Estimating a conversion factor for the gears used in the industry survey

VIP REPORT

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Contents

Samenvatting

Om de veranderingen in de bestandsgrootte van tong (*Solea solea*) en schol (*Pleuronectes platessa*) te bepalen wordt sinds 2011 jaarlijks een bedrijfssurvey uitgevoerd door twee commerciële vissersschepen. De UK45 vist met een traditionele boomkor en de OD1 vist met een pulswing. Na de uitvoering van de survey in 2014 is de UK45 op de pulswing overgestapt. Om het effect van deze verandering op de bestandschatting te bepalen is een vergelijkend vis experiment uitgevoerd. In dit experiment viste de UK64 parallel aan de UK45, waarbij de UK64 de traditionele boomkortuigen van de UK45 gebruikte. Op beide vissersschepen werd alle schol en tong verzameld uit de gehele vangst van elke trek, waarna de vissen werden gemeten. Hieruit kon een lengte-gebaseerde vangstvergelijking worden uitgevoerd en kon een omrekenfactor tussen de twee tuigen worden geschat. Een totaal van 39 gezamenlijke trekken was beschikbaar voor de analyse.

De resultaten voor tong zijn dat een pulswing significant meer tong vangt in de lengterange die dominant aanwezig is in de vangsten (24-31 cm). Eén trek echter was een extreme uitschieter en nadat deze trek verwijderd werd uit de dataset ving de pulswing significant meer tong tot een lengte van 29 cm. Om de vangsten van de traditionele boomkor tuigen om te zetten naar vergelijkbare vangsten door een pulswing wordt geadviseerd om een omrekenfactor van 1.5 toe te passen op de gehele lengterange van de tongvangsten. Mogelijk resulteert dit in een overschatting van de zeer kleine en zeer grote tongen, maar waarschijnlijk heeft dit een verwaarloosbaar effect op de berekende aantallen omdat deze lengteklassen nauwelijks worden gevangen. Als alternatief kan de omrekenfactor van 1.5 alleen worden toegepast op de lengterange 20-35 cm, waar de berekende omrekenfactor volgens de modellen significant verschilt van 1. De resultaten voor schol laten zien dat de pulswing significant meer kleine schol (<24 cm) ving en significant minder grote schol (>30 cm). Om de scholvangsten van de traditionele boomkor tuigen om te zetten naar vergelijkbare vangsten in de pulswing wordt geadviseerd om een lengte-afhankelijke omrekenfactor toe te passen, welke afneemt van 3 voor schol kleiner dan 15 cm tot 0.6 voor schol groter dan 45 cm.

Omdat er nog onzekerheid is over de omrekenfactor adviseren wij om de berekening van de indices uit te voeren met de verschillende voorgestelde omrekenfactoren, zodat de impact van de verschillen in omrekenfactor op de resulterende vangsten kan worden ingeschat. Daarnaast adviseren we om in de 2016 survey door te gaan met de vangstvergelijking opdat de huidige schattingen van de omrekenfactor kunnen worden verbeterd en de effecten van veranderingen in maaswijdte en vissnelheid beter kunnen worden onderzocht.

Summary

An Industry Survey directed at sole (*Solea solea*) and plaice (*Pleuronectes platessa*) has been running since 2011. This survey was yearly executed by two commercial fishing vessels (UK45 & OD1) each covering a different part of the southern North Sea. The UK45 fished with a traditional beam trawl and the OD1 with a pulse wing. The UK45 decided to change gear and fish with a pulse wing as well, which is a break in the time series of the Industry Survey. To continue the time series the catch efficiency and selectivity of the new pulse wing of the UK45 should be the same as of the traditional beam trawl gear, or a conversion factor compensating for the difference in catch efficiency is required. Therefore a comparative fishing experiment was conducted to estimate the catch efficiency of both gears. In this experiment, the UK64 fished parallel to the UK45 using the traditional beam trawl gears previously used by the UK45. On both vessels the whole catch of each tow was sorted for sole and plaice and these fish were measured. Based on these data a length-based catch-comparison was done to estimate a conversion factor between the two gears. A total of 39 parallel hauls were available for analysis.

The results for sole are that the pulse wing caught significantly more fish in the length range that dominated the catches (24-31 cm). However, one tow was an extreme outlier and when this tow was removed the pulse wing caught significantly more sole up to a length of 29 cm. To convert the catches of the traditional beam trawl to the pulse trawl level, a conversion factor of 1.5 is recommend for the whole length range, although this may result in an overestimation of the smallest and largest size classes, with potentially limited effect on the abundance estimates as these sizes are rarely caught. As an alternative, the conversion factor of 1.5 could be applied to only the length range of 20-35 cm where the conversion factor significantly differs from 1. The results for plaice indicate that the pulse wing caught significantly more small plaice (<24 cm) and significantly less large plaice (>30 cm). To convert the plaice catch of the traditional beam trawl, a length-dependent conversion factor is recommended decreasing from 3 for plaice <15 cm to 0.6 for plaice >45 cm.

As there is uncertainty in the conversion factor estimates we advise to do the index calculations with the different conversion factors to estimate the impact on the outcomes. Furthermore, we advise to continue the catch-comparison during the 2016 survey in order to improve the current estimates and to look into more detail at the effects of the changes in mesh size and towing speed.

1. Introduction

In 2011, an Industry Survey directed to sole (*Solea solea*) and plaice (*Pleuronectes platessa*) was initiated (Rasenberg et al. 2012) as a response to fishers criticism on the survey design of the statutory task fish beam trawl surveys under the European Data Collection Framework (DCF), which could not be incorporated in the statutory task surveys. The intention of the Industry Survey was to provide an age-based index time series for the two species, that could be used in addition to the indices of the DCF surveys in the ICES stock assessment process. The Industry Survey uses commercial fishing gears in commercially important fishing areas, which resultes in more data on large plaice and sole. The Industry Survey has been running yearly since 2011 (van der Reijden et al. 2014), with two commercial vessels (OD1 and UK45) systematically sampling a designated area using respectively a pulse wing and a traditional beam trawl. After the 2014 survey the UK45 decided to switch gears for their normal commercial activities. They switched to using a pulse wing, and as almost no traditional beam trawlers are active in the Dutch demersal fleet anymore, the fishing industry had a preference to continue the Industry Survey with the new pulse wing. This affects the consistency of the index time series. To overcome this issue it was decided that during the 2015 survey, a 3rd vessel still using the traditional beam trawl gears (UK64) would fish parallel to the UK45, using the gears previously used by the UK45 in the Industrial Survey. The data of this catch-comparison study would be used to estimate a conversion factor between the original gear (beam trawl) and the new gear (pulse wing) used in the survey. The comparison of the catches and the calculation of the conversion factor are reported here.

2. Assignment

Analyse the data for sole and plaice of the catch-comparison study executed as part of the Industry Survey in 2015. The final results of the analyses should provide an estimated length-based conversion factor between the two types of gears.

3. Materials and Methods

Vessels

The commercial vessel changing its gear from the traditional beam trawl to the new pulse wing (Photo 1) was the UK45 “Jacob Wilhelmina”. The second commercial vessel is the UK64 “Mattanja”, which fished with the traditional beam trawl. Except for the width of the gear the pulse wing and beam trawl are very different fishing gears (Table 3-1). Next to gear also the mesh size of the cod-end differed. For the index time series the UK45 had been fishing with a cod-end mesh size of around 75mm, while fishing with the new pulse wing they’ll use 80mm (the legal minimum). Unfortunately measurements of the cod-end mesh size of the beam trawl gear during the experiment indicated an average mesh size of 65 mm.

Table 3-1 Characteristics of the gears

UK64	
Gear	12 meter beam trawl
Tickler chains	7
Ticklers from the groundrope	18
Mesh size net (mm)	100 mm
Mesh size cod-end (mm)	75 (65) mm
Fishing speed (knots)	6.5 kn
UK45	
Gear	12 meter HFK pulse wing
Number of electrodes	24
Number, length and diameter (mm) of the conductors	24; length 4.4 m; diameter: 35 mm
Distance between electrodes (cm)	45 cm
Voltage over each electrode pair (V)	15 V AC

Voltage cable vessel to gear (V)	560 V direct current
Electrical power per meter beam width (kW)	5.7 kW
Pulsfrequency (Hz)	60 Hz
Pulswidth (µs)	330 µs
Mesh size net (mm)	100 mm
Mesh size cod-end (mm)	80 mm
Fishing speed (knots)	4.8-5 kn

Photo 1 HFK pulse wing used by the UK45 during the catch-comparison study.

Study design

In total the Industry Survey comprises 84 tows spread over 78 sampling location. Six stations are fished parallel by the UK45 and OD1 (fishing next to each other at the same time). The OD1 samples 40 locations and the UK45 samples 44 locations. Four of the UK45 locations are sampled without IMARES staff onboard. The other 40 stations are sampled with IMARES staff onboard supervising the sorting and measuring of the catch. All these 40 stations are fished parallell with the UK64. Parallell means as close to each other as possible minimising difference in fished habitats, however differences can not be excluded.

The catch-comparison study took place in two weeks in August 2015 (10-21 August). Each week (Monday-Thursday) 3 to 5 positions were fished per day. The geographical positions where determined prior to the study based on the locations in the previous year (Appendix A). The positions where placed such that two to four tows were done in each ICES rectangle (1° of longitude by 0.5° latitude). For the catch-comparison study 14 rectangles were fished. The OD1 fishes in the main distribution area of sole, while only a small number of tows of the UK45 are in the main distribution area of sole. Each location was trawled with a previously determined fishing speed (Table 3-1) for 30 minutes using two nets (port and starboard). After 30 minutes the gears are hauled and emptied in separated bins for further processing.

Photo 2: Sorting the catch on board the UK45

Handling the catch
For estimating the conversion factor between the two gears only sole and plaice catches were relevant. All sole and place were taken from the catch of the starboard net (Photo 2). Due to problems with the net at the UK64, in one tow sole and plaice were taken of the port side net. In one tow by the UK45, sole and plaice were taken of both nets together.
Both species were visually separated in undersized fish (<24 cm sole and <27 cm plaice) and landings by the fishers. Than the fish were measured to the cm-below (e.g. 15.0 to 15.9 cm = 15 cm). In case the catches were large, a subsample was taken from the total catch (undersized or landings), measuring half or less of the total catch. By very large catches the first steps in subsampling is selecting one of a number of baskets (± 35 kg), visually determining if the baskets have a similar amount of fish (preferably a small volume of fish from each basket is shuffled into an empty basket creating a new basket of similar volume, to overcome the problem that basket filled during a different part of the sorting process might differ in length distribution). In the next step the content of the bucket is split again visually estimating the volume. This continues till a subsample of 50 to 100 fish is left.

Statistical Analysis
The assignment is estimating a length-based conversion factor for each of the species. This is done by estimating by length (l) for each haul (h) the proportion caught by the pulse wing (UK45) of the total number fish of that length (Holst and Revill 2009):

$$Prop_{h,l} = n_{UK45,h,l}/(n_{UK45,h,l} + n_{UK64,h,l})$$

This proportion is than modelled as a function of the length of the fish. This is done by following the approach in Holst & Revill (2009) using the R function glmmPQL to fit the GLMM model with a binomial error distribution. Polynomial curves describing the relationship between the proportion and length were fitted starting with 5th order polynomials, and the order was reduced until all terms were significant. The subfactor used for the specific length (1/subfactor) and the duration of the tow were incorporated in the offset of the model. The combined number of fish at length $(n_{UK45,h,l} + n_{UK64,h,l)})$ was included as a weighting factor to give more weight to tows with a lot of fish and the haul (h) was included as random factor. This approach produced a curve with 95% confidence bands expressing this probability. To allow more flexibility than is possible with a polynomial fit, the same model is fitted using a GAM for fitting the length effect. This is done using the R-function *gamm4*.

The fitted curve gives the predicted proportion of fish caught in the pulse wing, where 0.5 means that both gears caught the same. The conversion factor at length is calculated based on this curve by transforming the predicted proportion $Prop_{pred,l}$:

$$Cf_l = Prop_{pred,l}/(1 - Prop_{pred,l})$$

Next to these length based analysis, the difference between the two gears is also tested for the groups discards (Sole: <24, Plaice <27) and landings using a paired t-test.

