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The History of Maritime Technology Conference

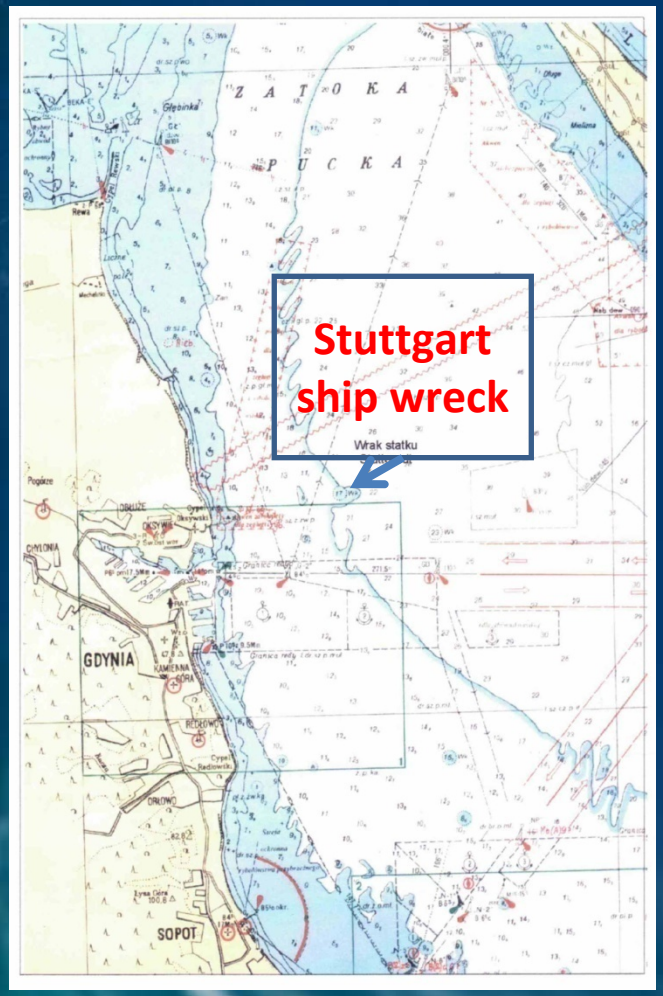
HAZARD OF SEABED CONTAMINATION BY OIL PRODUCTS FROM MOTOR SHIP WRECKS BASED ON THE EXAMPLE OF THE „STUTTGART" SHIP WRECK

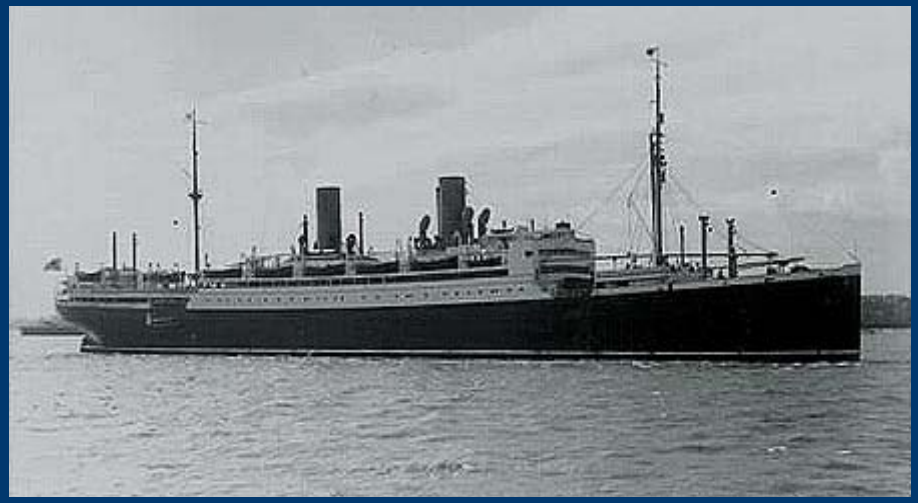
Dr. Eng. Hac Benedykt

Histmartech

Gdańsk 16-18.04.2015

s/s Stuttgart





- Main parameters of the ship:
  - length - 171.6 m
  - breadth - 19.8 m
  - gross tonnage - 13387 GRT
  - net tonnage - 7796 NRT

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s/s Stuttgart

View of the s/s „Stuttgart” ship as Lazaretschiff „C”

s/s Stuttgart

An aerial photograph presenting a fragment of the Kriegsmarine base in the Gdynia harbour right after the american air raid. The photograph was taken by an allied airplane. The fiercely burning „Stuttgart” steam ship (hospital) is shown in the bottom right corner.

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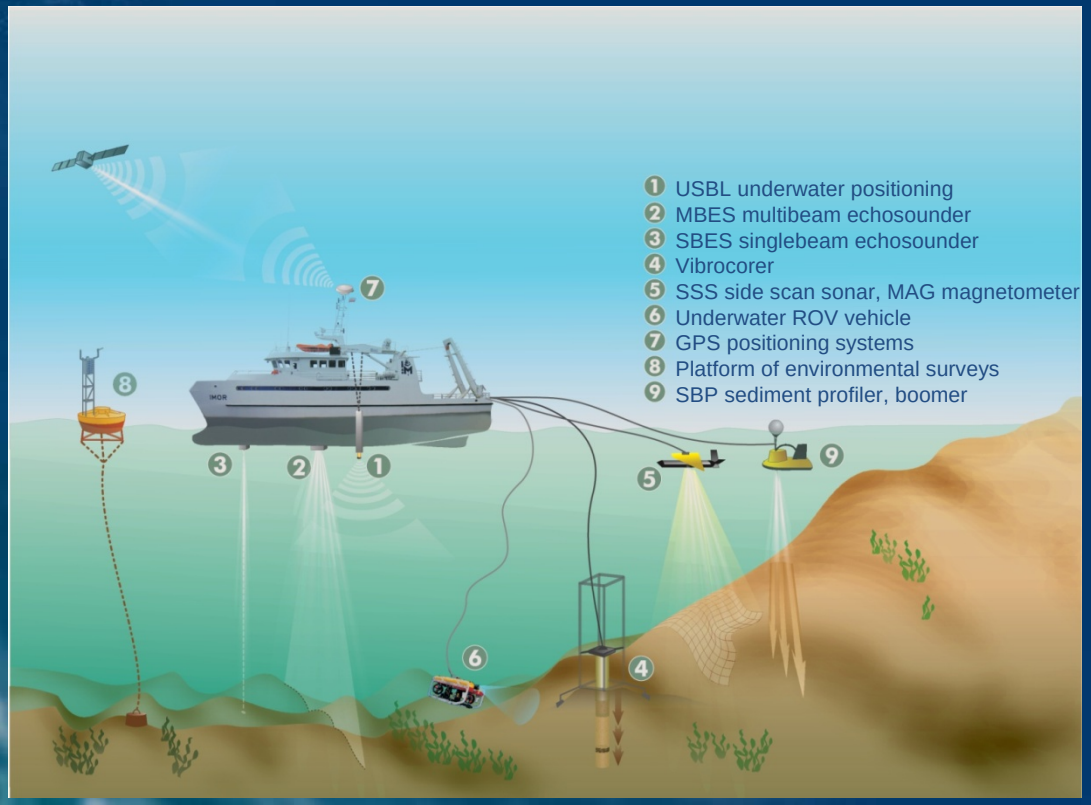
Research Vessel IMOR

Research Vessel IMOR



Sureying equipment of r/v IMOR

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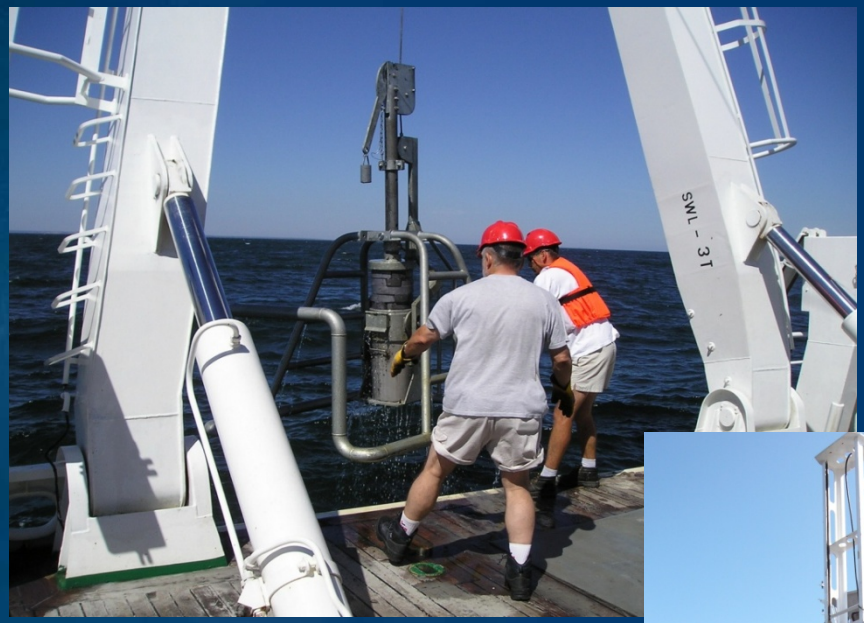
Research Vessel IMOR



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The main purpose of the carried out research and surveys of the s/s „Stuttgart” ship wreck in 2012 was the assessment of hazard it poses for the marine ecosystem in the area of the ship’s settlement and its impact on the sea water environment of the Gdańsk Bay.

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The purpose of the carried out work was also to answer the following questions:

- Was the run-off of substances contaminating the seabed in the area of the wreck stopped in a natural way?
- Is the contaminated area still expanding?
- Have there been any signs of returning life in the area of contamination after 13 years from the first survey ?

Detailed scope of work:

Collecting materials for the assessment of the environmental state in the area of the wreck involving:

- Collecting samples and performing geological analysis of the substratum in the area of the underwater fuel spill.
- Collecting samples and performing chemical analysis of water and bottom sediments.
- Assessing the state of zoobenthos as an indicator of the marine environment's condition.

