Effect based methods

Activity under WG Chemicals
(and experiences from Sweden)

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The problem

- 100,000 chemicals on the market
  - few risk assessors, managers
- Rough estimates of effective concentrations
  - EQS uncertainty, $10^{2\text{-}3}$
  - Single substances (little consideration of mixtures)
- Management in WFD
  - 45 priority substances + 8 other substances for chemical status
  - River basin specific pollutants (RBSP)
- Infinite number of possible combinations/mixtures

European EQS variability study

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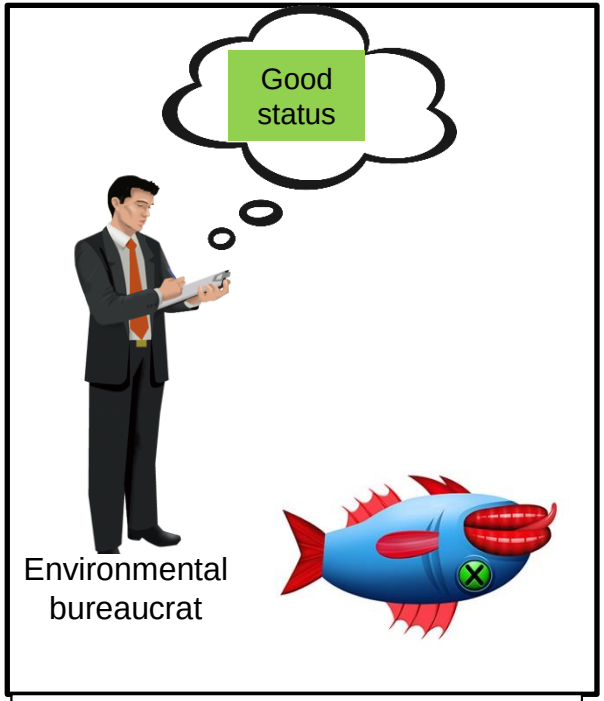
Aarhus University, Department of Environmental Science (Vorkamp & Sandersson, 2016)

Table 1. Selected compounds for assessment, based on data availability as of March 2015 and the selection criteria described in the text.

CAS no.	Compound name	Maximum EQS value (µg/L)	Minimum EQS value (µg/L)	Ratio Max/Min	Number of values	logKow
64743-03-9	Phenols (petroleum)	300	8	38	3	3.2
1066-51-9	(Aminomethyl)-phophonic acid (AMPA)	452	79.7	6	3	-2.5
106-93-4	1,2-Dibromo-ethane	2	0.002	1000	5	2.1
25057-89-0	Bentazone	500	0.1	5000	14	2.3
37680-73-2	PCB-101	0.0005	0.0001	5	4	7
75-01-4	Vinylchloride	100	0.008	12500	9	1.7
7440-61-1	Uranium	24	0.015	1600	6	-
108-90-7	Chlorobenzene	32	1	32	10	2.88
4770-48-4	Cobalt	50	0.2	250	8	-
7782-49-2	Selenium	20	0.052	385	12	-
298-00-0	Methyl-parathion	0.1	0.0002	500	9	2.75
121-75-5	Malathion	0.1	0.0002	500	11	2.4
86-50-0	Azinphos-methyl	0.1	0.001	100	7	2.5
7440-66-6	Zinc	1300	3.1	419	25	-
10-46-7	1,4-Dichloro-benzene	20	0.25	80	12	3.44
95-50-1	1,2-Dichloro-benzene	20	0.25	80	10	3.43
90-13-1	1-Chloro-naphthalene	2.7	0.01	270	6	3.8
7440-22-4	Silver	5	0.01	500	7	-
100-41-4	Ethylbenzene	65	1	65	14	3.1



