Les Substances Poly- et Perfluoroalkylées (PFAS) et leurs effets chez les oiseaux marins

Olivier Chastel, Pierre Blévin, Ségolène Humann-Guilleminot, Fabrice Helfenstein, Sabrina Tartu, Frederic Angelier, Manrico Sebastiano, William Jouanneau, Cécile Ribout, Christophe Babraud, David Costantini, Scott Shaffer, Frédéric Robin, Julien Gernigon, Jean-Christophe Lemesle, Paco Bustamante, Pierre Labadie, Hélène Budzinski, Børge Moe, Kjetil Sagerup, Sébastien Descamp, Dorte Herzke, Jan Ove Bustnes, Geir Wing Gabrielsen

Environmental pollution and biodiversity

Habitat loss

Over-exploitation

Climate change

Invading species

Pollution

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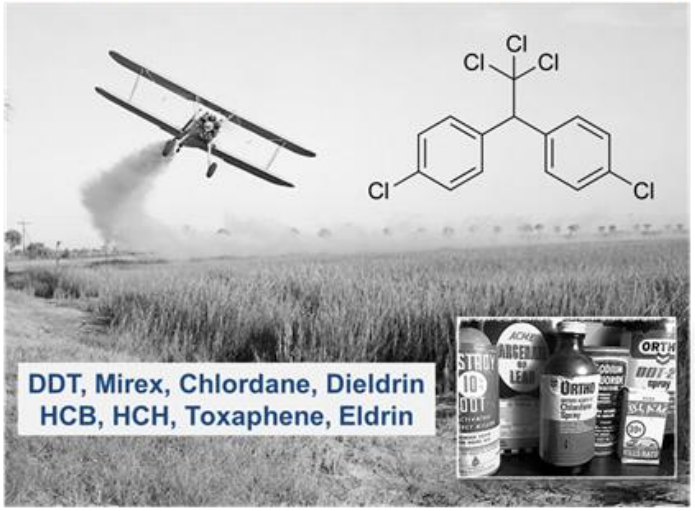
Organochlorine pesticides (OCP)



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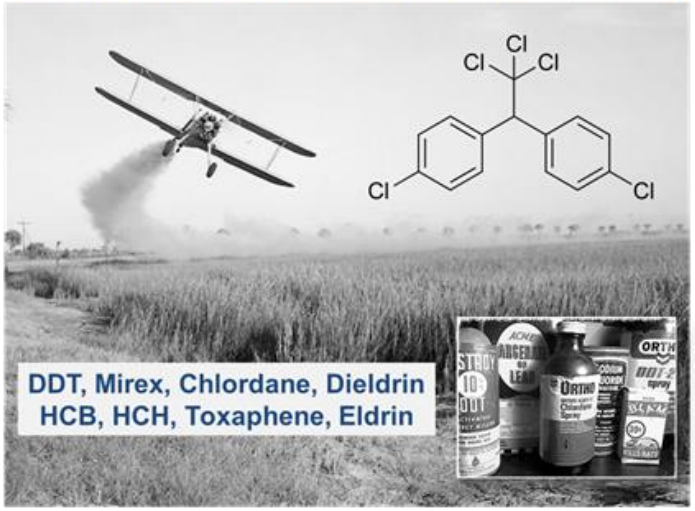

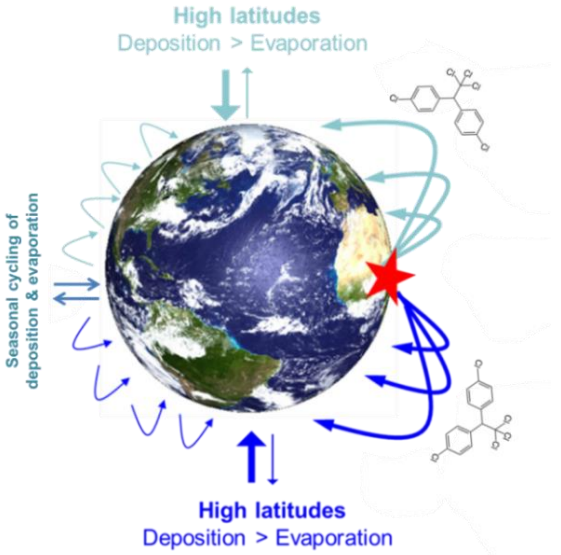

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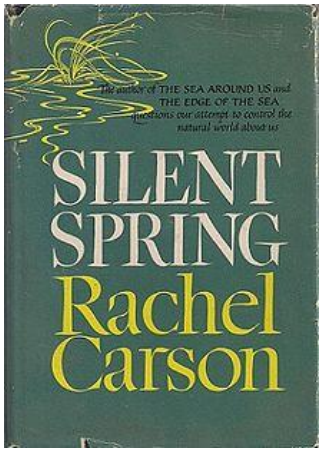

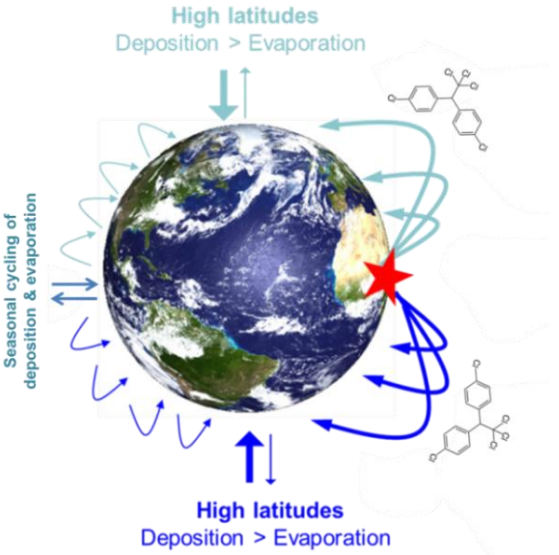

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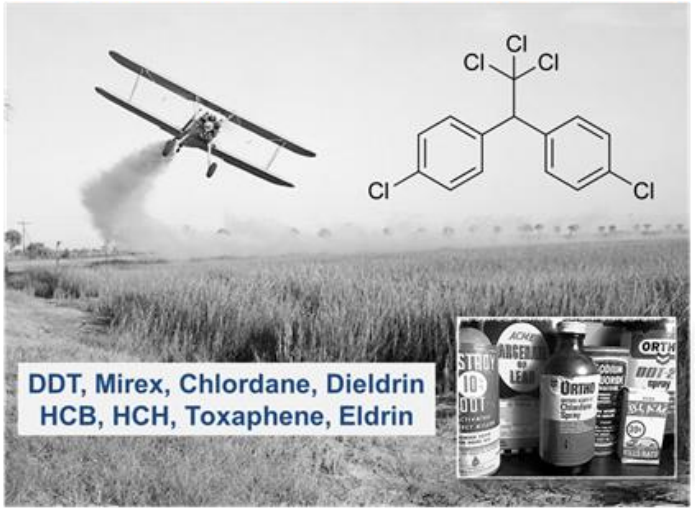
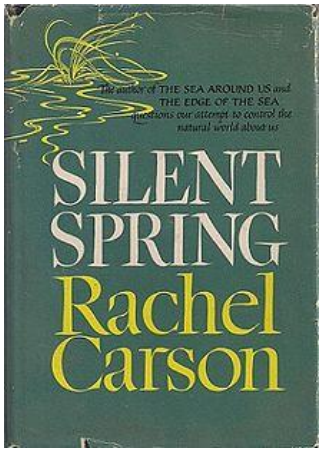
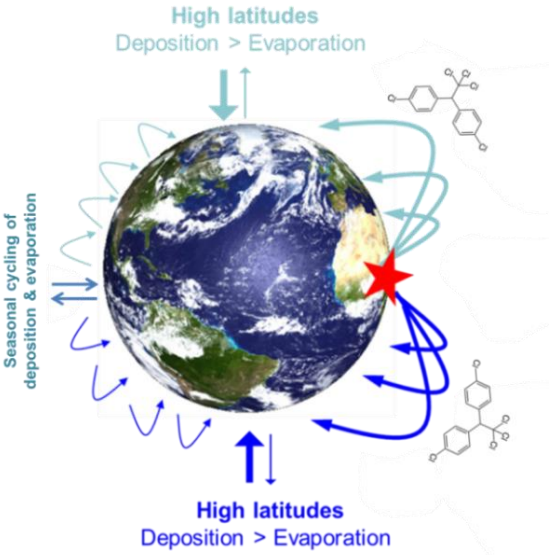


ECHA

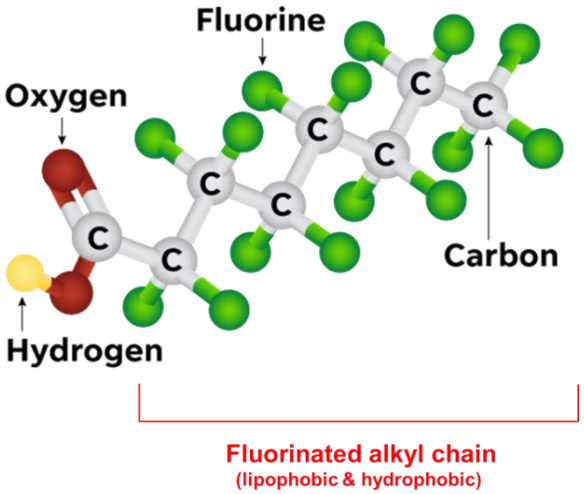
EUROPEAN CHEMICALS AGENCY

> 150 000 man made chemicals





Poly-and Per fluoroalkyl Substances (PFAS)



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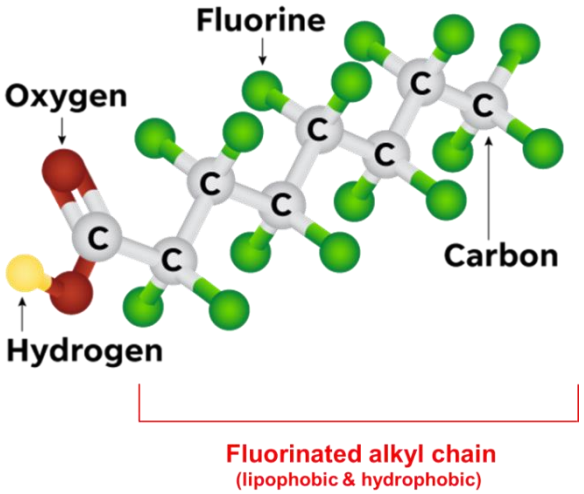