4. Results

Locations fished

The plan was to fish 40 sampling stations as part of the catch-comparison study. Owing to time constrains one station could not be fished, resulting in 39 stations (Figure 1). The first six tows were fished with three vessels parallel to each other, the other 33 stations were fished with the UK45 and UK64 parallel to each other.

Haul 19 was determined as invalid for the UK64. During that haul the net filled very quickly, recuding the speed of the vessel and making it necessary to haul the net. The net was filled with sediment, the haul was too short and the speed was inconsistent with the rest of the tows. Because the catch-comparison is haul-specific, this haul and the corresponding (valid) haul of the UK45 were excluded from the analysis.

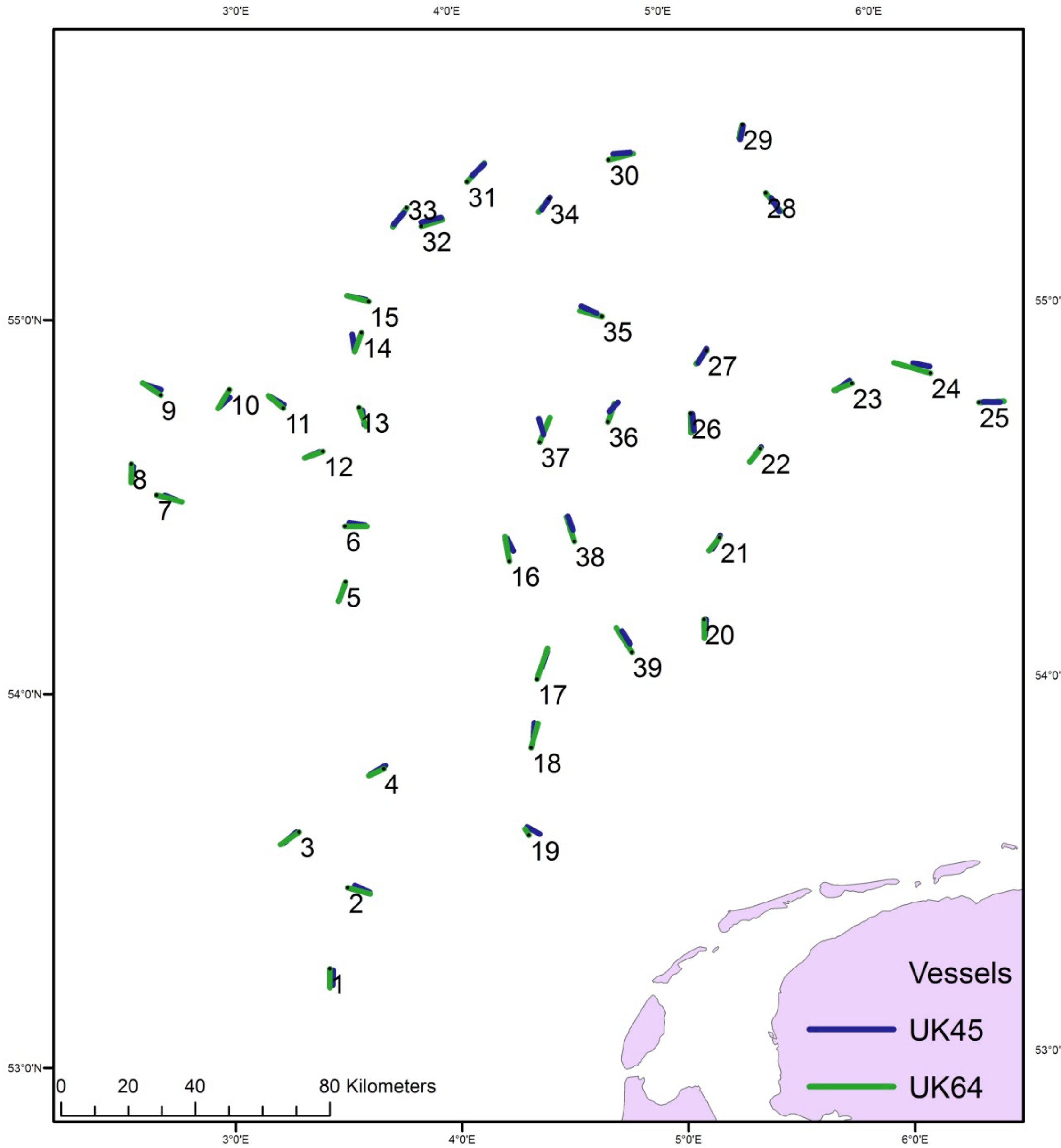

Figure 1: Fishing transects of the Comparison study. The numbers refer to the haul number. Haul number 19 was invalid.

Sole

Overview of the data

The distribution of large sole is mainly in the southern North Sea (Heessen et al. 2015). This can be seen in the catches of both vessels, with the majority of sole caught at the most southern sampling station (haul 1, Figure 1, Appendix B). Haul 1 of the UK64 contained 57.5% of all sole for the UK64 this survey, for the UK45 this percentage was 41.8%. Haul 1 is therefore an outlier and has a large impact on the analysis. The graph of mean numbers per hour clearly changes by leaving out this first tow (Figure 2). Especially when haul 1 is left out, most of the sole caught were of a length just above the Minimum Landing Size (MLS) up to 30 cm. In this range the UK45 clearly catches more sole per hour compared to the UK64.

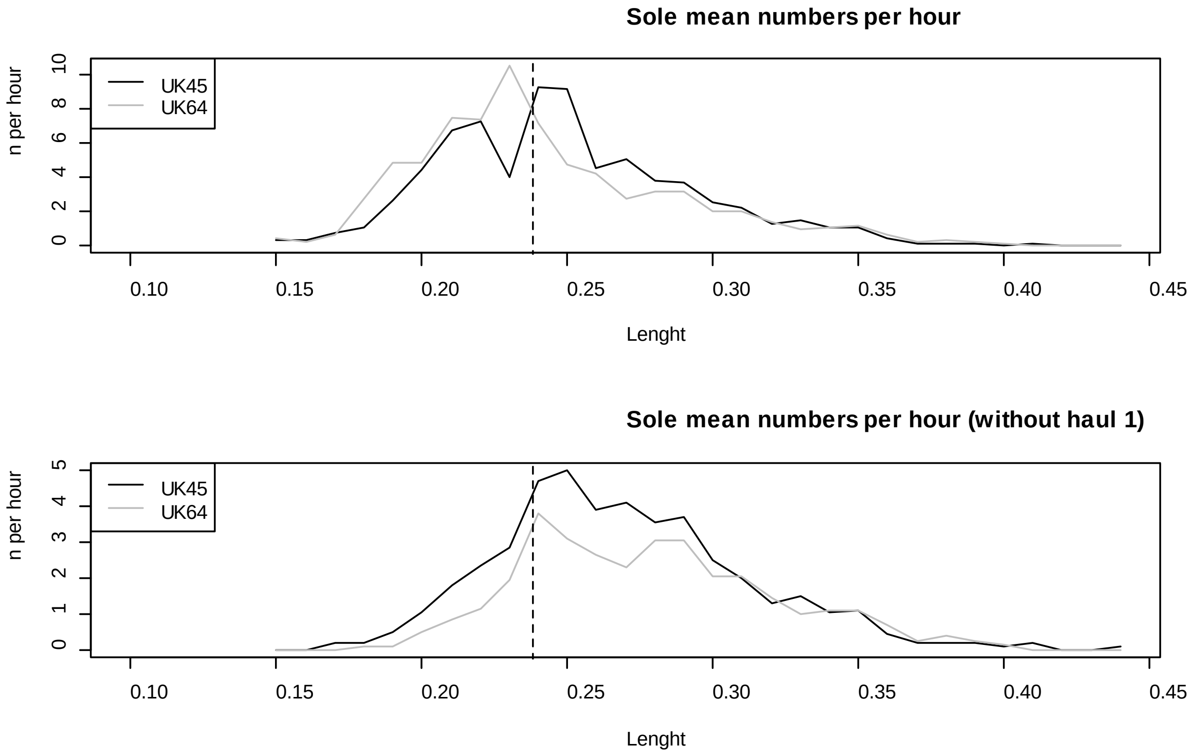

Figure 2 Number of sole at length, UK45 in black and UK64 grey. Vertical dashed line is the Minimum Landing Size (MLS). Top all tows, bottom without tow 1.

Statistical analysis

The glmm model indicates that a polynomial curve with length to the power 4 fits the proportional data including all tows “best”. This 4th order function is used for sole and results in a final estimate of the proportions as shown in Figure 3.

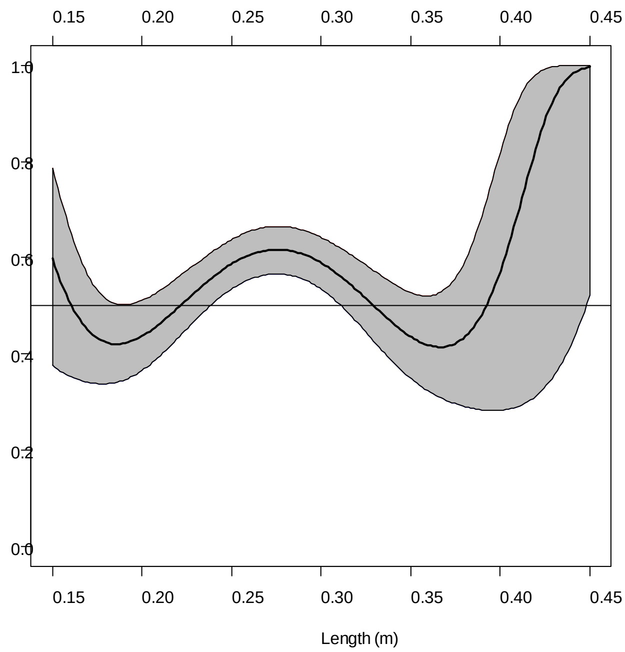

Figure 3 Proportion of sole from all tows retained by the UK45 (pulse wing) modelled by the glmm approach and the 95% confidence interval. Corrected for fishing time.

Fitting the data removing the first tow (a major outlier) from the data results in a fit indicating that a linear model is actually “best”. Resulting in a decreasing linear fit (Figure 4), with significantly more sole up to a length of 29 cm in the UK45 catches, and similar, not significantly different, amounts of larger sole (>28 cm).

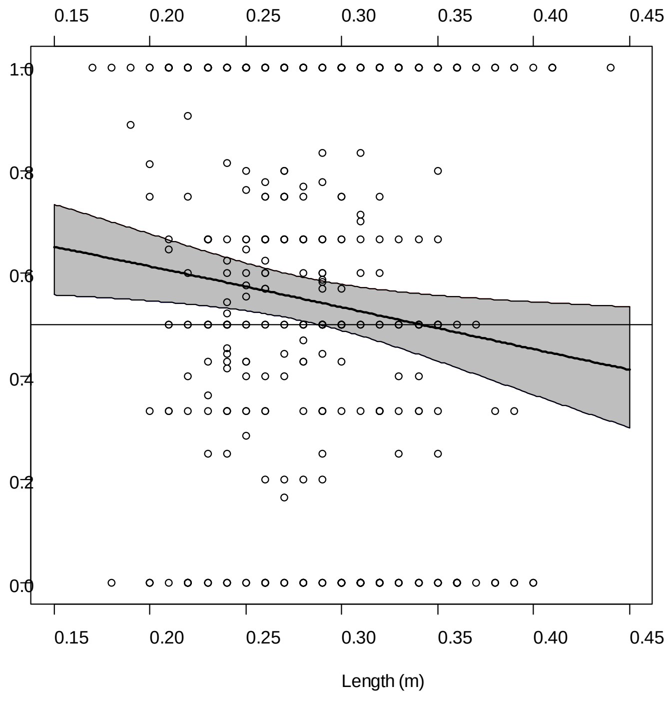

Figure 4 Proportion of sole retained by the UK45 (pulse wing), excluding the first tow, modelled by the glmm approach and the 95% confidence interval. Corrected for fishing time.

Paired t-test

All sole discards, <24 cm, are grouped per haul and these are plotted for the two gears (Figure 5). Here the large effect of the first tow is visible. A student paired t-test for all the tows gives t = 0.713, df = 37, p-value = 0.4803, while excluding tow 1 gives t = -1.3726, df = 36, p-value = 0.1784. Both p-values indicate that there is no significant difference in catches of discarded sole.

