Regulation of Produced Waters using Risk-Based Approach

FJORDS PROCESSING

Manchester | 2nd – 4th November 2015

Dr Kirit Wadhia | Principal Environmental Consultant

kirit.wadhia@fjordsprocessing.com

Presentation

- Company perspective
- Produced water
- Risk Based Approach (RBA) trial
  - Organisation & implementation
  - Outcome
- OSPAR perspective
- UK RBA Implementation Programme
  - Methodology
  - Assessment
  - Inference

FJORDS PROCESSING

Some key facts

- Global presence in all major oil and gas markets
- 2014 revenues of NOK 2.3 billion
- Formerly known as Aker Process Systems, as part of Aker Solutions
- Now part of Aker group - subsidiary of OSE listed Akastor ASA

620 employees worldwide

FJORDS PROCESSING

Global company with local presence

Staff representatives in

17 countries and **six** continents

FJORDS PROCESSING

Our solutions maximize the production through the entire lifecycle of onshore and offshore installation

Oil Solutions

We offer separation and processing solutions for oil based on a unique combination of extensive field experience, high-end product portfolio and complete package solution.

Gas Solutions

With more than 20 years of operational experience and process expertise, we offer conventional and innovative solutions for separation and processing of high quality gas.

Water Solutions

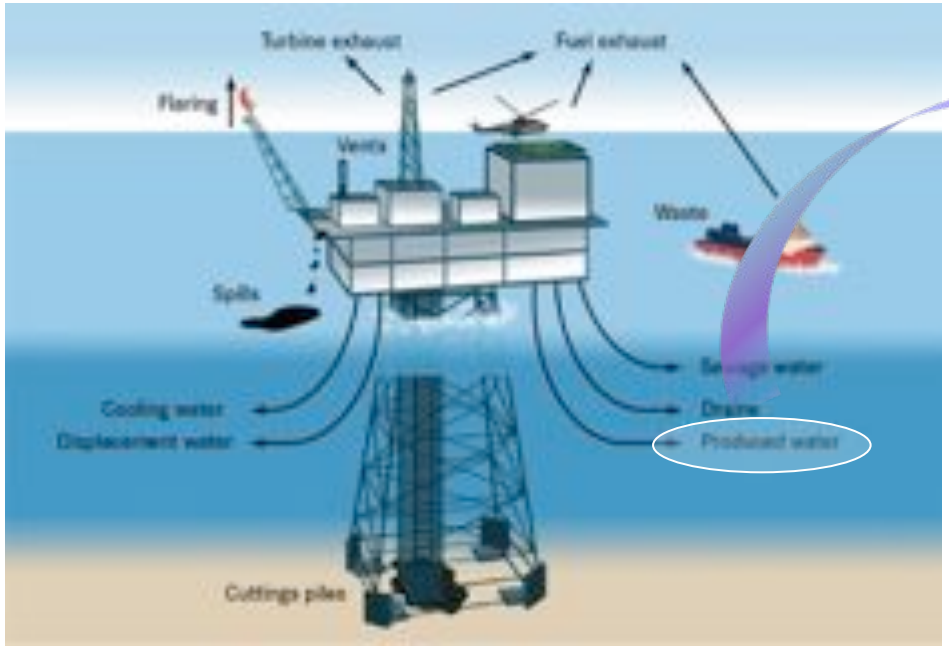
We offer environmental friendly solutions for water treatment, which treats liquids such as produced water, sea water or MEG to remove impurities in order to deliver fluids of required qualities.

Lifecycle Services

We provide full aftermarket services on our installed base, value-adding brownfield solutions from diagnostic studies to full revamp projects, and training services.

FJORDS PROCESSING

Discharges



Produced Water

- Anionic and cationic surfactants
- Emulsifiers/Demulsifiers
- Oxygen scavengers
- Scale inhibitors
- Defoamers
- Biocides
- Corrosion inhibitors

Naturally occurring substances

FJORDS PROCESSING

UK - WEA Testing Evaluation

- Test samples – practicalities
  - collection, shipping & logistics
- Sample stability
- Test sensitivity
- Platform / produced water characteristics – bioassay performance
- Risk based approach - produced water management

Project Organisation

National Coordinator
- Installations - selection
- Co-ordination process
- Assess outcome

WEA Study Contractor
- Offshore WEA Testing
- Onshore WEA Testing
- Data analysis & reporting
- Sample shipment logistics

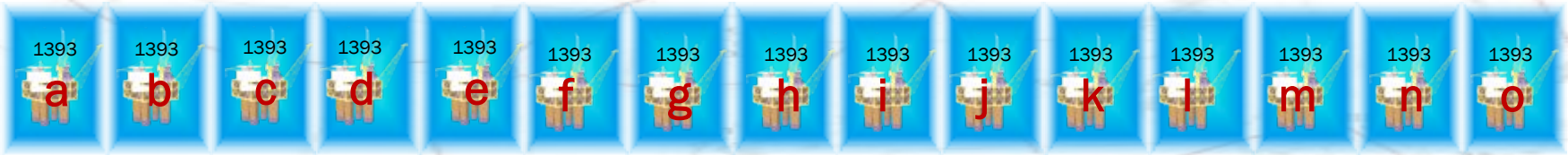
WEA Study Contractor
- Field equipment supply
- MARA/LumiMARA
- Data analysis & reporting
- Manage & Organise

Biannual Testing Laboratories

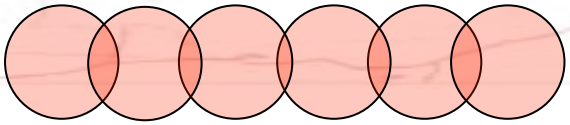
Operators

Installations

- 15 Installations



- Central North Sea (8)
- North North Sea (4)
- South North Sea (1)
- Irish Sea (1)
- West of Shetland (1)



