The bottom footprint of two different sea cucumber fishing gear

Thorleifur Agustsson
Sigmundur Einarsson
Fabio Grati
Thorleifur Eiriksson

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Sundaborg 1 • 104 Reykjavík • +354 577 3337 • +354 864 7999 • rorum@rorum.is • www.rorum.is

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Höfundar: Þorleifur Ágústsson Sigmundur Einarsson Fabio Grati Þorleifur Eiríksson			

Útdráttur:

Tvær gerðir veiðarfæra til veiða á sæbjúgum voru borin saman með tilliti til áhrifa á sjávarbotn. Til að hægt væri að bera saman hvernig tveir gjörólíkar hannanir hegða sér við veiðar m.t.t. áhrifa á botn, var einungis notast við framenda veiðarfæranna. Niðurstöður sýna að skíðisplógurinn (drag dredge/Drag gear) hafði meiri áhrif á botninn, þrátt fyrir að vega aðeins um helming af hjólasleðanum (Berg´s sledge/ Berg‘s gear). Hér er því um að ræða niðurstöður sem benda til þess að hjólasleði sá sem fyrirtækið Aurora Seafood notar við sæbjúgnaveiðar hafi minna umhverfisspor en skíðisplógur.

Abstract:

Two types of fishing gear, a traditional dredge on skis (Drag dredge/Drag gear) and a new design which uses set of wheels instead of skis (Berg´s sledge/ Berg‘s gear), were compared with regards to their impact on the bottom – as an estimation of environmental footprint. Results show that Berg´s sledge had smaller footprint on the bottom and less impact when colliding with obstacles. It is therefore concluded that even though Berg´s sledge is double the weight of the ski dredge it is more environmentally friendly.

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4 Útdráttur

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5 Abstract

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6 Introduction

The dominant anthropogenic activities affecting marine ecosystems (Halpern et al., 2008) is without a doubt fishing. It is a global concern about adverse effects of various fishing gear, particularly bottom trawls, on seabed habitats and the structure and functioning of benthic ecosystems (Dayton et al., 1995; Jennings and Kaiser, 1998; Watling and Norse, 1998). These mobile, bottom-contacting gears have proven efficient for catching a range of fish and shellfish species and their use has increased globally since the 1950s (Valdemarsen, 2001; Watson et al., 2006).

As the continental shelf habitats along the European coasts, including Iceland, are among the most productive fishing grounds for bottom-dwelling fish species, they have already been trawled for centuries (Horwood, 1993; Kerby et al., 2012; Bennema and Rijnsdorp, 2015).

The problem with bottom trawling is that it will reduce the biomass and biodiversity of the benthic ecosystem and may reduce the complexity of seabed habitats (Collie et al., 2000b; Kaiser et al., 2006; Buhl-Mortensen et al., 2016). This will affect the functioning and productivity of the benthic ecosystem (Jennings et al., 2001; Hiddink et al., 2011; Pusceddu et al., 2014) through a progression of state changes (Smith et al., 2016). The effects on the bottom will however be determined by the type of gear deployed, the type of seabed, direct effects of the passage of a trawl, the footprint of the trawl and the trawling frequency and the sensitivity of the seabed and benthic ecosystem (Jennings et al., 2005; Lucchetti and Sala, 2012; Rijnsdorp et al., 2016).

Few groups of demersal active gears can be distinguished: otter trawls, seines, beam trawls, dredges that are adapted to the specific target species and seabed habitats. Dredges which are designed for shellfish or flatfish can penetrate deep into the sediment (Buhl-Mortensen et al., 2013; O'Neill and Ivanovic, 2016). It is therefore extremely important to estimate the whole-gear footprint on the seabed surface and subsurface level.

It is well established that the mortality of benthic invertebrates imposed by the passage of a trawl is habitat specific and differs between benthic species groups and type of fishing gear and Collie et al. (2000a) and Kaiser et al. (2006) showed in their comprehensive reviews that the most severe impact occurred in response to scallop dredging in biogenic habitats, where deposit feeding macro-fauna were reduced by 40% and suspension feeders by 45% by scallop dredges. The recovery rate will depend on the life history characteristics, in particular the rate of reproduction and dispersal characteristics (Bolam et al., 2014) and may be affected by environmental conditions such as temperature and hydrodynamics (Lambert et al., 2014).