It's time we face reality, my friends..
We're not exactly ecotoxicologists

Review of WFD - window of opportunity for holistic approach

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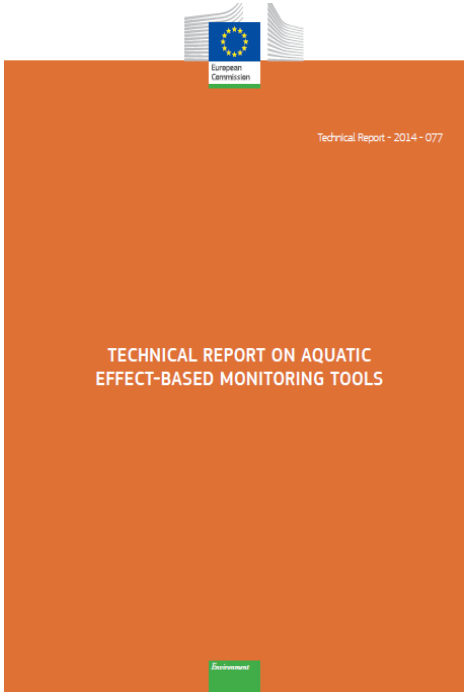
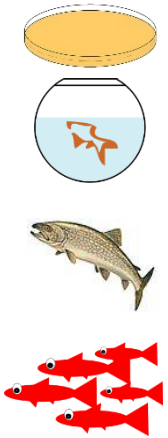
- Water directors meeting (Bratislava, 2016)
  - EQSs for groups with similar mode of action (MoA)
    - Alternative to ”ever growing” list of single substances
  - Identification of a list of **EBMs** for use in WFD and MSFD (harmonization)
  - Assess practical feasibility and cost effectiveness of **EBMs**



COM, 2014

Effect based methods?

- Bioassays (environmental samples)
  - In vitro – cell-lines (lab)
  - In vivo – organism (lab or field)
- Biomarkers
  - Organismal or sub-organismal level
- Ecological indicators
  - Population, community (BQE)



