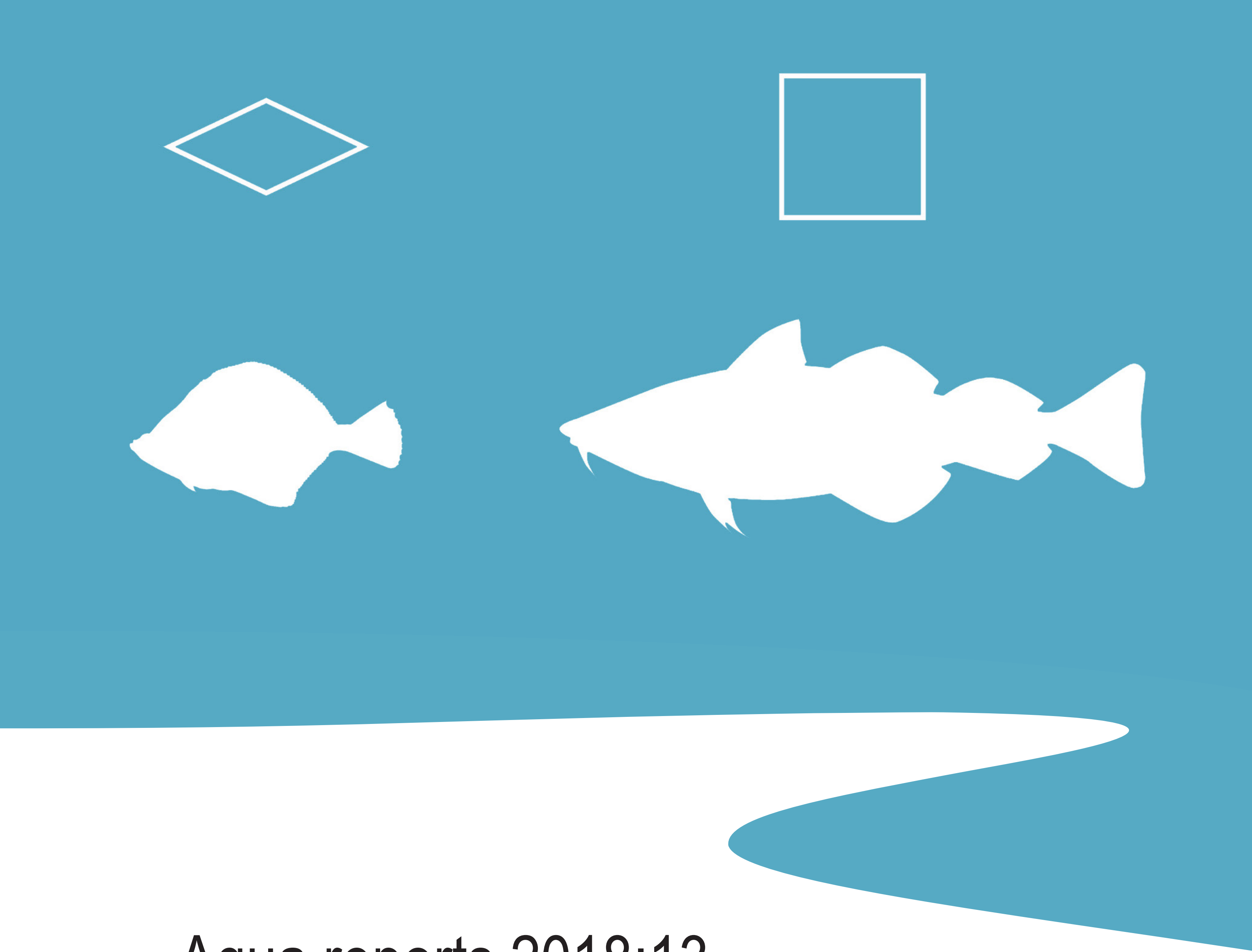

Aqua reports 2018:13

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SLU
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Institutionen för akvatiska resurser

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Hans Nilsson[1], Erika Andersson[1], Maria Hedgärde[2], Sara Königson[2], Peter Ljungberg[2], Sven-Gunnar Lunneryd[2], Johan Lövgren[1], Mikael Ovegård[1], Andreas Sundelöf[1], Daniel Valentinsson[1]

Swedish University of Agricultural Sciences, Department of Aquatic Resources, [1]Institute of Marine Research, Turistgatan 5, 453 30 Lysekil [2]Institute of Coastal Research, Turistgatan 5, 453 30 Lysekil

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Corresponding author:
hans.nilsson@slu.se

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Front cover: Selectivity and fish morphology Back cover: Calm sea, Photo: Therese Jansson.

Summary

Commissioned by the Swedish Agency for Marine and Water management, the Swedish University for Agricultural Sciences, established a Secretariat for selective fishing between 2014 and 2017. The secretariat main task has been to gather and evaluate ideas of new gears from the industry on how to minimize unwanted catches. The industry´s initiative and engagement are essential for the successful development of new ideas. All projects have followed the same work flow; a development of project ideas by science-industry collaboration, an industry lead development phase and finally scientific evaluation and reporting.

Thirty-four projects have been completed between 2014 and 2017. The separate projects have been reported yearly[1][2][3] (in Swedish). As there is also an apparent need to interact with similar initiatives in other countries and to disseminate to an international audience we here summarize all 34 projects according to the results of the scientific evaluations, their applicability given current fisheries regulations and fishing practises and also on the up-take of the new gears. The report is divided between active and passive gears and the different projects are grouped based on fisheries (gear type and target species). In the end of the report, fact sheets is included for the most relevant project.

[1] Valentinsson, D. (red) (2016). Sekretariatet för selektivt fiske-Rapportering av 2015 års verksamhet. Aqua reports 2016:8. Institutionen för akvatiska resurser, Sveriges lantbruksuniversitet, Lysekil. 126 pp. ISBN: 978-91-576-9403-4 (electronic version)
[2] Nilsson, H. (red) (2018). Sekretariatet för selektivt fiske-Rapportering av 2014 års verksamhet. Aqua reports 2018:2. Sveriges lantbruksuniversitet, Institutionen för akvatiska resurser, Lysekil, 63 pp. ISBN: 978-91-576-9549-9 (electronic version)
[3] Nilsson, H. (red) (2018). Sekretariatet för selektivt fiske-Rapportering av 2016 och 2017 årsverksamhet. Aqua reports 2018:4. Sveriges lantbruksuniversitet, Institutionen för akvatiska resurser, Lysekil, 211 pp. ISBN: 978-91-576-9557-4 (electronic version).

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1 Background

1.1 The Selective Fisheries Secretariat

On July 13th 2011, the European Commission presented its proposal for a revised common fisheries policy (CFP). The negotiations between the parties were finished in late 2013 when a new basic regulation was agreed (Regulation (EU) No 1380/2013). The new CFP shall ensure that fisheries and aquaculture are environmentally sustainable in the long term and are managed to achieve economical, social and employment benefits and to contribute to safeguard the EU food supply.

Some important components in the revised CFP are, amongst others, multiannual ecosystem based management and a demand that all stocks shall be fished in accordance with maximum sustainable yield (MSY) by 2020 at the latest. Furthermore, the revised CFP stipulates a gradual phasing-in of an obligation to land all catches of quota species between 2015 and 2018. By 2019 the landing obligation (LO) shall be fully implemented in EU waters.

Fishery discards, i.e. the practice of releasing part of caught fish, often dead or dying, back at sea can counteract a sustainable use of marine biological resources. The LO implies that all catches of quota species shall be registered, landed and counted against the quotas. By this, the LO is thought to incentivize improved selectivity and lead to improved data for stock assessments. The first demersal fisheries with a full implementation of the LO was fisheries for Baltic cod in 2015. For the North Sea region (including the Skagerrak and Kattegat), the LO is gradually phased in between 2016 and 2019. There are possibilities for exemptions from the LO based on whether the fishing method for a particular species enables the release of fish with a likelihood of high survival, protected species or if the unwanted catches are small and unavoidable and when the selectivity cannot be improved or the costs of handling the unwanted catches are disproportionate (de minimis exemption; 5%).

Against this background, the Swedish government commissioned the Swedish Agency for Marine and Water management (SwAM) to stimulate the development of selective fishing methods in order to reduce unwanted catches. The time horizon for the commission was four years (2014-2017) with a total budget of 38 million SEK (app. 3,8 million Euros).

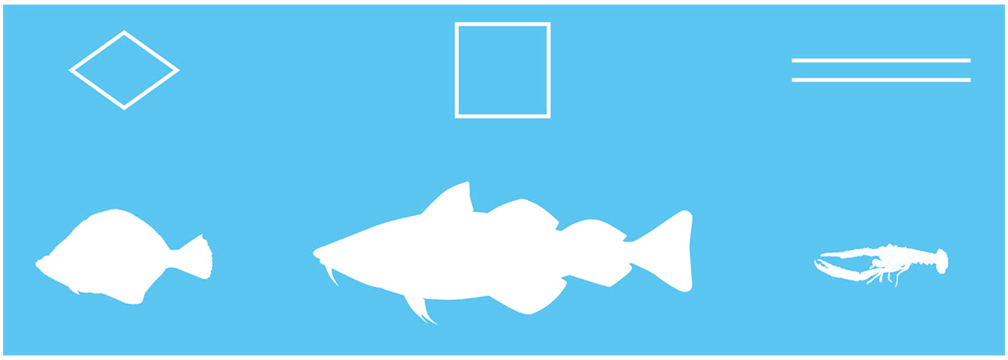
SwAM then asked the Department of Aquatic Resources at the Swedish University for Agricultural Sciences (SLU Aqua) to manage the initiative. Therefore, SLU Aqua established the Selective Fisheries Secretariat in order to gather and collate ideas from the industry, write projects proposals together with the industry for the deciding steering group at SwAM, run the funded projects and to scientifically analyse and report all projects.

1.2 Selective fishing

Fishers and fisheries managers can contribute to the recovery of weak fish stocks and reduce the amount of unwanted catches by the use of selective fishing techniques. Selective fishing is the ability of a fishing operation to avoid catching non-target species, undersized specimens or limiting species (choke species in mixed fisheries). Selective fishing methods should also be evaluated in terms of broader environmental effects (e.g. ecosystem impact and habitat effects).

Mechanisms to achieve the desired selectivity during practical fishing involves differences in morphology, size, escape behaviour to select and capture the target species and size. Morphological differences are in some cases obvious like the difference between flatfish (e.g. Plaice) and *Gadidae* species (e.g. Cod). Behavioural responses are sometimes different between species, some try to escape upwards (e.g. Saithe, Whiting and Haddock), while other species typically escape downward (e.g. Cod), which is usable in the design of selective trawls. A selective gear is thus characterised by a gear design that is adapted to the target species morphology, behaviour and size in best practical way.

- Selective methods are species- and/or size-selective
- Species-selection reduces impact on non-target species.
- Size-selective fishing can be used to optimize the exploitation pattern, which is a measure of how fishing pressure is distributed over the length composition of a fish stock.
- Selective fishing methods should be viewed as a part of the toolbox for management of sustainable marine resources.



Schematic figure showing different species morphology and how this affect selectivity in fishing gears. Flatfish is more easily selected through diamond mesh, Gadoids through square mesh and crustaceans with grids.

1.3 The Swedish Secretariat for Selective Fishing

Commissioned by the Swedish Agency for Marine and Water Management (SwAM), the department of Aquatic Resources at the Swedish University of Agricultural Sciences (SLU Aqua) established the Swedish secretariat for selective fishing in 2014. The aim of the secretariat is to gather new ideas from fishers and industry on how to fish more selectively in order to cope with the coming EU landing obligation. The industry´s initiative and engagement are essential for the successful development of new ideas. Project plans was worked out in close collaboration between fishers and scientists. Approved projects have been funded by the Swedish Agency for Marine and Water Management (national funds).

Project work-flow in The Swedish Secretariat for Selective Fishing:

1. Mailbox/meetings for gathering ideas
2. Development of ideas to projects by science-industry collaboration
3. Pre-evaluation and funding process
4. Call for tender of participating vessel(s)
5. Development phase
6. Scientific evaluation and reporting

Each accepted project had two main phases; a development phase in which the fishers test and modify (supported by net makers) their prototype gear iteratively, and an evaluation phase where scientists study the effectiveness of the alternative gear. Involved fishers was guaranteed full cost coverage during all project phases, which eliminates their economic risks. The scientific evaluation of the project was done by personal from SLU Aqua aboard the commercial fishing vessel via structured experimental fishing.

1.4 Prioritized areas for project

Theme areas prioritized for funding by SwAM during the project period 2014 to 2017 was:

- Priorities 2014
  - Survival of discarded salmon
  - Size- and species selectivity in demersal trawl fisheries in the Kattegat and Skagerrak
  - Size selectivity in *Pandalus* trawls
  - Size- and species selectivity in *Nephrops* trawls
  - Selectivity in the Baltic cod trawl fishery
- Priorities 2015 to 2017
  - Demersal fisheries in the Baltic sea- size selectivity in passive gear and the trawl fishery
  - Demersal trawl fisheries in the Kattegat and Skagerrak, further development of the *Pandalus* and *Nephrops* fisheries
  - Species- and size selectivity in the demersal mixed trawl fishery to avoid catches of choke species and sensitive stocks
  - Pelagic trawling - e.g. avoiding by-catch of saithe in the herring fishery

- o Purse seine fishery - development of system needed for the landing obligation to fulfil the exemption to be able to release the catch in the later phase of the fishing operation
- o Survival of bycatch in the demersal fisheries with special focus on flatfish e.g. Sole
- o Handling of unwanted catches aboard and when landed
- o Development of alternative fishing gears (pots and traps etc.)

2 Projects

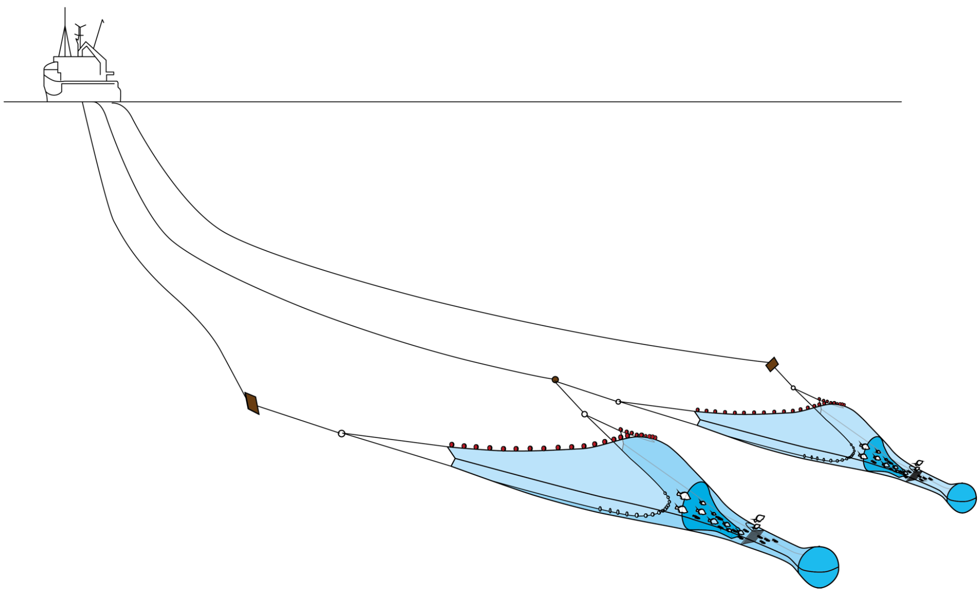
A total of 53 project ideas were received from the industry by the secretariat between 2014 and 2017. Of these, 34 projects were approved. Projects was refused funding due to several reasons. Some projects was very similar to each other and was rewritten into one project proposal. Some ideas was not directly linked to the landing obligation or other prioritized areas for funding, while other project ideas had been tested earlier or the project idea was unclear. Some of the rejected project proposals were suggested by the steering committee to apply for other type of funding (e.g. EMFF).

