
# ILVO – Animal Sciences - Fisheries

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# Building expert knowledge for integrated science and advice

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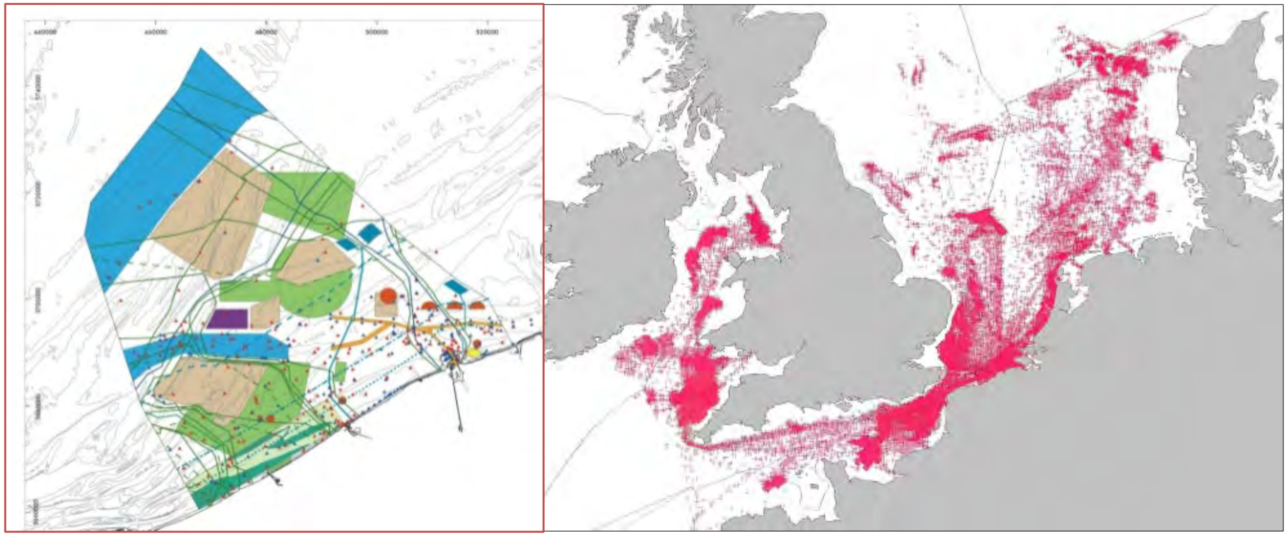
Institute for Agricultural and Fisheries Research
Unit Animal Sciences
www.ilvo.vlaanderen.be
Policy Domain Agriculture and Fisheries

# Three research cases from the southern North Sea


# Introduction

➢ 

➢ **Spacial planning of extraction, shipping lanes, dredging, cables, pipes, wind mill farms, aquaculture, fisheries etc.**

➢ **Visible forms of human interactions with the marine environment**

# Introduction

- Less visible or hidden human interactions with the marine environment

- Invasive species - climate change – ballast water
  - Opportunities e.g. sea bass
  - Threats and deseases:
    - e.g. M. leidy
    - White Spot Desease

- Microplastics/nanomaterial

- Natural disasters

- Acidification/pollutants

- Often cross-continental problems

# Introduction

- At least all the human interactions have their specific and/or common and cross-linked, regional and/or cross-continental effects on the marine food chains, living resources, health of the seas,…
- Need for better integrated science and advice to replace the current 'single purpose' policy
- And deterioration of the marine environment is very often a combination of human (and natural) interactions

# Case 1 – Effects of tributyltin (TBT) on crustacea

- **Evidence for the effects of the antifoulant TBT on the dogwhelk *Nucella lapilus* in the early 70s and later**
- **Causes imposex at 1-2ng/l; death at 5ng/l**
- **Resulted in world-wide ban**

- **In 2004 : EU-project: sources, consumer exposure and risks of organotin contamination in seafood – median of 90ng TBT/g edible portion was measured in the crustacean *Crangon crangon***
- ***Crangon plays an important ecological role in European estuaries and coastal zones***
- **Commercially important – annual catch in North Sea: 50,000 tons**

- **Research started on impairment of growth by TBT**

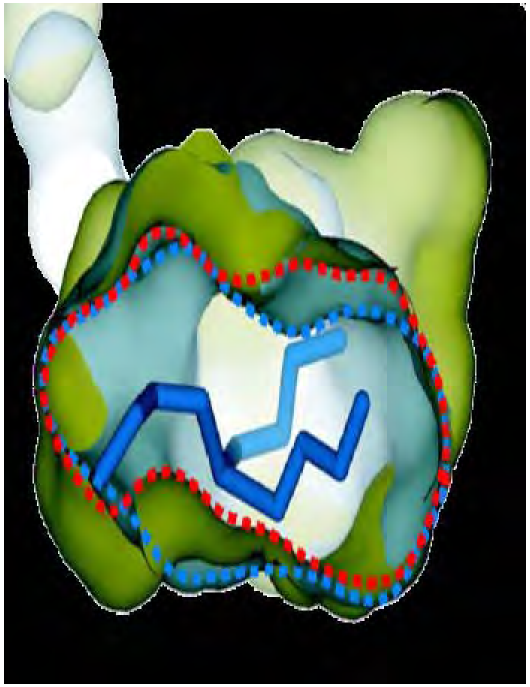
# Case 1 – Effects of tributyltin (TBT) on crustacea

- Focus on the ecdysteroid receptor protein for growth and development - complex regulatory system in arthropods
- The functionality is a heterodimer EcR/RXR ligand complex
  - Highly conservative regulator of growth and molting throughout phylogenetic evolution of arthropods
  - Used for endocrine disruption studies e.g. in
    - research on crop protection (QSAR)
    - imposex in gastropods (Sousa et al., 2010)
    - EcR/RXR activation and growth impairment in crustacea (Wang and Leblanc, 2009; Verhaegen et al. 2010) / etc.

