Offshore Water Toxicity Management

DTU Offshore Technology Conference 2022

Agenda – Offshore Water Toxicity Management

Hosts: Simon Ivar Andersen and Charlotte Lassen, Danish Offshore Technology Center

10:00 **Welcome / setting the scene**

10:05 **Where is legislation to protect the marine environment heading?**
Mathijs Smit, Shell Global Solutions

How toxic is toxic?

10:30 **- (I) Toxic components in discharged water**
Karen Louise Feilberg, Danish Offshore Technology Center

10:50 **- (II) Intelligent Testing Strategy**
Lars Michael Skjolding, DTU Sustain

11:10 **- (III) Marine biodegradation of discharged chemical components**
Philipp Mayer and Mette T. Møller, DTU Sustain

11:30 **Enabling PW reinjection in chalk**
Benjamin Lorenzen, IKM Ocean Team
Hamid Nick, Danish Offshore Technology Center

Topics

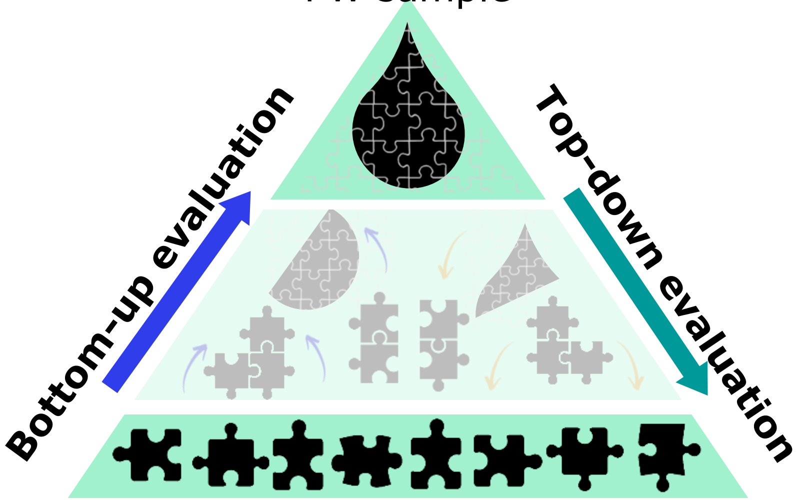
Legislation

§ Compliance §

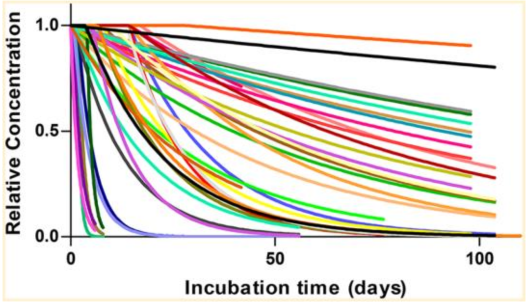
???

Assessing Environmental Impact
Proposing solutions

PW sample

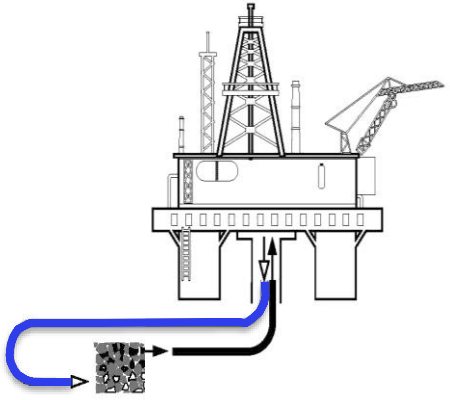


Individual PW constituents



Action

One possible solution



Produced water RI

Where is legislation to protect the marine environment heading?

Mathijs Smit, Shell Global Solutions

Management of offshore discharges and chemicals use

Where is legislation to protect the marine environment heading?

Mathijs Smit – Shell Global Solutions / IOGP

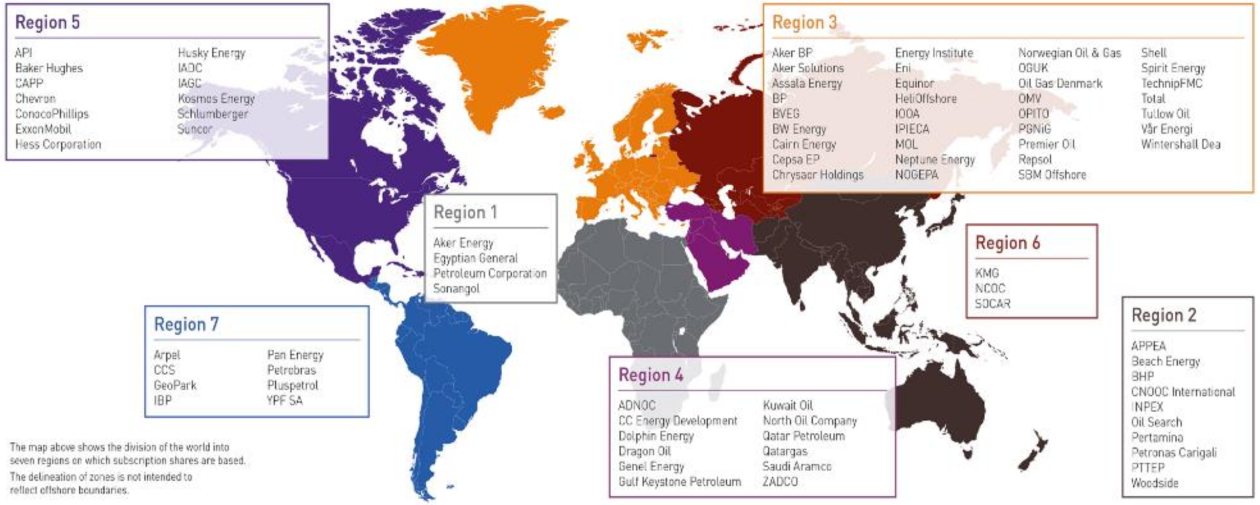
Content

- Introduction to IOGP
- Global regulatory concepts for marine discharges
- Risk-based assessment (RBA) approaches
- Developments in the OSPAR region
- Energy Transition and Water Stewardship

International Association of Oil & Gas Producers

Introduction to IOGP

- The International Association of Oil & Gas Producers (IOGP) is the principal safety and sustainability association for the global upstream industry
- IOGP's 80+ Members produce 40% of the world's oil and gas
- IOGP brings together members to identify and share knowledge and good practices in health, safety, the environment, security and social responsibility



International Association of Oil & Gas Producers

IOGP Environment Committee

- One of the founding Standing Committees in IOGP
  - Develop and promote good environmental practice
  - Sponsor and undertake scientific research to develop appropriate risk management approaches
  - Proactively develop and advocate the industry’s position in response to changing regulations
- Focus areas: environmental performance reporting, underwater sound, biodiversity and ecosystem services, regional policy, methane, energy efficiency, produced water, environmental monitoring

Report 629: Environmental sampling and monitoring from airborne and satellite remote sensing

Report 633: Risk Based Assessment of Offshore Produced Water Discharges

Report 254: Environmental Management in the Upstream Oil and Gas Industry

Report 630: Comparison of Methane Reporting Requirements

Report 601R: Microplastics in the Upstream Oil & Gas Industry.