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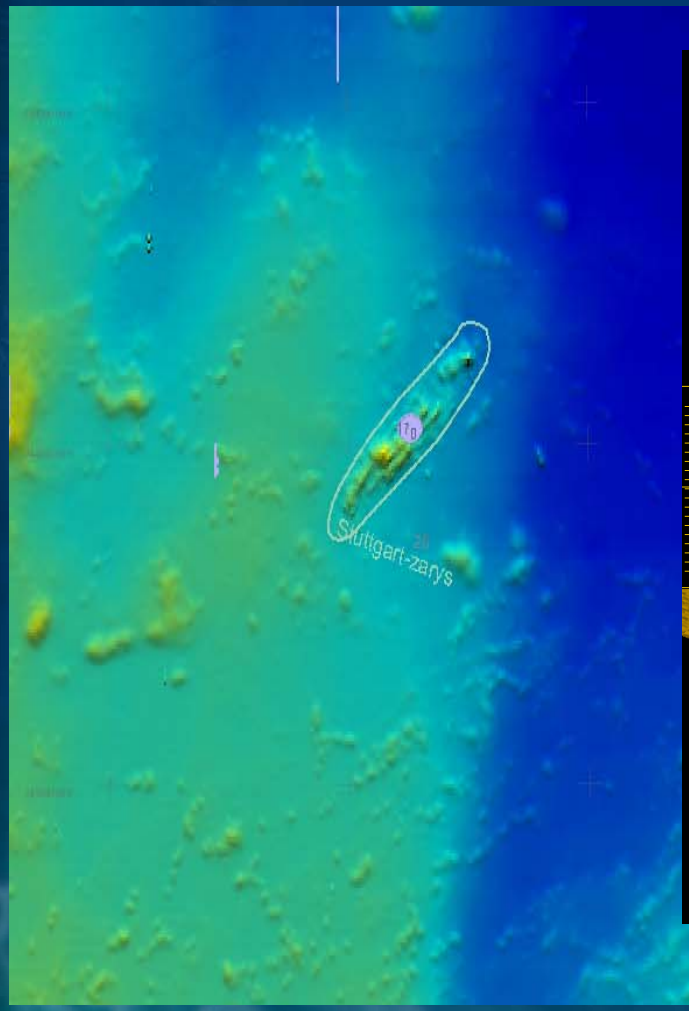
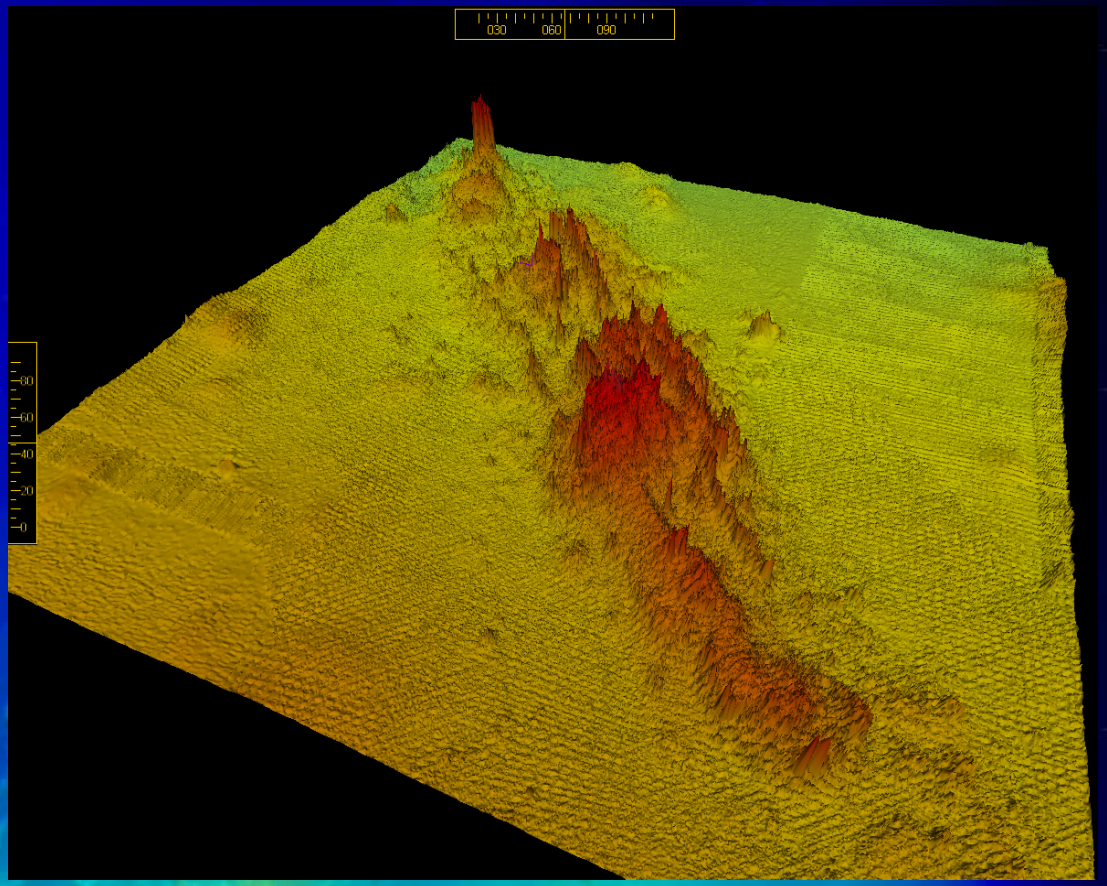
Sonar image of the seabed area where the monitored wreck is settled

Bathymetric conditions of the seabed in the area where the s/s Stuttgart wreck is settled





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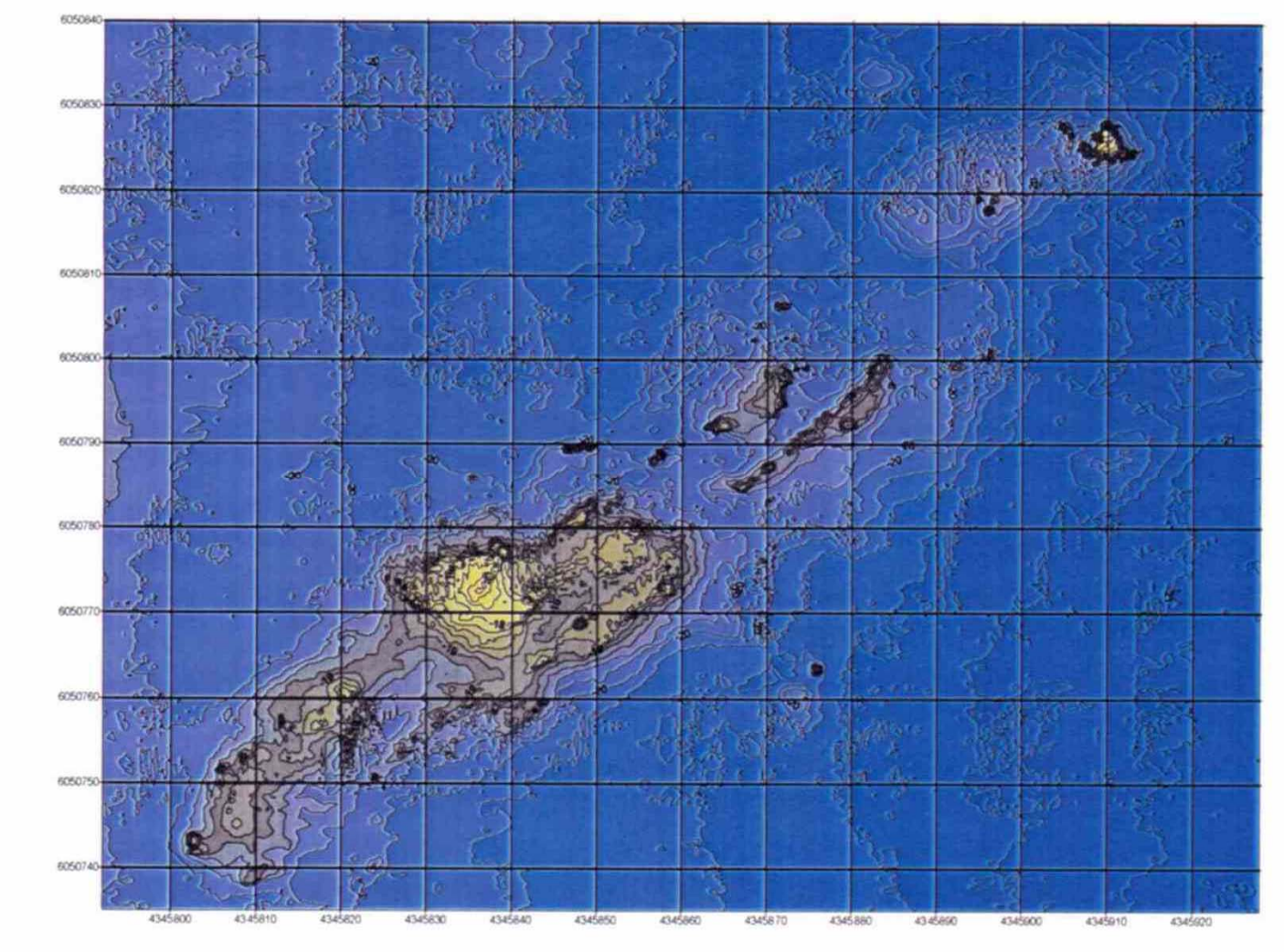
Bathymetric conditions of the seabed in the area where the s/s Stuttgart wreck is settled



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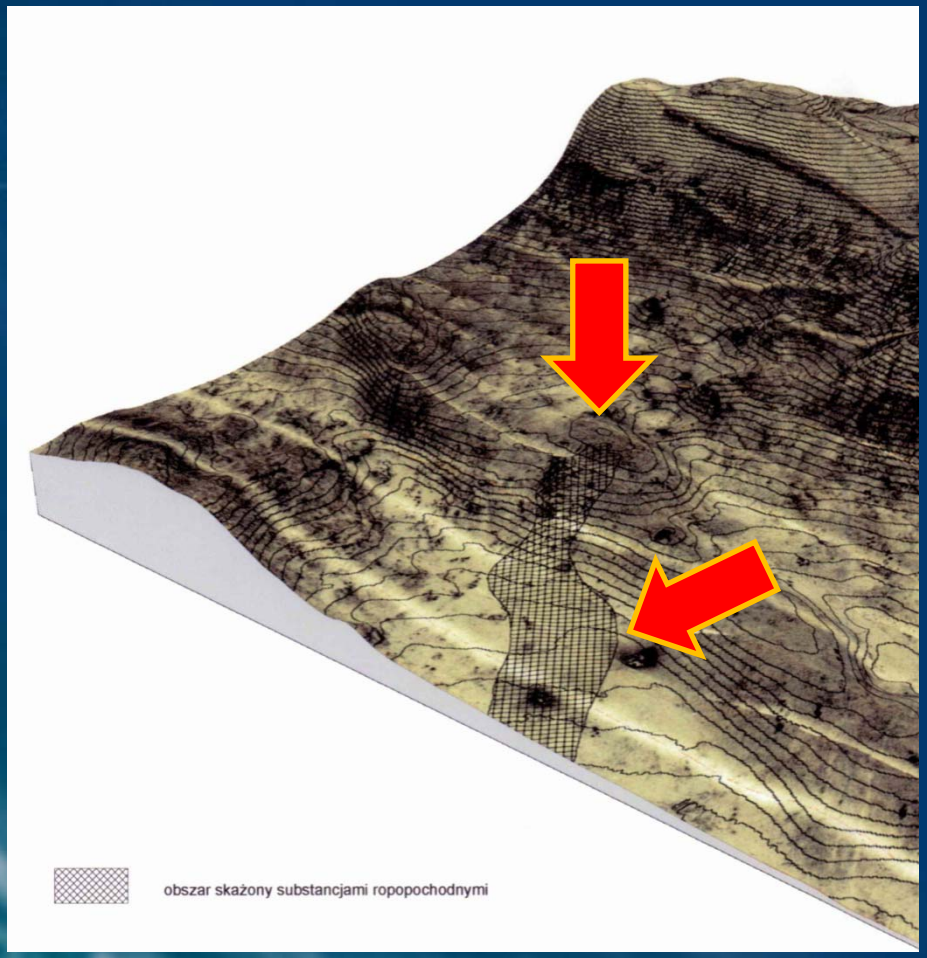
Bathymetric conditions of the seabed in the area where the s/s Stuttgart wreck is settled



Run-off of heavy fuel in the direction of deeper water.