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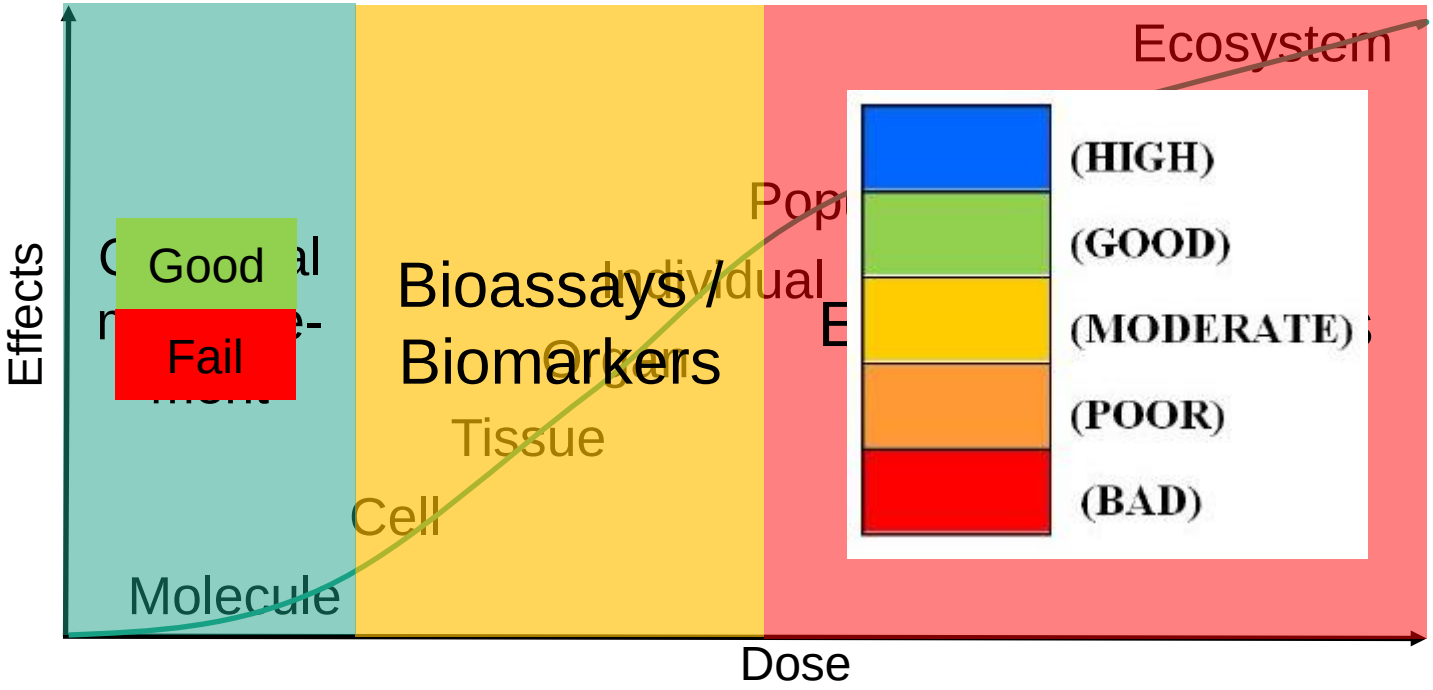
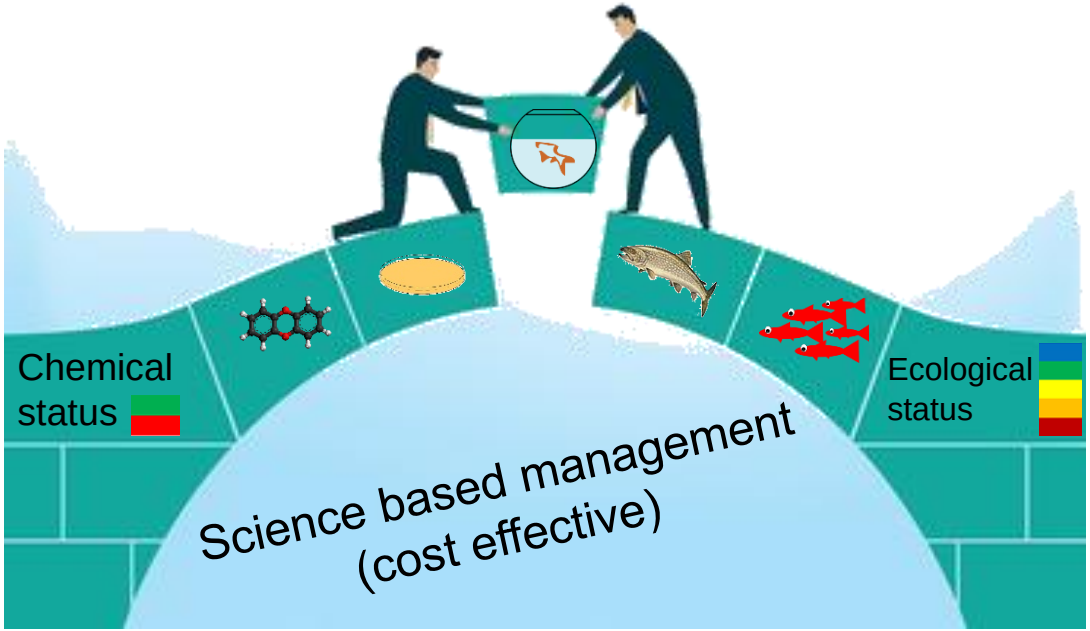
Effect based methods?



