

# Water Column Monitoring (WCM) programme 2021



Steven Brooks, NIVA

04.11.2021



# WCM2021

## Objective

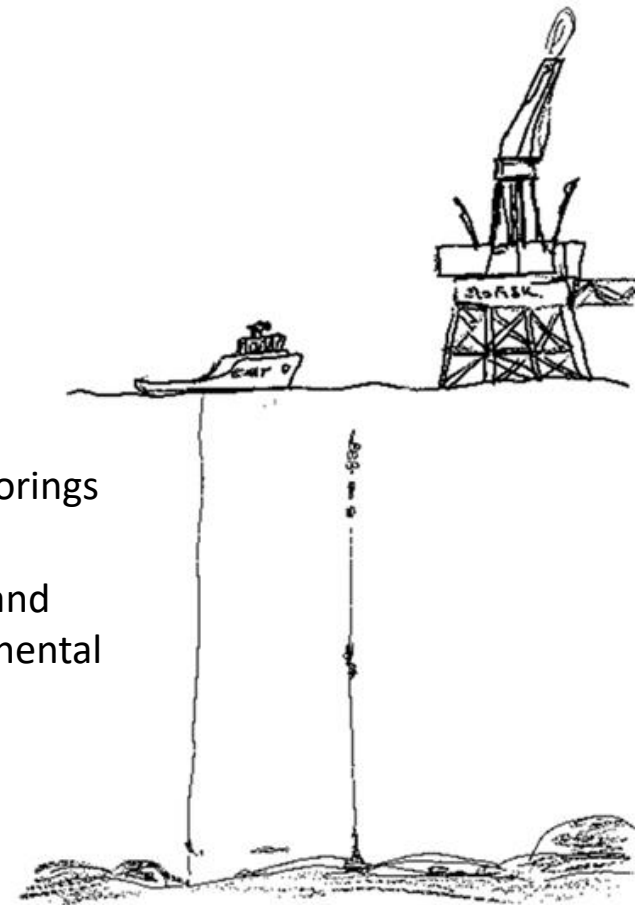
- to determine the potential biological effects of offshore oil and gas activity to marine life within the water column

## Risks to marine life

- Chemicals from produced water
- Chemicals from drill cuttings, leakages from seafloor, etc

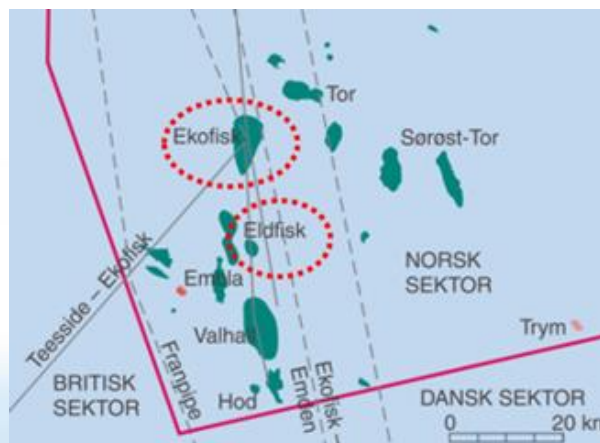
## Approach

- Biological effects monitoring programme
  - caged monitoring species, passive samplers on fixed moorings within the water column exposed to produced water
  - demersal fish populations from an offshore installation and compared to different locations on the Norwegian continental shelf

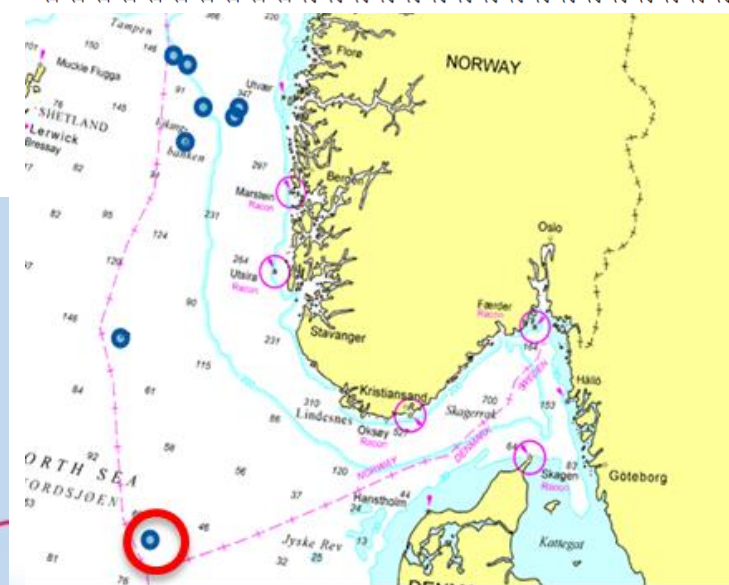
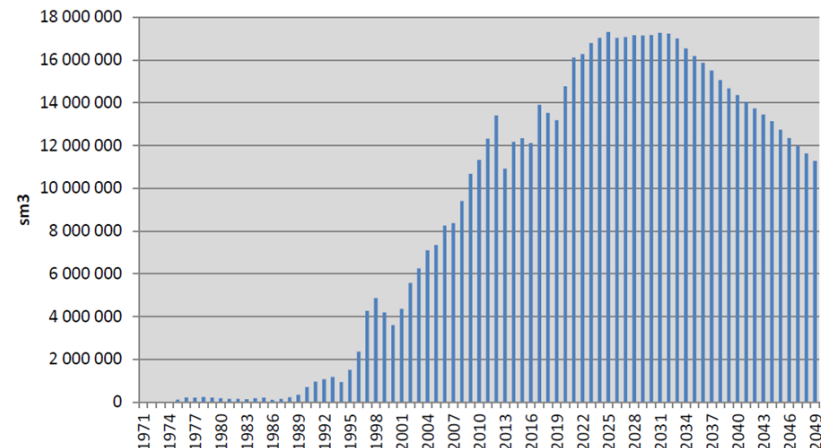


