ERMS Activity 5.8 Validation

(input from PROOF)

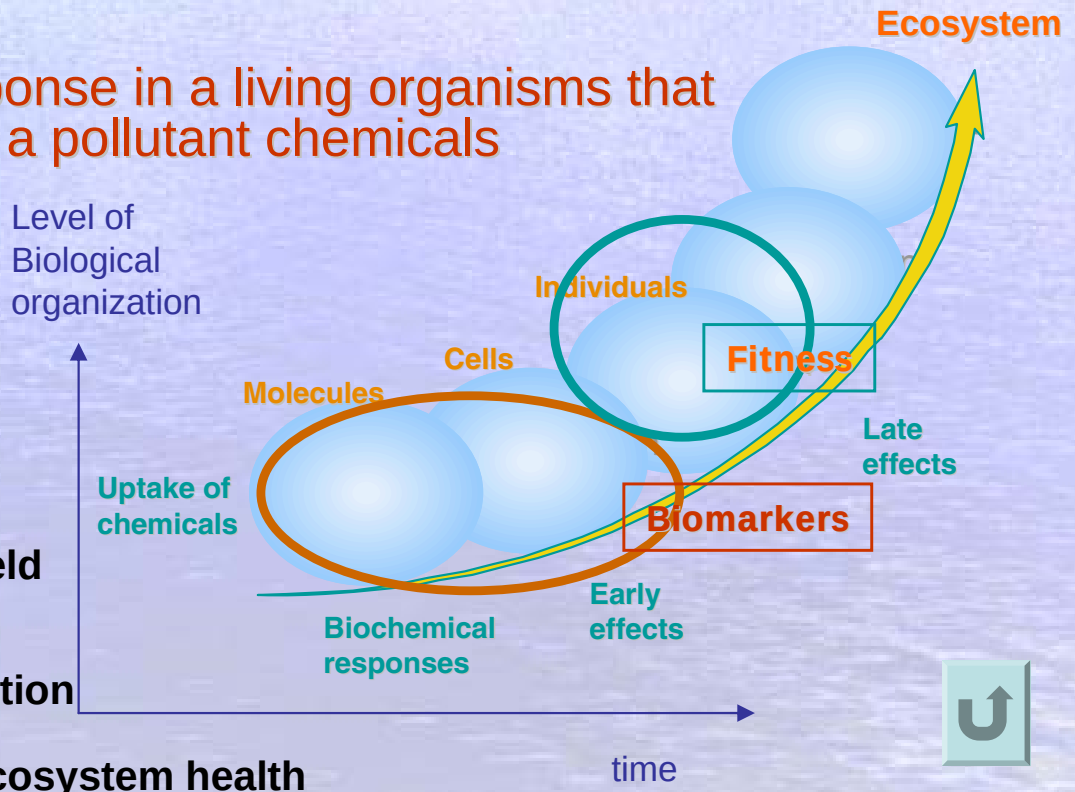
- Two main issues:
  - How can we control monitor estimated environment risks?
  - Check the validity of the currently applied risk values
    - The work…
    - Next steps…

The work…

- Theoretical work
  - to establish the conceptual basis for integration of risk assessment and biomarker based monitoring
- Laboratory studies
  - conducted field relevant exposures to examine relationships between biomarkers, fitness effects, and predicted ecological risks
- Field studies
  - Participated in field relevant exposures to validate biomarkers to oil industry discharges in relation laboratory exposures
- Applied Statistical extrapolation methods (SSDs)
  - to link biomarker response levels to ecological risk levels
  - to validate fitness response levels to existing risk curves
- Integrate biomarker distributions in ERMS models
  - application of the findings to extend the risk models

Key terms

- **Fitness**
  - Refers to the ability of the organism to successfully grow and reproduce and maintain the population of which it forms part
- **Biomarkers**
  - Refers to any biological response in a living organisms that results from the exposure to a pollutant chemicals



NB !

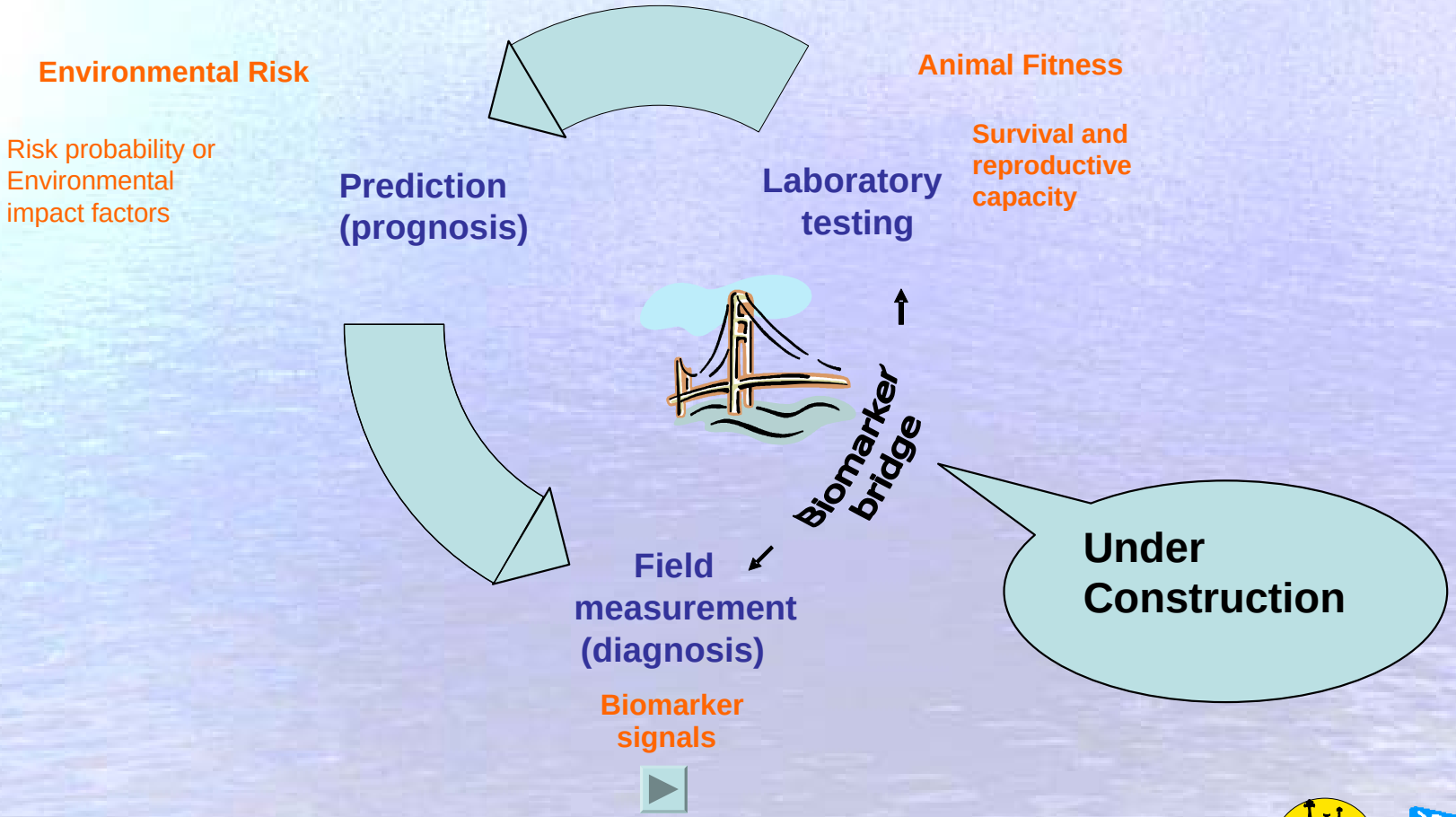
- **Fitness data are currently used for Environmental Risk Assessment**
- **Fitness is difficult to measure in the field**
- **Fitness and Biomarkers often differ in time and level of biological organization**
- **Biomarkers can be Early warning of Ecosystem health**