FJORDS PROCESSING

Testing

Biannual sampling – Chemical analyses

Bioassays

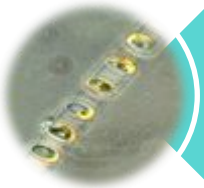
Biodegradation

Zootoxicity

Acartia tonsa

Onshore

Initial | Aged 3 weeks

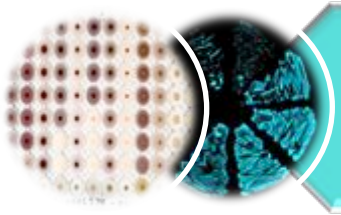


Phytotoxicity

Skeletonema costatum

Onshore

Initial | Aged 3 weeks



Microbial

MARA & LumiMARA

Onshore

Initial | Aged 3 weeks

Offshore

Initial | Aged 3 weeks

FJORDS PROCESSING

Offshore Sampling

MARA & LumiMARA kits

MARA & LumiMARA kits

Samples

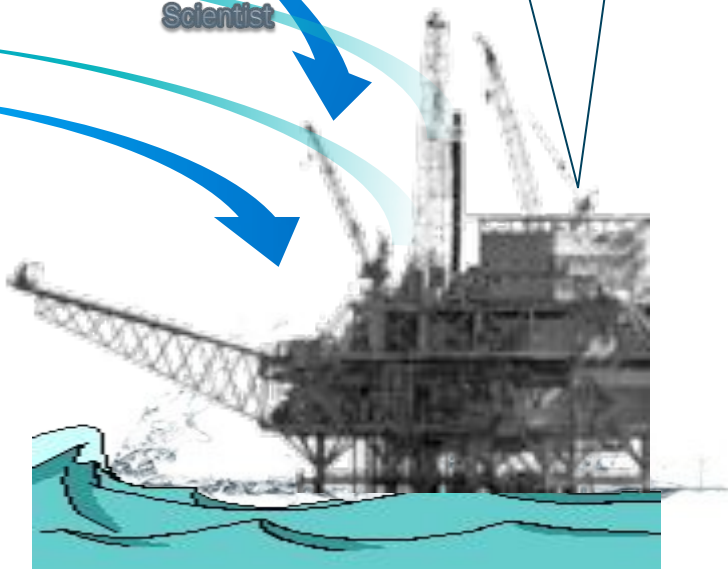
Scientist

[2 nights / 1 day]

On Installation

Sample collection – Chemical Analyses
WEA

MARA & LumiMARA Testing



FJORDS PROCESSING

Assays' Performance & Samples' Stability

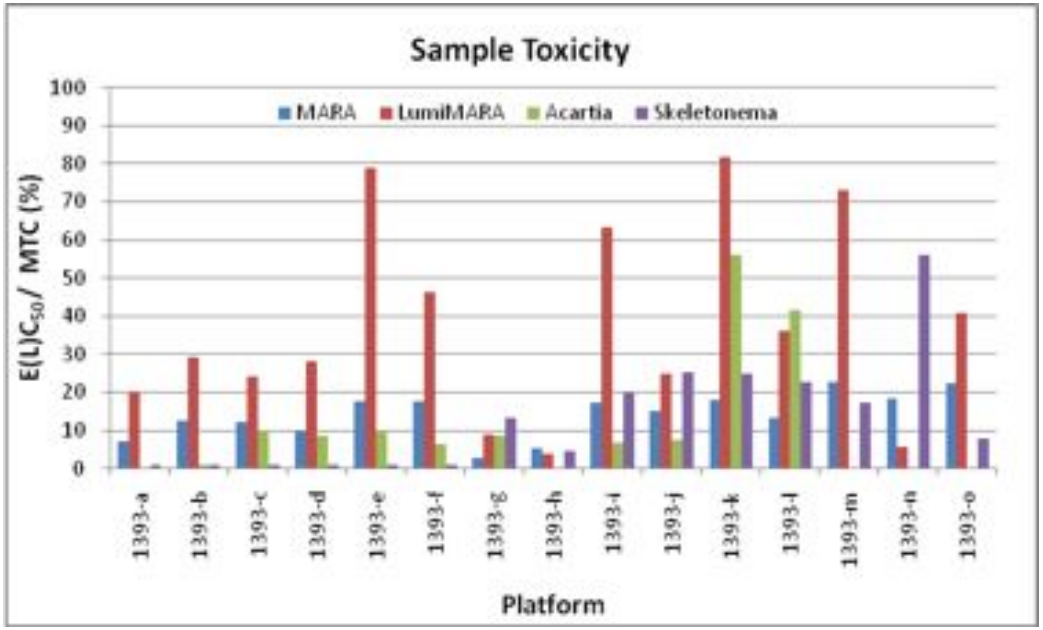
- Offshore vs. onshore testing
  - MARA : 1 platform
  - LumiMARA : 3 platforms

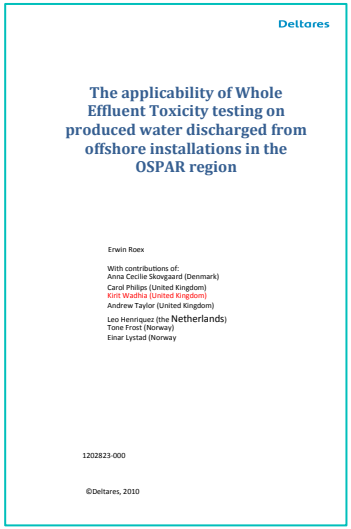
  Significant difference
- Onshore – Initial vs. Aged
  - MARA : 1 platform
  - LumiMARA : 1 platform

  Significant difference
- Acartia and Skeletonema - some variability evident
- **Suggests samples can be collected and sent back onshore as with the chemical biannual sampling programme**

