



Key-note

Underwater UXO DETECTION & CLASSIFICATION The European Perspective

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Structure of the presentation

- Introduction
 - Causes & dimension of the problem
 - Range of objects
- European Activities
 - Administrative Activities
 - Research Activities
 - Political Initiatives
- Technology challenges
- If I had a dream.....



Environmental impact



Concerns regarding munitions and explosives (MEC) under water



Corrosion

Direct contact and slow release of chemical compounds into sea water and sediment



Noise of blasts

et. al. Risk for divers and sea mammals.



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Time matters



- Increasing sensitivity of explosives during time
 - Improper “storages” conditions
 - Corrosion and other physicochemical processes
 - Salt formation at the brass-explosives interface of fuzes



British contact mine in-situ

© Min. of Interior, 2013

ZUSAMMENFASSUNG

Abstract

	Erscheinung	Schlagempfindlichkeit [Nm]	Wasserlöslichkeit bei 20°C [g/l] [11]
2,4,6-Trinitrotoluol	Schwach gelbliche Kristalle	15	0,127
2,4-Dinitrotoluol	Gelbe Nadeln	50	0,27
2,4,6,2',4',6'-Hexanitrodiphenylamin	Kanariengelbes Kristallmehl	7,4	<< 0,1
Ammoniumnitrat	Farblose Kristalle	49	1877

Realität:



© Fraunhofer

Fraunhofer ICT

More [de]: <http://dfabgmbh.de/wp-content/uploads/17-Untersuchung-altungsbedingter-M%C3%BCller.pdf>



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Did you notice?

- Moored sea mine floated off Windfarm „Gode Wind II“ on January, 10th 2018
- Detonated on purpose next day, close to port of Wilhelmshaven



The mine from WW I, 2019



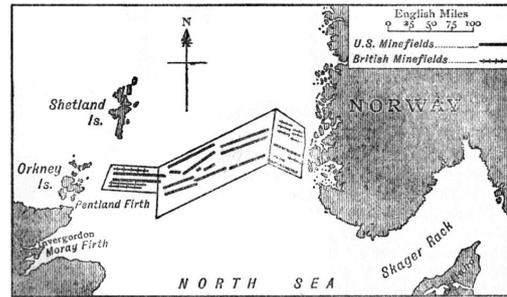
© German Life Saving Ass. – DLRG – www.cuxhaven.dlrg.de

Sea mine warfare

Northern Barrage 1918

Ø 70,000 mines, each containing 300 lbs of explosive were laid.

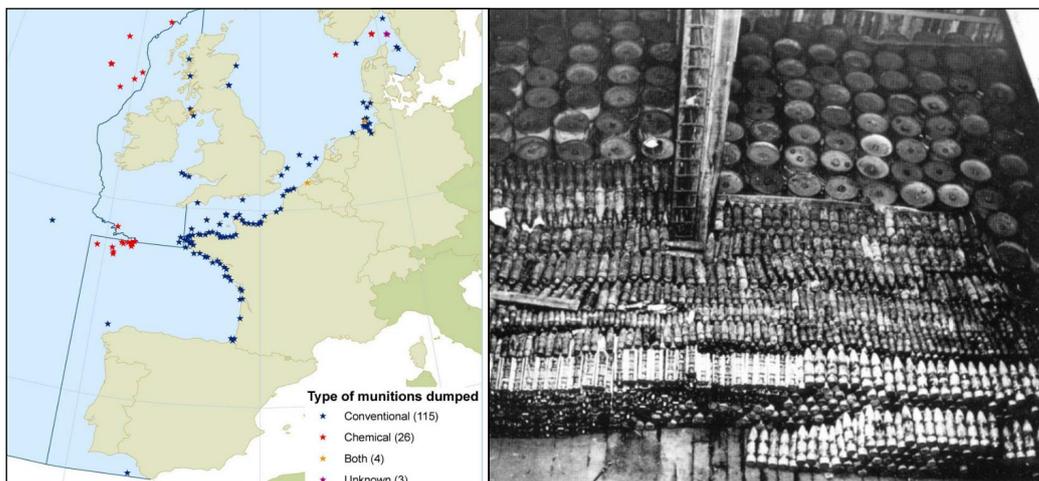
In the North & Baltic Seas, approx. 700,000 mines were laid during the two World Wars, many unrecovered and regularly encountered to this day.



