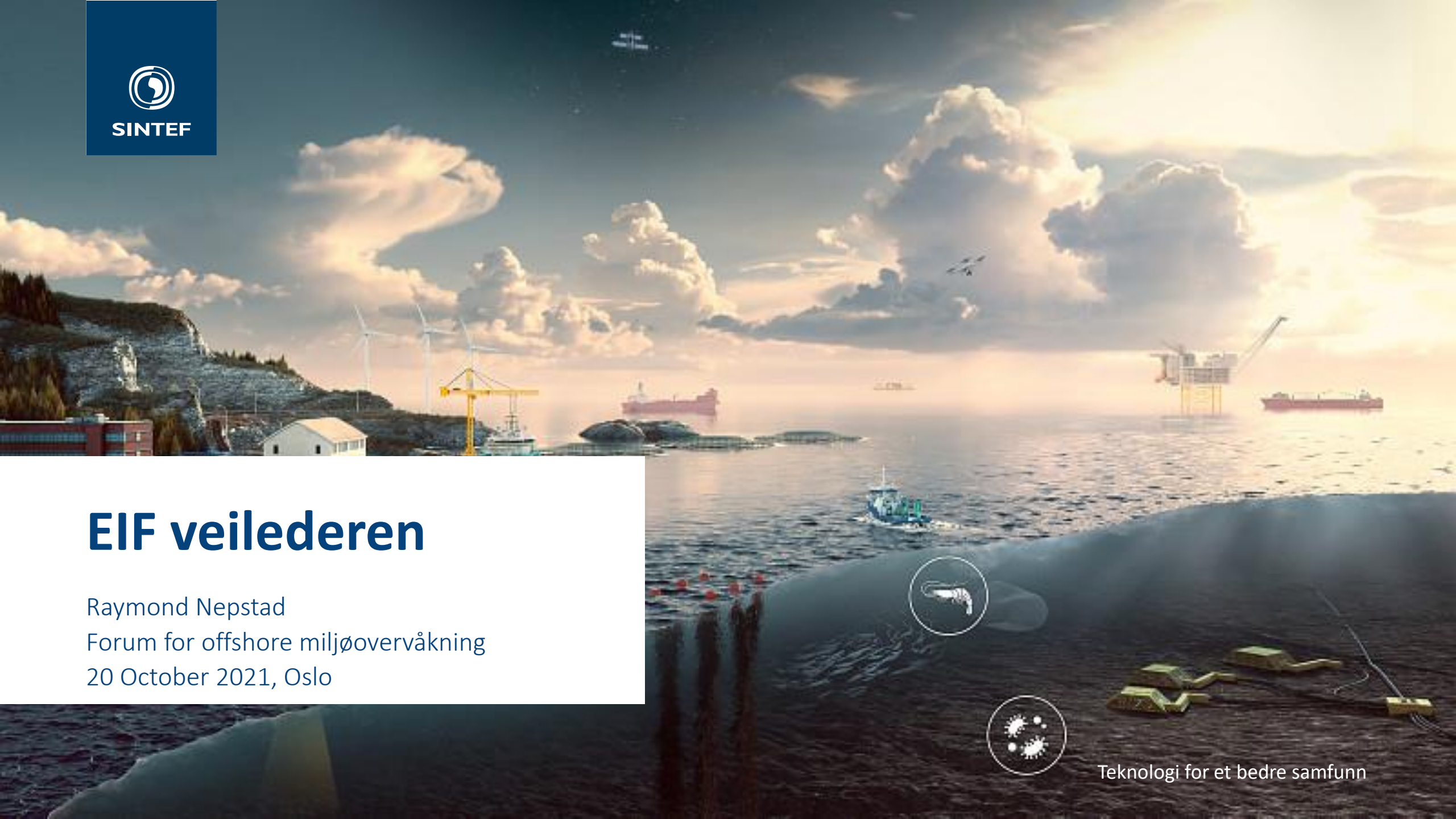


EIF veilederen

Raymond Nepstad

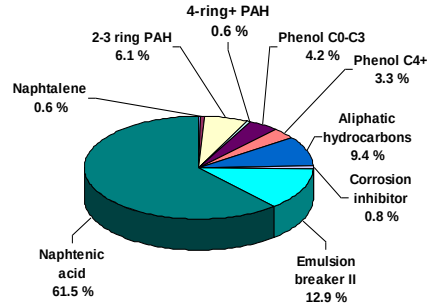
Forum for offshore miljøovervåkning

20 October 2021, Oslo

Teknologi for et bedre samfunn

Overview

- EIF – quick history and overview
- How the EIF is calculated
- EIF Guideline update
  - Initiated by NOROG
  - May Kristin Ditlevsen, Ståle Johnsen, Odd Gunnar Brakstad, Raymond Nepstad, at SINTEF Ocean
  - Input from operators



www.sintef.no/DREAM

The Environmental Impact Factor - EIF

- Launched in 2000
  - 20 year anniversary seminar in April 2022
  - Zero harmful discharge work
  - Implemented in the DREAM model
- Substance-based PEC/PNEC approach
  - Focus on discharge, components
- Environmental *risk management* tool
  - Identify risk-driving components
  - Inform actions for risk/effect-mitigating measures
  - Document environmental risk reduction over time

SPE 61178

The Environmental Impact Factor - a proposed tool for produced water in... reduction, management and regulation

S. Johnsen, Statoil F&U, Trondheim, and T. K. Frost, Statoil F&U, Trondheim, and Mona Hjelsvold, Statoil F&U, Trondheim, and Toril Røe Utvik, Norsk Hydro, Bergen

This paper was prepared for presentation at the SPE International Conference on Health, Safety, and the Environment in Oil and Gas Exploration and Production held in Stavanger, Norway, 26–28 June 2000.

Abstract

The Norwegian government issued in 1998 White Paper No. 58 followed by the "Zero discharge report" requiring the oil industry operating in the Norwegian sector of the North Sea to develop a strategy for reaching "zero environmental harmful discharges" of produced water (PW) within 2005. As a result Miljøsok proposed to develop a management tool based on environmental risk and hazard assessment to identify the most potential environmentally harmful discharges of PW, and to quantify the environmental benefit of different actions to reduce these. The Norwegian Oil Industry Association (OLF) working group for PW was asked to develop the Environmental Impact Factor (EIF), and the tool has so far been applied for PW management on a single platform level. The plan is to elevate this work to a regional scale in order to compare the potential benefit of measures to reduce PW discharges in the whole area, and to form a basis for a cost-effective total approach to PW management.