# Case 1 – Effects of tributyltin (TBT) on crustacea

**Results: TBT interference in EcR/RXR in shrimp on three levels is documented: physical, functional and gene regulation**

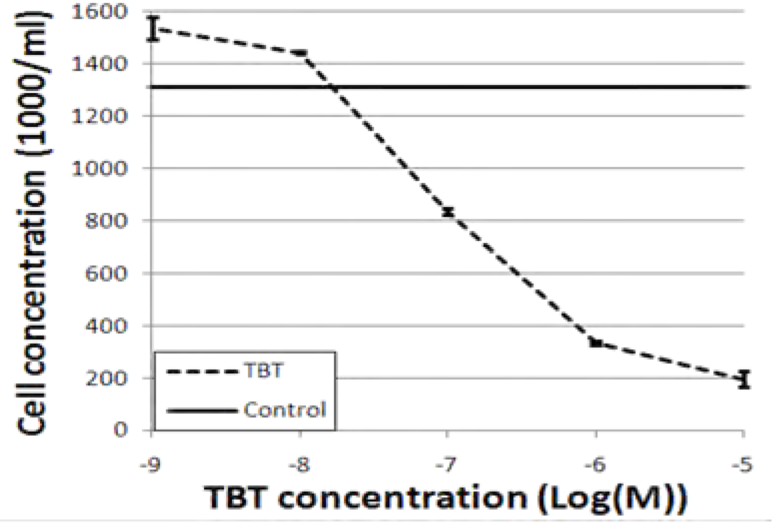
- **Physical: TBT blockage of the RXR ligand binding pocket**



# Case 1 – Effects of tributyltin (TBT) on crustacea

**Results: TBT interference in RXR in shrimp on three levels is documented: physical, functional and gene regulation**

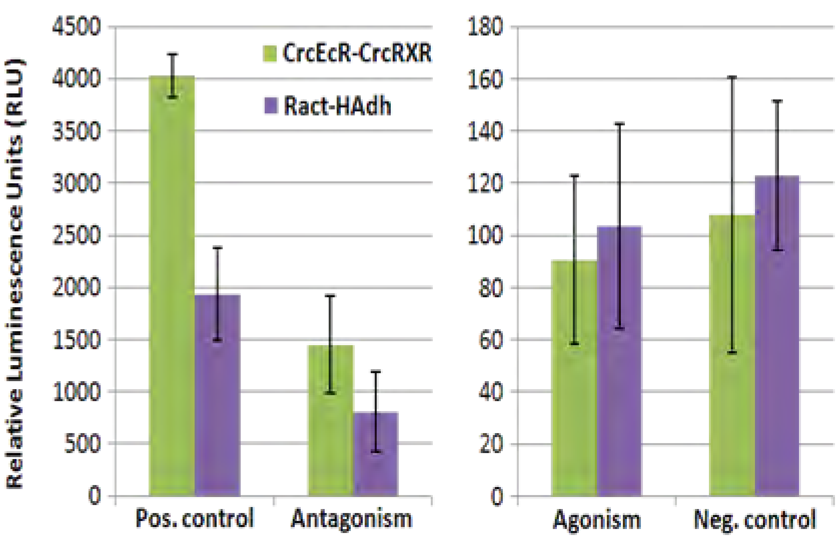
- **Functional: cell death at approx. $10^{-7}$M**




# Case 1 – Effects of tributyltin (TBT) on crustacea

**Results: documented TBT interference in RXR in shrimp on three levels: physical, functional and gene regulation**

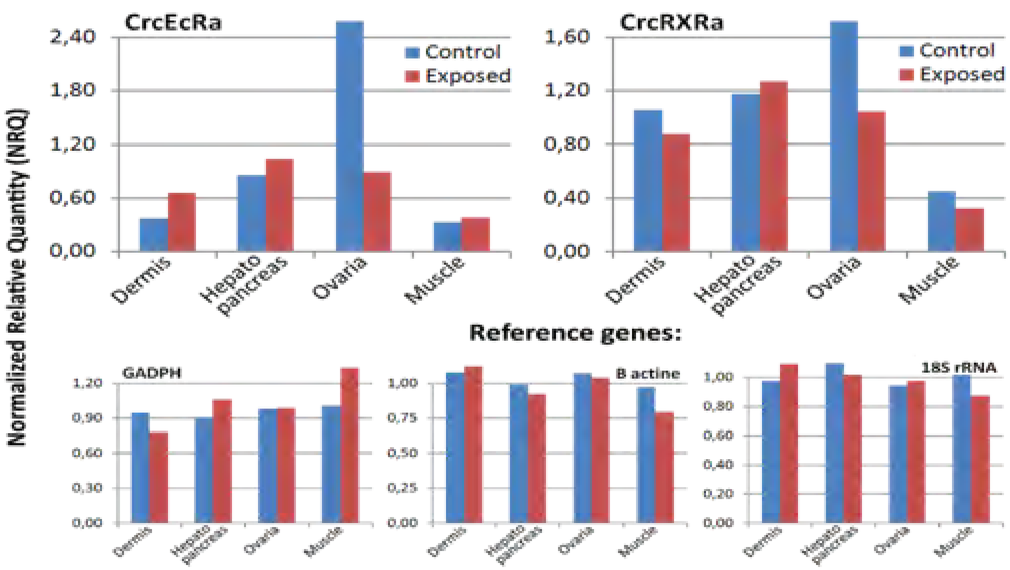
- **Functional: clear antagonistic effect at $10^{-8}$M on EcR/RXR complex – competition between the ecdysteroid hormone PonA (ecdysteroid hormone) and TBT is shown in the figure**




# Case 1 – Effects of tributyltin (TBT) on crustacea

**Results: TBT interference in RXR in shrimp on three levels is documented: physical, functional and gene regulation**

- **Gene regulation (*in vivo* exposure studies): clear tissue specific effect on EcR expression in ovaries**




# Case 1 – Effects of tributyltin (TBT) on crustacea

**What to do with the results? questions**

- **Are there effects of TBT on *Crangon* in the field?**
- ***What are the TBT concentrations in the marine environment?***
- **How do the TBT field concentrations evolve?**
- **How do the shrimp stocks evolve?**
- **Is it possible that TBT suppressed the shrimp stocks?**
- **Or did overfishing reduce the stocks?**

**What do we know?**

- **Low TBT levels impair the growth of *Crangon***
- ***The TBT concentrations in the marine environment before and after the total ban on TBT***
- ***Long-term stock assessment and recruitment data on shrimp***

**Solution: Integration of all data (involvement of ICES EGs WGBEC/MCWG/WGCRAN)**

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# Case 1 – Effects of tributyltin (TBT) on crustacea