Sea Dumping

Post-European wars: Millions of tons were dumped along an Oceanic Arc, in deep & shallow waters

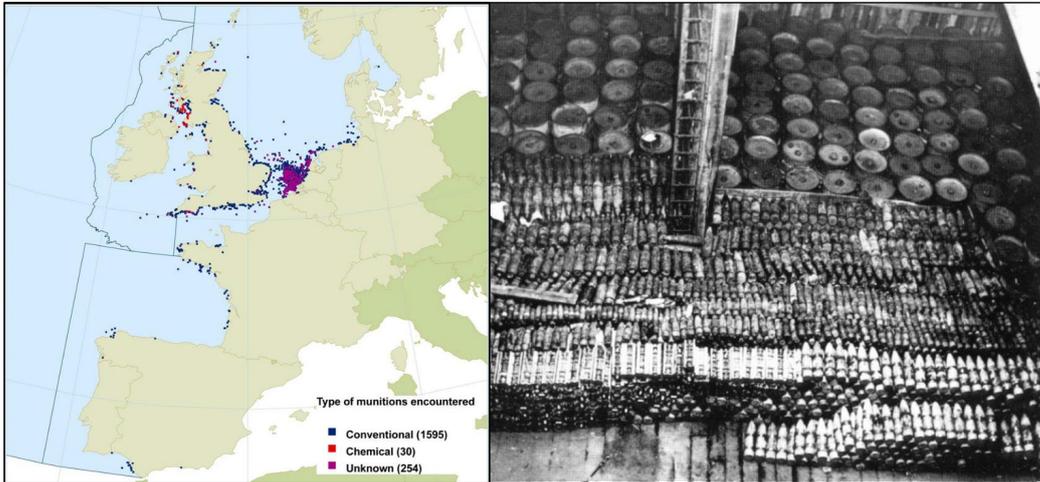
Types of Munitions Dumped



Sea Dumping

Post-European wars: Millions of tons were dumped along an Oceanic Arc, in deep & shallow waters

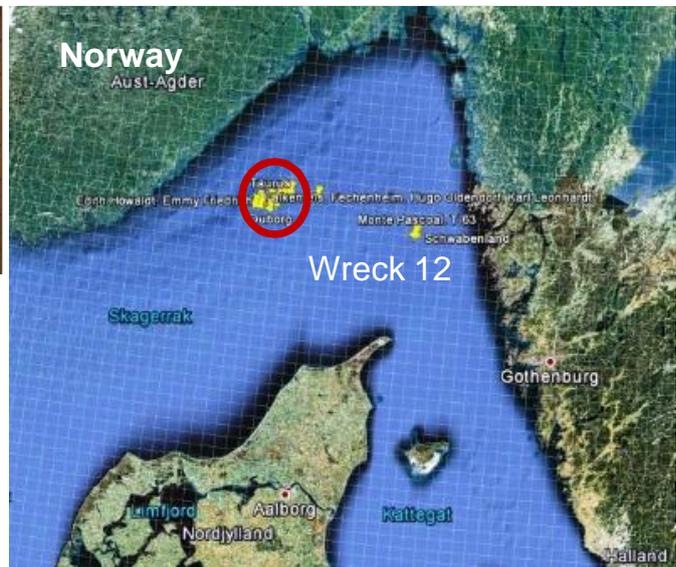
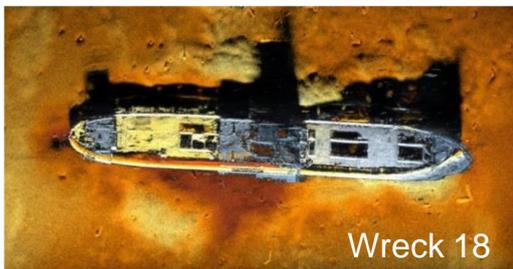
Types of Munitions Encountered



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Sunk Vessels NOR Skagerrak CW dump site

Courtesy FFI and Norwegian Coastal Administration



Source: <https://www.ffi.no/no/Rapporter/19-00245.pdf>

Courtesy FFI and Norwegian Coastal Administration

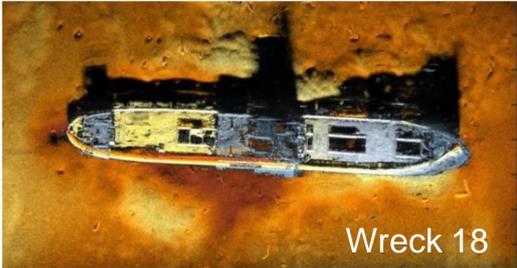


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Sunk Vessels NOR Skagerrak CW dump site

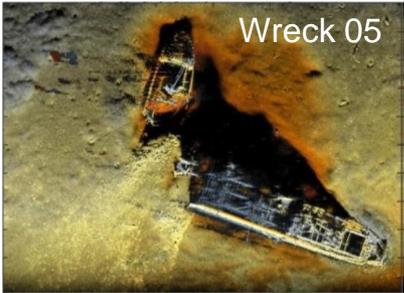
Courtesy FFI and Norwegian Coastal Administration



