

Mitigation of seal damages by improved fishing technology and by alternative fishing strategies



by

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Executive summary

This report presents the results of experiments conducted in 2004 in Denmark, Finland and Sweden in Project 661045-30248 (Mitigation of seal damages by improved fishing technology and by alternative fishing strategies). The report also summaries the main results of 2003 trials.

Seal attacks on stationary fishing gears such as eel fykes have increased in recent years in Denmark and Sweden. To test if fykes made from extra-strong Dyneema-netting would be able to withstand attacks of seals and determine whether Dyneema fykes have other advantages, a set of trials was conducted in June-October 2004 in Denmark. Because it was not possible to get Dyneema-netting made of a mesh size of 9-11 mm (required in the codend), the trials were conducted with fykes where the front and middle compartments were made from Dyneema-netting, whereas the codend was made from the knotless nylon netting of yarn no. 10 (this twine showed good resistance to seal attacks in 2003 trials). A total of 200 Dyneema-fykes were prepared for the trials. Data was collected on a total of 23,843 fyke-days, of which 16,984 days (71%) were collected by the fishermen, while the remaining 6,859 days (29%) were collected by the observers. On the basis of the observer data, the average catch rate of experimental fykes was less than half of that in standard fykes. On the basis of the fishermen's data, however, the average catch rate of experimental fykes was similar to that of the standard fykes. A total of 719 damages to the fykes were recorded, including broken bars and torn meshes. Of these, 704 (98%) were damages to the codend, while the remaining 15 (2%) were damages to the front or middle compartments. Of the 15 damages to the front or middle compartments, only 3 were in the Dyneema-fykes. Due to the relative high damage frequency in the codends of Dyneema-fykes it is obvious that the no. 10 nylon yarn is not sufficiently strong to protect the catch. A stronger Dyneema-netting is required also in the codend. A positive aspect of the Dyneema fykes was that they were easier to haul than traditional gears, and it was easier to shake the crabs out of these fykes.

Since early 1990s, seal-induced catch damages have increased dramatically in the trap-net fishery of salmon and whitefish along the coast of Gulf of Bothnia. Gear modifications that protect the catch from seal attacks have been developed in Sweden and Finland along the course of years. In our 2003 trials, four types of salmon trap-net modifications were tested in the Bothnian Sea in co-operation with commercial Finnish fishermen. Two models showed good results in terms of seal-protection and fishing efficiency (Pontoon trap and Pipe-trap). Further experiments were conducted in 2004. Three seal-safe trapnet-models were tested: Pipe-trap, Folded-hoops trap and Pontoon trap. A non-protected standard commercial trap was used as a control. The pontoon trap had markedly higher capture efficiency of salmon than the other experimental traps. After improvements in the rigging of other traps, they showed somewhat better capture efficiency but the pontoon trap was still the most efficient. In the pontoon trap, the overall proportion of salmon damaged by seal was on average less than 2% per haul. In the folded-hoops trap the average proportion of damaged salmon was ca 8%. In other models, the proportion of damaged salmon was 30-50%. The highest undamaged salmon catch per haul was caught with a pontoon trap (on average 5.6 fish). Second highest undamaged catch was caught with the folded-hoops trap (2.7 fish). During the last 10 days of the trials, after the improvements were made in rigging, the average catch of undamaged salmon was 3.1 fish in the folded-hoops traps (3.9 fish in the pontoon trap). In other traps the average quantity of undamaged catch was low. In the traditional traps ca 12% of all the salmon caught were captured in the meshes of middle chambers that were made of twisted nylon (PA) twine. In modified traps where the middle chambers were made of stiff PE-twine, the proportion of salmon caught in the chambers was less than 2%. Moreover, the seal-induced gear-damages

were negligible. Clearly, stiff and thick netting should be used in the chambers to prevent the meshing of fish. These trials showed that the Swedish pontoon trap has a very good seal protection and is practical and efficient gear in salmon fishery. It is very likely that pontoon trap will become a popular in Finland. The folded-hoops trap that was tested first time in 2004 showed encouraging results but this design needs some more development. The pipe-trap that was encouraging in 2003 trials largely failed in 2004 trials. Clearly, this gear-design requires further testing. It might be a potential alternative in the trap-net fishery of whitefish.

Our trials have demonstrated that the fish bag of a trap-net can be modified to protect the catch from seals. However, the traditional trap design still permits an efficient hunting by seals in other parts of the gear. In Sweden, the wings of traps are usually made of netting with 100 mm or smaller mesh sizes (bar length). In a large-mesh trap wings are made of 200 mm netting. Such a mesh size allows most fish to escape through the meshes when chased by seal. The fishing efficiency of a large mesh traps, however, may be poor. For a successful introduction of a large-mesh trap-net fishery as a substitute for the gillnet fishery of whitefish, it was necessary to demonstrate that larger meshes would not decrease the fishing efficiency of the gear compared to smaller mesh sizes that are traditionally used in the wings. The study was conducted in May-October 2004 in two different study areas in the archipelago of Stockholm. Two traps, that were identical except for the different mesh sizes in the wings, were placed close to each other in both study area. One trap had wings with a mesh size of 100 mm (small mesh trap, SM) while the other had wings with a 200 mm mesh size (large mesh trap, LM). Fishing efficiency of whitefish in the SM traps was higher irrespective of the fishing site suggesting that there were higher losses of fish when captured with a trap having large mesh wings. On the other hand, the LM traps caught about the same amount of salmon and trout as the SM traps. Apparently, salmon and trout were less reluctant to pass through large mesh nets compared to whitefish. It was concluded that if whitefish is the most important target species, a 100 mm mesh size in wings may be most useful since this mesh size is large enough for preventing seal-scared whitefish to entangle in the meshes. If salmon and trout are the target species, a larger mesh size in wings is an appropriate measure to help seal-chased fish to escape. The use of special escape panels in the fish bag is a potential solution to the problem of capturing of undersized whitefish.

In Sweden, small wire-pots are used for catching perch along many regions of the Bothnian coast. Besides catching perch very efficiently, these pots are seal-safe; seal-induced damages on gears and catch are insignificant. However, the proportion of small fish in the catches is often high. The survival of small individuals that are manually released is assumed to be relatively low. By improving the selectivity of the wire-pots, i.e. selecting out the small fish during capture, the survival could be improved significantly. This would be a major advantage and might launch a wider use of these seal-safe gears along the whole Baltic coast. In 2003 we tested seal-safe wire-pots with three different mesh sizes. The pot with the largest mesh size was clearly the most effective in selecting the smaller perch. In the survival experiments conducted in 2004, no injury was detected in the out-selected fish. All fish that were selected out from a wire-pot were found alive when the experiment was finished. The results indicate that using a larger mesh size in the pots' roof is an effective tool to reduce the proportion of smaller perch in the catch and thereby reducing the by-catches. Small, easily transported and flexible pot is a potential seal-safe alternative for the coastal perch and likely also for pike-perch fishery in the archipelago areas of the Baltic Sea.

Introduction

During the last decade, seal-induced gear and catch damages have increased dramatically in the coastal fishery in the northern Baltic Sea (Lunneryd and Westerberg 1997; Westerberg et al. 2000; Lunneryd 2001; Kreivi et al. 2002; Kauppinen et al. 2004). Most damages are caused by the rapidly growing grey seal (*Halichoerus grypus*) population. However, also the ringed seal (*Phoca hispida botnica*) population is causing catch damages in particular in the northernmost areas of the Gulf of Bothnia (e.g. Westerberg et al. 2000) and in the eastern parts of the Gulf of Finland. In many regions, the coastal fishery of salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*) is suffering of high economic losses due to the seal induced damage, and thereby the future of this traditional fishery is at stage. The conflict between the protection of seal stocks and the existence of the coastal fishery is growing in many areas. Hence, there is an acute need for developing mitigation measures such as trap-net modifications and operations that would prevent seals from entering into the trap while allowing fish to swim into the gear.

Gear modifications that have been tested in Finland and Sweden include a wire-grid installed in the funnel of a salmon trapnet and various types of fish bags made of extra-strong Dyneema netting material (e.g. Lunneryd 2001; Lunneryd et al. 2003; Lehtonen and Suuronen 2004). The Swedish pontoon trap (a trap with a so called "push-up bag") is already in wide use in salmon fishery in Sweden. It has proved to be effective in catching salmon and in the mitigation of seal damages. However, it is relatively expensive gear, and in some circumstances alternative seal-safe gear modifications may be more suitable. Furthermore, adequate capture efficiency of a pontoon trap towards whitefish has not yet been fully proved. New solutions and modifications are explored in this project.

It is noteworthy that when seal populations are expanding in the Baltic, seals are frequently entering the inner archipelago and river mouths. Hence, there are not many areas left in the northern Baltic coastal areas where static fishing gears are safe from seal attacks. In fact, during the very recent years, fisheries that are traditionally conducted in the inner archipelago, such as gillnet fishery of pike-perch and perch, have increasingly suffered due to seal induced gear and catch damages. Indeed, conducting of profitable gill-net fishery has become very difficult in many regions due to high catch losses and gear damages caused by seals. There are few practical means to prevent seal damages in gillnet fishery; one potential alternative is to replace gillnets by seal-safe trap-nets or pots. This may require substantial modifications in the fishing strategy and in the equipments needed in the fishery. This project attempts to develop pot-fishery as an effective and selective alternative for the gillnet fishery in particular for perch but also for pike-perch and whitefish.

In the very recent years, Danish and Swedish fishermen have experienced severe seal attacks also in the traditional eel fishery that is conducted with static gears such as pound and fyke-nets (e.g. Lunneryd and Königson 2004). The eel fishery is one of the most important sectors in the coastal fishery in both countries. The damages are mainly caused by harbour seal (*Phoca vitulina*). Seals are tearing and ripping holes in the chambers where the eel catch is trapped. Stronger materials have been tested over a number of years but there has been some resistance among fishermen to use them. This is mainly because they are suspecting that the modified fykes have a reduced fishing efficiency (Lunneryd and Königson 2004). This project attempts to find seal-safe fyke-net modifications that would be efficient and acceptable from fisheries point of view.

Task 1: Development of seal-safe and effective eel-fykes

1.1. Background

Complaints from Danish fishermen regarding seal attacks on stationary fishing gears such as pound and fyke nets have been increasing in recent years. The Danish Fishermen's Association (DFA) conducted a questionnaire survey of the problem in 1999 and concluded that seal damages were especially severe in the western part of Limfjorden, at the east coast of Jutland south of Aarhus, in the waters north of Læsø, in the southern part of Øresund as well as in Nysted Fjord-Lambo Farvand. DFA also conducted some trials with protective netting on fykes, but concluded that more trials were needed to determine what type of protection would be optimal.