FJORDS PROCESSING

Comparison of Bioassays




Deltares

The applicability of Whole Effluent Toxicity testing on produced water discharged from offshore installations in the OSPAR region

Erwin Roex

With contributions of:
Anna Cecilie Skovgaard (Denmark)
Carol Philps (United Kingdom)
Kirit Wadhia (United Kingdom)
Andrew Taylor (United Kingdom)
Leo Henriquez (the Netherlands)
Tone Frost (Norway)
Einar Lystad (Norway

1202823-000

©Deltares, 2010

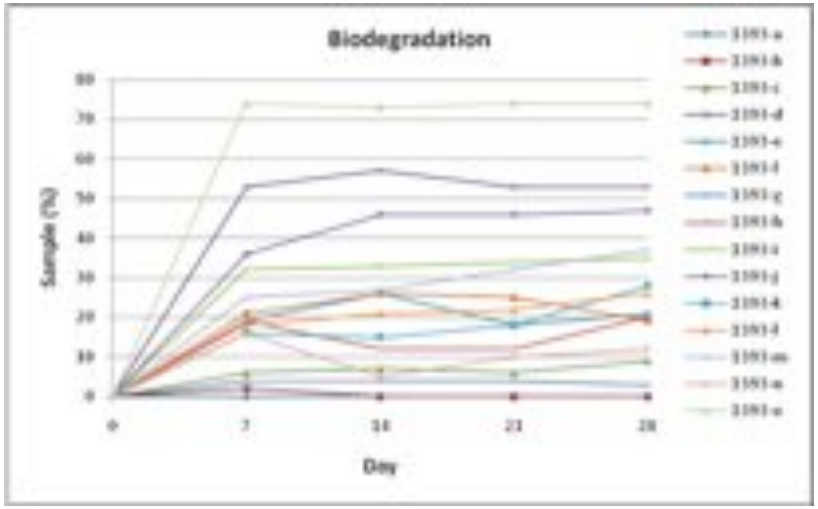
How do the different WEA bioassays compare?

- No single assay was the most sensitive for all 15 platforms
- Also found in the Dutch, Norwegian and Danish studies
- MARA and LumiMARA multispecies tests covered the range of test results for the higher trophic species

FJORDS PROCESSING

Biodegradation

Platform	COD (mgO_2/mg)	Addition Rate (mgCOD/l)	Day 7 (%)	Day 14 (%)	Day 21 (%)	Day 28 (%)
1393-a	0.01880	277	0	0	0	0
1393-b	0.01622	321	2	0	0	0
1393-c	0.00700	743	6	7	6	9
1393-d	0.00118	2203	53	57	53	53
1393-e	0.00022	11800	19	26	18	21
1393-f	0.00042	6190	21	26	25	19
1393-g	0.00048	10950	4	4	4	3
1393-h	0.00183	1424	19	12	12	20
1393-i	0.00017	15300	32	33	34	35
1393-j	0.00080	3250	36	46	46	47
1393-k	0.00070	3720	16	15	18	28
1393-l	0.00063	4160	18	21	22	26
1393-m	0.00104	2500	25	27	32	37
1393-n	0.00044	5900	16	5	10	12
1393-o	0.00215	1210	74	73	74	74



- All platforms showed different biodegradation potential
- Maximum biodegradation was seen by day 14

FJORDS PROCESSING

Comparison of Platforms

- Gas platforms
  - highest salinity
  - higher toxicity ranking
- Water cut / Production [Low]; Oil content discharges [High]
  - generally more toxic
- [Early] Production phase
  - higher toxicity with some bioassays
- Location
  - not a factor
- Chemicals use (↓/↑)
  - toxicity correlation ↓
- No biodegradation – [Early] Production phase (Gas/Oil) ; Oil content [High], Water cut [Low], Produced Waters [Complex], Chemicals usage (↑)

FJORDS PROCESSING

Summary

- Samples collection and processing
  - no practical constraints
- Tests
  - Differentiate platforms
  - No single assay most sensitive
  - Other studies similar findings
- MARA and LumiMARA
  - distinct fingerprints
- Salinity
  - factor for bioassays
- Sample ageing
  - relevant but not significant

FJORDS PROCESSING

Conclusions

- Test samples – practicalities
  - collection, shipping & logistics

  Feasible – no major issues
- Sample stability

  Limited evaluation
- Test sensitivity

  Need for >1 test
- Platform / produced water characteristics – bioassay performance

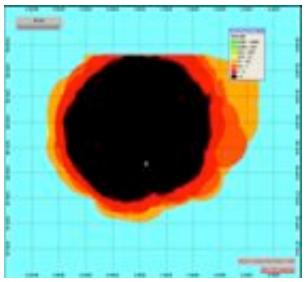
  Able to discriminate
- Risk based approach - produced water management