Similar analysis for the landings (Figure 6) for all the tows gives t = -2.3304, df = 37, p-value = 0.02534, while excluding tow 1 gives t = -2.3231, df = 36, p-value = 0.02594. This indicates significant higher landings for the UK45 compared to the UK64. This makes sense as the bulk of the sole is around 24-27cm, and for these length classes the other analysis showed higher catches for the UK45 as well.

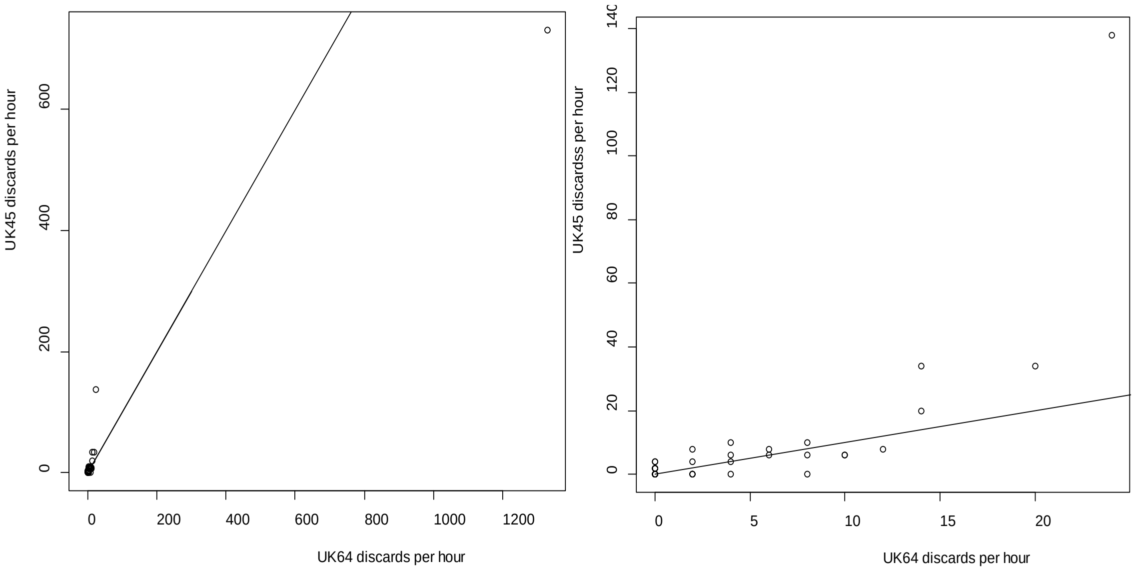

Figure 5 Number of sole discards per hour, x-axis is the UK64 and y-axis is the UK45. The points represent the discards of both gears in a specific tow. The line represents equal discard quantities. Points below the line show more discards in the UK64 while above the line show more discards in the UK45. Left figure is all tows; right figure is without tow 1.

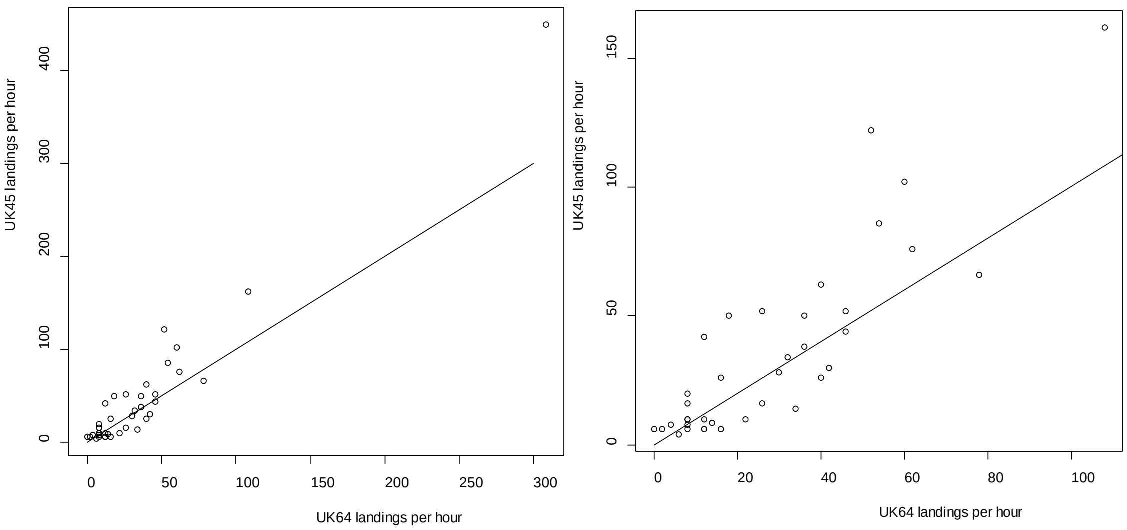

Figure 6 Number of sole landings per hour, x-axis is the UK64 and y-axis is the UK45. The points represent the landings of both gears in a specific tow. The line represents equal landing quantities. Points below the line show more landings in the UK64 while above the line show more landings in the UK45. Left figure is all tows; right figure is without tow 1.

The discrepancies between the results of the length-based analyses (more small sole in the UK45) and the t-tests (no difference in small fish) is a result of the definition of “small fish”, with discards being <24 cm.

Conversion factor

The conversion factor is calculated based on the predicted values in Figure 3 and results in a multiplication factor between 0.75 and 2 (Figure 7). At lengths larger than 40 cm the conversion factor increases rapidly up to a value of 50 (50 times more fishes caught in the pulse wing compared to the traditional beam trawl). The conversion factor of 1, indicating equal catches, is only outside the confidence interval for the lengths 24-31 cm, which is the length range in which most sole was caught. Thus for this range the statistical analysis indicates that the UK45 very certainly catches more sole requiring a conversion factor. The estimated conversion factor within this range has a maximum slightly above 1.5 and this value is within the confidence interval for the whole length range of 24-31 cm. When the conversion factor is calculated based on the fit in Figure 4, it results in a multiplication of 2 for the smallest lengths decreasing to 1 at length 35 cm (Figure 8). Taking account of the confidence intervals, a conversion factor would be required up to a length of 29 cm, as for larger lengths the conversion factor of 1 is within the confidence interval and the catches were not significantly different. Both conversion factor graphs indicate a factor of about 1.5 times more sole in the UK45, especially for the range in which the majority of the sole is caught. This factor could be used for the whole length range, possibly overestimating the smallest and largest sole. This is likely to have a limited effect on total abundance estimates as these small and large sole are rarely caught. Or a conversion factor of about 1.5 could be used to only the length range of 20-35 cm where the conversion factor significantly differs from 1, while outside this range a factor 1 could be used. Both conversion factors should be used in the same index calculation to estimate the effect on the outcomes.

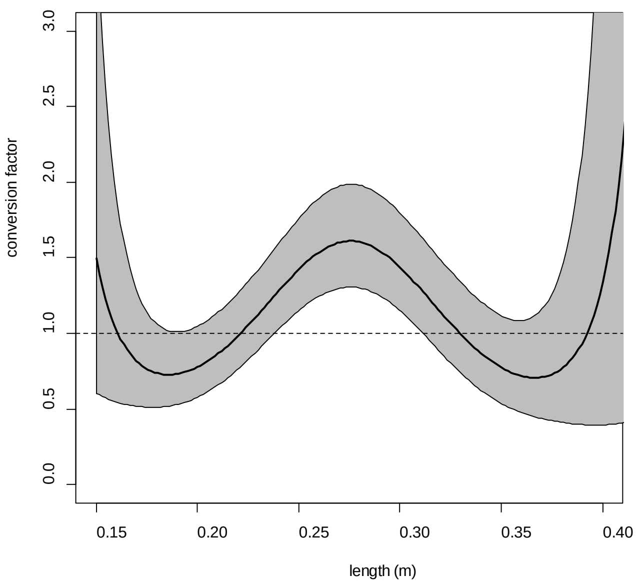

Figure 7 Conversion factor for sole (Traditional beam trawl catch * conversion factor), based on the fitted curve in Figure 3. Lengths larger than 40 cm are left from this graph. The horizontal line indicates a conversion factor of 1, e.g. the catches are already similar.

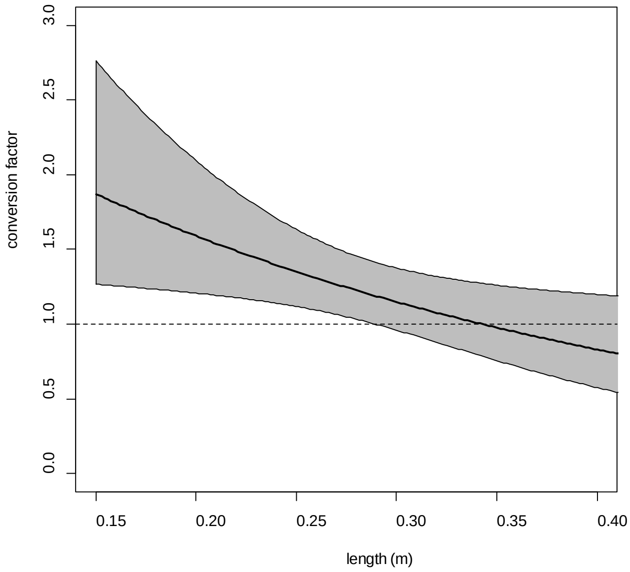

Figure 8 Conversion factor for sole (Traditional beam trawl catch * conversion factor), based on the fitted curve in Figure 4. Lengths larger than 40 cm are left from this graph. The horizontal line indicates a conversion factor of 1, e.g. the catches are already similar.

Plaice

Overview of the data

In tow 4 the landings of the UK45 were not measured and in tow 7 the discards of the UK45 were not measured (Appendix C), therefore these tows were excluded from the overall mean numbers per hour (Figure 9) and from the length-based analyses. The overall mean numbers reveal an unexpected difference between the two vessels. It suggests that, on average, the UK45 caught more plaice below 23 cm than the UK64. For the other lengths (>23 cm) the UK64 caught more plaice than the UK45. This is unexpected as the UK64 was fishing with a smaller mesh size, expecting a larger retention of small fish.

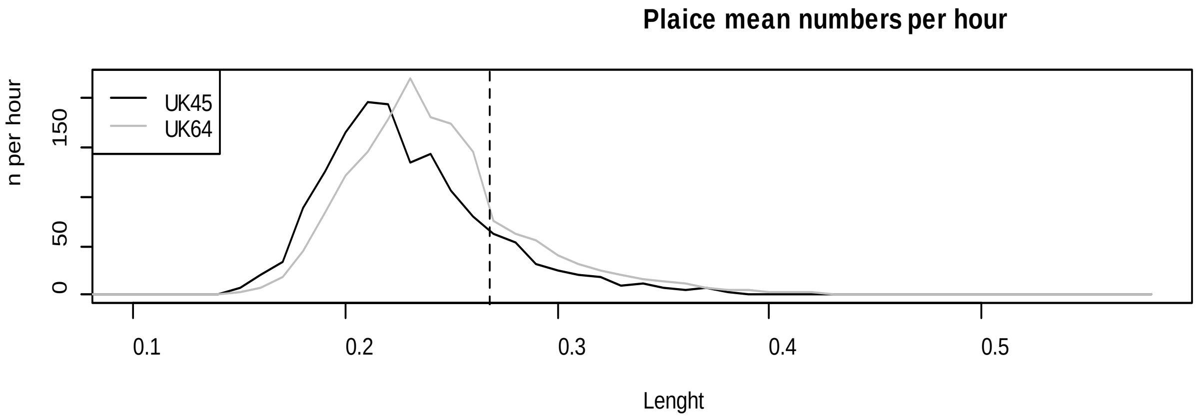

Figure 9 Number of plaice at length, UK45 in black and UK64 grey. Vertical dashed line is the Minimum Landing Size (MLS).

Statistical analysis

Tows 4, 7 and 19 are removed from these analyses resulting in a total of 37 parallel hauls to compare plaice catches. For this data the glmm model indicates that a polynomial curve with length to the power 3 fits the proportional data “best”. This 3th order function is used for plaice and results in a finale estimate of the proportions as shown in Figure 10. It is clear that this fit is driven by the difference between the two vessels at smaller fish lengths, where the UK45 caught more. Using a GAM rather than the polynomial model for fitting the effect of length on the proportion gives a very similar graph (Figure 10) showing that the UK45 catches significantly more small fish (<24 cm). In addition, the GAM approach indicates that the UK45 catches significantly less large fish compared to the UK64.

