Sustainable Ocean Monitoring for Industrial Applications: A Synergistic Approach Using Autonomous Vehicles

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Glider II

2020 - 2023

A data portal: Blue Insight

KONGSBERG

Sailbuoy
Echosounder

Otter
Echosounder

Slocum
Hydrophone, fluorometer

SeaExplorer
Fluorometer

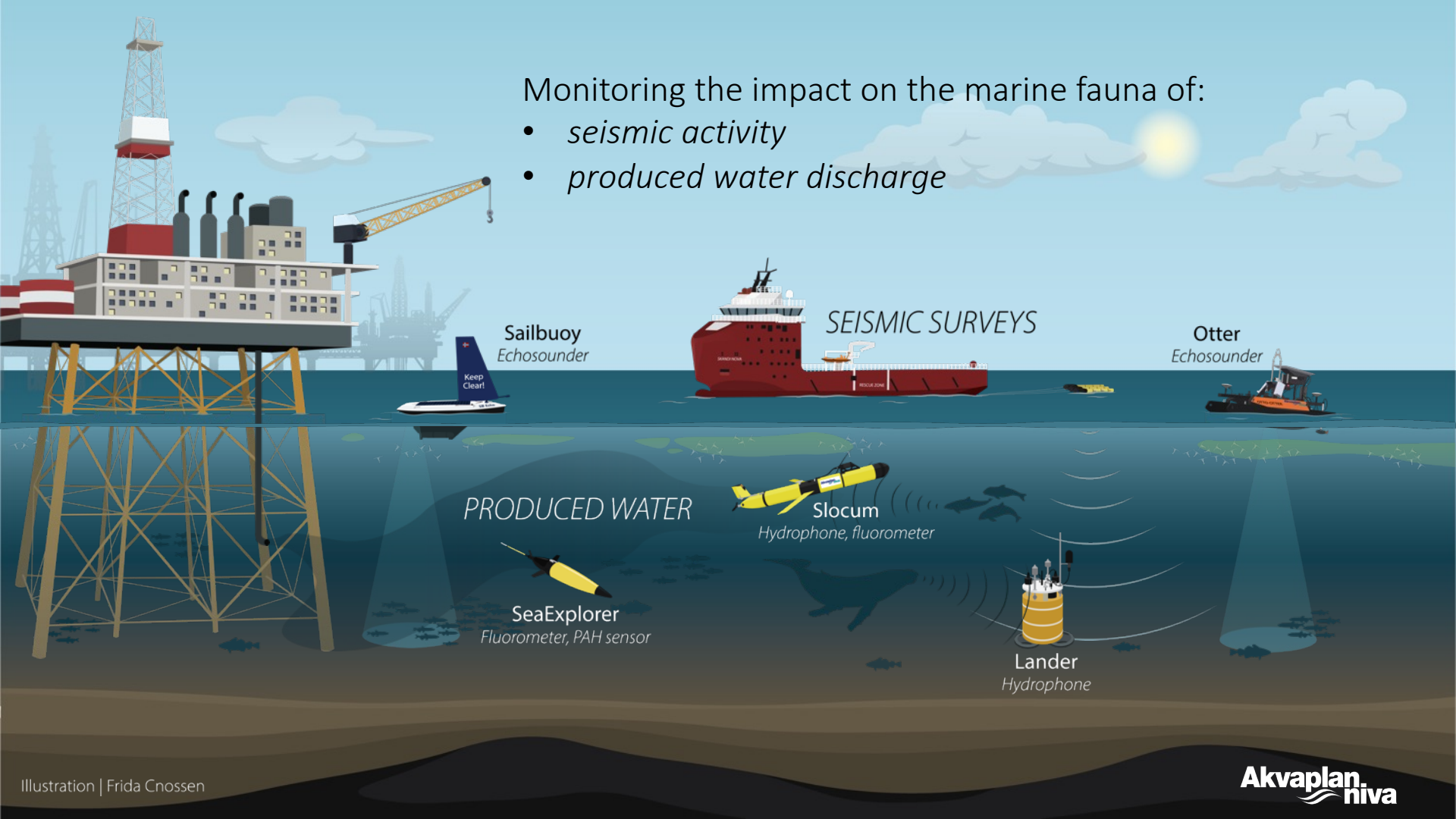
Lander
Hydrophone

A fleet of autonomous vehicles

Illustration | Frida Cnossen

CO_2 RISK

Remote Operation Centre


Monitoring the impact on the marine fauna of:
• seismic activity
• produced water discharge
Sailbuoy
Echosounder
Keep Clear!
SEISMIC SURVEYS
Otter
Echosounder
PRODUCED WATER
Slocum
Hydrophone, fluorometer
SeaExplorer
Fluorometer, PAH sensor
Lander
Hydrophone