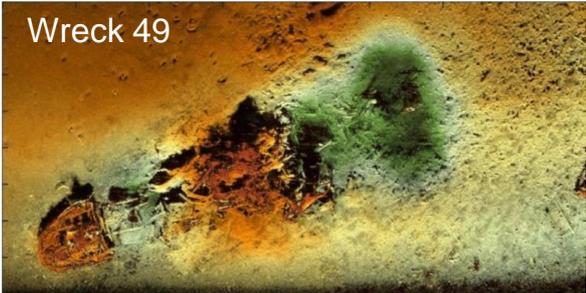
Wreck 18



Wreck 49



Wreck 05



Source: <https://www.ffi.no/no/Rapporter/19-00245.pdf>

Courtesy FFI and Norwegian Coastal Administration



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Range of objects

Artillery shells found in North Sea & Baltic Sea:

grenade, burst, 2016, rusted cartridge case, 2015, grenade - embedded in concrete, 2013



Covered mine



corroded mine



buried mine



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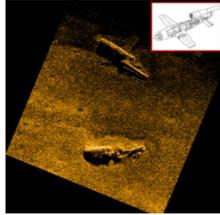
Range of objects

Other Objects found in North Sea & Baltic Sea :

ammunition box, 2016,



„V1“-missile, 2014,



gun cotton 2018



Munitions encountered:

Dumped to piles, sunk in hulls and vessels, single items of various shapes and conditions

Objects may or may not resemble original (expected) shape



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Administrative Activities in Germany



BLMP-Report

„Munitions in German Marine Waters - Stocktaking and Recommendations (Effective 2011)“



Cross-administrative working group of federal and coastal states representatives
approx. 1,100 pages



December 5th, 2011



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Overall assessment (Effective 2011)

Currently, it is not discernible that a large-scale threat to the marine environment exists



beyond the local area of munitions contaminated areas, nor is any foreseeable in the future.



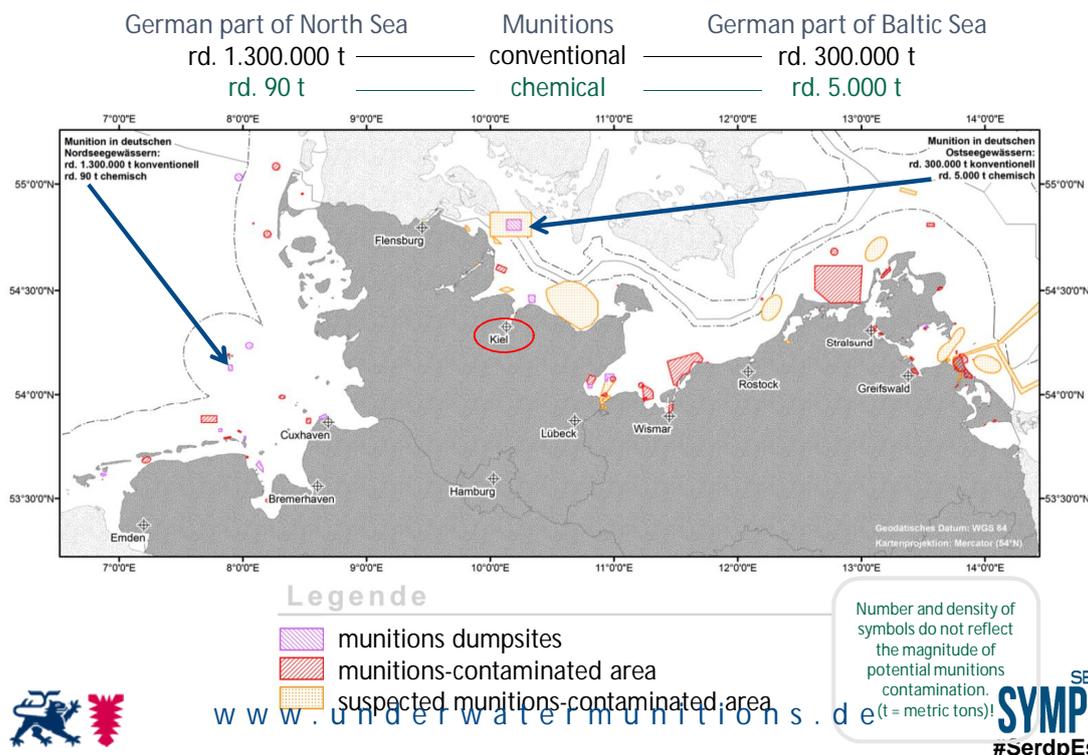
Hazards exists for people involved in activities bringing them into direct contact with the sea floor of the North and Baltic Seas.