The EIF is based on a combined environmental risk and hazard assessment of PW discharges, accounting for both composition and amount of the discharge. The EIF is also linked to the environmental impact assessment (EIA) studies in the area and the environmental monitoring programme for the water column, initiated in 1999.

Determination of the EIF for a single platform allows the operator to rank the available technologies for PW discharge reduction on a cost-benefit basis. The EIF identifies the source of potential environmental damage and quantifies the benefit of any action taken to reduce this. Technologies like PW re-injection, treatment and removal or replacement of process chemicals can thus be ranked based on cost and environmental benefit.

Introduction

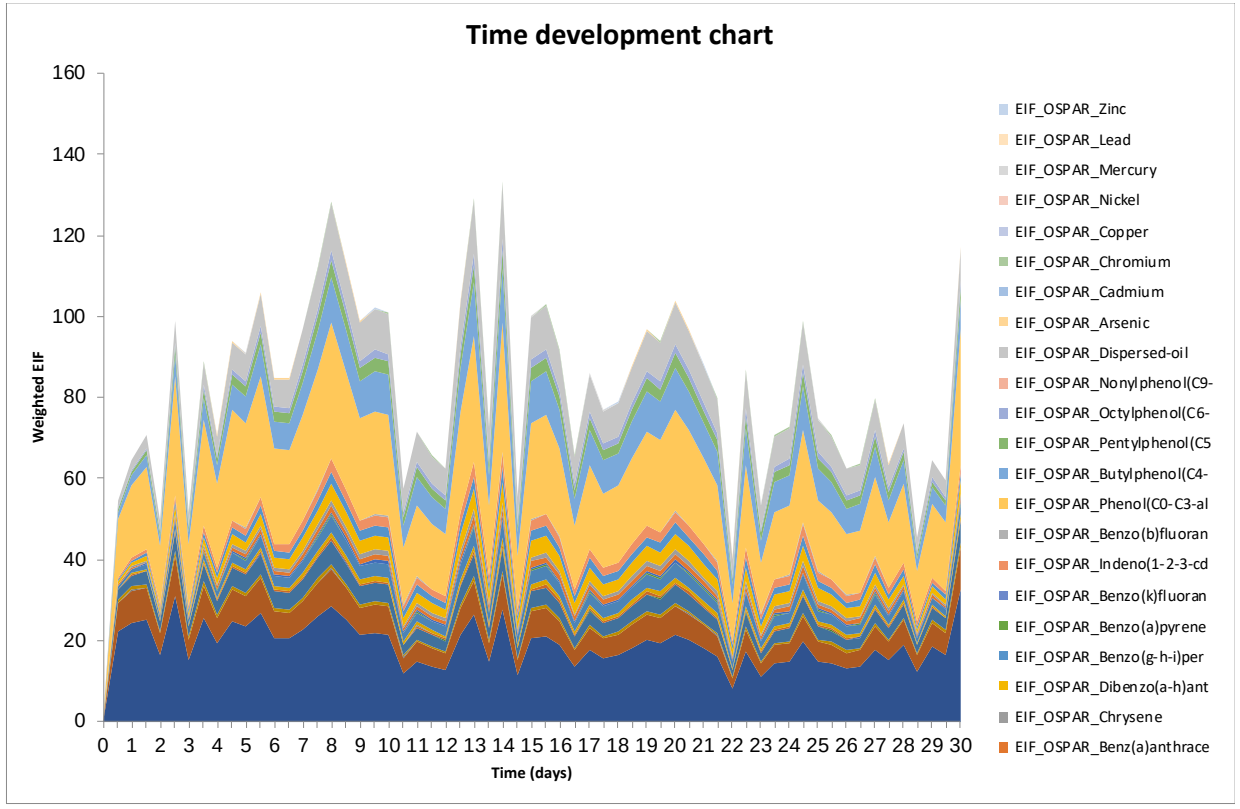
Produced water management in the Norwegian waters is currently based on the "Zero impact" mindset, meaning that the ultimate objective is to remove all potential environmentally harmful discharges (1). In general, a number of technological approaches are being considered and developed to meet this challenge;

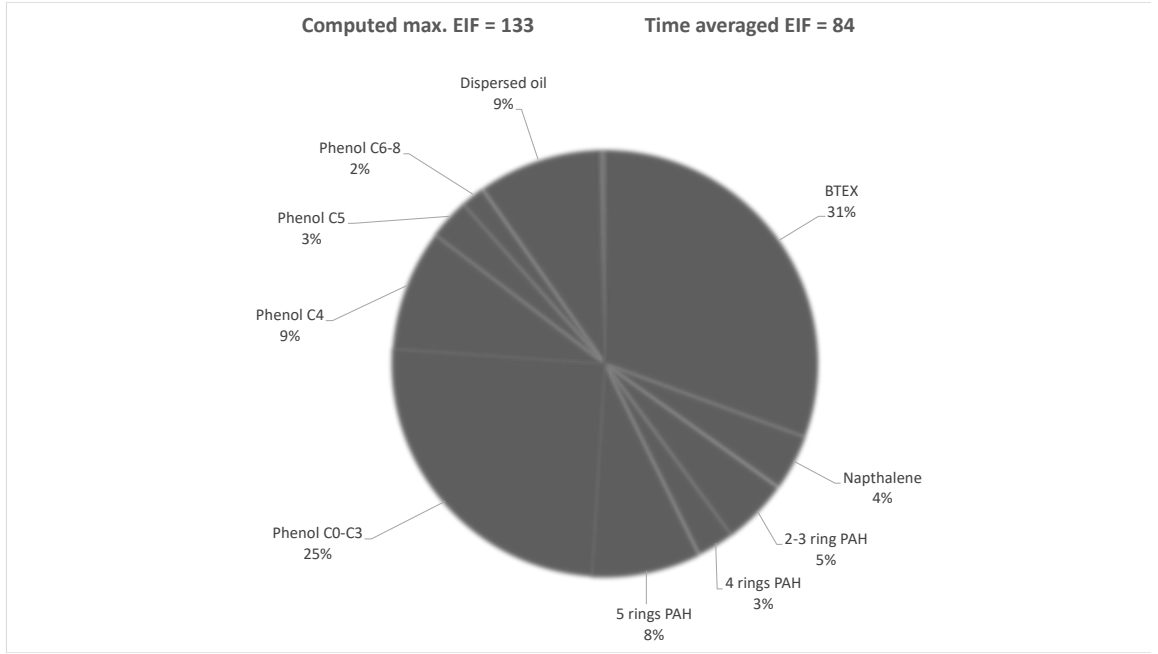
- Re-injection
- Treatment
- Water shut off
- Down-hole separation
- Removal or replacement of process chemicals

To meet the "zero impact" goal in a cost-efficient manner, a produced water management tool able to quantify the environmental benefit of implementing one or more of the above technologies for a specific field, is needed. Such a system should enable the operator of a production field to identify and rank different discharge reducing measures on a cost/benefit basis, and also allow direct comparison with other production fields within the actual area. The operator would, resulting from such considerations be able to present a strategy for reaching the state of "zero impact", and to identify the most important actions or milestones on the way.