Report 602: Environmental effects and regulation of offshore drill cuttings discharges

International Association of Oil & Gas Producers

Historical Development of Global Offshore PW Management

Blue Water 1 (1962)

Oil & Grease identified as an important indicator for discharge monitoring

PARCOM set OiW limit of 40 mg/L (1978)

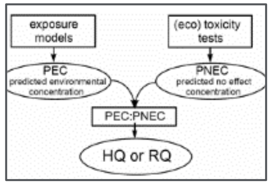
1st US Oil and Gas Extraction Effluent Guidelines and Standards Oil and grease limits of 48 and 72 mg/L (1979)

Implementation of PARCOM limit of 40 mg/L (1988)

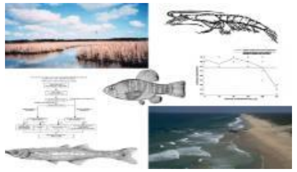
OSPAR COMMISSION

Established (1992)

Oil and grease limits of 29 mg/L and 42 mg/L, BAT & BPT (1993)



CHARM and HMCS (1996)

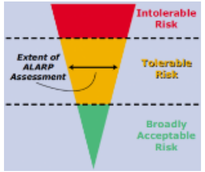


NPDES WET testing & Sheen monitoring

Norway zero harmful discharges (2000)

EGASPIN Nigeria ODZ (2002)

OSPAR OiW revised to 30 mg/l (2001) to be achieved by 2007 & 15% reduction of total oil



Australia ALARP (2009)

OSPAR RBA approach (2012)

EU - BAT guidance document (2019)

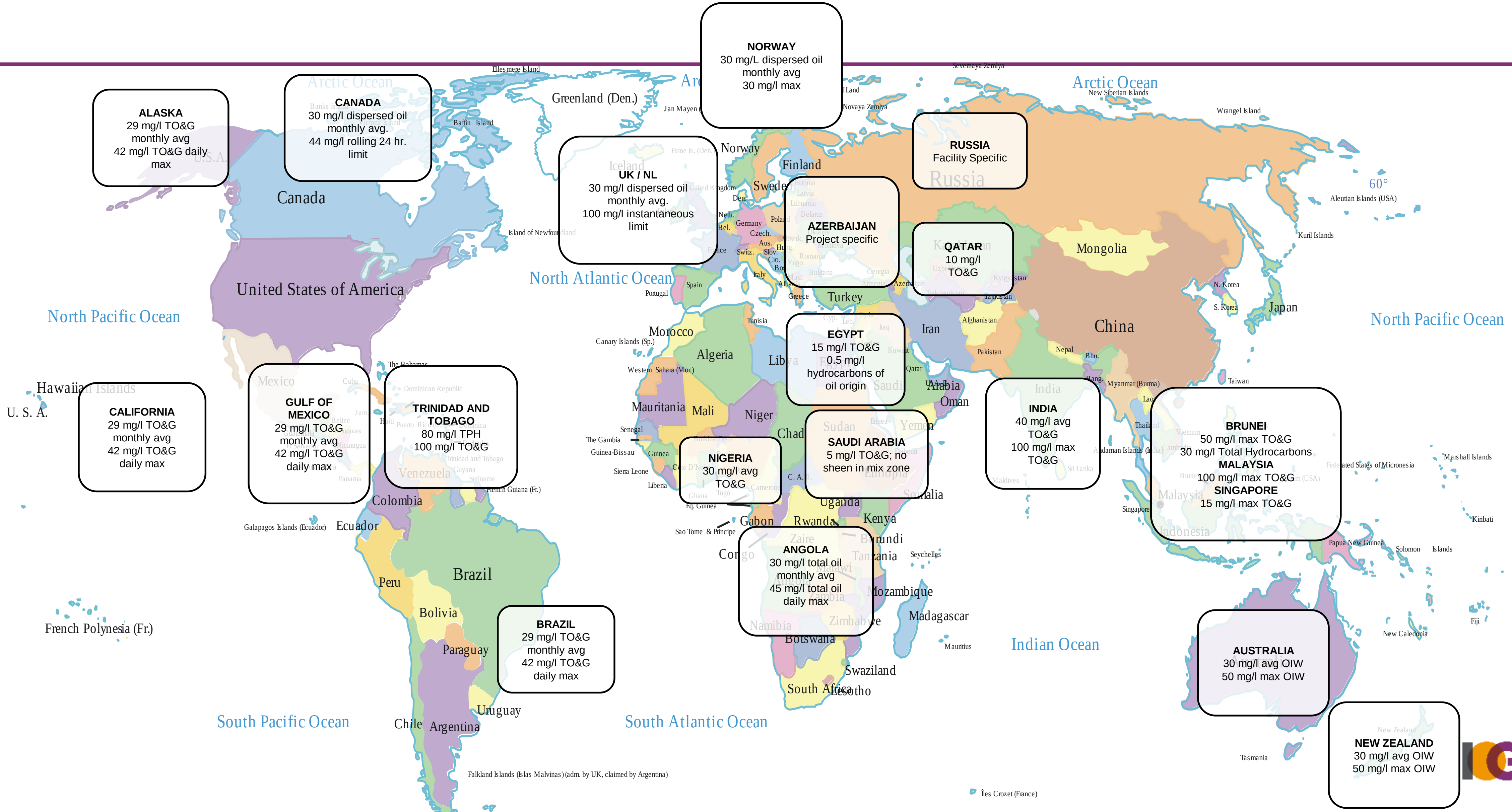
1970s 1980s 1990s 2000s 2010s

Technology driven end-of-pipe standards

Risk and impact driven standards

International Association of Oil & Gas Producers

Global overview of OIW Levels for offshore PW management



End-of-pipe limit values

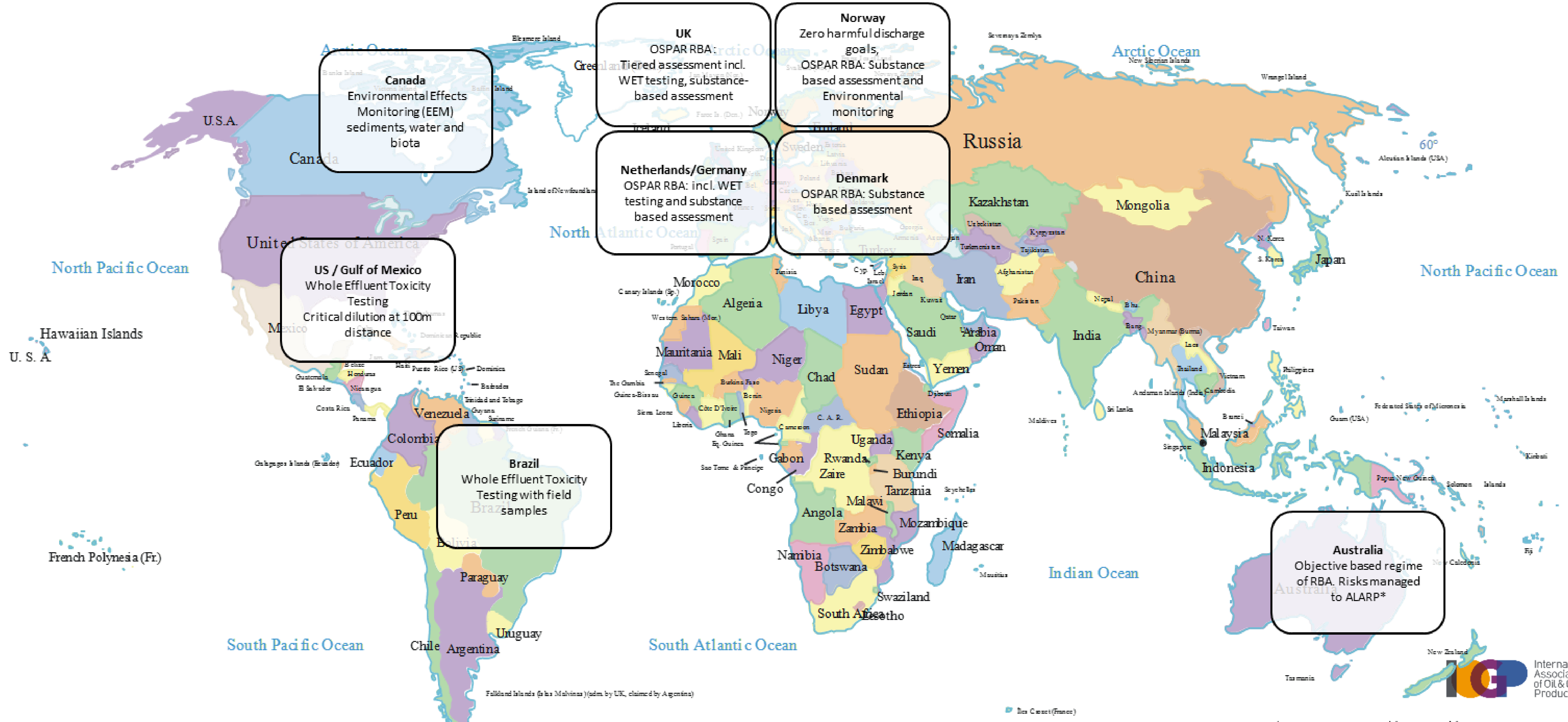
Límites permisibles Descarga a Cuerpo Receptor (mg/L)		
Parámetros	Agua dulce, incluyendo humedales	Aguas costeras y estuarios
Hidrocarburos Totales del Petróleo	10	10
Sólidos Disueltos Totales	500	32,000
Fenol	0.1	0.06
Sulfuro de hidrógeno	0.002	0.002
Hierro	1	0.05
Etilbenceno	0.1	0.5
Benceno	0.05	0.005
Tolueno	0.2	0.06
Hidrocarburos Aromáticos Policíclicos	-	0.1
Aluminio	0.05	0.2
Bario	0.01	0.5
Boro	-	0.009
Cloruros	250	-
Cromo	0.05	0.01
Manganeso	-	0.02
Acenafteno	0.02	0.01
Vanadio	0.5	0.5
Conductividad Específica, S/m	0.75	0.75