A key conceptual element:
How is Biomarkers linked with Ecosystem health

- What characterizes a healthy ecosystem?
  - The constituent animals, plants and microbes must, on the whole, be healthy
- How do we characterize ecosystem health?
  - Biomarkers measure exposure to pollutants and give an assessment of the health status of individual animals
  - By measuring the health status of a range of species representing different phylogenies and feeding types, we can use a weight of evidence approach to envisage the ecological concequences of pollutant exposures
    - » Depledge & Galloway, *Front Ecol Environ* 2005; 3(5): 251-258.

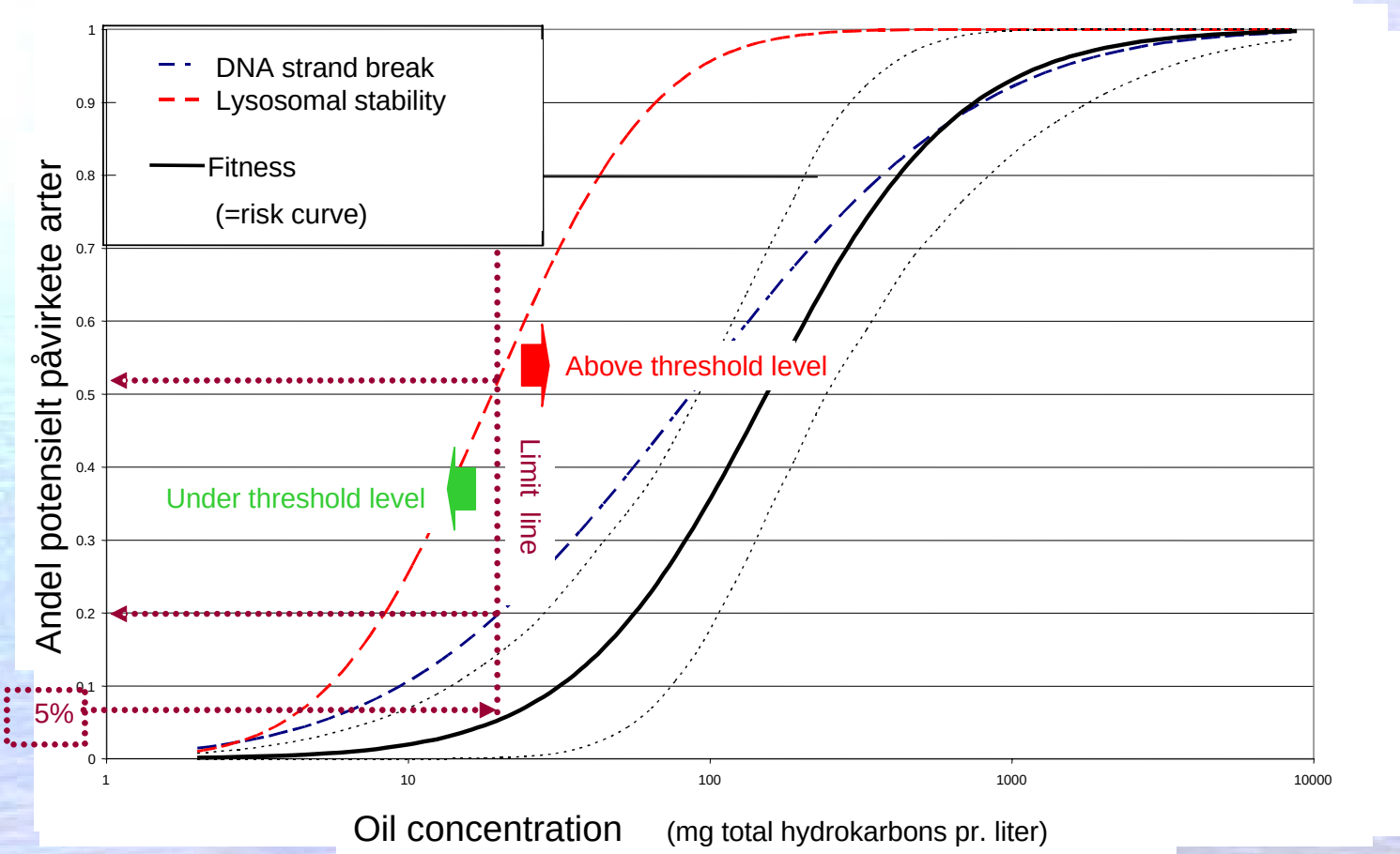
Link between environmental risk and monitoring

…enables predictions of ecosystem health
which can be control monitored



Approach: Compare (statistically) biomarker-response-distributions and fitness-SSDs