# WCM2021: Ekofisk and Eldfisk (operator ConocoPhillips)

- Significant volume of PW discharge
- Previous surveys in 1999, 2006, 2008 and 2009



**EKOFISK FELTET**  
Vannproduksjon 1971-2018 + prognose 2019-2049



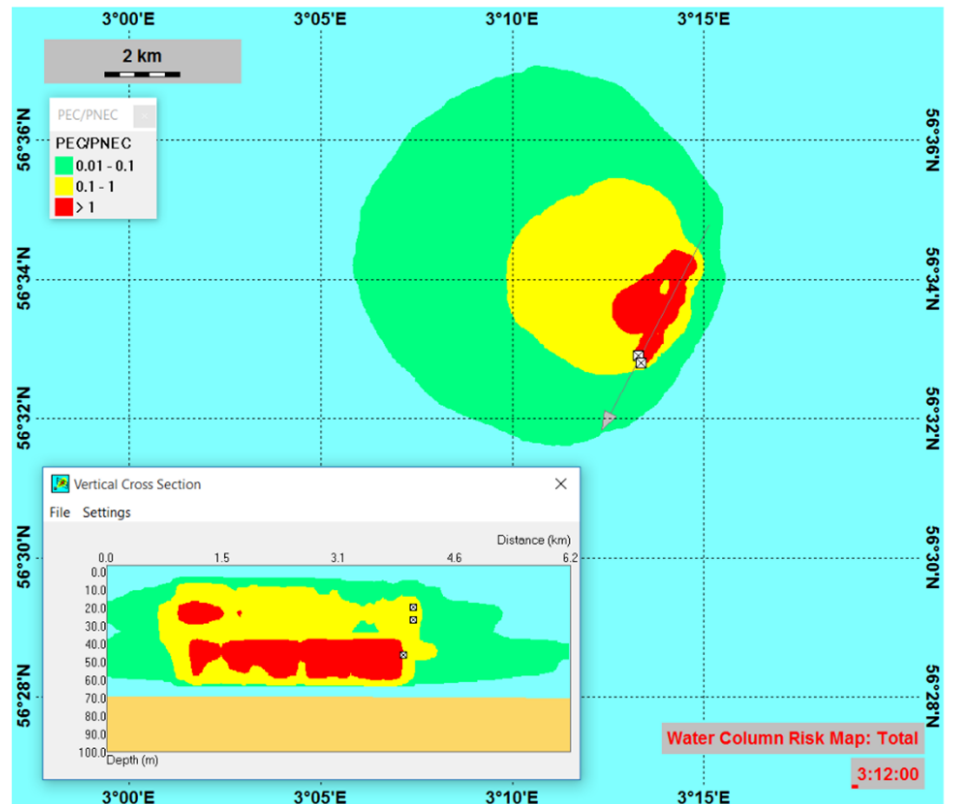
# Ekofisk



2/4 J:  
1 PW outlet at 49m

2/4 M:  
6 PW outlets 20 to 30m

		Totalt	Eko J	Eko M
Splitt Prognose			55%	45%
		Mbbl/d	m3/dag	m3/dag
År		WP Base case	WP Base case	WP Base case
Case nr/År	0abc	0abc	0abc	0abc
	1a, 4, 5	1a, 4, 5	1a, 4, 5	1a, 4, 5
Reelle tall	2015	211.8	21,397	12,274
Reelle tall	2016	208.8	21,234	11,961
Reelle tall	2017	239.7	23,224	14,880
Reelle tall	2018	233.1	20,423	16,639
Prognoser	2019	234.3	20,485	16,761
Prognoser	2020	256.5	22,428	18,350
Prognoser	2021	279.2	24,417	19,977
Prognoser	2022	274.3	23,983	19,622
Prognoser	2023	279.7	24,458	20,011
Prognoser	2024	306.6	26,807	21,933
Prognoser	2025	334.2	29,219	23,906
Prognoser	2026	331.0	28,941	23,679
Prognoser	2027	324.5	28,374	23,215
Prognoser	2028	323.6	28,300	23,155
Prognoser	2029	324.3	28,354	23,199
Prognoser	2030	322.5	28,197	23,070

