Fishing over the sides or over the stern: does it matter

Comparison of two fishing methodologies in the Wadden Sea Demersal Fish Survey

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Contents

Summary

Since 1972, the Demersal Fish Survey (DFS) in the Wadden Sea has been carried out with the RV Stern. Within a few years this vessel will be replaced by another vessel as a result of the current ship replacement policy of Rijkswaterstaat Rijksrederij. It is not yet clear which vessel will replace RV Stern. In the search for a new vessel the main question is if fishing over the sides is needed, or if fishing over the stern is possible without a major effect on catch efficiency. Especially in shallow waters, catch efficiency may be affected by fishing over the stern, because of the current created by the ship's propeller. To be able to continue the use of the long and valuable time-series the shift in vessel should not lead to a different gear efficiency.

In 2005, the Ministry of Agriculture and Fisheries (currently Ministry of Economic Affairs) considered replacing the RV Stern with the RV Navicula and comparative fishing was carried out by RIVO (currently Wageningen Marine Research). However, during the 2005 comparative fishing experiment it became clear that RV Navicula would not be available for the DFS in the years following, and the data were never analysed. As the RV Navicula fishes over the stern, and RV Stern fishes over the sides the 2005 data have been analysed to address the current question.

The 36 paired hauls of RV Stern and RV Navicula have been analysed for catch rate as well as length distribution of plaice (*Pleuronectes plateassa*), sole (*Solea solea*), and brown shrimp (*Crangon crangon*) to investigate if the catches of the Stern and Navicula differ when using the same gear and survey set-up. Two analyses have been carried out: a paired t-test and linear regression. The t-test allows to compute the average difference between two vessels, the results of the linear regression show the correlation between the catches.

The catches of Stern and Navicula differ when using the same gear, although not equally for all species. This is likely to be caused by a difference in fishing methodology. As fishing over the stern increases catches significantly, the vessel replacing RV Stern should be able to fish over the sides, following the original beam trawling set-up. Only in this way will the effect of the increased turbulence by the engine propeller be minimised, and will the catches reflect the gear efficiency.

Samenvatting

Sinds 1972 wordt de Demersal Fish Survey (DFS) in de Waddenzee uitgevoerd op onderzoeksvaartuig Stern. Binnen een aantal jaar zal dit schip worden vervangen door een ander schip ten gevolge van de vervangingsstrategie schepen van de Rijksrederij (Rijkswaterstaat). Het is nog niet duidelijk welk schip de Stern zal vervangen. Op dit moment is het vooral van belang om te weten of een schip over de zij moet kunnen vissen of dat over de achterkant vissen ook een optie is met een minimaal effect op de vangsten. Vooral in ondiep water zou het effect van schroefwater op de vangsten groot kunnen zijn wanneer over de achterkant van het schip wordt gevist. Om de lange tijdserie te kunnen gebruiken zal de vangstefficiëntie van het vistuig bij wisseling van schip zo minimaal mogelijk moeten zijn en zullen de vangsten de efficiëntie van het vistuig moeten weerspiegelen.

In 2005 was het toenmalige Ministerie van Landbouw en Visserij (tegenwoordig Ministerie van Economische Zaken) van plan de Stern te vervangen en onderzocht of de Navicula daarvoor een geschikt vaartuig was. Er is destijds vergelijkend gevist tussen beide schepen, waarbij het enige verschil was dat aan boord van de Navicula over de achterkant werd gevist en aan boord van de Stern over de zijkant. Tijdens de vergelijkende visserij bleek echter dat de Navicula niet beschikbaar zou zijn om de DFS over te nemen in de daaropvolgende jaren en dus zijn de resultaten van dat experiment nooit uitgewerkt. Voor de beantwoording van de huidige vraag zijn de gegevens echter zeer relevant omdat ze een indicatie kunnen geven over het verwachte effect van een wijziging van vismethodiek op de vangsten.

In totaal zijn 36 gepaarde trekken uitgevoerd in de Waddenzee in 2005. Deze zijn allemaal gebruikt in de analyses van de vangstgrootte en de gemiddelde lengte van de vangst voor schol (*Pleuronectes plateassa*), tong (*Solea solea*), en garnaal (*Crangon crangon*). Om overeenkomsten en verschillen te detecteren zijn twee analyses uitgevoerd: een gepaarde t-test en lineaire regressie. Met de t-test kan worden aangetoond of er verschil is tussen de vangsten van beide schepen, de uitkomsten van de lineaire regressie geven aan in welke mate de vangsten gecorreleerd zijn met elkaar.

De vangsten van beide schepen verschillen duidelijk, maar niet in gelijke mate voor alle geanalyseerde soorten. Het verschil wordt zeer waarschijnlijk veroorzaakt door het verschil in vangstefficiëntie bij vissen over de zijkant versus vissen over de achterkant. De laatste methode levert over het algemeen hogere vangsten op, wat verklaard kan worden door de turbulentie van het schroefwater. Zeker in de ondiepere gebieden kan het schroefwater vis en garnalen loswoelen waardoor ze makkelijker te vangen zijn.

Aangezien de verschillen tussen beide vismethodieken significant zijn is het noodzakelijk dat een vervangend vaartuig voor de Stern de mogelijkheid heeft om over de zijkant in de traditionele opzet te kunnen vissen. Alleen op deze wijze weerspiegelen de vangsten de werkelijke efficiëntie van het tuig en worden ze niet beïnvloed door de turbulentie van het schroefwater.

