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Cruise report

FRV „Solea“

Cruise 816,

16.01.-27.01.2023

Cruise leader: Dr. Jörn Peter Scharsack

CONMAR-Fish: Effects of marine dumped munition on fish in the North Sea

Summary

The cruise was performed to investigate if fish in the North Sea along the North-Western German coast are affected by munition compounds (MC) leaking from marine dumped munitions. During the cruise beam trawls were used in proximity to munition dumping sites and at control sites distant from munition dump sites, to collect flat fish for sampling. Main target species was the bottom dwelling flat fish, common dab (*Limanda limanda*), since they live relatively stationary and thus would be exposed to locally abundant contaminants. The operation of the beam trawl for flat fish in the target areas was generally successful. We started with short (5min) trawls which were extended up to 15 min trawling, depending on the amount of dab collected with the trawls. Trawls were repeated until 30 live dab were available for sampling from each sampling site. Even though sampling was not possible at all days of the cruise, due to bad weather conditions and technical problems of the ship, sampling was successful at most planned sites. Immediate inspection of the dab for externally visible diseases on board, did not reveal obvious differences between munition dumpsites and control sites. Generally, high prevalence of hyperpigmentation, an irritation of the skin of unknown cause, in the range of 50+% was observed in dab >22cm. Collected tissues and body fluids from the sampled dab are awaiting chemical analysis for MC residuals in the laboratory.

Background

During and after WW I and II huge amounts of munition were dumped in the North Sea (approx. 1.3 mio t). Due to corrosion munition compounds (MC), such as explosives are leaking into the marine environment, which might have negative effects on biota, including fish. Wilhelmshaven was a military harbour during WWII and from there, after the war, huge amounts of unused munition were dumped in the inner and outer Jade. Estimates range from 0.5-1 mio t dumped munition in the in the Jade area. The present cruise therefore focussed on the area of the outer Jade (see map for sampling sites), since this area has likely the highest density of marine dumped munition in German waters of the North Sea. Further areas with potential, but unclear contamination such as 'Scharhörn Reef' were included in the sampling, as well as sampling sites distant from known munition dumpsites, without known munition contamination, that served as controls.

In common dab sampled at munition dump sites in the Baltic Sea (Kolberger Heide), traces of TNT (trinitrotoluol) were detected in bile fluid, suggesting the dab take up munition compounds when living in close proximity to marine dumped munition. The present cruise aimed to reveal if also dab from North Sea munition dump sites are exposed to MC such as TNT. The comparison between North Sea and Baltic Sea munition dumpsites is needed, since the conditions differ substantially. Due to higher influences of tidal currents in the North Sea leaking MC might be diluted faster as in the Baltic Sea. Furthermore, sediments along the Northern German North Sea coast are shifted by currents and waves and therefore dumped munition can be covered with sediments. Yet it is unclear if the North Sea condition support or supress the leakage of MC to the environment, this however might also differ between locations. On the present cruise water samples were collected at respective sites, in addition to fish samples. We expect that results of the, water in combination with the fish samples, reveal potential leakage of MC from dumped munition in the North Sea and their potential effects on dab.

The research is implemented in the BMBF funded project CONMAR (CONcepts for conventional MArine Munition Remediation in the German North and Baltic Sea) and researching project partners from AWI Bremerhaven and UKSH Kiel joined the research cruise.