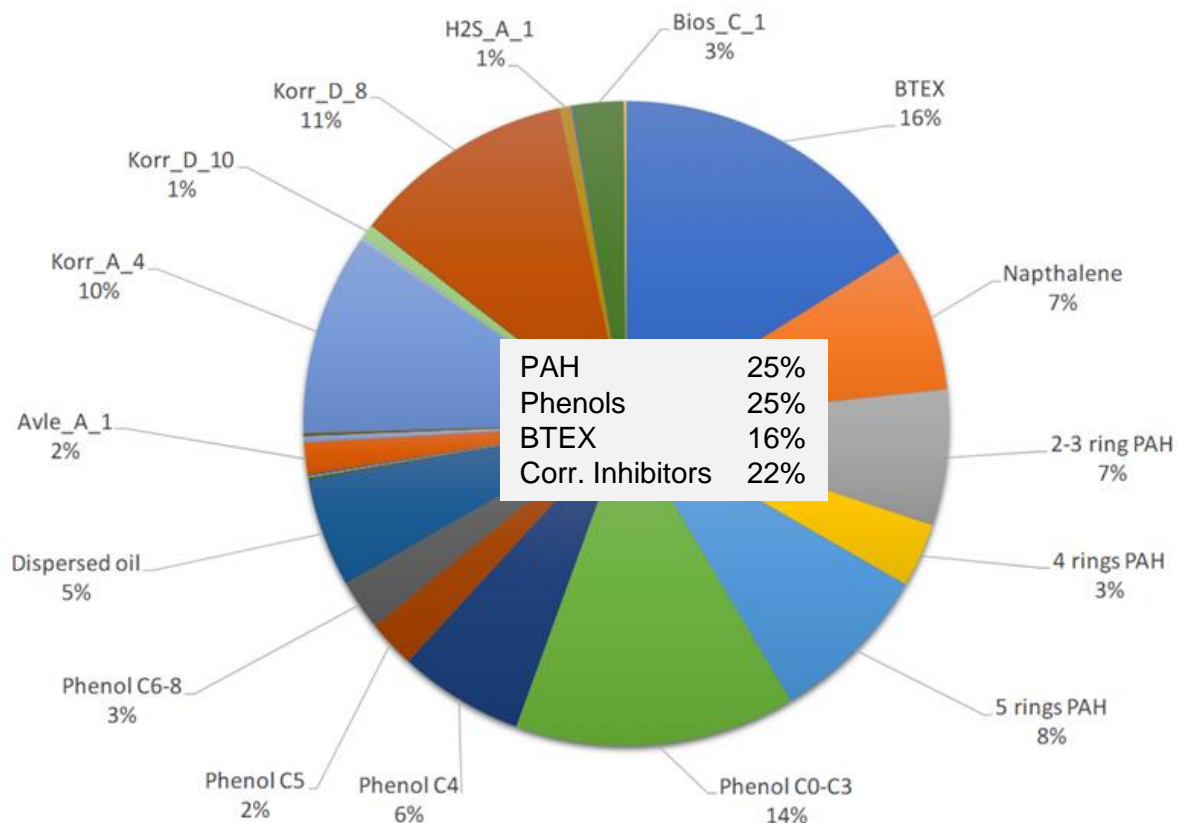


# Predicted risk



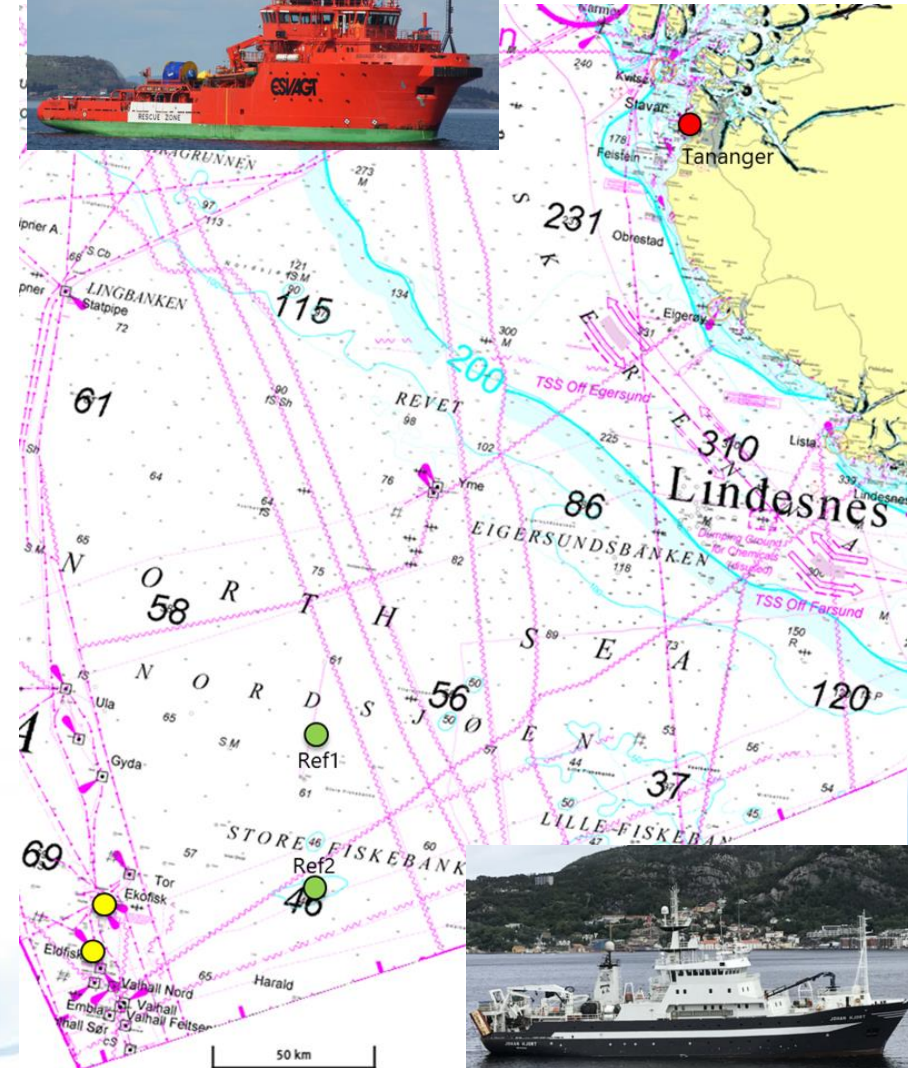
Components	Concentr. Mg/l	Concentr Mg/l	OSPAR PNEC µg/l (ppb)
Field	Ekofisk J	Ekofisk M	
Benzene	11.0	5.667	8
Toluene	4.133333	4.833333	7.4
Ethylbenzene	0.083333	0.240000	10
Xylene	0.633333	2.000000	8
Napthalene	0.559000	1.107833	2
Acenaphthene	0.000660	0.001550	0.38
Acenaphthylene	0.000353	0.000707	0.13
Fluorene	0.004633	0.010400	0.25
Anthracene	0.000035	0.000047	0.1
Phenanthrene incl substitutes	0.057617	0.058733	1.3
Dibenzothiophene incl substitutes	0.010363	0.011088	0.1
Fluoranthene	0.000098	0.000100	0.01
Pyrene	0.000438	0.000362	0.023
Benz(a)anthracene	0.000050	0.000033	0.0012
Chrysene	0.000287	0.000188	0.007
Dibenzo(a-h)anthracene	0.000020	0.000008	0.00014
Benzo(g-h-i)perylene	0.000053	0.000023	0.00082
Benzo(a)pyrene	0.000018	0.000007	0.022
Benzo(k)fluoranthene	0.000005	0.000005	0.017
Indeno(1-2-3-cd)pyrene	0.000010	0.000010	0.00027
Benzo(b)fluoranthene	0.000087	0.000045	0.017
C0-C3-alkyl-phenols	6.018333	6.440000	7.7
C4-alkyl-phenols	0.077667	0.111333	0.64
C5-alkyl-phenols	0.010950	0.020000	0.2
Octylphenol(C6-C8-alkyl-phenols)	0.000531	0.000796	0.01
C9-alkyl-phenols	0.000088	0.000191	0.3
Dispersed-oil	11.750000	4.983333	70.5
Arsenic	0.001850	0.002050	0.6
Cadmium	0.000112	0.000075	0.21
Chromium	0.000552	0.001260	0.6
Copper	0.000418	0.002250	2.6
Nickel	0.000750	0.000750	8.6
Mercury	0.000140	0.000065	0.048
Lead	0.000125	0.000514	1.3
Zinc	0.003158	0.011733	3.4