Mexico NOM-001-SEMARNAT

Permissible Levels					
	Water Pollutants	Receiving Environment			
No.	Parameters or Substances	Inland Surface Water	Coastal Nearshore	Marine Offshore	Environmentally Sensitive Areas and/or Groundwate
		Levels or Conditions			
1.	Temperature	35	40	45	NIAA
2.	Dissolved Oxygen	<4	<4	<4	<4
3.	Hydrogenion (pH)	6-9	6-9	6-9	6-9
4.	Five day Biological Oxygen Demand (BOD_5 at 20°C)	30	50	100	10
5.	Chemical Oxygen Demand (COD)	250	250	250	60
6.	Total Suspended Solids (TSS)	50	150	200	15
7.	Total Oil and Grease (TO&G) or n-Hexane Extractable\ Material (HEM)	10	15	100	No release
8.	Ammoniacal Nitrogen (as NH_3-N)	10	10	10	0.1
9.	Total Phosphorus (as P)	5	5	5	0.1
10.	Sulphide (as H_2S)	1	1	1	0.2
11.	Chloride (as Cl^-)	250	NIAA	NIAA	NIAA
12.	Total Residual Chlorine (as Cl_2)	1	1	2	0.2
13.	Dissolved Hexavalent Chromium (Cr^{6+})	0.1	0.1	0.1	0.01
14.	Total Chromium (Cr)	0.5	0.5	0.5	0.1
15.	Dissolved Iron (Fe)	3.5	3.5	3.5	1.0
16.	Total Petroleum Hydrocarbons (TPH)	25	40	80	No release
17.	Total Nickel (Ni)	0.5	0.5	0.5	0.5
18.	Total Copper (Cu)	0.5	0.5	0.5	0.01
19.	Total Zinc (Zn)	2	2	2	0.1
20.	Total Arsenic (As)	0.1	0.1	0.1	0.01
21.	Total Cadmium (Cd)	0.1	0.1	0.1	0.01
22.	Total Mercury (Hg)	0.01	0.01	0.01	0.005
23.	Total Lead (Pb)	0.1	0.1	0.1	0.05

Trinidad and Tobago Water Pollution Rules

Global Risk-based Approaches



* As Low As Reasonably Practicable

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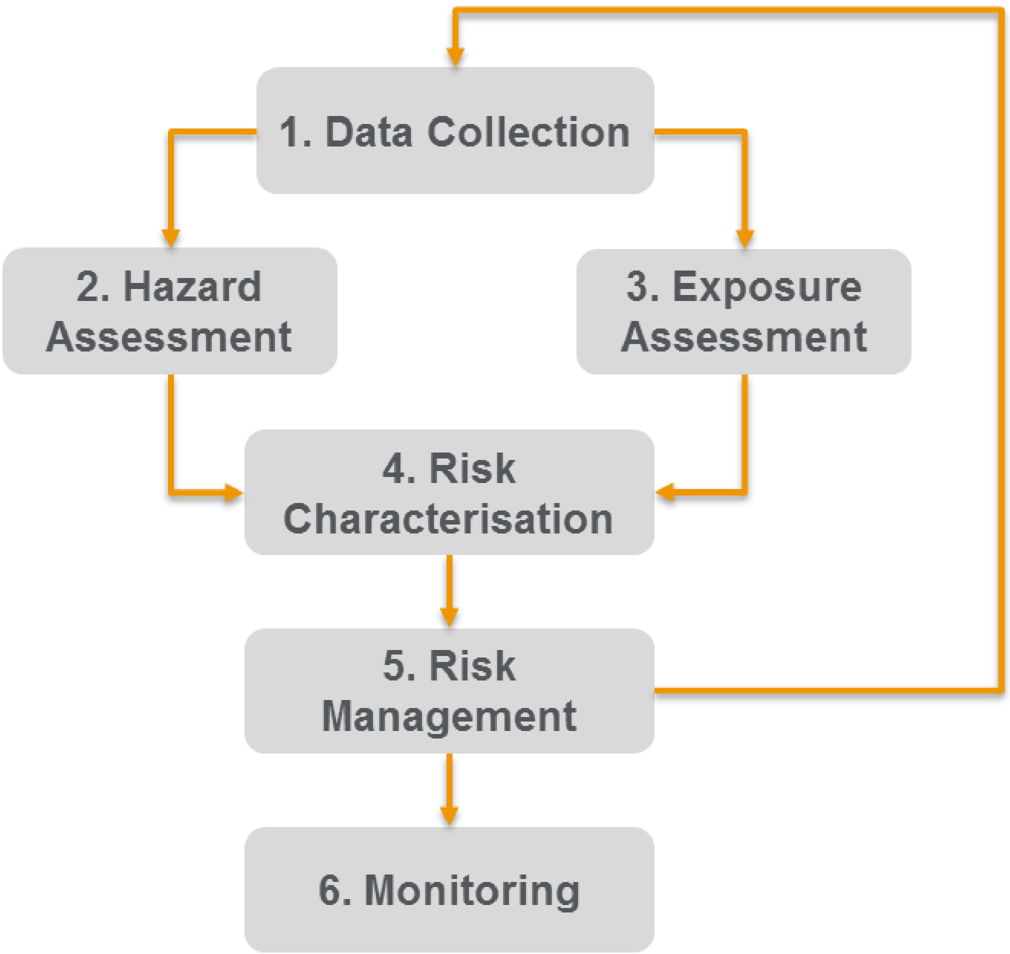
Why considering risk-based approaches?

- Increased effectiveness in assessing and reduction of potential environmental harm
- Not prescriptive: Absence of generic end-of-pipe limits for individual produced water components (although often used in combination with oil in water standards)
- Flexibility to evaluate site-specific discharges on a case-by-case basis using location specific inputs
- Efforts are scalable to situation; more severe or relaxed as required
- Provides priority of actions
- Accounts for uncertainties
- Can be executed in all phases of development from concept to operations (model based)

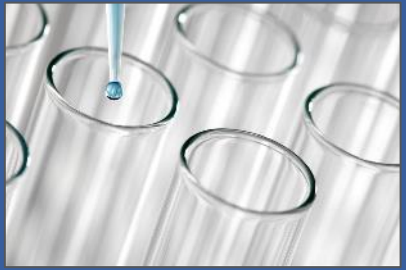
Risk-Based Approach Framework

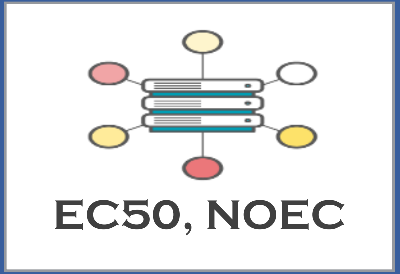


(USEPA 1993, EU-TGD 1996)

Assessment of (No) Effect Thresholds

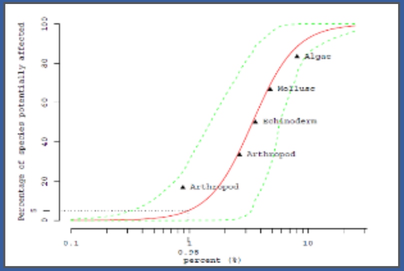
Substance Based Approach





- Chemical characterization of PW
- Combines chemical analysis and models
- Compare individual concentrations (after dilution) with established thresholds