The Danish Institute for Fisheries Research (DIFRES) in cooperation with the Swedish National Board of Fisheries, DFA and two Danish eel fishermen conducted a new series of trials in August-October 2003 to test if the use of a stronger twine could reduce damage by seals. These trials were conducted under the current Nordic project. The results suggested that the stronger twine reduced the incidence of seal damage, but the modified fykes had some disadvantages, the most important being heavier handling of the gear. It was concluded that more trials were required to test the use of Dyneema®¹ netting in the fykes. Dyneema® is more expensive than traditional twine, and a fyke with the codend made from Dyneema® fibres will cost approximately twice as much as a standard fyke.

However, a fyke made from Dyneema® will have a number of advantages, which could balance the higher costs. These advantages are:

- reduced damage of the fyke by seals (probably also reduced damage by cormorants);
- longer life time;
- increased water flow and thus potentially increased catch rates;
- reduced weight resulting in easier handling;
- reduced water drag resulting in easier hauling.

To test if fykes made from Dyneema® would be able to withstand attacks by seals and determine whether Dyneema® fykes have the expected advantages, a new set of trials was conducted in June-October 2004.

1.2. Experimental design and methods used in 2004

The trials were conducted in the shallow water area south of the island of Lolland, in the eastern part of Lambo Farvand, an area delineated to the east by the coast of Falster, to the south by a line from Hyllekrog to Rødsand and to the west and north by the coast of Lolland (Fig. 1). The fishery was conducted mostly from the harbour of Lundehøje Havn. Up to 200-300 harbour seals can be found at the seal reserve of Rødsand, east of the area shown in map, approximately 20-30 km from the fishing area. A variable number of harbour seals are also found at Vitten (see Fig. 1), a low sand bank with large boulders.

¹ Dyneema is a polyethylene fibre with a specific gravity of 0.97 and a breaking strength of 35 g/d; a 1 mm twine can carry 240 kg.

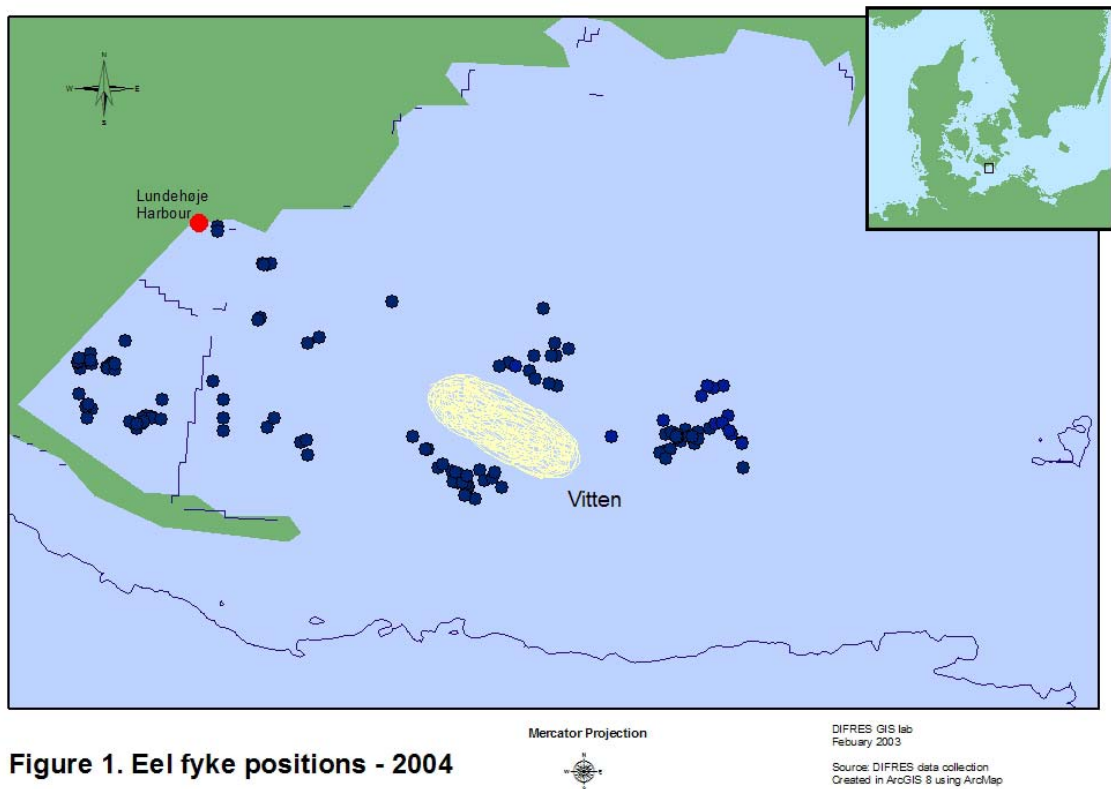


Figure 1. Eel fyke positions - 2004

It was originally planned to conduct the trials using fykes where the codend was constructed from Dyneema® and the other parts of the fyke made from a traditional nylon netting. However, it turned out to be difficult to have Dyneema® netting made with a mesh size as small as 9-11 mm, as was needed for the codend. Therefore, the trials were conducted with fykes where the front and middle compartments were made from Dyneema®, whereas the codend was made from the knotless nylon netting of yarn no. 10, which showed good resistance to seal attacks in our trials in 2003. The Dyneema® yarn used was made from the three-stranded Dyneema® CN1 yarn.

A total of 200 Dyneema® fykes were prepared for the trials. The netting materials used in the different parts of the fykes is shown in Table 1. Owing to personal preferences by the two fishermen involved in the trials, around half of the Dyneema® fykes were slightly longer (termed Long) than the other half (termed Short), but were otherwise identical. As a control group we used fishermen's standard fykes (Table 1). In addition, we collected catch data from an experimental fyke from 2003 (termed F3) still used by these fishermen. The front and middle compartments of this type of fyke are identical to the standard fyke, but the codend is similar to that of the Dyneema® fyke, *i.e.* made from knotless nylon netting of yarn no. 10.

During the trials, data were collected of the amount of eel caught in the fykes, amount of bycatch and the number of damages inflicted by seals on fykes and catch. Damages were also documented using digital cameras (where possible). In addition, data were collected on fishing effort, weather conditions, water depth and bottom type. Around 30% of the data were collected by observers from DIFRES, whereas the remaining data were collected by the two fishermen involved. The main difference between the two sets of data was that the sampling unit for the fishermen was a row consisting of normally 20 fykes, whereas the sampling unit

for the observers was the individual fyke. The durability of the Dyneema® fykes was assessed by the fishermen, who also assessed whether the Dyneema® fykes were easier to handle than the traditional fykes.

Table 1. Netting materials used in the fykes in 2004 trials.

		Standard fyke	Experimental fyke
Front compartment	<i>Material</i>	nylon	Dyneema®
	<i>Colour</i>	reddish brown	green
	<i>Yarn</i>	no. 3	1 strand from CN1
	<i>Breaking strength</i>	13 kg	33 kg
	<i>Knot type</i>	single knot	single knot
	<i>Mesh size</i>	16, 17 and 18 mm	17 mm
Middle compartment	<i>Material</i>	nylon	Dyneema®
	<i>Colour</i>	reddish brown	green
	<i>Yarn</i>	no. 3	1 strand from CN1
	<i>Breaking strength</i>	13 kg	33 kg
	<i>Knot type</i>	single knot	single knot
	<i>Mesh size</i>	13, 14 and 15 mm	14 mm
Codend	<i>Material</i>	nylon	nylon
	<i>Colour</i>	reddish brown	black
	<i>Yarn</i>	no. 3	no. 10
	<i>Breaking strength</i>	13 kg	37 kg
	<i>Knot type</i>	knotless or knots	knotless
	<i>Mesh size</i>	10 mm	9 mm

In the preliminary and exploratory analyses reported here, various sub-sets of the data were compared using the non-parametric Mann-Whitney U-test. For the observer data, the mean catch and damage rates are calculated as the mean of the individual fyke rates, and for the fishermen's data they are calculated as the mean of the catch rate for individual rows. For the mean catch rates, only fykes with no damages recorded are included in the calculations. Because of apparent differences between data collected by the observers and fishermen, these two data sets are considered individually.

1.3. Results

The collection of data by observers and fishermen began in early June and continued through August, after which data were collected only by the fishermen until the end of October. By the end of August, data had been collected on a total of 23,843 fyke-days², of which 16,984 fyke-days (71%) were collected by the fishermen, while the remaining 6,859 fyke-days (29%) were collected by the observers during a total of 13 fishing trips.

Table 2 presents the catch rates of eels for the four types of fykes calculated on the basis of the observer data. It is notable that the catch rates for the three experimental fyke types are less than half of the catch rate for the standard fyke. This difference is statistically significant for

² 1 fyke-day is the fishing effort of 1 fyke fishing for 24 hours.

the short Dyneema® fyke ($P < 0.001$) and for the F3 fyke ($P < 0.01$), but not for the long Dyneema® fyke. Table 3 presents the catch rates of eels for the four types of fykes calculated on the basis of the fishermen's data. In this data set the catch rates for the three experimental fyke types are similar to the catch rate of the standard fyke. Discard rates are variable but on average the same (ca 15%) for observed trips as well as unobserved trips.

A total of 719 damages to the fykes were recorded, including broken bars and torn mesh. Of these, 704 (98%) were damages to the codend, while the remaining 15 (2%) were damages to the front or middle compartments. Of the 15 damages to the front or middle compartments, 12 were from the standard and F3 fykes, while the remaining 3 were from the Dyneema® fykes.

Table 2 presents the codend damage rates for the four types of fykes calculated on the basis of the observer data. It is notable that the damage rate for the short Dyneema® fyke is significantly higher than for the standard fyke ($P < 0.05$), but the other differences are not statistically significant. Table 3 presents the codend damage rates for the four types of fykes calculated on the basis of the fishermen's data. These damage rates are not significantly different ($P > 0.05$). This is in line with the catch damage observations (see above).

Table 2. Catch rates of eel, damage rates and distribution of fishing effort in various fykes in the data collected by the observers. "Total eel" includes landed, undersized and damaged eels.