1 Introduction

Since 1972, the Demersal Fish Survey (DFS) in the Wadden Sea has been carried out with the RV Stern that, due to the age of the vessel, will be replaced. As a change of vessel may have an impact on catch efficiency, comparative fishing is advised whenever possible to evaluate the potential effect on the time-series. In 2005, the Ministry of Agriculture and Fisheries considered replacing the RV Stern with the RV Navicula and comparative fishing was carried out by RIVO (currently Wageningen Marine Research). However, during the 2005 comparative fishing experiment it became clear that RV Navicula would not be available for the DFS in the years following, and the data were never analysed. The RV Stern continued the DFS.

As a result of the current ship replacement policy of Rijkswaterstaat Rijksrederij, the RV Stern will be replaced by another vessel within a few years. It is not yet clear which vessel will replace RV Stern. Currently the main question is if fishing over the sides is needed, or if fishing over the stern is possible without a major effect on catch efficiency. Especially in shallow waters, catch efficiency may be affected by fishing over the stern, because of the wash created by the ship's propeller. To be able to continue the use of the long and valuable time-series the shift in vessel should not lead to a different gear efficiency. As the RV Navicula fishes over the stern, the 2005 data have been analysed to address this question.

2 Research questions

The main question is if any effect is to be expected when shifting from fishing over the sides to fishing over the stern in the Wadden Sea DFS (i.e. in shallow waters).

The question was addressed by comparing paired hauls of RV Stern (fishes over the sides) and RV Navicula (fishes over the stern) for two components: catch rate and length distribution. This resulted in the following questions:

Do the catches of Stern and Navicula differ when using the same gear?

a. Is there any difference in the catch rate? (paragraph 4.1)
b. Is there any difference in the length distribution? (paragraph 4.2)

3 Materials and Methods

3.1 Field work

In August/September 2005, Stern and Navicula fished in the Wadden Sea in parallel. The net was set at the same time and location as good as possible. Both vessels deployed the same gear (3 m DFS beam trawl). This resulted in 36 paired tows.

All hauls were treated equally: the catch was sorted following the standard DFS protocol (van Damme *et al*., 2005; current version van Damme *et al*., 2016). Data were entered in the programme Billie Turf, and after standard quality assurance procedures added to the database 'Frisbe'.

On board of the Stern the traditional beam trawl set-up was used: on each side of the vessel a net was set, one of which was sorted. On board of the Navicula a single net was lowered over the stern.

3.2 Data analysis

The most commonly occurring species of commercial interest were selected: plaice (*Pleuronectes platessa*), sole (*Solea solea*), brown shrimp (*Crangon crangon*) and whiting (*Merlangius merlangus*). However, the catch rates of whiting were too low for comparative analysis between vessels (only 6 samples contained whiting).

The catches were compared between the 2 vessels regarding two aspects:

a. the catch rate (total number caught per hour) per haul;
b. the mean length per haul, which is a summarized characteristic of the length frequency distribution of the catch.

A paired t-test and linear regression were conducted for both catch rate (4^{th} root transformed numbers per hour) and mean length (no transformation).

The average difference between two vessels or gears was computed using the paired t-test. A significant p-value at the significance level of 0.05 indicates a systematic difference between the two vessels. The significance level is however a matter of choice, and should always be seen in the scope of the question to be answered.

Three different linear models were fitted and the best model was selected based on AIC (Akaike information criterion).

- Model 1: $y_{\text{navicula},i} = \alpha + \beta \times y_{\text{stern},i} + \varepsilon_i$ implies that any differences in catch rates or mean lengths between the two vessels from the matched hauls are only attributed to vessel differences and random variance.
- Model 2 and 3 imply that the water depth class (0-10 m or 10-20 m) also plays a role in catch rate or mean length differences:
  - Model 2: $y_{\text{navicula},i} = \alpha + \beta_1 \times y_{\text{stern},i} + \beta_2 \times depth_i + \varepsilon_i$ assumes that depth class has an effect on the level, but not on the slope, of the linear relationship.
  - Model 3: $y_{\text{navicula},i} = \alpha + \beta_1 \times y_{\text{stern},i} + \beta_2 \times depth_i + \beta_3 \times y_{\text{stern},i} \times depth_i + \varepsilon_i$ assumes that depth class also modifies the slope of the relationship between the two vessels.

y_i indicates the catch rate or mean length of the i^{th} sample by Navicula or Stern. For each model, the error ε_i follows a normal distribution. Depth is categorised into 0-10 m, 10-20 m.

The estimated parameters of a linear regression may be used as conversion factors between the two vessels. Furthermore, the parameters (with standard error estimates (SE)) can be used to interpret the linear relationship between the two vessels.

If the catch rates or mean lengths are identical for both vessels then the estimated intercept (α) will be zero and Beta (β) will be one. The p-values indicate whether the estimated parameters are significantly different from zero. A significant intercept implies a significant difference between the vessels at catch rates or mean lengths close to zero. A significant Beta implies a strong linear correlation between the vessels.

Note that a significant p-value of Beta can be obtained if the vessels are in exact agreement (i.e. $\alpha=0$ and $\beta=1$), but also if there are large differences between the vessels (e.g. $\alpha=1$ and $\beta=2$; or $\alpha=0$ and $\beta=2$). Therefore, the fitted relationship is presented with the 95% confidence interval. This can be visually compared to the exact agreement relationship ($\alpha=0$ and $\beta=1$; also presented). If the exact agreement line falls within the 95% confidence interval of the fitted relationship, then the differences between the vessels can be considered to be insignificant.

4 Results

4.1 Vessel effect on catch rates

Plaice (*Pleuronectes platessa*)
The average catch rate of plaice was significantly higher (at the significance level of 0.05) in the Navicula catches compared to the Stern catches (Table 4.1.1). This is clearly visible in the scatterplots of the 4th root transformed data (Figure 4.1.1).