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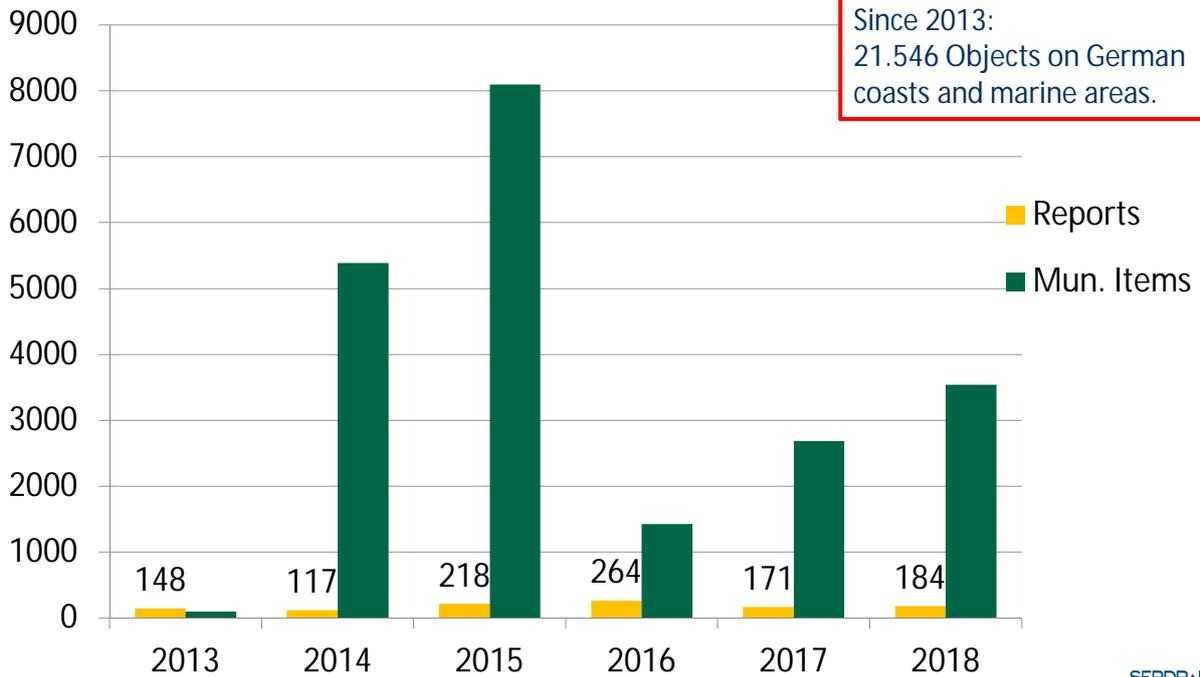
Simplified Chart on German munitions-contaminated areas



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Reported encounters 2013 to 2018



Milestones



- 2011 „Munitions in German Marine Waters - Stocktaking and Recommendations (Effective 2011)“
- 2012 Foundation of German Expert Group IV IDUM, Puerto Rico
- 2013 HELCOM-Muni
UN-Resolution A/RES/68/208
- 2014 Kick-off HELCOM SUBMERGED
- 2016 Recovery Plan for Baltic Harbour Porpoises
Kick-off of DAIMON (UDEMM, RoBEMM)
- 2019 Decision of Ministers of Environment to update the overall assessment



Sea dumped munitions: A local problem only?



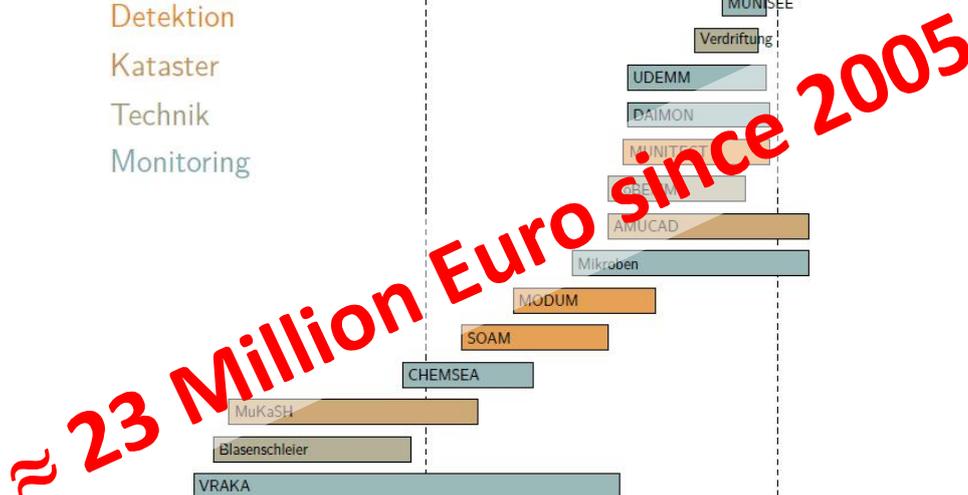
- No, but local programs have benefit from international concern:
 - Global activities:
 - United Nations (e.g. framework of the Convention on chemical Weapons)
 - OPCW
 - NATO AVT 330 (Impact of MEC under water)
 - International Dialogue on Underwater Munitions
 - European activities:
 - OSPAR (Oslo and Paris Commission – North Sea)
 - HELCOM (Helsinki Commission – Baltic Sea)
 - JPI-O (Action munitions in the sea)
 - BOSB (Baltic Ordnance Safety Board) è Baltic Ordnance Pilot (BOP)



