FINAL PUBLISHABLE SUMMARY REPORT

ARCTOX

Climate change is leading to a rapid decline of the sea-ice extent in the Arctic. This modification is bound to profoundly affect the functioning of Arctic marine ecosystems and understanding its impacts on the marine biodiversity is now a major issue raised by several international organizations. Among other threats, the expansion of ice-free areas is opening new shipping routes and increasing opportunities for human industries, thereby contributing to enhance pollution at sea. The rapid melting of sea ice, together with terrestrial glaciers and permafrost, is also releasing large amounts of pollutants trapped in sea ice over the last decades. In this context of increasing pollution risks in Arctic marine ecosystems, the ARCTOX project aimed to lead a comprehensive study of the contamination of the Arctic seabird community and its impacts on these vulnerable species. Studying the seabird community is indeed important as they represent an essential component of Arctic marine food webs but are also extremely sensitive to pollution risks. More specifically, the project proposed to use new and trans-disciplinary approaches combining pollutant analyses, biotelemetry and field monitoring to (1) evaluate how levels of pollutants changed in the Arctic seabird community over the last three decades. (2) Determine seasonal variations in the exposure of Arctic seabirds to pollutants and understand to what extent these migratory species get contaminated when inside or outside of the Arctic. (3) Investigate the impacts of pollutants on Arctic seabird reproduction and survival. (4) Build-up an international and pan-Arctic sampling network to use the Arctic seabird community as bio-indicators of the state of pollution in the Arctic marine environment and to thereby define sensitive hotpots for Arctic marine organisms.

We focused on mercury (Hg), a pollutant of high environmental concern in the Arctic. This non-essential metal is persistent in the marine environment and is highly toxic, even at low concentrations.

Under a collaboration between LIENSs (France) and Aarhus University (Denmark), we first analysed long-term trends of Hg in different seabird species breeding in two contrasting regions of Greenland. Results show that Hg concentrations have declined in every species and at both sites between the 80's and 2007, most likely as a result of the decrease of Hg emissions in Canada and Northern Europe during this period. However, this trend seems to have reversed since then in East Greenland. We indeed demonstrated that Hg levels measured in birds from East Greenland have increased at a rate of 3.4% per year since 2007 and this increase reflects a general increase of the marine food web contamination. Second, we developed a novel approach of spatial ecotoxicology combining

contaminant analyses with bio-logging and the use of electronic devices to investigate when and where birds were primarily exposed to contaminants. This very promising approach demonstrated the importance of areas outside of the Arctic for the contamination of Arctic seabirds. Our results indeed showed that birds can be 3 to 4 times more exposed to Hg during their non-breeding period spent outside of the Arctic than during their arctic breeding season. These results also demonstrate that ecotoxicological studies should be expanded to yield a comprehensive understanding of contamination risks and associated threats to seabirds over their entire annual cycle. In addition, these first two parts of the project highlighted how seabirds can be used as bio-indicators to investigate spatial and temporal variations in the contamination of the marine environment. Third, we initiated the study of the impacts of contaminants on seabird breeding success and survival. More specifically, we demonstrated that Hg is a major aggravating stress factor for wintering seabird. Indeed, Hg could have played a role in the recent massive seabird winter mortality in February-March 2014, when >43000 seabird originating from the sub-Arctic and northern Europe were found dead along the French Atlantic coasts. Additionally, by focusing on a population of little auks breeding in East Greenland, we showed that high levels of Hg accumulated by females prior to the breeding season (e.g. over the winter period) was related to smaller laid eggs and subsequent negative impacts on chick condition at hatching. This strongly suggests impacts of Hg on Arctic seabird reproduction. Finally, during the ARCTOX project, we set-up a large pan-Arctic sampling network involving researchers from Canada, U.S.A, Japan, Russia, Greenland, Denmark, Iceland, Faroe Island, Norway, Poland, France and the U.K. In 2015 and 2016, this network has allowed to collect and gather samples from >40 sites around the Arctic and for 12 different seabird species reflecting the different compartments of the Arctic marine ecosystems. This international network will be essential to study and monitor the Arctic contamination at a pan-Arctic scale.