Linear model 1 ($y_{\text{navicula},i} = \alpha + \beta \times y_{\text{stern},i} + \varepsilon_i$) gave the best fit, which means that depth class did not have a significant effect on the differences between Navicula and Stern. The parameter estimates (Table 4.1.2) are visualised by the fitted linear relation in Figure 4.1.2. The catch rates of the Navicula are higher than those of the Stern although the difference decreases with increasing catch rates.

Sole (*Solea solea*)
No significant differences were observed between the vessels in the average catch rate of sole (Table 4.1.1, Figure 4.1.3).

Like for plaice, linear model 1 (without depth class) gave the best fit. The parameter estimates indicate that the Navicula catches more at low catch rates, and that the Stern catches more at high catch rates (Table 4.1.2, Figure 4.1.4).

Brown shrimp (*Crangon crangon*)
The average catch rate of brown shrimp was significantly higher in the Navicula catches compared to the Stern catches (Table 4.1.1). This is clearly visible in the scatterplots of the 4th root transformed data (Figure 4.1.5).

Linear model 2 ($y_{\text{navicula},i} = \alpha + \beta_1 \times y_{\text{stern},i} + \beta_2 \times depth_i + \varepsilon_i$) gave the best fit, which means that depth class had a significant effect on the level of the line, but not on the slope of the line (Figure 4.1.6). For depth class 10-20 m, there is no significant difference between the vessels. The intercept is close to zero (2.26-2.53=-0.27, Table 4.1.2), Beta is close to 1 (Table 4.1.2) and the exact agreement line falls within the confidence interval of the fitted line. For depth class 0-10 m, there is a significant, constant difference between the vessels over the full range of catch rates (Figure 4.1.6).

Table 4.1.1 Results of the paired t-test comparing catch rate (numbers per hour; zero catches included)

species/group	n hauls	df	Mean of difference Navicula vs Stern	p-value
brown shrimp	36	35	2.33	<0.01
plaice	36	35	0.53	0.01
sole	36	35	0.19	0.23

Table 4.1.2 Results of the linear regression comparing catch rates (numbers per hour; zero catches included)

species/group	n hauls	Model parameter	Estimate	SE	p-value	Model number
brown shrimp	36	Intercept	2.26	1.47	0.13	2
		Beta	1.07	0.12	<0.01	
		Depth (10-20m vs. 0-10m)	-2.53	1.18	0.04	
plaice	36	Intercept	1.13	0.51	0.03	1
		Beta	0.76	0.18	<0.01	
sole	36	Intercept	0.83	0.24	<0.01	1
		Beta	0.75	0.07	<0.01	