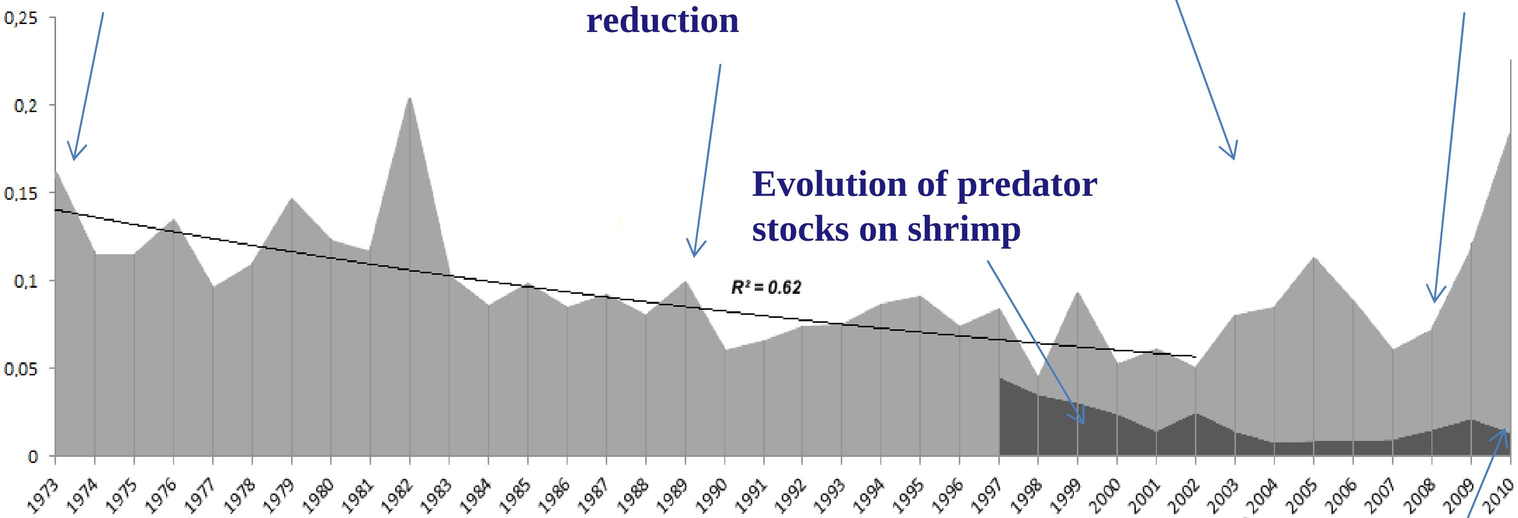
**Start use of TBT**

**Shrimp stock reduction**

**Start total ban on TBT**

**Total ban on TBT**

**Evolution of predator stocks on shrimp**




**High TBT levels in shrimp (*Crangon* and *Mysis* spp.) and sediment**

**TBT levels have decreased approx. 10–fold in shrimp and sediment; Crangon stock went back to the levels of the 70ties**

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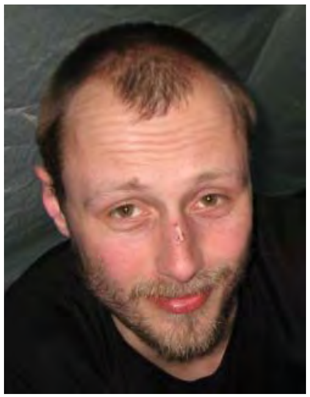
# Case 1 – Effects of tributyltin (TBT) on crustacea

**Conclusions**

- **TBT <u>may have had</u> an immense impact on the *Crangon* stock**
- **It is not an evidence of proof but uncertainties have been eliminated largely**
- **Likely to be a combination of shrimp fishing, recruitment capacity, predator numbers but maybe with TBT on top**
- **Advantage: the TBT problem in the food chain is hopefully solved since the ban but we should have had this type of integrated knowledge years earlier**
- **Drawback: every situation with contaminants is different and should be approached as such – newly emerging contaminants etc.**
- **Fisheries regulation is useless when the causes are not fisheries related**
- **This illustrates the need for an ecosystem based approach and integrated science and advice**
- **Did TBT adversely affect the basis of the food chain (zooplankton)**

# Case 1 – Effects of tributyltin (TBT) on crustacea

Thanks to



Yves Verhaegen[1,2,3], Ellen Renders[1], Koen Parmentier[2], Luc Swevers[4], Pierre Rougé[5], Wim De Coen[3], Kris Cooreman[2] and Guy Smagghe[1]

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**2** Institute for Agricultural and Fisheries Research (ILVO), Ankerstraat 1, B-8400 Ostend, Belgium

**3** Laboratory of Ecophysiology, Biochemistry and Toxicology, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium

**4** Insect Molecular Genetics and Biotechnology, National Centre for Scientific Research "Demokritos", Aghia Paraskevi Attikis, Athens, Greece

**5** Surfaces Cellulaires et Signalisation chez les Végétaux, UMR Université Paul Sabatier CNRS 5546, Castanet Tolosan, France

- *crangon septemspinosa*

  **Fabiola M. Akaishi, PhD.**

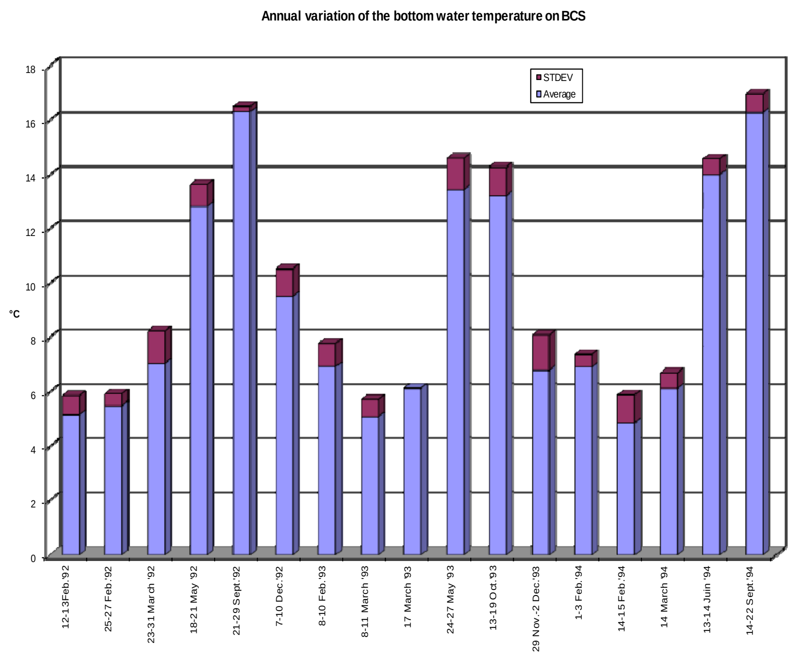
  **Environmental Chemist**
  **Environment Canada**
  **Toxicology Laboratory - ALET**

