UiT

THE ARCTIC UNIVERSITY OF NORWAY

ICES CIEM

ICES-FAO WGFTFB Symposium on Technology Development and Sustainable Fisheries

Mérida, Mexico, on 25-29 April 2016

Session 4: Technology and practice for managing bycatch and reducing discards

Effort to minimize unwanted by-catches in the North-East Atlantic trawl fisheries;

A brief review of 40 years' research and current status

Roger B Larsen,
The Arctic University of Norway UIT

27 April 2016

UNIVERSITY OF TROMSØ

Some important decisions for the North-East Atlantic (NEA) fisheries in order to mitigate the by-catch problems

11. April 1975: The Joint Norwegian–Russian Fisheries Commission was established

(The EU implement the new CFP 2015-2019; Discard ban and landing obligation)

1977: Quotas and TAC on important species NEA

1979: Pelagic trawling banned

1982: MLS increased for cod and haddock

1983: Codend mesh size for groundfish 135 mm

1983: By-catch rules for shrimp trawling

1984: Real time closures to protect juveniles

1984: By-catch reducing panels in shrimp trawls

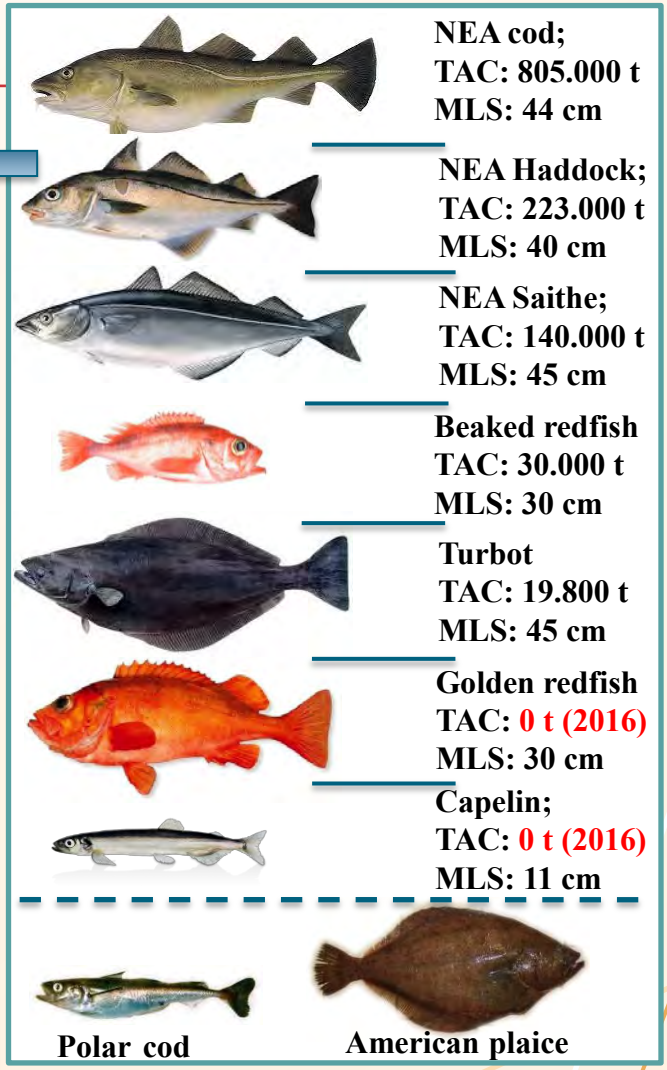
1991: The Nordmöre grid in shrimp-trawls (NOR)

1993: The Nordmøre grid in the (whole) NEA

1997: Sorting grid for groundfish trawls in NEA

2009: Landing obligation

Areas for bottom trawl fisheries in the North East Atlantic and along the coast north of N64º. The most important species (with TAC_{2016}) and two abundant non-target species.

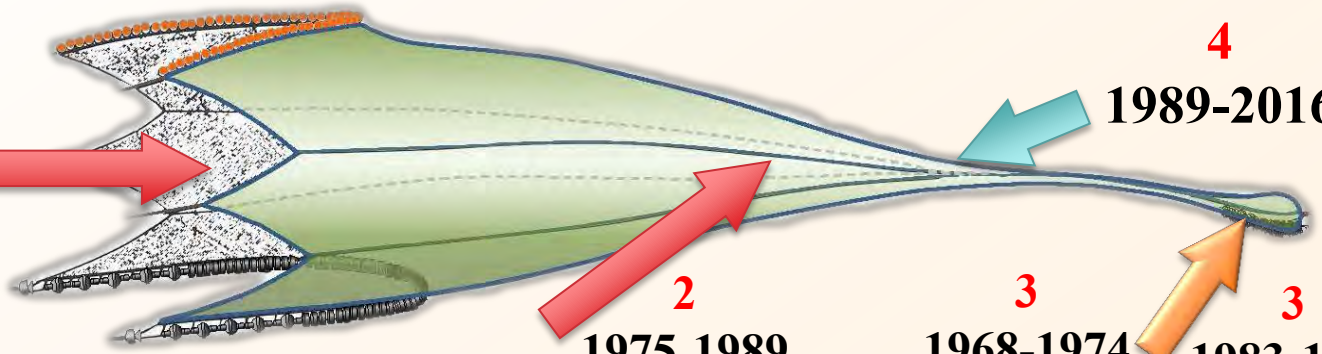


All images are copied from the internet

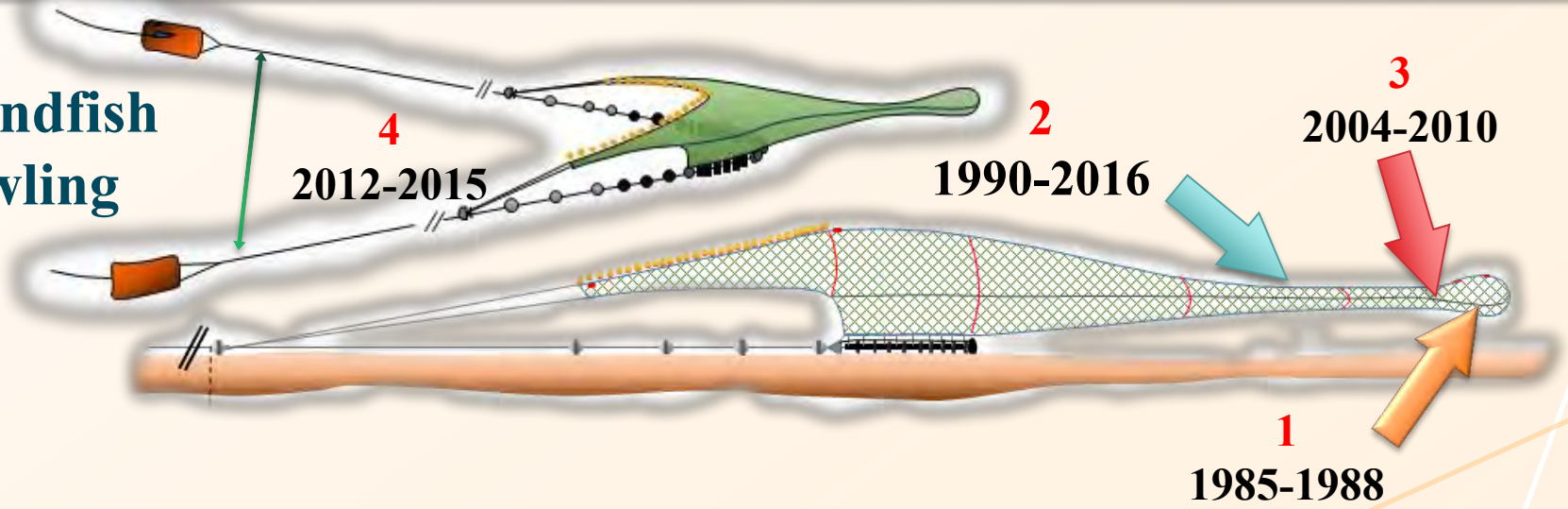
The Norwegian effort to mitigate by-catch problems in the bottom trawl fisheries of the North-East Atlantic

(Note: Over the next slides I will show extracts from the NEA research by the Norwegian part)

Shrimp trawling



Groundfish trawling



1968-1975: Codend mesh size experiments in shrimp trawls.

The minimum landings size was/is 15 mm carapace length = 70 mm body length.

Tore Thomassen & Øyvind Ulltang 1975. Report from mesh selection experiments on *Pandalus borealis* in Norwegian waters. ICES CM 1975/K:51

Trials with 4 different mesh sizes (30, 36, 40 and 41 mm) were made as alternate and covered codend hauls over several periods in different areas along the northern Norwegian coast.

1968-1971 selectivity experiments		
Year	Mesh size	$L_{50\%}$
1968	35	16 mm cpx
1969	40	19-21 mm cpx
1971	35	16.5 mm cpx

1974 selectivity experiments		
Mesh size	$L_{50\%}$	ca. SR
30	12.1-13.5 mm cpx	2.5 mm
36	15.5-16.1 mm cpx	5.5 mm
41	20.7 mm cpx	8.0 mm

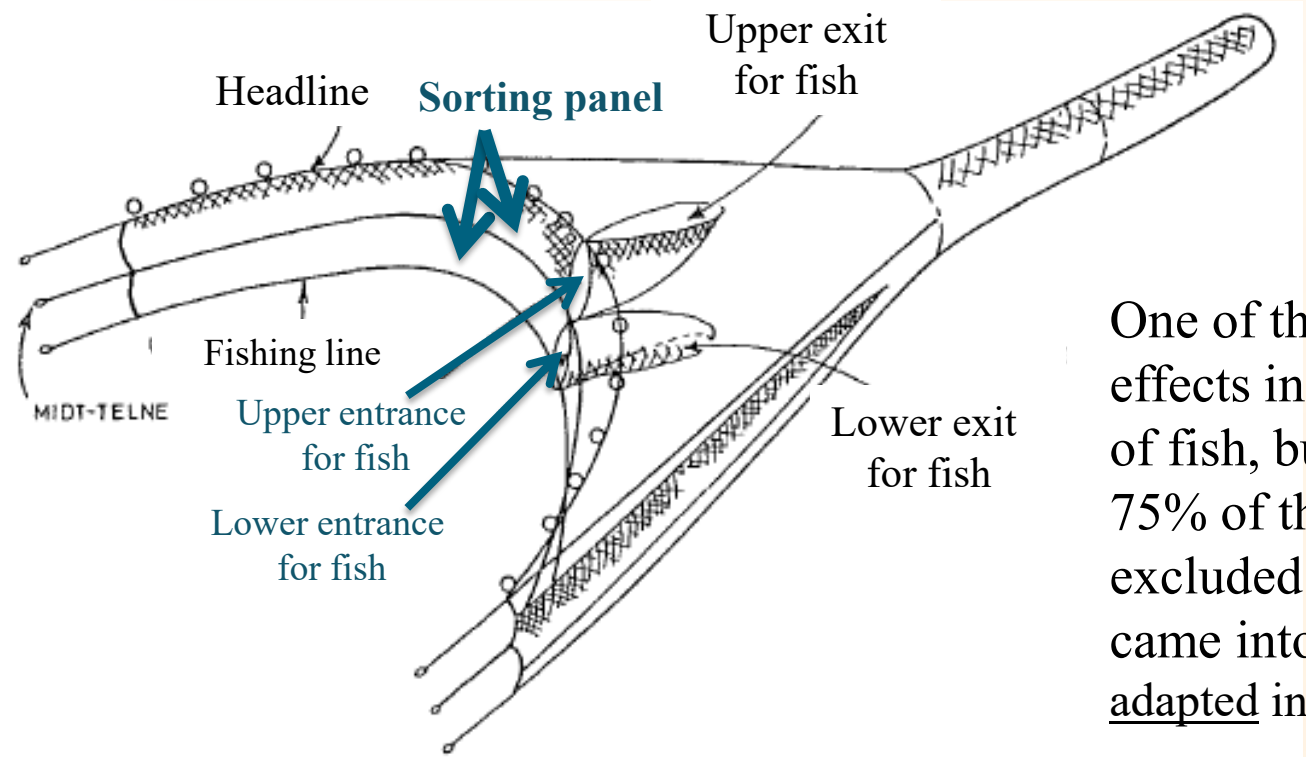
The report have no information on gear seat-up, twine thickness codend or cover designs, etc.

It was clear however that the preferred 35 mm mesh size was the size that fitted the industry better.

2016: Norwegian fishermen claim that the 35 mm mesh size is optimal despite trawls and operation have changed a lot over the last 45-50 years.

Period 1970-1974: The first by-catch reducing trawl to be tested in Norwegian waters was a modified version of the trawl tested by J.E. Juzkovich for the Pacific Northwest shrimp fishery (1969).

(**Birger Rasmussen and Per Øynes, 1974**. Experiments with shrimp trawl to reduce by-catch of fish and juvenile fish).



One of the versions gave good effects in reducing by-catches of fish, but between 30 and 75% of the shrimps were excluded. The system never came into practical use, i.e. not adapted in the fishery.

The Norwegian team by Dr. Birger Rasmussen (UIB) and Per Øynes & Albert Strøm (Directorate of Fisheries) made several test with various configurations of the trawl

Period 1975-1989: Various soft excluder panels were tested by the Institute of Fishery Technology Research Bergen (FTFI)*, i.e. Ludvig Karlsen, John W. Valdemarsen and Björnar Isaksen.

Ludvig Karlsen, 1976: Experiments with selective prawn trawls in Norway, ICES CM 1976/B:28

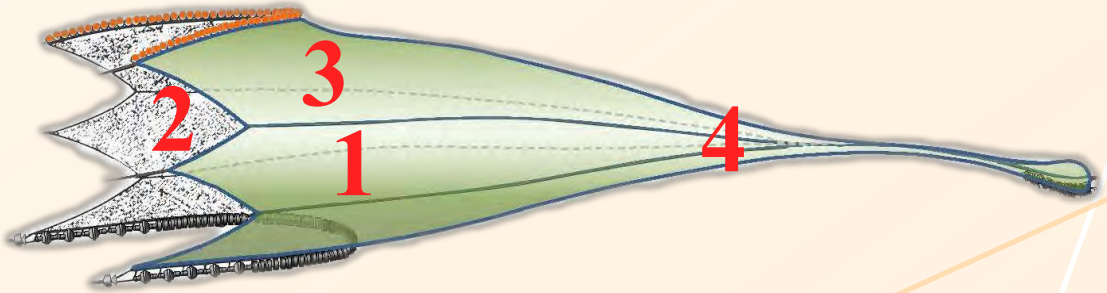
1) **Vertical side separator panels** covering 35 m^2 each side; 60 & 80 mm mesh size. Only 4-14% fish reduction.

