ylitalo et al., 2008, 2009). Cetaceans are particularly

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susceptible to accumulation of POPs, primarily in the blubber (Yordy et al., 2010a), because these species have long lifespans, have large fat deposits and occupy top positions in marine food chains. Although a plethora of studies have quantified POP concentrations in many cetacean species worldwide, only two species, rough toothed dolphins (*Steno bredanensis*, stranded) and false killer whales (free-ranging), have been examined for POP concentrations from the Hawaiian Islands (O'Shea et al., 1980; Ylitalo et al., 2009). The only study to examine POPs in stranded cetaceans for this tropical Pacific region (O'Shea et al., 1980) analyzed samples collected over forty years ago (1968 to 1976). Therefore, determining the concentrations and potential effects of these organic contaminants in tropical Pacific cetaceans is timely and important. This study establishes initial baseline concentrations of POPs in sixteen species of cetaceans stranded in the Pacific Islands region mostly from 2006 to 2011 with three samples dating back to 1997, including one novel species never before analyzed (*Indopacetus pacificus*, Longman's beaked whale). In addition, a preliminary assessment of species category differences within this region was conducted using multiple regression statistics that accounted for temporal changes and expected life history effects of sex and age class on POP concentrations.

2. Materials and methods

2.1. Sample collection

Forty-two blubber samples were obtained from Hawai'i Pacific University's (HPU) marine mammal stranding program (NOAA permit #932-1905). These samples originated from cetacean strandings that occurred in the central and western tropical Pacific regions (Fig. 1). Age class was estimated based on animal weight, total length and maturation of reproductive organs. In order to minimize the impact of postmortem degradation, the samples used in this study were from stranded cetaceans that were code 1 (alive then euthanized) or code 2

(considered freshly dead) (Hofman, 1991). Blubber was sampled from these dead stranded animals at time of necropsy, wrapped in aluminum foil and stored at -80°C until analyzed for POPs at the National Institute of Standards and Technology (NIST), Hollings Marine Laboratory, Charleston, South Carolina. The sample set represents sixteen cetacean species stranded in the tropical Pacific over 15 years (most from 2006 to 2011 with one from 1997, one from 1998, and one from 2000), encompassing different age classes and sexes (Table 1).

2.2. Analytical methods

2.2.1. Persistent organic pollutants

2.2.1.1. Sample preparation, extraction and cleanup. Blubber subsamples ($\approx 1.0\text{ g}$) of full depth, but not exceeding a depth of 7 cm, were weighed and manually homogenized using a razor blade in a beaker in a manner to prevent loss of lipids. The blubber was combined with sodium sulfate, transferred to a pressurized fluid extraction (PFE) cell and spiked gravimetrically with internal standard. The internal standard solution contained ^{13}C -labeled PCB congeners (28, 52, 77, 126, 169, 118, 153, 180, 194, 206), 6-F-PBDE 47, PBDE 104, 4'-F-PBDE 160, 4'-F-PBDE 208, ^{13}C -labeled PBDE 209, ^{13}C -labeled pesticides (hexachlorobenzene (HCB), *trans*-chlordane, *trans*-nonachlor, oxychlordane, *p,p'*-DDE, *p,p'*-DDD, *p,p'*-DDT), ^{13}C -labeled methyl-triclosan and ^{13}C -labeled α -, β - and γ -hexabromocyclododecanes (HBCDs). POPs were extracted from blubber samples with dichloromethane using PFE. Total extractable organic content (TEO), as a proxy for lipid content, was determined by removing 50% of the extract gravimetrically, allowing it to dry in an aluminum pan and weighing dried residue. Remaining extracts were cleaned up using size exclusion chromatography with additional clean-up and fractionation of the samples by acidified silica columns in an automated solid phase extraction system. The majority of POPs eluted into the first fraction (F1) followed by the HBCDs in the second fraction (F2).

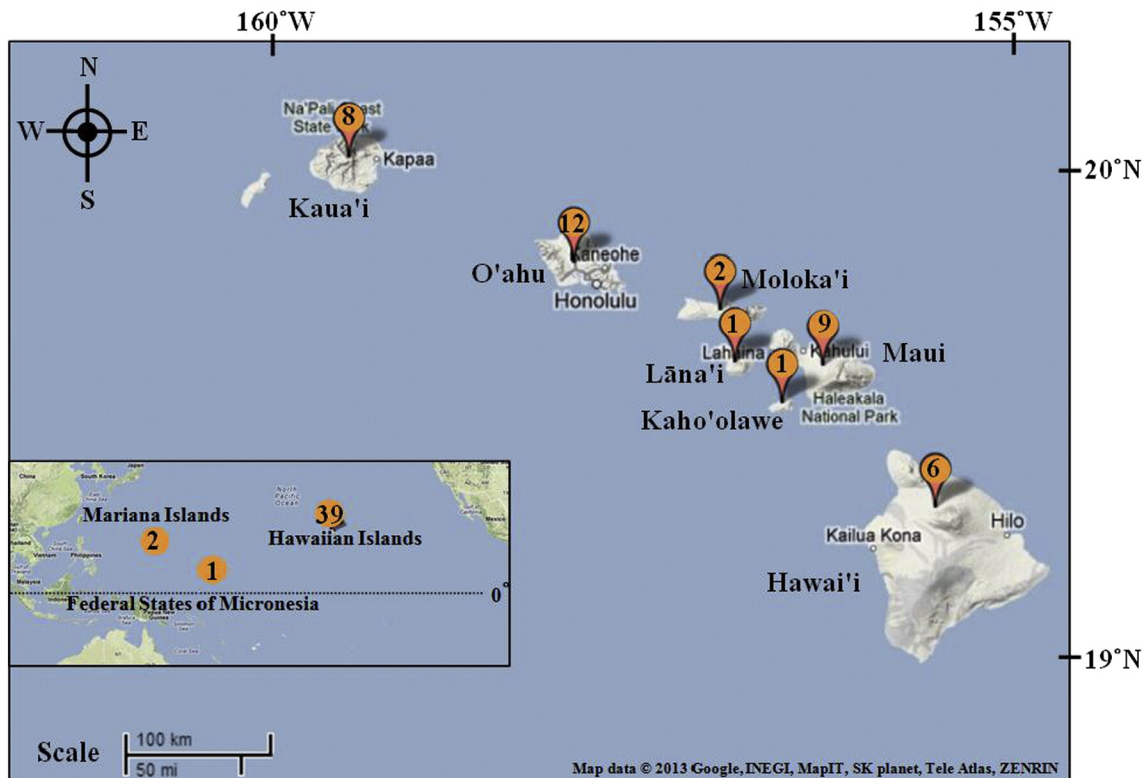


Fig. 1. Location of stranded cetaceans that were analyzed for persistent organic pollutants in the tropical Pacific from 1997 to 2011. Numbers indicate number of individuals that stranded on each island.

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