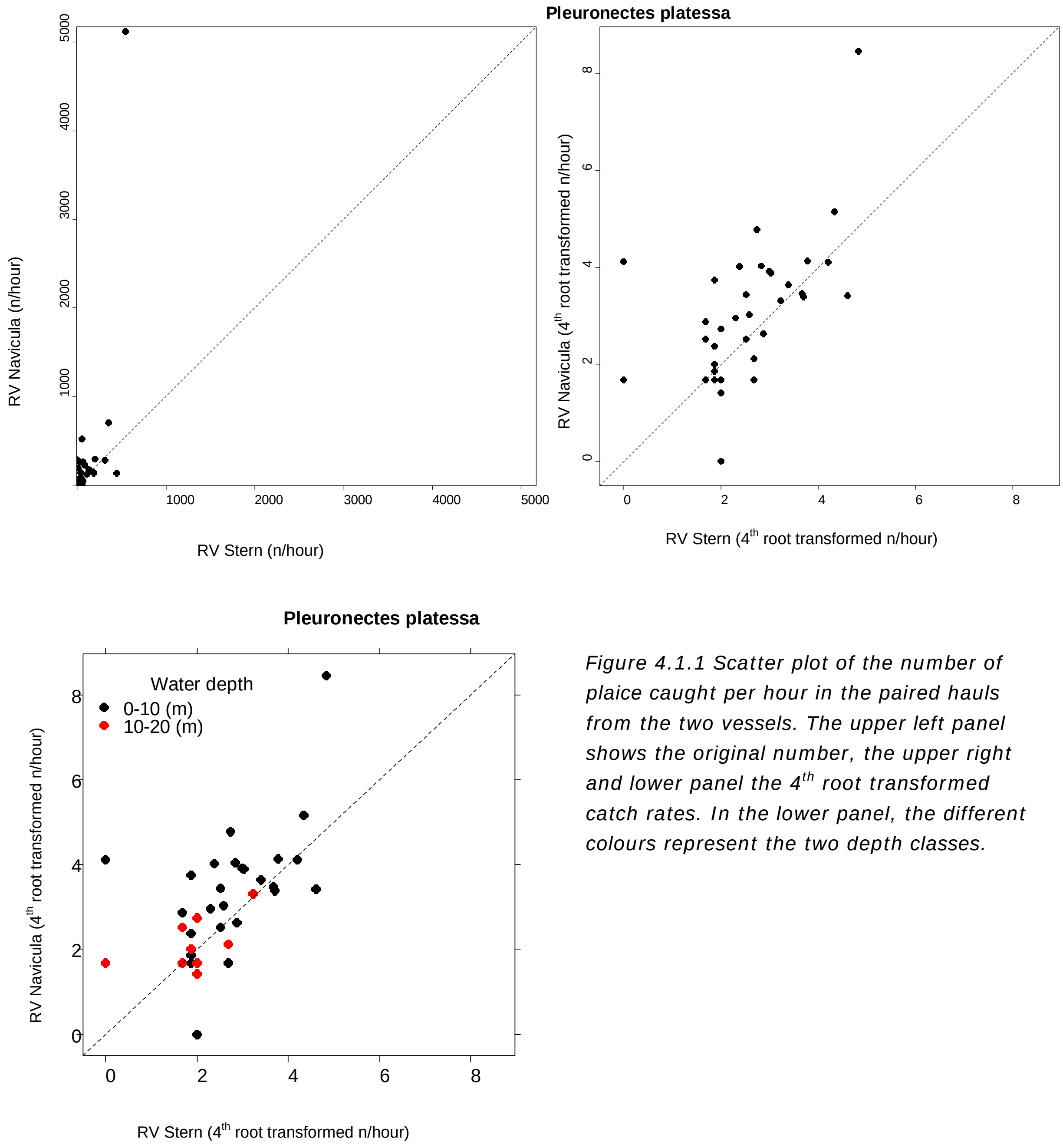


Figure 4.1.1 Scatter plot of the number of plaice caught per hour in the paired hauls from the two vessels. The upper left panel shows the original number, the upper right and lower panel the 4th root transformed catch rates. In the lower panel, the different colours represent the two depth classes.

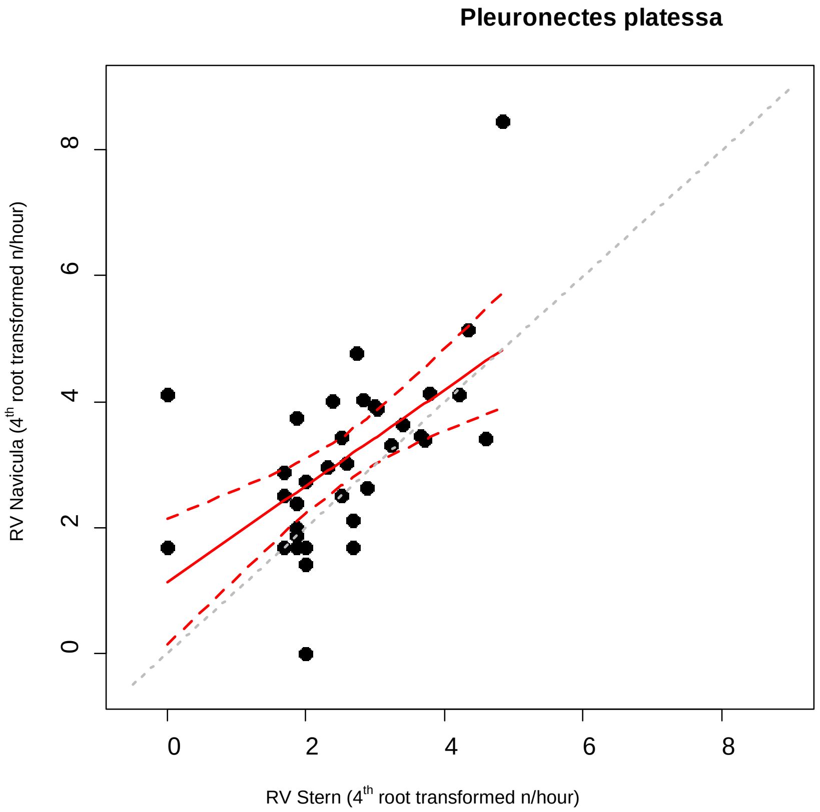
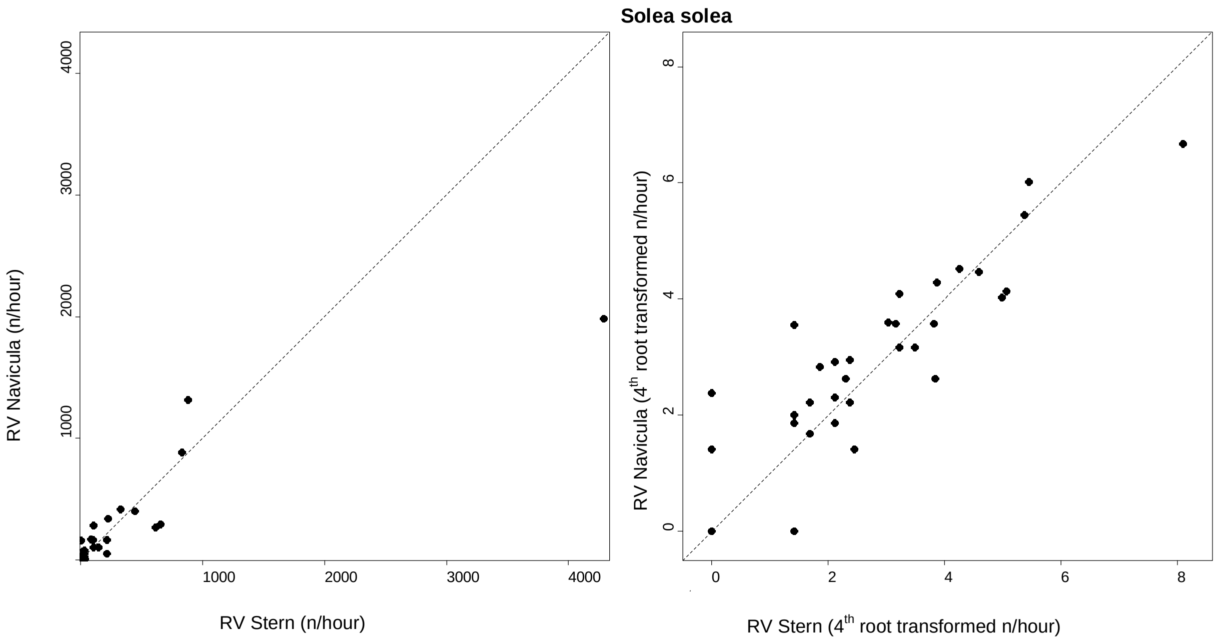


Figure 4.1.2 Observed and fitted linear relation of the 4th root catch rate between Navicula and Stern for plaice. The fitted relationship is plotted in red with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ and $\beta = 1$).