Species Sensitivity Distributions for fitness and biomarker responses



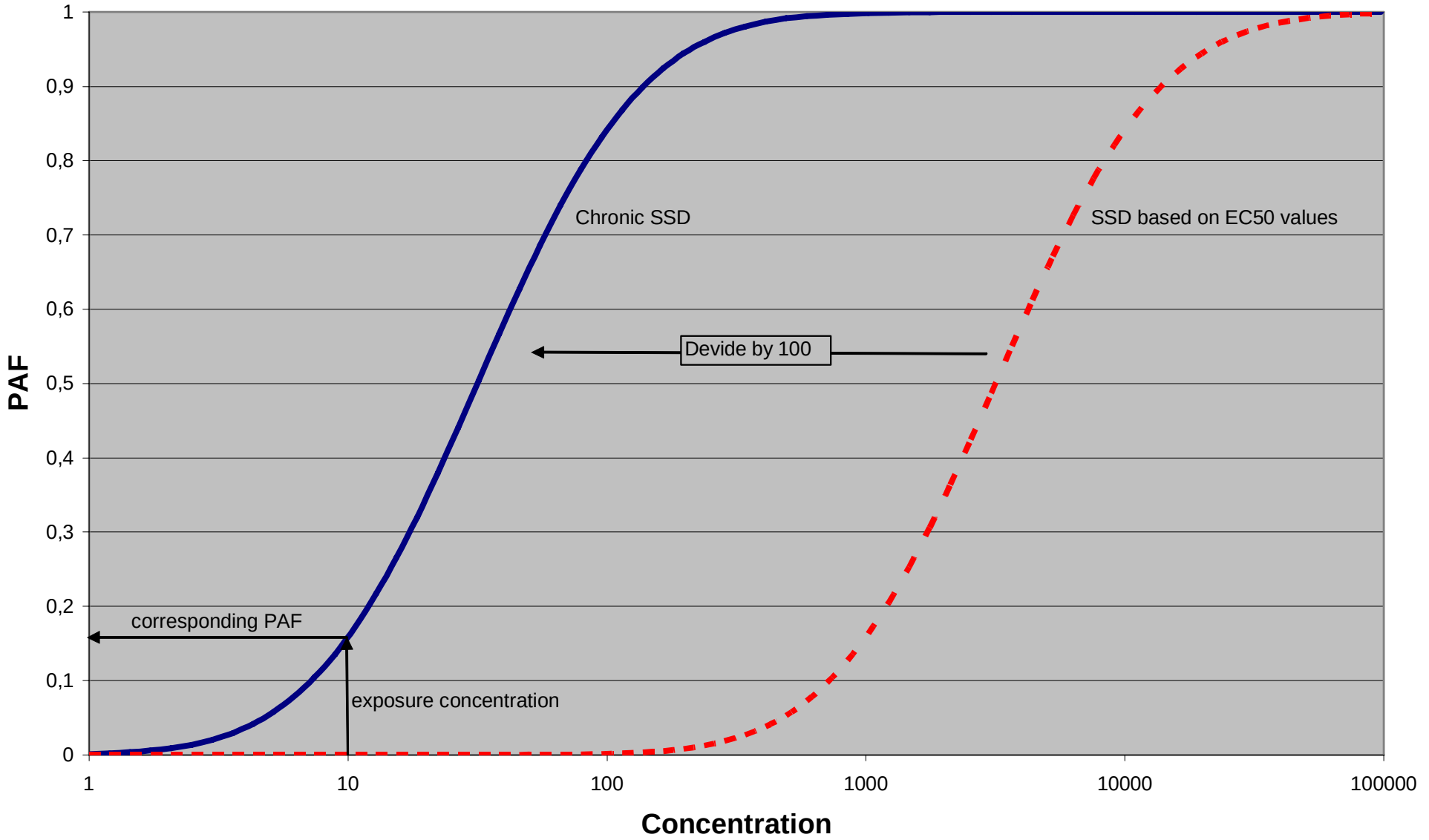
Threshold level

Construct Biomarker Sensitivity Distributions (BSDs) !

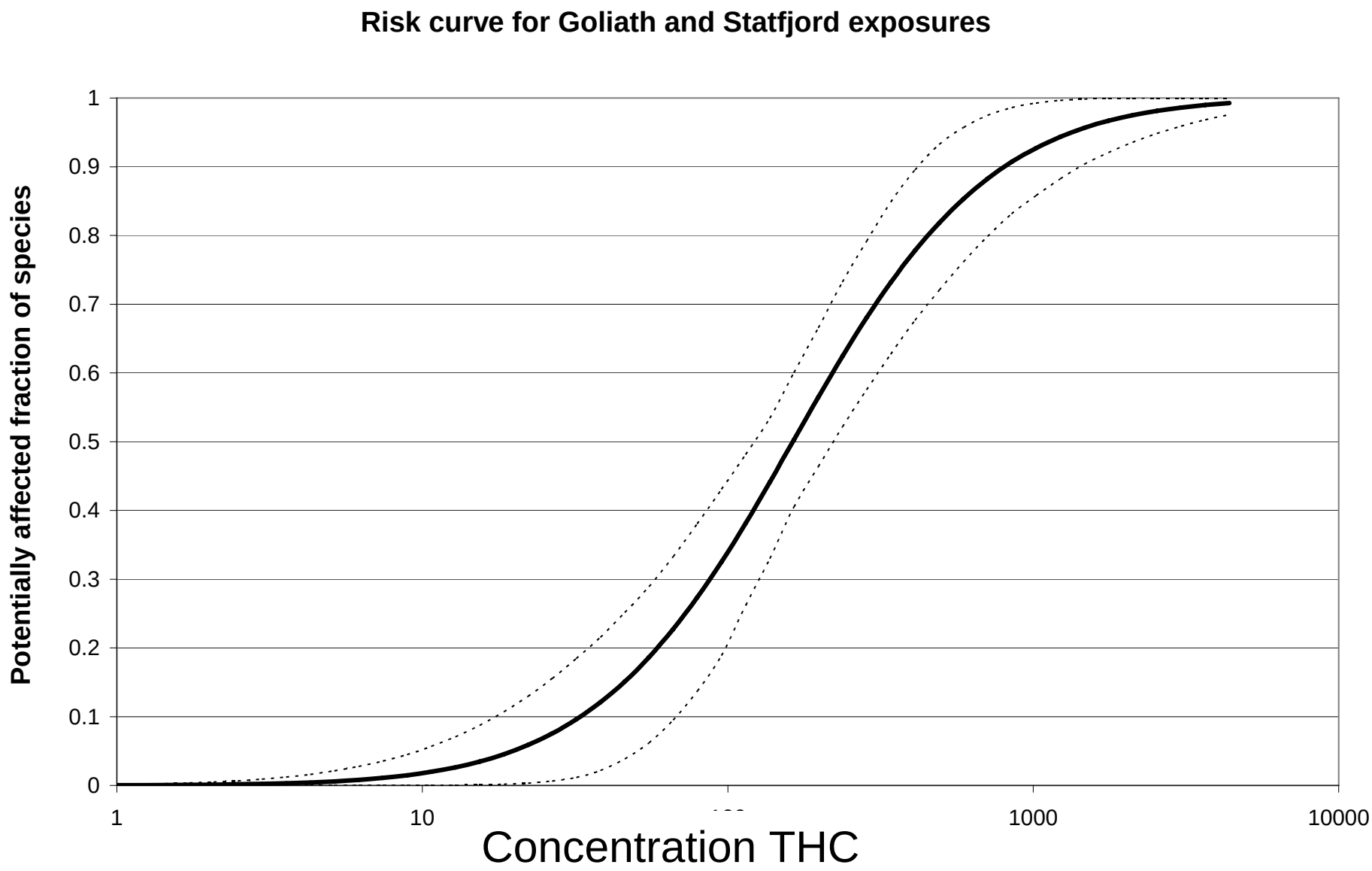
- Statistical evaluation of biomarker response levels versus risk levels
  - Comparison of
    - Species Sensitivity Distributions applied in risk assessment (based on literature data)
    - and Biomarker response distributions (based on our experimental data)