2) **Vertical panel in the mouth** covering 60 m^2; 60 mm mesh size; Only 44% fish reduction and a dramatic reduction of shrimps, i.e. 39% by weight.

3) **Oblique separator panel in the mouth** covering ca. 60 m2; Only 50% fish reduction, but a very low fraction (3.4%) of shrimps were lost.

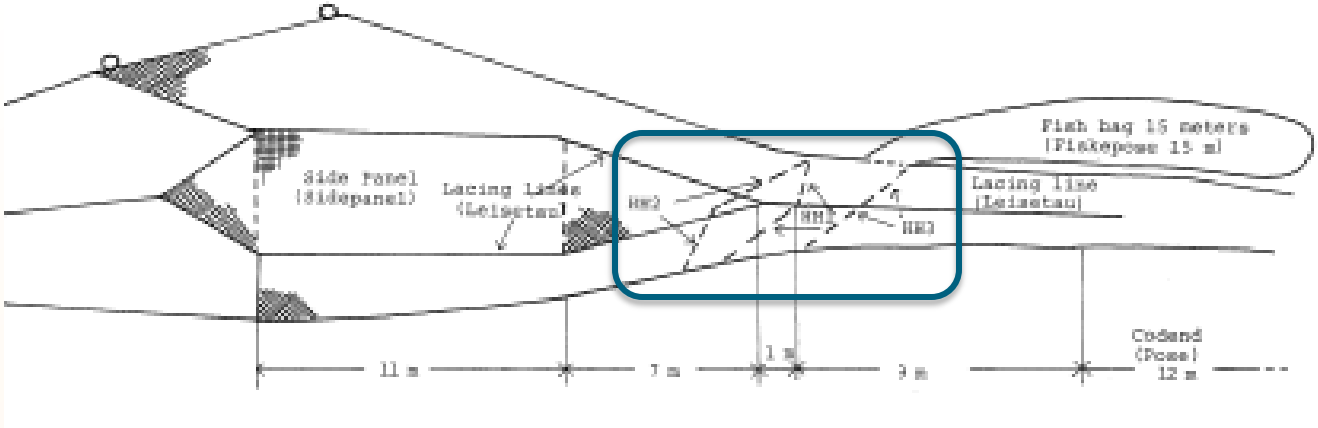
4) **The oblique HH separator panel in the aft** of the belly coving only 5.7m^2; 40-60 mm mesh size. Fish reduction up to 80-90% and reduction of shrimp 25-15%. See next slide.

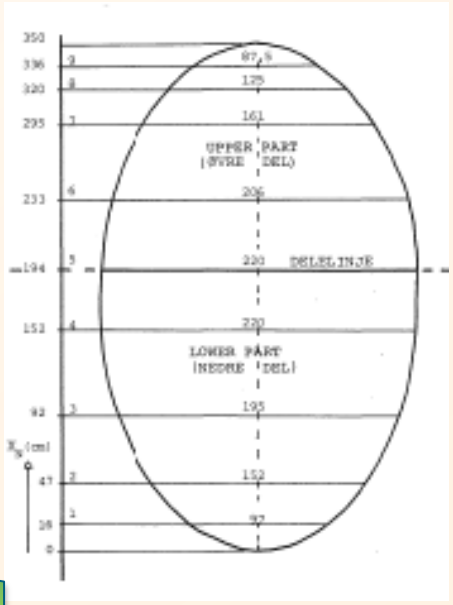
*FTFI merged with IMR in 1991

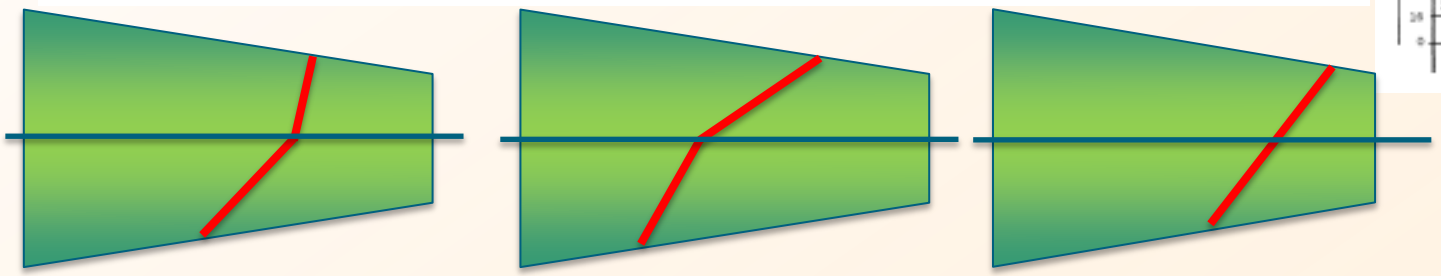


Period 1975-1976: The HH oblique mounted excluder panel in the aft belly of the trawl, ref. Ludvig Karlsen 1976.

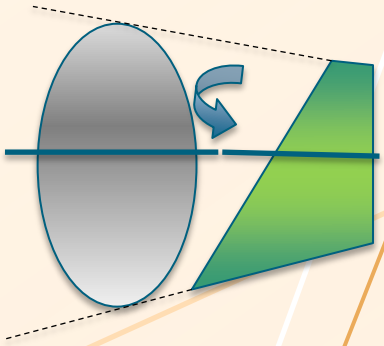
The HH3 (HH4) panel came into practical use (period 1983-1989)





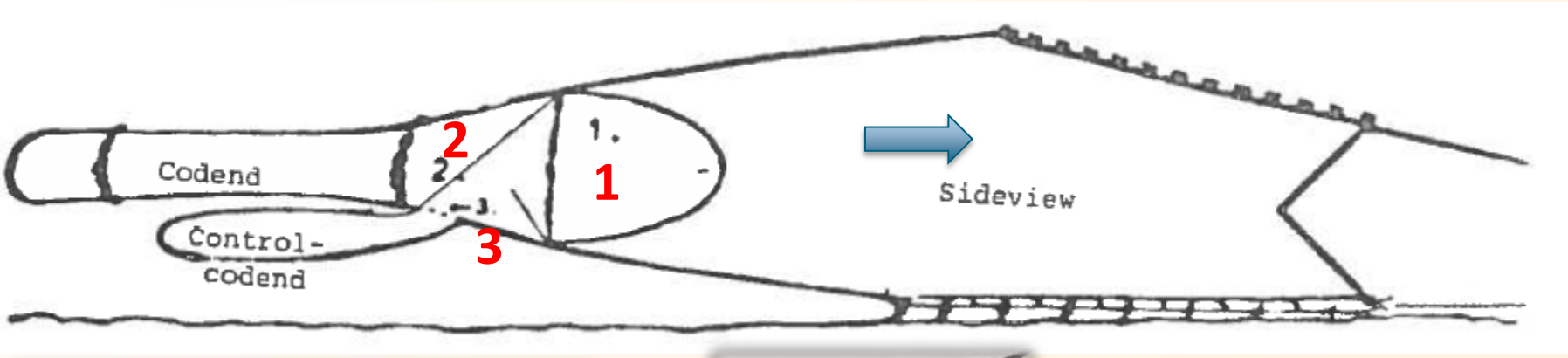


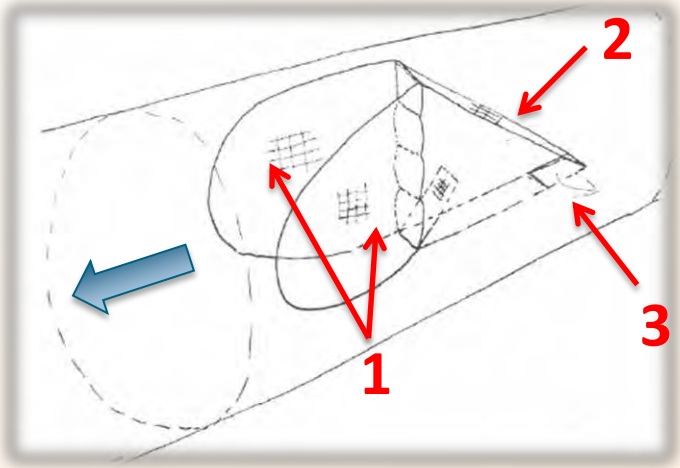
HH1 HH2 HH3

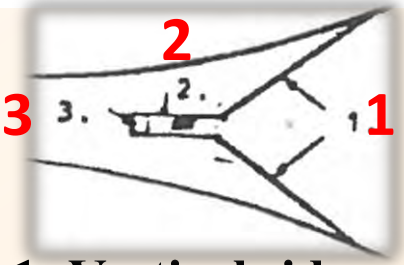


Period 1982-1983: Vertical side sorting panels tested by the Institute of Fishery Technology Research Bergen (FTFI)*,

Björnar Isaksen, 1983; Experiments with vertical side-sorting panels in Norwegian trawls 1982-1982. ICES, CM 1984/B:10.





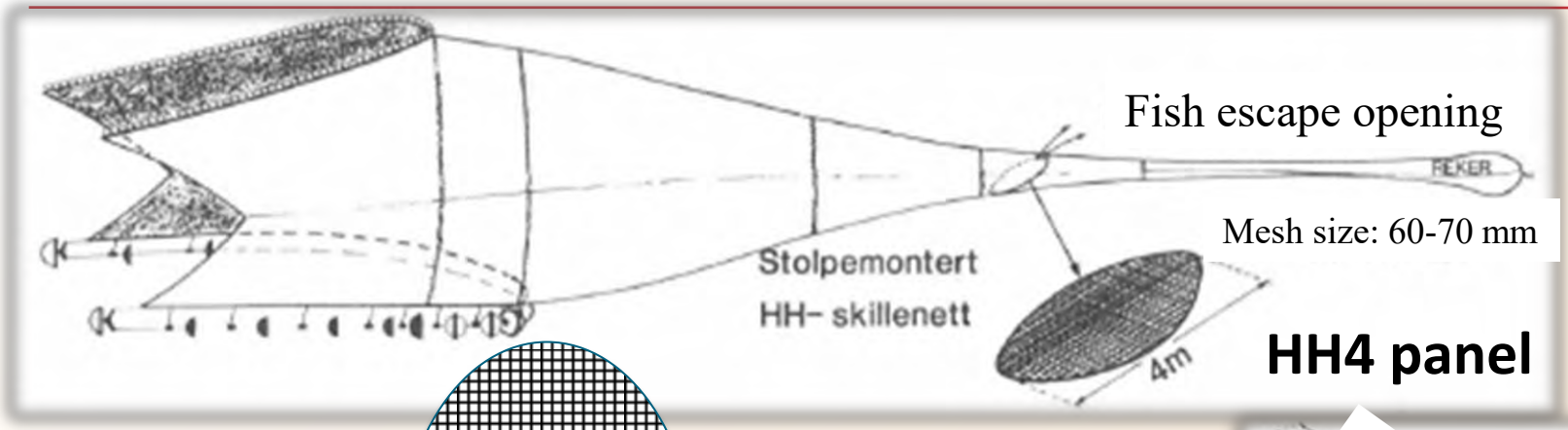


(from above)

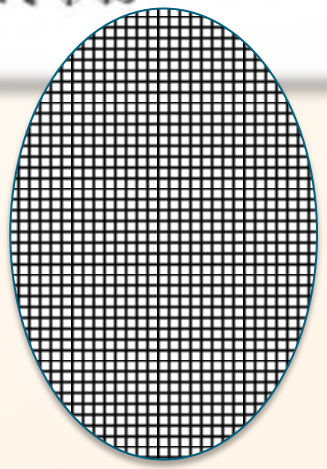
1: Vertical side-sorting panels (80 mm)
2: Oblique sorting panel (80 mm)
3: Fish escape opening

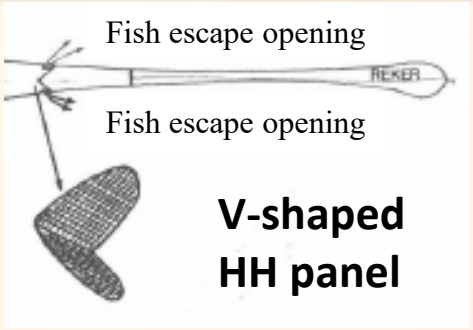
Up to 90 % fish reduction of fish > ca. 30 cm, but shrimp reduction was 11-19%.
The design was <u>not adapted</u> by the fishing industry.

