VIP – Pelagic Trawl Innovation

Publication date:
23 november 2015

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IMARES report:
C109/15

IMARES
WAGENINGEN UR

European Fisheries Fund: investment in sustainable Fisheries

Opdrachtgever:

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This report has been produced with financial support of the European Fisheries Fund: investment in sustainable fisheries.

European Fisheries Fund: investment in sustainable fisheries

IMARES, onderdeel van Stichting DLO.
KvK nr. 09098104,
IMARES BTW nr. NL 8113.83.696.B16.
Code BIC/SWIFT address: RABONL2U
IBAN code: NL 73 RABO 0373599285

A_4_3_1-V14.2

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Summary

In response to the landing obligation for pelagic species, that started in 2015, the Dutch pelagic fishing industry has tested sorting grids with the aim to avoid the capture of undersized and/or unwanted fish.

Data on catches were collected through a self-sampling programme. Crew members on board three large freezer trawlers of the Dutch Pelagic Freezer-trawler Association ("Jan Maria" (BX791), "Willem van der Zwan" (SCH302), and "Carolien" (SCH81)) collected data during trips fishing with their standard gears and a range of sorting grids. Overall, six trips were included in the analysis. In these six trips a modified net was used during 11 hauls (~9% of all hauls in these trips) in 2014 and 12 hauls (~5% of all hauls in these trips) in 2015.

In order to determine whether a grid is effective in letting small individuals escape, we hypothesised that the fraction of smaller fish in the catch when fishing with grids is smaller than the fraction of smaller fish in the catch when fishing without grid. Statistical tests were used to determine whether an association, between the fraction small fish caught and the usage of a sorting grid, exists. The number of hauls where grids were used was relatively small (23 hauls out of a total of 352 hauls). Analyses were conducted for horse mackerel (*Trachurus trachurus* L.) and mackerel (*Scomber scombrus* L.). The effect of grids for both species was found to be not statistically significant.

An analysis was also done on video footage identifying species that managed to escape through the grid. Length frequency distributions for mackerel and horse mackerel were constructed based on length estimations from the video footage. The accuracy of estimated lengths vary between 10 and 50 mm, and the percentages escaped between 3.4-7.9% for mackerel, and between 0.2-0.5% for horse mackerel. Underwater observations during two hauls showed no escapees of boarfish (*Capros aper* L.), indicating that this species did not escape through the grid. Direct observation with video recording of fish behaviour in proximity of the grids in combination with catch data analysis seems to be a better methodology for future research.

In the future it is recommended to make an attempt to increase the number of experimental hauls. The relatively small dataset made it difficult to draw conclusions from the statistical analyses.

Nederlandse samenvatting

Naar aanleiding van de aanlandplicht voor pelagische vissoorten, die in 2015 is ingegaan, heeft de Nederlandse pelagische visserij sector proeven uitgevoerd met zgn. sorteerroosters (EN: 'sorting grids') met als doel om de vangst van ondermaatse en/of ongewenste soorten te vermijden.

Vangstgegevens werden verzameld d.m.v. een zelfbemonsteringsprogramma. Bemanningsleden hebben aan boord van drie grote vriestrawlers van de Redersvereniging voor de zeevisserij ("Jan Maria" (BX791), "Willem van der Zwan" (SCH302), en "Carolien" (SCH81)) gegevens verzameld gedurende reizen waarbij gevist werd met standaard netten en een serie sorteerroosters. In totaal zijn zes reizen meegenomen in de analyse. Tijdens deze reizen werd gedurende 11 trekken (~9% van alle trekken in deze reizen) in 2014 en 12 trekken (~5% van alle trekken in deze reizen) in 2015 een sorteerrooster gebruikt.

Om te bepalen of een sorteerrooster effectief is in het laten ontsnappen van kleine individuen, werd de aanname getest dat de fractie kleine vis in de vangst tijdens een trek vissend met een sorteerrooster kleiner is dan de fractie kleine vis in de vangst tijdens een trek vissend zonder een sorteerrooster. Door middel van een statistische analyse is er getest of er een verband bestaat tussen de fractie gevangen kleine vis en het gebruik van een sorteerrooster. Het aantal trekken waar met sorteerrooster werd gevist, was relatief klein (23 trekken uit een totaal van 352 trekken). Analyses zijn uitgevoerd voor horsmakreel (*Trachurus trachurus* L.) en makreel (*Scomber scombrus* L.). Het effect van de sorteerroosters bleek niet significant te zijn.

Een analyse van video-opnamen toonde aan, dat zowel makreel als horsmakreel en vele niet geïdentificeerde vis door de roosters konden ontsnappen. Aan de hand van lengteschattingen van de ontsnappende vis werd een lengteverdeling opgemaakt met een nauwkeurigheid variërend van 10 tot 50 mm. De percentages ontsnapte makreel varieerde van 3.4 tot 7.9% en voor horsmakreel van 0.2 tot 0.5%. Onderwateropnamen gedurende twee trekken lieten geen ontsnapping van evervis (*Capros aper* L.) zien, wat erop duidt dat deze soort niet door de sorteerroosters ontsnapt. Directe waarnemingen met videoopnamen van visgedrag in de nabijheid van sorteerroosters in combinatie met kwantitatieve analyse van vangstgegevens lijkt een betere methode voor toekomstig onderzoek.

Er zijn meer aanvullende gegevens nodig om tot duidelijke uitspraken te komen over het effect van de geteste sorteerroosters. Het wordt dan ook aangeraden om in de toekomst een poging te doen om het aantal experimentele trekken te vermeerderen.

1. Introduction

During the review of the European Common Fisheries Policy (CFP) it was decided to give stronger incentives to the fishing industry to avoid unwanted by-catches, and make fishing gears more species and size selective, thus contributing to the objective of creating more sustainable fisheries. This led to the landing obligation of undersized fish quota species, being phased in over a number of years. Starting with the pelagic fisheries in 2015, extending to demersal fisheries in 2016, and being fully implemented across all TAC species by 2019 (EU, 2013; EU, 2015; STECF, 2014).

Research on improving selectivity of herring (*Clupea harengus* L.), Atlantic mackerel (*Scomber scombrus* L.), horse mackerel (*Trachurus trachurus* L.), and blue whiting (*Micromesistius poutassou* L.) in Dutch midwater trawling has been carried out by IMARES in the early 1990s. The selection devices tested consisted of a range of different sorting grid configurations, with the idea to use differences in behaviour to separate these species, which was not successful. When large volumes of fish entered the net, blockage of the sorting grids could occur leading to net damage (van Marlen, 1995; van Marlen et al., 1994).

The Dutch pelagic fishing industry resumed tests with sorting grids in 2012 within several projects. Two projects specifically aimed to avoid the bycatch of boarfish (*Capros aper* L.) through technical adaptations in the net and species identification, making use of acoustic technology (Fässler et al., 2013; van Marlen et al., 2014). Several different sorting grids were tested in another project that aimed to avoid the capture of undersized and/or unwanted fish (Pastoors et al., 2014). From these trials, no differences in the length range between catches of test and reference vessels could be distinguished, but there were some indications of an effect on mackerel, justifying further study.

The aim of this follow-up project was to develop and optimise the sorting grids tested in 2014 (Pastoors et al., 2014) and other effective gear modifications to release undersized and/or unwanted fish species prior to hauling the net and to quantify the effect on target catches and by-catches of these selective devices.

2. Materials and Methods

Fleet

In 2015, the European pelagic freezer-trawler fleet consisted of 19 freezer trawlers, registered in 5 EU countries. Eight freezer-trawlers were registered in the Netherlands. Freezer-trawlers operate large mid-water trawls, and catches are intermediately stored in buffer tanks filled with cooled sea-water to maintain the best quality. The catch is led from the butter tanks to sorting machines after which the sorted fish is led to a range of plate freezers where it is frozen in blocks of 20-25kg. The blocks of frozen fish are packed in carton boxes, called 'cartons' in this report. A plate freezer can hold 52 cartons. A complete charge of a plate freezer is called a 'batch'. From time to time persons charged with quality control (called Quality Managers), take samples from the fish going into the plate freezers, and determine the length and weight of these fish.

Vessels

Three vessels participated in this project and supplied data (Table 1).

Table 1. Vessels, main particulars.

Ship ID	Name	Length o.a. [m]	Beam [m]	GT [t]	Engine power [kW; hp]
BX791	"Jan Maria"	125.4	24	7646	6000
SCH302	"Willem van der Zwan"	142.5	19.06	9494	7920
SCH81	"Carolien"	126	18	6999	7690

Gears

The sorting grids consist of sections with parallel bars with three guiding panels underneath. The grids were placed right after the tapering section of the net in front of the tunnel and cod-end.

The grid used on board SCH302 (grid 1736) had a bar spacing of 25 mm, a bar thickness of 11 mm (8 mm Dyneema ropes, in 11 mm shrink tube), and consisted of 33 sections of 0.44 m each, thus reaching a total length of 14.52 m (Figure 1). The grid was intended for the horse mackerel fishery.

The sorting grid section used on board SCH81 (grid 1740) had a width of 1.494 m and a total length of 14.82 m built in 48 subdivisions. The bar spacing was 24 mm measured from centre rope to centre rope. Dyneema ropes of 5 mm thickness were used for the bars. A 6 m long floating line of 6 kgf buoyancy per m (thus in total 36 kgf lift) was used at the end of the three guiding panels (Figure 2). The grid was intended for the horse mackerel fishery.

The sorting grid section used on board BX791 (grid 1742) had a width of 1.517 m and a total length of 14.5 m built in 29 subdivisions of 0.5 m each. The bar spacing was 35 mm. Dyneema ropes of 10 mm were used. Again a 6 m long floating line of 6 kgf buoyancy per m (thus in total 36 kgf lift) was used at the end of the three guiding panels (Figure 3). The grid was intended for the mackerel fishery.

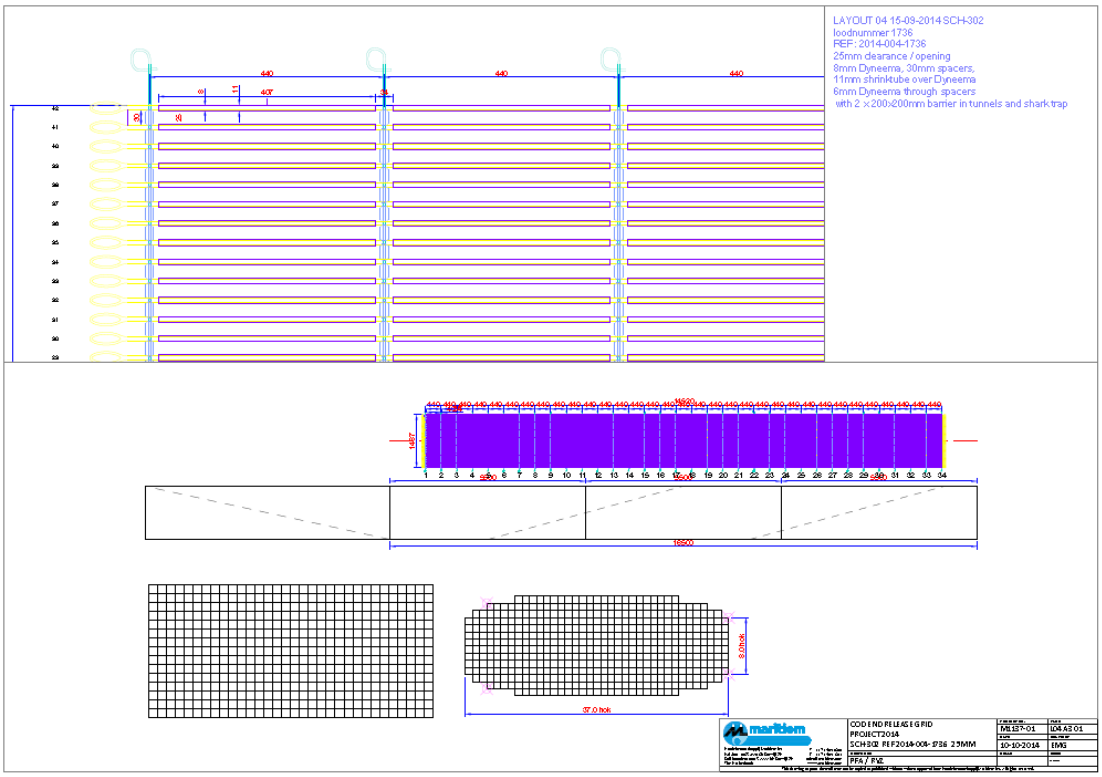

Figure 1. Sorting grid No 1736, Maritiem Ltd., Katwijk, the Netherlands used on SCH302.

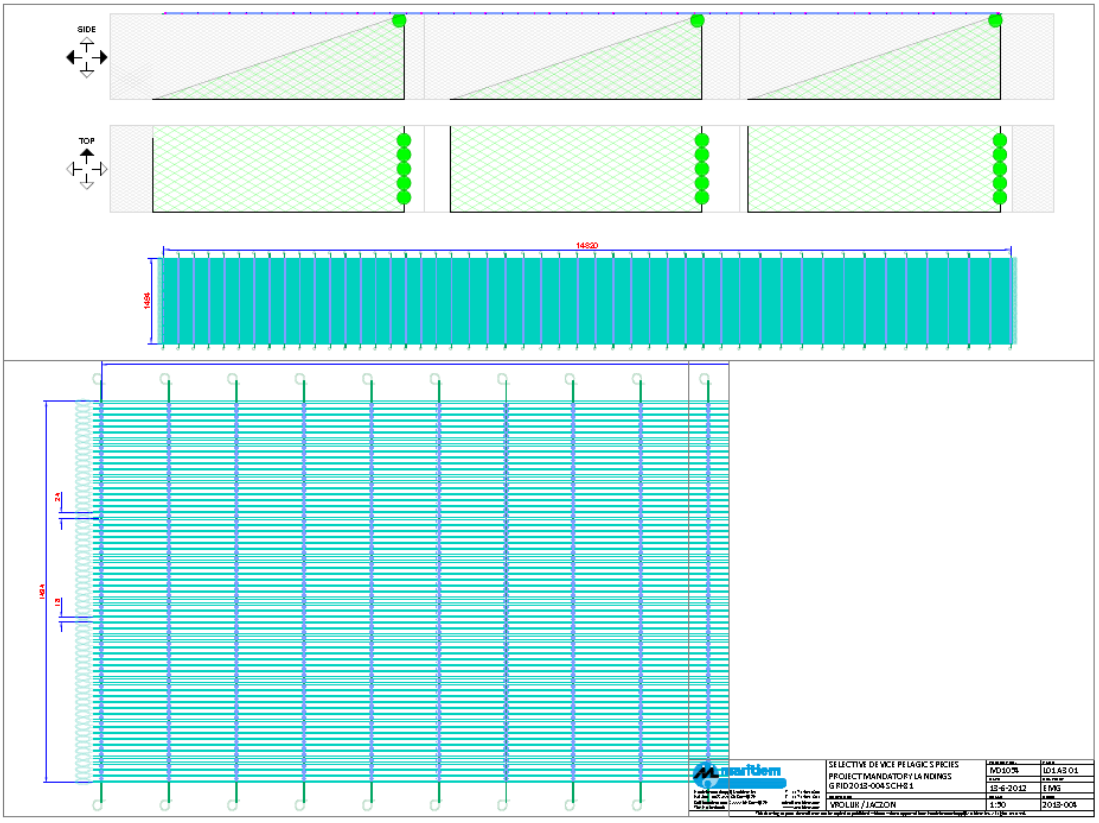

Figure 2. Sorting grid No 1740, Maritiem Ltd., Katwijk, the Netherlands, used on SCH81.

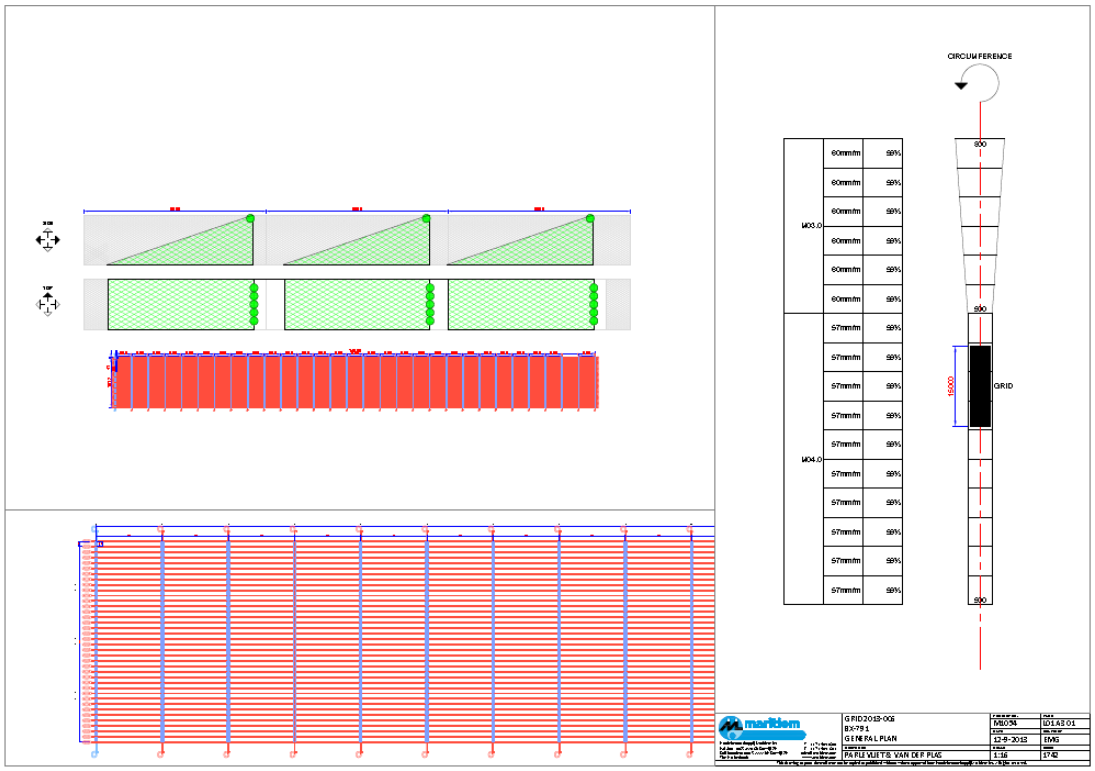

Figure 3. Sorting grid No 1742, Maritiem Ltd., Katwijk, the Netherlands, used on BX791.

Data collected on-board

Data

For analysis purposes it was essential that data was provided by fishing trip on a haul-by-haul basis. At the start of the project the Quality Managers and/or skippers were asked to collect:

- General information by haul on: date, starting time, end time, starting position, end position, duration, total catch, gear characteristics (including information on possible use of escape grid or other net configurations).
- Catch information by haul and batch on: number of cartons, number of fish in carton, number of fish in 10 kg, number of fish per kg, average weight carton, length range fish, average weight fish, food in stomach fish, fat percentage.
- Individual length measurements of fish by haul and batch.

Data was provided in different formats by the three participating vessels for the period October 2014 – April 2015. Table 2 and Table 3 show an overview of the received data. The haul information (Table 2) and catch information on number of cartons, number of fish in carton and number of fish per 10 kg (Table 3) was transferred into a standard format and used for analyses.

Table 2. Overview of the general information by haul received from the participating vessels per trip (++ = information readily available, + = information available in different format than requested, - = information not available).

				General information (by haul)							
Ship ID	**Trip**	**Year**	**Period**	**Date**	**Starting time**	**End time**	**Starting position**	**End position**	**Duration**	**Total catch**	**Gear characteristics**
BX791	9	2014	Oct-Nov	++	++	++	++	++	++	++	++
BX791	10	2014	Nov-Dec	++	++	++	++	++	++	++	++
BX791	1	2015	Jan	++	++	++	++	++	++	++	++
BX791	2	2015	Feb	++	++	++	++	++	++	++	++
BX791	3	2015	Apr	++	++	++	++	++	++	++	++
SCH302	I	2014	Oct-Dec	++	++	++	++	++	++	++	++
SCH302	A	2015	Jan	++	++	++	++	++	++	++	++
SCH302	B	2015	Jan-March	++	++	++	++	++	++	++	++
SCH81	155	2014	Oct-Nov	++	++	++	++	++	++	++	++
SCH81	157	2015	Jan-Feb	++	++	++	++	++	++	++	++
SCH81	158	2015	Feb-March	++	++	++	++	++	++	++	++

Table 3. Overview of the catch information by haul and batch received from the participating vessels per trip (++ = information readily available, + = information available in different format than requested, - = information not available). *[1] Is an estimation calculated by multiplying the provided information on number of plate freezers filled by haul and batch with the plate freezer capacity (i.e. 52 cartons each). *[2] Catch information not available for entire trip. *[3] Incidentally not registered. *[4] Only minimum length value available. *[5] Measurements available per species (not by batch). *[6] Only range available.

				Catch information (by haul and batch)									
Ship ID	**Trip**	**Year**	**Period**	**Number of cartons**	**Number of fish in carton**	**Number of fish per 10 kg**	**Number of fish per kg**	**Average weight carton**	**Length range**	**Average weight fish**	**Food in stomach fish**	**Fat percentage fish**	**Length measurement fish**
BX791	9	2014	Oct-Nov	+*[1]	++*[3]	++*[3]	++	++	++	++	-	-	++
BX791	10	2014	Nov-Dec	++	++	++	++	++	++	++	-	-	++
BX791	1	2015	Jan	++	++	++	++	++	++	++	-	-	++
BX791	2	2015	Feb	++	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	-	-	++
BX791	3	2015	Apr	++	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	-	-	++
SCH302*[2]	I	2014	Oct-Dec	++	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	++*[3]	-	+*[5]
SCH302	A	2015	Jan	++	++*[3]	++*[3]	++*[3]	++*[3]	+*[3,4]	++*[3]	++*[3]	-	+*[5]
SCH302	B	2015	Jan-March	++	++*[3]	++*[3]	++*[3]	++*[3]	+*[3,4]	++*[3]	++*[3]	-	+*[5]
SCH81	155	2014	Oct-Nov	-	+*[6]	++*[3]	++*[3]	-	++*[3]	-	++*[3]	++*[3]	-
SCH81	157	2015	Jan-Feb	++	+*[6]	-	-	-	-	-	-	-	-
SCH81	158	2015	Feb-March	++	+*[6]	-	-	+*[1]	-	-	-	-	-

Fraction small mackerel and horse mackerel in catches

In order to determine whether a grid is effective in letting small individuals of mackerel and horse mackerel escape, each recorded batch was assigned to a size class.

Mackerel

Only for the trips by BX791, size class information for mackerel was recorded by the Quality Manager; each batch was assigned to category K, M, G or R. The four categories coincide with a length range (based on BX791 Trip 9 2014) of 27-33 cm, 31-36 cm, 29-39 cm and 35-44 cm respectively. For the analysis the categories were divided into classes 'small' (*i.e.* category K), 'medium' (*i.e.* category M), and 'large' (*i.e.* categories G and R). The available size classification appeared to be strongly associated with the number of fish per carton and the number of fish per 10 kg, where number of fish per carton was associated the strongest. These characteristics were used to assign size class to the mackerel batches of the other two vessels. A batch was assigned to a size class based on the number of fish per carton. When this information was not available assignment was based on number of fish per 10 kg. Ranges used for the classification are listed in Table 4.

Table 4. Ranges used for classification of mackerel batches into size classes 'small', 'medium' and 'large' based on number of fish per carton or 10 kg.

Size class	Range number of fish per carton	Range number of fish per 10 kg
Small	>80	>40
Medium	>65 and ≤80	>30 and ≤40
Large	≤65	≤30

Horse mackerel

For horse mackerel there was, in comparison with mackerel, no information available beforehand on different size classes. Information on the number of fish per carton and the number of fish per 10 kg was used to create size classes. Ranges have been chosen as such that for every size class comparable amounts of data are available. A batch was assigned to a size class based on the number of fish per carton. When this information was not available assignment was based on number of fish per 10 kg. Ranges used for the classification are listed in Table 5.

Table 5. Ranges used for classification of horse mackerel batches into size classes 'small', 'medium' and 'large' based on number of fish per carton or 10 kg.

Size class	Range number of fish per carton	Range number of fish per 10 kg
Small	≥115	>53
Medium	≥76 and <115	>36 and ≤53
Large	<76	≤36

Catch size category

When large volumes of fish enter the net, blockage of the sorting grids could occur possibly resulting in the grid being less effective. For analysis purposes each haul was therefore differentiated into catch size category; Catch S (i.e. catches 0-100 tonnes), Catch M (i.e. catches 100-200 tonnes) and Catch L (i.e. ≥ 200 tonnes), based on total catch (i.e. all species in the haul).

Underwater observation

On board two vessels, SCH81 and SCH302, a TrawlCamera LowLux Camera +1xLED was used for real time observations of fish escapes through the grids (www.trawlcamera.com). In addition, stored footage was analysed through video observation by IMARES. The camera was attached to the net, facing the grids on two different positions, just in front of the grid and halfway the grid, see schematic drawings (Figure 4.).

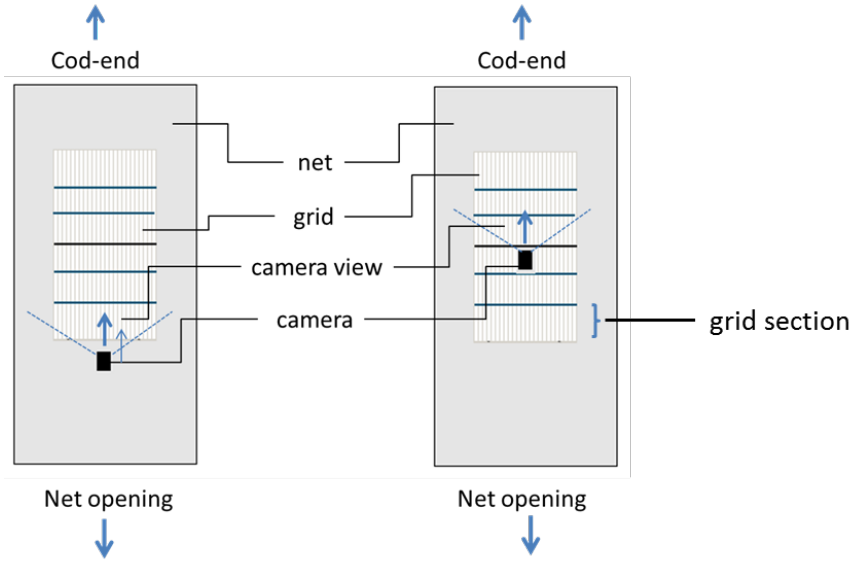

Figure 4. Schematic overview from above of camera position, camera view and grid position in the net. Left panel, in front of grid. Right panel, middle of grid.

A video review was conducted. VLC media player of VideoLAN was used to view the footage. Image analysing was done manually. The video reviewer counted each individual fish that escaped through the grid and identified the species when possible. Based on a reference length in the video image the reviewer estimated the total length of the fish (Figure 5). Because of distortion caused by camera lenses and sometimes blurred view over longer distances, the video reviewer only counted escapes in the first grid section right in front of the camera.

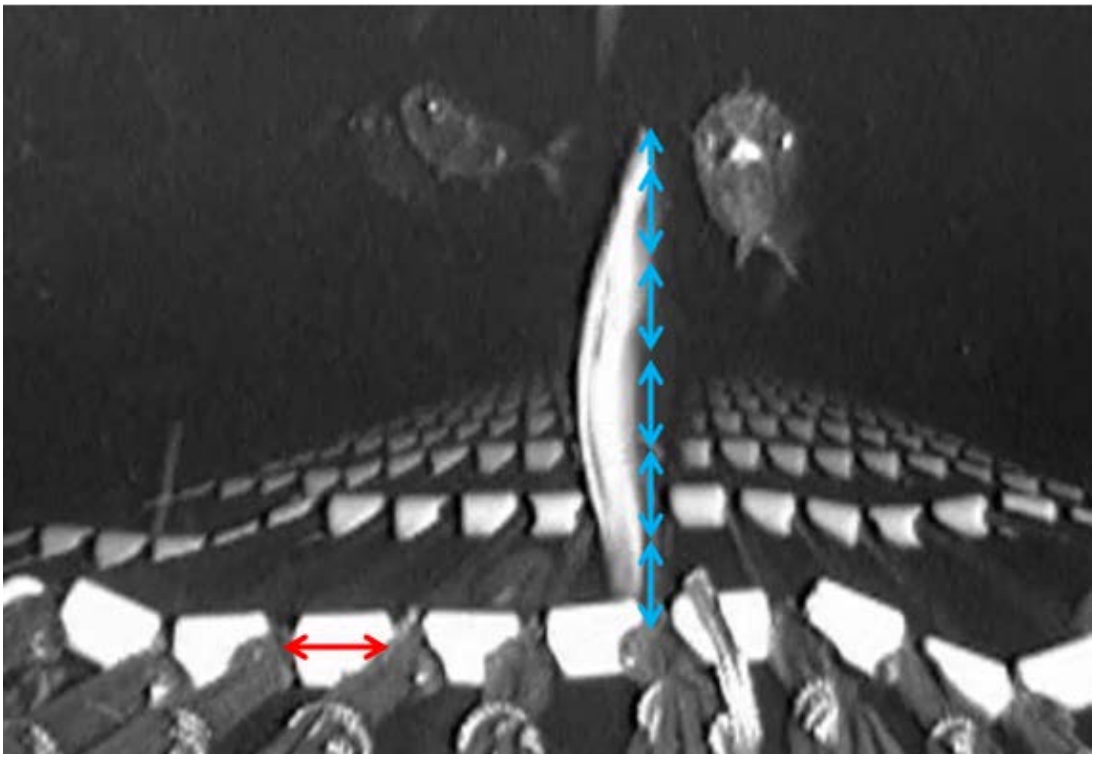

Figure 5. Video review: Length estimation of escaped fish. Reference length in this picture is a “grid holder” of 35 mm. In this case the total fish length is estimated at 193 mm (5.5 x 35 mm).

Based on the video review a length frequency per species was constructed for the fish that escaped through the grids. An estimation of the total number of escapes during a complete haul is based on extrapolation of the fish counts of the video review. The counts of one grid section is multiplied by the total number of grid sections. In situations where video review did not cover the total haul duration the number was also extrapolated to total haul duration.

Statistical test of differences in fraction of small fish with and without grid

A table of the number of hauls with a fraction of small fish larger or smaller than 0.5 for the experimental hauls with a sorting grid and hauls without a grid for both mackerel and horse mackerel was produced. The p-value was calculated using Pearson's Chi-squared test with Yates' continuity correction for both cases, to determine whether an association exists between the fraction small fish caught and the usage of a sorting grid. However, it should be borne in mind that the choice of using a grid was not a fully random choice, and other factors affecting this choice may have a bearing on these differences. If an effect was found, this therefore may have been caused by these other factors than just the use of a grid.

Communication

Skipper interviews and expressed points of view

During a meeting with crew members and fleet managers on 18/06/2015 it became clear that the methods used and assumptions made for the preliminary analysis differed from the viewpoints of the crew. Therefore, individual meetings with the skippers were organised. During these meetings each fishing trip was discussed with the skipper. Questions that were discussed included:

- Why was a net modification used during specific hauls?
- Can these hauls be compared with other hauls (i.e. haul with net modification *vs*. haul without net modification)?
- In which type of fisheries do you think the net modification could be useful for releasing undersized or unwanted fish?

Project Meetings

A total of six project meetings were held with staff of PFA and IMARES, and five internal staff meetings by IMARES to determine: allocated hours on the project, contacts with Quality Managers and skippers, gear configurations to test, underwater video footage and fish behaviour, data formats and sampling protocols, data and image analysis, presentation of results and contents of the report.

3. Results

Trip overview

Data was provided for four trips (from three vessels) in 2014 and seven trips (from three vessels) in 2015), corresponding with 222 and 326 hauls respectively (Table 6). Trips were considered suitable for analysis when (i) a modified net was used during one or several hauls (Table 6), (ii) general information was available by haul (Table 2), and (iii) number of cartons and number of fish in carton and/or number of fish per 10 kg by haul and batch were available (Table 3). Overall, this resulted in six trips to be included in the analysis (Table 6). In these six trips a modified net was used during 11 hauls (~9% of all hauls) in 2014 and 12 hauls (~5% of all hauls) in 2015.

Table 6. Overview of trips 2014-2015 – vessels, target species (Hom = horse mackerel, Mac = mackerel, Whb = blue whiting, Arg = argentines), period, hauls, and whether trip was included in analysis. *[1] cod-end 80 mm mesh opening.

Ship ID	Trip	Year	Period	Target species	N hauls	N hauls with modified net	Included in analysis
BX791	9	2014	Oct-Nov	Mac	28	9 (grid 1742)	Y
BX791	10	2014	Nov-Dec	Hom	37	0	N
BX791	1	2015	Jan	Mac, Hom	29	0	N
BX791	2	2015	Feb	Whb, Hom, Mac	42	0	N
BX791	3	2015	Apr	Whb, Arg	26	0	N
SCH302	1	2014	Oct-Dec	Hom	95	2 (new cod-end)*[1]	Y
SCH302	A	2015	Jan	Mac, Hom	28	1 (grid 1736)	Y
SCH302	B	2015	Jan-March	Hom, Whb	82	4 (grid 1736)	Y
SCH81	155	2014	Oct-Nov	Hom, Mac	62	3 (grid 1740)	N
SCH81	157	2015	Jan-Feb	Hom	76	4 (grid 1740)	Y
SCH81	158	2015	Feb-March	Hom, Whb	43	3 (grid 1740)	Y

Trip locations

The locations of hauls of all trips for which data was supplied are presented in Figure 6 (left), indicating the hauls that are and were not included in the analyses. Figure 6 (right) shows the locations of the trips included in the analyses indicating the hauls with(out) a modified net. Trip locations per vessel included in the analyses are presented in Figure 7.

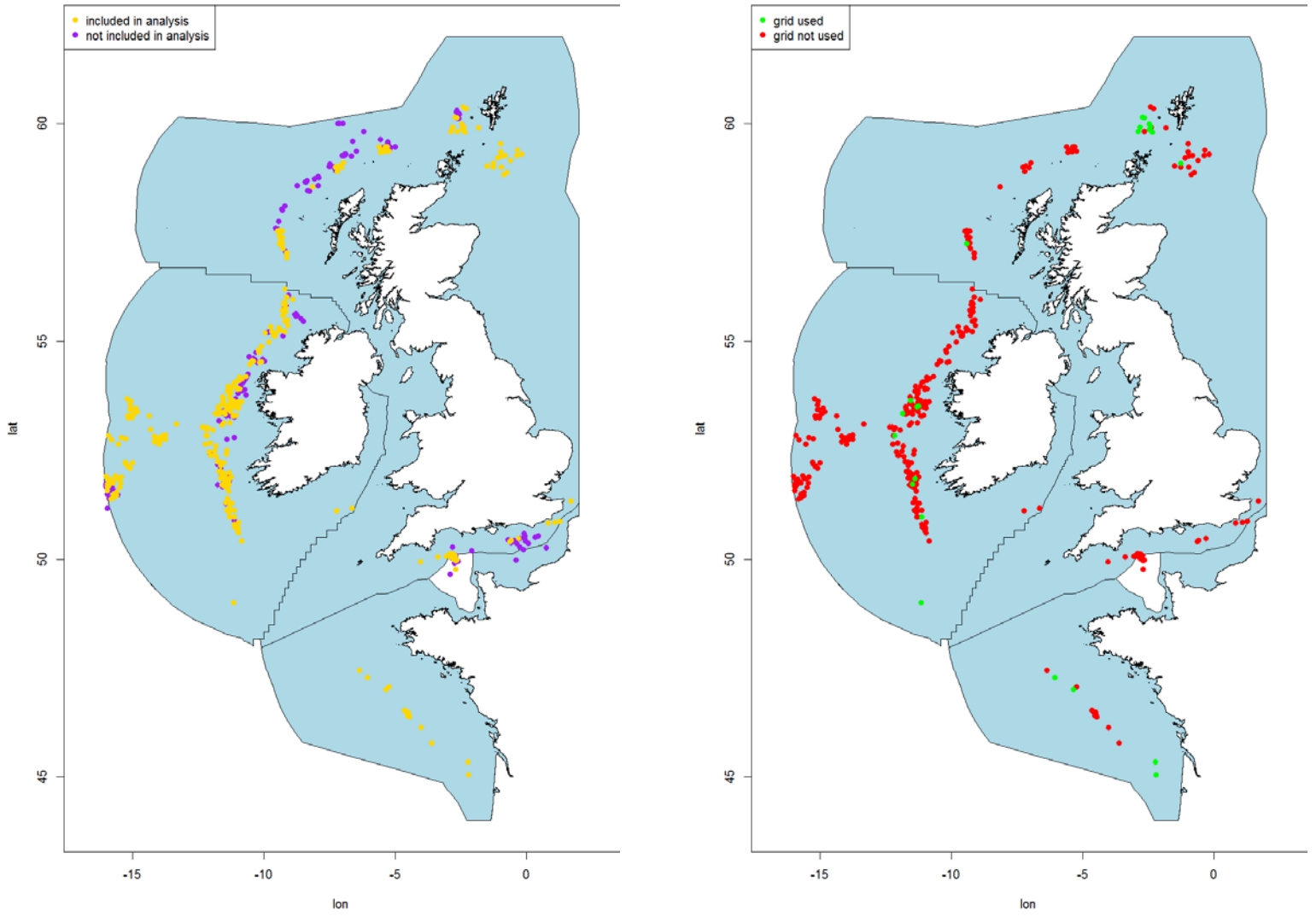

Figure 6. Map of all sampled trips from which data was supplied by the participating vessels (left; yellow = hauls included in the analysis, purple = hauls not included in the analysis) and of all trips included in the analysis (right; green = hauls with grids, red = hauls without grids).

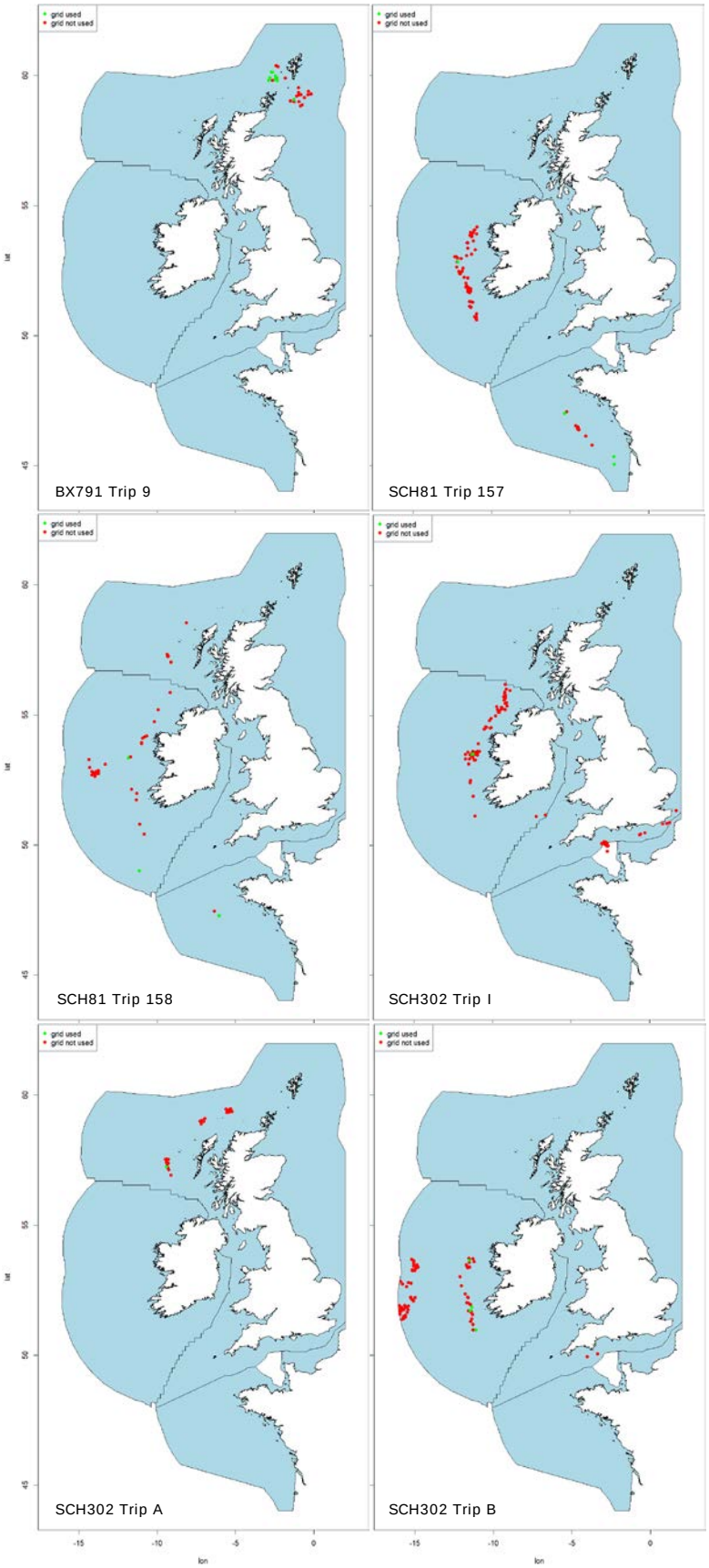

Figure 7. Map of individual trips included in the analysis, indicating hauls with grid (green) and without grid (red).

Fraction small mackerel and horse mackerel in catches

Mackerel

In order to determine the fraction of small mackerel in the catches, hauls where mackerel was caught were selected; mackerel was caught in 161 hauls. Only 14 hauls (out of a total number of 161 hauls) were carried out with a grid. The fraction of small mackerel (>80 individuals per carton) in relation to all mackerel catches per haul was plotted, differentiating hauls with grid and without grid (Figure 8). Each dot represents a haul. The fraction of small mackerel ranges from 0 to 1 in hauls both with and without grid. On average hauls without grid had a fraction of ~0.55 small mackerel while hauls with grid a fraction of ~0.3 small mackerel.

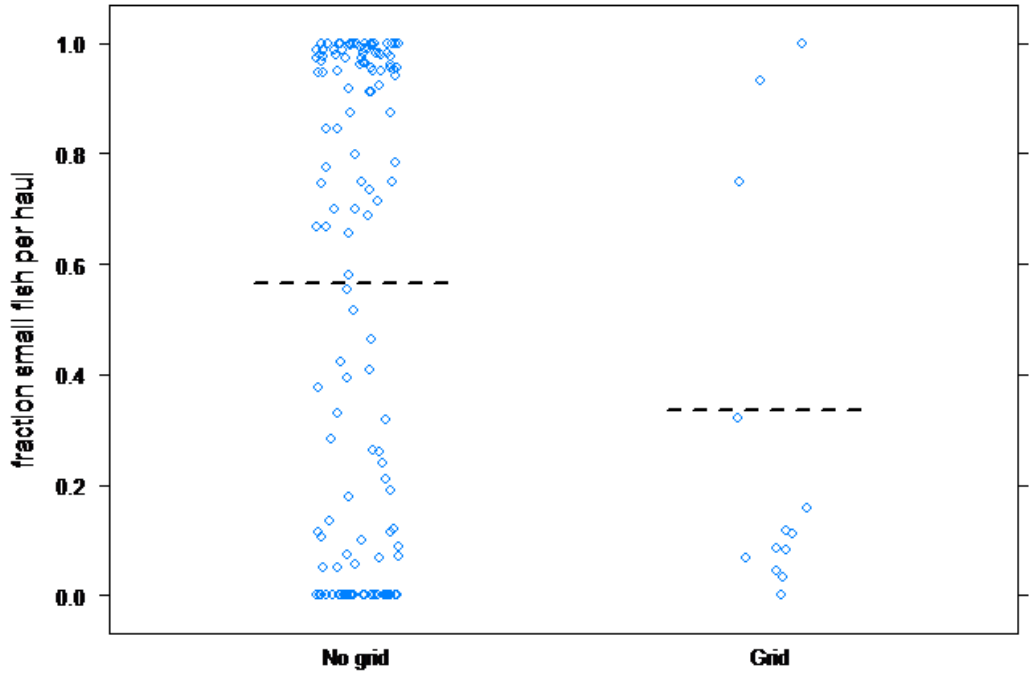

Figure 8. Fraction of small mackerel in hauls with and without grid. Each marker represents a haul. Dashed black line indicates the mean fraction.

The fraction of small mackerel of the total mackerel catch in that haul was also plotted, differentiating for the total catch size (i.e. including all species) of the hauls (Figure 9). Most hauls resulted only in small total catches (< 100 tonnes). Hauls with large catches had a relatively low fraction of small mackerel, regardless of the use of a grid.

Table 7 gives the number of hauls with and without grid with a fraction of small mackerel larger or smaller than 0.5.

Table 7. Table of number of hauls with and without a grid with fraction of small mackerel ≥ and < 0.5 in relation to all mackerel catches.

Fraction small fish	N hauls grid used	N hauls grid not used
≥ 0.5	4	82
< 0.5	10	60

The Chi-squared test resulted in: χ-squared = 3.2849, df = 1, p-value = 0.06992, which means that, although it may seem that there are relatively more hauls with larger fish for the case that a grid was used, the effect was not significant.

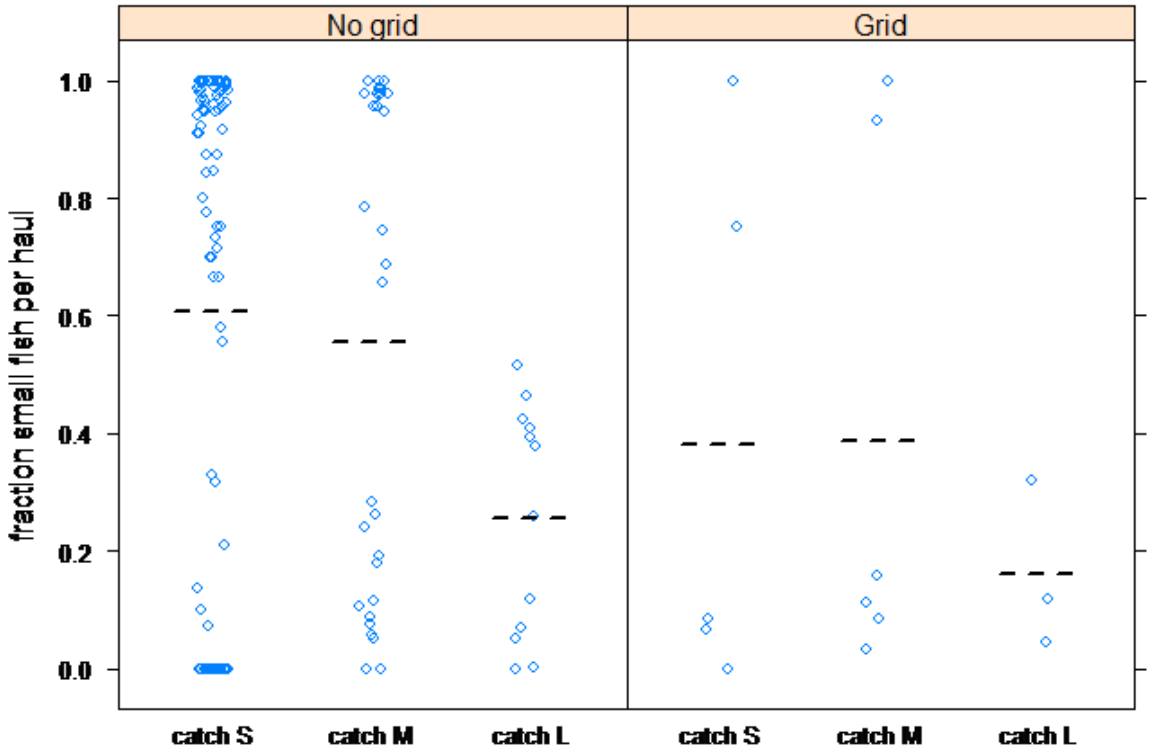

Figure 9. Fraction of small mackerel in hauls with and without grid used in small (S), medium (M) and large (L) catches, representing total catches (i.e. all species in the catch) of <100 (S), 100-200 (M) and >200 (L) tonnes. Each marker represents a haul. Black lines indicate mean.

Horse mackerel

In order to determine the fraction of small horse mackerel in the catches, hauls where horse mackerel was caught were selected; horse mackerel was caught during 197 hauls. Only 12 hauls (out of a total number of 197 hauls) were carried out with a grid. The fraction of small horse mackerel (≥115 individuals per carton) in relation to all horse mackerel catches per haul was plotted, differentiating hauls with grid and without grid (Figure 10). Each dot represents a haul. The fraction of small horse mackerel ranges from 0 to 1 in hauls both with and without grid. On average hauls without grid had a fraction ~0.3 small horse mackerel while hauls with grid had a fraction of ~0.35 small horse mackerel.

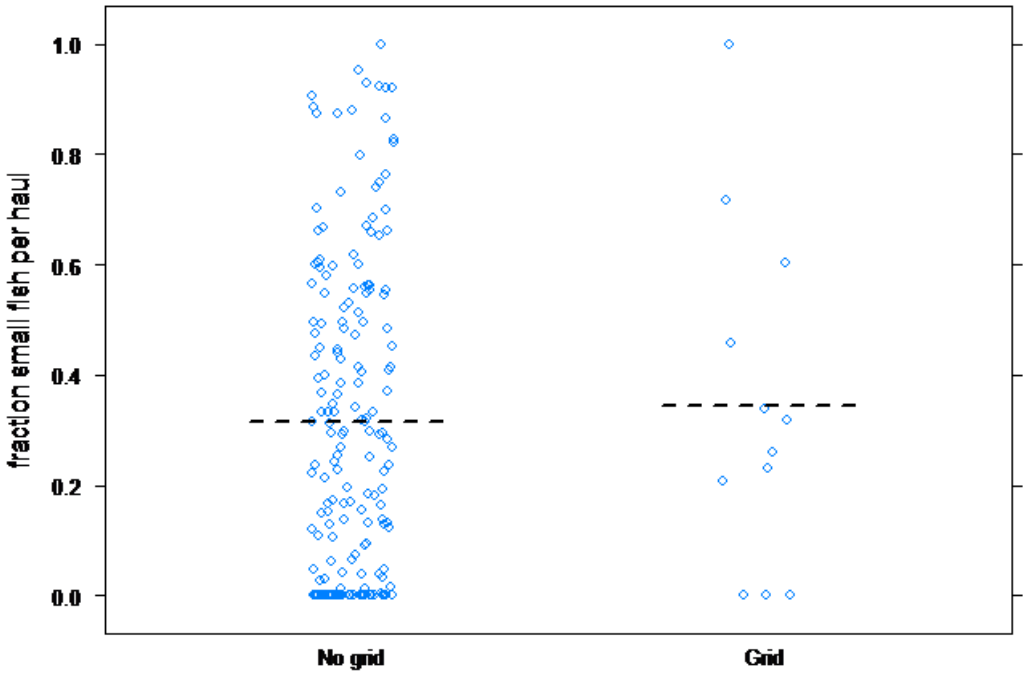

Figure 10. Fraction of small horse mackerel in hauls with and without grid. Each marker represents a haul. Dashed black line indicates the mean fraction.

The fraction of small horse mackerel of the total horse mackerel catch in that haul was also plotted differentiating for the total catch size (i.e. including all species) (Figure 11). Most hauls were from small catches (< 100 tonnes).

Table 8 gives the number of hauls with and without grid with a fraction of small horse mackerel larger or smaller than 0.5.

Table 8. Table of number of hauls with and without a grid with fraction of small horse mackerel ≥ and < 0.5.

Fraction small fish	N hauls grid used	N hauls grid not used
≥ 0.5	3	49
< 0.5	9	133

The Chi-squared test resulted in: χ-squared = 5.8521e-29, df = 1, p-value = 1, which means that, although it may seem that there are relatively more hauls with larger fish for the case that a grid was used, the effect was not significant.

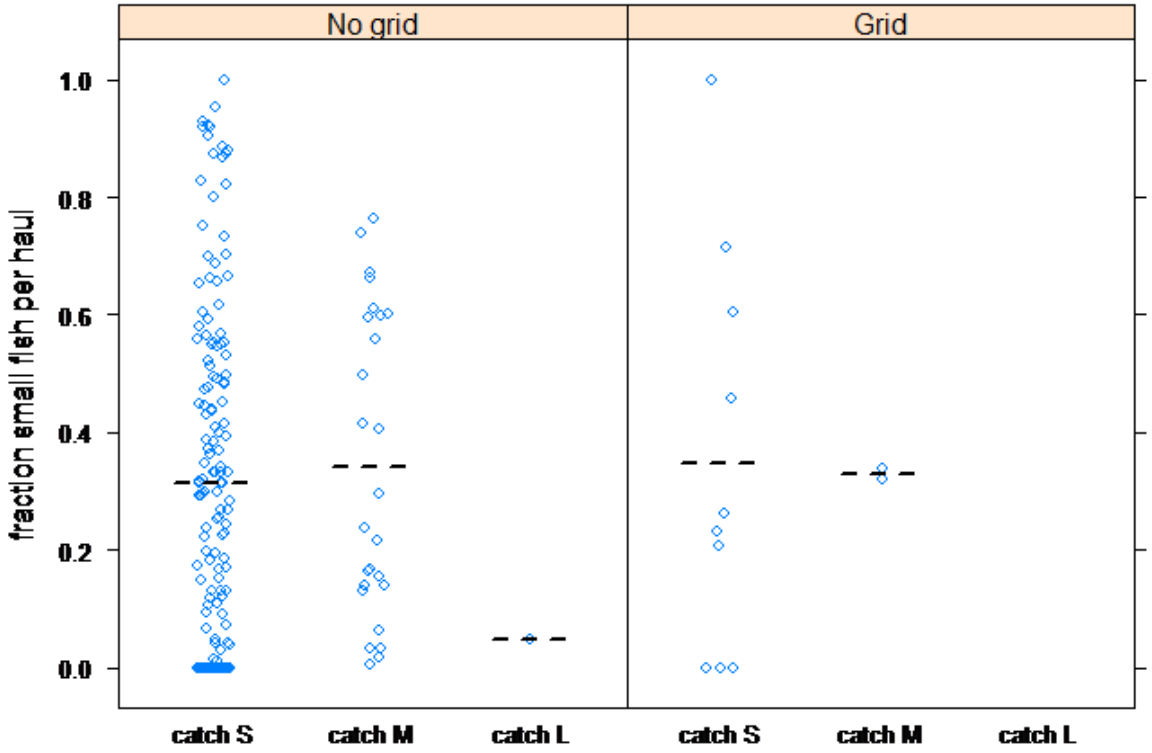

Figure 11. Fraction of small horse mackerel in hauls with and without grid used in small (S), medium (M) and large (L) catches, representing total catches (i.e. including all species) of <100 (S), 100-200 (M) and >200 (L) tonnes. Each marker represents a haul. Black lines indicate mean.

Boarfish

A modified net was used during two hauls (SCH81 trip 157 and trip 158) during which the skipper intentionally targeted boarfish. There is not enough data to statistically test the release of boarfish through the panel. However, based on the catches in the net the skipper concluded that the panel does not work for this purpose (see also Viewpoints of the skippers).

Underwater observation

Video analysis

In total footage of five hauls of two different trips was made available for video analysis, three hauls of the SCH81 and two hauls of the SCH302. Eventually, only footage of two hauls, both of the SCH302, were analysed (Table 9). A total of 262 minutes of video data was analysed.

Table 9. Overview of video analysis, two hauls of the SCH302.

Haul (date)	Total haul duration (in minutes)	Duration of analysed footage (in minutes)	Position of camera on grid (see Figure 4)
25 (9 Feb. 2015)	60	60	In front
26 (9 Feb. 2015)	225	202	Middle

During the video analysis two species that managed to escaped through the grid were identified: Mackerel and horse mackerel. Fish that could not be identified were categorized as “unknown” (Figure 12).

A specific characteristic that could be used for the identification of mackerel are the striped patterns on the side of the fish. For Horse mackerel the long pectoral fins, lateral line and oval body shape were distinguishing marks. Due to low frame frequency of recorded video, it was not possible to capture a clear picture of a fast swimming fish. This technical limitation was the main reason that some individuals could not be identified to the species level, and were classified as “unknown”, see Figure 12 bottom panel.

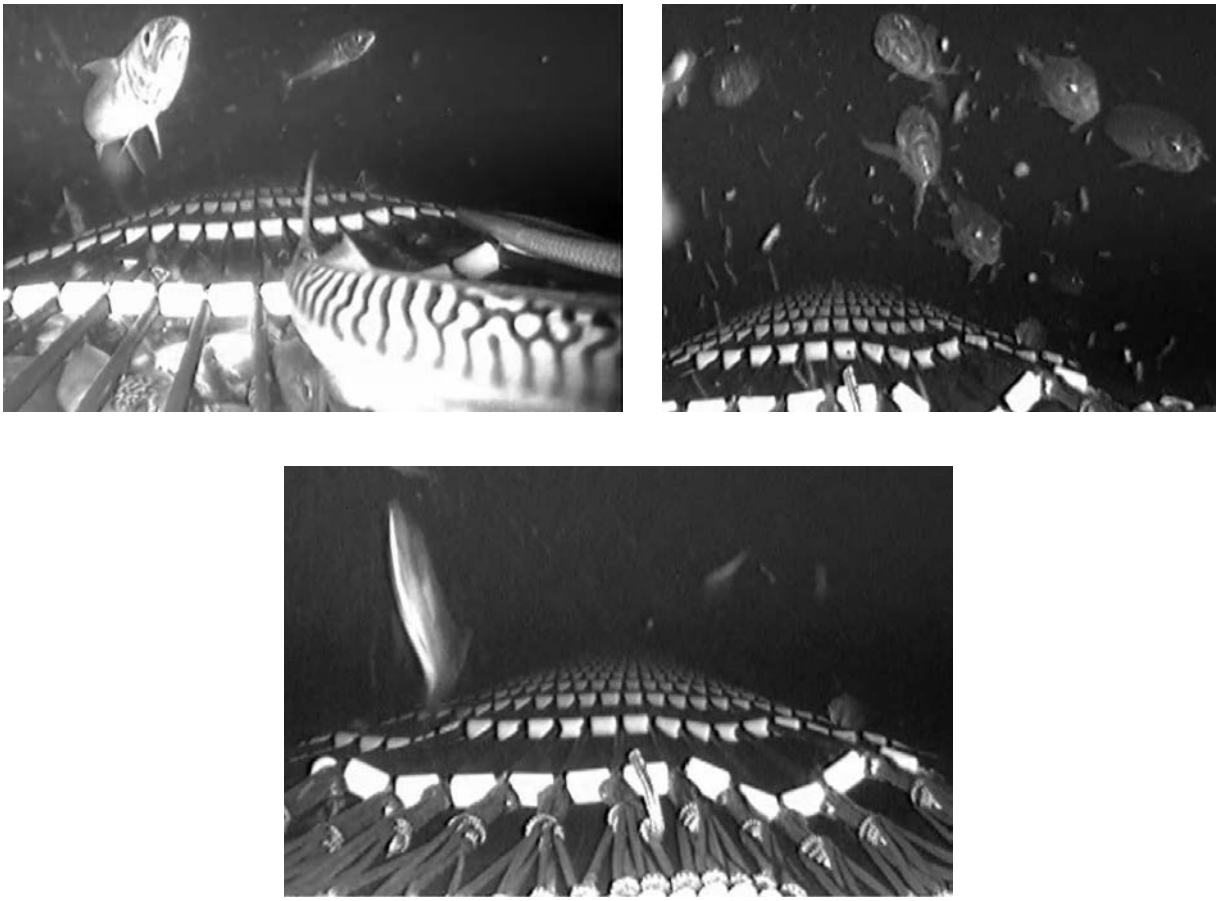

Figure 12. Fish species identified during video analysis: mackerel (top left), horse mackerel (top right), and “unknown” (bottom).

In total 33 escapes were recorded for haul 25 and 502 for haul 26. During the analysis the video viewer was able to estimates lengths of 155 escaping fish (Table 10). Reliable length estimates were obtained from 27% of the observed mackerel and 8 % of the observed horse mackerel. Escapes were only counted in the first grid section in front of the camera, because of distortion caused by camera lenses and a sometimes blurred view over longer distances.

Table 10. Overview of escape counts and length estimates for one grid section for two hauls of the SCH302.

Species	No. escapes, analysis of haul 25	No. escapes, analysis of haul 26	Estimated lengths, analysis of haul 25	Estimated lengths, analysis of haul 26
Mackerel	2	233	0	63
Horse mackerel	9	83	3	4
"Unknown"	22	186	7	78

Size of escaped fish from video footage

Based on the length estimations from the video analysis, a length frequency for each observed species was constructed. Accuracy of estimated lengths vary between 10 and 50 mm (Figure 13).

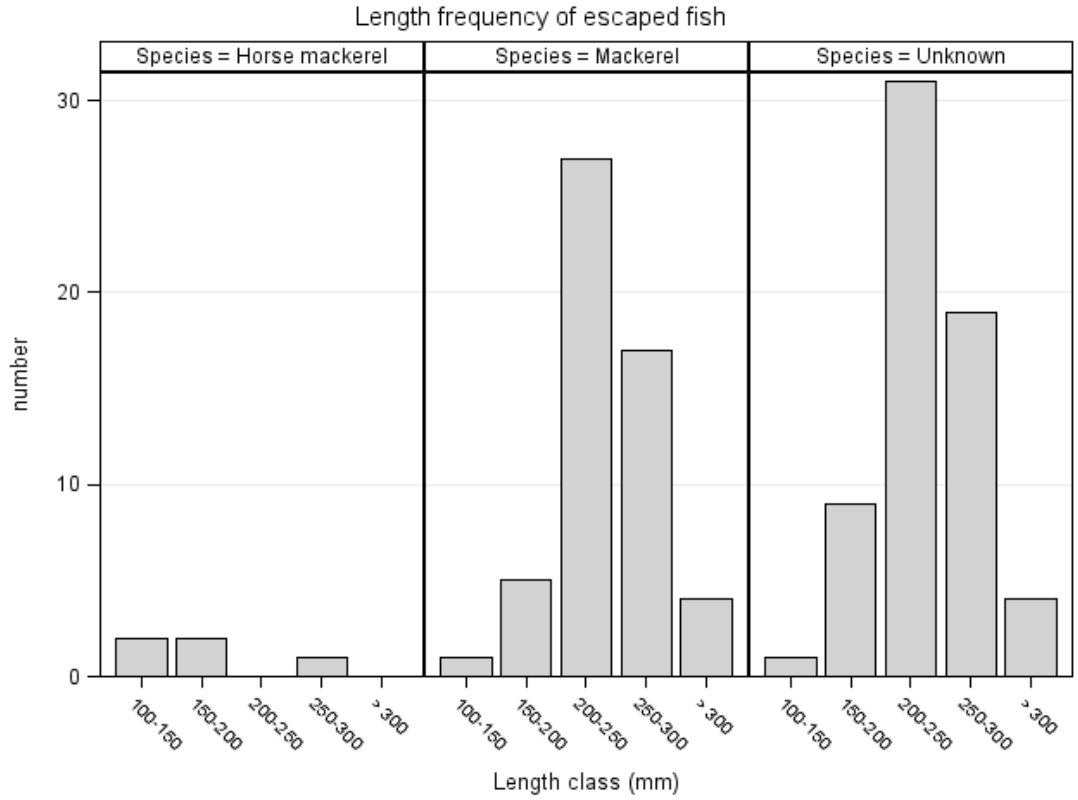

Figure 13. Number of escaped fish by species and length class, based on all available video-data.

Total number of fish escapes and species composition

Based on the escape counts of the video analysis a total number of fish escapes per haul was estimated. During the video analysis only escaping fish in the first grid section in front of the camera were counted. The grid counted 33 grid sections in total. All video data of haul 25, a total of 60 minutes was analysed (Table 8). Extrapolation to the total grid based on the assumption that all grid sections have an equal escape number for haul 25 of the SCH302 resulted in an estimation of 1089 fish escapes: 66 mackerel, 297 horse mackerel and 726 unknown. For haul 26, 202 minutes of the total haul duration of 225 minutes was analysed. Extrapolation to the total grid and total duration for haul 26 of the SCH302 resulted in an estimation of 18.223 fish escapes: 8.458 mackerel, 3.013 horse mackerel and 6.752 unknown (Table 11). Species composition of escaped fish for each haul is presented in Figure 14.

Table 11. Estimated total fish retained and escaped for two hauls of the SCH302.

Haul (date)	Species and total catch	Total number of fish retained	Total number of fish escaped	Percentage (%) escaped
25 (9 Feb. 2015)	Mackerel	1.955	66	3.4
	Horse mackerel	149.850	297	0.2
	Total catch*	152.605	1.089	0.7
26 (9 Feb. 2015)	Mackerel	106.490	8.458	7.9
	Horse mackerel	653.096	3.013	0.5
	Total catch*	759.586	18.223	2.4

*) includes “unknowns” and species other than mackerel and horse mackerel.

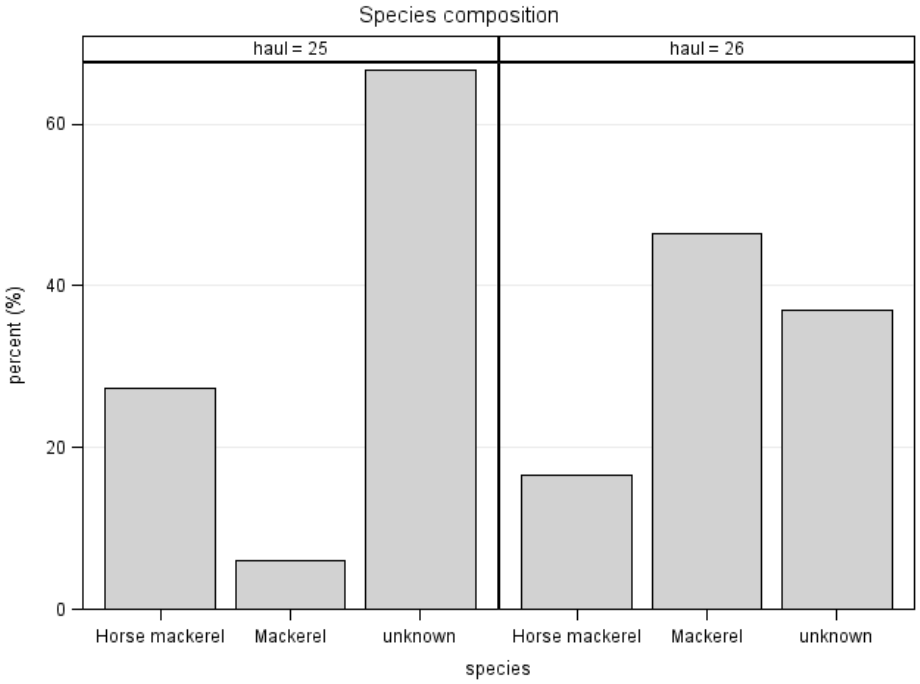

Figure 14. Species composition of escaping fish, as a percentage per haul.

Viewpoints of the skippers

Unfortunately, planning did not permit to meet with the skipper of BX791.

Meeting skipper SCH81 on 01-07-2015

During 10 hauls a net modification (*i.e.* sorting grid 1740) was used on board SCH81 (Table 6). In general, the skipper is of the opinion that a sorting grid could be useful to avoid catches of (i) small mackerel, or (ii) blue whiting within the horse mackerel fishery. However, the skipper thought that during the testing period on the fishing grounds there was no small mackerel present.

Trip 155 (2014)

Within this trip a sorting grid was used during three hauls (~5% of all hauls) (Table 6) to avoid small mackerel within the horse mackerel fishery. However, the skipper indicated that at that time and place there was no small mackerel present. As no information is available on number of cartons by batch by haul (Table 3), this trip is not included in the analysis (Table 6).

Trip 157 (2015)

Within this trip a sorting grid was used during four hauls (~5% of all hauls) (Table 6) for different purposes (*i.e.* hauls 14, 15, 16 and 66). During two hauls (*i.e.* hauls 14, 15) the panel was used to avoid undersized horse mackerel. However, as catches were extremely low (*i.e.* 1 and 0 tonne respectively) no analysis can be conducted on these specific hauls (Figure 15). During haul 16 the skipper intentionally targeted boarfish in order to test whether this fish would escape through the panel. Based on the catches in the net (*i.e.* 2571 cartons boarfish; Figure 15) the skipper concluded that the panel did not work for this purpose. During haul 66 the skipper wanted to determine whether blue whiting could be avoided using the sorting panel. The skipper is of the opinion that the panel was useful for this purpose. He advised to compare catches of haul 66 with haul 67 during which no panel was used; catches of blue whiting were higher during haul 67 *(i.e.* 168 cartons) than haul 66 (*i.e.* 118 cartons) (Figure 16).

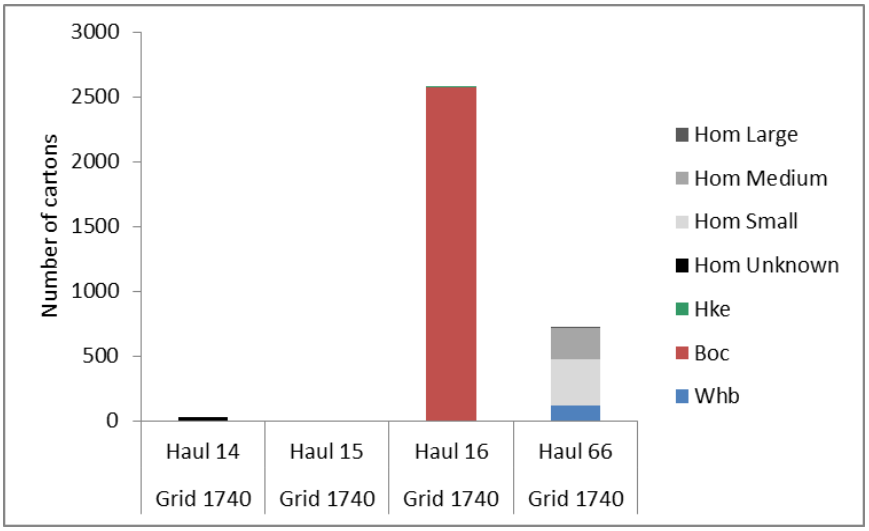

Figure 15. Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 5) for hauls fished with sorting grid (Boc = boarfish, Hke = hake, Hom = horse mackerel, Mac = mackerel, Whb = blue whiting).

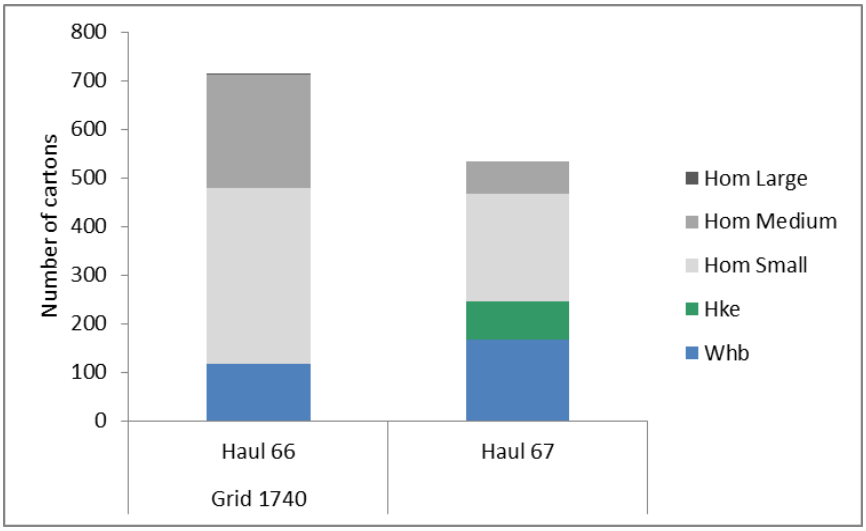

Figure 16. Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 5) hauls 66 (fished with sorting grid) and 67 (Hke = hake, Hom = horse mackerel, Whb = blue whiting).

Trip 158 (2015)

Within this trip a sorting grid was used during three hauls (~7% of all hauls) (Table 6) for different purposes (*i.e.* hauls 2, 5 and 7). During haul 2 the skipper intentionally targeted boarfish in order to test whether this fish would escape. Based on the catches (*i.e.* 1980 cartons boarfish; Figure 17) the skipper concluded that the grid did not work for this purpose. In the preceding haul, during which no grid was used, 1508 cartons boarfish were caught. During haul 5 the skipper used the sorting grid to avoid blue whiting catches in a horse mackerel haul. Again, the skipper is of the opinion that the grid was useful for this purpose. However, a comparable haul without grid to found this conclusion with numbers is not available. Finally, the skipper did not have a specific purpose beforehand to use the grid in haul 7. This concerned a haul mainly catching mackerel; 32% of the mackerel catch consisted of 'small' mackerel (Figure 17). Adjacent hauls showed varying percentages of 'small' mackerel; 80% and 5% of the mackerel catch from hauls 6 and 8 respectively consisted of 'small' mackerel.

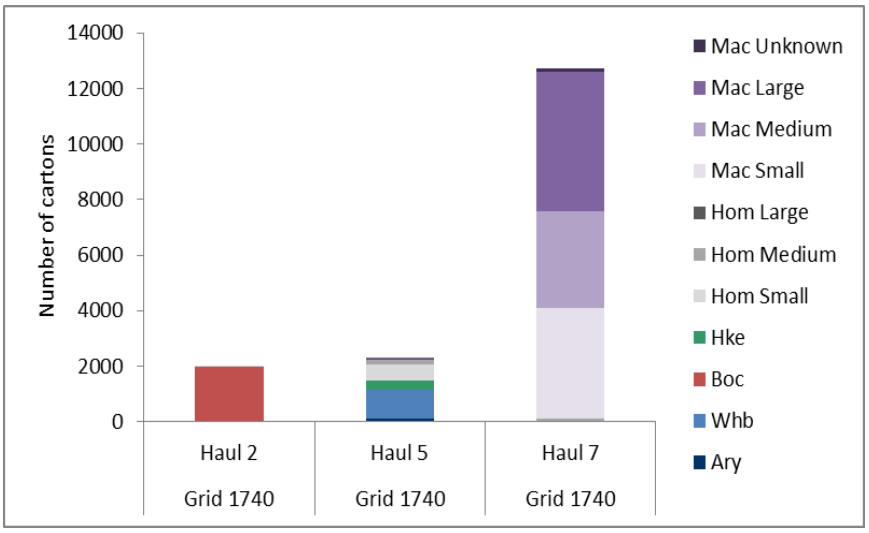

Figure 17. Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 4, Table 5) for hauls fished with sorting grid (Ary = Argentine, Boc = boarfish, Hke = hake, Hom = horse mackerel, Mac = mackerel, Whb = blue whiting).

Meeting skipper and fleet manager SCH302 13-07-2015

During 7 hauls a net modification (*i.e.* sorting grid 1736 or cod-end 80 mm mesh size) was used on board SCH302 (Table 6). In general, the skipper is of the opinion that a sorting grid could be useful to avoid catches of (i) undersized mackerel, or (ii) blue whiting within the horse mackerel fishery. However, the skipper thought that during the testing period there was no small mackerel present. Furthermore, it was noted that the current grid does not work to let boarfish escape. This would need a system where boarfish and roundfish are gradually guided down in the net after which they can escape.

Trip 1 (2014)

Within this trip a cod-end modification (*i.e.* 80 mm cod-end) was used during two hauls (~2% of all hauls) (Table 6) to avoid undersized mackerel in the horse mackerel fishery (*i.e.* hauls 30 and 45). During these hauls no mackerel was present in the catches (Figure 18). Mackerel was also not present in the hauls surrounding haul 45 (no information is available from the hauls surrounding haul 30 as catch information is not available for the entire trip; Table 3).

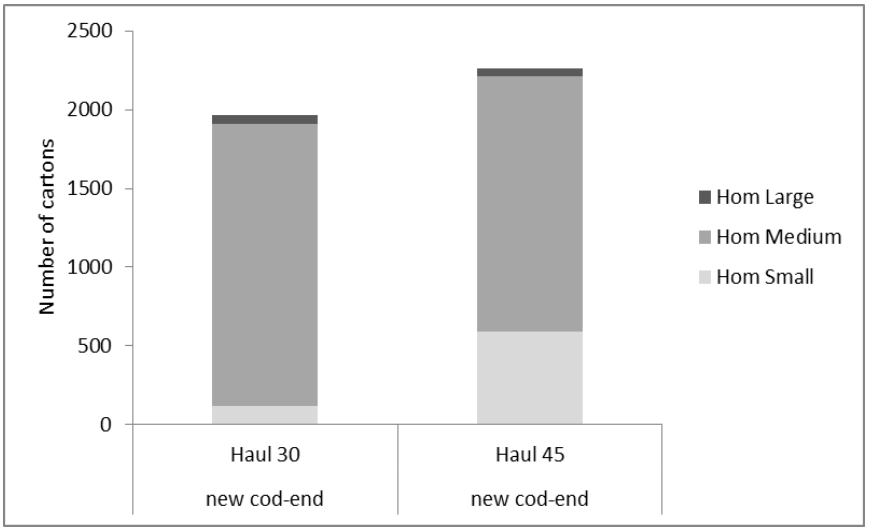

Figure 18. Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 5) for hauls fished with new cod-end (Hom = horse mackerel).

Trip A (2015)

Within this trip a sorting grid was used during one haul (~4% of all hauls) (Table 6) (*i.e.* haul 25). The skipper did not have a specific purpose beforehand to use the grid in this haul. According to the skipper only large individuals of horse mackerel were caught during this trip. The use of a grid was therefore found to be not necessary. For indicative purposes Figure 19 shows an overview of the catch fishing with sorting grid and surrounding hauls. The skipper noted that the low catches during haul 25 (*i.e.* 6.4 tonnes; Figure 19) were a coincidence.

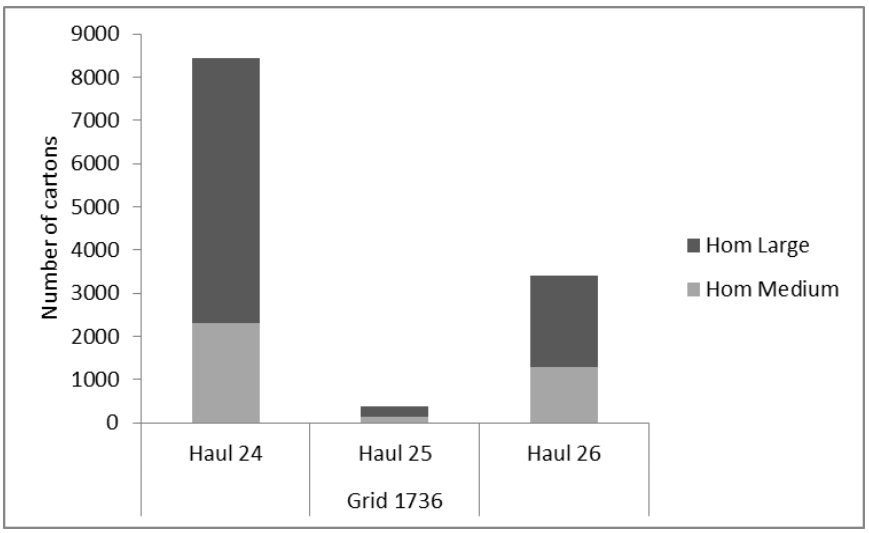

Figure 19. Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 5) hauls 24, 25 (fished with sorting grid) and 26.

Trip B (2015)

Within this trip a sorting grid was used during four hauls (~5% of all hauls) (Table 6). Again the skipper did not have a specific purpose beforehand to use the grid in these hauls (*i.e.* hauls 16, 25, 26 and 27). Horse mackerel and mackerel were caught during these hauls (Figure 20). Under the assumption that 'small' mackerel escapes when fishing with a grid, a comparison of % 'small' mackerel for the hauls with grid and surrounding hauls shows varying % 'small' mackerel (Table 12).

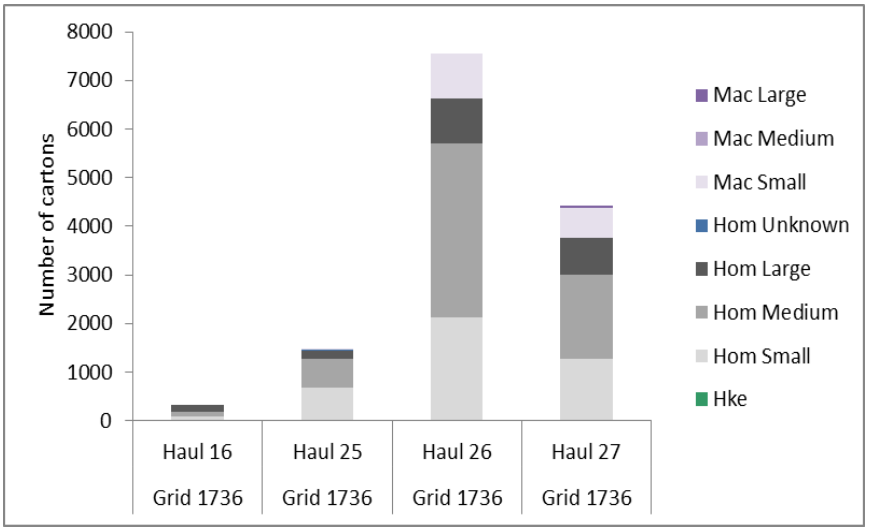

Figure 20 Overview catch composition expressed in number of cartons per species and size class (based on the ranges listed in Table 4, Table 5) for hauls fished with sorting grid (Hke = hake, Hom = horse mackerel, Mac = mackerel, Mac = mackerel, Whb = blue whiting).

Table 12. Overview of hauls with net modification (*i.e.* 16, 25, 26, 27) and surrounding hauls (*i.e.* 15, 17, 24, 28) and corresponding % 'small' mackerel in relation to total mackerel catch. *1 based on the ranges listed in Table 4.

Haul	N cartons mackerel	N cartons small mackerel*[1]	% small mackerel*[1]
15	0	0	0%
16	0	0	0%
17	22	22	100%
24	12	12	100%
25	17	17	100%
26	926	926	100%
27	669	624	93%
28	439	417	95%

4. Discussion

The number of hauls where grids were used within this study was relatively small (23 hauls out of a total of 352 hauls). Analyses were conducted on the data collected within the self-sampling programme for horse mackerel and mackerel. Small mackerel (in relation to total mackerel catches) seemed to be able to escape in greater numbers from a grid than small horse mackerel (in relation to total horse mackerel catches) (Figure 8, Figure 9). However, the effect of grids for both species was found to be not statistically significant. The relatively small dataset made it difficult to draw conclusions from the statistical analyses Therefore, in the future it is recommended to make an attempt to increase the number of experimental hauls. Furthermore, the work could have benefitted from more standardisation in data collection within the fleet of freezer trawlers.

Based on the results of the video analysis of the underwater Trawler Camera it is clear that both mackerel and horse mackerel escape through the grid. An increase in the frame frequency when video recording would possibly reduce the number of unidentified fish species. Reliable length estimations of horse mackerel were difficult to obtain. For only 8% of the horse mackerel a length estimation could be obtained. This was considerably higher for mackerel, where a reliable length estimation was obtained for 27% of the observations. An important observation is that the majority of escaped mackerel is smaller than the smallest market category of mackerel (25 cm based batch information from trawlers) (Figure 13). This indicates that the grids are selective for smaller mackerel, and therefore, have potential to increase the selectivity for the mackerel fishery. The position of the camera differed between the two video-analysed hauls of the SCH302 trips. When the camera was located in the middle of the grid, we observed 502 escapes. Compared to only 33 escapes in the beginning of the grid (first grid section) (Table 10). Also the species composition of the escaped fish differed slightly between the two positions (Figure 14). This could mean that fish escape more or easier in the latter sections of the grid. However, there is large variation between hauls in catch and length composition (van Overzee et al., 2013).

The advantage of underwater observation with video monitoring over catch or vessel data comparisons, is that the effect of the grids can be directly observed. There are no uncertainties related to variations between catch compositions or external factors, e.g. weather, visibility, time (day vs. night), etc. However, a drawback of the video monitoring used in this study is that only a small portion of a grid is in the field of view, and escape rates of unseen panels have to be estimated. Moreover, on video you cannot see the retained part of the catch, i.e. the fish that not escape through the grid, therefore, it is not possible to estimate what the rate of escapes of the total catch is.

In addition to the self-sampling data and the underwater observations, individual meetings with the skippers were organised to collect feedback on the usage of net modifications and to discuss why net modifications were used during specific hauls. Based on the feedback received from the skippers (see section viewpoints of the skipper) it became clear that cooperation already in the early stage of a research project (i.e. when defining research aims) is crucial. Opinions were divided on the effectiveness of the grids used in this study. Wide support and believe in the success of grids could have increased the number of hauls where grids were used and consequently increased available data for statistical analysis.

5. Conclusions

The sorting grids tested during the trials in 2014 and 2015 seemed to release some small mackerel, but not horse mackerel. However more quantitative data would be needed to draw a statistically firm conclusion. The video analysis confirms this view showing escapement of both mackerel and horse mackerel. There was not enough data for drawing any conclusion on the release of boarfish, but indications from targeted hauls on boarfish, showed no escapees on camera. It is unlikely that the grids tested are effective in releasing boarfish from the trawl, but observations with the underwater camera were lacking. Data comparison and inference of effects can only improve if selective devices (*e.g.* sorting grids) are used in a substantially larger number of hauls in future trials.

6. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

This report was internally reviewed and has been written in close cooperation with Martin Pastoors (Chief Science Officer of the Pelagic Freezer-trawler Association (PFA)).

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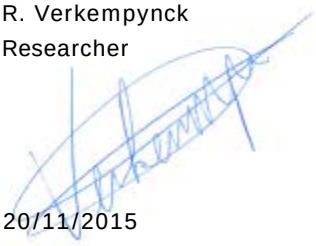
Justification

Rapport C109/15
Project Number: 430.1503.401

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: R. Verkempynck
Researcher

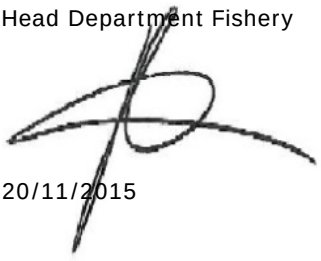
Signature:



Date: 20/11/2015

Approved: Dr. N. A. Steins
Head Department Fishery

Signature:



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