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35 AND 40MM SWEDISH GRIDS IN A SCOTTISH *NEPHROPS* TRAWL FISHERY

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Summary

Experimental trials were conducted on North Sea *Nephrops* grounds to compare the catch rate of an 80mm diamond mesh codend fitted with (i) a 35 mm Swedish grid and (ii) a 40 mm Swedish grid to that of a 40 mm control codend.

Both grids were very successful in eliminating catches of large fish and no cod, haddock, whiting or hake greater than 34, 35, 38 or 39 cm were caught by the 35 mm grid gear and none greater than 41, 45, 41 or 47cm by the 40 mm grid gear.

There was a significant loss of smaller *Nephrops* (< 41-45 mm carapace length), which can be attributed to the selection of smaller *Nephrops* from the 80 mm codend.

There was no significant loss of larger *Nephrops* from either the 35 or 40 mm grid gear.

Introduction

At the EU December Council meeting in 2008, Scotland committed to trialling the Swedish grid in the West Coast *Nephrops* (*N. norvegicus*) fishery. In 2009 two sets of trials, on the west and east coast of Scotland respectively measured the selectivity of a 35 mm Swedish grid fitted in the extension fished in conjunction with an 80 mm diamond mesh codend. These trials gave encouraging fish results with all species examined from the grid gear showing a very significant decrease in retention as compared to a 40 mm total population net tending to a point of zero catch. However the trials also showed a decrease in retention of the larger size classes of *Nephrops*. The *Nephrops* results were a source of industry concern and during a Conservation Credits meeting of 2009 interest was expressed in trialling a grid with a wider bar spacing to see if this would retain more large *Nephrops*. A bar spacing of 40 mm was considered an appropriate step up in size as there was a need to avoid too large an increase in fish retention.

Materials and Methods

Vessel, Gear and Test Cases

The trials were carried out on the *Fruitful Bough* (PD 109), a 522kW twin-rig *Nephrops* trawler working out of Peterhead. The vessel fished its usual matched pair of scraper nets (Pisces design), each with a fishing circle of 520 x 80 mm meshes. The vessel's own extensions and codends were replaced with experimental extensions pre-rigged at the Marine Laboratory with the grids or a small mesh codend. Overall groundgear length was 55 m and consisted of 200 mm discs in the centre reducing to 150 mm out to the wing ends. The trawls were fished using a three-warp system with a 1000 kg roller clump and spread using 1.7m/700 kg Type 11 Thyboron doors. This is a net design and rig setup that is commonly used in the Fladen *Nephrops* fishery.

The 80 mm (nominal) diamond mesh codends and extensions were made from 4 mm single polyethylene (PE) twine. They had 120 open meshes around the circumference and were fitted with 160 mm diamond mesh lifting bags made from 5 mm double PE twine with 54 open meshes.

The Swedish grids were made from aluminium tubing and hinged at the mid point along their length. They were approximately 1.52 m long by 0.87 m wide, had bar spacing of 35 and 40 mm and weighed 22 kg and 21 kg respectively. They are here referred to as the 35 grid and the 40 grid. The 35 grid had 14 bars and the 40 grid had 13 bars in the top and bottom sections. The grid was positioned in the extension, 13 m from the codline, so that it inclined backwards at a 45º angle to the selvedge. This is the same position as was used for earlier Scottish trials. A fish-release vent hole in the shape of a truncated triangle was cut out of the top sheet in front of the grid and three 8" floats attached on each side, above the hinge, to support the grid weight and aide stability. A chaffing strip of heavy netting was attached to the bottom sheet to protect the grid lacing.

Trial Procedures

Prior to commencing the trials the twin rig gears were hauled ashore and checked to confirm that they were matching and to carry out any necessary mending. After steaming some 30 miles from the harbour two short tows were undertaken to run a check on Scanmar instrumentation and to make observations on the grid angles before heading off to the grounds. The trials were carried out on *Nephrops* grounds in Fladen and to the east of Shetland during January and February of 2010.

Most selectivity hauls lasted between 3 and 4 hours, with the vessel towing at its normal fishing speed of 2.6-2.9 knots. Scanmar instrumentation was used to measure the angle of the upper and lower panels of the grid, wing-end and door spreads and headline height. To minimise tidal effects on the twin rig geometry, hauls were conducted either directly with or against the tide and to minimise the risk of washout, the catch from the test case was taken

aboard before that from the control gear. To counter any net effect each test extension was trialled on both port and starboard nets.

