Overview of the General Methodology of Oil Removal Operations on Baltic Shipwrecks

on the example of dangerous wrecks of the Gulf of Gdańsk

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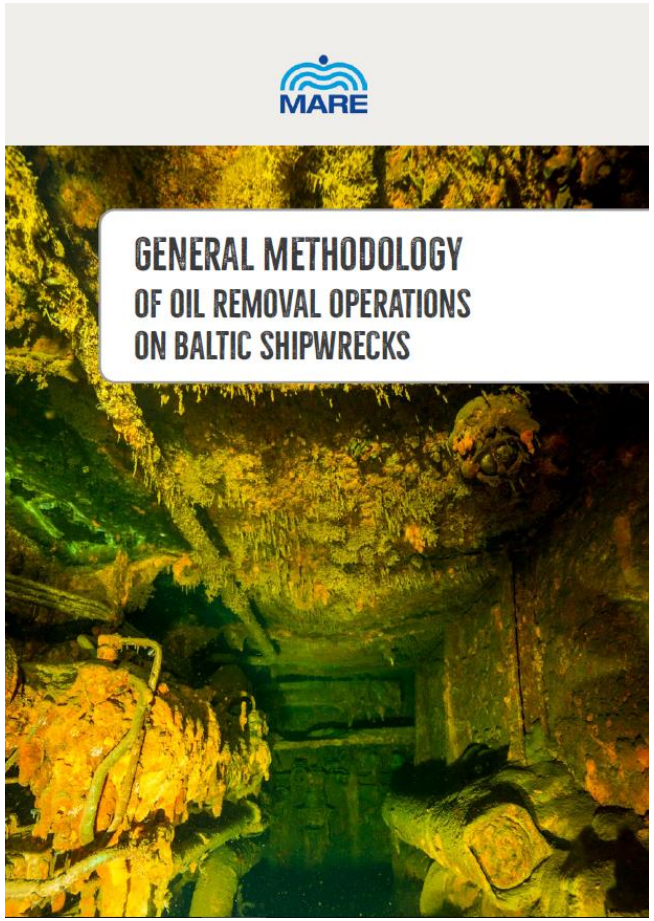
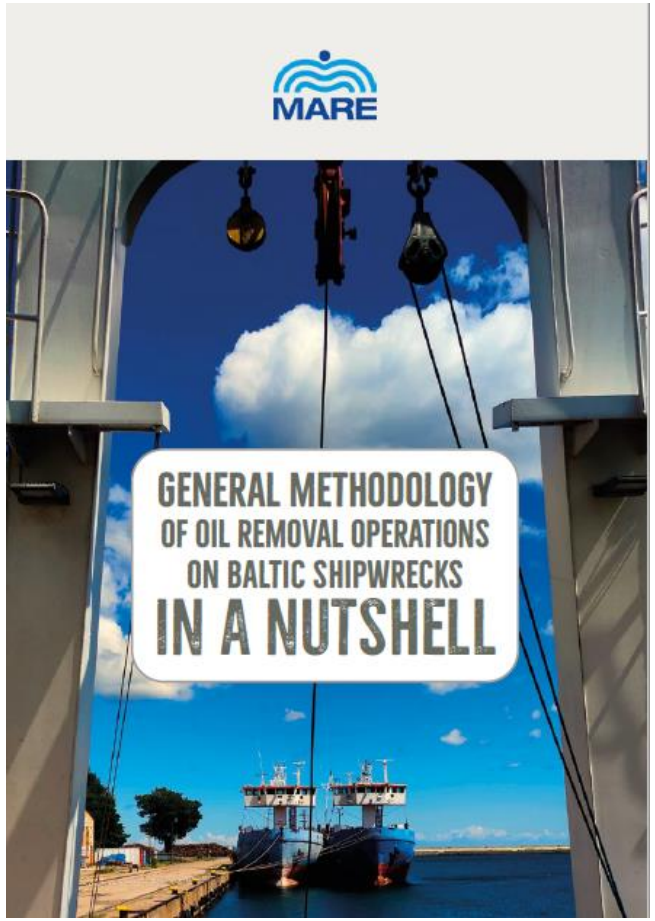
International Conference: Dangerous Wrecks Vol. 2





General Methodology of Oil Removal Operations on Baltic Shipwrecks published by the MARE Foundation is a proposal of a **Wreck Management Plan for Poland** and was developed on the basis of programs already being implemented in Great Britain and Sweden.

The full version of the document (as well as a summary „*Methodology in a nutshell*”) can be downloaded at:

POLISH version:
www.fundacjamare.pl/metodykaPL

ENGLISH VERSION:
https://fundacjamare.pl/methodologyENG/

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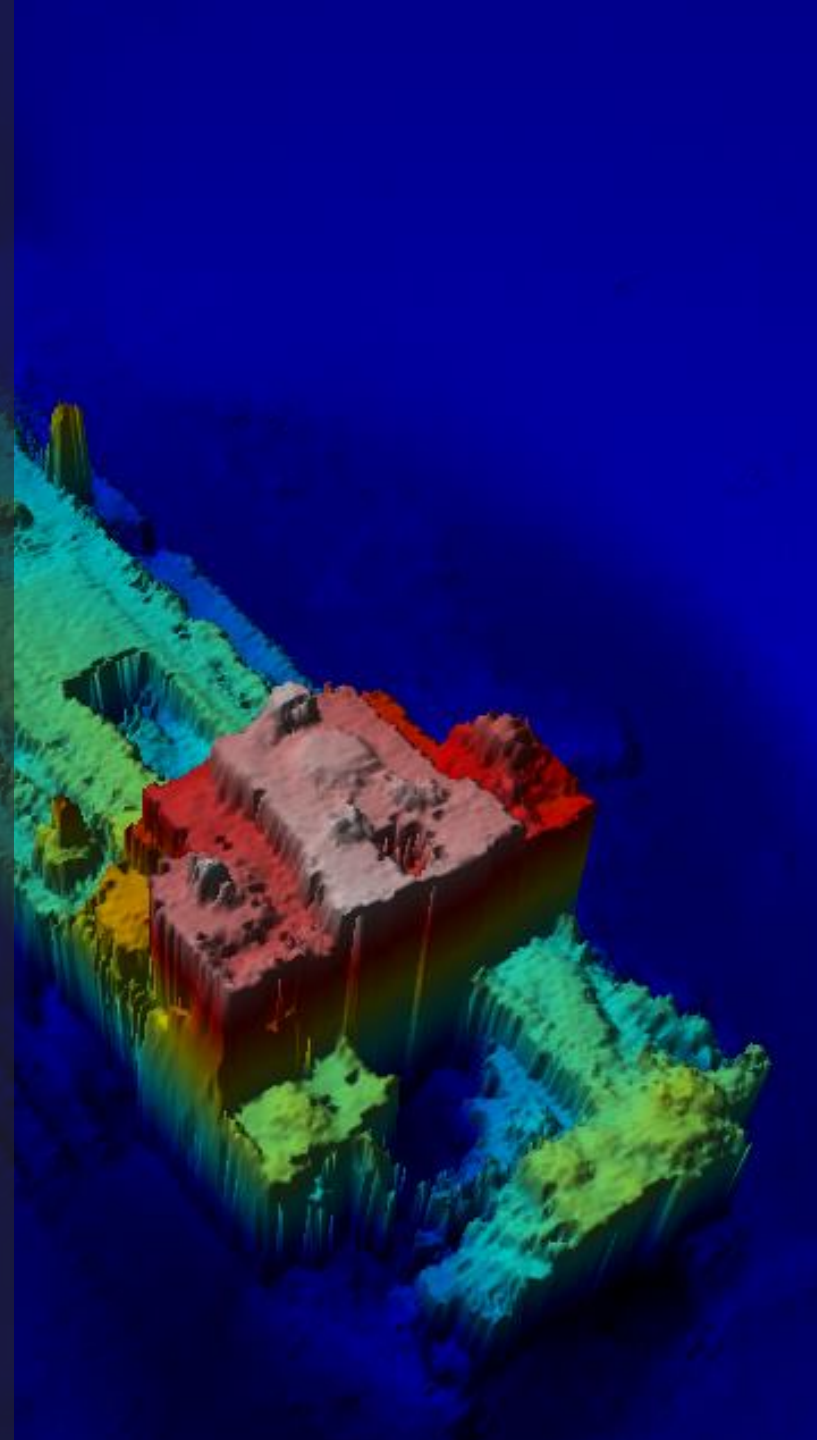
„Dangerous wreck” – what does it mean?