# Case 2 – Seasonal effects on the distribution of POPs in fish

- **This study is specifically on seasonal distribution of chlorinated POPs in fish**
- **These POPs (PCBs, dioxins, etc.) accumulate (get burried) in the fat phase**
- **But fat is being used as energy source in winter and produced and stored in warmer conditions**
- **How do POPs behave in these conditions of changing fat concentrations?**
- **Study organism was dab (*Limanda limanda*; flatfish) from the southern North Sea**
- **Dab stores its fat reserves in its liver**

# Case 2 – Seasonal effects on the distribution of POPs in fish

- **This is the temperature profile of the research area**
  - **Shallow sea – thermoclines are very rare**
  - **Bottom water temperatures of 4-5°C in February/March and approx. 16-17°C in July/September**

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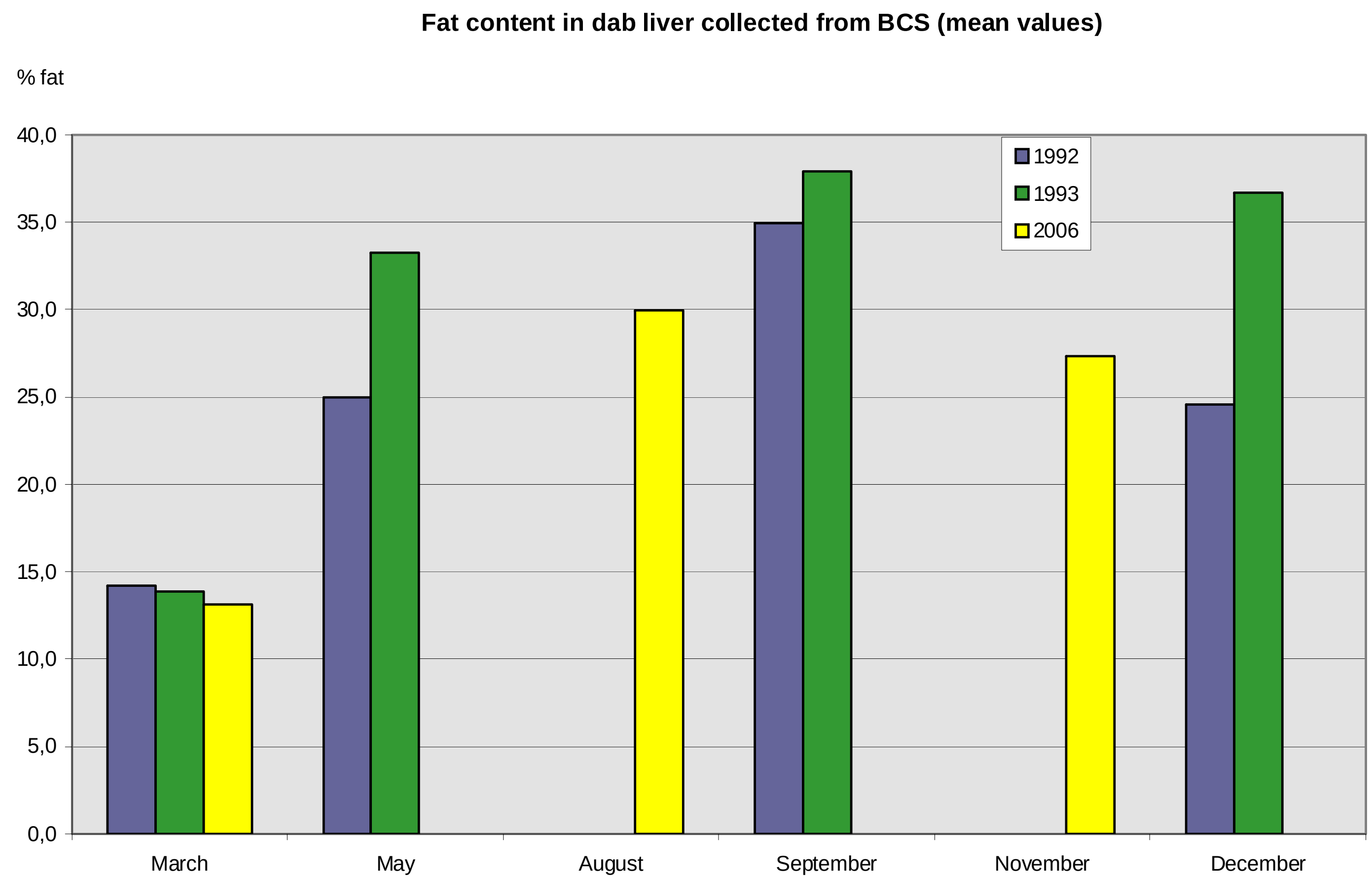
# Case 2 – Seasonal effects on the distribution of POPs