Leglislation on the composition of produced water offshore has, in general, been limited to "total oil" concentration (currently 40 mg/l in the North Sea). Studies of bioavailability and toxicity of produced water compounds (2) show however, that the water soluble fraction of the natural organic compounds and man-added chemicals in produced

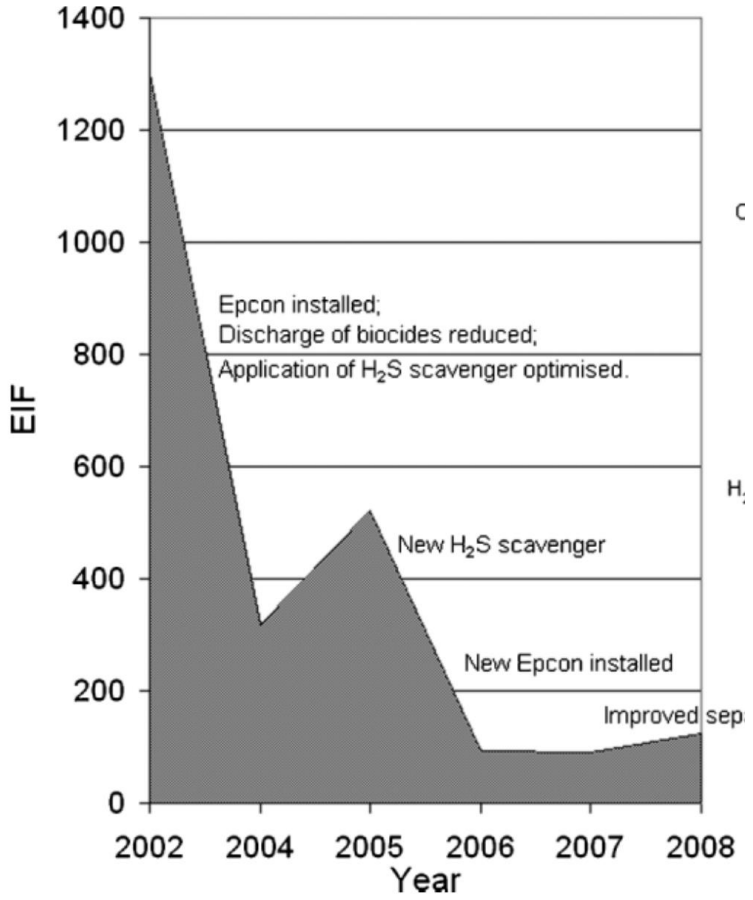
EIF pie and chart





EIF on the NCS

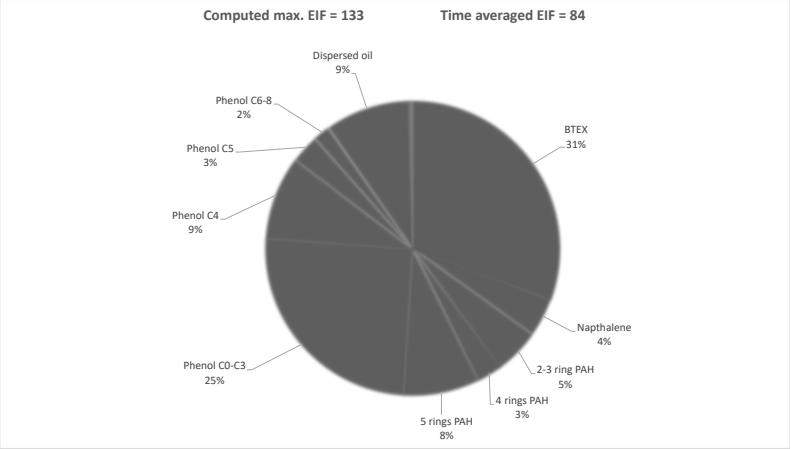
- Typically calculated and reported by the operators on a yearly basis
- Standardization: DREAM simulation run for 30 days with May 1990 currents (North Sea)
- Historically, reductions in EIF through targeted mitigations have been documented (Smit *et al.* 2008)
- The 2012 OSPAR RBA includes both substance-based (e.g. EIF) and the WET approach

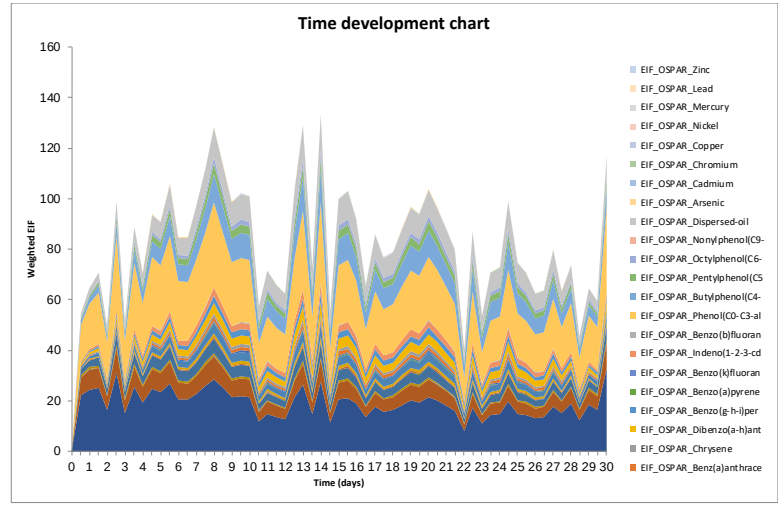


From: Smit *et al.* (2008)

EIF

- Relatively quick to calculate
- Moderate input needs, mainly
  - Discharge rate and composition
  - Component PNECs and biodegradation rates
  - Ocean currents
- However, the EIF does not directly reflect the exact environmental impact of a PW discharge
- Mostly useful for comparing values over time on the same location





