# Breaching the line: Persistent organic pollutant concentrations exceeding thresholds in endangered Hawaiian false killer whales (*Pseudorca crassidens*)


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## Why is this important?

False killer whales are highly social, long-lived apex predators found in the tropics and sub-tropics. The resident main Hawaiian Islands population is small (~167) and subdivided into 4 or 5 social clusters.

This population was listed as "endangered" under the Endangered Species Act in 2012. Among threats to their population is exposure to persistent organic pollutants (POPs). POPs are toxic industrial chemicals and pesticides that contaminate marine environments. They are lipophilic, highly resistant to degradation, and readily bioaccumulate.

POP exposure has been linked to (1) immunosuppression; (2) reproductive disruption/impairment; and (3) thyroid disruption in aquatic mammals[2,3]

***We examine variance in POP concentrations in blubber and assess the risk of exposure to individuals based on:***

- ***Age class***
- ***Sex***
- ***Reproductive status***
- ***Mother/offspring relationships (e.g., birth order)***
- ***Social cluster***

## What we did

We took blubber biopsies from false killer whales using a Barnett crossbow and biopsy dart [a] and analyzed them for several contaminants[6]:

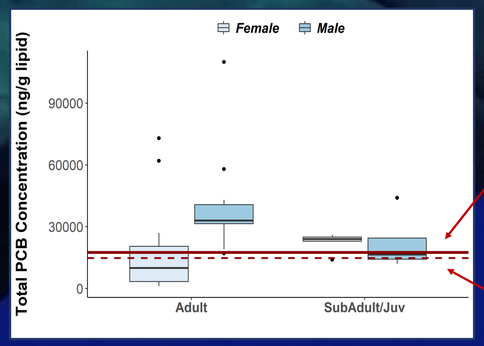
- Total polychlorinated biphenyls (PCBs) – flame retardant
- Total DDTs – pesticide
- Total polybrominated diphenyl ethers (PBDEs) – industrial uses
- Total Hexachlorocyclohexanes (HCHs) – insecticides/pesticides
- Hexachlorobenzene (HCB) – pesticide
- Dieldrin – pesticide
- Mirex – pesticide, was used in pineapple plantations

We identified whales using a long-term photo ID catalog[1] that includes information on sex, age class, reproductive status, and social cluster assignment.

We used principal components analysis (PCA) to summarize variance among POP concentrations into factors.

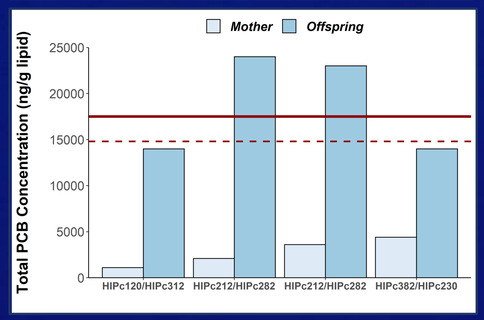
Linear mixed effects models were used to examine how life history factors and social cluster explain the variance described by each retained principal component (PC).

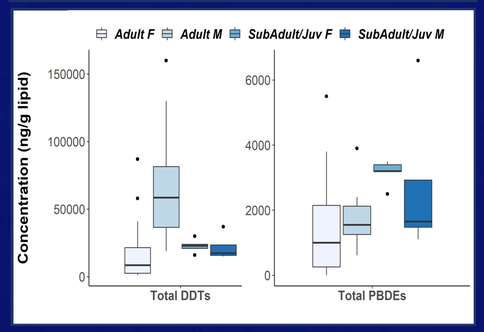
## PCB levels exceed health thresholds for all adult males and many females and juveniles




Threshold for the onset of thyroid disruption and immunocompetence[2]

Threshold for the onset of reproductive disruption and/or impairment[3]