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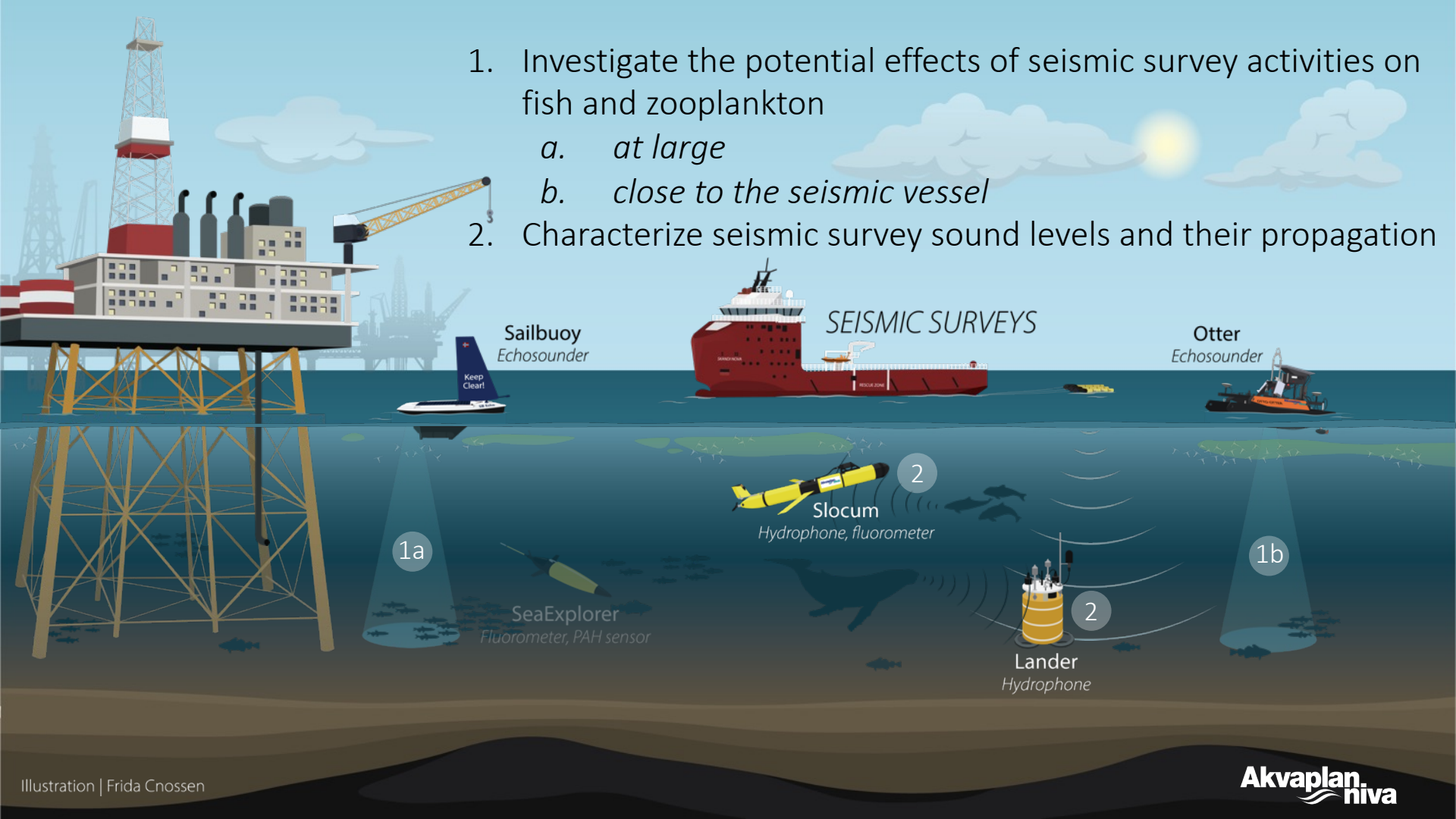
1. Investigate the potential effects of seismic survey activities on fish and zooplankton
   a. *at large*
   b. *close to the seismic vessel*
2. Characterize seismic survey sound levels and their propagation



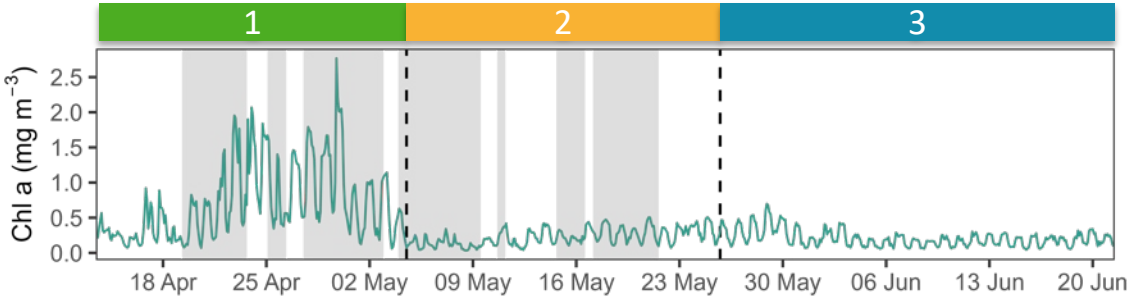
Field activities during seismic survey May 2022

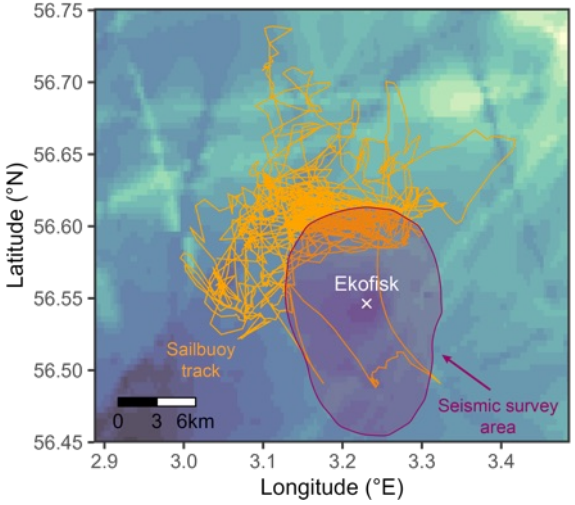
- Monitoring pelagic fish and zooplankton with the Sailbuoy Echo at mesoscale (2-25 km distance; 2.5 months)
- Microscale experiments (50 m-16 km distance; 3 days) with Otter during the joint-field with IMR's ZoopSeis project
- Monitoring seismic sound
  - Sound propagation model
  - Slocum hydrophone: 2 weeks
  - JASCO Lander: 1 year