DREAM and the EIF

From discharge mixture to environmental risk

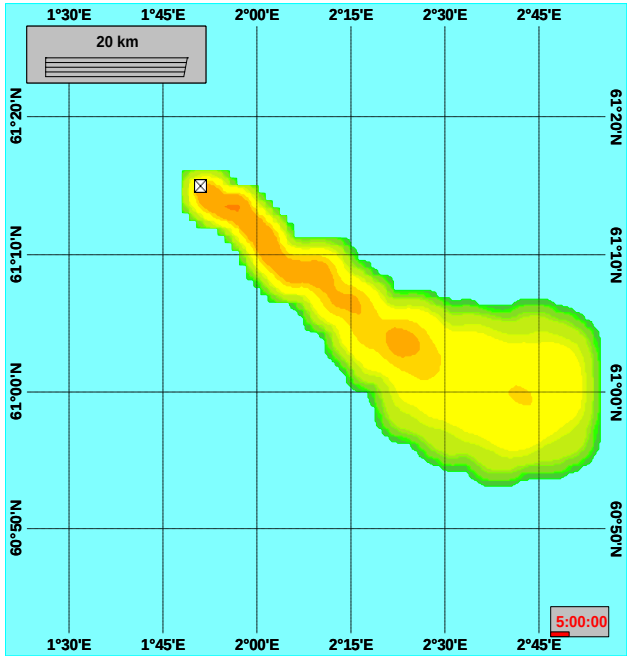
DREAM model steps (PEC):

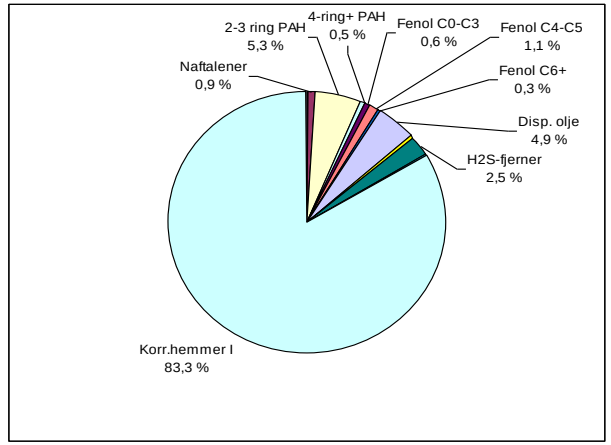
Discharge mixture -> transport/dilution -> fate processes

-> concentrations (PECs)

EIF steps:

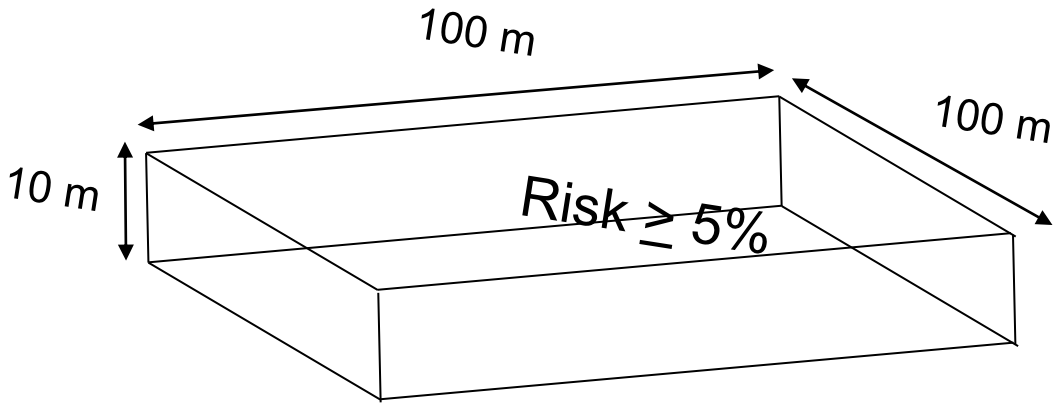
PEC -> PEC/PNEC -> Risk -> EIF





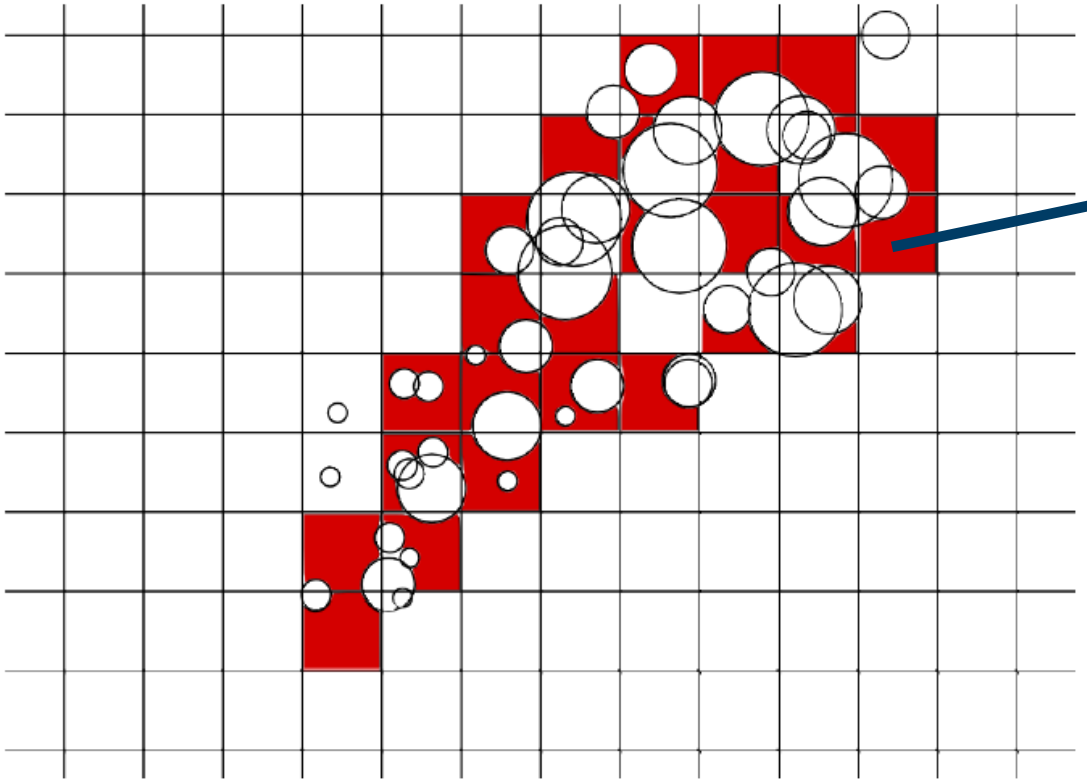
The Environmental Impact Factor (EIF)

$$EIF = \frac{\text{Volume in which total risk} > 5\%}{10\ \text{m} \times 100\ \text{m} \times 100\ \text{m}}$$