Research Projects

Munitions in German Marine Waters – Stocktaking and Recommendations (Effective 2011)

Kategorien
 Detektion
 Kataster
 Technik
 Monitoring



Research activities at WTD 71

Test, improve & evaluate different sensors /methods for buried UXO detection

SOAM – Sounding Ammunition (2013-16)

Parametric Sonar
(INNOMAR)



AUV with R2Sonic & BOSS Sonar
(Atlas Electronic)



AUV with sniffer:
Raman and electro
chemical



MAGRAY
(SENSYS)

The Allied Munitions Detection Underwater Initiative (2016-18)

DESCRIPTION

- Collaboration between US & Germany to
 - Advance technologies and techniques for the detection classification, and mapping of bottom and buried munitions
 - Develop an automated unmanned and autonomous underwater munitions survey system



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NATO – Science for peace & Science & Technology Organization

2013-16: NATO-SPS Project MODUM

Participation Poland, Russia, Canada, Germany, Lithuania, Estonia, Sweden, Denmark and Finland

Goal: Development of cost-effective and accurate methods for surveying, identifying and onboard analysis of dumped chemical munitions [...], using Autonomous and Remotely Operated Underwater Vehicles.

2020-22: NATO STO – AVT-330

Participation: Norway, Netherlands, Great Britain, Germany, Poland; Bulgaria, Switzerland, Belgium, ...

Objective: Impact of MEC on maritime safety, security and sustainable remediation



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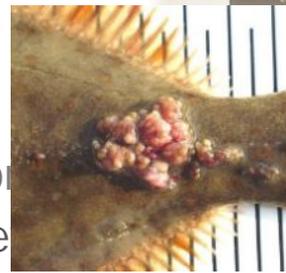
EU Project DAIMON („Decision Aid for Marine Munitions“ 2016-19)

Baltic Sea as multinational waterbody

Munition contaminated areas

Seafood and other marine products

e.g.
Bio-effects



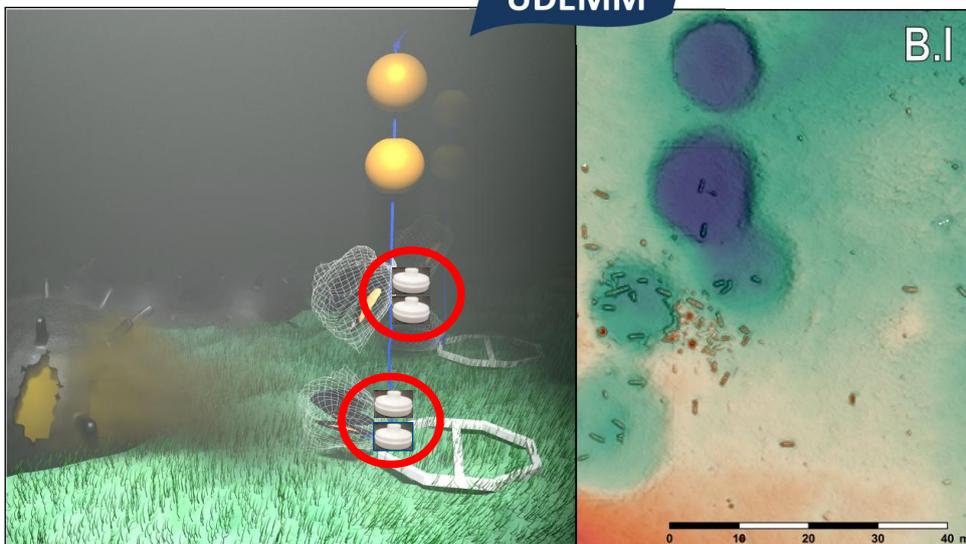
non
Marine Munitions



<https://www.daimonproject.com/>
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German Project UDEM M (2016-19) - Detection, toxic effects, distribution -



J.S. Strehse, D. Appel, H-J. Martin, E. Maser, Biomonitoring of 2,4,6-trinitrotoluene and degradation products in the marine environment with transplanted blue mussels (*M. edulis*), *Toxicology* 390 (2017), 117-123., D. Appel, J.S. Strehse, H-J. Martin, E. Maser, Bioaccumulation of 2,4,6-trinitrotoluene (TNT) and its metabolites leaking from corroded munition in transplanted blue mussels (*M. edulis*), *Marine Pollution Bulletin* 135 (2018), 1072-1078.