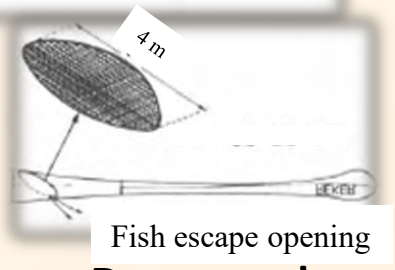
1983-1989: Several versions of the HH separator panel were tested. The model HH4 was compulsory in the northern shrimp fisheries during parts of the year in the period 1983-1989



Mesh size: 60–70 mm
Square mesh
Knotted net
PE or PA twine





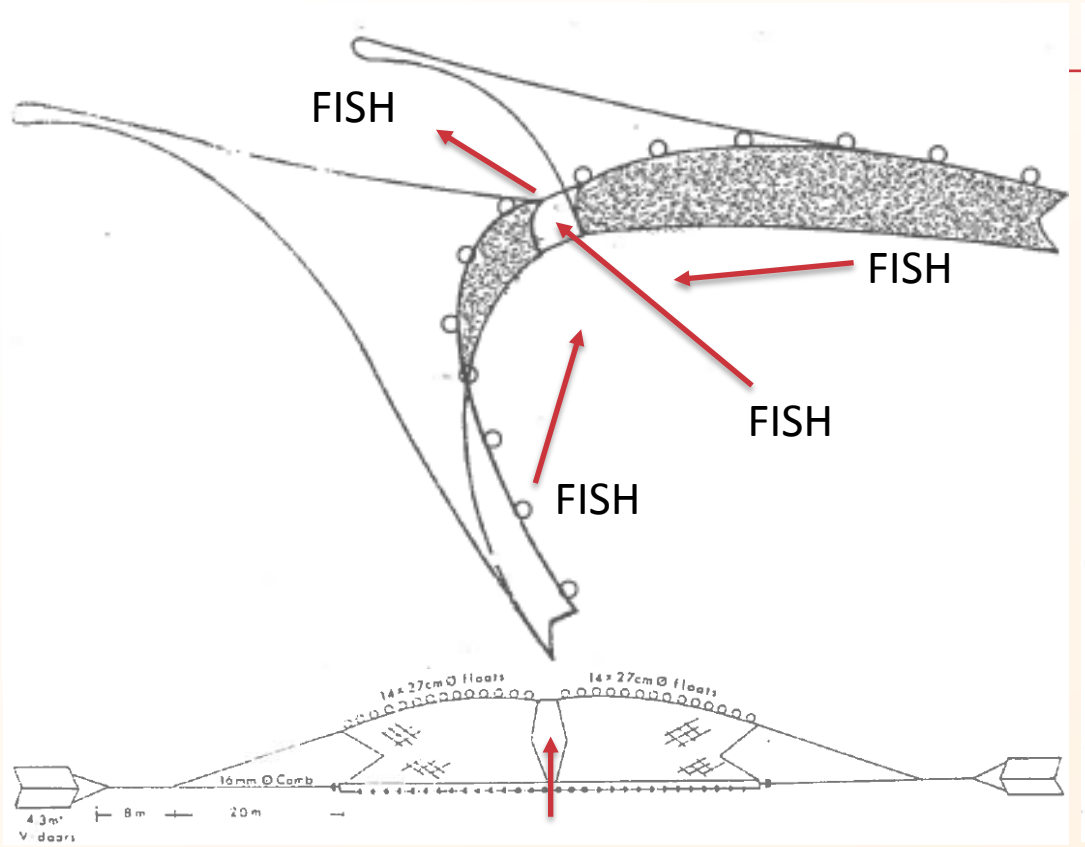


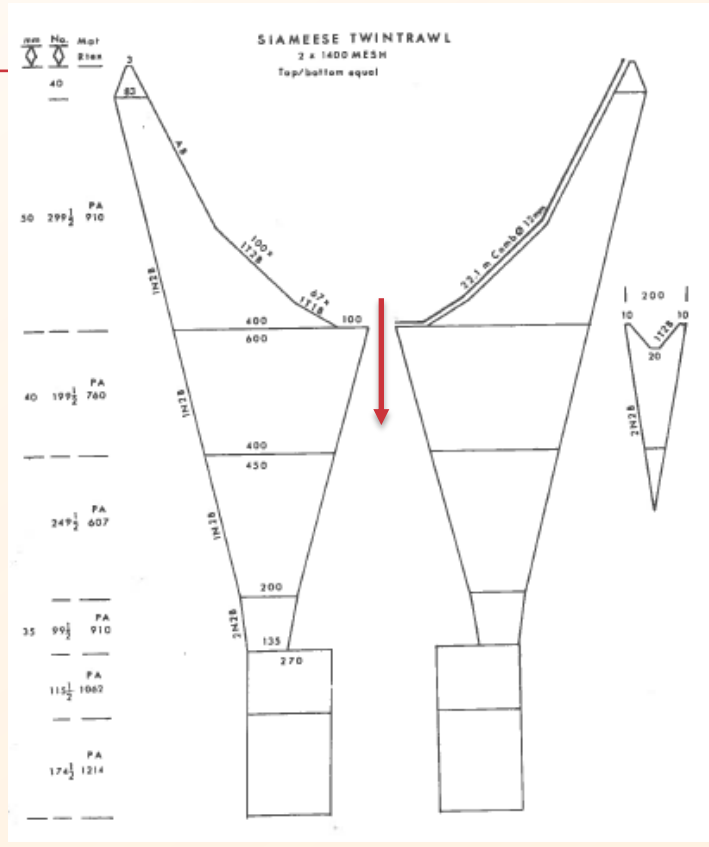
Roger B. Larsen 1986. Further experiments with sorting panels in shrimp trawls. Results from model testing in a flumetank and fishing trials in Varangerfjorden, Northern-Norway. ICES FTFB WG (Hull).

Ludvig Karlsen and Roger B. Larsen 1989. Progress in the selective trawl development in Norway. Proceedings of the World Symposium on Fishing gear and Fishing vessels, St. John's, Canada.

1984: The Siamese twin trawl – Fish excluder system (and test trawl)

J.W. Valdemarsen & B. Isaksen 1984: Siamese twin trawl developed in the Norwegian shrimp fishery. ICES CM 1992/B:37.

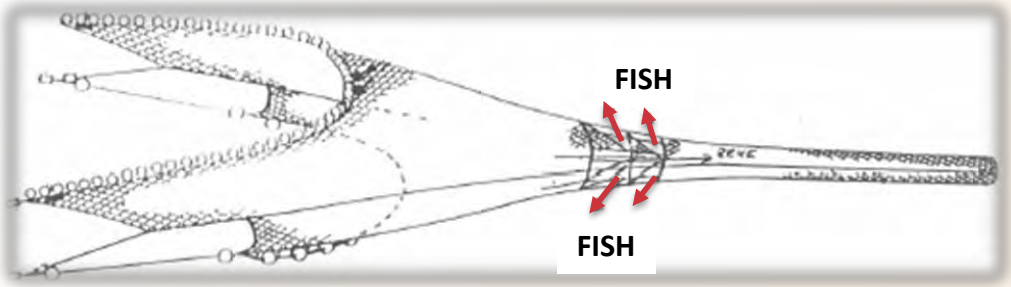


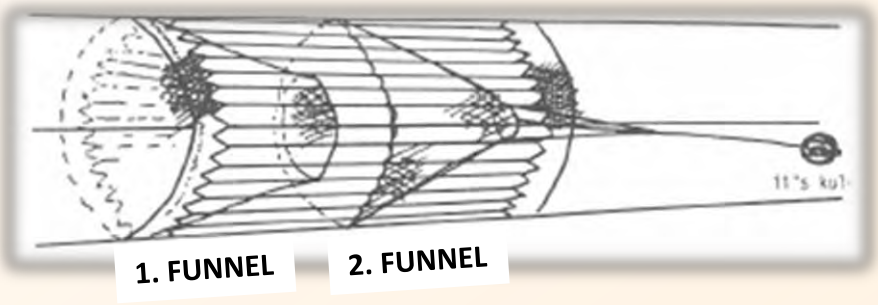


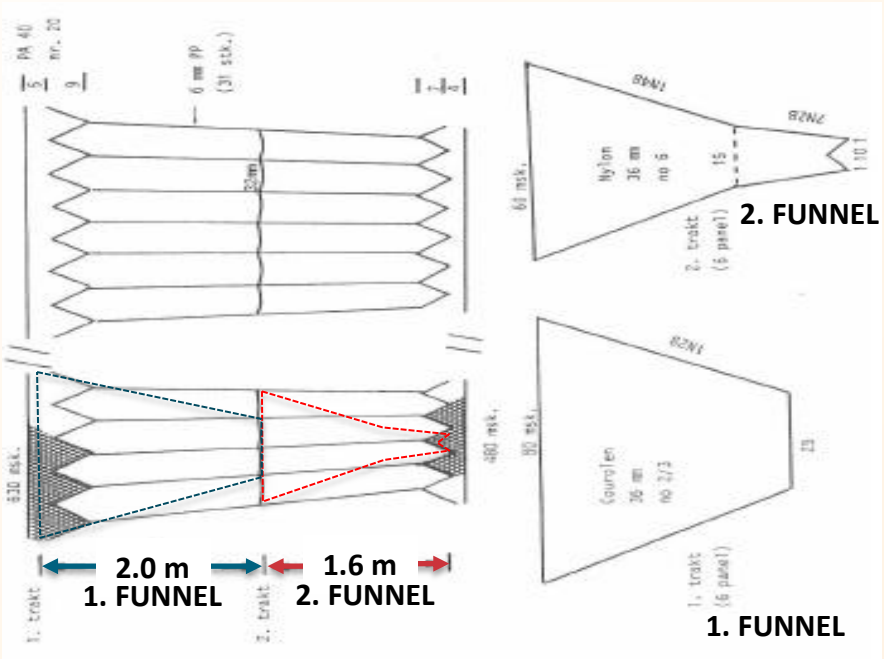
This design was <u>not adapted</u> by the fishing industry. Two comparative hauls showed that the Siamese trawl caught 12% less shrimps, 54% less haddock and 11% less cod during comparative fishing with a conventional shrimp trawl (1400# Sputnik) of similar size. (In one other experiment, the Siamese trawl caught 73% more shrimps than the Sputnik trawl).

1985: Funnel sorting section with rib-lines – a system to reduce bycatches of fish and undersized shrimps.

John W. Valdemarsen 1985: Funnel section – an alternative to reduce by-catch of fish and small shrimps in the shrimp fishery. Report , FTFI.







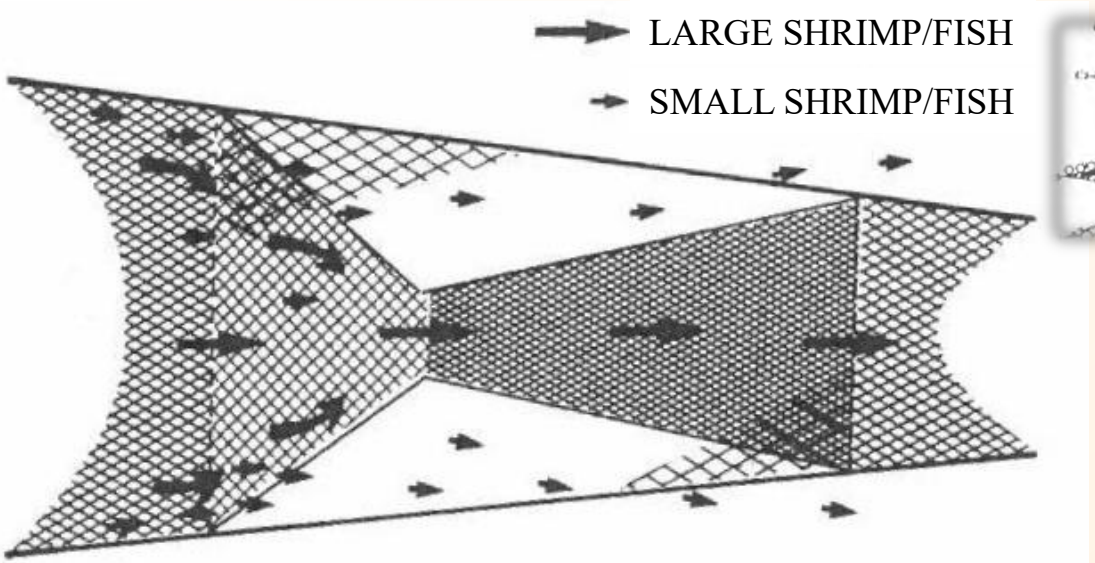
Fishing trials gave good results on haddock, while low proportions of cod and flounder escaped.

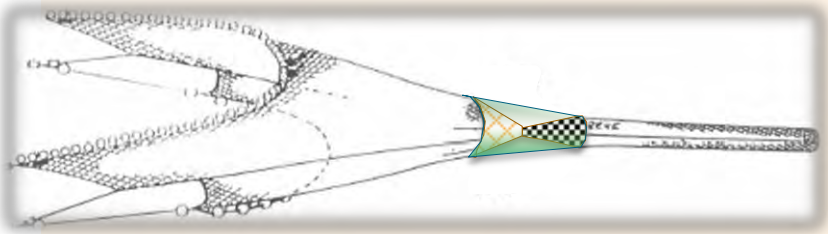
The section reduced shrimps <70 mm (full body length) by 67-30%.

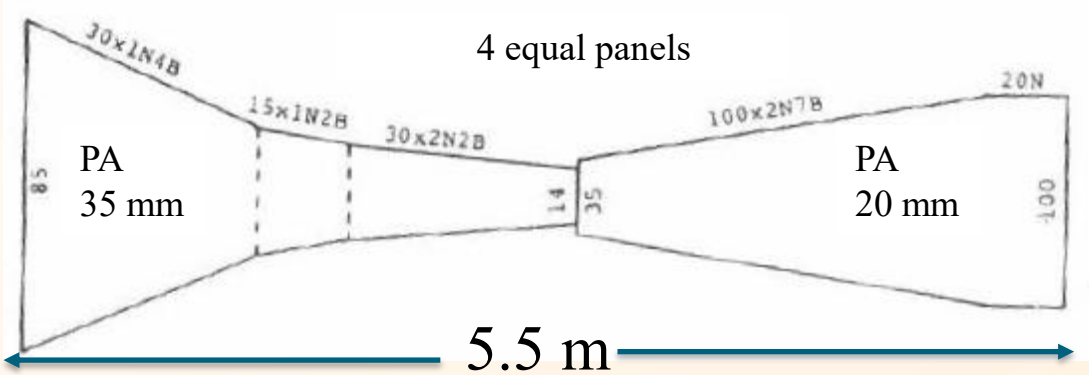
The system was <u>not adapted</u> by the fishing industry.

1984-1986: The Radial Escape Section (RES) – A system to reduce by-catches of shrimps below minimum landing size.

