Occurrence of off-flavors in water and fish (rainbow trouts) in RAS in Denmark and procedures for reduction of the off-flavors

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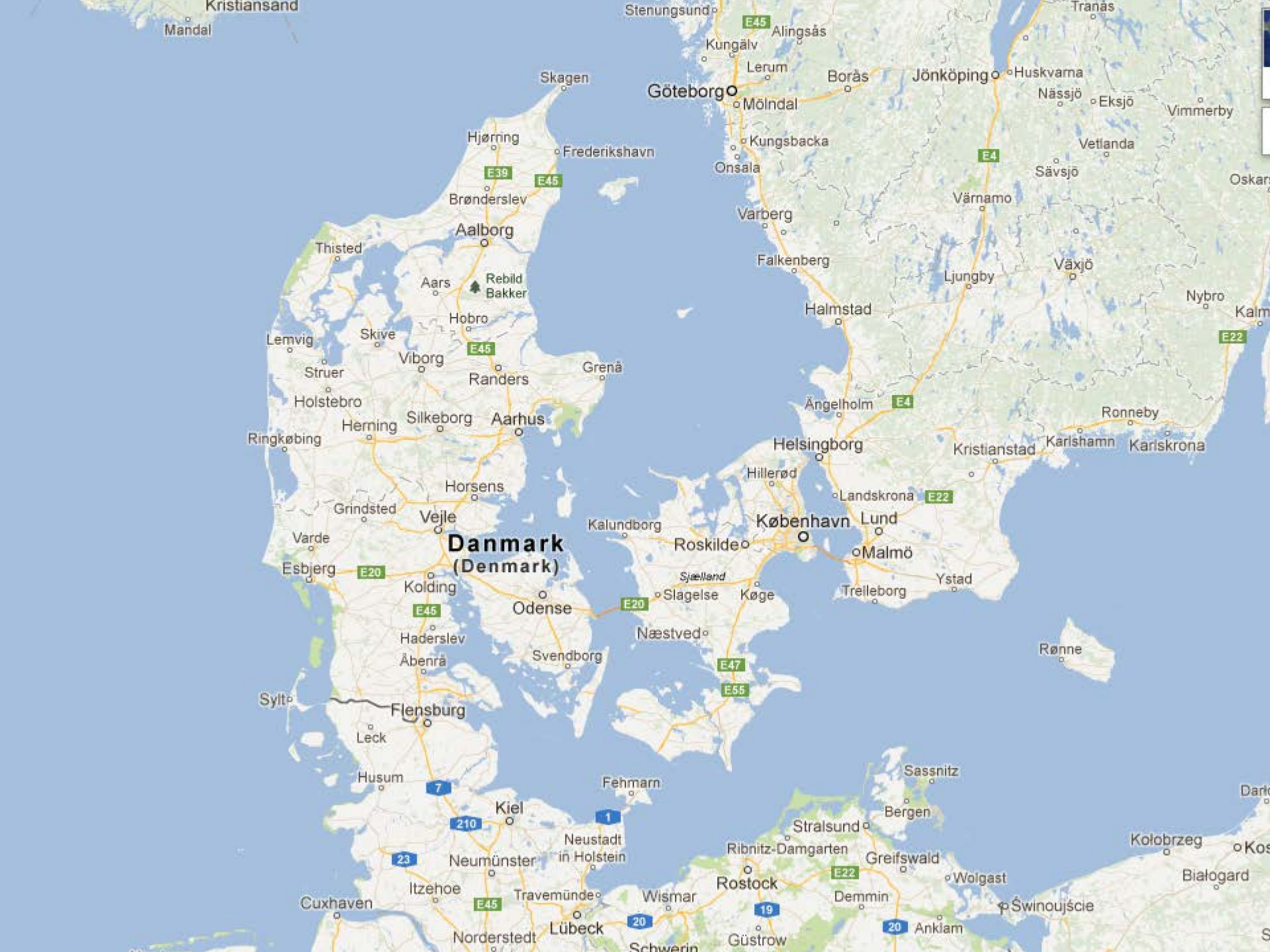
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Holstebro
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Itzehoe
Cuxhaven
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Lübeck
Travemünde
Neustadt in Holstein
Fehmarn
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Kalundborg
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White Pangasius - Unique Fully Integrated System in VN

Why worry about off-flavors?

1. General information:

- Commercial name: FROZEN PANGASIUS HEADLESS & GUTTED
- Latin name: Pangasius Hypophthalmus

2. Product information:

- Headless, gutted, fin off, tail off, skin on cleaned, bone in.
- 5%, 10% or protective glazing depend on clients' order.
- 300-500, 500-700, 700-1000 gram per piece or sizing by customers' order.

4. Ingredient declaration (%): Pangasius 100%

5. Supply stability: Stably for whole year round

6. Raw material: 100% raw fish is from Aquatex Bentre's farms where are all GLOBAL G.A.P certified

6. GM status: Product is free from GMO

7. Organoleptic characteristics:

Appearance:	Frozen
Colour:	Natural colour
Flavour:	No muddy taste
Smell:	No off odour
Texture:	Firm

8. Usage information:

- Storage conditions: < - 18°C
- Life time: 24 months from production date
- Consumption advice: Fully cooked before consumption

9. Packaging information:

- Brand name: By Aquatex Bentre or by client's brand
- Inner packing: + Individually wrap packing, 5 Kg net or with glazing per PE bag/Carton

White Pangasius - Unique Fully Integrated System in VN

Off-flavors make consumers opt out fish from freshwater:

In Denmark, Pangasius from Vietnam have a low consumer acceptance

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Increasing taste-and-odor (TOC) problems in recirculated trout systems in Denmark

Resume from study of about 200 rainbow trouts:

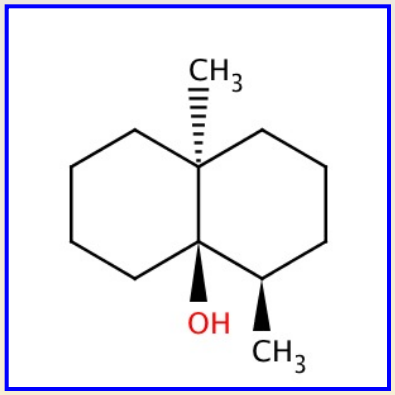
- ***Sensory panels:***
  63% of the fish from production basins had detectable content of TOCs
- ***Chemical analysis:***
  About 90% of fish from production basins had a TOC level >0.1 µg/kg (human detection limit)
- ***Supermarkets:***