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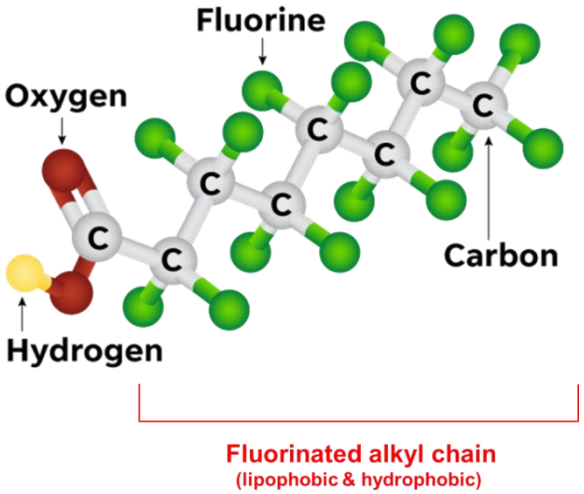

Used in a multitude of manufactured products

Toxicological effects of PFAS

PFAS are extremely persistent (C-F bound) "For ever chemicals"

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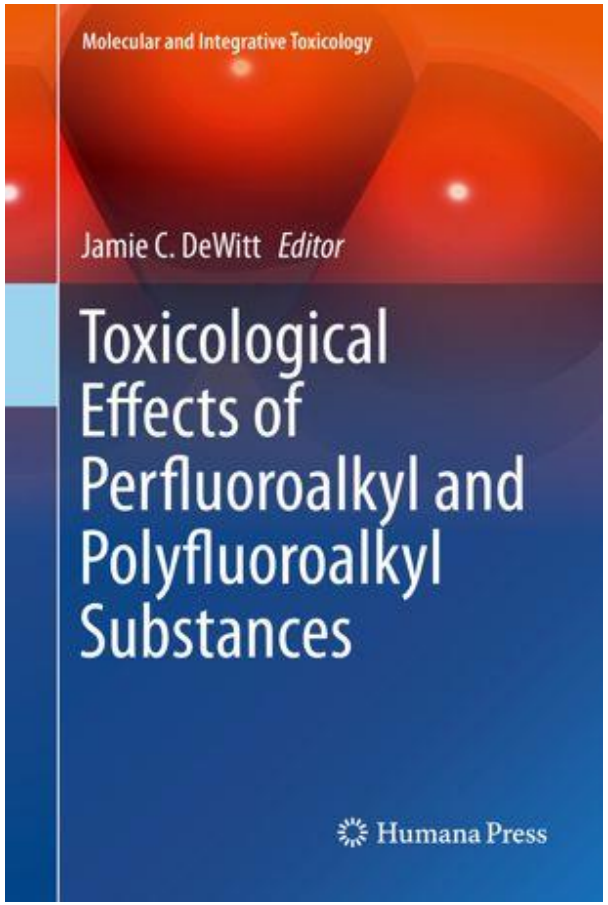

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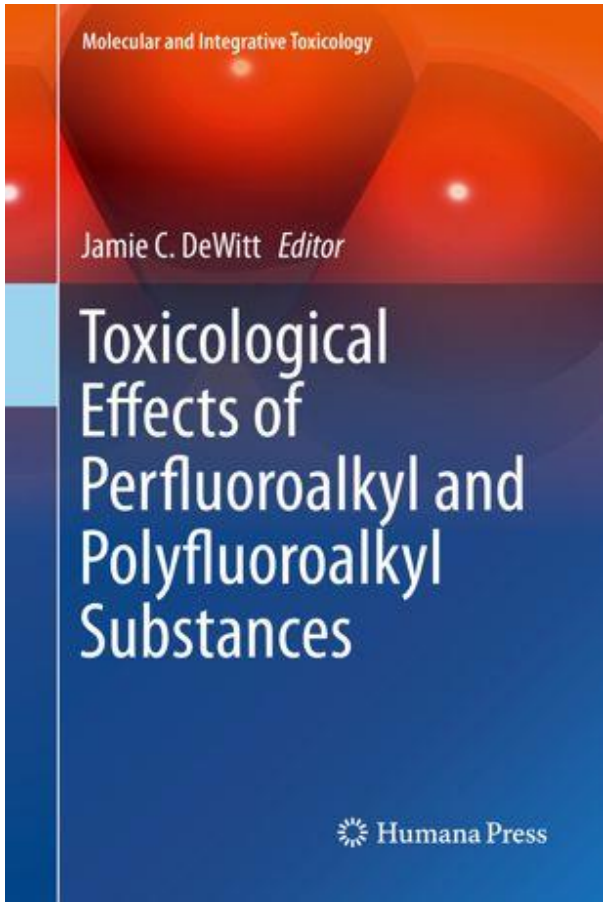

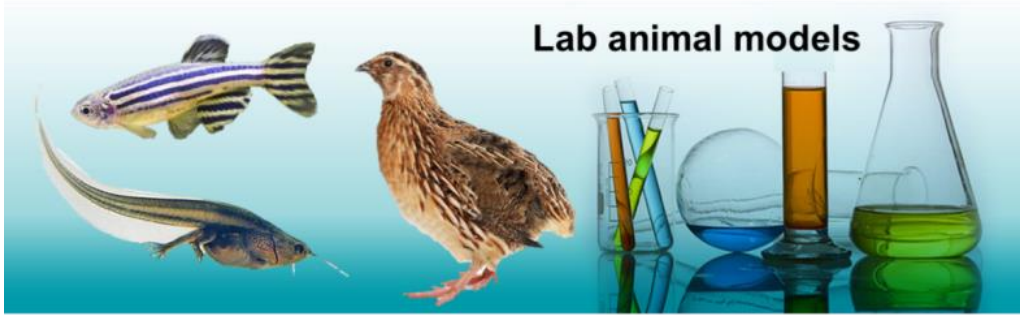

In humans and lab models, PFAS can cause cancer, affect immunocompetence, delays in physical development, neonatal mortality and endocrine disruption.

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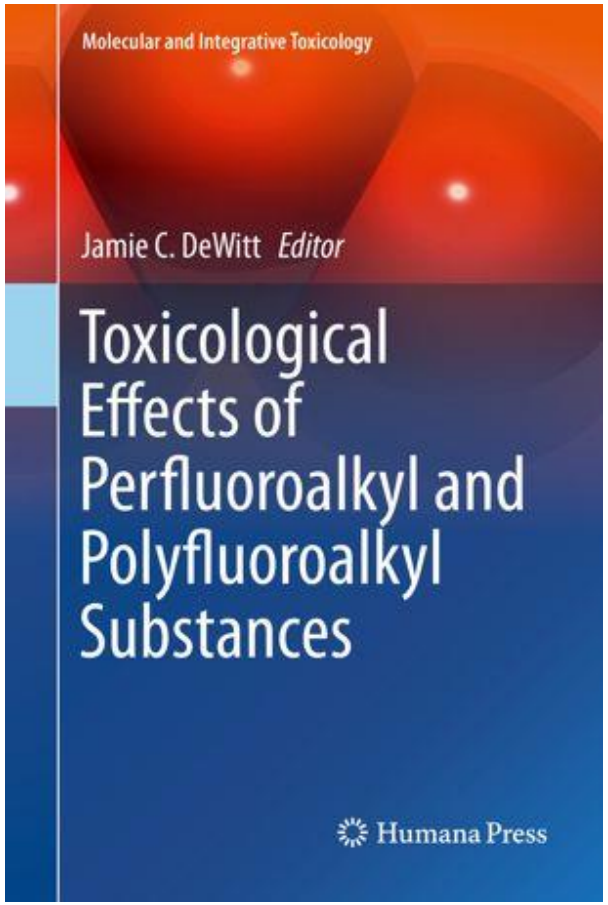

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Perfluorooctane sulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) have been included under the Stockholm Convention on POPs. The vast majority of PFAS are not regulated yet.

PFOA FREE COATING

Health & Environment

Toxicological effects of PFAS

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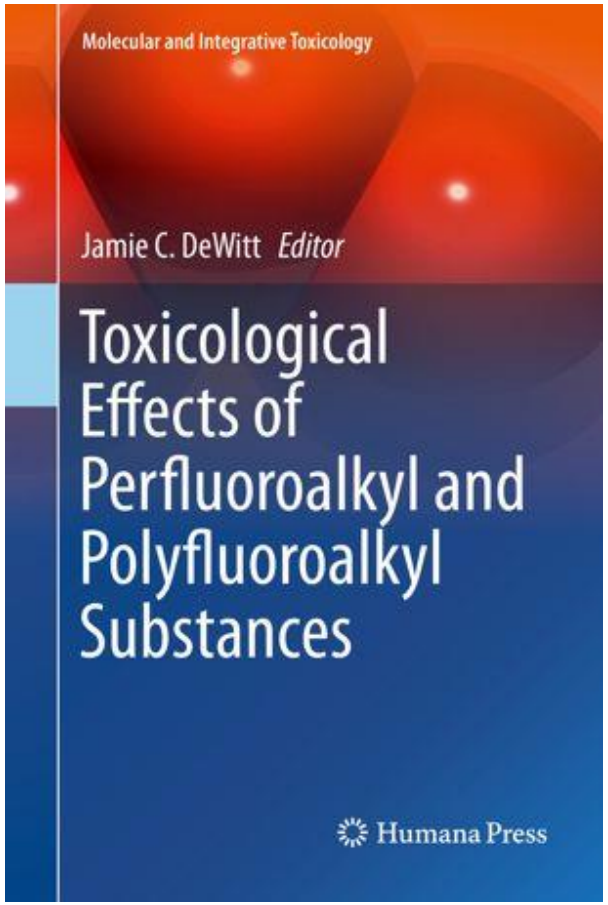

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PFOA FREE COATING
Health & Environment

The PFAS group covers more than 4,700 substances…

PFAS: What consequences for willdife?

PFAS have bioaccumulation and biomagnification properties. However, the consequences of PFAS exposure on physiology and fitness (fecundity, survival) are poorly investigated in wildlife.