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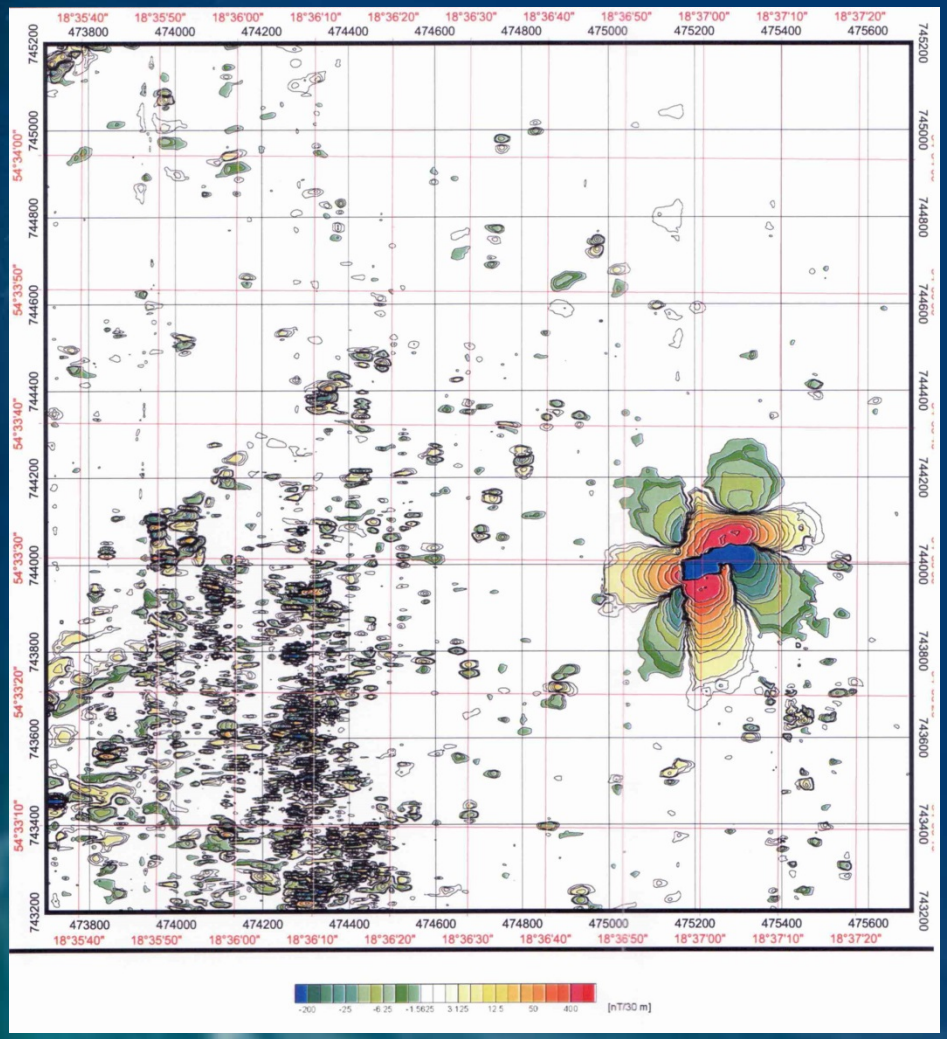
Anomalies of the natural field of magnetic induction in the vicinity of the wreck



Anomaly isolines of the magnetic induction field caused by the magnetic mass of the s/s Stuttgart ship wreck and other magnetic masses in the area.

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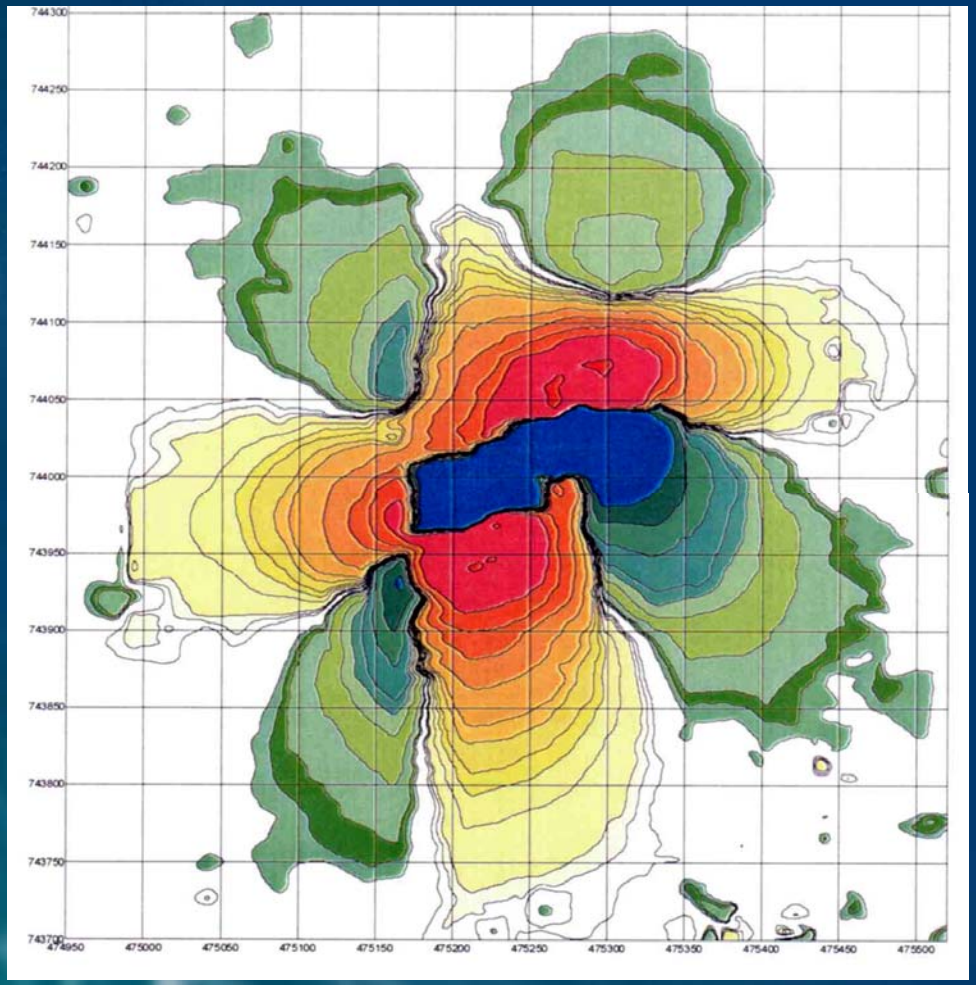
Anomalies of the natural field of magnetic induction in the vicinity of the wreck



Anomaly isolines of the magnetic induction field caused by the magnetic mass of the s/s Stuttgart ship wreck – area limited to the wreck.

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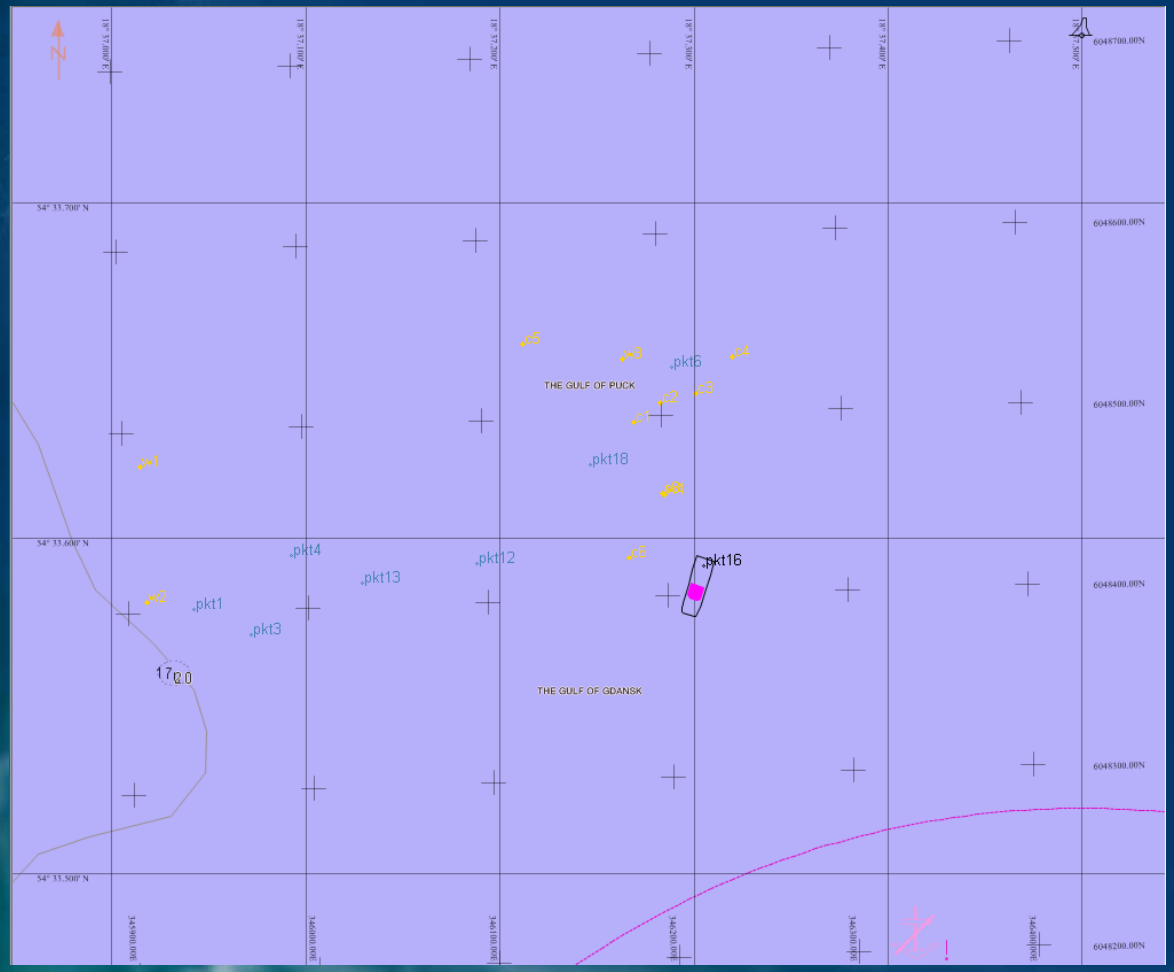
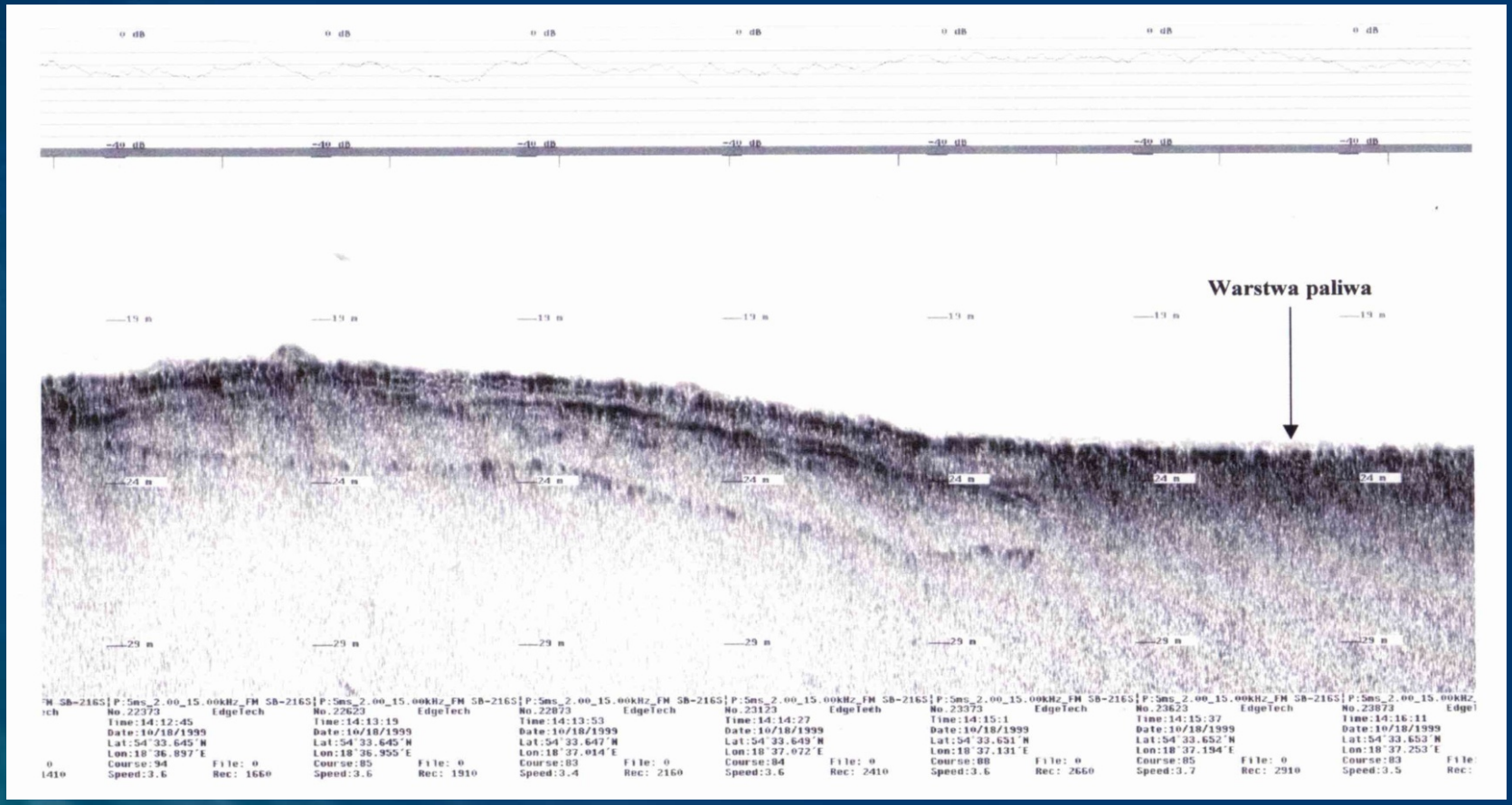
Geological conditions in the area where the wreck is settled