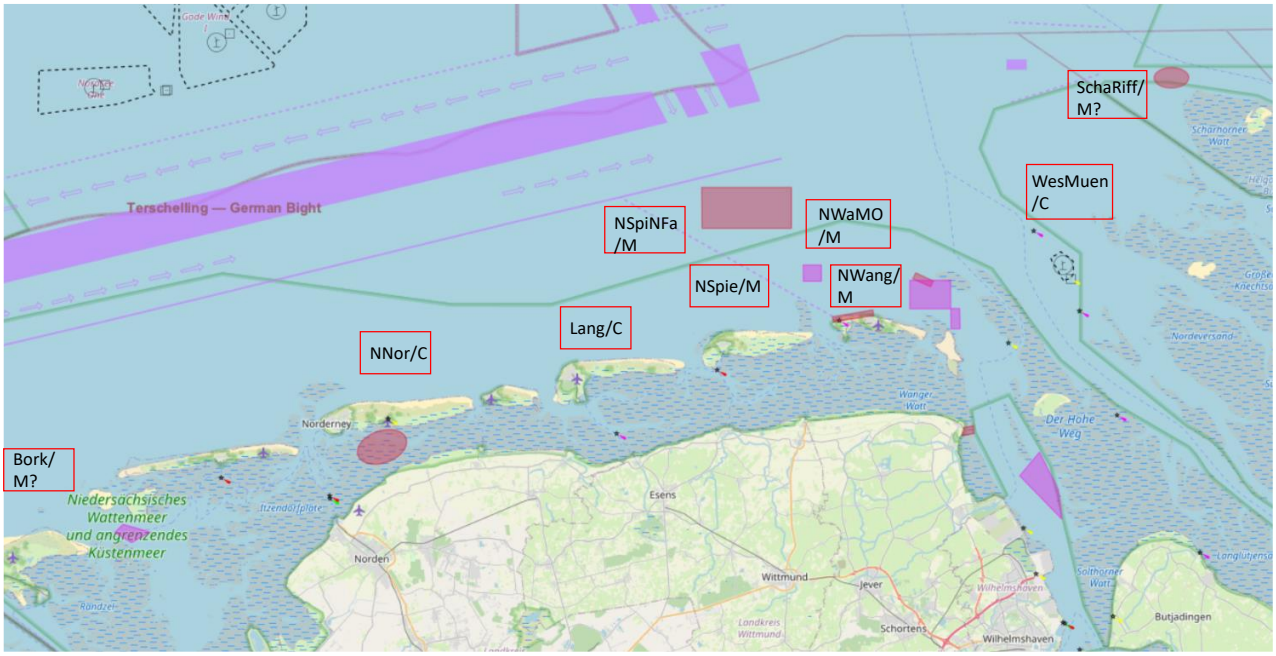

Fig. 1. Map of sampling areas. Underlying map with indicated munition dump sites (red and pink areas with dark red and dark pink frames) was obtained from https://legacy.amucad.org/map. Sampling was performed in areas with red frames. Abbreviations: /M = munition, /M? = munition unclear /C = control without munition, Bork = Borkum, Lang = Langeoog, NNor = Nördlich Norderney, NSpie = Nördlich Spiekeroog, NSpiNFa = Nördlich Spiekeroog, nördlich Fahrwasser, NWaMO = Nördlich Wangerooge bis Umfahrung Minsener Oog, Nwang = Nördlich Wangerooge, SchaRiff = Scharhörn-Riff , WesMuen = Wesermündung

Methodology

Selection of sampling sites

Directly at marine munition dumping sites, use of fishing gear with ground contact is not possible, due to the risk of collecting munition which might still be fused and explosive or harmful in other ways. However, the method of choice to collect flat fish in the North Sea is the use of beam trawls with a flatfish net ,which accordingly could only be used in the surrounding of munition dump sites. This was facilitated by previously established and archived information on trawling routes (Schleppstriche) by the research vessel Solea. With Solea a 7m beam trawl was used. At each location, after taking a CTD measurement and water sample, we started with a 5 min hauls, to check the abundance of dab and quantity of by catch. The intention was to collect the dab alive and store them live in sea water tanks on deck of the ship until sampling. Sampling was depending on live fish, that were only anaesthetised and killed immediately before sampling, since body fluids such as blood, bile and urine were collected, which would not have been possible with dab that might have died during long hauls or processing of large catches on board. Duration of hauls was extended to

15min, if bycatch was low. Sampling of dab was initiated when the first 10 dab were in the tanks and alternated with further hauls until up to 30 dab >22cm were sampled per site.

Sampling of fish

Bottom dwelling flat fish (dab, *Limanda limanda*) were taken in focus, since they live on the seafloor and in close proximity to marine dumped munition. Collected fish were reared in tanks with sea water supply on ship, until sampling. Fish were killed with an overdose of clove oil inspected for externally visible diseases, and measured for weight and length. Body fluids (blood, bile, urine) and tissue samples (liver, spleen, muscle) were collected and stored frozen for later laboratory analysis. Samples from each individual fish were shared between the three involved laboratories (AWI, UKSH and Thünen) with slightly different foci, but the aim to collect as much information as possible from each individual fish. AWI focussed on liver samples to analyse activities of detoxifying enzymes, UKSH received liver samples for gene expression studies and Thünen collected body fluids for analysis of TNT residuals and shared tissue samples with UKSH and AWI.