OBSERVER DATA	FYKE TYPE			
	Standard	Dyneema - short	Dyneema - long	F3
Total eel per fyke-day	0.303	0.119	0.159	0.122
Landed eel per fyke-day	0.255	0.114	0.119	0.109
Codend damages	27	57	0	8
Codend damages per fyke-day	0.009	0.029	0	0.011
Damages to front and middle compartments	7	2	0	3
Distribution of fishing effort	48 %	28 %	7 %	18 %

Table 3. Catch rates of eel, damage rates and distribution of fishing effort in various fykes in the data collected by the fishermen. "Total eel" include landed, undersized and damaged eels.

FISHERMEN'S DATA	FYKE TYPE			
	Standard	Dyneema - short	Dyneema - long	F3
Total eel per fyke-day	0.261	0.258	0.276	0.205
Landed eel per fyke-day	0.206	0.237	0.204	0.191
Codend damages	292	117	61	142
Codend damages per fyke-day	0.052	0.051	0.031	0.025
Damages to front and middle compartments	2	1	0	0
Distribution of fishing effort	32 %	16 %	13 %	39 %

1.4. Discussion and conclusions

When considering the results presented here it should be kept in mind that the analyses conducted so far are preliminary and exploratory in nature. A more in-depth analysis is needed to determine whether the differences found between the different fyke types are real. Especially the differences in catch rates between the observer data and the fishermen's data warrant more careful consideration. One possible explanation for the differences in catch rates between the observer data and the fishermen's data is that new fykes are at the beginning inefficient but become gradually more efficient with age. This explanation was suggested by the fishermen. It is thus possible that the catch efficiency of the Dyneema® fykes has increased after the collection of observer data ended; fishermen's data covers a longer period than the observer data. This does not explain, however, why the F3-fykes which were more efficient than the standard fykes in 2003 trials, were less efficient in 2004. Other factors that need to be considered are fishing area and soak time/gear saturation, as they could also cause the differences observed.

When looking at the damages in the codends it is quite clear that the no. 10 nylon yarn, despite a breaking strength almost three times higher than the standard yarn, is not sufficiently strong to protect the catch. This is in contradiction to the results of the trials in 2003, where the no. 10 yarn sustained lower damage rates than the standard yarn. However, the trials in 2003 were conducted at a time of year when the intensity of the seal attacks is in general much lower. The front and middle compartments made of Dyneema® on the other hand seem to have performed very well. Of a total of 15 damages recorded to front and middle compartments only 3 were from Dyneema® fykes. Another positive aspect of the Dyneema® fykes was that they were easier to haul, and, in particular, it was easier to shake the crabs out of the fykes. Considering the large number of crabs in the fykes at certain times of the year, this is an important advantage.

Although these results are promising, it is apparent that more trials are needed to find the optimal solution to mitigate the seal damages in the eel fyke-net fishery. Apparently, the whole gear should be protected from seal. In our trials, the Dyneema® netting performed well in the front and middle compartments of the fyke. It should be tested also in the codend by using a suitable mesh size. Such a test will be conducted in 2005.

Responsible institute: Danish Institute for Fisheries Research (DIFRES)

Task 2: Development of seal-safe salmon trapnet fishery

2.1. Background

Seal-induced catch damages have since early 1990s increased dramatically in the trap-net fishery of salmon and whitefish, in particular along the coast of Gulf of Bothnia and Gulf of Finland (Westerberg et al. 2000; Kreivi et al. 2002; Kauppinen et al. 2004). Modifications that have been tested include a wire-grid installed in the funnel of the trap to prevent seals from entering through the funnel into the bag, and various types of fish bags made of extra-strong Dyneema netting to prevent seals from entering through the net (e.g. Lunneryd 2001; Lunneryd et al. 2003; Lehtonen and Suuronen 2004). In particular, the Swedish pontoon trap developed in late 1990s has proved in Sweden to be effective in catching salmon and in mitigating seal damages. However, it is relatively complex and expensive gear, and may not be suitable in all circumstances. This sub-project aims to (a) test and demonstrate the efficiency and suitability of pontoon trap in various Finnish circumstances, and (b) find effective, inexpensive and practical alternative designs.

2.2. Main results of 2003 trials

In the experiments conducted in 2003, six types of salmon trap-nets were tested during the salmon spawning migration in May-June off the coast of Bothnian Sea, near Merikarvia, in co-operation with local fishermen. Two of the trapnet models represented the traditional traps that are in common use along the coast of the Gulf of Bothnia; four models were modified in terms of seal protection. Four separate fishermen groups participated in the trials. Each group had all six trapnet models that were located randomly within the fishing area of each group. Detailed daily data of catches, of fish entangled and enmeshed, and of seal damages were collected at sea (by the staff of FGFRI) from each trapnet in order to assess effect of various design principles and materials on the capture efficiency and on seal-protection. Two of the four modified trapnet models showed good results in terms of seal-protection and fishing efficiency (for a more detailed description of 2003 trials, see Siira et al. 2004 and Suuronen et al. 2004).

The Swedish Pontoon trap (“push-up trap”) was the most successful design in the 2003 tests; seal-induced catch damages were almost insignificant and the capture efficiency of salmon was good. This design also had the additional advantage that the hauling of the gear was extremely easy with help of the air-pontoons that lift the bag up from the sea. The Finnish fishermen who participated in the trials were convinced that this trap design has major advantages compared to other designs. Two fishermen immediately purchased two pontoon traps. It is notable that some young (small) seal were able to squeeze through the small wire grid into the fish house of the pontoon trap; these seals could not find their way out of trap and were drawn.

The other trapnet modification that showed promising results during the 2003 trials was “the pipe-trap” (floating pipe trap). This was encouraging because this model was only a prototype that was tested very first time during these experiments. Seal protection was not quite as good as with the pontoon trap but markedly better than in other designs. This design, however, has the disadvantage that it takes somewhat more time to haul the fish bag than with other gears; the difference is noticeable in particular when compared to the pontoon trap that is very easy to haul. On the other hand, due to larger size of fish bag, pipe-trap may be more applicable than for instance pontoon trap in the whitefish fishery. On the basis of 2003 results it was obvious that there were still substantial needs to improve the “float-anchor pipe” system. The pipes were designed to prevent seals from lifting the bottom netting of the bag and thereby to prevent

the attacks through the netting. It appeared, however, that four pipes, one in each corner, may not have been enough; seals apparently were able to lift the middle part of the bag upwards and could attack some fish through the netting (there were no direct observations, however, of this behaviour). Moreover, it appeared that some young seals were able to enter into the bag through the large wire-grid. It was concluded that the design of the wire-grid still needs further work; a grid should be strong enough to prevent large seals to damage it but it should also prevent the smallest seals from entering into fish bag. This is possible in technical terms but it may also mean that some potential catch will be lost. It was also concluded that more work is needed on finding optimal netting-materials and mesh sizes in various parts of the trap to prevent meshing of fish in any part of the gear and to guide the fish as fast as possible into the fish bag, where they would be protected from seal attacks.

2.3. Experiments with modified “seal-safe” salmon trapnets in 2004

Further experiments with modified salmon trapnets were conducted in May-June 2004 on the coast of Bothnian Sea (in Merikarvia) in co-operation with the same professional fishermen as in 2003. The following trapnets were tested (see also the drawings in Appendix 1):

A. Control trap: The control trapnet was traditional trapnet design that is commonly used along the southern coast of the Bothnian Bay (Model B in the 2003 trials). It has no seal-protection; its capture principle is based on catching the fish into the fish bag (not by meshes). The large fish bag is made of traditional 35 mm (bar length) twisted PA-netting (18 fibres). The wings are made of 150 mm (bar length) PE-netting made of 1.5 mm twine and the chambers (chutes) of 50 mm (bar length) PA netting (18-fibres).

B. Pipe-trap (Float-anchor pipe trap): This trap had a large fish bag made of 35 mm green Dyneema-netting and it was equipped with a wire-grid. There was one float-pipe in each corner of the bag (see Appendix 1). These pipes had in their lower end a weight of ca 25 kg that kept them vertical and a rope (+ chain) that is connected to the lower seam of the bag. With help to these pipes the bottom of the bag is under some tension. Therefore, seals cannot easily lift the bottom netting from below or push from the side. The rope-release system, however, allows fisherman to haul the gear in a normal way. In contrast to the original plan, no pipes were used in the middle of the bag; this was considered to make the hauling of the gear too slow. Instead, the bag was made somewhat shorter (12 m) than in previous 2003-model. The funnel was also somewhat shorter and there was more open space on the sides and below the funnel in order fish could swim more freely there. The middle chambers (chutes) of the gear were made of green 45-60 mm (bar length) PE-netting (twine thickness 1.6 mm). The rigging of chambers was designed so that there would be no steep netting angles that might disturb fish when avoiding an attacking seal. The wings were made of 150 mm PE-netting (twine thickness 1.5 mm) and their rigging was as round as possible. There was also bottom netting in the wings (in 2003, there was no bottom). The installation of the wire-grid was slightly different compared to the 2003 trials. Moreover, two different sizes of grid were tested. First, a small 40 x 60 cm grid was tested; later a 120 x 120 cm grid was used. The wire spacing was 18.5 cm in both cases. During the course of the experiment, two extra Dyneema twines were installed horizontally in the grid (see next paragraphs).

C. Folded-hoops trap: This prototype had a double Dyneema-netting in the fish bag and it was equipped with hoops (like in pontoon trap). The diameter of the hoops was 2.5 m. During capture, the system was kept stiff by help of an anchor that was fixed at the end of

the bag. The chambers and the wings were constructed and rigged like in model B but the netting in the first chamber was green instead of black. A 40 x 60 cm wire-grid with 18.5 cm wire spacing was used in the funnel (i.e. there was one wire vertically in the middle of the grid).

D. Seal trap: This model was principally designed and used to test whether seals could be effectively captured alive with a typical commercial salmon trapnet. The trap had a traditional large fish bag but it was made of Dyneema netting. No wire-grid was used in the funnel. Hence, seals could freely enter into the fish bag through the funnel. The wings were made of thick PE-netting and chambers of twisted nylon. In the end of the fish bag there was attached a hooped bag made of Dyneema netting for catching seals. The diameter of the hoops was 2 m. The idea of this bag was that seals captured in the fish bag would enter into this smaller bag where they would be captured alive. Then they could be released or transported away.

E. Pontoon trap: (the Swedish “Push-up trap” model, see 2003 trials).

Each fisherman group had four traps. All had the traditional model (A), the floating pipe model (B) and the folded hoop model (C). In addition, two groups had the live capture trap (D) and two groups the pontoon trap (E). That is, there were only two examples of these latter two models in our trials. The location of experimental gears was randomized within each group. The data concerning catches, meshing of fish, seal damages and handling properties was recorded in details for each experimental gear in each hauling by the FGRI staff. Generally, traps were hauled once in each day but during peak catches occasionally twice a day.