The graphs in Figure 10 are based on the assumption that tows in which more fish were caught (combined for the two gears) give better information than tows with lower numbers of fish. In the case of sole this assumption is considered correct, however, all tows contained a good amount of plaice. Actually, when large amounts of fish were caught, the catch was subsampled (measuring only a subsample of the total catch), resulting in a lower certainty of the exact length distribution and quantity. In some cases the subsample of plaice <27 cm consisted of about 50-75 individuals representing only 1/16 to 1/48 of the total amount. This subsampling might have introduced an error that questions the assumption "large tows provide better information". Therefore, the models were also fitted without the weighting factor, resulting in an approximately linear model. The model still indicates significant larger catches of the UK45 below <24 cm and significantly larger catches for the UK64 above >30 cm (Figure 11).

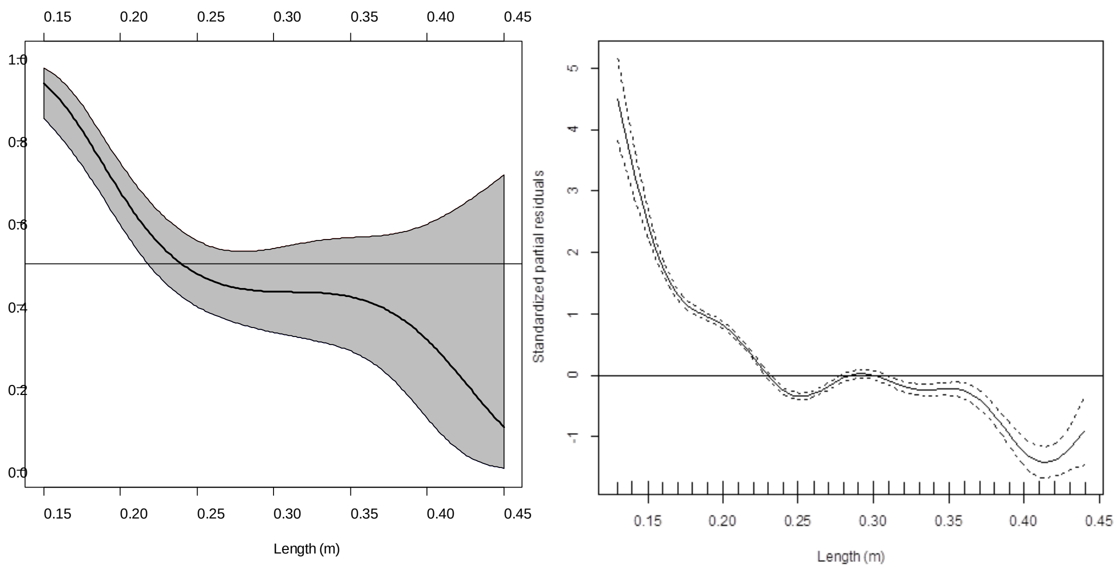

Figure 10 Proportion of plaice retained by the UK45 (pulse wing) modelled by the glmm (left) and GAM (right) approach and the 95% confidence interval. Corrected for fishing time.

Paired t-test

All discards, plaice <27 cm, are grouped per haul and these are plotted for the two gears (Figure 12). A student paired t-test for all the tows gives t = 0.3188, df = 36, p-value = 0.7517. This indicates that there is no significant difference in catches of discarded plaice. Similar analysis for the landings (Figure 12) for all the tows gives t = 3.365, df = 36, p-value = 0.00183 indicating significant higher landings for the UK64 compared to the UK45. These results are in line with the length-based analysis, where the individuals in the length 23-27 cm dominate the discards and in the length-based analysis it was shown that there was no difference between the vessels in this length range. The numbers of small plaice (<24 cm) are low compare to the length range 24-27 cm that they have relative little impact on the total discard quantity. Therefore, the significant higher numbers of small plaice (<24 cm) did not result in significant higher plaice discard (<27 cm) numbers.

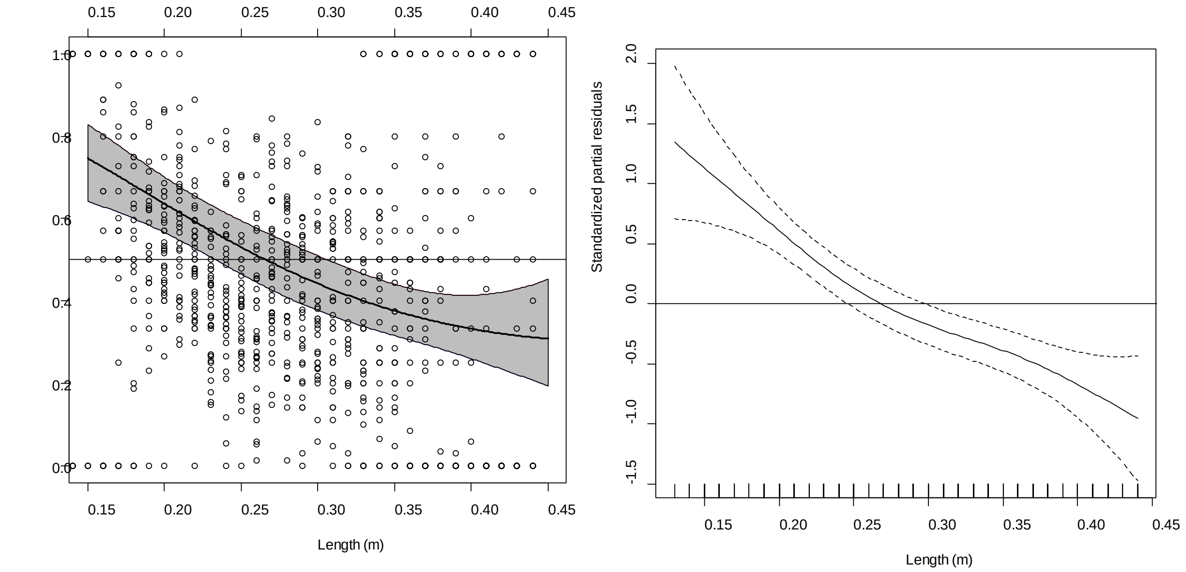

Figure 11 Proportion of plaice retained by the UK45 (pulse wing) modelled by the glmm (left) and GAM (right) approach and the 95% confidence interval. Corrected for fishing time. Without the weighting factor for the total amount of fish caught at each sampling location.

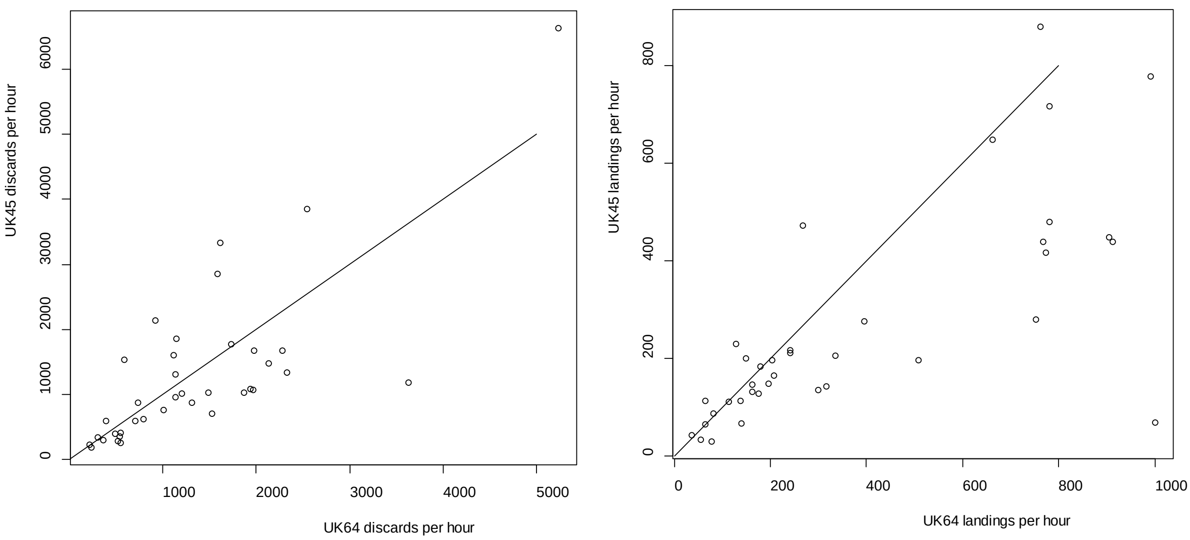

Figure 12 Number of plaice discards and landings per hour, x-axis is the UK64 and y-axis is the UK45. The points represent the discards or landings of both gears in a specific tow. The line represents the same discards or landings. Points below the line mean more in the UK64 while above the line means more in the UK45. Left figure is discards, right figure is landings.

Conversion factor

The conversion factor is calculated based on the predicted values in Figure 11 and results in a multiplication factor between 3 and 0.6 (Figure 13).

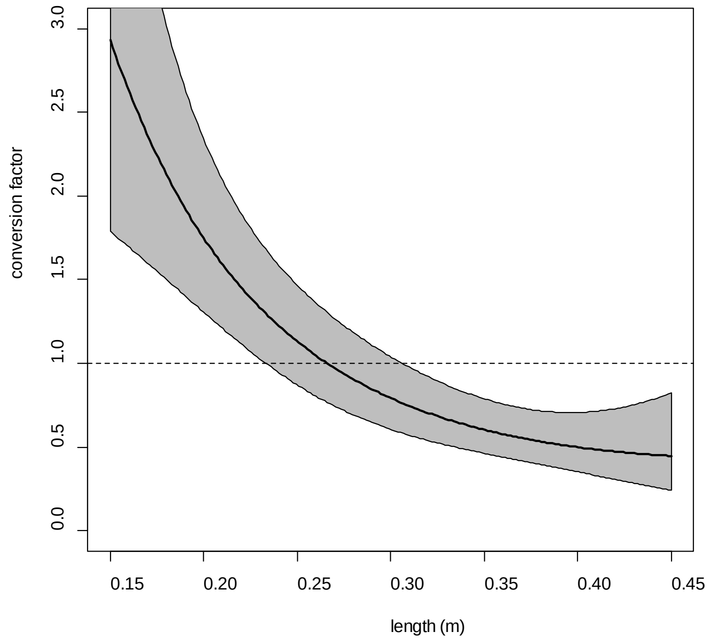

Figure 13 Conversion factor for plaice (Traditional beam trawl catch * conversion factor) based on the fitted curve in Figure 11. Lengths larger than 45 cm are left from this graph. The horizontal line indicates a conversion factor of 1, e.g. the catches are similar.

5. Discussion

The initial plan for the catch-comparison study was 40 tows, which was in accordance with a preliminary power analysis on the low side considering the variation in the catches of sole and plaice. Owing to time constrains, tow failure, and sampling mistakes this number was further reduced complicating the estimation of the conversion factor. Additionally, extra variation was introduced because it is impossible to fish the same track. As the habitat and fish are not homogenously distributed fishing different tracks (especially when they are further apart) is affecting the catches and with that reducing the comparability. This external variation was minimized as much as possible, by fishing very closely together with both vessels. Other factors affecting the variation are the differences in mesh size (smaller in the UK64), the vessels differ (for example UK64 difficulty managing the required speed) and the crews and the IMARES staff differed resulting in small differences in executing the same protocol. The latter has effect on how the sorting and especially the subsampling is done although instructions were similar. This affected the amount of fish measured per tow and with that affected the size of the subsampling factor. Preferably this factor is as low as possible, however measuring all fish will not be possible. The dominant IMARES activity is fish monitoring surveys in which the amount of fish and length distribution are averaged over multiple tows. This method allows for relatively small amounts of fish to be measured per subsample, while tow by tow compassions as done here preferably requires smaller subsamples. Depending on the research question, the staff will need to measure different minimum quantities for subsampling the catch.