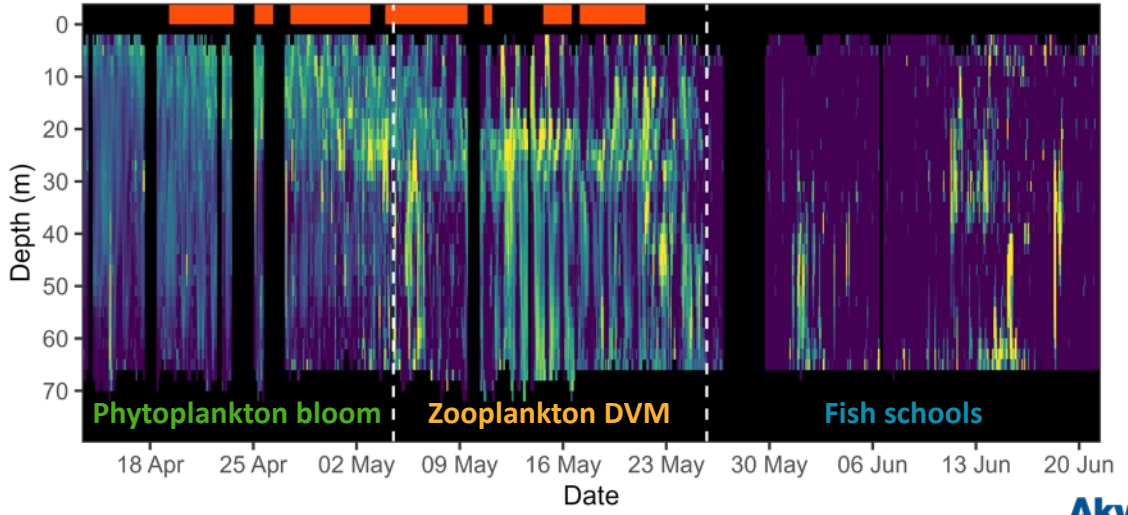
Seismic effect over the Ekofisk area at large

Three phases:

1. **Phytoplankton bloom**
2. **Zooplankton DVM**
3. **Fish schools**







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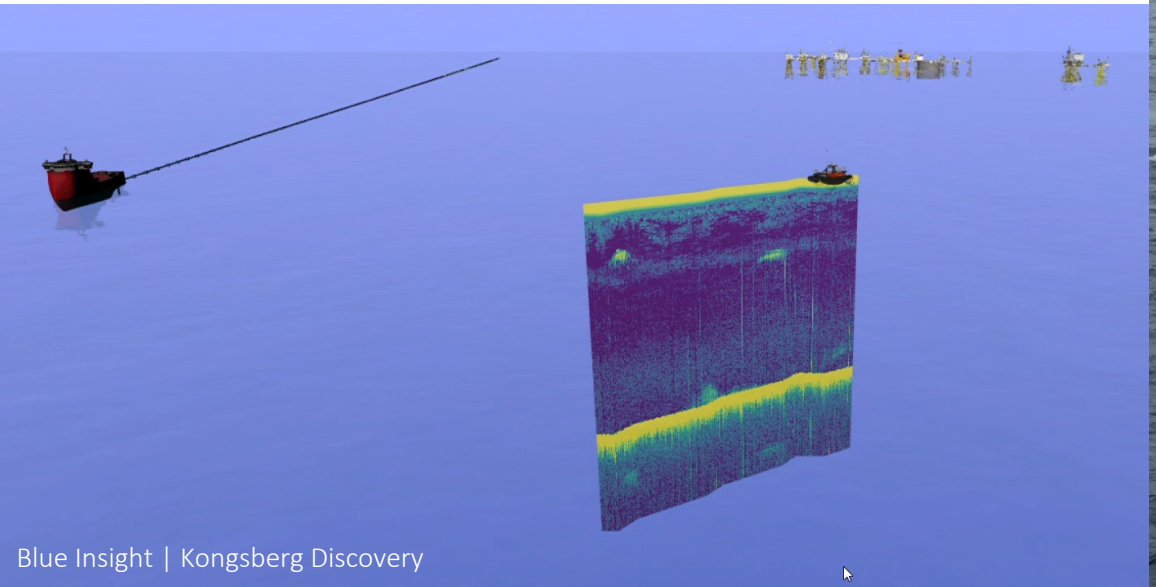
Microscale experiment – effects close to the seismic vessel

- Continuous monitoring of pelagic fauna with USV's echosounder while the seismic vessel was approaching
- Similar approach to McCauley et al. 2017 but with full scale air-guns