John W. Valdemarsen 1986: Radial escape section (RES) as sorting device in shrimp trawl. FAO expert consultation on selective shrimp trawl development. Mazatlán Mexico, 1986





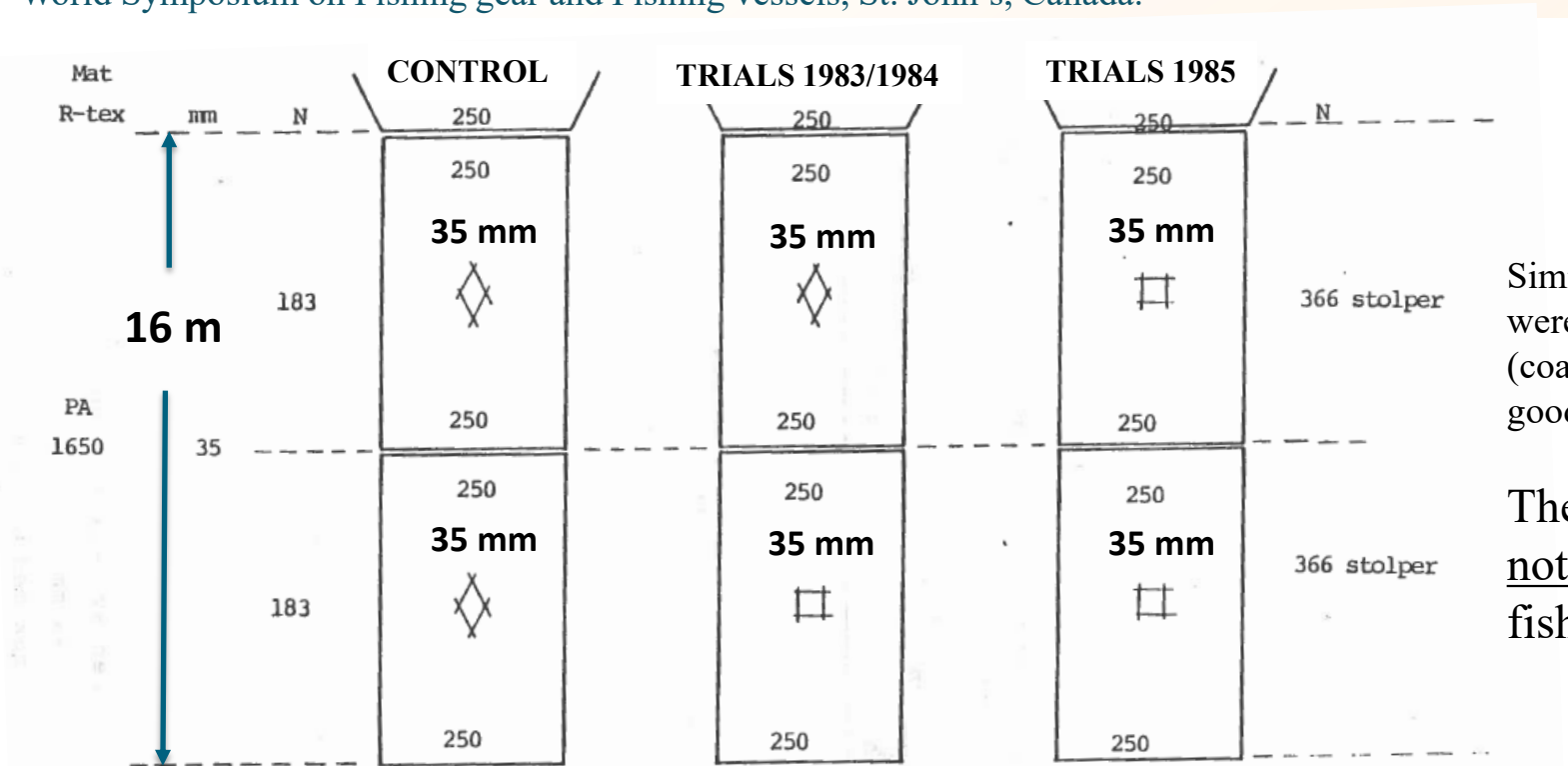


This system reduced the catch of shrimp below minimum landing size (70 mm total length) by 80%, but some marketable sizes were excluded.

The system was not adapted by the fishing industry.

1983-1985: Codend square mesh trials in deep sea shrimp trawls

Ludvig Karlsen 1986. Fishing experiments with square mesh codends in Norwegian shrimp trawls. ICES WG Meeting, Hull.
Ludvig Karlsen and Roger B. Larsen 1989. Progress in the selective trawl development in Norway. Proceedings of the World Symposium on Fishing gear and Fishing vessels, St. John's, Canada.



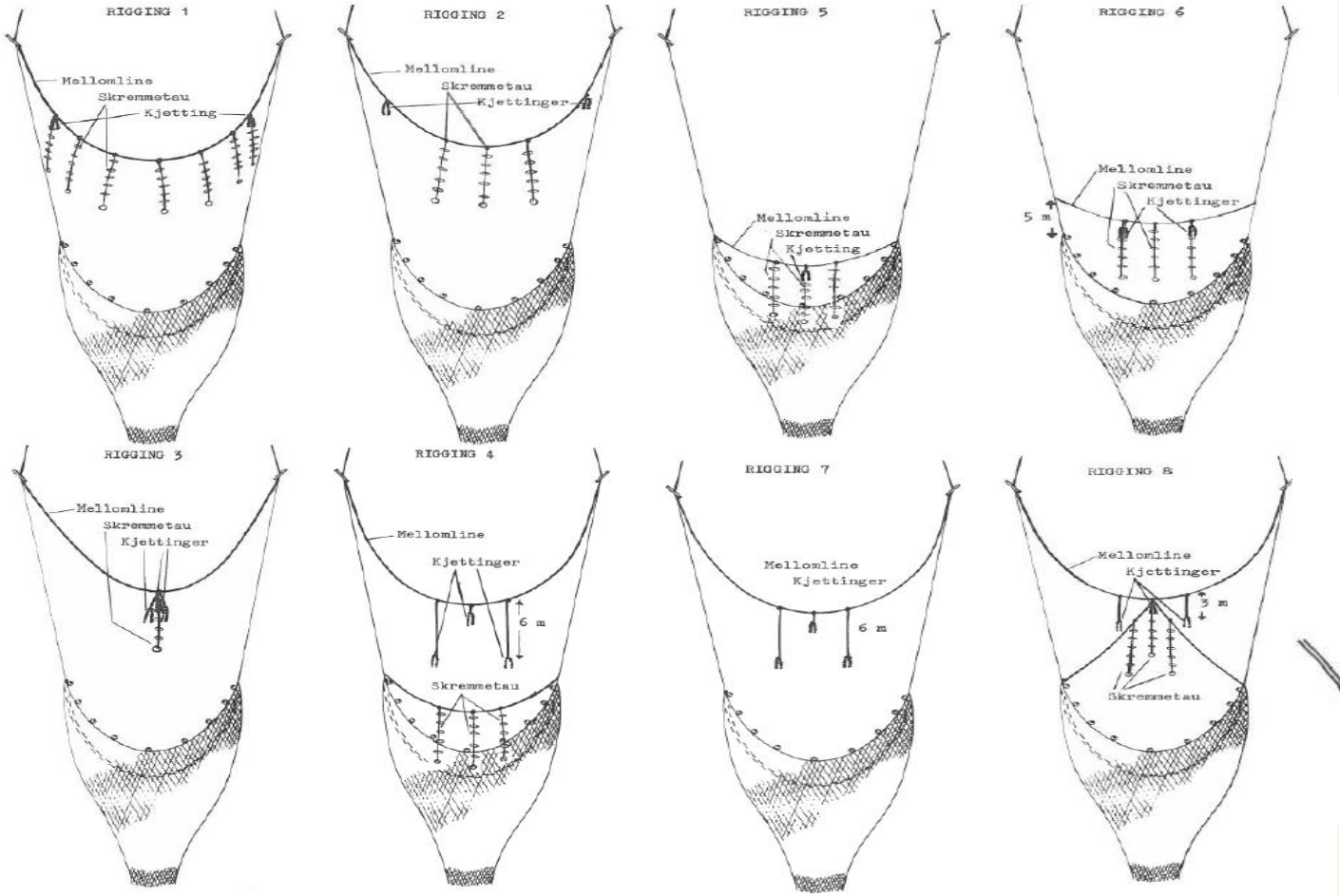
Similar configuration were tested in th inshore (coastal) fisheries with good results.

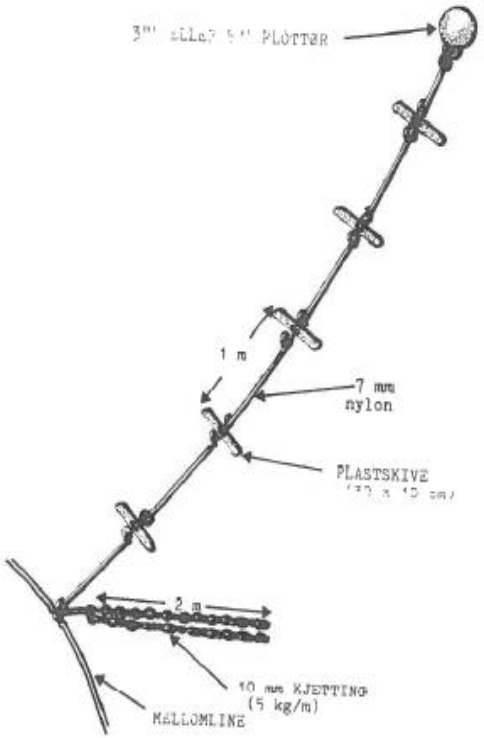
The system was <u>not adapted</u> in the fisheries.

Deap sea, Svalbard area: These trials were made in combination with the HH4 sorting panel. Three 16 m long codends, i.e. 35 mm diamond and square mesh configurations, were tested during experiments in 1983-1985. Square mesh excluded 51-90% of shrimps below MLS compared to the diamond mesh, but too many marketable shrimps were lost. The square mesh codend gave a considerable reduction in by-catch of small fish, i.e. polar cod (8-15 cm) between 79-90% and snake blenny (10-25 cm) between 87-97%.

1985: Various «stimulators» in inshore shrimp trawls in an attempt to reduce by-catches of fish.

Roger B. Larsen, 1985. Experiments with various arrangements in the mouth of a shrimp trawl. Cruise report.





A mix of visual and audible stimulators were tested, but the effects were unclear. Would white light work?

"The Nordmöre-grid team" from NTNU, IMR and UIT: We wrote more than 60 reports and conference contributions on by-catch excluders in shrimp trawls, but managed only 1 co-authored publication:

Isaksen, B., Valdemarsen, J.W., Larsen, R.B. & Karlsen, L. 1992. Reduction of fish by- catch in shrimp trawl using a rigid separator grid in the aft belly. Fish. Res., 13: 335-352

We joined forces with our Russian colleagues at PINRO, had inter-Nordic workshops & research projects and we shared our knowledge with DFO Canada and many others.

<u>The 1989-1992 focus</u>: Implementation of the Nordmöre grid in inshore and deep sea shrimp fisheries.

Ludvig Karlsen (1987 & 2015)

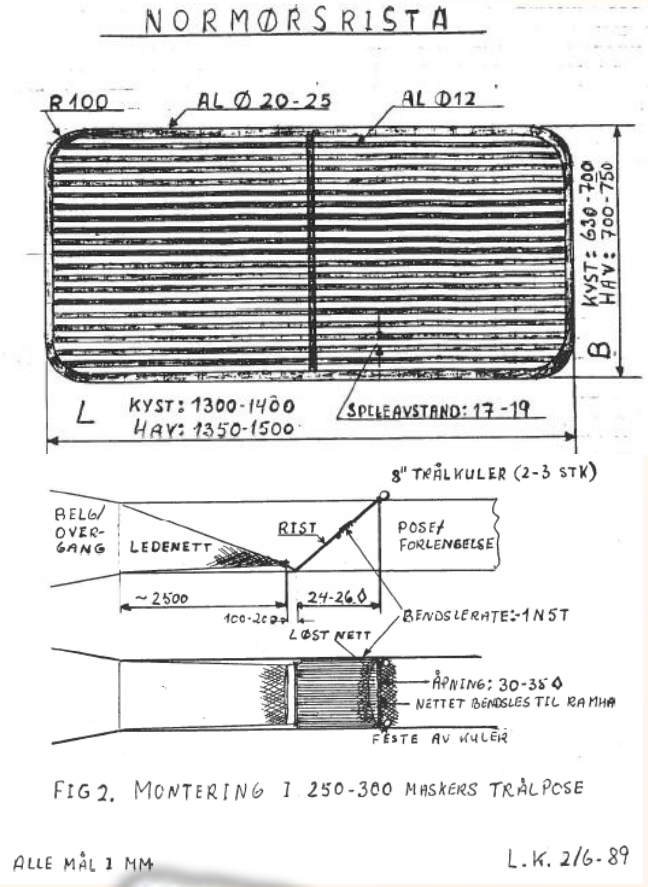
John W Valdemarsen (1986)

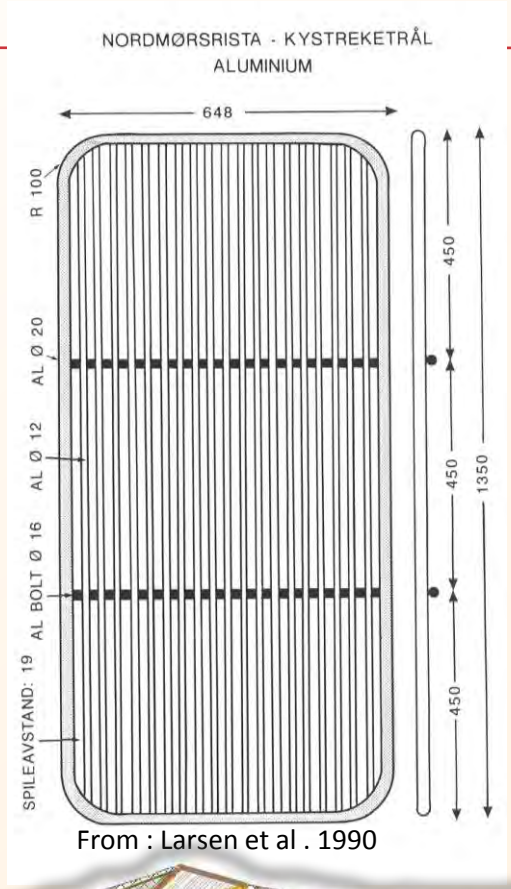
Bjørnar Isaksen (1989)

Roger B Larsen (1991)

The original construction of the Nordmöre grid was based on an idea by fisherman Paul Brattøy (Nordmöre district, mid-Norway).

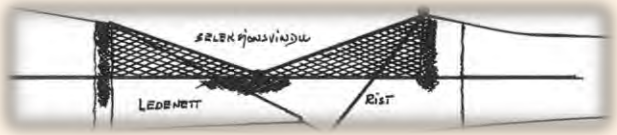
Ludvig Karlsen made us a handmade sketch…..