  Consumer complaints on TOC-tainted fish

Common off-flavor compounds in fish:

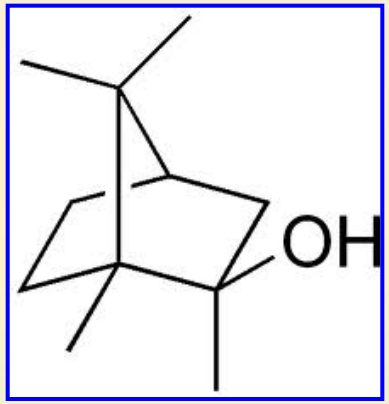
Geosmin

Earthy taste and flavor



2-methylisoborneol (MIB)

Mildewed taste and flavor



Alcohols. Volatile compounds. Microbial metabolites.

Which organisms produce geosmin and MIB?

- **If light, N and P are present:**

  Cyanobacteria (bluegreen algae)

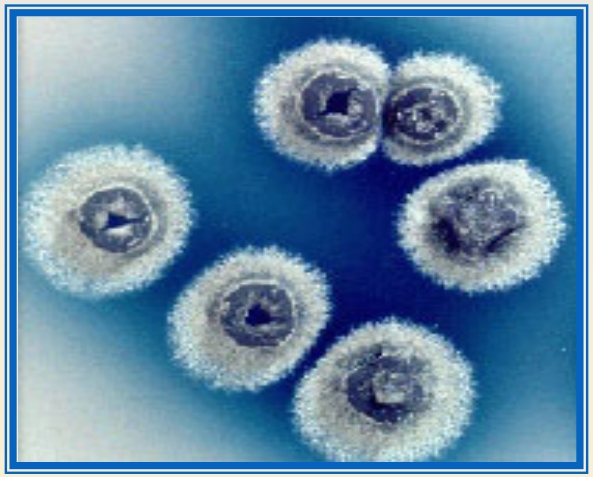
- **If organic matter and oxygen are present:**

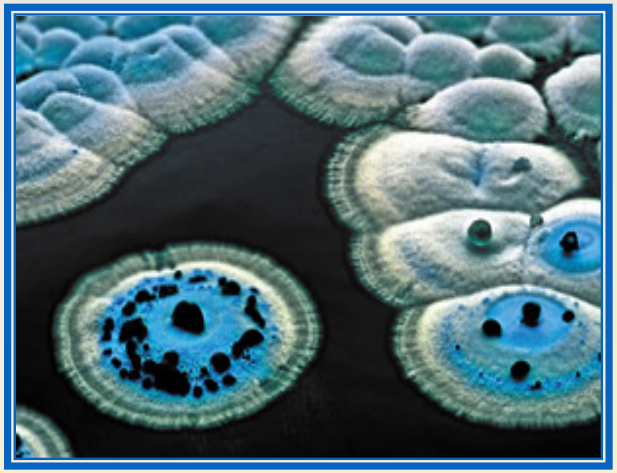
  Streptomycetes (filamentous bacteria)

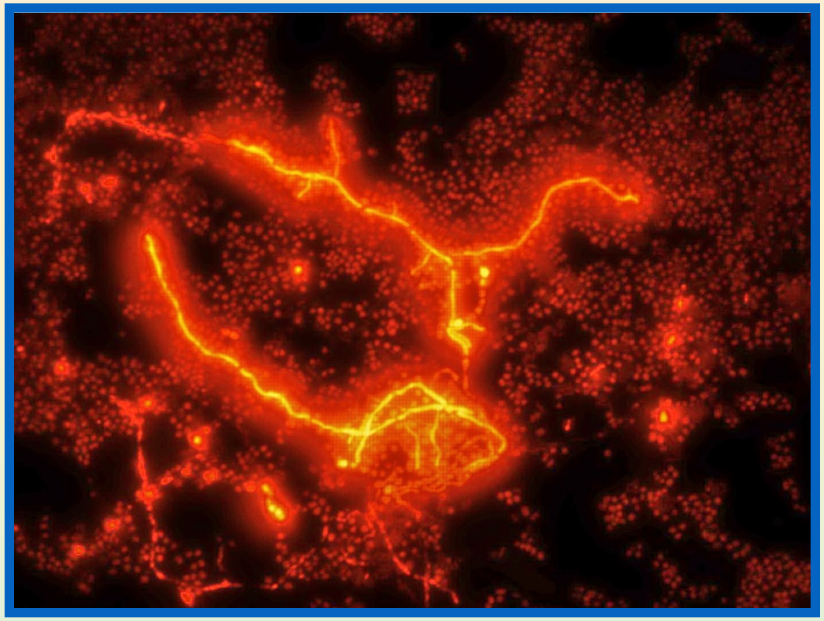
  Myxobacteria (slime or gliding bacteria)

Cyanobacteria: free cells or filaments

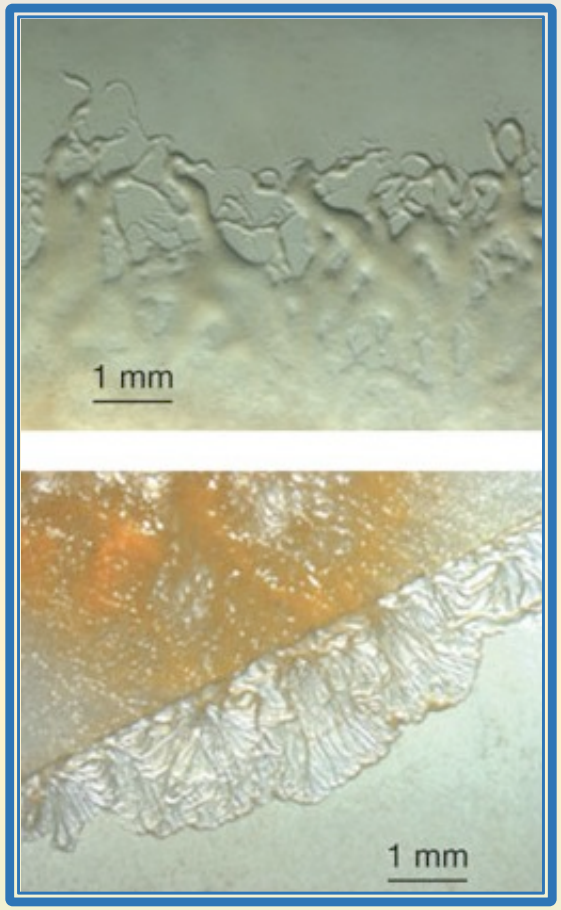
Streptomycetes: Gram-positive, filamentous bacteria