Whole Effluent Approach

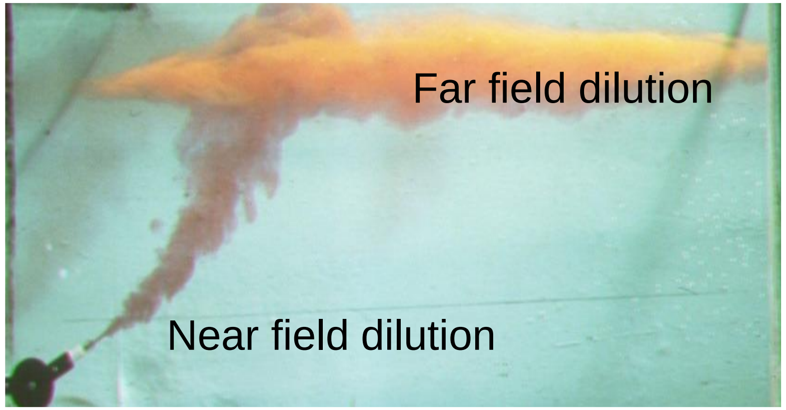


- Determine toxicity of the whole effluent
- Establish (critical) dilution required to reach safe levels
- Compare required dilution with actual dilution

Assessment of Exposure

Screening Tiers

Higher Tiers



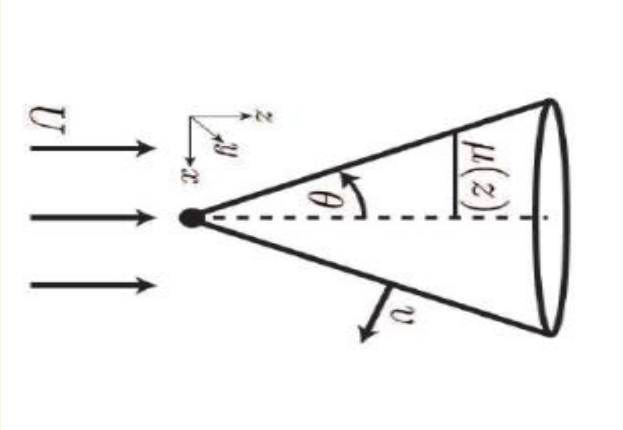
Lookup tables (e.g. NPDES)

Table 1: Produced Water Critical Dilutions

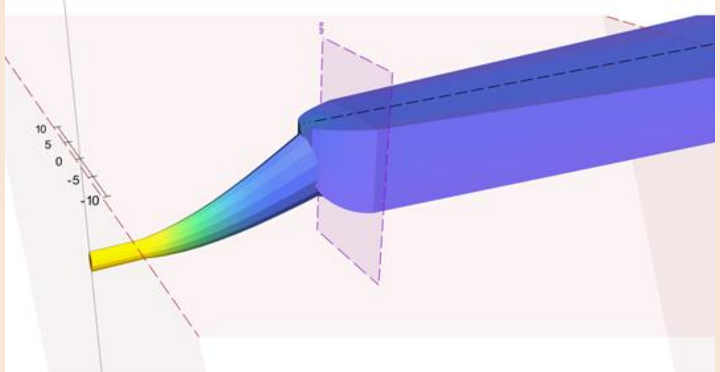
Table 1-A: Critical Dilution (Percent Effluent) for Discharges with a Depth Difference Between the Discharge Pipe and the Sea Floor of Greater than 0 Meters to 4 Meters

Discharge Rate	Pipe Diameter (inches)					
(bbl/day)	>0" to 5"	>5" to 7"	>7" to 9"	>9" to 11"	>11" to 15"	>15"
0 to 500	0.07	0.20	0.16	0.13	0.10	0.08
501 to 1000	0.16	0.39	0.32	0.26	0.20	0.16
1001 to 2000	0.35	0.35	0.63	0.56	0.40	0.31
2001 to 3000	0.55	0.54	0.94	0.79	0.60	0.47
3001 to 4000	0.89	0.85	0.85	0.85	0.85	0.85
4001 to 5000	1.14	1.09	1.08	1.08	1.08	1.08
5001 to 6000	1.40	1.35	1.30	1.31	1.31	1.31
6001 to 7000	1.66	1.59	1.51	1.53	1.53	1.54
7001 to 8000	1.90	1.83	1.75	1.74	1.73	1.73
8001 to 9000	2.13	2.07	2.00	1.94	1.93	1.94
9001 to 10,000	2.38	2.30	2.21	2.13	2.13	2.14
10,001 to 15,000	3.15	3.39	3.28	3.18	3.04	3.04
15,001 to 20,000	4.34	4.39	4.25	4.15	3.83	3.92
20,001 to 25,000	5.14	5.43	5.20	5.17	4.77	4.46
25,001 to 35,000	6.36	7.18	7.18	6.86	6.56	5.96
35,001 to 50,000	7.29	8.91	9.44	9.20	8.62	8.03
50,001 to 75,000	8.33	10.52	11.72	12.22	11.34	10.90

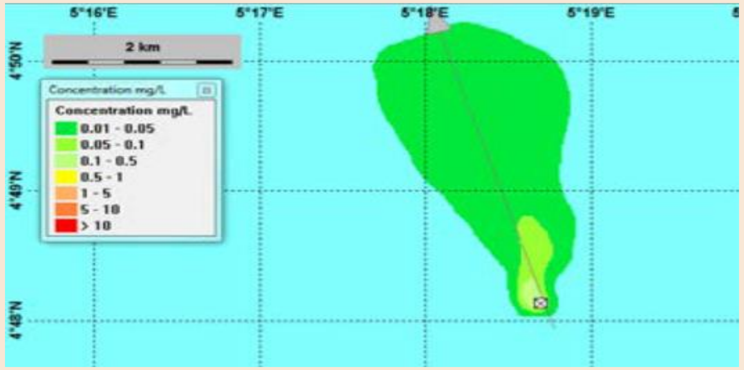
Analytical model (2D steady-state)



e.g. CORMIX (3D steady-state)



e.g. DREAM, MIKE (3D – time variable)