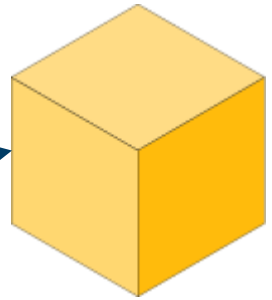


From PEC to risk

at time *t*, in grid cell *k*



Grid cell k



N compounds

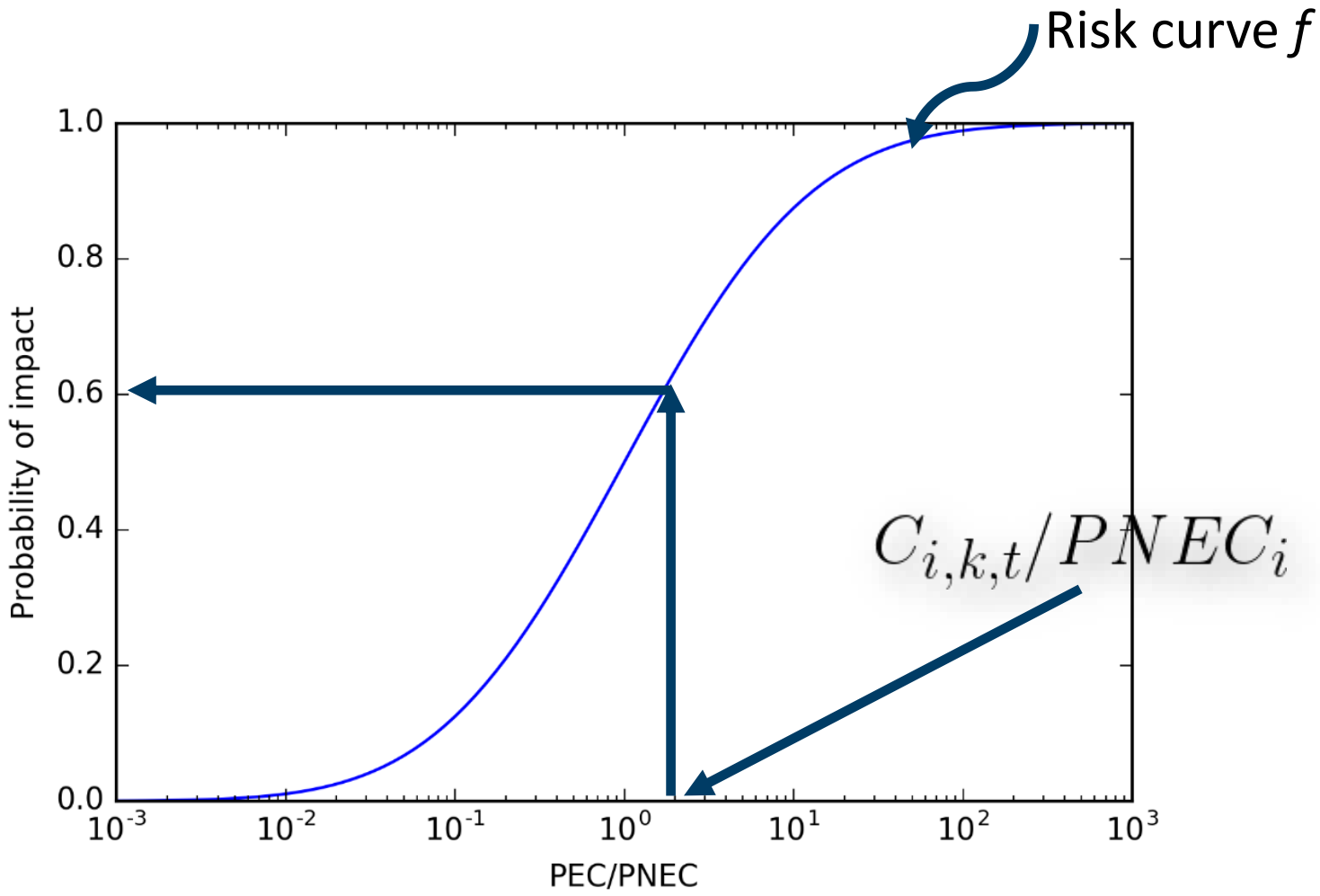
$$C_{1,k,t}$$
$$C_{2,k,t}$$
$$C_{3,k,t}$$
$$\vdots$$

Calculating risk for a single component

Component *i*, at time *t*, in cell *k*

$$P_{i,k,t} = f\left(\frac{C_{i,j,k}}{PNEC_i}\right)$$

Risk contribution
* from this component
* in given cell
* at given time step



Calculating the total risk
in a cell *k* at time *t*

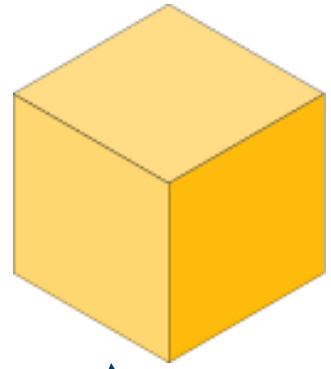
Total risk from one or more of *N* compounds in mixture. Indenpendent Action assumption (IA):

$$P = 1 - \prod_i (1 - P_i)$$

$$P(A \vee B) = P(A) + P(B) - P(A \wedge B)$$

For IA, see: Dyer, S., Michael, S. J. W., Meyer, J. S., Leslie, H. A., & Escher, B. I. (2011). Tissue residue approach for chemical mixtures. Integrated Environmental Assessment and Management, 7(1), 99–115.