Blue Insight | Kongsberg Discovery

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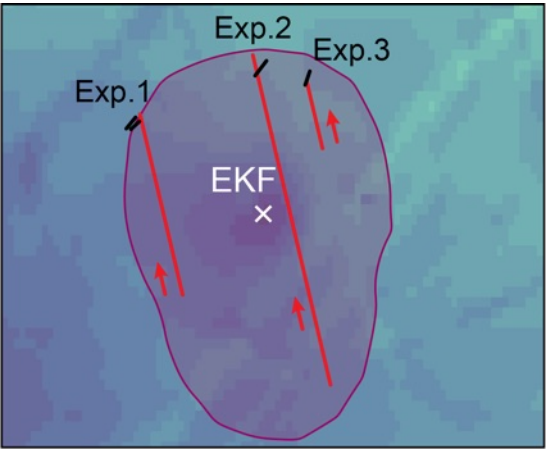
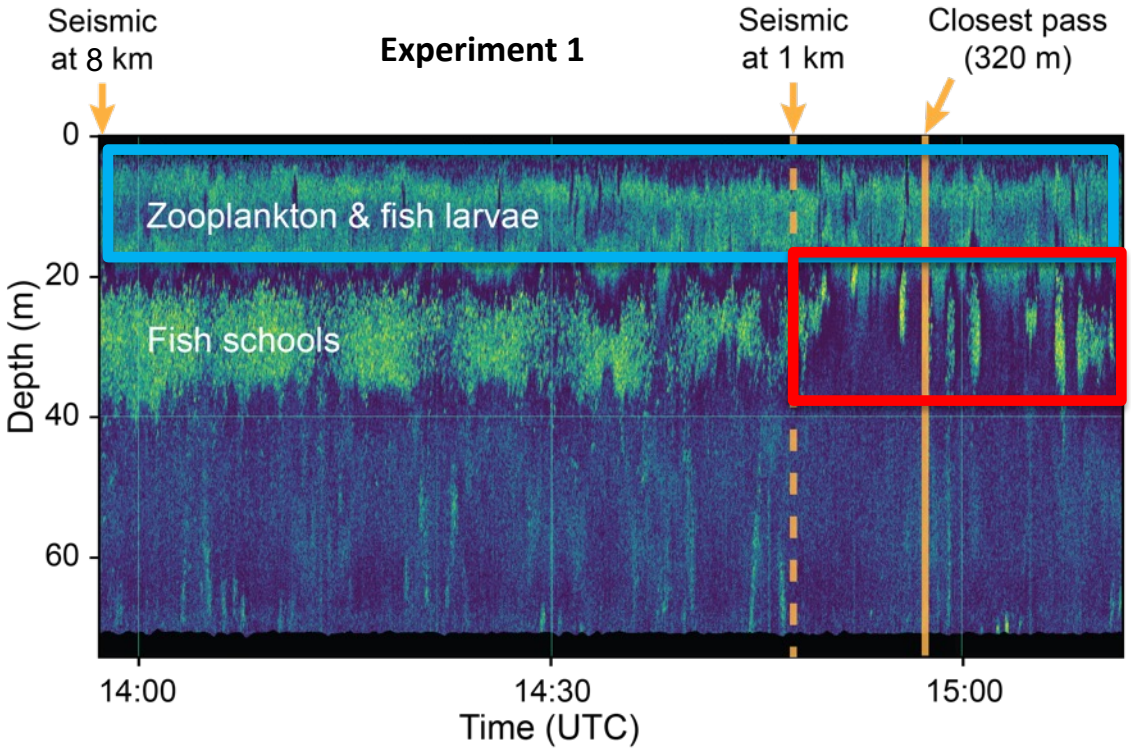
Seismic effect close to the seismic vessel

