# 60 years of development in the selection systems used in bottom trawls for gadoid species

A review of the literature produced in the period between 1963 and 2021



Nadine Jacques, MSc 6-30-2021

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### 1. Summary of research conducted in the selectivity of bottom trawls for gadoid species in the period between 1963 and 2021

This document is a collection of research conducted throughout the last 60 years concerning the selectivity of bottom trawls for gadoid species. While the primary focus in this work was to summarize research conducted in the North -East Atlantic and Barents Sea, studies are also included from fisheries deploying similar gears in the USA, the Mediterranean, the Baltic Sea, the Pacific and regions throughout the Atlantic Ocean. As well as selectivity studies regarding gear modifications to bottom trawls, studies were also included that provided new knowledge concerning selectivity of important bycatch species, advances in methodologies used, research in fish behavior as well as various other gear related studies where trawl selectivity was impacted.

#### 1.1 Early studies

Several early selectivity studies stemmed from interest from ICES seeking to alleviate problems of discard such as that conducted by Beverton (1963) in order to understand in more detail the degree of escapement that occurred in the codend. Particular focus was on the rows of meshes immediately in front of the bulk of the catch bulk in the codend. Escapement was found to be highest in this area of the codend compared to areas situated more forward in the trawl. Studies from ICES followed that sought to improve trawl selectivity by comparing for example double and single codends (Hylen and Smedstad, 1974), different headline lengths (Warren and Lovewell, 1976), horizontal separator panels (Main and Sangster, 1976) and lastridge rope designs (Isaksen and Valdemarsen, 1990).

#### 1.2 Mesh size and configuration

Armstrong et al, (1990) highlighted the potential that finding a suitable mesh size coupled with other gear design factors can have on the selection efficiency. With the selectivity systems predominantly used today in the Barents Sea (the Flexigrid or Sort-V combined with a size selective codend), it is known that most of the fish escape through the grid section in a sequential selection process (Brinkhof et al., 2020), however it has been found that the selective properties of the codend are still unfavorable when it comes to undersized fish (Sistiaga et al., 2016a). According to Jørgensen and Ingolfsson (2006) however, the difference in efficiency between the codend compared to the sorting grid is not significant. Diamond mesh and square mesh of the same size can have significant differences in terms of the subsequent selection they produce for different gadoid species (Halliday et al., 1999; He, 2007) as well as the survivability that can be expected for escaping individuals (Suuronen et al., 2005). Unsurprisingly, larger mesh sizes are expected to retain larger fish, however, a square mesh compared to a diamond mesh codend of the same size can have a much narrower selection range (SR) and enable additional release of flatfish species that are often caught as bycatch in the demersal gadoid fisheries (He, 2007).

#### 1.3 Escape windows and panels

Devices such as mesh windows or panels were shown to have good potential at increasing 50% retention length (L50) while maintaining or reducing the SR if placed optimally in the codend (Madsen et al., 2002; O'Neill et al., 2006; Grimaldo et al., 2007; Grimaldo et al., 2008). In the North-East Atlantic, square mesh panels and sorting grids are the two most-applied technical devices in the bottom trawl fishery to supplement the selection of diamond mesh codends (Sistiaga et al., 2018). Some variation is given with these results in the literature however, as different configurations and installations of the panels have led to varying results (Bullough et al., 2007; Herrmann et al., 2015; Brčić et al., 2016). Mesh windows may be a more optimal alternative compared to diamond mesh in terms of survivability, in particular for larger individuals (Suuronen et al., 2005; Grimaldo et al.,

2008). This can be an economical alternative to changing the entire mesh size as fishermen may still keep their standard gear, only adjusting the mesh in a section of the codend.

#### 1.4 Rigid sorting grids

In efforts to supplement diamond mesh codend size selectivity, developments of rigid sorting grids as excluder devices began in the late 1980s in the North East Atlantic (Larsen, 1989). Today, sorting grids are one of the key mandatory selective gears enforced in the Barents Sea gadoid fishery. These became more common place following experiments that were done in Norway and Russia (Larsen and Isaksen, 1993; Isaksen et al., 1996) to reduce the high levels of juvenile fish retention that was being observed by fishermen. By 1997 the Sort-X and the Sort-V grid systems (Isaksen et al., 1996; Norwegian Directorate of Fisheries, 2017) with a minimum bar-spacing of 55 mm became mandatory. However, there were many reports from fishermen of concerns regarding safety at sea during the handling of these gears, particularly during bad weather conditions as these grids were made of steel. Further, studies have argued that the codend compared to the grid could have similar selection efficiency (Graham et al., 2004; Kvamme and Isaksen, 2004) and that the added selection by adding the sorting grid could have been achieved by increasing the mesh size alone by 20 mm (Jørgensen et al., 2006). Alternative grid designs were however then trialled using various plastic materials. A grid system called the Flexigrid was successful during these trials and was made of Polyamide (PA) bars and rubber frames. This system was lighter, smaller, more flexible, and therefore could alleviate the handling issues faced by fishermen (Angell et al., 2001). As a result, this grid system became legalized in 2002. In analyses of the individual contributions of the grids and the diamond mesh codend in a flexigrid system (Sistiaga et al., 2016; Brinkhof et al., 2020) it was found that 77% of haddock as well as 16% of cod above the minimum size escaped from this configuration (Brinkhof et al., 2020). This leads to added fishing effort required in order to compensate for the loss of legal sized fish and the associated greenhouse gas emissions that it produces. This is also reflected as added damage to the seabed and more retention of bycatch. Sistiaga et al (2016a) however found higher retention probabilities above and below the MRL both for cod and for haddock. A primary explanation for the variability in efficiency recorded by the flexigrid can be the angle at which the grids are installed at. A higher grid angle can lead to higher grid contact values, and therefore the development of methods to reduce this variation in grid performance may be beneficial.

Ongoing challenges have been in relation to the reduced speed of water flow through the grid section as this can increase the potential for blockages to occur and thereby reduce the selective potential of the grid. Changing from the standard 2-panel codend design to a 4-panel design has improved this as well as selectivity of the system somewhat (Grimaldo et al., 2015; Sistiaga et al., 2016a). However, the lifting panel that is usually used has been described as a major source of the reduction in flow (Gjøsund et al 2013). Therefore, alternatives are sought that can still maintain sufficient grid contact.

#### 1.5 Selectivity at the mouth of the trawl

Investigations by Warren and Lovewell (1976) found that shortening the headline and reducing the size of the wings reduced catches of shrimp as well as gadoid bycatch in the Nephrops and whitefish fishery in the North Sea. Ingolfsson and Jørgensen (2006) identified the fishing line to also play a significant role in fish selection, particularly for cod, whereby up to one third of cod that would be caught by the mouth of the trawl were shown to escape below the fishing line. Modifications at the mouth of the trawl that affect bottom contact with the seabed have also been an important area of continued focus (Winger et al., 2004; Sistiaga et al., 2015). For gadoid species however it is difficult to maintain the herding mechanism created by the bottom contact of the gear, with significant

reductions observed for both cod and haddock catches when the degree of bottom contact is reduced (Sistiaga et al., 2015; Sistiaga et al., 2016b).

The vertical distribution of fish as they enter the bottom trawl has also been explored numerous times in the literature (e.g; Beutel et al., 2008; Krag et al., 2010; Sistiaga et al., 2015; Karlsen et al., 2018). Cod were shown to predominantly orientate themselves downwards as they enter, while haddock and saithe swim more upwards. Differences may also depend on length differences in the species. For example, Krag et al, (2010) saw smaller cod swam lower more frequently in the trawl during the night compared to trials conducted during the day. Differences between gadoid species may also have a high dependence for how far aft the separator devices are installed, as haddock for example tend to enter at all levels but swim upwards as they move aft (Engås et al, 1998). This tendency for haddock was harnessed in a USA haddock fishery when the mesh size of lower and upper wings was increased as well as the side panels and the lower belly in order to increase escapement for cod, while no impact on the retention of haddock was observed (Beutel et al., 2008). The topless trawl design tested by Krag et al, (2015) in the Nephrops fishery was also successful at releasing haddock over the headline as well as cod when this was installed at a lower height, with differences in escape being length dependent for both species.

#### 1.6 Other miscellaneous studies

Several methodology studies are presented in this review that over time have shaped the way experiments have been designed in order to minimise sources of error and produce estimates that best describe selection processes taking place while fishing (Cadigan and Millar, 1992; Wileman et al, 1996; Millar and Fryer, 1999; Zuur et al, 2001; Herrmann 2005; Sistiaga et al., 2009; Herrmann et al., 2016). Improvements made to survey sampling methods (Engås and Godø, 1989; Dremiere et al, 1999; Herrmann et al., 2016) have helped to reduce instances of underestimation made during surveying with trawls. Many selectivity studies implement covers to quantify the change in escapement through a device of interest. Madsen and Holst (2002) assessed the efficacy of this experimental design with findings suggesting that covers can significantly affect the passage through devices such as square mesh windows. Techniques such as the paired gear method were also shown to have shortcomings in estimating the true variability between selection systems compared to the covered codend method (Herrmann et al., 2007; Sistiaga et al., 2009). Selecting the paired gear method rather than the covered codend method can have consequences if the same number of individuals are measured during sampling. The paired gear method was shown to require a much higher sampling effort to achieve a specific uncertainty level compared to the covered codend method (Herrmann et al., 2016). Other modern approaches that also consider the contact likelihood on grids as well as the angle of attack can help to explain the individual contribution of each of the selective gears more precisely (Sistiaga et al., 2010; Herrmann et al., 2013). In this situation, attaining precise results can be dependent on the experimental design, for example, the number of compartments that is used during the data collection process.

The survival of fish after they escape from a bottom trawl is an important factor when estimating the total impact of bottom trawling operations (Breen et al., 2007). Soldal et al, 1993 and Sangster et al, 1996 found that survival was high in general, with slightly more mortalities for haddock compared to cod and saithe. Sangster et al., (1996) found a length-dependent relationship for mortality after escape, with smaller individuals being less likely to survive. The relationship between survivability and mesh size however could not be determined. Suuronen et al., (2005) identified temperature as a determinant of survival after escape, with higher sea temperatures leading to higher risk of mortality for cod.

Various types of different stimuli have been shown to affect selectivity of fish in a bottom trawl, for example differences of trawling during day conditions compared to the night (Engås and Ona, 1990; Aglen et al., 1997). Gadoids behaved more consistently during the night and showed less frequent attempts at escape over the trawl compared to during the day, while gadoids also entered the mouth much more irregularly in space in the day compared to the night. Other forms of stimulation can also affect gadoid behavior in a bottom trawl. Mechanical stimulation for example fluttering float lines can affect haddock escape through a square mesh section, while cod seem to show much more reluctance to react to these as well as forms of light stimulation (Grimaldo et al., 2018).

## 1.7 Current status in gadoid bottom trawling technology and future recommendations

In recent years, pressure from the consumer and other industry stakeholders has been mounting to improve the bottom trawl fishery in numerous ways. While bycatch reduction remains high on the agenda, research is also needed to improve the quality of the final marketable product caught. The impact that this fishery has on the environment must also be considered, for example by reducing fuel consumption, moving towards biodegradable materials in the twine used as well as minimizing the unaccounted-for mortality. This can be a difficult task in a fishery involving multiple target and non-target species (Winger et al., 2010) as well as gear components and selection processes that take place during the fishing process (Suuronen et al., 2020).

As rigid grid designs used in the North-east Atlantic bottom trawl fishery for gadoid species have shown undesirable catch patterns and are difficult to maneuver, alternatives are needed that improve selectivity and regulate the catch quantity in order to preserve the quality of the catch (Brinkhof et al., 2018a; Ingolfsson and Brinkhof, 2020). Lastridge shortening has gained interest in recent years (Ingolfsson and Brinkhof et al., 2020, Herrmann et al., 2020) as it is thought that the diamond meshes become more open and the release of juvenile fish is increased due to the higher flow through the meshes.

Improving the quality of the catch by regulating the catch quantity during fishing at the sea floor will reduce the degree of deterioration that occurs on the catch before the catch reaches the surface (Madsen et al., 2008; Grimaldo et al., 2007, Brinkhof et al., 2021). The standard knotted codend design used today in the North-East Atlantic has been shown to inflict damages to atleast 90% of cod caught (Tveit et al., 2019; Digre et al., 2010; Olsen et al., 2013). Configurations using T90 mesh orientation may provide more favourable quality (Wienbeck et al., 2011; Digre et al., 2010). But more development is still needed to suit innovations such as that made by Brinkhof et al, (2018a) to industry scale use, as a new quality improving codend design could add significant value to the industry while simultaneously avoiding additional retention of juvenile fish.

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2. List of selectivity research conducted in the bottom trawl fishery for gadoid species

Title: Escape of Fish Through Different Parts of a Codend			
Author(s): Beverton	Institution: ICES	Year: 1963	
Document type: Article	Gear type: bottom trawl	Location: Barents Sea	
open and stretched meshes at	s well as pelagic species throu	arough the first few rows of odend. This was measured by agh a covered codend divided	
approximately 95% escaped to escapement was also seen three compared to the middle two of greater area of net as well as of escapement, in particular free compared to the middle two.	ed for whiting, dab and horse through the aft most compartment compartments. However, the finet that had a larger mesh size for dab, was probably less from The results highlight the high last few rows of 'clear' meshe	nent. Fr all species, more overing the rear of the belly first compartment covered a e, therefore the true frequency in this compartment degree of escapement that	

Title: Observations from the Barents Sea in spring 1973 on the discarding of cod and haddock caught in bottom and midwater trawls fitted with double cod ends			
Author(s): Hylen and Smedstad	Institution: ICES	Year: 1974	
Document type: Article	Gear type: bottom and midwater trawls	Location: Barents Sea	
midwater trawls with double	rding onboard commercial travand single codends. These had uppe chafer fastened to the antele codend.	l a 130 mm codend. Some	
Results: Discarding of cod caught using a trawl fitted with a double cod end was 27% by numbers and 11% by weight. For the midwater trawl catches 39% of cod was discarded by number and 22% by weight.			
Discarding of haddock from the same bottom trawl hauls was 3 - 7% by weight and no discarding was observed from the midwater trawl catches.			