Situation map created during the collection of core samples from the seabed with the use of a VKG-03 vibrocorer (the postion of the research vessel during the collection of core sample in point 16 is marked in black)

Geological conditions in the area where the wreck is settled



An example of a seismoacoustic profile with a layer of sand suffused with heavy fuel.

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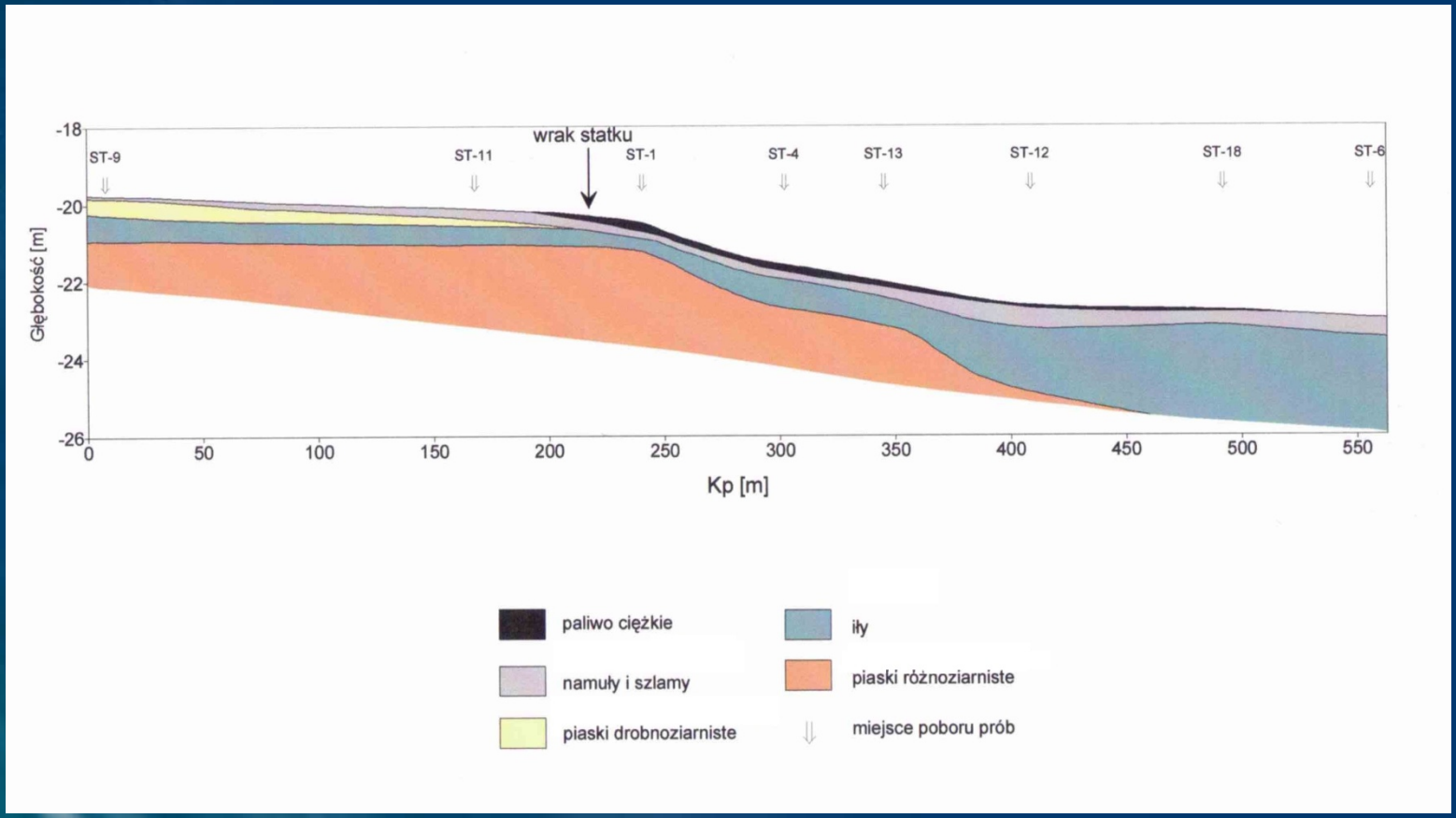
Range of occurrence of contamination with the heavy fuel flowing out of the s/s „Stuttgart” wreck – state for 1999



Geological situation and the distribution of contamination

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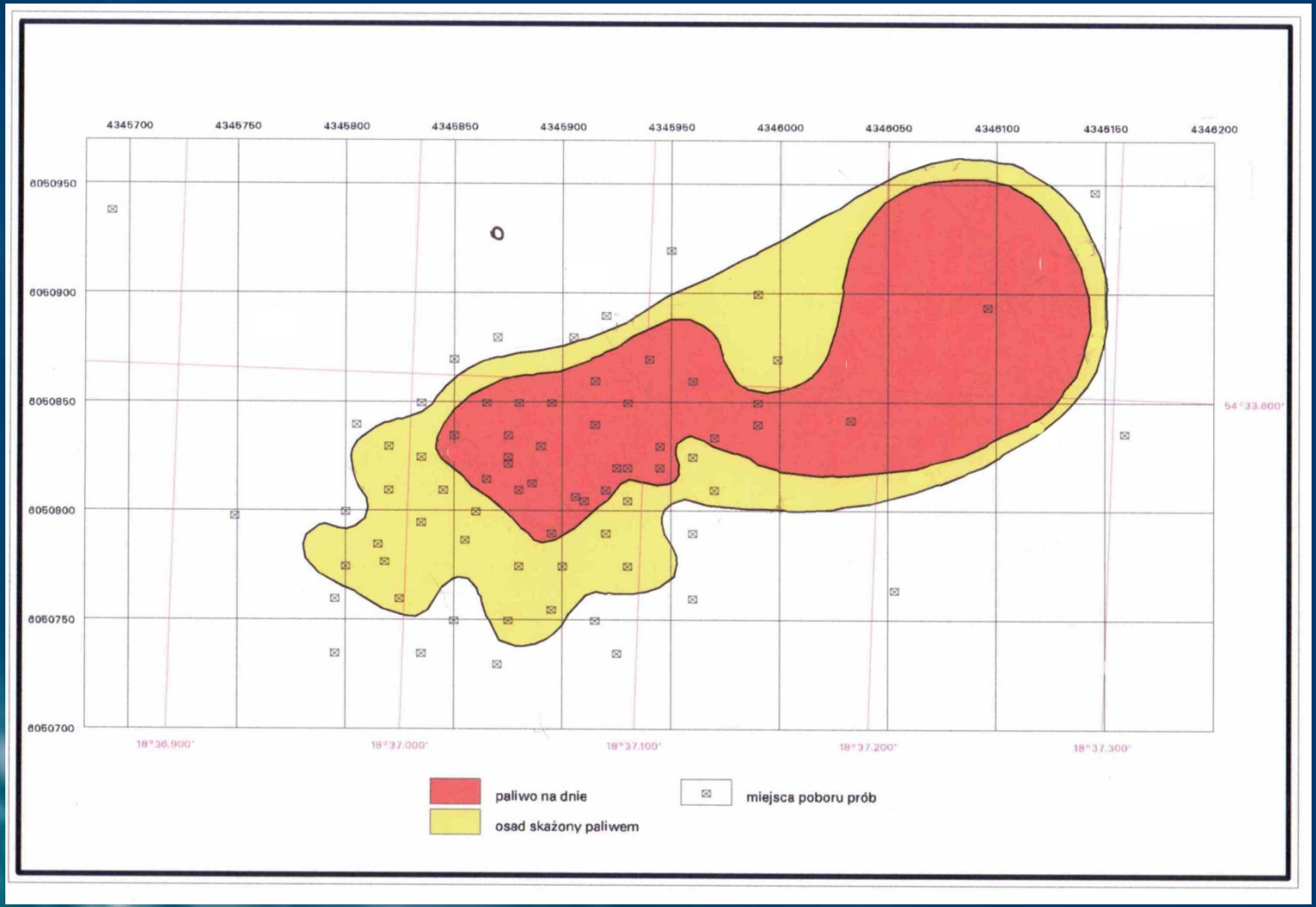
Range of occurrence of contamination with the heavy fuel flowing out of the s/s „Stuttgart” wreck – state for 1999