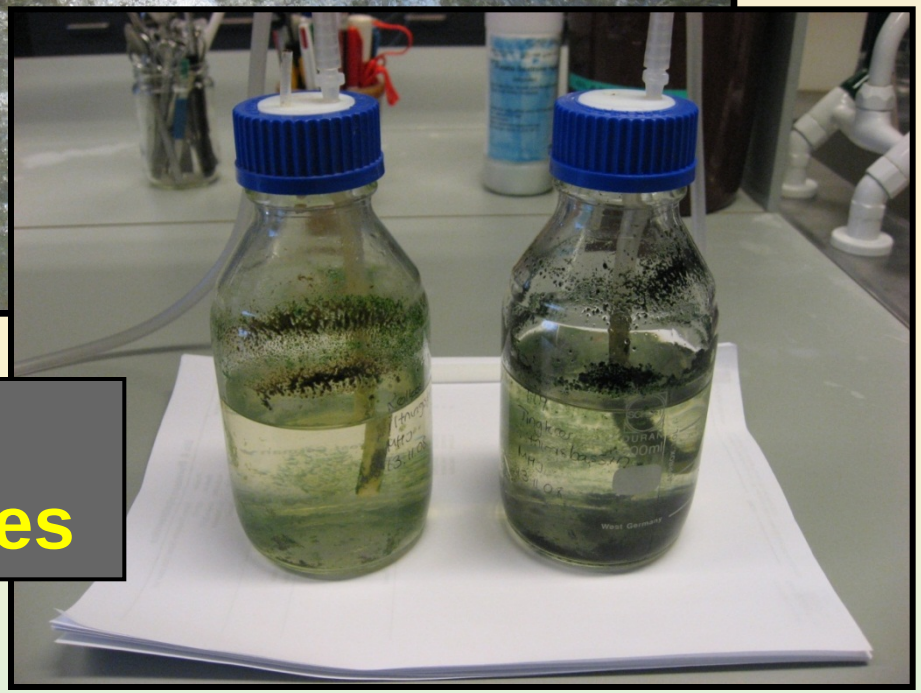
Myxobacteria (*Sorangium* and *Nannocystis*): Gram-negative, slime- and spore-forming bacteria



Molecular method indicate capability to produce geosmin (presence of the gene encoding the geosmin synthase enzyme)*

*Auffret et al. (2013). Impact of water quality on the bacterial populations and off-flavours in recirculating aquaculture systems. FEMS Microbiology Ecology 84, 235-247

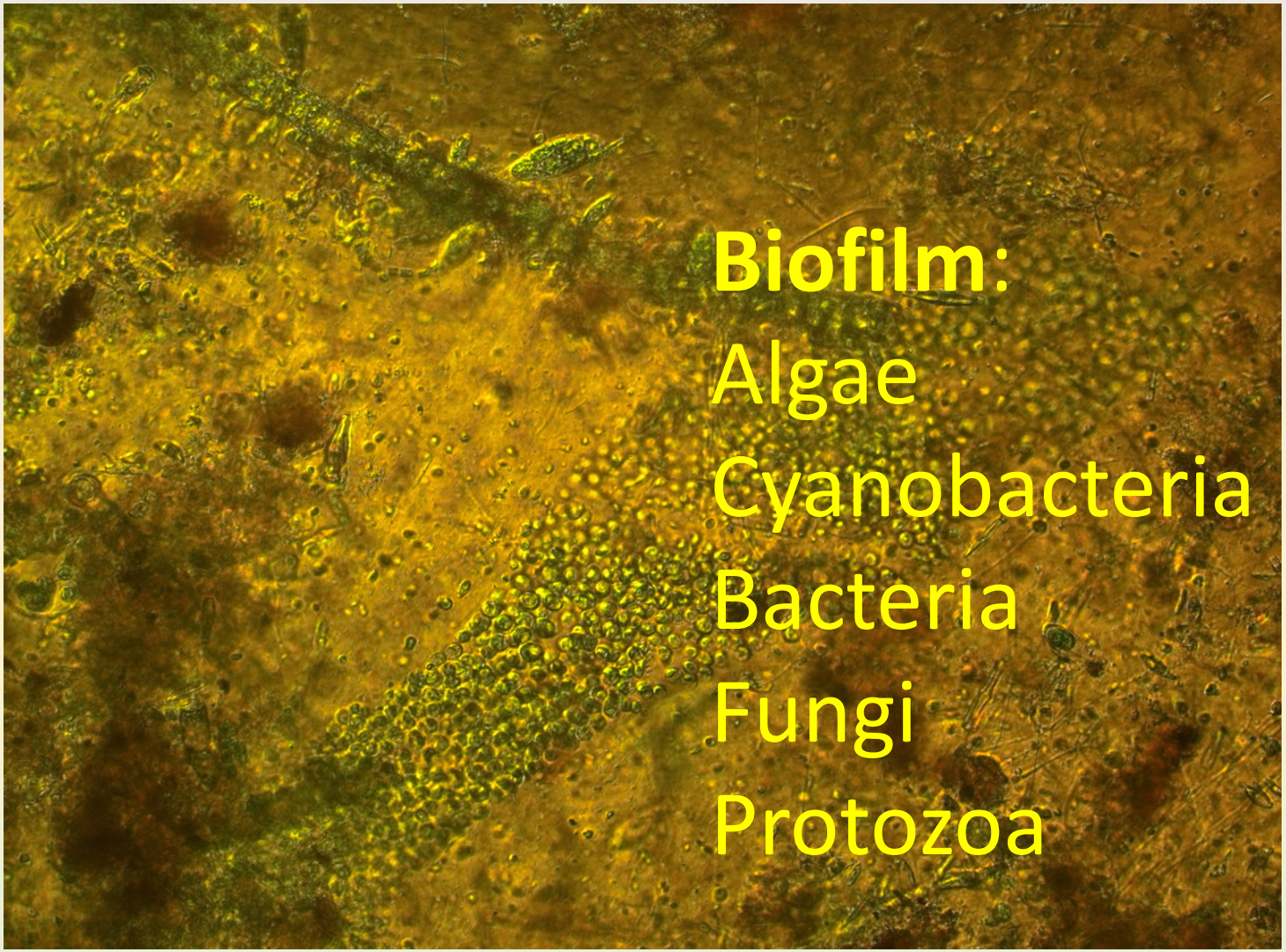
Cyanobacteria on walls in RAS



Cyanobacteria in laboratory cultures

RAS (biofilm on walls)