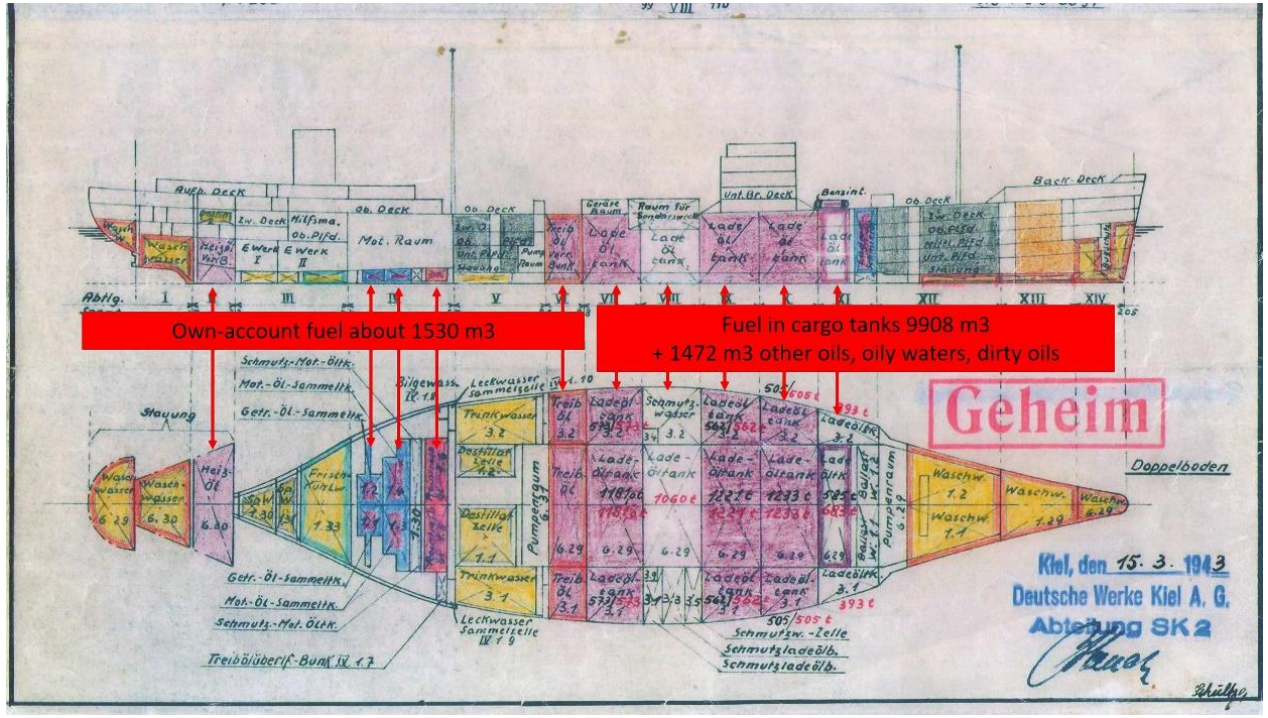
The term “**dangerous wreck**” should be understood as a wreck containing in its tanks (or any other enclosed space) fuel and/or other hazardous substances in quantities greater than 10 m^3. To be categorized as a dangerous to the environment, such a wreck must be located less than 10 nautical miles from the coast that is a sand beach, a rocky beach or a cliff. Depending on such parameters as the amount of fuel, the distance from the coast and the type of the coastline, a concept of the **RISK DEGREE** has been introduced:

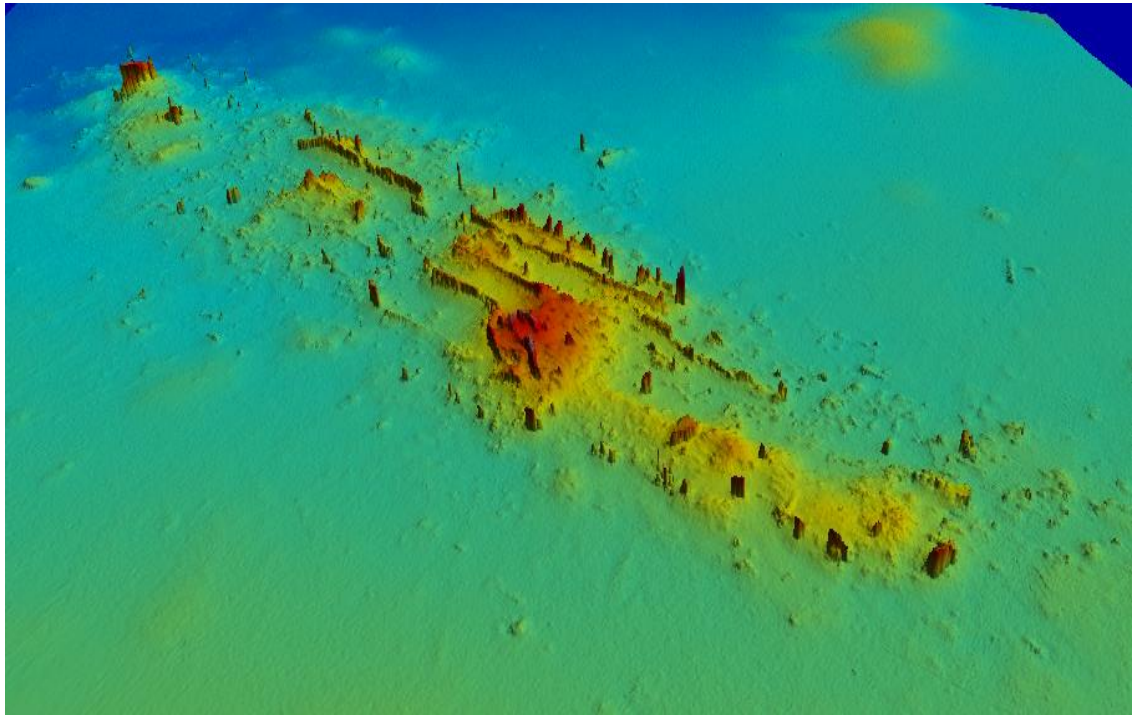
- **MODERATELY DANGEROUR or DANGEROUS WRECK** – is a shipwreck containing from 10 to 500 m^3 of fuel, lying at a distance of 1 to 10 nautical miles from sandy, cliff, rocky or gravel beaches;
- **VERY DANGEROUS WRECK** – is a shipwreck containing more than 500 m^3 of fuel and lying at a distance less than 1 nautical mile from the coast.

When classifying shipwrecks, other parameters such as the uniqueness of the site, where the wreck is located **(e.g. closeness of natural reserves, protected areas of unique environmental value, presence of endangered fish and other marine or endemic species),** as well as many other environmental aspects should be also taken into account.



Examples of dangerous wrecks in the Gulf of Gdańsk – **Stuttgart and Franken**





Algorithm 1. **Steps to be taken during the study of wrecks in terms of risks and threats to the environment**

Environmental impact assessment of wrecks

Long-term and chronic release of oil from a wreck

Instantaneous, acute oil release from a wreck

Assessing the likelihood of oil release from wrecks

Information of the assessment of the current state of a wreck with confidence scores

Risk assessment criteria	Weighting of criteria	Low (score of 1)	Medium (score of 2)	High (score of 3)
Vessel depth	2	low >100 m	30-100 m	high <30 m
History of leaks	3	no known leaks	unknown or anecdotal evidence	documented history of leaks
Integrity of wreck	2	broken into more than three pieces	broken into two or three pieces	intact, in one piece or unknown
Age of vessel at time of sinking	1	<10 years	10-30 years	>30 years
Length of time vessel has been submerged	2	<50 years	50-90 years	>90 years
Method of storage	2	specific bunker tank	in hold	on deck, drums, containers, crates
Type of incident causing sinking	1	multiple torpedo detonations, multiple mines, severe explosion	single torpedo, shellfire, single mine, rupture of hull, breaking in half, grounding on rocky shoreline or unknown	foul weather, grounding on soft bottom, collision
Seabed type	2	known to be stable seabed	relatively stable or not known	unstable and/or high degree of movement

Risk of oil release
Sum of all weightings for each criteria (weighting criterium and weighting)

Risk of oil release	Score
Low	< 22
Medium	22-24
High	> 32

Confidence to data
Sum of all weightings for each criteria (assessment criteria x confidence weighting)

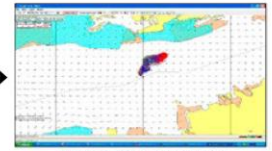
Confidence to data	Score
Low	8-12
Medium	13-19
High	20-24

Modelling oil release/spill

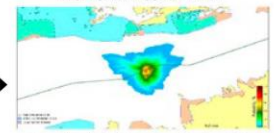
Seatrack Web: A tool for environmental risk assessment in the Baltic

Input data:
- wreck-specific area - model domain
- position of the wreck
- oil type
- direction and data on sea currents
- direction and velocity of wind
- duration of modelling (time window)
- other complementary data (if available): suspended sediment; settling velocity; oxygen content; temperature profile; salinity profile

Modelling output maps



Dryf wycieku ropy 23.07.2007



Prawdopodobieństwo wycieku ropy [%]

Prawdopodobieństwo dryfu wycieku [%]

A

Quantification of risk for sensitive areas and selected environmental receptors

Ecological sensitive marine receptors:
- coastal and marine protected areas (to protect biological resources),
- marine mammals (cetaceans, porpoises, seals),
- birds,
- fish (nursery and spawning grounds),
- benthos communities

Socio-economic sensitive marine receptors:
- infrastructure at sea (wind farms, mining installations, water intakes for industry e.g. nuclear power plants, aquaculture, ports etc.)
- tourism in recreational areas along the shore, diving, kitesurfing
- demersal, pelagic fishery and crustaceans,
- shipping,
- others – e.g. protected wrecks

Marine living organisms	Low risk	Medium risk	High risk
Living organisms	< 0,2	0,2-1,0	> 1,0
Birds	< 0,002	0,002-0,2	> 0,2

Risk assessment criteria	Relevant oil spill model (shoreline, sea surface, water column or sediment)	Low (score as 1)	Medium (score as 2)	High (score as 3)
Coastal and marine protected areas	water column, sediment, sea surface and shoreline	< 0,002	0,002-0,2	> 0,2
Species and features of conservation interest				
Marine mammals (seals)	water column, sea surface and shoreline	< 0,2	0,2-1	>1
Marine mammals (cetaceans and sirenians)	water column and sea surface	< 0,2	0,2-1	>1
Marine Reptiles	water column, sea surface and shoreline	<0,2	0,2-1	>1
Seabirds	sea surface and shoreline	<0,002	0,002-0,2	>0,2
Benthic features and species including designated shellfish grounds	water column and sediment	Predicted total footprint of oil deposition on sediment <100 km² and <0.002 PEC/PNEC risk of any overlap with protected benthic features and species.	Predicted total footprint of oil deposition on sediment between 100-1 000 km² or 0.002-0.2 PEC/PNEC risk of any overlap with protected benthic features and species.	Predicted total footprint of oil deposition on sediment >1 000 km² or >0.2 PEC/PNEC risk of any overlap with protected benthic features and species.
Fish spawning and nursery areas	water column and sediment	No known spawning or nursery areas.	Oil spill interacts with known discrete areas used for spawning and/or nursery area.	Oil spill interacts with high intensity spawning and/or nursery areas.
Fish (sensitive or charismatic species)	water column and sediment	No known species.	Oil spill interacts with known discrete areas used by sensitive or charismatic species.	Oil spill interacts with area used by large numbers of sensitive or charismatic species.
Shipping				
Important shipping lanes	Sea surface	No overlap with any important shipping lanes.	Seasonal overlap at a concentration above the threshold with any important shipping lanes.	Year round overlap at a concentration above the threshold with any important shipping lanes.
Ports	Shoreline	No overlap with any ports.	Seasonal overlap at a concentration above the threshold with any ports.	Year round overlap at a concentration above the threshold with any ports.

