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Cruise report

FRV „Solea“

Cruise 831

15.01.-26.01.2024

Cruise leader: Dr. Jörn Peter Scharsack

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

Summary

The fisheries research trip was carried out to investigate whether fish in the North Sea along the north-western German coast are contaminated with munition compounds (MC) that could leak from ammunition dumped in the sea. During the trip, a 7m beam trawl was used to catch flatfish for sampling. The main target species was the bottom-dwelling flatfish, dab (*Limanda limanda*). Dabs live relatively stationary and are therefore exposed to locally present pollutants. The use of the beam trawl for flatfish in the target areas was successful. We started with short hauls (5 minutes) which were extended up to 15 minutes depending on the number of dabs caught per trawl. The hauls were repeated until approx. 30 live dabs were available for sampling at each sampling point. Unfortunately, the research cruise was affected by bad weather (storms, waves) and the trip was cancelled prematurely ended on January 21st due to persistent bad weather. Nevertheless, sampling was successful at a total of 4 of the planned locations during the first days at sea (January 16-18). An immediate inspection of the dabs for externally visible diseases on board revealed a high prevalence (>50%) of hyperpigmentation, a skin irritation of unknown cause. At three of four sites examined, the rate of liver anomalies was increased in the medium size class (20-24cm) of dab, which may be related to exposure to ammunition residue. Body fluids and tissue from the dabs are being chemically examined in the laboratory for ammunition residue; the results are not yet available.

Background

During and after the First and Second World Wars, large quantities of ammunition were dumped in the North Sea (approx. 1.3 million t). Due to corrosion of the ammunition casings, residues such munition compounds (MC) are leaking into the marine environment and can have negative effects on biota, including fish. After the Second World War, the North Sea port of Wilhelmshaven was used as a collection point for ammunition, which was transported from there to dumping areas, for example north of Wangerooge and Spiekeroog (Fig. 1.A). Estimates range from 0.5 to 1 million tons of munitions dumped in the inner and outer Jade Bay area. The focus of this trip was on areas of the outer Jade, as these areas probably have the highest density of marine ammunition in German waters of the North Sea (Fig. 1.B).