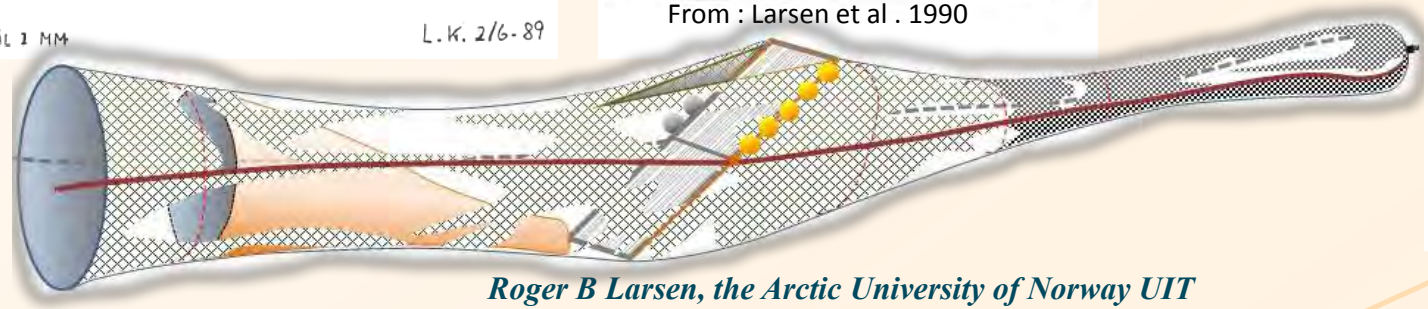


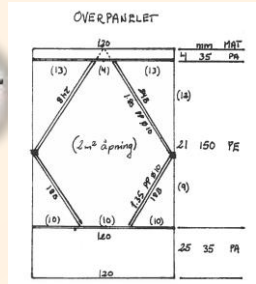


From : Larsen et al . 1990

I still use the original 1989 model of the Nordmöre grid during various student cruises



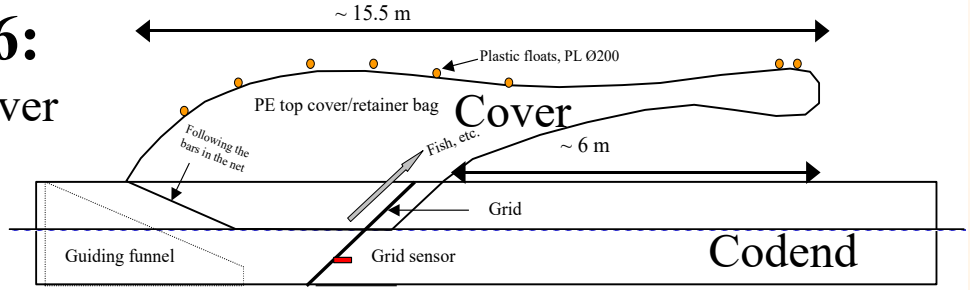




Selectivity experiments 1989-2016:

In most trials we used a fine-meshed retainer cover to document the effect of the Nordmöre grid.

Below: Typical images from the North-East Atlantic shrimp fisheries



Turbot and cod

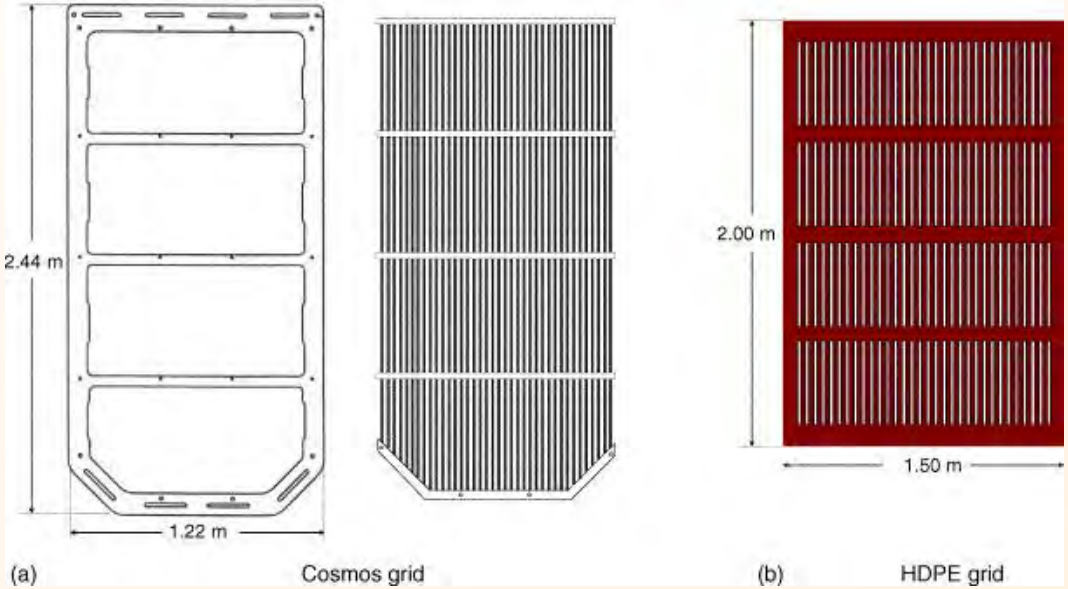
Haddock and saithe

Shrimps and various non-commercial species

Cod and haddock

1989-2005: We made numerous experiments to compare grid shapes, materials and bar distances. Stainless steel is still the material being preferred in the northern fisheries.

Larsen, R.B, Grimaldo, E., Vollstad, J., Jensvoll, T. & Bertelsen, B. 2003: Comparison between two types of Nordmøre grids made from plastics in the Shrimp fishery along Svalbard. Report, University of Tromsö.



The HDPE grids are more or less out of the Norwegian shrimp fishery.
A few vessels use the PA/Fibre glass version, some smaller boats stay with aluminium grids and the majority use stainless steel grid.

Selectivity experiments 1989-2016: Many shrimp grounds in the Arctic are home for Greenland sharks (*Somniosus microcephalus*)*. Since the introduction of the Nordmöre grid the incidental catch of them by shrimp trawls ceased.

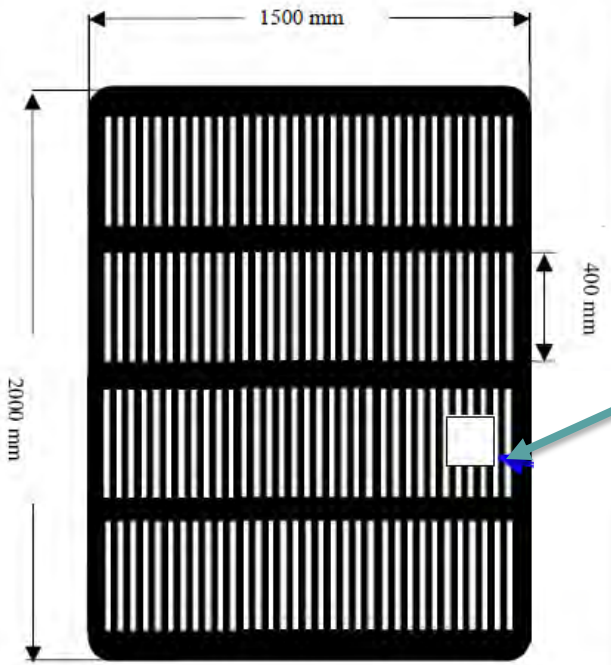
***The Greenland shark** can grow to 7 m and weigh up to 1400 kg (and reach an age of 300+ years).

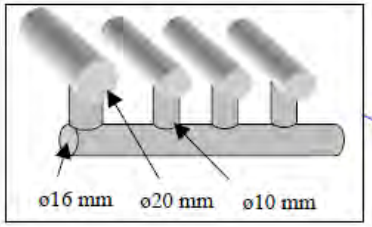
Fishermen soon discovered that the use of a Nordmöre grid reduced sorting time on board and improved the quality of the catches

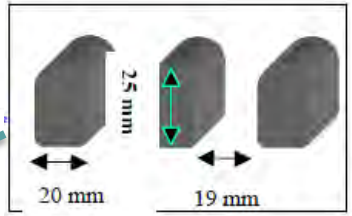
The Nordmöre grid 1990-2000. Shapes and materials tested and used:

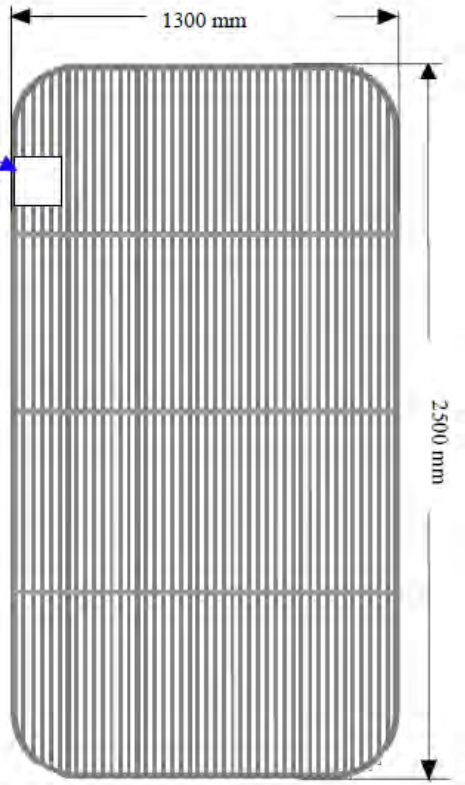
Rectangular, elliptical and circular shapes & materials aluminium, stainless steel, HDPE plastics, PA plastics, fibreglass, composite materials.

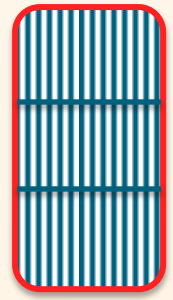
Roger B. Larsen, 1996. Experiments with a new, larger type of fish/shrimp separator grid with comparisons to the standard Nordmöre grid. ICES FTFB W.G.

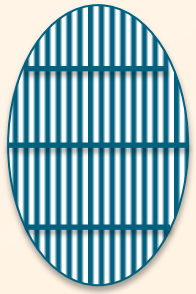


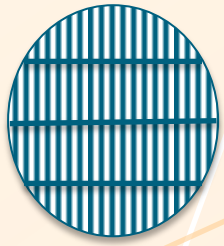










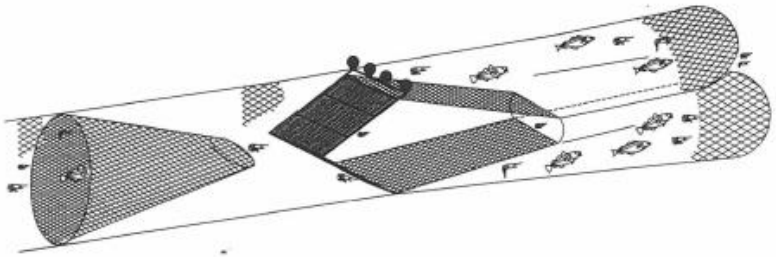


A Canadian produced (Nordsea Ltd) 19 mm HDPE grid (2.0x1.5 m)

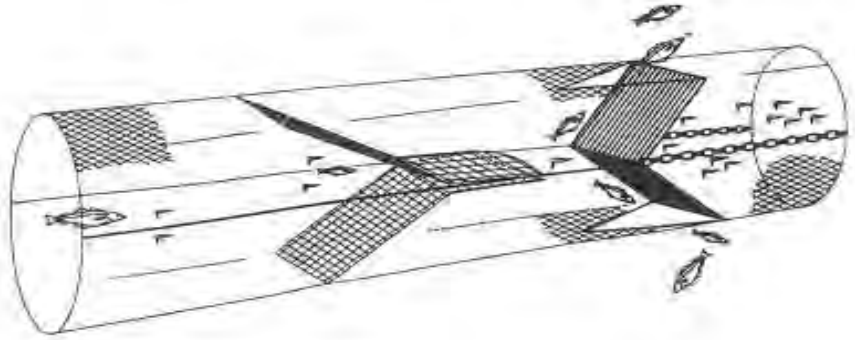
The most popular deep sea grid, a Norwegian produced 19 mm steel grid (1.3x2.5 m).

1991-1992: Inter-Nordic project on «Selectivity in the Shrimp Fishery»

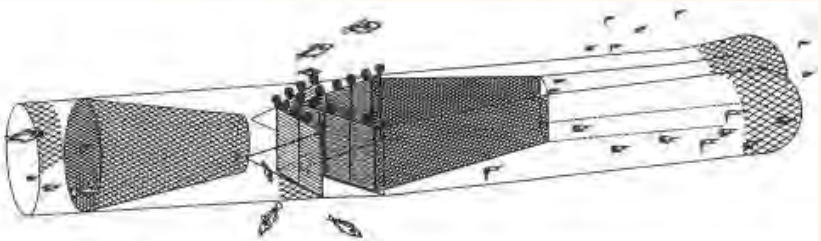
John W. Valdemarsen 1993: Selectivity in the Shrimp Fishery. Report to RCN, project 1701-2100.061.



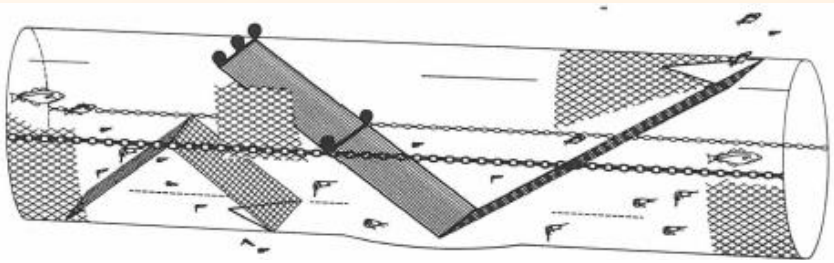
V-shaped grid for shrimp size selectivity



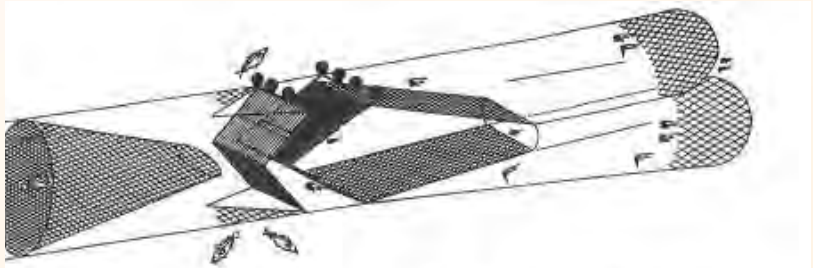
V-shaped grid for fish reduction



Double V-shaped grids for shrimp and fish selectivity



Grid system for shrimp size selectivity

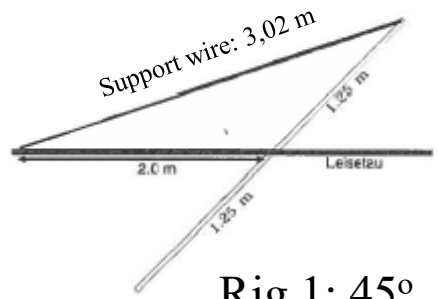


Double V-shaped grids for shrimp and fish size selectivity

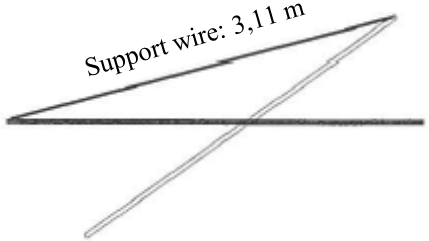
None of these systems were adapted by the fishing industry or management. The results were comparable to results obtained with the standard Nordmöre grid.