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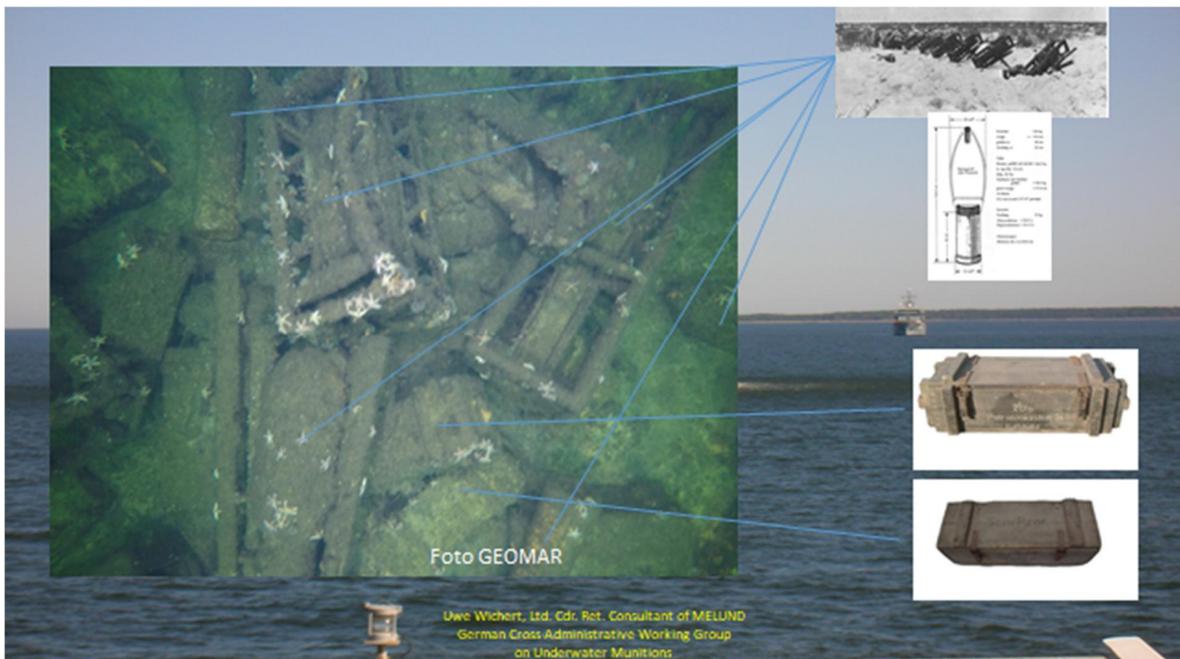
German Project UDEMM (2016-19) - Detection, toxic effects, distribution -



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German Project RoBEMM (2016-19) - Robotic remediation -



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German Project RoBEMM (2016-19) - Robotic remediation -

<https://vimeo.com/320259541>

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German Project RoBEMM (2016-19) - Robotic remediation -

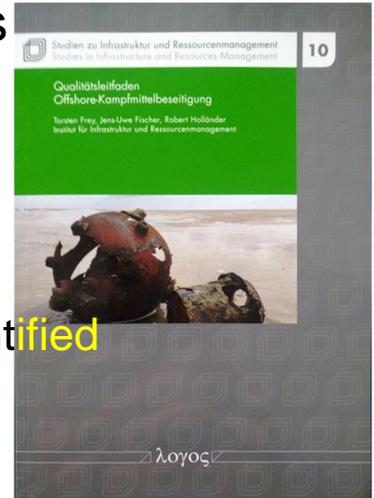


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Quality Guideline for UXO offshore operations

- A comprehensive Quality Guideline for the Treatment of Unexploded Ordnance Encountered During Offshore Construction Projects
- Definitions per phase
 - (I) Desk top study
 - (II) Site survey
 - (III) Individual MILCO inspection
 - (IV) Clearance and disposal of UXO identified



Web:

https://www.researchgate.net/publication/333115488_A_Comprehensive_Quality_Guideline_for_the_Treatment_of_Unexploded_Ordnance_Encountered_During_Offshore_Construction_Projects/citation/download



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Inherent Challenges for Detection