1. Development of SSDs for different oil component groups
2. Construction of risk curve for the different exposures
3. Construction of one average risk curve for all exposures
4. Construction of BSDs for different types of biomarkers: DNA damage, oxidative stress, lysosomal stability and PAH metabolites
5. Comparison of biomarker response levels and risk levels

From SSD based on EC50 to risk curve



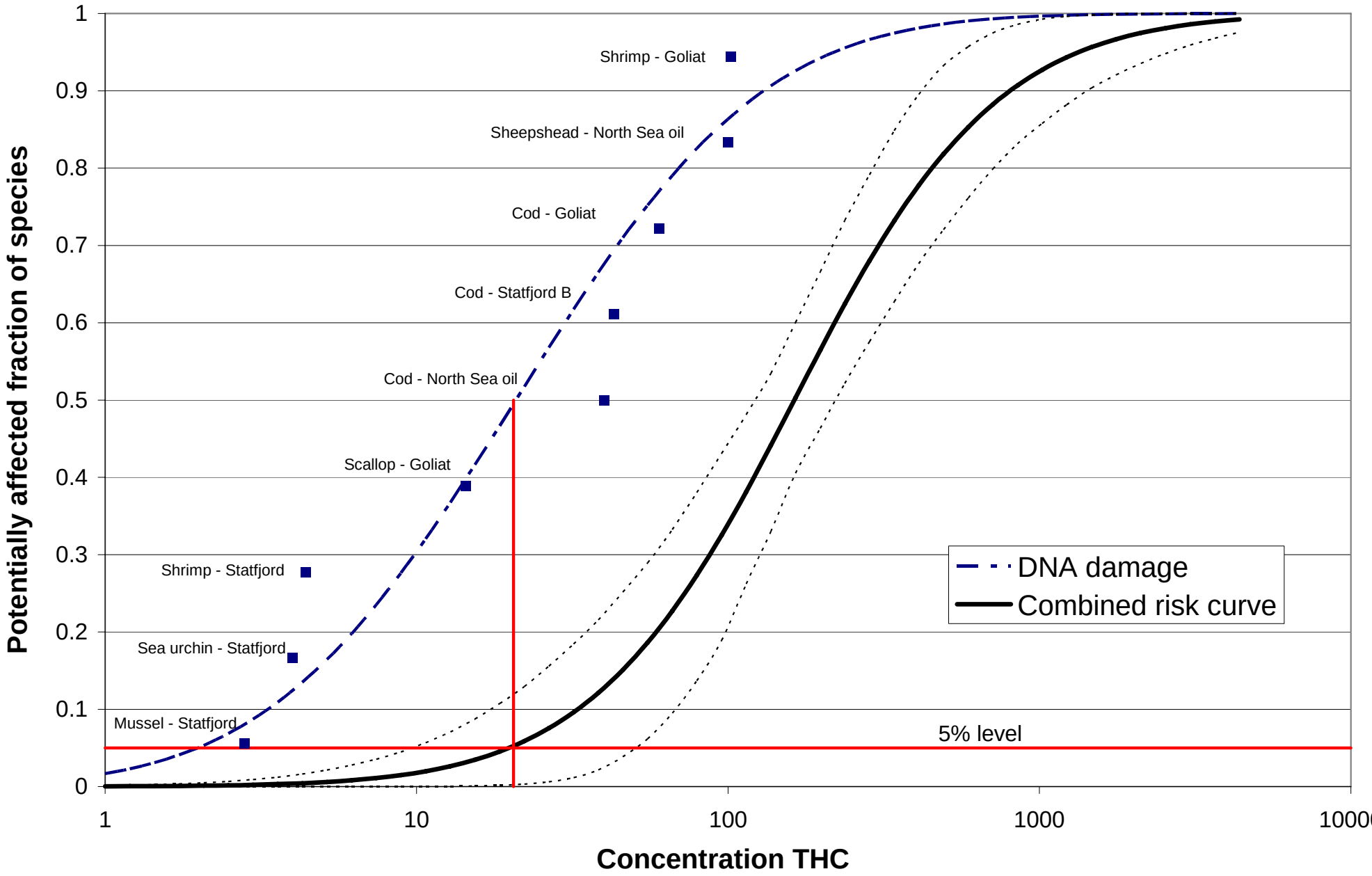
3. Construction of one average risk curve for all exposures



