SURVEY REPORT FOR CRIMAC SFI 2023

Toktrapport No. 7 2024

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The complete report is available at: https://www.hi.no/hi/nettrapporter/toktrapport-en-2024-7. Below is Chapter 8 that involves experiments that are part of the FHF 901926 "Testing av metoder for å redusere interaksjoner mellom fiskeri og hval"

Chapter 8 - Testing whale scarer sounds on herring behaviour

8.1 - Objective

Norwegian catches of the pelagic species herring, mackerel and capelin are about 1 mill tons annually, and about 80% of these are caught using purse seines (Fiskeridirektoratet). This approach make the fish easily accessible for marine mammals and birds, and some species, such as killer whales, may follow fishing vessels in the search of "a free meal" (e.g. Vogel et al., 2021). This may create unfortunate incidents with whales getting entangled in the nets; with potential for both injury and even death for the animal and lost catches and gear for the fishermen (Bjørge et al., 2023). In the ongoing project "Kartlegging og testing av metoder for å redusere interaksjoner mellom fiskeri og hval", it is tested whether sound can be used to keep whales away from ongoing fishing operations. The project results show a good deterrent effect on killer whales (Langstein, 2023). These sounds can be detected by herring, a species with good hearing due to a duct connecting its swimbladder to the inner ear (Enger, 1967). If the herring respond to the sound signals, it may negatively affect the fishing operation. The objective of this task is to test whether the whale deterrent sounds affect the behaviour of herring or not.

8.2 - Methods

The TAST (target specific startle technology) system, developed by Genuswave LDT, transmits sound pulses that are of short duration and rise time with random intervals between transmitted pulses. Based on the published literature on this system (Götz and Janik, 2015; Langstein, 2023), we generated sound sequences with the following properties:

- Each signal was 200 ms in duration
- Signal rise time was less than 5 ms
- Interval between pulses was random, varying from 1 to 40 seconds
- Signals were band passed white noise

The TAST system also randomizes the frequency bands within the sound sequence, however, in our experiment, we aimed at testing different frequency bands separately to assess if any frequency bands influenced herring behaviour. Consequently, we separated the sound clips into 4 different frequency band, each covering one octave:

Frequency band 1: 200-400 Hz

Frequency band 2: 400-800 Hz

Frequency band 3: 800-1600 Hz

Frequency band 4: 1600-3200 Hz

In addition to the TAST signals, we also played back recordings of killer whales. These sounds were recorded in Vestfjorden, Northern Norway in 2006, of killer whales feeding on overwintering herring. Recordings consisted both of calls and echolocation signals.

The playbacks were done with an underwater speaker (Lubell Labs LL1424HP) designed for Underwater Acoustic Deterrent Systems. It transmits within the frequency range of 200Hz - 9kHz, with maximum power at 600 Hz. Sound recordings, to monitor the sound level and proper output, were done with a sound trap 300 hydrophone from ocean instruments.

The sound source was lowered from a crane from the side of the ship to a depth of 15 m, limited by its cable length. A hydrophone was deployed 10 m below the source to measure the sound source level close to the source. A second hydrophone was lowered from a crane to 100 m depth, which was the assumed depth of the main herring layer, to measure the sound level received by the herring (c.f. Figure 25).