For acute releases the area covered with oil with relations to the site specific area

Low risk	< 5%
Medium risk	5-50%
High risk	> 50%

B

B

Risk assessment criteria	Relevant oil spill model (shoreline, sea surface, water column or sediment)	Low (score as 1)	Medium (score as 2)	High (score as 3)
Current and planned infrastructure				
Offshore wind farms	Sea surface	No overlap of sea surface oil with any windfarm.	Seasonal overlap of sea surface oil at a concentration above the threshold for more than 5% of a windfarm lease area.	Year round overlap of sea surface oil at a concentration above the threshold for more than 5% of a windfarm lease area.
Offshore oil and gas installations	Sea surface	No overlap of sea surface oil with any installation.	Seasonal overlap of sea surface oil at a concentration above the threshold for any installation.	Year round overlap of sea surface oil at a concentration above the threshold for any installation.
Industrial water intakes	Shoreline	No overlap with any industrial water intake.	Seasonal overlap at a concentration above the threshold with any industrial water intake.	Year round overlap at a concentration above the threshold with any industrial water intake.
Aquaculture	Water column and sea surface	No overlap with any aquaculture facility.	Seasonal overlap at a concentration above the threshold with any aquaculture facility.	Year round overlap at a concentration above the threshold with any aquaculture facility.
Tourism and leisure areas				
Tourism	Shoreline	No overlap with any known tourist areas impacted.	Seasonal overlap at a concentration above the threshold of any known tourist areas impacted.	Year round overlap at a concentration above the threshold of any known tourist areas impacted.
High use areas	Shoreline	No overlap with any high use areas.	Seasonal overlap at a concentration above the threshold with any high use areas.	Year round overlap at a concentration above the threshold with any high use areas.
Fishing grounds				
Demersal	Sediment and sea surface	<180 days of fishing effort impacted in area of oil contamination occurring.	180-365 days of fishing effort impacted in area of oil contamination occurring.	>365 days of fishing effort impacted in area of oil contamination occurring.
Pelagic	Water column and sea surface	<180 days of fishing effort impacted in area of oil contamination occurring.	180-365 days of fishing effort impacted in area of oil contamination occurring.	>365 days of fishing effort impacted in area of oil contamination occurring.
Crustacean	Sediment and sea surface	<180 days of fishing effort impacted in area of oil contamination occurring.	180-365 days of fishing effort impacted in area of oil contamination occurring.	>365 days of fishing effort impacted in area of oil contamination occurring.

For acute releases the area covered with oil with relations to the site specific area

Low risk	< 5%
Medium risk	5-50%
High risk	> 50%

C

Final risk score

Final ecological risk assessment score = likelihood of release × ecological risk

Final socio-economic risk assessment score = likelihood of release × socio-economic risk

Final ecological risk assessment score

Score min = 90
Score max = 810

- Low risk <240
- Medium risk 240-360
- High risk >360

Final socio-economic risk assessment score

Score min = 60
Score max = 540

- Low risk <160
- Medium risk 160-240
- High risk >240

Calculating confidence score

High confidence >80% | Medium confidence 50 – 80% | Low confidence<50%

CRITERIA FOR THE OVERALL ASSESSMENT OF RISK

High risk	Medium risk	Low risk
There is a high potential for oil to be released. Detailed analysis is required to understand the severity of the threat to sensitive marine receptors.	The risk of oil being released is moderate. Further analysis is recommended to understand the severity of the threat to sensitive marine receptors.	The risk of oil being released is minimal. If the condition of a wreck changes a re-assessment is recommended to confirm risk.
RECOMMENDED ACTIONS		
Assessment has shown that there is a considerable threat to sensitive marine receptors, essential management actions will need to be considered.	The assessment has shown there is a threat to sensitive marine receptors, monitoring and that management may be required.	If the condition of a wreck changes a re-assessment is recommended to confirm risk. Monitoring may be required.

DEFINITIONS OF CONFIDENCE LEVELS IN THE RISK ASSESSMENT PROCESS

High confidence	Medium confidence	Low confidence
The data and information used are timely, the best available, robust and the outputs are well supported by evidence. There is consensus amongst experts.	The data and information is based on limited evidence and or proxy information. There is a majority agreement between experts; but conflicting evidence/opposing views exist.	The data and information is limited and is not well supported by evidence. There is no clear agreement amongst experts.

FINAL RISK ASSESSMENT REPORT

CHAPTER 2: Survey methods

In order to determine all parameters relevant to the assessment of a wreck and the risk posed by it the following actions should be carried out:

- **Desk-based review** (i.e. examination of existing documents and information);
- Conducting **geophysical surveys** (i.e. bathymetric surveys, sidescan sonar, circulating sonar or an acoustic camera surveys, sea bottom surveys using an acoustic sub-bottom profiler (SBP), magnetometric survey of metal object distribution)
- **Geological exploration of the seabed**;
- **Chemical tests** of soil and near-bottom water;
- **Biological and ecotoxicological tests** of bottom sediment samples
- **Obtaining hydrographic data /navigational data**
- Inspection carried out on the wreck using **Remote Operated Vehicles (ROVs);**
- Collection and analysis of environmental data other than chemical, biological and other parameters

CHAPTER 3: Wreck environmental risk assessment methods.

The Wreck Oil Removal Program implemented in the United States by the National Oceanic and Atmospheric Administration

DEEPP Project ("Development of European guidelines for Potentially Polluting shipwrecks")

Norwegian Pollution Control Authority – NPCA

The South Pacific Regional Environment Program

The Swedish model "VRAKA – Probabilistic risk assessment of shipwrecks"

The British risk assessment system called "Wreck assessment protocol – Environmental Desk Based Assessment"

Best method for the Baltic Region

The **British E-DBA method** seems to be the most appropriate for implementation in Poland in the region of southern Baltic.

It is relatively simple, and at the same time highly effective.

It permits to assess the risk based on a three-step scale and to assess the confidence level in risk assessment results.

This method takes into account two basic scenarios:

- **an acute release and its impact on the environment,**
- **and a slow release and its long-term effect on the marine environment.**

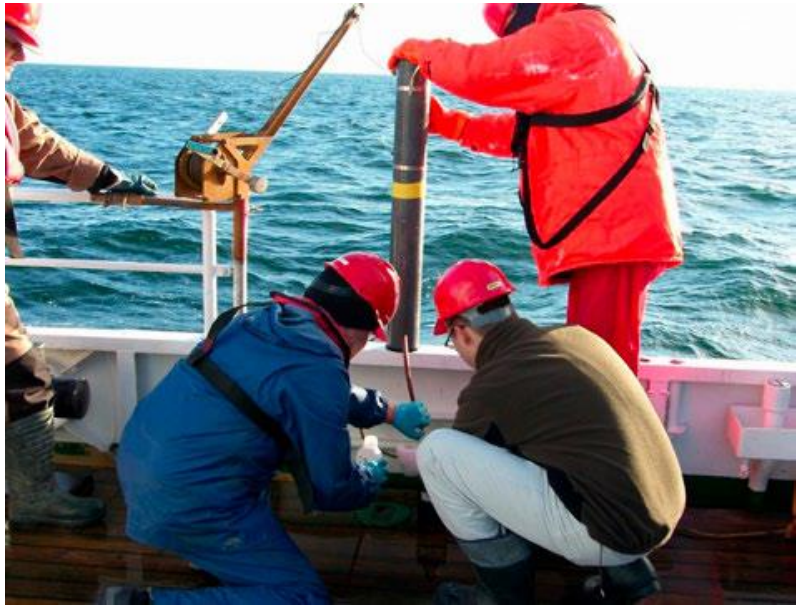
It permits a relatively quick oil release risk assessment for different wrecks and their classification, **but it does not allow to determine the changes of the risk level with time. Such predictions can however be made using the VRAKA method.**