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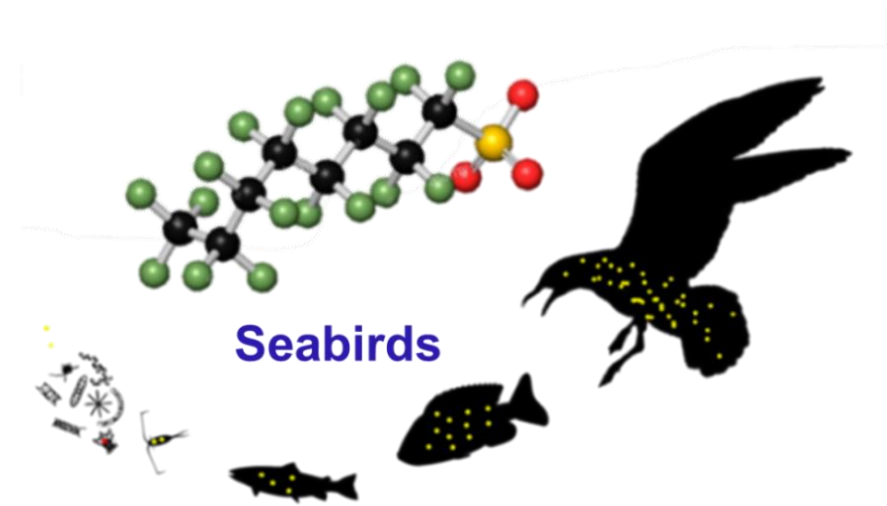

Apex predators, relevant bioindicators for PFAS contamination

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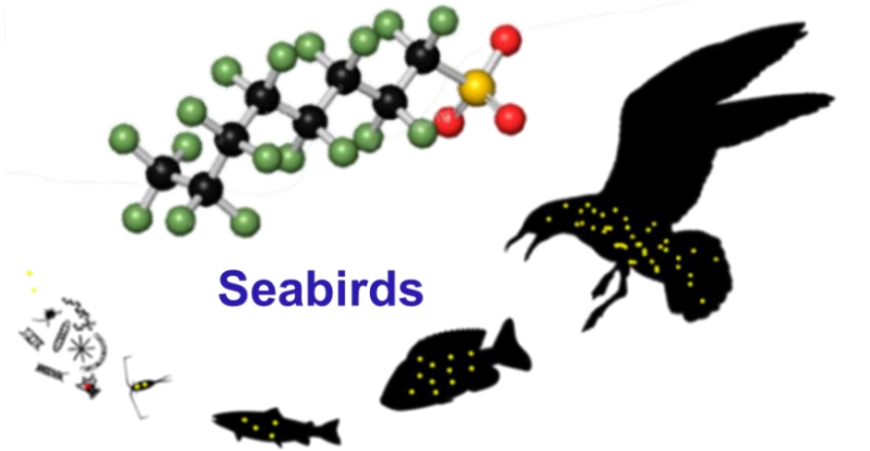

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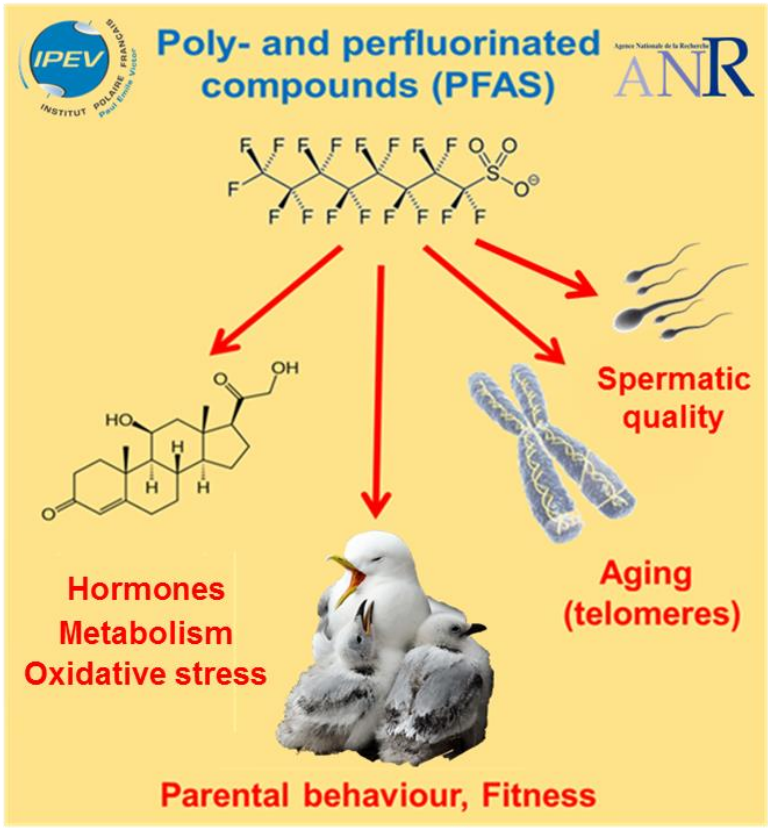

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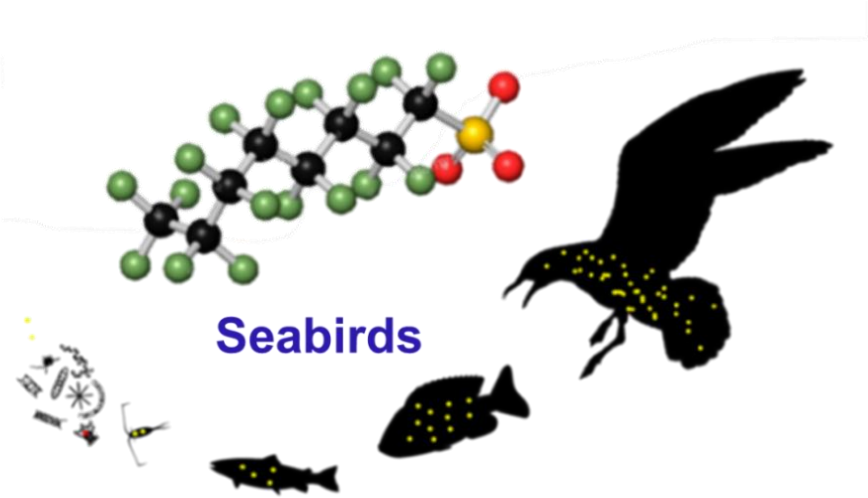

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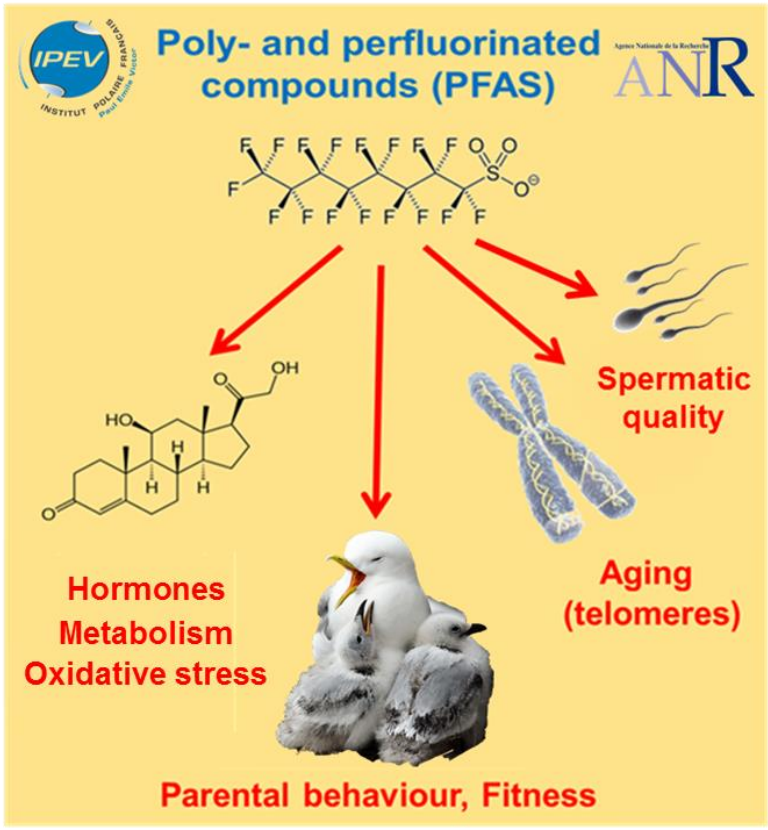
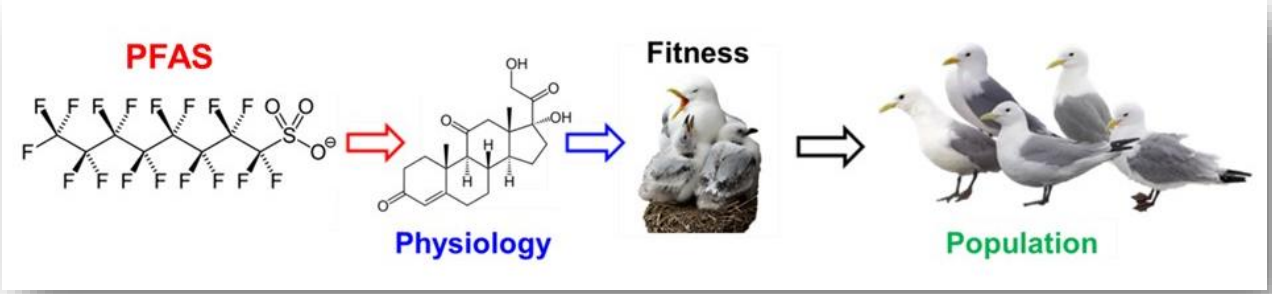
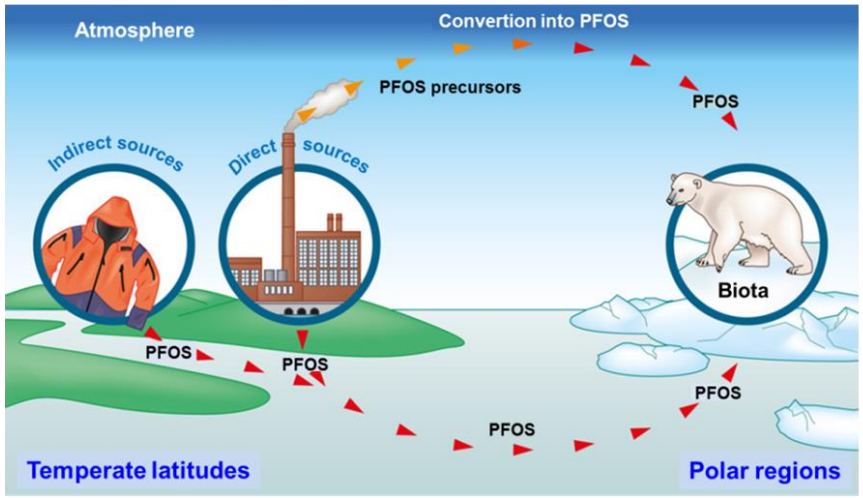




PFAS: What consequences for polar seabirds?