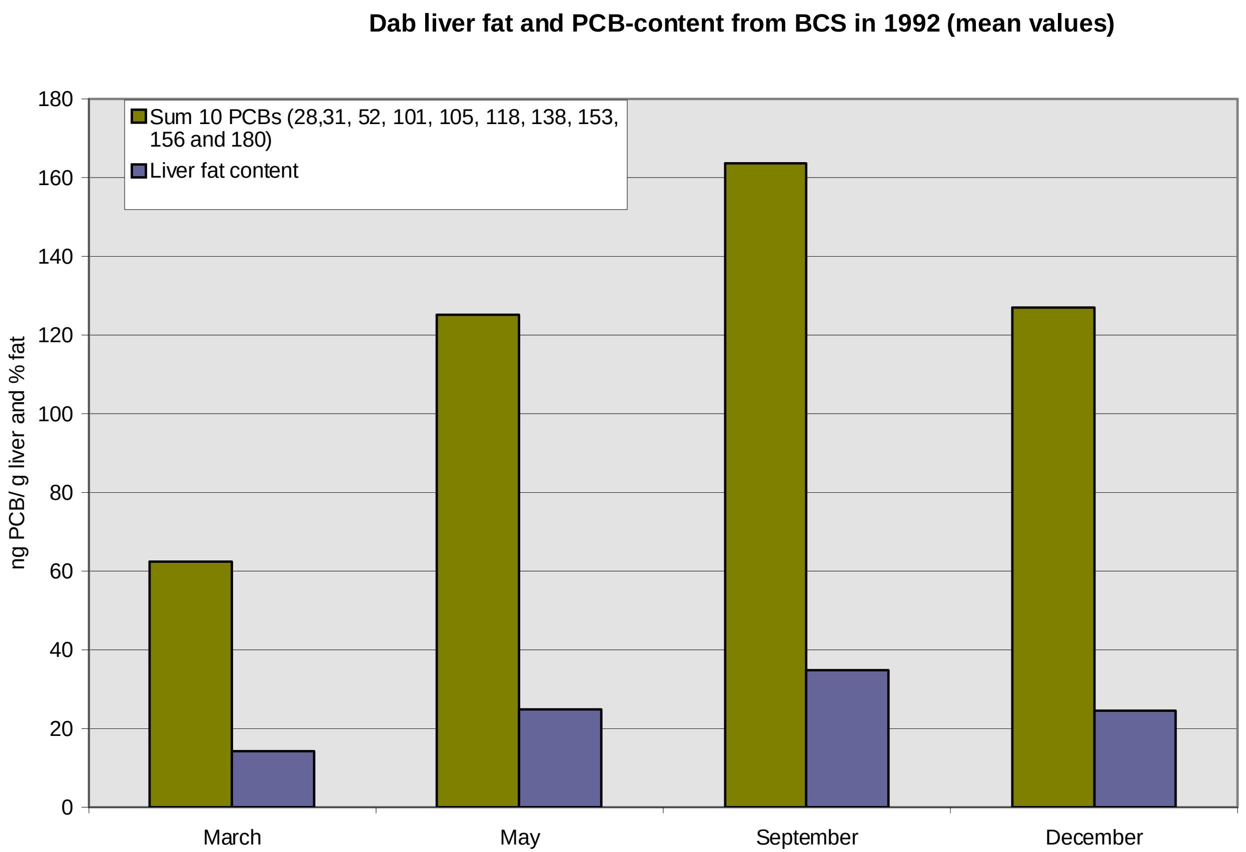



Significant differences between March and the other sampling months
More than 2-fold difference between March and September

# Case 2 – Seasonal effects on the distribution of POPs in fish

- **Fat tissue is produced and stored in ‘summer’ and the reserves are used in ‘winter’ (depending on the temperature regime of the sea)**
- **Big question is: how do POPs behave when the fat is being recirculated?**
- **Are POPs diluted during fat production and storage?**
- **Are POPs concentrated in the remaining fat tissue?**

# Case 2 – Seasonal effects on the distribution of POPs




Same results obtained in 1993
Actual purpose of study: examine seasonal variations of biomarkers of pollution
In relation to seasonal variations of other parameters such as POPs

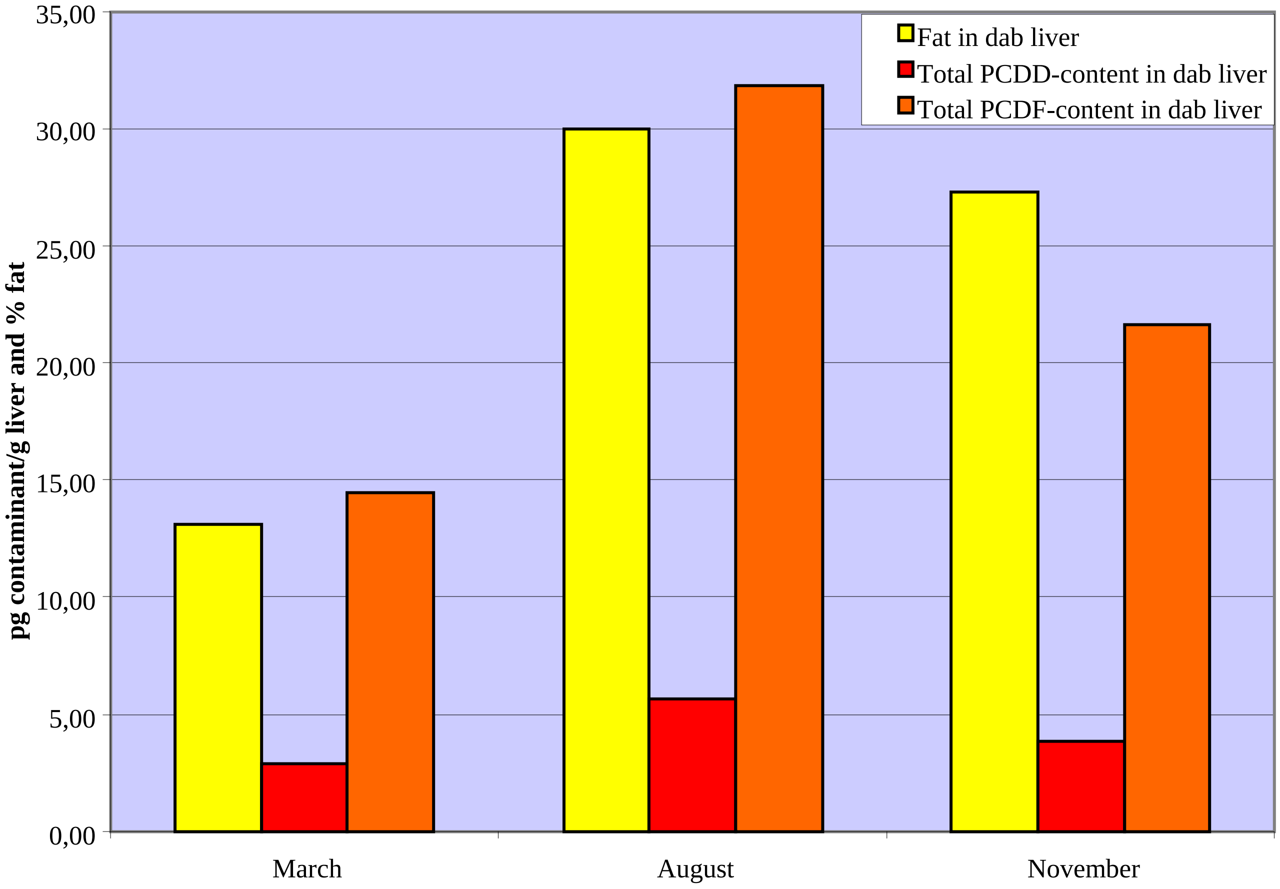
# Case 2 – Seasonal effects on the distribution of POPs

