If the suggested scenario is correct, the question remains as to why glaucous gull females with low levels of OC overproduce daughters. This result is in accordance with a selection in favour of the less common sex at the population level. Since an effect with high loads of OCs will bias the sex ratio towards males at the population level, females with low levels of OCs may benefit from producing the rare sex (females). This suggests that a flexible and adaptive strategy in response to the sex ratio at the population level is adopted by females with low OC levels.

The observed skew in sex ratio is alarming and could also affect other species than birds. Data on evolutionary effects of sub-lethal exposure to OC contamination are still exceedingly scarce and more research is needed. Environmental changes due to pollution are generally reversible, but evolutionary changes are often irreversible. Consequently, such effects may be more serious than other environmental changes caused by pollution.

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Bearded seal in Svalbard. Photo: G. W. Gabrielsen

Brominated Flame Retardants: Exposure and Accumulation in Arctic Animals

Hans Wolkers
(hans.wolkers@npolar.no)
Geir W. Gabrielsen
(geir.gabrielsen@npolar.no), Norwegian Polar Institute, Polar Environmental Centre, Tromsø

Industrial chemicals, particularly PCBs and pesticides like DDTs, have been a major environmental threat for several decades. As these compounds are difficult to break down, they accumulate through the food chain, ultimately exposing top predators to high levels of toxic chemicals. Thanks to international restrictions on the production and use of these compounds, levels seem to be declining in the Arctic environment. However, while manufacturing and application of these hazardous compounds are limited by international agreements, other potentially dangerous compounds – like polybrominated diphenyl ethers (PBDEs) – are still manufactured. These industrial chemicals are routinely used as flame retardants in many consumer products such as computers, TV sets, airplane and car seats and clothing. Approximately 70 brominated flame chemicals account for a global consumption of 300 000 tonnes per annum. An estimated 50 tonnes per year are used in Norwegian production.

PBDEs are chemically very similar to PCBs: they are transported over long distances, they are persistent and they accumulate in fatty tissues of animals. As a result they are effectively transferred through food chains. In addition, similar toxic effects as caused by PCBs have been described for PBDEs, with impacts on hormone and immune systems being the most important and destructive.

While PCBs and pesticides seem to be declining in the environment, PBDE concentrations in wildlife are on the rise. Although levels in the Arctic are still relatively low, a study in Canada showed a dramatic increase over a period of 15 years. Generally, a doubling every five years seems to be the rule. These "PCBs of the 21st century" may, without proper restrictions, cause an environmental disaster as bad as the PCBs. Sources of environmental PBDE contamination include leakage from consumer products and industrial facilities that manufacture PBDEs as well as from disposal sites of products containing PBDEs. The bioaccumulation of some PBDEs (for example, congeners 47, 99 and 153) can be similar or higher than that of PCBs in some animals. PBDE congeners 47, 99 and 100 show particularly high biomagnification in fish-eating birds and mammals. Because these animals are usually long-lived and feed high in the food chain, they are very sensitive to the effects of contaminant exposure in general and PBDE exposure in particular.

In response to the alarming increase of environmental PBDEs, the Norwegian Polar Institute launched one of the first investigations on the occurrence and persistence of PBDEs in the European Arctic. Seabirds and marine mammals were studied to investigate if, and to what extent, these compounds pose a threat to wildlife in the Arctic.

In glaucous gull (a scavenger–predatory species) from Svalbard, PBDE 47 and 99 were found in both liver and intestinal content. Measurements showed the presence of PBDE 100, 153, 190 and other congeners. The concentrations of PBDEs were 10 times lower than the concentration of PCB. The finding of many different PBDEs in seabirds may indicate long-range transport of the components and bioaccumulation via feed, a limited capability to excrete these compounds and subsequently metabolization via debromination.

Glaucous gull chick on Bjørnøya, Svalbard. Photo: K. Sagerup

In ringed seals and beluga whales, over 20 PBDE congeners were measured. PBDE 47, 99 and 100 were the dominant congeners, with PBDE 47 the most prevalent in both species. Levels found were about 10-20 times higher than in Canadian seals and whales, but substantially lower than in seals from more southern latitudes. A similar geographic distribution for persistent contaminants was also found for PCBs. The relatively high levels in the European Arctic compared to the Canadian Arctic are probably due to a more effective PBDE transport from lower latitudes to the European Arctic. Calculations on the persistence of PBDEs suggested that PBDE 47 and 99 were persistent in both ringed seals and beluga whales, while PBDE 100 was persistent in beluga whales only. Overall, more different PBDE congeners could be detected in beluga whales and this is probably caused by their relatively limited capability to metabolize these compounds.

As the apex predators of the Arctic ecosystem, polar bears usually have the highest levels of contaminants. Surprisingly, however, only PBDE 47 could be detected in both male and female bears, in relatively low concentrations. Polar bears have a remarkable capability to metabolize a wide range of contaminants and the current results suggest an effective metabolism of most PBDEs, including PBDE 47, in this species. However, because of the polar bear's effective conversion of industrial compounds into metabolites, research on the toxicity and persistence of these reaction products is essential.

The Norwegian Government has adopted a new action plan to substantially reduce emissions of brominated flame retardants. The ban covers the use of penta-, octa- and decabromodiphenylether. The Pollution Control Authority in Norway will draft regulations prohibiting the use of penta- and octa-BDE from 1 July 2004, which is similar to the EU directive. A prohibition of deca-BDE will probably be in place by 1 January 2005.