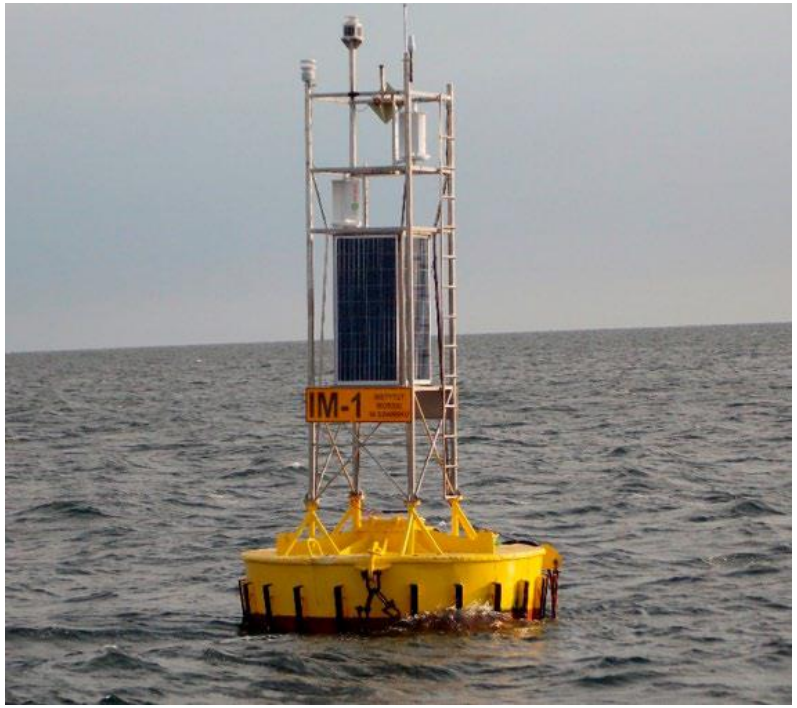
de&S

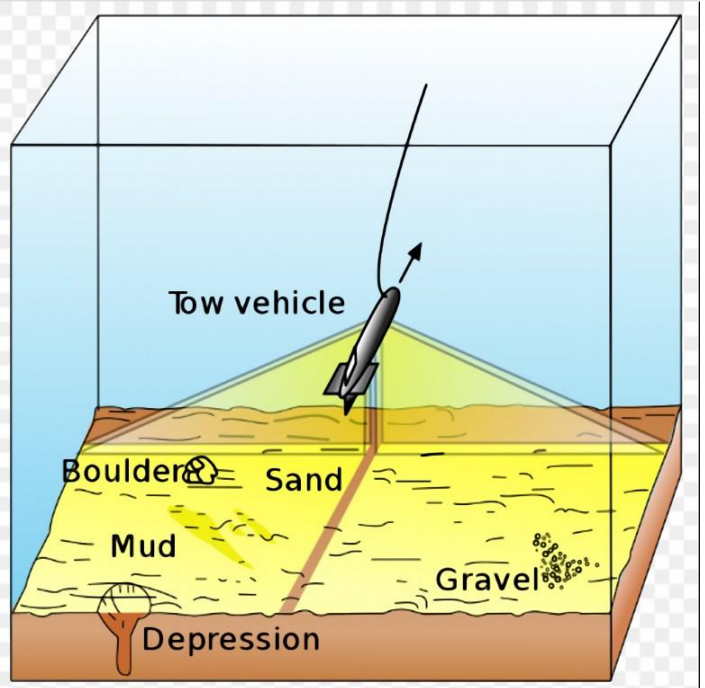
Ministry of Defence

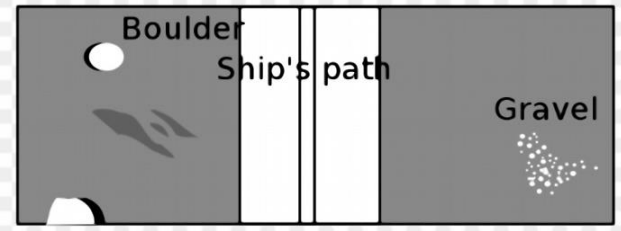
CHAPTER 4: Methodology for conducting geophysical surveys

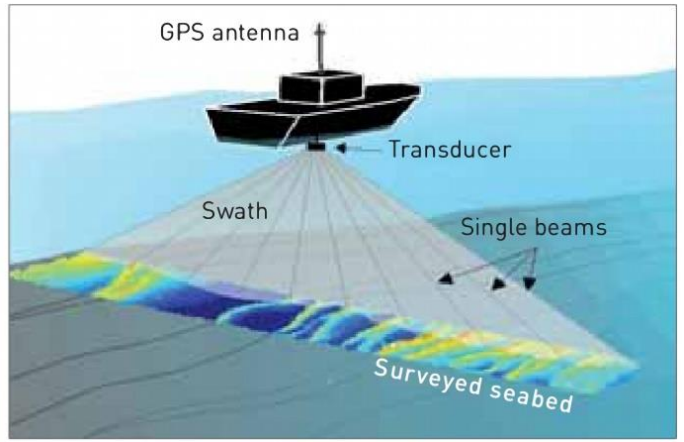
- Positioning systems
- Bathymetric and 3D data
- Sidescan sonars
- Sub-bottom profilers
- Magnetometere surveys
- Marine laser systems
- Environmental data
- Geological analysis
- Photovideo data
- Chemical and biological tests
- Exotoxicological analysis











CHAPTER 5: Review of available methods and technologies for removing fuel and remediating the contaminated sediments

in situ

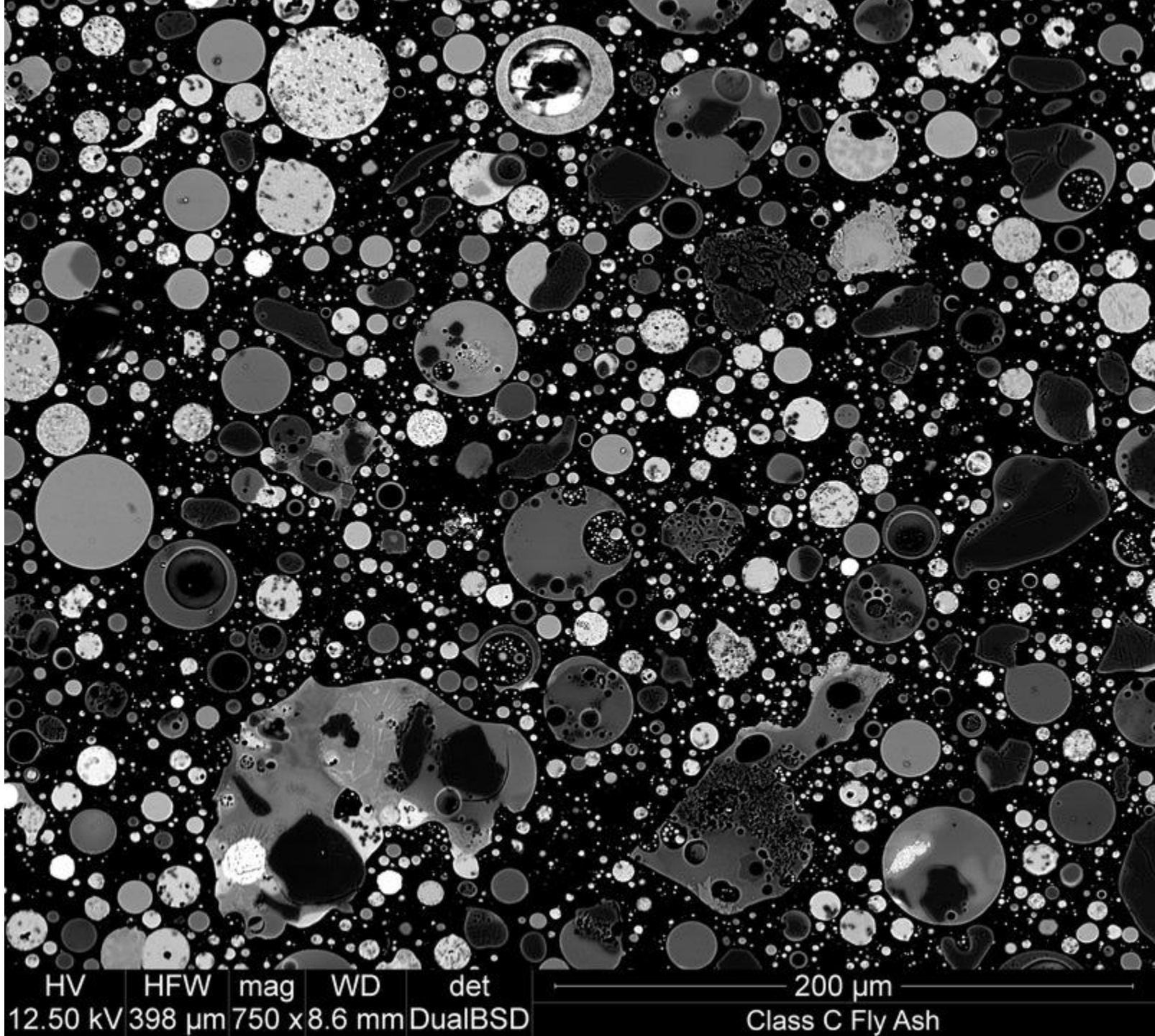
ex situ

Monitored natural recovery

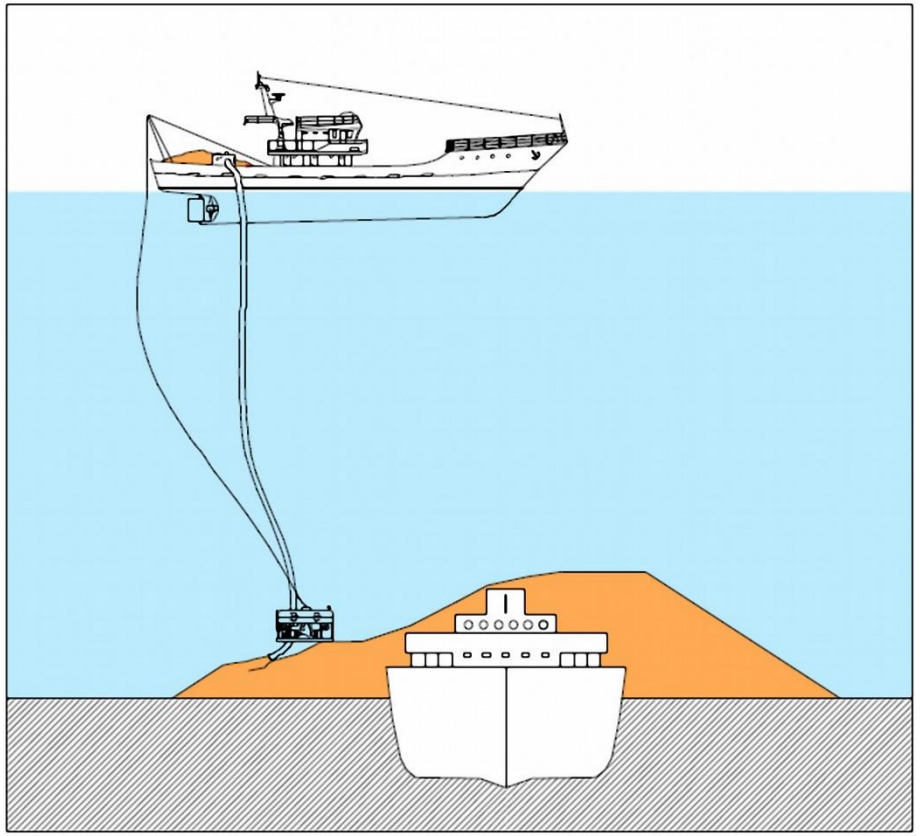
- Biodegradation
- Sorption
- Sedimentation