2006: Excercise redone with a larger number of chlorinated dioxin-like POPs

| | | WHO-TEF |
|---|---|---|
| PCDFs | 2,3,7,8-TCDF | 0.1 |
| | 1,2,3,7,8-PeCDF | 0.05 |
| | 2,3,4,7,8-PeCDF | 0.5 |
| | 1,2,3,4,7,8-HxCDF | 0.1 |
| | 1,2,3,6,7,8-HxCDF | 0.1 |
| | 2,3,4,6,7,8-HxCDF | 0.1 |
| | 1,2,3,7,8,9-HxCDF | 0.1 |
| | 1,2,3,4,6,7,8-HpCDF | 0.01 |
| | 1,2,3,4,7,8,9-HpCDF | 0.01 |
| | OCDF | 0.0001 |
| | | |
| PCDDs | 2,3,7,8-TCDD | 1 |
| | 1,2,3,7,8-PeCDD | 1 |
| | 1,2,3,4,7,8-HxCDD | 0.1 |
| | 1,2,3,6,7,8-HxCDD | 0.1 |
| | 1,2,3,7,8,9-HxCDD | 0.1 |
| | 1,2,3,4,6,7,8-HpCDD | 0.01 |
| | OCDD | 0.0001 |
| | | |
| pPCBs | PCB 81 | 0.0001 |
| | PCB 77 | 0.0001 |
| | PCB126 | 0.1 |
| | PCB 169 | 0.01 |
| | | |
| moPCBs | PCB 123 | 0.0001 |
| | PCB 118 | 0.0001 |
| | PCB 114 | 0.0005 |
| | PCB 105 | 0.0001 |
| | PCB 167 | 0.00001 |
| | PCB 156 | 0.0005 |
| | PCB 157 | 0.0005 |
| | PCB 189 | 0.0001 |

# Case 2 – Seasonal effects on the distribution of POPs

**Fat (%), total PCDD and PCDF-content (pg/g liver ww) in dab liver from BCS in 2006**

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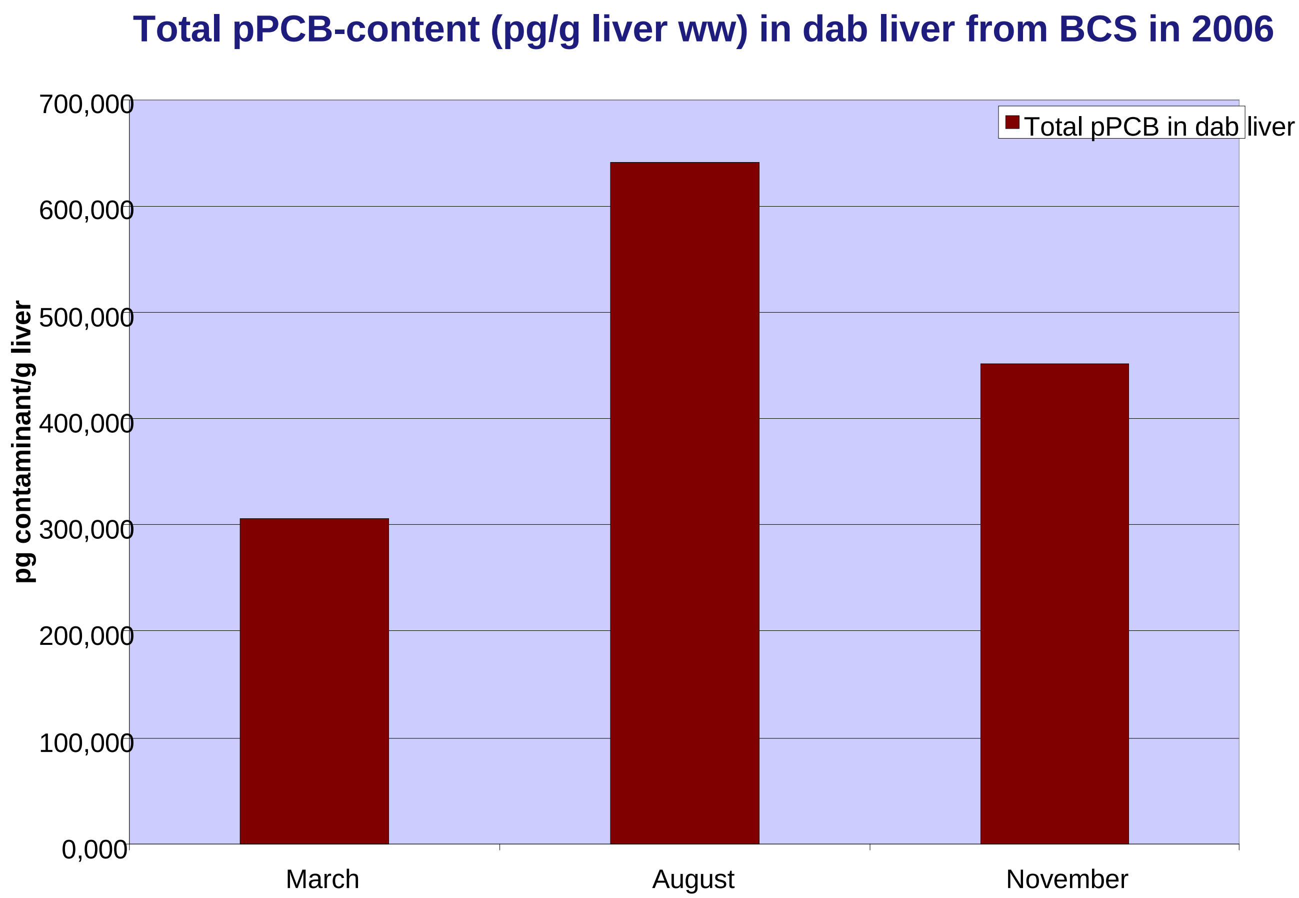