Title: Further consideration of two types of trawl used in a whitefish/Nephrops fishery			
Thie. I artifel consideration of two types of trawl used in a wintensity replicops history			
Author(s): Warren and	Institution: ICES	Year: 1976	
Lovewell	institution. ICES	1 car. 1970	
Document type: Report	Gear type: Shrimp and prawn trawl	Location: North Sea	
Objectives: Comparing the catch from a standard Nephrops/whitefish trawl with that of a Gulf of Mexico penaeid shrimp trawl. Both trawls were constructed with a 35 mm unimesh but the headline lengths differed by a factor of two; the prawn trawl had a 86 foot headline and long wings and the Gulf trawl had a 41 foot headline and short wings.			
despite the different headline consistently smaller in the Gu	he towing warps for both traw lengths. Catches of shrimp as alf trawl compared to the "prayops than the "prawn" trawl. Lo	well as gadoid bycatch were wn" trawl. The Gulf trawl	

Title: Trawling experiments vector in a Nephrops fishery	with a two-level net to minimi	se the undersized gadoid by-
Author(s): Main and Sangster	Institution: ICES	Year: 1976
Document type: Article	Gear type: Fish/prawn trawl	Location: Scottland
•	bility of a 70 mm separator pash/prawn trawl to separate had d, flatfish and skates).	•
haddock (89%) and whiting (Of these, 60.2 and 52.3% were	or trawl, it was possible to sep 55%) into the top codends where smaller than 27 cm. Fish can more damaged fish in the low	en the 75 cm panel was used. ught in the top codend were

Title: Selectivity experiments with square mesh codends in bottom trawl			
Author(s): Isaksen and	Institution: -	Year: 1986	
Valdemarsen			
Document type: Article	Gear type: two sizes of	Location: Barents Sea	
	diamond mesh and square		
Objectives: To reduce retenti	mesh codend on of small cod and haddock ι	ising square much codends	
	and to compare selection curve		
	nate haul method (using trouse		
D 1. 701 1.0° 1.	. 1 .1 1 0 1	.1 1 1	
	r trawl method was favoured on the same of		
<u> </u>	sh codend for both cod and ha	_	
with emptying large catches	when using the square mesh co		
circumference.			

Title: The effect of different sweep lengths on length composition of bottom sampling			
trawl catches			
Author(s): Engås and Godø	Institution: -	Year: 1987	
Tuthor(s). Engas and Godo	mstrution.	1 car. 1907	
Document type: Article	Gear type: Different sweep	Location: Barents Sea	
	lengths on a standard		
	sampling trawl		
Objectives: To compare leng	th and species selection by a s	tandard sampling trawl	
configured with 4 different sv	weep lengths.		
	s with increasing sweep length		
	figured with longer sweeps bu	it no species selection was	
observed throughout the trial	s.		

Title: Escape of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results		
Author(s): Engås and Godø	Institution: -	Year: 1989
Document type: Article	Gear type: Sampling trawl	Location: Barents Sea
	with underestimation by samplements were carried out with order to quantify this loss.	
	escape of cod and haddock was beneath the ground gear a rvey estimations.	

Title: Gear selectivity and the conservation of fish			
Author(s): Armstrong, Ferro, MacLennan and Reeves	Institution: -	Year: 1990	
Document type: Article	Gear type: Trawls and seines	Location: Barents Sea	
Objectives: A discussion on important factors related to gear design that should be considered in order to attain optimal selectivity, to preserve juvenile stocks for harvest at maturity and to reduce the risk of future stock collapse.			
Results: The complexities of species and size specific measures that must be compromised for good selection is highlighted.			
An overview is provided on t gear.	he selection ogive and how it	depends on the design of the	
aspect of fisheries manageme	oriate to the fishery in question ent to reduce the retention of u must be balanced with what is	indersized fish. This as well	

Title: Codend with short lastridge ropes to improve size selectivity in fish trawls		
Author(s): Isaksen and Valdemarsen	Institution: ICES	Year: 1990
Document type: Article	Gear type: Trawls and seines	Location: Barents Sea
Objectives: To test the efficie ropes.	ency of a 135 mm codend with	12-15% shortened lastridge
ropes was comparable to a re	ial of a 135 mm codend with 1 gular 155 mm codend. The code catch accumulated. Practical ared to square-mesh panels.	dend held its shape well in

Title: Day and night fish distribution pattern in the net mouth area of , the Norwegian bottom-sampling trawl		
Author(s): Engås and Ona	Institution: -	Year: 1990
Document type: Article	Gear type: bottom-sampling trawl	Location: Barents Sea
ambient levels of light. Using	osition of gadoids in the mouth g a high-frequency scanning so lay and night trials using a Nor	onar mounted as a net sonde,
fish were observed escaping of entered more irregularly, using over the headline. The observed trawling may be equally efficient	ered the middle of the trawl, clover the headline. During obsets the whole opening of the travations indicate that the herdingient by day and night, and that is under non-visual conditions.	ervations in daylight the fish awl, and haddock were lost g process during bottom t hearing must play a

Title: Reliability of selection curves obtained from trouser trawl or alternate haul experiments		
Author(s): Cadigan and Millar	Institution: ICES	Year: 1992
Document type: Article	Gear type: Trawl selectivity	Location: Barents Sea
curves which consider the "pr which instead is calculated by	efficiency of two traditional materials of two traditional materials. These were a considering the proportion of which is in the test codend along the proportion of the test codend along the test	e compared to a third method f the total catch from the test
consistently had the lowest m	ELECT method) was found to nean square error of the three ned L50 and exhibited considerated to the considerate the considerat	nethods. The first two

Title: Survival of gadoids that escape from a demersal trawl		
Thie. But vivar of gadords that escape from a definersal flavi		
Author(s): Soldal, Engås and Isaksen	Institution: -	Year: 1993
Document type: Article	Gear type: Bottom trawl	Location: Barents Sea
Objectives: To examine the vulnerability of saithe, cod and haddock towards gear damages inflicted by the catch process of bottom trawls. Simulated net injuries were inflicted on penned gadoid individuals who additionally were forced to swim through net panels. Physical exhaustion was also induced by swimming cod and haddock on a treadmill in order to simulate the swimming activity in the trawl mouth and belly.		
Results: This study suggested that a high survival rate can be expected for gadoids escaping a bottom trawl. No immediate mortality was observed for cod and saithe, whereas about 10% mortality was found for haddock. Both saithe and haddock developed infections in the wounded skin areas, leading to a delayed mortality of about 10%. Full-scale field experiments during bottom trawling for cod and haddock in the Barents Sea supported the low mortality rates found in the small-scale tests. No mortality was observed for cod, while for haddock it was less than 10%.		

Title: Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod ( <i>Gadus morhua</i> ) and haddock ( <i>Melanogrammus aeglefinus</i> )			
Author(s): Larsen and Isaksen	Institution: -	Year: 1993	
Document type: Article	Gear type: Rigid 55 mm grid	Location: Barents Sea	
mm grid section is inserted in Selectivity was measured usin was intended to improve selec-	size selectivity in trawls on con the grid section of a trawl, ahing a cover over the grid section ectivity of the codend as selections ahead of the accumulating cases.	nead of the codend. on and a blinded codend. This ion could only occur there in	
Results: Selection ranges on or retention lengths of 47.8 cm a	cod and haddock ranged from and 50.2 cm were obtained.	4.6 cm to 8.5 cm while 50%	

Title: Experiences using the constraint technique on bottom trawl doors		
Author(s): Engås and Ona	Institution: ICES	Year: 1993
Document type: Article	Gear type: Bottom trawl doors	Location: Barents Sea
Norwegian surveys; a GOV t	chnique was tested on two diffrawl and a Campelen trawl. The veen the two warps in order to aring trawling.	he constraint technique
reduced when the constraints were minimal when condition surveying shrimp using botto	bility in geometry of the two to were used. Handling and practices at sea were fair, and this tect in trawls in the Barents Sea are cod and haddock surveying in	ctical problems of the rope chnique was adopted for and Svalbard area and is

Title: Joint Russian-Norwegian selectivity experiments on cod ( <i>Gadus morhua</i> ) in the Barents Sea, 1995		
Author(s): Isaksen, Lisovsky, Larsen, Sakhnoe, Gamst, Misund	Institution: Havforskningsinstituttet	Year: 1996
Document type: Report	Gear type: Sort-X and the Russian single grid sorting system	Location: Barents Sea
single grid sorting system use	ectivity differences between the din the Barents Sea in order to Both grids used had a bar-space	to establish sorting grids to
Russian one. The sort-X selection compared to 15 cm for the Russian of small fish; with an fish smaller than 47 cm of 88 commercial fishing without a almost equal length distribution.	ing system (sort-X) gave a slig ection curve was slightly sharpe ussian single grid system. Both escape rate for fish smaller that 8-89%. When the sorting system my kind of cover net, Norwegi ons of fish, whereby introduct edly improve selection in bottom	h systems had a very good an 42 cm of 93-94% and of ms were used during ian and Russian trawls gave tion of either of the systems

Title: Commercial fishing experiments to assess the survival of haddock and whiting after escape from four sizes of diamond mesh cod-ends		
Author(s): Sangster, Lehmann and Breen	Institution: -	Year: 1996
Document type: Article	Gear type: Bottom trawl diamond mesh codend	Location: Inner Sound, Scotland
ž .	e survival of haddock and whinond mesh in the codend when.	0 1
individuals that escaped, char individuals, suggesting that s	ol fish was 100% for both spences of survival were much low urvival may be a more completween survival and mesh size	wer than for larger ex function of length. No

Title: Manual of methods of measuring the selectivity of towed fishing gears		
Author(s): Wileman, Ferro, Fonteyne, Millar	Institution: ICES	Year: 1996
Document type: Article	Gear type: Towed fishing gears	Location: -
measuring the selectivity of f approaches for work done wi understanding of the principle parameters known to have a sin measurements taken at sea made to statistical models and technology.  Results: The manual provides	etions of a previous FAO many ishing gears to give a more in th towed gears. This follows in es of fish selection by gears to significant effect on selection a. This manual also includes ded the technique of analyses importing their experiments, descriptions.	depth description of existing improvements to include important new and that need to be included evelopments that have been plemented using modern

Title: Vertical distribution of cod, haddock and redfish; Impact on bottom trawl and acoustic surveys in the Barents Sea		
Author(s): Aglen, Engås, Huse, Michalsen and Stensholt	Institution: ICES	Year: 1997
Document type: Report	Gear type:	Location: Barents Sea
selected location in the Baren samples and acoustic data we	n and pelagic trawl catch data on the Sea, near the North Cape Bare analysed and positions of comeasurements of light, curren	ank. To do this, trawl od, haddock and redfish
Results: High acoustic values could only be extracted during a few hours of the day. These recordings were found to be large haddock ascending from the bottom, when sampled using the pelagic trawl. When the pelagic trawl was used at night, the recordings were dominated by small haddock and small redfish. The bottom trawl data collected indicated higher variability and larger catches during the day compared to the night time. However, this data was lower in variation compared to that collected using acoustic readings. The findings were in accordance with the pelagic data collected for small haddock and small redfish, displaying their migrations clearly to the sea floor during the day. Cod was found to remain on the sea floor in general throughout the day and the night recordings made.		

Title: A species-selective trawl for demersal gadoid fisheries		
Thie. It species selective trawit for demersal gadola fisheries		
Author(s): Engås, Jørgensen and West	Institution: -	Year: 1998
Document type: Article	Gear type: Horizontal square mesh panel	Location: Barents Sea
and saithe. The sorting sytem mm bar length) dividing the t	selective bottom trawl for sepa was composed of a horizonta trawls body and extension sect to vertically separated trouser of	l square mesh panel (150 tion into upper and lower
saithe were caught I the uppe the second cruise 90% of the codend with 65% of the cod of tendency for haddock to enter	se approximately 90% of the hr codend, with 70% of the cod haddock and 60% of the saith caught in the lower codend. Vir the trawl at all levels but substituting the separating panel	I in the lower codend. During e were caught in the upper ideo recordings indicated a sequently, several that

Title: Escapement from the main body of the bottom trawl used for the Mediterranean international trawl survey			
Author(s): Dremiere, Fiorentini, Cosimo, Leonori, Sala, Spagnolo	Institution: -	Year: 1999	
Document type: Article	Gear type: Bottom trawl	Location: Mediterranean	

Objectives: To assess escapement through the body or under the footrope of a Mediterranean sampling trawl using visual observations and by attaching small collection bags to the outside of the trawl body as well as under the footrope.