Linking chemical and ecological status



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Activity under WG Chemicals (2017-2018)

1. Identification of MoAs of relevance
2. Inventory of MoAs for currently regulated/monitored substances
3. Identification and prioritisation of EBMs (based on 1 and 2)
4. Development of ”trigger values”, signalling risk
5. Selection of relevant EBMs (based on 3 and 4)
6. Evaluation of ecological methods (BQEs for toxic effects)
7. List of EBMs to considered for use in WFD and MSFD
8. Assess use of EBMs to identify sources and facilitate measures
9. Practical feasibility and cost effectiveness at EU-scale

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Inventory and selection of bioassays and biomarkers

- In total, 138 EBMs
  - 57 in vitro assays 
  - 37 in vivo assays 
  - 34 biomarkers 
- Evaluation criteria
  - Standard operating procedures, ”trigger values”, comercially available etc.
  - All information available in report

Suggested EBMs to assess regulated substances

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- Dioxins
  - Chemical analysis is complex (sum of many substances, TEF)
  - EBM for screening (trigger chemical analysis), several methods available (EROD)
- TBT
  - EQS for water, accumulates in sediment (gastropods)
  - Imposex in gastropods (biomarker) sensitive and specific (used in MSFD), can be used in OOAO approach
- DDT
  - EQS for water (to protect predators, secondary poisoning)
  - Egg shell thinning has high specificity for DDT, but lower geographic specificity

Suggestions for mixtures

- Mixtures with specific MoA
  - Estrogenicity, genotoxicity (established in vitro methods)
- Complex mixture (unknown composition)
  - EBMs only possibility, list of biomarkers in report
  - Best used in combination (battery of biomarkers)
  - Harmonisation with MSFD

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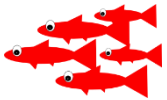
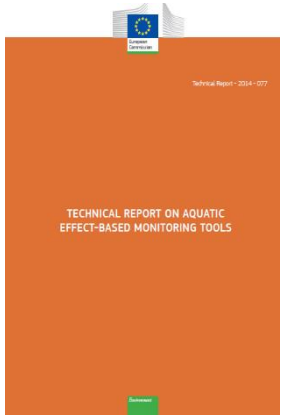
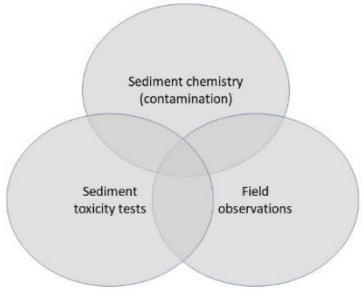
Ecological indicators



- Biological quality elements (ecological status)
  - Reported for some MS
    - IQI (UK), DKIVer2 (DK), M-AMBI (ES), BOPA/BO2A (FR)
  - Difficult to determine cause of degradation
    - Chemical stress almost always in combination with other stress
- Used in combination (triad approach)
  - Bioassays and biomarkers
  - Based on sediment quality triad (SQT)





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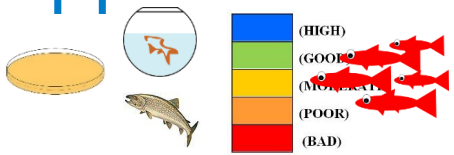
Triad-approach

Good
Fail



EQS	EBM	BQE	Possible conclusion
Yes	Yes	Yes	Strong evidence for pollution-induced degradation of ecosystem
No	No	No	Strong evidence against pollution-induced degradation of ecosystem
Yes	No	No	Contaminants are not bio-available
No	Yes	No	Unmeasured contaminants have potantial for degradation
No	No	Yes	Degradation is not caused by toxic contamination
Yes	Yes	No	Contaminants are bio-available, Early warning for degradation
No	Yes	Yes	Unmeasured contaminants are causing degradation
Yes	No	Yes	Contaminants are not bio-available. Other cause of degradation

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Conclusions and proposed actions

- Option 1, supportive component of chemical and ecological status
  - Line of evidence to support chemical and ecological status classification
    - In vitro bioassasy, support for chemical status (estrogens, dioxins etc)
    - In vivo bioassays, support chemical or ecological status
    - Biomarkers support for ecological status
  - Identify cause of ecological degradation (for identification of effective measures)
  - Requires changes in WFD

Conclusions and proposed actions

- Option 2, include EBMs in monitoring and screening
  - Useful in pressure and impact assessment
  - Prioritization of water bodies for further (chemical) monitoring
  - Investigative monitoring (unknown cause)
  - Already possible (voluntary) under WFD
    - Could be promoted