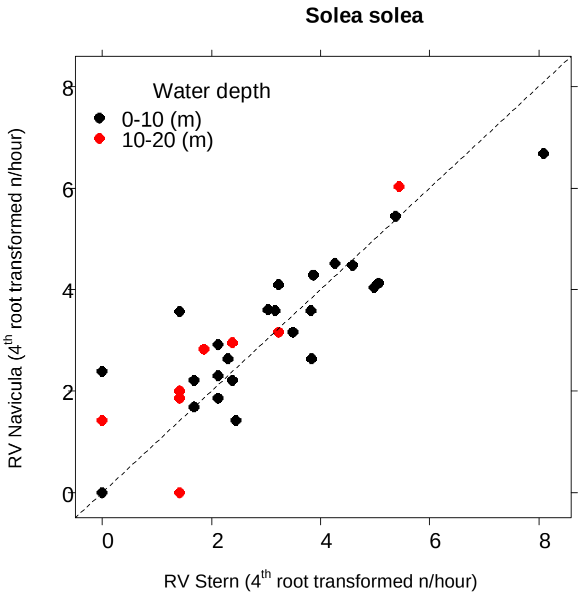


Figure 4.1.3 Scatter plot of the number of sole caught per hour in the paired hauls from the two vessels. The upper left panel shows the original number, the upper right and lower panel the 4th root transformed catch rate. In the lower panel, the different colours represent the two depth classes.

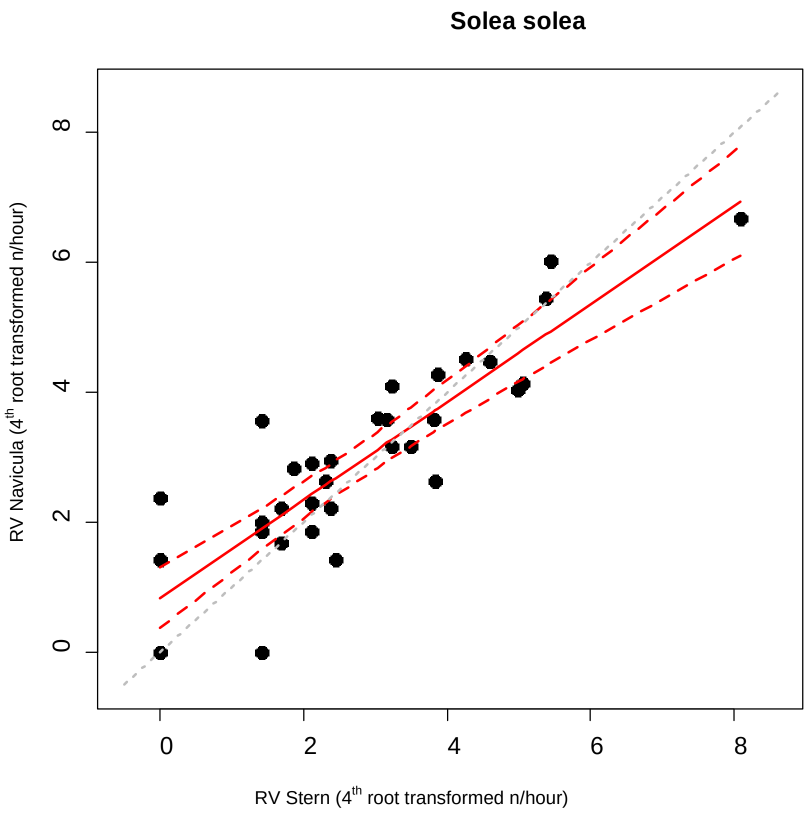


Figure 4.1.4 Observed and fitted linear relation of the 4th root catch rate between Navicula and Stern for sole. The fitted relationship is plotted in red with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ *and* $\beta = 1$*).*