2.4. Results of 2004 trials

2.4.1. Problems encountered in the constructions – two study periods

The experiments started on May 20, 2004. Compared to all other models the pontoon trap (model E) had markedly higher capture efficiency from the very first day of the experiments. This was in contrast to the 2003 trials where there was not a marked difference in the capture efficiency with pontoon trap and pipe-trap. Major failures were observed in the construction of the funnels in the modified pipe-traps and folded-hoops traps. Funnels were too small and narrow, and the inlets (gaps) in the middle chambers were too small. Moreover, the small-sized wire-grid that was installed below water surface, did not work adequately. It is possible that wave-induced movements of the grid were relatively large and abrupt, perhaps substantially larger than with the larger grid that was used in 2003, and also larger than in the pontoon trap. It is likely that many fish turned around in front of the grid or even earlier, and swam out of trap, although no direct observations exist of this behaviour. Furthermore, it was noticed that the space between the leader netting and the wing (i.e. the inlet where the fish are swimming into the wings) was ca 7 m wide in pontoon trap whereas it was only 5 m in other traps. This difference may have caused some variation in the capture efficiency of various gears.

Due to these problems, the experiment was interrupted on June 9th (after 20 days) and some relatively minor changes were made in the rigging of the funnels and middle chambers of pipe-traps and folded-hoops traps. Moreover, the small wire grid (40 x 60 cm) in pipe-traps was changed to the larger grid (120 x 120 cm) that was used in 2003. Two horizontal 6 mm dyneema-twines were installed in these grids to divide each vertical 120 cm high wire spacing in three 40 cm high compartments. This was done to prevent seals to expand the wire spacing

in the middle of the grid and swim into the fish bag (that was in 2003 trials a potential problem with the large grids). The wire spacing was kept at 18.5 cm in all grids. The experiments with the new installations started on June 19th and continued until June 29th (i.e., the overall duration of the second experimental period was 10 days). It is apparent that the most important fishing period was missed due to the technical problems encountered in experimental gears. It is also obvious that the minor changes that we were able to make were not adequate to get these gears to fish in normal or expected efficiency. To make the results more understandable, the data has largely been analyzed separately for the two periods.

2.4.2. Number of salmon caught in experimental gears (catching efficiency)

During the first period (20.5. – 9.6.), the average number of salmon caught per haul was in pontoon traps substantially higher than in other traps; the average catch per haul was 6.6 salmon (Table 1, Fig. 1). It should be kept in mind, however, that there were only two pontoon traps in our trials; hence, pure chance may have played a marked role in these results. During the first period, the poorest capture efficiency was observed in the pipe-traps (1.4 salmon per haul) but generally, the number of salmon per haul was low in all other traps too (2.2 – 2.8 salmon per haul).

During the second period (29.6. – 29.6), the average number of salmon caught by pontoon trap (4.0 fish per haul) had decreased by one third but was still better than in any other trap models (Fig. 1). The number of salmon caught in pipe-traps (2.5 fish per haul) had increased by almost 45 %. This improvement may have been at least partly due to the changes made in the funnels and wire-grids of these traps. The number of salmon caught by folded-hoops trap (C) increased by almost 20% and was now close to that of pontoon trap (3.2 vs. 4.0 fish per haul). In other models the number of fish captured decreased (which may in case of non-protected models partly be due to the fact seal may have taken the fish completely out of these traps, i.e. all fish were not observed).

Table 1. Number of salmon caught per haul in different trapnet-models during the two study periods and both periods combined. The numbers shown include all salmon observed in the traps, i.e. also those that were damaged by seal. S.E. is the Standard Error of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

Trapnet model	20.5 - 9.6		19.6 – 29.6		The whole period	
	Number	S.E	Number	S.E	Number	S.E
A	2.8	0.4	1.6	0.3	2.4	0.3
B	1.4	0.2	2.5	0.5	1.7	0.2
C	2.7	0.4	3.2	0.6	2.9	0.3
D	2.2	0.6	1.5	0.5	2.0	0.4
E	6.6	0.7	4.0	0.8	5.7	0.5

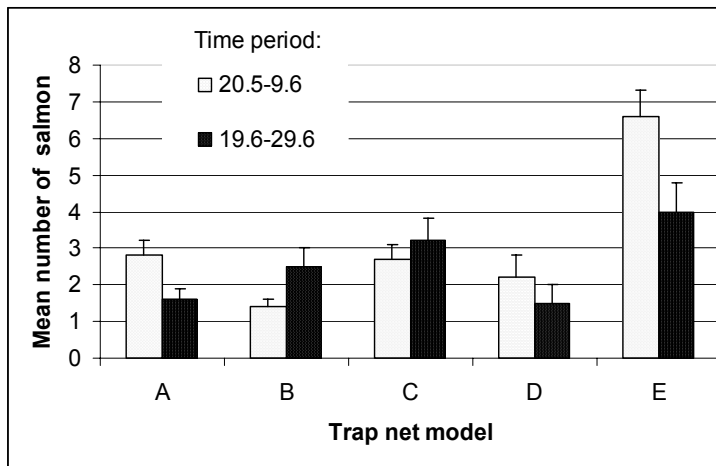


Figure 1. Average number of salmon caught per haul in different trapnet-models during the two study periods. The numbers shown include all salmon observed in the traps, i.e. also those salmon that were damaged by seal. Error bars indicate the Standard Error (S.E.) of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.4.3. Proportion of salmon damaged by seal

There was substantial variation in the proportion of damaged salmon between the experimental gear types (Fig. 2). In the pontoon trap (E), the overall proportion of salmon damaged by seal during the whole experimental period was on average less than 2% per hauling. In the folded-hoops trap (C), the average proportion of damaged salmon was ca 8%. In other three trap models, the proportion of damaged salmon was substantially higher, around 30-50%. Clearly, the pipe-trap (B) did not perform according to the expectations; the proportion of damaged salmon was even higher than in the control trap (A), where there was no seal protection.

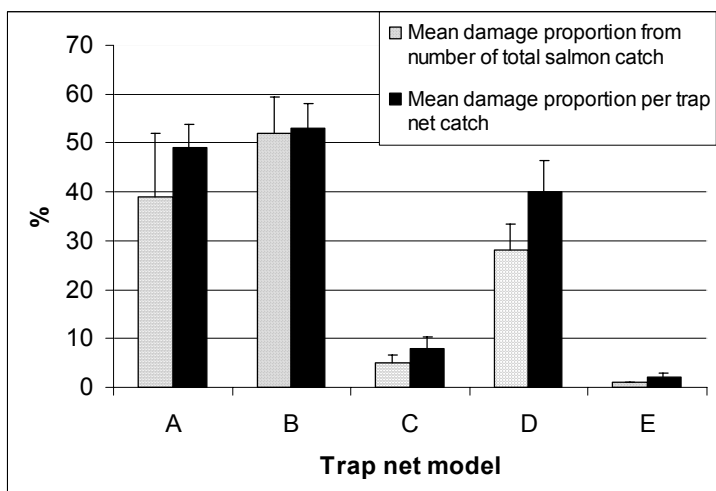


Figure 2. The proportion of salmon catch damaged by seal in different experimental traps during the whole experimental period in 2004. The dotted columns show the percentage from the total observed catch. The black columns show the average proportion of damaged salmon per each haul. Error bars indicate the Standard Error (S.E.) of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

When investigating the percentages presented in figure 2, it should be taken into account that the better the capture efficiency of a trap is (i.e. the more there are fish in the fish bag at any given time), the smaller proportion of these fish seals are likely able or willing to damage (see Kauppinen et al. 2004). The low catching efficiency of model B was partly the reason that it had a high damage-percentage. That is, there were only a few fish captured at time, and seals apparently did damage many of them. Clearly, comparisons with absolute numbers instead of percentages would give a more accurate picture of the damages. It is also noteworthy that the mean size of salmon usually decreases during the spawning migration. It means that at the end of fishing season those traps that have a poor seal protection will show even larger damage-percentage than during earlier in the season (because seal have to kill and eat more salmon to get the same quantity of food).

In figure 3, the catch damage-data has been divided into two experimental periods. Clearly, the average damages were higher during the second period. However, in the folded-hoops trap (C) there was a decline in the average damage-percentage. This may at least partly be caused by the fact that there were during the second period more salmon inside the fish bag because of changes made in the funnels and middle chambers.

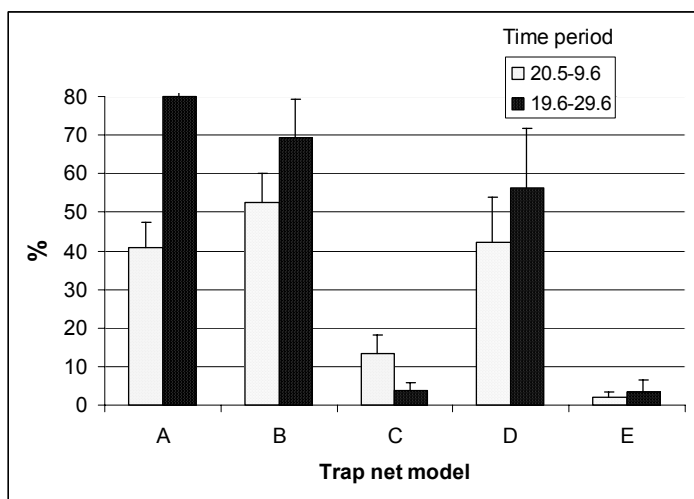


Figure 3. The proportion of salmon damaged by seal in the different experimental traps during the two different experimental periods in 2004. The dotted columns show the percentage of damaged salmon per haul during first (20.5. – 9.6.) and the black columns during the second (19.6. – 29.6.) period. Error bars indicate the Standard Error (S.E.) of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.4.4. Quantity of undamaged salmon catches in experimental traps

Salmon that had no seal-induced damage or had such a slight damage that did not prevent their marketing were classified as undamaged salmon. Table 2 summaries the average number of undamaged salmon caught by different trapnet models. This table should be compared to the numbers presented in table 1.

