WAGENINGEN UR
For quality of life

Stichting DLO
Centre for Fisheries Research (CVO)

Discards Sampling of the Dutch and German Brown Shrimp Fisheries in 2009 - 2012

Josien Steenbergen[1], Jens Ulleweit[2], Marcel Machiels[1], Rosemarie Nijman[1], Kay Panten[2], Edwin van Helmond[1]

[1] IMARES
[2] Thünen Institute for Sea Fisheries

CVO report: 15.003

Commissioned by:
Ministerie van EZ, directie DAD
C.J.M. Verbogt
Postbus 20401
2500 EK Den Haag

Project number: 4311213005
BAS code: WOT-05-001-004

Publication date: 13 January 2015

Stichting DLO
Centre for Fisheries Research (CVO)
P.O. Box 68
1970 AB IJmuiden
Phone. +31 (0)317-487418
Fax. +31 (0)317-487326

Visitor address:
Haringkade 1
1976 CP IJmuiden

Table of Contents

Summary

In the European Union the collection of discard data is enforced trough the Data Collection Regulation or Framework (DCF) of the European Commission (EC). To comply with this ruling, shrimp trawlers have been monitored since 2008 for the Netherlands and since 2006 for Germany. This report presents the information of both sampling programmes from 2009 to 2012. The initiative to describe the methods and results of the monitoring of brown shrimp fisheries in a joint report anticipates on the harmonised regional sampling of commercial fisheries as described in the DCF.

Both countries use observers on board shrimp vessels to monitor the catch. Vessels are selected on ad-hoc non-random approach. The on board sampling procedure is similar in both countries; a representative catch-sample is taken from as many hauls as possible during one trip. Fish and shrimps are measured and benthos is counted, additionally in Germany benthos is also weighted. In the Netherlands all sampled components are raised in relation to the estimation of the total catch volume. This raising method differs from the German method where all sampled components are raised in relation to the total brown shrimp landings given by the skipper after each haul.

In the period of 2009 to 2012, 26 trips where conducted by the Netherlands and 24 by Germany. During these trips 167 hauls where sampled by each country in 44 and 47 days respectively. Results presented provide an indication of the catches throughout the year and throughout the German and the Dutch fishing areas. Because of low sampling coverage and large variation between hauls discard numbers that are presented in this report are not suitable to raise to entire fleet per year. Hence, such estimates are not presented in this report.

Overall the shrimp component of the catch, landings and discards, is larger than the fish and benthic component. In the Netherlands on average the amount of shrimp landed were about equal to the amount of shrimp discarded (55 kg/hr landed and 56 kg/hr discarded). In Germany the average amount of discarded shrimp exceeds the amount of landed shrimp (61kg/hr landed and 105kg/hr). For both countries most shrimp is caught in the fourth quarter of the year and catches are relatively low in the beginning of the fishing season (first quarter in the Netherlands and second quarter in Germany). Highest discard rates for shrimp in the Dutch sampling programme were observed in the fourth quarter of the year, whereas highest discard rates for Germany were observed in the third quarter of the year. By-catch composition was similar for both monitoring programmes. Most abundant fish species in the discard fraction is the goby which is present in 92% of the Dutch hauls and 95% of the German hauls. In following order; plaice, herring, whiting, dab and sole where among the most frequently caught commercial species. In Germany cod was also observed in 31% of the hauls while in the Netherlands cod is only observed in 4% of the hauls.

Future considerations for both monitoring programmes are:

1. We need to find profound methodologies to raise shrimp discard data to fleet level, for example by increasing the sampling coverage and/or by the introduction of a statistically sound sampling scheme.
2. Protocols on board need to be optimized. There is a need for a better estimation of different catch fractions.
3. Harmonized Dutch and German sampling programmes and methods.