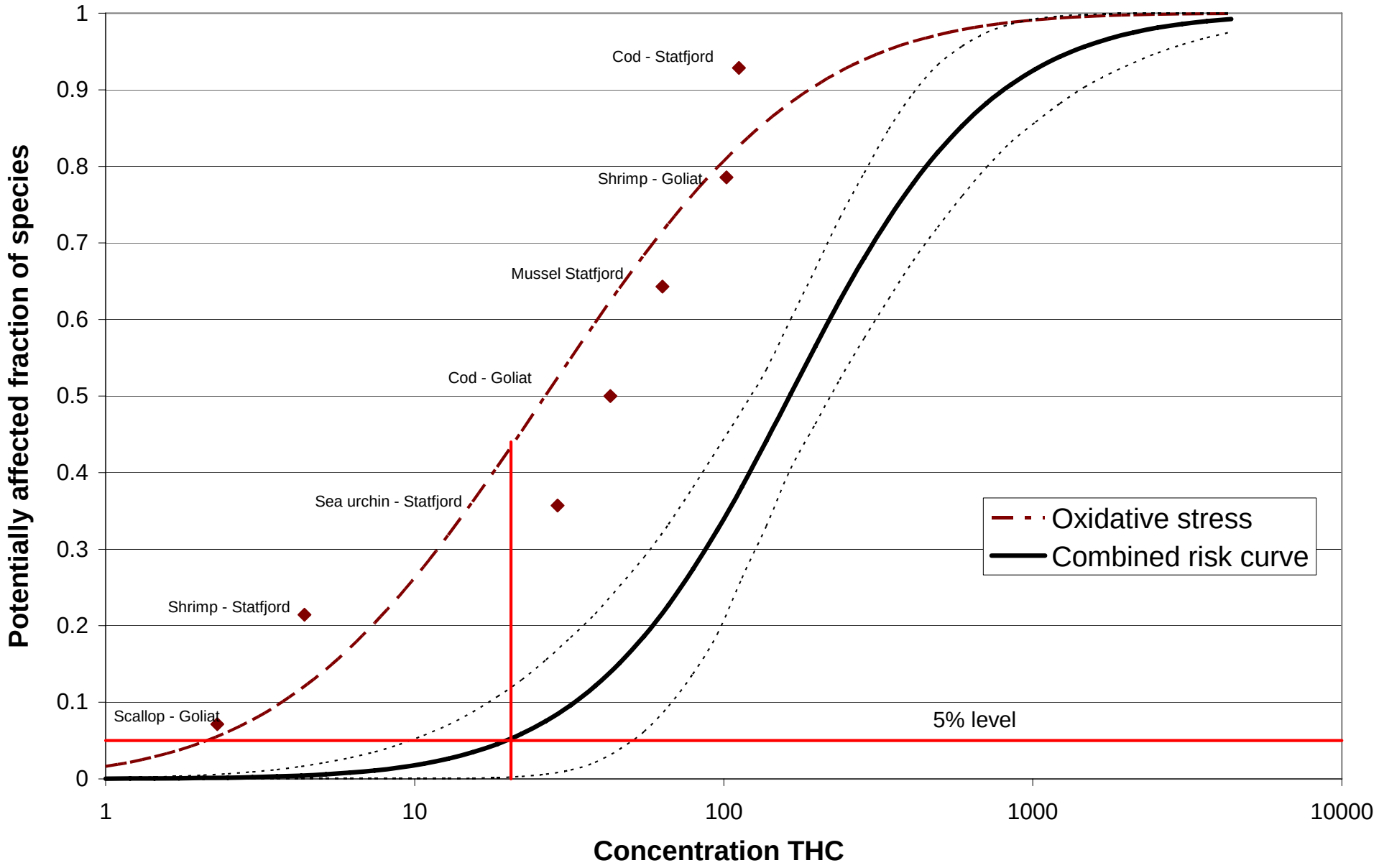
4. Construction of BSDs

- Results from different experiments are combined in BSDs
- The sensitivity of the species tested (Cod, Shrimp, Sheepshead minnow, Sea urchin, Mussel & Scallop) represents the sensitivity of all species
- Four oil types and one produced water exposure
- Lowest Observable Effect Concentrations (LOECs) in biomarkers are applied
- BSDs indicates the variation in lowest exposure levels where the specific biomarkers come to expression for different species
- Biomarkers which respond at low levels but do not respond at higher concentrations are not suited for this. At levels higher than the LOEC the biomarkers must still respond.