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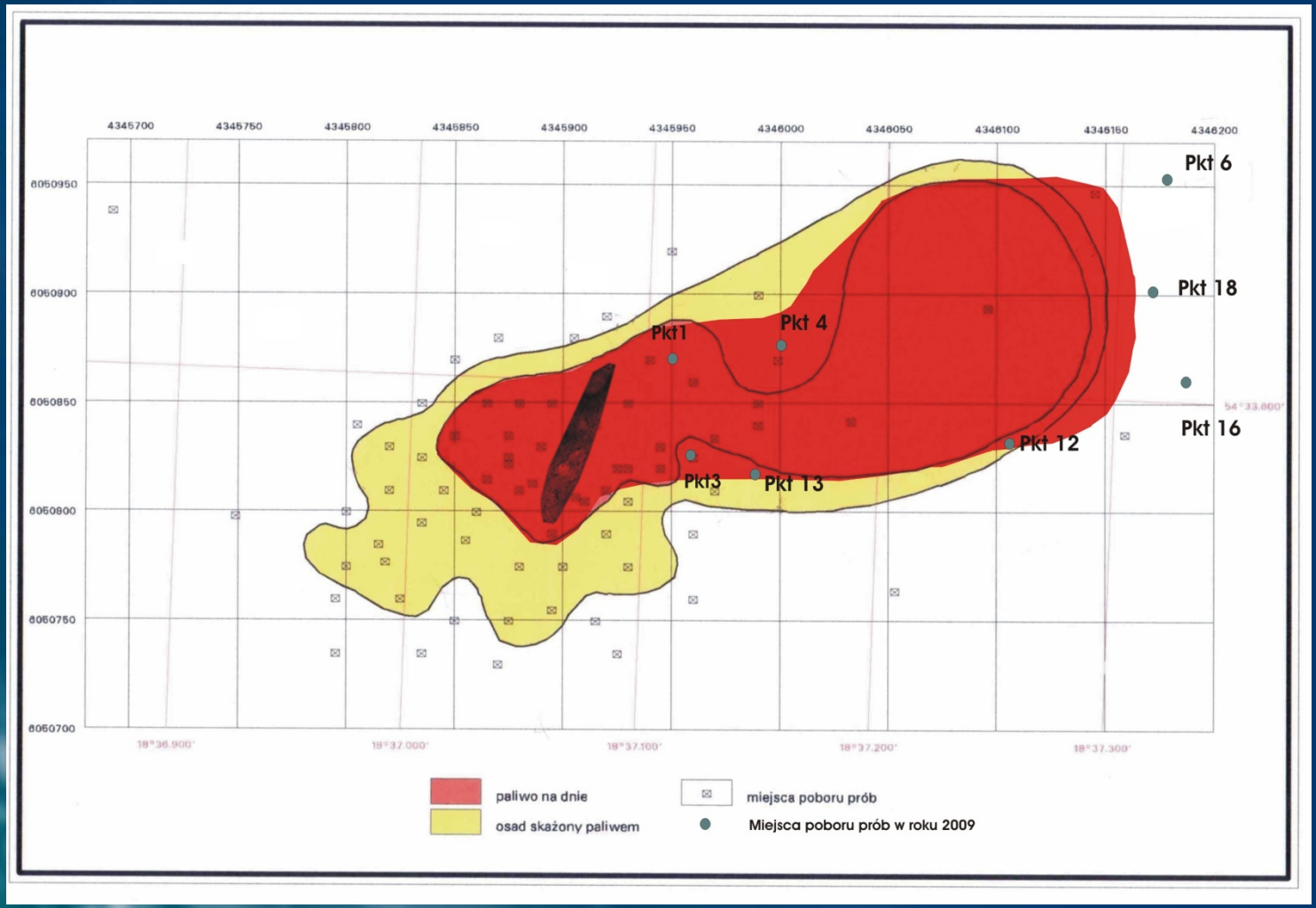

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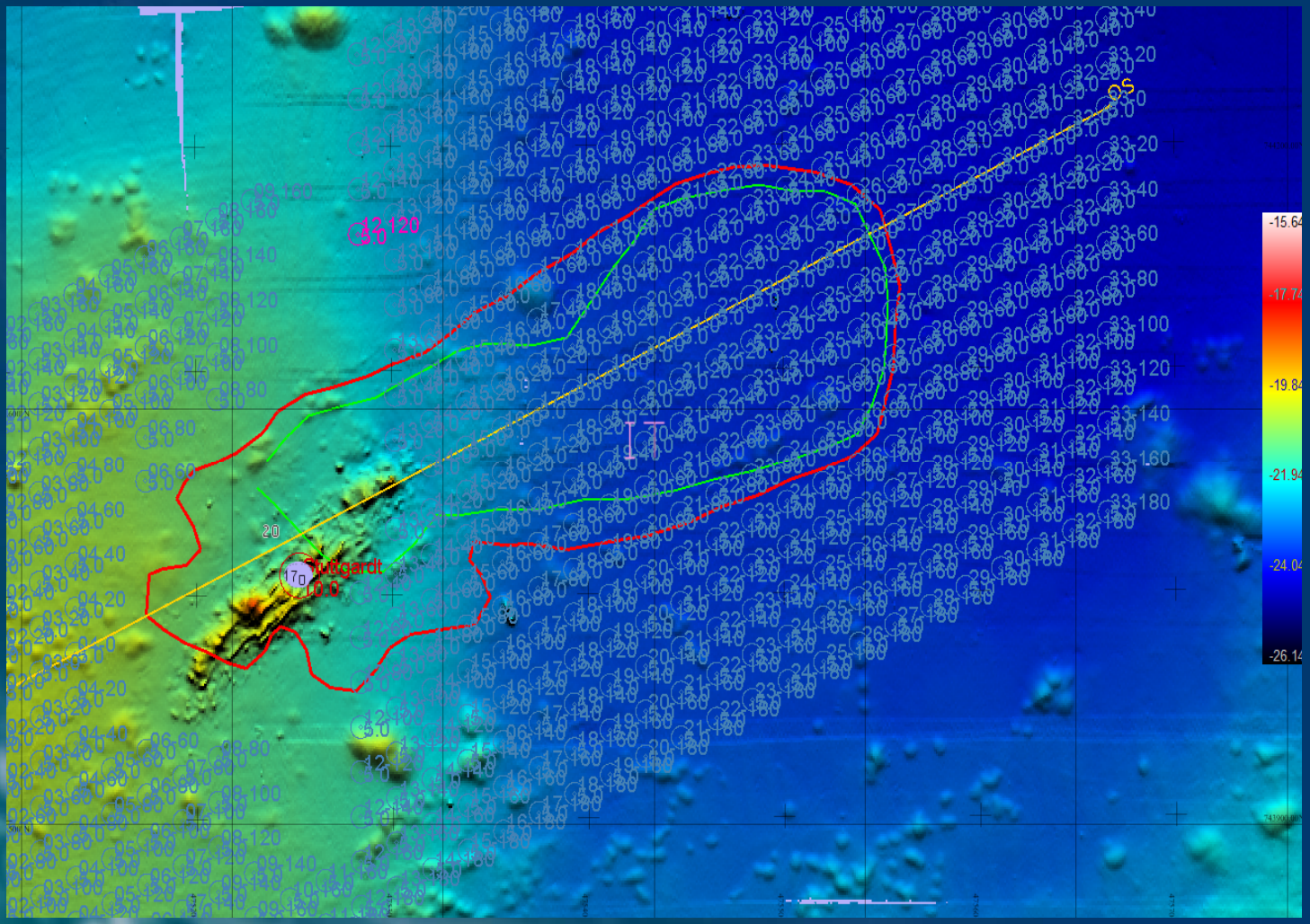
Range of occurrence of contamination with the heavy fuel flowing out of the s/s „Stuttgart” wreck – state for 2012



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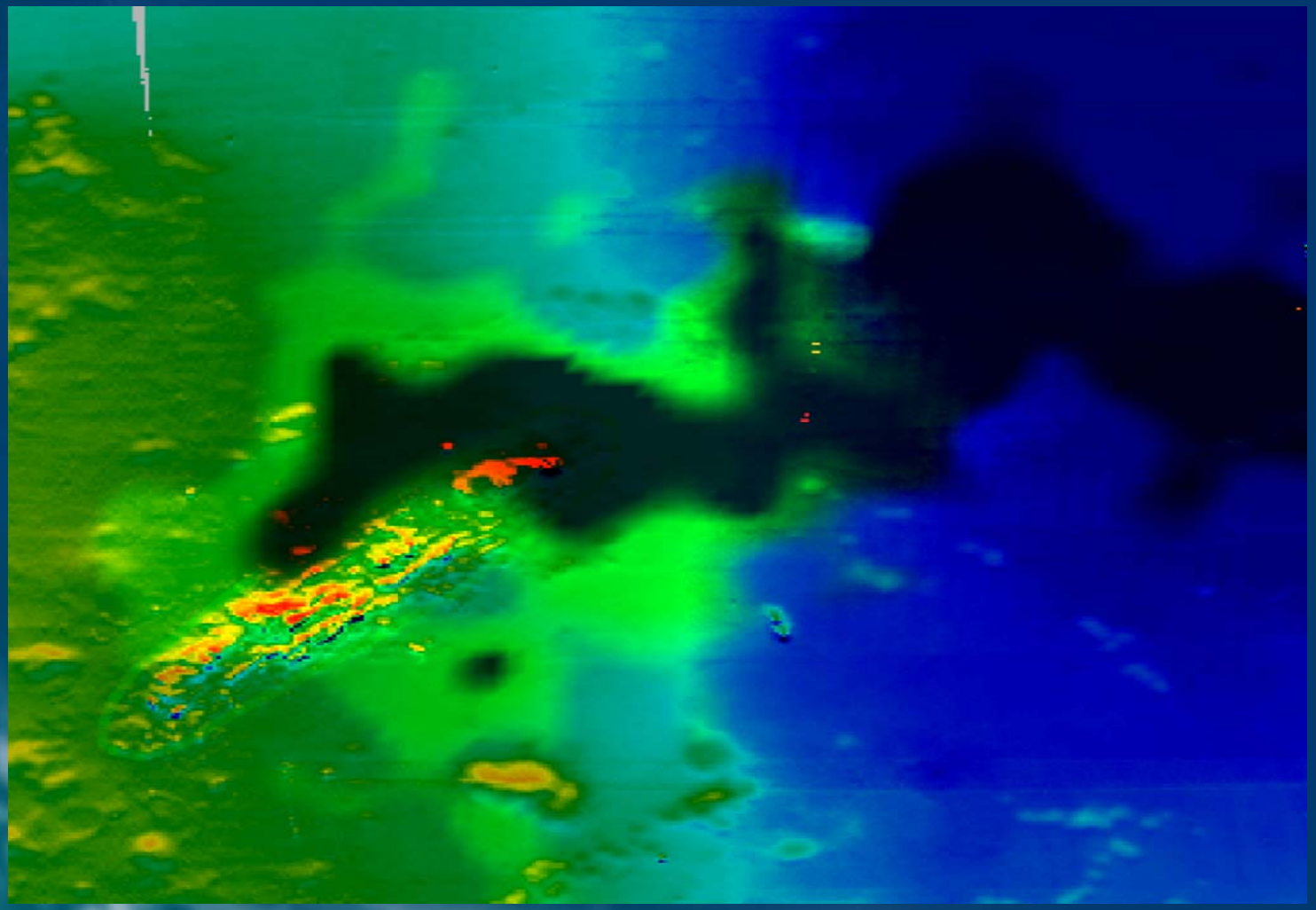
Range of occurrence of contamination with the heavy fuel flowing out of the s/s „Stuttgart” wreck – state for 2012