Results: Data were collected for Norway lobster, greater forkbeard, hake, common pandora, poor cod, red mullet, horned octopus and blue whiting. Escapement was found to be highly species dependent. Significant escapement of many species occurred in the lower part of the side panels. Norway lobster had the highest escapement rate (64 %), mainly represented by small individuals. The escapement of greater was also high (53 %). For hake, common pandora and poor cod rates ranged from 10 to 16 %. The escapement of red mullet was very low despite their great abundance. Blue whiting escaped mainly through the mid-height part of the side panel. This great variability of escapement values could affect the proportion rates of the species sampled during a standard survey. Different escape behaviours among size classes were observed for blue whiting, poor cod and common pandora, with smaller individuals tending to escape towards the bottom and larger ones towards the higher parts of the trawl body. In the species where the escape rate was size-dependent, therefore, the size-frequency distributions obtained from the codend catch may not reflect actual size-frequency distributions.

Title, Size selection of Atlant	tio and haddools and mallools (	agith a) by attantmayyla yyith	
Title: Size selection of Atlantic cod, haddock and pollock (saithe) by otter trawls with square and diamond mesh codends of 130-155 mm mesh size			
Author(s): Halliday, Cooper, Fanning, Hickey, Gagnon	Institution: -	Year: 1999	
Document type: Article	Gear type: Otter trawl	Location: Atlantic, Canada	
	ize selection of square or diam or cod, haddock and pollock. T aod.		
haddock than for the diamond haddock was approximately 3 diamond mesh configuration.	Is gave an L50 approximately d mesh codends of the same means of the square means and the square means are generally similar to those for the square means are generally to the square means are generally similar to those for the square means are generally similar to those for the square means are generally similar to those for the square means are generally similar to the square means are generally similar to those for the square means are generally similar to the square means are generally	nesh size. The SR for cod and esh configuration than for the ock were too few to allow	

Title: Estimating the size-sele	ection curves of towed gears, t	raps, nets and hooks
Author(s): Millar and Fryer	Institution: -	Year: 1999
Document type: Article	Gear type: -	Location: New Zealand
selectivity data. This formal s definitions of the selection pr	ts a general statistical methodo statistical modelling of selective occess and specification of und resulting estimates of gear sel	vity is built on explicity lerlying assumptions and
	is given on ensuring an adequ haul had a comparatively sma	
gears having windows or grid data from replicate deployme the fixed and random effects	egy to studies using subsample ds is outlined as well as examp ents is covered in detail, with p of between-haul variation. Rec ents are introduced and demon	oles provided. The analysis of particular regard to modelling cent developments on the

Title: Modelling the size sele panel	ctivities of a trawl codend and	an associated square mesh
Author(s): Zuur, Fryer, Ferro and Tokai	Institution: -	Year: 2001
Document type: Article	Gear type: square mesh panel	Location: Scotland
	thodology for modelling the dad in the codend or extension p	
depending on the type of data haddock and whiting using a different curves were used to curves, codend contact-curve	ws a wide selection of possible a collected. The model is fitted covered square mesh panel and describe the selectivity of the is and codend available-curves the contact logistic model. In the individual haul data.	I to data collected for a covered codend. Three panel (panel availables) by three different models,

Title: Escape windows to improve the size selectivity in the Baltic cod trawl fishery		
Author(s): Madsen, Holst, Foldager	Institution: -	Year: 2002
Document type: Article	Gear type: Escape windows	Location: Baltic Sea
the upper panel of the codeno mesh sizes were tested (105, different window configuration	efficiency of square mesh escard compared to the standard cood 120 and 140 mm nominal mestons (110, 125 and 135 mm now ered codend method was used	dend. Three nominal codend sh size) against three minal window mesh size). A
substantially higher L50 than window. A window codend window mesh size was select SR was positively correlated	e codend fitted with a single to the standard codend with a m was also predicted to have a su red to give the same predicted with mesh size and hence L50 ning it was a constant paramet	besh size equal to that of the bstantially lower SR if the L50 as a standard codend.  a finding which had not

Title: Assessment of the cove	er effect in trawl codend select	civity experiments
Author(s): Madsen, Holst	Institution: -	Year: 2002
Document type: Article	Gear type: Bottom trawl	Location: Baltic Sea
tested against a similar uncoverto assess whether or not the colearance, kites were attached was determined by the covered	with a square mesh window and vered codend in a twin trawl secover impacts coded selectivity of to the cover. The selectivity and codend method while that comethod. The selectivity data was a selectivity data was a selectivity data was a selectivity.	etup. This was done in order v. To maintain sufficient of the codend with the cover of the uncovered codend was
without the cover. The L50 w significantly different. The pa L50 was significantly lower to codend with the cover but no	red the codend with the cover of vas 2.4% lower for the codend arameter variance and the between the covered codend. The Sold significantly different. Retented to have been higher in the	with cover but not veen-haul variance in the R was 15.8% lower for the tion rates of cod in the 35–55

Title: An investigation of the cod-end selection	relationship between sea state	induced vessel motion and
Author(s): O'Neill, McKay, Ward, Strickland, Kynoch and Zuur	Institution: -	Year: 2003
Document type: Article	Gear type: Bottom trawl	Location: Scotland
selectivity. The study was div between vessel motion and co catch dynamics of a codend p	e effect of sea state induced veryided into 3 parts. The first est odend dynamics. The second a bulsing in a flume tank. The first amics, catch dynamics and fist	ablishes the relationship analyses hydrodynamics and all part compares direct
Results: Part 1 of the study co state induced vessel motion.	onfirmed that the pulsing of th	e codend is a response to sea
Three categories of longitudi	amic forces acting on the catch nal codend motion are identification forces that are acting is pre-	ed and a qualitative
dynamic movement of the co	sing of the codend to be an implement. Dynamic forces acting conent of the movement of these accement of the codend.	on the fish ahead of the catch

Title: Total selectivity of a co and codend selectivity of nort	ommercial cod trawl with and th-east Artic cod	without a grid mounted: grid
Author(s): Kvamme and Isaksen	Institution: -	Year: 2004
Document type: Article	Gear type: Cod trawl with and without a rigid grid	Location: Barents Sea
the grid section (as developed experimental setups; a trawl of with a 55 mm grid and grid co grid, grid cover, codend and of	are the selectivity of the total of by Larsen and Isaksen, 1993, codend without a grid and a coover and codend without a covered codend (GC). The two with the same vessel and methode.	). This was done using 3 overed codend (C), a trawl ver (G) and a trawl with the o gear types were studied
codend selection. Selection of significantly. Selection of the	ion range was about 10 cm for f the grid (G) and codend (C) grid in the GC setup had to be d was very probable that this v	setups did not differ e left out as it was near

Title: Selectivity of a 120 mm a square mesh panel	n diamond codend and the effe	ect of inserting a rigid grid or
Author(s): Graham, O'Neill, Fryer, Galbraith, Myklebust	Institution: -	Year: 2004
Document type: Article	Gear type: 120 mm diamond mesh codend, 110 mm square mesh panel, 35 mm selection grid	Location: North Sea
codend fitted with a 110 mm selection grid fitted in the ext selectivity.	ency of a 120 mm diamond me square mesh panel and a 120 n ension in the North Sea for co	mm codend with a 35 mm d, haddock and saithe
Results: Saithe and cod result caution.	ts are based on limited data and	d so should be treated with
_	nificant difference for the stan end+grid was tested, the SR w codend+ panel.	
For saithe and cod there was nets.	no significant difference found	d for selectivity between the

Title: Mitigation measures against seabed impact of mobile fishing gears		
Author(s): Winger Fonteyne, Pol, MacMullen, Løkkeborg, Marlen, Moth- Poulsen, Zachariassen, Sala, Thiele, Hansen, Grimaldo, Revill and Polet	Institution: ICES-FAO	Year: 2004
Document type: Report	Gear type: Mobile fishing gears	Location: -
impacts made by mobile fishing effects on the benthic communication of the efficiency and therefore the fi	rt of measures that are being taing gears on the seabed as well inities. In particular, measures ishing time required were investigated to the seabed contact in general	l as mitigating the negative that improve fishing estigated, as well as
the seabed contacting area of provision of dropout aft-belly for whiting, and "wheeled" for system and the "Auto-trawl"	which have less seabed effects trawl footgears, the use of ser openings in beam trawls, add totgears to replace rockhopper system showed good potential depressors in trawls, but some	mi-pelagic trawls for shrimps, option of "sweepless" trawls rs. The "Active Trawl" I for reducing seabed contact

Title: Escapement of gadoid to overall trawl selectivity	fish beneath a commercial bot	tom trawl: Relevance to the
Author(s): Ingólfsson and Jørgensen	Institution: -	Year: 2005
Document type: Article	Gear type: bottom trawl	Location: Barents Sea
commercial bottom trawl und placed behind the footgear un connected to the fishing line	scapement of gadoid species be a typical fishing circumstance and the trawl, with the hof the trawl. The groundgear useasurements for cod, haddock	ees. Collection bags were eadline of the bags used on the trawl was a 60 cm
been retained by the mouth o cod depended on length with Length dependance for escap 7% of individuals passing un- identified as being length dep	hird of cod and one quarter of the trawl escaped below the approximately 50% of cod of ement of haddock was less proder the fishing line. Saithe escendent, with an average escaparge proportion of roundfish by the gear.	fishing line. Escapement for length 38.5 cm escaping. conounced, with on average, eapement was also not be rate observed at 7.2%.

Title: Escape mortality of trav temperature, fish size and coo		morhua) — the effect ofwater
Author(s): Suuronen, Lehtonen and Jounela	Institution: -	Year: 2005
Document type: Article	Gear type: bottom trawl	Location: Baltic Sea
a commercial cod trawl. A 12 window codend, and a 105 m Escapees were collected durin	nortality of cod that escape the 20 mm diamond mesh codend, am square mesh top panel Bacing the last 20 min of each hau cages anchored on the seabed	oma codend were compared. I using a caging method.
for all codend types. Higher r was approximately 15°C, how experience under commercial higher mortality was predicte mesh codend while in the 105	s low when they were kept in a mortalities were observed whe wever these temperatures are a l conditions during the trawlin ed for larger fish that escaped a 5 mm escape window codend the number of dead escapees v	en the water temperature used not typical for cod to ag process. A somewhat from the 120 mm diamond the effect was reversed. In

Title: Effect of catch size and	shape on the selectivity of dia	amond mesh cod-ends I.
Model development		
Author(s): Herrmann	Institution: -	Year: 2005
Document type: Article	Gear type: Diamond meshed codends	Location: -
process in a diamond-mesh co PRESEMO.	individual-bases model to simple odend of a towed fishing gear.	This model is called
populations entering the code girth, width and height accord cross-section. Further, individend, a period for swimming in escape attempts and a packing escape attempt is deemed suc position in the cod-end where obtained and the codend shap the end of a simulation, a logic	and a few minutes and could act and during the tow duration. Earling to its length, and is assumed as a located a period of a the cod-end without being extended a fish can pass through the escape attempt takes place is updated continuously as the istic function is automatically etention length and the selection	ach fish is assigned a weight, ned to have an elliptical f travel time down the cod- exhausted, a period between ahead of the catch. An aigh the mesh opening at the nee. The mesh opening value is the catch size increases. At fitted to the selection data to

Title: Effect of catch size and Theoretical study of haddock	shape on the selectivity of dia selection	amond mesh cod-ends II.
Author(s): Herrmann	Institution: -	Year: 2005
Document type: Article	Gear type: Diamond meshed codends	Location: -
series of computer simulation using a diamond mesh coden	Its collected from a sea trial wins using PRESEMO. The data d, and total catch, by-catch, entit up were analysed. Assuming investigated.	was for haddock caught atry time of by-catch and the
the by-catch weight. They als important influence on both thad a similar effect, for the ca differences in the values for I of the codend remained const	cated that the L50 increases who indicated that the entry time he L50 and the SR. The shape ases analyzed. Different coden L50 as well as more narrow SF ant during the tow. The simulation much mesh cod-end as the cate SR.	of the by-catch may have an of the catch in the cod-end d shapes showed very large Rs, assuming that the shape ations strongly indicated that

Title: Size selection of cod by rigid grids – Is anything gained compared to diamond mesh codends only?		
Author(s): Jørgensen, Ingólfsson, Graham and Isaksen	Institution: -	Year: 2006
Document type: Article	Gear type: cod trawl grid and codend	Location: Barents Sea
Objectives: To compare the selectivity of the 135 mm mesh trawl codend with the combined 135 mm mesh trawl and Sort-V 55 mm grid setup introduced. This is then compared to the selectivity of a trawl without a grid but with a 155 mm mesh codend instead.		
Results: The experiments showed that the grid and mesh combination did not have a sharper size selection than codend meshes. The selectivity of the 155 mm codend was similar to that of the grid and codend selectivity, therefore showing that the introduction of the latter into the legislation effectively only increased L50 and corresponded to an increase in codend meshes by approximately 20 mm.		