Basecase 2017 K2 år 2017:	Eko J	Eko M
Vannmengde m3/dag	23224	14880



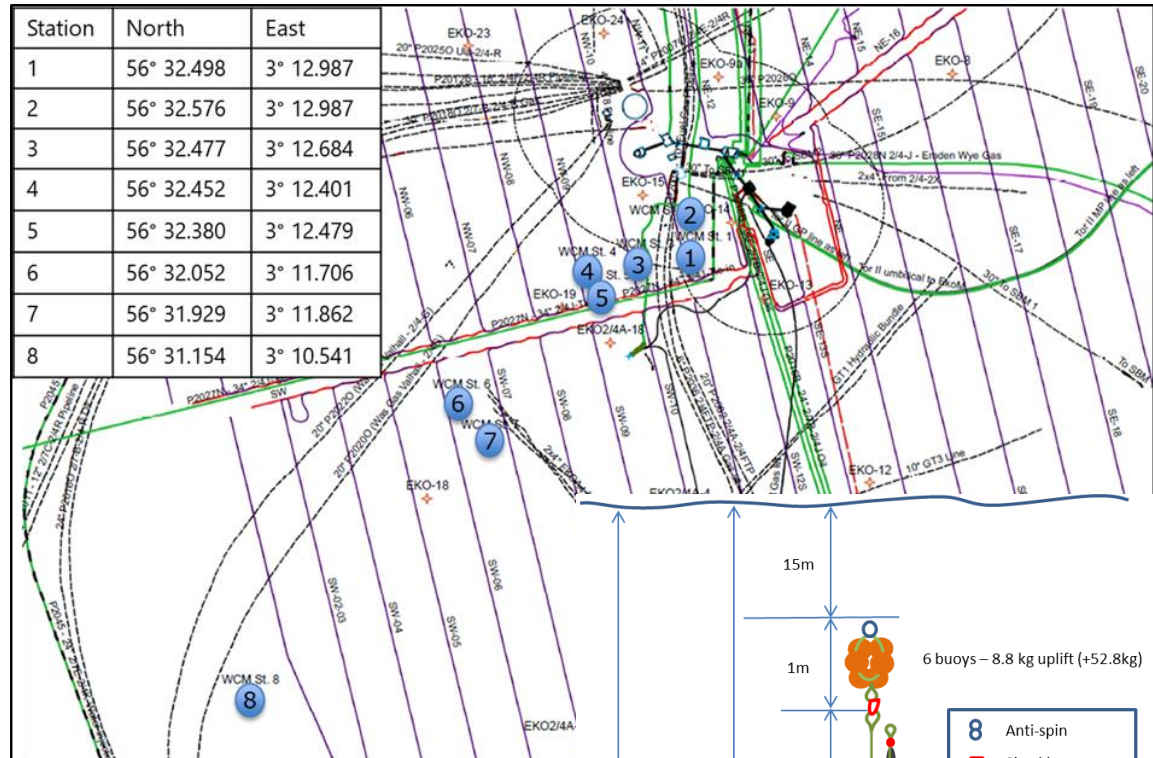
# WCM2021 Monitoring cruises

- **Deployment cruise (week 12, 22-27 March)**
  - Deploy monitoring rigs at Ekofisk, Eldfisk and reference locations
  - Test fishing at Ekofisk (check species availability)
  - Calanus sampling
  - Produced water tracking (dye release and IMiRO sensor)
  - Benthic flux chamber (sediment-water interchange)
  - Fish tagging with baited tags
- **Retrieval cruise (week 18, 3-10 May)**
  - Retrieve monitoring stations and process mussels, scallops, passive samplers
  - Fish in the safety zone and process for chemical and biological effects endpoints
- **Fish trawling cruise (week 19, 10-16 May)**
  - Trawling for same fish species as those caught at Ekofisk in at least 2 regions of the North Sea
  - Calanus sampling