RAS (biofilm microscopy, 20x magnification)



Rainbow trout systems

250 systems with traditional water flow (stream water)

Water treatment: Drum filter + lagoon (some systems)

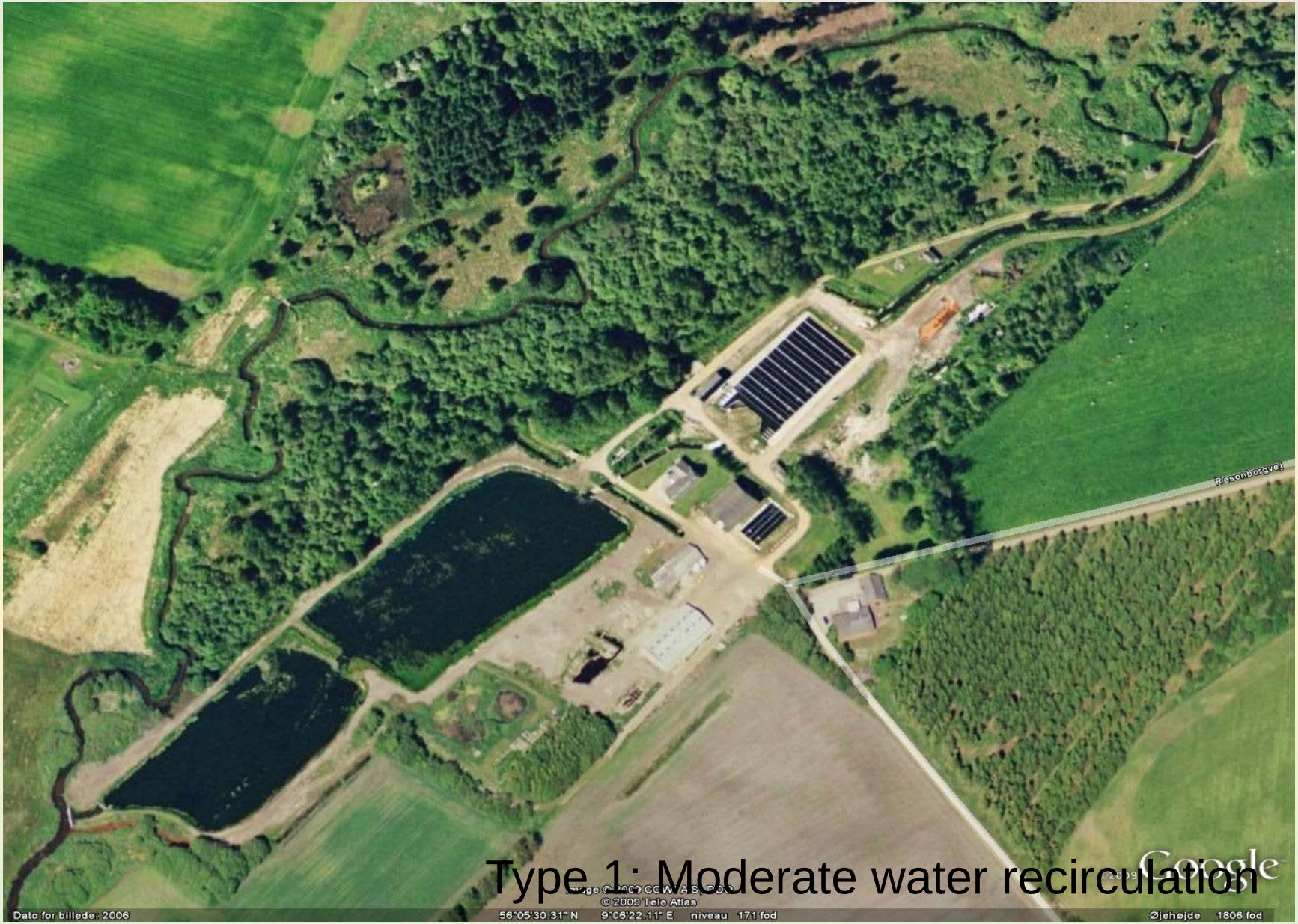
35 systems with water recirculation:

- **Type 1 systems (raceways)**

Moderate water recirculation (70%). Stream water.
Drum filter + moderate biofilter water treatment. Lagoon

- **Type 2 + 3 systems (raceways)**

Water recirculation (85-98%). Well water (groundwater).
Drumfilter + biofilter water treatment. Lagoon