Table 2. Average number of undamaged salmon caught per haul by different trapnet models during the two study periods. S.E. is the Standard Error of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

Trapnet model	20.5 - 9.6		19.6 - 29.6		20.5-9.6 + 19.6-29.6	
	Number	S.E	Number	S.E	Number	S.E
A	1.8	0.3	0.3	0.1	1.3	0.3
B	0.6	0.1	0.8	0.3	0.7	0.1
C	2.4	0.3	3.1	0.6	2.7	0.3
D	1.5	0.6	0.6	0.3	1.2	0.4
E	6.5	0.7	3.9	0.8	5.6	0.6

Table 3 and figure 4 summaries the average quantity (kg) of undamaged salmon caught by different trap models. The highest undamaged catch per haul was caught with a pontoon trap (model E); during first period the average catch was 42 kg and during the second period 18 kg. Second highest undamaged catches were caught with the folded-hoops trap (15.5 kg and 10 kg). With all the other trap models the average quantity of undamaged catch was low. With the pipe-trap the average undamaged catch was smaller than with those traps that did not any have seal-protection. Clearly, these results strongly suggest that the design of the pipe-trap was not successful. It is notable that the average undamaged catch decreased in all model during the second period; quantity of catch decreased more than the number of fish. This was because the average size of fish decreases during the season.

Table 3. Average quantity (kg) of undamaged salmon caught by different trap models during the two study periods. S.E. is the Standard Error of the mean.

Trapnet model	20.5 - 9.6		19.6. - 29.6.		20.5-9.6 + 19.6-29.6	
	kg	S.E	kg	S.E	kg	S.E
A	10.4	2.4	1.3	0.6	7.2	1.6
B	3.7	0.8	3.3	1.5	3.6	0.7
C	15.5	2.5	10.0	2.1	13.6	1.8
D	10.6	4.0	3.7	2.0	8.1	2.7
E	42.3	5.5	18.1	4.5	34.1	4.2

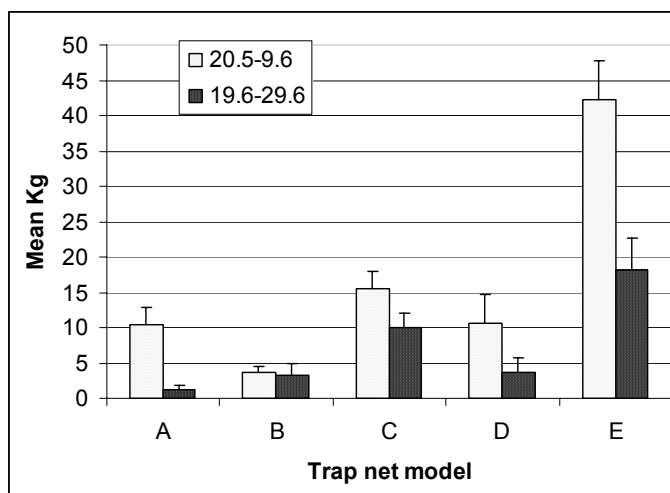


Figure 4. Average quantity (kg) of undamaged salmon catch per haul caught by different trap models during the two study periods. Error bars indicate the Standard Error (S.E.) of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.4.5. Proportion of slightly damaged salmon

The proportion of slightly damaged salmon catch of the total catch was highest (10.7%) in the pipe-trap (Fig. 5). In other traps the average proportion was around 2.5 – 5 %. Note that the slightly damaged salmon were marketable. The high proportion in the pipe-trap suggests that seals were likely able to attack fish through the netting, i.e. outside the bag.

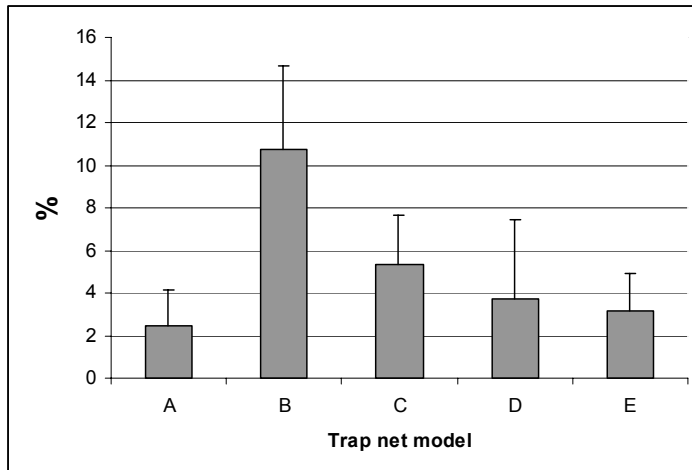


Figure 5. Proportion of slightly damaged salmon catch of the total catch in each trapnet model. Error bars indicate the Standard Error (S.E.) of the mean. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.4.6. Distribution of salmon catches among various parts of the traps

In the trapnet model A (traditional non-protected design) that had middle chambers made of twisted nylon (PA) twine, ca 12% of all the salmon caught were captured in the chambers (Fig. 6). In trapnet models B, C and E, where the middle chambers were made of thick and stiff PE-twine, the proportion caught in the chambers was less than 2%. It is notable that in the trapnet model D (seal trap), where the middle chambers were made of nylon netting, the proportion of salmon caught in the chambers was relatively low too. This may be connected to the fish bag that was made of Dyneema netting. Moreover, there was no wire-grid at the funnel to prevent seals entering through there. It may also be just a result of pure chance; two trapnets are not enough to make any firm conclusions. Minor differences in the gear set-up may cause major changes in the catchability of various gear components. The variation in the existence of seals around each trapnet may also explain the large variation observed.

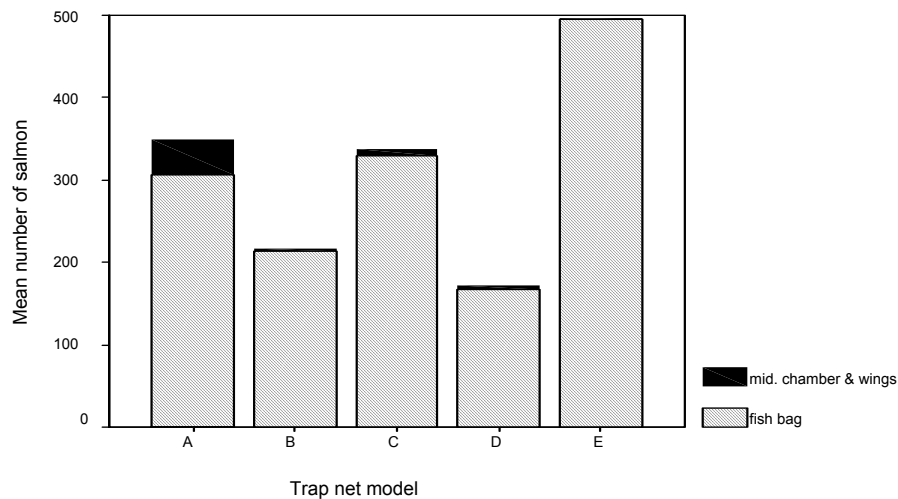


Figure 6. Distribution of salmon catch captured in various parts of the experimental trapnets (bag vs. middle chamber and wings). The salmon catch includes undamaged and damaged salmon. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.4.7. Distribution of seal-induced gear damage in different parts of the traps

There was practically no seal-induced damage in the fish bags (fish house) made of Dyneema netting (models B, C, D and E; Fig. 7). Damages in the middle chambers were negligible in those trapnets that had the chambers made of PE-netting (models B, C and E) but in the traps A and D that had middle chambers made of nylon the frequency of damage was around 6%. Highest overall gear-damage frequency was observed in the traditional trapnet (A) that has the fish bag and the middle chambers made of nylon (PA) netting.

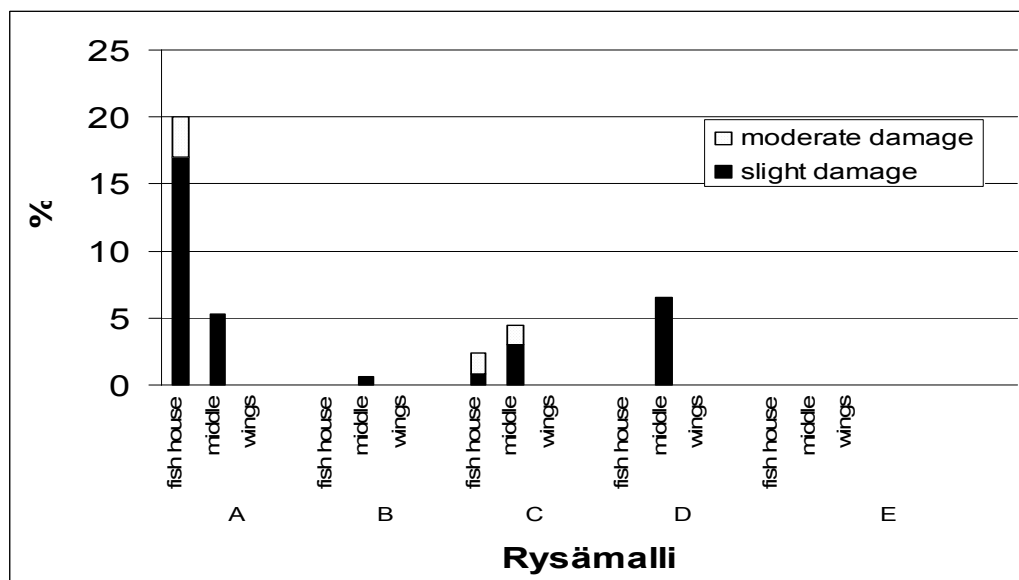


Figure 7. Distribution of seal-induced gear damage in different parts of the traps. The damage has been divided in moderate and slight ones. Rysämalli = Trapnet type. A = Non-protected trap, B = Pipe-trap, C = Folded-hoops trap, D = Seal trap, E = Pontoon trap.

2.5. Conclusions

The results of salmon trapnet trials made in 2003 and 2004 clearly show that the pontoon trap has a very good seal protection and it is practical and efficient gear (at least in salmon fishery). However, because of relatively high price of a pontoon trap, it appears that majority of coastal fishermen in Finland are not able to invest on this gear unless they are economically supported. In Sweden this design has gained a lot of popularity. Swedish fishermen, however, are economically supported (up to 80%) by the government-funds when purchasing such a gear. In Finland the economic support for purchasing seal-safe gears is substantially smaller than in Sweden. That may slow down the wider adoption of pontoon traps in Finland but it is nevertheless fairly sure that this model will start to gain popularity also in Finland, in particular in those regions where seal damages are most severe. It is worth of noting that in 2004, several Finnish fishermen (or their associations) were able to buy, rent or lease pontoon traps for further commercial testing; there were in total about 20 pontoon traps in use along the southern and southwestern Finnish coast. It is likely that in 2005 the number of pontoon traps will be even higher. The folded-hoops trap that was tested first time in 2004 showed encouraging results but this design still needs some more development. The pipe-trap that was fairly successful in 2003 trials failed in 2004 trials. Clearly, this gear-design required further testing. If it would be possible to improve the practicality of this gear, it might become a serious alternative in particular in the trapnet fishery of whitefish where pontoon trap may be inefficient and too expensive.