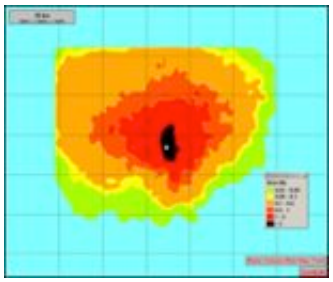
  Assess pros & cons

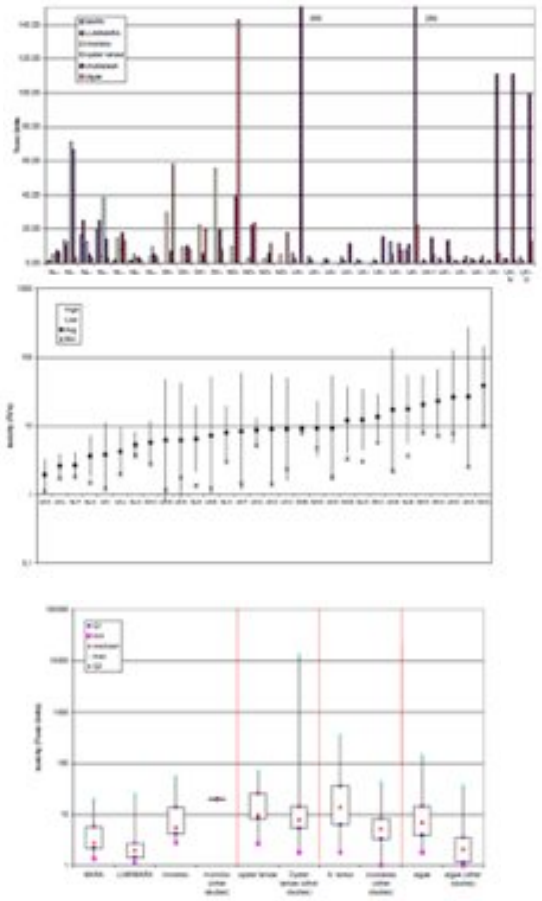
FJORDS PROCESSING

OSPAR Implementation Strategy

- Member states consultations
  - criteria; parameters
- WEA testing
  - 30 Installations – UK, N, NL, DK
- RA Guideline doc (Manual)
- Comparative Study







FJORDS PROCESSING

Risk Based Approach

- 30mg/l oil discharge limit

Produced Water

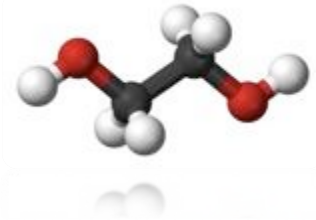
- OSPAR Recommendation 2012/5

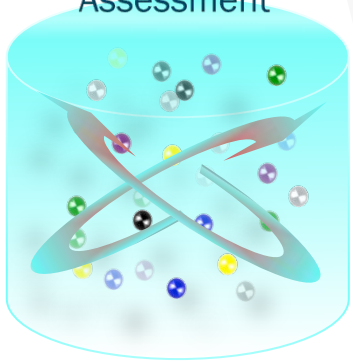
OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Whole Effluent Assessment