Title: Square mesh panels in cod-end selectivity	North Sea demersal trawls: Se	eparate estimates of panel and
Author(s): O'Neill, Kynoch and Fryer	Institution: -	Year: 2006
Document type: Article	Gear type: Square mesh panel	Location: North Sea
•	ectivity of a trawl with no squaresh panel inserted 3–6, 6–9 and	± ±
clear benefits in reducing the were used to show that, for hat panels were more selective the panel in the 6–9 and 9–12 m the 3–6 m position. The same level of significance. For had	It that using a square mesh panel degree of retention of undersite addock and whiting, all three to that the net without a panel. For positions were more selective the result was suggested for haddedock, a six-parameter model where a better fit for the dual select andard logistic curve.	ized haddock. Smoothers trawls with square mesh or whiting, the nets with a than the net with the panel in dock, but only at a marginal was fitted to a subset of the

Title: Selectivity of large mesh trawl codends in the Gulf of Maine I. Comparison of square and diamond mesh		
Author(s): He	Institution: -	Year: 2007
Document type: Article	Gear type: Diamond and square mesh codends	Location: Gulf of Maine, USA
Objectives: To compare the selective properties between five different mesh sized codends. Using the covered codend method, 152, 165 and 178 mm mesh size was tested for diamond meshed codends and 165 and 178 mm mesh sizes was tested for square meshed codends. A new hydrodynamic codend cover design was used for the experiments which was expended using 12 water-bourne kites. Data was collected for cod and haddock as well as for four flounder species.		
Results: The results indicate that larger codend mesh sizes retained larger fish for all species for both diamond and square mesh codends. The mesh shape had no significant effect on the L50 for roundfish while the square mesh codends had significantly smaller L50s for flounders. The square mesh codend had a narrower selection range than the corresponding diamond mesh codend for both cod and haddock.		

Title: Simulation-based investigation of the paired-gear method in cod-end selectivity studies		
Author(s): Herrmann, Frandsen, Holst and O'Neill	Institution: -	Year: 2007
Document type: Article	Gear type: Paired gear and covered codend gear	Location: -
simulator PRESEMO is used	electivity of trawls estimated and method. A modified version to simulate the data that woulst codend also has a small mes	on of the codend selectivity ld be collected from a paired-
Results: It is demonstrated that extreme parameter estimates as well as discrepancies between the paired-gear and covered cod-end experiments do not necessarily reflect physical or biological mechanisms. This phenomenon may help explain cases in the literature where the covered codend and paired-gear methods produce different estimates of codend selectivity.		

Title: SURVIVAL: An assessment of mortality in fish escaping from trawl codends and its use in fisheries management

Author(s): Breen, Huse, Institution: - Year: 2007

Ingólfsson, Madsen and Soldal

Document type: Report Gear type: Trawl Location: Barents Sea

Objectives: To develop sampling techniques that overcome biases in escape mortality estimation and to test these techniques directly against previous protocols. Methods to investigate selectivity and survival of fish escaping at the surface, in a side-trawler fishery was also done. This work also investigated the effect of repeated encounters by fish with trawls and whether escape mortality could be attributed to seasonal variations. These findings were then utilized using modelling techniques and their potential to contribute to stock assessments and other applications to stakeholder groups was assessed.

Results: A new and improved protocol for survival studies was successfully developed including a new sampling cover that does not affect the flow of water around the trawl codend, thus collecting fish without exposing them to additional stressors.

The proportion of gadoids escaping at the surface was estimated using the multi-sampler technique showing that a significant proportion of fish escape when the gear has reached the surface during haul back of the trawl.

For estimations of repeat encounters by cod, PIT tags were successfully used, showing that approximately 8% are recaptured by sampling trawls at least once. Survival after repeat encounters was generally high (99% for cod and haddock approximately).

No significant seasonal variations in selectivity and survival of escaping haddock or whiting was found between spring and summer periods. Throughout each period, mortality for these species was length dependent with the majority of dead fish being less than 15 cm long.

Escape per se was not found to be the reason for death of haddock and whiting. Due to the length dependent mortality it was argued that death could be as a result of injuries and stress experienced during the capture process, and not as a result of escapement. Escapement was however found to cause mortality for larger haddock individuals. These were also contributed towards by stressors associated with surface escape, such as elevated temperature, sea state and the physical condition of the individual.

Title: Separating species usin trawl fishery	g a horizontal panel in the Sco	ottish North Sea whitefish
Author(s): Ferro, Jones, Kynoch, Fryer and Buckett	Institution: -	Year: 2007
Document type: Article	Gear type: Horizontal panel	Location: Scotland
pattern of North Sea cod, whi species by fitting a trawl with species into an upper and low vessels to measure separation	cies-selective trawl gear that in ile maintaining the catch of oth a a horizontal panel in the tape wer compartment. Trials were of a performance for nine species and with different lengths of par	her important commercial cred part of the net to separate conducted on research in different light conditions,
most cod, flatfish, and monkf had no significant effect on the dab, sole, plaice, and cod pass	ng, and saithe were found to passed below it. The towing separation. At lower light leased below the panel. Using act the height at which fish enternd water clarity.	ng speed and panel length evels during the night fewer oustic data collection

Title: Exit Windows as an alt Fishery for cod and haddock	ternative selective system for the	he Barents Sea Demersal
Author(s): Grimaldo, Larsen and Holst	Institution: -	Year: 2007
Document type: Article	Gear type: Exit windows	Location: Barents Sea
Objectives: Trouser trawl experiments were performed to assess the cod and haddock selection capacity of a codend fitted with two 130 mm exit windows. These windows were 10 meshes high and 45 meshes long and were inserted in the rearmost part of the codend. This was done in order to find a potential alternative to the rigid grid system used in this fishery.		
the L50 was far above the MI values varied between 53.6 arcm. Haddock was measured cand the mean SR values at 6.6 metric tonnes. In some cabe detected. This experiment can considerably reduce catch	y efficient in releasing large and LS for both the analysed speciend 57.3 cm and the mean SR viduring two trials with the mean 3 and 6.0 cm. Total catch weignses, an important effect of catch indicated that 130 mm exit withes of undersized fish. The L2 rell below the MLS for these species.	es. For cod, the mean L50 values varied from 6.8 to 9.3 in L50 at 50.5 and 50.6 cm ghts varied between 0.7 and ch weights on the L50 could indows in a 135 mm codend 5 means found for cod and

Title: A year-long trial of a square mesh panel in a commercial demersal trawl		
Author(s): Bullough,	Institution: -	Year: 2007
Napier, Laurenson, Riley,		
Fryer, Ferro and Kynoch		
Document type: Report	Gear type: Square mesh panel	Location: Shetland, Scotland
Objectives: To evaluate the effects of a square mesh panel on the catches of a demersal trawl during normal commercial fishing operations over a period of 1 year. A 100 mm codend fitted with a 90 mm square mesh panel between 6.3 and 9.3 m from the cod-line was compared with an identical codend with no panel, attached to the same net, using the alternate haul method.		
Results: The square mesh panel significantly reduced the catch of undersized whiting and of whiting greater than the minimum landing size by up to lengths of about 32 cm. However, the square mesh panel had no significant effect on the catches of haddock or cod. Hauls with a small-mesh codend showed that large numbers of small haddock were present in the areas where the trials were carried out. Few of these fish were retained by the standard codend, either with or without the square-mesh panel, suggesting that fitting the square mesh panel did not improve the selectivity of the codend design used in these trials.		

Title: Selectivity and escape percentages during three phases of the towing process for codends fitted with different selection systems		
Author(s): Grimaldo,	Institution: -	Year: 2007
Larsen, Sistiaga, Madsen		
and Breen		
Document type: Article	Gear type: A conventional	Location: Barents Sea
	codend, one with escape	
	windows and one with a	
	sorting grid	

Objectives: The selectivity of cod and haddock escaping from three different selection systems (a conventional diamond-mesh codend, a codend fitted with escape windows, and a codend fitted with a sorting grid) using the covered codend technique, was analysed. A MultiSampler attached to the codend enabled the fish entering the codend to be partitioned as they escaped. Escapement was analysed at depth, during haul back and at the surface.

Results: For escaping individuals at depth, the diamond mesh codend allowed significantly fewer individuals to pass through than the two other configurations. This was opposite for escapement at the surface, with the diamond mesh codend releasing significantly more compared to the exit windows or the sorting grid. No difference was found in the percentages of escaping fish between the codend with escape windows and the codend fitted with the sorting grid. Thus, the codends with escape windows and the sorting grid functioned most efficiently in terms of reducing the stress and injury likely caused for fish as fewer were brought to the surface.

When analysed with respect to the whole haul, all three selection systems yielded similar selection values (narrow SR) for cod and haddock; and only differences in the L50 of cod were detected among them. When analysed by towing phase however, the selectivity parameters estimated at depth for both species were mostly lower than those estimated for the whole haul. This difference was, however, more pronounced when comparing the L50 and SR estimates for the haul back and at the surface with that of the whole haul.

Title: Selectivity in a trawl codend during haul-back operation—An overlooked phenomenon		
Author(s): Madsen, Skeide, Breen, Krag, Huse and Soldal	Institution: -	Year: 2008
Document type: Article	Gear type: A conventional codend, one with escape windows and one with a sorting grid	Location: Scotland

Objectives: To estimate selectivity of a trawl codend during towing, haul-up and at the surface. The selectivity of a 99 mm mesh size codend was analysed using a codend cover fitted with a MultiSampler, which was acoustically triggered to take separate samples at the three different haul phases. Data were collected for haddock, whiting and Norway lobster.

Results: This experiment clearly indicated that escapement is considerable during the haul back and surface towing periods of fishing. The mean escapement at the surface was 16, 12 and 38% for haddock, whiting and Norway lobster respectively, while 17, 8 and 28% escaped during the haul-back phase. The selectivity parameters L50 and SR were estimated and compared for the three different phases and for the whole haul for haddock, whiting and Norway lobster. For all three species there was no significant difference in L50 between the three phases analysed. There was also no significant difference for whiting and Norway lobster when comparing the SR of the three phases, whereas the SR was significantly lower for haddock when comparing the surface phase with towing and haul-up. The estimate of L50 when towing was about 6 cm lower for haddock and whiting and 9 mm for Norway lobster compared to the selection curve estimated conventionally for the whole haul. The effect of sea state, duration and codend catch were also estimated for the individual phases and for the whole haul. A significant effect of at least one variable was found in all phases.

Title: Bycatch reduction in the Northeast USA directed haddock bottom trawl fishery		
Author(s): Beutel, Skrobe, Castro, Ruhle Sr., Ruhle Jr., O'Grady and Knight	Institution: -	Year: 2008
Document type: Article	Gear type: large mesh faced bottom trawl	Location: Northeastern USA
Objectives: To test the performance of an 'Eliminator Trawl' configured with large meshed upper and lower wings, side panels and lower belly in order to retain haddock and release cod and other species. The experiments were conducted on two vessels using side by side catch comparison hauls with the conventional net as a control.		
important bycatch species wh	I successfully reduced catches nile not leading to any addition ign an efficient tool in enablin	nal loss of the target species,

Title: Size selectivity patterns in the North-east Arctic cod and haddock fishery with sorting grids of 55, 60, 70 and 80 mm		
Author(s): Sistiaga, Grimaldo and Larsen	Institution: -	Year: 2008
Document type: Article	Gear type: Sorting grids	Location: Barents Sea
Objectives: To estimate the change in selectivity parameters when changing the grid bar spacing. Four different bar spacings were tested; 55, 60, 70 and 80 mm, of steel material. These were combined with a 135 mm codend. It was also sought to investigate the relationship existing between selectivity parameters (L50 and SR) and bar spacing. Selectivity was measured for cod and haddock.		
spacing was increased from 5 selectivity were found between but the first two differed sign 55 to 80 cm led to an increase SR to increase from 7.46 to 1 sharpness, and the 95% confidence.	ation found in the selectivity part of the 55 and the 60 mm grids ifficantly from the latter. The interior in the mean L50 from 56.08 at 4.28 cm. The selection curves dence areas increased gradually onship was found for cod and here.	cod, no differences in or the 70 and 80mm grids, ncrease of bar spacing from to 73.33 cm and the mean moved to the right and lost ly as the bar distance of the

Title: Evaluation of codends with sorting grids, exit windows, and diamond meshes: Size selection and fish behaviour		
Author(s): Grimaldo, Sistiaga and Larsen	Institution: -	Year: 2008
Document type: Article	Gear type: Sorting grids	Location: Barents Sea
Objectives: A 135 mm diamond-mesh codend fitted with a 55 mm sorting grid (sort-V) was tested against a 135 mm diamond-mesh codend fitted with two lateral exit windows and a codend built entirely of 155 mm diamond mesh. Cod and haddock selection was quantified.		
and 6 cm for haddock. The La observations revealed that mo codends as soon as they reach remained inside the diamond- more exposed to physical dan	I three codends were similar, a 50s were all far above the ML ost of the fish escaped from the ned the vicinity of the sorting comesh codend for a longer time mage before escape. In additionand these fish were not likely	S in this fishery. Underwater e grid and exit-window device. In contrast, fish e, and consequently were n, many fish escaped from

Title: Investigation of the paired-gear method in selectivity studies		
Author(s): Sistiaga, Herrmann and Larsen	Institution: -	Year: 2009
Document type: Article	Gear type: Sorting grids	Location: Barents Sea

Objectives: to investigate whether the patterns of the deviations between the paired-gear and covered codend methods observed in the simulation study by Herrmann et al., (2007) also occur in data collected at sea. Furthermore, we investigated whether these patterns occur for cod and haddock and for grid-based systems in addition to diamond mesh codends.

Results: When using the paired-gear method, the distribution of the estimated L50 and SR is wider; the distribution of the estimated split parameter (sum of the fish in the test codend and the cover, divided by the total number of fish retained by the whole gear) has a higher variability than the true split; the estimated mean L50 and SR can be biased; the estimated between-haul variation is different from that estimated by the covered codend. The variation of the L50 and the SR decreases when the number of fish in the codend increases, but they do not necessarily progress towards zero. This is positively correlated with the deviation between the split and the true split. The authors recommended that the methodology used to obtain selectivity estimates using the paired-gear method should be reviewed.

