**Pollutants accumulation and effects in relation to trophic niches of the high-Arctic ivory gull (*Pagophila eburnea*)**

Publishable summary

The Arctic Region is currently undergoing dramatic environmental changes, with temperature increasing twice as fast as the global average and sea ice extent reaching a record minimum in 2012 with a reduction of 45% compared with the 1979-2010 climatology. It is predicted that climate change will result in profound modifications of the Arctic marine food web and contaminant pathways in this region through temperature increase, more low-pressure activity, increased river discharges and runoff from glaciers, as well as accelerated rate of sea-ice melting. These climate-related variables may therefore influence the transport and thus the bioavailability of contaminants to Arctic biota.

The ivory gull is a high-Arctic species that spends the entire year closely associated with sea ice. This species is considered endangered in most parts of its breeding range. Nevertheless, it is one of the world’s least known species even though its high position in the marine food web makes ivory gulls particularly sensitive to contaminant exposure. Overall, climate-related perturbations, are expected to profoundly impact the trophic behaviour of the ivory gull and potentially increase its contaminant pressure. Therefore, this project had for objective to assess the accumulation and effects of pollutants in relation to trophic niches of the vulnerable ivory gull at different levels of biological organization (cellular, organism and population levels). This general aim was reached through the following specific objectives:

**Objective 1A – Assess temporal variations of persistent organic pollutants (POPs) and trace elements (TEs) in a well-studied ivory gull breeding colony in Svalbard, Norway**. Our first objective was to investigate temporal trends of the contamination of gulls in the Svalbard Archipelago (Svenskøya and Barentsøya). As of today, all samples collected during the first year of this project, and previously obtained in Svalbard, were analysed for contaminants in collaboration with the Norwegian Institute for Air Research (NILU) and the LIENSs laboratory (Coastal Environment and Societies) from the CNRS-University of La Rochelle. Two publications are currently either in preparation or submitted to scientific journals (Polar Biology). Overall, few discrepancies appeared between sampling years and no clear patterns could be observed. Contaminant concentrations seem rather to follow episodic events of contamination in Svalbard.

**Objective 1B – Assess spatial variations of POPs and TEs levels in ivory gull populations from Svalbard, Canada, Greenland and Russia** (Figure 1). The second part of objective 1 was to compare contaminant levels in eggs of ivory gulls breeding in different areas across the Arctic region. A scientific paper entitled “Circumpolar contamination in eggs of the high-Arctic ivory gull *Pagophila eburnea*” was published in Environmental Toxicology and Chemistry (doi: 10.1002/etc.2935). The most quantitatively abundant organochlorines (OCs) found in this study were *p*,*p′*-DDE (dichlorodiphenyldichloroethylene) and sum PCB (polychlorobiphenyl). Mercury (Hg) concentrations were higher in Canada compared with other colonies. Eggs from Nagurskoe (Russia) often were characterized by higher concentrations. However, geographical tendencies were chemical-dependent. Perfluorinated alkyl substances (PFASs) concentrations, especially PFOA (perfluorooctanoate) and PFNA (perfluorononanoate), were higher in Greenland. Some of the contaminants, especially Hg and *p*,*p′*-DDE, exceeded published thresholds known to disrupt the reproductive success of avian species. Overall, the levels of OCs, brominated flame retardants, and PFASs did not suggest direct lethal exposure to these compounds, but their potential synergetic/additive sublethal effects warrant monitoring.



Fig. 1. Map of the circumpolar sampled colonies of the ivory gull in Seymour Island (Canada), Station Nord (Greenland), Svenskøya (Svalbard, Norway), Nagurskoe and Cape Klyuv in Franz Josef Land, and Domashny Island in Severnaya Zemlya (western Russian Arctic).

**Objective 2 – Determine the relation between contaminant concentrations and trophic habits of gulls**. The second objective was to analyse stable isotopes in seabird feathers, eggs and blood from samples used in objective 1 to elucidate broad‐scale and intraspecific dietary patterns, and so determine whether differences in foraging strategy explained variations in contaminant uptake. As of today, all the samples needed for this objective have been collected and treated in collaboration with the LIENSs laboratory. A manuscript titled “Contamination of four ivory gull (*Pagophila eburnea*) colonies in Svalbard in link with their trophic behaviour” has been submitted to Polar Biology. This study highlighted an inter-individual variability in trophic behaviour during the breeding and moulting periods. Overall, similar feeding habitats and strategies were used between breeding sites which was echoed by similar contaminant levels. Several compounds including most of the PFASs, *trans*-nonachlor, *cis*-nonachlor, and BDE-28 demonstrated their biomagnification potential in the Ivory Gull’s food web.

**Objective 3 – Determine contaminant effects on ivory gulls at the cellular and organism levels.** This objective aimed at studying sublethal effects of a cocktail of contaminants in a sensitive Arctic species. All blood samples necessary for the realization of this objective were collected in July 2015 on Barentsøya, Svalbard. Those samples are currently being processed in collaboration with Akvaplan Niva for enzymes activities and the Norwegian University of Science and Technology (NTNU) for molecular biology analyses (gene expressions).

Overall, this project resulted in the acquisition of basic, but until now, not acquired knowledge which will assist the protection and management of endangered seabird species in the Arctic, providing valuable clues on methodologies that could be applied under the EU Birds Directive and Marine Strategy Directive. This project also allowed communicating with the general public about issues in the Arctic through publications of reports and a book entitled “At the edge” in 2016.