The twin trawl method was used to measure the selectivity of the two test codends, where one net of the twin-rig fishes a test codend while the other fishes a 40 mm diamond mesh codend (control codend) to estimate the population of *Nephrops* and fish available on the grounds.

Nephrops, cod, haddock, whiting, saithe, ling, hake, anglerfish, megrim, lemon sole, plaice, witch and all species of skate were sorted from the catch, subsampled where necessary, and measured. *Nephrops* carapace length (cl) was measured to the mm below and fish length to the cm below. In the case of *Nephrops* special attention was paid to the largest size classes and these were fully sampled in all catches. All target fish species were weighed using a calibrated 50 kg Salter hanging balance. An in-house weight/length conversion factor was applied to the cod length frequencies to assist with further analysis. Non target fish species such as pout and dabs were recorded as a bulk weight from a volume incorporating the number of times the waste fish chute was emptied per codend. Potential obstructions, such as kelp, skates, boulders, benthos or rubbish which gathered on the grid surface or immediately ahead (at point of contact with the bottom sheet) were also recorded where possible.

Data Analysis

For each species where there were sufficient data the catch rate of the test gears relative to the control net were estimated and compared using the smoother based methodology of Fryer *et al*. (2003). The analysis was in three stages:

1. a smoother was used to model the log catch rate of the test gear relative to the control gear for each haul;

2. the fitted smoothers were combined over hauls to estimate the mean log relative catch rate for each gear;

3. boot strap hypothesis tests using the statistic T_{max} were used to assess whether the mean log relative catch rates depended on gear, and to compare the mean log relative catch rates to zero (or equivalently the mean relative catch rates to unity).

All p-values of pair wise comparisons have been adjusted for the number of comparisons, unless otherwise stated. The analysis was on the logistic scale, but the results have been back-transformed for presentation. The results are presented in the figures below where the relative catch rate is shown as the proportion of fish retained in the test gear at each length as compared to the control net. A value of less than one indicates that the test gear caught fewer fish at that length and a value greater than one indicates more fish were caught in the test gear compared to the control. A dashed line indicates where the relative catch rate did

not differ significantly from one, whereas an unbroken line indicates there is pointwise significance at the 5% level.

Results

The initial instrument checks showed that net geometry when fishing was excellent but the angles obtained from one or more of the panels on both grids was considered suboptimal (< 45^{o}). Following re-rigging both sections of the 35 grid maintained a stable 42-45^{o} angle throughout the trials. However the top section of the 40 grid showed a tendency to settle at a lower angle of 30-40^{o} for some of the hauls and several adjustments were required to get both angles for this grid at approximately 45^{o} throughout the trials. Analysis of data from 40 grid with optimal and suboptimal top section showed no significant differences between the performance of the two and for this report results for both are combined. Mean wingspread/heights were measured as 19.0m/1.7m (Port) and 19.3m/1.5m (Stbd) for the 35 grid trials and 19.2m/1.6m (Port) and 19.5m/1.5m (Stbd) for the 40 grid trials.

A total of 31 catch comparison hauls were completed of which 29 were considered valid with damage to gear invalidating two. The valid hauls were composed of 11 hauls with the 35 grid and 18 hauls with the 40 grid. Deployment and hauling of the test gears was slower than normal fishing operations in moderate to rough seas with careful handling needed during shooting and considerably more handling during hauling operations. There was one instance where combination of poor seas and darkness meant work with the grid was postponed until daylight due to handling concerns. Manual lifting of the grid over the roller bars was required at least four times during a complete shooting and hauling operation and more if the gear needed any twists taken out. Care was needed here as the grid had a tendency to catch on the roller bars when coming inboard. On one occasion shooting of the gear for a haul in the dark was postponed until daylight as there were concerns with the grid swinging about too much during hauling. The grid fit onto the net drum moderately well, although often requiring some assistance the crew, but there was only just enough space above and behind the drum for it to go on. Use of the block towards the end of hauling operations tended to put twists into the extension requiring that care was used when shooting to ensure all were removed.