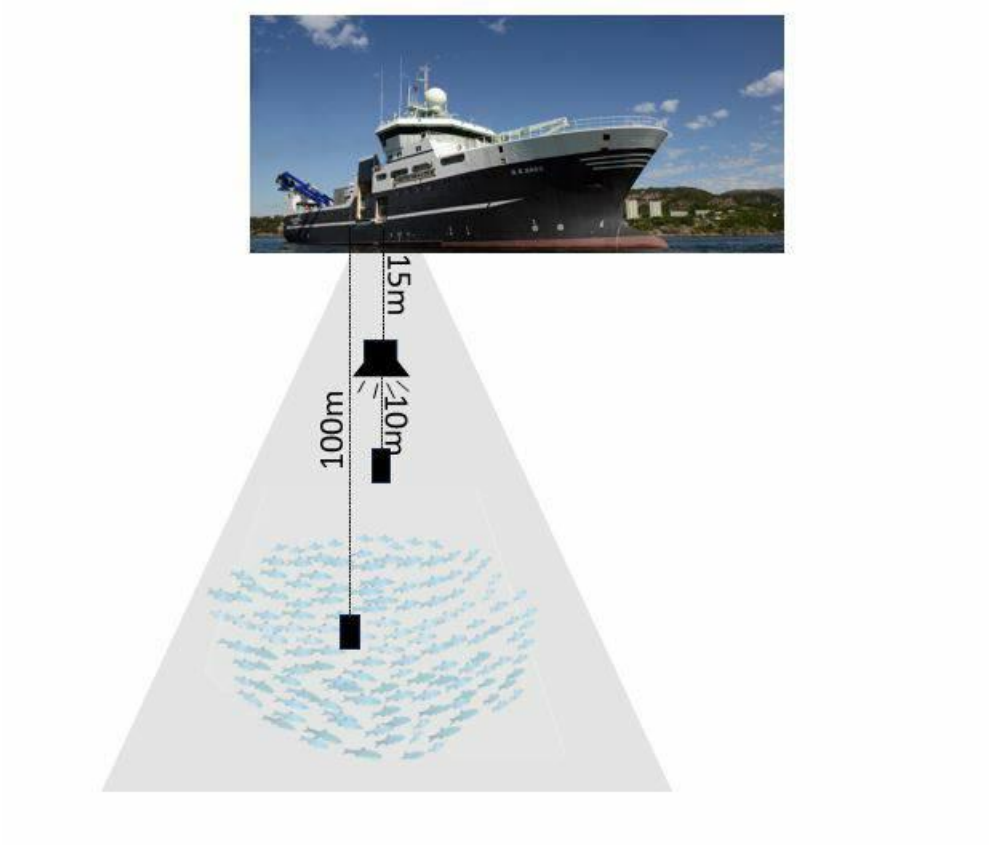

Figure 25. Set up of sound source, hydrophones and echosounder.

The experiment was conducted as a block design, where each block consisted of a 10 min sequence of each of the 4 frequency bands. The order of the frequency bands within each block were randomized prior to start of the experiment. Also, a random selection of each of the 20 available clips were made for each frequency band.

Prior to start, we surveyed the area with echosounder and sonar to map herring distribution in the area. Once a suitable location was selected, the sound source and hydrophones were lowered. After deploying the instrument, we allowed the fish to acclimatize after any potential disturbance from the operation. The ship's main engine was turned off and the ship were drifting to avoid sound from

the ship to disturb the fish. The 10 min sound sequences were played with 10 min no-sound control between, and we always started with a 10 min control.

After each block, we waited 1 h before starting the next exposure. During this period, the equipment was brought back on deck, and the ship relocated before the next block.

Observations of herring behaviour were conducted by the ships echosounder (EK80), measuring the density and depth structure of the herring layer, hence detecting potential vertical or horizontal avoidance behaviour.

8.3 - Preliminary results

The experiments were conducted over 3 days in November 2023, and a total of 10 blocks were conducted, and 4 playbacks of killer whale vocalisations (Table 9). All experiments were conducted in Kvænangen, which is the main overwintering area for the Norwegian Spring Spawning herring. Due to differences in wind conditions, the distance drifted during a block varied from 3500 m (block 2) to less than 100 m (block 6).

Table 9. Overview of the experimental blocks. Treatment refers to the different frequency bands. Freq1 is the 200-400 Hz band, Freq 2 is the 400-800 Hz band, Freq3 is the 800-1600 Hz band, and Freq4 is the 1600-3200 Hz band.