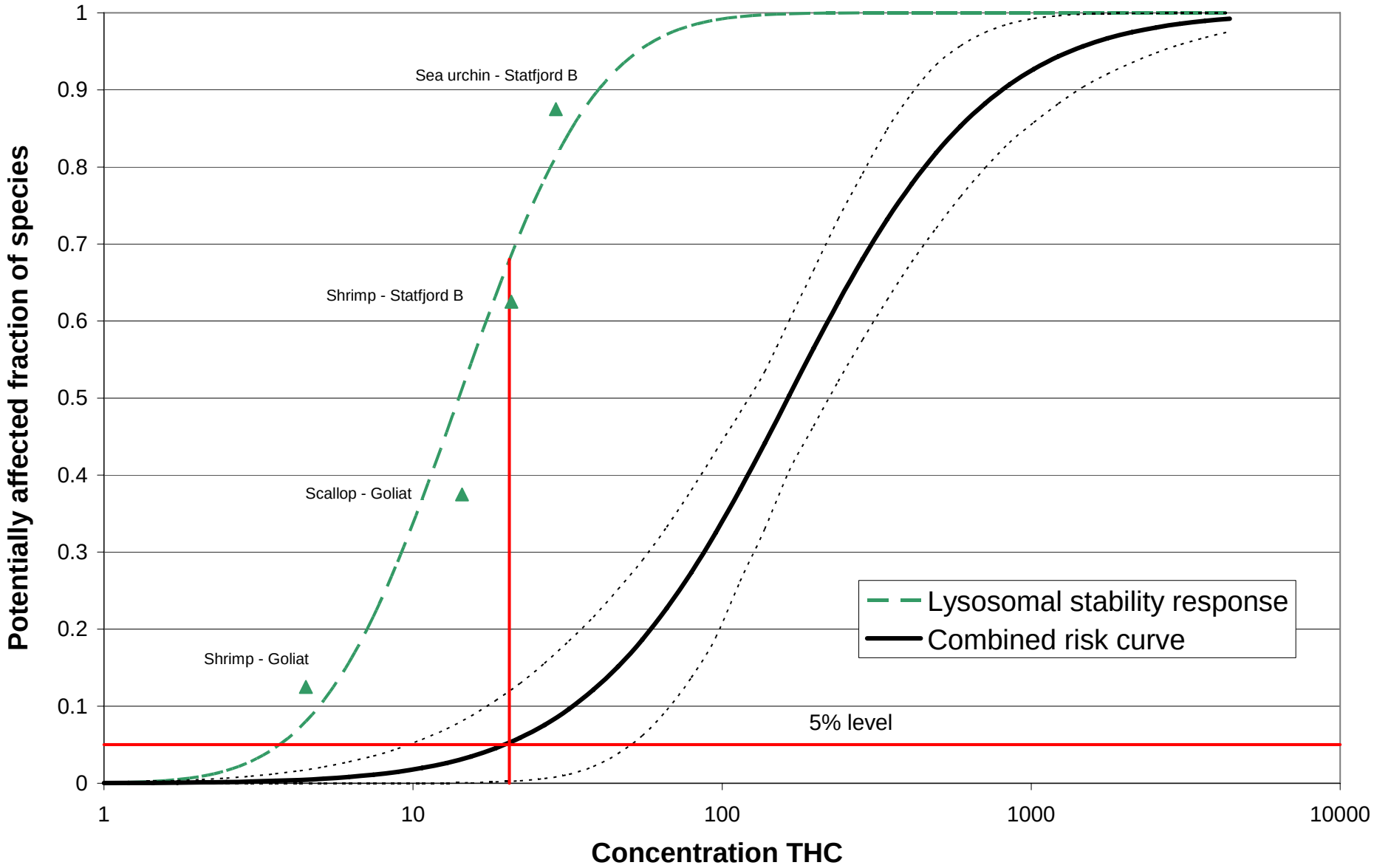
BSD: DNA damage related biomarkers



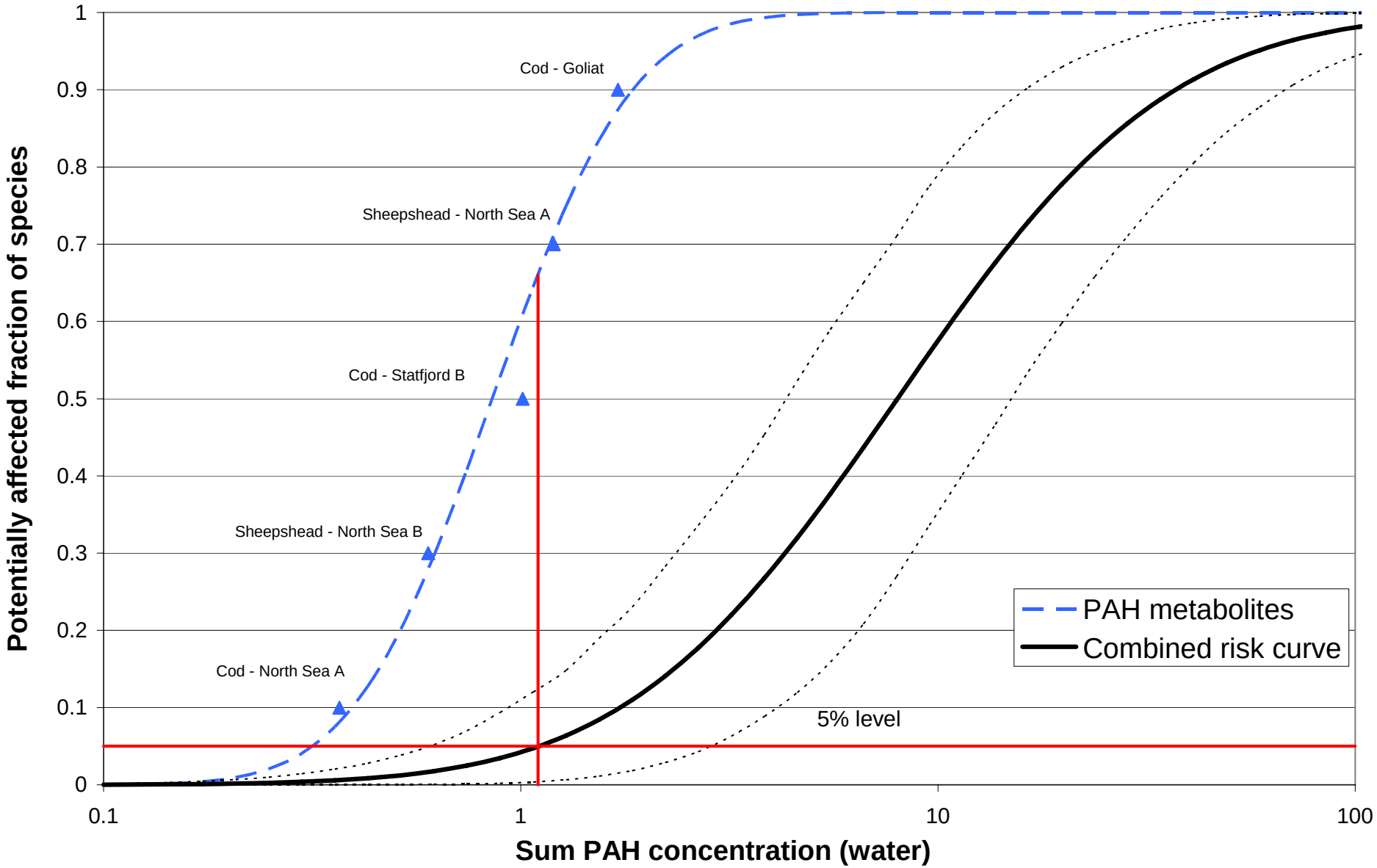
BSD: Oxidative stress related biomarkers



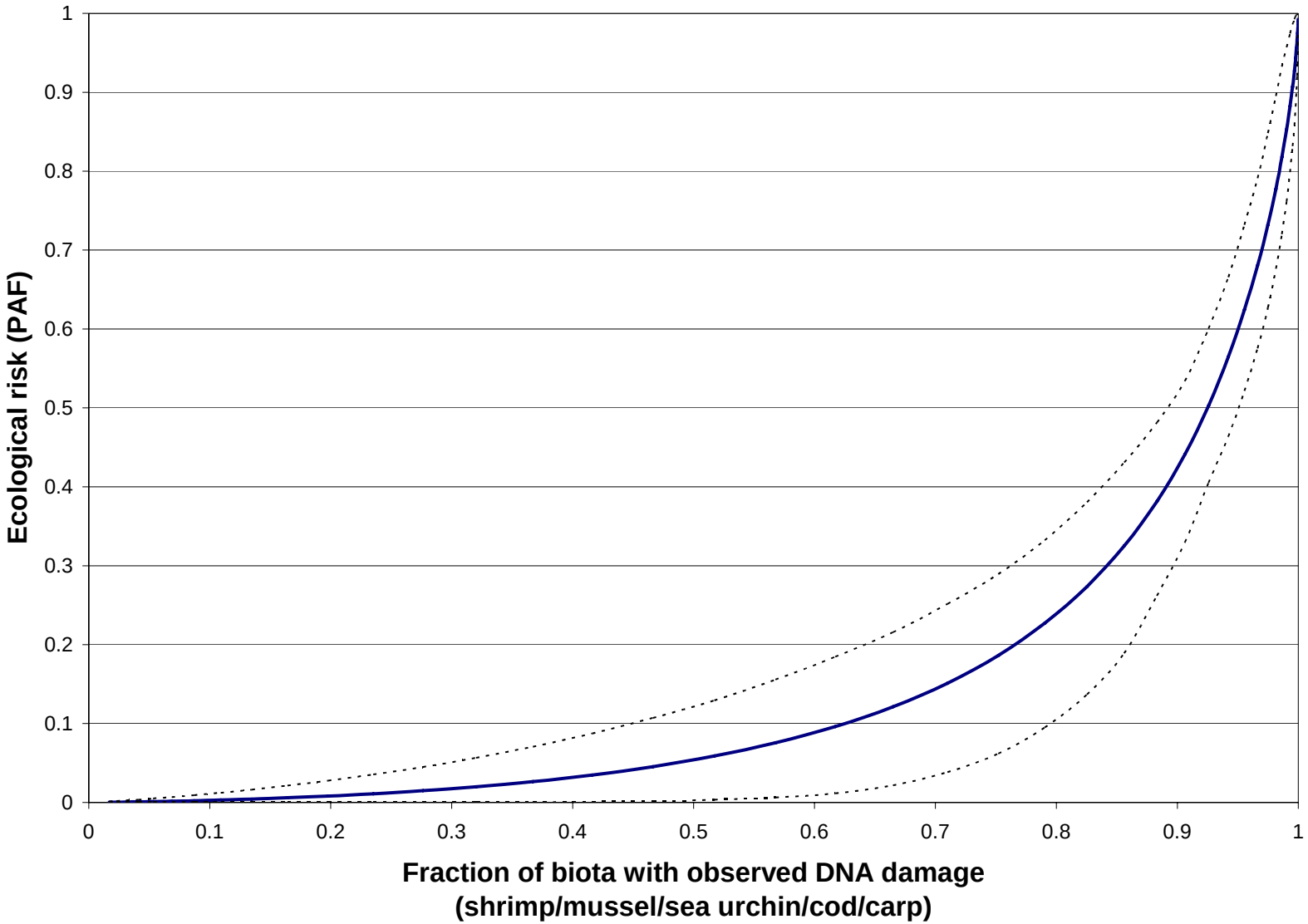
BSD: General toxicity related biomarkers (Lysosomal stability)