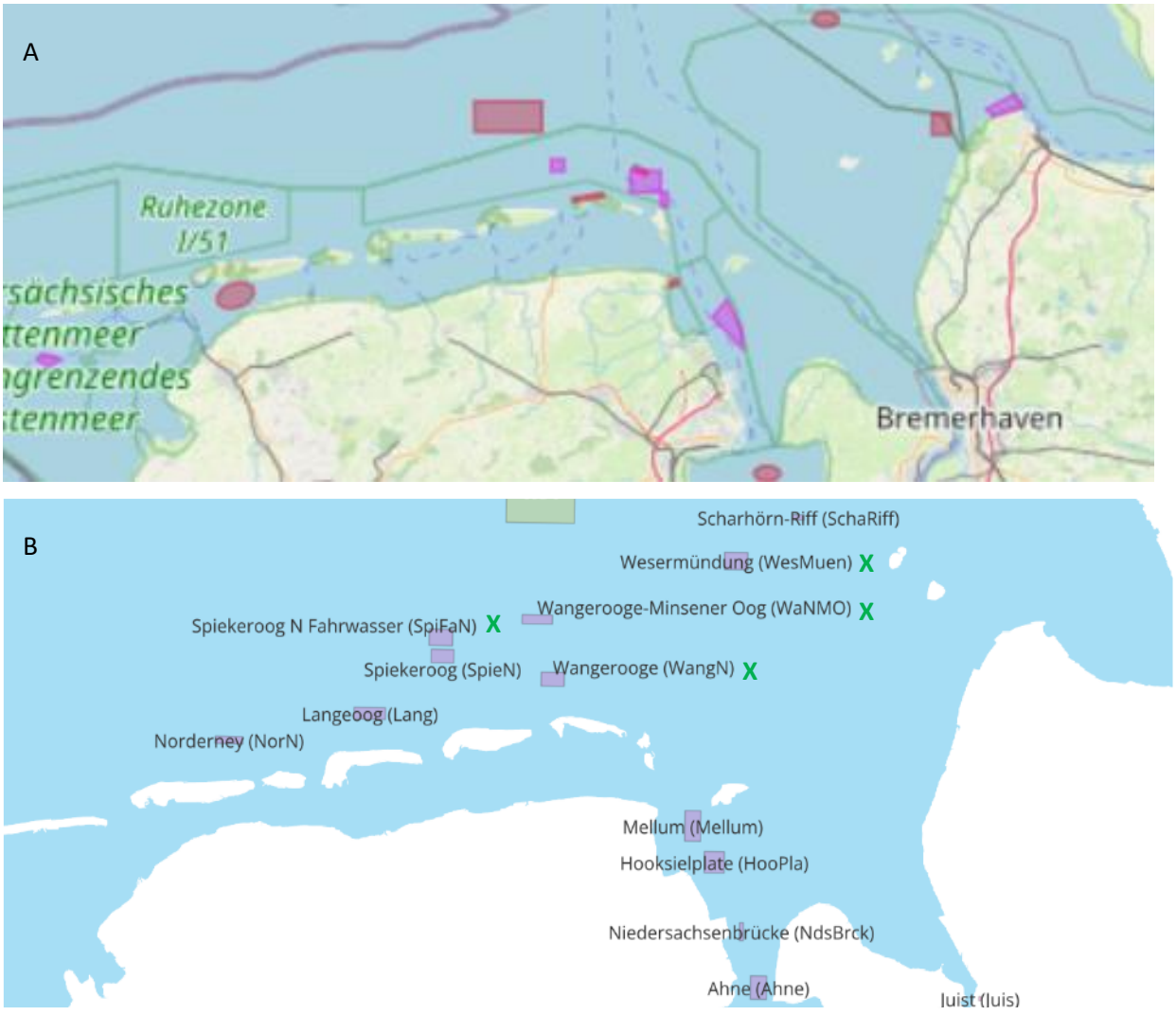

Fig 1. **A** Ammunition-contaminated areas in red or pink, source: https://legacy.amucad.org/map. **B** Sampling areas (squares). Due to bad weather, only the locations marked with an **X** could be sampled.

Munition compounds (MC, here metabolites of TNT) were detected in bile in some dabs (*L. limanda*) that were examined in the Jade area last year (SOL816). The highest values were measured in dabs from the locations Wangerooge-Minsener Oog (WaNMO), Norderney Nord (NorN) and Schahörn Riff (SchaRiff). Values just above the detection limit were measured at Langeoog (Lang), Spiekeroog north of the fairway (SpiFaN), Wangerooge Nord (WangN) and Wesermünde (WesMuen) (Kammann, Töpker et al. 2024). This research voyage made it possible to take further samples in some of the affected areas. The research is being implemented as part of the CONMAR (CONcepts for conventional Marine Munition Remediation in the German North and Baltic Sea) project funded by the BMBF in the DAM Mission sustainMare, and research project partners from AWI Bremerhaven took part in the research trip.

Methodology

Selection of sampling sites

Due to the weather conditions, sampling was only possible in the first few days of the trip. Locations were therefore prioritized that could be reached relatively quickly from Cuxhaven in the outer Jade area. The method of choice for catching flatfish live in the North Sea is to use beam trawls with flatfish nets. The towing times of the beam trawl (7m trawl) were kept relatively short (5-15 minutes) in order to keep the bycatch quantities small and the mechanical stress on the fish low.

The catches were spotted directly on deck (and not on the conveyor belt) and live dabs were immediately transferred to seawater tanks. Favoured by the cold January temperatures, it was possible to keep the dabs alive for several hours. Live dabs were required for sampling, which were only stunned and killed immediately before sampling. This made it possible to collect body fluids such as blood, bile and urine, which would not have been possible with dabs, which might have died on board during long hauls or when processing large catches.

At each site we started after a CTD measurement and taking a water sample for MC measurements. A 5-minute haul followed to check the abundance of dabs and the amount of bycatch. If bycatch was low, the fishing time was extended to 15 minutes. Dab sampling began when the first 10 dabs were in the tanks and alternated with additional captures until approximately 30 dabs could be sampled per site.

Sampling of fish

The focus of the investigations was on dabs (*L. limanda*), a bottom-dwelling flatfish species that lives on the seabed in the immediate vicinity of sunken ammunition. The collected fish were kept in tanks with a seawater supply on the ship until sampling. The dabs were killed with an overdose of clove oil, examined for externally visible diseases, and weight and length were measured. Body fluids (blood, bile, urine) and tissue samples (liver, spleen, muscle) were collected and stored frozen for later laboratory analysis. The livers were examined for tissue changes (liver anomalies), particularly nodules (potential tumours). Samples from each individual fish were shared between the participating laboratories (AWI, Thünen) with slightly different analysis focuses. The AWI focused on liver samples to analyze the activities of detoxifying enzymes, and Thünen collected body fluids and tissue samples to examine for TNT residues.

Narrative

The scientific crew embarked in Cuxhaven on January 15, 2024 and installed the scientific equipment on board with the help of the crew. Due to bad weather conditions, the Solea did not leave Cuxhaven until January 16th. High seas caused problems for the ship and crew, but the Solea reached calmer areas in the 'Spiekeroog Nord Fairway' area at midday where fishing began after a CTD.

In the evening the Solea withdrew to the Jade bay near Wilhelmshaven. On January 17th, the Wangerooge North area was successfully sampled. According to the weather forecast, it was not safe to work with the beam trawl from January 19th onwards and so on January 18th two more locations (Wangerooge-Minsener Oog and Weser estuary) were sampled on the way back to Cuxhaven.