Narrative

The scientific crew embarked on January 16th 2023 in Cuxhaven and installed the scientific equipment on board. In the afternoon, the Solea crew received an instruction be personal of the Lower Saxony explosive ordnance clearance service how to behave in case munition items would be picked up during the cruise. Due to bad weather conditions, Solea had to stay in Cuxhaven until January 18th. On the 18th, sampling started at Scharhörn Reef. Use of beam trawls in that area proved to be difficult due to high ship traffic in that area and time of the day. Catches contained relatively few dab, but many sea stars. Sampling was ended with only 17 dab due to weather deterioration early afternoon.

On the 19th, sampling continued North of Wangerooge were 30 dab were collected. At the evening of the 19th, one of the two main engines of Solea went off and the ship steamed with one engine to Wilhelmshaven. On January 20th, the engine could be restarted and was checked by manufacturers service person who did not find problems that would inhibit the continuation of the cruise. Solea left Wilhelmshaven in the afternoon and steamed to Langerooge.

On January 21st, sampling was performed North of Spiekeroog. In the evening, Solea had to steam back to Cuxhaven, due to health problems of the steward. On January 22nd, the control area in the Weser estuary was sampled successfully and Solea steamed towards Borkum, where sampling was performed on 23rd. On the same day, sampling at Norderney was started and finished on 24th and thereafter, the Langeoog control site was sampled. Langeoog was completed in the morning of the 25th and sampling went on at the site North of Spiekeroog near the shipping channel.

On January 26th, the area north of Wangerooge at the bypass Minsener Oog was sampled. One of the trawls yielded a munition casing, which was stored moist in one of the containers provided by the explosive ordnance clearance service. Due to an allergic reaction of one of the members of the scientific crew, sampling was terminated on at the site north of Wangerooge at the bypass Minsener Oog after 20 dab were sampled. Solea steamed to Cuxhaven, where the allergic person went to hospital. Fortunately, the allergic reaction was treated successfully in the hospital.

The cooperation of scientific staff and Solea crew members was excellent throughout the cruise. Despite bad weather conditions at the beginning of the cruise, technical problems of the ship and health issues of one crew and one scientific staff member, desired sample numbers were reached at most sampling sites.

Preliminary results

In total 249 common dab (*L. limanda*) >22cm were sampled throughout the cruise. At sven out of nine sampling sites at least 29 dab were sampled. At one site 17 and at another 20 dab could be sampled (see table 1). To investigate if dab at munition dump sites are more heavily affected by diseases, dab were measured for body condition factors and inspected for externally visible diseases. Generally, collected dab were in good condition and no obvious differences of externally visible diseases of dab between sites with and without dumped munitions were detected (table 1). At all sampling sites proportion of dab with hyperpigmentation, a skin irritation of dab with unknown cause, was with about 50% or more relatively high.

Table 1. Externally visible diseases of common dab, *Limanda limanda*. Prevalence as percent at the sampling sites (locations).

Location	N	Ly	EpPap	Ulc	AkHei	FloF	AkHei	KieHy	Mel	Skel	Steph	Acanth	Lepe	Cryp
Bork/M?	29	0	0	3.4	3.4	0	48.3	0	0	17.2	31	0		
Lang/C	30	0	3.3	0	0	0	63.3	0	3.3	26.7	40	0		
NNor/C	30	6.7	0	13.3	10	0	53.3	3.3	3.3	20	30	0		
NSpie/M	33	9.1	9.1	3	0	0	51.5	0	9.1	9.1	9.1	0		
NSpiNFa/M	30	0	0	3.3	0	0	50	0	10	16.7	30	0		
NWaMO/M	20	0	5	0	5	0	55	5	15	5	40	0		
NWang/M	30	6.7	6.7	0	23.3	0	73.3	0	3.3	6.7	10	0		
SchaRiff/M?	17	0	0	5.9	23.5	0	76.5	0	17.6	17.6	41.2	0		
WesMuen/C	30	10	3.3	3.3	0	0	53.3	0	3.3	20	13.3	0		
sum	249													