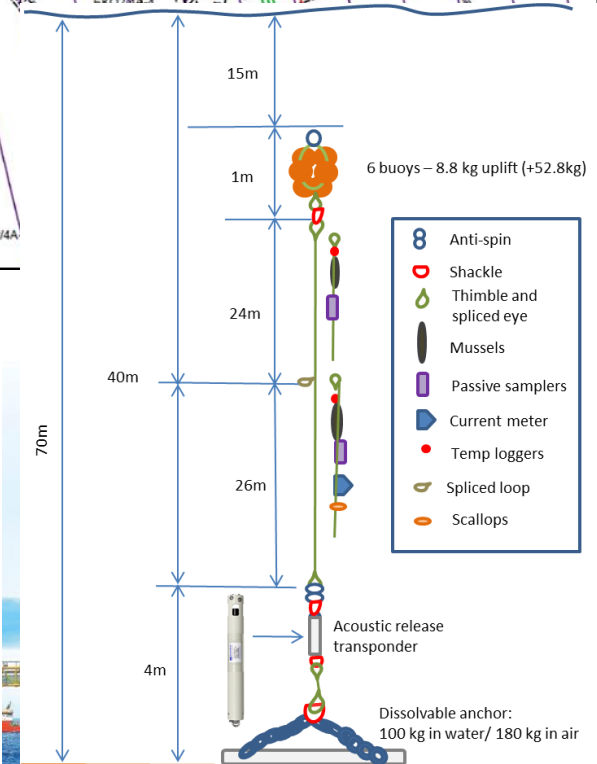
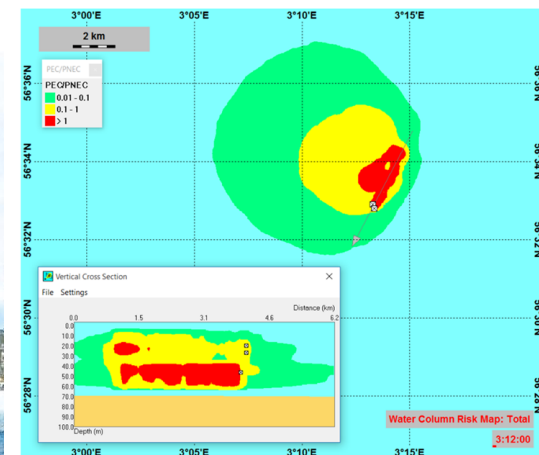


# Monitoring stations at Ekofisk

- Number and position of stations
  - DREAM modelling used to optimise rig position south-west of Ekofisk
  - 8 stations at Ekofisk (2 depths)
  - 3 stations at Eldfisk (1 depth)
  - 2 reference stations (2 depths)
- Acoustic release used to avoid conflict with vessels
  - Depth of mussels (two depths per station, 15-20m and 45-50m)
  - Scallops at two stations plus reference at 40 m depth
  - Passive samplers
  - Current, temp, turbidity, chlorophyll
  - Sediment traps at 4 stations
  - CTD profiles



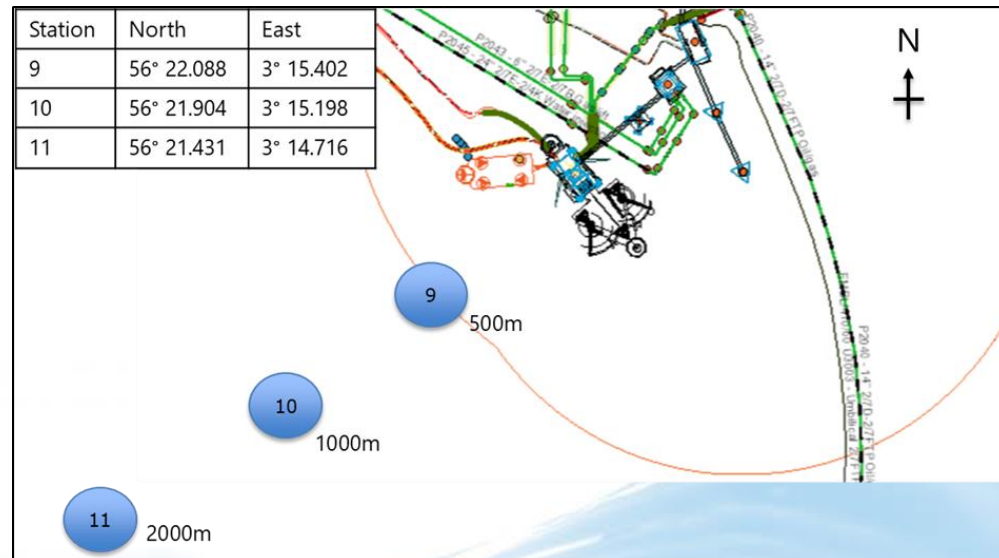
- Exposure period
  - Outside mussel spawning season
  - 6 weeks (week 12 – 18)





# Monitoring stations at Eldfisk

- 3 stations south-west of the platform at 500, 1000 and 2000 m
- Mussels only at 1 depth, 15-20 m