Separating the contaminated area with a fence

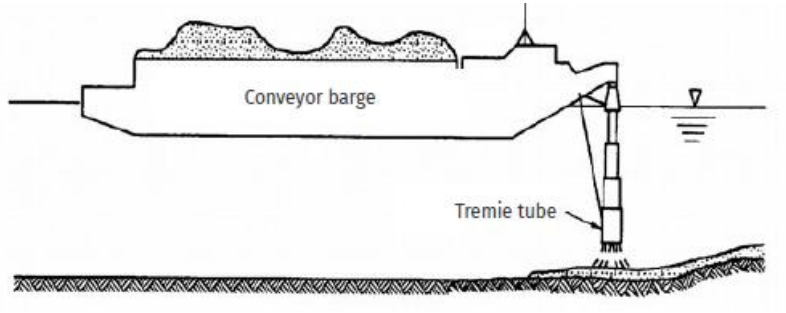
Solidification and stabilisation of contaminated sediment (use of fly ash)

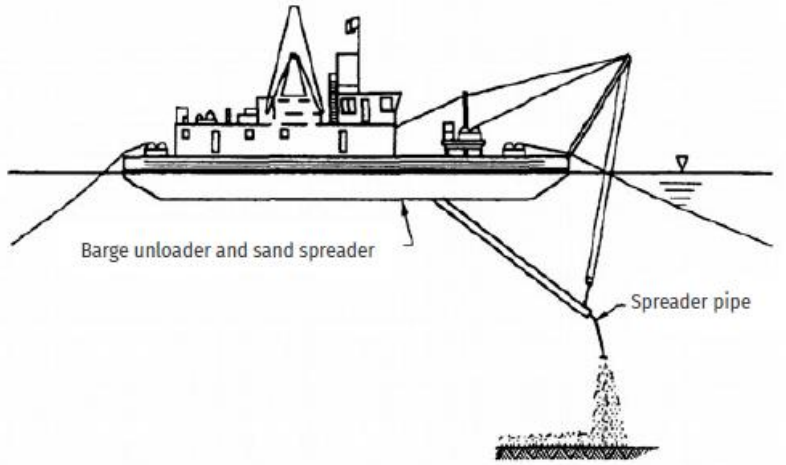


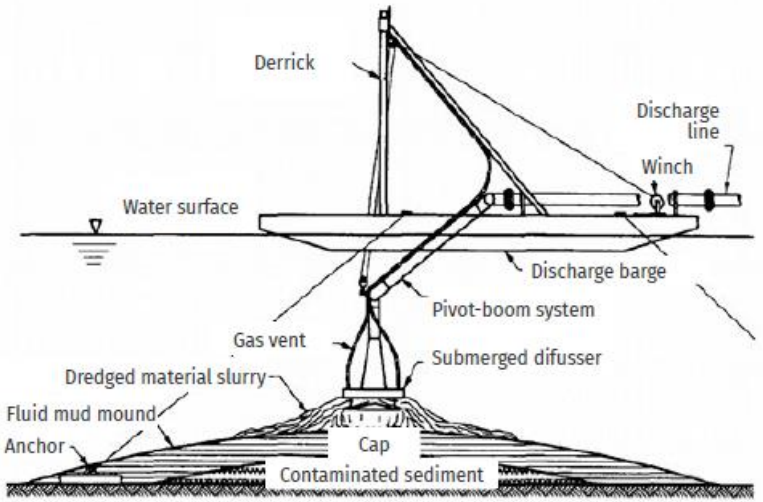
Capping the contaminated area



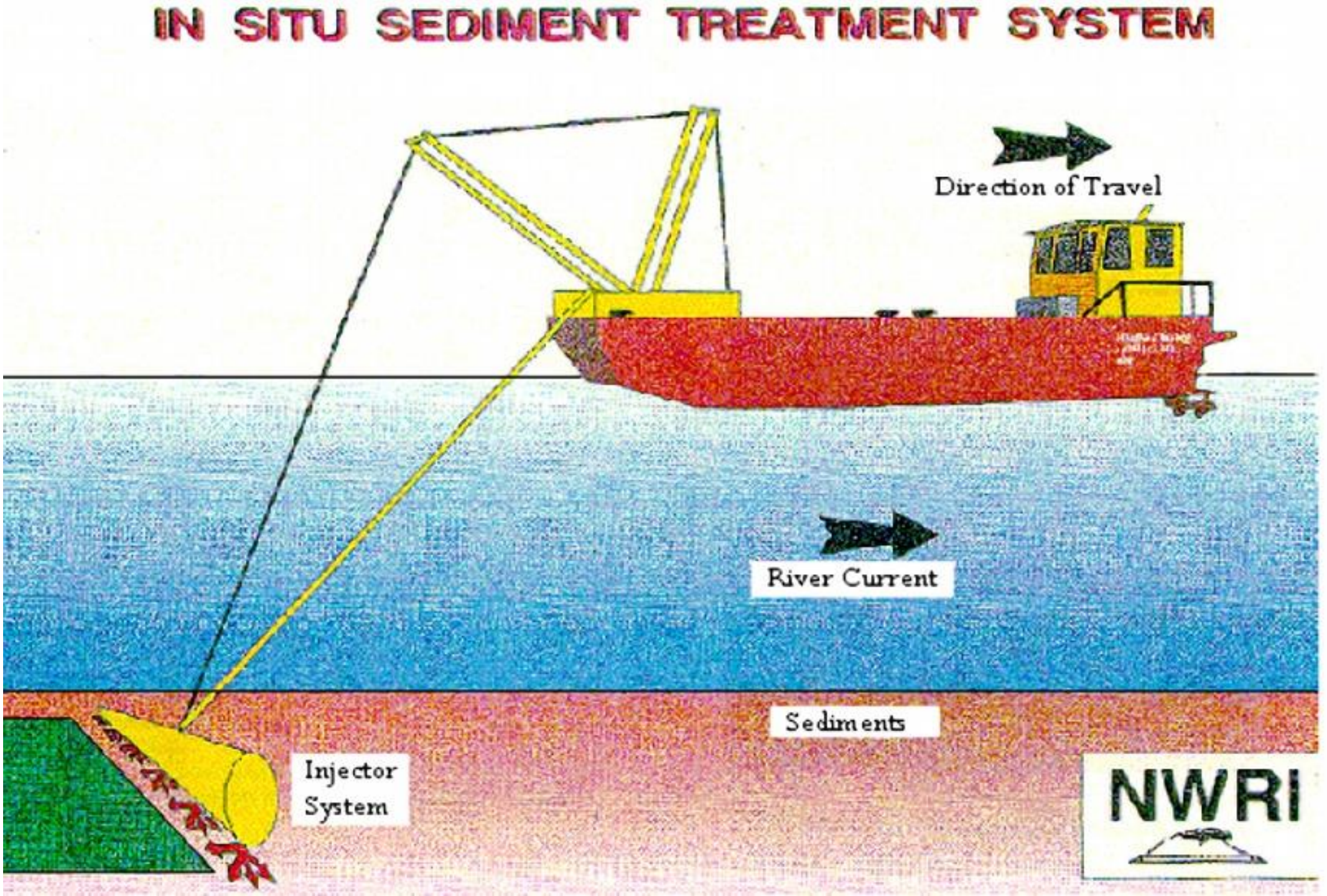
CAPPING OF WRECK BY A ROV



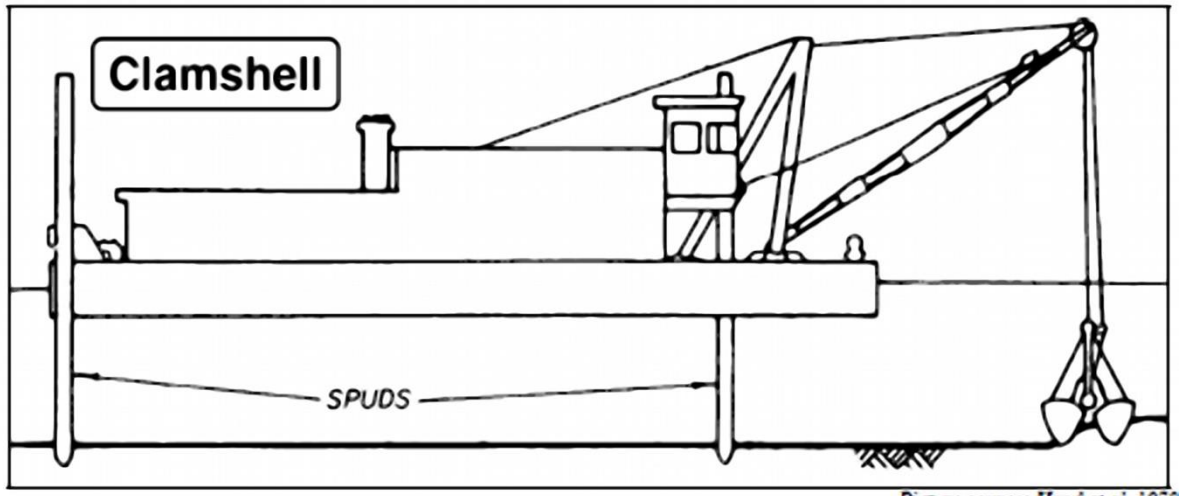




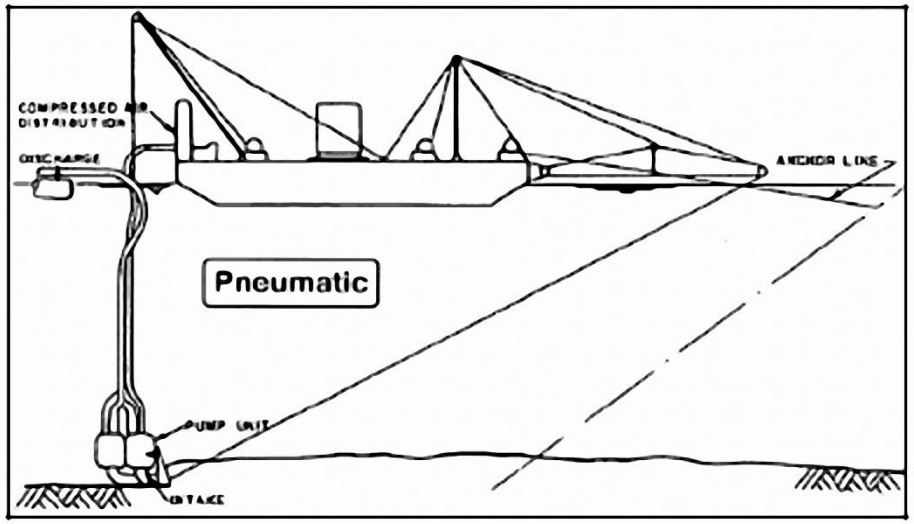
Bioremediation

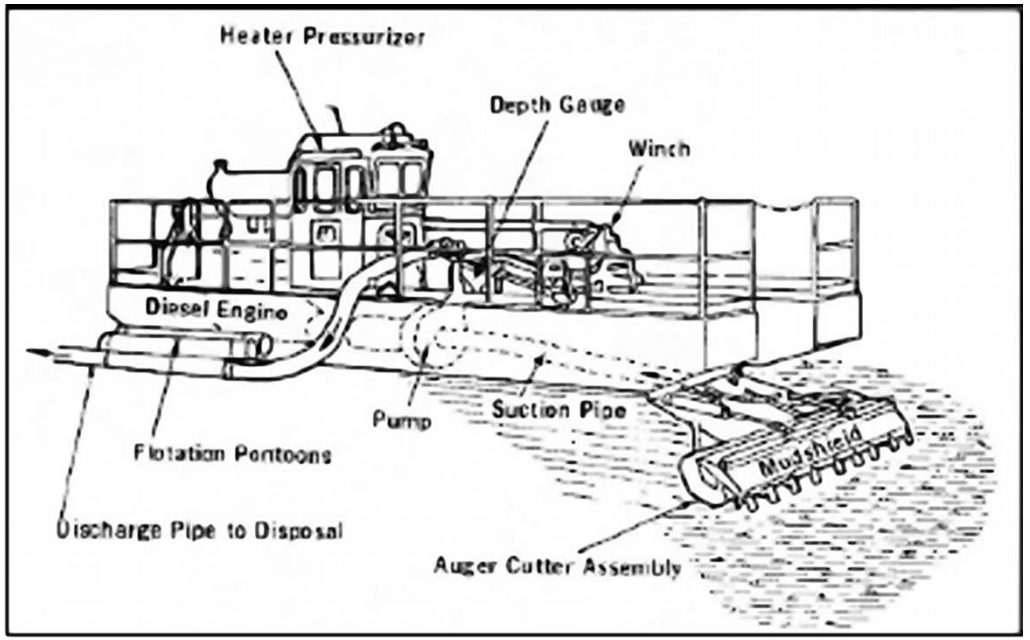


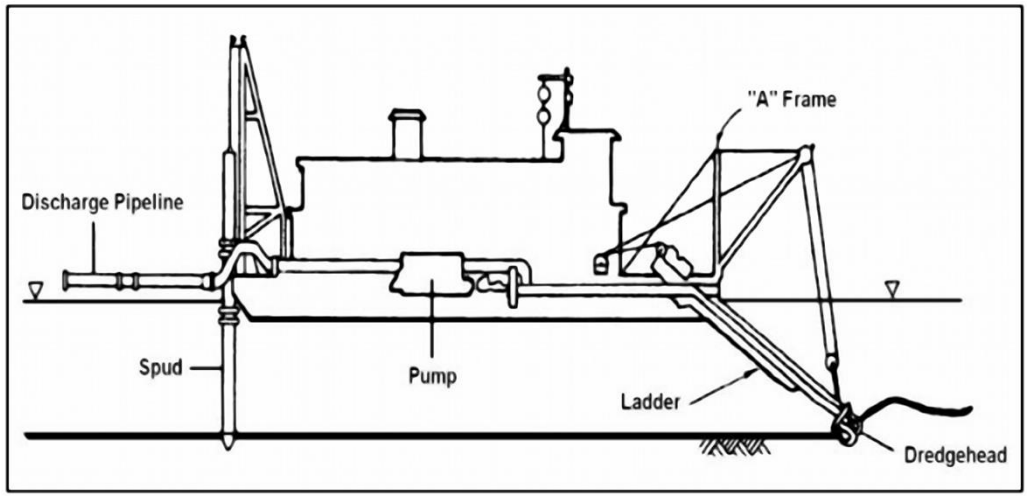
Removal of contaminated sediment by dredging