BSD: Exposure related biomarkers (PAH metabolites)



5. “A Biomarker Bridge”: Comparison of biomarker response levels and risk levels



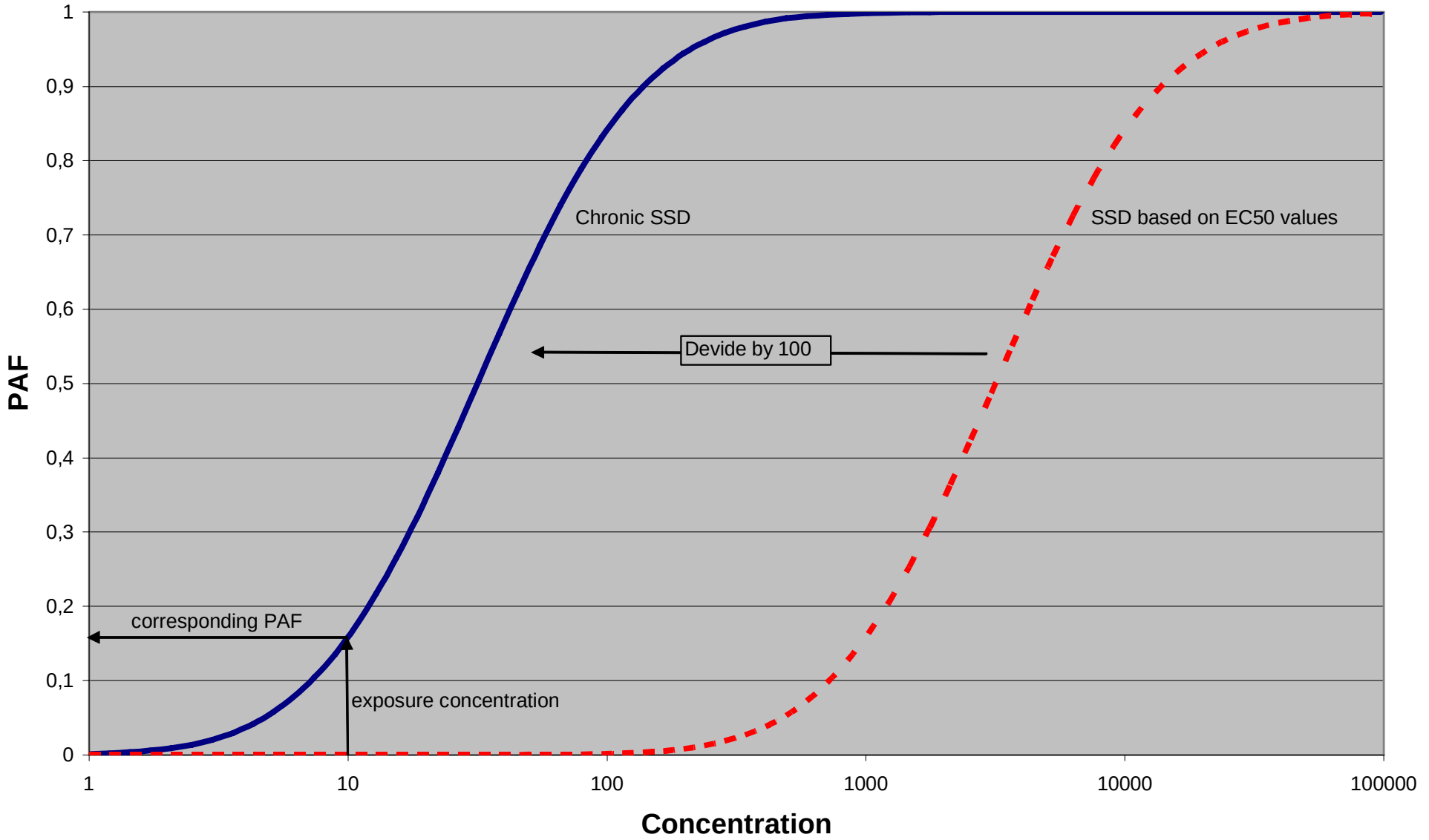
Conclusions – part 1

- How can we control monitor estimated environment risks?
  - A bridge that links environmental risk and biomarkers has been constructed
  - It allows to express environmental risk with biomarker values
  - It makes it possible to control measure accepted risik with biomarker measurements in the field
  - There is a need for biomarker- and fitness- measurements for produced water for more animal species to build a sufficiently robust BSD (approx. 15 species) which can be used to characterize ecosystem health
  - Biomarker data from Svan field study and preliminary results from PROOF Drilling Discharges project indicate that the approach will be applicable also for drilling discharges (effects in the water column)