Towed demersal gear also has major environmental effects on by-catch species, on epi- and infauna organisms, and on the physical environment. Trawls and dredges scrape or plough the seabed, resuspend sediment, change grain size and sediment texture, destroy bedforms, and remove or scatter non-target species (Pranovi et al., 2000). Short-term effects included reductions in the structural complexity of the habitat, liberation of space and the selective removal of a large proportion of the benthos. The indirect and longer-term effects are not known but are expected to favour opportunistic species and juvenile stages and a reduction in the abundance of large long-lived epifauna. Long-term changes of this nature have been detected in the marine ecosystem of the German Wadden Sea (Reisen and Reise, 1982; Reise, 1982), and several authors speculate that trawling is the cause of shifts in the community structure of the benthos (Kaiser and Spencer, 1996; Philippart, 1998) and overlying plankton (Lindley et al., 1995). Increasing food availability to mobile predators and scavengers (through by-catch discards and non-catch mortality) may also contribute to shifts in the composition of benthic communities that are repeatedly disturbed by fishing, just as seabird populations benefit from discards at the sea surface (Garthe et al., 1996). Fisheries research has traditionally focused upon gear efficiency and stock management in terms of securing sustainable yields of commercial target species, with little consideration being given to the effects of fishing on non-target species and ecosystem structure. One towed gear about which little is known in terms of its environmental impact is the sea cucumber dredge. Therefore, it is extremely important to try to investigate the potential impact. Sea cucumber fishermen with years of experience, have reported dead and damaged sea cucumbers as a result of using the commercial ski-dredge gear as well as observations that with longer constant fishing effort on the same area this usually increased significantly. Their believe is that the skies are slicing the sea cucumbers that go directly underneath the skies, not always catching them but certainly killing them, which indicates that the fishing gear has negative impact directly on the sea cucumbers (Bergur Garðarsson & Kjartan B. Sigurðsson, 2021 personal communication). As a previous report by Ólafsdóttir et al. (2018) from the same project focused on the bycatch of the commercial dredge, the objective of this research was to compare the benthic footprint of two types of dredges: a) the commercial dredge which is equipped with sledges on both sides of the fixed mouth opening (Thórarinsdóttir & Gunnarsson, 2010) (hereafter the Drag gear); and b) an experimental sledge which is provided with wheels on both sides of the fixed mouth opening (hereafter the Berg's gear).

7 Methods

7.1 Location for experiments

The experiments were conducted at Búðarsandur in Hvalfjörður, Iceland. This is a shoreline where the seabed emerges during low tide and is therefore a good representative of a natural seabed (Figure 7-1). Also, due to the necessary impact that the experiments would include, such as digging and driving around in heavy vehicles, this was an ideal location as every six hours the area would go under water and hench all footprints would be erased. It can therefore be said that we conducted an experiment that had no environmental impact whatsoever (Figure 7-2).

Figure 7-1. Búðarsandur is in Hvalfjörður, south-west part of Iceland.

Figure 7-2. Experimental area in the early morning. Tide is going out and the seabed emerging which consists of fine gravel.

7.2 Experimental setup and fishing gear

The experiments were set up to answer two main questions:

a. Is there an impact/footprint on the seabed during trawling, and if so, is there a difference between the two types of the fishing gear, the “Drag gear” and the “Berg’s gear”?
b. What is the impact of the two different gear on obstacles during trawling?

In the trials, only the front part of the gear was used. This was done to emphasise the measurements and comparison of the footprint on the parts of the gear that are fundamentally different. The total weight (including all parts of the fishing gear) of the Drag gear is 700 kg while the total weight of the Berg´s gear is 1000 kg, making the Berg´s gear 30% heavier.

7.3 Drag gear.

The front end of the Drag gear (Figure *7-3*) consists of several components constructed out of mild steel, with some tempered steel added for reinforcement as described in Barret et al., 2007.

7.4 Berg‘s gear.

The front end of the Berg´s gear (Figure 7-4) consists of several components constructed out of mild steel. This gear has a more complicated structure than the Drag gear. Main feature is the 2500 mm wide I-beam which on to are attached 10 mm short bracket ears. To the short bracket ears are attached triangle arms. On each end of the I-beam are attached 260 mm wheels made of rubber for lifting the front gear of the bottom and better preserve fragile bottom and to cross obstacles of more ease.