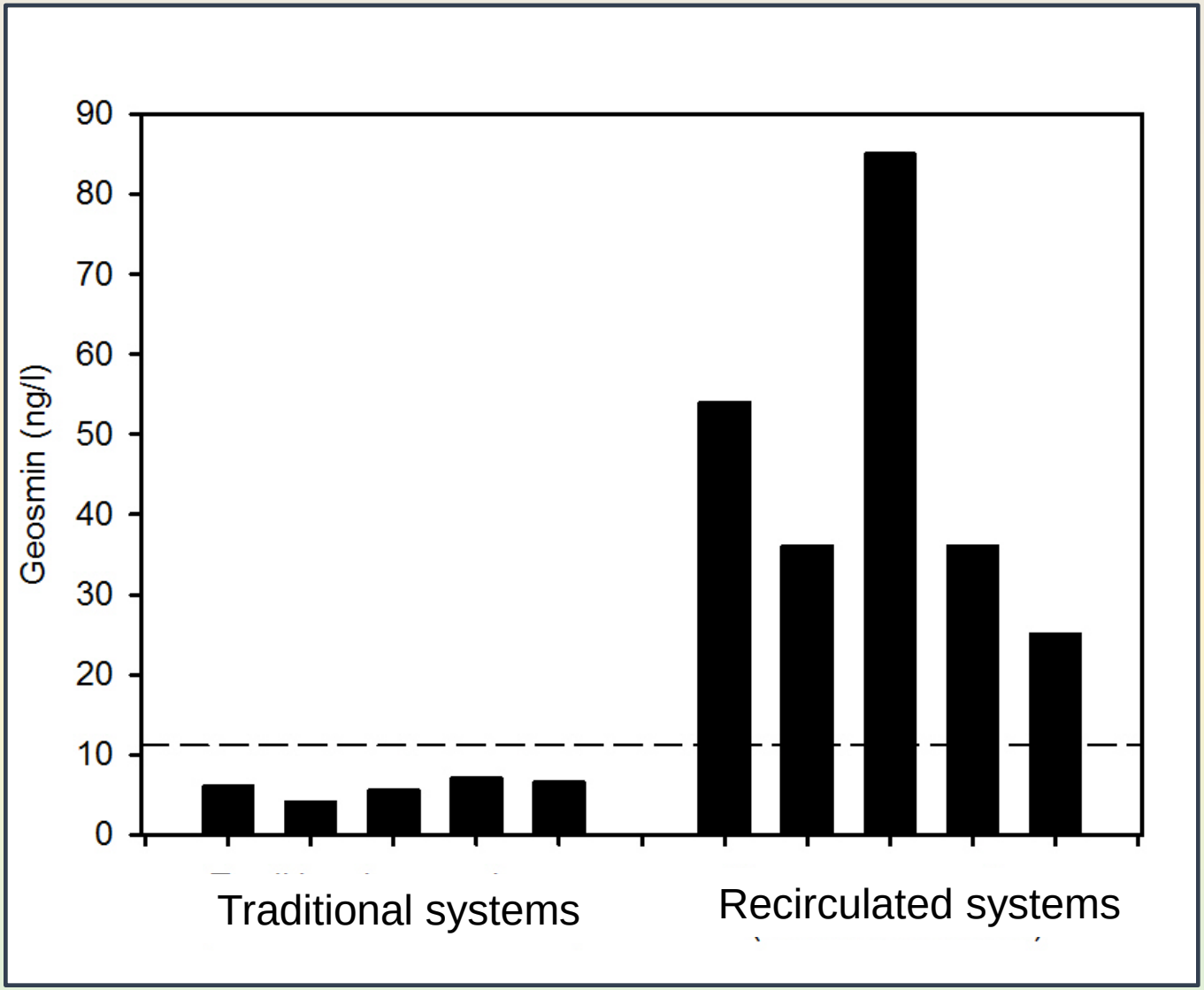


Type 1: Moderate water recirculation


Type 3: Intense water recirculation

TOCs in aquaculture systems

Geosmin and MIB in traditional and recirculated systems



Ways to reduce TOC content in water and fish

1. ***Maintain a low TOC level in ponds***

   Unrealistic:

   N + P + sunlight ➔ cyanobacteria

   Organic matter + O_2 ➔ Streptomycete bacteria

Ways to reduce TOC content in water and fish

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   Unrealistic:

   N + P + sunlight ➔ cyanobacteria

   Organic matter + O_2 ➔ Streptomycete bacteria

2. ***Depuration ponds with TOC-free water***

   Require sufficient supply of clean water
   No feeding (weight loss)
   Cyanobacteria and streptomycetes may grow in the ponds

Does depuration reduce the off-flavor in trout?

Concentrations of geosmin and MIB in production and depuration ponds in 8 Danish RAS*

Table 2. Background Data on Pond Systems and Water Parameters

pond facility	type of system[a]	production of fish (tons/year)	degree of recirculation (%/day)	water temperature (°C)	geosmin (ng/L) PP[b]	geosmin (ng/L) DP[c]	MIB (ng/L) PP	MIB (ng/L) DP
1	O	1200	95	14.0	6.6	13.7	3.2	3.1
2	O	1150	95	13.0	27.1	8.4	4.3	5.4
3	O	200	70	12.0	17.7	17.8	6.1	5.3
4	O	550	95	13.2	36.1	26.1	28.5	10.6
5	I	500	95	15/8[d]	7.9	5.3[d]	4.7	4.6[d]
6	O	220	70	8.7	10.1	11.2	3.8	4.3
7	O	450	95	9.0	12.4	1.2	4.2	1.2
8	O	400	95	9.9	16.7	14.6[e]	4.2	6.4[e]

[a] Open terrain (O) or indoor (I). [b] Production ponds (PP). [c] Depuration ponds (DP). [d] Outdoor depuration ponds. [e] Production pond used as depuration pond (increased water exchange).

Production ponds: 16.8 ng geosmin/l (6.6 – 36.1 ng/l)

Depuration ponds: 12.3 ng geosmin/l (1.2 - 26.1 ng/l)

***Petersen, M. A., Hyldig, G., Strobel, B. W., Henriksen, N. H., Jørgensen, N. O. G., 2011. Chemical and Sensory Quantification of Geosmin and 2-Methylisoborneol in Rainbow Trout (*Oncorhynchus mykiss*) from Recirculated Aquacultures in Relation to Concentrations in Basin Water. J. Agri. Food Chem. vol. 59, 12561-12568**

Concentrations of geosmin and MIB in production and depuration ponds in 8 Danish RAS*

Table 2. Background Data on Pond Systems a

pond facility	type of system[a]	producti (ton						MIB (ng/L)	
									DP
1	O	1							3.1
2	O	11							5.4
3	O	20						.1	5.3
4	O	550						28.5	10.6
5	I	500						4.7	4.6[d]
6	O	220						3.8	4.3
7	O	450					1.2	4.2	1.2
8	O	400	9			16.7	14.6[e]	4.2	6.4[e]

[a] Open terrain (O) or indoor (I). [b] Production ponds (PP). [c] Dep ponds (DP). [d] Outdoor depuration ponds. [e] Production pond used as depuration pond (increased water exchange).