Effect based methods

Experiences from Sweden

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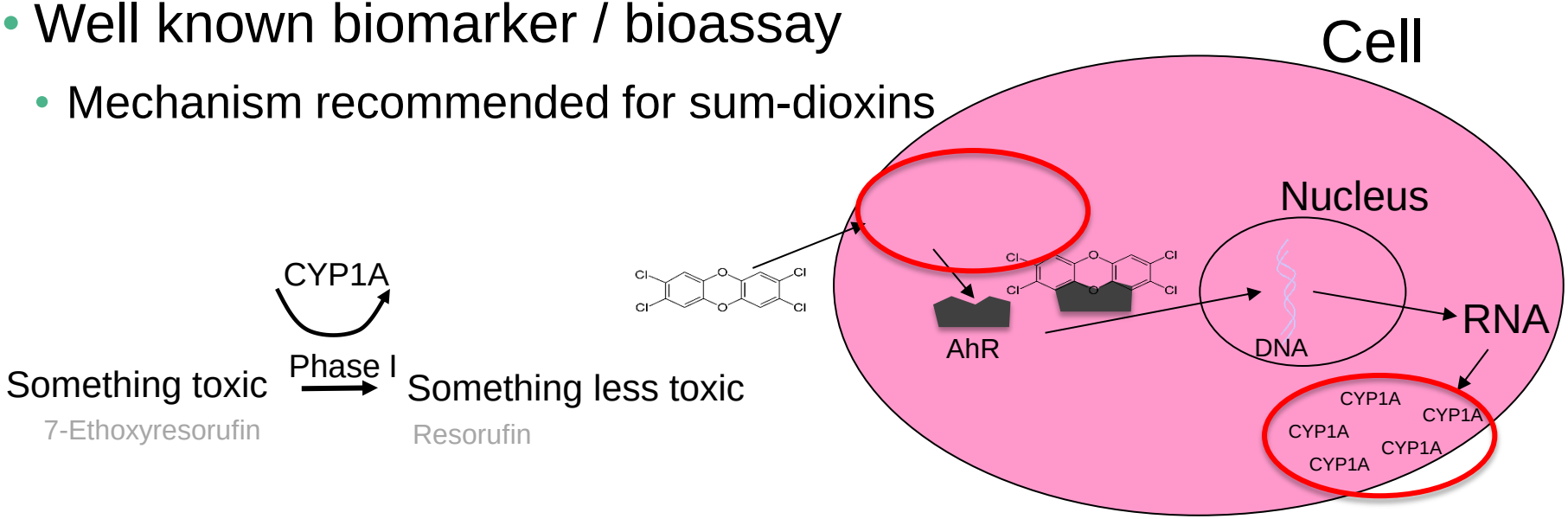
Example 1: Integrated fish monitoring

- Monitoring of biomarkers in fish
  - National reference sites
  - Started in 1988
  - ≈25 biomarkers
  - 4 sites (soon 7?)

EROD (Ethoxyresorufin-O-deethylase)