All 34 funded projects are shown in Table 2.1, with references to the relevant fact sheet (where applicable). The table is divided in active (A) and passive fishing methods (P). The projects are grouped depending on target species and fishery: the Baltic cod trawl fishery (ACOD), *Nephrops* trawls (ANEP), *Pandalus* trawls (APRA), demersal trawls in the Kattegat and Skagerrak (ADEM), and pelagic trawls (APEL) for active gears. Passive fisheries are divided into: fisheries with traps (PPU), gentle catch handling of Salmon and Whitefish (PWH), fisheries targeting demersal fish with pots (PPOT), and *Pandalus* pots (PPRA). Appendix 6.3 provides a list of references to all individual project reports (SLU Aqua reports 2016:8, 2018:2 and 2018:4; in Swedish).

All projects in Table 2.1 are rated according to a 5-degree colour scale, which summarises (1) whether the results of the scientific evaluation showed that the new gear had the intended effect(s), (2) if the gear is directly applicable in commercial fisheries and (3) if changes in legislation is needed for use of the new gear need or (4) whether the gear is within legislation but needs additional incentives for a wider up-take in the fleet.

Colour scale:
Red: Project with unclear potential, results not as intended. These project ideas have normally ended after the scientific evaluation.
Orange: Project where further development is needed to achieve project goals. Several of these projects were continued in follow-up projects to further develop the idea (e.g. combination grid *Pandalus*).
Yellow: The gear work as intended but need changes to national or international regulations in order to be legal to use.
Light green: The gear work as intended and is implementable but needs further incentive to get a wider uptake in the fishery.
Dark green: The gear work as intended and is in use, no further actions needed

Several project ideas (e.g. increased selectivity in Baltic T-90 trawls [ACOD-1], size selective grids in both *Nephrops* and *Pandalus* trawl fishery [ANEP-1 and APRA-1], and development of predator safe pots [PPOT-1]) was first scored as orange or yellow. These ideas were further developed to "green" status in later projects (Table 2.1). As can be seen in Table 2.1, only two projects are today scored as "dark green - already in use, no further action needed". For many of the gears, scored as "light green", despite that they have been shown to work and would therefore likely facilitate the implementation of landing obligation, the gears are not used to any significant extent. This issue is further discussed in section 5.2.2.



The scientific evaluations made in trawl projects under the selective fisheries secretariat have normally been performed in the form of catch-comparison experiments with twin-trawls where the catches of a normal trawl (control) is compared to the catches of an experimental trawl.

Table 2.1. Summary table of the outcome of project between 2014 and 2017.

Active gear	Target species	Main topic	Project	Outcome	Fact sheet
Baltic cod trawl	Cod	Size selectivity cod	Improved selectivity in T90-codends in the Baltic cod fishery	[orange]	
Baltic cod trawl	Cod	Size selectivity cod	Improved selectivity in T90-codends in the Baltic cod fishery phase II	[dark green]	ACOD-1
Baltic cod trawl	Cod	Size selectivity cod, species selectivity flounder	Multifunction selective codend in the Baltic cod fishery	[yellow]	ACOD-2
Pandalus trawl	Pandalus	Size selectivity Pandalus	Increased mesh size 47 mm (diamond and square mesh) in Pandalus trawl	[orange]	
Pandalus trawl	Pandalus	Size selectivity Pandalus	Testing a Norwegian design of sorting grid to improve Pandalus size selectivity	[orange]	
Pandalus trawl	Pandalus	Size selectivity Pandalus	Sorting grid to improve Pandalus size selectivity	[orange]	
Pandalus trawl	Pandalus	Size selectivity Pandalus	Improved size selectivity for small Pandalus trawlers phase I	[orange]	
Pandalus trawl	Pandalus	Size selectivity Pandalus	Improved size selectivity for small Pandalus trawlers phase II	[red]	
Pandalus trawl	Pandalus	Size selectivity Pandalus	Flexible sorting grid to improve Pandalus size selectivity	[light green]	APRA-1
Nephrops trawl	Nephrops	Size- and species selectivity (Nephrops and fish by-catches)	Size selective sorting grid and improved codend design to reduce catches of small Nephrops and by-catch fish phase I	[yellow]	
Nephrops trawl	Nephrops	Size- and species selectivity(Nephrops and fish by-catches)	Size selective sorting grid and improved codend design to reduce catches of small Nephrops and by-catch fish phase II	[light green]	ANEP-1
Nephrops trawl	Nephrops	Species selectivity - Reduced catch of roundfish	Low topless Nephrops trawl	[light green]	ANEP-2
Demersal trawl	Mixed demersals	Size- and species selectivity (Nephrops and fish by-catches)	Reduced bycatch of undersized Nephrops and fish	[light green]	ADEM-1
Demersal trawl	Witch and cod	Speceis selectivity- Separation of catches	Separation of roundfish and flatfish by a grid and two cod-ends phase I	[light green]	
Demersal trawl	Cod, saithe, haddock	Species selectivity- Separation of catches	Vertical trouser trawl for separating cod from haddock and saithe	[light green]	ADEM-2
Demersal trawl	Mixed demersals	Size selectivity cod, whiting, haddock and plaice	Testing selectivity equivalence for three alternative legislated cod-ends in the Skagerrak-Kattegat mixed fishery	[light green]	ADEM-3
Demersal trawl	Plaice and cod	Species selectivity- Separation of catches	Separation of roundfish and flatfish by a grid and two cod-ends phase II	[light green]	ADEM-4
Pelagic trawl	Herring	Species selectivity- minimize saithe by-catch	Reduced by-catch of saithe in herring trawls by a flexible grid phase I	[light green]	
Pelagic trawl	Herring	Species selectivity- minimize saithe by-catch	Reduced by-catch of saithe in herring trawls by a flexible grid phase II	[light green]	APEL-1
Passive gear	**Target species**	**Main topic**	**Project**	**Outcome**	**Fact sheet**
Pontoon trap	Cod	Alternative, selective fishing method - trap	Increased selectivity in pontoon traps targeting cod	[orange]	PPU-1
Pontoon trap	Atlantic mackerel	Alternative, selective fishing method - trap	Can seal safe selective traps targeting atlantic mackerel reduce the seal fishery conflict?	[red]	
Pontoon trap	Herring	Alternative, selective fishing method - trap	Development of a seal safe and selective trap for herring	[red]	
Pontoon trap	Whitefish	Harmless treatment of salmon	Harmless method for emptying pontoon traps fishing salmon and whitefish	[yellow]	PWH-1
Pontoon trap	Whitefish	Harmless treatment of salmon	Harmless method for emptying pontoon traps fishing salmon and whitefish	[yellow]	PWH-2
Pontoon trap	Whitefish	Harmless treatment of salmon	Selective pontoon trap for whitefish	[orange]	PWH-3
Pontoon trap	Whitefish	Harmless treatment of salmon	Ergonomic and selective method for emptying a pontoon trap	[yellow]	
Pot	Cod	Alternative, selective fishing method - pot	Development of a selective pot for cod	[orange]	
Pot	Multi species	Alternative, selective fishing method - pot	Multi species pot	[orange]	
Pot	Cod and flatfish	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	[dark green]	PPOT-1
Pot	Cod	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	[orange]	
Pot	Flatfish	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	[orange]	
Pot	Multi species	Alternative, selective fishing method - pot	Multi species pot	[light green]	PPOT-2
Pot	Pandalus	Alternative, selective gear - pandalus	Pandalus pot	[light green]	PPRA-1
Pot	Pandalus	Alternative, selective gear - pandalus	Pandalus pot	[light green]	PPRA-2

[red] **Unclear potential, not as intended**
[orange] **Further development needed**
Direct useable, management action needed [yellow]
Direct implementable, incentive needed [light green]
Already in use, no further actions needed [dark green]

3 Active gears

3.1 Baltic cod trawl fishery (ACOD)

In total 3 project was performed to increase the selectivity in the Baltic cod trawl fishery (Table 2.1, fact sheet ACOD). Two different design was scientifically evaluated, one T-90 design and one design with multiple selective devices.

Improved selectivity in T90-codends in the Baltic cod fishery (ACOD-1)

- Aim: increased selectivity of undersized Cod.
- Simple design with increased no. of meshes in the circumference (n = 80), decreased mesh size (at least 115 mm) and increased length (at least 9 m) of codend compared to a standard T90 codend.
- Significantly reduced catches of Cod below 34 cm.
- Significantly increased catches of Cod between 38 and 52 cm.
- Since 1 of January, 2018 is this codend a legal codend in the Baltic cod trawl fishery (Regulation EU 2018/47).

Multifunction selective codend in the Baltic cod fishery (ACOD-2)

- Aim: increased selectivity of undersized Cod and reduce catch of flatfish e.g. Flounder.
- The codend together with the extension part are divided in three selective compartments: 1. a self-supporting ring system with controlled opening of large mesh panel (400 mm), 2. a grid system with in total 4 flexible grids (grid spacing 55 mm), and 3. a codend with exit windows (square mesh panel 115 mm, "the Swedish exit window").
- Significantly reduced catches of Cod smaller than 33 cm.
- 70 percent reduction of catch of Flounder.
- Complex design, not legal to use under current EU regulations.

3.2 Trawls for Northern prawn (*Pandalus borealis*) in the Skagerrak and Kattegat (APRA)

A total of 6 projects aimed at improved size selectivity in *Pandalus* trawls have been undertaken. (Tab. 2.1, Fact sheet APRA). Three different technical solutions were developed and evaluated scientifically

47 mm square mesh ring section

- Aim: improved size selectivity for *Pandalus.*
- Catches from a trawl fitted with an extension piece with a 3 m section of 47 mm square meshes (mounted between two rings to keep the meshes open) was compared to a standard 47 mm diamond mesh trawl.
- Large unexplained differences in selectivity and catches between the two participating vessels.
- Significantly less catches of the smallest *Pandalus* for one of the vessels.
- The idea needs to be developed and tested further before safe conclusions can be drawn.

A selective trawl adapted for small *Pandalus* trawlers

- Aim: improved size selectivity for *Pandalus*
- One or two conical narrowings with larger meshes in the extension piece to sort out small *Pandalus*
- The extension piece and codend did not improve size selectivity
- The developed and tested trawl modification is legal to use but the results indicate that the applicability is limited

Combination grid for *Pandalus* trawls (APRA-1)

- Aim: improved size selectivity for *Pandalus.*
- A two-section Nordmøre grid that combines species- and size selectivity in *Pandalus* trawls. The lower grid section has narrow (9-10 mm) bar spacing to sort out small shrimp and the upper grid section has standard 19 mm bar spacing to sort out fish.
- The combination grid sorted out unwanted sizes of *Pandalus* effectively. At least 60 % of the smallest shrimp fraction was sorted out, but also catches of medium sized (industrial) shrimp was reduced significantly.
- Loss of the largest (fresh consumption) shrimps was around 5 % but is affected by the choice of lower grid bar spacing
- The combination grid is legal to use but additional incentives are probably needed due to marginal industry up-take.

3.3 *Nephrops* trawls in the Skagerrak and Kattegat (ANEP)

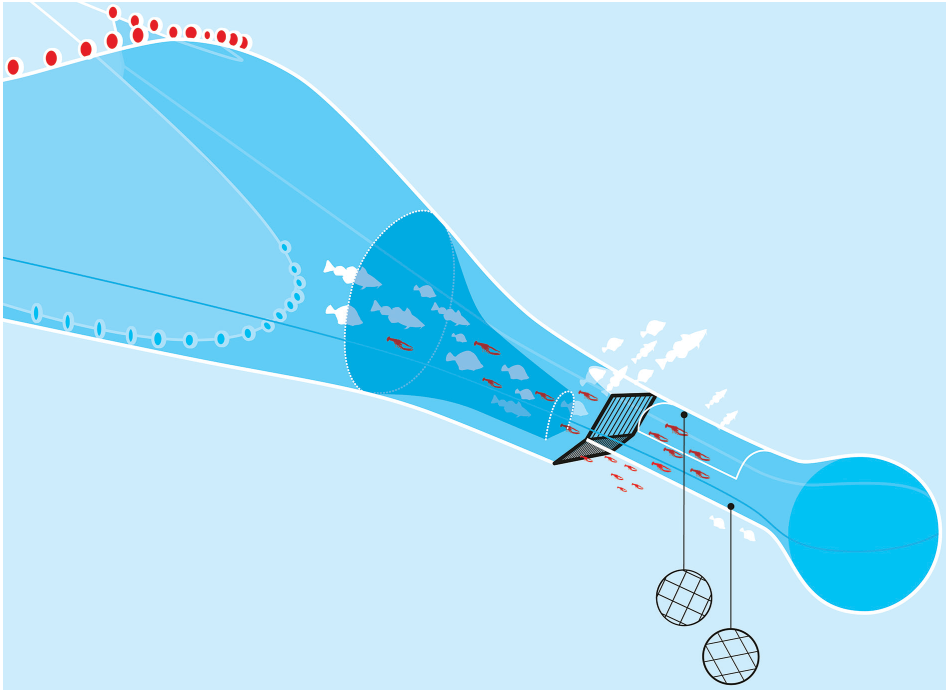
A total of 4 projects were finished during the project period. The aim of all projects was to improve the species- and size selective characteristics in currently used *Nephrops* trawls in the Skagerrak and Kattegat. (Tab. 2.1, fact sheet ANEP). Two different gear modifications was developed and evaluated scientifically.

Further development of the Swedish grid: Combination grid for *Nephrops* trawls (ANEP-1)

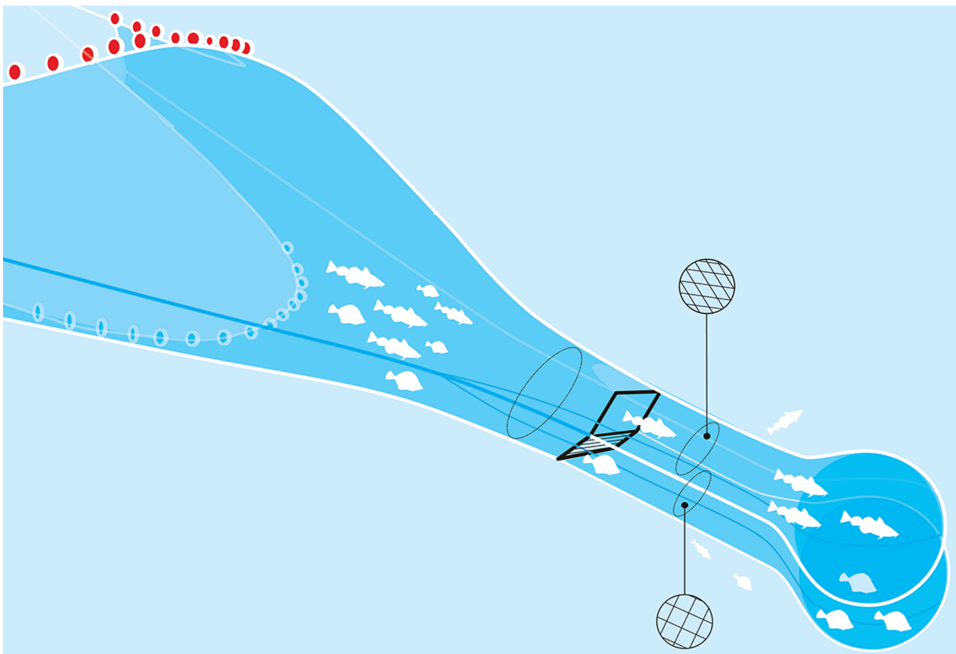
- Aim: improved size selectivity for *Nephrops* and a further reduction of fish by-catches in grid trawls.
- A two-section Nordmøre grid for improvement of *Nephrops* size selectivity and an improved codend design to increase fish selectivity. The lower grid section has narrow (21 mm) bar spacing to sort out small *Nephrops* and the upper grid section has standard 35 mm bar spacing. A composite codend with diamond- and square mesh sections and additional escape panels.
- The improved grid design reduced catches of *Nephrops* <13 cm by more than 50 %, with a limited loss of prawns >13 cm compared to the standard Swedish grid.
- The improved grid and composite codend showed large reductions in catches of Cod, Whiting, Dab, Plaice and Long rough dab compared to the proven highly selective standard Swedish grid.
- The developed and tested combination grid and composite codend is legal to use outside coastal waters area IIIa. However, the lowered MCRS (from 13 cm to 10,5 cm) for *Nephrops* in area IIIa at the onset of the landing obligation in 2016 drastically reduced incentives for industry up-take. An overhaul of national legislation for improved incentives in coastal waters is a possible measure if the MCRS is not changed back.