Picture source: Hand et al. 1978

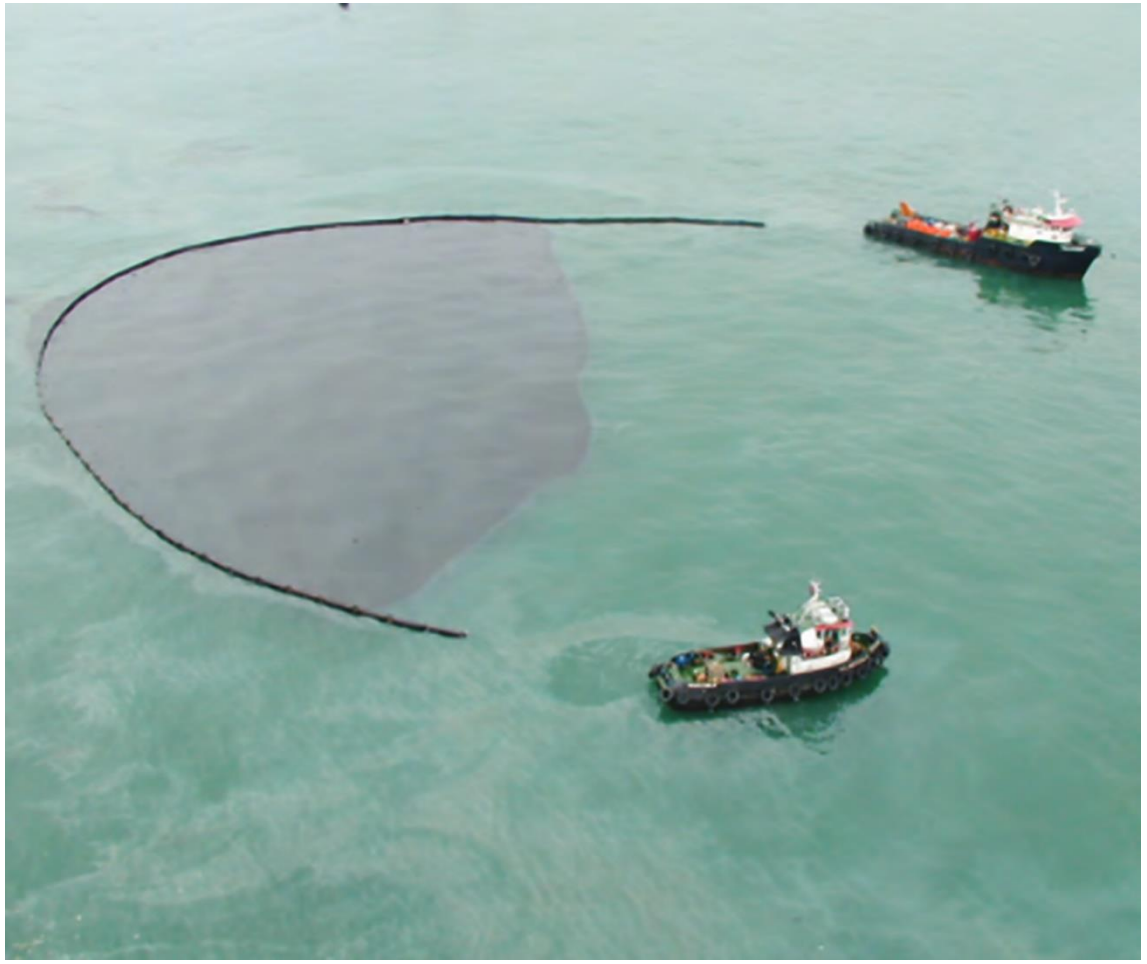


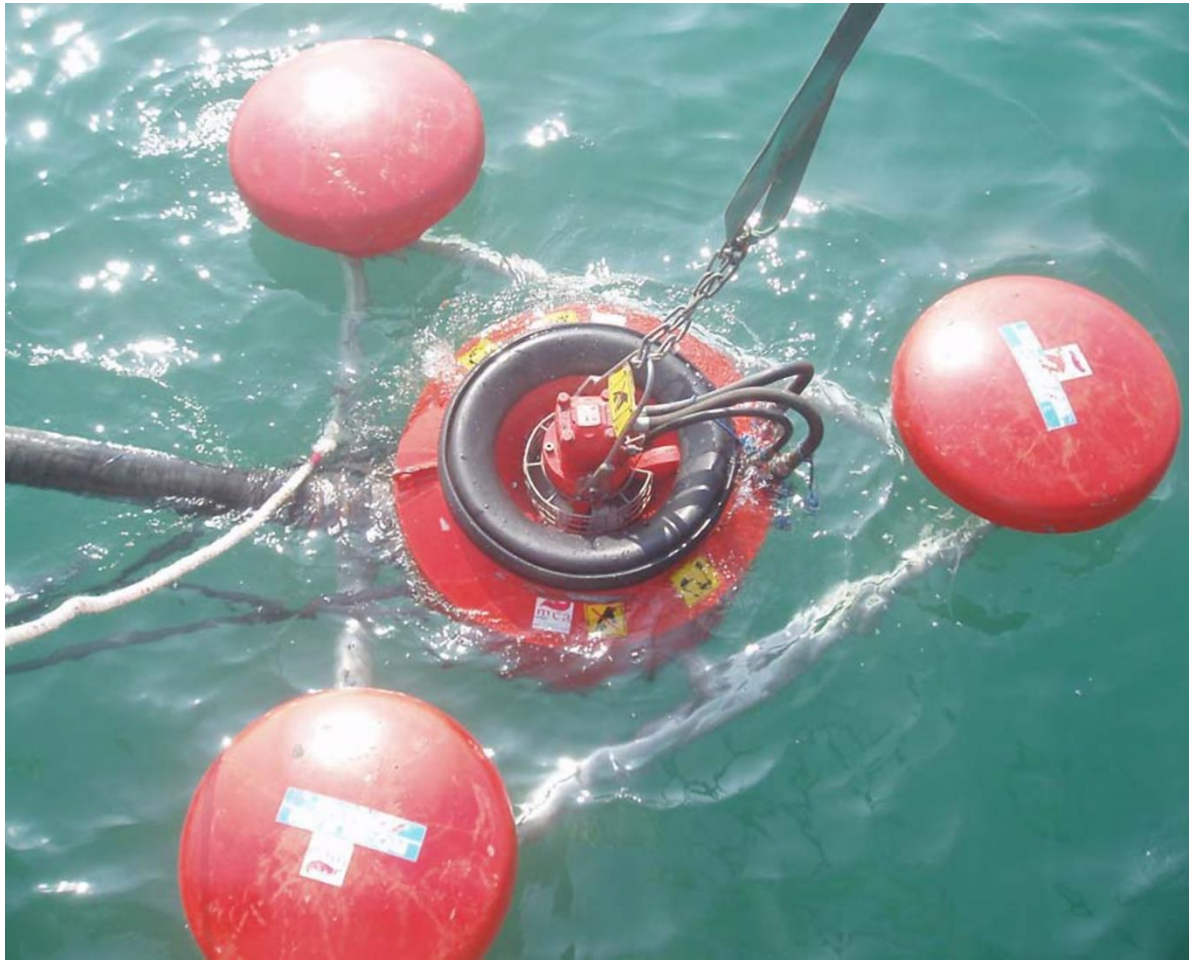




Hot-tapping and pumping fuel residues from the wreck with a ROV

Auxiliary supporting technologies for oil removal





General costs assessment

Complexity of operation	Waters	Depth metres/ feet	Oil viscosity	Water temperature	Wreck condition	Vessel factors	Distance from mobilisation point	Cost range
		⟷	⟷		⟷			
Simple	Protected	65	Low	High	Good	Not very old. Optimal construction. Not very damaged Thick plating. Low location sensitivity	Local	$ 1-5 M
Moderate	Problems with weather or sea condition	65-164	Medium	Moderate	Medium	Not very old. Stable structure. Not very damaged. Thick plating of the hull. Low location sensitivity	Regional	$ 2-7 M
Complex	Open	164-820	High	Low	Weak	Old. Multiple structure damage. High location sensitivity	Distant	$ 5-20+ M
Highly complex	Open	>820	High	Very low	Very weak	Very old. Poor structure. Severely damaged. Covered with corroded plating, Highest location sensitivity	Distant	$ 20-100+ M