- Well known biomarker / bioassay
  - Mechanism recommended for sum-dioxins



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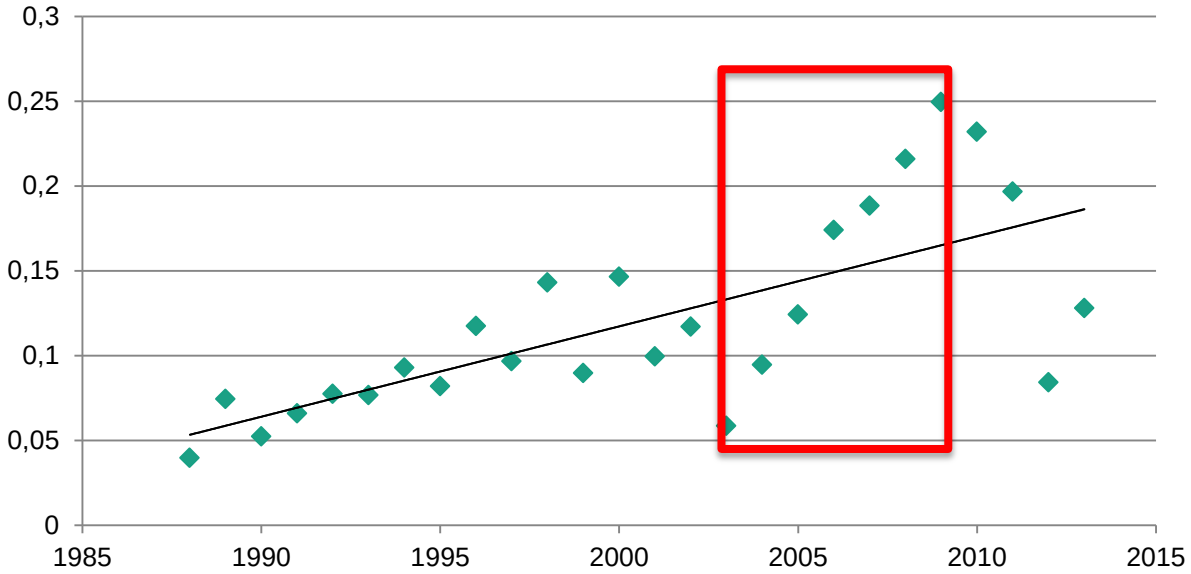
Increase in EROD since 1988



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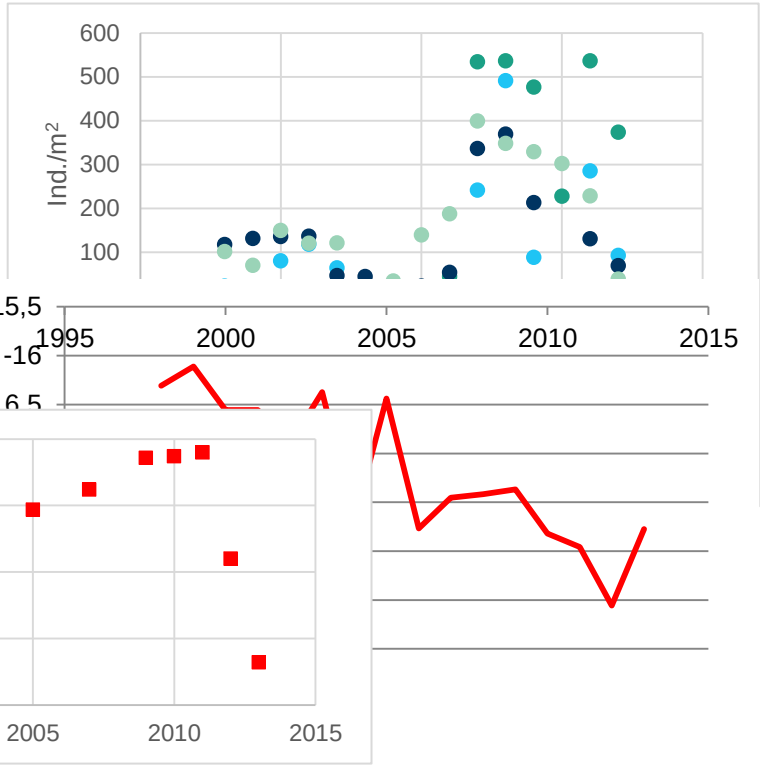
Further investigations

- Change in abundance/composition
- Change in stable isotops
  - Retrospective study
  - More benthic carbon
- PAHs (BaP)
  - Blue mussel