Additional complication for sole is that the study had only a small number of tows in the main distribution area of this species. The tows at sole grounds had a different catch composition compared to the rest of the area and the absolute numbers, as it is the main distribution area, were higher. As a result this small number of tows in the main distribution area dominated the estimates of the average catch composition. However, as the larger catches are difficult to handle on board, and require subsampling as time will not allow measuring all the individuals, the absolute amounts in these larger tows are sensitive for errors. This was especially the case in the first tow, where everyone had to get used to the sampling process while it happened to be the largest catch of sole. The difference observed between the sole catches of both vessels in tow 1 could represent reality of fishing gear differences at sole fishing grounds. However the observed differences might also be a result of the described circumstances. As none of the other tows had this large amount of sole or had a similar difference between the two gears, the conversion factor dominated by this tow should not be used to convert all other tows. Therefore, the results with and without the first tow are shown for sole. For the conversion factor we advise using the results without the first tow, as this is the difference based on most of the tows and not dominated by a single tow. Moreover, the survey area is not changed over the years, so the tows used for calculation of the conversion factor are as representative as possible for the data-to-be-converted.

The pulse wing caught significantly more sole up to a length of 29 cm, with the majority of sole caught occurring within the range 24-27cm. This result is different from what was shown by van Marlen et al. (2014). They showed in their analysis, corrected for tow duration, significantly lower catches of sole up to a length of 15 cm, above this length the catches did not differ significantly. Similar to our study, the number of sole < 20 cm was low resulting in wide confidence limits for these lengths. Our analysis of the total number of sole <24 cm indicate no difference between the two gears. The data by van Marlen et al. (2014) comes from the southern North Sea which overlaps better with the sole distribution, their results of less small sole compared to the beam trawl are more similar to the results shown in our first tow which was also in the sole area and are more similar to the difference found with the OD1 (first six tows Appendix B).
Furthermore, the results of van Marlen et al. (2014) indicates that the catches of larger sole in the pulse wing were higher than in the beam trawl, however that difference was not significant. We found significant larger catches for the pulse wing up to a length of 29 cm and non-significant larger catches up to 34 cm, both overlap with the range of van Marlen et al. (2014). In our results the total landings, corrected for tow duration, were also significantly higher in the pulse. Both conversion factor graphs

indicate a factor of about 1.5 times more sole in the UK45, especially for the range in which the majority of the sole is caught. Therefore this factor could be used for the whole length range, possibly overestimating the smallest and largest sole. Or this factor could be used for only the length range of 20-35 cm where the conversion factor significantly differs from 1, while outside this range a factor 1 could be used. Both options can be used in the index calculation, showing the effect of the possible overestimation on the final indices.

Large catches are also an issue for the calculation of the conversion factor for plaice. As described, large catches are difficult to handle on board. It results in multiple baskets full of fish of similar size, that have to be subsampled as measuring all fishes is impossible. The issue is enhanced by the sorting process of the crew, which results in an immediate split between landings and discards (which is a deviation of the work program that stated that all plaice and sole are sorted of the catch, without giving attention to length). Landings and discards are than subsampled differently, often resulting in a different subsample factors. In some tows this resulted in a questionable split at the border between the two groups (10 times as much fish of 26 cm than fish of 27 cm). In some tows high subsamples were used (up to 48 times) measuring a small number of fish, while the other vessel at the same station measured much more fish having a smaller subsample factor and showing a distinct difference in length distribution. Parallel tows with such deviation in subsampling factor are questionable, as they might reflect realistic differences between gears as well as an effect of the different sampling and subsampling factors used on both vessels. The sampling method currently used is developed for the regular IMARES surveys where all the tows are combined to give an average image of the fish community rather than a tow by tow comparison. In the larger picture the effects of subsampling are averaged out, however in a tow by tow comparison a difference introduced by sampling differences might result in a significant effect especially in the case of a low number of sampling stations. For plaice there were some questionable large tows, therefore it was decided to remove the weighting factor from the analysis, giving each sampling station equal sample power. This gave a different result (Figure 10, Figure 11), which was believed to be the better answer.

The plaice catches indicate that the pulse wing catches significantly more small plaice (<24 cm), while the beam trawl catches significantly more large plaice (> 30 cm). The analysis on total discards indicates that there is no significant difference between the vessels. The results of van Marlen et al. (2014) indicated that the beam trawl caught significantly more plaice for the full length range. Our observed difference is caused by the smallest plaice (<24 cm), which were caught more in the pulse than in the beam trawl, which was not the case in the data of van Marlen et al. (2014). The result that the pulse caught more small plaice was unexpected as the pulse fished with an 80 mm cod-end mesh while the beam trawl fished with an average cod-end mesh of 65 mm. Correcting for the effect of mesh size would have enhanced the difference between the pulse and beam for the smallest length classes. However, this might not be as straightforward as using experimentally determined factors for mesh size, because both vessels were fishing with large meshed protection bags around the cod-end potentially affecting the effective mesh size.

One explanation for the unexpected result we could come up with is that the smallest plaice stunned by the pulse do not recover within the short tow duration of half an hour and as they are stunned they do not actively escape through the meshes, which could lead to a higher retention. In the same line of reasoning, the effect might be caused by the difference in speed rather than the effect of stunning. For the short 30 minute duration of the tow the small plaice could be capable of swimming along with the fishing speed of the pulse wing retaining them in the net, while the larger speed of the traditional beam trawl might be too fast forcing the small plaice through the meshes. Both explanations might however be somewhat farfetched as we have no other reference discussing this. Especially because the catches in the OD1, first six tows (Appendix C), are more in line with the results of van Marlen et al. (2014). Even though unexpected, the difference is observed and affects the conversion factor.

Large plaice (>30 cm) were caught more by the traditional beam gear than with the pulse wing. This result was congruent to the experience of pulse fishing of the fisheries industry. Their theory is that not the electric pulses are causing this effect, but the usage of the wing-method is the explanatory factor, in combination with the lowered fishing speed of the pulse vessels. The wing-method is a method to replace the traditional beam in beam trawl gears by an aerodynamic wing-panel. This panel is hovering above the sediment, with only a “nose” touching the sediment. This nose is up to three meters in front of the net opening and could function as a warning-mechanism for the fish. Large fish could than escape the net, facilitated by the lowered fishing speeds of a pulse-vessel. Small fishes are not fast enough to escape the net and are therefore caught. Although this explains the reduced catches of large plaice (>30 cm) by the pulse wing, it does not explain the observed higher catches of small plaice (< 24 cm) by the pulse wing. This explanation assumes a change in catch efficiency between the pulse and traditional beam trawl, while the observed difference between these two gears might just be the result of fishing a smaller surface while having a very similar catch efficiency for plaice. Preliminary analyses indicate no significant differences between the landings if these are corrected for fished surface.

The GLMM method (Holst and Revill 2009; van Marlen et al. 2014; Fryer et al. 2003), with restrictions determined by the polynomials, as well as the GAMM method fit the statistically best curve through the available data. Both models however are not a mechanistic approach that explains the difference between the two gears relating to theory using purely physical or deterministic terms. The fit in Figure 3 for example is difficult to explain by theory as it is completely different from an expected ogive shape which would be based on theory on the difference between pulse and beam trawl. An ogive could have been forced through the data, always resulting in a statistically worse fit compared to the statistical approach, further complicating the results. Fitting an ogive is based on expected effects of the gears on the catches by length, while other factors might hamper the ogive shape, e.g. the difference in mesh size, the speed and the surface trawled. Both the GLMM and especially the GAMM methods are able to incorporate these other factors. However, some very curvy fits, like the one in Figure 3, are still difficult to explain using these other factors. Some of these curves seem to be caused by low catches at specific lengths. If these lengths were rare, a single fish of this length can determine the proportion for that sampling station. A deviation of 0.5 (equal catch) is than not determined by a difference in catchability of the gears but by the small chance of catching a fish of that length. Thus here, all these methods have disadvantages and it was chosen to follow the method of Marlen et al. (2014). In the case of plaice, the results are strengthened by the highly comparable results of the GAMM.

Overall the estimated conversion factors are somewhat arbitrarily determined largely due to some of the assumptions made. As can be seen in length distributions by tow (Appendix B & C) there is enormous variation between the catches. As it currently stands the amount of data is too limited to draw firm conclusions about the conversion factor. Using other studies, like the one from van Marlen et al. (2014) (or the catches of the OD1), is flawed as well because in those studies the objective is to explain the overall difference between pulse and beam trawl catches, while in this study the intention is to estimate the exact difference between the pulse wing used on board of the UK45 and the traditional beam trawl used in earlier years by the UK45 for this particular area. The only way to improve the accuracy of the conversion factor is to do the same type of catch-comparison study over more stations. If so decided, the advice is to improve on the methodology, by sampling the catch as a whole, thus not discards and landings separately, and measure larger subsamples.

6. Conclusions

The assignment was to estimate a conversion factor for the difference in catch efficiency between the UK45 pulse wing and UK64 traditional beam trawl. The difference between the two vessels is not just the type of gear, the type of gear also influences the fishing speed (slower in the UK45) and with that the surface trawled. Besides this also the mesh size differed (smaller in the UK64), the vessels differed (UK64 difficulty managing the required speed), the crews and the IMARES staff differed. The conclusions below are all based on total numbers caught, corrected for differences in tow duration. The total numbers caught are not corrected for all above mentioned differences between vessels. Therefore, these factors cannot be identified or qualified as affecting the conclusions.

Sole (number per fishing hour):

- The UK45 pulse wing caught significantly more fish in the length range that dominated the catch (24-31 cm).
- If the outlying tow 1 is removed, significantly more fish below 29 cm were caught by the UK45 (with low certainty for the smallest lengths because of the low catches).
- Overall discards in numbers (<24 cm) were similar in both gears
- Overall landings in numbers (>=24cm) were significantly larger in the UK45 pulse wing.
- A conversion factor of 1.5 is advised for the whole length range or for only the length range of 20-35 cm where the conversion factor significantly differs from 1.

Plaice (number per fishing hour)

- The UK45 pulse wing caught significantly more small plaice (<24 cm) and significantly less large plaice (>30 cm).
- That the catches of small plaice by the UK45 were significantly less is a surprising result that we do not understand yet.
- Overall discards in numbers were similar in both gears
- Overall landings in numbers were significantly smaller in the UK45 pulse wing.
- No conversion factor or a decreasing conversion factor (from 3 to 0.6) could be applied.

7. Recommendations

In the conclusion we advise to use two conversion factors for both species which is impractical, however with the current information it isn't possible to decide between the two. Therefore, the recommendation is to use the various conversion factors in the index calculations to show the impact of the differences on the outcome. This will give some idea on the effect of the over- or underestimation of size classes and of the uncertainty of using the conversion factor.
To improve the estimated conversion factors it is advised to continue the catch-comparison study during the 2016 survey, with slight improvement of the protocol. In that study, it would also be nice to look in more detail at the effects of mesh size and towing speed, which especially for plaice showed some surprising results. Currently, we can only speculate on the potential explanations for the results.

8. 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 2018. 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.