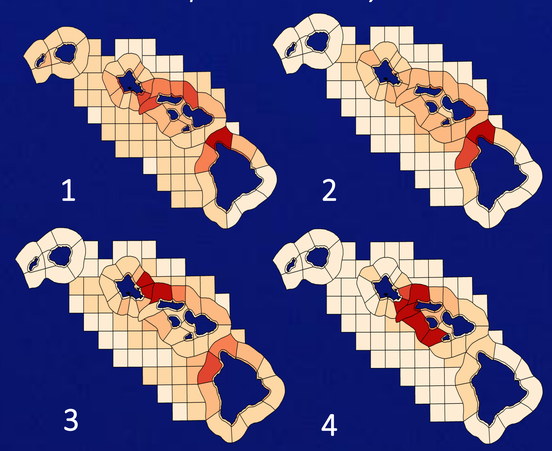




*Principal components: % variance explained*

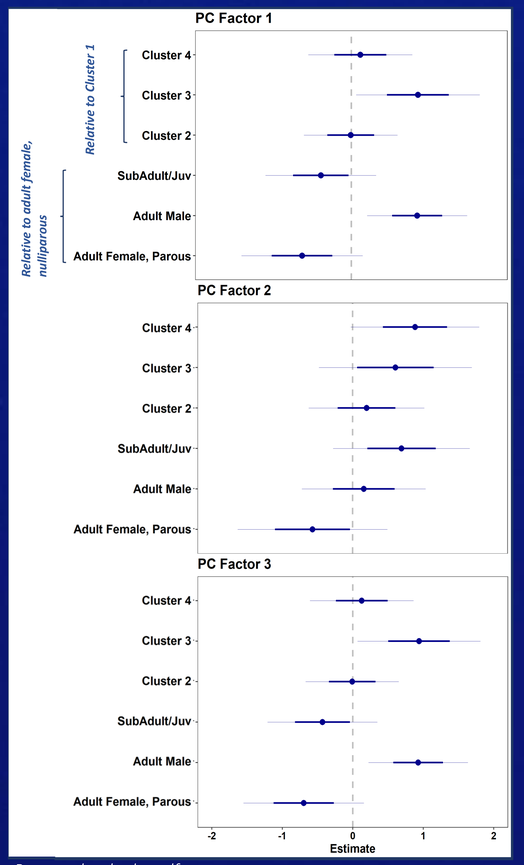
*POP loadings >0.5*

| PC 1 (42%) | PC 2 (33%) | PC 3 (18%) |
|---|---|---|
| ΣPCBs | ΣHCHs | ΣPBDEs |
| ΣDDTs | HCB | |
| ΣCHLDs | dieldrin | |
| mirex | | |

*False killer whale space use varies by social cluster*




*Linear mixed effects models: PC factor ~ AgeClass/Sex/Reproductive status + Social Cluster + (random = whale ID)*




*Parous = has had a calf*
*Nulliparous = has never had a calf*

## Key findings

- ***Age/sex class, reproductive status, and birth order influence POP levels - adult males accumulate POPs throughout their lives whereas adult females offload POPs to offspring via lactation and gestation.***
- ***Sub-adults/juveniles are at greater risk of health effects from POPs - they're born with high levels from maternal offloading and have higher levels of PBDEs, which are known to have neurobehavioral effects[5].***
- ***POP concentrations vary among social clusters likely due to differences in spatial use (i.e., primary foraging areas).***
- ***POP exposure poses a considerable risk to this population's long-term viability. Continued monitoring of POP levels is essential in evaluating persistent threats to this endangered population.***


*Poster presentation at: The Joint Meeting of the American Fisheries Society and The Wildlife Society, Reno, NV October 2019 & Society of Environmental Toxicology and Chemistry North America 40th Annual Meeting, Toronto, ON, CA November 2019*



Citations: [1]Baird et al. 2008a. False killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands: Long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24(3):591-612.; [2]Kannan et al. 2000. Toxicity reference values for the toxic effects of polychlorinated biphenyls to aquatic mammals. Human and Ecological Risk Assessment 6(1):181-201.; [3]Schwacke et al. 2002. Probabilistic risk assessment of reproductive effects of polychlorinated biphenyls on bottlenose dolphins (*Tursiops truncatus*) from the southeast United States coast. Environmental Toxicology and Chemistry 21(12):2752-2764.,; [4] Baird et al. 2012. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18:47-61.; [5]Falsness, C.E. 2008. Overview of toxicological aspects of polybrominated diphenyl ethers: A flame-retardant additive in several consumer products. Environmental Research 108:158-167.; [6]Ylitalo et al. 2009. High levels of persistent organic pollutants measured in blubber of island-associated false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. Marine Pollution Bulletin 58(12):1932-1937.,[a]Samples collected under NMFS MMPA/ESA Permits #774-1714, #14097.


Photo credit: Daniel Webster/Cascadia Research Collective