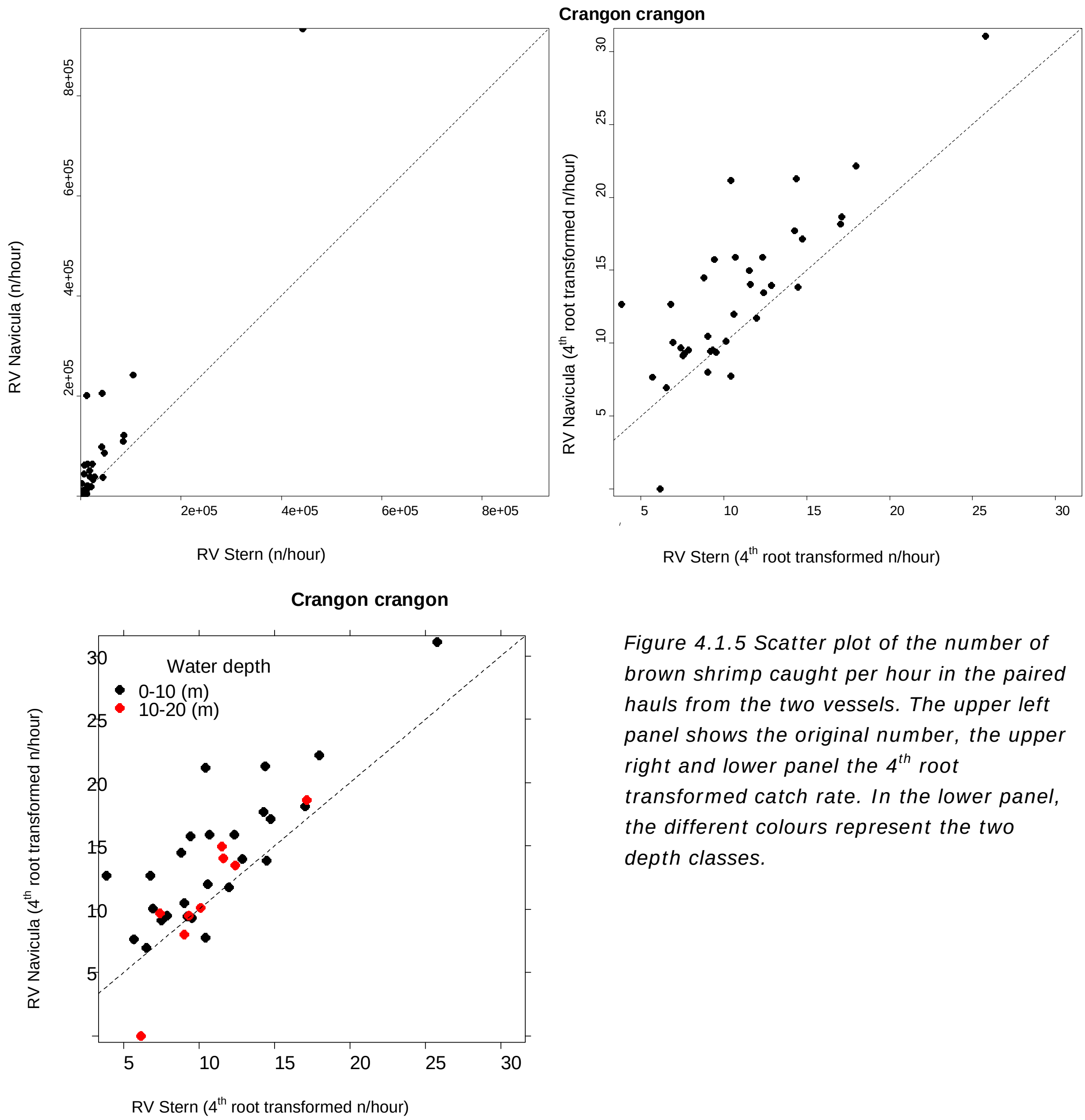


Figure 4.1.5 Scatter plot of the number of brown shrimp caught per hour in the paired hauls from the two vessels. The upper left panel shows the original number, the upper right and lower panel the 4th root transformed catch rate. In the lower panel, the different colours represent the two depth classes.

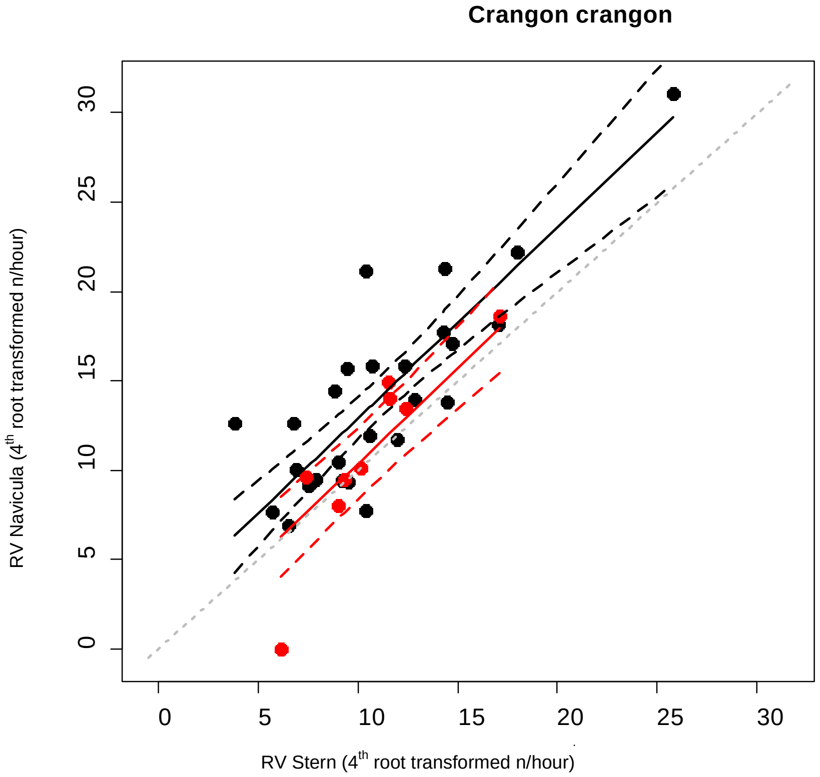


Figure 4.1.6 Observed and fitted linear relation of the 4th root catch rate between Navicula and Stern for brown shrimp. The fitted relationship is plotted in black (0-10 m depth) and red (10-20 m depth) with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ *and* $\beta = 1$).

4.2 Vessel effect on mean lengths

In the linear regression analyses, linear model 1 ($y_{\text{navicula},i} = \alpha + \beta \times y_{\text{stern},i} + \varepsilon_i$) was the best model for all three species. Depth class did not have a significant effect on the differences between Navicula and Stern in mean length.

Plaice (*Pleuronectes platessa*)
There is no significant difference (at the significance level of 0.05) in the overall average of mean lengths of plaice between the two vessels (Table 4.2.1). The intercept is not significantly different from zero (Table 4.2.2) in the linear regression analysis. Additionally, the confidence interval of the fitted line covers the exact agreement line (Figure 4.2.1). This result indicates a good absolute agreement between the two vessels.

Sole (*Solea solea*)
There is no significant difference in the overall average of mean lengths of sole between the two vessels (Table 4.2.1). However, linear regression shows that the intercept is significantly different from zero and that the estimated Beta is far from 1 (Table 4.2.2). Consequently, the exact agreement line does not fall within the confidence interval of the fitted line (Figure 4.2.2). This result indicates that, although the mean length is the same for both vessels, the length frequency distribution differs between the 2 vessels.