Low topless *Nephrops* trawl (ANEP-2)

- Aim: reduced catch of roundfish in *Nephrops* trawls.
- The roof panel of the a traditional *Nephrops* trawl body was removed from 1-1.5 m down to 0.4 m in height. The netting in the roof panel was exchanged with very large "Dynema" meshed to maintain shape of the trawl.
- Catches of Haddock, Saithe and Whiting was reduced with > 80%.
- Cod catches was reduced with 47%.
- Reduction in the catch of the *Nephrops* was insignificant.
- The gear is legal to use.



Combination grid: the lower grid - size selective, and the upper grid - species selective.



Species selective grid mounted to a twin codend. The lower grid system let the flatfish pass into the lower codend, large round fish pass into the upper codend through an open frame.

3.4 Demersal trawls in the Skagerrak and Kattegat (ADEM)

Demersal trawls used for mixed *Nephrops*/fish and for demersal fish typically targets several species. Five projects were undertaken during the project period. The projects covered four different problem formulations and thereby focussed on different modifications (Tab. 2.1, fact sheet ADEM). In three of the projects, a sorting grid was used to size select or to separate the catch between two different codends.

Reduced bycatch of undersized *Nephrops* and fish (ADEM-1)

- Aim: reduced catches of small *Nephrops* and fish in mixed fisheries.
- A size selective grid section with 21 mm bar spacing to sort out small *Nephrops* mounted in a combination grid to an open frame. A standard SELTRA (360 square mesh) codend was then mounted to the open frame.
- The size selective grid reduced catches of *Nephrops* <13 cm by more than 50 %.
- Decreased catches of small flatfish (Dab, Plaice and Long rough dab), cod and whiting.
- There are no legal restrictions to use the codend. However, the lowered MCRS (to 10,5 cm) for *Nephrops* in area IIIa at the onset of the landing obligation in 2016 drastically reduced incentives for industry up-take. An overhaul of national legislation for improved incentives is a possible measure.

Vertical trouser trawl, separating cod from haddock and saithe (ADEM-2)

- Aim: to separate catches of demersal roundfish species with a vertical trouser trawl in an upper (Saithe, Haddock and Whiting) and a lower (Cod) codend.
- Vertical mounted trouser trawl with two codends (horizontally divided trawl).
- More than 90% of all Saithe, Haddock and Whiting was caught in the upper codend.
- Over 2/3 (69 %) of Cod was caught in the lower codend.
- By selecting different mesh size in codends the fisher can choose the exploitation pattern of the species caught in the different codends.
- There is no legal restriction to use this trawl as long as the codends follows the regulation.

Relative selectivity for demersal fish in three alternative codends legislated and used in the Skagerrak and Kattegat (ADEM-3)

- Aim: to compare the selectivity for demersal fish in the three legislated trawl alternatives used in the mixed *Nephrops* and fish trawl fishery.
- Comparisons between (1) a 120 mm codend, (2) a 270 mm SELTRA codend (90 mm codend with a 270 mm diamond mesh escape window 4-7 m the codline), and (3) a 300 mm SELTRA (90 mm codend with a 300 mm square mesh window 3-6 m above the codline).
- Both SELTRA-variants caught significantly more undersized roundfish (Cod, Haddock and Whiting) than the 120 mm codend. The SELTRA codends also caught more undersized Plaice.
- Especially SELTRA 270 showed consistently larger catches of small roundfish than both SELTRA 300 and a 120 mm codend.
- These results indicate that fish size selectivity for the three codends is not equivalent (as intended by legislators).

Separation of roundfish and flatfish by a grid and two codend´s (ADEM-4)

- Aim: to separate flatfish and round fish into two separate codends.
- The experimental trawl divides the catch after a special grid into two cod-ends. The upper part of the grid is open and attached an upper codend. The lower part of the grid has horizontal slots and is attached a lower codend.
- Flatfish was primarily caught in the lower codend while the opposite was true for roundfish.
- Depending on choice of mesh size and mesh orientation in the upper and lower codends, the fishermen can choose the size distribution they want to catch of flatfish and roundfish and separate them between the codends.
- There is no legal restriction to use this trawl as long as the codends follows the regulations.

3.5 Removing saithe in pelagic trawling (APEL)

Bycatch of Saithe may periodically be a problem in the pelagic trawl fishery after consumption Herring in the Skagerrak (Table 2.1, fact sheet APEL).

Reduced by-catch of saithe in herring trawls by a flexible grid (APEL-1)

- Aim: reducing bycatch of Saithe in Herring trawls.
- Semi-pelagic trawl with grid (3x3.6 m large with 50 mm bar spacing) with positive attack angle.
- Scientific evaluation was done by a video analysis.
- The grid removed 98% of the bycatch of Saithe and 5 to 10% of the target species (Herring).
- The flexible material in the grid prevented specimens above 53 cm to enter the codend, and was flexible enough to handle on the net drum.
- The gear is used by some vessels, but is not the standard gear in the fishery.

An image showing the assembly of the large grid into the nettings of a pelagic trawl.

4 Passive fishing gears

4.1 Pontoon traps targeting Cod, Atlantic mackerel and Herring (PPU)

Due to an increasing seal-fishery conflict in Sweden the need for seal-safe and selective fishing gear is large. Two projects were carried out on the Swedish west coast trying pontoon traps as an alternative to nets when fishing Herring and Atlantic mackerel. On the south coast a pontoon trap was modified to fish cod. (Table 2.1, fact sheet PPU)

Increased selectivity in pontoon traps targeting Cod (PPU-1)

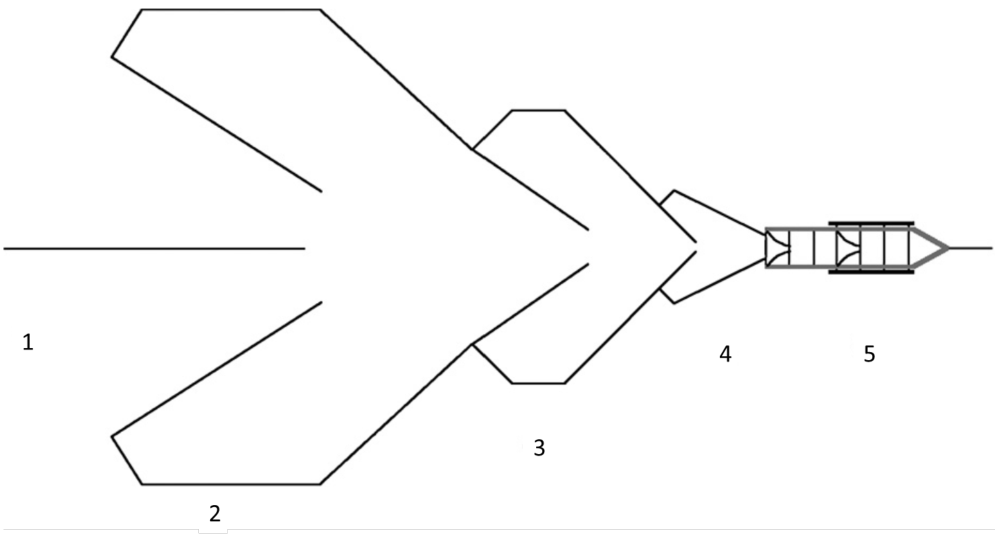
- Aim: evaluate pontoon traps targeting cod.
- Evaluation of bottom-, mid water- and surface-set fish houses, along with evaluation of different sized selection panels. Also, test of survival rate of cod caught in pontoon trap.
- Only bottom-set traps caught substantial amount of cod, probably due to that cod hesitate to swim upwards in the water column.
- A 40 mm selection panel allowed for cod bycatch reduction before emptying the trap.
- Survival rate was almost 100%, six days after handling Cod when emptying the trap.
- The traps are susceptible to external impact from wind and current, especially in an open seascape environment. Moreover, cod populations are mobile during different seasons, why a stationary gear for Cod is only effective during certain times a year, something that will affect the fisherman's financial sustainability.

Seal safe and selective fixed gear for Atlantic mackerel

- Aim: evaluate if pontoon traps can be used for Mackerel.
- Due to its behaviour, Mackerel did not swim into a fish chamber with a small entrance. If the entrance was larger the trap would no longer be seal safe.
- Large amounts of jellyfish got stuck in the gear, blocking the trap and killing caught fish.
- The pontoon trap can therefore not be recommended as an economically viable, seal safe and selective fishing method for Mackerel.

Seal safe and selective fixed gear for Herring

- Aim: develop a mobile pontoon trap consisting of only a fish chamber with a leader net to fish herring on the Swedish west coast.
- Artificial light was used to attract fish to the gear.
- The gear was difficult to handle in the trial area due to heavy traffic and a lot of current.
- The Herring did not follow the leader net into the fish chamber.
- Light attracted some Herring but also seals.
- The pontoon trap can therefore not be recommended as an economically viable, seal safe and selective fishing method for Mackerel.



Pontoon trap from above. (1) leader net, (2) wings, (3-4) middle chambers, (5) pontoon fish chamber.

4.2 Pontoon traps for Whitefish (PWH)

Four different projects focused on selectivity when fishing Whitefish with pontoon traps (Table 2.1, fact sheet PWH). The aim was to decrease bycatch of Salmon as well as minimizing the impact on bycaught salmon when fishing Whitefish. The goal was to find a method that could be used during times when Salmon fishery is not allowed.
Two of the projects focused on modifications of the trap or fish chamber while the other two tried out selective ways of emptying a trap.

Harmless method for emptying pontoon traps fishing Salmon and Whitefish (PWH-1)

- Aim: harmless handling of bycaught Salmon by using a hose net or a selection chute when emptying a pontoon trap.
- Modification 1: a hose net attached to the fish chamber to decrease injury on salmon when emptying the trap. Modification 2: a selection chute on the boat as a method to separate Whitefish from Salmon with minimal impact on the bycaught Salmon. In the fish chamber the fiberglass chute was replaced with a tarpaulin to further decrease scale loss of salmon.
- Using a hose net increases emptying time of the trap but the modification successfully decreased the visible injuries on Salmon. Other trials by the Seals and Fisheries Program at SLU has shown that a selection panel inside the hose net further decrease impact on salmon.
- The selection chute worked well and was ergonomic favourable for the fisherman.
- Both modifications were successful and can be recommended for fishing whitefish with minimal impact on bycaught Salmon.

Harmless method for emptying pontoon traps fishing Salmon and Whitefish (PWH-2)

- Aim: separate Whitefish and Salmon by using an extra fish chamber on the trap.
- The trap has an additional fish chamber with a selection panel in the entrance stopping larger fish from entering.
- The selection worked well, 86 % of Whitefish passed the selection panel while 90 % of Salmon did not pass.
- The disadvantages are that the construction is weather sensitive and is an expensive investment for the fisherman.
- Economic incentives for investing in new gear as well as changes in fishing regulations are needed for implementation.

Selective pontoon trap for Whitefish (PWH-3)

- Aim: separate Whitefish and Salmon by hindering Salmon from entering the trap.
- Modification 1: a 2 m deep prohibiting net was hung in the entrance to the wings of the trap to stop Salmon, which swims close to the surface, from entering. Below the net the entrance to the trap was open.
- Modification 2, selection panel: a selection panel in the entrance to the fish chamber which allows smaller fish (Whitefish) to pass and larger (Salmon) to turn around.
- Both modifications decreased catches of Salmon but also Whitefish significantly.
- The modifications cannot be used when catches of Salmon are large.

Selection chute to separate salmon from whitefish when fishing whitefish with pontoon traps.

4.3 Selective and seal safe pot fishery for Cod, Lobster and flatfish (PPOT)

In total six different trials have been performed (Table 2.1, fact sheet PPOT) to develop the pot fishery targeting Cod, Lobster and flat fish species. Main objective was to develop selective and seal safe pots for multi target species use. At the Swedish east coast pots were developed to target cod and flat fish species, while target species at the west coast were lobster and cod.

Seal safe, development of a selective gear for Cod

- Aim: gain knowledge about how Cod may be attracted during a prolonged period of time to a certain fishing spot. Further, attracting the Cod into a larger pot equipped with multiple entrances and exits with barriers for preventing escapes.
- The possibility to attract Cod using white and green light was studied. A certain pot type was developed to catch the attracted Cod.
- Cod, preferably smaller individuals, are attracted by both white and green light.
- The pot developed for the study didn't catch any Cod during the trial period.
- The method using light to attract Cod along with the pot type are not ready for implementation. Further studies are needed on how light attraction affect Cod catchability.

Seal safe, selective pot fishing targeting Cod and flatfish (PPOT-1)

- Aim: evaluation of a foldable pot targeting Cod and flatfish, suitable for smaller vessels.
- A foldable pot type using target species specific entrances was evaluated.
- The pot caught cod in the same quantity as similar non-foldable pot types.
- No flatfish where caught regardless of entrance type.
- The foldable pot type is ready for implementation in the coastal fishery targeting cod as it shown on sufficient catch ratios.

Seal safe, selective pot fishing targeting Cod

- Aim: evaluation of a Cod pot with a frame made from composite material.
- A light, partly foldable pot was developed and evaluated for targeting Cod.
- The pot caught Cod in the same quantity as similar pot types.
- The pot type was more susceptible for damages inflicted by external sources, as seal and coarse substrate.
- The pot type is not ready for implementation in the fishery predominantly due to its susceptibility to damages, why modification of the material and construction is needed. Moreover, the pot type show on sufficient catch rates.

Seal safe, selective pot fishing targeting flatfish

- Aim: evaluation of a lead net equipped pot, targeting flatfish.
- The pot showed on low catch rates for the target species Flounder and Turbot.
- The pot type is not ready for implementation due to a combination of low catch rate and few fishing occasions. More studies are needed to fully evaluate its potential within the fisheries.

Development of predator safe multi species pots (PPOT-2)

- Aim: evaluation of a baited, multi species pot targeting shellfish and Cod.
- Different pot types, entrances and bait types were evaluated.
- Fine mesh size has to be used to reduce seal inflicted damage of the catch.
- Different selection panel windows have to be tested to reduce bycatch of smaller fishes
- There are now pot types catching both fish and shellfish. A matter which is valuable for the interest of using seal safe pots.
- However, Cod catches were low as a result of a low cod population in the area. To allow for better catch rates of Cod, Cod populations along the Swedish west coast has to increase.

The entrance of a pot can be adapted to the target species.