RAS in Denmark typically consist of several **production** basins and one **depuration** basin

Production ponds: 16.8 ng geosmin/l (6.6 – 36.1 ng/l)

Depuration ponds: 12.3 ng geosmin/l (1.2 - 26.1 ng/l)

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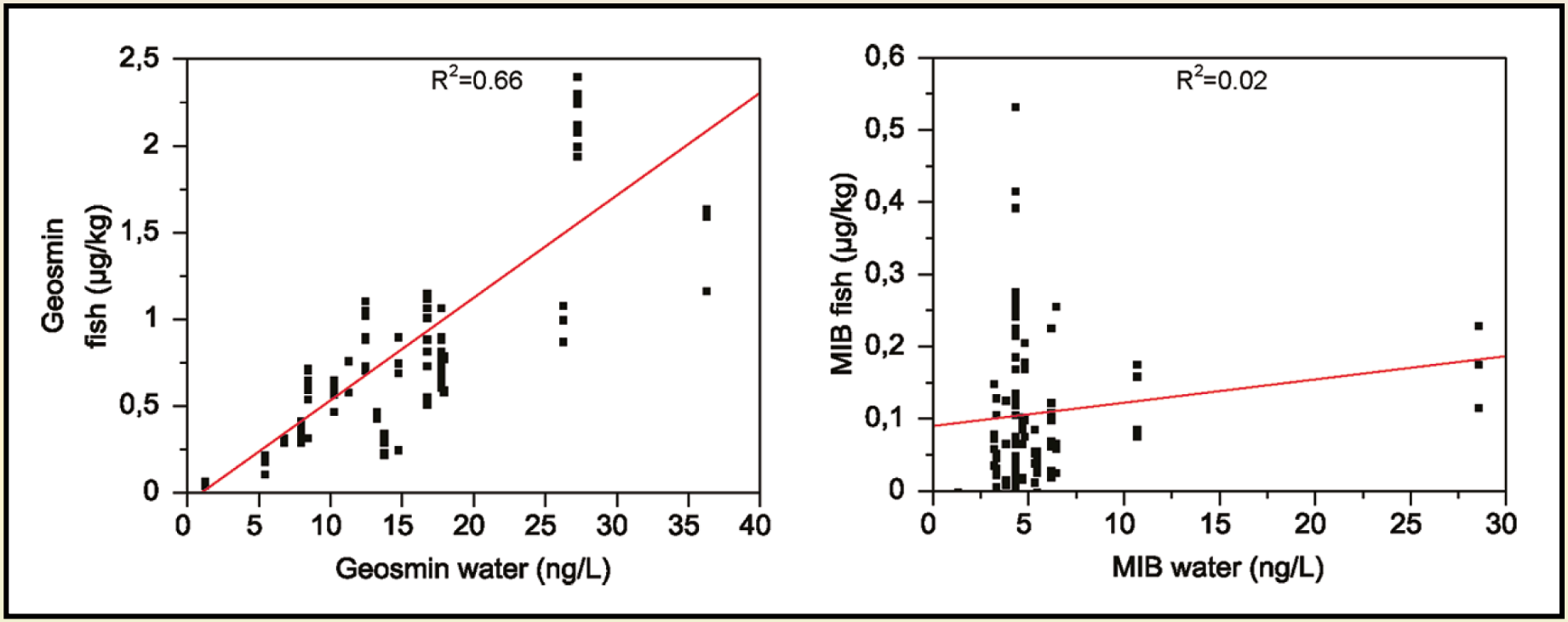
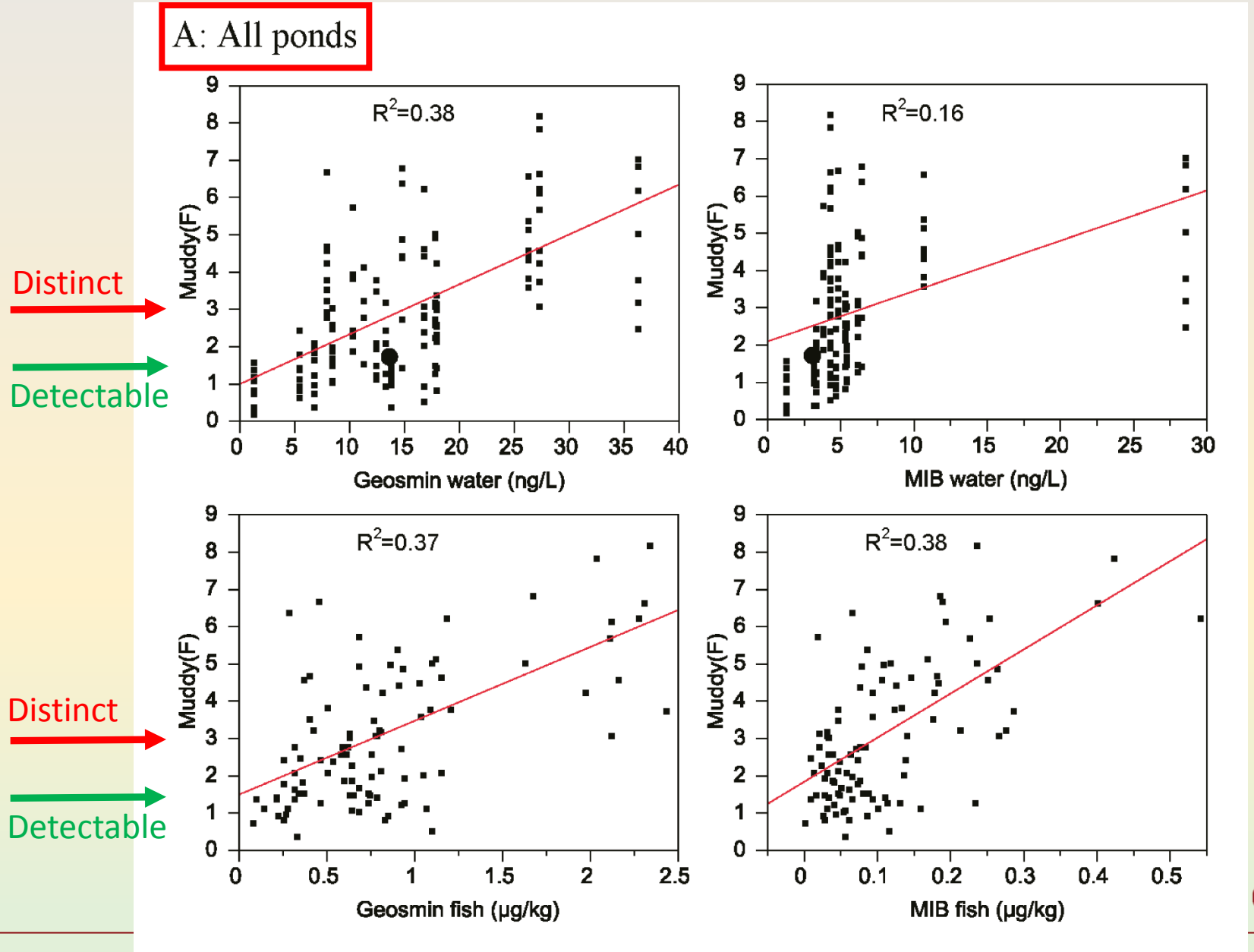
Study on geosmin and MIB in trouts from 8 RAS in Denmark: Relations between geosmin in water and fish