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Justification

Rapport C004/16
Project Number: 4301502002

The scientific quality of this report has been peer reviewed by a colleague scientist and the Interim Management team member

Approved: Prof. dr. A.D. Rijnsdorp

Signature:

Date: 5th of February 2016

Approved: Dr. N.A. Steins
Interim Management Team member

Signature:

Date: 5th of February 2016

Appendix A. Trawl locations of the OD1 and the UK45

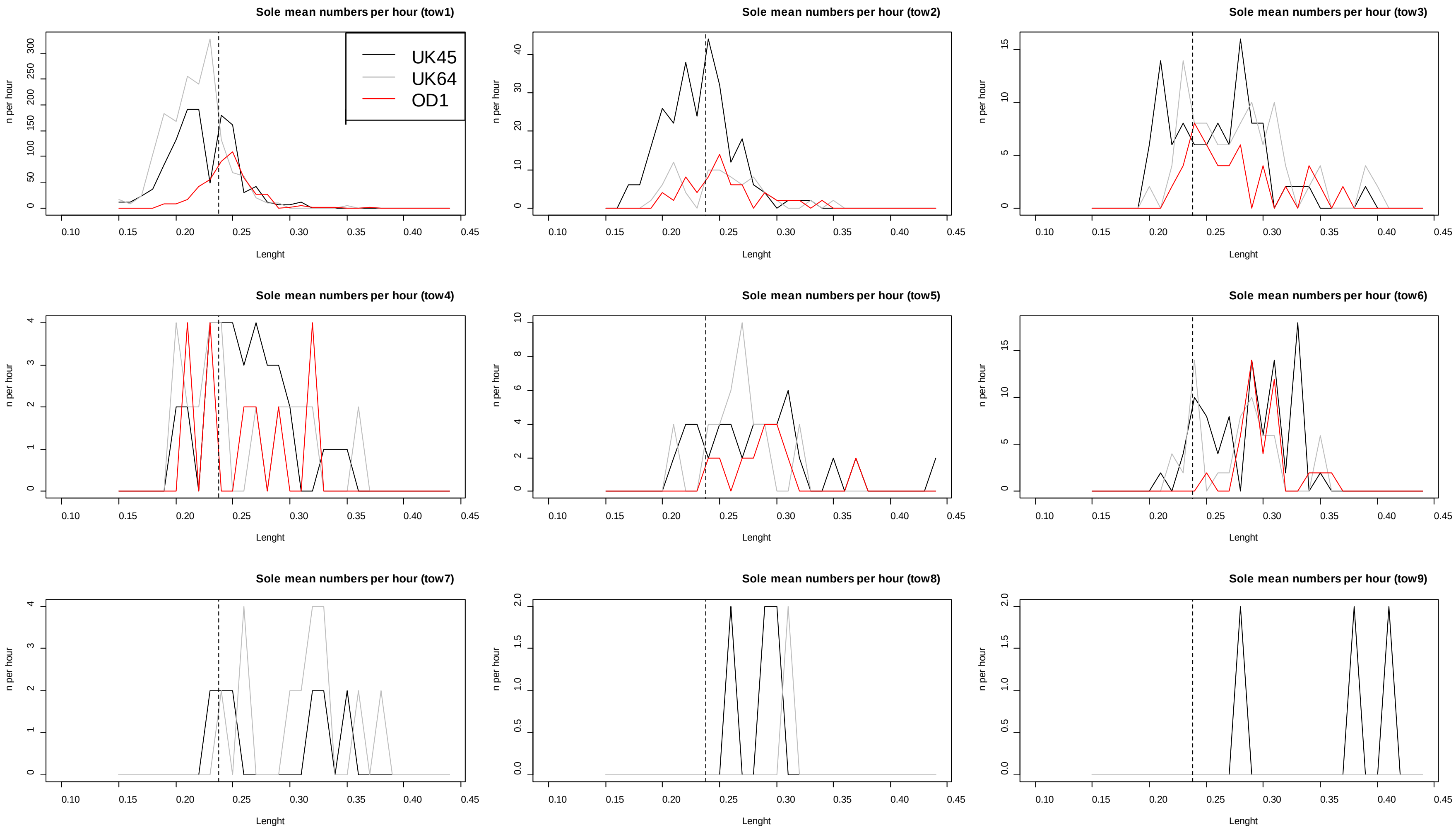
Table A1. Trawl start positions for the OD1, as determined by IMARES. For each rectangle, the number of sector-determined trawls is given.

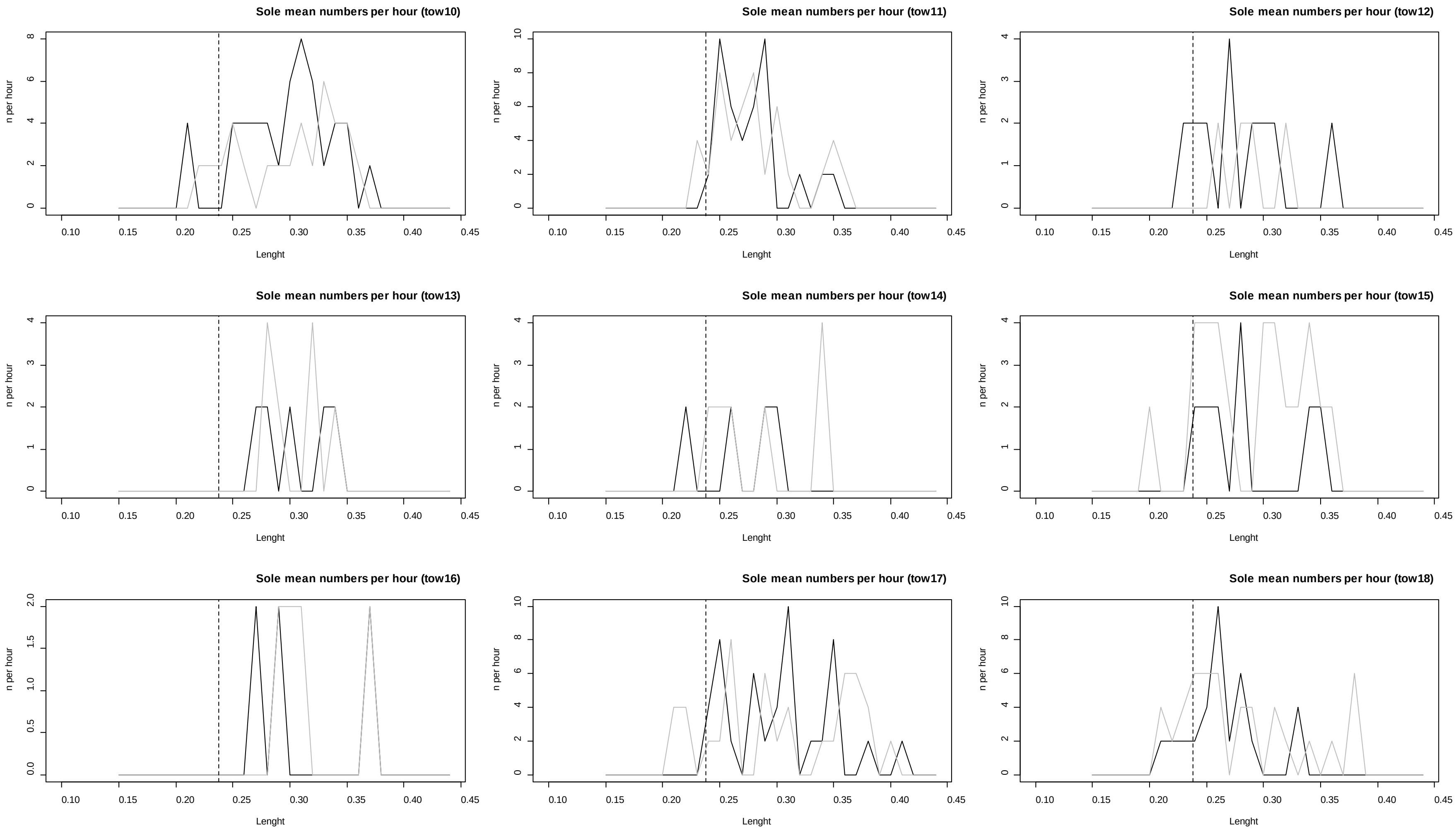
Rectangle	*Number of sector-determined trawls in this rectangle*	*Latitude* (grad,min)	*Longitude* (grad,min)	*Remarks*
32F1	1	51.41	1.53	
32F2	2	51.50	2.21	
		51.48	2.41	
32F3	1	51.44	3.23	
33F2	2	52.29	2.55	
		52.21	2.47	
33F3	2	52.24	3.25	
		52.13	3.37	
34F2	2	52.59	2.51	
		52.47	2.30	
34F3	2	52.57	3.46	
		52.59	3.44	
35F2	2	53.11	2.54	
		53.23	2.45	
35F3	0	53.13	3.25	Parallel with the UK45
		53.28	3.36	Parallel with the UK45
36F2	2	53.50	2.45	
		53.36	2.23	
36F3	0	53.36	3.12	Parallel with the UK45
		53.47	3.36	Parallel with the UK45
37F2	1	54.08	2.45	
37F3	0	54.15	3.28	Parallel with the UK45
		54.27	3.36	Parallel with the UK45

Table A1. Trawl start positions for the UK45, as determined by IMARES

Rectangle	*Latitude* (grad,min)	*Longitude* (grad,min)	*Remarks*
35F3	53.13	3.25	Parallel with the OD1
	53.28	3.36	Parallel with the OD1
36F3	53.36	3.12	Parallel with the OD1
	53.47	3.36	Parallel with the OD1
36F4	53.38	4.18	
	53.55	4.22	
37F3	54.15	3.28	Parallel with the OD1
	54.27	3.36	Parallel with the OD1
37F4	54.25	4.14	
	54.10	4.44	
	54.28	4.31	
	54.07	4.25	
37F5	54.08	5.08	
	54.22	5.10	
37F6*	54.10	6.46	Additional trawl without researcher onboard
	Start position determined by sector		Additional trawl without researcher onboard
37F7*	54.13	7.27	Additional trawl without researcher onboard
	Start position determined by sector		Additional trawl without researcher onboard
38F2	54.34	2.31	
	54.50	2.34	
	54.31	2.45	
	54.46	2.55	
38F3	54.48	3.09	
	54.38	3.19	
	54.43	3.36	
	54.55	3.33	
38F4	54.44	4.24	
	54.46	4.46	
38F5	54.41	5.06	
	54.47	5.46	
	54.52	5.8	
	54.36	5.22	
38F6	54.44	6.33	
	54.51	6.09	
39F3	55.15	3.44	
	55.20	3.30	
	55.16	3.58	
	55.04	3.31	
39F4	55.17	4.25	
	55.26	4.52	
	55.01	4.36	
	55.25	4.10	
39F5	55.16	5.33	
	55.28	5.22	