Case 1

Whole Effluent Approach US – Gulf of Mexico

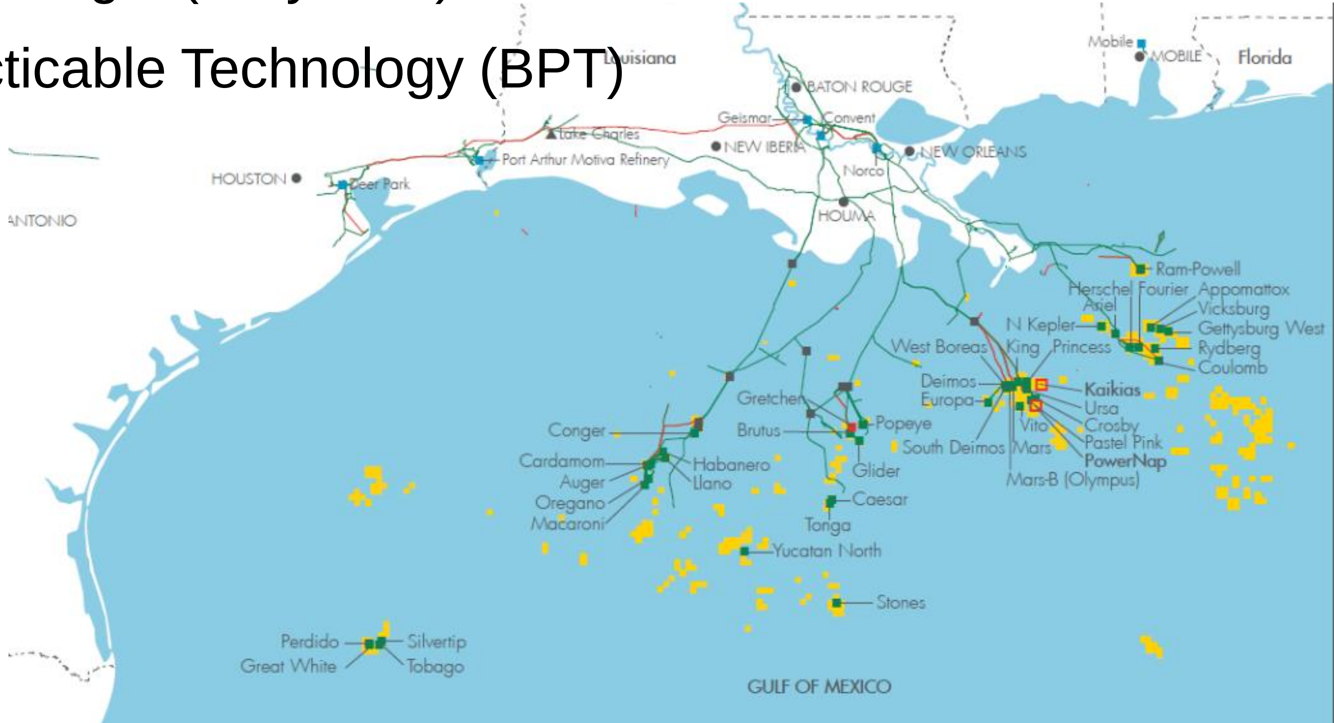
1

Produced Water Management - Gulf of Mexico

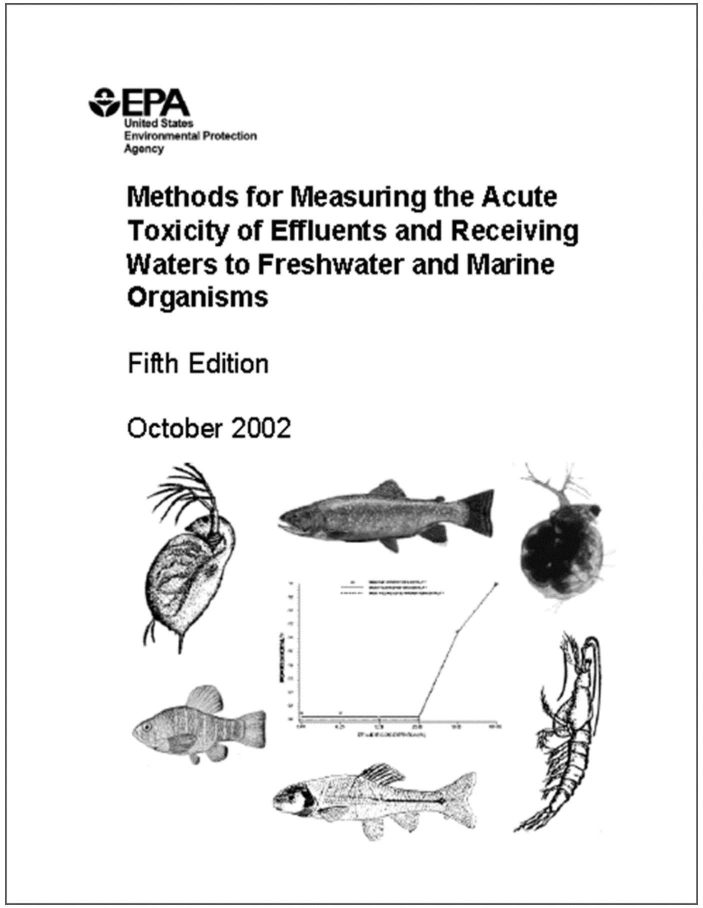
- EPA - Oil and Gas Extraction Effluent Guidelines and Standards (1979 - 2016):

- No discharge of produced water to coastal zones (< 3 nm)
- Oil and Grease: 29 mg/L (monthly average) 42 mg/L (daily max)
- Best Available Technology (BAT) or Best Practicable Technology (BPT)

- Monitoring requirements:
  - Flow
  - Toxicity (input to RBA)
  - Oil and Grease
  - Visual sheens



Toxicity Testing and Critical Dilution

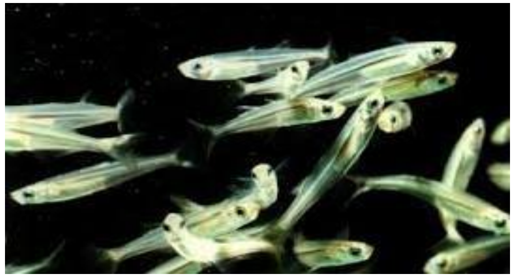

EPA
United States Environmental Protection Agency

Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

Fifth Edition

October 2002


Mysid (*Mysidopsis bahia*)


Silverside (*Menidia beryllina*)

Depth Difference Greater than 19 Meters				
Discharge Rate (bbl/day)	Pipe Diameter (inches)			
	>0" to 5"	>5" to 7"	>7" to 9"	>9" to 11"
8001 to 9000	0.20	0.20	0.20	0.20
9001 to 10,000	0.21	0.21	0.21	0.21
10,001 to 15,000	0.39	0.39	0.39	0.39
15,001 to 20,000	0.44	0.44	0.44	0.44
20,001 to 25,000	0.48	0.48	0.48	0.48
25,001 to 35,000	0.55	0.55	0.55	0.55
35,001 to 50,000	0.64	0.64	0.64	0.65
50,001 to 75,000	1.32	1.33	1.32	1.30