Calculating the total risk volume



$$P_{k,t} > 5\%$$

Yes

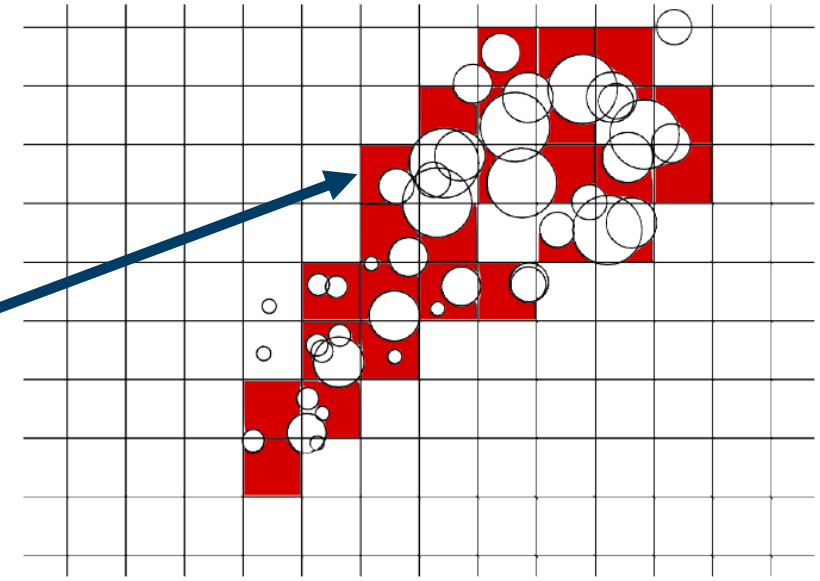
$$V_{P>5\%} += V_k$$

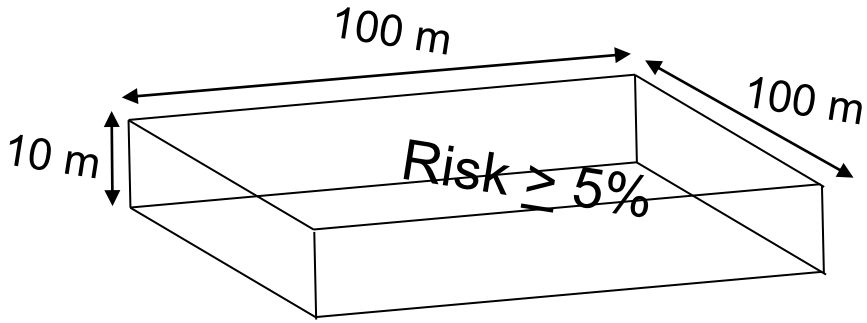
No

Discard cell

Calculating the EIF

$$EIF(t) = \frac{V_{P>5\%}(t))}{V_{EIF}}$$

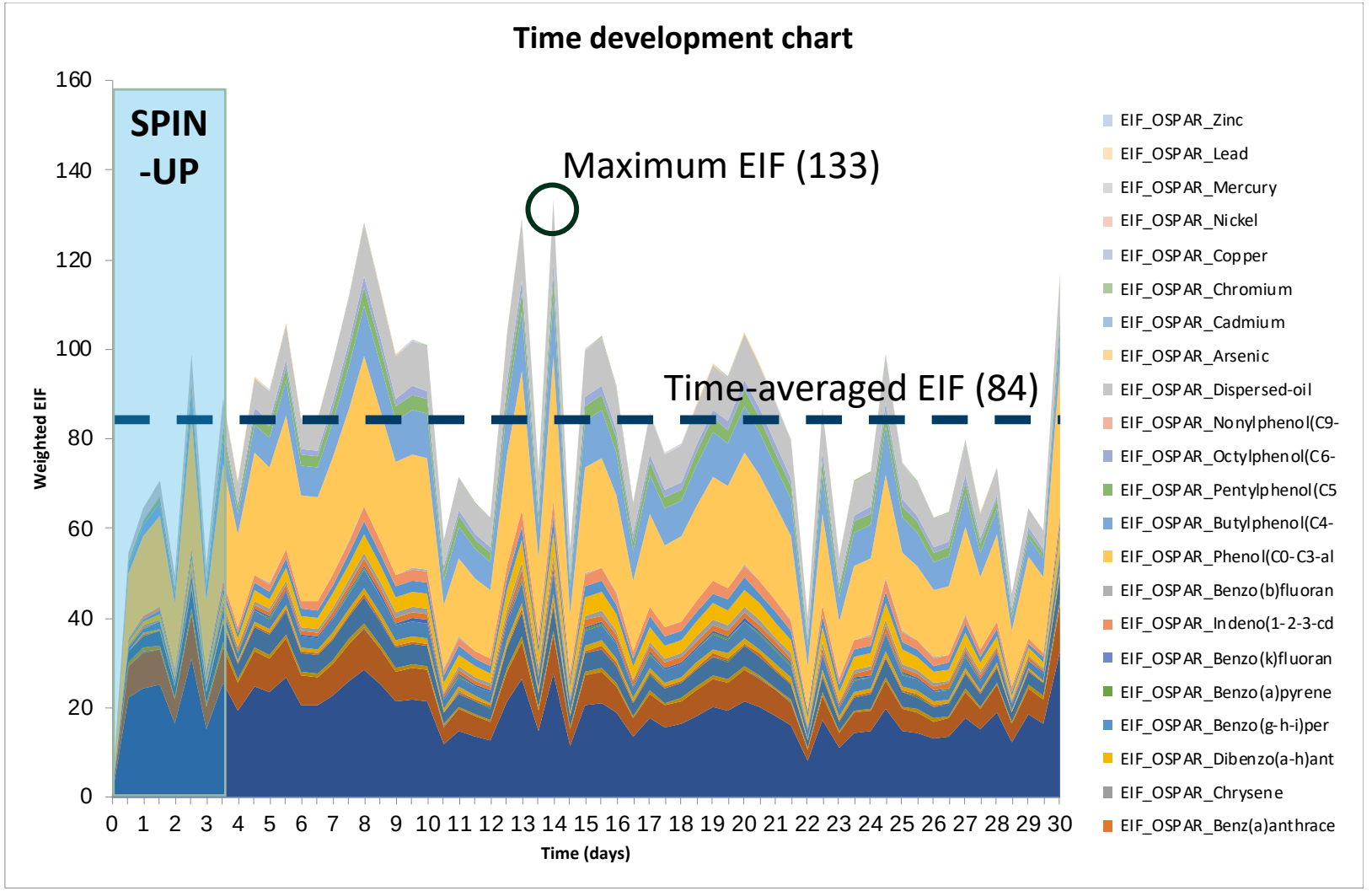




EIF: Maximum vs. time-averaged

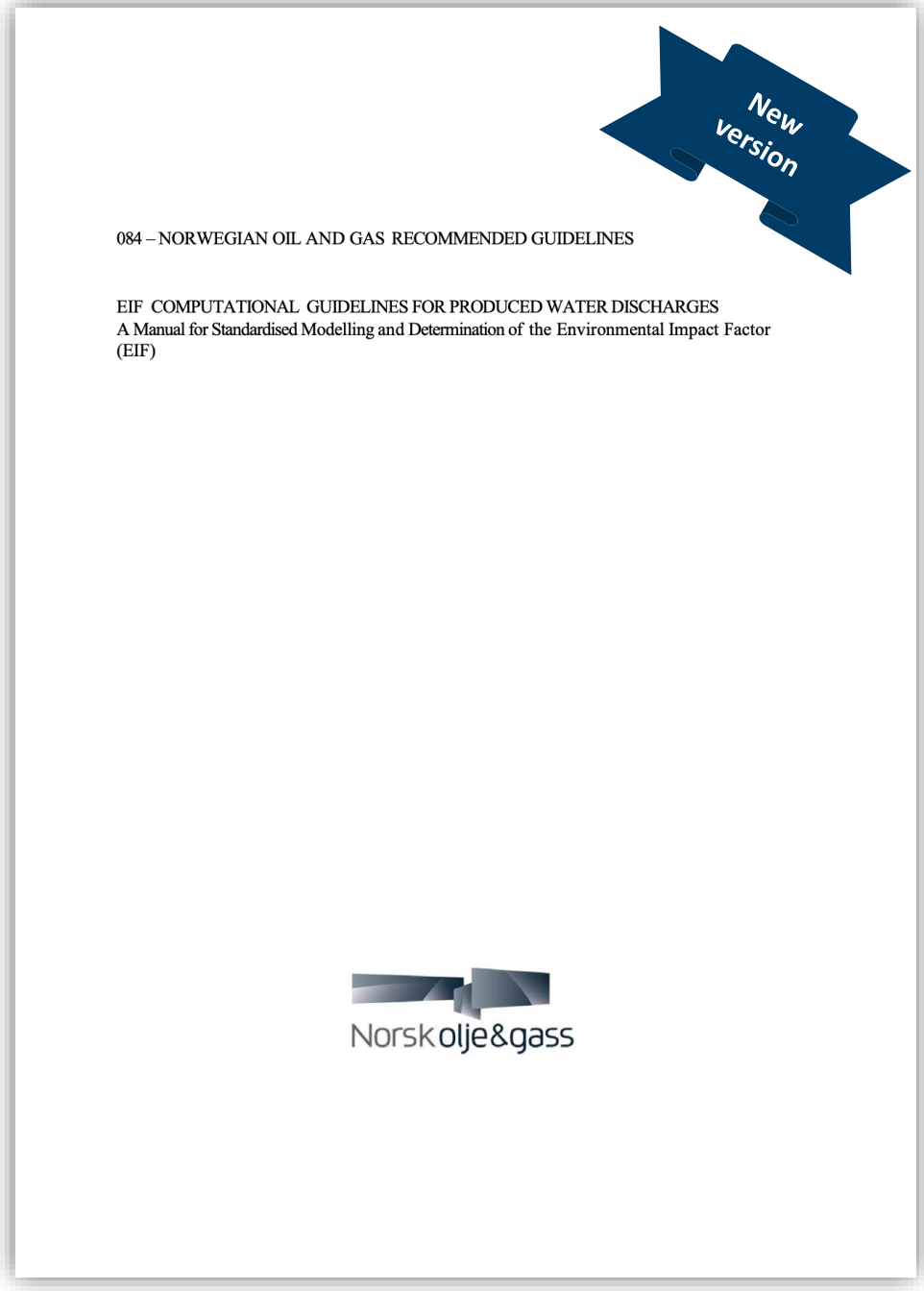
Time-averaged EIF

$$EIF = \frac{1}{T}\int_0^T EIF(t)$$



EIF Guideline

- Praktisk guide til *standardiserte* EIF simuleringer med DREAM