Observations on the grid as it surfaced were usually compromised by the rough sea conditions that prevailed for much of the trials. It was noted that when hauled clear of the water the grid would tend to flip so that the escape gap pointed downwards allowing some or all of any debris build up to be lost though the gap before measurements could be made. However, notes were taken of obstructions on the surface of the grid itself and build-up of debris at the base of the grid where possible.

For about a third of cases minor amounts of material were observed on the grid at the surface upon hauling. Typically this consisted of 0.5 kg or less of kelp or a single brown crab or flatfish occupying a very small percentage of the grid area. For a total of five out of the 29 hauls there was observed to be more significant blockages of the grid upon hauling with

20-40% of the grid being covered. These blockages included sheets of plastic and mixtures of kelp, fish and *Nephrops* and other benthic invertebrates. Debris build-up on the bottom sheet in front of the grid gears varied from nothing to 2-4 kg of buckies (*Neptunea antique*), starfish (*Asterias rubens*), brown crabs and kelp. Approximately double this amount would be found in the control codend and would often include more Stone crab (*Lithodes maja*). Only very small amounts of benthos/debris (< 1 kg) were recorded from the test codend. A total of 10 kg of kelp build-up in front of the grid was recorded over the trials which can be compared with 21 kg in total recorded from the control codend. There were no observations of mudding up or blockage of the grid gears by large skate and there were no instances of boulders being caught during these trials.

Whitefish catches were moderate and there was sufficient numbers of haddock, whiting, hake, megrim, plaice lemon sole and witch for smoother based analysis. Species such as cod, anglerfish and ling were caught in fair numbers in the control codend but very few were retained by either of the test gears. Results for anglerfish combine data from catches of the two species *Lophius piscatorius* and *L. budegassa.* *Nephrops* catches were variable according to time of day with very small amounts being caught during dark tows. Catch weights in the test gear ranged from 38-338 kg and had the appearance of clean *Nephrops*, whereas in the control gear the weights ranged from 310-1154 kg and were of mixed species.

The relative catch rates of both grid gears from smoothed data are significantly different from the control codend for haddock, whiting, *Nephrops*, plaice, witch, megrim and hake.

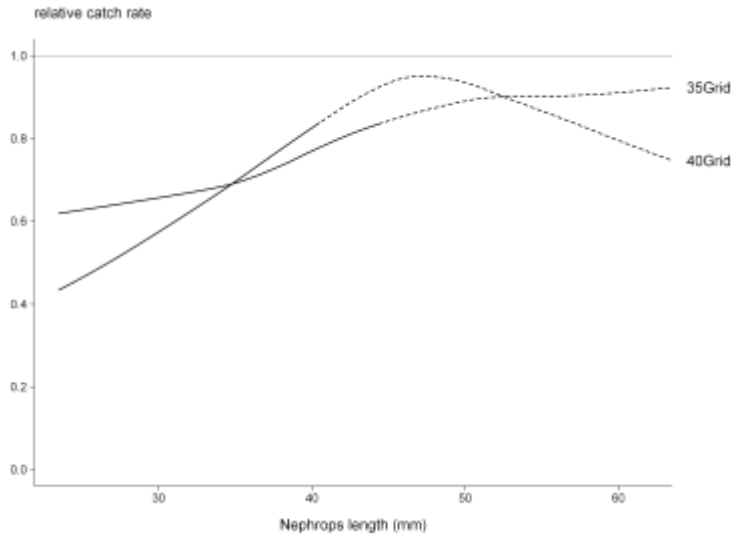

Figure 1: The relative catch rates of *Nephrops* of the two gears tested in comparison to the small mesh control.