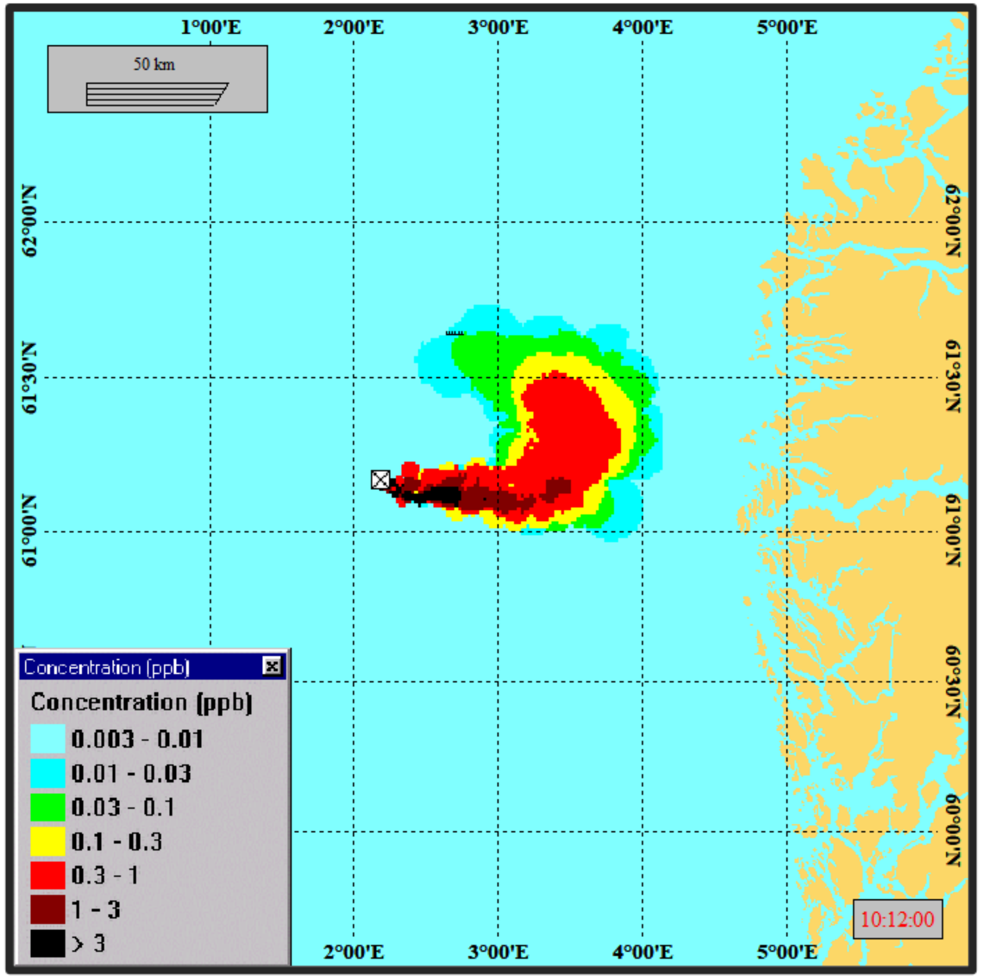
Case 2

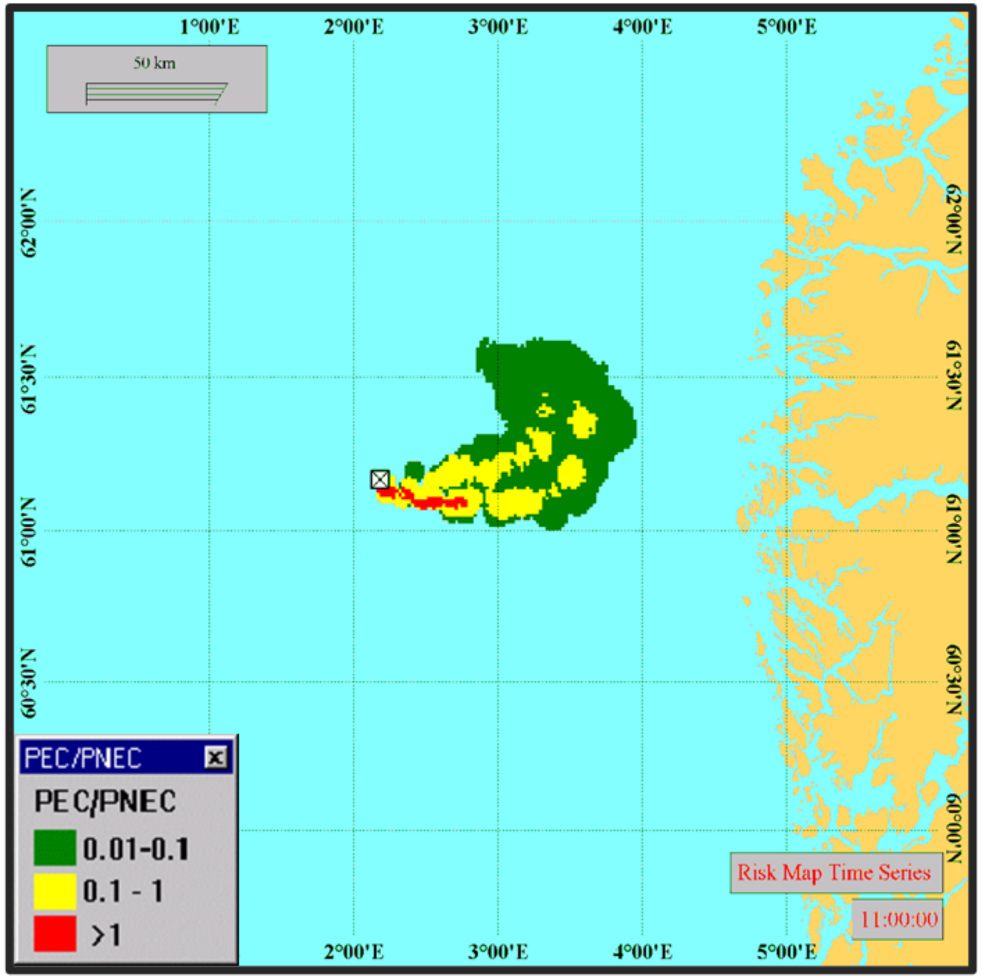
Norwegian Zero Harmful Discharge Approach

2

Exposure and Risk Characterisation

Aliphatic hydrocarbons
BTEX
Naphthalenes
PAH 2 – 3 ring 4 –ring +
Alkyl-phenols C0 – C3 C4 - C5 C6 - C9
Metals (Cu, Cd, Hg, Zn, Pb, Ni)
Added chemicals Corrosion inhibitor Biocide Scale inhibitor Flocculent Emulsion breaker H_2S-scavenger Others





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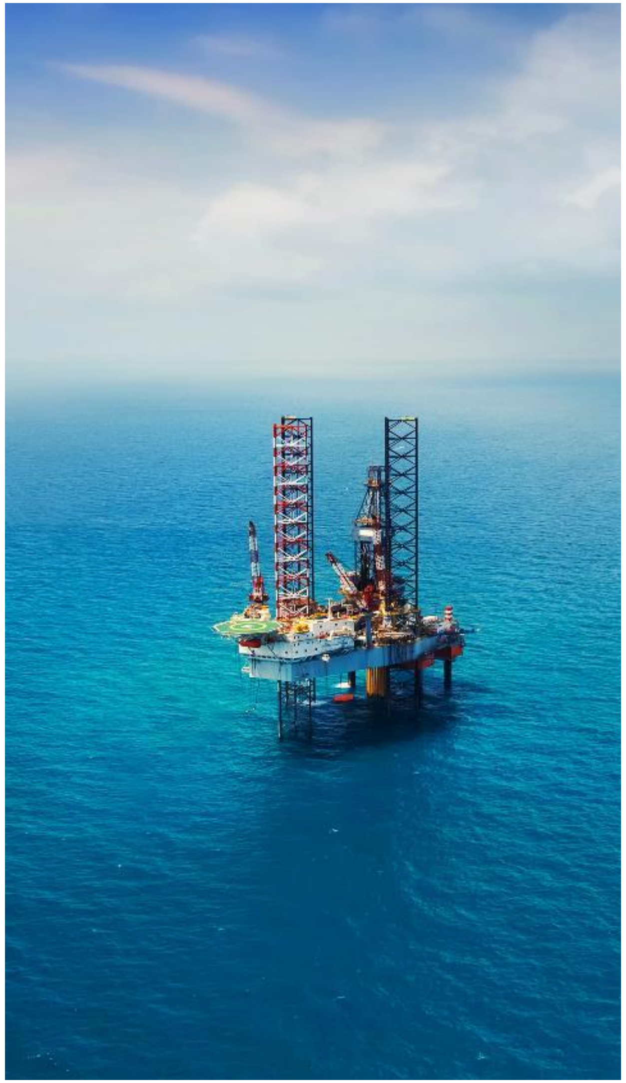
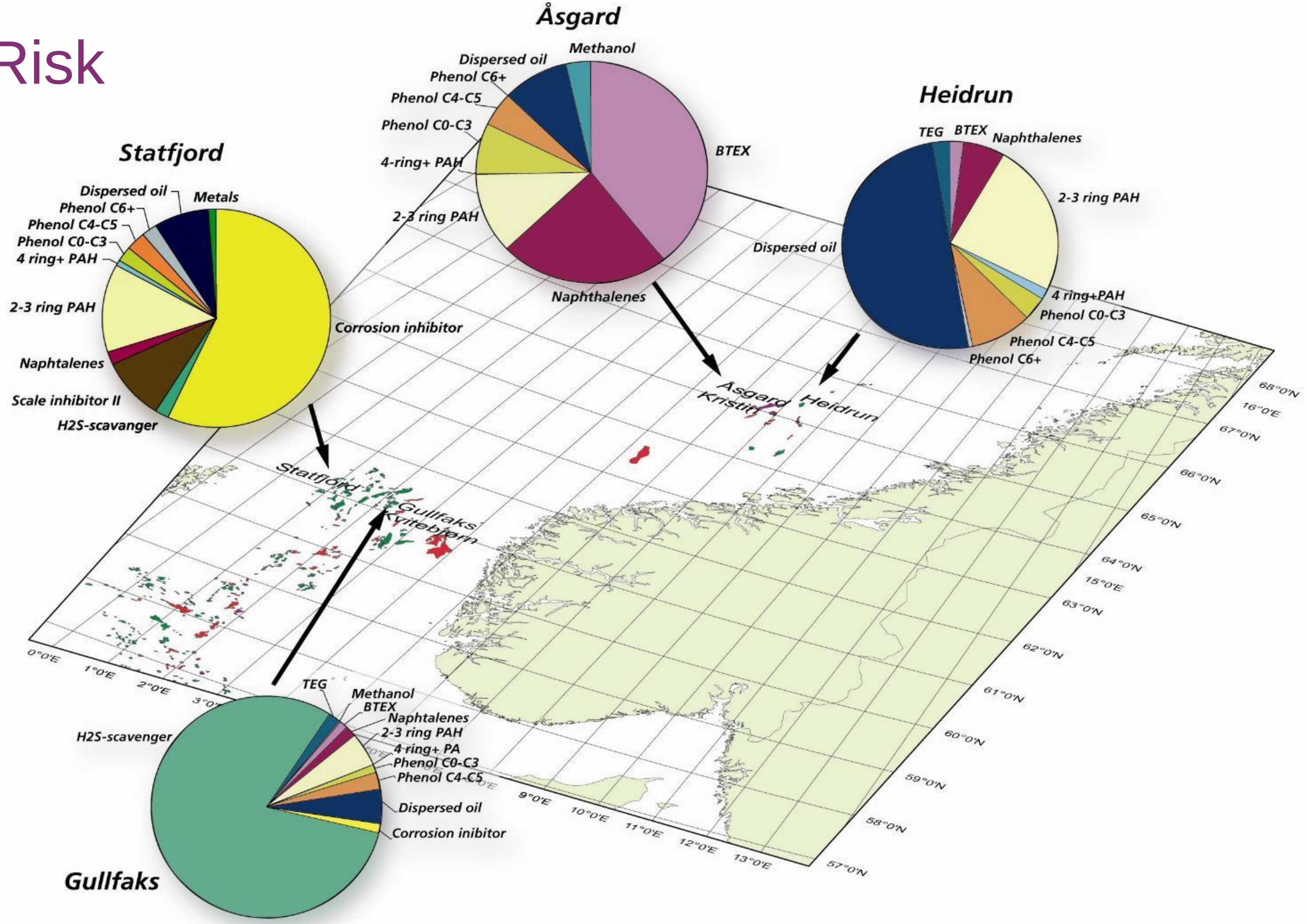
Contribution to Risk