Long range transport of PFAS to polar areas



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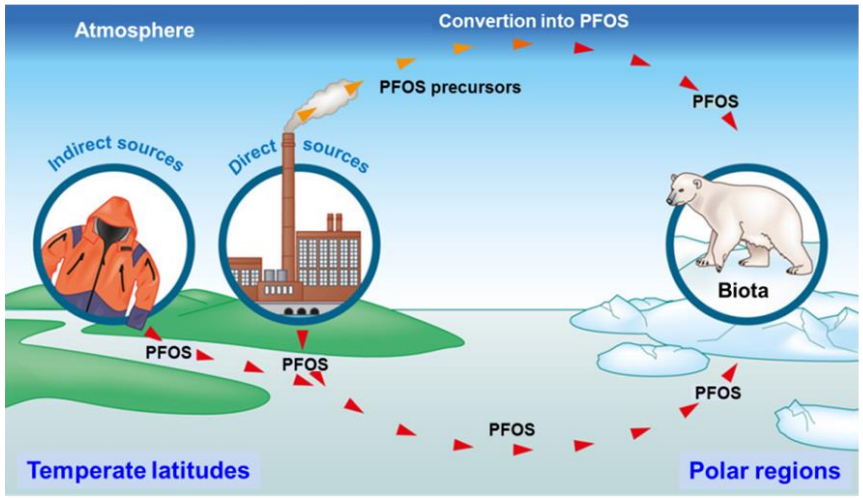
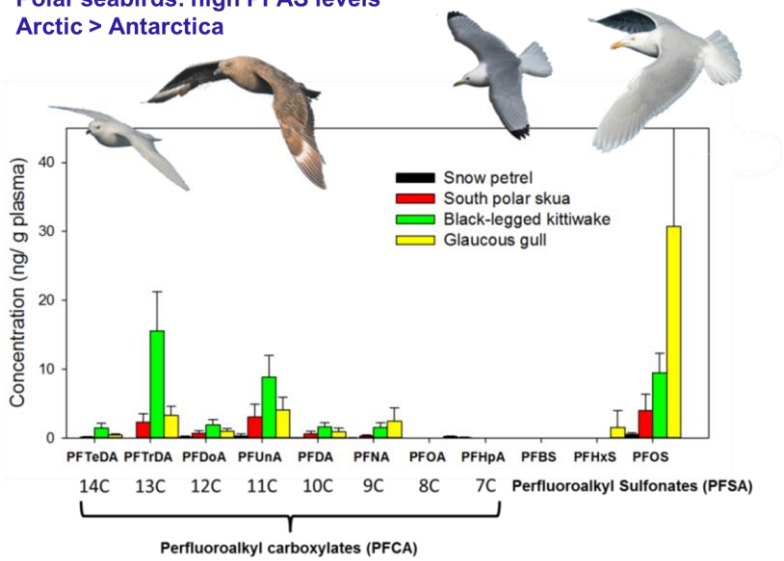


Polar seabirds: high PFAS levels
Arctic > Antarctica



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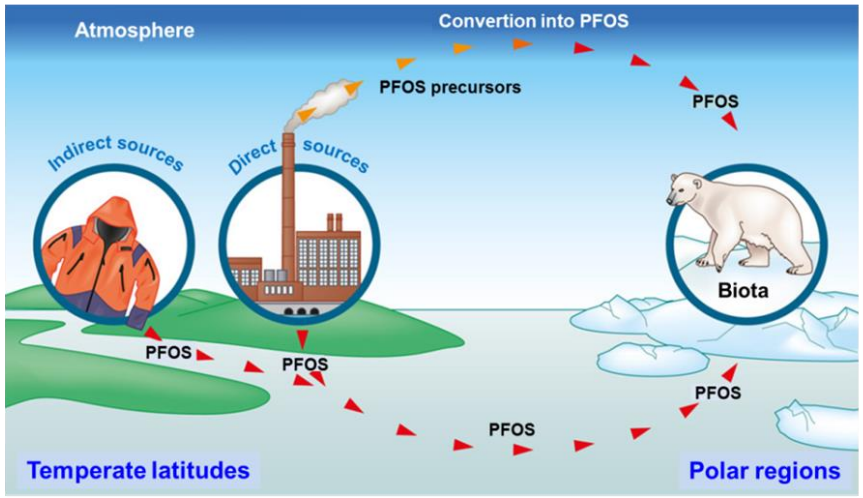

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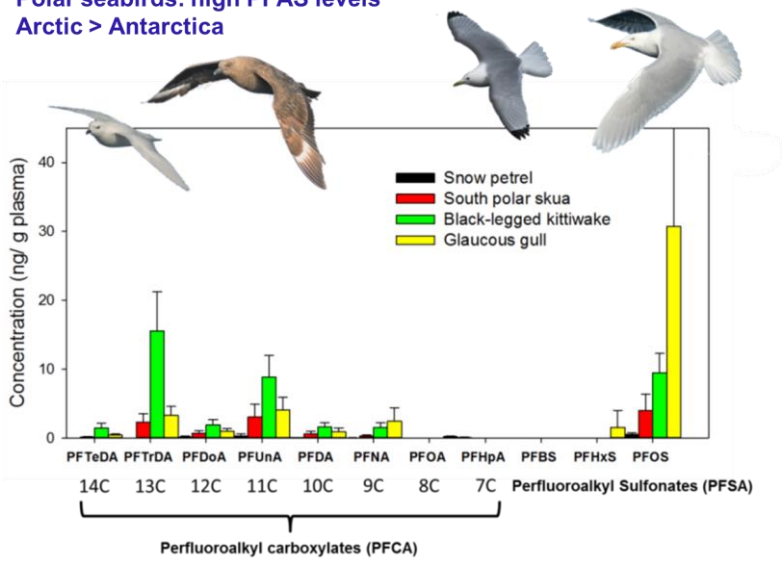

14 PFAS

Carboxylates: Br-PFOA, L-PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA

Sulfonates: PFHxS, Br-PFHpS, LPFHpS, Br-PFOS, L-PFOS, FOSA

Munoz, Labadie, Geneste, Pardon, Tartu, Chastel, Budzinski (2017) *J. Chromato A*

Blévin, Tartu, Chastel, Bustamante, Parenteau, Herzke, Angelier, Ellis, Gabrielsen (2017) *Envir Research*

Demographic response to PFAS exposure – Fecundity

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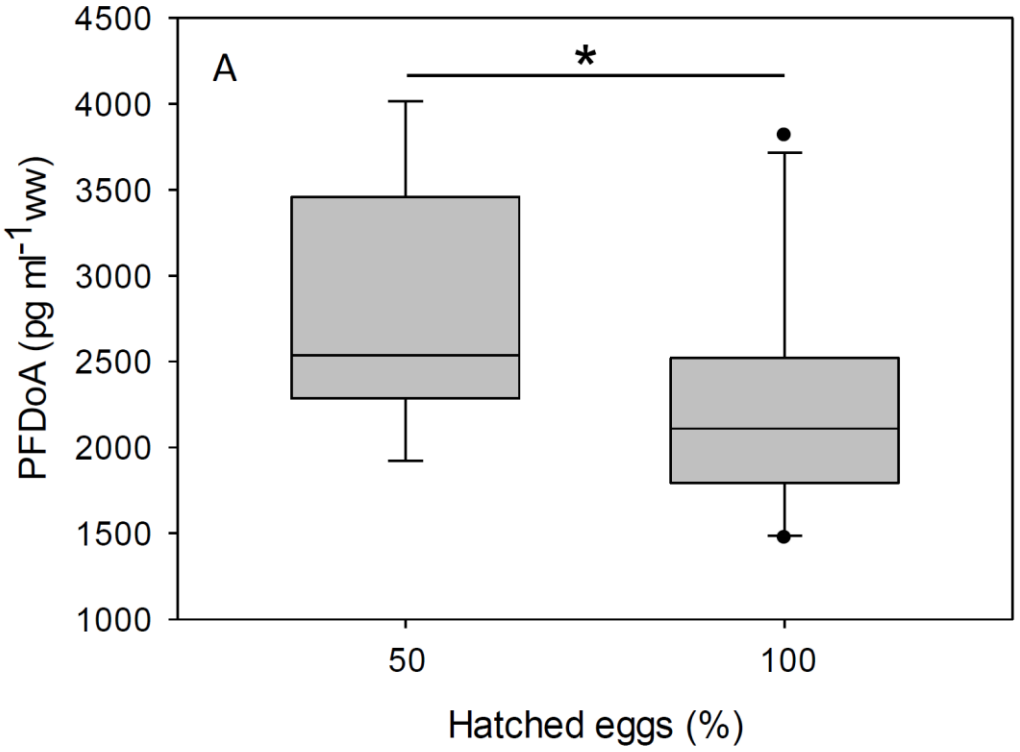
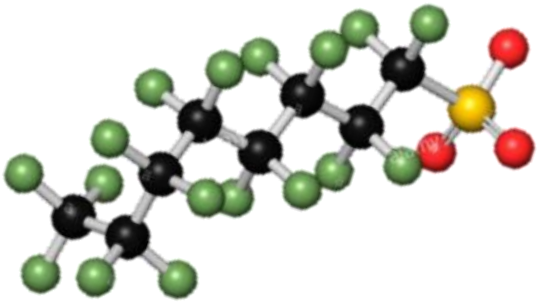


Exposure to long-chain PFAS associated with a lower hatching success

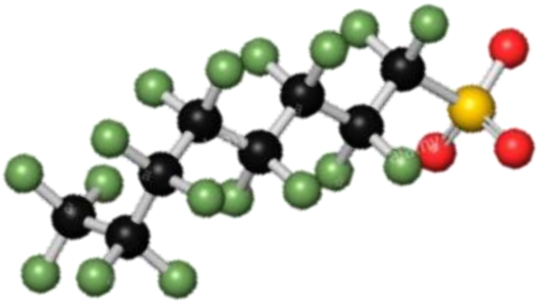
Tartu,Gabrielsen, Blévin, Ellis, Bustnes,Herzke, Chastel (2014) *Environmental Science and Technology*

Demographic response to PFAS exposure – fecundity and sperm quality



Some studies on humans suggest adverse effects of PFAS on sperm quality (Toft et al. (2012) Human Reproduction). For wildlife, the effect of PFAS exposure on sperm quality has not been documented yet.

Demographic response to PFAS exposure – fecundity and sperm quality



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Field study of kittiwake sperm quality (mobility, morphology)

Demographic response to PFAS exposure – fecundity and sperm quality

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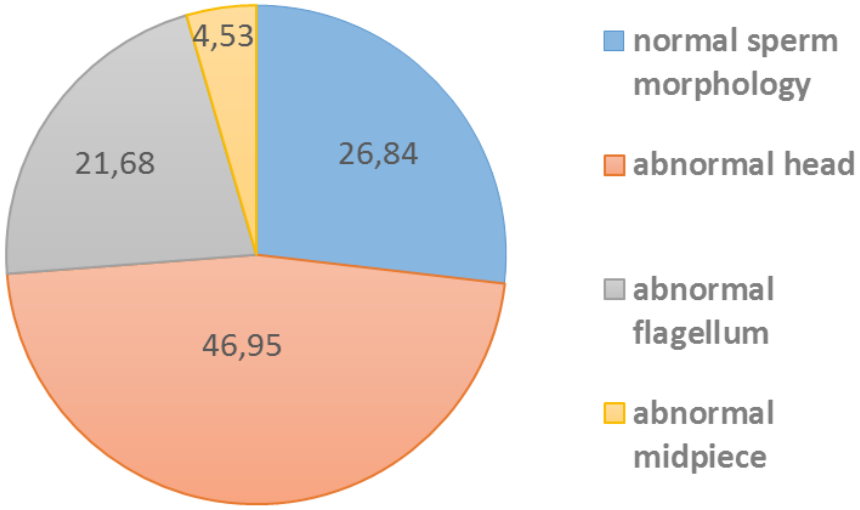