Title: Assessment of dual selection in grid based selectivity systems		
Author(s): Sistiaga, Herrmann, Grimaldo and Larsen	Institution: -	Year: 2010
Document type: Article	Gear type: Sorting grids	Location: Barents Sea

Objectives: To investigate the potential for a new method of assessing dual selection in grid-based selectivity systems. The parameter 'grid contact likelihood' was compared to models previously used and tested using cod and haddock catch data.

Results: For the three cases tested in this study, the fit of the new model (dual selection considering the grid contact likelihood) is superior to that of the logit model. Using the new model instead is most important when comparing devices that have a big difference in selective properties, such as a 80 mm grid compared to a 135 mm codend, and less so for example with a 55 mm grid compared to a 135 mm codend.

For cod and haddock, the new model was found to be relevant for modelling selection. A greater amount of haddock contacted the grid compared to cod, and the L50 was significantly higher for both species on the grid compared to the codend suggesting higher escapement on the grid compared to the codend.

The importance of a three-compartment setup for such studies was highlighted compared to a two compartment setup in order to avoid imprecise estimates of grid contact, grid L50, grid SR, codend L50 and codend SR. The two-compartment setup may only be suitable for estimates of combined grid and codend selectivity.

Title: Fish behavior near bottom trawls		
Author(s): Winger, Eayrs and Glass	Institution: -	Year: 2010
Document type: Article	Gear type: Bottom trawl	Location: Global

Objectives: A review of the current knowledge of fish behaviours in relation to bottom trawls, building on previous reviews. The study summarises more than 100 studies since the 1960s on fish behavior in response to visual and auditory stimuli produced by the vessel, doors, sand clouds, sweeps, footgear, and trawl netting. Individual variabilities in behaviours is also assessed in terms of maximizing benefits and minimizing costs at the individual level. Finally, an anti-predator behaviour model is also applied.

Results: The following subject areas were reviewed;

- Learning behaviors of fish is explored, based on encountering the trawl on more than one occasion, learning from other individuals (social learning), learned avoidance behaviour, etc.
- Physiological influence on response threshold, motivational state, swimming capabilities for escape in a trawl and mesh penetration capability
- Motivational state related to tradeoff of maximizing benefit and minimizing cost at the individual level.
- The impact of extrinsic factors such as water temperature, fish density and light level were reviewed.

Title: Selective haddock (Melanogrammus aeglefinus) trawling: Avoiding cod (Gadus morhua) bycatch		
Author(s): Krag, Holst, Madsen, Hansen and Frandsen	Institution: -	Year: 2010
Document type: Article	Gear type: bottom trawl	Location: North Sea
Objectives: Behavioral differences (behaviour during the day and night as well as swimming behaviour differences) between cod and haddock are utilized in order to separate cod from haddock. A selective trawl is used that raises the fishing line 60 cm above the sea bed. Sampling bags with a small mesh size were attached beneath the fishing line in order to retain escapees. Whiting, saithe, lemon sole, and plaice were included in the analysis.		
and 99% of the marketable has escape rates were highly leng numbers than larger individual	were reduced by 55% during the addock was caught during the 4th dependent: smaller cod escals did. At night the proportion nents was higher compared to	day and 89% at night. Cod aped the trawl in greater of smaller individuals

Title: Selectivity studies in the Barents Sea bottom trawl gadoid fishery: Gear and methods		
Author(s): Sistiaga	Institution: -	Year: 2010
Document type: Article	Gear type: bottom trawl	Location: Barents Sea

Objectives: To positively contribute to the understanding of the selection processes that occur in the gear used in this fishery as well as alternative gears used in other seas and to develop improvements for the sampling methodologies and selectivity estimation approaches used today. The thesis summarises findings collected throughout five scientific publications for cod and haddock. The first two investigate alternatives to the obligatory grid and codend setup (a diamond mesh codend of 155 mm nominal mesh size and a diamond mesh codend of 135 mm with two lateral 142 mm nominal mesh size exit windows). The second analyses the effect on the selectivity of cod and haddock of increasing the grid bar spacing. The third paper investigates the paired gear method compared to the covered codend method following simulations made comparing these in 2007. Paper four presents the parameter 'grid contact' that takes place during dual selection and its importance in interpreting the selection process. The final paper is a multidisciplinary approach to size selectivity that combines recent methodological developments and technology, morphology-based selection approaches, sea trial results from the second, third and fourth papers as well as results from underwater observations.

Results: The first and second papers found selection efficiency equivalent to the standard gear however video surveillance indicated additional release occurring during haulback with the 155 mm codend. Increasing the bar spacing increased the L50 and SR for both species. The third paper indeed found that the paired gear method has associated bias and thus that the covered codend method is a better alternative for use in selectivity studies. The 'grid contact' parameter was found to be an important component for assessing passage for fish through a dual selection system in the fourth paper. The final paper provides a global view of the selection process and differences in morphology were found to explain differences between L50's of up to 6 cm between the species.

Title: Effect of trawling with traditional and 'T90' trawl codends on fish size and on different quality parameters of cod <i>Gadus morhua</i> and haddock <i>Melanogrammus aeglefinus</i>		
Author(s): Digre, Hansen and Erikson	Institution: -	Year: 2010
Document type: Article	Gear type: bottom trawl	Location: Barents Sea
Objectives: The effect of trawling on fish size and on different quality parameters of cod and haddock was evaluated using two trawls in a double rig fitted with a traditional and a novel 'T90' codend, respectively.		
Results: There was no difference between the two types of nets in terms of catch volume, but significantly slightly bigger fish were caught with the T90 than with the traditional trawl net. Haddock caught with the traditional trawl net had more external injuries related to the trawl gear than haddock caught with the T90 gear. The gaping frequency for cod caught with the traditional trawl net tended to be higher than cod caught with the T90 gear, but the difference was not significant. No other differences in fish quality between fish caught in the trawl nets were observed.		

Title: Effect of netting direction and number of meshes around on size selection in the codend for Baltic cod ( <i>Gadus morhua</i> )		
Author(s): Wienbeck, Herrmann, Moderhak and Stepputtis	Institution: -	Year: 2011
Document type: Article	Gear type: mesh circumference, mesh orientation	Location: Baltic Sea
and halving the number of meshes around in the circumference in a diamond mesh codend.		
study. Both modifications had The best selection results wer together. For that codend, ver	ts agreed with predictions of a d a significant positive effect of re obtained for a codend in what y little between- haul variation d to the reference codend in what was a code	on the size selection of cod. nich both factors were applied n in cod size selection was

Title: Understanding the Size Trawl Codends	Selectivity of Redfish (Sebas	tes spp.) in North Atlantic
Author(s): Herrmann, Sistiaga, Nielsen and Larsen	Institution: -	Year: 2012
Document type: Article	Gear type: bottom trawl	Location: Barents Sea
from trawl selectivity studies analysed for three species of fasciatus. Codend size selection other two species mentioned,	gical characteristics of redfish, more specifically, codend selected selections, Sebastes marinus, Sebastes marinus were and finally new experiments. Northeast Atlantic redfish traw	lection. Results were pastes mentella and Sebastes are also extrapolated for the were conducted with catch
also explain and understand of	tion of the FISHSELECT precedend size selection of <i>S. mer</i> ric characteristics with respect	ntella and S. fasciatus
FISHSELECT predictions an selection of <i>S. marinus</i> in dia morphological characteristics	d regarding the effect of coder d the different sea trial results mond mesh codends to a large s of the species, and less so for y of the fish as well as the girt electivity was dependant on.	extent can be explained by behavioural aspects. In

Title: Influence of grid orientation and time of day on grid sorting in a small-meshed trawl fishery for Norway pout (*Trisopterus esmarkii*)

Author(s): Eigaard, Herrmann and Nielsen	Institution: -	Year: 2012
Document type: Article	Gear type: small-meshed trawl	Location: North Sea

Objectives: To develop and test a lightweight sorting grid to be used in the Norway pout fishery in order to overcome handling issues faced with other more heavy alternatives previously trialled in the fishery- as sorting grids were not yet a mandatory device. Thus a grid made from synthetic materials was developed for testing. Grid orientation (leaning backwards or forwards) as well as distinctions in day and night trials was also examined in terms of sorting efficiency.

To make the results comparable to other fisheries containing different size structures, an additional objective was to carry out length-based analyses of the catch data. As very large catches were obtained in combination with an experimental population structure containing only a few length classes, a new methodological approach was needed to support the heavy subsampling required.

Results: An estimated release of between 88.4 and 100% of the total number of haddock and whiting was found with the different grid orientation in distinct day and night hauls. However, bycatch reductions were not significantly different between day and night or between grid orientations, indicating that the grid rejection of haddock and whiting was not influenced by fish behavior. The loss of the target species, Norway pout, was low (between 5.6% and 13.7%) in comparison with the bycatch excluded, and clearly length dependent. Although results were not statistically significant, the grid rejection likelihood for particularly smaller Norway pout (<16 cm) was higher when fishing with the forwards-leaning grid during the night; this might be explained by behavioral and visual aspects for this species in relation to the gear.

Title: Velocity measurements	s in 2- and 4-panel single grid	sections (in Norwegian).
	2	T 2012
Author(s): Gjøsund, Grimaldo, Sistiaga and Hansen	Institution: Sintef Ocean	Year: 2013
Document type: Report	Gear type: 4 and 2-panel grid section	Location: Barents Sea
observed using underwater re speed of water flow through t flow speed through the single order to identify key challeng hydrodynamics through the g		to be caused by the reduced stablishes measures of water wegian cod trawler fleet in improving the
Results: The lifting panel is a major source of reduced flow of water in a grate section, and should be removed or substantially modified if grid contact can be maintained in another way. 4-panel sections have a significantly larger and more stable cross-section than 2-panel sections. This reduces the importance of boundary layers, and improves the installation of the grid and panel elements. Speed measurements in the trawl and grate sections must be interpreted with caution, as the speed can vary significantly both over a cross section and further back in the section.		

Title: Size selectivity of redfi based selection systems for tr	sh (Sebastes spp.) in the North	neast Atlantic using grid-
Author(s): Hermann, Sistiaga, Larsen and Nielsen	Institution: -	Year: 2013
Document type: Article	Gear type: bottom trawl	Location: Barents Sea
	e size selection of redfish using selection system consisting of	
Results: Not all redfish made physical contact with the sorting grids on their way to the codend, and therefore the escapement of some undersized redfish was dependant on the size selection in the codend. Most of the escapement occured through the grid rather than the codend. For one of the two grid systems investigated the increase in size selection obtained by increasing the grid-bar spacing was well in line with what could be expected based on the morphology of redfish. However, the size selection observed experimentally was significantly lower than the size-selective potential of the grids estimated based on the morphology of redfish. Computer simulations, suggested that a possible explanation for this difference could be that not all redfish that attempted escape through the grid made their attempt with an optimal angle of attack.		

Title: A comparative analysis	of legislated and modified Ba	ltic Sea trawl codends for
simultaneously improving the	e size selection of cod (Gadus	morhua) and plaice
(Pleuronectes platessa)		
Author(s): Wienbeck,	Institution: Sintef Ocean	Year: 2013
Herrmann, Feekings,		
Stepputtis and Moderhak		
Document type: Article	Gear type: codend	Location: Baltic Sea
Objectives: Five different codend setups were assessed in order to improve selectivity		
of cod and plaice. The modifications included refining the selective performance of the		
current Bacoma codend by increasing the mesh size of the lower panel from 109 mm		
double twine to 129 mm single twine and increasing the mesh size in the upper square		
mesh panel from 132 to 147 mm. Finally, the design of the lower panel was made the		
the same as the upper panel; i	.e. a full square mesh codend.	These three experimental
designs were tested in conjunction with the legislated codends; the Bacoma and the T90		

Results: The most effective setups tested were the T90 and the Bacoma codends with a modified lower panel (increased mesh size and single twine replacing the double twine). For the T90 codend, the selection parameters (L50 and SR) were 43.4 and 6.7 cm for cod, and 24.7 and 2.1 cm for plaice, respectively. The selection parameters for the modified Bacoma codend were 41.1 and 8.3 cm for cod and 25.2 and 3.9 cm for plaice, respectively. With respect to the minimum landing sizes for cod (38 cm) and plaice (25 cm) in the Baltic Sea at this time, this selection was appropriate for use commercially.

The fully square mesh codend led to low retention of cod as well as high retention of small flatfish. Increasing the mesh of the upper panel led to a significant reduction in legal sized cod and plaice compared to the standard gear.