Case 3

OSPAR's recommendation for a risk-based approach to the management of produced water discharges from offshore installations

3

Produced water management – OSPAR

1978 ➢ **Provisional standard for dispersed oil of 40**

1988 ➢ 40 mg/L fixed for all installations

2001 ➢ 30 mg/l maximum monthly average concentration to be achieved by 1 January 2007

➢ 15% reduction of oil in produced water discharged in the year 2006 compared to 2000

➢ Review of BAT every 5 years

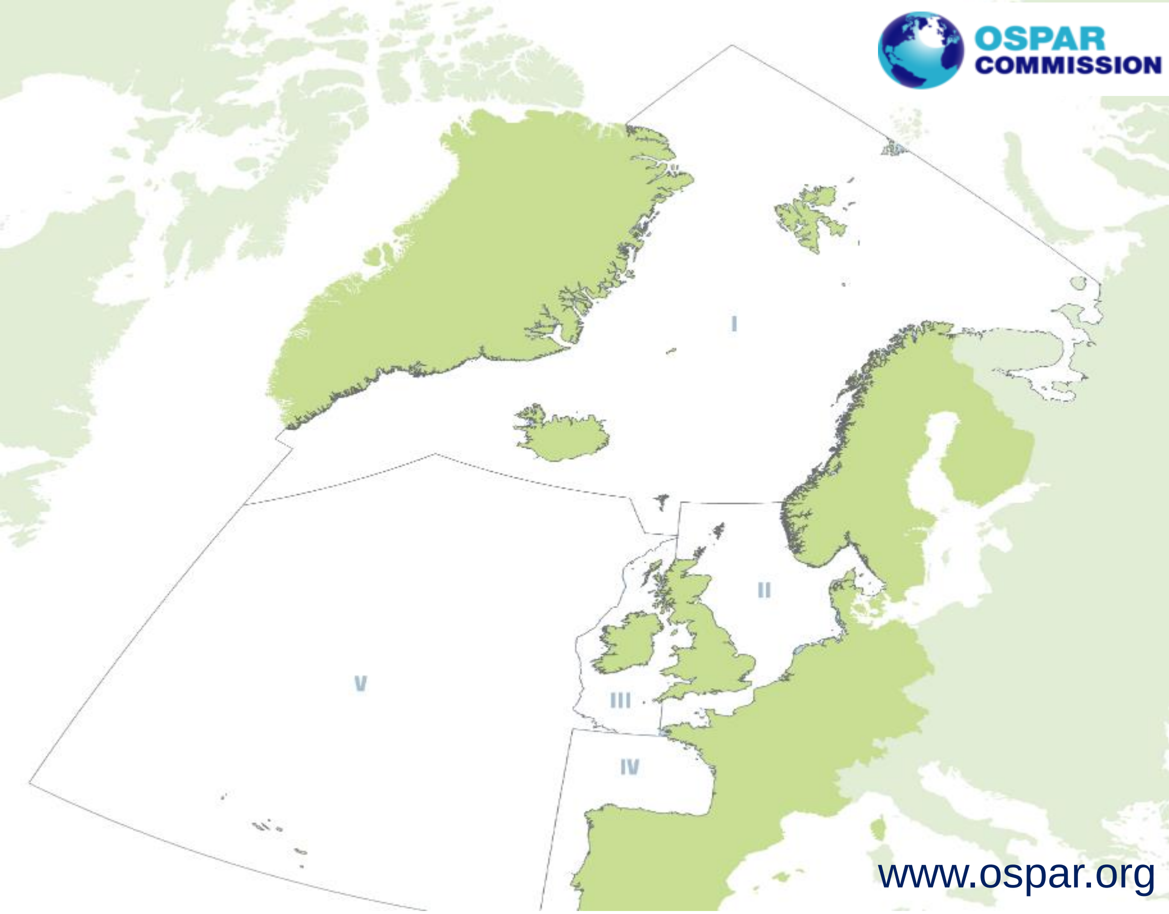
➢ Control of use and discharges of offshore chemicals

Achieved (2005 – 2009):

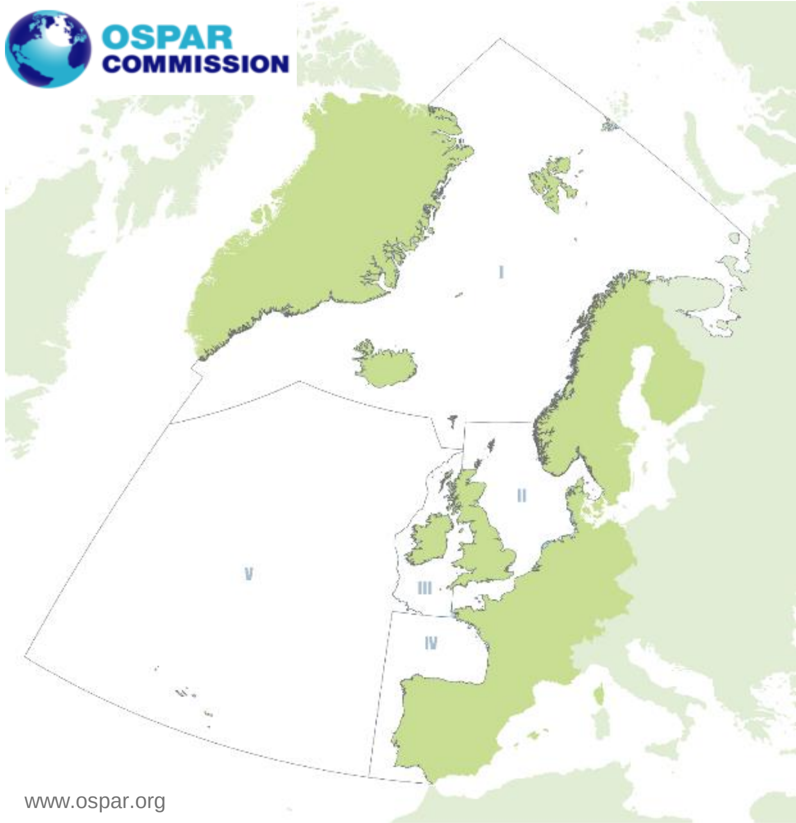
20 % reduction of oil discharges

50 % reduction discharge of hazardous chemicals

2012 ➢ Risk-based Assessment of PW



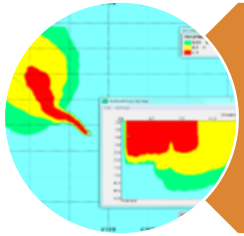
Implementation of OSPAR Recommendation 2012/5 for a Risk-Based Approach to the Management of Produced Water



- 2014 – 2018
- Assessment of all PW discharges within the OSPAR region:
  - ➢ UK: 79 installations
  - ➢ NO: 41 installations
  - ➢ NL: 78 installations
  - ➢ DK: 16 installations
  - ➢ GE: 1 installation

Whole Effluent Toxicity Testing

Chemical analysis



Dispersion Modelling

OSPAR Framework for the Management of Discharges

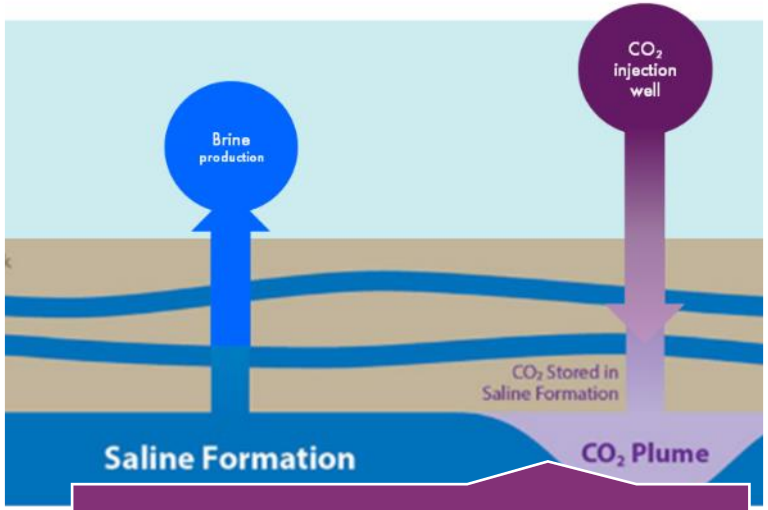
- RBA highlights shortcomings of HMCS data
- Restrictions to only use HOCNF data hamper the ability of operators to accurately assess risk
- Reduction of risk is the operator's responsibility