On January 19th, the Solea remained in Cuxhaven and all but one of the scientific crew disembarked. The plan was to remain on standby until January 21st and continue the journey if the weather would improve. The scientist who remained on board carried out post-processing of the samples.

When on January 21st There was no sign of any improvement in the weather, it was decided to end the research cruise on January 25th.

Preliminary results

A total of 128 dabs (*L. limanda*) >20 cm were sampled during the research trip (Table 1). To investigate whether dabs at ammunition dumps are more affected by disease, dabs were measured for body condition factors and externally visible diseases and liver abnormalities were examined.

At all sampling sites, the proportion of dabs with hyperpigmentation, a skin irritation of the dabs with an unknown cause, was relatively high at around 50% or more. A connection between hyperpigmentation and munition contamination has not yet been identified (Table 1).

Table 1. Externally visible diseases of the dab, Limanda limanda. Prevalence in percent at the sampling points (locations).

Area	N dab	Ly	EpPap	Ulc	AkHei	FloF	AkHei	KieHy	Mel	Skel	Steph	Acanth	Lepe	Cryp
WesMuen	35	5.7	2.9	2.9	0	0	37.1	0	8.6	22.9	8.6	0		
WangN	35	2.9	5.7	2.9	2.9	0	65.7	0	0	8.6	25.7	0		
WaNMO	34	0	0	2.9	2.9	0	55.9	0	8.8	11.8	20.6	0		
SpiFaN	24	8.3	0	0	0	0	62.5	0	0	0	25	0		
SUMME	128													

Abbreviations: NSpiNFa = Nördlich Spiekeroog, nördlich Fahrwasser, WaNMO = Wangerooge Nördlich bis Umfahrung Minsener Oog, WangN = Nördlich Wangerooge, WesMuen = Wesermündung, Ly = Lymphozystis virus, EpPap = Epidermales Papillom (Virus), FloF = Flossenfäule (bakteriell), KieHy = Kiemen Hyperplasie, Mel = Melanom Hyperpigmentierung, Skel = Skeletdeformationen, Steph = *Stephanostomum baccatum*, Acanth = *Acanthochondria cornuta*, Lepe = *Lepeophtheirus pectoralis*, Cryp = *Cryptocotyle lingua*.

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

Area	Length (cm)	N dab	Liver nodules %	Nematodes %
SpiFaN	15 bis 19	1	0	0
SpiFaN	20 bis 24	18	5.6	11.1
SpiFaN	25 bis 40	5	0	0
WangN	15 bis 19	6	0	50
WangN	20 bis 24	28	14.3	14.3
WangN	25 bis 40	1	0	0
WaNMO	15 bis 19	8	12.5	0
WaNMO	20 bis 24	26	15.4	11.5
WesMuen	15 bis 19	14	0	14.3
WesMuen	20 bis 24	20	30	20
WesMuen	25 bis 40	1	0	0
SUMME		128		

Abbreviations: NSpiNFa = Nördlich Spiekeroog, nördlich Fahrwasser, WaNMO = Wangerooge Nördlich bis Umfahrung Minsener Oog, WangN = Nördlich Wangerooge, WesMuen = Wesermündung.

To answer the question of whether dabs at ammunition dumps are more frequently affected by liver diseases, prepared livers were examined macroscopically for abnormalities. Macroscopic examination of the livers revealed the presence of liver nodules (potentially tumors) in a number of the livers examined (Table 2).

Since the general frequency of liver nodules increases with the age of the dab, the examined dabs are divided into length classes that correspond to age classes. Most of the dabs collected and examined were in the 20–24 cm size class and only a few dabs 15–19 cm in size were sampled. The abundance of dabs between 25 and 40 cm was also relatively low (Table 2).

At some of the sites, liver anomalies were found in more than 10% of dabs in the 20-24cm size class. This is worrying because dabs of this size are only 2-4 years old and the frequency of liver abnormalities should not yet increase due to age, i.e. naturally. Since residue measurements from the previous year demonstrated carcinogenic TNT metabolites in dabs at the affected locations, there could be a connection between increased liver abnormalities and the dumped ammunition.

Participants

Name	Institution	Function
Jörn Peter Scharsack	TI-FI	Cruise leader
Romina Schuster	AWI	Scientist
Verena Töpker	TI-FI	Engineer
Lea Riemeier	TI-FI	Technician
Susanne Bach	TI-FI	Student assistant
Murielle Muesfeldt	TI-FI	Student assistant

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Literature

Kammann, U., V. Töpker, N. Schmidt, M. Rödiger, M.-O. Aust, M. Gabel and J. Scharsack (2024). "Explosives leaking from dumped munition contaminate fish from German coastal waters: a reason for chronic effects?" Environmental Sciences Europe 36.