Relations between geosmin in water and fish vs. sensory perception



Relations between geosmin in water and fish vs. sensory perception

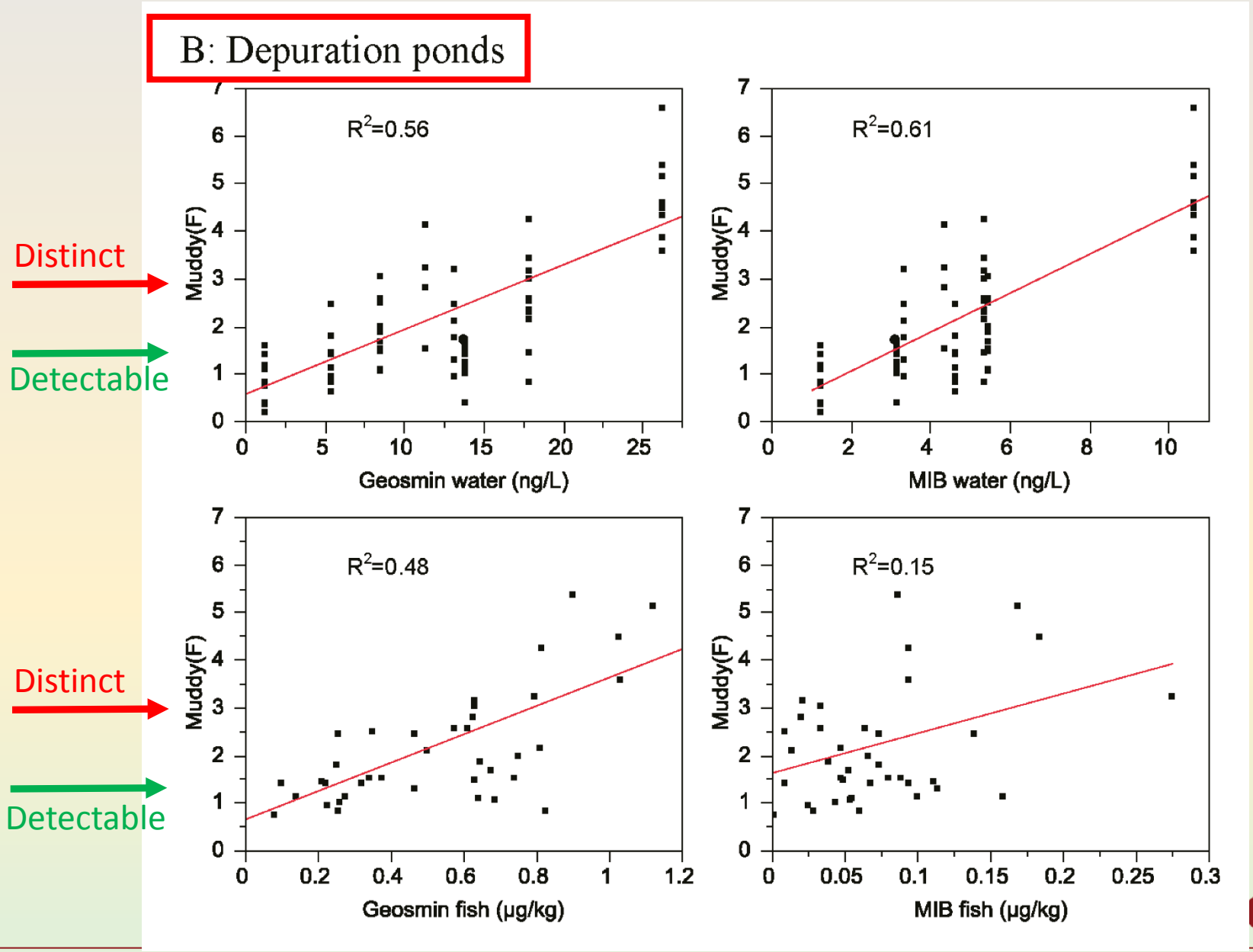
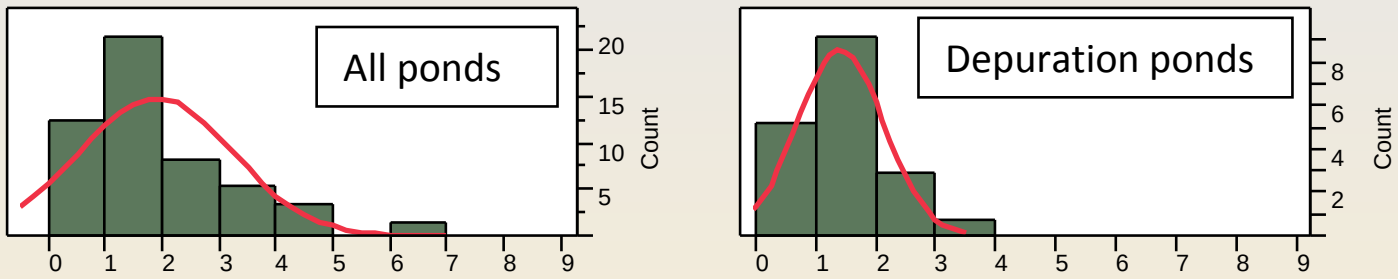