Zusammenfassung

Das Sammeln von Discard- oder Rückwurfdaten wird durch das Fischereidatensammlungsprogramm der Europäischen Union vorgeschrieben. Im Rahmen dieser Datensammlung wird die Krabbenfischerei seit 2008 von den Niederlanden und seit 2006 von Deutschland beprobt. Der vorliegende Bericht stellt die Beprobungsprogramme der beiden Länder für die Jahre 2009 bis 2012 vor. In einer ersten Initiative werden die Methoden und Ergebnisse der beiden Monitoringprogramme beschrieben. Zukünftiges Ziel ist es, beide Monitoringprogramme wie ursprünglich im Datensammlungsprogramm vorgesehen zu harmonisieren.

In beiden Ländern wird das Monitoring von wissenschaftlichen Beobachtern an Bord der Krabbenkutter durchgeführt. Die Auswahl der zu beobachtenden Krabbenkutter ist dabei bisher nicht zufällig. Die Beprobungen selbst werden in beiden Länder ähnlich durchgeführt: Von möglichst vielen Hols werden während einer Fischereireise repräsentative Proben genommen und nach Bestandteilen sortiert. Fisch und Krabben (Garnelen) werden in beiden Ländern gemessen und gewogen, das Benthos wird gezählt und in Deutschland noch zusätzlich gewogen. Bei der Hochrechnung der Bestandteile gibt es zwischen den Ländern Unterschiede. In den Niederlanden werden alle Holkomponenten in Bezug auf den Totalfang hochgerechnet. Dabei wird der Totalfang, sobald er vollständig an Bord ist, vom Beobachter mit Hilfe des Kapitäns und der Besatzung abgeschätzt. Bei der deutschen Methode werden alle Holkomponenten in Bezug auf das Gewicht der Krabbengesamtanlandung hochgerechnet, deren Gewicht vom Kapitän abgeschätzt wird.

In den Jahren 2009 bis 2012 wurden 26 Beprobungsreisen von den Niederlanden und 24 von Deutschland durchgeführt. Insgesamt wurden während dieser Reisen von beiden Ländern jeweils 167 Hols in 44 bzw. 47 Tagen beprobt. Die Ergebnisse zeigen die Verteilung der Fänge über die Jahre in den deutschen und holländischen Fischereigebieten. Allerdings können zurzeit die vorgestellten Ergebnisse aufgrund der mangelnden Abdeckung der Gesamtfischerei und den hohen Variationen in den Fangzusammensetzungen nicht dazu verwendet werden, Discardabschätzungen für die Gesamtflotte pro Jahr zu berechnen.

In den Niederlanden halten sich der Anteil der angelandeten Krabben mit den Anteil der rückgeworfenen etwa die Waage (55 kg/h Anlandungen gegenüber 56 kg/h Discards). Bei den deutschen Daten ist der Discardanteil deutlich höher als der Anteil der angelandeten Krabben (61kg/h Anlandungen gegenüber 105kg/h Discards). In beiden Ländern werden die meisten Krabben im vierten Quartal des Jahres und die wenigsten am jeweiligen Beginn der Fischereisaison (1. Quartal in den Niederlanden und 2. Quartal in Deutschland) gefangen. In den Niederlanden treten dabei auch im vierten Quartal mit den meisten Fängen die höchsten Discardraten auf während die deutschen Discardraten am höchsten im dritten Quartal sind. Insgesamt ist der Krabbenanteil (Anlandung und Discard) größer als der Anteil von mitgefangenen Fisch und Benthos. Die Fangzusammensetzungen sind in beiden Ländern ähnlich. Grundeln sind die Fischart mit der höchsten Abundanz und Präsenz in den Fängen (in 92% der holländischen und 95% der deutschen Hols). Hohe Abundanzen in den Fängen beider Programme zeigen auch Scholle, Hering, Wittling, Kliesche und Seezungen. Kabeljau wurde in 32% der deutschen Hols gefunden aber nur in 4% der holländischen Hols.