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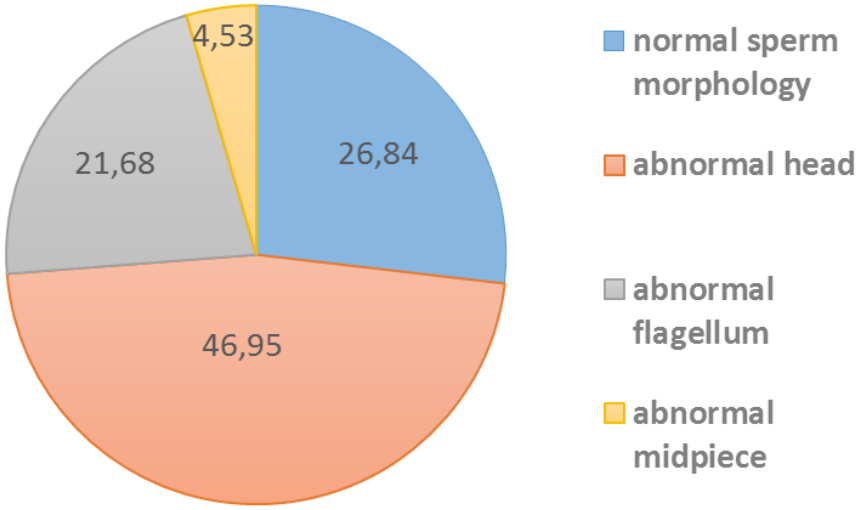

High frequency (>70%) of abnormal (head length) sperm cells in this kittiwake population

Humann-Guilleminot, Blévin, Azou-Barré, Yacoumas, Gabrielsen, Chastel, Helfenstein (2018) *Avian Research*

Demographic response to PFAS exposure – fecundity and sperm quality

Sperm mobility unrelated to plasma PFAS

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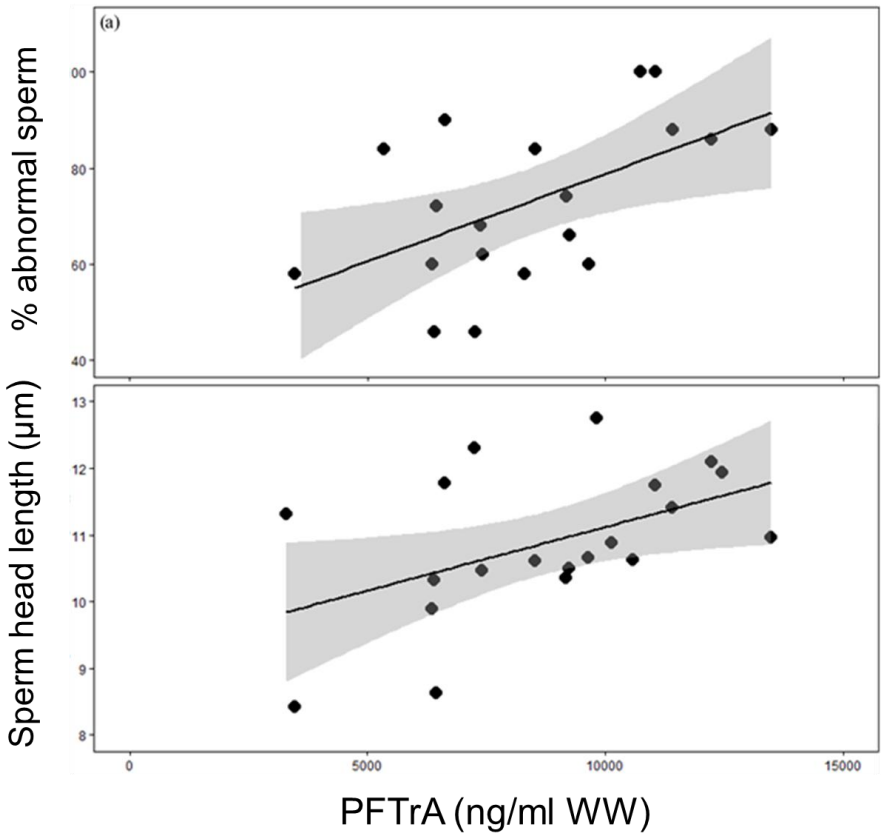
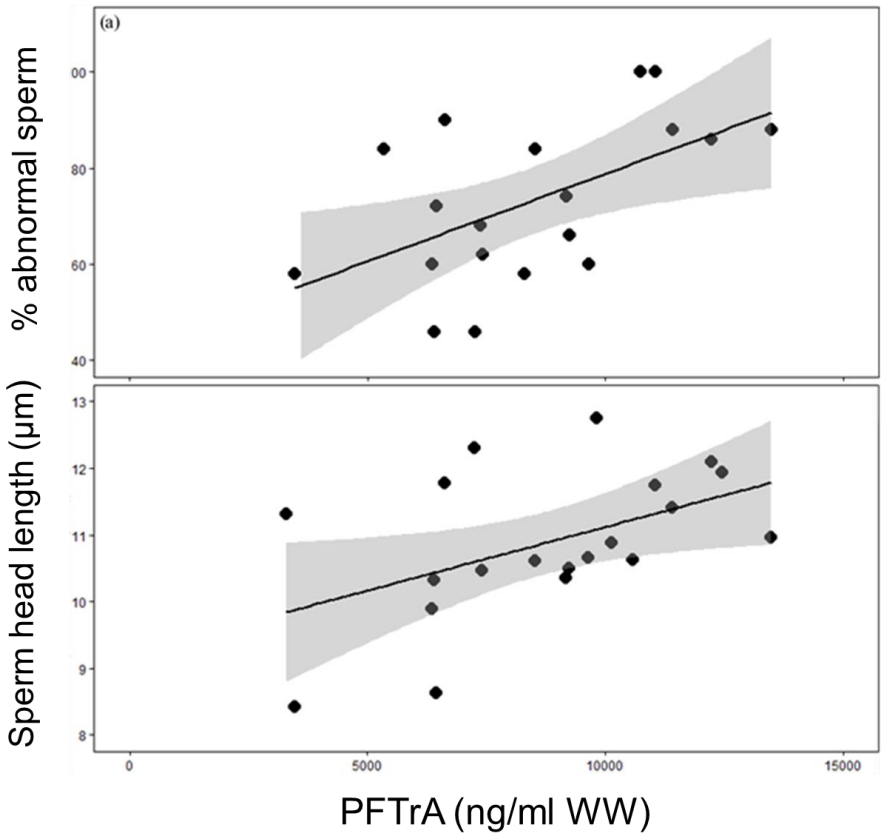


Exposure to long-chain PFAS associated with a high frequency of abnormal (head length) sperm cells.

Demographic response to PFAS exposure – fecundity and sperm quality

Sperm mobility unrelated to plasma PFAS



Exposure to long-chain PFAS associated with a high frequency of abnormal (head length) sperm cells.

Lower sperm cell quality induced by PFAS exposure may contribute to a lower hatching success. However, the potential mechanism by which long-chain PFAS may affect sperm morphology is not fully understood:

- **Testosterone levels unrelated to PFAS,**
- **Oxidative stress, stimulated by exposure to PFAS, may play a role (*Costantini, Blévin, Herzke, Moe, Gabrielsen, Bustnes, Chastel (2018) Environmental Research*).**

Chastel, Humann-Guilleminot, Azou-Barré, Yacoumas, Gabrielsen, Helfenstein, Blévin *In prep*

Demographic response to PFAS exposure – Adult survival

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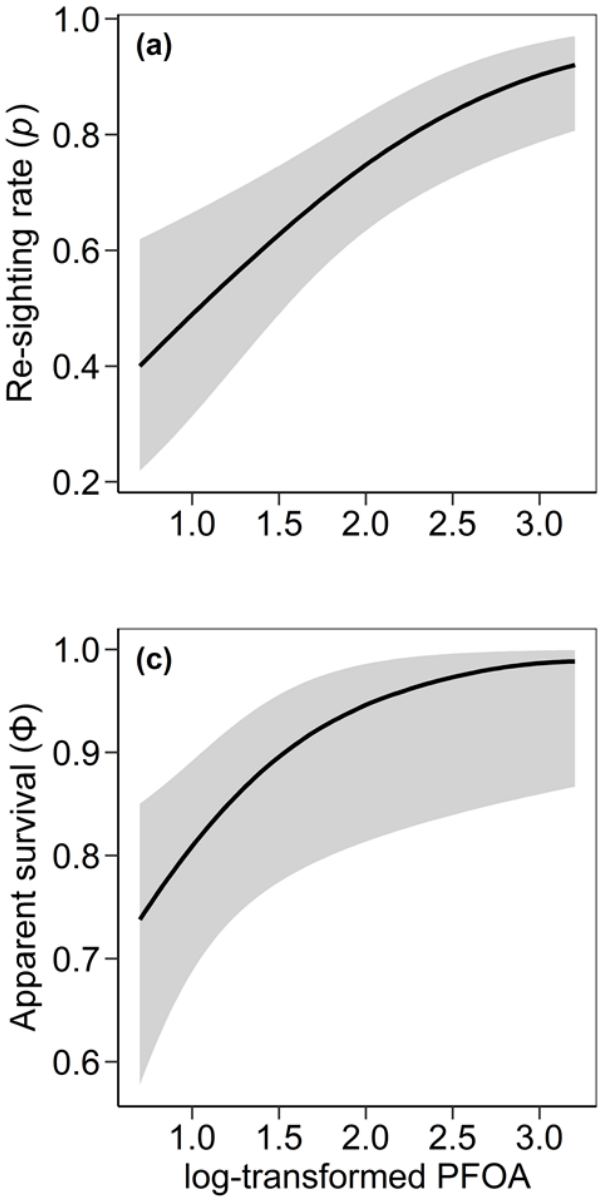
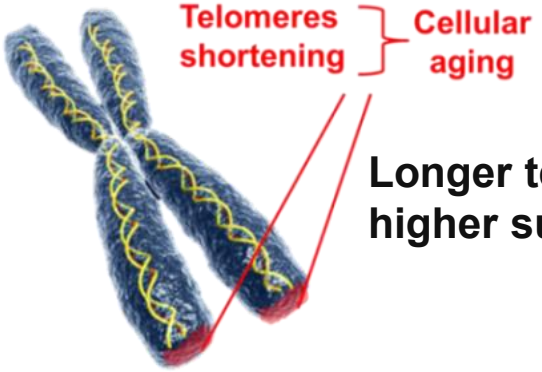
Unexpectedly, exposure to PFOA was associated with a higher adult survival and resighting probability



