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Cruise report

FFS „Solea“

847 Cruise,

22.04.-30.04.2025

Cruise leader: Dr. Jörn Peter Scharsack

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

Summary

The fisheries research cruise was conducted to investigate whether fish in the North Sea along the northwestern German coast are contaminated with munition compounds (MCs) that could be released from munitions dumped at sea. During the cruise, a 7m beam trawl was used to catch flatfish for sampling. The primary target species was the bottom-dwelling flatfish, the common dab (*Limanda limanda*). Dab are relatively sedentary and therefore exposed to locally present pollutants. The use of beam trawls for flatfish in the target areas was successful. We began with short hauls (5 minutes), which were extended to up to 15 minutes depending on the number of plaice caught per trawl. The hauls were repeated until 30 live dabs were available for sampling at each sampling site. All seven sites for monitoring munitions contamination were successfully sampled, and at least 30 plaice per site were examined. Immediate onboard inspection of the plaice for externally visible diseases revealed a high prevalence (>50%) of hyperpigmentation, a skin irritation of unknown cause. At two of the seven sites examined, the rate of liver abnormalities was elevated in the medium size class (20-24 cm), which is possibly related to munitions contamination. Body fluids and tissues of the plaice are being chemically analyzed in the laboratory for munitions residue; the results are not yet available.

Background

During and after the First and Second World Wars, large quantities of munitions were dumped into the North Sea (approximately 1.3 million tons). Due to corrosion of the munition casings, munition compounds (MCs) are released into the marine environment and can have negative impacts on biota, including fish. After the Second World War, the North Sea port of Wilhelmshaven was used as a collection point for munitions, which were then transported to dumping grounds, 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 expedition was on areas of the outer Jade Bay, as these areas presumably have the highest density of marine munitions remnants in German North Sea waters (Fig. 1.B).