- Første utgave i 2003 – moden for oppdatering
- Flere endringer i EIF metodikk i senere tid
- Ny versjon med oppdatert tilnærming fra 2022



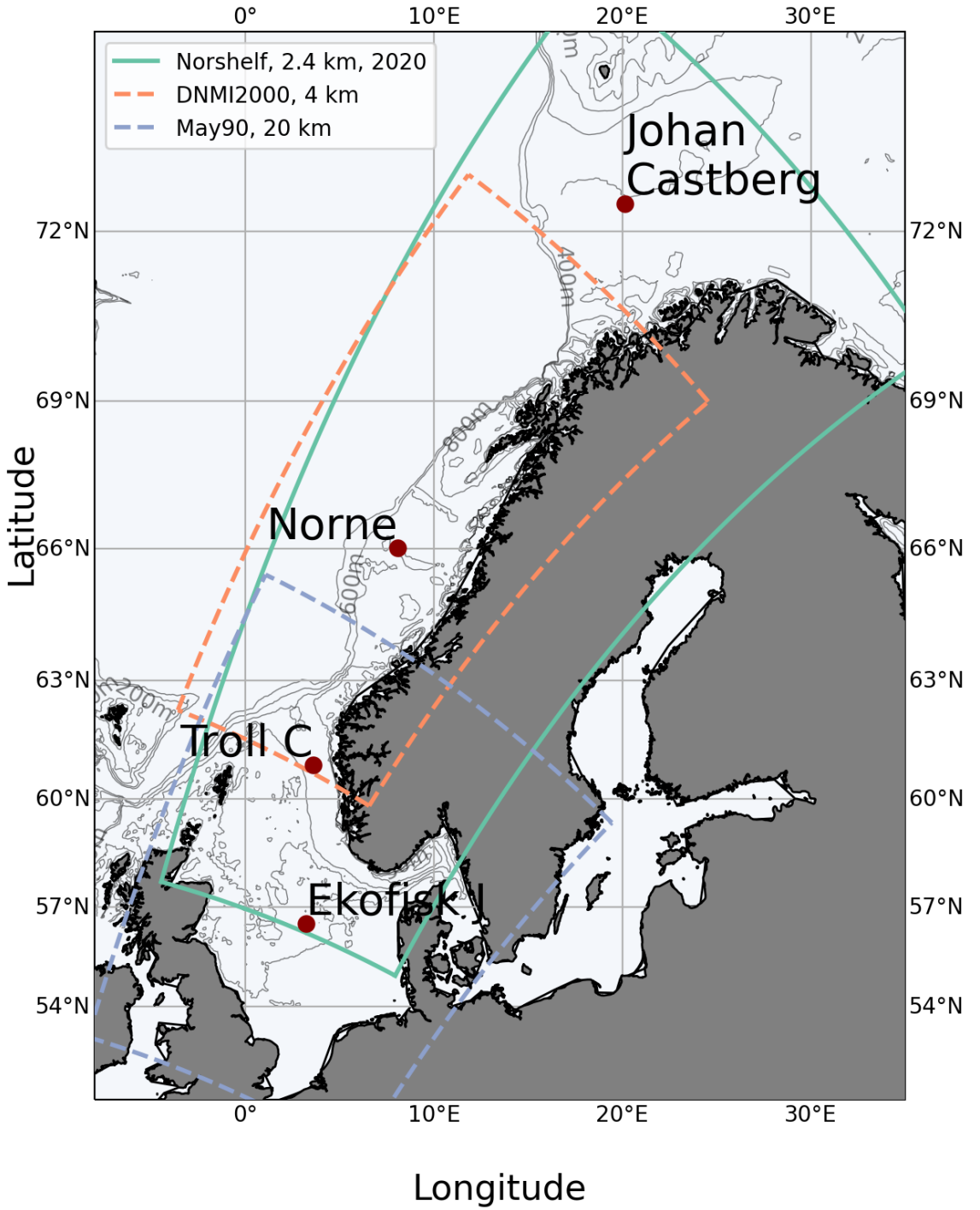
Endringer siden forrige guideline

- Utvidelse av antall naturlige komponenter (14 -> 35)
- Oppdatert OSPAR PNEC verdier
- Oppdaterte biodegraderingsrater (og andre fysiske kjemiske parametere)
- EIF metodikken endret: vektingsfaktorer fjernet på P & B kjemikalier og time-average EIF rapportert
- Nye og mer høyoppløselige strømdata (NorShelf)