Responsible institute: Finnish Game and Fisheries Research Institute (FGFRI)

Task 3. Capture efficiency of whitefish by a “large-mesh” trapnet

3.1. Background

The successful introduction of a seal-safe pontoon fish bag (so called “push-up house”) has significantly decreased seal-induced damages particularly in salmon fishery along the Swedish coast of the northern Baltic Sea (e.g. Lunneryd and Fjälling 2004). The traditional trap design, however, permits an efficient hunting by seals in other parts of the gear. Fish chased by seal easily entangle themselves in the netting of wings and can then be consumed by seals, with associated damage to the net. The wings of trap-nets are traditionally made of netting with 100 mm or smaller mesh sizes (bar length). In a large-mesh trap-net wings are made of 200 mm (bar) netting. Such a mesh size allows most fish to escape through the mesh.

In earlier Swedish experiments, large meshes in wings worked well for salmon and trout (Lunneryd et al. 2003). It allowed seal-chased salmon to pass through the meshes while less stressed individuals were guided reasonably efficiently towards the fish chamber. This was confirmed by analyses of catch statistics (Lunneryd and Fjälling 2004). Apparently, the potential losses of salmon that may pass through the large meshes are compensated by the significantly reduced amount of salmon-catch that is damaged by seal. Regarding whitefish, the results have so far been more contradictory. An earlier study of tagged whitefish showed that large meshes have an effective herding capacity for whitefish (Lunneryd et al. 2002). Furthermore, some Swedish fishermen have experienced good catches (up to a daily average of 80 whitefish) in large mesh traps. However, our recent field studies with large mesh trap-net (Lunneryd et al., in press) and pilot studies in summer 2003 with tagged whitefish showed that the fishing efficiency for whitefish in large mesh traps sometimes can be quite poor. This was also noted by a number of fishermen who were testing the large mesh trap.

Nevertheless, a successful introduction of a seal-safe trap-net fishery for whitefish in the Baltic is desirable for many reasons. Firstly, it may substitute the gillnet fishery of whitefish in areas that are heavily exposed to seal-damage. Secondly, introduction of a seal safe fishery in areas where there is a low level of damage today could prevent seals from developing a behaviour pattern that includes food searching from fishing gears. Furthermore, there have been reports on high by-catches of undersized whitefish in the trap-net fishery. To enhance a sustainable whitefish fishery these by-catches need to be minimized, for instance by the use of large-mesh wings. For an efficient introduction of seal-safe large-mesh trap-nets in whitefish fishery, it is necessary to demonstrate that larger meshes would not decrease too much the fishing efficiency compared to smaller mesh sizes that are used traditionally in the wing panels.

3.2. Materials and methods

The study was conducted between May and October 2004 in close co-operation with two local professional fishermen in the archipelago area south-east of Stockholm (Fig. 1). This area was chosen because so far it has had only a few reports of seal damages. That is, the presence of seals around the experimental trap-nets would not influence the behaviour of the fish. One fisherman was fishing close to Sandhamn and the other near Utö. Both fishermen used two whitefish trap-nets, equipped with pontoon bags that were modified to be effective for whitefish. The entrance to the first compartment of the fish bag was U-shaped. Also, the first few meters after the entrance were wider than usual and an outer protection net was lacking. The last compartment, where the fish are finally accumulated, was normal, i.e., with a small

entrance and with an outer protection net. The distance between the traps in Utö was 800 m and in Sandhamn around 1200 m.

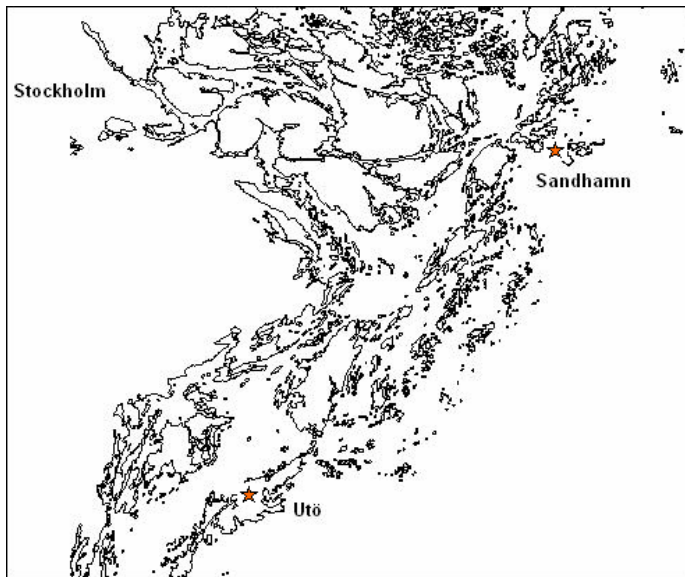


Figure 1. Map of the Stockholm archipelago and the two study areas near Sandhamn and Utö (marked with stars).

Traps were identical apart from different mesh sizes in the wing panels (Fig. 2). One trap had wing panels with a mesh size of 100 mm (SM trap, smaller mesh trap) while the other trap had wings with a 200 mm mesh size (LM trap, large mesh trap). Both were made of a polyethylene net. A 100-150 m long leader net was placed from the shore to the trap where the depth was between 17-20 m.

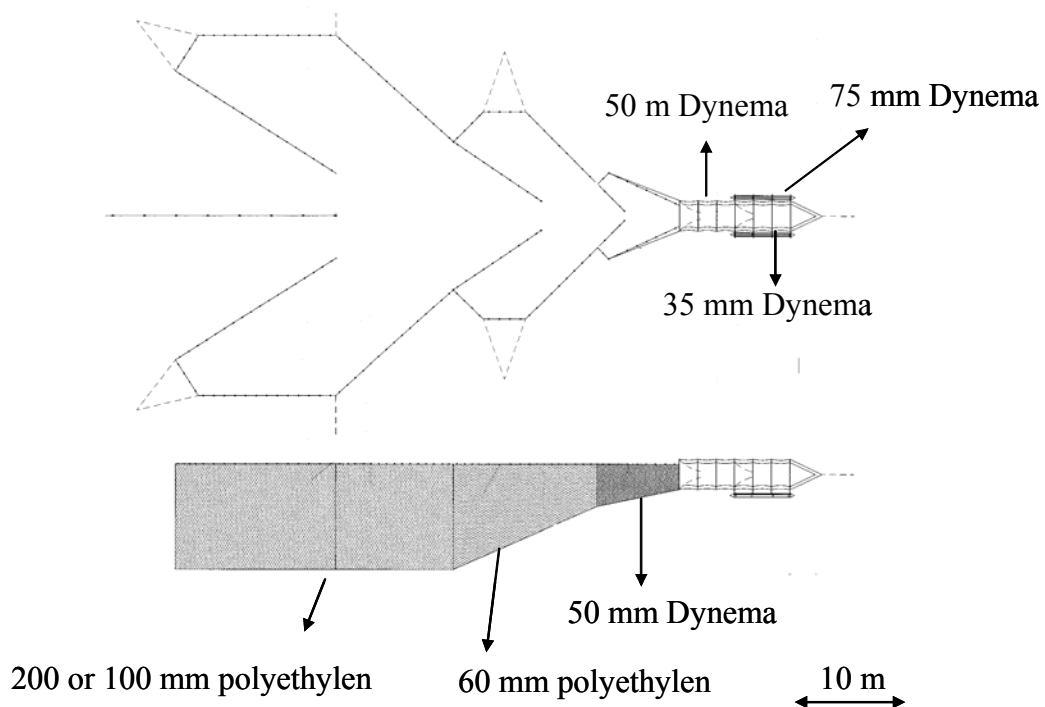


Figure 2. Schematic drawing of a trap with a pontoon bag; from above (upper) and from side (lower).

At every emptying the number and weight of all fish caught were recorded in logbooks. Damages to the gear and catch, weather conditions, time of emptying, water visibility and current direction were also recorded. The fishermen were instructed to report about seal observations around the trap. In the middle of the test period, the positions of the two traps were swapped to avoid influence of potential local catch differences. In Utö, this change took place in July 3-6 and in Sandhamn in July 19-26. Traps were cleaned at the same time.

Escape panels (grading screens) were mounted in pontoon house of three traps. In two of these traps the small fish that passed through the panel were collected in a cover-net for measurements. These traps were used in Utö. In one trap, that was not part of the large mesh study, the panels were alternatively either in normal function or covered with a small mesh net.

3.3. Results

The traps were emptied on average every second day (2.3 days between hauls). In Utö, both traps were emptied in total of 68 times between May 28 and September 4, and in Sandhamn in total of 84 times during the period of June 13 to September 26 (Table 1).

Table 1. Periods, dates and number of emptying of the small mesh (SM) and large mesh (LM) traps during the two fishing periods in 2004 in Utö and Sandhamn.

	<i>UTÖ</i>		<i>SANDHAMN</i>	
	<i>Period 1</i>	<i>Period 2</i>	<i>Period 1</i>	<i>Period 2</i>
Date	28/5 -3/7	6/7 – 4/9	13/6 – 19/7	26/7 – 26/9
No emp. SM trap	19	15	21	21
No emp. LM trap	16	18	21	21
Total no of emptyings	35	33	42	42

Whitefish dominated the catch in both areas and in all traps followed by sea trout and salmon (Table 2). In Utö, the total whitefish catch in SM trap was 1123 kg and in LM trap 647 kg. In Sandhamn the traps caught less whitefish, 521 kg in SM trap and 130 kg in LM trap. Statistical analyses showed a significant difference in the catches of whitefish in SM and LM traps in both areas (Mann-Whitney U-test, $p < 0.05$). The mean number of whitefish caught per emptying in SM trap at Utö was 75.3 and in LM trap 46.2. On average, 25.8 whitefish were caught per haul in SM trap in Sandhamn compared to 7.9 in LM trap.

Table 2. Catch (in number) of whitefish, trout and salmon in the small mesh (SM) and large mesh (LM) traps during each periods and in both study areas. The trap or fishing site with the highest number of fish is indicated with bold (statistically significant).