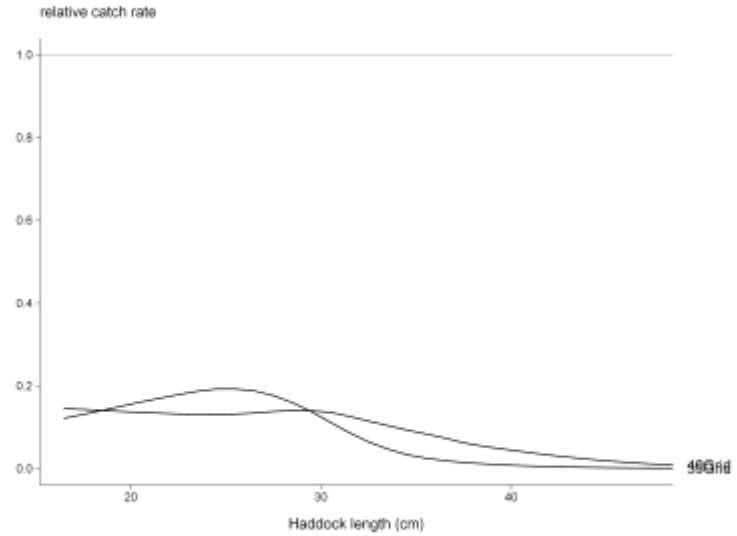

Figure 2: The relative catch rates of haddock of the two gears tested in comparison to the small mesh control.

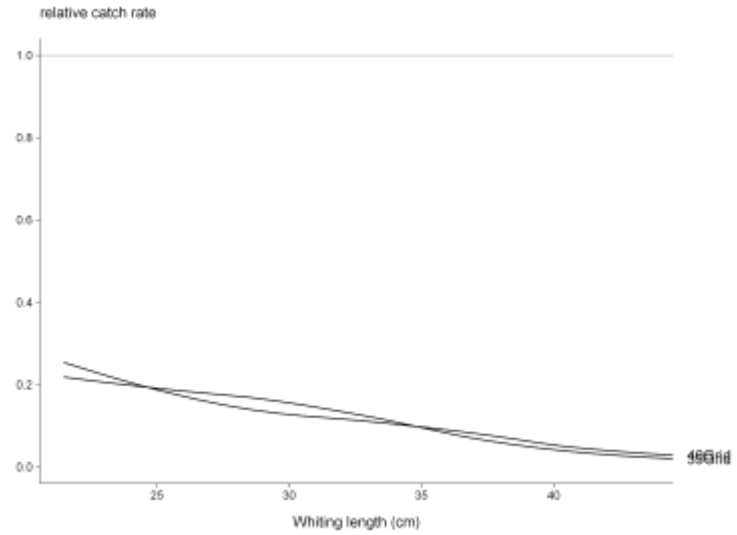

Figure 3: The relative catch rates of whiting of the two gears tested in comparison to the small mesh control.

Table 1

Numbers and estimated weights of cod by 5 cm size class as retained by the two grid gears. Cod weights analysed here are an estimate from a weight/length relationship.

length class (cm)	35 grid						40 grid					
	control no.	test no.	catch rate %	control wt.	test wt.	catch rate %	control no.	test no.	catch rate %	control wt.	test wt.	catch rate %
15-19	0	0	**0**	0	0	**0**	7	2	**29**	0.5	0.1	**29**
20-24	5	6	**120**	0.6	0.7	**119**	17	9	**53**	1.9	1.2	**64**
25-29	3	1	**33**	0.6	0.3	**44**	14	8	**57**	3.1	1.7	**56**
30-34	26	3	**12**	9.7	1.1	**12**	39	11	**28**	15.0	4.3	**28**
35-39	54	0	**0**	29.3	0	**0**	94	16	**17**	51.7	8.7	**17**
40-44	34	0	**0**	25.9	0	**0**	67	1	**1**	50.7	0.8	**2**
45-49	11	0	**0**	11.7	0	**0**	15	0	**0**	15.6	0	**0**
>-50	35	0	**0**	106.8	0	**0**	63	0	**0**	203.5	0	**0**
totals	168	10	**6**	184.5	2.1	**1**	316	47	**15**	342.0	16.8	**5**
largest fish	**34cm**						**41cm**					

Nephrops

The relative catch rates of the two test gears were not significantly different from each other. They were, however, significantly different to the 40 mm control gear and there is evidence, on a pointwise basis, that the grid gears lost some of the smaller *Nephrops*: For the 35 mm grid gear there are significant losses (50% decreasing to approximately 18%) of *Nephrops* < 45 mm cl but no significant losses of larger *Nephrops*. For the 40grid gear there are significant losses (approximately 57% decreasing to approximately 8%) of *Nephrops* < 41 mm cl but no significant losses of larger *Nephrops* (Figure 1).