Title: Understanding sorting	grid and codend size selectivit	y of Greenland halibut
(Reinhardtius hippoglossoide	es)	
Author(s): Herrmann, Sistiaga, Larsen, Nielsen and Grimaldo	Institution: -	Year: 2013
Document type: Article	Gear type: Bottom trawl	Location: Barents Sea and Norwegian Sea
morphology-based FISHSEL sea trials carried out in the Ba	selectivity of Greenland halib ECT methodology. Size select arents Sea (Sort-V gear) and the storical selectivity data collect	tivity data from two sets of ne Norwegian Sea (Sort-X
sea. Despite similar bar spaci were found to be due to the d prior to contacting the grid de found to be an important fact for flatfishes.  The sea trials coupled with the compared to what would have	differed significantly between ngs of the sort-x and sort-v co- ifferences in angle of attack. The etermines this outcome. Accor- or that should be included in factorical data, showed sign the historical data, showed sign the been expected using the FIS of ever gave selectivity estimate	onfigurations, the differences The ability of the fish to turn anting for angle of attack was atture grid selectivity studies difficantly lower L50 values HSELECT methodology.

	el on selectivity of a compulse fleet in the Barents Sea cod fis	
Author(s): Grimaldo, Sistaga, Herrmann and Gjøsund	Institution: -	Year: 2015
Document type: Article	Gear type: bottom trawl, lifting panel	Location: Barents Sea
using a 4-panel Sort-V grid so using the alternate haul metho sections made to connect the panel used was with 80 mm r	e effect of the lifting panel on ection with and without the lift od on two identical 2-panel traz 2-panel trawl bellies to a 4-panetting. Small meshed grid coverell as blinded codends over the state of the state	ting panel. This was done was with transitional nel grid section. The lifting vers were used to assess
the lifting panel approximated make contact with the grid. T the setup. Additionally, an im- as the former as the 4-panel g	g panel had a significant effectly one third of the fish that entry one third of the fish that entry is reduced to 18% when the approved grid section design was rid section together with a more ough the section compared to diffting panel design.	er the grid section do not ne lifting panel is included in as established in the fishery odified lifting panel provided

Title: Understanding the release efficiency of Atlantic cod (*Gadus morhua*) from trawls with a square mesh panel: effects of panel area, panel position, and stimulation of escape response

Author(s): Herrmann,	Institution: -	Year: 2015
Wienbeck, Karlsen,		
Stepputtis, Dahm, and		
Moderhak		
Document type: Article	Gear type: Square mesh	Location: Barents Sea
	panel, bottom trawl	

Objectives: To investigate the selective potential of a square mesh panel in the codend of a bottom trawl based on its placement, area and the stimulation potential to led to an escape response by fish. Six different codend designs were tested.

- 1) A standard BACOMA codend
- 2) 50% shorter square mesh panel towards the aft
- 3) 50% shorter square mesh panel towards the extension piece
- 4) Identical to (3) but with fluttering ropes as a stimulation device
- 5) Identical to (3) but with an inclined panel stimulation device
- 6) Identical to (3) but with float ropes as the stimulation device

Results: The selective potential of the BACOMA codend could not be matched by the other five designs studied. Square mesh panels inserted in an area of the codend that overlapped with the catch accumulation zone were most efficient, independent of the length of the panel. Panels that were positioned closer to the extension piece could release bycatch as efficiently as the panels inserted near the accumulation zone when they were coupled with a stimulation device.

Title: Effect of lifting the sweeps on bottom trawling catch efficiency: A study based on the Northeast arctic cod ( <i>Gadus morhua</i> ) trawl fishery			
Author(s): Sistiaga, Herrmann, Grimaldo, Larsen, Tatone	Institution: -	Year: 2015	
Document type: Article	Gear type: Trawl sweeps	Location: Barents Sea	
	eatch efficiency and herding be to one with sweeps towed on		
sweeps towed on the sea floo lengths between 41 cm and 1 lifted, ie; fish were lost. Conv	vas estimated to reduce cod cator. Cod loss was length depend 04 cm. Herding was negatively versely, when the sweeps were buld be herded into the catch z	lent and significant for y affected when sweeps were e on the seafloor,	

Title: Species selectivity in different sized topless trawl designs: Does size matter?		
Author(s): Krag, Herrmann, Karlsen, Mieske	Institution: -	Year: 2015
Document type: Article	Gear type: Topless trawl	Location: Kattegat and Skagerrak
a large trawl configuration are would be higher and lower, re	vl in the Nephrops fishery, the and a smaller trawl configuration espectively. Species specific entertion well as the bycatch species, has a species of the configuration of the	n where the headline height ffects were assessed for the
a significant length dependent individuals above 32 cm esca found when the low headline	act to the high or the low head at effect to both the high and the aping in both experiments. For height was implemented. This caping from the gear in higher	ne low headline, with most cod, an effect could only be s was length dependent, with

Title: Can a square-mesh panel inserted in front of the codend improve the exploitation pattern in Mediterranean bottom trawl fisheries?			
Author(s): Brčić, Herrmann and Sala	Institution: -	Year: 2016	
Document type: Article	Gear type: Square-mesh panel	Location: Mediterannean	
mullet, poor cod, broadtail sh mesh panel inserted in front of	electivity of Atlantic horse ma fortfin squid and deep-water ro of the codend. The square-mes final tapered section of the trav	ose squid through a square- th panel had a 50 mm mesh	
any of the species analysed. It poor release efficiency may h	id not contribute significantly Majority of escapement occurrave been due to the excessive he net where fish have no chareshes.	ed through the codend. The distance of the panel from	

Title: How Many Fish Need to Be Measured to Effectively Evaluate Trawl Selectivity?		
Author(s): Herrmann, Sistiaga, Santos and Sala	Institution: -	Year: 2016
Document type: Article	Gear type: Trawl	Location: Mediterannean, Barents Sea

Objectives: To provide general and understandable guidelines for specialists in trawl selectivity for determining the quantity of fish that should be length measured in order to attain selectivity parameters at a designated uncertainty level. The dependency of this uncertainty level on the experimental method used to collect data was also investigated as well as the potential effects of factors such as the size structure in the catch relative to the size selection of the gear. Simulated data was used for cod and red mullet from the Barents Sea and the Mediterranean Sea respectively.

Results: The uncertainty in the selection parameters decreased with increasing number of fish measured and it was possible to describe this relationship using a power model. The sampling effort needed to achieve a specific uncertainty level for the selection parameters was always lower for the covered codend method compared to the paired gear method. In many cases, the number of fish that would need to be measured to maintain a specific uncertainty level was around 10 times higher for the paired-gear method than for the covered codend method. The trends observed for the effect of sampling effort in the two fishery cases investigated were similar; therefore, these guidelines should be applicable to other fisheries.

Title: The effect of sweep bottom contact on the catch efficiency of haddock (Melanogrammus aeglefinus)			
Author(s): Sistiaga, Herrmann, Grimaldo, Larsen and Tatone	Institution: -	Year: 2016	
Document type: Article	Gear type: Sweeps	Location: Barents Sea	
sweeps at two different angle	ifference in bottom contact for s and lengths. The impact of the catch comparison and catch rates	his change was also observed	
length led to less bottom cont haddock. Retention of haddoc was length dependent for a sr sweeps that had actual contact	ith the higher sweep angle and tact. A length dependency was ck was higher for the setup with mall range of length classes. In the with the seabed can be releved usually also indicate that the heredent.	s also found for selectivity of th longer sweeps and this a general, the length of the ant for the fishing efficiency	

Title: Size selection of redfish ( <i>Sebastes</i> spp.) in a double grid system: Estimating escapement through individual grids and comparison to former grid trials			
Author(s): Larsen, Herrmann, Sistiaga, Grimaldo, Tatone and Onandia	Institution: -	Year: 2016	
Document type: Article	Gear type: Grid designs	Location: Barents Sea	
lower and an upper grid in a f bycatch species of redfish we new gear had a cross sectiona grid replaced the lifting panel provide an additional sorting grid. The angle of the first gri	tivity using a new double stee four-panel section. Selectivity are assessed. This was done ment area 45% larger to that of the typically used. This additional area and to simultaneously guid was investigated using two	of cod, haddock and two easuring grid contact. The e Sort-V gear and the second al grid was intended to ide fish to the second, upper different angles.	
significantly. The release efficient be significantly lower than the fraction of redfish reaching the redfish made contact with at l	dfish escaping through the two ciency of the first (lower) grid at of the second grid when according to the second grid when according to the individual grids least one of the two grids. How redfish was not higher than whe standard Sort-V gear.	I was, however predicted to counting for the actual s. An estimated 80% of the wever, the release efficiency	

Title: Reducing flatfish bycat	Title: Reducing flatfish bycatch in roundfish fisheries		
Author(s): Santos, Herrmann, Kieske, Stepputtis, Krumme and Nilsson	Institution: -	Year: 2016	
Document type: Article	Gear type: Flatfish rigid escape windows	Location: Baltic Sea	
Objectives: To reduce the bycatch of flatfishes in the Baltic sea roundfish fishery using rigid escape windows in a commercial twin trawler. The vessel was rigged with two trawls; one standard trawl gear and one incorporating the experimental gear. The extension piece was made with four net panels of 4 mm double twine and diamond mesh netting. The mesh size was 120 mm, and the number of meshes around was 4 × 25. A V-shape guiding device of 860 mm high and 200 mm wing length, was mounted in the centerline of the extension piece ahead of the windows, with the aim of directing fish from the central path of the extension towards the windows. Cod and the bycatch of two flat fish species was assessed, plaice and flounder.			
reduction in flatfish bycatch the catch of undersized cod wmarketable cod were relative	atches from both trawls exhibited for the trawl with the new win was reduced by approximately ly minor (~7%). Further simulation of more than 50% in flatfished.	dows mounted. In addition, 30%, whereas losses of lations predicted that, in the	

Title: Size selective performance of two flexible sorting grid designs in the Northeast Arctic cod ( <i>Gadus morhua</i> ) and haddock ( <i>Melanogrammus aeglefinus</i> ) fishery			
Author(s): Sistiaga, Brinkhof, Herrmann, Grimaldo, Langård and Lilleng	Institution: -	Year: 2016	
Document type: Article	Gear type: flexible sorting grid	Location: Barents Sea	
section to that of the tradition interested in analysing the prosubsequently escape, for undertrawl with three compartment	performance of a flexigrid designally used 2-panel design. In participation of contact on either contact of the first contact of the first was done for the first was used to test the 2-panel	articular, the study was of the two grids and recod and haddock. A single and the 4-panel design.	
the 2-panel design, however to observed difference in unders shape of the two sections. The the 26 hauls conducted also re- blockages were observed usin The video recordings also rev	ration released more undersized both designs displayed similar sized fish release could be attributed is was observed using underwevealed blockages when the 2-range the 4-panel design, and this wealed differences in vertical segupwards and cod escaping designs.	r grid contact values. The ibuted to the difference in rater video recordings. 3 of panel section was used. No a difference was significant. eparation between the two	

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Title: Bell-shaped size selection in a bottom trawl: A case study for Nephrops directed fishery with reduced catches of cod.			
Author(s): Lövgrena, Herrmann and Feekings	Institution: -	Year: 2016	
Document type: Article	Gear type: selective grid and square mesh codend	Location: Barents Sea	
investigate the contribution o Nephrops fishery, trawls use codend to avoid bycatches of this system has a bell shape w selection curve. Therefore, a and biological mechanisms the	based model to the size select f the individual parts of the sy a Nordmøre type sorting grid a cod while retaining Nephrops which is not sufficiently describ structural model aimed to desc nat determine selection was ap changes to individual compone	stem. In the Swedish as well as a square mesh as The size selection curve for bed by a monotonous cribe the underlying physical plied. This model was then	
both Nephrops and cod. Furth the selective processes of the in the fishing gear. This appro	priately described the experimermore, this approach provide individual parts of the system each could act as a useful tool ishing gear in use in the fisher	ed a direct quantification of to the overall size selection to fisheries managers	

Title: Improving catch efficiency by changing ground gear design: Case study of Northeast Atlantic cod ( <i>Gadus morhua</i> ) in the Barents Sea bottom trawl fishery		
Author(s): Brinkhof, Larsen, Herrmann and Grimaldo	Institution: -	Year: 2017
Document type: Article	Gear type: semicircular spreading gear	Location: Barents Sea

Objectives: To improve the catch efficiency of cod by replacing the conventional rockhopper gear with a new semicircular spreading ground gear (SCSG). To do this the escape rate of cod below the fishing line was quantified by collecting escapees in a catch bag mounted behind the fishing line and these were compared with the retention of cod in the trawl codend. Length dependencies were thus measured between the two ground gears. Seasonal, diurnal and area-based differences in escape rate were also investigated.

Results: The catch efficiency of the SCSG was significantly improved for a certain length class of cod for both cruises. The first cruise was conducted in the central region of the Barents Sea, the second took place towards the southeast of the Barents Sea. On the first cruise the catch efficiency was improved for cod between 45 cm and 100 cm, on the second cruise, this was for individuals between 81 cm and 100 cm. Overall, this confirms a significant improvement when the SCSG was used for cod of lengths between 39 and 105 cm, however this inference should only be used for individuals above the minimum size limits as smaller individuals should be expected to be affected by selective processes in the codend, trawl body and retainer bag.

Diurnal comparisons did not reveal any changes to selectivity between different light conditions for the same gear, however the catch efficiency was higher using the SCSG for a given group of length classes, reaffirming the improved efficiency when this gear is used compared to the conventional rockhopper gear.

Video recordings revealed that cod escaped frequently on the sides of the rockhopper gear and only in the central parts when the SCSG was used. Considerably larger mud clouds were also produced by the rockhopper gear compared to the SCSG.

Title: Escape rate for cod (Gadus morhua) from the codend during buffer towing		
Author(s): Brinkhof, Herrmann, Larsen, Sistiaga	Institution: -	Year: 2017
Document type: Article	Gear type: Bottom trawl	Location: Barents Sea
towing. To do this, a new ana configuration to be used as in	escape rate and size selectivity llytical approach is used which the commercial industry in or collection was done using the	n allows the same rder to minimize any sources
Results: A significant reduction of cod was found for individuals up to the length of 42 cm, and 60 % of individuals of length 20 cm were estimated to escape as a result of buffer towing. For individuals of 30 and 40 cm length, 53 and 45% of individuals escaped due to buffer towing, respectively		

Title: Improving release efficiency of cod (Gadus morhua) and haddock (melanogrammus aeglefinus) in the Barents Sea demersal trawl fishery by stimulating escape behaviour

Author(s): Grimaldo,
Sistiaga, Herrmann, Larsen,
Brinkhof and Tatone,

Document type: Article

Gear type: mechanical and light stimulation devices

Location: Barents Sea

Objectives: To improve cod and haddock release efficiency through a square mesh section by using mechanical and light stimulation compared to the configuration without any stimulation device. This was done by comparing release results and by using underwater video recordings. The mechanical stimulator was produced by attaching two rows of fluttering lines with floats to the lower panel of the section. LED stimulation was done using eight green Electralume underwater fishing lights. Four were placed at the centre of the square mesh section to scare fish to the side panels and four were attached to each of the selvedges of the section but 20 meshes further back from the first four lights in order to stimulate escapement through the square meshes.