4.4 Potting for *Pandalus* (PPRA)

There is interest for a selective and small scale alternative to *Pandalus* trawling. Two projects have been conducted in order to evaluate pots as a commercial alternative to trawl (Table 2.1, fact sheet PPRA). The trials have been conducted in the Gullmar fjord on the Swedish west coast, where the catch rates of different pot and bait types have been evaluated.

Shrimp pots (PPRA-1)

- Aim: evaluate different pot models for catching *Pandalus*.
- Eight different pot models were tested for shrimp fishery in the Gullmar fjord.
- The best catching pot model had a mean catch of 10 shrimps per hauling occasion, ranging between 0 and 129 individuals.
- The best catching pot model was a larger pot, equipped with two oval entrances on its sides.
- The best catching pot also caught a significant amount of Norwegian lobster.
- The pot type is ready to implement within the fishery.

Shrimp pots (PPRA-2)

- Aim: evaluate different pot models and bait types for catching *Pandalus*.
- Eight different pot models were tested. Besides Herring as bait, light with three different wave lengths were tested.
- The best catching model was equipped with two oval side entrances and a roof entrance.
- All three wave lengths increased shrimp catch with a factor of three, however light simultaneously decreased the catch of Norwegian lobster to one third.
- Wave length have also a species specific effect on catch rate of fish bycatch.
- Pots and light are ready to implement within the fishery.

5 Evaluation

5.1 Scope and priority areas

Overall the 34 funded project covers most of the initial priorities decided by the steering group. Table 5.1 shows the number accepted of projects per year and fishery, and the number of declined proposals per fishery. Furthermore, the budget distribution between fisheries is indicated. Priority areas not covered by any funded projects are also listed in the table. The reason why these areas was not covered was that the secretariat did not receive any ideas from the industry for these categories or that the quality of suggested projects was considered too low. Survival of bycatch and development of gillnet and seine was listed as a priority by the steering group. Survival of bycatch was not covered within the work done by the secretariat. However, discard survival of trawl and creel caught *Nephrops* was covered in a related project by SLU Aqua, which was funded by other sources. Several project to increase the survival rate of bycatched Salmon was also done (PWH).

Table 5.1. Number of projects by fishery, area (B=Baltic sea, K=Kattegat and S= Skagerrak) and year, total number of refused project and economical distribution, between fisheries.

Fishery		Area	2014	2015	2016	2017	Refused	Budget
Baltic cod trawl	ACOD	B		1	2		3	11%
Demersal fishery - fish	ADEM	K&S	1	1	1	2	3	21%
Nephrops trawl	ANEP	K&S	2	1	1		2	12%
Pandalus trawl	APRA	K&S	2	1	2		2	26%
Pelagic trawl	APEL	S		1	1			6%
Development pot	PPOT	B, K&S	1	1	3	2	3	8%
Development Pandalus pot	PPRA	K&S		1	1			4%
Handling of bycaught salmon	PWH	B	2	1	1		1	4%
Development Push-up trap	PPU	B, K&S			2			7%
Development gillnet								
Development seine							1	
Survival bycatch							2	
Other (no priority)							2	
Sum			8	8	14	4	19	100%

5.2 Management measures

5.2.1 Legislation

The allowed design characteristics of fishing gears are often regulated in either EU or national technical conservation measures. When a new gear is developed it is therefore necessary to check the legality before it is put forward and used. Often however, as seen for many of the projects summarised in this report (Table 2.1), new gears do not conflict with the regulations in force. If the new gear is not legal to use there are different ways to tackle this depending on whether it is a EU or national issue. EU member states cooperate in regional groups and have the possibility to send a scientifically justified proposal in the form of a joint recommendation to COM. The joint recommendation can, among other specified subject areas, include proposals to adopt rules about revised gear specifications provided they are at least equal in terms of selectivity as the minimum requirements for the gears legislated in a particular fishery today. If COM, normally after review by STECF, judges that the proposal is satisfactory they can introduce the new gear via a delegated act. Scientific reports from projects ran via the selective fisheries secretariat has been used in such regional proposals and have been adopted by COM. Sweden also has the authority to adopt national rules provided they are at least as strict as operative EU legislation.

5.2.2 Incentives for up-take of new selective fishing gears

For the new gears evaluated in this report that work as intended, industry up-take is non-existent or limited (light green projects in Table 2.1). There are several reasons for a limited up-take of innovative new selective fishing gears:

- The investment costs of replacing functioning gears.
- Traditions and the sense of security of using gears that are familiar and well known.
- Variability in size selectivity (selection range) can cause losses of individuals >MCRS, and thus less income. This must though be weighed against the purpose of the new gear, i.e. a reduced risk of catching unwanted fish with no/low value.
- The landing obligation is not yet fully phased-in or fully implemented. Several of the gears developed under the selective fisheries secretariat 2014-2017 can help with mitigation of choke species situations in certain fisheries. Major up-take of these (or similar) gears will not happen as long as the detection risk of illegal discards is minimal.
- Individual fishers that act as forerunners by the use and promotion of new gears are often subject to strong peer pressure from colleagues that do not want any changes.

The quickest way to increase the implementation of new gears is to change the legislative requirements. Another less drastic and efficient way to stimulate up-take is by positive special treatment, whereby the new gear is given extra advantages compared to the traditional gear that managers want to phase-out. Examples of such advantages are extra quota allocations (including using the quota top-ups for benign gears), access to valuable areas or periods that cannot be accessed when using the traditional gears.

One example of such positive special treatment is the way the Swedish *Nephrops* fisheries were managed until 2016. The quota was allocated between three principal fisheries (creel, Swedish grid trawls and conventional trawls) in such a way that vessel that opted to fish with the selective creels or grid trawls were never quota limited. In addition, creel and grid fisheries was also unlimited in terms of allowed days at sea and were granted access to valuable *Nephrops* grounds where conventional trawls did not have access. This incentive structure had large effects on the gear use in the Swedish *Nephrops* fleet, with accompanying reduced pressures on unwanted catches and on the sea floor[4].

[4] Hornborg, S., Jonsson, P., Sköld, M., Ulmestrand, M., Valentinsson, D., Eigaard, O. R., Feekings, J., Nielsen, J. R., Bastardie, F., and Lövgren, J. 2016. New policies may call for new approaches: the case of the Swedish Norway lobster (*Nephrops norvegicus*) fisheries in the Kattegat and Skagerrak. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsw153.

6 Appendix

6.1 Fact sheet Active gear

ACOD-1

ACOD-2

APRA-1

ANEP-1

ANEP-2

ADEM-1

ADEM-2

ADEM-3

ADEM-4

APEL-1

6.2 Fact sheet Passive gear

PPU-1

PWH-1

PWH-2

PWH-3

PPOT-1

PPOT-2

PPRA-1

PPRA-2

6.3 List of Aqua report references

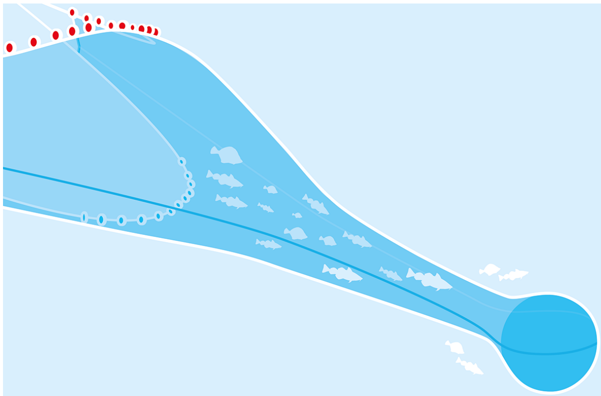
Baltic cod fishery – modified T90 codend design (phase II)

ACOD-1

- to decrease catch of undersized cod in the Baltic trawl fishery

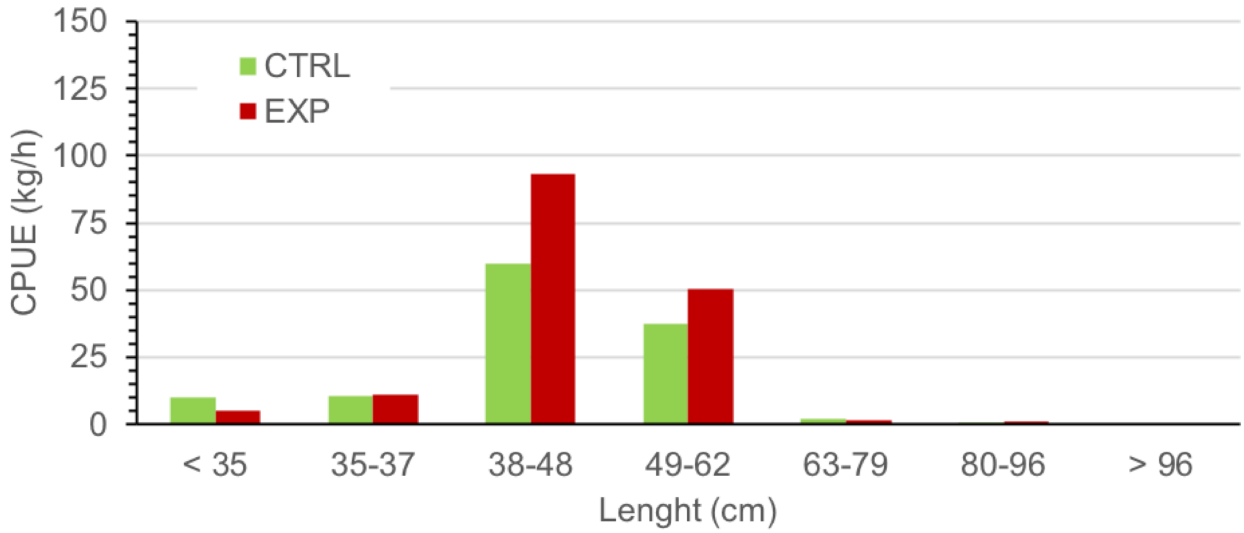
Fishery / target species: Baltic cod trawl fishery / Cod
Area: Baltic sea, ICES SD 22, 24-32
Vessel: GG-500 Vingaskär, LOA 23.7 m / 490 kW
Gear type: Baltic cod codend, T90/120mm
Gear modification: Increased no. of meshes in the circumference, decreased mesh size and increased length of codend compared to a standard T90 codend
Number of haul: 11 twin-rig

Gear design (EXP=experimental codend and CTRL= standard codend)



Gear parameters	EXP	CTRL
Mesh size (mm)	115	121
Thread (n/mm)	2/4	2/4
Material	PE	PE
No. of mesh in the circumfrence	80	50
Length (m)	9	6

Results (average catch of cod per unit effort in the different size classes)



Conclusion

- Significantly reduced catch of cod below 34 cm length.
- Significantly increased catch of cod between 38 and 52 cm length.
- Since 1 of January 2018 is this codend legal and described in regulation EU 2018/47.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: hans.nilsson@slu.se
www.slu.se/selective-fishing/en

Multi-selective trawl for Cod

- Reducing the bycatch of Flounder and Cod below MCRS

Fishery / target species: Baltic cod trawl fishery / Cod

Area: Baltic sea, ICES SD 22, 24-32

Vessel: KA-250 Almy West, LOA 22.5 m

Gear type: Demersal fish-trawl

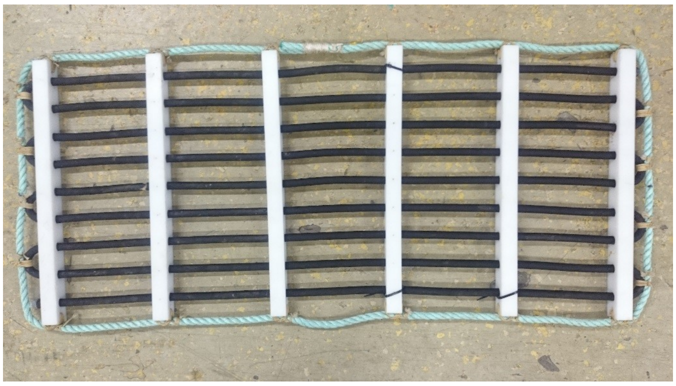
Gear modification: Posterior extension of the trawl was equipped with two vertically angled and two horizontal grids. Guiding nets forced the fish towards the selective surfaces. A ring-system with large meshed net was mounted between the belly of the trawl and the extension.

Number of haul: 20 alternating TEST and CTRL

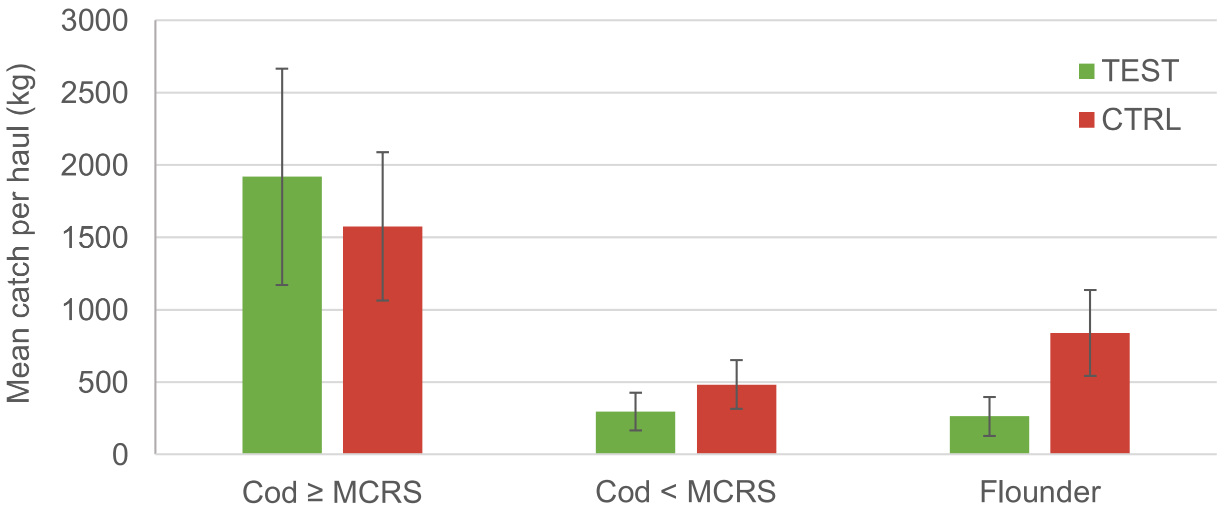
Gear design: A = Ring-system with large mesh. **B** = Picture showing one of the flexible grids used in the extension

A

B



Results (average catch of Cod and Flounder per haul)



Conclusion

- The multi-selective trawl retained significantly less Cod below 33 cm.
- The multi-selective trawl reduced the catch of flounder with about 70%.
- More studies is needed to determine which components of the gear that influenced selectivity and fishing efficiency.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: hans.nilsson@slu.se
www.slu.se/selective-fishing

A combination grid for Northern prawn trawls

- to reduce catches of small Pandalus

Fishery / target species: Bottom trawling for Northern prawn (*Pandalus borealis*)

