Sea-testing of the Campelen 1800 trawl with North Sea rigging, cruise 2021601 07-09.01.2021

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Background

During the 2020 method cruise (cruise number 2020115), it was shown that North Sea rigging of the Campelen 1800 trawl, as specified in the trawl manual for *North Sea NOR shrimp NSDK cruise in Jan. – Nov.*, may need more wire out (i.e., constraining rope < 35 m above seabed; Fig. 1) than the standard rigging to maintain seabed contact and proper roll of the doors (0-20° inward roll). Only a limited number of experiments were carried out during the method cruise, with a single trawl so it was proposed that during sea-testing for cruise 2021601 a series of experiments would be carried out to test the effect of trawling with additional wire out. Additionally, insufficient tows were carried out during the method cruise to establish the target range for opening height and door spread when using North Sea rigging so additional data will be collected during sea-testing on cruise 2021601.

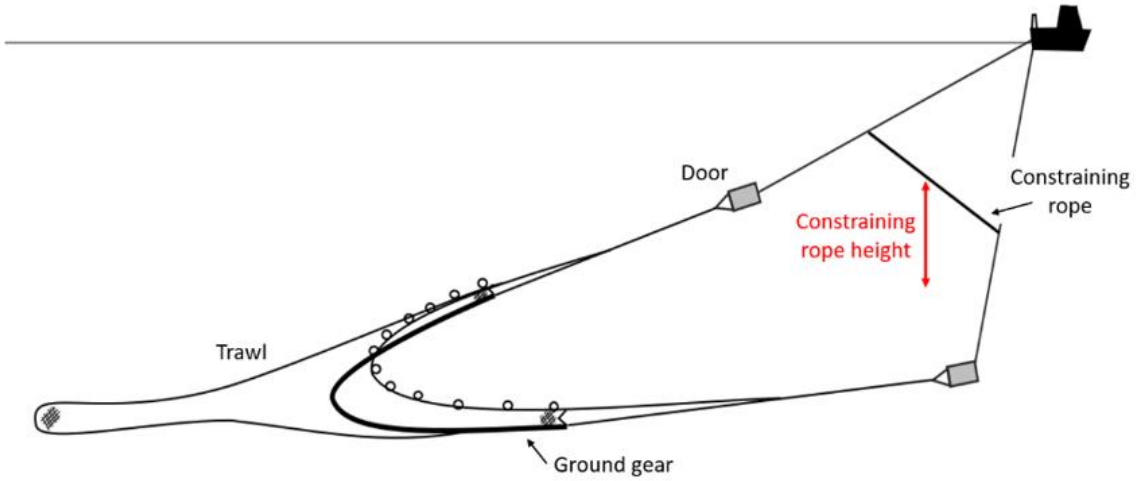


Figure 1: Bottom trawl with a constraining rope. The red arrow shows the height of the constraining rope over the seabed.

Material and Methods

Three Campelen 1800 trawls with the North Sea rigging were tested during the first 2 days of the 2021601 cruise with either the height of the constraining rope at 35 or 30 m from seabed (Fig. 1) at the designated sea-testing area "Vest av Bergen/vestkanten av

Norskerenna" (60° 05’ N, 03° 11’ W). Sea-tests were carried out as per manual (2x 15-minute hauls in opposite directions (180°), speed through water 1.5 m^{-1}; *North Sea NOR shrimp NSDK cruise in Jan. – Nov.*). Experience from cruise 2020115 showed that there was often significant variation in trawl geometry during the first 5 minutes of the 15-minute sea-testing stations (the trawl was not truly stable). Because we are using this data to establish the geometry criteria for future sea-tests, we waited an additional 5 minutes after the trawl was stable before starting the station. Scanmar sensors were used to record trawl geometry and trawl speed through water. Before any sea-tests with the North Sea rigging were conducted, all Scanmar depth sensors were calibrated as well as the trawls and ground gear were weighed, measured and rigged in accordance to the trawl manual.

As speed as well as wire length can affect the contact a trawl has on the seabed, the effect of a slightly increased speed when the constraining rope was 30 or 35 m from the seabed was tested for two trawls. The trawl was originally towed at 1.5 ms^{-1} for 15 mins before raising the speed to 1.75 $^{-1}$ for 15 mins. The door roll and bottom contact were recorded for these experiments.