Fall through experiments were also conducted for cod and haddock through the square mesh section used and the results from this would then be used to infer whether the results were as a result of fish behaviour or release potential through the square meshes.

Results: From video recordings, both species did not attempt escape through the square mesh when no stimulator was used. For haddock, the release efficiency calculated was length dependent – decreasing with increasing length. For cod this was very low throughout all length classes without any stimulation. When the mechanical stimulators were used, both species responded by stopping infront of the device. However, the release efficiency for haddock doubled with stimulation compared to without, while cod release efficiency remained very low, showing strong reluctance to respond to the mechanical stimulation.

In response to the LED lights, haddock displayed a very erratic response compared to cod which just kept swimming in a regular way infront of the lights before falling back into the codend. Haddock turned quickly towards the square mesh panels or towards the codend. Several made contact with the trawl netting but many did not manage to escape due to having an incorrect orientation. Haddock release efficiency also decreased with increasing size, as seen for mechanical stimulation. Cod release efficiency remained low for individuals around the minimum catch size, confirming their reluctance to respond to these two forms of stimulation, compared to haddock.

Fall through experiments showed that overall the escape rates were not satisfactory for either type of fish when considering the minimum catch sizes in the Barents Sea (44 and 40 cm for cod and haddock, respectively). This was as the difference between the measured percent of fish that could pass through and those that actually passed through was high.

Title: Size selection of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus)		
in the Northeast Atlantic bottom trawl fishery with a newly developed double steel grid		
system		
Author(s): Larsen,	Institution: -	Year: 2018
Herrmann, Sistiaga,		
Grimaldo, Tatone, Brinkhof		
Document type: Article	Gear type: Lower grid coupled with a Sort-V grid	Location: Barents Sea

Objectives: To examine an alternative design for the lifting panel used in a standard sort-v grid section in order to improve water flow. This involved replacing the lifting panel with an additional steel grid. The speed of fish passage through the section as well as the water flow was examined. And finally, the size selective performance of this alternative gear was investigated in order to quantify if it performed at least as well as the existing grid section.

Results: The new 4-panel grid section had a stronger flow than the standard 2-panel sort-V configuration, however video recordings showed how this also negatively affected the grid contact. More active swimming behaviour by haddock than cod enabled more smaller haddock to escape than cod.

Release of fish was lower through the first grid compared to the second, and more larger fish were released through the first grid when the angle was higher (40°) compared to when it was lower (35°).

When comparing the double grid system to the flexigrid and the sort-v systems the double grid can be an alternative to the flexigrid due to its release efficiency of smaller cod and haddock. For the sort-v configuration, it releases more undersized fish but also more target sized fish compared to the double grid configuration.

Title: Assessing the impact of buffer towing on the quality of Northeast Atlantic cod (Gadus morhua) caught with a bottom trawl		
Author(s): Brinkhof, Larsen, Herrmann and Olsen	Institution: -	Year: 2018
Document type: Article	Gear type: Standard gear	Location: Barents Sea
Objectives: To document the effects that buffer towing has on the quality of the whole fish as well as the fillet of the fish produced. Quality was measured by assessing gear marks, vitality, exsanguination, ecchymosis, skin abrasion, fillet gaping and fillet redness.		
increasing the probability of p by 209%. Furthermore, when	pound to have a clear negative e poor exsanguination by 307% in the results from all catch indefended cood from direct haul back was	and fillet redness occurrence exes were combined,

Title: Combination of a sortir	ng grid and a square mesh pand	el to optimize size selection
in the North-East Arctic cod	(Gadus morhua) and redfish (S	Sebastes spp.) trawl fisherie
Author(s): Sistiaga,	Institution: -	Year: 2018
Herrmann, Grimaldo,		
Larsen, Olsen, Brinkhof and Tatone		
Document type: Article	Gear type: Sorting grid and a square mesh panel	Location: Barents Sea
Objectives: To investigate the potential for a new sorting section comprised of a sorting grid and a square mesh panel to replace the standard grid section of the fishing sector. Selectivity was measured for cod and redfish. The new section was shorter and the sorting grid was installed upside down compared to the Sort- V section and the top panel was substituted by a square mesh panel. The steel grid was installed in the lower panel to act as the first sorting mechanism. Fish that respond to the grid with an avoidance response are guided upwards towards the second sorting device, the square mesh panel. In this sense, the new design combined the most commonly applied sorting devices in trawls into one system, where the second device is meant to sort at least part of those fish that avoid the first device		

Results: The grid in the new design was found to contribute to the largest proportion of fish release, while the release through the square mesh panel was low. However, the results showed that the grid was successful at guiding fish not escaping through the grid to a second selection process in the panel. However, the square mesh panel did not result in the intended release efficiency except for the smallest sizes of fish, most likely due to that the guiding angle of the grid and the square meshes in the panel used did not provide a suitable escape path for the desired size range of fish. Therefore, optimizing the mesh size/shape in the panel and/or the guiding angle for the grid potentially could led to the desired selectivity pattern in the new sorting section.

Title: Selectivity of Different Panels (RSEP)	Alternative Cod Ends and Ra	dial Square Mesh Escape
Author(s): Ceylan and Sahin	Institution: -	Year: 2018
Document type: Article	Gear type: Codend and radial square mesh escape panels	Location: Black Sea
•	ivity of five different codends els on red mullet as the target s	_
tested compared to the comm	yed for catches of red mullet watercial setup. A 40 mm square very high L50 values and none bycatch of bluefish.	mesh codend and a 50 mm
It was noted that future studie than that applied in this study	es should include escape panel	s that cover a greater area

Title: Using vertical distribution to separate fish from crustaceans in a mixed species trawl fishery		
Author(s): Karlsen, Krag, Herrmann and Lund	Institution: -	Year: 2019
Document type: Article	Gear type: bottom trawl	Location: Skagerrak

Objectives: A horizontally divided codend with small square meshes (40 mm) and a simple frame to stimulate fish to swim into the upper compartment was tested in order to separate Nephrops from bycatch species. The separator frame had two identical bars which were intended to stimulate fish to swim upwards while keeping the targeted Nephrops in the lower compartment. A length-based quantification of the species-specific separation efficiency was provided which enabled comparisons of the selectivity estimates with those made in other studies. Finally, length based diel differences in species separation was investigated in order to examine the influence of light intensity on the vertical distribution of the species.

Results: The majority of the fish were separated successfully from Nephrops, but their preference was uniform. Less than 10% of the Nephrops entered the upper compartment. Length- based analysis revealed three patterns of separation efficiency among nine commercial species: length-dependent separation and preference for the upper or lower compartments. The separation efficiency should be improved for small roundfish and flatfish. There was little diel effect on the separation efficiency. The preference of fish for a compartment, taking the relative height of that compartment into account, was established for this and similar previous studies in order to enable comparison of these results.

Title: Catch Efficiency of Groundgears in a Bottom Trawl Fishery: A Case Study of the		
Barents Sea Haddock		
Author(s): Larsen, Herrmann, Brinkhof, Grimaldo, Sistiaga and Tatone	Institution: -	Year: 2018
Document type: Article	Gear type: Rockhopper groundgear and Semicircular spreading gear groundgear	Location: Barents Sea
Objectives: The catch efficiency was assessed for the semicircular spreading gear (SCSG) compared to the standard rockhopper gear used by the industry. Catches of haddock were compared between the two gears using a retainer bag attached behind the footrope of both trawls. These comparisons were made during nocturnal and diurnal periods for haddock.		
compared to the standard geal between 4.5 and 12.3%. This gear of more than 70%. For the low as 76%, which correspond for the rockhopper gear between the could be detected to occur when commercial implementation.	proved the catch efficiency of ar. The degree of variation in it was equivalent in a reduction he rockhopper gear, catch efficiended with previous findings. A een day and night experiments hen the SCSG was used. The Son due to its optimized efficient to the rockhopper gear, as we	in escapement below the ciencies were found to be as and differences were found s, while no such difference SCSG also has good potential acy for fuel consumption as it

Title: Sequential codend improves quality of trawl- caught cod		
Author(s): Brinkhof, Olsen, Ingólfsson, Herrmann and Larsen	Institution: -	Year: 2018
Document type: Article	Gear type:	Location: Barents Sea
conventional codend compare differences as well as function the two different codends. Ca	e extent of catch damage on co ed to a new sequential codend nality differences were analys the damage was analysed bas sure injuries and skin abrasion	design. These catch damage sed and quantified between ed on poor exsanguination,
catch damages for 96.4% of fitimes fewer instances of catch codend had a 14%–32% increase.	rement on cod quality using the entional codend used in the infish caught, while using the send damage. Furthermore, cod cleased probability of obtaining njuries', depending on the dar	ndustry was found to led to equential design led to five eaught in the sequential score 0 for all damage

Title: Catch and release patterns for target and bycatch species in the Northeast Atlantic			
deep-water shrimp fishery: Effect of using a sieve panel and a Nordmøre grid			
Author(s): Larsen, Herrmann, Sistiaga, Brinkhof and Santos	Institution: -	Year: 2018	
Document type: Article	Gear type:	Location: Barents Sea	
Objectives: To test a sieve panel design as an alternative to using the Nordmøre grid to mitigate bycatch of fish in the Norwegian trawl fishery targeting deep-water shrimp. The sieve panel installed in front of the Nordmøre grid as an additional sorting device was also explored. The sieve panel was installed at a low angle (ca. 9°) in the extension piece to encourage fish to swim towards the escape opening without making physical contact with the net. Effectiveness of the selection was also examined.			
Results: The bycatch reduction patterns differed significantly between the two devices and a more efficient bycatch reduction was obtained by combining them. However, while the loss of commercial-sized shrimp was only between 0 and 2% for the Nordmøre grid, it was between 37 and 56% for the tested sieve panel, making this completely unacceptable for commercial fishing			

Title: Catch quality and size s	selectivity in the Barents Sea l	oottom trawl fishery: effect
of codend design and trawling	g practice	
Author(s): Brinkhof	Institution: UiT	Year: 2019
Document type: Article	Gear type: Bottom trawl	Location: Barents Sea
Objectives: To present the results of an investigation into the effects of buffer towing or the quality of the catch as well as a catch comparison method to present the impact of this fishing practice on size selectivity.  Secondly, the thesis presents the potential applications of a new device named the 'dual sequential codend, in the gadoid bottom trawl fishery as an approach for improving catch quality. The size selectivity of this new device is also investigated.		
to have a significantly negative technique is used also was for were used (Brinkhof et al., 20). The new sequential codend comore flawless cod than when 2019). This design enabled mimpede its consideration for i	oncept greatly improved cod of	quality, leading to five times ed (Brinkhof et al., 2018b, cod however this should not a quality that could be

Title: Predicting optimal combinations of by-catch reduction devices in trawl gears: A meta-analytical approach		
Author(s): Melli, Herrmann, Karlsen, Feekings and Krag	Institution: -	Year: 2019
Document type: Article	Gear type: Bycatch reduction devices	Location: Skagerrak and Kattegat Sea

Objectives: To predict the selectivity of 100 bycatch reduction devices tested in the Skagerrak and Kattegak seas in the Nephrops fishery in previous studies, to select against cod and haddock, that could not otherwise be tested experimentally due to practical limitations. This was in order to identify combinations that show significant promise for improving selectivity based on different catch compositions and quota available to fishermen. Bycatch reduction device combinations were compared in terms of absolute selectivity and performance under realistic catch scenarios, under both single and multispecies scenarios.