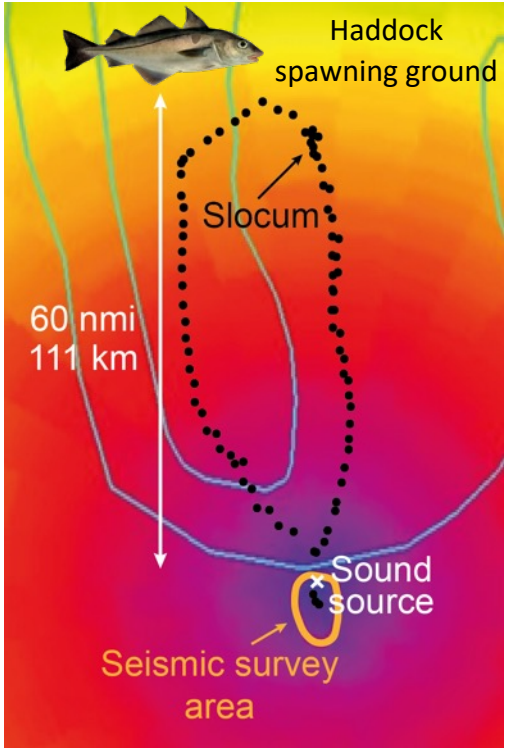


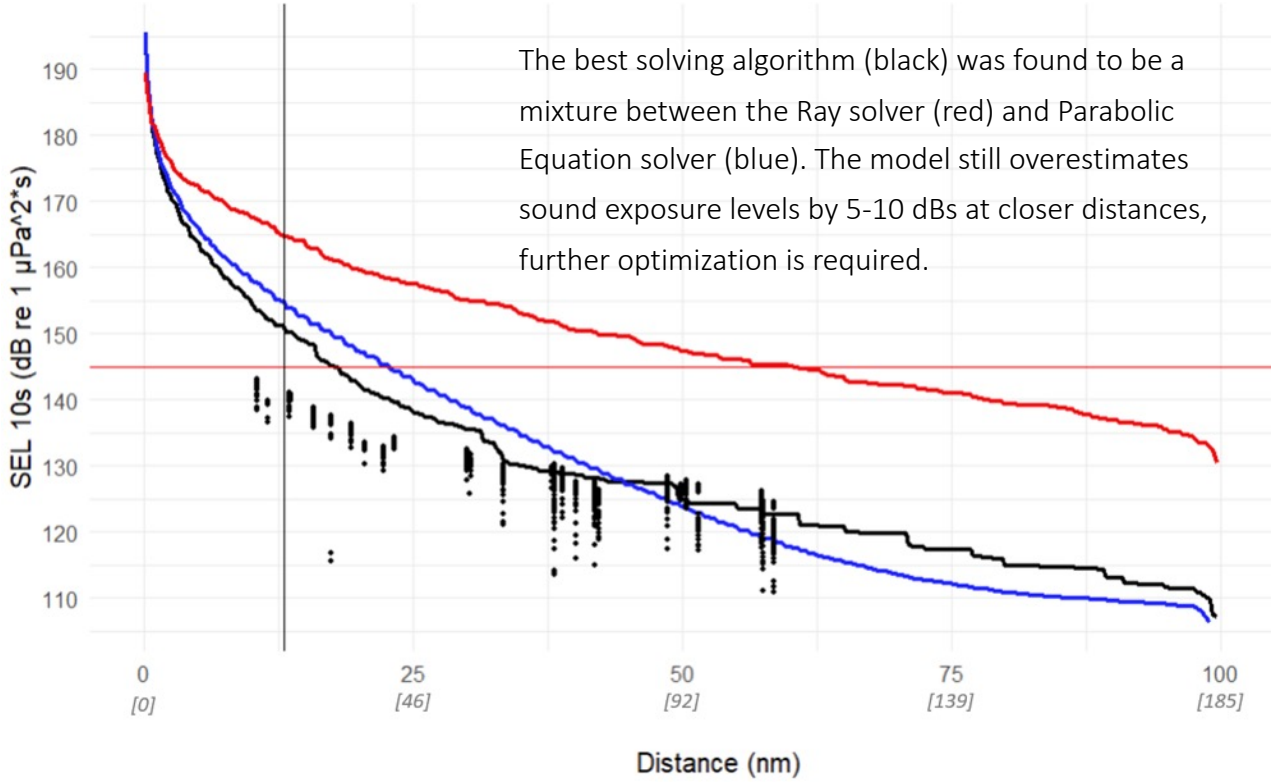


Within 1 km of the seismic vessel, denser and shallower fish schools

Characterize seismic sound propagation

Sound propagation models were created to determine sound levels in the vicinity of the seismic survey area and were then validated by the PAM Slocum

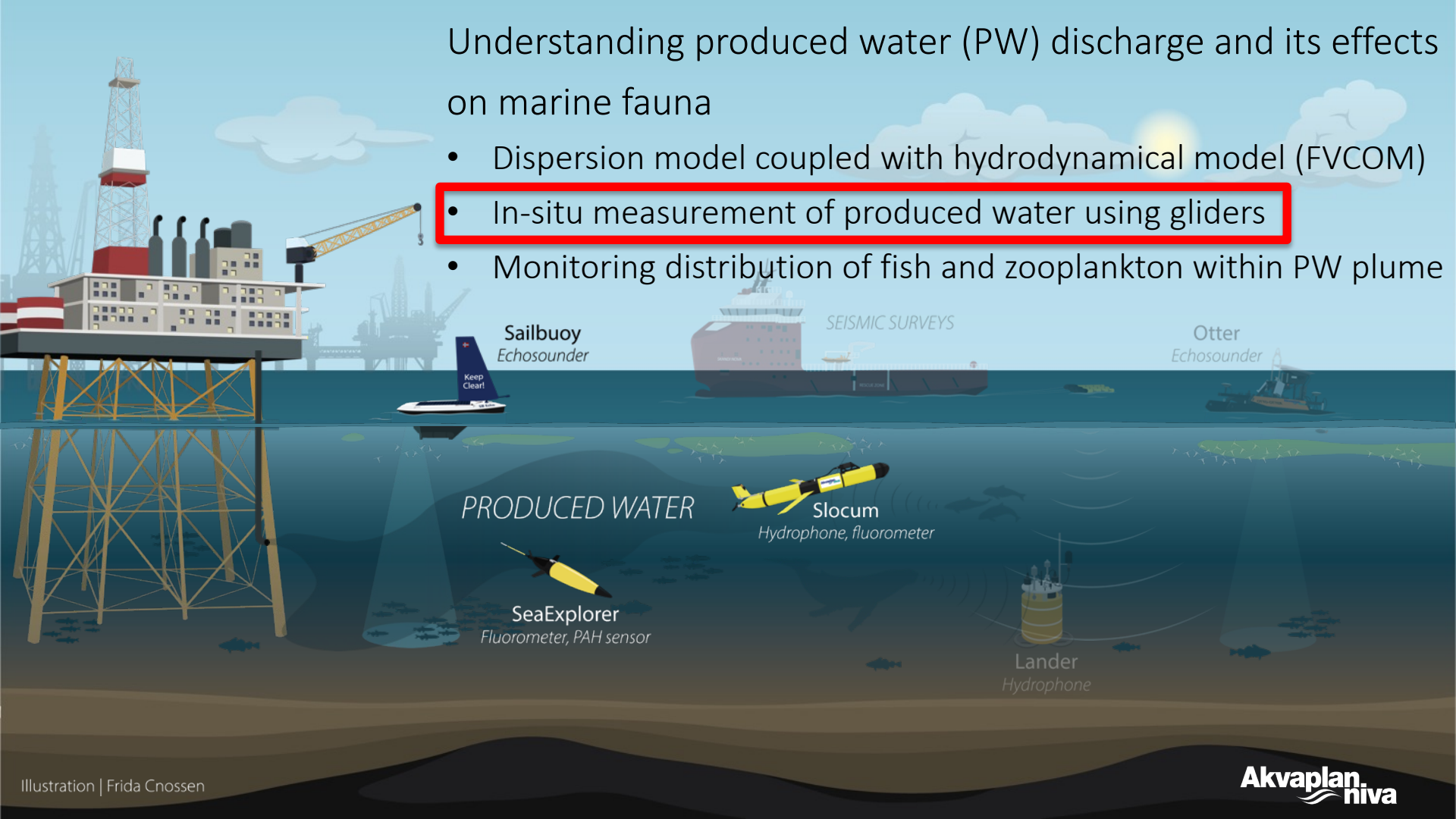


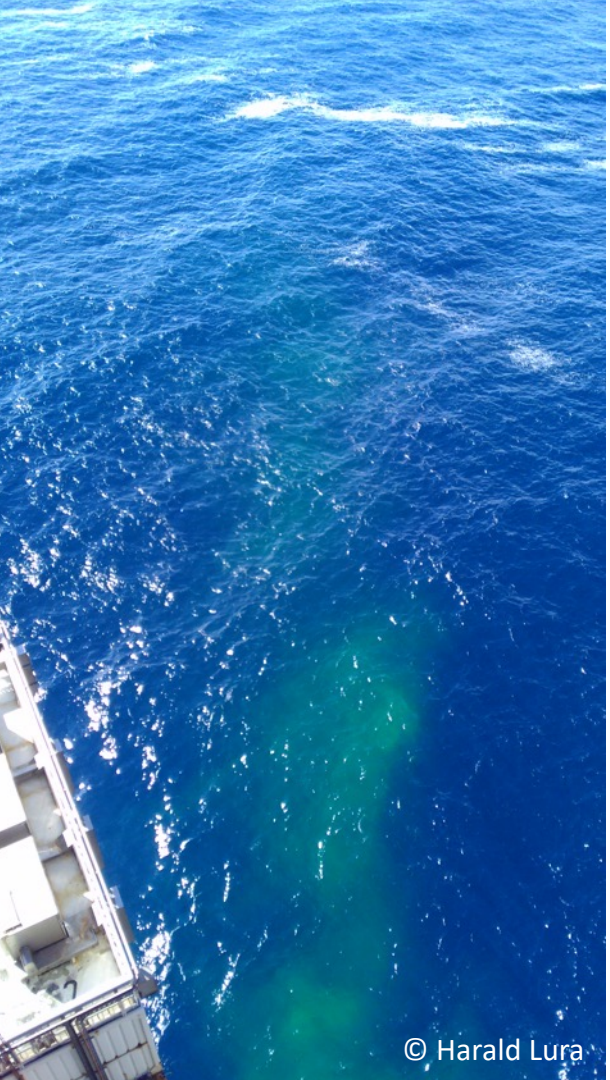


The best solving algorithm (black) was found to be a mixture between the Ray solver (red) and Parabolic Equation solver (blue). The model still overestimates sound exposure levels by 5-10 dBs at closer distances, further optimization is required.

Understanding produced water (PW) discharge and its effects on marine fauna

- Dispersion model coupled with hydrodynamical model (FVCOM)
- In-situ measurement of produced water using gliders
- Monitoring distribution of fish and zooplankton within PW plume





Mapping produced water discharge

- Test available autonomous technologies for detecting produced water in a real-industrial environment
  - **Indirect measurements**: Fluorescence observations after injection of a fluorescent dye (Uranine) in produced water
  - **Direct measurements**: in-situ observations of Polycyclic Aromatic Hydrocarbons (PAHs) in the water
- One Slocum with fluorescence sensor (ECOPUCK) and two SeaExplorer with fluorescence (ECO FLBBCD) and PAHs sensors (MiniFluo-UV)
- The data was used to validate the produced water plume dispersion model

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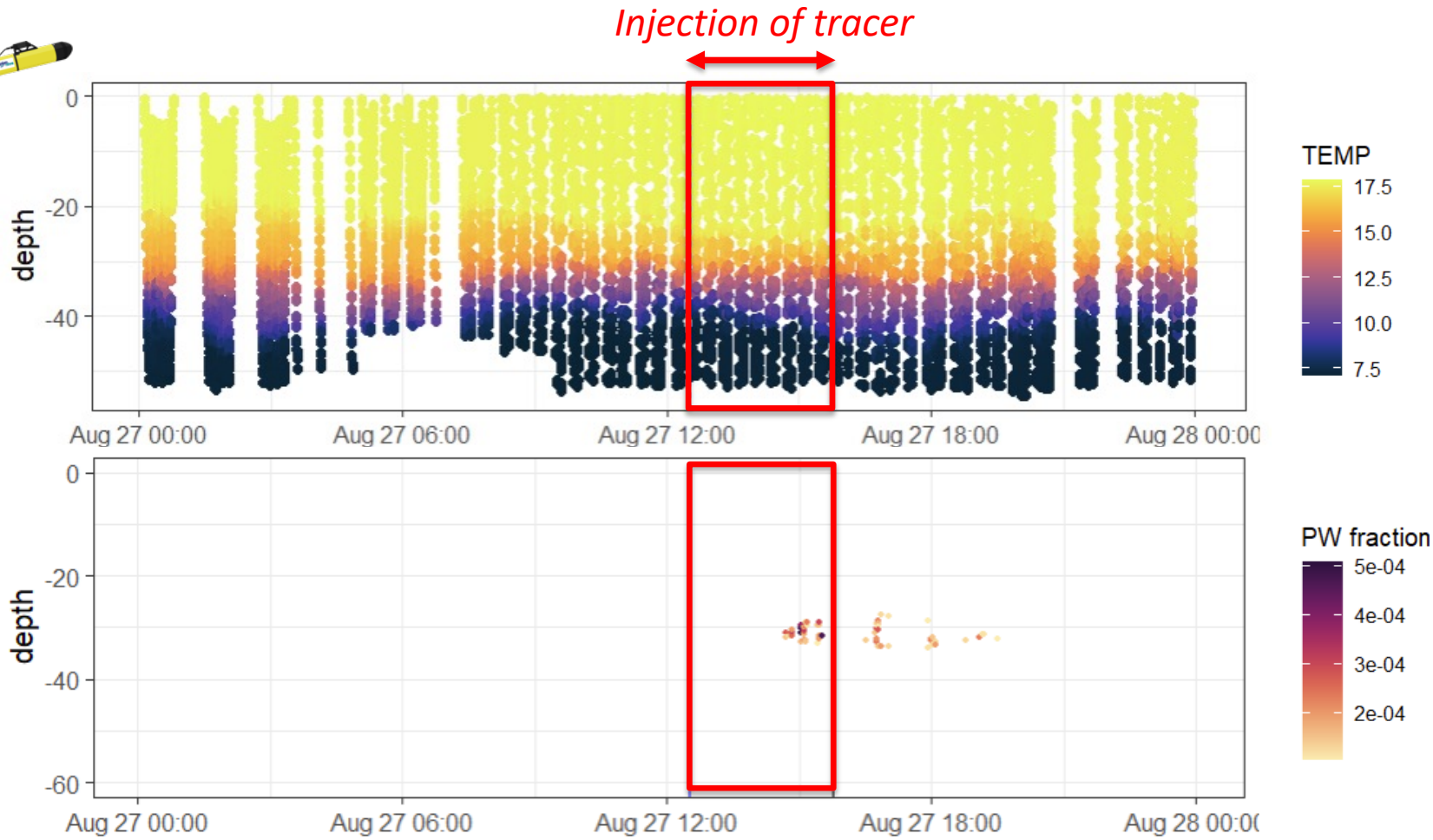
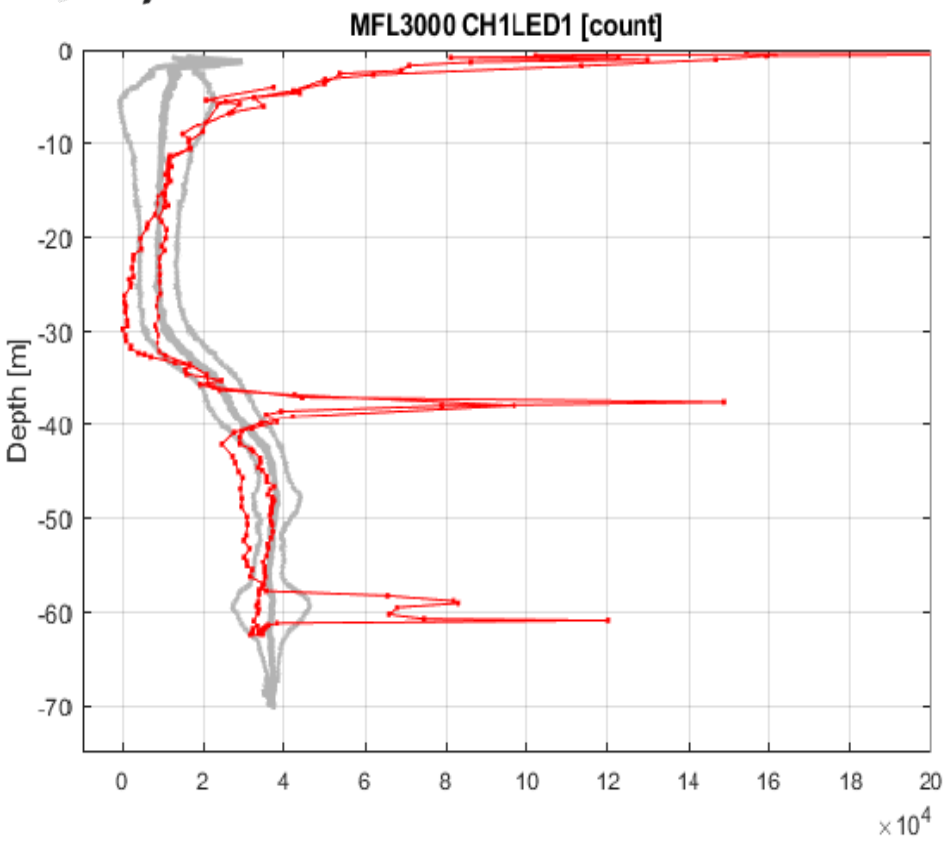
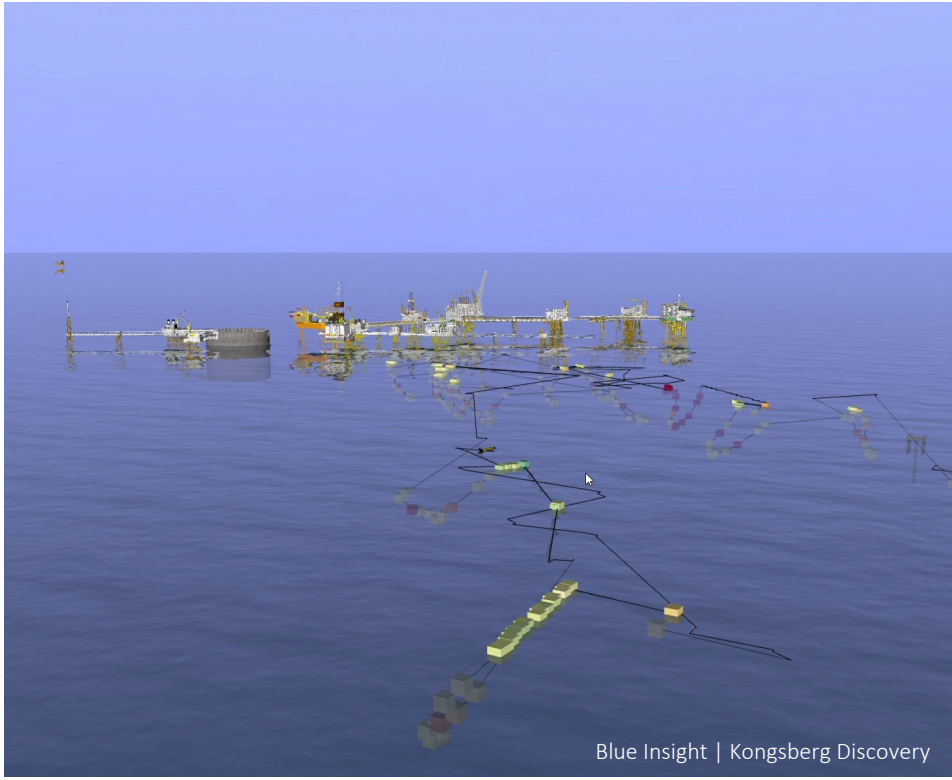
Detection of produced water dye tracer