Die Schwerpunkte für die zukünftige Zusammenarbeit beider Länder sind:

1. Es muss zukünftig möglich sein, die Discardabschätzungen für die Gesamtflotte zu berechnen. Dazu muss zum einen die Beprobungsintensität erhöht werden und / oder ein statistisch abgesichertes Beprobungsschema eingeführt werden.
2. Die Abläufe der Beprobungen an Bord müssen optimiert werden. Insbesondere wird bei beiden Programmen eine genauere Abschätzung der unterschiedlichen Krabbenbestandteile im Fang benötigt.
3. Die Beprobungsprogramme und angewandten Methoden müssen harmonisiert werden. Dazu ist zunächst ein Vergleich beider Methoden auf einer gemeinsame Beprobungsreise nötig.

Samenvatting

Het Data Collectie Framework (DCF) van de Europese Commissie (EC) verplicht zijn lidstaten om gegevens te verzamelen over ongewenste bijvangst. Om hieraan tegemoet te komen is Nederland in 2008 gestart met een monitoringsprogramma naar ongewenste bijvangsten aan boord van schepen die vissen op Noordzeegarnaal (*Crangon crangon*), in Duitsland wordt deze monitoring sinds 2006 uitgevoerd. Deze rapportage presenteert de informatie van de bemonsteringsprogramma's in beide landen van 2009 tot 2012. Het initiatief voor deze gezamenlijke rapportage waarin de methoden en de resultaten worden beschreven en vergeleken kan worden gezien als een eerste stap richting een geharmoniseerde regionale monitoring van commerciële visserij zoals is beschreven in de DCF.

De monitoring naar ongewenste bijvangsten aan boord van garnalenschepen wordt door beide landen uitgevoerd door waarnemers. De schepen waarop de monitoring plaatsvindt, worden geselecteerd op ad-hoc-niet-random wijze. De bemonsteringsprocedure aan boord is vergelijkbaar in beide landen; tijdens een reis wordt er van zoveel mogelijk trekken een representatieve steekproef (monster) genomen. Vis en garnalen worden gemeten en benthos wordt geteld, benthos wordt in Duitsland bovendien ook gewogen. In Nederland wordt opgewerkt van monsterniveau naar trekniveau aan de hand van de geschatte totaalvangst. Deze methode van opwerken verschilt van de Duitse methode waar van monster naar trek wordt opgewerkt aan de hand van de aangelande hoeveelheid garnaal per trek.

In de jaren 2009 tot en met 2012, zijn in Nederland 26 reizen uitgevoerd en in Duitsland 24. In totaal zijn tijdens deze reizen per land 167 trekken bemonsterd in 44 dagen in Nederland en 47 dagen in Duitsland. De gepresenteerde resultaten geven slechts een indicatie van de vangsten gedurende door de jaren heen en van de Duitse en de Nederlandse visgebieden. Vanwege lage bemonstering dekking en grote variatie tussen de trekken worden de gegevens van discards in deze rapportage niet geschikt geacht om op te werken naar vlootniveau.

In Nederland werd gemiddeld genomen op gewichtsbasis evenveel garnaal aangeland als gediscard (gemiddeld 55 kg/hr aangeland en 56 kg/hr gediscard). In Duitsland daarentegen was de hoeveelheid gediscarde garnaal hoger dan de aangelande garnaal (gemiddeld 61 kg/hr aangeland en 105 kg/hr gediscard). In beide landen werden in het vierde kwartaal gemiddeld per uur de meeste garnalen gevangen en in het begin van de visseizoenen waren de vangsthoeveelheden het laagst. Gedurende het hele jaar maken beide garnalen fracties het grootste deel uit van de vangst.