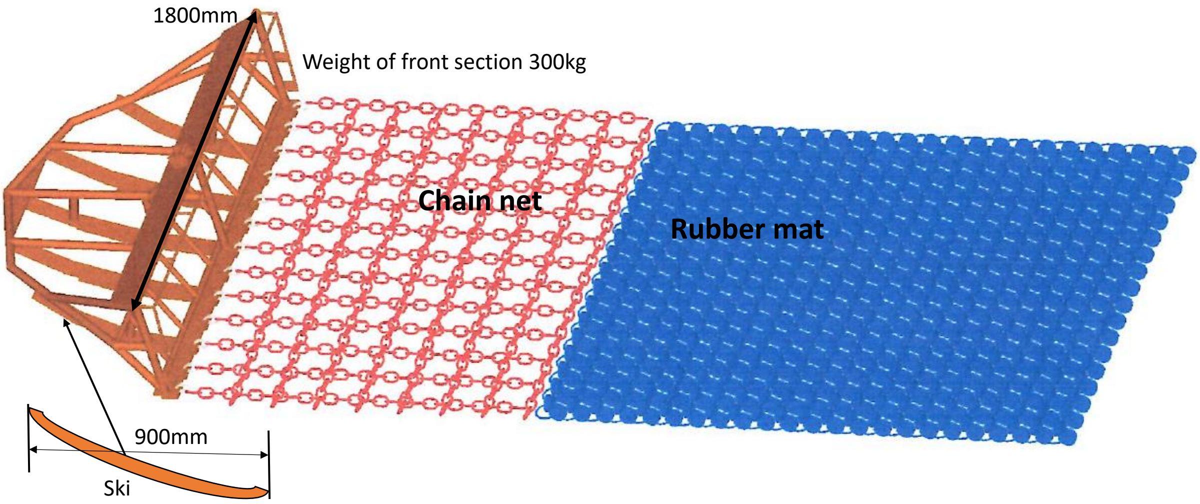

Figure 7-3. The dimensions of the *"Drag gear".* Only the front part is used during trials. Total weight of the Drag gear is 700 kg.

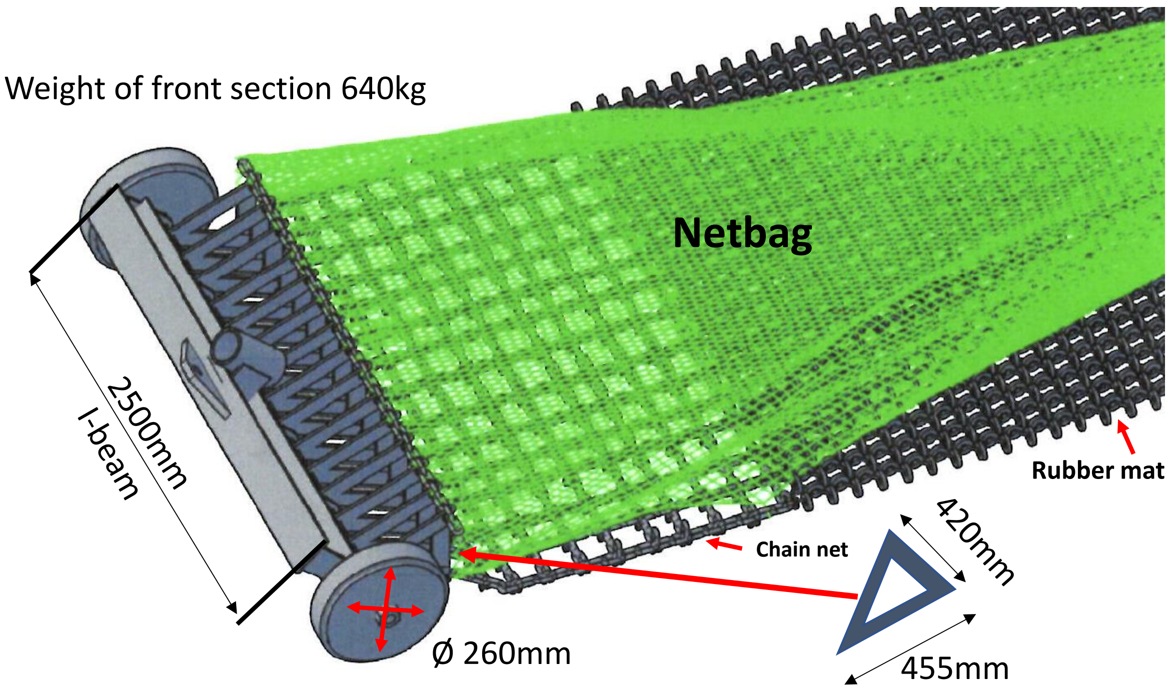

Figure 4. The dimensions of the "Berg's gear". Only the front part is used during trials. Total weight of the Berg's gear is 1000 kg.