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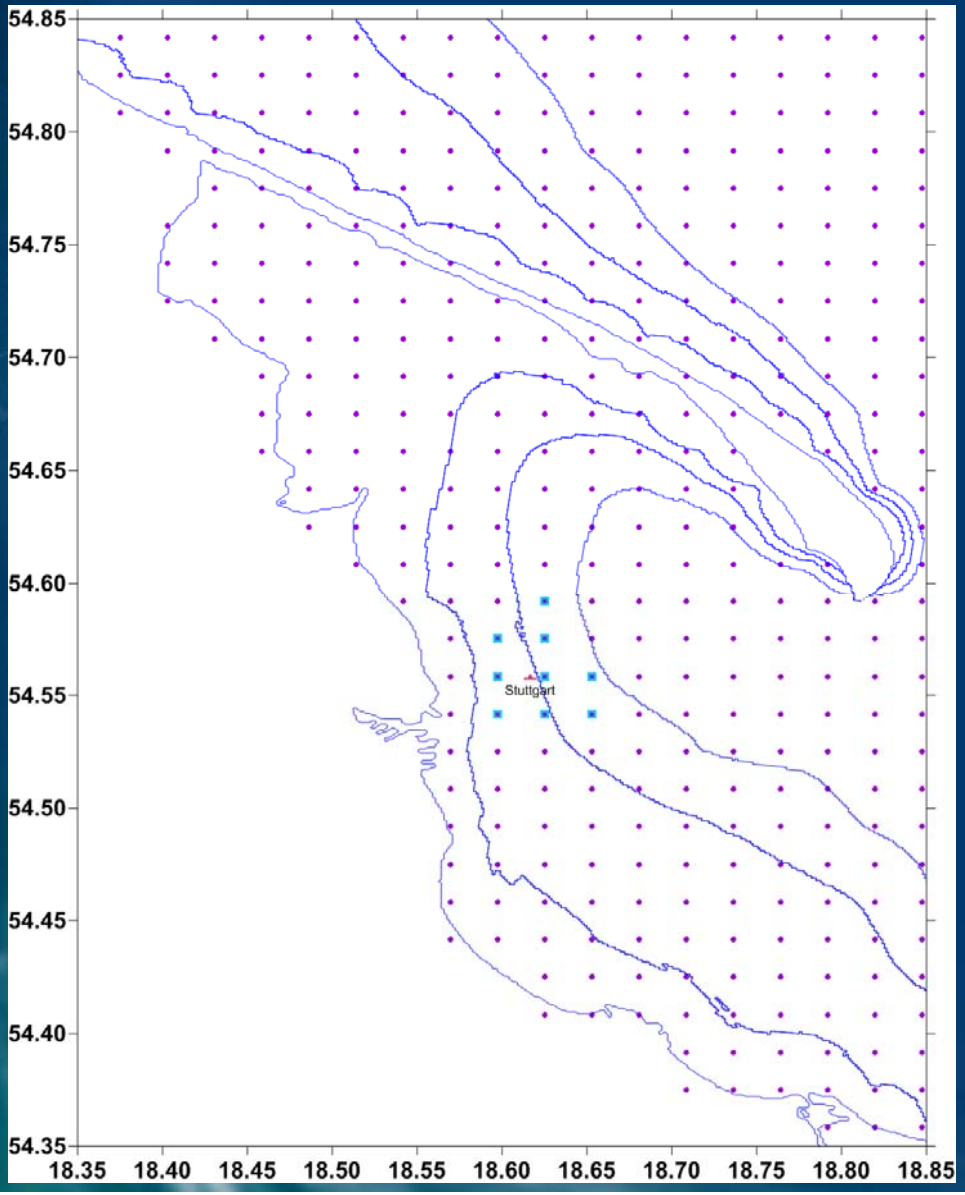
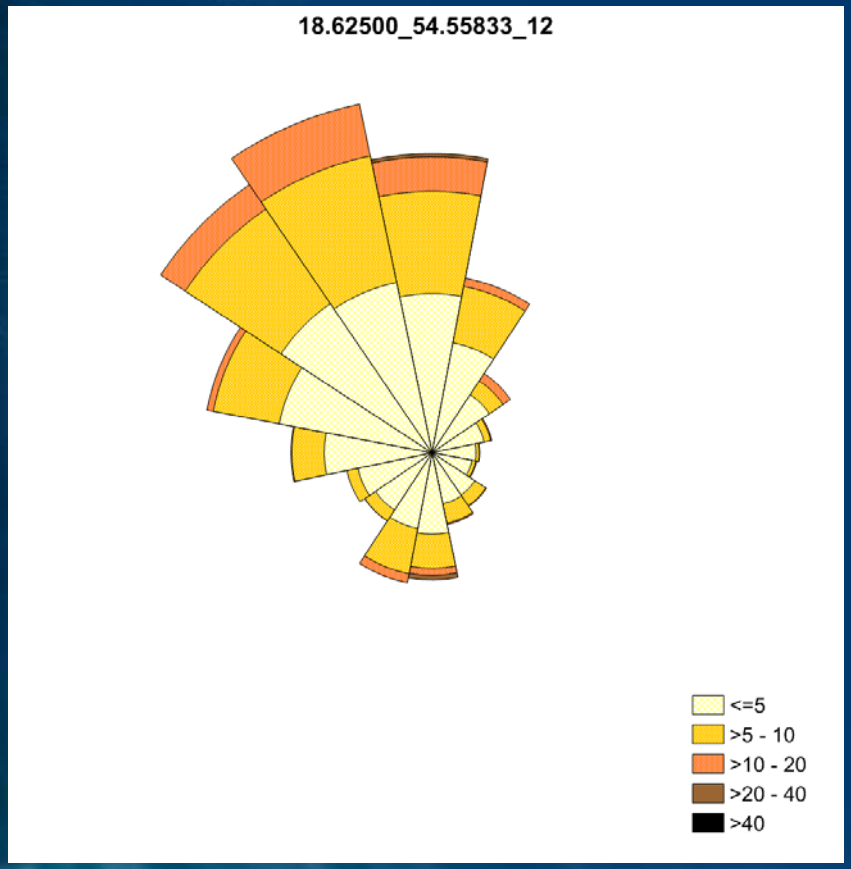
Survey of currents in the vicinity of the s/s Stuttgart wreck

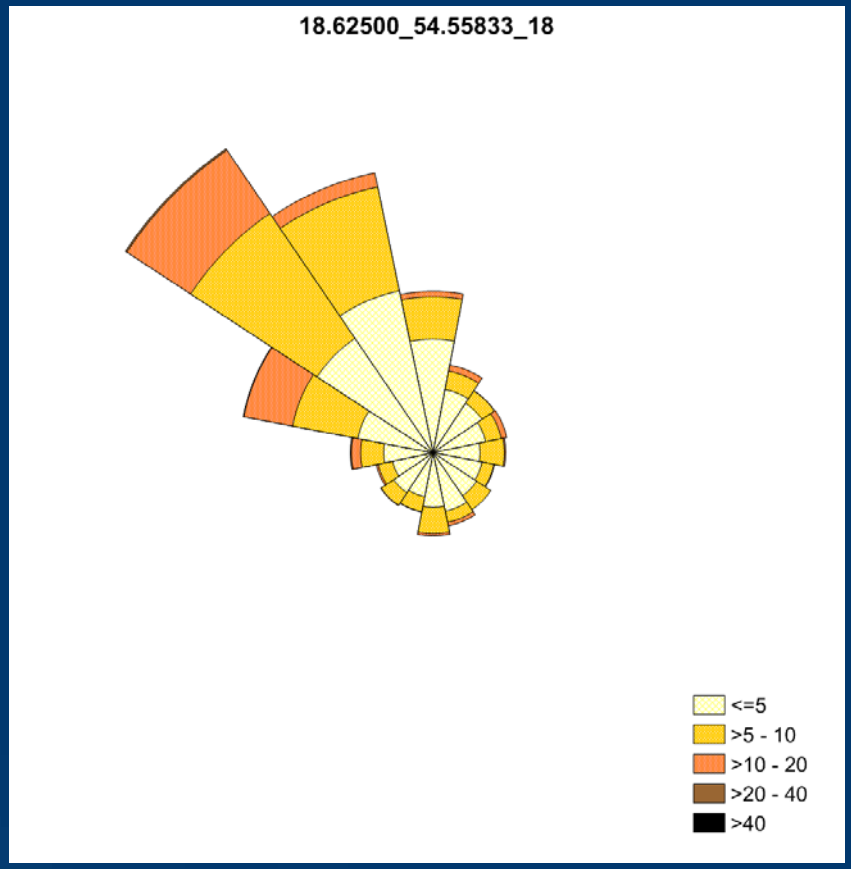


Map of points used for modelling currents in the area of the Gdańsk Bay.
The position of the wreck and the points chosen for modeling are marked on the figure.

Survey of currents in the vicinity of the s/s Stuttgart wreck



Distribution of currents in the depths of the water at the level of 12 meters.



Distribution of currents in the depths of the water at the level of 18 meters.

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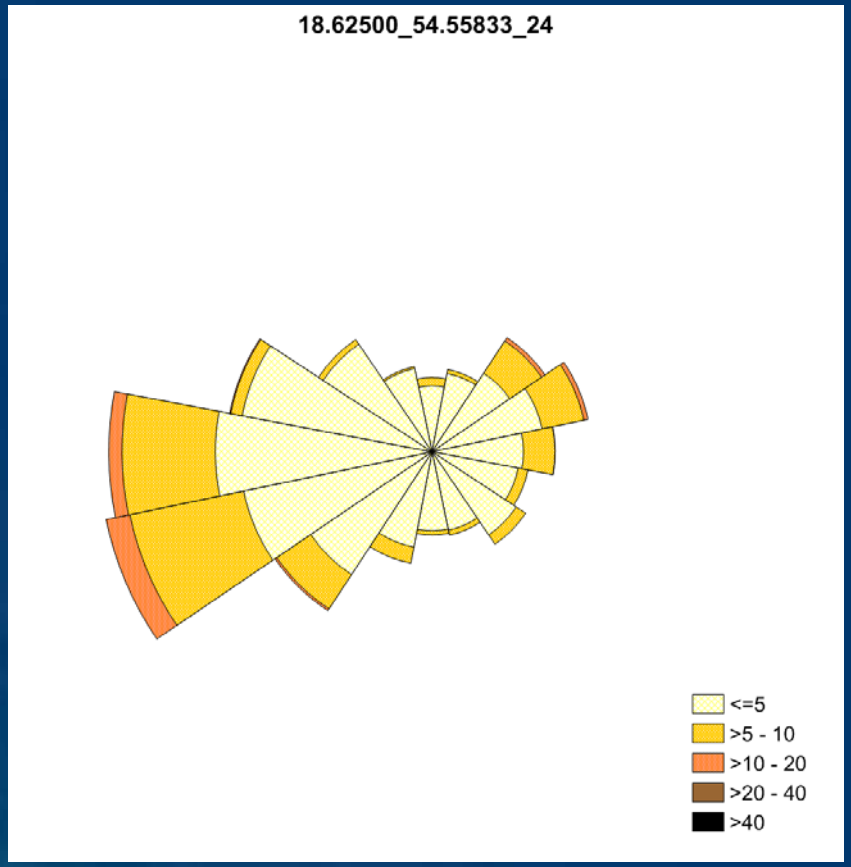
Survey of currents in the vicinity of the s/s Stuttgart wreck



Distribution of currents in the depths of the water at the level of 24 meters (nearbottom layer).