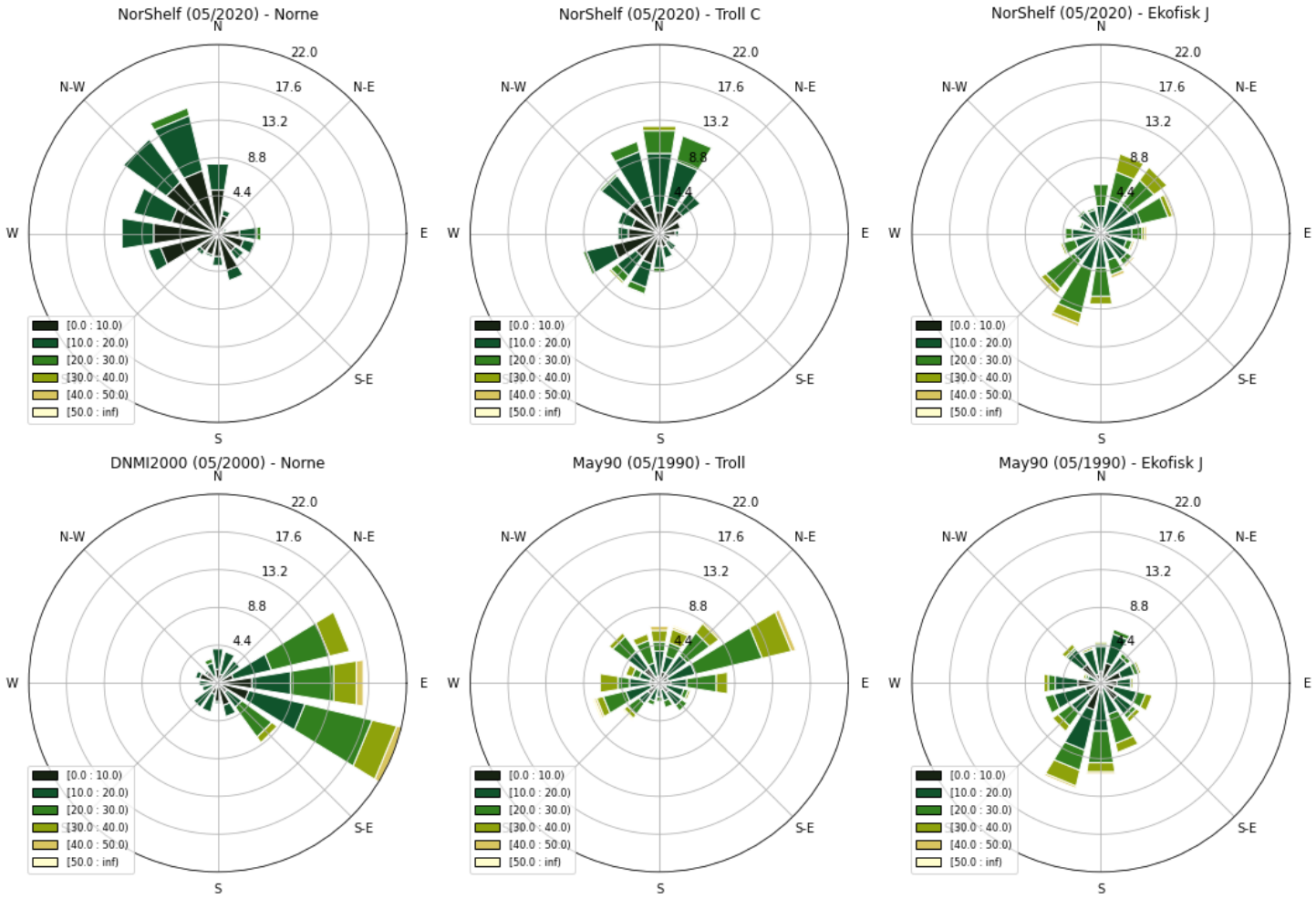
Nye strømmodelldata

Bedre oppløsning og enhetlig dekning

- Nåværende EIF-beregninger bruker nokså grovoppløst modellstrøm
  - Dekker også for perioder noe tilbake i tid (Mai 1990 og Mai 2000)
- Operasjonelle modeller fra met.no tilbyr bedre oppløsning for senere år
- NorShelf 2.4
  - Dekker hele sokkelen inkludert Barentshavet
  - 2.4 km horisontal oppløsning
  - Dataassimilering
- Ny foreslått standardmåned: Mai 2020



Sammenligning strøm



Revised EIF method -> different results

- When changing the EIF method (e.g. updated PNECs, new current dataset), the calculated values for the EIF must be expected to change
- Hence, the EIF values under the revised approach cannot be directly compared with previously calculated values
- A new baseline can be established by calculating the EIF with both methods for the same (discharge) year

Summary

- EIF – a successful environmental risk management tool used for two decades on the NCS
- Method have been revised since it was launched 20(+) years ago
- Updated “EIF Guideline” being launched soon, in use from 2022
- When EIF method is changed, values can no longer be directly compared with historical values
  - Run old and new method for same year to establish new baseline

SINTEF

Modellering for et bedre samfunn

Some literature

- *Produced Water: Environmental Risks and Advances in Mitigation Technologies* (ISBN: 1461400465), chapter: The DREAM Model and the Environmental Impact Factor: Decision Support for Environmental Risk Management. 2011
- Karman, C. and Reerink, H.G., 1997: *Dynamic Assessment of the Ecological Risk of the Discharge of produced Water from Oil and Gas producing Platforms*. SPE 37905, 1997
- Johnsen, S., T.K. Frost, M. Hjelsvold and T.R. Utvik, 2000: *The Environmental Impact Factor – a proposed tool for produced water impact reduction, management and regulation*. SPE 61178, 2000
- More provided in the EIF Guideline

The EIF pie

- Contribution to risk from each component
  - Integrated over time
  - Integrated over all grid cells (> 5% risk)

$$P_i = \frac{\sum_k \sum_t P_{i,j,k}}{\sum_i P}$$