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Víkurbraut 11 • 230 Reykjanesbær
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Kt: 410190-1099

Vigtarnóta
númer: 02417

Drag gear

Dags: 17.11.2020 Tími: 14:21:06

Skráningarnr ökutækis: Skíðisplógur

Kaupandi : Aurora Seafood ehf v/Tapbalat

Kennitala: 510613-1200

Tara:	Brúttó
4.840 Kg	5.140 Kg

Farmur:

Umbúðir Fjöldi	Kg	Umbúðir alls
		0
		0
		0
		0
	Samtals	0

Nettóvigt farms: 300 kg

Löggild Vigt: Cardinal Detocto
Model no.210 Serial# E31806-0100

Löggildur vigtarmaður

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Sími 420-3220 • Bréfasími 420-3229
Kt: 410190-1099

Vigtarnóta
númer: 02416

Berg's gear

Dags: 17.11.2020 Tími: 14:18:39

Skráningarnr ökutækis: Hjólaplógur

Kaupandi : Aurora Seafood ehf v/Tapbalat

Kennitala: 510613-1200

Tara:	Brúttó
4.840 Kg	5.480 Kg

Farmur:

Umbúðir Fjöldi	Kg	Umbúðir alls
		0
		0
		0
		0
	Samtals	0

Nettóvigt farms: 640 kg

Löggild Vigt: Cardinal Detocto
Model no.210 Serial# E31806-0100

Löggildur vigtarmaður

Figure 7-4. The two gear were weighted using a Governmental harbour scale official.

In preparation for the trials, a runway was made ready, as well as obstacles. The obstacles consisted of 3 new and undamaged 200 l metal barrels – painted prior to each trial run. This was so that damages could be registered (Figure 7-6).