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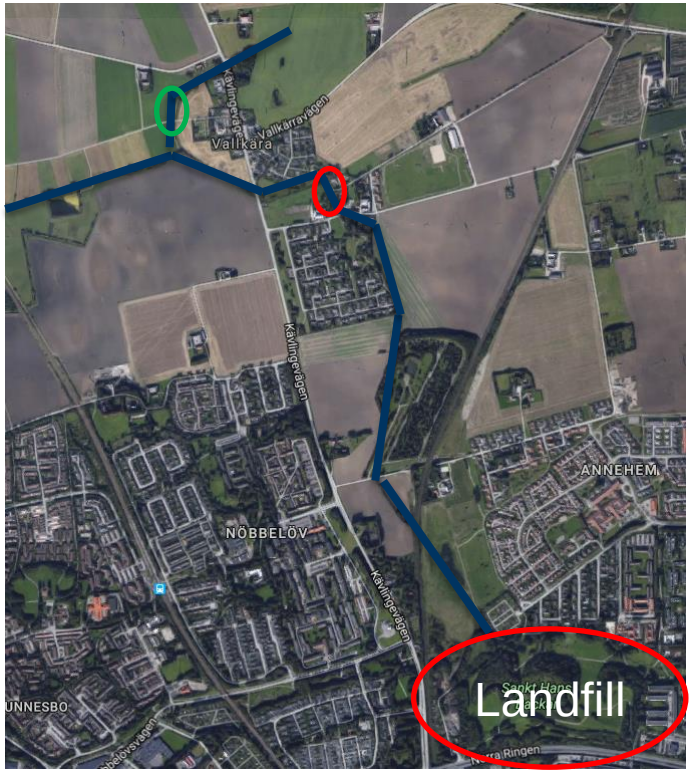
Monitoring (electro fishing)

- Malformed brown trout
  - 1999: 29%
  - 2002: 16%
  - 2006: 53%’
- Possible causes
  - Chemicals
  - Disease
  - Genetics



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Chemical monitoring (2007-2008)

- Metals, organic pollutants (PAHs, PCBs, dioxins etc)
  - No elevated levels
- Mixtures? Unknown/unexpected? Degradation products?
- EBMs??

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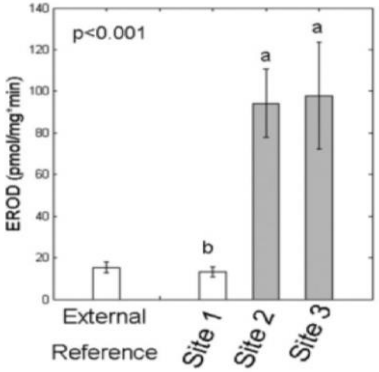
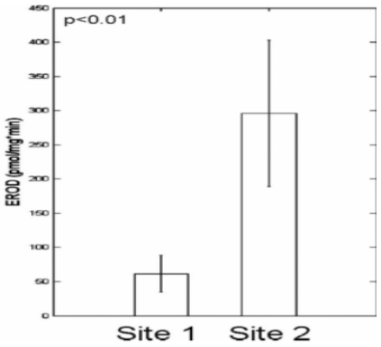
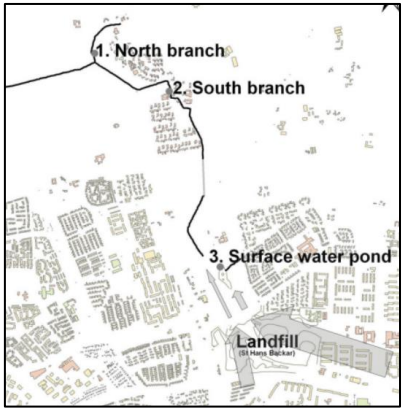
EBMs, 2008

- In vivo bioassay on rainbow trout
  - EROD
    - Five times higher i southern branch
- Biomarkers in brown trout
  - Similar results







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Result of measures

- Measures taken 2013-2015
  - Treatment installed: 2.4 M EUR
  - Bioassay: 0.012 M EUR
  - Biomarkers: 0.005 M EUR
- Improvement in water body
  - Average: 2014-2018: 9% malformed
  - Average: 1999-2006: 32% malformed