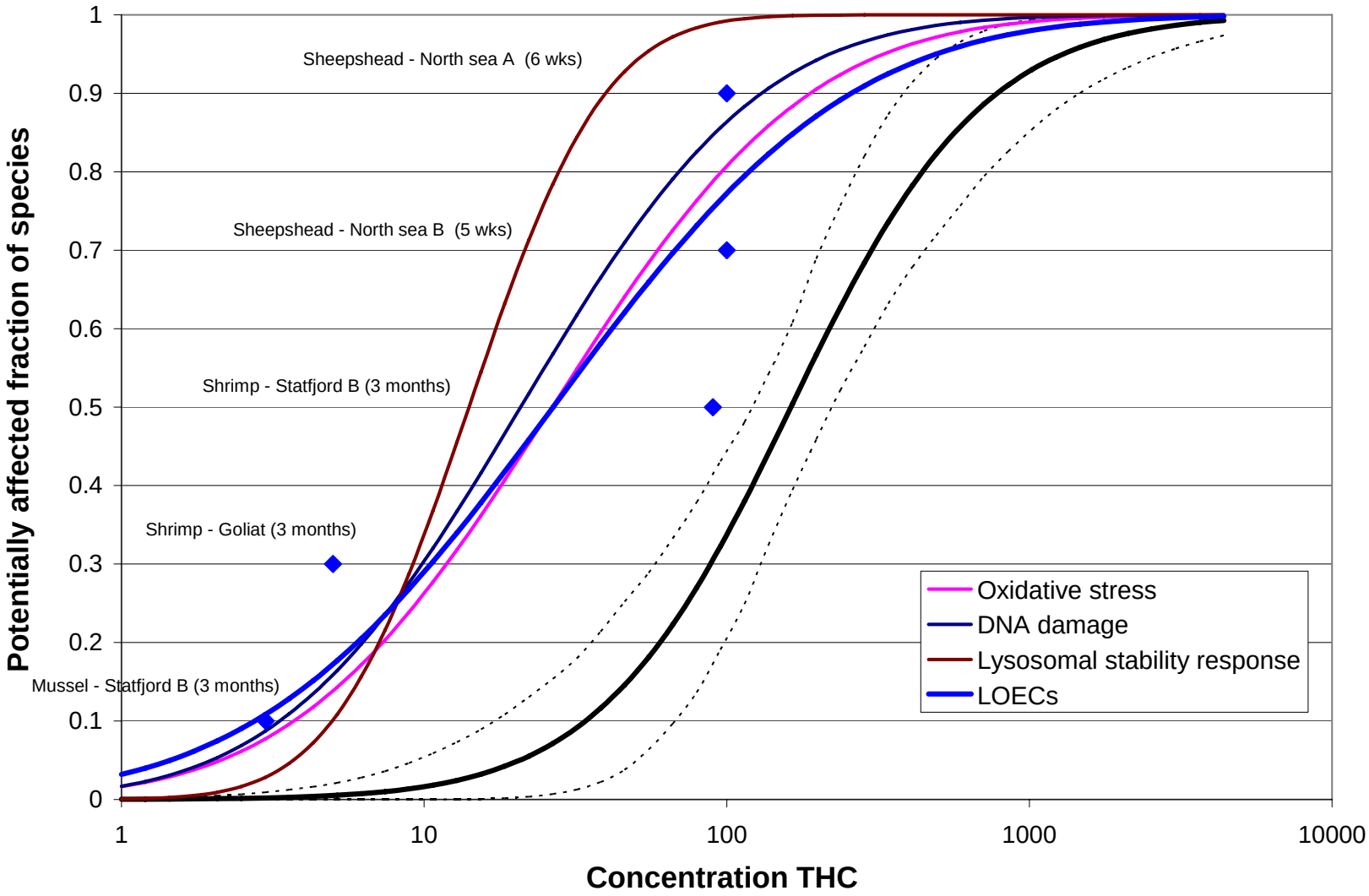
Validation by comparing to laboratory experiments

- Produced water – low dose
- Log term (chronic) exposures
- Vulnerable life stages
- Fitness LOECs

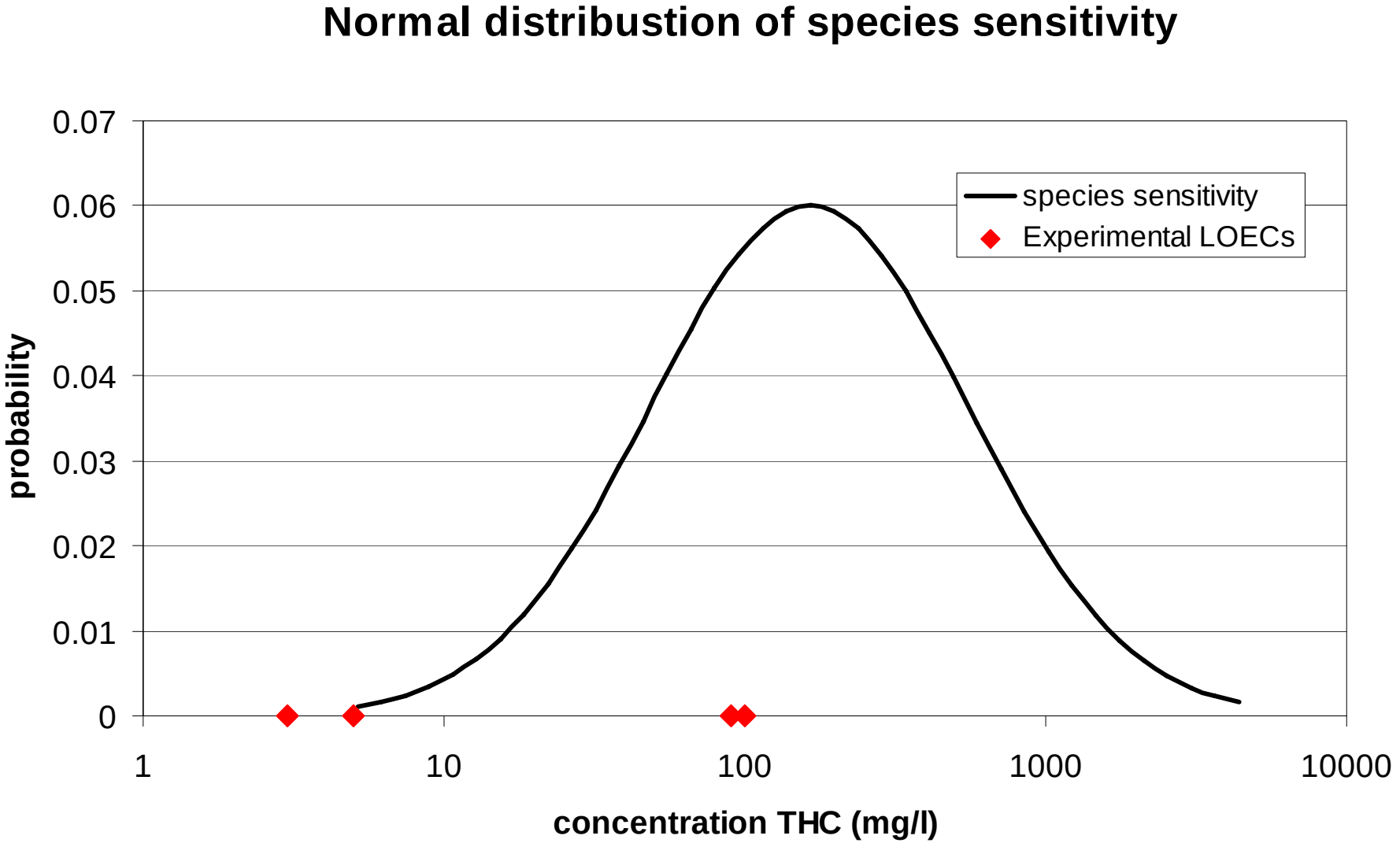
From SSD based on EC50 to risk curve



Risk curve, BSDs and LOEC curve for Goliath and Statfjord exposures



Fitness LOECs plotted in the normal distribution of the SSD



Conclusions - part 2

- Checking the validity of existing ERA values
  - A validation of the presently used SSD for Risk assessment has been done based on relevant laboratory experiments
  - The LOEC values obtained from these fitness studies were lower than the present SSD

Next steps

- Biomarkers integrated in ERA
  - BSDs should be fully developed for PW discharges
  - BSDs should be considered developed for drilling discharges
  - The concept should be taken into account in next revision of monitoring programmes related to oil and gas discharges
- The Validation results with chronic exposures and vulnerable life stags should be
  - taken into account in the evaluation of application factors for ERA related to oil and gas discharges
- Thank you!