Cod

Numbers of cod retained by the grid gears were not sufficient to carry out a smoother analysis for either of the two grids. For the 35 grid trials 168 cod (lengths 20-99 cm) were retained in the control gear with 10 cod (19-34 cm) retained in the test. For the 40 grid trials 316 cod (15-105 cm) were retained in the control codend with 47 cod (19-42 cm) being retained in the test. This gear also retained somewhat more of the smaller cod. Over the full length range the 35 grid retained 6% by number and an estimated 1% by weight of the control catch, while the 40 grid retained 15% and an estimated 5% respectively (Table 1). Neither grid gear catches large cod; no cod greater than 34 cm are caught by the 35 grid gear and none greater than 42 cm by the 40 grid.

Haddock

The two test gears are significantly different from the control and from each other. Both gears retained fewer haddock than the control codend with the 40 grid gear catching slightly more haddock than the 35 grid in the length range 30-47 cm. No haddock greater than 35 cm are caught by the 35 grid gear and none greater than 45 cm by the 40 grid gear.

Whiting

The two test gears are significantly different from the control with both retaining fewer whiting but are not different from each other. No whiting greater than 38 cm are caught by the 35 grid gear and none greater than 41 cm by the 40 grid gear.

Hake

The two test gears are significantly different from the control and from each other. Both gears retained fewer hake than the control codend but the 40 grid gear caught slightly more hake in the length range 27-47 cm. Neither grid gear catches large hake; no hake greater than 39 cm are caught by the 35 grid gear and none greater than 47 cm by the 40 grid gear.

Megrim

There was no significant difference between the relative catch rates of the two grid gears but both retain significantly fewer than the control. Approximately 33% of megrim are retained at 19cm which reduces to approximately 11% at 45 cm.

Plaice

There was no significant difference between the relative catch rates of the two grid gears but both retain significantly fewer than the control. About 62% of plaice are retained at 21 cm reducing to about 29% at 38 cm.

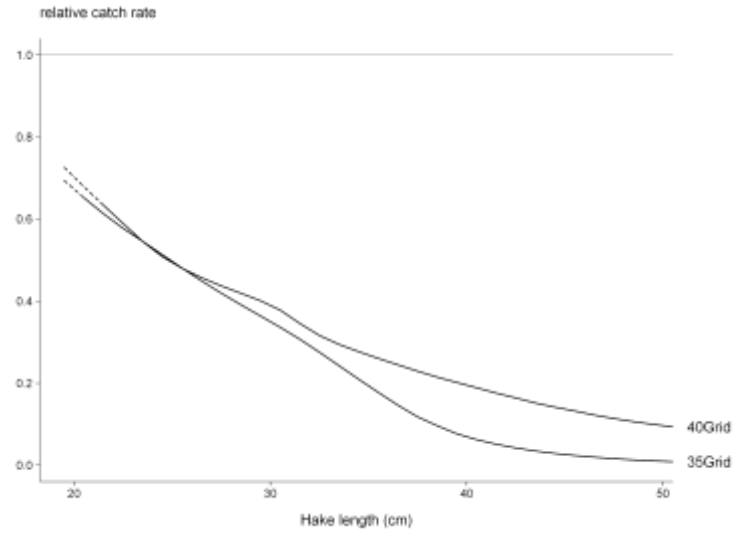

Figure 4: The relative catch rates of hake of the two gears tested in comparison to the small mesh control.

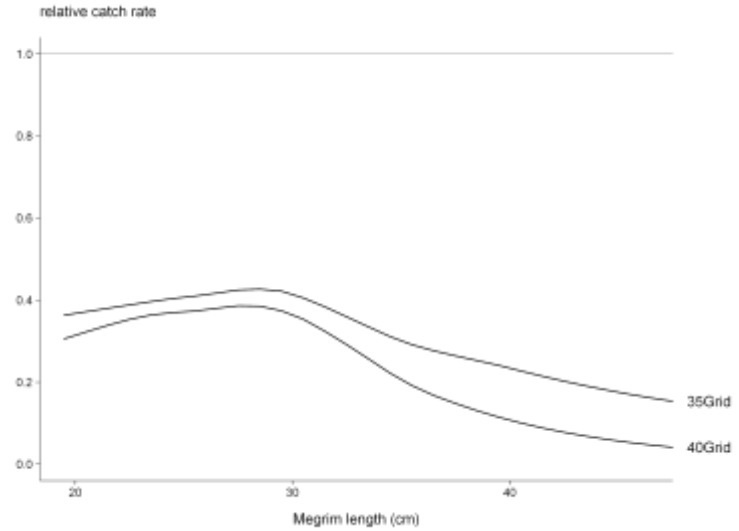

Figure 5: The relative catch rates of megrim of the two gears tested in comparison to the small mesh control.