1995: A 2.5 m long Nordmöre grid proved to give good by-catch reduction, especially at low angles.

E. Maurstad and R.B. Larsen 1995: Experiments with a new, larger Nordmöre grid in deep sea shrimp trawl. Report.

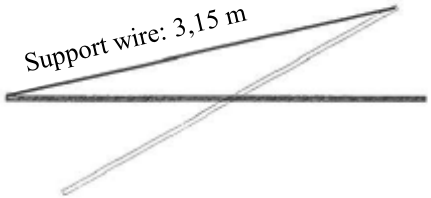


Rig 1: 45°

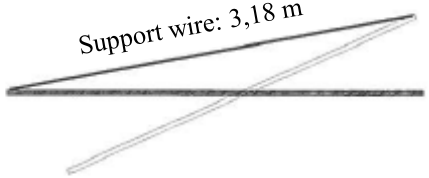


Rig 1: 40°

Rigging 1

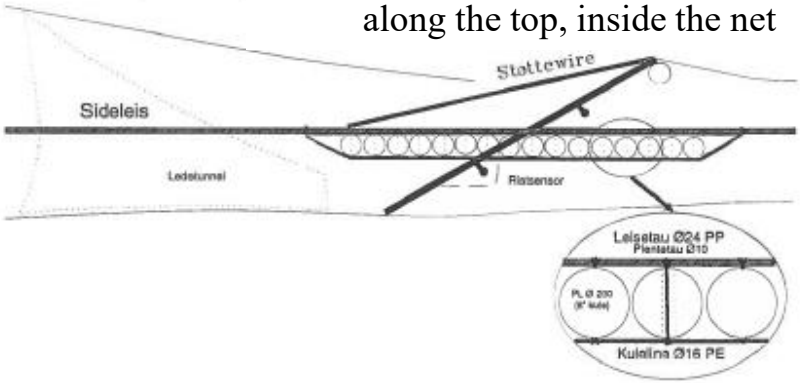


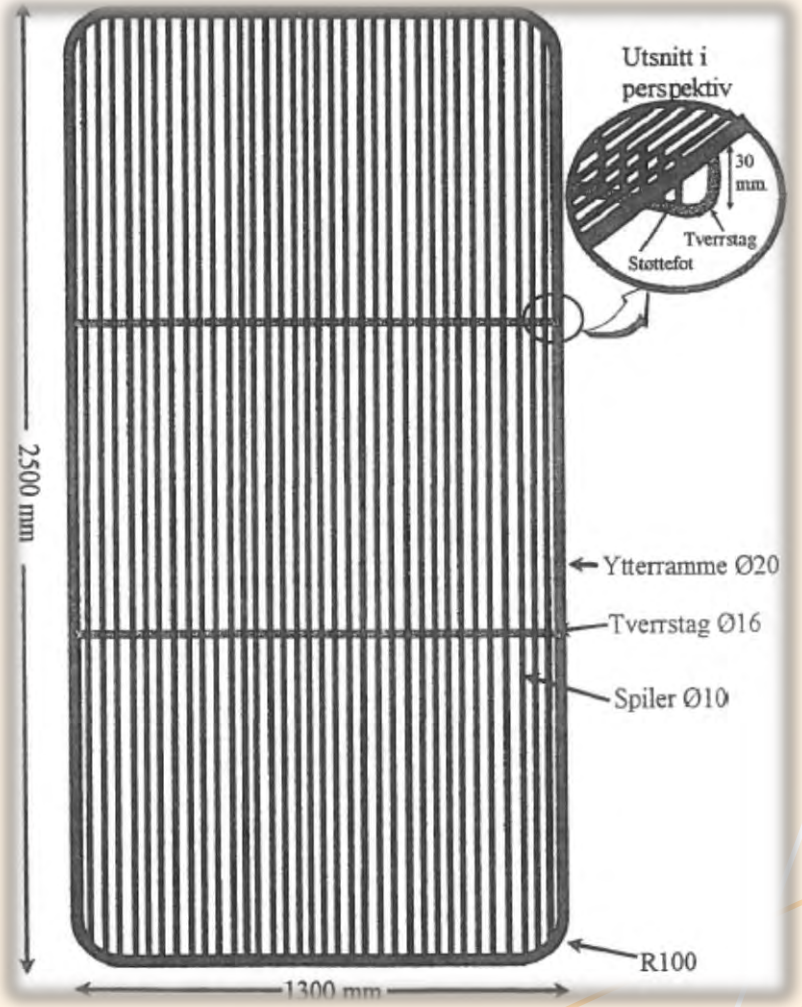
Rig 3: 30°



Rig 4: 25°

2x16 floats (Ø200) along sides + 6 floats along the top, inside the net



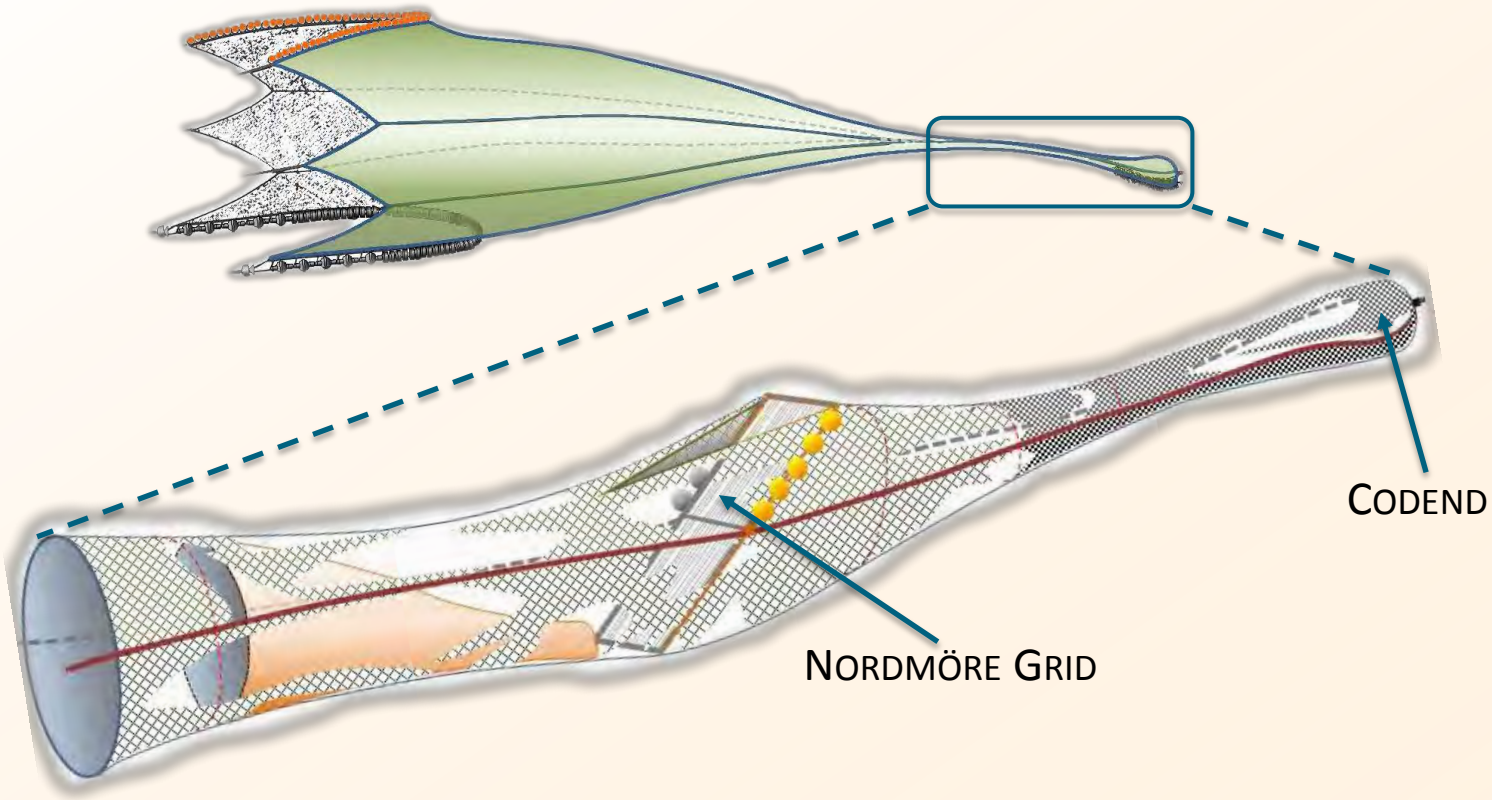


Nordmöre grid experiments since 1989: In Norway we have spent many hundred days at sea in order to improve the effect of the Nordmöre grid and to seek alternative sorting techniques. By-catch excluder grids have been tested on a large variety of international fishing vessels, research vessels, the full vessel size and engine power range, a number of trawl sizes, single trawl systems to triple systems, …….

- Various grid designs; rectangular, square, oval. Rectangular being used.
- Various materials; aluminium, steel, HDPE, fibre glass PA. PA, ST and AL being used.
- Various bar-distance: 16-17-**19**-20-21 mm. Low bar-distance improves by-catch reduction.
- Various grid-angles (45-35-30-25 degrees). Low angel improves by-catch reduction on fish.
- Various designs of funnel in front of the grid. Flapper or funnel. Both being used.
- Various distances between grid and funnel. Distance > 50 cm improves by-catch reduction.
- Large mesh panel in the grid section. No clear results.
- No net in the upper section in front of the grid. Fish escape easier, no clear results.
- Exit windows in the side-panels of the grid section. Few fish escape, no clear results.
- Second grid for removing undersized fish and shrimps. Grid is easily clogged.
- LED lights along the fishing line. No clear results on fish, but loss of shrimps.
- Exit holes behind the NM grid. No effect on fish, some loss of shrimps.
- By-catch excluders in 4-panel sections. Data to be analysed.

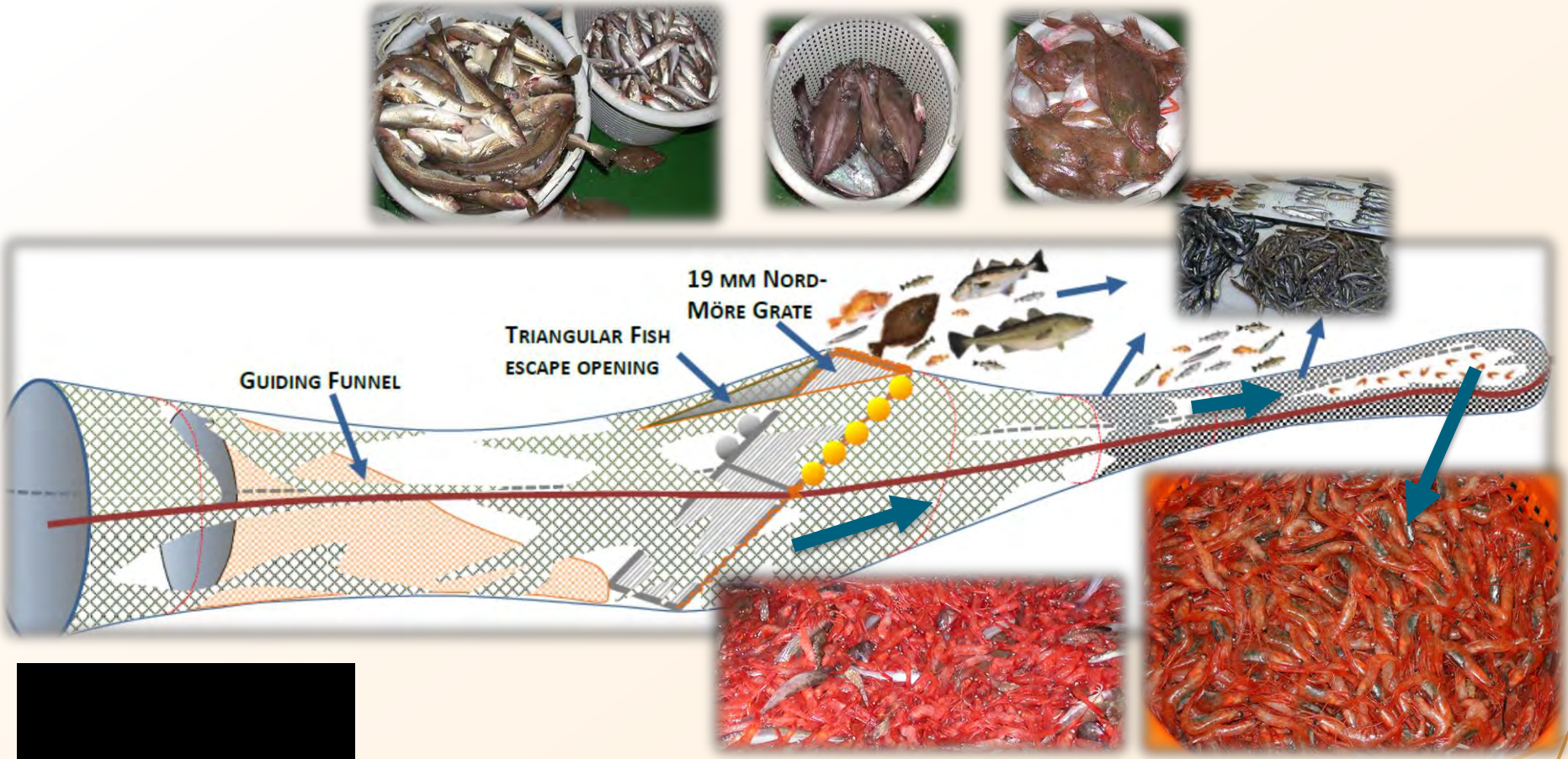
Current technical regulations in the North East Atlantic shrimp trawling:

1) Minimum 35 mm codend mesh size
2) Nordmöre grid with maximum 19.0 mm bar distance



The challenge: Find effective techniques to minimize by-catches during shrimp trawling

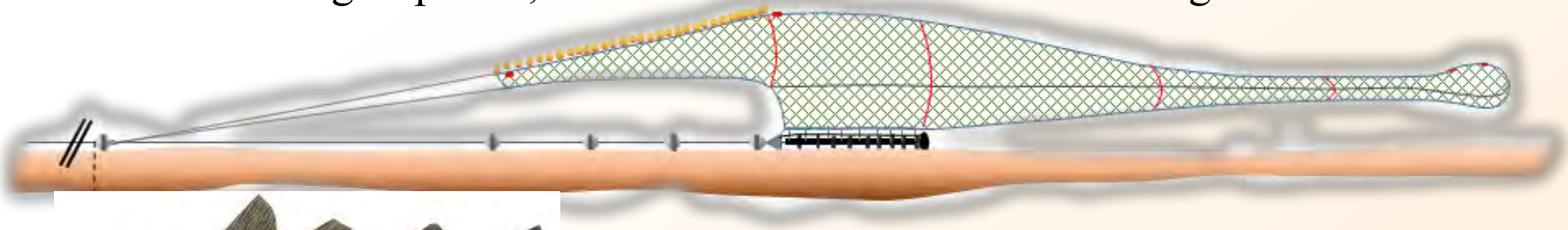
(i.e. remove fish of all sizes and shrimps below minimum landings size).