- Production chemicals



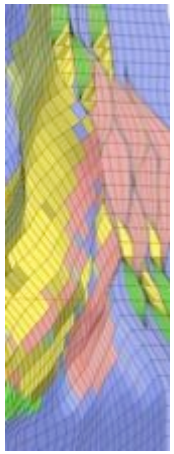


- Naturally occurring substances

FJORDS PROCESSING

Environmental Impact Factor

PEC



Dispersion modelling - DREAM

PNEC

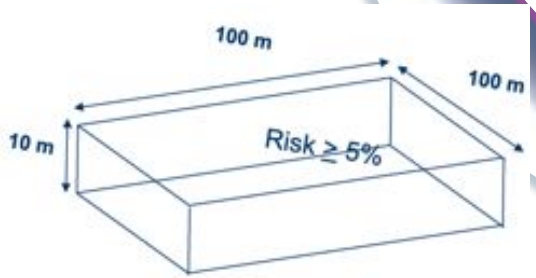
Lab Toxicity Testing

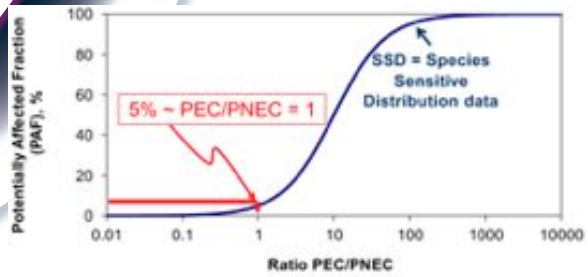
EIF

RBA

PEC : PNEC

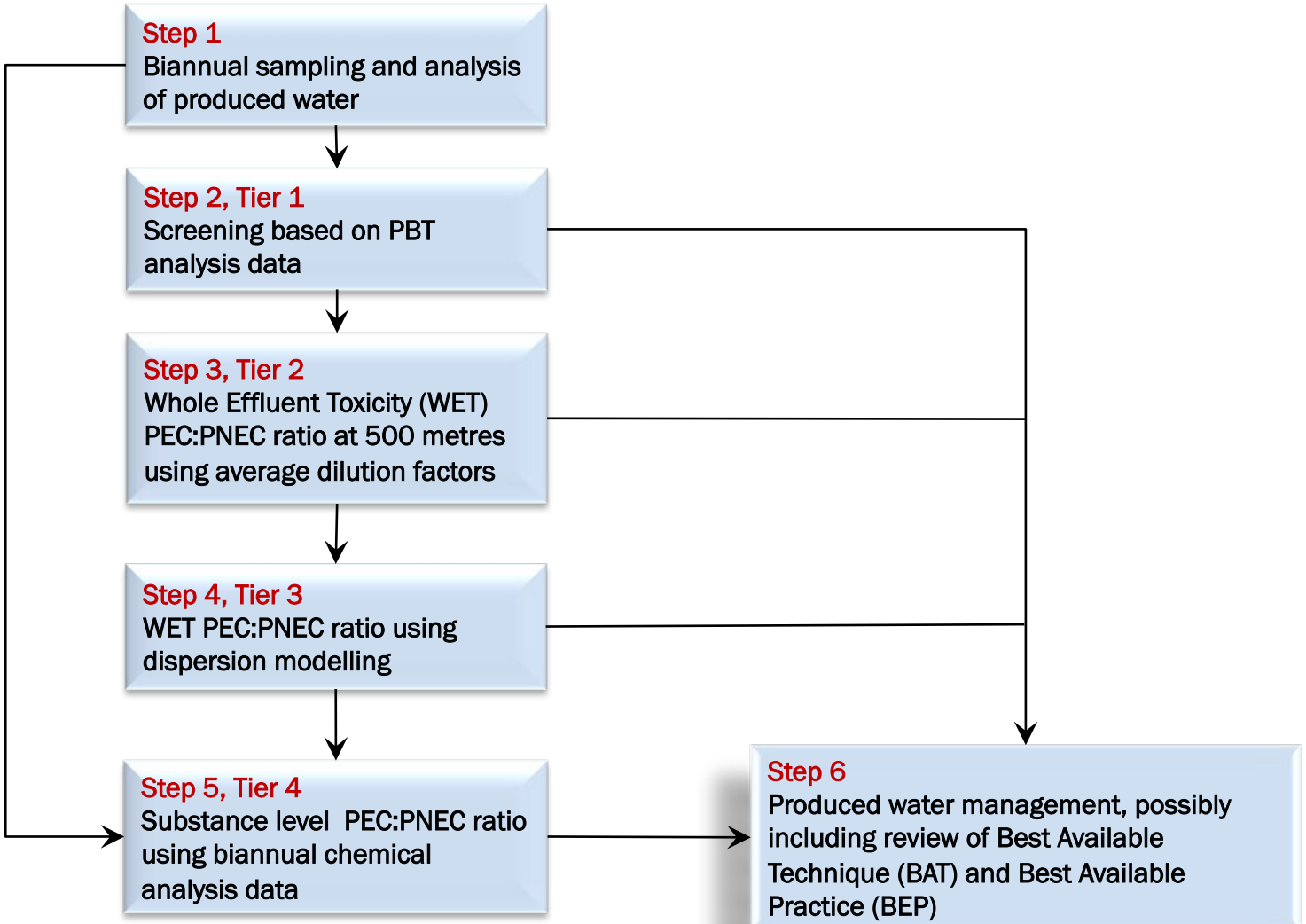
BAT >/1 BEP





FJORDS PROCESSING

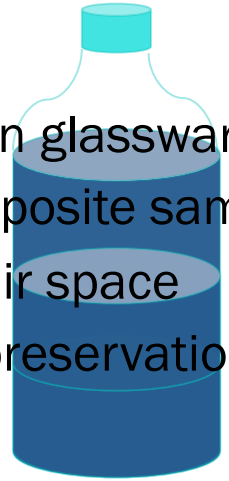
UK Methodology for Risk Based Approach



FJORDS PROCESSING

Opus RBA Assessment - Learning Outcomes

Step 1
Biannual sampling and analysis of produced water



- clean glassware
- composite sample
- no air space
- no preservation / freezing

Salinity

- Bacteria
  MARA & LumiMARA
- Algae
  Skeletonema costatum
- Crustacea
  Acartia tonsa

FJORDS PROCESSING

Opus RBA Assessment - Learning Outcomes

Step 2, Tier 1
Screening based on PBT analysis data

Criterion	PBT criteria	vPvB-criteria
P	Half-life >60 days (d) in marine water or >40 d in freshwater*, or half-life >180 d in marine sediment or >120 d in freshwater sediment*	Half-life >60 d in marine water or freshwater, or >180 d in marine sediment or freshwater sediment
B	Bio-Concentration Factor (BCF) >2,000	BCF >5,000
T	Chronic NOEC <0.01 mg/l or CMR or endocrine disrupting effects	Not applicable
* For the purpose of marine environmental risk assessment, where marine half-life data is available it is used in preference to freshwater data.		

Step 6
Produced water management, possibly including review of Best Available Technique (BAT) and Best Available Practice (BEP)

FJORDS PROCESSING

Opus RBA Assessment - Learning Outcomes

Step 3, Tier 2
Whole Effluent Toxicity (WET)
PEC:PNEC ratio at 500 metres using average dilution factors

Assessment Factor = 1000

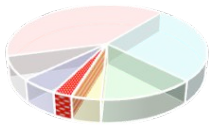
Discharge volume

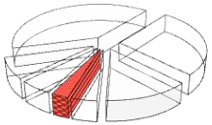
Chronic tests

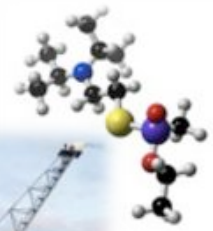
- Bacteria
  - MARA & LumiMARA
- Algae
  - *Skeletonema costatum*
- Crustacea
  - *Acartia tonsa*

FJORDS PROCESSING

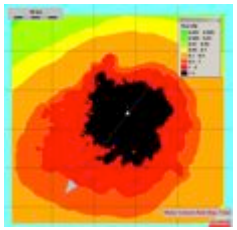
Opus RBA Assessment - Learning Outcomes







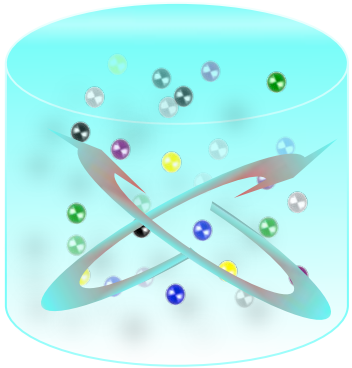
Component with worse Hazard Quotient (HQ) [toxicity] – Greatest impact



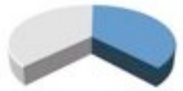
Step 4, Tier 3
WET PEC:PNEC ratio using dispersion modelling

Step 5, Tier 4
Substance level PEC:PNEC ratio using biannual chemical analysis data