Brown shrimp (*Crangon crangon*)
There is a significant difference in the overall average of the mean lengths of brown shrimp between the two vessels. On average Navicula caught larger brown shrimp than Stern (Table 4.2.1). Linear regression shows that this difference is most pronounced in the lower part of the size range (Table 4.2.2 and Figure 4.2.3).

Table 4.2.1 Results of the paired t-test comparing mean length (zero catches excluded)

species/group	n hauls	df	Mean of difference Navicula-Stern	p-value
brown shrimp	35	34	0.21	<0.01
plaice	33	32	-0.30	0.12
sole	28	27	0.03	0.85

Table 4.2.2 Results of the linear regression comparing mean length (zero catches excluded)

species/group	n hauls	Model parameter	Estimate	SE	p-value	Model number
brown shrimp	35	Intercept	2.81	0.83	<0.01	1
		Beta	0.44	0.18	0.02	
plaice	33	Intercept	0.46	1.45	0.75	1
		Beta	0.92	0.15	<0.01	
sole	28	Intercept	4.04	0.81	<0.01	1
		Beta	0.50	0.10	<0.01	

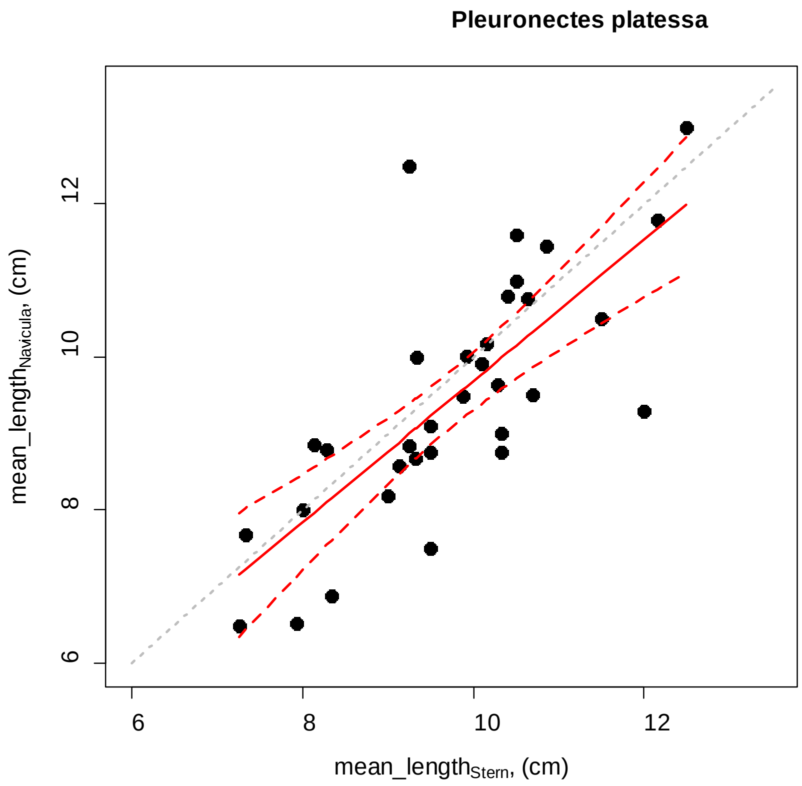


Figure 4.2.1 Observed and fitted linear relation of the mean length between Navicula and Stern for plaice. The fitted relationship is plotted in red with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ and $\beta = 1$).

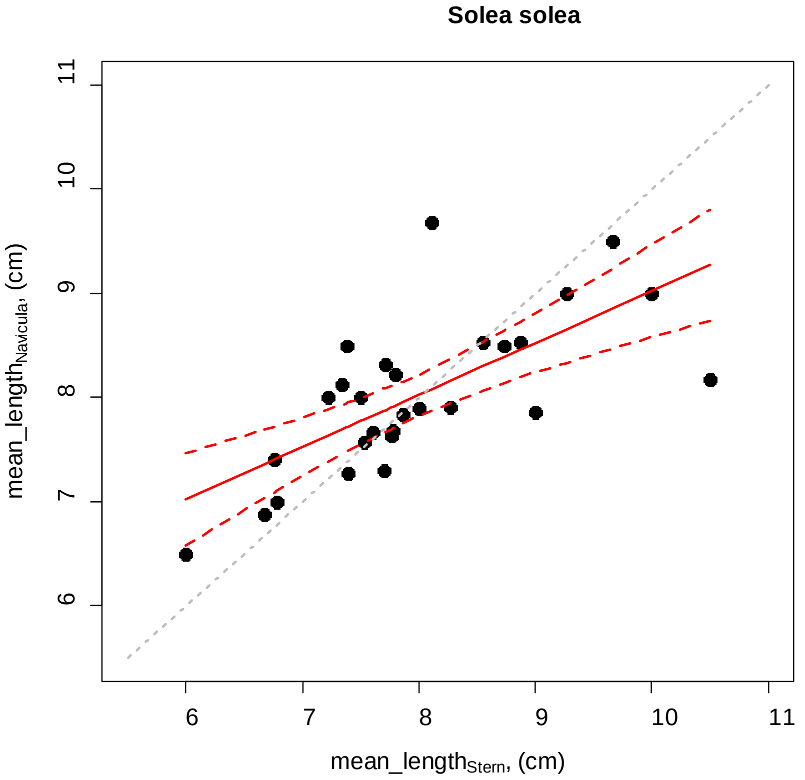


Figure 4.2.2 Observed and fitted linear relation of the mean length between Navicula and Stern for sole. The fitted relationship is plotted in red with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ and $\beta = 1$).