IOGP Guidance 663
Risk-based Assessment Produced Water Discharges

- Principles and fundamentals of produced water risk-based assessment
- Data collection strategies
- Defining a no effect level and addressing uncertainties
- A tiered approach to RBA throughout an asset's lifecycle
- Demonstration of acceptable risk

IOGP Report 633 – RBA of Offshore Produced Water Discharges is available to download from: www.iogp.org/bookstore/

Water Quality in the Energy Transition



CCUS

Hydrogen

Wind

Water Stewardship and ESG:
Increased focus on No-harm principles

ALLIANCE FOR WATER STEWARDSHIP

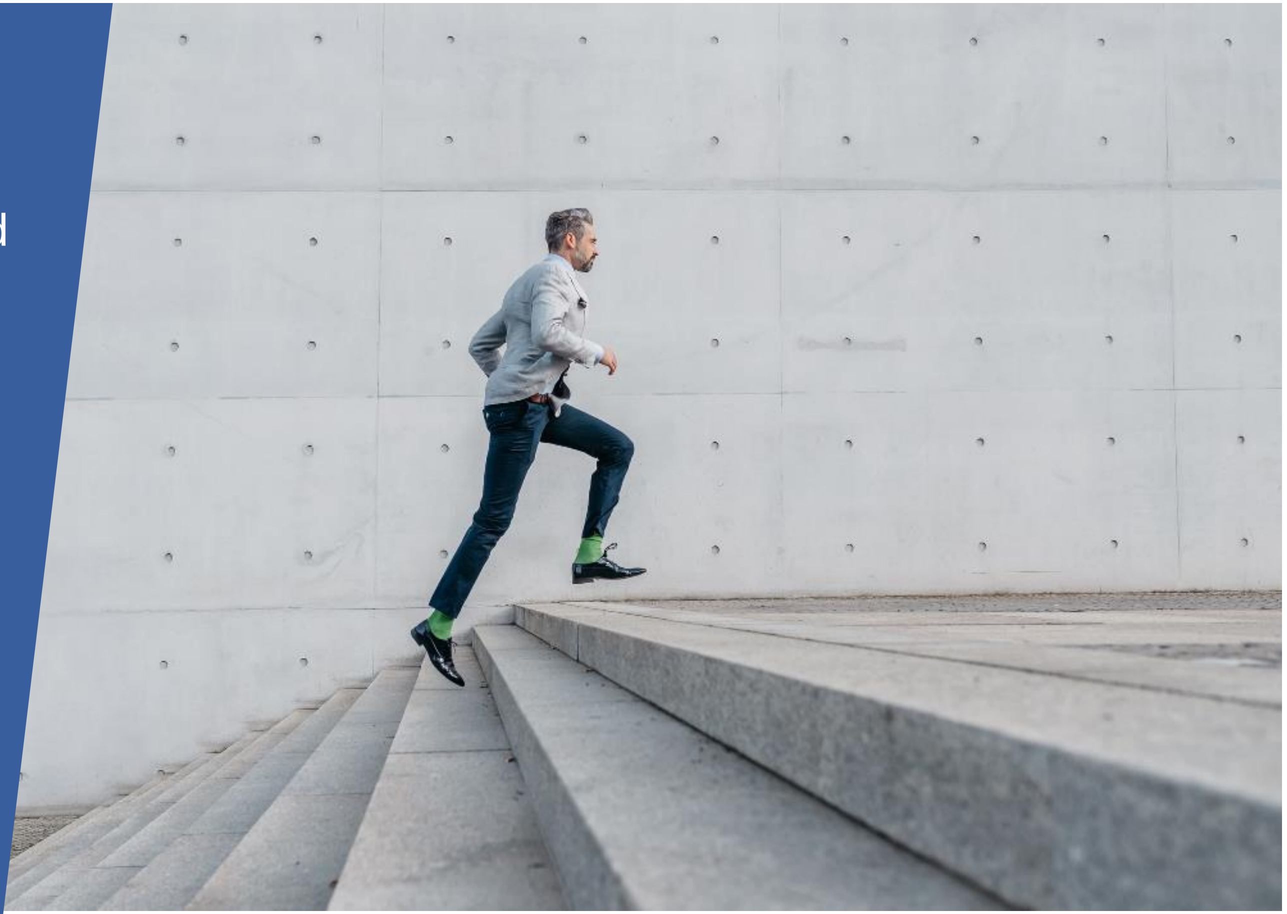
UN GLOBAL COMPACT

CEO Water Mandate

risk management and disclosure framework for organizations to report and act on evolving nature-related risks

Summary

- Offshore energy operations involve discharge of water and/or chemicals
- Produced water discharges are highly regulated and approaches vary globally
- Move from end-of-pipe standards to assessments that quantify environmental risks and demonstrate adequate management to mitigate risks
- OSPAR regulatory development needed to increase RBA effectiveness
- Increased focus on water and no-harm principals

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Topics

Legislation

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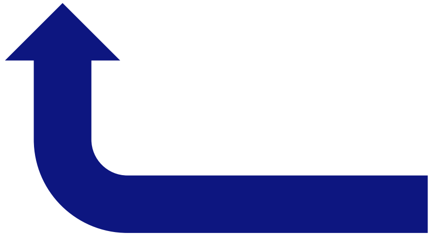
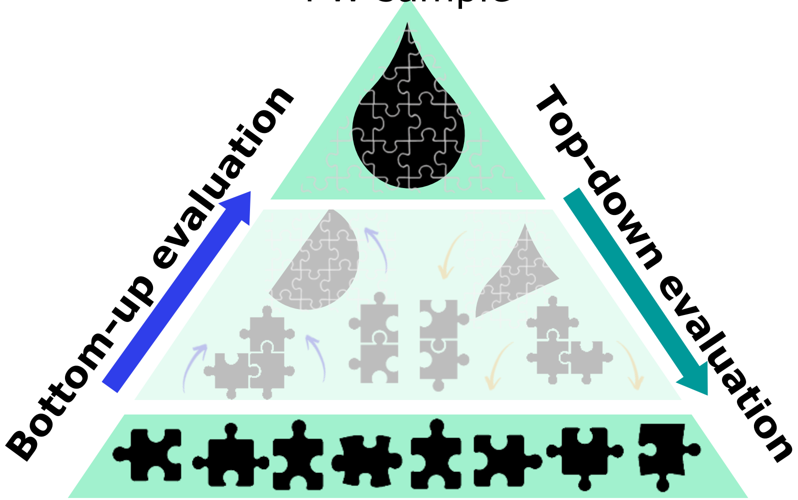
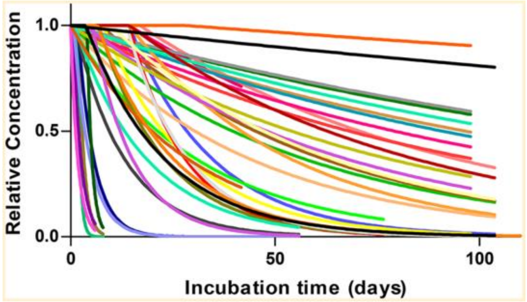


Assessing Environmental Impact
Proposing solutions

PW sample



Individual PW constituents



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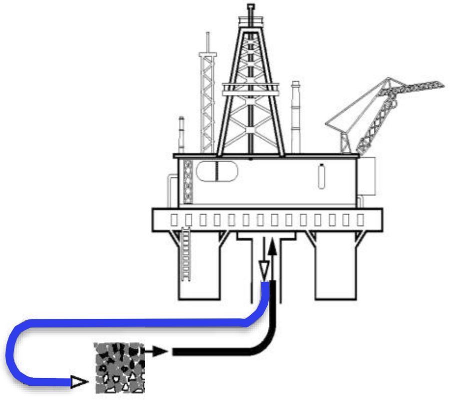
One possible solution



Produced water RI