Video ca. 40 sec

Fish trawling in the North East Atlantic

Target species, the 2016 TAC and minimum landing sizes



Cod *Gadus morhua;*
TAC: 805.000 tons, MLS: 44 cm

Haddock *Melanogrammus aglefinus*;
TAC: 223.000 tons, MLS: 40 cm

Saithe *Pollachius virens*;
TAC: 140.000 tons, MLS: 45 cm

Beaked redfish *Sebastes mentella*
TAC: 30.000 tons, MLS: 30 cm

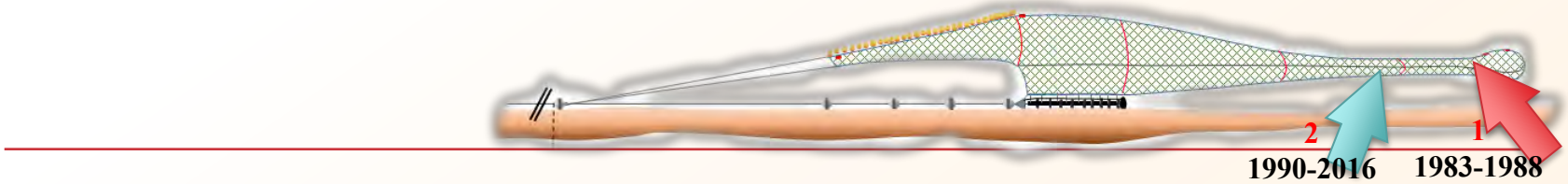
Turbot *Reinhardtius hippoglossoides;*
TAC: 19.800 tons, MLS: 45 cm

Golden redfish *Sebastes marinus;*
TAC: 0 tons (2016), MLS: 30 cm

As unavoidable by-catch only

All images of fish are copied from the internet

Groundfish trawling: Norwegian effort to mitigate by-catch problems in the North-East Atlantic



Traditionally, by-catch control in fish trawls were/are made as mesh size regulations of the codend.

To reduce the by-catch of fish below minimum landing size the mesh size increased several times. Until 1972 a mesh size of 110 mm was accepted, and the new mesh size was set to 120 mm. By 1981 it was increased to 125 mm, in 1983 to 135 mm and in by 1997 the compulsory use of sorting grid with minimum 55 mm bar spacing was introduced. Finally, in 2011 the codend mesh size was reduced to 130 mm (+ the use of 55 mm sorting grid).

In the end of the 1970ties pelagic trawls were banned in the North-East Atlantic and several leading fisheries biologists expressed worries over the increasing effort by bottom trawling.

After 1983, several experiments were made to test how mesh configuration, codend size, lastridge-ropes, etc. affected the selectivity properties of bottom trawls.

1985-1986: Square mesh codends in the North-East Atlantic

Bjørnar Isaksen and John W Valdemarsen 1986: Selectivity experiments with square mesh codends in bottom trawls. ICES CM/B: 28.

Species: Cod and haddock

- 120 mm codends compared: Knotless PA (210/d520) 120 mm Square and Diamond mesh
- 135 mm codends compared: Knotted double Ø6mm PA 135 mm Square and Diamond

General results were:

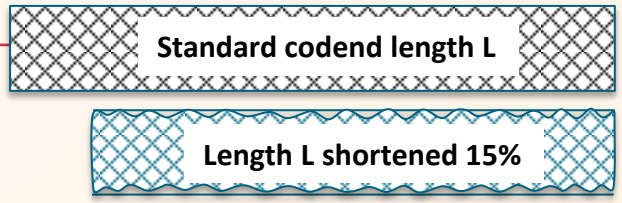
- The square mesh codends (120 & 135 mm) retained fewer small/undersized fish.
- The knotless material was too soft and mesh size varied over the codend length.
- Especially in the knotless square mesh (120 mm) codend was heavily meshed by redfish.
- The escapement of especially haddock was too high through 135 mm square mesh codend.
- Square mesh codends with more than 2 tons of fish were too complicated too empty.

Conclusion:

Practical problems with knot slippage of PA (nylon) net, handling problems on deck and unstable results made the construction unsuitable for the objectives.

1990: Short codend lastridge ropes in the North-East Atlantic

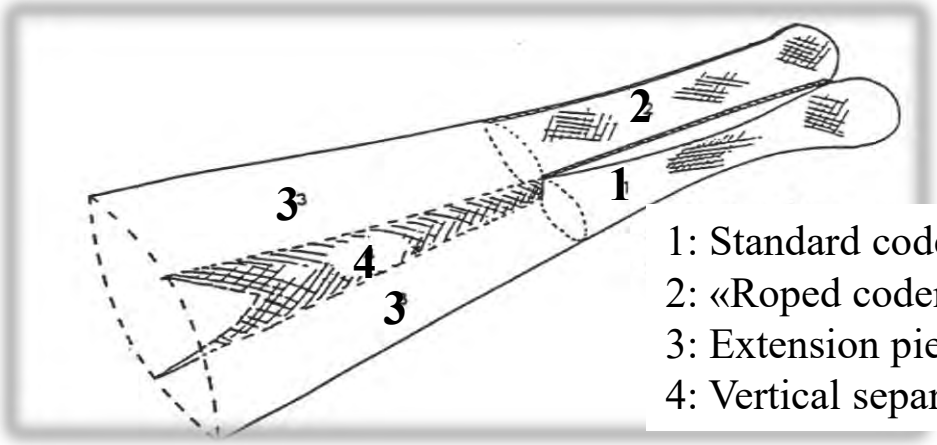
- Two 135 mm codend-lengths tested, i.e. 60# (ca. 9 m) and 99# (ca. 15 m).
- Comparison between standard setup and "roped" codends (i.e. 12-15% shortened by lastrigde ropes).



Bjørnar Isaksen and John W Valdemarsen 1990: Codend with short lastridge ropes to improve size selectivity fish trawls. ICES CM/B: 46.

General results were:

- The "roped codend" opened the meshes (similar to square mesh codends)
- The "roped codend" retained less small fish than a standard codend
- The "roped codend" retained less small fish than a square codend (comparable size)
- The 60 mesh long codend had higher selection than the 90 mesh long codend

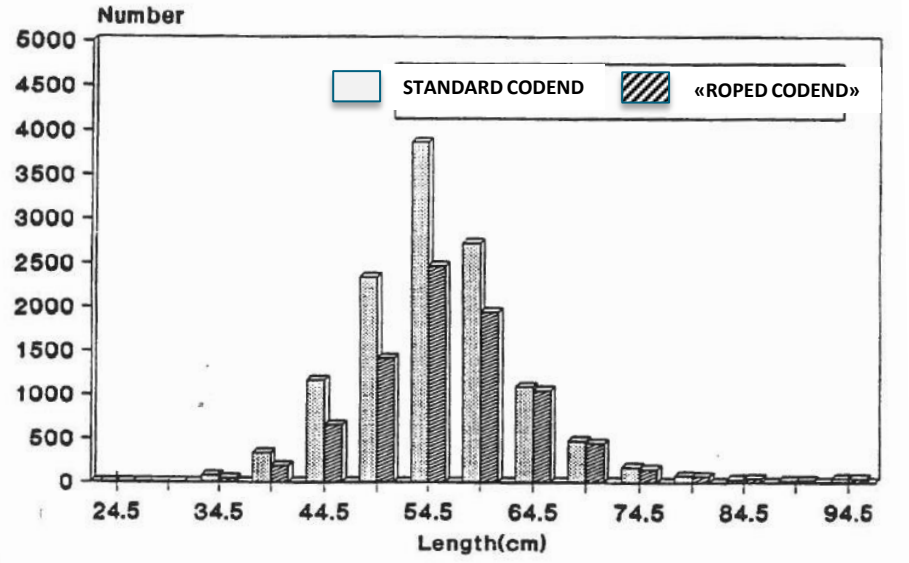


1: Standard codend
2: «Roped codend»
3: Extension piece
4: Vertical separator panel

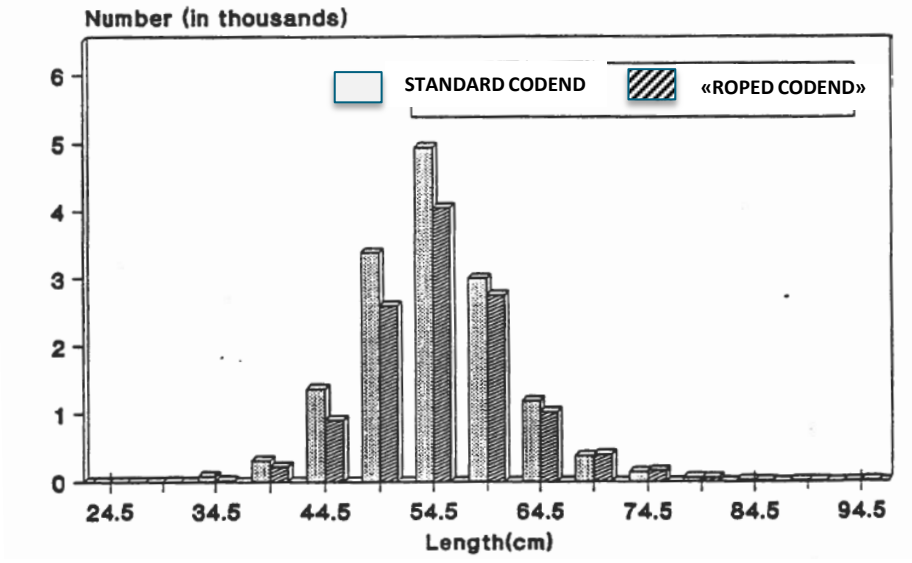
See next slide

1990: Short codend lastridge ropes in the North-East Atlantic - Some of the results on species cod (*Gadus morhua*)

Bjørnar Isaksen and John W Valdemarsen 1990: Codend with short lastridge ropes to improve size selectivity fish trawls. ICES CM/B: 46.



Size composition on cod in 9 m long codends

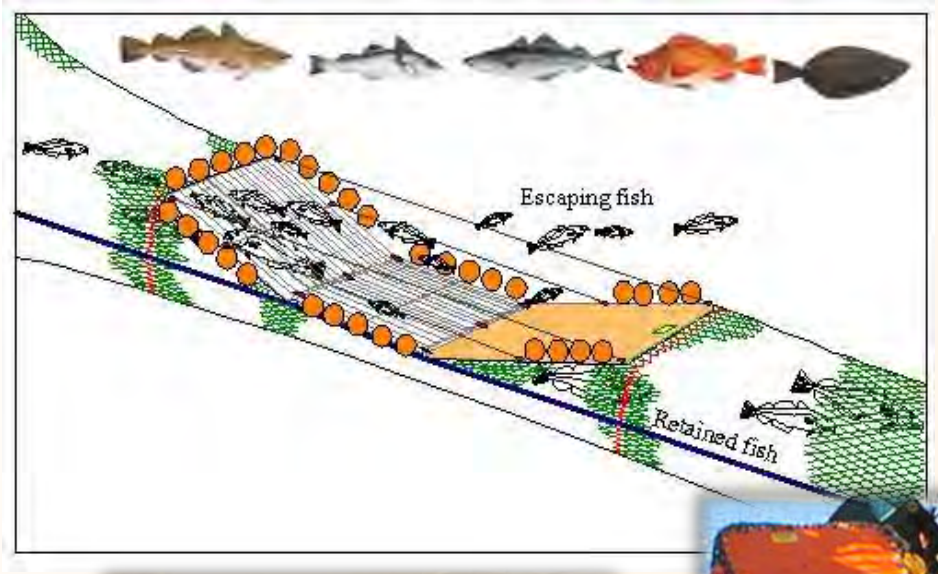


Size composition on cod in 16 m long codends

1989-1997: Size selective grids for groundfish in the North-East Atlantic

Roger B. Larsen, 1989: Pilot experiments with a new device in bottom trawls to avoid bycatch of juvenile fish. Cruise report.
Roger B. Larsen, 1990: A new approach of size selectivity in commercial codfish trawls using the "trollex"system. ICES W.G. Meeting.

***Larsen, Roger B.; Isaksen, Bjørnar.* 1993**. Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). ICES Mar. Science Symp. Vol.196.



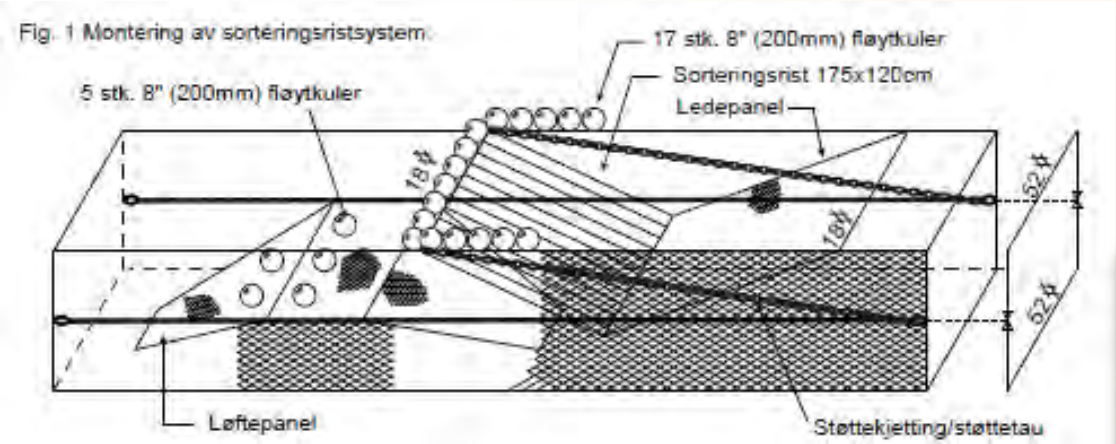
The original version of the size sorting grid was named Sort-X. The grid was tested during several cruises with commercial boats and research vessels. It came into practical use during 1993 as vessels got access to closed areas provided they used a sorting device.