Block	Treatment	Sound clip	Date	Start			Stop		
				Time (UTC)	Lat	Lon	Time (UTC)	Lat	Lon
1	Freq2	1	23.11.2023	20:03:00	70° 02.7970	21° 21.5581	20:13:00	70° 02.9382	21° 20.7925
1	Freq3	7	23.11.2023	20:23:00	70° 03.0985	21°20.1008	20:33:00	70° 03.2709	21° 19.54
1	Freq1	2	23.11.2023	20:43:00	70° 03.4353	21° 19.0100	20:53:00	70° 03.5889	21° 18.4655
1	Freq4	16	23.11.2023	20:53:00			21:03:00		
2	Freq1	2	23.11.2023	22:30:00	70° 03.0859	21° 22.4477	22:40:00	70° 03.19	21° 21.9587
2	Freq4	8	23.11.2023	22:50:00	70° 03.3286	21° 21.5122	23:00:00	70° 03.4410	21° 20.9601
2	Freq2	18	23.11.2023	23:10:00	70° 03.5412	21° 20.3905	23:20:00	70° 03.6914	21° 19.6117
2	Freq3	9	23.11.2023	23:30:00	70° 03.7905	21° 19.0820	23:40:00	70° 03.9084	21° 18.4711
3	Freq3	18	24.11.2023	01:10:00	70° 03.3241	21° 21.8073	01:20:00	70° 03.4261	21° 21.4238
3	Freq2	13	24.11.2023	01:30:00	70° 03.5580	21° 20.9224	01:40:00	70° 03.7007	21° 20.3202
3	Freq1	5	24.11.2023	01:50:00	70° 03.8491	21° 19.6970	02:00:00	70° 03.9847	21° 19.1156
3	Freq4	6	24.11.2023	02:10:00	70° 04.1054	21° 18.5046	02:20:00	70° 04.1952	21° 18.0275
4	Freq2	3	24.11.2023	03:56:09	70°03.3472	21°21.4728	04:06:16	70°03.4029	21°20.9631
4	Freq1	1	24.11.2023	04:16:08	70°03.4674	21°20.4649	04:26:08	70°03.5591	21°19.9779
4	Freq4	20	24.11.2023	04:36:05	70°03.6655	21°19.5003	04:46:04	70°03.7953	21°19.0285
4	Freq3	6	24.11.2023	04:56:03	70°03.9123	21°18.6263	05:06:00	70°04.0370	21°18.0839
5	Freq2	6	24.11.2023	20:45:00	70° 04.3129	21° 23.4295	20:55:00	70° 04.2872	21° 23.4212
5	Freq1	3	24.11.2023	21:05:00	70° 04.2755	21° 23.4195	21:15:00	70° 04.2776	21° 23.4207
5	Freq3	17	24.11.2023	21:25:00	70° 04.2808	21° 23.4604	21:35:00	70° 04.2776	21° 23.5203

5	Freq4	3	24.11.2023	21:45:00	70° 04.2595	21° 23.5755	21:55:00	70° 04.2372	21° 23.6494
6	Freq3	7	24.11.2023	23:05:00	70° 04.2952	21° 20.4899	23:15:00	70° 04.3001	21° 20.4454
6	Freq1	6	24.11.2023	23:25:00	70° 04.3073	21° 20.3982	23:35:00	70° 04.3025	21° 20.3737
6	Freq4	8	24.11.2023	23:45:00	70° 04.2903	21° 20.3883	23:55:00	70° 04.2757	21° 20.4327
6	Freq2	18	25.11.2023	00:05:00	70° 04.2692	21° 20.4910	00:15:00	70° 04.2579	21° 20.5165
	Killer whale playback		25.11.2023	00:25:00	70° 04.2170	21° 20.4412	00:35:00	70° 04.2006	21° 20.4163
7	Freq3	17	25.11.2023	01:30:00	70° 04.0957	21° 20.6217	01:40:00	70° 04.0862	21° 20.7318
7	Freq2	17	25.07.1972	01:50:00	70° 04.0751	21° 20.7987	02:00:00	70° 04.0615	21° 20.9004
7	Freq1	3	25.03.1921	02:10:00	70° 04.0464	21° 20.0210	02:20:00	70° 04.0319	21° 21.1081
7	Freq4	15	25.07.1972	02:30:00	70° 04.0234	21° 21.2236	02:40:00	70° 03.9966	21° 21.2825
8	Freq3	14	25.11.2023	04:05:00	70° 04.7295	21° 24.9886	04:15:00	70° 04.7220	21° 25.1773
8	Freq2	4	25.11.2023	04:25:00	70° 04.7221	21° 25.3613	04:35:00	70° 04.7040	21° 25.5132
8	Freq4	12	25.11.2023	04:45:00	70° 04.7003	21° 25.6642	04:55:00	70° 04.7080	21° 25.8766
8	Freq1	20	25.11.2023	05:05:00	70° 04.7098	21° 26.0699	05:15:00	70° 04.7080	21° 26.2897
	Killer whale playback		25.11.2023	05:25:00	70° 04.7161	21° 26.5306	05:35:00	70° 04.7161	21° 26.5306
9	Freq1	1	25.11.2023	17:39:00	70° 05.0908	21° 23.8230	17:49:00	70° 04.9905	21° 23.7241
9	Freq2	9	25.11.2023	17:59:00	70° 04.8974	21° 23.6813	18:09:00	70° 04.8974	21° 23.6813
9	Freq3	12	25.11.2023	18:30:00	70° 04.5597	21° 23.8611	18:40:00	70° 04.4537	21° 23.9663
9	Freq4	19	25.11.2023	18:50:00	70° 04.3389	21° 24.1216	19:00:00	70° 04.2412	21° 24.2885
	Killer whale playback		25.11.2023	19:10:00	70° 04.1648	21° 24.4727	19:20:00	70° 04.0471	21° 24.7151
10	Freq3	17	25.11.2023	20:35:00	70° 04.5601	21° 20.3392	20:45:00	70° 04.3959	21° 20.3567
10	Freq2	1	25.11.2023	20:55:00	70° 04.2276	21° 20.3804	21:05:00	70° 03.9715	21° 20.4941
10	Freq4	2	25.11.2023	21:15:00	70° 03.8923	21° 20.5425	21:25:00		
10	Freq1	6	25.11.2023	21:35:00	70° 03.6319	21° 20.7099	21:45:00	70° 03.5162	21° 20.8360
	Killer whale playback		25.11.2023	21:55:00	70° 03.4168	21° 20.9938	22:05:00	70° 03.3193	21° 21.1426