Appendix B. Sole length distributions by tow

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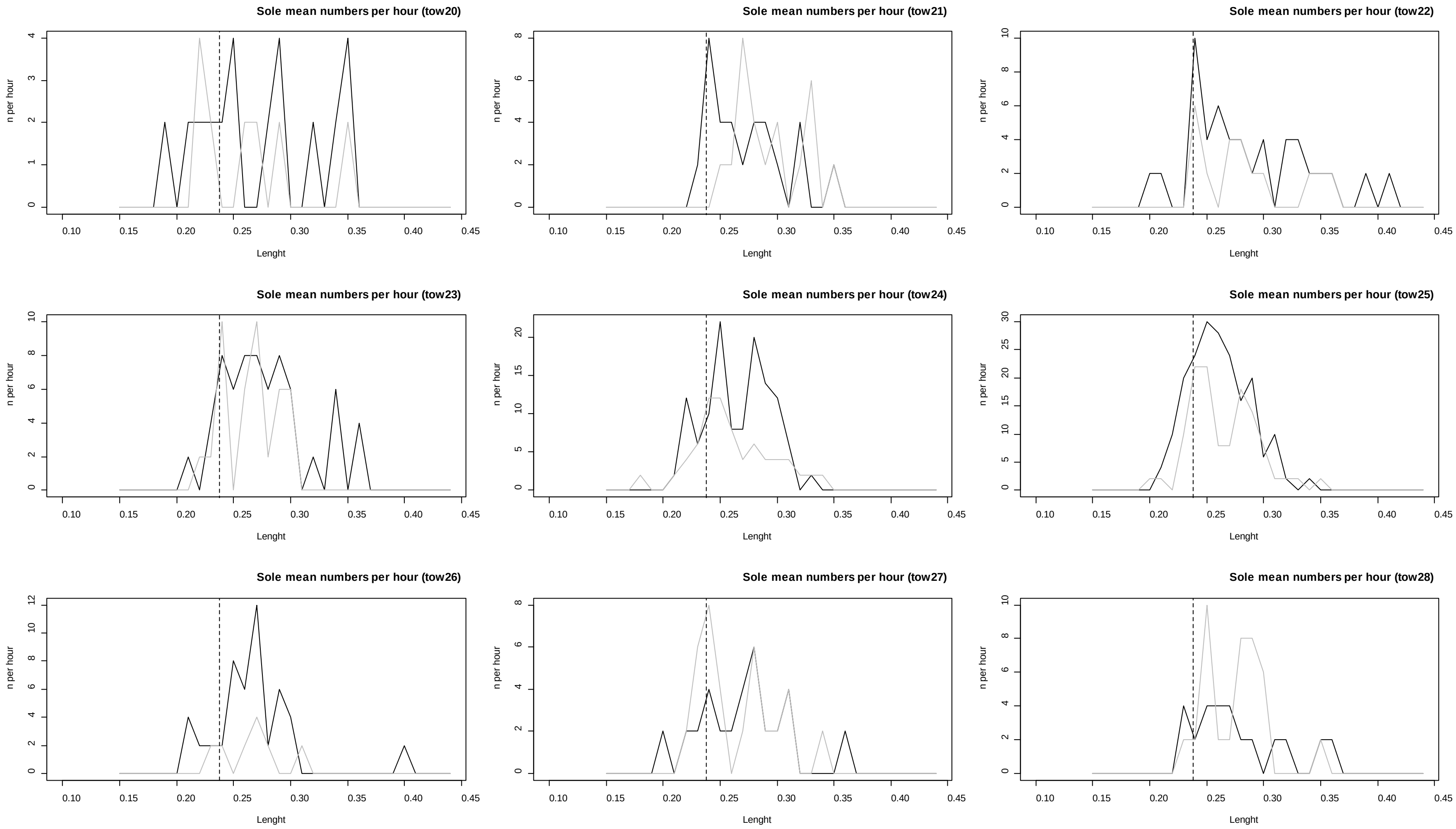
Sole mean numbers per hour (tow11)
Sole mean numbers per hour (tow12)
Sole mean numbers per hour (tow13)
Sole mean numbers per hour (tow14)
Sole mean numbers per hour (tow15)
Sole mean numbers per hour (tow16)
Sole mean numbers per hour (tow17)
Sole mean numbers per hour (tow18)
n per hour
Lenght
0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45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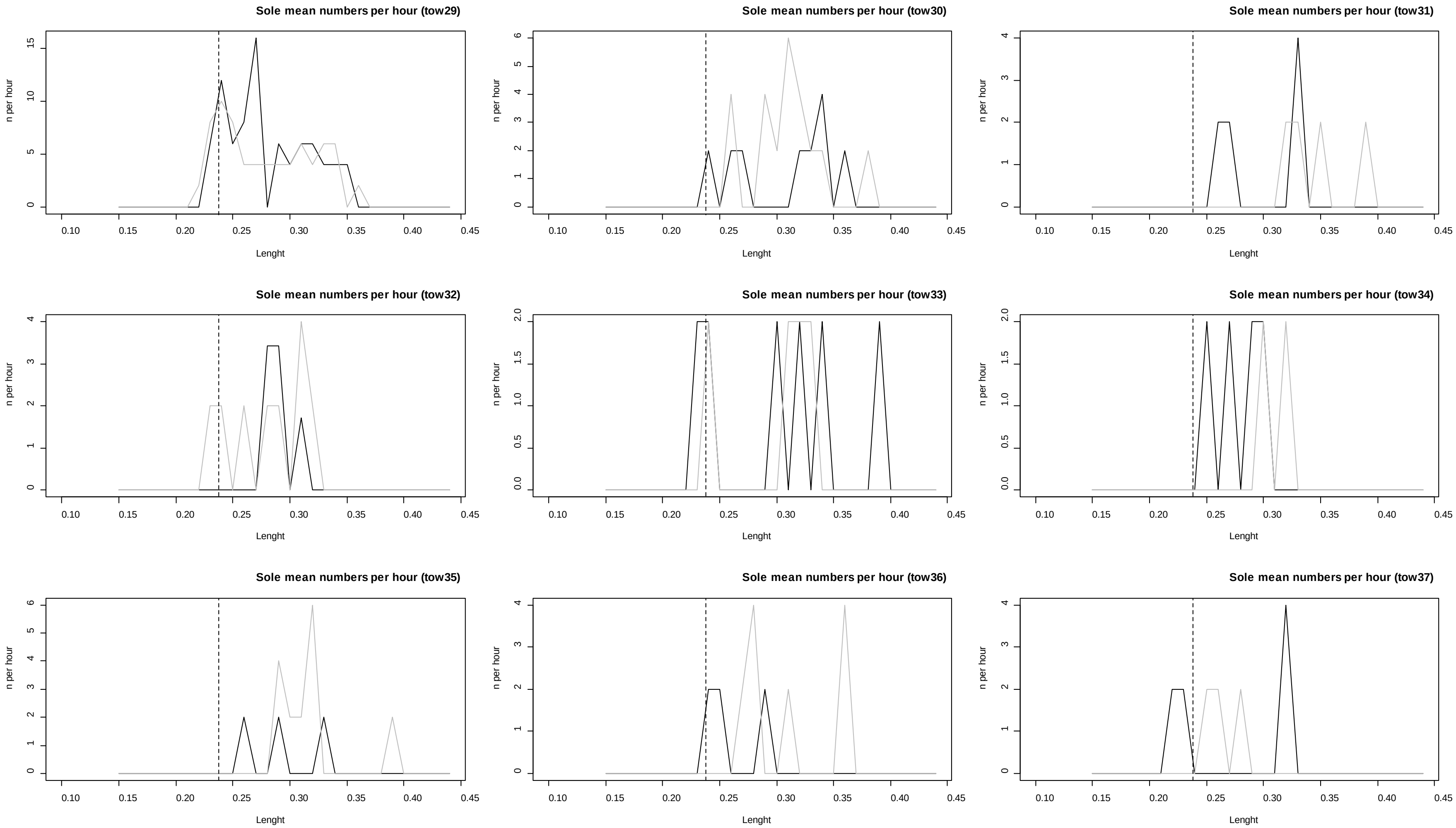
Sole mean numbers per hour (tow21)
Sole mean numbers per hour (tow22)
Sole mean numbers per hour (tow23)
Sole mean numbers per hour (tow24)
Sole mean numbers per hour (tow25)
Sole mean numbers per hour (tow26)
Sole mean numbers per hour (tow27)
Sole mean numbers per hour (tow28)
n per hour
Lenght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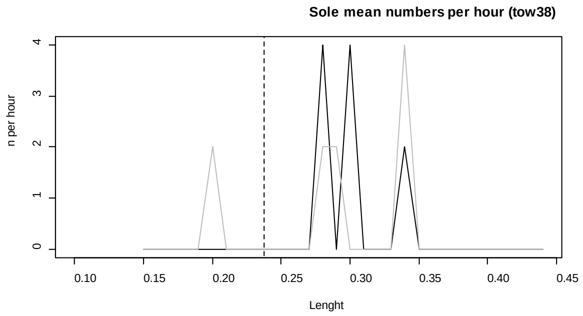
Sole mean numbers per hour (tow30)
Sole mean numbers per hour (tow31)
Sole mean numbers per hour (tow32)
Sole mean numbers per hour (tow33)
Sole mean numbers per hour (tow34)
Sole mean numbers per hour (tow35)
Sole mean numbers per hour (tow36)
Sole mean numbers per hour (tow37)
n per hour
Lenght
0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45


Sole mean numbers per hour (tow38)
n per hour
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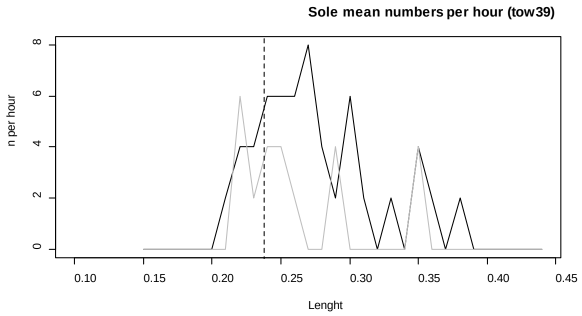
1
2
3
4
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Lenght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n per hour
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2
4
6
8
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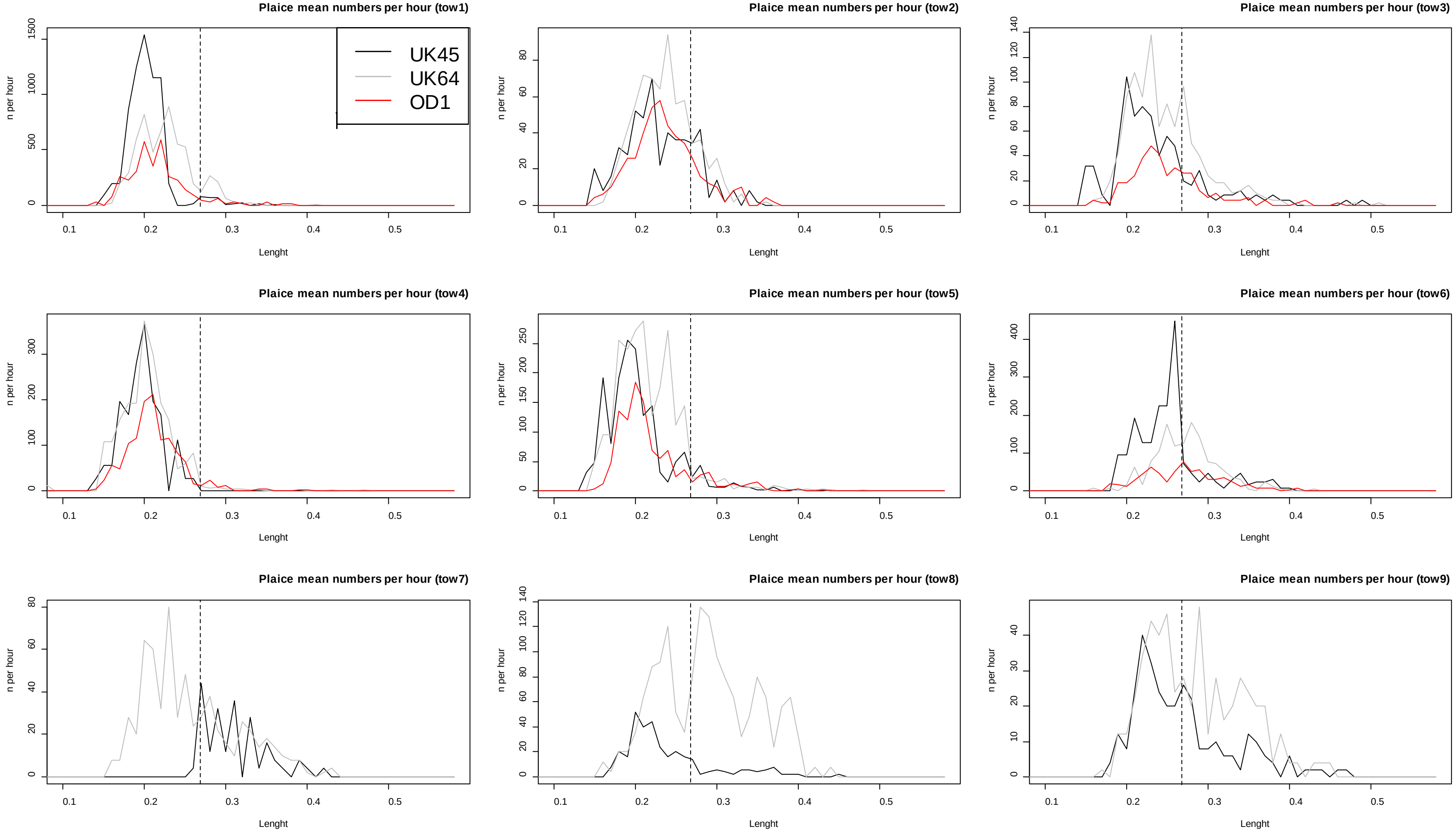
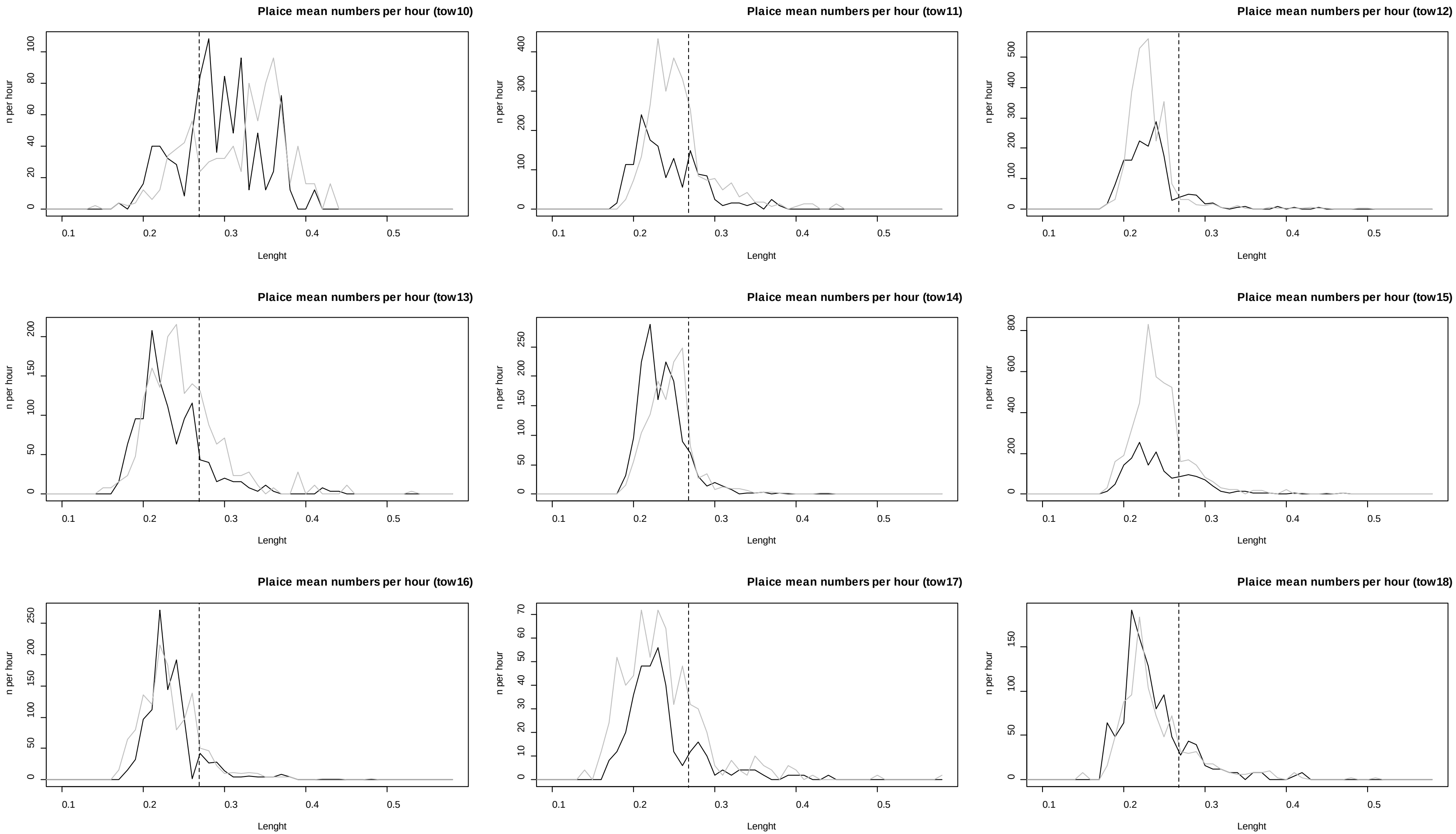
0.30
0.35
0.40
0.45
Lenght