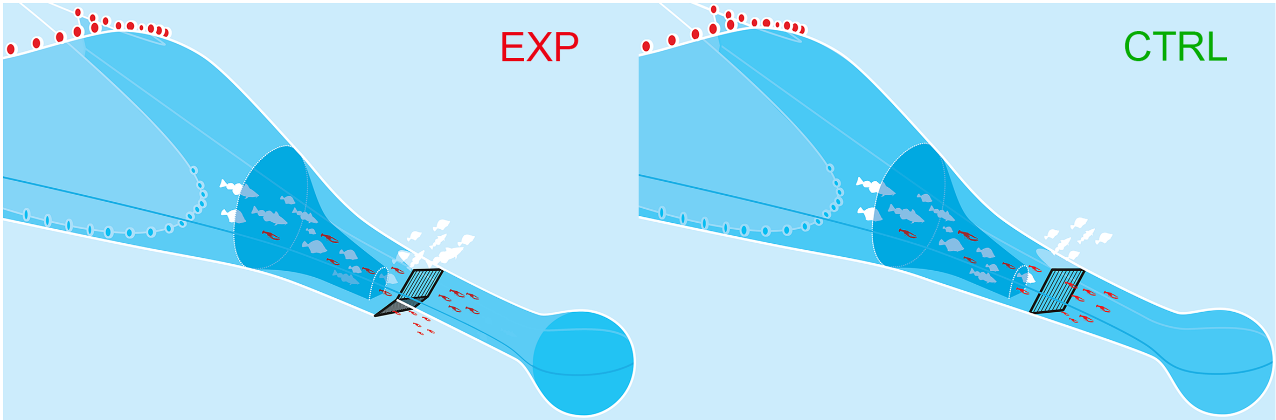
Area: Skagerrak, Kattegatt and eastern North Sea (ICES divisions 3.a and 4.a East)

Vessels: SD 511 Eros III, LOA 15,3 m / 245 kW och GG 707 Arkö, LOA 26,1m/736 kW

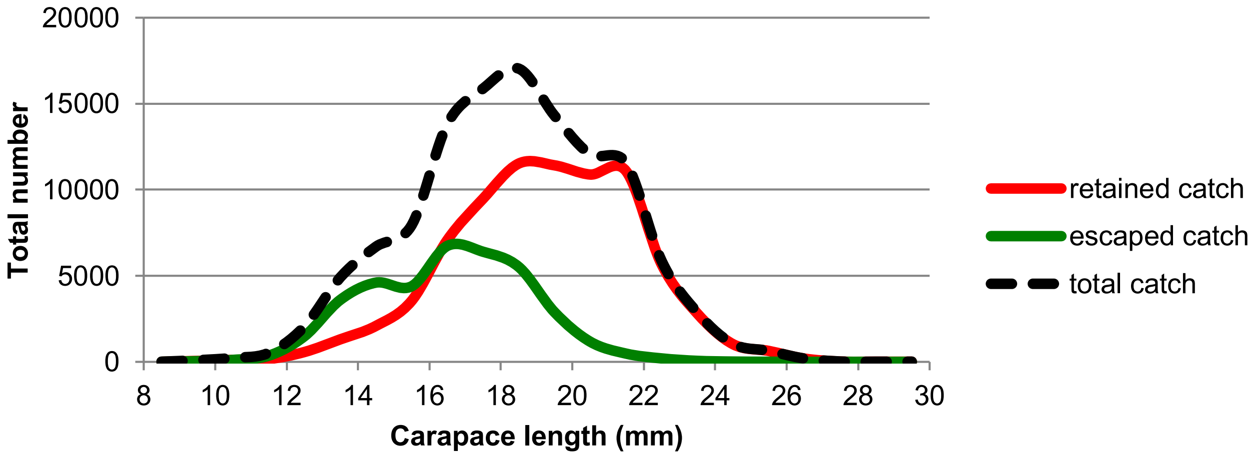
Gear: Northern prawn trawl with Nordmøre grid

Gear modification: A two-section Nordmøre grid that combines species- and size selectivity in *Pandalus* trawls. The lower grid section has narrow (9-10 mm) bar spacing to sort out small shrimp and the upper grid section has standard 19 mm bar spacing to sort out fish by-catches

Experimental design (**EXP**=experimental trawl, **CTRL**= standard trawl)



Results (retained and escaped *Pandalus* by size)



Conclusions

- The combination grid sorted out unwanted sizes of *Pandalus* effectively. At least 60 % of the smallest shrimp fraction was sorted out, but also catches of medium sized (industrial) shrimp was reduced significantly.
- Loss of the largest (fresh consumption) shrimps was around 5 % but was affected by the choice of lower grid bar spacing
- The combination grid is legal to use but additional incentives are probably needed due to limited up-take in the fishery

The Swedish Secretariat for Selective Fishing
Department of Aquatic Resources (SLU Aqua)

contact: daniel.valentinsson@slu.se
www.slu.se/selektivtfiske

An improved Swedish grid: Combination grid for *Nephrops* trawls

ANEP-1

- to sort out all sizes of fish by-catches and small *Nephrops*

Fishery / target species: Directed bottom trawling for Norway lobster (*Nephrops norvegicus*)

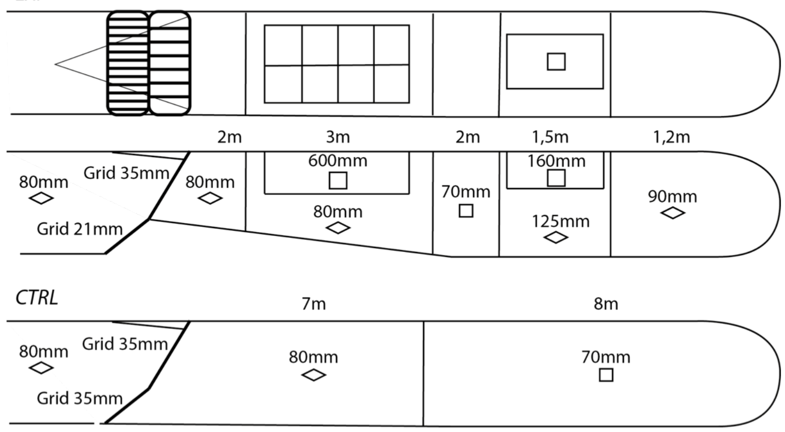
Area: the Skagerrak and Kattegat, ICES SD 20, 21

Vessel: VG 350 Althea, LOA 16,7 m / 405 kW

Gear: *Nephrops* grid trawl

Gear modification: A two-section Nordmøre grid for improvement of *Nephrops* size selectivity and an improved codend design to minimize fish by-catches: The lower grid section has narrower (21 mm) bar spacing to sort out small *Nephrops* and the upper grid section has standard 35 mm bar spacing. A composite codend with diamond- and square mesh sections and additional escape panels.

Experimental design (**EXP**=experimental trawl, **CTRL**= standard Swedish grid trawl)



Results (Average catches for the dominating species in the CTRL and EXP trawl and difference (in %). Significant differences are indicated in the far right column. (ns=p>0,05, *<0,05, **<0,01, ***<0,001.)

Species (weight)	CTRL	TEST	Difference (%)	sign.
Nephrops tot	28.4	21.1	-26	***
Nephrops legal	20.15	17.8	-12	*
Nephrops small (<13cm)	8.26	3.3	-60	***
Cod	5.17	1.27	-75	***
Plaice	21.7	8.3	-62	*
Dab	60.1	8.12	-86	***
Long rough dab	17.8	2.49	-86	***
Whiting	5.3	1.2	-77	*

Conclusions

- The improved grid design reduced catches of *Nephrops* <13 cm by more than 50 %, with a limited loss of prawns >13 cm compared to the standard Swedish grid.
- The improved design showed large reductions in catches of cod, whiting, dab, plaice and long rough dab compared to the proven highly selective standard Swedish grid.
- The tested gear is legal to use outside coastal waters in Sweden. However, the lowered MCRS (to 10,5 cm) for *Nephrops* in area IIIa at the onset of the landing obligation in 2016 drastically reduced incentives for industry up-take..

The Swedish Secretariat for Selective Fishing
Department of Aquatic Resources (SLU Aqua)

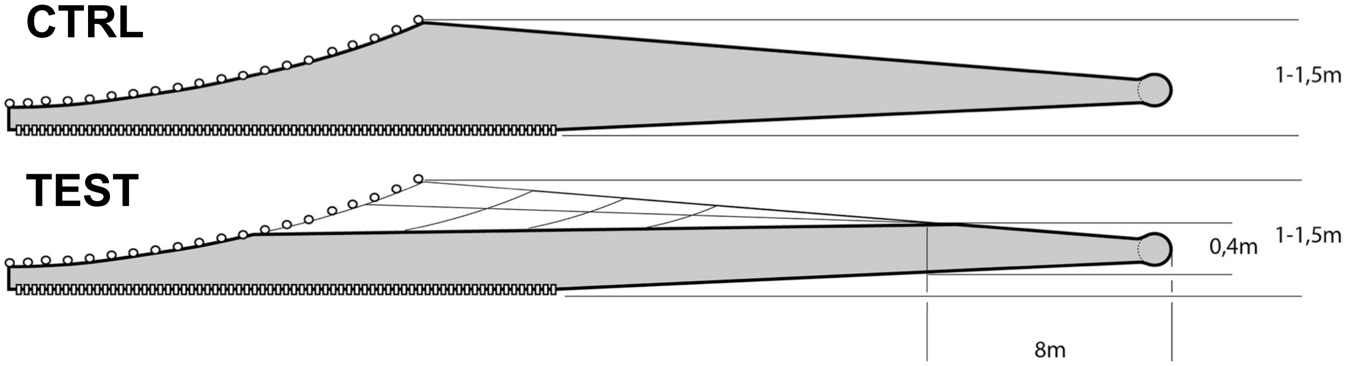
Contact: daniel.valentinsson@slu.se
www.slu.se/selektivtfiske

Topless trawl reducing bycatch in Neprops fishery

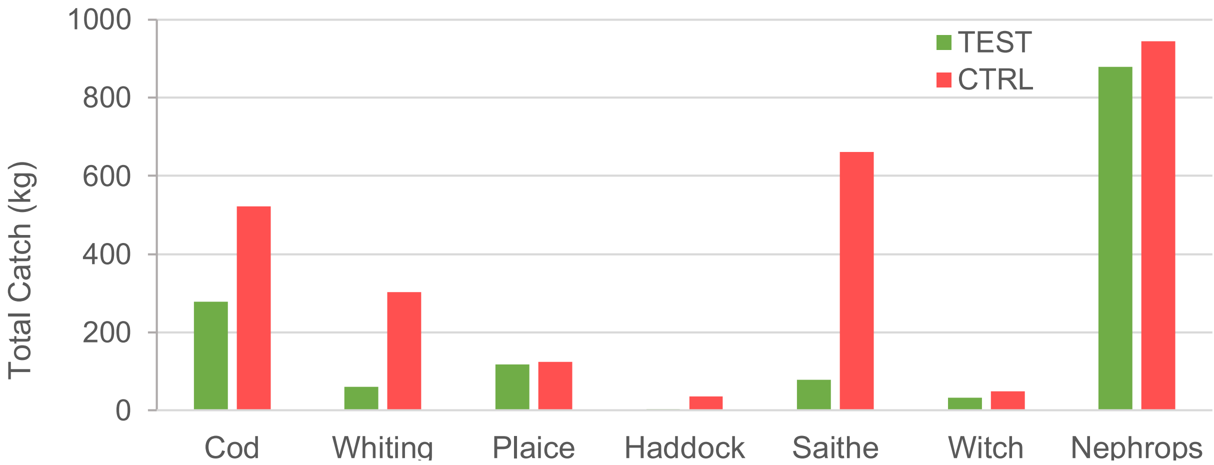
ANEP-2

Fishery / target species: Demersal trawl fishery / Nephrops
Area: Skagerrak, Kattegat, ICES 20 / 21
Vessel: GG 840 Rossö, LOA 24 m / 551 kW
Gear: Nephrops trawl
Gear modification: The top panel of the trawl was removed

Gear design (**CTRL**= standard nephrops trawl, **TEST** = Low topless trawl)



Results (Total catch)



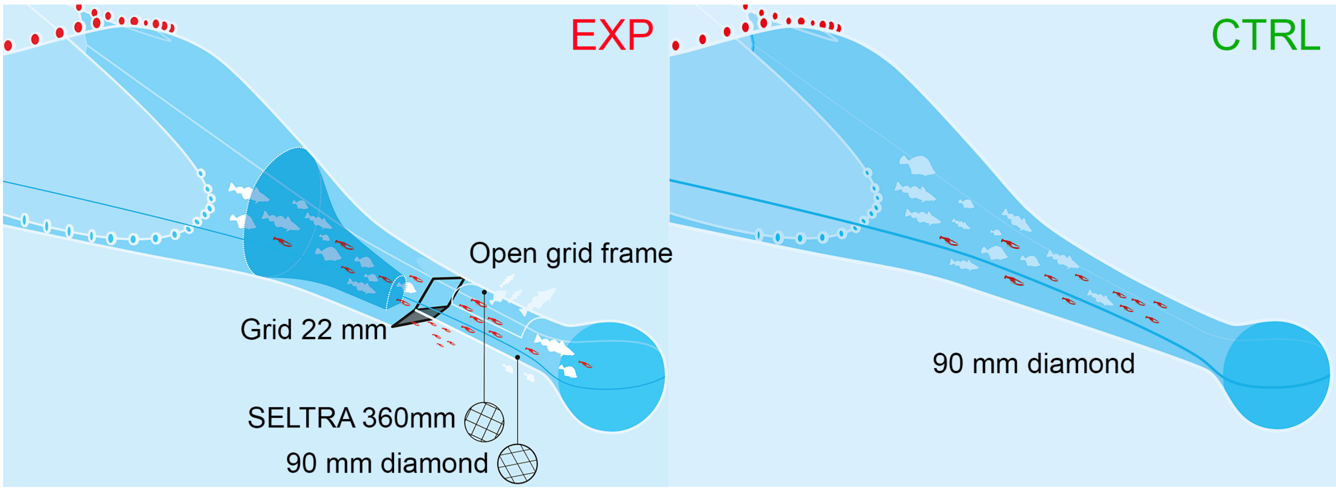
Conclusions

- Bycatch of Haddock, Saithe and Whiting was reduces with > 80%.
- Bycatch of Cod was reduced with 47%
- Reduction in the catch of the target species was marginal to nonexistent

Reduced bycatch of undersized Nephrops and fish

Fishery / target species : Demersal trawl fishery / Mixed fishery
Area: Kattegatt. ICES IIIa
Vessel: VG-97 Tärno. LÖA 15.1 m / 112 kW och VG-117 Kungsvik. LÖA 17 m / 339 kW
Gear type: Size selective grid (22 mm) and SELTRA codend (360 mm)
Number of haul: 17 twin-rig

Gear design (EXP=experimental codend and CTRL= standard codend)



Results (average catch in CTRL and EXP codend and % difference

Species	Unite	EXP	CTRL	Diff.
Nephrops	Antal (<40mm)	154	354	-57%
	Antal (≥40mm)	282	312	-10%
Haddock	Weight (kg)	4.6	4.0	16%
Hake	Weight (kg)	2.0	2.8	-28%
American plaice	Weight (kg)	1.6	5.2	-70%
Plaice	Weight (kg)	27.8	35.3	-21%
Dab	Weight (kg)	2.8	8.1	-66%
Cod	Weight (kg)	11.7	30.9	-62%

Conclusion

- The size selective grid reduce catch of undersized Nephrops and smaller American place and Dab
- SELTRA-codend reduce the catch of Hake and Cod, but not Haddock

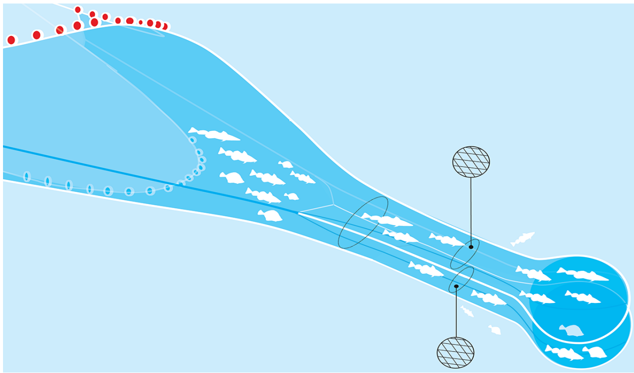
Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: Johan.lovgren@slu.se
www.slu.se/selective-fishing/en