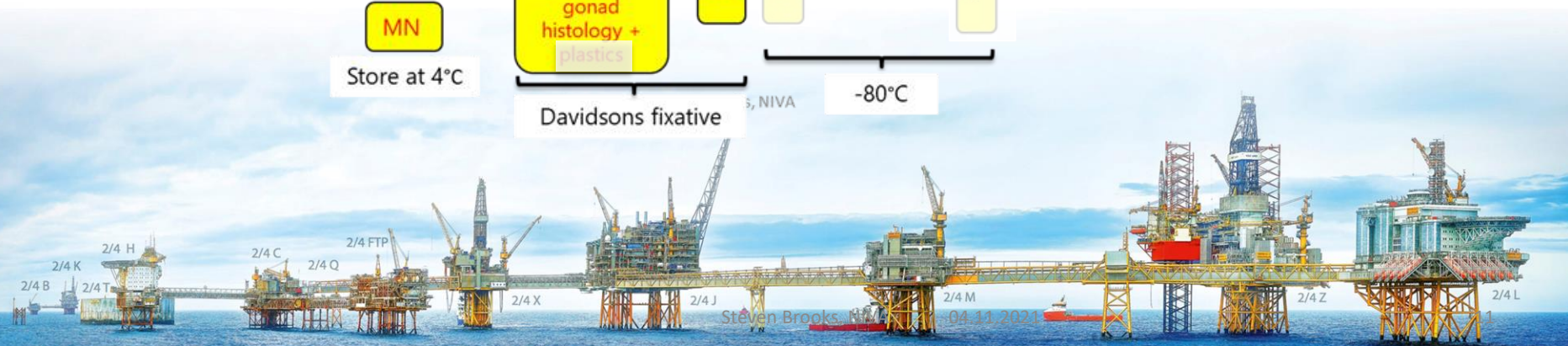
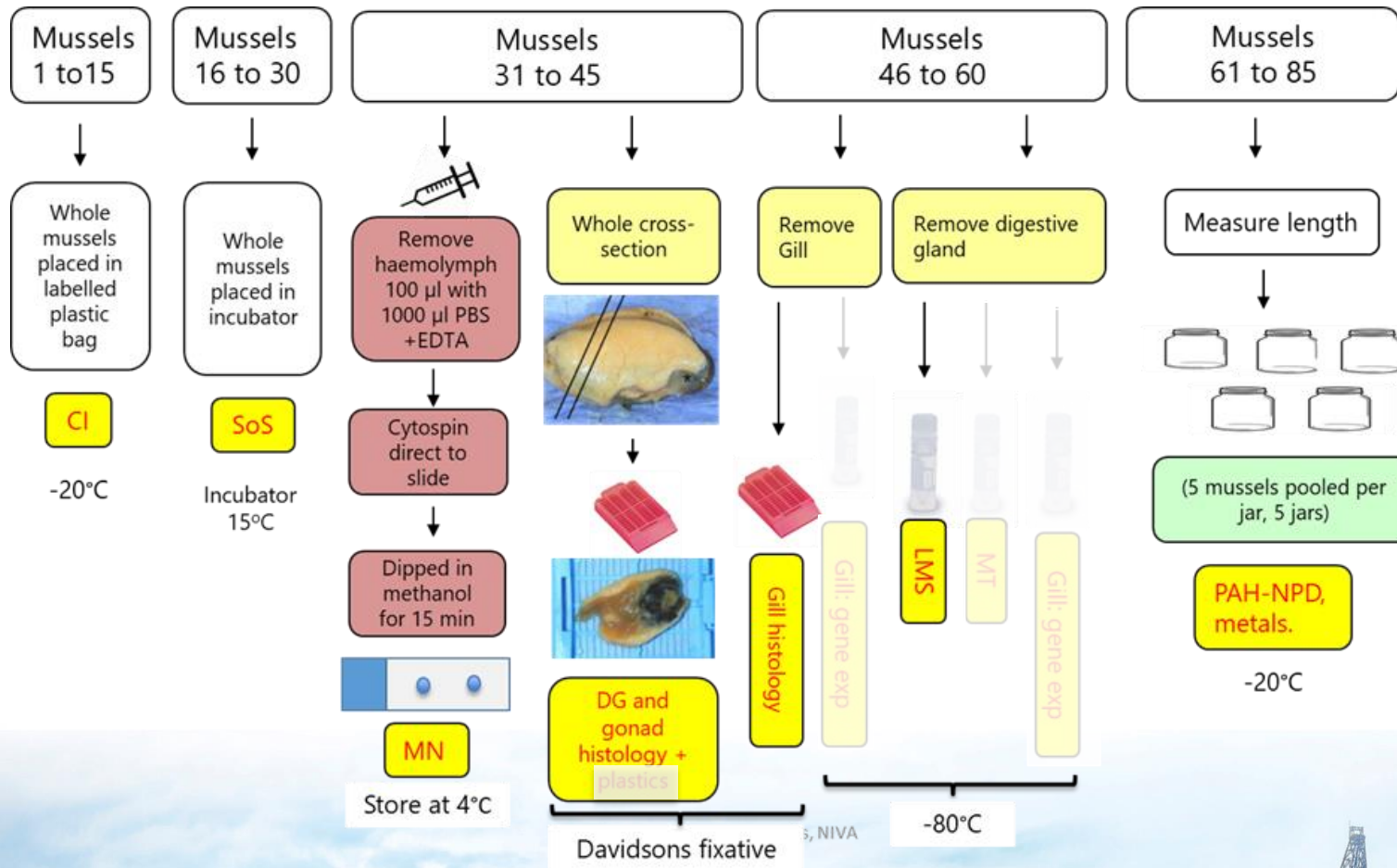
# Deployment cruise