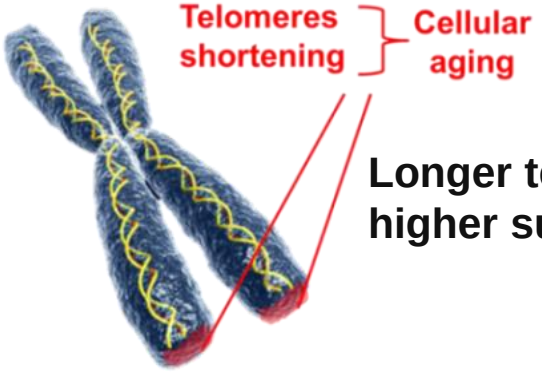
Sebastiano, Angelier, Blévin, Ribout, Sagerup, Descamps, Herzke, Moe, Barbraud, Bustnes, Gabrielsen, Chastel (2020) *Environmental Science and Technology*

Demographic response to PFAS exposure – Adult survival and cellular aging



Longer telomeres: higher survival

Demographic response to PFAS exposure – Adult survival and cellular aging



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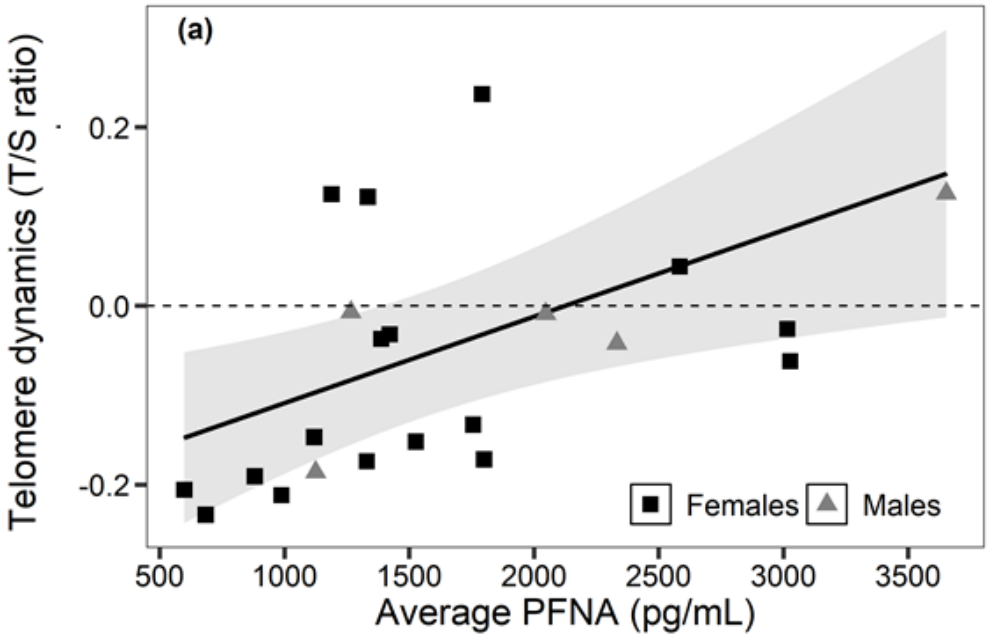
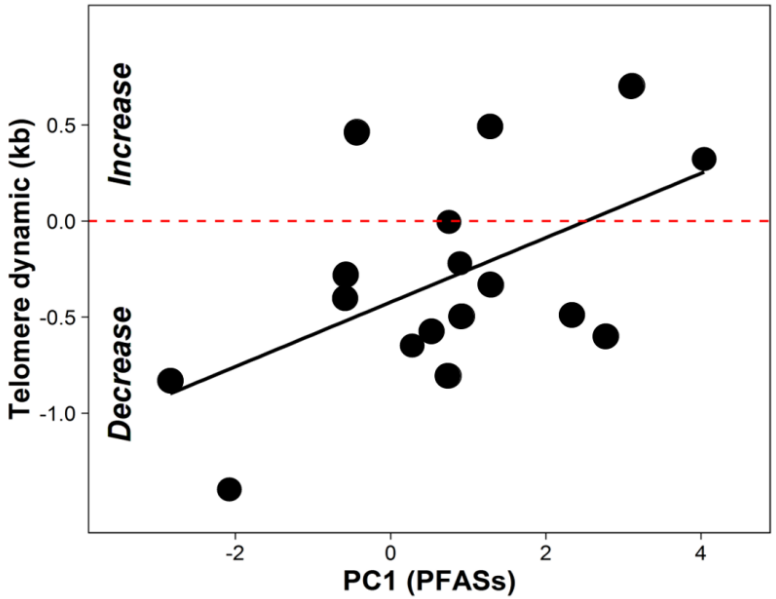


Glaucous gulls exposed to higher concentrations of long-chain PFAS showed the slowest rate of telomere shortening. Telomere elongation was even observed in most PFAS contaminated individuals. This is consistent with a higher survival rate in most PFAS-contaminated individuals

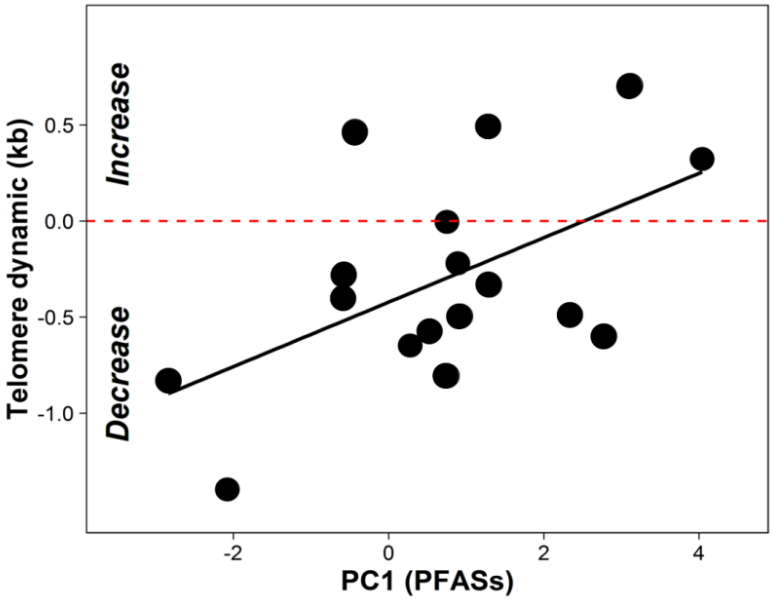
Sebastiano, Angelier, Blévin, Ribout, Sagerup, Descamps, Herzke, Moe, Barbraud, Bustnes, Gabrielsen, Chastel (2020) *Environmental Science and Technology*

Demographic response to PFAS exposure – Adult survival and cellular aging



As for glaucous gulls, kittiwakes exposed to higher concentrations of PFAS showed the slowest rate of telomere shortening and even display telomere elongation.

Demographic response to PFAS exposure – Adult survival and cellular aging



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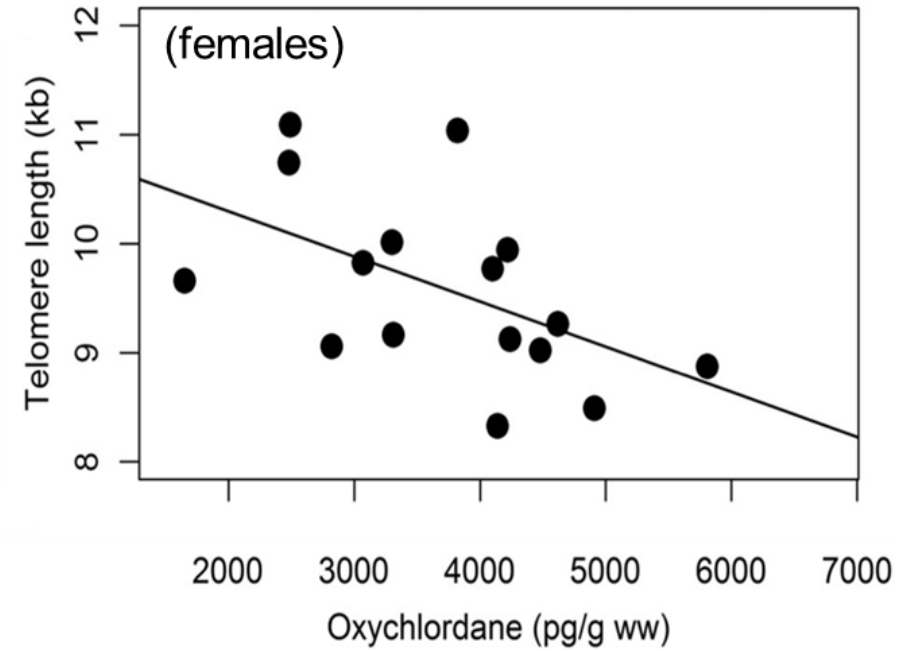
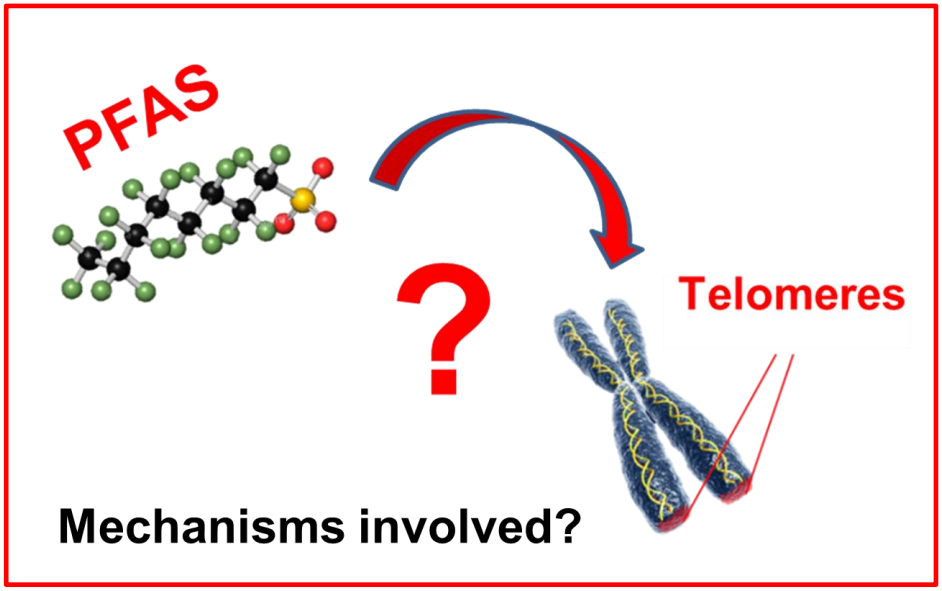


The reverse pattern is observed for organochlorine pesticides (Chlordane)

Blévin, Angelier, Tartu, Bustamante, Herzke, Moe, Bech, Gabrielsen, Bustnes, Chastel (2017) *Envir Poll*

Blévin, Angelier, Tartu, Ruault, Bustamante, Herzke, Moe, Bech, Gabrielsen, Bustnes, Chastel (2016) *STOTEN*