Locations: /M = munition, /M? = munition unclear /C = control without munition, Bork = Borkum, Lang = Langeoog, NNor = Nördlich Norderney, NSpie = Nördlich Spiekeroog, NSpiNFa = Nördlich Spiekeroog, nördlich Fahrwasser, NWaMO = Nördlich Wangerooge bis Umfahrung Minsener Oog, Nwang = Nördlich Wangerooge, SchaRiff = Scharhörn-Riff , WesMuen = Wesermündung (see also map). N = number of fish

investigated, Ly = lymphocystis virus, EpPap = epidermal papilloma virus, FloF =bacterial fin rot (Flossenfäule), KieHy = gill hyperplasia, Mel = skin melanoma, Skel = skeletal deformations, Steph = *Stephanostomum baccatum*, Acanth = *Acanthochondria cornuta*, Lepe = *Lepeophtheirus pectoralis*, Cryp = *Cryptocotyle lingua*.

To address the hypothesis that dab at munition dump sites are more frequently affected by liver diseases, dissected livers were macroscopically inspected for anomalies. Macroscopic inspection of livers revealed the presence of liver nodules (potentially cancer) in a number of the investigated dab (table 2). Since generally the abundance of liver nodules increases with age, investigated dab are divided in length classes, which correspond to age. Most of the collected and investigated dab were in the size class 20-24 cm and only few dab 15-19 cm were sampled and also the frequency of dab 25-40 cm was relatively low (table 2). In comparison of the control and the potentially munition contaminated sites, a clear pattern, such that liver nodules would be more frequent at munition dump sites, was not detectable. The high prevalence of 66.7% was 2 out of 3 dab 15-19 cm at a potentially munition contaminated site (NSpie/M, table 2). Given the low number of dab in this size class at the sampling site, and the absence of liver nodules in larger fish at the same site, this observation has to be interpreted with caution. Further comparison of dab size classes 20-24 cm and 25-40 cm from control and munition dump sites do not support the hypothesis that dab at munition dump sites develop more frequent liver anomalies. Macroscopic liver parasites (Nematodes) were not detected in any of the and investigated.

In sum preliminary results of the present research cruise did not reveal obvious changes of the health of dab in close proximity to munition dump sites in the investigated areas.

Table 2. Prevalence of liver nodules as percent per size class and sampling site.

Location	Length (cm)	N investigated	Prevalence of liver nodules (%)
Bork/M?	20 - 24	27	0
Bork/M?	25 - 40	2	0
Lang/C	15 - 19	1	0
Lang/C	20 - 24	23	21.7
Lang/C	25 - 40	6	33.3
NNor/C	20 - 24	25	20
NNor/C	25 - 40	5	0
NSpie/M	15 - 19	3	66.7
NSpie/M	20 - 24	28	0
NSpie/M	25 - 40	2	0
NSpiNFa/M	15 - 19	2	0
NSpiNFa/M	20 - 24	27	11.1

Location	Length (cm)	N investigated	Prevalence of liver nodules (%)
NSpiNFa/M	25 - 40	1	0
NWaMO/M	15 - 19	1	0
NWaMO/M	20 - 24	18	5.6
NWaMO/M	25 - 40	1	0
NWang/M	15 - 19	1	0
NWang/M	20 - 24	24	0
NWang/M	25 - 40	5	0
SchaRiff/M?	15 - 19	5	0
SchaRiff/M?	20 - 24	11	9.1
SchaRiff/M?	25 - 40	1	0
WesMuen/C	15 - 19	1	0
WesMuen/C	20 - 24	26	11.5
WesMuen/C	25 - 40	3	0
Sum		249	

Locations: /M = munition, /M? = munition unclear /C = control without munition, Bork = Borkum, Lang = Langeoog, NNor = Nördlich Norderney, NSpie = Nördlich Spiekeroog, NSpiNFa = Nördlich Spiekeroog, nördlich Fahrwasser, NWaMO = Nördlich Wangerooge bis Umfahrung Minsener Oog, Nwang = Nördlich Wangerooge, SchaRiff = Scharhörn-Riff , WesMuen = Wesermündung (see also map).

Participants

Name	Institution	Function
Jörn Peter Scharsack	TI-FI	Cruise leader
Marcellus Rödiger	TI-FI	Engineer
Michael Gabel	TI-FI	Scientist
Susanne Bach	TI-FI	Student assistant
Romina Schuster	AWI	Scientist
Kristina Thiemann	UKSH	MSc Student

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