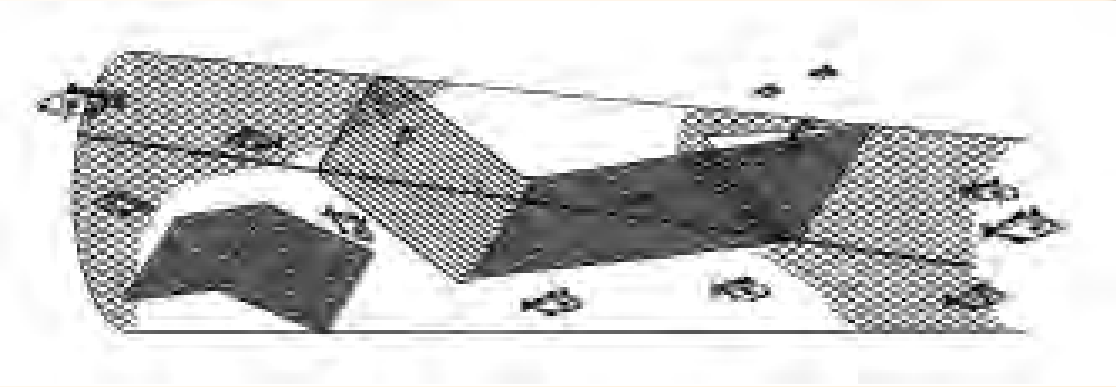
Our Russian counter parts at PINRO developed a version named Sort-V during 1995.

The size sorting grid (minimum 55 mm bar spacing) was made compulsory for the NE Atlantic trawl fisheries by 01.01.1997.

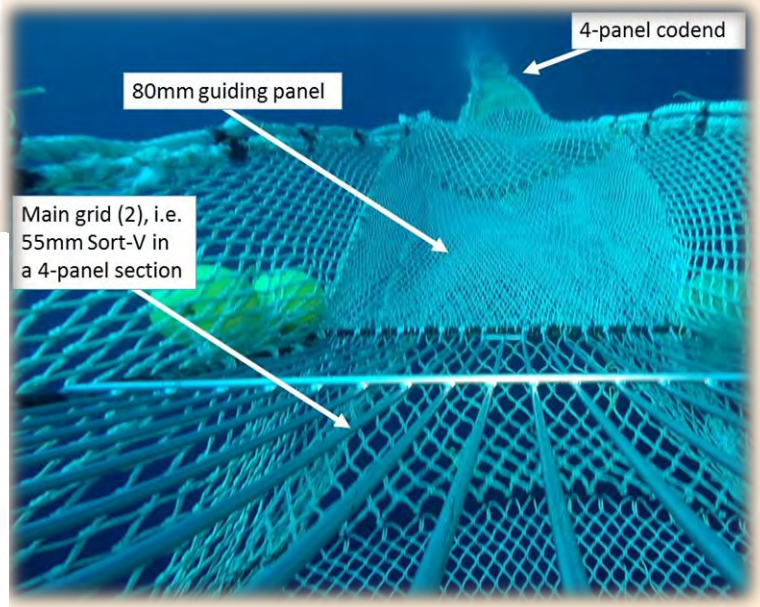
1996: The development of a Norwegian version of the Sort-V started and became approved for fisheries in 2000.

Bjørnar Isaksen, Stanislav Lisovsky, Roger B. Larsen, Vladimir Sakhnoe, Kjell Gamst and Robert Misund, 1996: Joint Russian – Norwegian selectivity experiments on cod (*Gadus morhua* L.) in the Barents Sea. Fisken og Havet nr. 16.



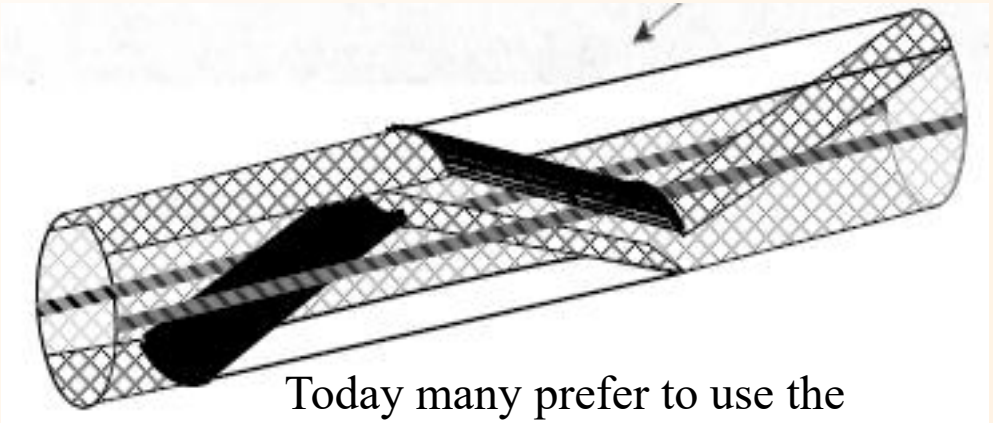


The Sort-V is still used in the northern fisheries.

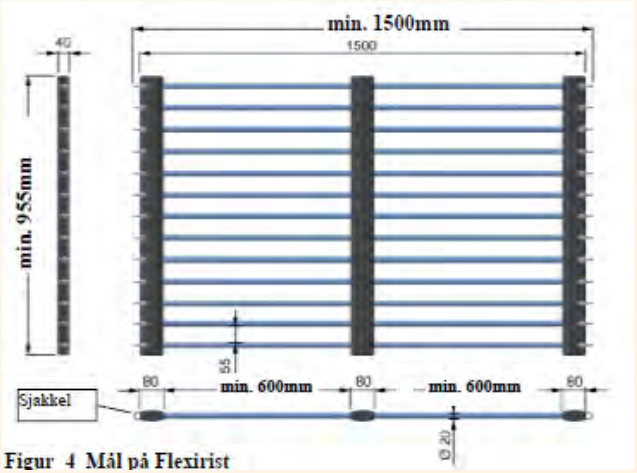


1999: The development of the Norwegian Flexigrid started and became approved for fisheries in 2002.

Snorre Angell, 1999: Development of a flexible selection system for fish trawls. MSc thesis, University of Tromsø.



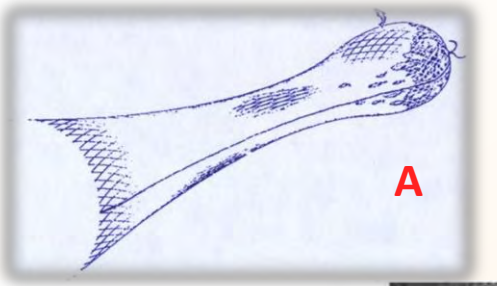
Today many prefer to use the Flexigrid

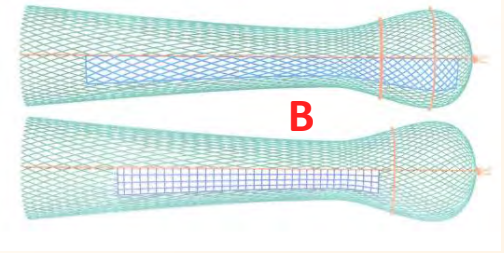


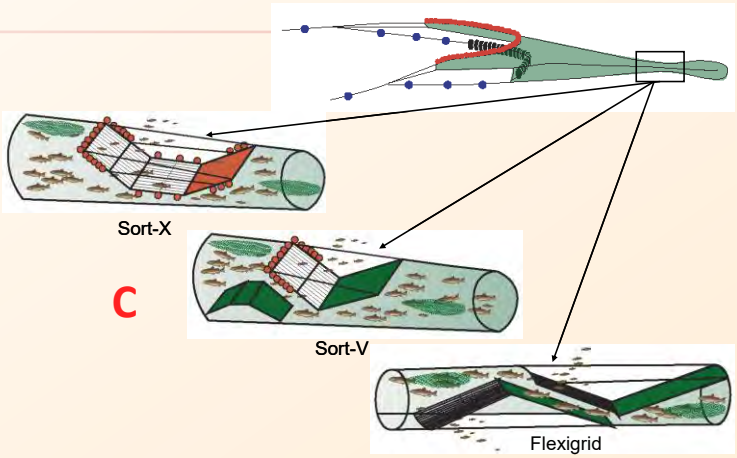
Figur 4 Mål på Flexirist

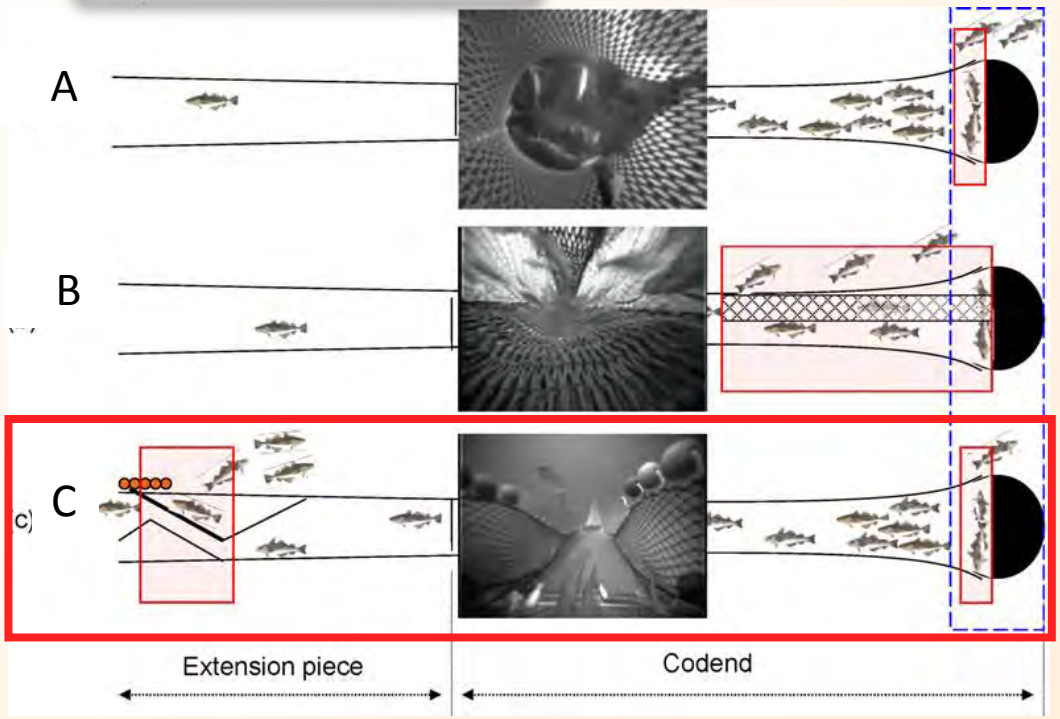
2005-2006: Comparisons between different types of sorting grids, codend mesh size and exit windows

Eduardo Grimaldo, Manu Berrondo Sistiaga and Roger B.. Larsen, 2008. Evaluation of codends with sorting grids, exit windows, and diamond meshes: Size selection and fish behaviour. Fish. Res. Vol. 91 (2-3).









Despite many systems were tested over the last 15 years, none of them compete with the (Norwegian) sorting Grid systems for improved size selectivity

Current regulation of the NEA groundfish trawls: Sorting grid (minimum 55 mm) + minimum 130 mm codend mesh size

1987: A discard ban was introduced in the North-East Atlantic fisheries … and it started a chain reaction.

P. Gullestad et al. 2015: The "Discard Ban Package": Experiences in efforts to improve the exploitation patterns in Norwegian fisheries. Marine Policy 54 (2015) 1–9

The Minister of Fisheries during 1986-1989 Mr. Bjarne M Eidem forced the administration to create a national discard ban to save the important North East Atlantic cod and haddock stocks from collapse. Against all "political odds" it was enforced by the Directorate of Fisheries in April 1987 (Fisheries bulletin J-45-87).

The North-East Atlantic way to reduce risk of fish discarding:

- **Quotas** on species, which are split into various vessel/gear groups
- **By-catch control** and development of selective fishing gears
- **Change fishing ground** if catches exceed limits of by-catch
- **Real time closures** when by-catch levels are too high

Did it work?

Table 1 **Source: P. Gullestad et al. 2015**
Mean age- and weight-at-landing of Northeast Arctic cod (*Gadus morhua*) in different decades from 1946 to 2013 (*source*: [23]).

	Mean age- and weight-at-landing of NEA cod in different decades							
Decades	1946–1949	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2013
Mean age-at-landing (years)	7.76	5.90	5.30	5.32	5.49	5.71	5.62	6.78
Mean weight-at-landing (kg)	3.20	2.13	1.63	1.88	2.23	2.60	2.36	3.33

[23] ICES. Report of the Arctic fisheries working group. Lisbon; 23–29 April 2014. ICES C.M. 2014/ACOM:05, p. 656.

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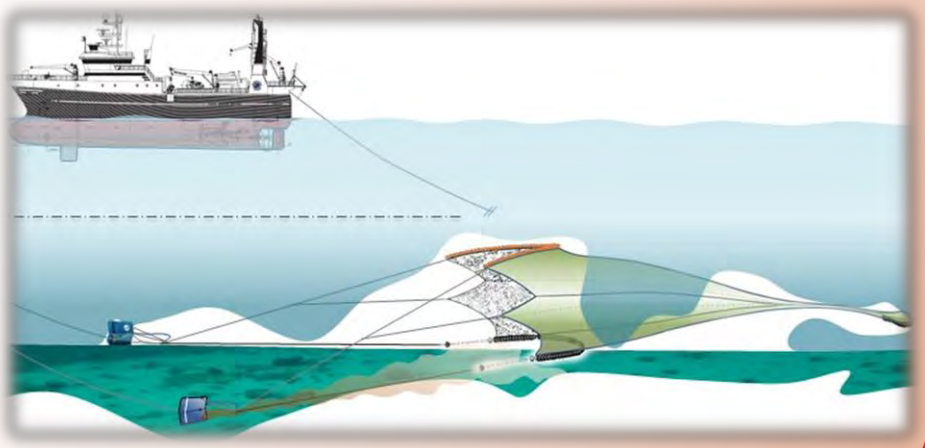
Thank you for listening

Gracias por su atención



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