Appendix C. Plaice length distributions by tow

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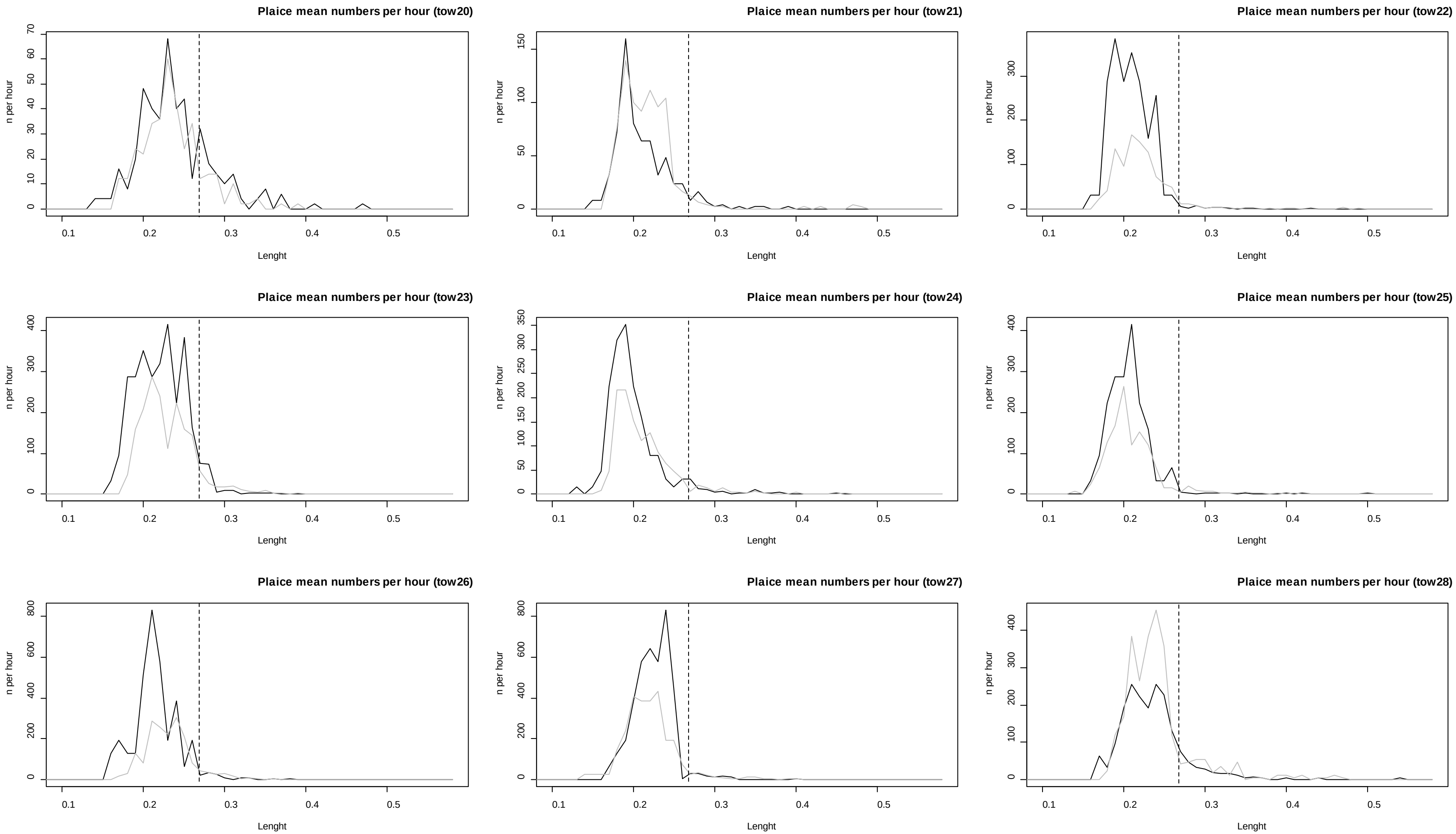
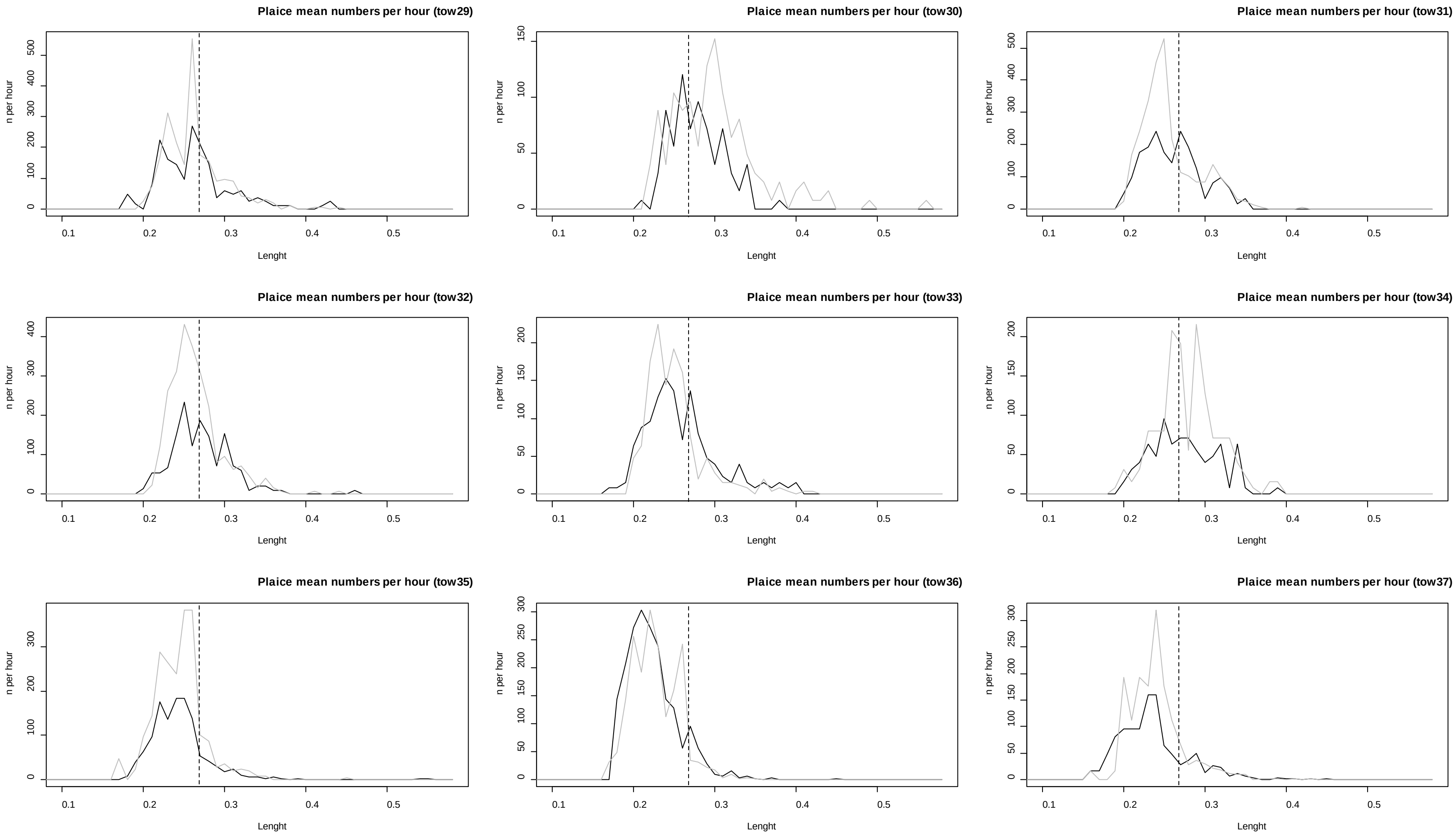
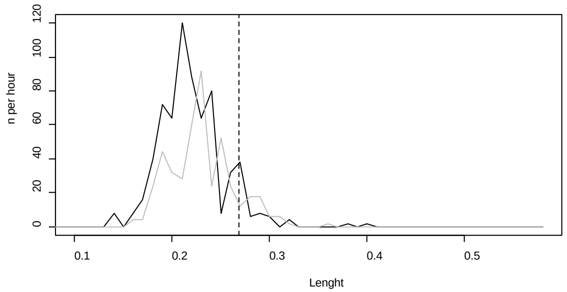
Plaice mean numbers per hour (tow11)
Plaice mean numbers per hour (tow12)
Plaice mean numbers per hour (tow13)
Plaice mean numbers per hour (tow14)
Plaice mean numbers per hour (tow15)
Plaice mean numbers per hour (tow16)
Plaice mean numbers per hour (tow17)
Plaice mean numbers per hour (tow18)
n per hour
Lenght


Plaice mean numbers per hour (tow20)
Plaice mean numbers per hour (tow21)
Plaice mean numbers per hour (tow22)
Plaice mean numbers per hour (tow23)
Plaice mean numbers per hour (tow24)
Plaice mean numbers per hour (tow25)
Plaice mean numbers per hour (tow26)
Plaice mean numbers per hour (tow27)
Plaice mean numbers per hour (tow28)
n per hour
Lenght
0.1
0.2
0.3
0.4
0.5


Plaice mean numbers per hour (tow29)
Plaice mean numbers per hour (tow30)
Plaice mean numbers per hour (tow31)
Plaice mean numbers per hour (tow32)
Plaice mean numbers per hour (tow33)
Plaice mean numbers per hour (tow34)
Plaice mean numbers per hour (tow35)
Plaice mean numbers per hour (tow36)
Plaice mean numbers per hour (tow37)
n per hour
Lenght

Plaice mean numbers per hour (tow38)



Plaice mean numbers per hour (tow39)