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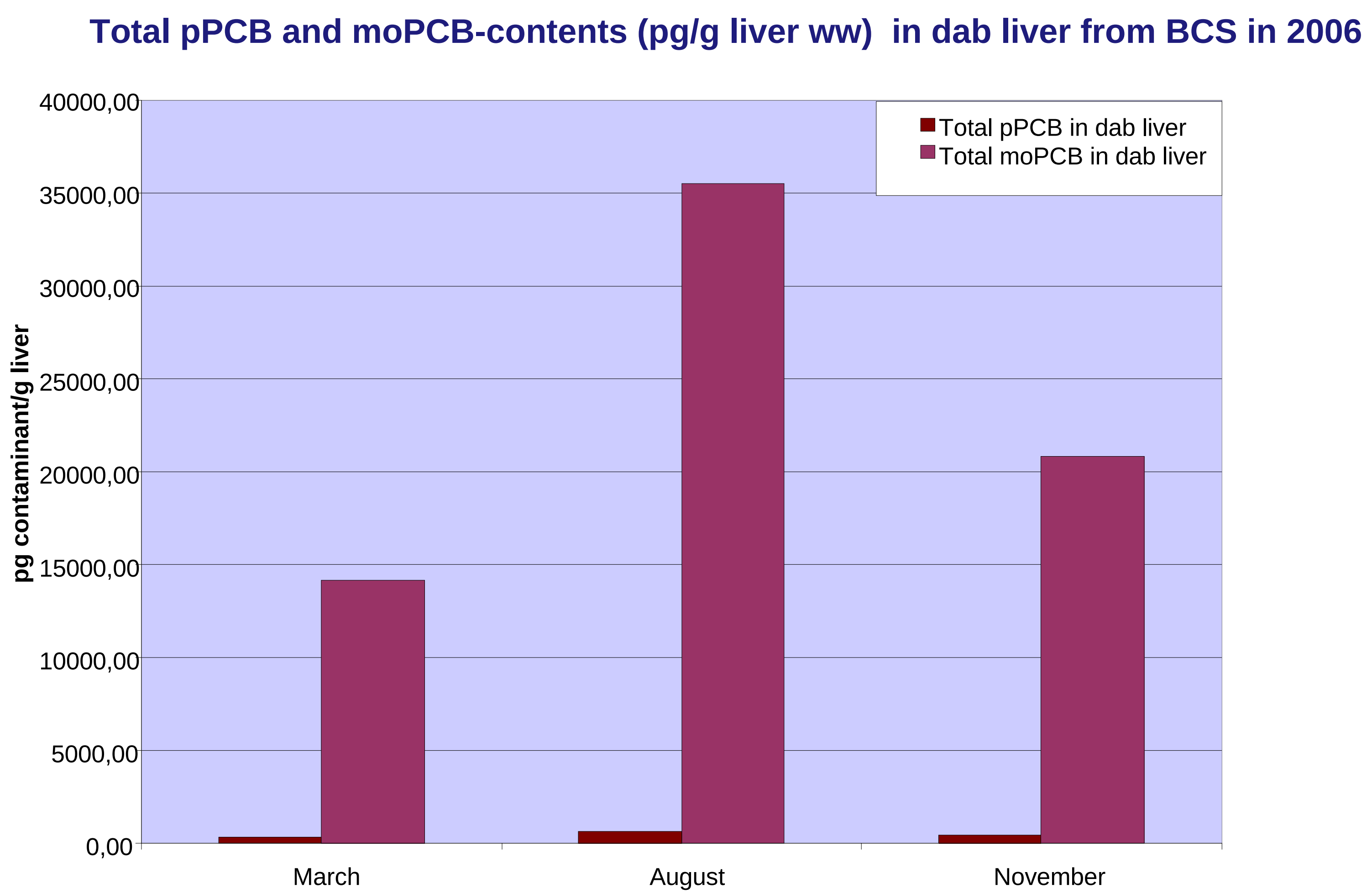