Results: The meta-analytical approach used worked sufficiently for utilizing existing knowledge in order to led to new insights. 15 potential combinations were identified for future investigation experimentally. The methodology determines whether the addition of any device and the associated complexity added to the gear has sufficient reduction of unwanted catches associated to it. The selectivity achieved is also not bound to the standard S-shaped curvature, and thus can be adapted to suit goals held by fisheries managers. This cost – effective approach to planning future studies could be applied to any well studied fishery implementing bycatch reduction devices. The findings must be followed up in experimentally however in order to determine any interactions between gear types as the approach assumes that each device operates independently.

coving cod end on size selective	rity and catch patterns of cod	
Institution: -	Year: 2019	
Gear type: Quality improving codend	Location: Barents Sea	
Objectives: To quantify and compare the size selectivity and catch pattern for cod of the standard codend with the dual-sequential codend described by Brinkhof et al. (2018). This was found to provide improved catch quality however concerns were raised regarding its selectivity. This new codend retains cod in an anterior section of the codend during towing and upon haul back a posterior codend section is opened using a hydrostatic codend releaser. This section is made entirely of small meshes therefore no escapement happens after fish enter this compartment. Since the anterior codend is identical to that used for a conventional codend, selectivity should be unaffected during fishing with the new gear. However, if selectivity of the conventional gear continues also during haul back, the fine meshed posterior section used in the new design would impact overall selectivity, leading to an increased total amount of undersized fish retained in the catch.		
Results: Size selectivity between the conventional and quality-improving codends differed significantly during the sea trials with the conventional codend releasing significantly more small cod, however when compared to the total selectivity this difference was found to be minor. As no significant difference in the catch pattern could be found between the two designs, the new quality improving codend may be used in the industry with low risk of retaining small cod.		
	Gear type: Quality improving codend compare the size selectivity an I-sequential codend described proved catch quality however new codend retains cod in an on haul back a posterior coder This section is made entirely on enter this compartment. Since the enter this compartment is employed to the conventional codend, selectivity of the conventional posterior section used ding to an increased total amount of the conventional codend, selectivity of the conventional codend posterior section used ding to an increased total amount of the conventional codend posterior section used ding to an increased total amount of the conventional codend posterior section used to the conventional and quality in the conventional codend posterior section used to the conventional and quality in the conventional codend posterior section used to the conventional and quality in the conventional codend posterior section used to the conventional and quality in the conventional codend posterior section used to the conventional codend posterior posterior section used to the conventional codend posterior posteri	

Title: Comparing size selectivity of traditional and knotless diamond-mesh codends in the Iceland redfish ( <i>Sebastes</i> spp.) fishery		
Author(s): Cheng, Einarsson, Bayse, Herrman and Winger	Institution: -	Year: 2019
Document type: Article	Gear type: traditional and knotless diamond mesh codends	Location: Iceland
perimental four-panel ultra-ci	ffectivity of a traditional two- ross knotless mesh codend. The suring selectivity of redfish (Se	is was done using the
lengths greater than 29 cm for for smaller length classes could both codends demonstrated a but also had a high retention was low however due to few and have similar morphologie combined was analysed, resulbut a large increase in actual	ence in size selectivity was seen as a norvegicus and 19 cm for all not be reliable due to small high retention ratio above the below MRL. The actual proposmall fish caught. Since these es, the size selectivity of the two lines in similar results of no discatches below MRL, primarily improve the size selectivity or	S. viviparous. Conclusions catches. For S. norvegicus, minimum reference length rtion of catch below MRL fish are difficult to tell apart vo codends for both species fference in size selectivity, S. viviparous. In general,

Title: External damage to trawl-caught northeast arctic cod ( <i>Gadus morhua</i> ): Effect of codend design		
Author(s): Tveit, Sistiaga, Herrmann and Brinkhof	Institution: -	Year: 2019
Document type: Article	Gear type: knotless codend, 4-panel codend,	Location: Barents Sea

Objectives: to investigate the extent of external damage (gear marks, pressure injuries, ecchymosis and skin abrasion) present on trawl-caught cod and to examine whether the extent of damage could be reduced by introducing changes in the gear. The effect on damage by changing the 2-panel knotted codend used by the Norwegian trawler fleet to a 2-panel knotless codend or a 4-panel knotless codend was measured.

Results: the probability for cod to be without any external damage was 9.4% (4.7%–15.8%) with the codend used in the fishery today. Thus, most fish in these catches are likely to have slight or moderate damage. Gear marks were the most frequent type of damage, with only 11.5% (6.0%–18.9%) of the cod being free of this type of injury. When gear marks were not considered in the analysis, 68.4% (58.8%–78.3%) of the fish was estimated to be flawless. Replacing the knotted netting in the codend increased the probability of obtaining fish without gear marks to 15.5% (6.2%–28.0%). However, the confidence intervals were wide, and this effect was not statistically significant. For the other three damage types, the estimated effects of changing the design of the codend were small and not statistically significant. Changing from a 2- to 4-panel codend was estimated to reduce the probability for gear marks by a further 1.7% (–13.4%–16.8%). However, this increase was not significant. Overall, the two codend design changes tested in this study did not significantly decrease the external damage present on trawl-caught cod.

1.

Title: Size selectivity and length-dependent escape behaviour of haddock in a sorting device combining a grid and a square mesh panel		
Author(s): Herrmann, Sistiaga, Grimaldo, Larsen, Olsen, Brinkhof, Tatone	Institution: -	Year: 2019
Document type: Article	Gear type: Sorting grid and square mesh panel	Location: Barents Sea
gadoid fishery. In the new system square mesh panel (144.3 mm section. The new grid configuto guide additional bycatch to haddock only, and a new mood differences in escape behavior	ting grid system based on the stem however, the grid was installed in the top panel aration was aimed to act simulo the panel for size selection. Stelling approach was implement for different length classes. It scaping individuals from the panel for the	stalled upside down and a el of the four-panel grid taneously as a lifting panel electivity was measured for nted which accounted for The covered gear method
Results: The new model applied was able to describe escapement better compared to previous models. Specifically, the results showed that the likelihood for smaller haddock to seek escape through the grid and the square mesh panel was higher than that for bigger haddock that would still have managed to escape through the devices if they had attempted to.		

Title: Effect of three different the Barents Sea shrimp trawl	codend designs on the size se fishery	electivity of juvenile cod in
Author(s): Herrmann, Sistiaga, Larsen and Brinkhof	Institution: -	Year: 2019
Document type: Article	Gear type: square mesh panel, sorting cone	Location: Barents Sea
standard gear used in the Bard square mesh panels (inserted	elective performance of three of ents Sea deap water shrimp fis towards the aft which covered a square mesh sorting cone sec infiguration.	hery, a codend with 35 mm the base panel and half of
Results: The diamond mesh codend worked as expected, producing the signature bell shaped selectivity curve and retaining small cod most frequently between the sizes of 12 and 20 cm. The two other configurations tested did not led to significant changes to selectivity compared to the standard gear used in the industry.		

Title: Can a large-mesh sieve panel replace or supplement the Nordmøre grid for bycatch mitigation in the northeast Atlantic deep-water shrimp fishery?		
Author(s): Jacques, Herrmann, Larsen, Sistiaga, Brčić, Gokce and Brinkhof	Institution: -	Year: 2019
Document type: Article	Gear type: Sieve panel	Location: Barents Sea
shrimp of the Nordmøre grid	e size selectivity of redfish, po combined with four sieve pand and inclination angle (10 and	el configurations differing in
Results: The sieve panels were unable to replace the Nordmøre grid as a stand-alone device due to increased catches of the bycatch species. However, combining the two devices provided promising results. Specifically, when a large-mesh sieve panel was placed in front of the Nordmøre grid, 20–40% fewer small redfish and polar cod in a specific size range entered the codend, while the loss of targeted shrimp was less than 5%.		

Title: Relative size selectivity of a four-panel codend with short lastridge ropes compared to a flexigrid with a regular codend in the Barents Sea gadoid trawl fishery		
Author(s): Ingólfsson and Brinkhof	Institution: -	Year: 2020
Document type: Article	Gear type: Shortened lastridge ropes, 4-panel codend, dynamic catch control system	Location: Barents Sea
Objectives: To test the efficiency of a new codend fitted with 30% shortened lastridge ropes, a dynamic catch control system (for regulating the catch quantity) as well as a 4-panel 153 mm mesh size codend. This was compared with the conventionally used 130 mm mesh size, 2-panel, flexigrid configuration and selectivity of cod, haddock and saithe was quantified.		
saithe individuals below the 179–92) respectively, which, i	nd significantly reduced the cam MLS by 90 (ci = 85–94), 92 (cf used instead, would improve approximately half of the fish being this new design.	i = 88–96) and 86 % (ci = the selectivity measured by

Title: Stimulating release of u otter trawl fishery	ındersized fish through a squa	re mesh panel in the Basque
Author(s): Cuende, Arregi, Herrmann, Sistiaga, Onandia	Institution: -	Year: 2020
Document type: Article	Gear type: Rope, floats and LED stimulation, Square mesh panel	Location: North Atlantic
tested; 1. No stimulation 2. Stimulation based on 3. Stimulation based on 4. Stimulation based on Hake, horse mackerel and bluanalysed. The trawl was built	ropes and floats LED lights  le whiting selectivity using the in a four-panel configuration, or panel of the extension piece.	ese configurations was , with the square mesh panel
selectivity, however floats ha stimulation led to increased re	hanisms tested had no effect of d a significant effect for blue etention. In general, the addition, and this was confirmed by	whiting escape. While LED onal release contributed by

Title: Size selectivity and catch efficiency of bottom trawl with a double sorting grid
and diamond mesh codend in the North-east Atlantic gadoid fishery

Author(s): Brinkhof, Larsen, Herrmann, Sistiaga	Institution: -	Year: 2020
Document type: Article	Gear type: Flexigrid and conventional codend	Location: Barents Sea

Objectives: When the size selective performance of the flexigrid section was investigated previously by Sistiaga et al. (2016) it did not consider the size selectivity of the legal diamond mesh codend. Thus, an estimate of total size selective performance still lacked from the literature for this setup, including individual contributions by the flexigrid and the codend. The catch efficiency was measured for fish above and below the minimum reference limit (MRL) as well as for a new flexigrid compared to a used flexigrid with a lower grid angle.

This was demonstrated by supplementing size selectivity data with estimates of the actual catch efficiency of the gear, which was quantified using exploitation pattern indicators.

Results: Sistiaga et al. (2016) reported a large proportion of undersized cod and haddock not being released through the flexigrid which therefore passed into the codend. Results from the current study however indicate that almost all undersized cod and haddock that passed into the codend were subsequently released by the codend meshes. The contact probability for the second grid was significantly higher than that for the first grid. This also included large proportions of release of fish above the MRL, where the second grid was responsible for 70.6% of cod loss and 80.2% of haddock loss by the gear. For individuals below the MRL, the second grid was responsible for 56.2% of cod loss and 55.9% of the haddock that were lost from the gear.

*	selectivity for a gear designed a North-East Atlantic demersa	1 0
Author(s): Herrmann, Sistiaga, Larsen, Brinkhof, Gjøsund, Jacques and Santos	Institution: -	Year: 2020
Document type: Article	Gear type:	Location: Barents Sea
Objectives: To test the efficiency of a new gear configuration to optimize fish quality but to have selective properties atleast comparable to the standard gear used in the cod and haddock bottom trawl fishery. Cod, haddock and redfish catches were measured. The new gear was composed of a large mesh segment, a subsequent quality/welfare preserving segment identical to the one used by Brinkhof et al. (2018) but without any acoustic releaser. Because no sorting grid was used, the size selectivity of this gear configuration relied completely on the sorting characteristics of the large mesh segment. The motivation for testing this new configuration was a perception that a quality/welfare preserving segment made out of high solidity netting would cause a partial flow blockage and deflect a significant portion of the water flow out through the large meshes in front of the high solidity segment. The hypothesis was that most fish would be guided by the water flow towards the large meshes and be size selected by them, thereby preventing capture of undersized fish.		
Results: The new gear was not successful at maintaining the selective potential of the standard setup. More juvenile individuals were retained for all three species in the new gear. The size selectivity results suggest that the water flow directed towards the large mesh panel was probably not as significant as intended, and not substantial enough to stimulate the escape of any of the three species investigated through the large mesh segment.		

Title: Effect of gear design on catch damage on cod ( <i>Gadus morhua</i> ) in the Barents Sea demersal trawl fishery			
Author(s): Brinkhof, Herrmann, Sistiaga, Larsen, Jacques and Gjøsund	Institution: -	Year: 2021	
Document type: Article	Gear type: Compulsory grid and codend as well as a quality preserving codend design	Location: Barents Sea	

Objectives: To improve the catch quality and strain put on targeted catch in cod fisheries by replacing the grid section and standard codend by a knotless, large-meshed section and a quality preserving codend (identical to that used by Brinkhof et al., 2018). This gentle codend was not closed during fishing as in the case for Brinkhof et al. (2018). The rationale behind this design was for the gentle codend to produce a 'bucket effect' whereby the water would push more undersized fish out sideways before they enter the gentle codend section. Simultaneously, this codend was expected to improve catch quality due to the reduced water flow through the section, reducing stress and strain on the catch.

This study also investigated catch damage on cod when the compulsory grid and codend configuration of the fishery are used

Results: When the alternative design was used, the probability that cod would have no catch damage compared to when the standard gear was used, increased by 6%. The alternative gear also led to a significant reduction in severity of all catch damage categories assessed for cod compared to the standard gear.

All improvements in catch quality found in the alternative design compared to the standard design were lower than those achieved by Brinkhof et al. (2018) except for the category of scale loss. Thus, markings, ecchymosis and poor exsanguination could all be improved more when the quality preserving codend was closed during fishing, as done by Brinkhof et al. (2018).

Title: Bycatch reduction in the deep-water shrimp ( <i>Pandalus borealis</i> ) trawl fishery			
with a large mesh top panel			
Author(s): Cerbule, Jacques, Pettersen, Ingólfsson, Herrmann, Grimaldo, Larsen, Brinkhof, Sistiaga, Lilleng and Brčić	Institution: -	Year: 2021	
Document type: Article	Gear type: Large mesh top panel	Location: Barents Sea	
the last three sections (29.4 m while simultaneously not lead	y of a large 200 mm mesh size, a) of the tapered belly to reduce ding to additional loss of targe a was analysed, as well as deap ar method.	te the retention of bycatch t shrimp. Greenland halibut,	
reduced, while no effect was mesh panel led to the loss of this study illustrate how a sim	ad halibut and the smallest polar found for redfish. No indication deep-water shrimp, for all lenguage modification of a fishing without significant losses of the	on was given that the large gth classes. The results of gear can mitigate the bycatch	

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