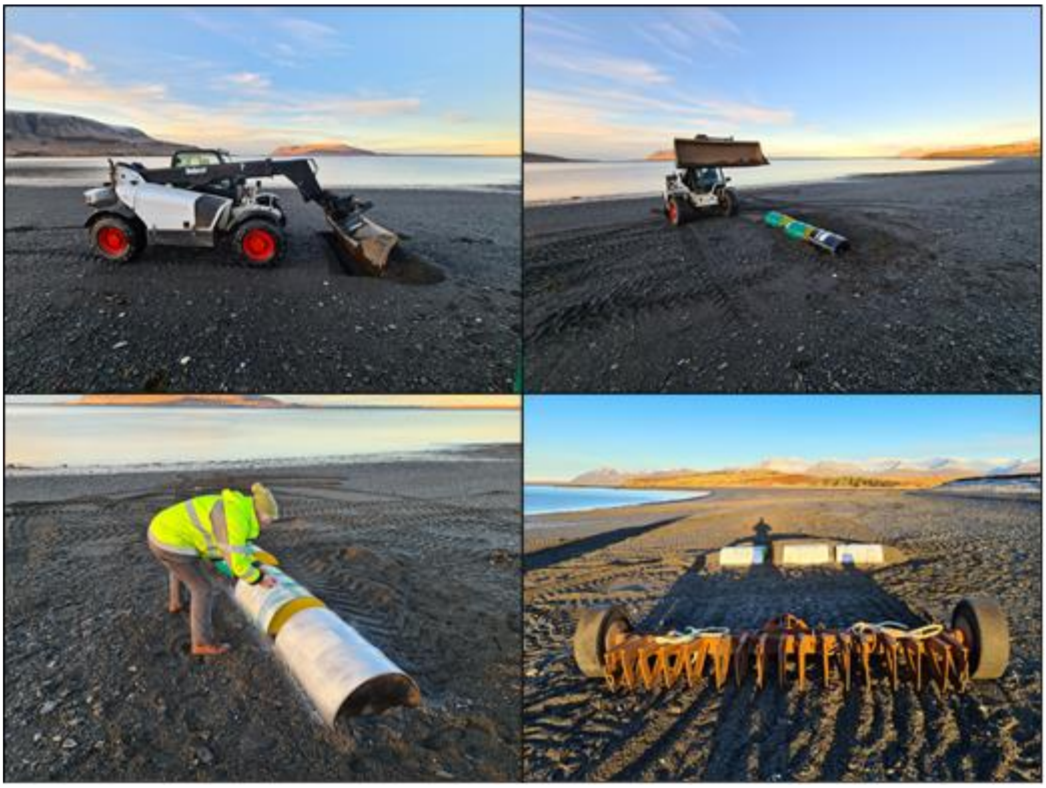

Figure 6. A Telescopic forklift was used to place obstacles prior to each trial run (upper left). Barrels were lined up in a row – not exceeding the width of the dredge (upper right). Each barrel was painted to better see impact (lower left). Seen from behind the Berg's gear prior to trial run (lower right).

7.5 Experimental trials

Both types of dredges were tested the same way as follows:

I. The runway was made ready by raking to even the surface.
II. Towing angle was set as close to 45 degrees as possible (Figure 7-5).
III. Speed during towing was set at 2-2.5 nautical mile per hour, which is the speed normally used during dredging.
IV. A continuous towing was maintained through the runway and over obstacles to best mimic real-life situation (Figure 7-6).
V. Impact on obstacles, the barrels, was registered for comparison (Figure 7-6).
VI. Footprint was registered by comparing impact of the two dredges (Figure 7-8).
VII. A second type of obstacle was introduced, corrugated roof iron plates. This was done to see what if fishing gear had enough impact to move the plates and to see if the fishing gear would carry bottom material onto the plates (Figure 7-7).

Figure 7-5. During each run the angle of which the gear was pulled was kept as close to 45 degrees as possible.

Figure 7-6. Dredges were towed at similar angle and speed as would be during actual fishing. Plate A shows the Berg's gear impacting the obstacle and plate B moments after. Plate C and D show same event for the Drag gear.

Figure 7-7. Corrugated steel plates were uses to demonstrate how easily the dredges would run over flat obstacles. Plates A and B show the impact of the Berg's gear and plates C and D that of the Drag gear.

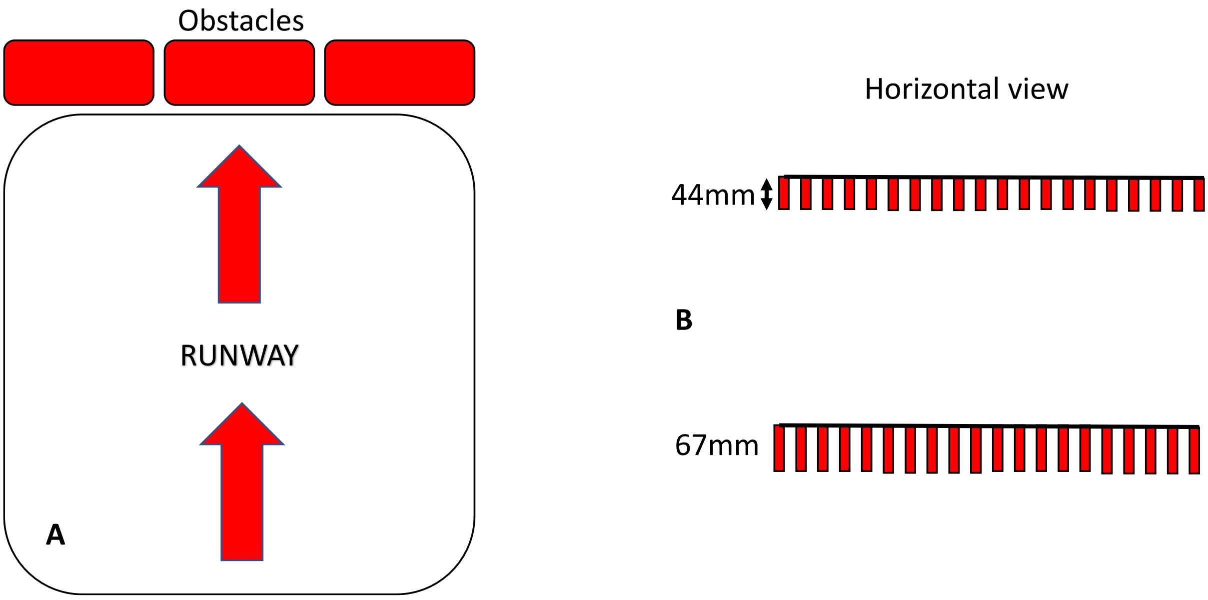

Figure 7-8. A schematic drawing of the setup (A) and a horizontal view (B) representing the footprint of Berg´s gear (A & B) and drag dredge (C & D), measured as how deep the gear penetrated at the most (numbers are not average, rather the deepest penetration mark was registered). The different footprint is registered.