		Whitefish		Trout		Salmon		Salmon and trout	
		SM Trap	LM trap	SM trap	LM trap	SM Trap	LM trap	SM trap	LM trap
Utö	<i>period 1</i>	1923	999	54	14	4	0	58	14
Utö	<i>period 2</i>	638	571	15	59	0	2	15	61
Utö	total	2561	1570	69	73	4	2	73	75
Sandham n	<i>period 1</i>	973	273	4	5	0	7	4	12
Sandham n	<i>period 2</i>	110	60	6	1	1	0	7	1
Sandham n	total	1083	333	10	6	1	7	11	13

Whitefish catches varied over the season in the Utö traps. Both SM and LM trap in this area showed approximately the same variation in catches, although LM trap continuously caught less whitefish than SM trap (Fig. 3). In Sandhamn, the seasonal fluctuation was less distinguished (Fig. 4). Apart from a high peak in the end of June, whitefish catches remained low over the entire season.

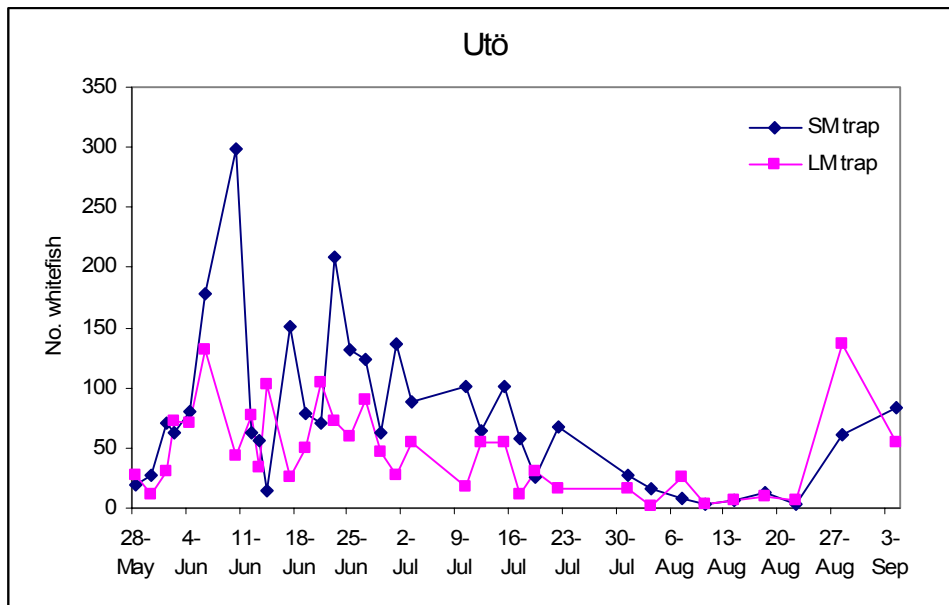


Figure 3. Catch of whitefish in the emptyings of SM and LM traps in Utö.

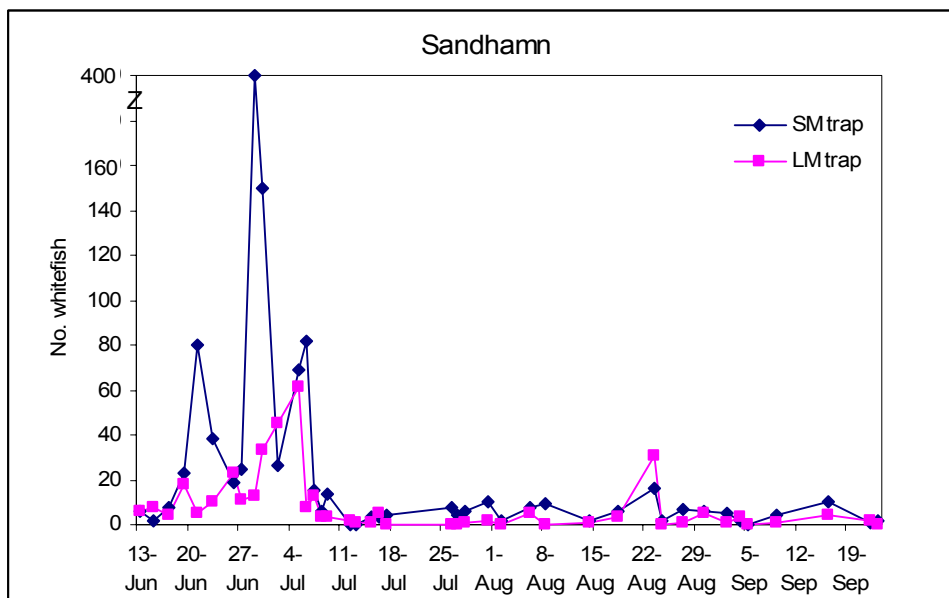


Figure 4. Catch of whitefish in the emptyings of SM and LM traps in Sandhamn. Note that the y-axis is cut off due to one high sample value.

Catch rates of trout and salmon did not differ significantly between the two types of traps (Table 2). However, when comparing the catch of the pooled number of salmon and trout between the fishing sites by the fishermen, a significant difference independent of the trap construction was revealed (Mann-Whitney U-test, $p < 0.05$).

Flounder (*Platichthys flesus*) was the most common non-salmonid species in SM and LM traps. Other species caught in the traps were roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), turbot (*Psetta maxima*), bream (*Abramis brama*) and garpike (*Belone belone*). There was a tendency of higher catches of these species in the SM trap (Fig. 5). This trend was the same for both fishermen, and they were therefore pooled. Other fish species were caught in very few numbers.

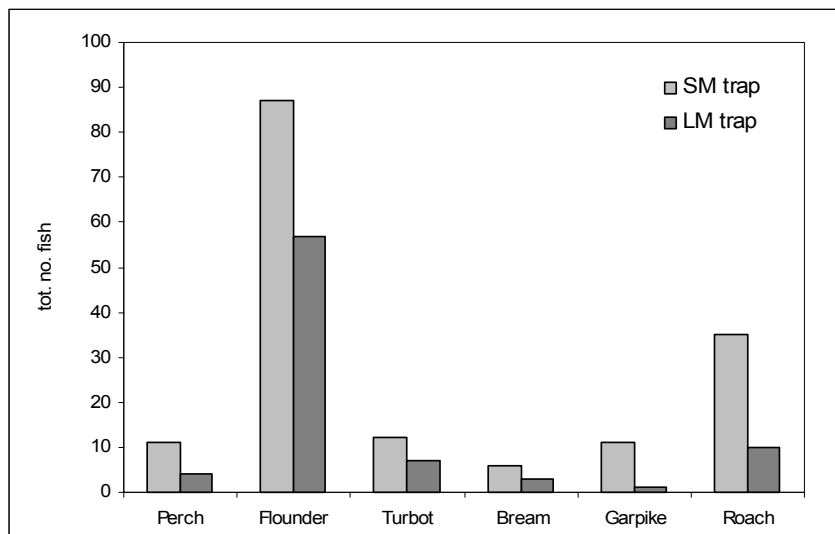


Figure 5. Catches of various fish species (in total number) in SM and LM trap by both fishermen.

None of the fishermen reported any seal damages. At one occasion a grey seal was observed from land at a distance of 60 m from the LM trap in Sandhamn. One grey seal was bycaught in the LM trap at Sandhamn.

The body length of whitefish able to pass a 35 mm panel was estimated to 35.9 cm (body width < 35 mm). In the trial with collection of fish, 133 out of 336 fish (40%) with the capacity to pass the panel actually did so. In the trial without collection of fish the catch of fish smaller than 35 cm was 35% lower when the panels were open than when they were covered.

3.4. Discussion

An important objective with the use of a large-mesh trap is to prevent fish from being entangled in the net where they become easy targets for seals. It has earlier been proven that in areas with a high level of seal damages, a 200 mm mesh size (bar length) wing netting in trap catches more salmon and trout than a conventional trap by reducing the losses caused by seals. It has been speculated that the observed losses due to escapes of fish through the meshes could be explained by seal presence inside the trap and this would be reduced if the seals abandon the gear (Lunneryd et al. 2003). In this study the fishing efficiency of whitefish in the SM traps was higher irrespective of the fishing site for both fishermen. It appears that the capture of whitefish is less effective with 200 mm meshes in the wings than with 100 mm meshes due to

higher losses of fish swimming through the meshes. This is contradictory to what we found when studying whitefish reactions to different leader arms by using ultrasonically tagged whitefish in a 10,000 m² large enclosure. In that experiment fish did not even pass through meshes with a bar size of 800 mm. It is obvious that the behaviour may change when a fish is locked inside the trap; the unwillingness to pass through meshes may substantially decrease. A circumstance that complicates the analysis of whitefish catches is that there are two different stocks (types) of whitefish in the Baltic; one stock that is spawning in the sea and another that migrate and spawn in freshwater streams. Fishermen reports that the two stocks behave differently in relation to the capture processes. This could explain why fishermen have such different opinions and catches of whitefish in the large mesh traps.

Even if the salmon and trout catches were low especially in Sandhamn, the results indicate that the location of trap affects the catch rates more than the trap construction. The LM traps caught in absolute numbers more or almost the same amount of salmon and trout as the SM traps for both fishermen. There seems to be a different behaviour of salmon and trout; they are less reluctant to pass through large mesh nets compared to whitefish.

The results show that the mesh size should be adjusted to the main target species. If whitefish is the most important target species, a 100 mm mesh size (bar length) could be useful since this mesh size is large enough for preventing seal-scared fish to entangle in the meshes. If larger salmon and trout are the most common target species, a 100 mm mesh size would enhance the seal behaviour of hunting inside the trap to entangle and consume fish. This would result in catch losses, gear destruction, and an increase of the seal presence around the trap which may influences the whole fishing process in a negative way by scaring fish away from the area.

Selection efficiency for the prototype panels was 35–40%. The efficiency was probably lowered by factors related to the experiment situation. In regular fishing and with optimized construction and placement of the panels, an efficiency well exceeding 50% is expected. The use of escape panels is thus likely to solve the problem with catch of undersized whitefish.

Responsible institute: National Board of Fisheries, Sweden

Task 4: Development of seal-safe and selective wire-pots for perch fishery

4.1. Background

In Sweden, small wire-pots are used as a complement to gill-net fishing for catching perch along many parts of the coast of Gulf of Bothnia. Besides catching perch very efficiently, these pots are seal-safe; seal-induced damages on fishing gears and catch are insignificant. However, the proportion of small fish in the catches is often high. The survival of these small individuals that are first caught in the pot and then manually released is assumed to be relatively low. By improving the selectivity of the wire-pots, i.e. selecting out the small fish during capture, both the survival and the subsequent recruitment could be improved as the total fishing mortality would be reduced. This would be a major advantage and might launch a wider use of these seal-safe gears along the whole Baltic coast.