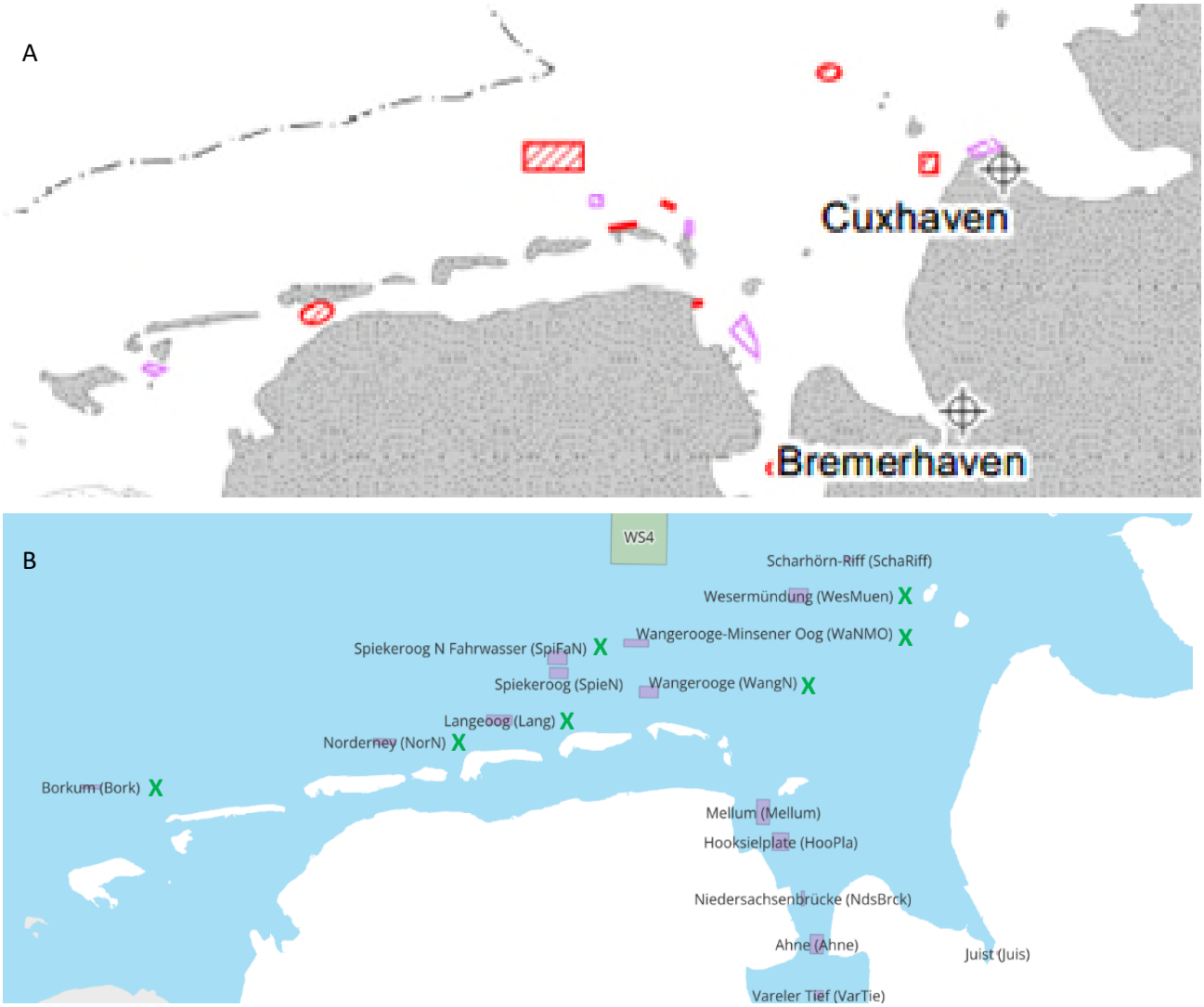

Fig. 1. A Areas contaminated with munitions in red or pink, Source: https://www.schleswig-holstein.de/mm/downloads/MEKUN/anhang_10200.pdf. B Sampling sites (rectangles). All locations marked with an X were sampled during Solea 847.

Methods

Selection of sampling sites

Munition compounds (MC, here metabolites of the explosive TNT) were detected in bile fluid in some dab (*L. limanda*) examined in 2023 (SOL816) in the outer Jade estuary. The highest values were measured in dab from the locations Wangerooge-Minsener Oog (WaNMO), Norderney North (NorN), and Schahörn Reef (SchaRiff). Values just above the detection limit were measured at Langeoog (Lang), Spiekeroog north of the fairway (SpiFaN), Wangerooge North (WangN), and Wesermünde (WesMuen) (Kammann, Töpker et al. 2024). The following year, the Solea 831 expedition was plagued by bad weather, and not all of the planned sampling locations could be sampled. The current research cruise Solea 847 aimed to collect further samples in the affected areas to document whether the STV contamination of the fish and any potential health effects changes over time. The present research cruise allowed for the collection of further samples in the affected areas (Fig. 1). The research is being conducted within the framework of the CONMAR project (CONcepts for conventional Marine Munition Remediation in the German North and Baltic Sea), funded by the German Federal Ministry of Research, Technology and Space (BMFTR) as part of the DAM mission sustainMare, and research partners from the Alfred Wegener Institute (AWI) in Bremerhaven participated in the cruise.

Collection of flatfish

One preferred method for catching live flatfish in the North Sea is the use of beam trawls with flatfish nets. Trolling times for the beam trawl (7m trawl) were kept relatively short (5-15 minutes) to minimize bycatch and mechanical stress on the fish. The catches were inspected directly on deck (not on a conveyor belt), and live dab were immediately transferred to seawater tanks. Favored by the cool spring temperatures, it was possible to keep the plaice alive for several hours. Live plaice were required for sampling; these were stunned and killed immediately before sampling. This allowed for the collection of body fluids such as blood, bile, and urine, which would not have been possible with dab that might have died during long hauls or while processing large catches on board.

At each location, we began beam trawling after a CTD measurement and taking a water sample for MC measurements. This was followed by a 5-minute haul to check the abundance of dab and the amount of bycatch. If bycatch was low, the haul time was extended to 15 minutes. Dab sampling began once the first 10 dab were in the tanks and alternated with further catches until at least 30 dabs could be sampled at each location.

Sampling of dab

The investigations focused on common dab (*Limanda limanda*), a bottom-dwelling flatfish species found on the seabed in close proximity to dumped munitions. The collected fish were kept in seawater-supplied tanks on the ship until sampling. The dabs were killed with an overdose of clove oil, examined for externally visible diseases, and their weight and length were measured. Body fluids (blood, bile, urine) and tissue samples (liver, spleen, muscle) were collected and frozen for later laboratory analysis. The livers were examined for tissue changes (liver anomalies), particularly nodules (potential tumors). Samples from each individual fish were shared between the participating laboratories (AWI, Thünen, TiHo) with slightly different analytical focuses. The AWI concentrated on liver samples to analyze the activity of detoxifying enzymes, while Thünen collected body fluids and tissue samples to test for TNT residues. In addition, samples for later laboratory tests for pathogens were taken by a colleague from the University of Veterinary Medicine Hannover (TiHo).

Narrative

The scientific crew embarked in Cuxhaven on April 22nd, 2025, and, with the help of the crew, installed the scientific equipment on board. In good weather, all planned locations were sampled. In addition, plaice were caught and sampled in GB1, southwest of Heligoland, for a project to determine the age of plaice using DNA. In the Steingrund area, southeast of Heligoland, attempts were made to catch fish using hand lines, as the use of a beam trawl was not possible there due to stony grounds. The fishing was not very successful, yielding only one dab. Dismantling of equipment took place in Cuxhaven on April 30.