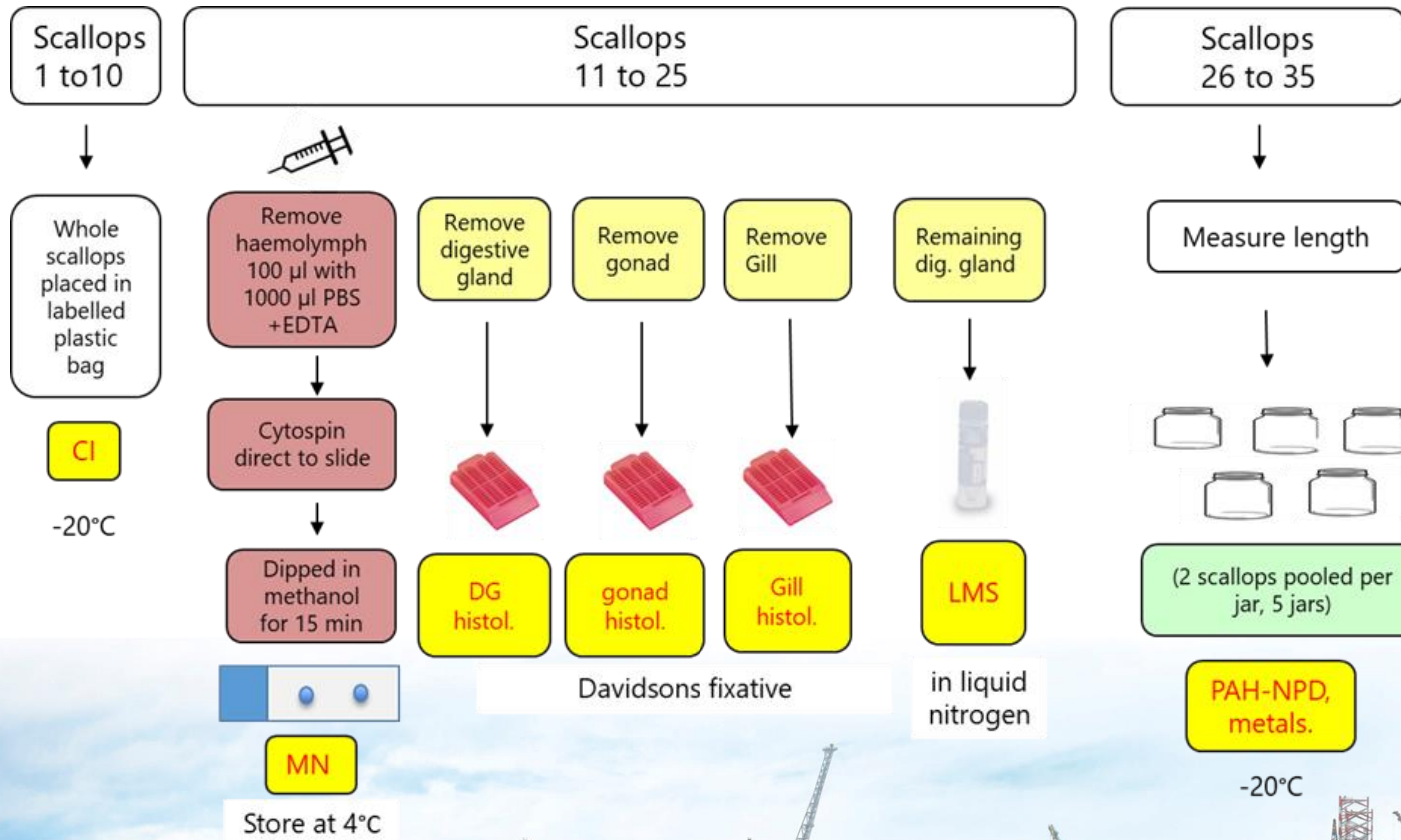
# Retrieval cruise



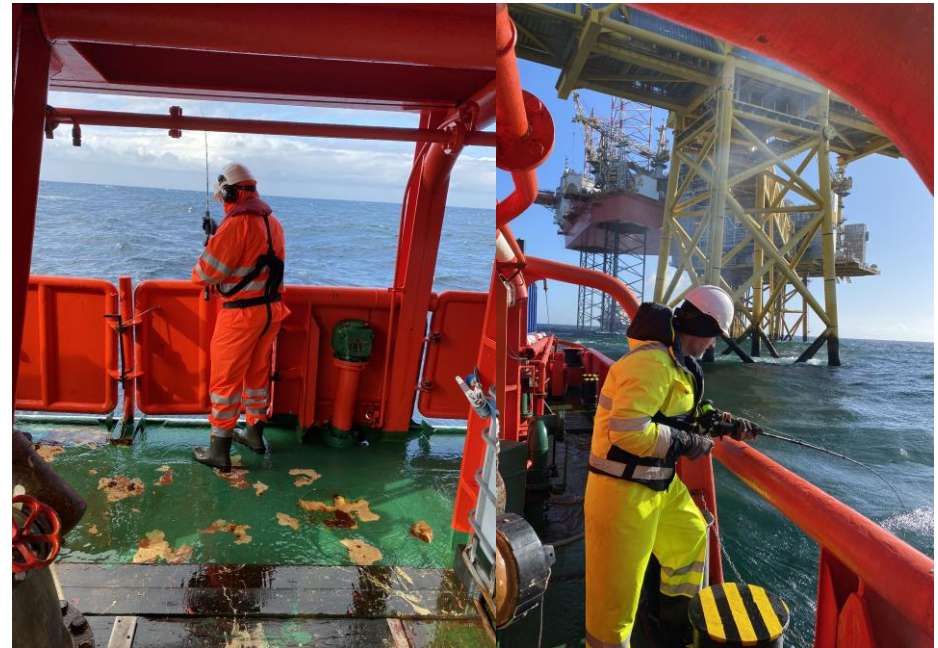
# Chemical and biological effects measurements in mussels



# Chemical and biological effects measurements in scallops



# Fish sampling and tissue collection



- Target: minimum of 3 species
- 30 fish per species
- only cod and dab present, 30 of each sampled