Demographic response to PFAS exposure – Adult survival and cellular aging



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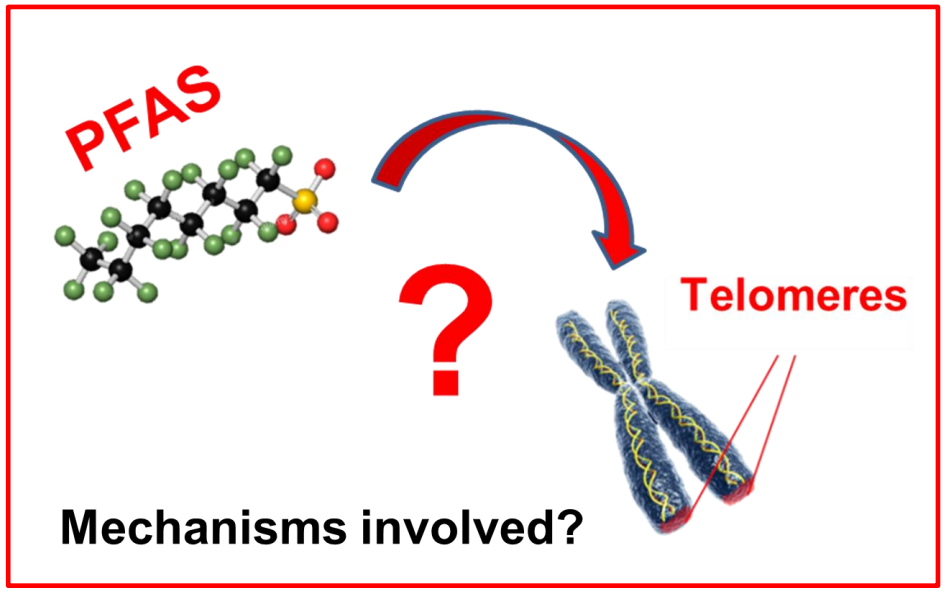

Glucocorticoids (stress hormones) are known to play a significant role in telomere dynamics. Shorter telomeres associated with high doses of glucocorticoids

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Do glucocorticoids mediate the link between environmental conditions and telomere dynamics in wild vertebrates? A review

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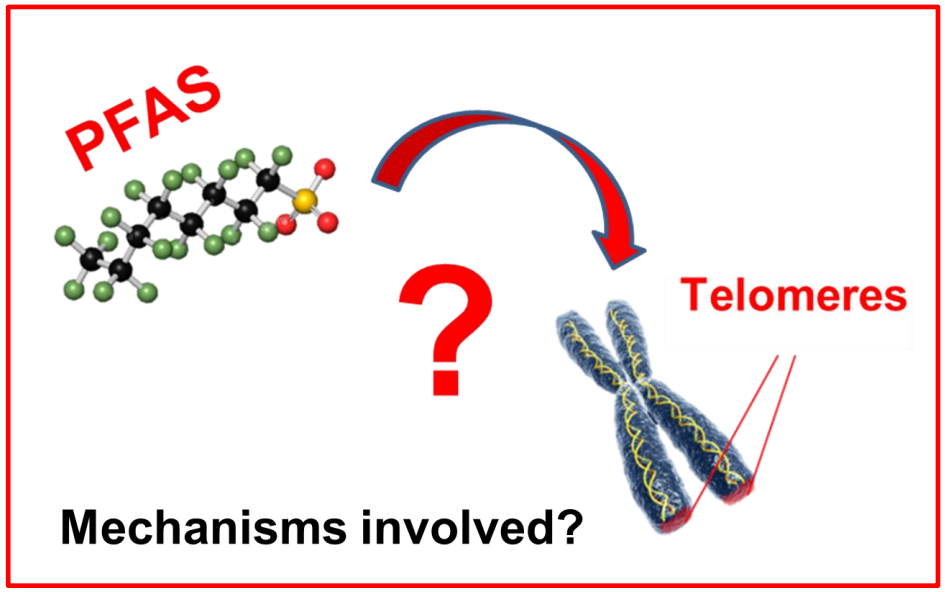

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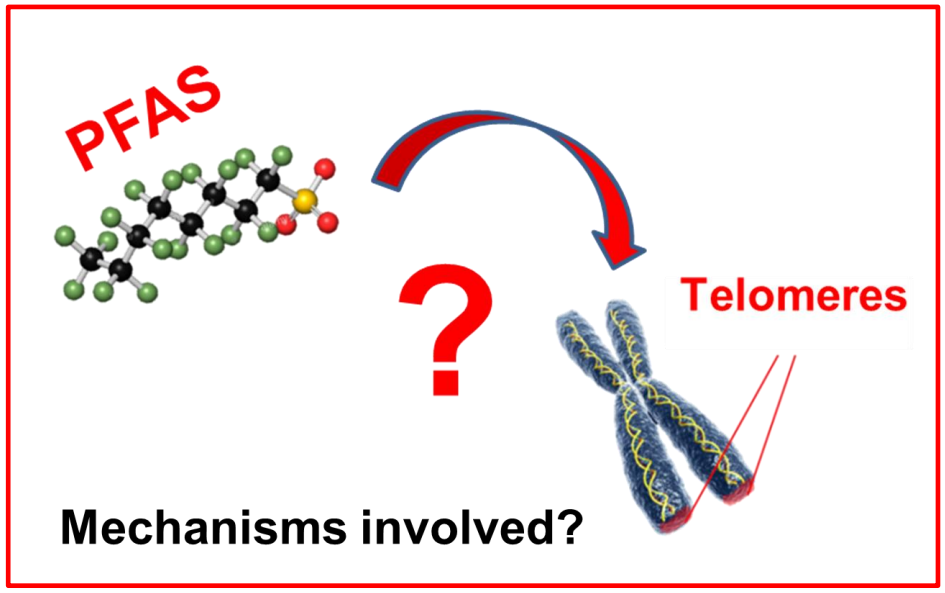

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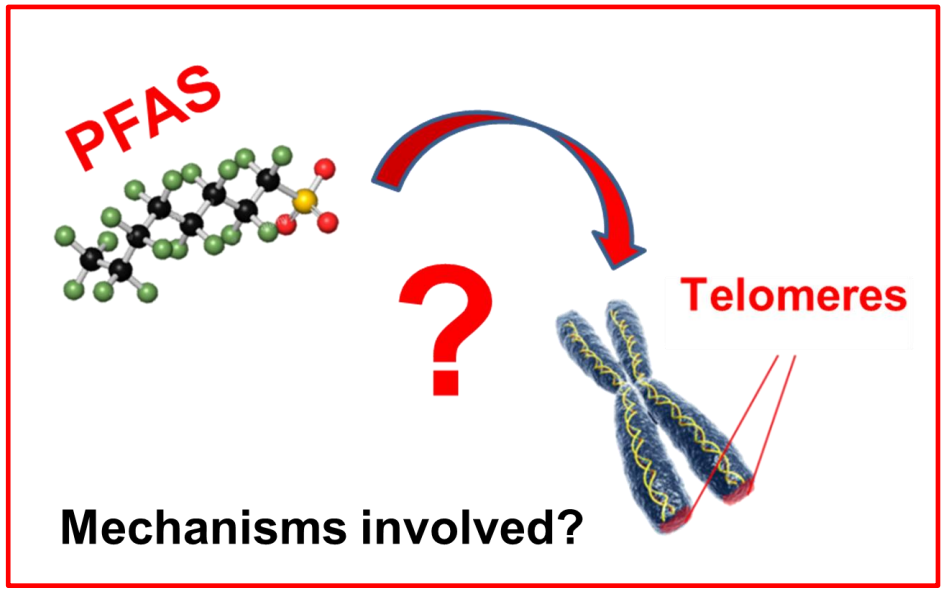

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The relationships between PFAS, physiology and fitness appear to be the reverse of what is observed for chlorinated POPs.
Further investigations are needed to identify the mechanisms involved.

Seabirds of continental France: what level of PFAS contamination?

In France, most studies on PFAS occurrence and exposure in aquatic ecosystems focused on water, sediments, invertebrates, and fishes

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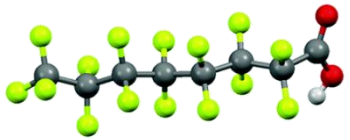

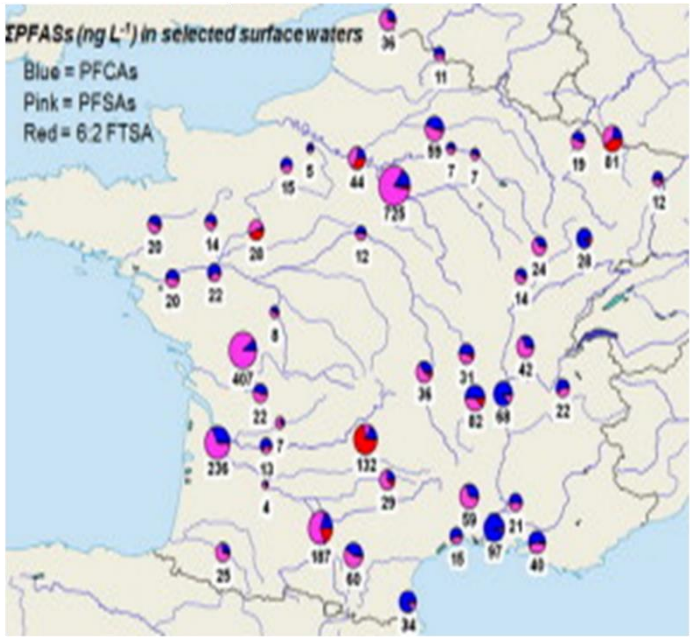

Munoz et al. 2015 *STOTEN*

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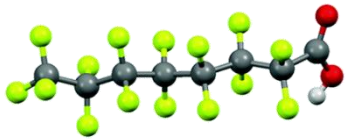

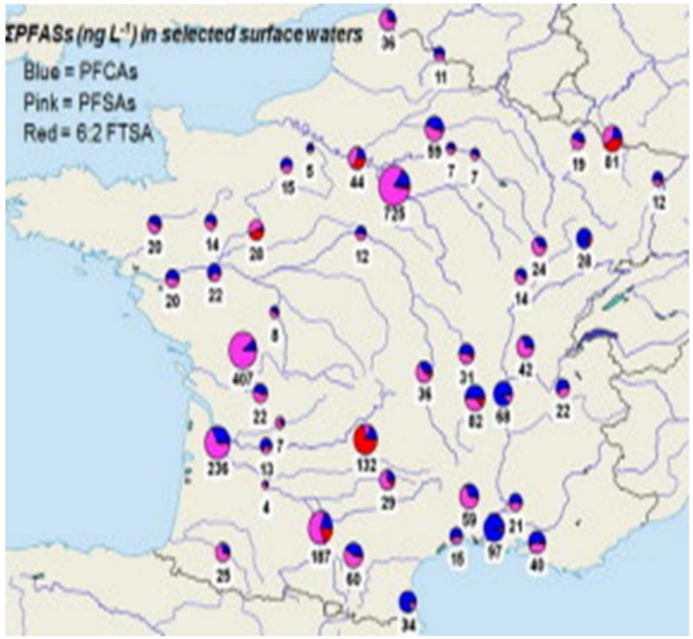

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Gulls (Larus) are relevant bioindicators for PFAS contamination:

- **High trophic position**
- **Inter and intra specific variation in foraging ecology**
- **Colonial nesting**
- **Large distribution**
- **Capture Mark Recapture studies**

PFAS exposure in French seabirds

Larus marinus
Larus argentatus
Larus fuscus graellsii
Larus michaelis

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Larus marinus
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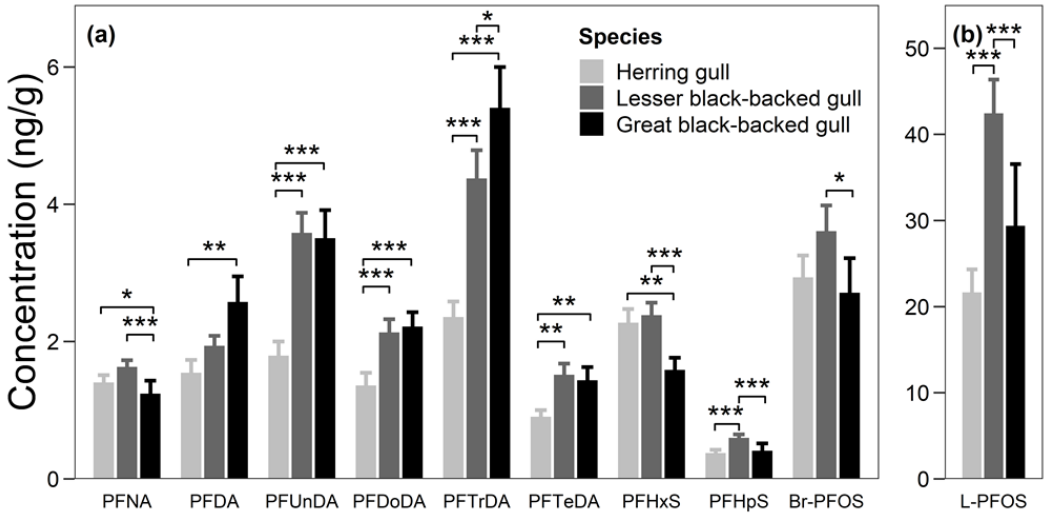
PFAS exposure in French seabirds

Blood contaminants:
- Mercury, legacy POPs (DDT, PCB), PFAS

Biomarkers:
- Hormones, oxidative stress, telomeres

Fitness:
-Breeding succes, survival

PFAS exposure in French seabirds



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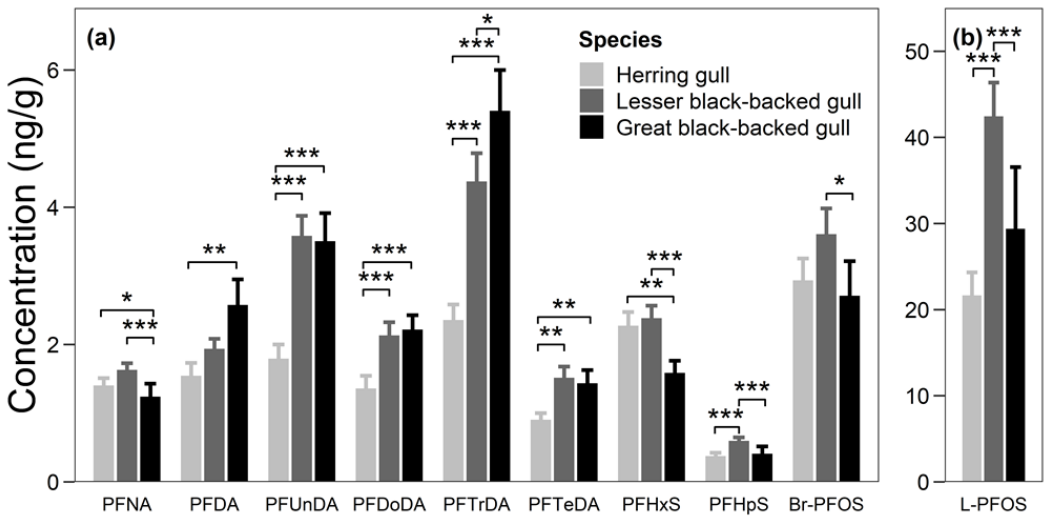

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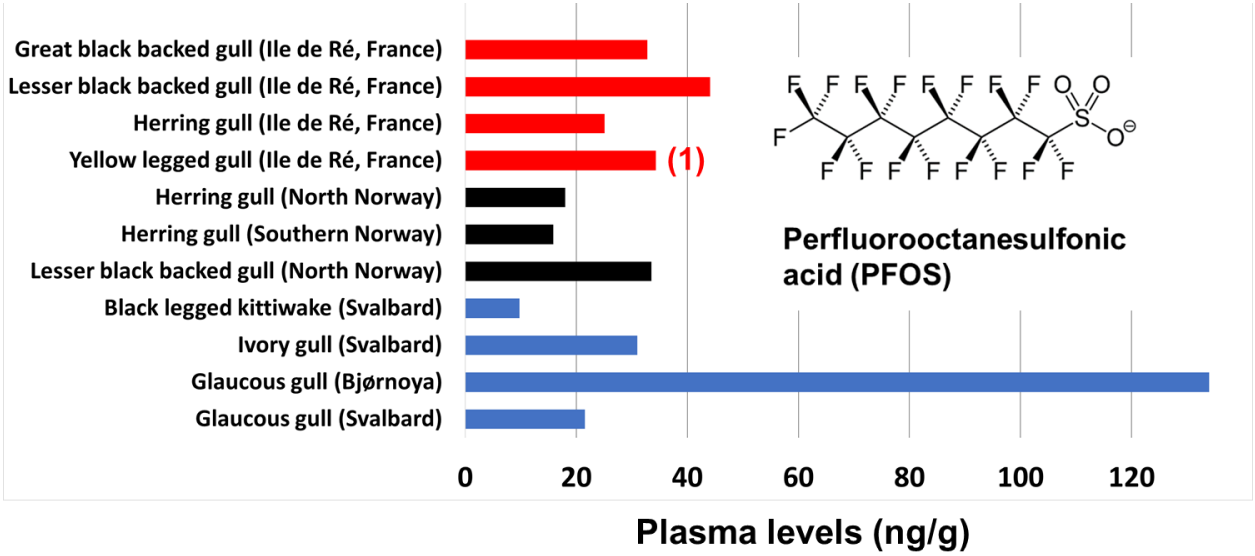

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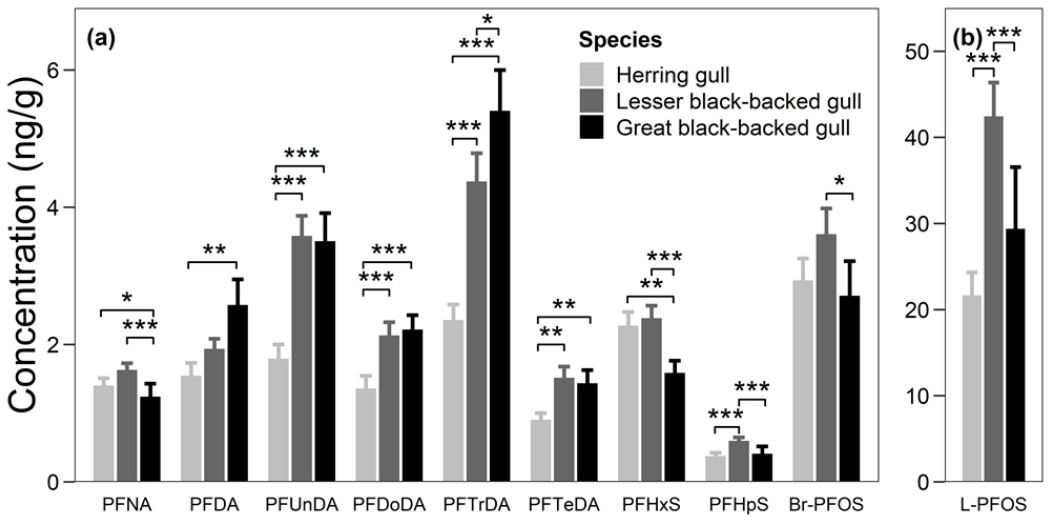

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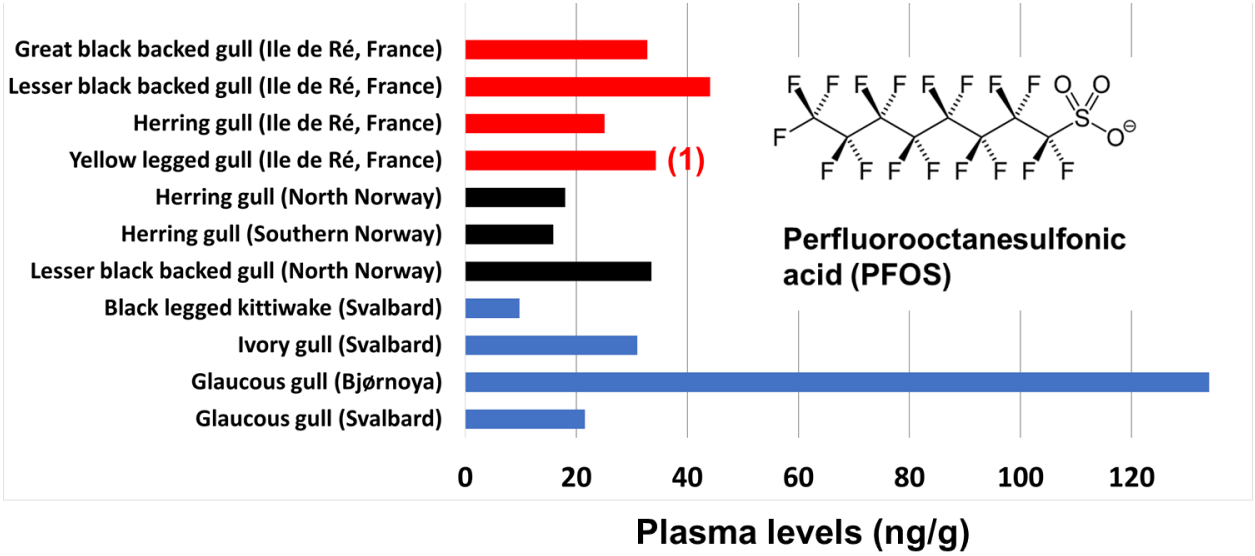

The levels of PFAS found in Ile de Ré gulls are equivalent to or exceed those for which effects (physiology-fitness) have been observed (Svalbard glaucous gulls and kittiwakes)

Thank you!

INSTITUT POLAIRE FRANÇAIS PAUL-ÉMILE VICTOR

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The Research Council of Norway

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