- § Poor documentation of sea dumps
- § Diverse compositions and wide spectrum of dimensions
- § Encrustation, fragmentation, burial – environmental complexity
- § Sea bed varies from mud via sand to rock
- § Sediment surface varies from rough to rippled, crafted by bioturbation and humanitarian activities
- § Challenging hydrodynamic conditions, difficult localization

Biologic/Man-Made Clutter



Environmental Challenges



Concealed by
Grasses / Kelp



Obscured by
Edges/Rocks



Partial/Complete
BURIAL



Poor
Visibility



Ridges, Valleys,
Outcrops

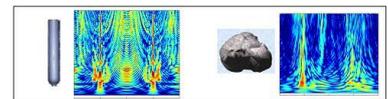
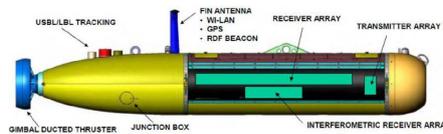
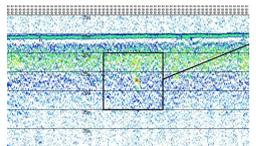
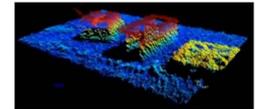


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SONAR – UXO Detction / Classification

- High-frequency sidescan sonar
 - Capture seafloor texture and proud objects
 - Fine resolution, degrades with range, bathy, inexpensive
- § High-resolution multi-beam sonars / Acoustic cameras
 - Fine detail 3D imagery/bathy
- Sub-bottom profilers and parametric sonars
 - Sediment penetration, Detection of small buried objects
- § Synthetic aperture sonar
 - Fine – constant - resolution imaging of texture and objects at long range
- § Acoustic spectroscopy
 - Information on object structure and composition

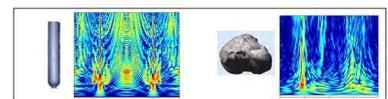
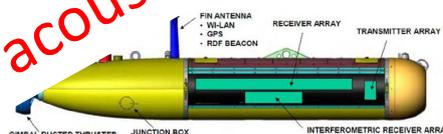
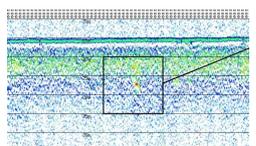
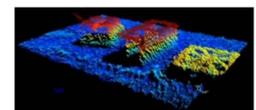


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Resolving buried objects represents a significant challenge for acoustic systems

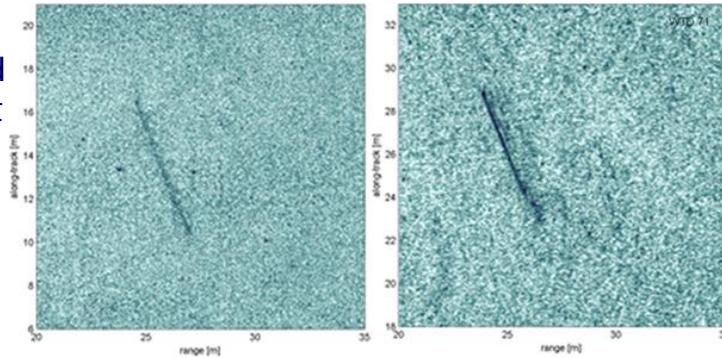


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SONAR – UXO Detection / Classification

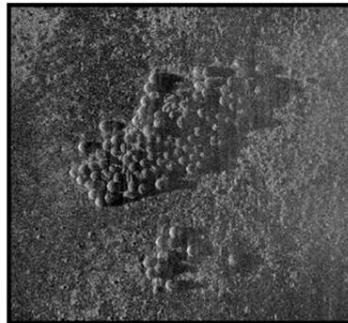
Torpedo,
flush-buried
in sediment



LF-SAS

Approx. 70 Germany moored mines, laying on the sea bed

MBE
R2Sonic



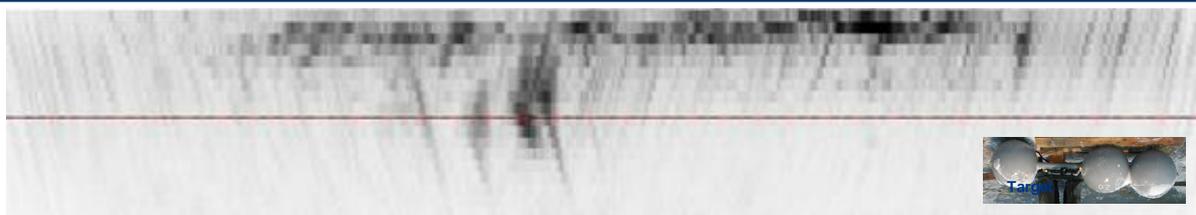
HISAS



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Limited Capabilities for Detecting / Classifying Buried Objects