Results

Calibration of depth sensors and weight of ground gear

Depth and door sensors were calibrated at the pier (Table 1). The sensors were submerged to a depth of 1 m at the stern of the vessel (Fig. 2). RV “*Kristine Bonnevie*” did not have the individual doors or depth sensors put into the bridge system, ScanBas (i.e., two door sensors were used with the same sensor ID in the ScanBas system). New lines for each individual sensor with serial numbers were created.

Figure 2: A door sensor (orange rectangle) at 1m depth at the stern of the vessel.

Table 1: Depth offset used after calibrating the depth and door sensors.

Sensor	Serial	Depth Offset (m)
Door Master	2029	-1.9
Door Master	2027	-2.8
Door Slave	2028	-1.7
Door Slave	2030	-5.4
Depth	1695	-2.2
Depth	1694	-1.3

Prior to leaving the dock, both ground gears were weighed in air and water. In addition, ground gear 1 with trawl #1618 was weighed in air and water (Table 2; Fig. 3). However, a weight in water when combining trawl #1618 with ground gear 1 was not possible due to the shallow depth of water near the pier (Fig. 3). The weight of the ground gears was comparable to ground gear #1 on RV "*G.O. Sars"* (Table 2).

Figure 3: Weighing the ground gear in air (left) and the ground gear with a trawl in water (right). It was too shallow to submerse all of the trawl floats and therefore the weight in water is expected to be less (Table 2).

Table 2: Weight of the ground gear (with and without a trawl) compared to the ground gears on RV "*G.O. Sars*".

Ground Gear	In Air (kg)	In Water (kg)	In air with trawl (kg)	In water with trawl (kg)
#1 (KB)	1160	430	1905 (trawl # 1618)	270/300 * (trawl # 1618)
#2 (KB R1)	1140	410		
G.O. Sars #1	1200	420		
G.O. Sars #2	1360	500	2230 (trawl # 1620)	350 (trawl # 1620)

* Tested twice: some floats were still on the surface and therefore these values are expected to be less.

Measuring of the trawls and ground gear

Trawls numbered 1639 and 1618 were measured prior to the sea-tests (Appendix 1). However, due to the limited time with decent weather, it was decided to measure trawl #1629 after sea-tests in harbour on the 9th (Appendix 1). Sweep length was estimated as 20 + 20 m on the upper and 40 m on the lower sweeps. Due to high swells when shooting, rough 5 m increments were used to estimate sweep length. The length of the ground gear was comparable the manual requirements (Table 3). However, ground #1 had two rubber spaces that were damaged and twisted (Fig. 4).

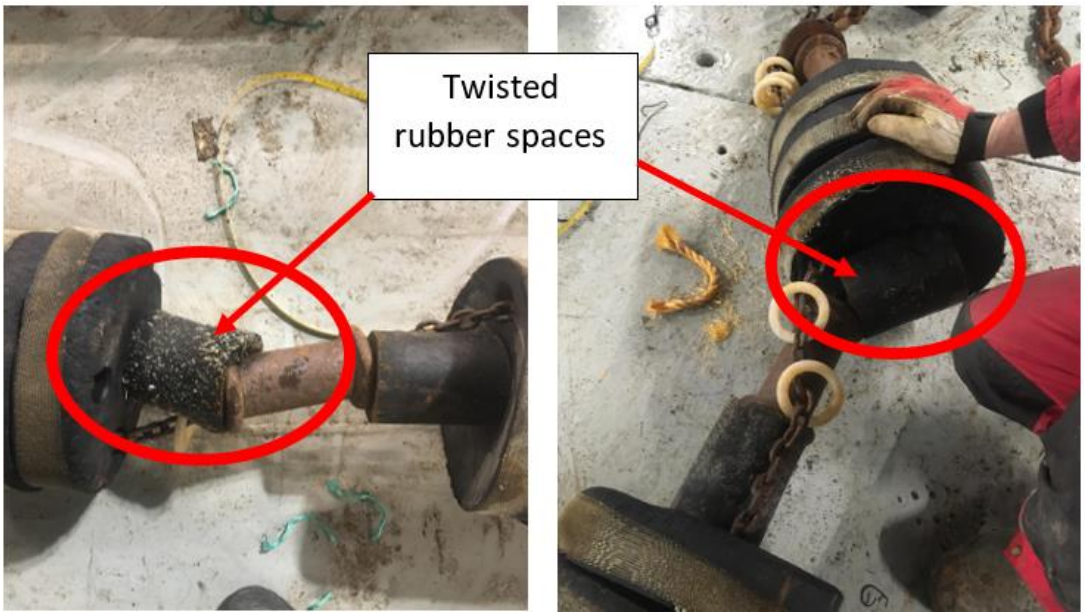


Figure 4: Broken and displaced rubber spacers on ground gear #1.