⟷ Interrelated factors

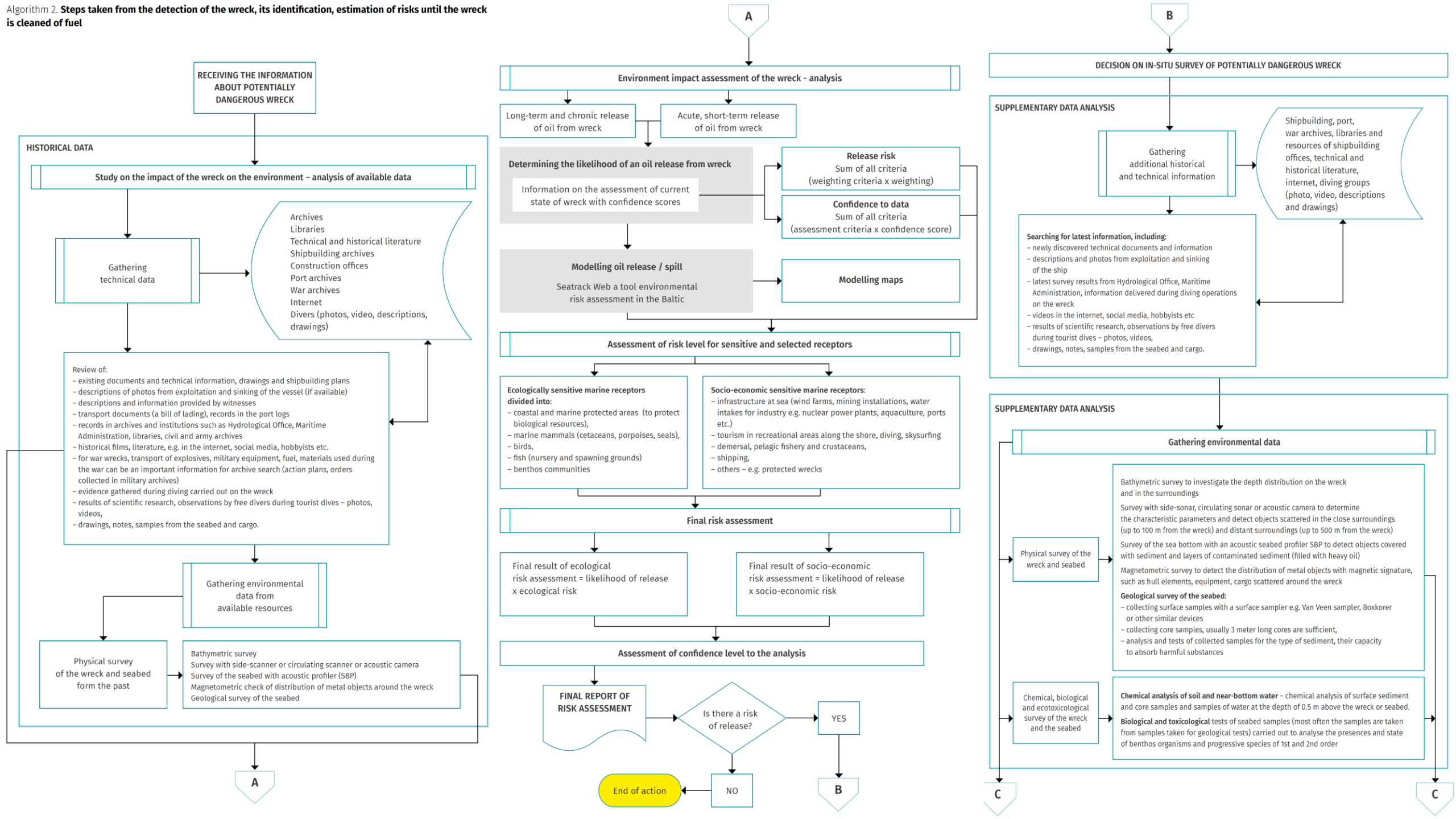
Table 12. **Daily staff rates**

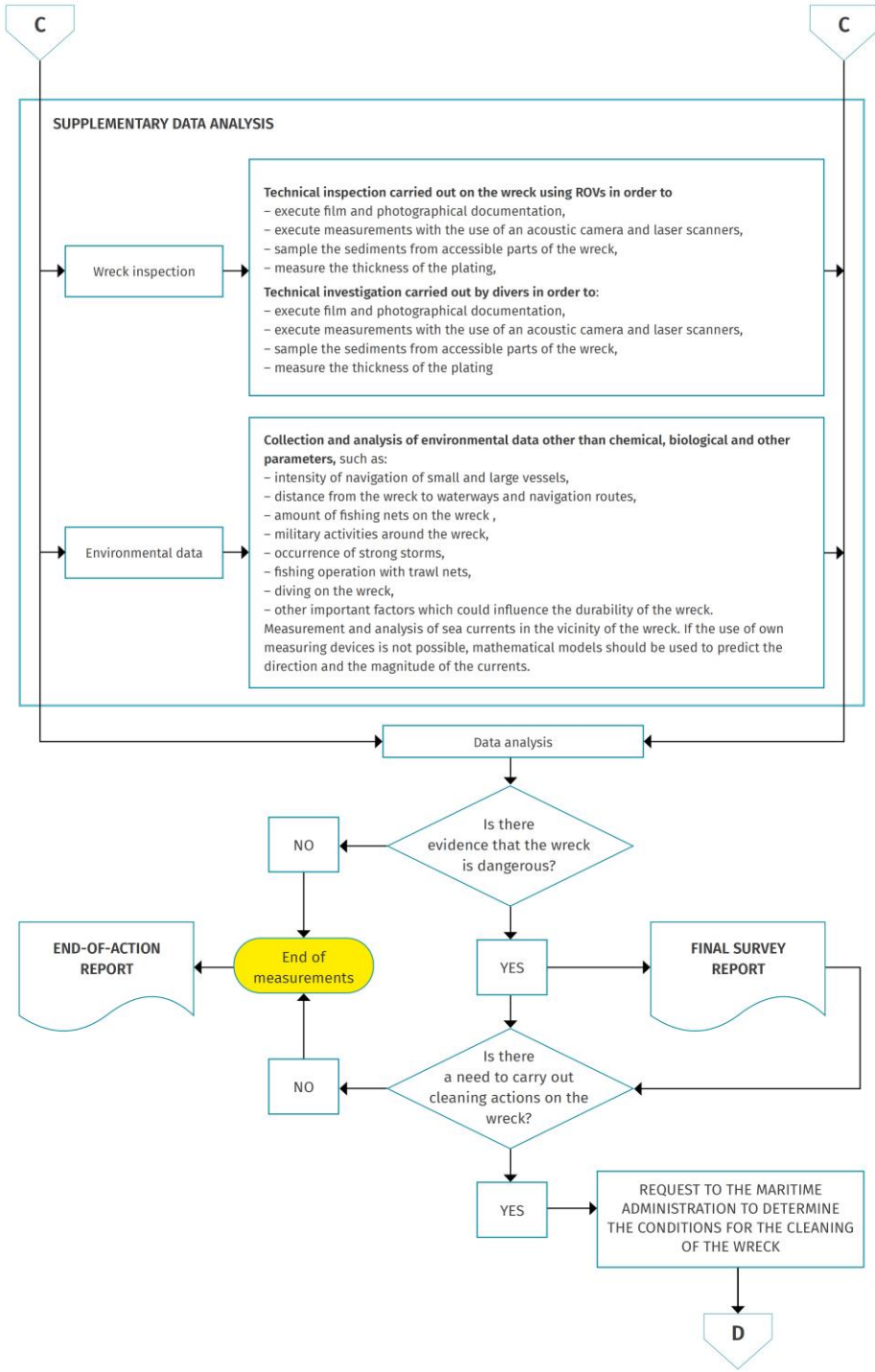
Personnel	US $
Office administration, including communications	1,361
Salvage Master	2,029
Naval Architect or Salvage Officer/Engineer	1,692
Assistant Salvage Officer/Engineer	1,356
Diving Supervisor	1,356
HSE qualified diver or his equivalent but excluding saturation or mixed gas drivers	1,217
Salvage Foreman	1,014
Riggers, Fitters, Equipment Operators	812
Specialist Advisors – Fire Fighters, Chemicals, Pollution Control	1,361

Table 13. **Costs of equipment (cost per one day of rental/work)**

Portable salvage equipment	US $
Hot Tap Machine, including support equipment	1,351
Air Lift 8”	405
Oil Boom, 48”, per 10 metres	263
Pumping Equipment Air 3 „Hydraulic 8”	117 1,351
Air Hose 2”	11

Algorithm 2. **Steps taken from the detection of the wreck, its identification, estimation of risks until the wreck is cleaned of fuel**

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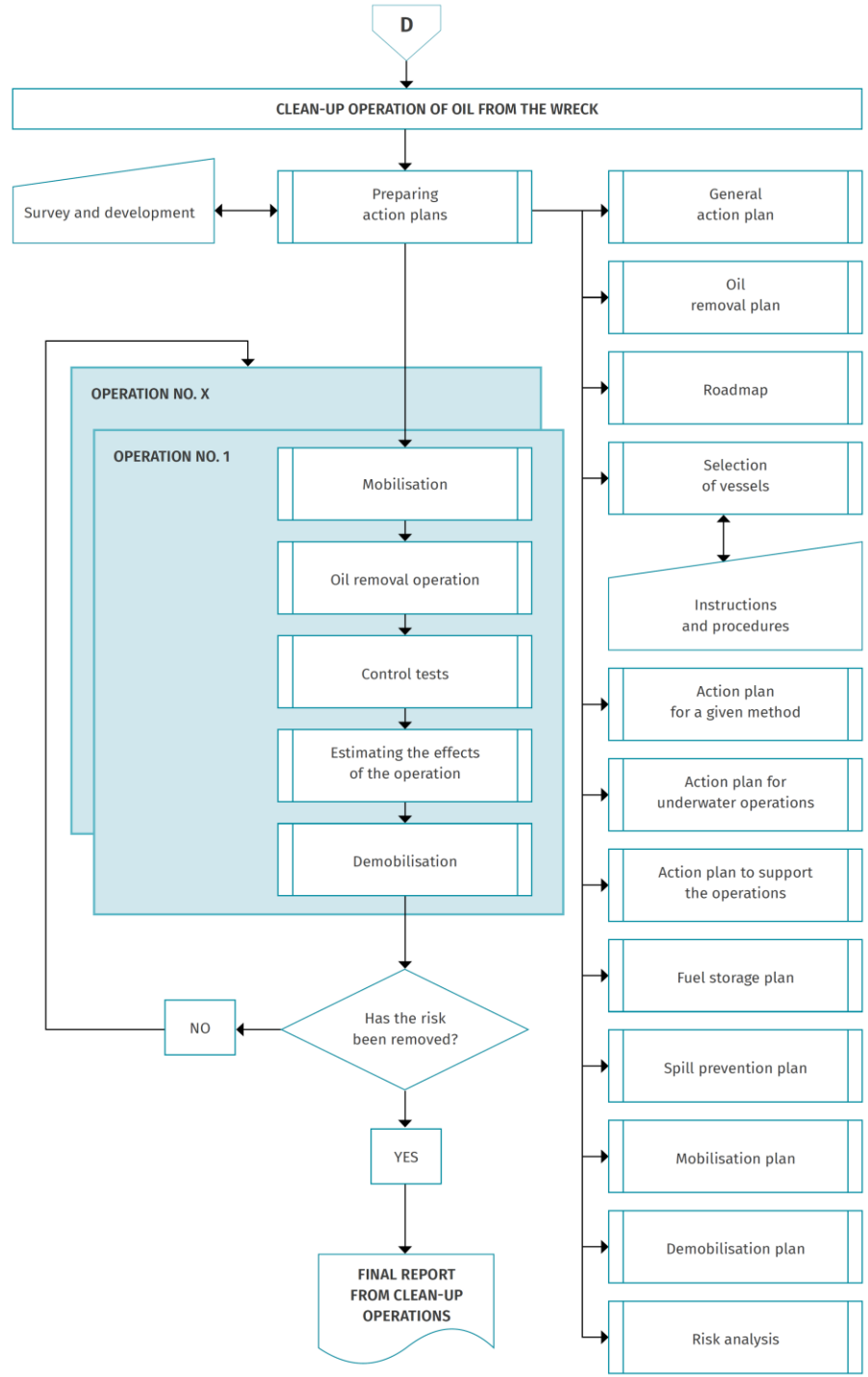
C
SUPPLEMENTARY DATA ANALYSIS
Wreck inspection
Technical inspection carried out on the wreck using ROVs in order to
– execute film and photographical documentation,
– execute measurements with the use of an acoustic camera and laser scanners,
– sample the sediments from accessible parts of the wreck,
– measure the thickness of the plating,
Technical investigation carried out by divers in order to:
– execute film and photographical documentation,
– execute measurements with the use of an acoustic camera and laser scanners,
– sample the sediments from accessible parts of the wreck,
– measure the thickness of the plating
Environmental data
Collection and analysis of environmental data other than chemical, biological and other parameters, such as:
– intensity of navigation of small and large vessels,
– distance from the wreck to waterways and navigation routes,
– amount of fishing nets on the wreck ,
– military activities around the wreck,
– occurrence of strong storms,
– fishing operation with trawl nets,
– diving on the wreck,