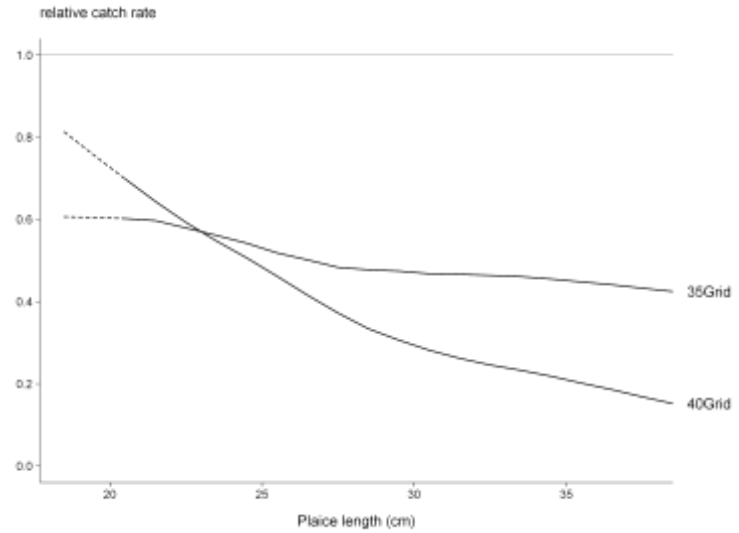

Figure 6: The relative catch rates of plaice of the two gears tested in comparison to the small mesh control.

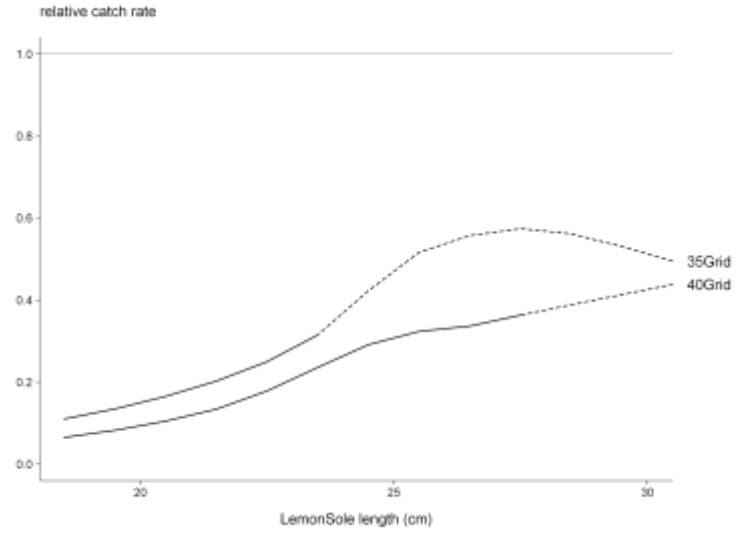

Figure 7: The relative catch rates of lemon sole of the two gears tested in comparison to the small mesh control.

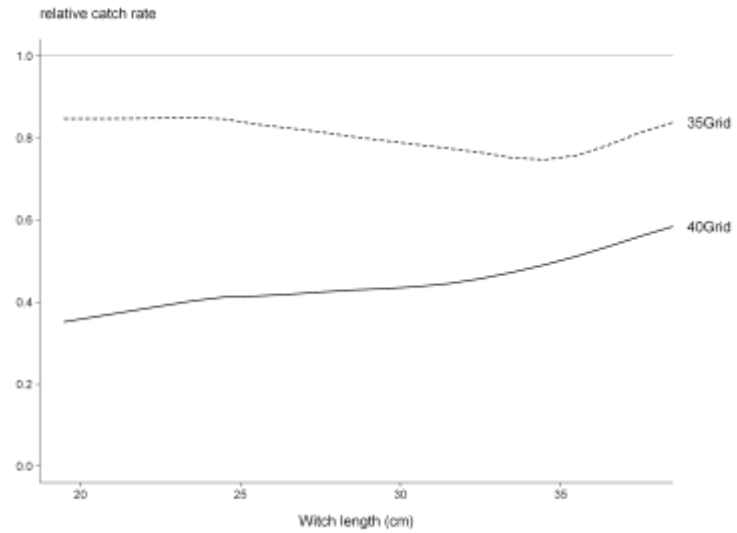

Figure 8: The relative catch rates of witch of the two gears tested in comparison to the small mesh control.

Lemon Sole

There were no significant differences between the relative catch rates of the two test gears or between the relative catch rates of either of the test gears and that of the control. There is, however, pointwise evidence that the grid gears retain only about 9% of lemon sole at 18 cm rising to about 27% at 23 cm.

Witch

The 40 mm grid retained fewer lemon sole than the control codend with approximately 37% being retained at 19 cm rising to about 58% at 40 cm. Results for the 35 mm grid did not differ significantly from the control.

Anglerfish

Numbers of anglerfish retained by the grid gears were not sufficient to carry out a smoother analysis for either of the two grids. Test retention throughout the trials was observed to be low. For the 35 mm grid trials 159 anglers (12-77 cm) were retained in the control gear and 16 anglers (lengths13-21 cm) retained in the test. For the 40 mm grid trials 149 anglers (14-104 cm) were retained in the control codend and 20 anglers (11-31 cm) were retained in the test. Over the size ranges where fish are being retained by the test gears this equates to retention rates of approximately 70% by number overall for the 35 mm grid and approximately 68% for the 40mm grid.

Saithe

Numbers of saithe retained by the grid gears were not sufficient to carry out a smoother analysis for either of the two grids. For the 35 mm grid trials 22 saithe (31-76 cm) were retained in the control gear with none retained in the test. For the 40 mm grid trials 128 saithe (31-96 cm) were retained in the control codend with 5 saithe (27-39 cm) retained in the test.

Ling

Numbers of ling retained by the grid gears were not sufficient to produce selectivity parameters for either of the two grids. For the 35 mm grid trials 12 ling (lengths 46-120 cm) were retained in the control gear and none retained in the test. For the 40 mm grid trials 85 ling (lengths 32-95 cm) were retained in the control codend and 1 ling (length 30 cm) was retained in the test.

Skate

Both number and size of skate caught was low during these trials. Species encountered were common skate (*Dipturus batis*) cuckoo ray (*Raja naevus*) and starry ray (*Raja radiata*). Overall 46 skate (all species combined) were caught in the control gear and 26 in the test. During the 35mm grid trials 21 skate (8-55 cm) were retained in the control gear with 19 (11-45 cm) retained in the test. For the 40 mm grid trials 25 skate (15-46 cm) were retained in the control codend with 7 skate (19-40 cm) retained in the test. None of these skate caught during these trials were large enough to have presented a serious potential for affecting the performance of either test case by becoming jammed in place on the grid. A summary of probability is presented in Table 2.

Table 2
Bootstrap analysis results indicating significant differences ($p \leq 0.05$) between test gears as well as between test gears and control gear.

	Global p-value between test gears	Global p-value between test gears and control	P value between each test gear and control
Nephrops	0.697	0.013	both 0.062
Haddock	0.011	< 0.01	both < 0.01
Whiting	0.838	< 0.01	both < 0.01
Hake	0.020	< 0.01	both < 0.01
Megrim	0.409	< 0.01	both < 0.01
Plaice	0.105	< 0.01	both < 0.01
Lemon Sole	0.687	0.063	both < 0.12
Witch	0.058	< 0.01	35mm grid 0.28, 45mm grid < 0.01

Discussion

There was a loss of smaller *Nephrops* for both test grids in comparison to the 40 mm control codend from about 57% at 20 mm to about 18% at 40 mm. This loss can be attributed to selection through the 80 mm codend of the test gear during the rough seas that prevailed for most of the experiment. There was no significant loss of larger *Nephrops* for either the 35 grid or 40 grid gears.

Both grids eliminated catches of large fish and no cod, haddock, whiting or hake greater than 34, 35, 38 or 39 cm were caught by the 35 mm grid gear and none greater than 41, 45, 41 and 47 cm by the 40 mm grid gear.

