Project Number: MCEF22014

Hong Kong Offshore LNG Terminal Project
Marine Conservation Enhancement Fund

Completion Report

(From 2023 June 1 to 2025 May 31)

Project Title 项目名	**(English)**	Comprehensive Risk Assessment on Finless Porpoises Exposed to Chlorinated Paraffins and Chemical Mixtures Using High-resolution Mass Spectrometry and Toxicokinetic Model
	(Chinese)	通过高分辨质谱及毒代動力學模型全面評估氯化石蜡及化学品混合物暴露对江豚的生態風險

Contact information
Dr. Qi Wang
State Key Laboratory of Marine Pollution (SKLMP), City University of Hong Kong

Executive Summary and Way Forward

This study comprehensively investigated the tissue-specific accumulation, composition, biomagnification, and body burden of chlorinated paraffins (CPs) in finless porpoises (*Neophocaena phocaenoides*) and the marine food web of the South China Sea. By integrating advanced analytical methods and trophic transfer modeling, the findings provide critical insights into CP contamination, bioaccumulation, and potential risks to marine ecosystems, particularly in apex predators. The research highlights the complexity of CPs' environmental behavior and underscores the need for informed conservation and regulatory actions.

High detection frequencies were observed for SCCPs (100%), MCCPs (100%), and LCCPs (94%) across all analyzed tissues, with total CP concentrations varying by tissue type. On a wet weight basis, CP levels were highest in lipid-rich tissues such as blubber and melon. However, lipid-normalized concentrations revealed elevated CP levels in metabolically active tissues like muscle, liver, and kidney. These findings suggest that CP accumulation is influenced by multiple factors, including blood perfusion rates, metabolic activity, and tissue-specific physiology, rather than lipid content alone. For example, the liver exhibited a notable accumulation of vLCCPs, implying limited metabolic degradation of these highly hydrophobic compounds. The detection of CPs in the brain further indicates their ability to cross the blood-brain barrier, raising concerns about potential neurotoxic effects. MCCPs were the dominant CP group in all tissues (>50% of total CPs), while vSCCPs and vLCCPs showed distinct tissue-specific patterns. The brain and melon accumulated higher proportions of vSCCPs, whereas vLCCPs were more prevalent in muscle and liver. These findings highlight the need for congener-specific toxicity assessments to understand the health impacts of different CP groups on marine mammals. The total body burden of CPs in finless porpoises was estimated at 138.1 g, significantly exceeding reported burdens for other marine contaminants, such as parabens (44.4 g) and PFASs (0.424 g). Blubber served as the primary storage compartment, accounting for 60% of the total CP burden, followed by muscle (39%). MCCPs contributed the largest portion of the total body burden (83.0 g), followed by SCCPs (45.4 g), with vLCCPs showing higher burdens than LCCPs. These findings demonstrate that blubber acts as both a long-term reservoir and a potential source for redistribution of CPs to other tissues via blood circulation. The elevated body burdens of CPs, particularly highly persistent congeners like vLCCPs, raise concerns about long-term health risks, including developmental toxicity, hepatotoxicity, and neurotoxicity in marine mammals.

Regarding biomagnification and trophic transfer, the biomagnification potential of CPs was confirmed through trophic magnification factors (TMFs), which ranged from 2.35 (vSCCPs) to 4.97 (vLCCPs). Long-chain CPs, such as LCCPs and vLCCPs, exhibited higher TMFs than SCCPs and MCCPs, reflecting their persistence and bioaccumulation potential in apex predators like cetaceans.

The relationship between TMFs and the octanol-water partition coefficient (K_{ow}) revealed an inverted U-shaped trend for SCCPs and MCCPs, with bioaccumulation peaking at moderate hydrophobicity levels (log K_{ow} ~6.5). However, for vLCCPs, TMFs increased continuously with K_{ow}, indicating that highly hydrophobic CPs remain persistent and accumulate in lipid-rich, higher-trophic-level organisms. These findings underscore the importance of considering both physical-chemical properties and trophic transfer processes in assessing CP risks.

The completion of this project has significantly advanced our understanding of CP contamination in marine ecosystems, particularly its bioaccumulation, biomagnification, and tissue-specific distribution in marine mammals and the South China Sea food web. The detection of CPs in critical tissues such as the liver, muscle, and even the brain highlights their ability to persist and accumulate in metabolically active and sensitive organs, raising concerns about potential neurotoxic and hepatotoxic effects. This is especially true for persistent congeners like LCCPs and vLCCPs, which exhibited the highest bioaccumulation and biomagnification potential in this study. Despite these findings, significant gaps remain in understanding the mechanisms of CP toxicity, particularly in marine mammals, and in establishing toxicity thresholds that can guide risk assessments. To build on these findings, future research should focus on congener-specific toxicity studies, as different CP groups exhibit distinct accumulation patterns and ecological behaviors. Expanding biomonitoring efforts to other marine ecosystems, particularly those in regions with high industrial activity, will help to assess the global distribution and risks of CPs. Such monitoring should prioritize tissues like blubber, liver, and muscle, which play critical roles in CP storage and metabolism, offering a more accurate picture of exposure. Additionally, identifying and prioritizing key CP pollutants for regulation is essential. Long-chain and very long-chain CPs should be a primary focus, given their persistence, high Kow values, and strong biomagnification potential, which make them particularly hazardous to top predators like marine mammals. Regulatory frameworks must address the entire CP family, including unregulated groups, to effectively mitigate their environmental release and ecological impact. Alongside regulatory measures, public awareness campaigns should be initiated to highlight the risks associated with CPs and promote conservation efforts. These actions will not only fill critical knowledge gaps but also ensure that effective measures are in place to protect vulnerable marine species and ecosystems.