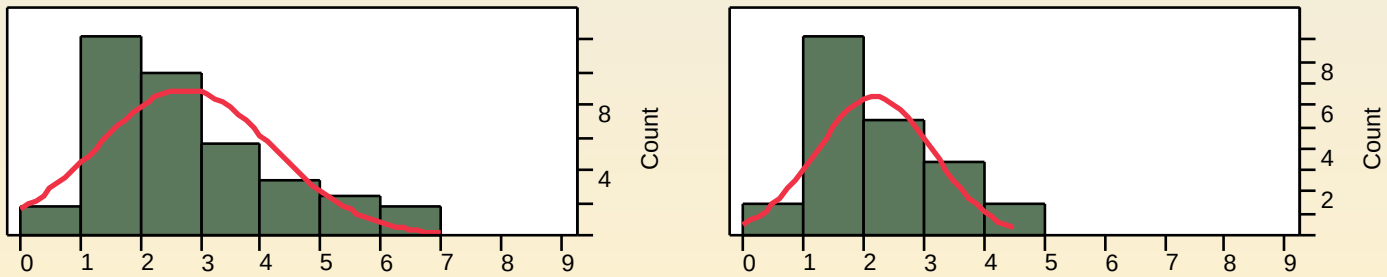
Table 5. Number and Percentage of Fish Having Distinct Muddy Flavor (Muddy (F) > 3) in Ponds with Different Geosmin Concentrations[a]

fish having muddy (F) > 3	geosmin in water <10 ng/L	10–20 ng/L	>20 ng/L	total	significance of relationship
all ponds					
number	9 of 50	26 of 74	24 of 25	149	$p < 0.0001$
%	18	35	96		
depuration ponds					
number	1 of 31	7 of 31	8 of 8	70	$p < 0.0001$
%	3	23	100		

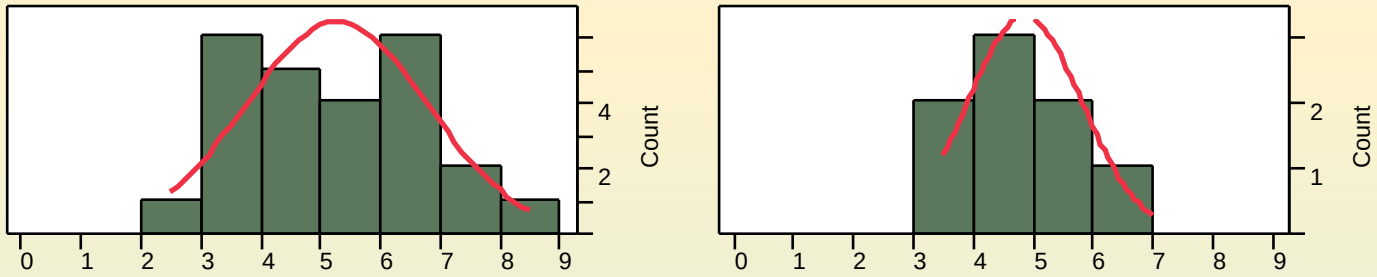
[a] p values from chi-square tests are shown.



Muddy flavour intensity at geosmin <10ng/l



Muddy flavour intensity at geosmin between 10 and 20 ng/l



Muddy flavour intensity at geosmin >20ng/l

How to keep a low off-flavor level in a depuration basin?

1. Spray with formaldehyde solution every 3rd to 4th week (lower water level by 0.5 m before treatment)
2. Empty tank and spray with hydrogen peroxide solution, e.g., once a month
3. Empty basin and use high pressure cleaning (water) when biofilm on walls is present

All procedures are labor-demanding and require a period (days) to reestablish an acceptable water quality for fish

FISH PROCESSING INDUSTRY IN DENMARK SUMMER 2012:

Recommended treatment to minimize TOC in trout:

- Keep fish in depuration basins for up to 6 days in clean water (<10 ng geosmin/l)
- Documentation for 6 annual analyses of geosmin in the water

Industry testing for TOC in fish

Selected fish from each party (loading) of fish are cooked and tasted by selected employees

Chemical quantification of TOC in fish

No commercial facilities for the analysis are available yet

Conclusions

1. **Fish in production basins may have a high content of TOCs if depuration facilities with clean water are available**

2. **Water quality (TOC content) in depuration tanks must be controlled**

3. **Geosmin below 10 ng/l seems not to cause off-flavor in trout**

4. **Simple and cheap techniques for analysis of TOC in water and fish are needed**

Bonus info:

Off-flavors in fish in ponds from Bangladesh (southern in the Patuakhali region)

Collaboration between Patuakhali Science and Technology University and University of Copenhagen, Denmark

Problem:
Freshwater fish in Bangladesh often have a bad taste

Purpose of study:
Determine concentrations of TOC in fish and water in local fish ponds

Examine if water treatment (**sand filtration**) or **probiotic bacteria** improve water and fish quality

Tilapia and pagasius were grown for 6 months (January to August 2012)


EXPERIMENT:
- 8 ponds
- 4 types: Control, PondPlus, AquaPhoto, sand filter
- Pangas and tilapia kept in ponds for 6 months


Research on
Off-flavor Reduction in Fish
Pond No.: T3R1 Aria: 425.04 m2
Implemented by: Faculty of Fisheries, PSTU
Funded by: RFLDC, Barisal.
Kappa

Off-flavors in fish:

Geosmin in 45 fish (pangasius and tilapia):

14.9 ng/kg fw (0 – 91 ng/kg fw)

MIB detected in 7 fish: 5.2 – 68 ng/kg fw

Human threshold for detection of geosmin in trout: 100 - 200 ng/kg fw

OTHER COMPOUNDS DETECTED IN THE FISH

Organic solvents: Benzene, ethyl-benzene, 2-butanone, toluene, m-xylene (35 compounds found)

Terpenes (essential oils, e.g. in plants): Junipene, β-caryophyllene, α-humulene, ledene, α-muurolene, 1S-cis-calamene, 4-methyl-1-pantenol (18 compounds found)

Polyaromatic hydrocarbons (PAH, tar compounds or naphtalenes): 1,8-dimethyl-naphthalene, phenol, 1-methyl-naphthalene, 4-methyl-1-pentanol
(9 compounds found)

Conclusions - Bangladesh

Off-flavours (geosmin and MIB):
Not detectable by humans

Metals:
As and Pb did not pose health risks

Organic compounds:
Not expected to be present in fish.
Source is unknown (landfills, combustion of wood, ….)

Thank you for your attention!

Questions and comments:

nogj@life.ku.dk