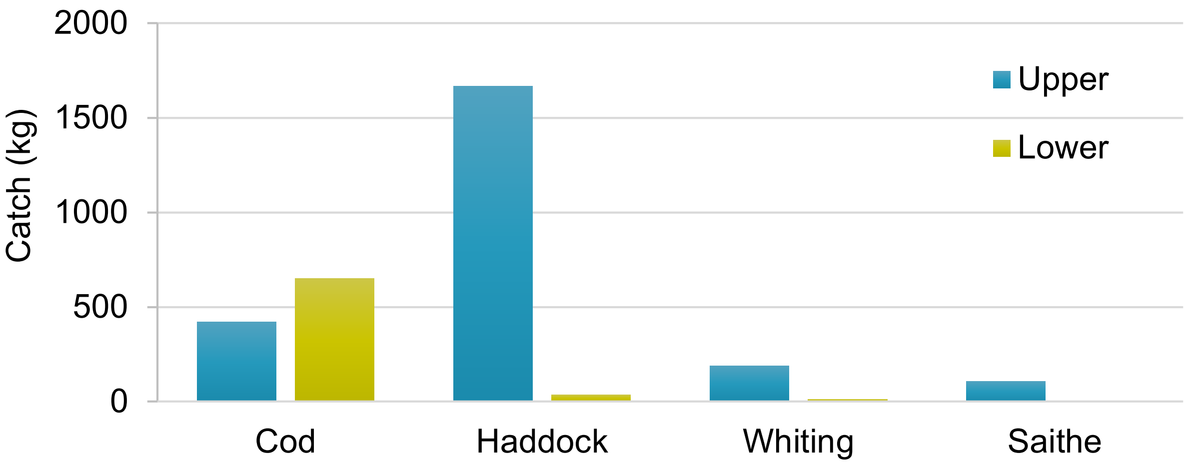
Horizontally divided trouser trawl for species specific catch separation

Fishery / target species : Demersal trawl fishery / Round fish
Area: Skagerrak/Kattegatt, ICES 20/21
Vessel: GG-840 Svanen. LOA 24 m / 578 kW
Gear type: Horizontally divided trouser trawl
Gear modification: The trawl was divided internally in two sections, each section ended with a separate extension and codend

Gear design



Results (Total catch of commercial fish in each compartment)



Conclusion

- In weight 90 – 99% of all Whiting, Haddock and Saithe was caught in the upper part.
- There was no significant difference between upper and lower part in weight of Cod, however, the number of individuals was significantly higher in the lower part.
- The species specific selection properties of the horizontally divided trouser trawl allows the fishermen to control the composition of the catch and thereby reduce the catch of limited stocks.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)
Contact: hans.nilsson@slu.se
www.slu.se/selective-fishing

Relative selectivity in three alternative codends in the Skagerrak and Kattegat

- is fish size selectivity equivalent?

ADEM-3

Fishery / target species: Demersal mixed Nephrops/fish trawling

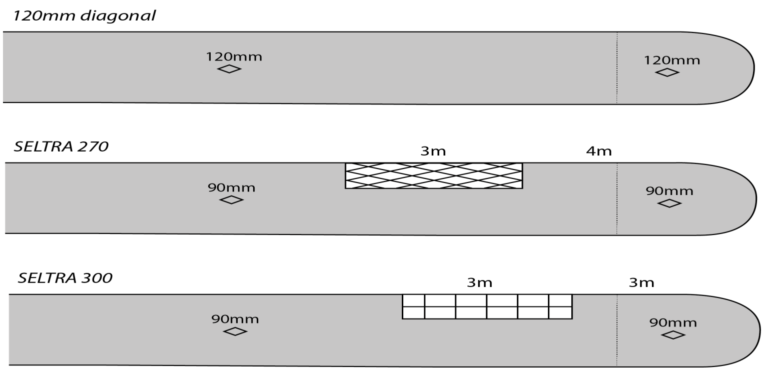
Area: the Skagerrak and Kattegat, ICES SD 20, 21

Vessels: VG 117 Kungsvik, 17,0 m, 339 kW och FG 96 Cindy Vester, 18,0 m, 300 kW.

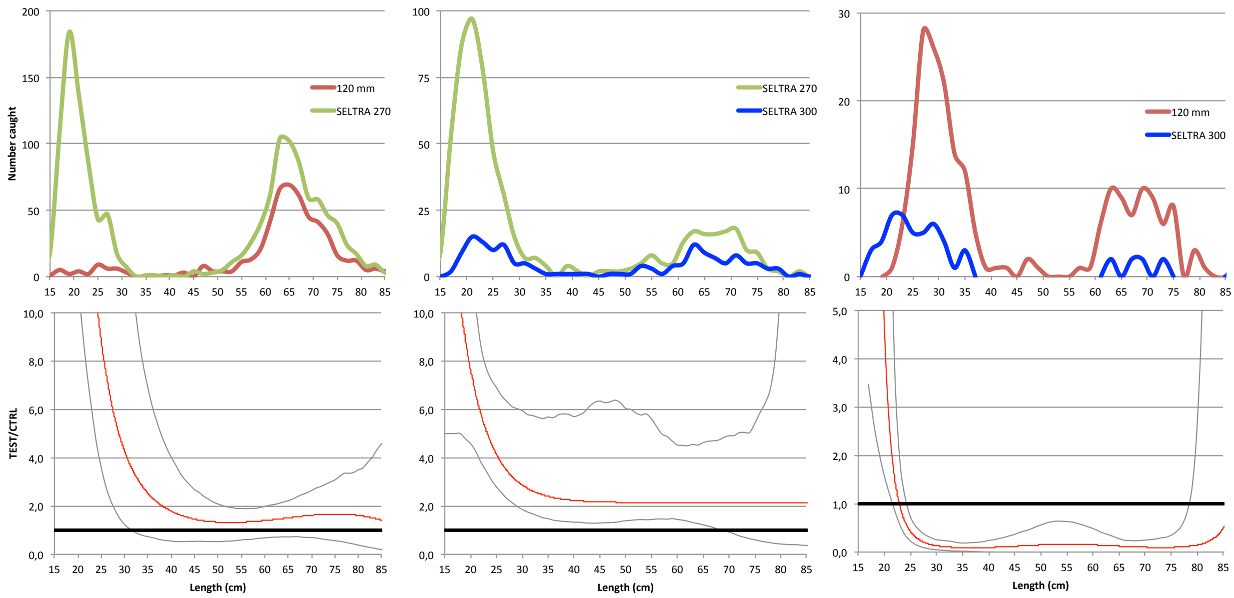
Redskap: Demersal trawl

Modifikation: 90 mm lyft med takpanel av 270 mm diagonalmaska monterad 4-7 m framför lyftets slut (SELTRA 270), samt 90 mm lyft med takpanel av 300 mm fyrkantsmaska 3-6 m framför lyftets slut (SELTRA 300). 120 mm lyft som kontroll.

Experimental design (120 mm is the baseline gear; the two SELTRA codends arelegal alternatives)



Results Upper panel: numbers caught by codend for each comparison and in lower panel catch ratio over length including 95% conf. limits (grey). Graphs show the results for cod.



Conclusions

- Both SELTRA-variants caught significantly more undersized roundfish (cod, haddock and whiting) than the 120 mm codend. The SELTRA´s also caught more undersized plaice
- Especially SELTRA 270 showed consistently larger catches of small roundfish than both SELTRA 300 and a 120 mm codend
- These results indicate that fish size selectivity is not equivalent for the three codends (as intended by legislators)

The Swedish Secretariat for Selective Fishing
Department of Aquatic Resources (SLU Aqua)

Contact: daniel.valentinsson@slu.se
www.slu.se/selektivtfiske

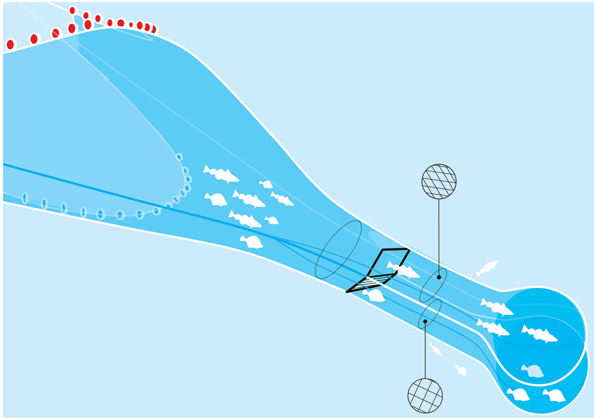
Trawl separating flat- and round fish

ADEM-4

- to separate round and flatfish into different cod-ends and select for large round fish

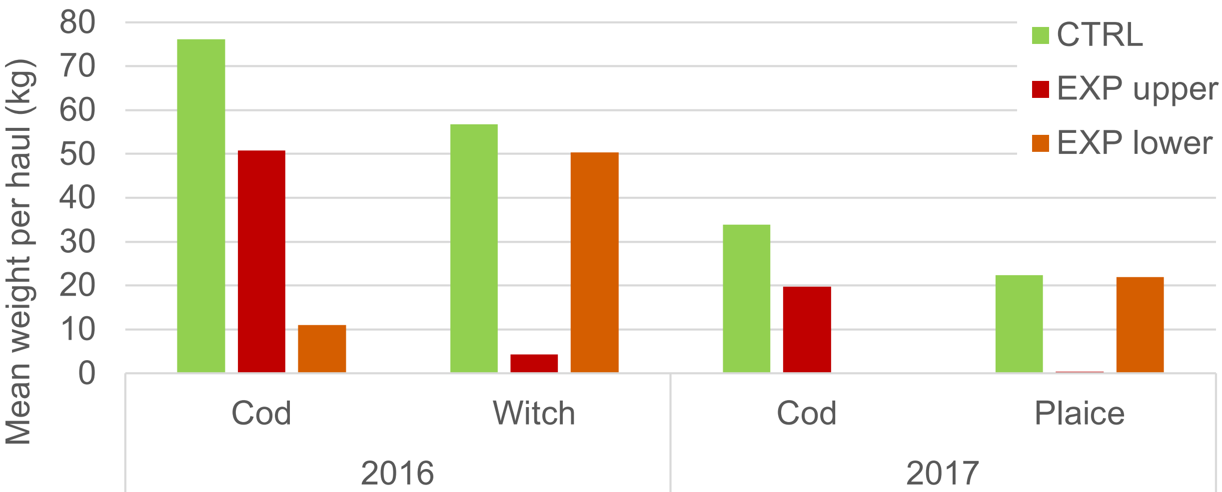
Fishery / target species: *Bottom trawl / 2016: witch flounder and cod, 2017: plaice and cod*
Area: Skagerrak and Kattegat
Vessel: GG 840 Svanen av Rörö, Stefan Larsson, 23.91 m, 578 kW
Gear: Bottom trawl with grid
Gear modification: *The experimental trawl divides the catch going through the grid into two cod-ends. The upper part of the grid is open and attached to the upper codend. The lower part of the grid has horizontal slots and is attached to the lower codend. The mesh size is larger in the upper codend.*

Gear design (**EXP**=experimental trawl and **CTRL**= control trawl)



Gear parameters	Mesh size (mm)	Mesh type	Grid
CTRL 2016	120	diamond	-
EXP upper 2016	220/150	diamond	30 cm opening
EXP lower 2016	120/126/120	diamond/square/ diamond	5-8 cm slot width
CTRL 2017	120	diamond	-
EXP upper 2017	180/200	diamond	50 cm opening
EXP lower 2017	120	diamond	5 cm slot width

Results (Catch comparison)



Conclusions

- Flat fish was primarily caught in the lower cod-end while the opposite was true for round fish.
- No significant difference was found between the trawls regarding catch of witch 2016 or plaice and cod 2017. Cod was caught in a significantly higher amount by the control 2016.
- No significant size difference was found between the trawls regarding witch 2016 or plaice 2017. Fewer small cod were caught in the experimental trawl compared to the control in both years.

The Swedish Secretariat for Selectiv Fishing
Department of Aquatic Resources (SLU Aqua)

Contact: erika.andersson@slu.se
www.slu.se/selective-fishing/en

Grid for eliminating saith from a semi-pelagic trawl

- facilitating escapement of large saith in a herring fishery

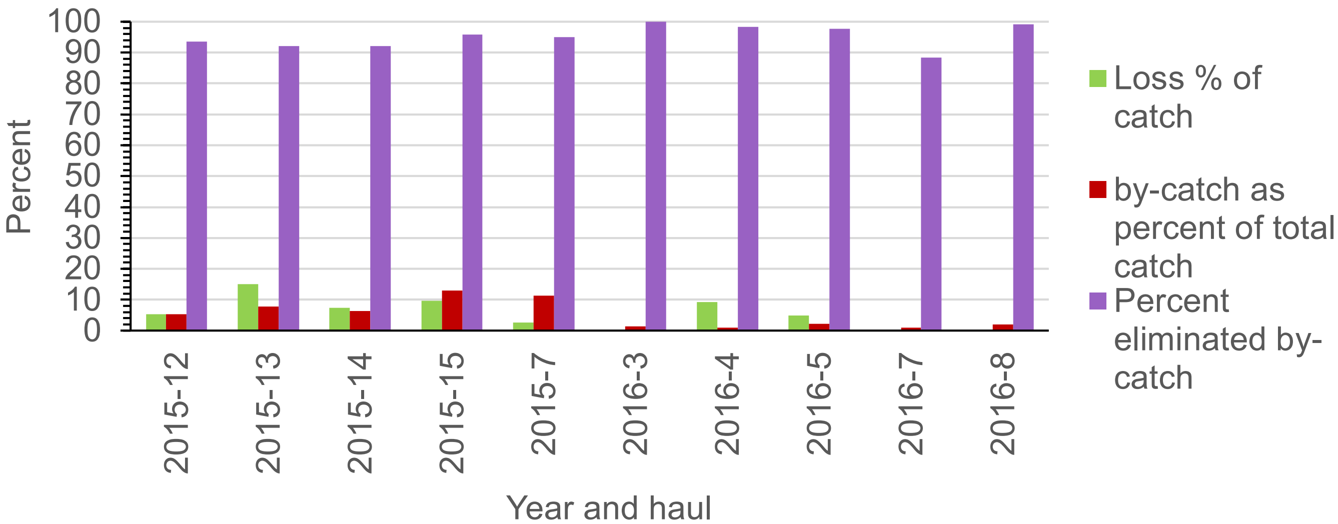
APEL-1

Fishery / target species: Herring for consumer market
Area: Skagerrak
Vessel: GG-330 Carmona, LOA 50 m / 2000 kW
Gear: Gloria 1032, semi pelagic trawl
Modification: Grid with exit in the bottom of the trawl

Gear design

Gear parameter	Grid
Width	3m
Height	3.6m
Material	Polyuretan
Slot posts	12mm
Slot width	50mm
Slot height	200mm

Results (Sorting efficiency and loss of catch)



Slutsats

- 98% elimination of unwanted by-catch, 5-10% loss of catch
- New stiffer material rejected fish > 53 cm to go through the grid
- Optimal size of exit. Increased size of exit facilitated the release of saith without affecting catch efficiency.

Increased selectivity in cod pontoon traps

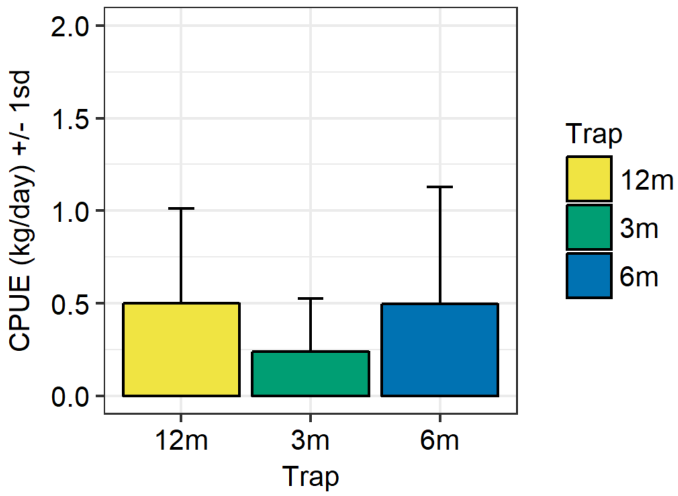
PPU-1

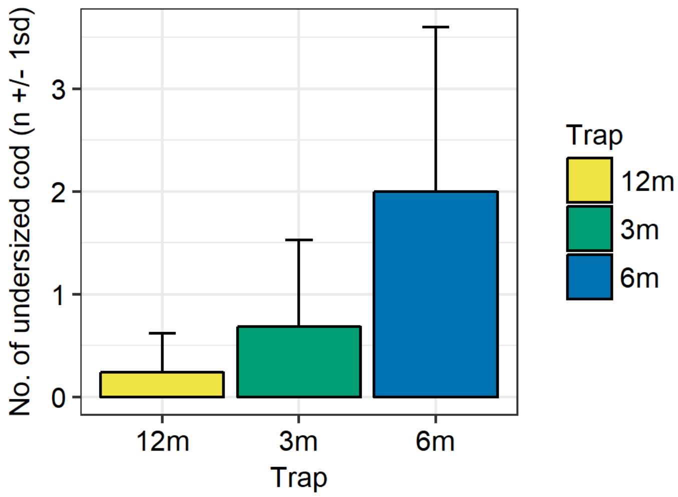
- Evaluation of selection panels in cod pontoon traps

Fishery / target species: Cod (*Gadus morhua*)
Area: Baltic Sea, ICES area 25
Fisherman: Glenn Fridh
Gear type: Pontoon traps in the Baltic Sea
Modification: Development of pot design and light attraction

Gear design Bottom set pontoon traps for cod. Selection panels with different mesh sizes.

Result left: CPUE, mean catch of legal sized (> 38cm) cod per day (kg ± 1sd). Right: Number of discarded (live) cod (n ± 1sd) using selection panel, 40 mm between knots mesh size, (12m) and without selection panel, 20 mm between knot mesh size (3m and 6m).





Conclusion

- Using a 40 mm between knots selection mesh in relation to 20 mm between knots mesh in the pontoon trap fish house may reduce the amount of cod bycatch with 70% to 90%.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Kontakt: peter.ljungberg@slu.se
www.slu.se/selektive-fishing/en

Harmless method for emptying pontoon traps fishing salmon and whitefish

PWH-1

SLU

- Decreasing injuries on bycaught salmon and creating an ergonomic working position for the fisherman

Fishery/ target species: Pontoon traps in the Bothnian Bay. Target species is whitefish.

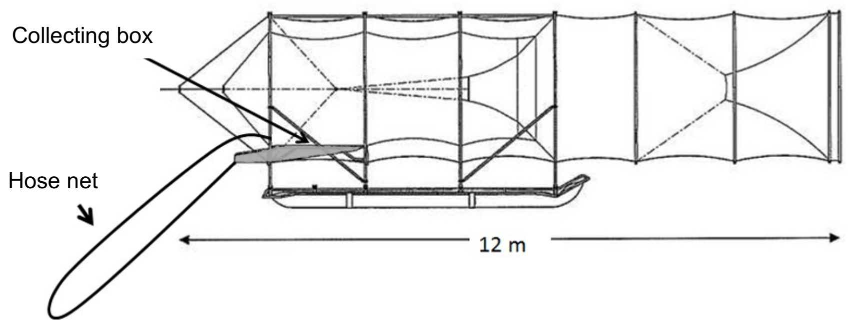
Area: Baltic Sea, ICES SD 31

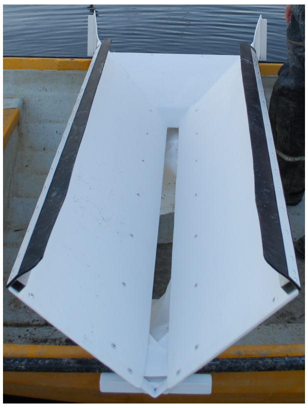
Fishermen: Patrik Blomberg and Gunnar Nilsson

Gear type: Pontoon trap for whitefish and salmon

Gear modification: Gunnar Nilsson used a hose net attached to the collecting box decrease injury on salmon when emptying the trap. Patrik Blomberg used a selection chute on the boat as a method to separate whitefish from salmon with minimal impact on the bycaught salmon. In the fish chamber the collecting box was replaced with a tarpaulin to further decrease scale loss of salmon.

Gear design (Left side: Hose net (8 m knotless hose net, 20 mm stretched mesh) attached to the collecting box in the fish chamber. Right side: The selection chute placed on the boat leading larger fish back to the water.





Results

Gear modification	Catch salmon & sea trout (No.)	Catch whitefish	Comments
Hose net	200	116 kg	No visible damage on the salmon.
Selection chute	156	~15 kg	All whitefish fell through the chute into the boat. 94 % of the salmon and sea trout passed the chute into the water.

Conclusion

- The hose net is easy to fit on a trap and it decreases injuries on bycaught salmon.
- The disadvantage is that it is heavy to handle large amount of salmon and when separating fish in the hose net outside the boat the fisherman is in a bad working position.
- The selection chute decreased emptying time and injuries on salmon. The tarpaulin in the fish chamber also prevented scale loss. The disadvantage is that usage of the selection chute requires good weather conditions.
- Both modifications meet the goal to in a more harmless way separate salmon and whitefish.
- The selection chute is also ergonomic for the fisherman.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: maria.hedgarde@slu.se
www.slu.se/selective-fishing/en

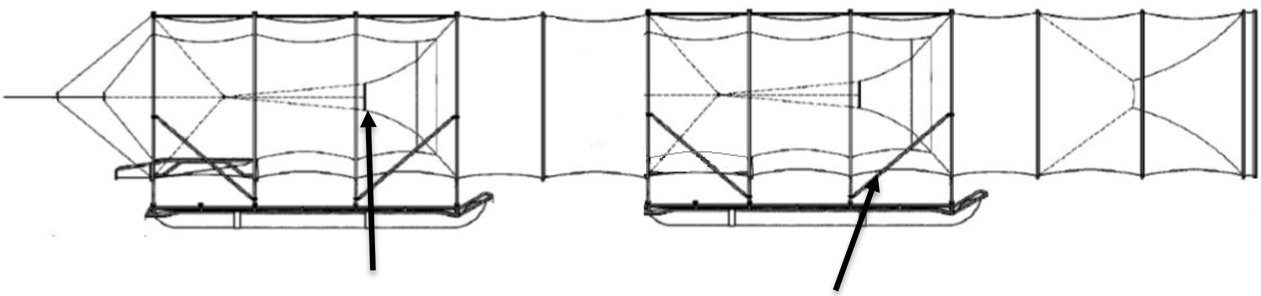
Harmless method for emptying pontoon traps fishing salmon and whitefish

PWH-2

- A trap that separates fish by size to minimize impact on bycaught salmon

Fishery/ target species: Pontoon traps in the Bothnian Bay. Target species is whitefish.
Area: Baltic Sea, ICES SD 31
Fisherman: Linus Bylund. Construction by Harmånger Maskin o Marin.
Gear type: Pontoon trap
Gear modification: The pontoon trap has an additional fish chamber. In the entrance to the second chamber there is a selection panel that allows smaller fish such as whitefish to enter.

Gear design (Salmon are caught in the first fish chamber while smaller fish, such as whitefish, can continue through the selection panel into the second fish chamber)



Selection panel
Whitefish chamber

Hatchway for salmon
Salmon chamber

Results (Catch in the two different fish chambers)

Fish chamber	Salmon	Whitefish	Sea trout
Salmon chamber	96 (90%)	49	17
Whitefish chamber	11	294 (86%)	44 (72%)

Conclusion

- The selection process with two fish cambers was successful. Human handling of bycaught salmon was eliminated by the use of an opening in the salmon chamber.
- The disadvantages are that the construction is weather sensitive and an expensive investment for the fisherman.

Selective pontoon trap for whitefish

PWH-3

SLU

- Decreasing bycatch of salmon in pontoon traps targeting whitefish

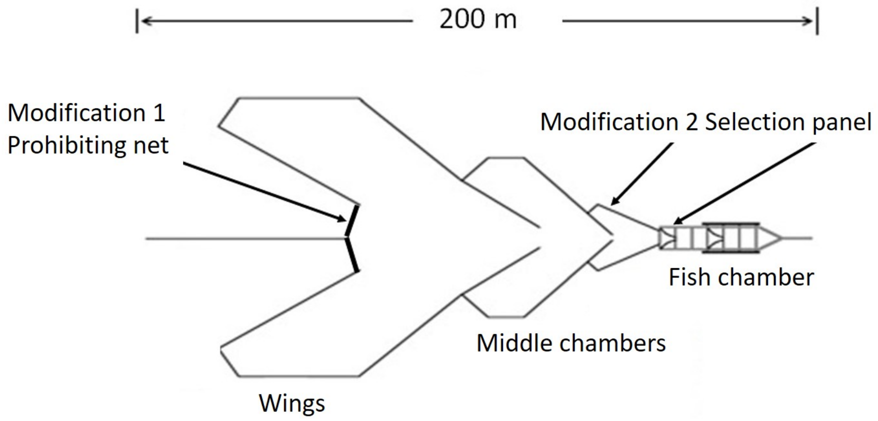
Fishery/ target species: Pontoon traps in the Bothnian Bay. Target species is whitefish.
Area: Baltic Sea, ICES SD 31

Fisherman: Viktor Medström

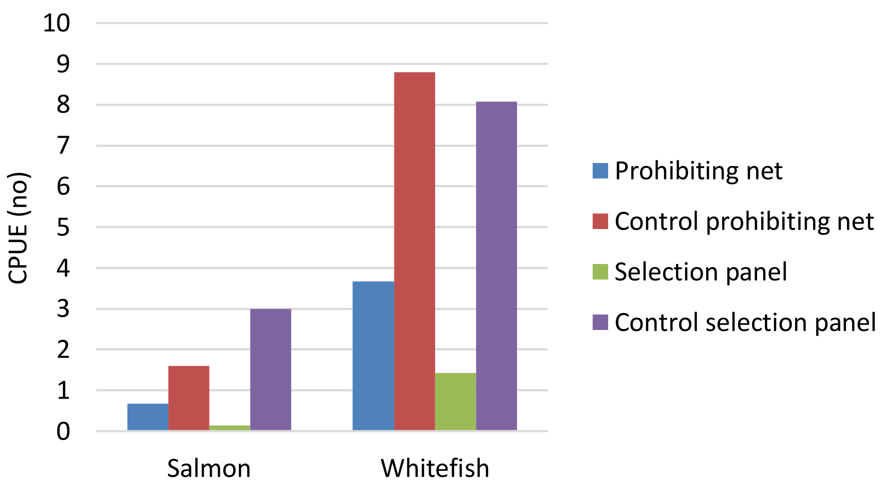
Gear type: Pontoon trap

Gear modification: Modification 1, prohibiting net: A 2 m deep net was hung in the entrance to the wings of the trap. Below the net the entrance to the trap was open. This method is based on behavioural thought differences between species, the salmon swim near the surface while the whitefish approach the trap closer to the bottom. Modification 2, selection panel: A selection panel in the entrance to the fish chamber which allows smaller fish to pass and larger to turn around. An escape hole was opened in the entrance section to let fish escape from the trap to prevent seal damage.

Gear design



Results (Catch using a prohibiting net, selection panel or a control pontoon trap.)



60 % of both salmon and whitefish were stopped by the prohibiting net. When a selection panel was used 95 % of salmon and 83 % of whitefish did not enter the fish chamber.

Conclusion

- A relatively large part of the salmon entered the trap with the prohibiting net while the selection panel successfully decreased catches of salmon.
- Both modifications decreased catches of whitefish significantly and can therefore not be recommended.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: maria.hedgarde@slu.se
www.slu.se/selective-fishing/en

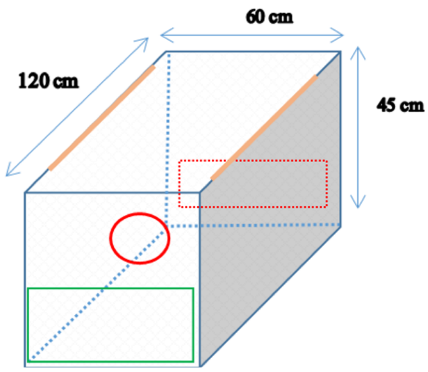
Development of selective pot fishery targeting cod and flat fish

PPOT-1

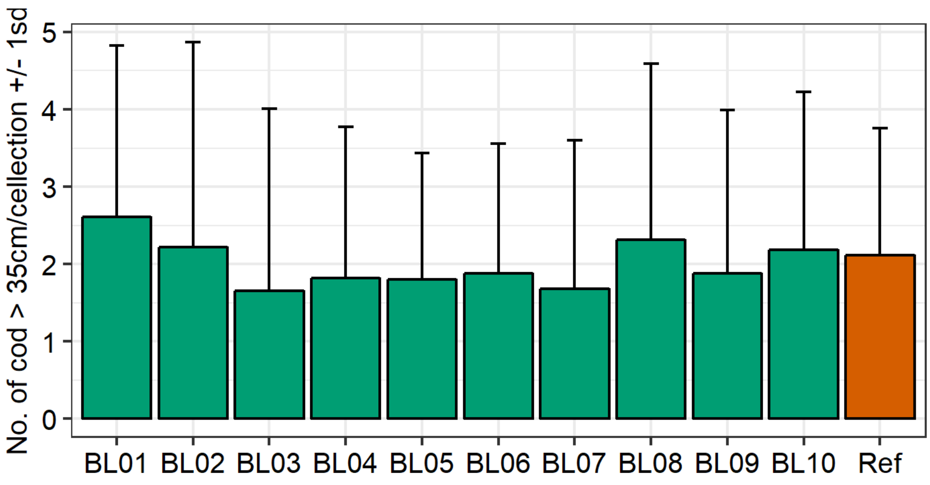
- May a collapsible pot be used in a combined cod and turbot fishery

Fishery / target species: Cod and Turbot
Area: Baltic Sea, ICES 25
Fisherman: Bengt Larsson
Gear type: Collapsible, baited pots in the Baltic Sea
Modification: The pot is modified from an earlier pot model showing good catch rates and have been made collapsible along with being equipped with entrances for turbot.

Gear design
(Main mesh size is 25 mm between knots. Selection panel with mesh size 35 mm between knots. Cod entrance is made from a round metal ring, circumcise 200 mm, while the Turbut entrance is rectangular shaped 400x100 mm)



Result
CPUE, mean catch of cod per haul (n±1sd) for collapsible pots (green) and the reference pot (red).)



Conclusion

- The collapsible pot models (green) show statistically same catch rate of cod as the reference pot (red)., allowing for storage of more pots on the boat.

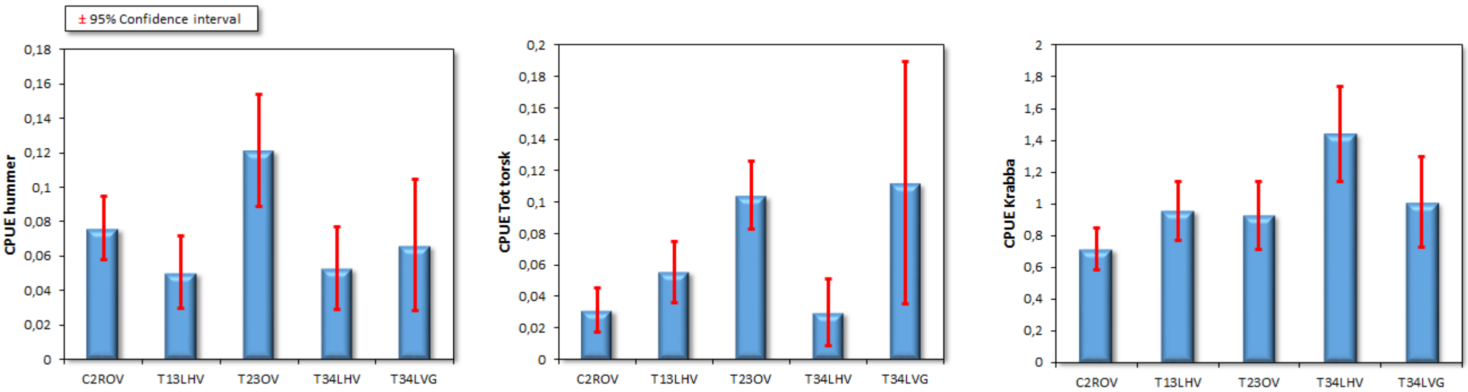
SLU

Developing seal-safe pots for multispecies

Fishery / target species: Lobster (*Homarus gammarus*)/Cod (*Gadus morhua*)
Area: Kattegat and Skagerrak, ICES area 20, 21
Fisherman: Henrik Björklund
Gear type: Pots for multispecies
Modification: Development pot design targeting multi species

Gear design Bottomstanding pots in green polythen with a meshsize of 22 mm (knot to knot) with different numbers of entrances and type of entrance.

Results Figure 1a, b, c. Number of catch per pot and day (CPUE) for lobster (a), cod (b) and crab (c) for the different pot types. Error bars indicate 95% c.i.



1a. b. c.
C2ROV- traditional lobsterpot; T13LHV- Entrance is 3 closed funnel in white mesh material; T23OV - 3 open entrances and a catch chamber; T34LHV- 4 horizontel funnel entrances in white material; T34LVG- 4 vertical funnel entrances in green material.

Conclusion

Catch of lobster per effort were explained by pot type, number of crabs in the pot, soak time, location and fishing period. Pots with open entrances caught more lobster than pots with funnel entrances. Catch of cod per effort was explained by pot type, number of crabs in the pot,nuber of days after fishing started, bait, location and fishing period. The pots that caught the most pots were as for lobster the T23OV a pot in green material with 3 open entrances. Catch of crab per effort was explained by the same variables as for lobster and cod except number of crabs in the pot. All pot types caught the same number of crab.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: sara.konigson@slu.se
www.slu.se/selektive-fishing/en

Shrimp pot, development of pot design

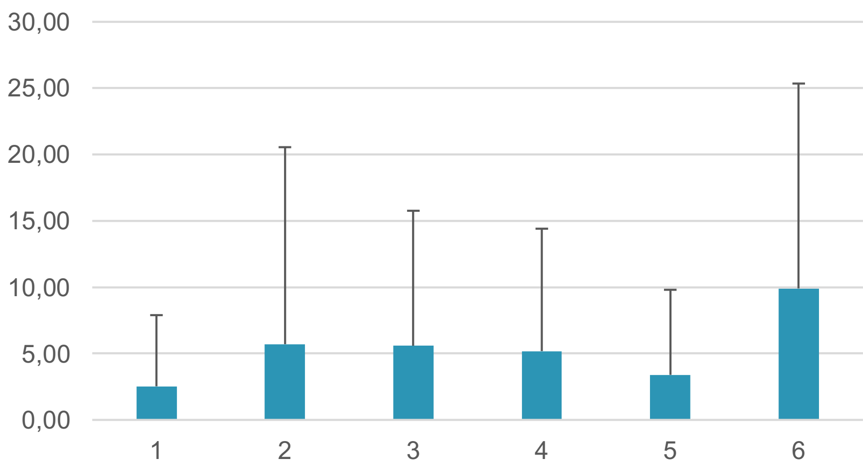
- Evaluating pots in the Swedish shrimp fishery

Fishery / target species: Shrimp pot / shrimp; Nordic prawn (*Pandalus borealis*)
Area: Skagerrak, Gullmar fjord
Fisherman: Robert Roysson
Gear type: Shrimp pot in Gullmar fjord
Modification: Development of pot design

Gear design Frame shape and Mesh size is depending on pot model

The pot type showing highest catch rates (type 6)

Result Mean catch of shrimp (n±1sd) of shrimp depending on pot model. Catch rate varied between 2.3 shrimp in pot 1 to 9,8 shrimp in pot type 6.



x-axis: Pot model
y-axis: Mean number of caught shrimp per collection with carapace length larger than 20 mm. Error bars are 1 sd.

Conclusion

- Our study show how the pot model that was developed within the project, which has side entrances in relation to the conventional top entrance, catch about three times more shrimp than the conventional pot type (pot 5) used in US and Canada.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: peter.ljungberg@slu.se
www.slu.se/selektive-fishing/en

Shrimp pot, development of pot design and light attraction

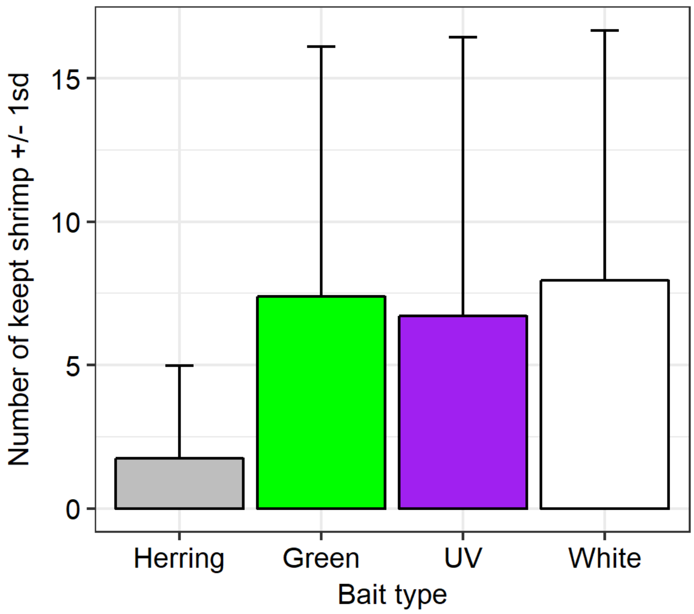
PPRA-2

- Evaluating pots in the Swedish shrimp fishery

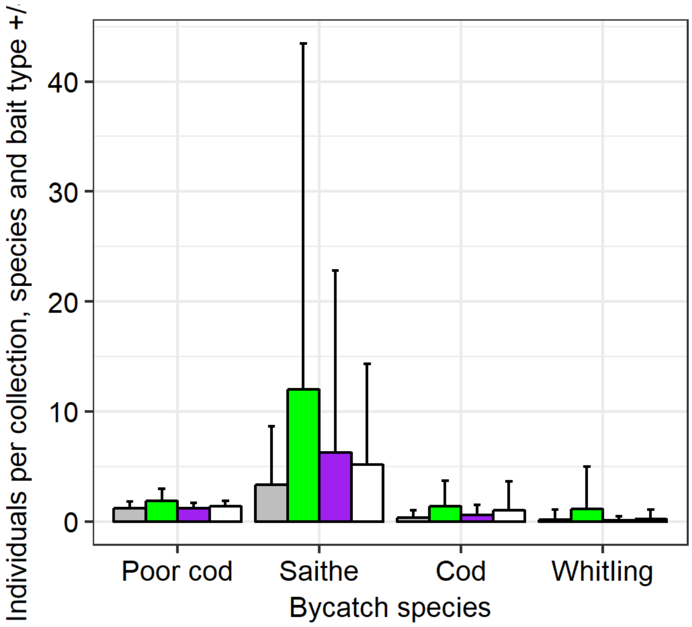
Fishery / target species: Shrimp pot / shrimp; Nordic prawn (*Pandalus borealis*)
Area: Skagerrak, Gullmar fjord
Fisherman: Robert Roysson
Gear type: Shrimp pot in Gullmar fjord
Modification: Development of pot design and light attraction

Gear design Frame shape and mesh size is depending on pot model

Result Light increase shrimp catch.



Mean catch of shrimp (n±1sd) of shrimp with carapace length larger than 20 mm in the bait type experiment, for pots baited with herring, green, UV or white light..



Mean catch of capelin (*Trisopterus minutus*) seith (*Pollachius virens*), cod (*Gadus morhua*) and whitling (*Merlangius merlangus*) in the shrimp pots, depending on bait type (herring, green, UV and white light). The difference in catch rate depending on species is statistically significant for seith, cod and whitling.

Conclusion

- A three time increase in shrimp catch when baiting with light.
- Light will affect the bycatch of commercial species, thus the effect is both species and wavelength dependent.

Swedish secretariat for Selective fishing
Department of Aquatic Resources (SLU Aqua)

Contact: peter.ljungberg@slu.se
www.slu.se/selektive-fishing/en

Appendix 6.3

Active gear	Target species	Main topic	Project	Aqua reports	Contact
Baltic cod trawl	Cod	Size selectivity cod	Improved selectivity in T90-codends in the Baltic cod fishery	2016:8 Ch. 6	hans.nilsson@slu.se
Baltic cod trawl	Cod	Size selectivity cod	Improved selectivity in T90-codends in the Baltic cod fishery phase II	2018:4 Ch. 2	hans.nilsson@slu.se
Baltic cod trawl	Cod	Size selectivity cod, species selectivity flounder	Multifunction selective codend in the Baltic cod fishery	2018:4 Ch. 1	hans.nilsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Increased mesh size 47 mm (diamond and square mesh) in Pandalus trawl	2018:2 Ch. 1	hans.nilsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Testing a Norwegian design of sorting grid to improve Pandalus size selectivity	2018:2 Ch. 2	daniel.valentinsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Sorting grid to improve Pandalus size selectivity	2016:8 Ch. 1	daniel.valentinsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Improved size selectivity for small Pandalus trawlers phase I	2016:8 Ch. 2	daniel.valentinsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Improved size selectivity for small Pandalus trawlers phase II	2018:4 Ch. 7	daniel.valentinsson@slu.se
Pandalus trawl	Pandalus	Size selectivity Pandalus	Flexible sorting grid to improve Pandalus size selectivity	2018:4 Ch. 6	daniel.valentinsson@slu.se
Nephrops trawl	Nephrops	Size- and species selectivity (Nephrops and fish by-catches)	Size selective sorting grid and improved codend design to reduce catches of small Nephrops and by-catch fish phase I	2018:2 Ch. 3	daniel.valentinsson@slu.se
Nephrops trawl	Nephrops	Size- and species selectivity(Nephrops and fish by-catches)	Size selective sorting grid and improved codend design to reduce catches of small Nephrops and by-catch fish phase II	2016:4 Ch. 4	daniel.valentinsson@slu.se
Nephrops trawl	Nephrops	Species selectivity - Reduced catch of roundfish	Low topless Nephrops trawl	2018:4 Ch. 8	mikael.ovegard@slu.se
Demersal trawl	Mixed demersals	Size- and species selectivity (Nephrops and fish by-catches)	Reduced bycatch of undersized Nephrops and fish	2018:2 Ch. 4	hans.nilsson@slu.se
Demersal trawl	Witch and cod	Speceis selectivity-Separation of catches	Separation of roundfish and flatfish by a grid and two cod-ends phase I	2016:8 Ch. 5	erika.andersson@slu.se
Demersal trawl	Cod, saithe, haddock	Species selectivity-Separation of catches	Vertical trouser trawl for separating cod from haddock and saithe	2018:4 Ch. 3	mikael.ovegard@slu.se
Demersal trawl	Mixed demersals	Size selectivity cod, whiting, haddock and plaice	Testing selectivity equivalence for three alternative legislated cod-ends in the Skagerrak-Kattegat mixed fishery	2018:4 Ch. 4	daniel.valentinsson@slu.se
Demersal trawl	Plaice and cod	Species selectivity-Separation of catches	Separation of roundfish and flatfish by a grid and two cod-ends phase II	2018:4 Ch. 5	erika.andersson@slu.se
Pelagic trawl	Herring	Species selectivity-minimize saithe by-catch	Reduced by-catch of saithe in herring trawls by a flexible grid phase I	2016:8 Ch. 7	andreas.sundelof@slu.se
Pelagic trawl	Herring	Species selectivity-minimize saithe by-catch	Reduced by-catch of saithe in herring trawls by a flexible grid phase II	2018:4 Ch. 9	andreas.sundelof@slu.se
Passive gear	**Target species**	**Main topic**	**Project**	**Outcome**	**Contact**
Pontoon trap	Cod	Alternative, selective fishing method - trap	Increased selectivity in pontoon traps targeting cod	2018:4 Ch. 13	peter.ljungberg@slu.se
Pontoon trap	Atlantic mackerel	Alternative, selective fishing method - trap	Can seal safe selective traps targeting atlantic mackerel reduce the seal fishery	2016:8 Ch. 14	sven-gunnar.lunneryd@slu.se
Pontoon trap	Herring	Alternative, selective fishing method - trap	Development of a seal safe and selective trap for herring	2016:8 Ch. 15	sara.konigson@slu.se
Pontoon trap	Whitefish	Harmless treatment of salmon	Harmless method for emptying pontoon traps fishing salmon and whitefish	2018:2 Ch. 5	maria.hedgarde@slu.se
Pontoon trap	Whitefish	Harmless treatment of salmon	Harmless method for emptying pontoon traps fishing salmon and whitefish	2018:2 Ch. 5	maria.hedgarde@slu.se
Pontoon trap	Whitefish	Harmless treatment of salmon	Selective pontoon trap for whitefish	2016: 8 Ch. 8	maria.hedgarde@slu.se
Pontoon trap	Whitefish	Harmless treatment of salmon	Ergonomic and selective method for emptying a pontoon trap	2018: 4 Ch. 16	maria.hedgarde@slu.se
Pot	Cod	Alternative, selective fishing method - pot	Development of a selective pot for cod	2018:2 Ch. 6	sara.konigson@slu.se
Pot	Multi species	Alternative, selective fishing method - pot	Multi species pot	2016:8 Ch. 9	sven-gunnar.lunneryd@slu.se
Pot	Cod and flatfish	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	2018:4 Ch. 10	peter.ljungberg@slu.se
Pot	Cod	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	2018:4 Ch. 10	peter.ljungberg@slu.se
Pot	Flatfish	Alternative, selective fishing method - pot	Evalutaion of seal safe, selective pot fishing for cod and flatfish	2018:4 Ch. 10	peter.ljungberg@slu.se
Pot	Multi species	Alternative, selective fishing method - pot	Multi species pot	2018:4 Ch. 11	sven-gunnar.lunneryd@slu.se
Pot	Pandalus	Alternative, selective gear - pandalus	Pandalus pot	2016:8 Ch. 3	peter.ljungberg@slu.se
Pot	Pandalus	Alternative, selective gear - pandalus	Pandalus pot	2018:4 Ch. 12	peter.ljungberg@slu.se