8 Results

Prior to each trial run, the towing angle was set as close to 45 degrees (Figure 7-5). During towing the angle maintained steady as can be seen in Figure 7-5. The two types of gear showed a different footprint on the bottom during operation.

The Drag gear (Figure 7-4 A), which is approximately half the weight of the Berg's gear (Figure 7-4 B), behaved much like a „plough"– pulling a lot of sediment (Figure 7-6 C & D). This resulted in that lot of sediment was moved and the obstacles became covered with benthic material after passing of dredge (Figure 7-6 C & D). This was also seen when the Drag gear was towed over corrugated metal plates, as benthic material covered the plates, and they were moved (Figure 7-7 C & D).

The Berg's gear showed a very different footprint, generating grooves into the bottom (Figure 7-7 A & B) but without showing any ploughing impact (Figure 7-7 A & B). This was confirmed when the impact on the metal barrel was observed (Figure 7-6). When the Berg's gear was towed over the corrugated metal plates, it did not move any bottom material, nor did the Berg's gear damage the plates (Figure 7-7 A & B). To assess the impact on the bottom, the deepest penetration was measured. As the two gear showed a very different „penetration tracks ", where the Drag gear behaved more as a plough and the Berg´s gear generated grooves by the triangle arms. This difference in footprint made it difficult to do a comparison. However, result show that the Drag gear penetrated 52% deeper into the bottom, with maximum depth of 67 mm (Figure 7-8 B) compared to depth of 44 mm by the Berg´s gear.

9 Discussion

Due to complicity of such survey, costs, and the fact that fishing efficiency study had already been undertaken by the Marine and Freshwater Research Institute in Iceland (Ólafsdóttir et al. 2018), it was decided to go for a "simulation" test. Also, considering that during the commercial activity at sea the chain and the net bag tend to smooth the footprint of tracks generated by the fixed mouth frame, that would make it difficult to evaluate the real impact of the dredges on the sea bottom, even by using a sides-can sonar and/or a multibeam echosounder, we assumed that the most important parameter to be measured and compared between the two dredges was the track depth.

The site selected for the trials was therefore based on simulating natural conditions, a shoreline on low tide, to be able to monitor behaviour, footprint on bottom and the impact on potential obstacles. This choice proved to be convenient, with easy access to the location and optimal weather conditions. Further, the way the gear was towed, using a Telescopic forklift, was successful as both the corrected angle, 45 degree, and speed, 2-2.5 nautical miles per hour, was as planned, simulating the behaviour of fishers during their commercial activity.

The gear showed a very different behaviour during towing and which was not surprising as both structure and weight were different. The Drag gear was much lighter and perhaps should have been expected to easily glide over the surface on its skis but did instead plough through the top layer of the bottom, carrying with it a lot of material. The Berg's gear on the other hand, even though double the weight compare to the Drag gear, did not plough through the bottom in the same way, but rather ran easily over the surface as well as the obstacles. The footprint on the bottom was estimated by measuring depth of tracks made by the gear. Results show that the wheel system is of great importance as it carried the gear over the bottom without „ploughing "and therefore it seemingly a great improvement.

These differences that were observed here are of paramount importance, as ploughing the bottom can have significant impact on benthic ecosystems and may reduce the complexity of seabed habitats (Collie et al., 2000b; Kaiser et al., 2006; Buhl-Mortensen et al., 2016). Not least, it effects the functioning and productivity of the benthic ecosystem (Jennings et al., 2001; Hiddink et al., 2011; Pusceddu et al., 2014) through a progression of state changes (Smith et al., 2016). This study did not focus on by-catch or fishing efficiency of the two dredges as it has been tested recently and reported (Ólafsdóttir et al. 2018).

Taken together, the Berg's gear has less impact on the bottom, both seen here as well as in the report by Ólafsdóttir et al. 2018. The findings here are therefore consistent of earlier findings.

It can be concluded that the Berg's gear is overall, likely a better fishing gear that has less direct impact on the bottom and crosses obstacles more easily that the Drag gear.

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