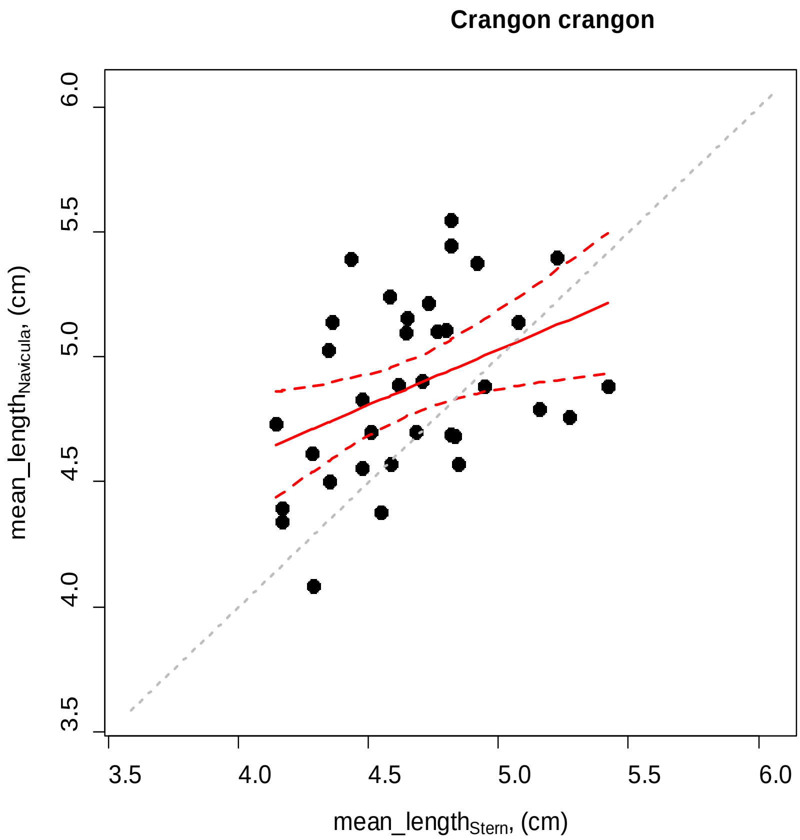


Figure 4.2.3 Observed and fitted linear relation of the mean length between Navicula and Stern for brown shrimp. The fitted relationship is plotted in red with 95% confidence interval in dashed lines. The grey dotted line is the 45 degree diagonal line ($\alpha = 0$ *and* $\beta = 1$).

5 Discussion

5.1 Vessel effect on catch rates

For all species, a significant vessel effect on catch rates was observed. In general catch rates of the Navicula were higher than those of the Stern, the only exception being sole at high catch rates. For plaice, overall catch rates are higher for the Navicula, the difference is more pronounced at low catch rates. For brown shrimp, overall catch rates are much higher for the Navicula. The overall difference is based on differences observed in the shallowest depth class. For sole, no significant overall effect was observed as the Navicula catch rates were higher at low catch rates, while the Stern catch rates were higher at high catch rates.

These results suggest an effect of fishing methodology: fishing over the stern (Navicula) vs. fishing over the side (Stern). When fishing over the stern, fish and shrimp in front of the trawl are exposed to increased turbulence caused by the propeller of the engine. As a result, they may come out of the sand thus increasing the catchability of the gear. When fishing over the side, only the fishing gear itself triggers this process.
Reiss *et al*. (2006) show that disturbance of the surface sediments may result in a greater vulnerability to be caught in a trawl. Turbulence by the propeller is expected to have a larger effect in shallow waters compared to deeper waters. The brown shrimp results clearly showed that the higher catch rates of the Navicula were based on the catches in the shallowest depth class. This was not observed in the other species, perhaps due to limited sample sizes. It may also be that the effect on shrimp is larger due to the smaller size of shrimp compared to flatfish.

5.2 Vessel effect on mean lengths

Navicula on average caught larger brown shrimp than the Stern, but the reasons for it cannot be specified. It may have to do with the difference in fishing methodology, but the mechanism involved is unclear. It might also be a crew effect as small shrimps are easily overlooked in demersal catches with a lot of epi-benthos. If the Stern crew was more apt at spotting small shrimps then this could explain the difference. However, if this is the case it is to be expected that the differences between the Navicula and the Stern in catch rates would even be larger.

Although on average the mean length of sole was estimated to be the same for both vessels, the linear regression suggested that the length distributions might differ. The smallest size classes appeared to be more prevalent in the Navicula catches, whereas the largest size classes occurred more often in the Stern catches. This difference is unlikely to be caused by a vessel or a crew effect.

6 Conclusions and recommendations

The catch rates of Stern and Navicula differ when using the same gear, although not equally for all species. This is likely to be caused by a difference in fishing methodology. As fishing over the stern increases catches significantly, the vessel replacing RV Stern should be able to fish over the side, following the original beam trawling set-up. Only in this way will the effect of the increased turbulence by the engine propeller be minimised, and will the catches reflect the gear efficiency.

Based on the current data it is not possible to conclude if differences in mean length between vessels fishing with the same gear truly exist or that they are artefacts (e.g. coincidence, crew effect). If it is necessary to better understand differences in mean length between vessels fishing with the same gear additional sampling is required.

7 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

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Justification

Report C122/16
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BAPS: BO20 KVB-2016-069

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: R. van Hal
scientist

Signature: 

Date: 22 December 2016

Approved: Jakob Asjes
Manager integration

Signature: 

Date: 22 december 2016

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- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.
- Wageningen Marine Research is an independent, leading scientific research institute

Wageningen Marine Research is part of the international knowledge organisation Wageningen UR (University & Research centre). Within Wageningen UR, nine specialised research institutes of the Stichting Wageningen Research Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment.