Underwater Ordnance Contamination: Managing Risks, Developing Capacities

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TETRA TECH

Underwater Explosive Ordnance (EO)

Todd Biggs, VP

Developing Capacity

- Underwater EO & Diver Training
  - Training for underwater EO and dive operations
  - Specialized diver safety and UW EOD procedures
- Regulations and standards - Mixed
- Dive regulations vs explosive/EOD regulations
- Local dive capacity vs local EOD capacity

Risks

- EO Investigation & Removal
  - EO identification and disposal
    - Dive personnel or via remote means
- Reduce in water work to a minimum
- If ordnance is safe to move – move it out of water
  - To land or barge
- Contamination – easier to control out of the water
- What are the ordnance risks? CWM

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Human-first Innovation : from Tech-Driven to Human-Focused Recalibrating Innovation for a Better Tomorrow

HAMAP HUMANITAIRE

Cédric Tisserand

EOD Regional OPS Management Advisor

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Human-First Innovation

In a world constantly seeking technological innovation, it's often overlooked that behind every **SUCCESSFUL MISSION IS A HUMAN PRESENCE**. In Underwater Explosive Ordnance operations, robots, drones, and other advanced technologies are valuable, but at the end, it’s the human who takes the risk and decides.

This requires managing complex techniques and physiological and psychological stress.

Faced with these sources of stress, which lead to a high risk of diving incidents or accidents, it seems necessary and essential to protect divers' health.

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Quality Monitoring of **Decompression Procedures**

Risk Management: Prevention of Decompression Sickness

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Prevention of decompression sickness

Factors increasing the risk of diving accidents:

- Physical exertion of the diver
- External conditions (cold, depth, poor visibility, current…)

These accidents could occur randomly, despite compliance with regulatory decompression procedures.

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Prevention of decompression sickness

How can diving incident be mitigated when operating at a site remote from any medical infrastructure with recompression capabilities?

- CUSTOMIZED DECOMPRESSION
- IN WATER RECOMPRESSION

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Customized Decompression

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Customized decompression

Personalized decompression would allow for the quality of decompression procedures to be controlled and monitored under real-world working conditions.

How to proceed ?

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Customized decompression

Analyze the quality of decompression procedures, based on the physical measurement of the number of microbubbles present in the venous system of divers after a dive.

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Customized decompression

Prevention of Decompression Sickness

The quality of the dive procedures is analyzed for each dive that takes into account the level of vascular bubbles detected as well as the severity of the dive (deepth, time, strenous physical effort).

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Customized decompression

SIGNALS
VENOUS FLOW

HYPERBARIC
EXPOSURE
DATA

DATA SENT
TO
AN EXPERT
FOR
ANALYSIS

CUSTOMIZED
DECOMPRESSION
DEPENDING ON
THE RESULTS

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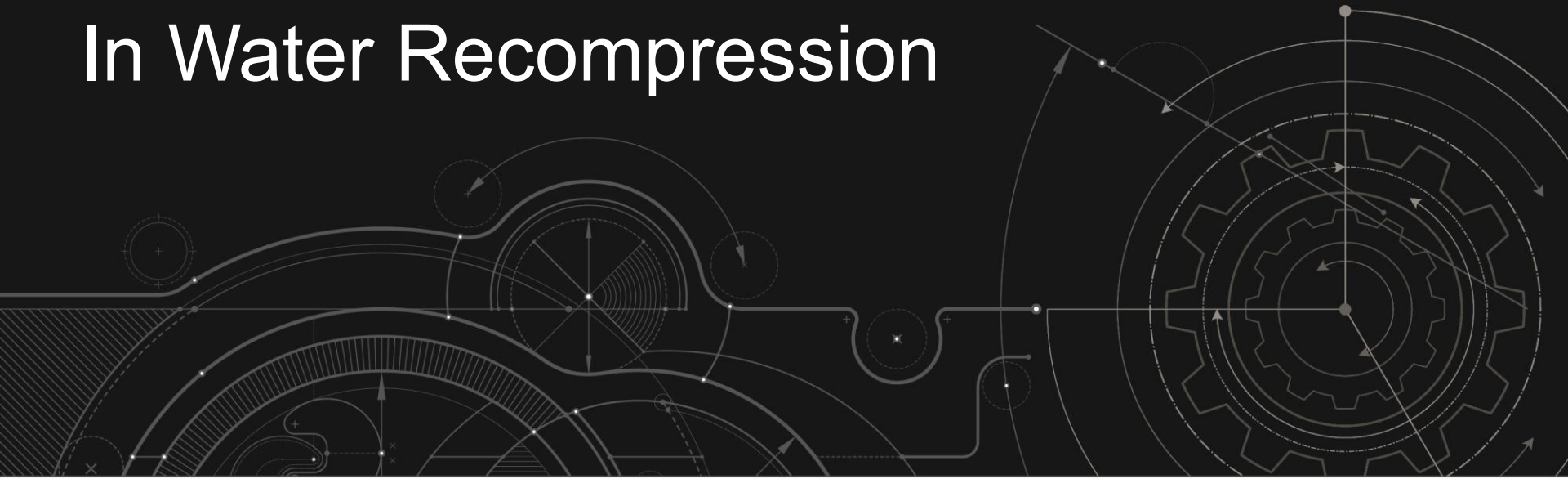
In Water Recompression



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In Water Recompression

- 2022, HAMAP project in Raqqa (NorthEast Syria)
- Clear Underwater EO contamination in the Euphrates River, wells, and irrigation canals.
- Recommended medical support for underwater activities:
  - recompression chamber
  - specialized hyperbaric doctor

NOT AVAILABLE IN RAQQA

Other solutions had to be found.

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In Water Recompression

- Diving in remote areas, far from any medical facilities, presents challenges in managing and evacuating diving accidents.

- In the absence of an on-site hyperbaric medicine specialist and hyperbaric chamber, remote medical evaluation via teleconsultation should be sought.

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In Water Recompression

- The goal is to establish a diagnosis by identifying cases that do not require hyperbaric treatment from those that do.

- Provided that certain well-identified risks are managed and specific training is in place, therapeutic in-water recompression may be considered when no hyperbaric chamber is available.

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In Water Recompression

The main objectives of this teleconsultation are:

- ✓ to verify the absence of life-threatening conditions requiring immediate first aid;
- ✓ to clarify the diving conditions and circumstances of the incident;
- ✓ to identify the patient's medical history, treatments, and individual risk factors;
- ✓ to clarify all symptoms that have appeared and their chronology.

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In Water Recompression

Following the consultation, the medical opinion will inform the diving supervisor of the appropriate course of action and, if necessary, refer the diver to an In Water Recompression.

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In Water Recompression (IWR)

IWR for treatment of Decompression Sickness (DCS):
a reality in fields of diving professionals.

Abalone divers in Australia
Diving fishermen in Hawaii

Many of these individuals walking around today might be dead or confined to a wheelchair had they not re-entered the water immediately after noticing symptoms of DCS.

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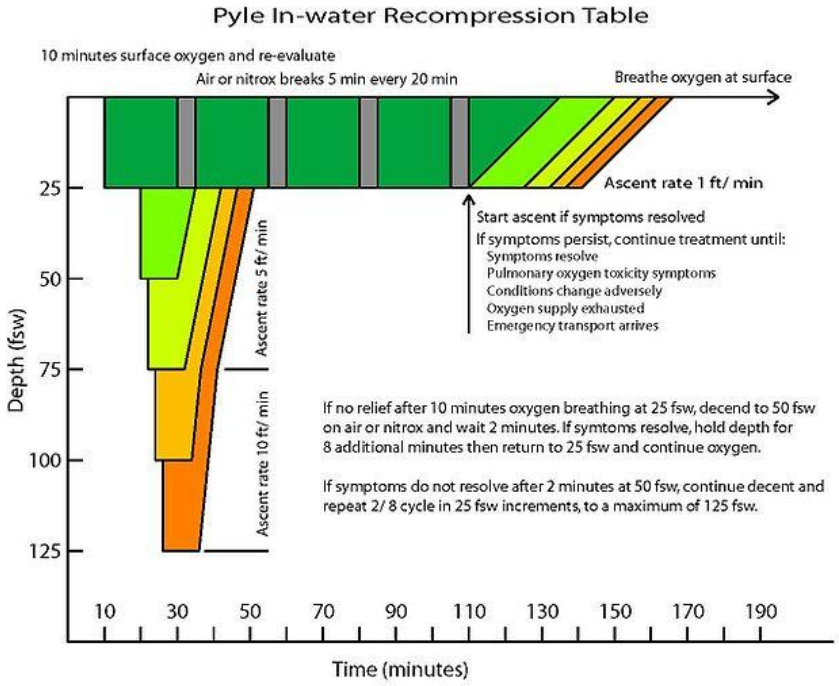
In Water Recompression

HAWAIIAN PROTOCOLE

Case Study of 527 Hawaiian fishermen divers : re-immersion in air

- 462 cases (88%) resolution of symptoms
- 51 cases (10%) mild residual symptoms
- 14 cases (2.6%) persistent symptoms + additional treatments
- No divers worsened after re-immersion



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In Water Recompression

CLIPERTON PROTOCOLE

The **Clipperton Expedition** was an ambitious scientific mission focused on biodiversity.

- Daily Dives 60 m depth
- Nearest hospital acapulco, mexico 1280 km

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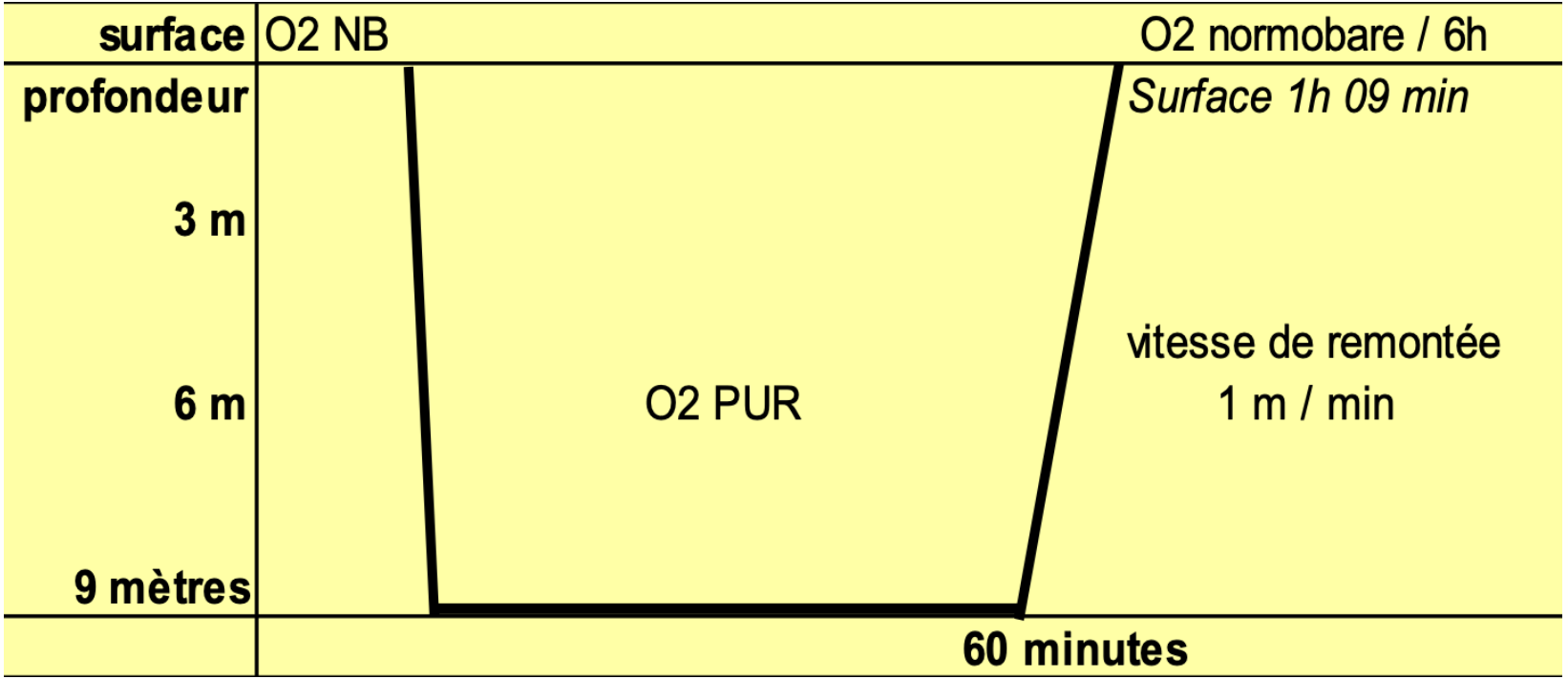
In Water Recompression



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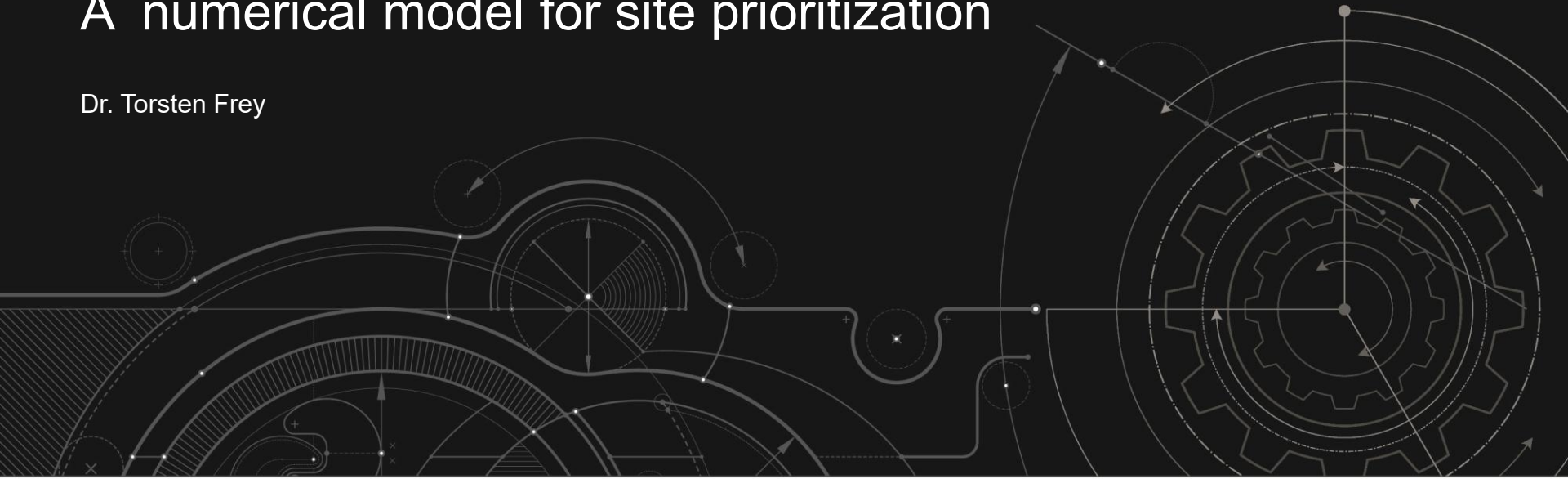
Multicriteria decision making – A numerical model for site prioritization

Dr. Torsten Frey



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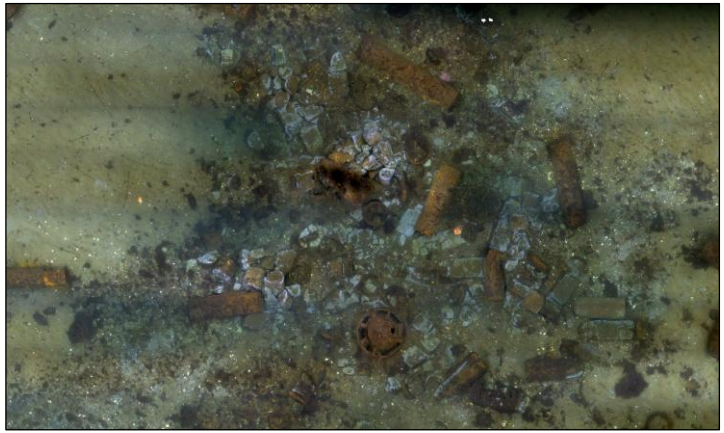
Background and Aim

Aim:

Participatory creation of a priority list for the clearance of ammunition piles

Question:

Where in the German Baltic Sea should the clearance of sea-dumped munitions begin?



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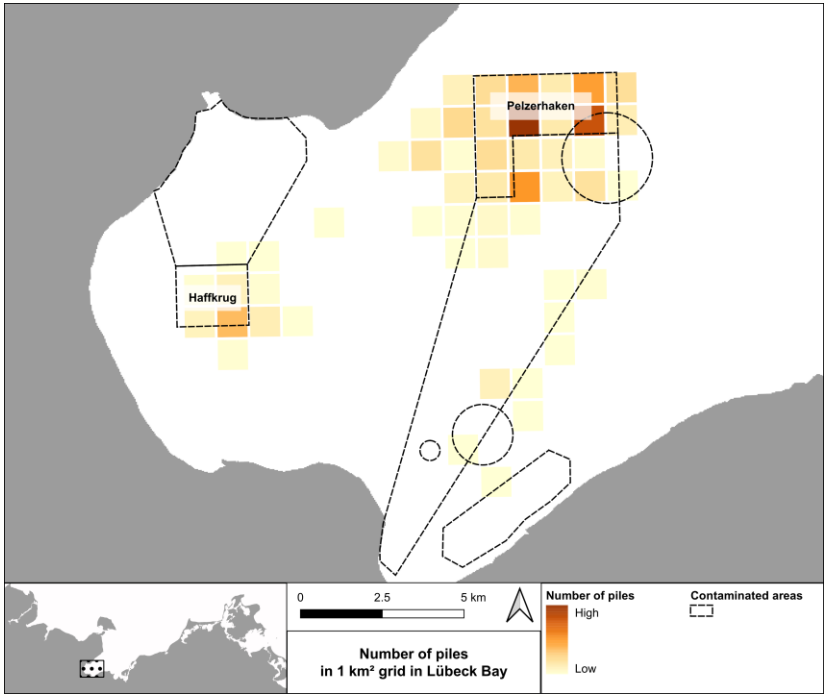
Background and Aim



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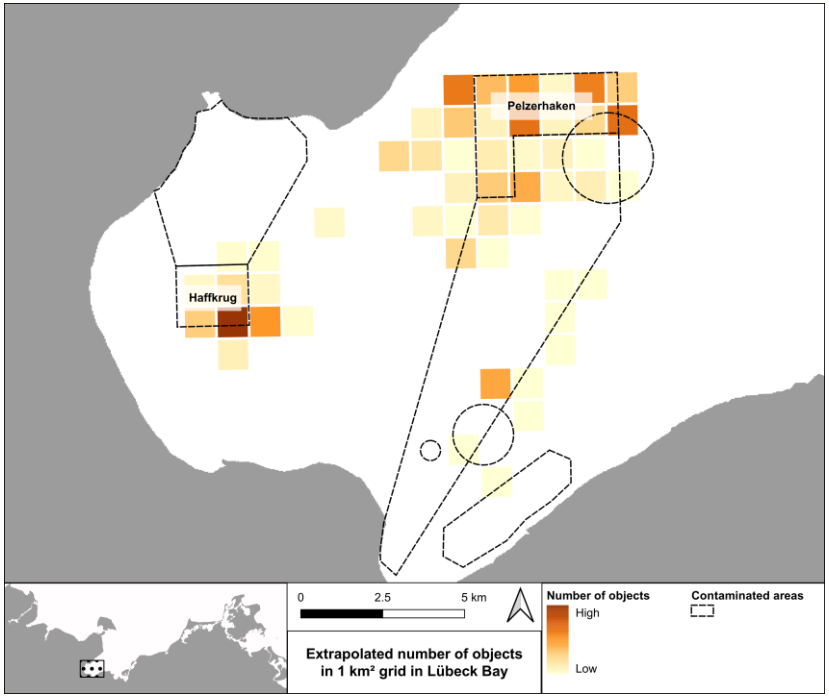

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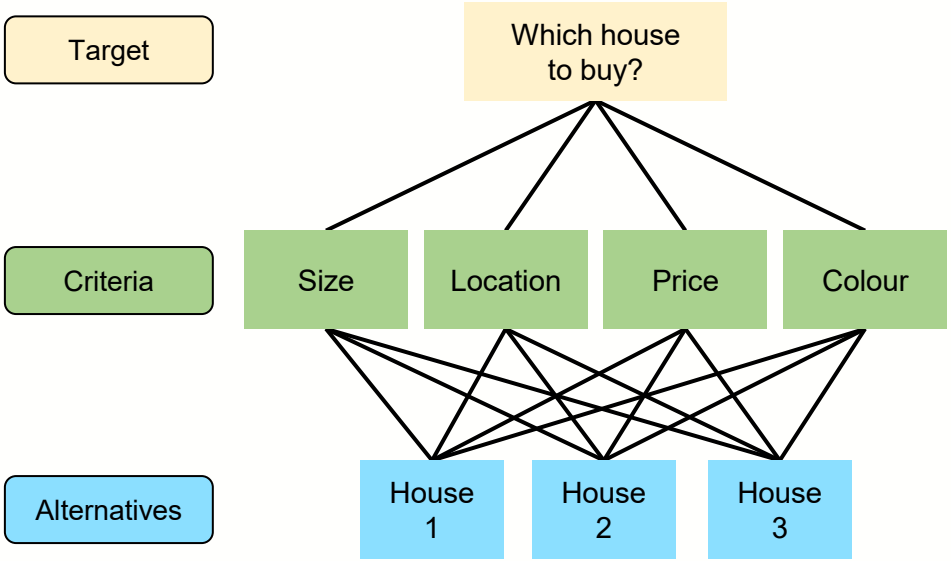
Method – Analytical Hierarchy Process

Method to support complex decision-making problems (Saaty, 1977)

Steps

1. Target definition
2. **Identification and organisation of criteria**
3. Pairwise comparison of criteria on a given level concerning the contribution to the next level
4. Calculation of a score for each alternative



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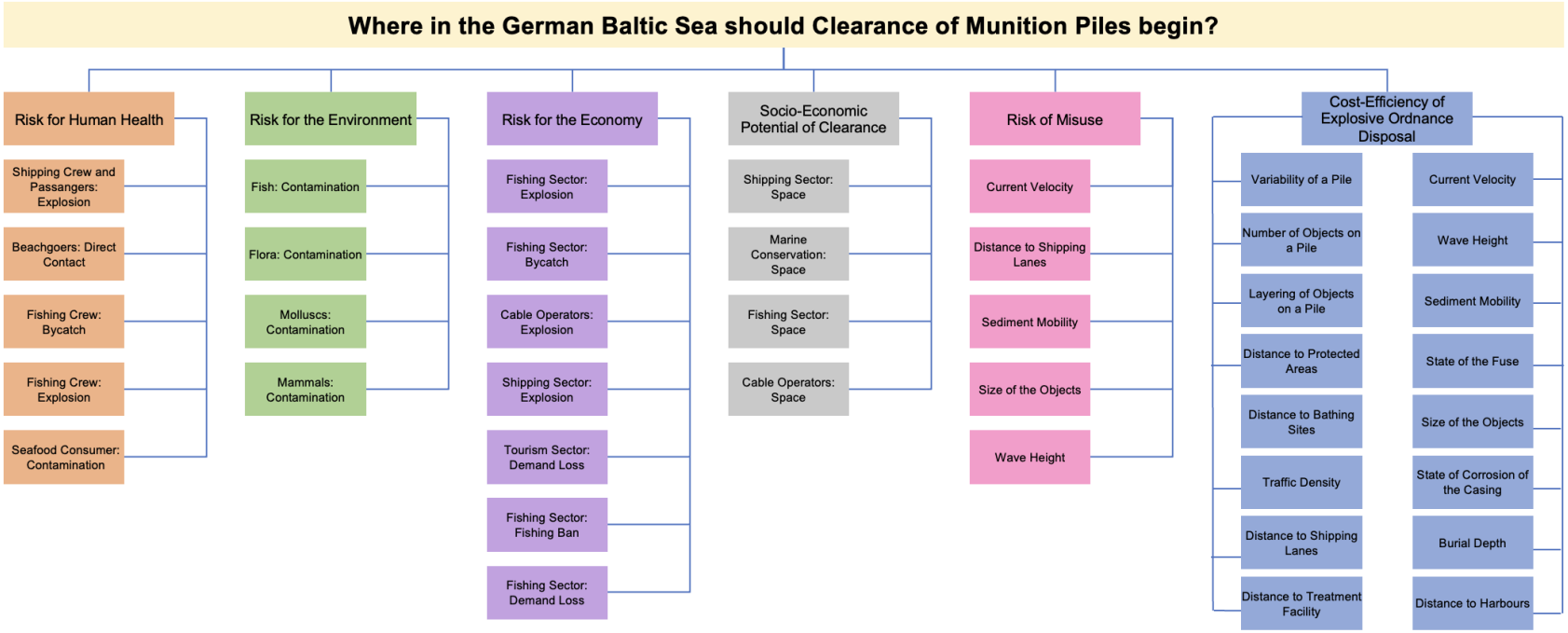
Method – Decision Tree



Currently 484 (potential) Munition Piles

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Method – Co-Creation Process

Data Collection **(CONMAR)**

Co-Design Workshop **(Stakeholders and experts)**
Preliminary identification of criteria

Co-Development Workshops: Determination of criteria, identification of data, weighting of criteria

Type A **(Experts)**	Type B	Type C
• Determination of criteria and relevant input data (using SPRC model)	• Pairwise comparison of criteria to obtain opinions on relative importance of criteria **(Stakeholder)** • Pairwise comparison of criteria to obtain expert knowledge on relationships between criteria **(Experts)**	• Identification and weighting of factors for cost efficiency (**EOD experts**)

MCA Application **(CONMAR)**
Creation of a priority list of munitions piles using MCA

Co-evaluation workshop: Presentation and evaluation of the results (**stakeholders and experts**)

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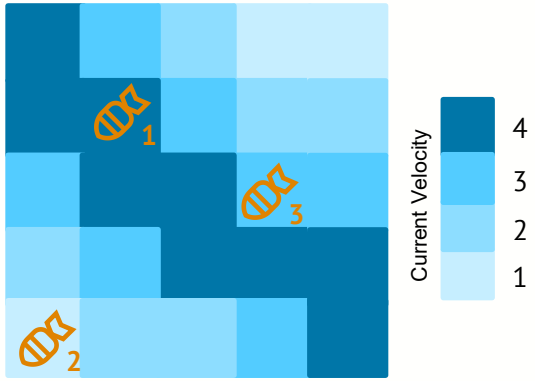
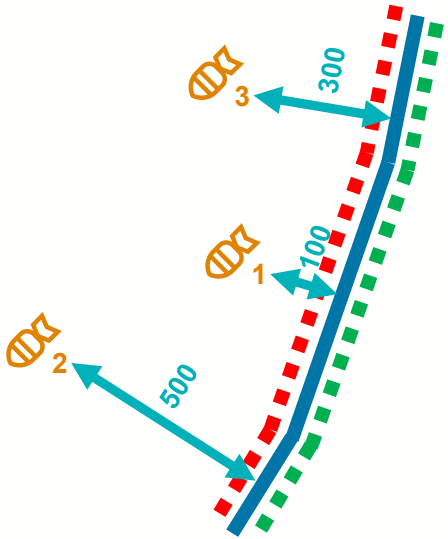
Method – QGIS Implementation

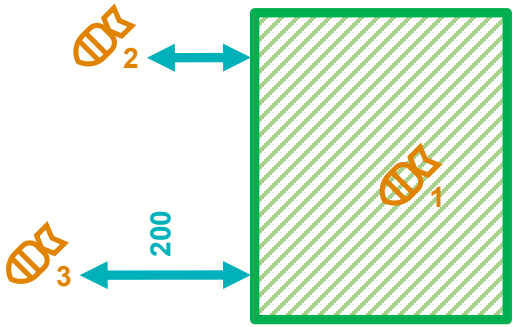
Current Velocity



Distance to Waterways



Distance to Nature Protected Areas



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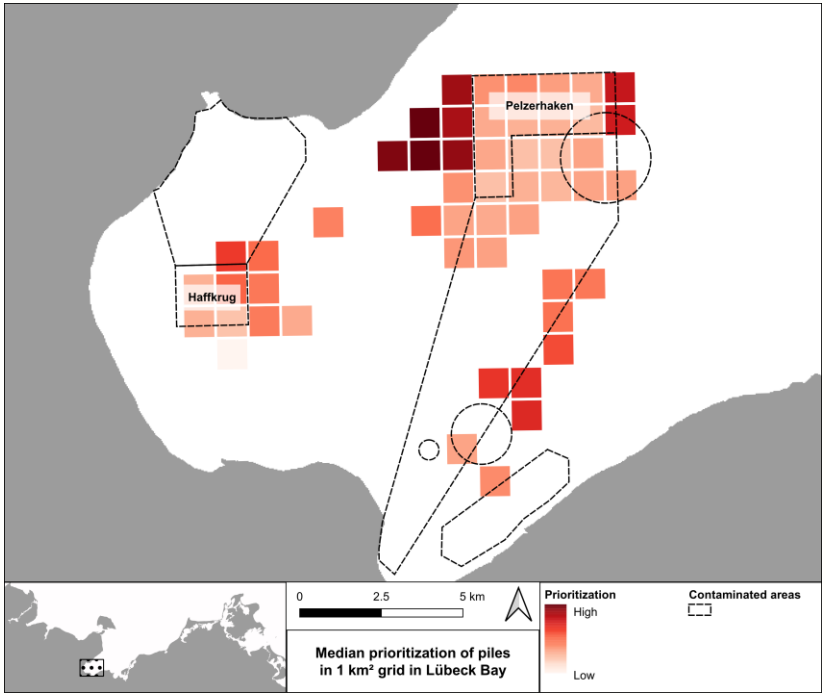
Results – Analytical Hierarchy Process



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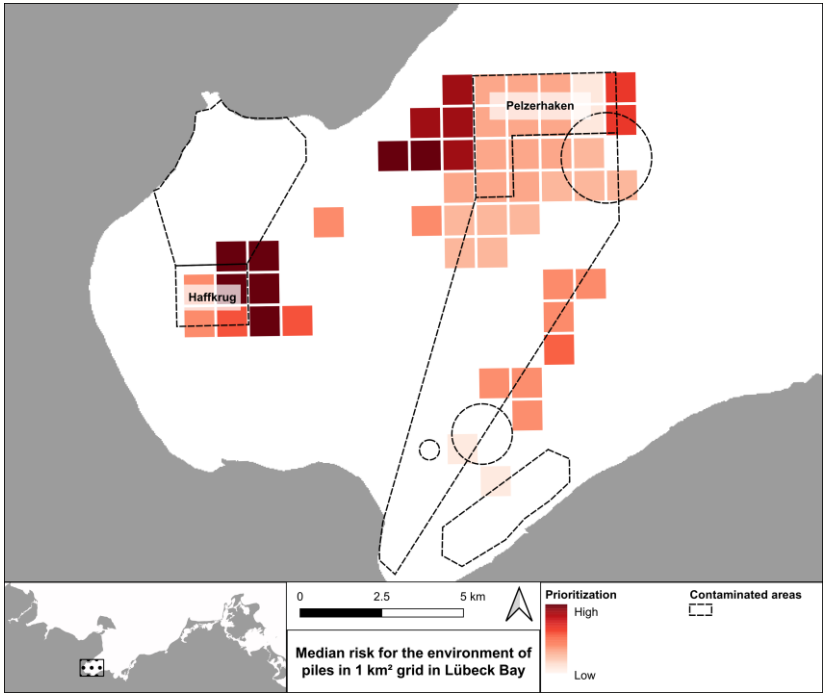

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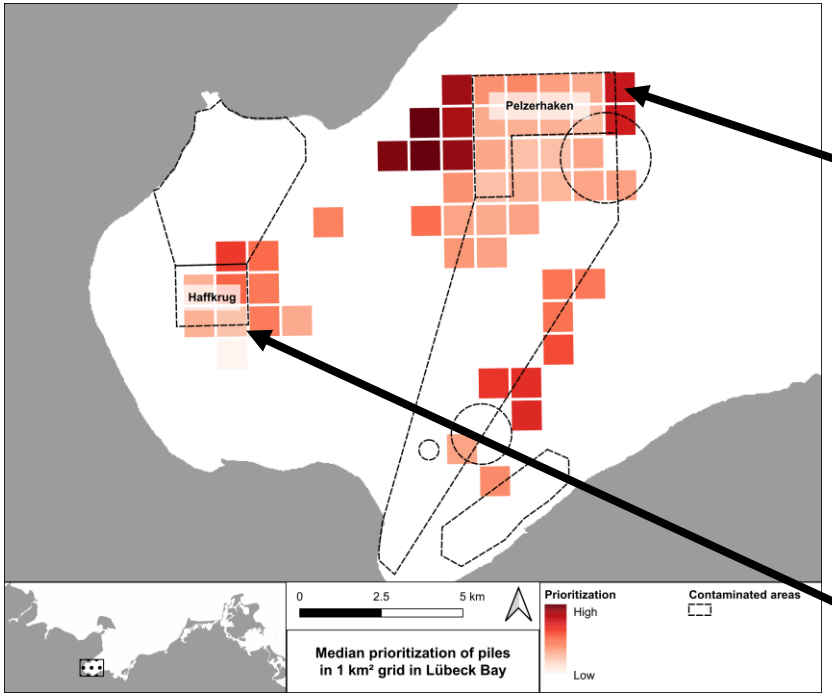
Results – Analytical Hierarchy Process



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Pile ID	**Prioriti-sation**	Risk for Human Health	Risk for the Economy	Risk for the Environment	Risk of Misuse	Cost Efficiency of EDO	Socio-Economic Potential
Pzh_00266	**5.15**	5.77	2.82	3.03	6.61	6.98	7.60
Pzh_00009	**5.10**	5.47	2.57	3.03	7.45	6.66	7.60
Pzh_00066	**5.08**	5.64	2.74	3.03	6.79	6.63	7.60
Pzh_00222	**4.46**	4.44	1.56	3.95	6.56	4.97	5.74
Pzh_00032	**4.38**	3.69	1.01	3.95	6.62	6.13	6.18
Pzh_00219	**4.37**	3.51	0.83	3.95	7.25	6.17	5.86
Pzh_00200	**4.18**	3.41	1.42	3.03	6.51	6.78	6.38
Pzh_02219	**4.11**	3.31	1.36	3.03	6.74	6.40	6.20
Pzh_00202	**4.10**	3.45	1.46	3.03	6.40	6.23	6.31
Pzh_00269	**4.06**	3.00	1.12	3.03	7.31	6.46	6.10
Kbh_00001	**3.80**	2.94	1.31	3.63	6.79	5.30	3.38
Haf_00320	**3.56**	1.62	0.42	4.29	7.55	6.37	1.19
Haf_00323	**3.51**	1.75	0.51	4.29	7.71	5.74	0.65
Pzh_00037	**3.49**	3.04	1.29	1.77	6.65	5.90	4.80
Pzh_00241	**3.43**	2.72	0.86	1.77	6.71	6.21	5.12

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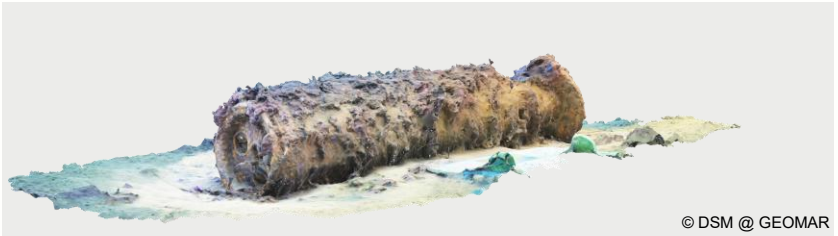
Summary

- In the German Baltic Sea 484 (potential) munition piles have been detected
- The model MCA-DuMP
  - Considers stakeholder opinion and expert knowledge
  - Uses existing and new data
  - Is implemented in QGIS
- The model calculates a priority list for the clearance of munitions in the German Baltic Sea



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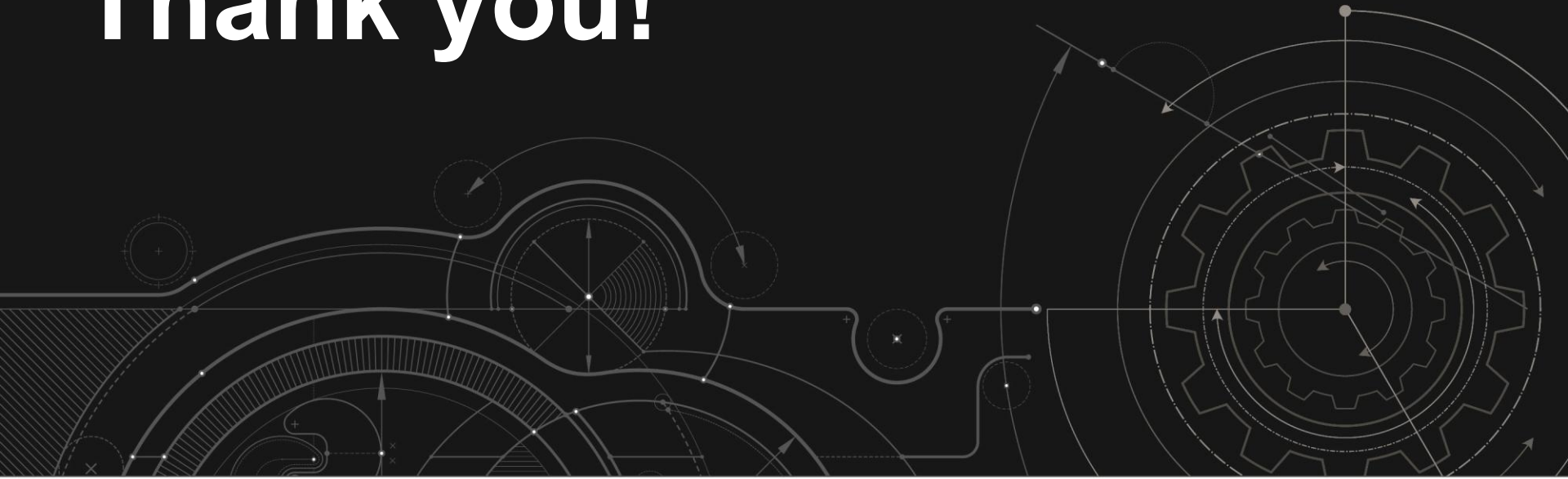

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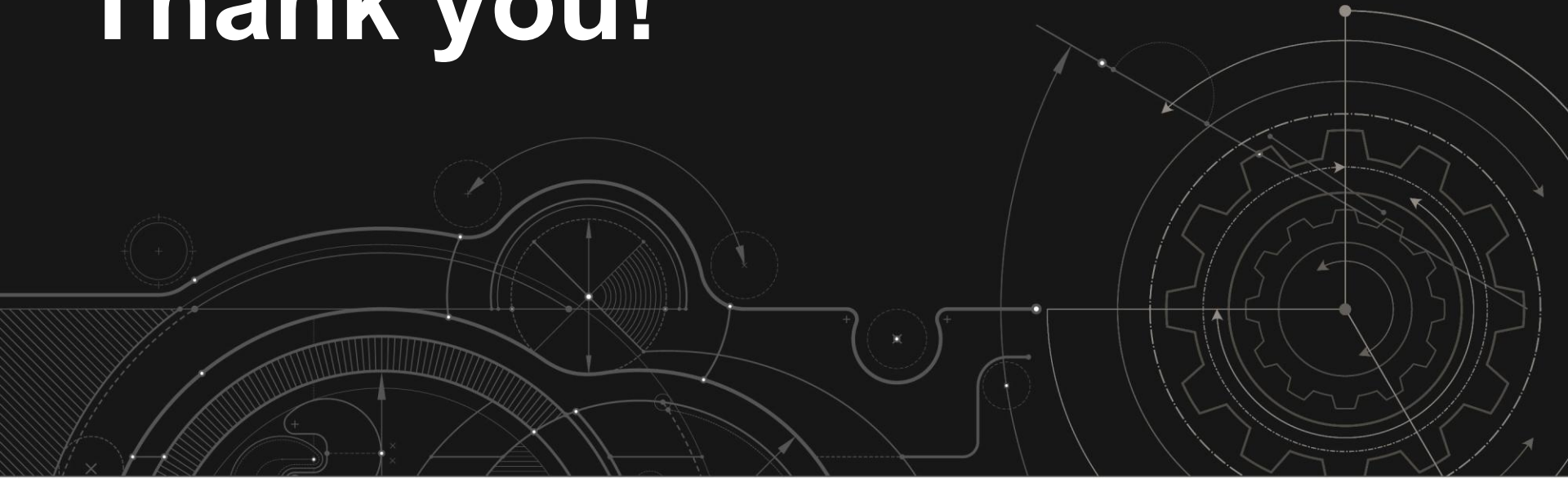

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