Before starting the experiments, the sound source was tested with all the frequency bands and levels measured with the hydrophones 10 m below the source and at 100 m depth. Based on these measurements the source level for the 4 frequency bands were calculated (Figure 26).

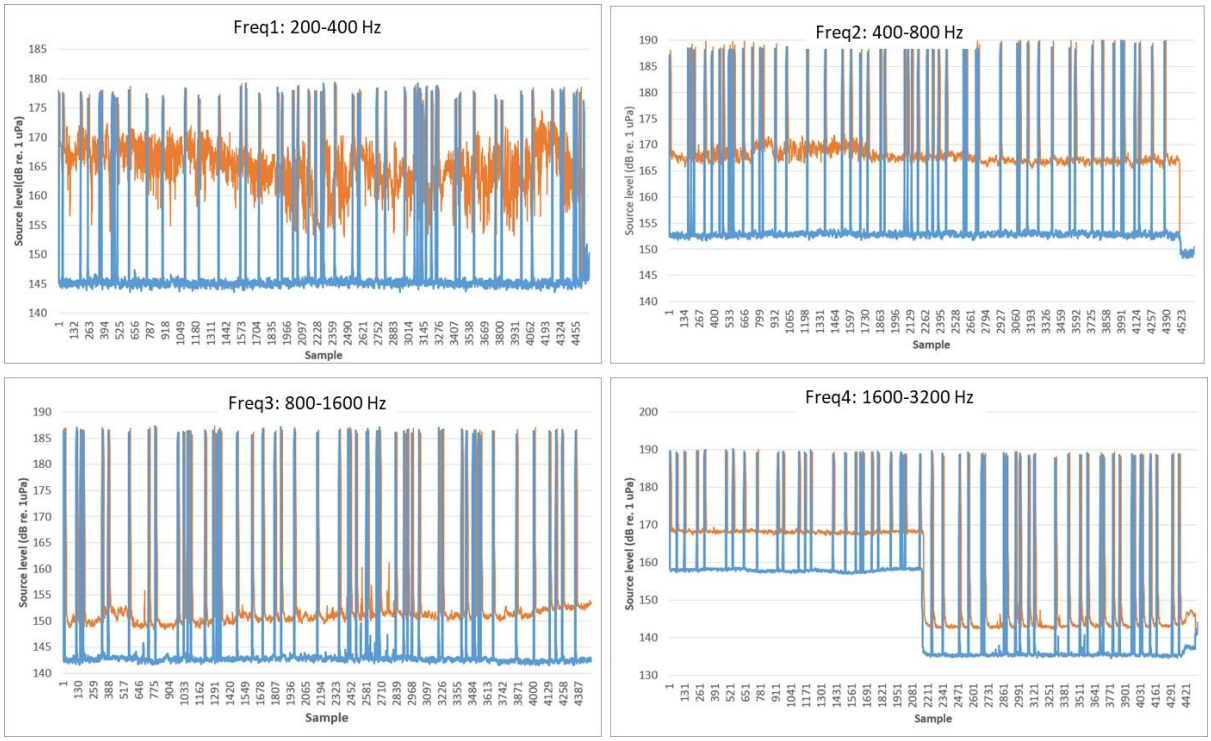

Figure 26. Approximate source level for the 4 frequency bands. The blue curve is based on the measurements of the hydrophone 10 m below the source, the orange curve on the hydrophone at 100 m depth. In particular the hydrophone at 100 m depth show quite a lot of noise due to hydraulics and/or echosounder. This is particularly apparent for Freq 4, where the hydraulics were turned off approximately midway into the measurement.