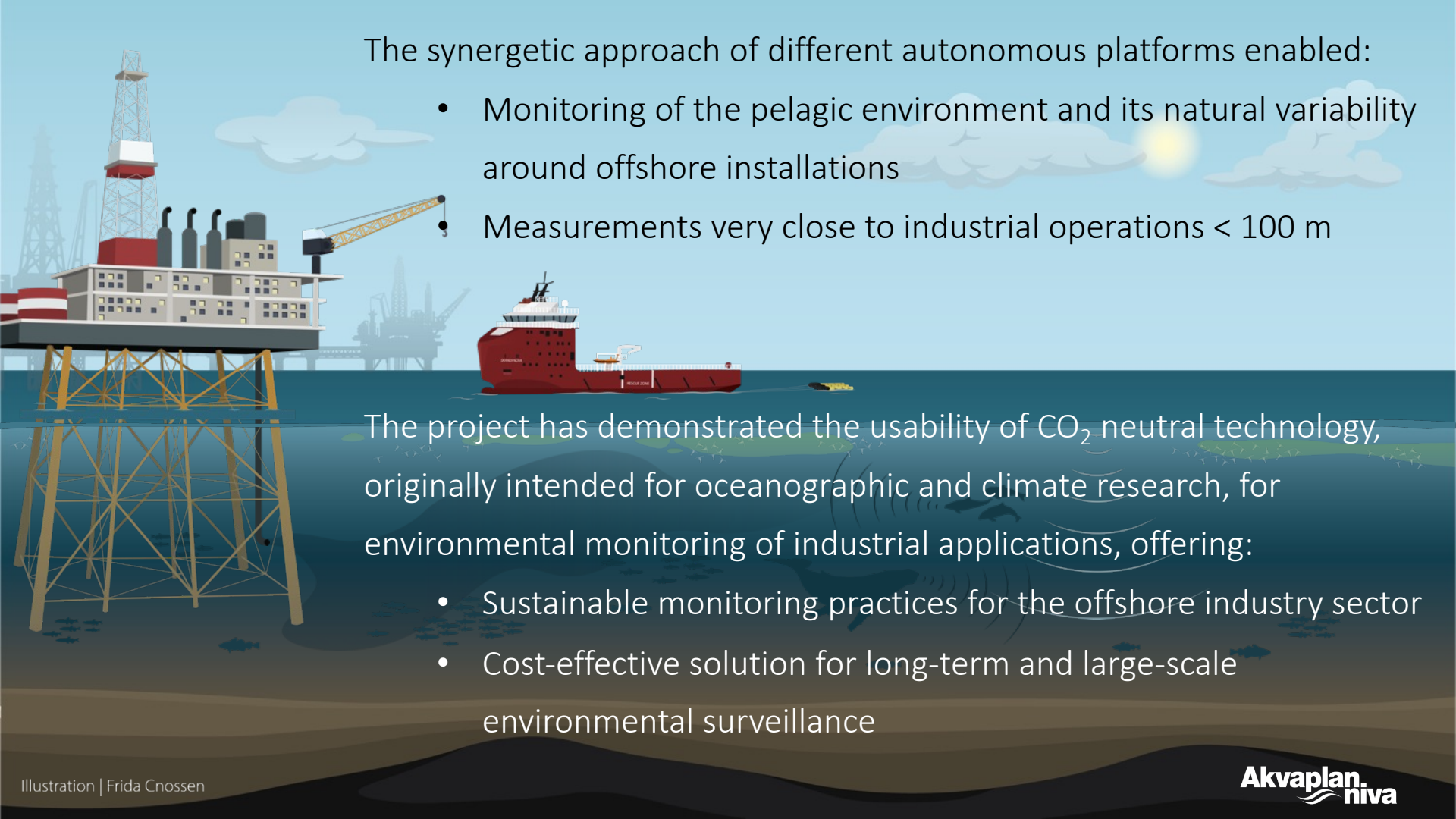


Detections of PAHs in the produced water plume

Naphthalene







The synergetic approach of different autonomous platforms enabled:

- Monitoring of the pelagic environment and its natural variability around offshore installations
- Measurements very close to industrial operations < 100 m

The project has demonstrated the usability of CO_2 neutral technology, originally intended for oceanographic and climate research, for environmental monitoring of industrial applications, offering:

- Sustainable monitoring practices for the offshore industry sector
- Cost-effective solution for long-term and large-scale environmental surveillance

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