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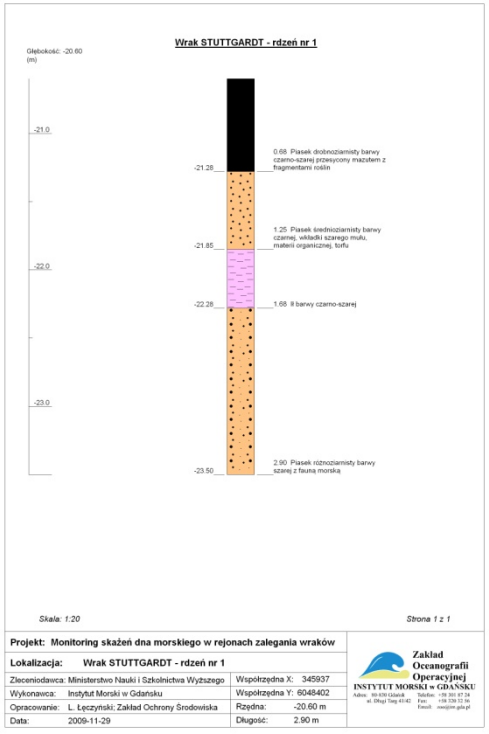
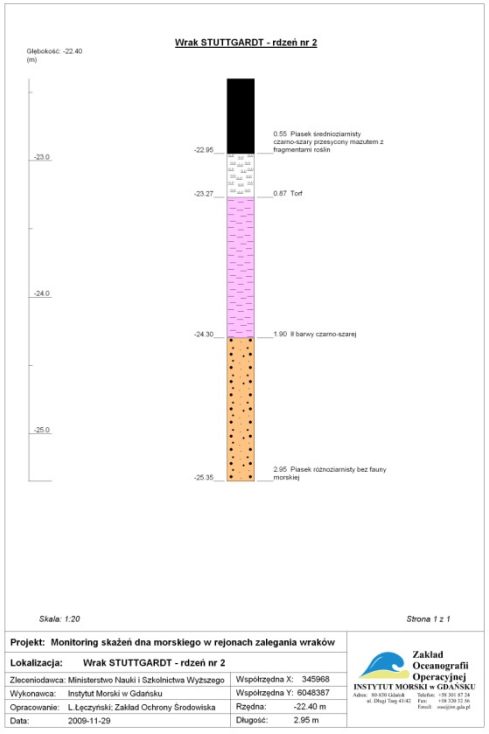
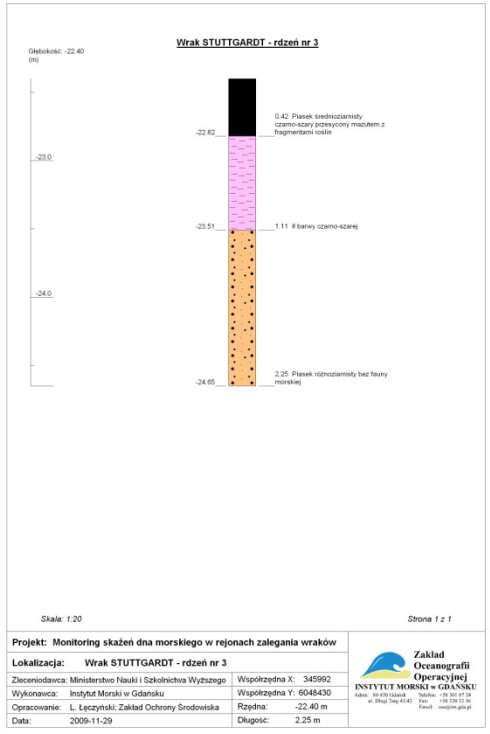
Range of occurrence of contamination with the heavy fuel (mazout) flowing out of the s/s „Stuttgart” wreck – state for 2009





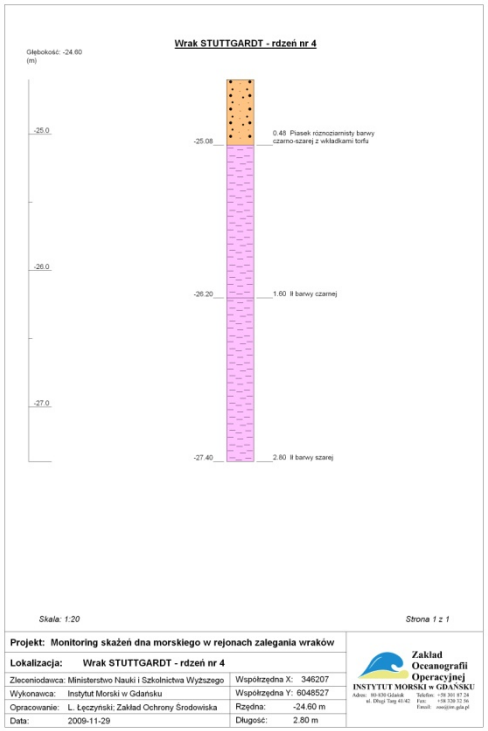


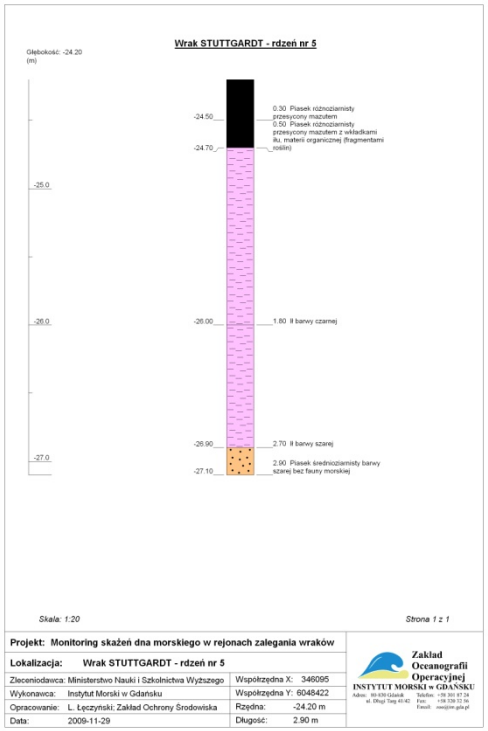
Core no. 1 collected in control point no. 1.

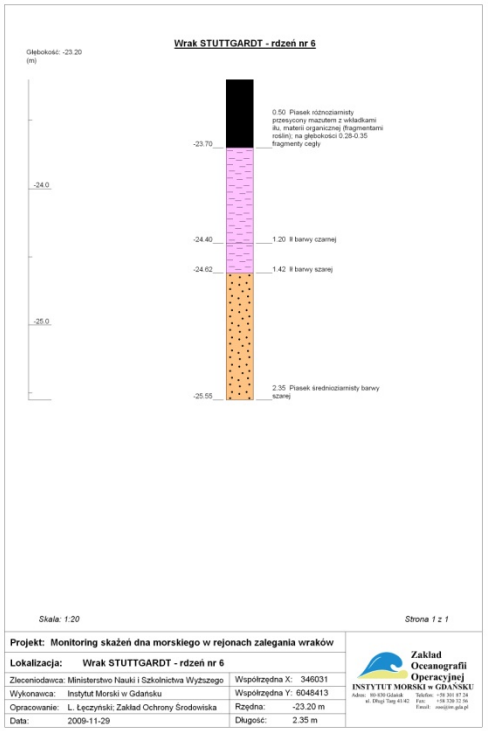
Core no. 2 collected in control point no. 3.

Core no. 3 collected in control point no. 4.

Range of occurrence of contamination with the heavy fuel (mazout) flowing out of the s/s „Stuttgart” wreck – state for 2009







Core no. 4 collected in control point no. 6.

Core no. 5 collected in control point no. 12.

Core no. 6 collected in control point no. 13.

Assessment of the chemical state of sediments and waters in the vicinity of the monitored wrecks

- Sediments were collected in close vicinity of the wrecks, in such a way as to include potential contamination of sediments with fuel leaking from the wreck, in order to assess the level of contamination of bottom sediments in the vicinity of the monitored wreck.

- Samples were collected with a standard van Veen type scoop.

- Water samples for the assessment of water quality were collected with a plastic batometer in the location of core sample collection, at the height of about 1 meter above the seabed.

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Assessment of the chemical state of sediments and waters in the vicinity of the monitored wreck

Survey results

*The survey report includes survey results covered with the scope of accreditation as well as unaccredited surveys. Results from beyond the scope of accreditation were indicated with the following mark: *)*

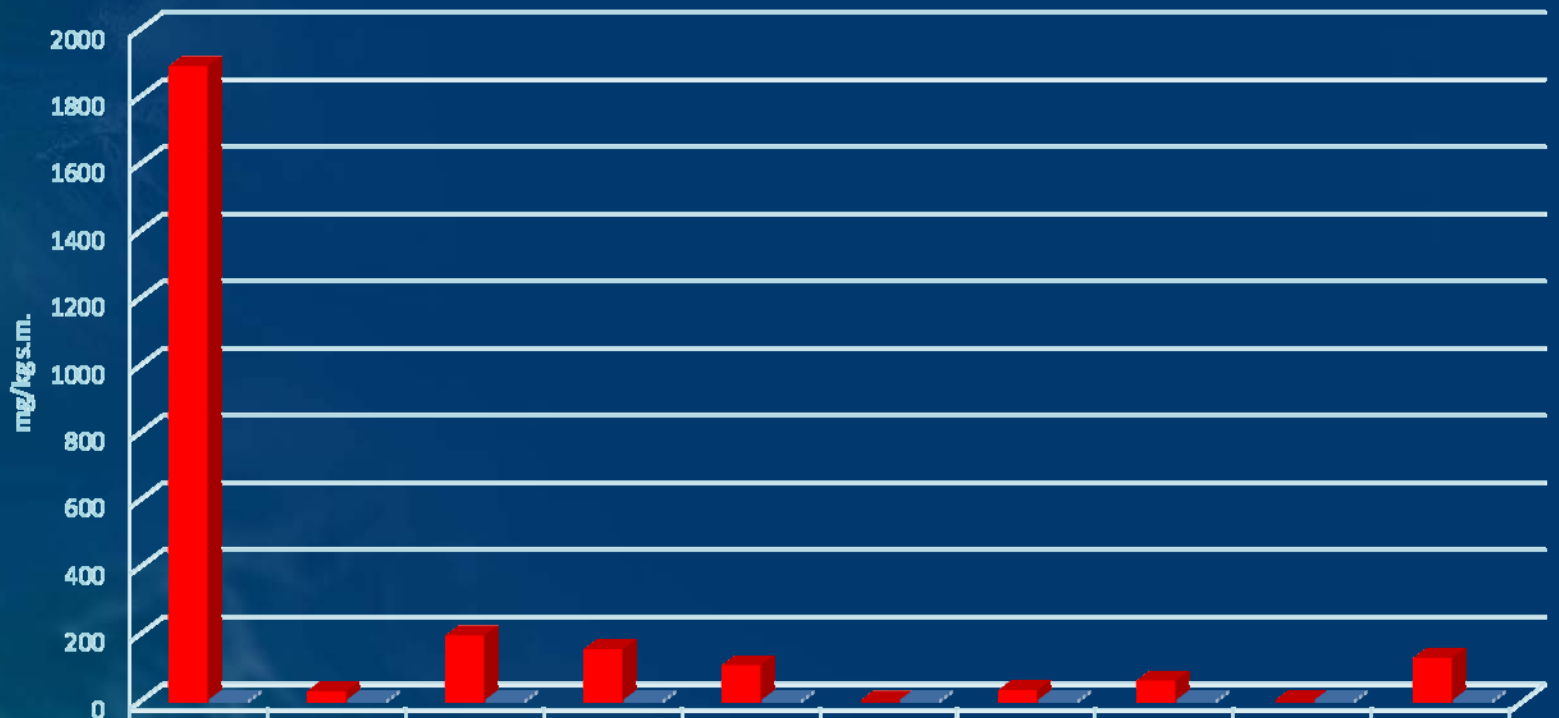
Samples were averaged from the whole core including the surface layer of mazout.