Table 3: Ground gear measured as per manual. Either 'KB' or 'KB R1' was welded onto the ground gear

Ground Gear	Port (m)	Starboard (m)	Middle (m)	Port extension (m)	Starboard extension (m)
Manual	6.5	6.5	6	8	8
#1 (KB)	6.53	6.5	6	8	8
#2 (KB R1)	6.4	6.5	6.1	8	8

Sea – testing with constraining rope at 35 m or 30 m from the seabed

Twelve comparison hauls were conducted at the sea-testing area (Table 4). The opening height of the reserve trawl #1639 was lower than expected (~3 m instead of ~4 - 4.5 m) and was not included in the constraining rope comparisons (8 stations). Trawls #1618 and #1629, both had expected trawl geometries (mean door spread between 48 -52 m and trawl opening height between 3.9 – 4.4 m) when the constraining rope was at 35 m and 30 m from the seabed (Fig. 6). The roll of the doors generally increased when the constraining rope was lowered to 30 m from seabed (Table 4) and the port door was turned inwards more than the starboard door during most hauls. Unlike the 2020115 cruise, seabed contact was maintained with a constraining rope height of 35 m (echograms in Fig. 6) and shooting additional trawl wire to lower the constraining rope to 30 m from the seabed did not seem to improve the trawl geometry. After the trials, the trawl geometry with a constraining rope at 35 m from the seabed in this cruise and 2020115 was used to create the preliminary criteria for the Campelen 1800 trawl with North Sea rigging (Table 5).

Table 4. Station information for sea-testing of three trawls rigged with the North Sea rigging. Mean roll for the port door (PT) and starboard door (SB). Seabed contact is the percentage of time the trawl was on the seabed during the haul (0 clearance measured by Trawleye).

Station	Date	Start Time (UTC)	Trawl Number	Ground Gear	Constraining Rope height (m)	Speed (ms^{-1})	Sea-test pair	Direction	Mean Door Roll (PT/SB) (°)	Seabed Contact (%)
1	08-01-2021	08:01	1639	1	35	1.5	1-1	North	16.6 / 14.7	100
2	08-01-2021	09:50	1639	1	35	1.5	1-2	South	18.7 / 15.2	91
3	08-01-2021	10:36	1639	1	30	1.5	2-1	North	19.4 / 20.1	100
4	08-01-2021	11:37	1639	1	30	1.5	2-2	South	18.3 / 19.3	100
5	08-01-2021	13:08	1618	2	35	1.5	1-1	North	18.6 / 8.9	100
6	08-01-2021	14:01	1618	2	35	1.5	1-2	South	16.1 / 12.7	100
7	08-01-2021	14:56	1618	2	30	1.5	2-1	North	25.2 / 22.7	100
8	08-01-2021	15:45	1618	2	30	1.5	2-2	South	20.7 / 10.2	100
13	08-01-2021	19:47	1629	1	35	1.5	1-1	North	22.6 / 6.8	88
14	08-01-2021	20:34	1629	1	35	1.5	1-2	South	26.8 / 9.3	100
15	08-01-2021	21:28	1629	1	30	1.5	2-1	North	20.2 / 16.5	*
16	08-01-2021	22:21	1629	1	30	1.5	2-2	South	24.7 / 13.2	*

* No values due to Trawleye misidentifying seabed.