– other important factors which could influence the durability of the wreck.
Measurement and analysis of sea currents in the vicinity of the wreck. If the use of own measuring devices is not possible, mathematical models should be used to predict the direction and the magnitude of the currents.
Data analysis
Is there evidence that the wreck is dangerous?
NO
END-OF-ACTION REPORT
End of measurements
YES
FINAL SURVEY REPORT
Is there a need to carry out cleaning actions on the wreck?
NO
YES
REQUEST TO THE MARITIME ADMINISTRATION TO DETERMINE THE CONDITIONS FOR THE CLEANING OF THE WRECK
D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CLEAN-UP OPERATION OF OIL FROM THE WRECK
Survey and development
Preparing action plans
General action plan
Oil removal plan
Roadmap
Selection of vessels
Instructions and procedures
Action plan for a given method
Action plan for underwater operations
Action plan to support the operations
Fuel storage plan
Spill prevention plan
Mobilisation plan
Demobilisation plan
Risk analysis
OPERATION NO. X
OPERATION NO. 1
Mobilisation
Oil removal operation
Control tests
Estimating the effects of the operation
Demobilisation
Has the risk been removed?
NO
YES
FINAL REPORT FROM CLEAN-UP OPERATIONS

Final words

- Determining the necessary procedures to be followed while examining the impact of wrecks and the fuel they contain on the marine environment, estimating the threats those wrecks pose to the environment, and how to mitigate the effects of these threats – **is at present one of the most pressing challenges in the protection of the Southern Baltic**.

- It should be an important task for scientific institutions dealing with the marine environment, as well as for the management bodies, responsible for marine areas, i.e. maritime administration at all levels.

- **A situation where, despite the classification of the wrecks as dangerous, appropriate measures to prevent the environmental disaster are not taken, is not acceptable.**

Thank you for your attention!

Dr inż. Benedykt Hac

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