No.	Survey type	Unit	Sample number			
			469/09/1938	469/09/1939	469/09/1940	469/09/1941
			Client Code			
			PKT-1	PKT-3	PKT-4	PKT-6
I. Basic indicators						
1	Humidity in 105^0C	%	26.8	39.5	27.9	61.3
2	Loss on ignition*)	% d.m.	4.89	5.63	2.97	7.94
3	Phenols *)	mg/kg	45.5	5.37	10.9	44.7
4	Ether extract *)	mg/kg	1521	548	609	283

Assessment of the chemical state of sediments and waters in the vicinity of the monitored wreck

No.	Survey type	Unit	Sample number			
			469/09/1938	469/09/1939	469/09/1940	469/09/1941
			Client code			
			PKT-1	PKT-3	PKT-4	PKT-6
II.Metals						
1	Arsenic	mg As/kg	5.77	5.95	2.61	5.66
2	Chromium	mg Cr/kg	15.14	14.08	12.83	41.24
3	Zinc	mg Zn/kg	333.2	430.4	37.75	85.53
4	Cadmium	mg Cd/kg	0.69	0.62	0.09	b. 0.05
5	Copper	mg Cu/kg.	56.28	26.34	5.51	23.60
6	Nickel	mg Ni/kg	12.03	10.46	8.67	33.53
7	Lead	mg Pb/kg.	419.5	200.6	16.36	22.60
8	Vanadium *)	mg V/kg	15.59	13.72	14.18	45.89
9	Molybdenum *)	mg Mo/kg	b.0.25	0.41	b. 0.25	0.51
10	Mercury *)	mg Hg/kg	1.03	0.19	0.06	0.09
III. Nonpolar aliphatic hydrocarbons						
1	Mineral oil ($C_{12} - C_{35}$) *)	mg/kg d. m.	**2972.96**	**1659.27**	**1126.16**	**37.64**
IV. Polycyclic aromatic hydrocarbons (PAHs)						
1	Naphthalene	mg/kg d. m.	9.199	5.136	7.118	0.070
2	Acenaphthylene	mg/kg d. m.	0.838	0.525	0.425	0.004
3	Acenaphthen	mg/kg d. m.	35.846	23.460	22.524	0.106
4	Fluorene	mg/kg d. m.	38.801	20.819	19.545	0.094
5	Phenanthrene	mg/kg d. m.	3.016	36.445	3.393	0.187
6	Anthracene	mg/kg d. m.	13.300	9.422	8.132	0.039
7	Fluoranthene	mg/kg d. m.	27.533	17.823	16.129	0.078
8	Pyrene	mg/kg d. m.	18.205	11.727	10.777	0.048
9	Benzo(a)anthracene	mg/kg d. m.	10.450	6.401	5.263	0.012
10	Chrysene	mg/kg d. m.	9.686	5.299	4.161	0.012
11	Benzo(b)fluoranthene	mg/kg d. m.	5.880	4.151	2.544	0.005
12	Benzo(k)fluoranthene	mg/kg d. m.	3.425	1.828	1.454	0.006
13	Benzo(a)pirene	mg/kg d. m.	6.989	4.013	2.873	0.006
14	Indeno(1,2,3-cd)pirene	mg/kg d. m.	6.606	3.821	0.240	0.001
15	Dibenzo(a,h)anthracene	mg/kg d. m.	0.944	0.455	0.127	b.0.001
16	Benzo(g,h,i)perylene	mg/kg d. m.	3.516	2.092	1.411	0.001

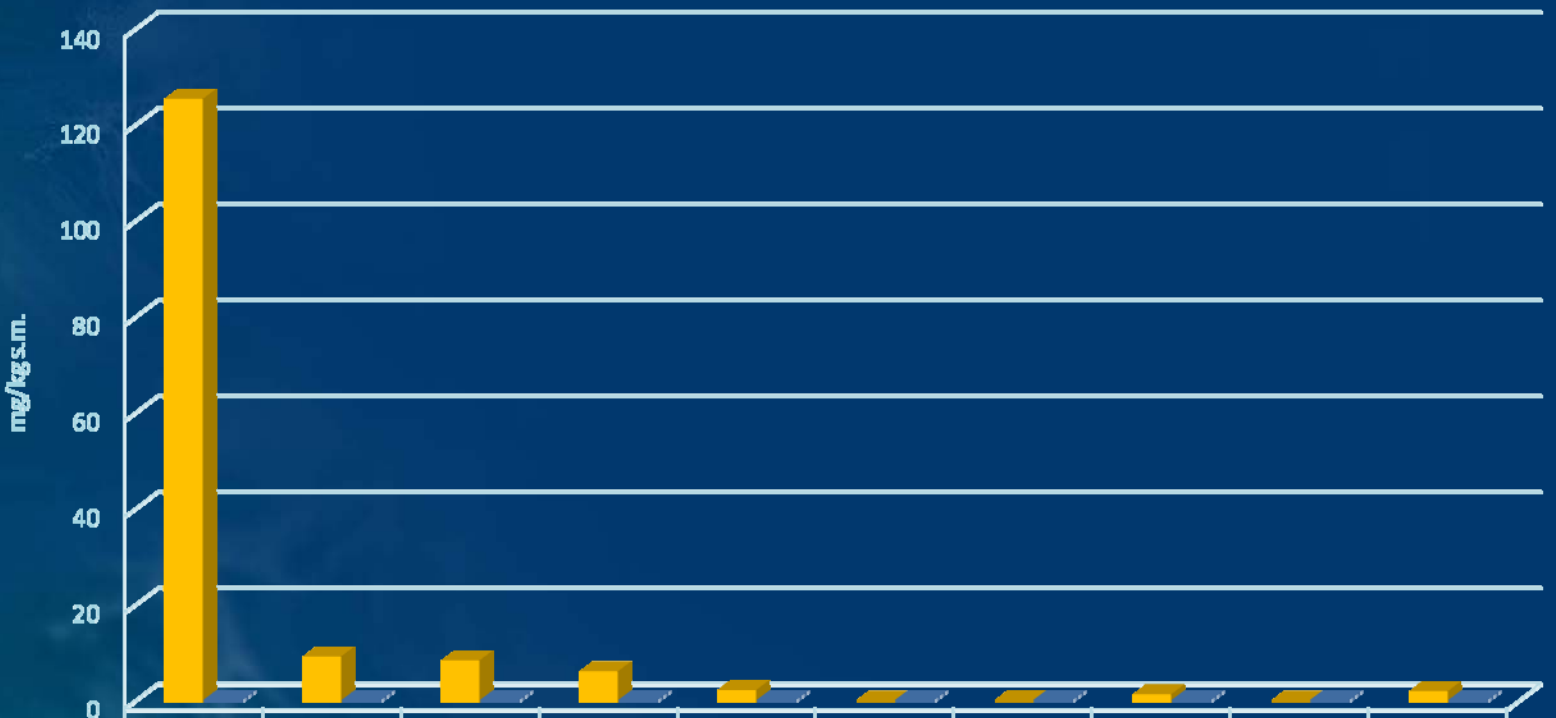
Assessment of the chemical state of sediments and waters in the vicinity of the monitored wreck



	1ST3	P-21	PKT-1	PKT-3	PKT-4	PKT-6	PKT-12	PKT-13	PKT-16	PKT-18
WWA	1889	28,29	194,234	153,417	106,116	0,669	31,848	60,575	1,618	127,805
Norma	1	1	1	1	1	1	1	1	1	1

The contents of polycyclic aromatic hydrocarbons (PAHs) is surveyed cores

Assessment of the chemical state of sediments and waters in the vicinity of the monitored wreck



	1ST3	p-21	PKT-1	PKT-3	PKT-4	PKT-6	PKT-12	PKT-13	PKT-16	PKT-18
BTEX	125,4	9,24	8,4	6,14	2,26	0,06	0,1	1,35	0,05	2,03
Norma	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1

Contents of aromatic hydrocarbons (BTEX) in surveyed samples.

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Assessment of the chemical state of sediments and waters in the vicinity of the monitored wreck

- In the area of the s/s STUTTGART wreck sediments **do not comply** with the cleanliness standards for dredged material determined in the Regulation of the Minister of Environment dated 9th September 2002 (Journal of Laws No. 165, item 1359 **– samples indicate great contamination of the seabed with heavy fuel – some indicators were exceeded by a 1000 or more times.**

- In the area of the s/s STUTTGART wreck samples of water comply with the cleanliness standards

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State of macrozoobenthos in the area of the wreck as an indicator of marine seabed contamination

Macrozoobenthos samples collected in the area of the Stuttgart wreck in November 2009.

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State of macrozoobenthos in the area of the wreck as an indicator of marine seabed contamination

- The environment's state in the region of the Stuttgart wreck identified in November 2009 is equal to the status of a local ecological catastrophy.
- The layer of mazout occurring at the point of contact of bottom sediment and the depths of the water created an azoic zone – devoid of macroscopic life.
- However the limited number of stations where the samples were collected prevents the determination of the range of this zone.

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State of macrozoobenthos in the area of the wreck as an indicator of marine seabed contamination

- In relation to year 1999, when the previous surveys were performed, in the area of the Stuttgart wreck, the ecological state of the region has significantly deteriorated.

- In 1999 a black layer of mud, nonmineralized organic matter and empty mollusc shells formed the sediment in the area of the wreck. An oil film formed on the surface of the collected samples and the samples (including individuals of invertebrate fauna) had a distinct smell of oil-derivative substances. The benthic fauna, however, consisted of 7 species forming a relatively large community with the Mytilus edulis trossulus being the dominant mussel. (Gajewski et al., 2000).

- In 2009 a layer of loose sediment was removed, uncovering a layer of mazout.

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State of macrozoobenthos in the area of the wreck as an indicator of marine seabed contamination

• In November 2009 the state of the environment identified on the basis of macrozoobenthos surveys in the area of the Stuttgart wreck poses a direct threat not only for biocenoses of the marine seabed, but directly and indirectly for the whole trophic chain of the ecosystem.

•It seems justified to perform surveys in order to determine the surface range and thickness of the layer of mazout, and then apply methods for recultivation of the degraded area of the bottom.

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CONCLUSIONS

- **On the basis of analysis of sediments collected in the settlementarea of the STUTTGART wreck it can be qualified as a wreck being a huge threat for the marine environment (category A) – it is the only (known) such dangerous wreck in the area of the Gdańsk Bay**

- **A direct negative impact of the wreck on communities of benthic fauna was identified – present state of the environment in the area of the Stuttgart wreck corresponds to the status of a local ecological catastrophy.**

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CONCLUSIONS

- **Surveys – repeated after 10 years – indicate a significant deterioration of the environment's state.**
- **Surveys performed in 2012 (after 13 years) indicate that the contaminated area may be even 2-3 times larger than it was previously considered to be contaminated with heavy fuels**
- **In places of sample collection for surveys there was an uncovering of contaminated substratum and a complete atrophy of living forms.**
- **It is necessary to start immediate work aimed at developing a method of cleaning and recultivating the seabed in the area s/s Stuttgart wreck.**

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Thank you for your attention

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