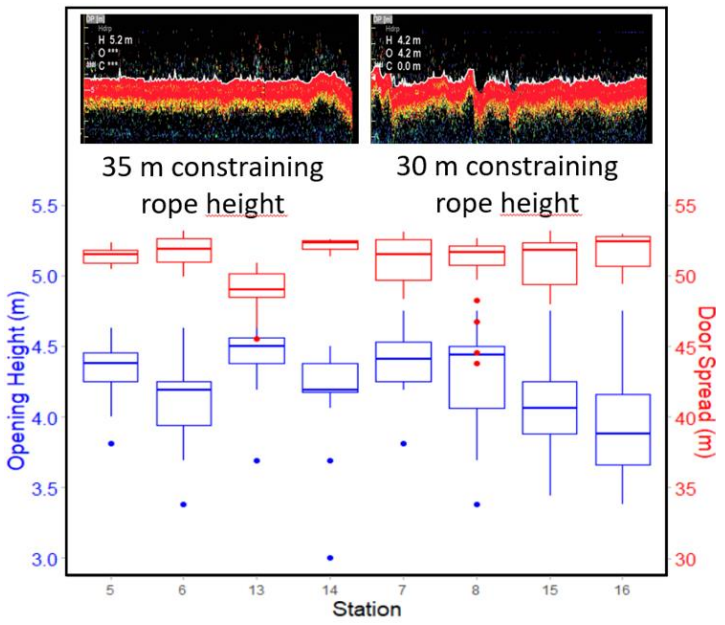


Figure 6: Mean Door spread (red) and opening height (blue) with a constraining rope at 35 and 30 m height from the seabed for two trawls (n=8). Examples of the seabed contact shown in the Trawleye echogram are above the boxplots. The boxes represent the 25th–75th percentiles, the solid horizontal line is the median and the whiskers illustrate 1.5× the interquartile range.

Table 5. Preliminary criteria for Campelen 1800 trawl with North Sea rigging.

Parameter	Criteria
Speed through Water	1.4 – 1.6 ms^{-1}
Door Spread	47 – 53 m (±3)
Opening height	4.0 – 4.6 m (±0.5)
Constraining Rope Height	34 – 36 m
Bottom contact	90 %
Constraining Rope position (Wireout)	100 – 120 m

One issue that was apparent during the trials was the limited trawl geometry data that was stored compared to other HI vessels (i.e., *G.O. Sars, John Hjort* or *KPH*). The Scanmar update interval of the trawl geometry data was slower on the RV "*Kristine Bonnevie*" than other HI vessels (15-30 s vs 3-5 s). The update interval was manually set to 5 s but this was not reflected in the logged data which continued to show an interval of 15 – 30 s. In addition, the Trawleye (sensor used to estimate seabed contact) misidentified the seabed on two stations (15 and 16) and recorded the trawl at 4 m off the seabed when it was on the seabed, indicating that the seabed threshold for the echogram needed to be adjusted.

Sea – testing with speed through water at 35 m or 30 m from the seabed

Eight comparison hauls were conducted at the sea-testing area to test the effect of speed (Table 6). It was difficult to keep the trawl on the seabed when the speed was increased from 1.5 to 1. 75 ms^{-1} and the constraining rope was at 35 m off the seabed. In addition, we were unable to get trawl # 1629 back on the seabed after it initially lifted of the seabed, irrespective of the constraining rope height.

Table 6. Station information for sea-testing of two trawls rigged with the North Sea rigging at 1.5 ms^{-1} and 1.75 ms^{-1}. Mean roll for the port door (PT) and starboard door (SB). Seabed contact is the percentage of time the trawl was on the seabed during the haul. Sp indicates the speed experiment stations.

Station	Date	Start Time (UTC)	Trawl Number	Ground Gear	Constraining Rope height (m)	Speed (ms^{-1})	Sea-test pair	Direction	Mean Door Roll (PT/SB) (°)	Seabed Contact (%)
9_Sp	08-01-2021	16:39	1618	2	35	1.5	Sp_1-1	North	17.1 / 5.1	96
10_Sp	08-01-2021	17:00	1618	2	35	1.75	Sp_1-2	North	1.2 / 8.7	47
11_Sp	08-01-2021	17:47	1618	2	30	1.5	Sp_2-1	South	21.8 / 13.8	100
12_Sp	08-01-2021	18:31	1618	2	30	1.75	Sp_2-2	South	9.3 / 7.1	91
17_Sp	09-01-2021	00:11	1629	1	35	1.5	Sp_1-1	North	12.3 / 18.9	89
18_Sp	09-01-2021	00:33	1629	1	35	1.75	Sp_1-2	North	7.7 / 10.9	17
19_Sp	09-01-2021	01:19	1629	1	30	1.5	Sp_2-1	South	17.3 / 15.5	*
20_Sp	09-01-2021	01:48	1629	1	30	1.75	Sp_2-2	South	6.8 / 5.7	3

* No values due to Trawleye misidentifying seabed.