Whole Effluent Assessment



Antagonistic

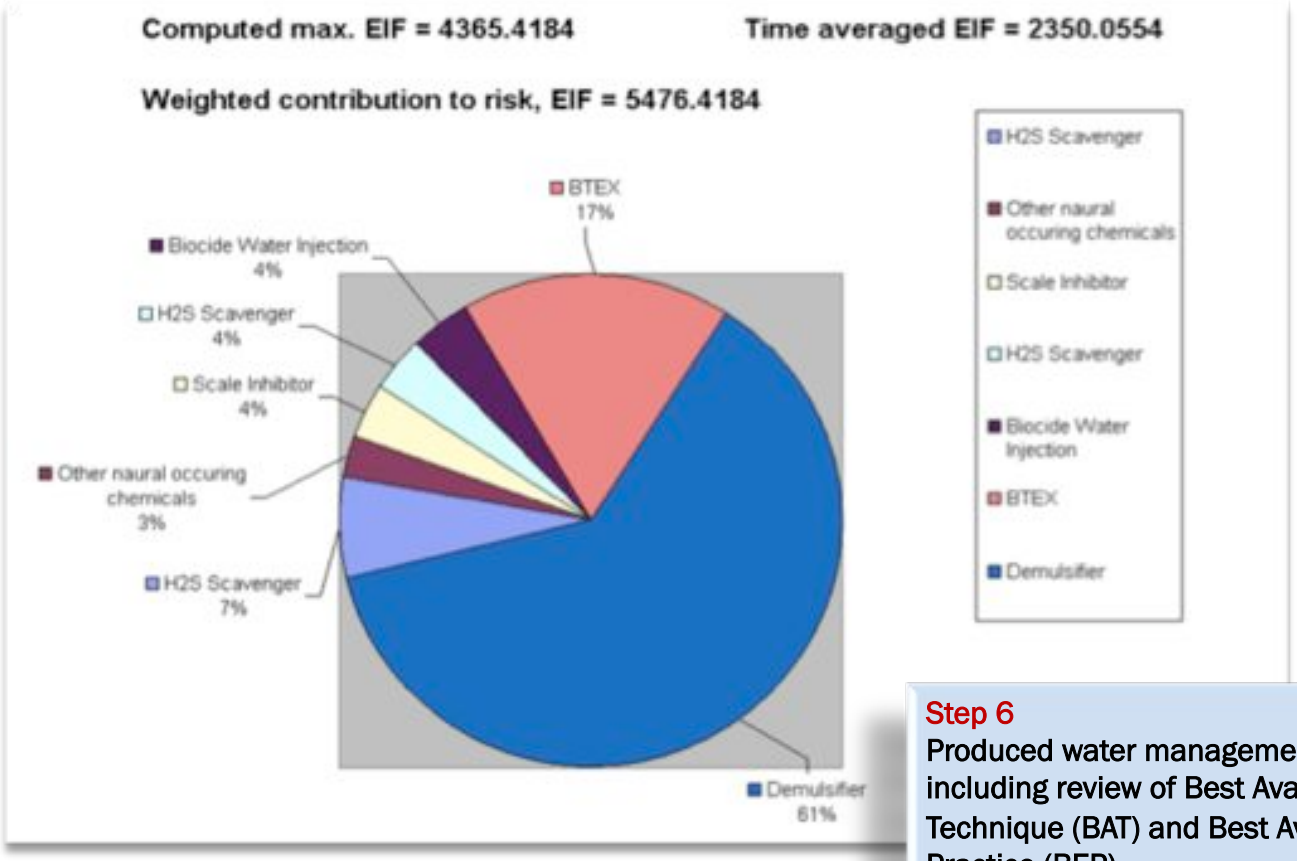


Synergistic

FJORDS PROCESSING

Opus RBA Assessment - Learning Outcomes

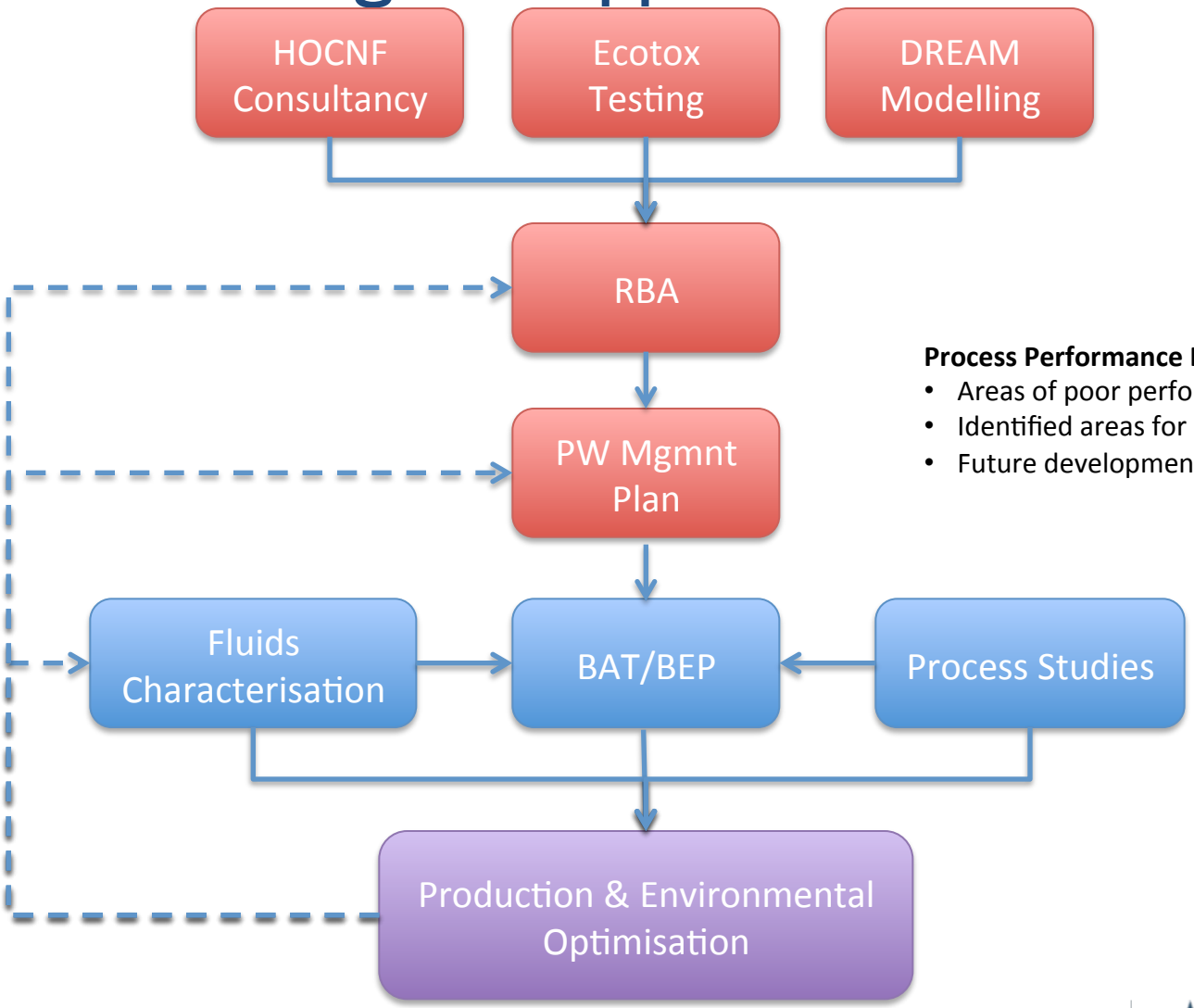
Example of major contributors to EIF presented graphically at product level