4.2. The main results of 2003 trials

In summer 2003 we tested seal-safe wire-pots in the Gulf of Bothnia in collaboration with a group of fishermen. Three pot types with different “mesh” sizes were tested: 19*19 mm (pot A), 19*25 mm (pot B) and 19*33 mm (pot C). The pot type with the smallest mesh size (A) was the type that the fishermen in the test area are normally using. During 35 days we tested each of the pot types simultaneously in 15 different areas (in total 45 pots: 3 times 15). We checked all pots every third day. After each check, the location of each pot type was changed (rotated one step each time). For each pot, the length of all perches was recorded together with total weight of the perch catch. We analyzed the results using mixed ANOVA with pot type as a fixed effect and area as a random effect. Number of fish caught was log-transformed before doing the statistical analysis. After the initial experiment in 2003, we placed extra pots on the roof of the largest mesh sized pots (pot C) first to check the size distribution of the out-selected fish, and secondly to study the survival of them. We measured all perches (length in mm) caught in the lower cages and in the upper extra cages and then compared the size distributions.

Pot C (the largest mesh size) was clearly the most effective in selecting out the smaller perch. Fish caught in Pot C were significantly larger than fish caught in the two trap-nets with smaller mesh size (pot A and pot B) ($F_{2,19,8} = 6.73$, $p < 0.0059$). Between Pot A and Pot B there was no difference in fish size (Fig 1). The length of fish did not vary among the 15 areas ($Z = 1.09$, $p = 0.14$), but the number of fish caught differed both between the areas ($Z = 2.2$, $p = 0.014$) and between the three pot types ($F_{2,28} = 14.34$, $p < 0.0001$). Pot B with the intermediate mesh size caught perch most effectively of the three tested pot types (Fig 2). There was a significant difference in length between the out-selected fish (found in the upper extra cages) and the fish caught in the lower cages (Fig 3).

Survival experiments were not completed in 2003 because not enough perch were caught to allow statistical analysis of the material. Exceptionally high water temperature in the experimental area during the study period may explain the low number of fishes caught.

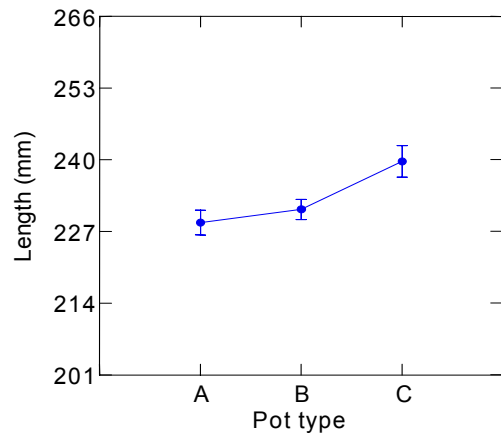


Figure 1. Length (mm) of the perch individuals caught in the three pot types (A, B or C) in 2003 trials.

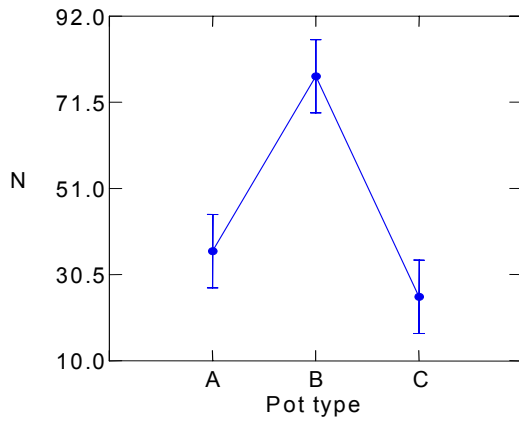


Figure 2. Number of fish caught in the three pot types (A, B or C) in 2003 trials.

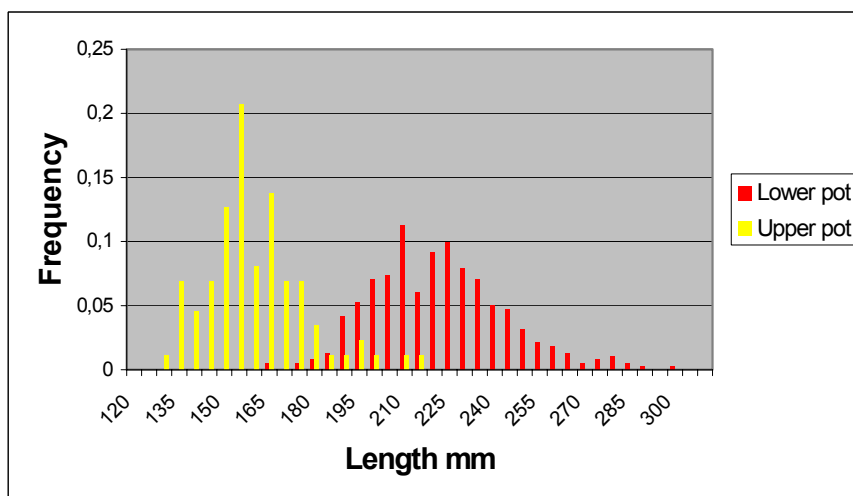


Figure 3. Size distribution of fish caught in pots with the largest mesh size (pot C) (Lower pot) and the out-selected fish (Upper pot) in 2003 trials.

4.3. Results of 2004 trials

The survival experiment was resumed in summer 2004. As in 2003, the pot with the largest mesh size was equipped with an upper pot to collect and hold the escapees. In addition to this, a control pot with the mesh size of 19 x 19 mm was placed near the experimental pot-unit. This pair setting was repeated in five stations. After a ten days catch period both the control and the experimental pots were closed and the fish were held in respective pots for five more days. Thereafter the fish were collected, measured for length and weight, and inspected for any injuries or signs of disease.

Enough data was obtained from only three of the five pot stations. Unfortunately, no data of the length distribution of the fish in the lower pot of the experimental pot-unit was collected. The length distribution of the out-selected fish in the upper pot of the experimental pot-units was compared to the length distribution of fish from the control pots. There was a clear difference in the length distribution between the out-selected fish and fish in the control pots ($F_{1,3} = 853.5$, $p = 0.000$)(Fig. 4). There was also a clear difference in the length of fish between the areas ($F = 17.7$, $p = 0.000$). Neither injuries nor sign of disease was detected either in the out-selected fish or in the control fish. All fish were found alive when the experiment was finished.

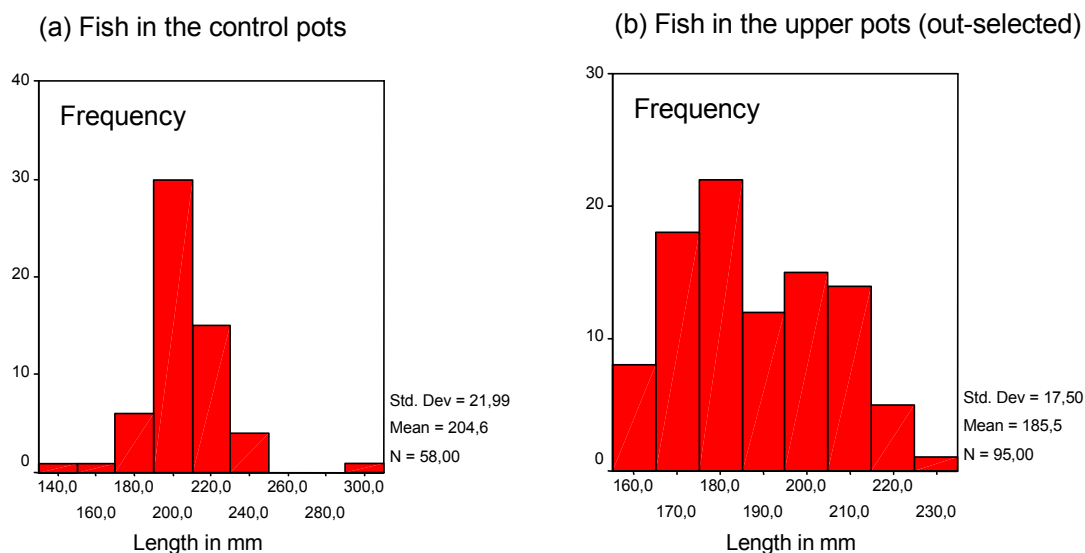


Fig 4. Length distributions of fish (a) in the upper pots of the experimental pot-unit (out-selected) and (b) in the control pots.

4.4. Discussion

Our trials suggest that it is a realistic option to use pots as an alternative fishing gear, at least in case of perch gill-net fishery. Pots can more easily be protected from seal attacks. In addition, a clear advantage of pots is that the overall selectivity of the gear can easily be improved, and the bycatch can be released or selected alive.

Fish caught in pots with the largest mesh size (pot C) were larger than fish caught in the pots with smaller mesh sizes (pot A and pot B). Also, the size distribution experiment showed that in Pot C there was a clear difference in length between the out-selected and retained perch.

This indicates that using a larger mesh size in the pots' roof is an effective tool to reduce the proportion of smaller fish in the catch and thereby reducing the by-catches. This appears also to be a safe way of selecting out the small fish, because no damages in the fish were observed. However, the time that fish spent in the upper pot after passing through the meshes in the roof of the lower pot varied from only five up to fifteen days. Since the inlet of the pots were closed after ten days fishing and the fish were removed five days after closing it was not possible to keep track of the exact time period each fish spent in the pot. For those fish which were caught late in the fishing period the time spent in pots may have been too short to develop any symptoms of diseases. However, no physical damages were observed after passing through the meshes.

The development of size-selectivity of the pots is important because they are very effective in catching juvenile perch leading to potentially high fishing mortality of the local perch populations. By selecting the small fish out alive, the overall fishing mortality can be effectively reduced. This, together with the fact that no seal damages were recorded, makes it possible to introduce this type of gear as an alternative, seal-safe catching method to gill-netting.

These type of pots can likely be used in many type of small scale coastal fishery targeting for instance pike-perch. However, the pots have to be adapted to local fishing conditions. Moreover, gears have to be easily moved and stored. Small and flexible pots and trap-nets are potential seal-safe alternatives for the coastal pike-perch and perch fishery in the archipelago areas of the Baltic Sea. It is impossible to develop effective and practicable seal-protection system for gill nets.

Responsible institute: National Board of Fisheries, Institute of Coastal Research, Sweden.

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Appendix 1. The design of the floating pipe system ("kohopaino") tested in Merikarvia-experiments in 2004. Explanations are in Finnish.

KOHOPAINO