First results

A total of 239 common dab (*L. limanda*) cm^2 were sampled during the research expedition (Tables 1 and 2). To investigate whether dabs at munitions dump sites are more severely affected by disease, body condition factors were measured in the plaice, and externally visible diseases and liver abnormalities were examined.

At all sampling sites, the proportion of plaice with hyperpigmentation, a skin irritation of unknown cause, was relatively high at over 40%. Specific samples were taken from affected and unaffected dab in collaboration with the University of Veterinary Medicine Hannover (TiHo Hannover) to investigate the cause of hyperpigmentation.

Since the general frequency of liver nodules increases with the age of the flounders, the examined flounders were classified into length categories corresponding to age groups. Most of the collected and examined flounders were in the 20–24 cm size range, and only a few flounders measuring 15–19 cm were sampled. The frequency of flounders between 25 and 40 cm was also relatively low (Table 2).

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

Area	N	Ly	EpPap	Ulc	FloF	KieHy	Mel	Skel	Steph	Acanth	Lepe	Cryp
SpiFaN	35	2.9	2.9	2.9	0	0	62.9	2.9	0	0	0	0
WangN	35	0	5.7	2.9	0	0	42.9	0	8.6	0	5.7	0
HelgoStein	1	0	0	0	0	0	0	0	0	0	0	0
Lang	35	0	2.9	8.6	0	0	60	0	0	0	0	0
Bork	35	2.9	5.7	0	0	0	68.6	0	0	0	0	0
WesMuen	30	0	6.7	0	0	0	66.7	0	3.3	3.3	0	0
NorN	35	0	11.4	0	0	0	51.4	0	0	0	2.9	0
WaNMO	33	0	3	9.1	0	0	42.4	0	3	3	6.1	0
SUMME	239											

Abbreviations: Lang = Langeoog, NorN = North of Norderney, SpiFaN = fairway North of Spiekeroog, WangN = North of Wangerooge, WaNMO = North of Wangerooge to bypass Minsener Oog, WesMuen = Weser mouth (see Fig. 1), N = number of sampled fish. Abbreviation's diseases: Ly = Lymphocystis Virus, EpPap = Epidermal Papilloma (Virus), Ulc = Ulceration of the skin, FloF = finrot (bacterial), KieHy = Kiemen Hyperplasia of the gill, Mel = Melanom Hyperpigmentation, Skel = Skeletal deformation, Steph = *Stephanostomum baccatum*, Acanth = *Acanthochondria cornuta*, Lepe = *Lepeophtheirus pectoralis*, Cryp = *Cryptocotyle lingua*.

To investigate whether plaice found near munitions dumps are more frequently affected by liver diseases, prepared livers were macroscopically examined for anomalies. The macroscopic examination of the livers revealed the presence of liver nodules (potentially tumors) in a number of the examined livers (Table 2).

Particularly striking were the proportion of liver anomalies (tumors) exceeding 10% in plaice found at the SpiFaN (fairway north of Spiekeroog) and WaNMO (north of Wangerooge to the Minsener Oog bypass), which are located near munitions dumping areas. Elevated rates of liver nodules were also observed near Norderney. It is still unclear whether this could also be related to legacy munitions contamination off Norderney. The results of the plaice tests for STV are not yet available.

Tabelle 2. Prevalence of liver nodules and nematodes in the liver of dabs in percent per size class and sampling site.

Area	Length (cm)	N	Liver nodules %	Nematodes %
Bork	20 bis 24	25	8	4
Bork	25 bis 40	10	10	0
HelgoStein	15 bis 19	1	0	0
Lang	20 bis 24	27	7.4	3.7
Lang	25 bis 40	8	0	0
NorN	15 bis 19	1	0	0
NorN	20 bis 24	30	16.7	0
NorN	25 bis 40	4	0	0
SpiFaN	20 bis 24	29	6.9	0
SpiFaN	25 bis 40	6	16.7	16.7
WangN	20 bis 24	27	0	0
WangN	25 bis 40	8	0	0
WaNMO	15 bis 19	6	33.3	0
WaNMO	20 bis 24	25	20	12
WaNMO	25 bis 40	2	0	0
WesMuen	15 bis 19	7	0	0
WesMuen	20 bis 24	17	0	0
WesMuen	25 bis 40	6	0	0
Summe		239		

Abbreviations: Lang = Langeoog, NorN = North of Norderney, SpiFaN = fairway North of Spiekeroog, WangN = North of Wangerooge, WaNMO = North of Wangerooge to bypass Minsener Oog, WesMuen = Weser mouth (see Fig. 1) N = number of sampled fish.

Scientific staff members

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Literature

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