Step 6
Produced water management, possibly including review of Best Available Technique (BAT) and Best Available Practice (BEP)

FJORDS PROCESSING

Fjords Processing RBA Approach



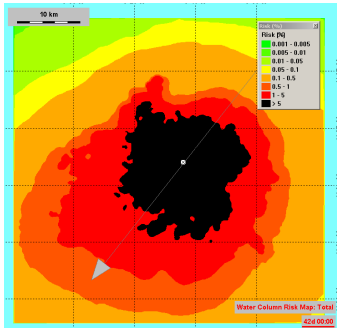
Process Performance Feedback Loop

- Areas of poor performance
- Identified areas for improvement
- Future development plans

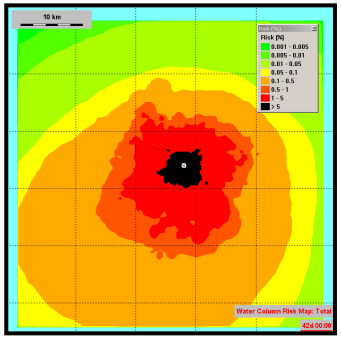
FJORDS PROCESSING

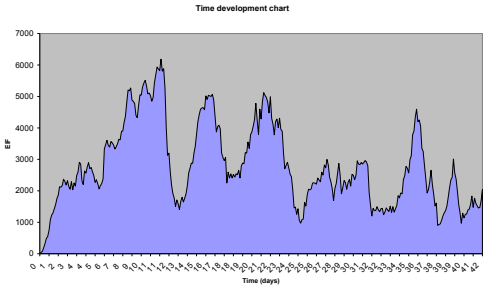
RBA Assessment Case Study – Asset ‘X’

- Maximum risk of whole effluent model

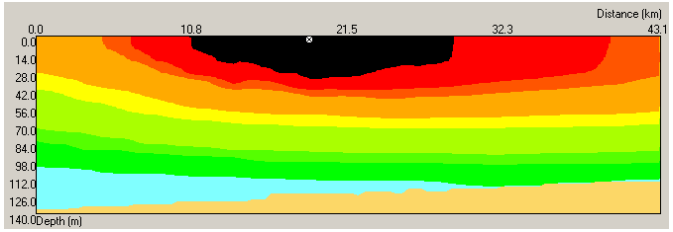


- Whole effluent time averaged risk model (black ≥5% risk)