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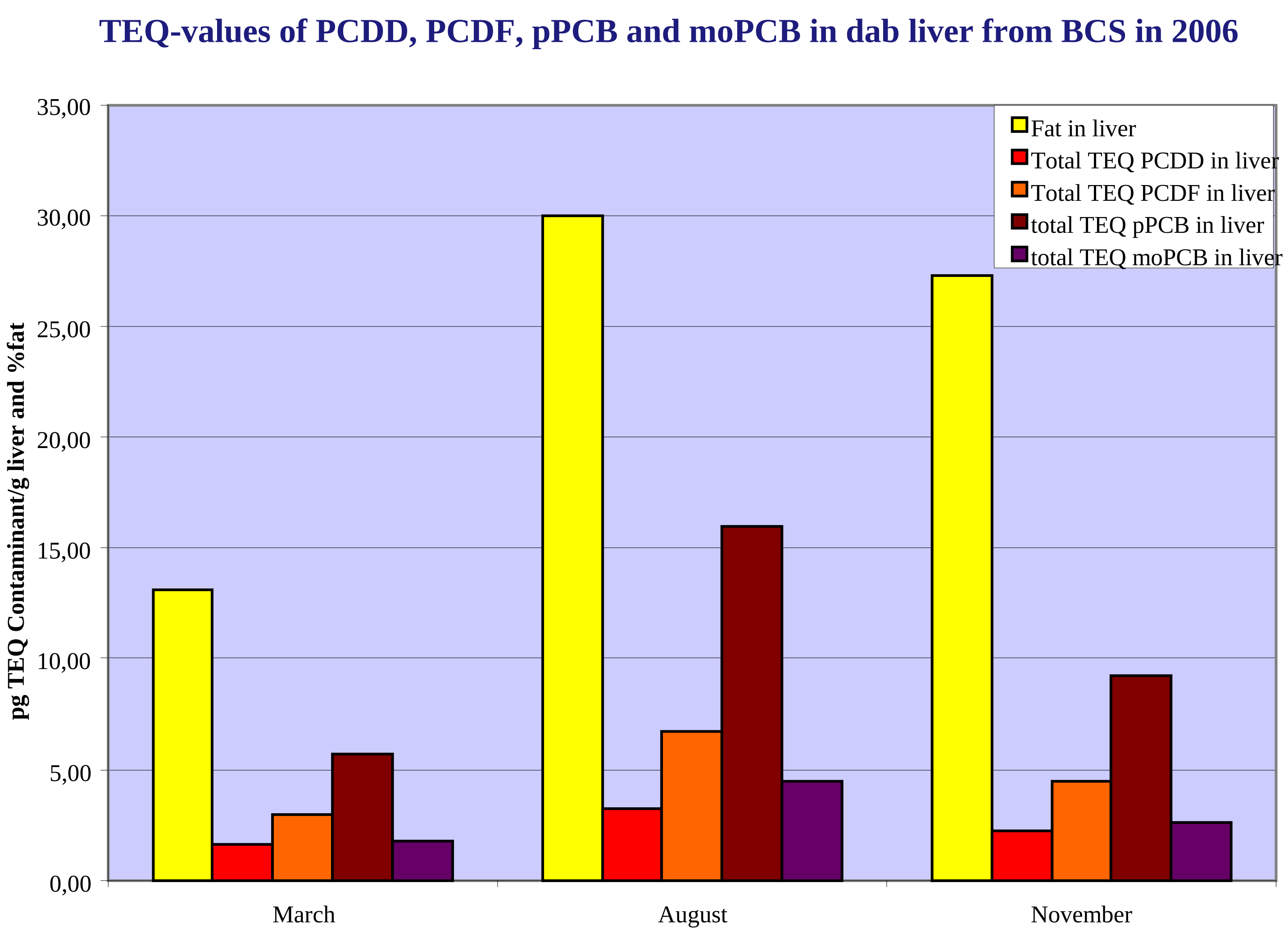
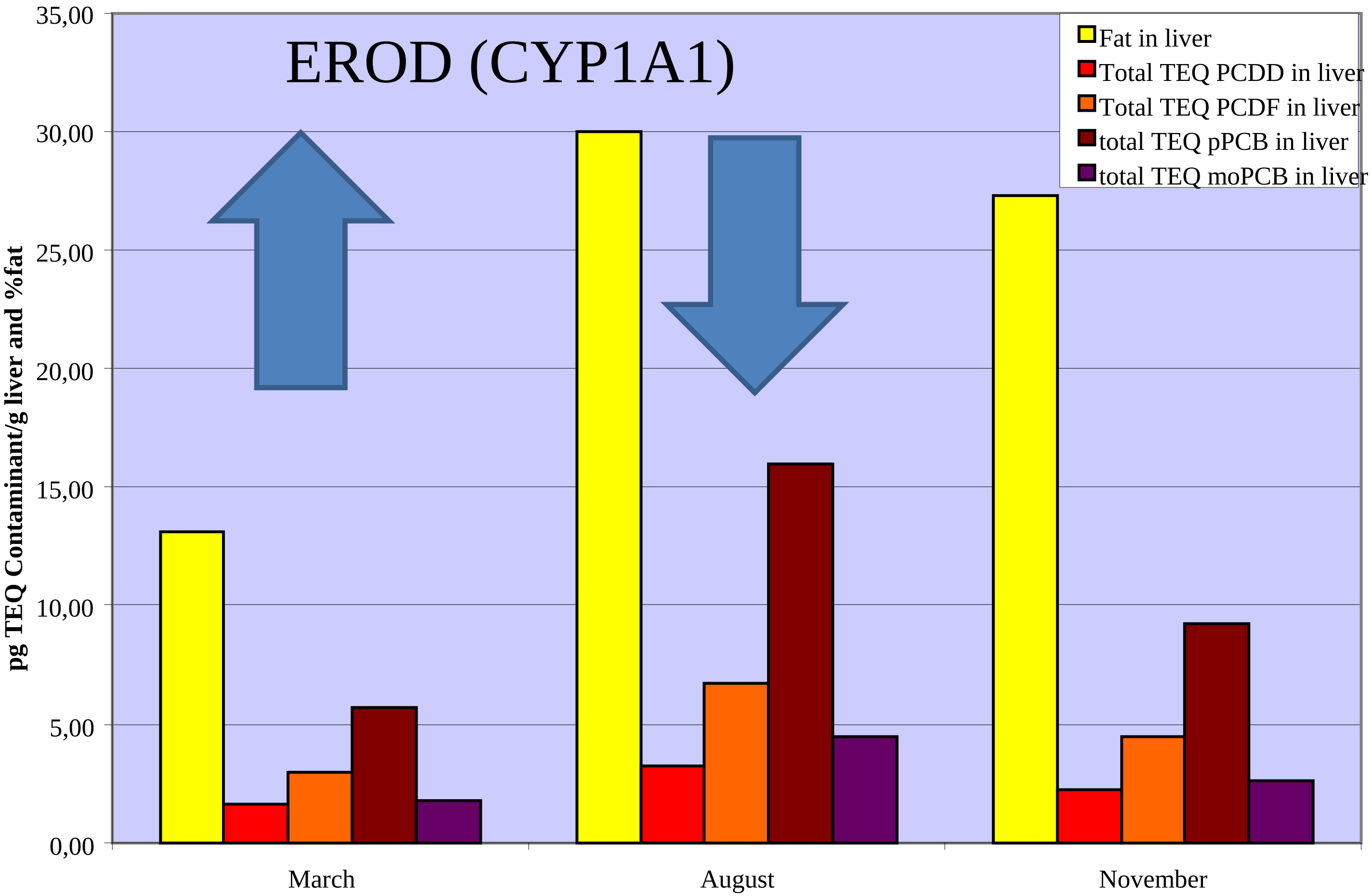



# Case 2 – Seasonal effects on the distribution of POPs

**TEQ-values of PCDD, PCDF, pPCB and moPCB in dab liver from BCS in 2006**

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# Case 2 – Seasonal effects on the distribution of POPs

- The seasonal changes (temperature) have profound impact on liver fat and POP-burden
- Dab 'eliminates' up to 60% of the POPs stored in the liver during winter time. This coincides nicely with the fat metabolism. What is the fate of these chemicals? Where do they go to?
- POPs do not redistribute (concentrate) in the remaining liver fat during winter
- The POP concentrations remain quite constant when normalized to fat
- The POP-fluxes can be quantified as active doses of exposure when sampling periods are narrowed.
- The approach offers possibility to model the mechanistic role of POPs in a kinetic way instead of a steady state model
- The fluxes identify the most vulnerable periods of the year
- Toxicological importance (based on WHO-TEFs) : pPCBs > PCDFs > PCDDs > moPCBs
- Remarkble: EROD is strongly induced during elimination of POPs and not during accumulation
- The approach could form the basis for a better understanding and assessment of biological effects of POPs (e.g. EROD)

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# Case 2 – Seasonal effects on the distribution of POPs

Thanks to

Patrick Roose (ILVO/MUMM), Koen Parmentier (ILVO) and Kris Cooreman

AND THANKS TO YOU TOO

# Case 3 – The biomarker Cellular Energy Allocation

- **Was not presented because of lack of time**