# Fish trawling cruise

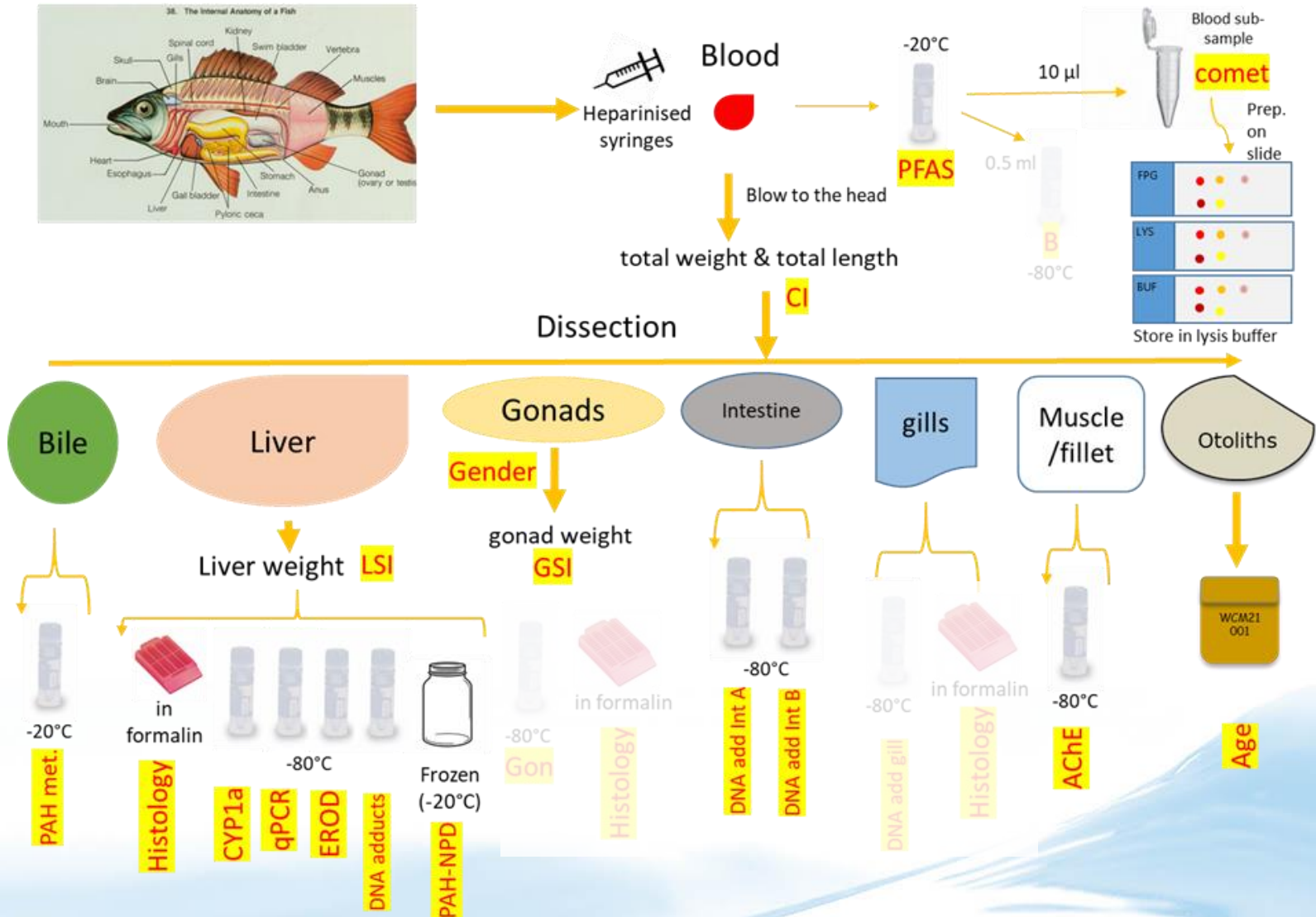
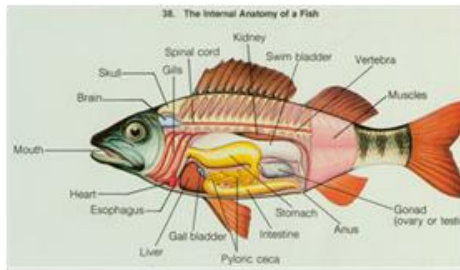
- Collection of the same fish species from two regions in the North Sea: Ekofisk region and Egersund bank, plus Viking bank



	Ekofisk platform	Ekofisk region	Egersund bank	Viking bank
cod ( <i>Gadus morhua</i> )	30		17	
dab ( <i>Limanda limanda</i> )	30	30	30	
haddock ( <i>Melanogrammus aeglefinus</i> )		30	30	30
whiting ( <i>Merlangius merlangus</i> )		15	15	8
grey gurnard ( <i>Eutrigla gurnardus</i> )		18		



# Fish sampling



# Passive sampling

- Placed at the same locations as the mussels
- SSP Silicon rubber, SPMDs and polar samplers.



Description	No. samples + field and lab blanks and +ve controls
PAH-NPD analysis in silicon (23 groups, n=3)	69 + 8
PAH-NPD analysis in SPMD (4 stations, n=3)	12 + 2
Alkylphenol (AP) analysis in silicon (23 groups, n=3)	69 + 8
Naphthenic acid (NA) analysis in POCIS (23 groups, n=3)	69 + 6
Total hydrocarbon (THC) analysis in silicon (23 groups, n=3)	69 + 6

# Sediment traps

- Placed on 4 mussel rigs, 50 m depth
- PAH analysis of the settled material
- Toxicity effects assessment of the settled material by either *in vivo* or *in vitro* bioassays if sufficient material





# Results: chemical and biological effects

- Mussels

- Body burden
  - PAH-NPD, metals
- Condition index (CI)
- Stress on stress (SoS)
- Micronuclei (MN)
- Lysosomal membrane stability (LMS)
- Histology
  - Digestive gland, gill, gonad

- Scallops

- Body burden
  - PAH-NPD, metals
- CI
- MN
- LMS
- Histology
  - Digestive gland, gill, gonad

- Fish

- CI, LSI, GSI
- PAH metabolites (bile)
- PFAS (blood)
- PAH-NPD (liver)
- Comet
- DNA adducts (liver & intestine)
- AChE (fillet)
- CYP1a, pPCR, EROD (liver)
- Histology (liver)
- Age (otolith)

- Supporting data

- Passive samplers (PAH, AP and NA)
- Current, salinity, temperature, turbidity, chlorophyll
- Sediment traps (PAH, invitro bioassays)

# Time schedule of events

Activity	Description	2021												2022											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Cruise preparation	Preparation of mussel rigs, field equipment for fish sampling, DREAM simulation																								
Deployment cruise	a) Deploy mussels and passive samplers, b) IMiRO deployment, c) Calanus sampling, d) test fishing approach (Week 12, 22nd March, 5 days).																								
Retrieval cruise	Retrieve mussel cages and process samples, collect and sample fish around Ekofisk (week 18, 3rd May, 7 days)																								
Regional fishing cruise	Collect wild fish populations from 2 regions (May 10th, 7 days)																								
Lab analysis	Chemical and biomarker assessment																								
Reporting	Draft report deadline 1 <sup>st</sup> June 2022																								
	Report hearing response by 1 <sup>st</sup> Sept 2022																								
	Final report submission 1 <sup>st</sup> Dec 2022																								



Thank you for your attention