- Whole effluent time development

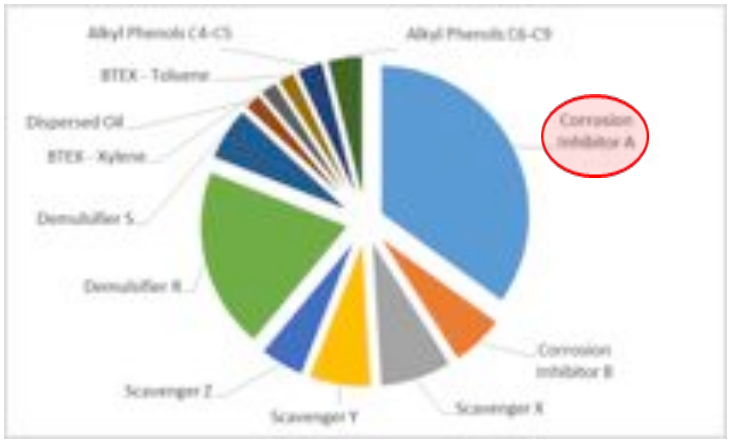


- Transect through whole effluent maximum risk model

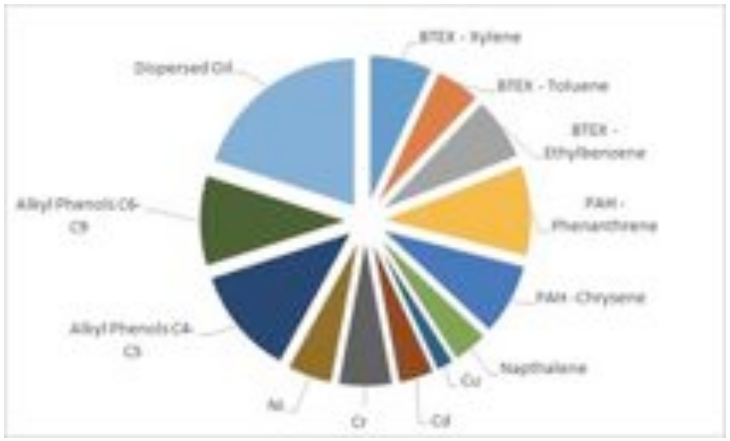
FJORDS PROCESSING

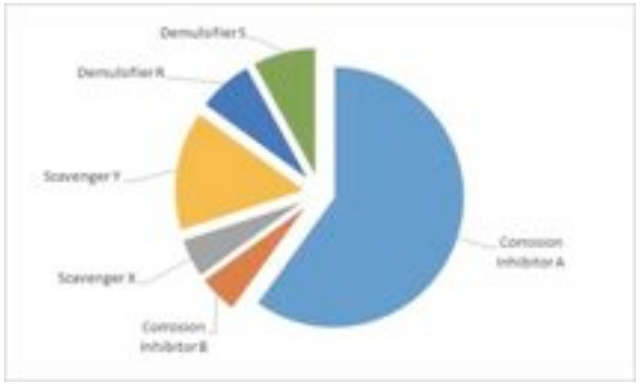
RBA Assessment Case Study – Asset 'X'

- Produced water components contributing to >1% of overall risk

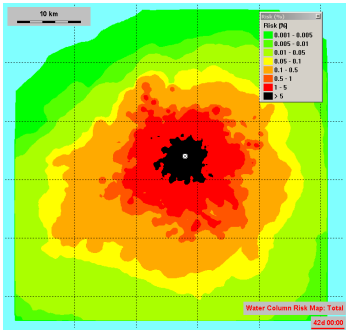


- Model of naturally occurring substances only





- Added chemicals modelled independently



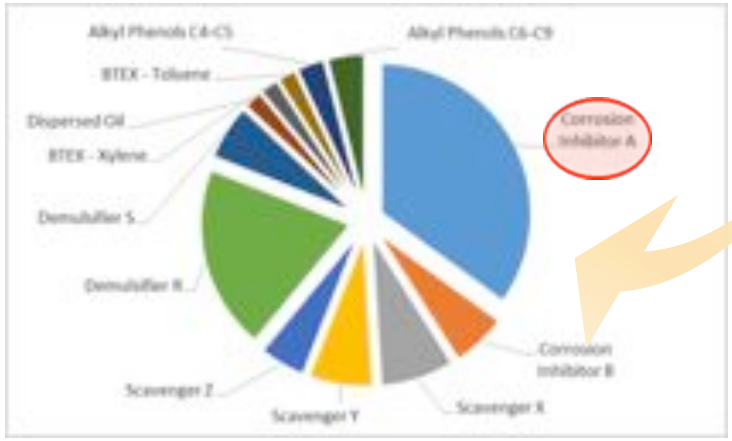
- Time averaged risk model of specific chemical

FJORDS PROCESSING

RBA Assessment Case Study – Asset 'X'

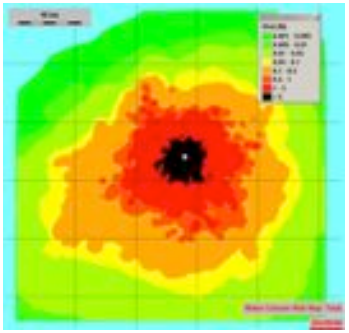
PW

Biannual chemical analysis + WET



Not PBT

Modelling at chemical level



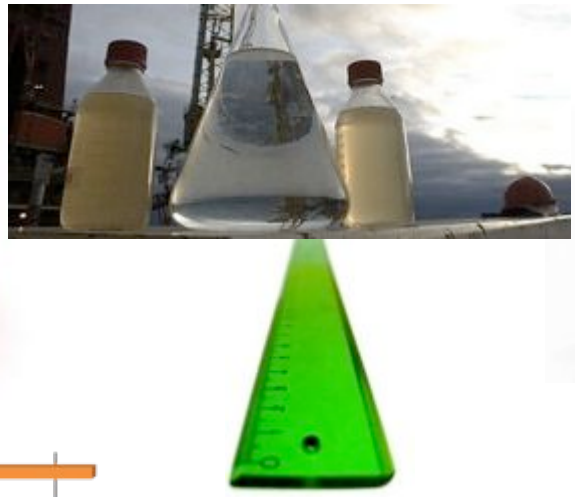
EIF > 1

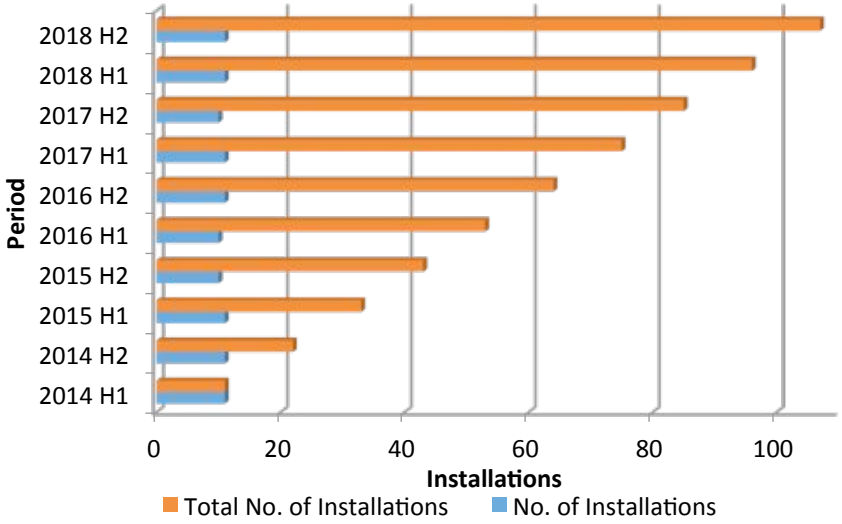
BAT / BEP

FJORDS PROCESSING

OSPAR RBA Perspective

- By 2020 all offshore installations PW assessment to determine risk





UK Risk Based Approach Implementation Programme

FJORDS PROCESSING