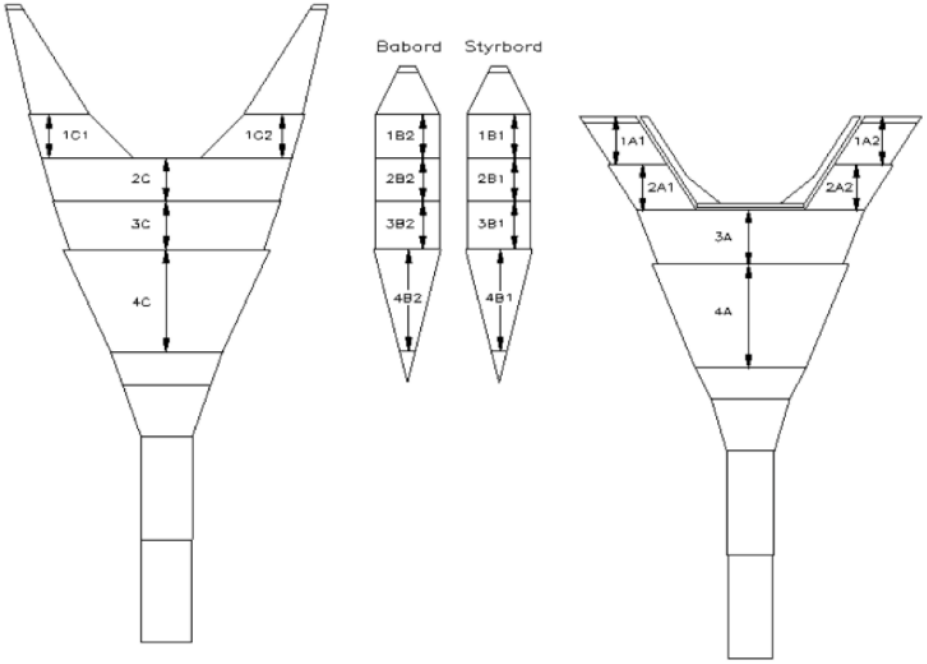
Conclusion

Increasing the wireout to lower the constraining rope height from 35 m to 30 m off the seabed did not improve the seabed contact or trawl goemetry during these trials. However, these trials were conducted in an area known to have a hard and flat seabed and during good weather conditions. In bad weather or soft seabed, more wire out may be needed to maintain seabed contact. In addition, data collection for these trials highlighted the difference in Scanmar update interval and Trawleye echogram seabed threshold on the RV "*Kristine Bonnevie*" compared to other HI research vessels. Standardization of Scanmar data collection rates and echogram thresolds are needed. The automated routines for analysis of sea testing stations require a total number of measurements corresponding to a 15 minute tow with a new measurement each 3-5 seconds, and since

the raw acoustic data from the trawleye are not saved, the data cannot be reprocessed if clearance between the footrope and seabed is improperly estimated during initial data collection.

Appendix 1. Trawl net measurements

Sections
0
1
2
3
4
5
6
7
8



Trawl	Upper panel					Side panels							
	1C1	1C2	2C	3C	4C	1B1	1B2	2B1	2B2	3B1	3B2	4B1	4B2
1639	3.35	3.35	3.25	3.87	8.30	3.35	3.34	3.40	3.40	3.90	3.80	8.00	8.00
1618	3.35	3.30	3.33	4.09	8.00	3.30	3.30	3.33	3.33	4.02	4.00	8.00	8.00
1629	3.35	3.46	3.36	4.05	8.32	3.45	3.35	3.45	3.45	4.12	4.10	8.10	8.10

Trawl	Lower panel						Section stretched-mesh sizes							
	1A1	1A2	2A1	2A2	3A	4A	0, 1	2	3	4	5	6	7	8
1639	3.65	3.60	3.60	3.70	4.08	8.08	80	60	60	42	42	42	42	22
1618	3.35	3.35	3.82	3.78	4.07	8.14	80	60	60	42	42	42	42	22
1629	3.68	3.66	3.87	3.87	4.10	8.30	80	60	60	42	42	42	42	22