Some small fish, however, pass through the grid and are retained in the codend (~ 15 - 20% haddock < 25 cm, ~ 20% of whiting < 25 cm). In addition, fewer anglerfish, ling and saithe were caught in the grid gears, while the results for flatfish were variable.

For many species there was little significant difference between the two grids despite the 14% increase in bar spacing with whiting in particular showing very similar catch rates. This may be evidence that there is more to the grid's function than just physical size-sorting and that fish behaviour may also be a factor, in which case retention may vary with the condition of the fish as well as the size.

The Scottish fishing industry has raised several concerns about the operation of the Swedish grid, including the possible loss of catch due to blockages of the grid by kelp, boulders, large skate, general seabed detritus/benthos and rubbish. For five of the 29 hauls of these trials, the grid was observed to be 20-40% blocked on hauling. It is not possible, however, to ascertain at what point during a tow these obstructions occur and hence it is difficult to quantify how they may affect the catch. Nevertheless, in total, during these five tows, 76 kg

of *Nephrops* were caught in the test gears while 99kg were caught in the control gear (Table 3).

Table 3

Comparison of weights caught of the four main species between the grid gears and the control by haul. In the Obstruction column N refers to nothing observed on the grid as it surfaced, + refers to a minor obstruction such as a single flatfish or small bit of kelp being present, and Y refers to a more significant obstruction.

Haul	Grid	Obstruction	Test weights (kg)					Control weights (kg)				
No.	(mm)	(on grid surface)	Nephrops	Cod	Haddock	Whiting	Tot. Catch	Nephrops	Cod	Haddock	Whiting	Tot. Catch
1	35	N	184	0	6	2	218	229	15	58	15	618
2	35	N	290	0	7	5	338	359	19	38	31	900
3	35	+	51	0	3	3	108	51	9	65	29	576
4	35	N	27	0.1	8	13	122	32	4	33	34	508
5	35	N	17	0	7	34	110	19	2	24	103	684
8	40	Y	24	0	5	23	94	23	12	34	146	655
9	40	+	33	0	0.5	9	85	35	12	17	207	689
11	40	+	44	6	11	13	104	44	125	84	147	1154
12	40	N	3	4	10	20	92	3	34	70	254	862
13	40	N	34	3	4	7	78	33	27	55	128	482
14	40	N	2	0.2	4	7	38	0.5	0	21	45	572
15	40	N	35	5	4	13	81	35	35	75	160	895
16	35	N	69	0	4	13	118	121	64	31	160	790
17	35	N	9	0.2	8	41	120	11	22	47	104	836
18	35	+	118	3	6	7	221	116	55	92	169	978
19	35	N	22	0	10	13	121	21	2	78	97	507
20	35	Y	23	4	5	12	114	29	4	59	95	468
21	35	N	48	0.5	3	7	110	49	11	36	56	378
22	40	N	20	0.1	10	14	82	19	12	42	78	505
23	40	+	7	2	4	7	66	6	3	47	59	310
24	40	+	48	0	3	11	115	42	8	50	78	583
25	40	+	22	1	7	9	103	22	7	57	76	640
26	40	N	3	0.1	8	12	64	4	4	66	76	441
27	40	Y	4	0.5	12	32	88	11	5	42	78	470
28	40	Y	22	0.5	21	56	144	30	7	65	87	504
29	40	Y	3	0.1	3	6	49	6	26	38	48	370
30	40	+	25	0.4	5	10	89	26	8	38	60	376
31	40	N	0.5	3	28	19	80	3	24	390	134	1066
33	40	N	34	1	74	15	139	75	18	485	88	1153

The fact that there was some difficulty getting one of the grids rigged satisfactorily illustrates that the extension in a Scottish *Nephrops* trawler being typically 120 meshes round is not an ideal position for a grid of these dimensions. Fitting it into a section in the taper where the net is naturally more open and where it would not need to be forced in to position may be a more suitable place for it. This would also have the advantage that the grid could be wound onto the drum earlier during hauling when there would be more space to accommodate it.

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References

Fryer R.J, Zuur A.F, Graham N, 2003. Using mixed models to combine smooth size-selection and catch-comparison curves over hauls. Canadian Journal of Fisheries and Aquatic Sciences 60: 448-459.

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