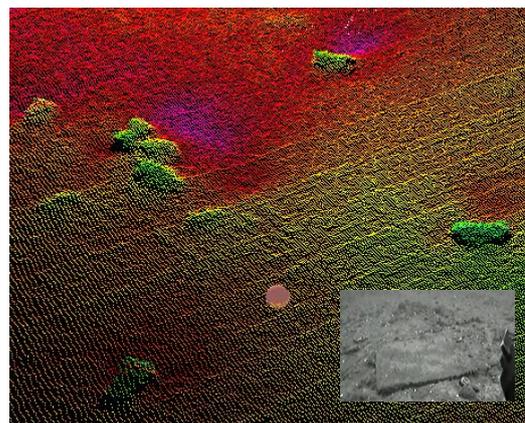
BOSS Sonar



DD AUV SeaHorse (Atlas Elektronik)



R2Sonic Sonar

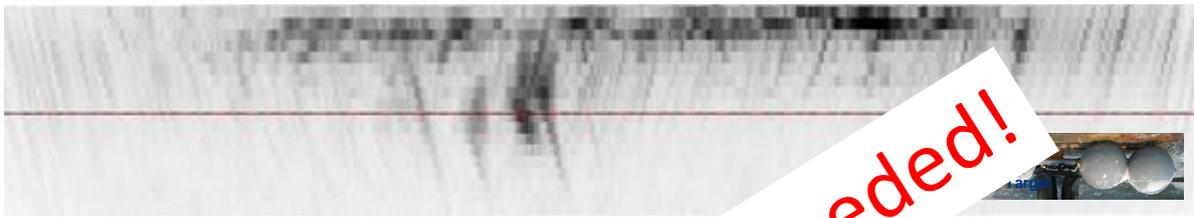


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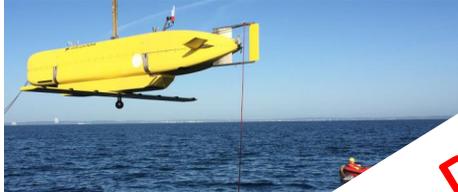
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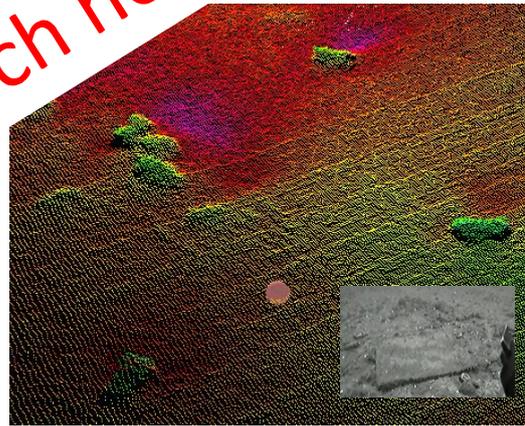
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DD AUV SeaHorse (Atlas Elektronik)



Further Research needed!

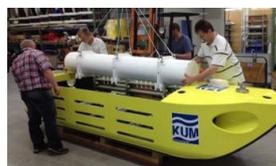
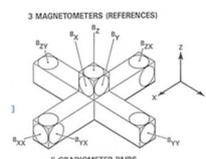


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Electro-optics, magnetics, electro-magnetic induction

- Turbidity and light-attenuating limits video range
 - Primarily used for close target identification
 - Develop active electro-optic systems to increase range of view
- Passive magnetic systems to detect ferrous objects
 - Limitations include short stand-off range, ferrous magnetic waste and electromagnetic platform interference
- Electro-magnetic Induction (EMI) used to detect ferrous & non-ferrous electric conductors; limited in range!
- High confidence classification of buried objects by combined data of various sensors achieved.



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Challenge: Wide area assessment & remedial investigation

Sensor Performance

- ✓ Resolving small and fragmented objects
- ✓ Detection ranges
- ✓ Sub-bottom sensing
- ✓ Explosives identification
- ✓ Near-shore (< 10 ft) sensing

Data/Image Analysis

- ✓ ATR and change detection
- ✓ Multi-sensor fusion
- ✓ Simple, accurate decision tools
- ✓ Rapid end-to-end processing

Systems

- ✓ Near-shore vs deep water operation
- ✓ High sea states and currents
- ✓ Ops in confined areas

Operations

- ✓ Safe management of multiple systems in simultaneous ops
- ✓ Inter-system data co-registration
- ✓ Minimized manning



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If I had a dream...

- International agreement to stop the introduction of warfare material to marine ecosystems
- Monitoring and risk assessment standards to identify hot spots
- International funds to develop effective remediation devices
- Immediate start of systematic remediation, according to priorities!

- The commitment to act now!



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