A preliminary screening of the echograms did not show any apparent reaction of the herring (c.f. Figure 27). Further, no apparent indication of a change in acoustic density could be determined from the preliminary screening, c.f. block 1 in Figure 28.

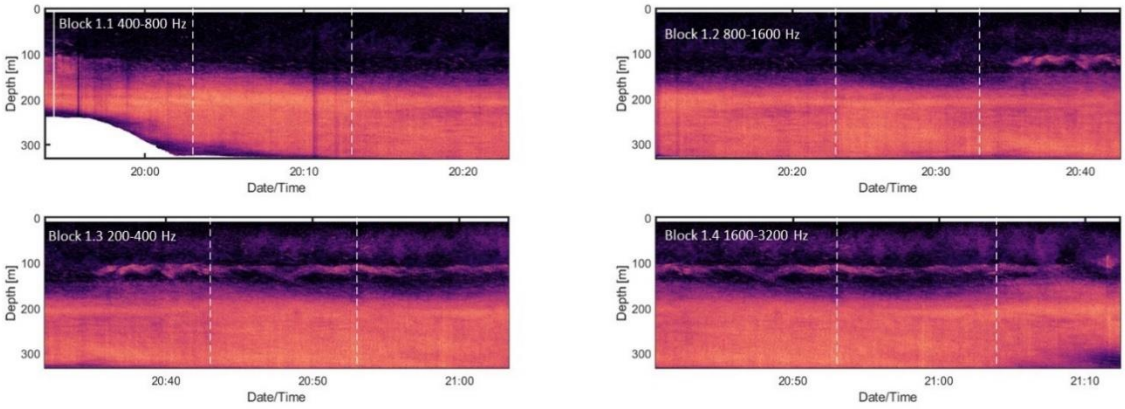

Figure 27. Echogram for block 1. Dashed white lines indicate start and stop of the sound transmission.

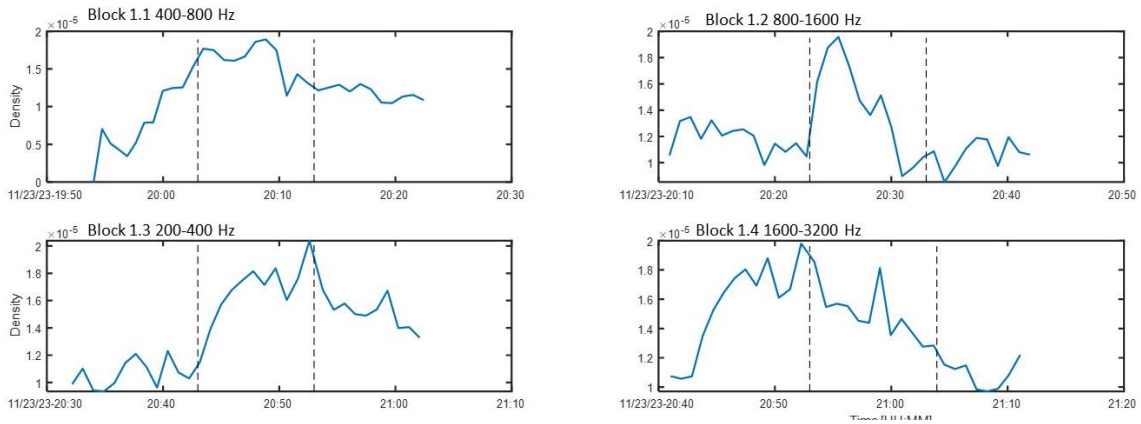

Figure 28. Acoustic density as a function of time for block 1. Dashed lines indicate start and stop of sound transmission.

References

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