Het overige deel van de vangst bestaat uit vissen, benthische soorten en overige soorten. Deze bijvangst wordt over het algemeen allemaal gediscard. De samenstelling van de bijvangst is in beide landen vergelijkbaar. De meest voorkomende vissoort is de gobie, die aanwezig was in 92% van de Nederlandse trekken en 95% van de Duitse trekken. Op volgorde van meest voorkomende werden de volgende commerciële vissoorten vaak aangetroffen: schol, haring, wijting, schar en tong. In Duitsland werd bovendien kabeljauw in 31% van de trekken aangetroffen, terwijl in Nederland kabeljauw slechts in 4% van de trekken aanwezig was.

Toekomstige overwegingen voor beide monitoringsprogramma's zijn:

1. We moeten manieren vinden om de data te kunnen opwerken naar vlootniveau. Bijvoorbeeld door de inspanning te verhogen en/of door een meer statistisch robuuste wijze van selecteren van schepen te introduceren.
2. De protocollen aan boord moet worden geoptimaliseerd. Er is behoefte aan een betere schatting van verschillende garnalen fracties na het eerste en de tweede zeefproces in beide landen.
3. Geharmoniseerde Nederlandse en Duitse monsternemingsprogramma door het vergelijken van beide methoden.

1. Introduction

EU Member States are required to compile a wide range of fisheries data within the Data Collection Framework (DCF) of the European Commission (2008/949/EC and 2010/93/EU). Since 2007 the European Data Collection Regulation (DCR) has also become mandatory for the shrimp fishery on European brown shrimp (*Crangon crangon*) (ICES, 2008). In order to meet this requirement, shrimp trawlers have been monitored annually since 2008 in the Netherlands, this research is performed within Wettelijke onderzoekstaken (WOT) of EZ-programmes. Sampling in Germany started already in 2006 (Ulleweit et al. 2010). Both programmes intend to monitor the traditional shrimp fisheries with conventional beam trawl gear. So far, innovative gears, e.g. pulse trawling, are not included in these monitoring programmes.

The brown shrimp fisheries mainly take place in the coastal shallow areas of Denmark, Germany and the Netherlands, and to a lesser extent in Belgium, UK and France (ICES, 2013b; Figure 10a, b for the recent effort of Dutch and German fleet). Total annual landings of shrimp for the Netherlands fluctuated between 10 and 15 million kg for the period 2003 to 2012. In recent years, 2013 and 2014, total annual landings surpassed the 15 million kilogrammes, 17 and 16 million kilogrammes respectively, indicating an uptake of shrimp landings for the first time since 2009 (Figure 1). Total annual landings of shrimp of Germany fluctuated between 15 and 20 million kg for the period 2003 to 2012, with the exemption of 2005, when the total annual landing exceeds 20 million kg (~ 23 mln. kg) (Figure 2). The total North Sea fleet targeting shrimp includes 523 to 630 active vessels, during the period 2009-2011, with 2/3 of the vessels belonging to Germany and the Netherlands (ICES, 2013b). Bottom trawls with small mesh sizes of 16 - 26 mm (mean 20 mm) are used in the brown shrimp fisheries (ICES, 2013b). This is a single species fisheries, however occasionally by-catches of other commercial fish species like sole are landed (Steenbergen et al, 2013). In recent years total shrimp landings from the North Sea were >30.000 tons with the Dutch and German landings accounting together for >80% of these landings (ICES, 2013a,b). The majority (>90%) of the German shrimp trawlers are smaller than 20 m, whereas in the Netherlands 60% of the trawlers are larger than 20 m (but not larger than 24 m, ICES, 2013b). The average trip duration of a shrimp vessel in the Netherlands is 3 days (van Helmond et al, in prep). In Germany the majority of trips last between 12 and 36 hours (Respondek et al, 2014).

Given the small mesh size that is used in the brown shrimp fisheries, by-catch and discarding of (juvenile) fish, undersized shrimps and benthos is inevitable. EU regulation[1] requires all fishers operating in the European brown shrimp fisheries to use selective gear in order to reduce discarding. Since 2002 the use of sievenets is obligatory for all shrimpers in the Netherlands and Germany (Tulp et al, 2010). Sievenets (also known as veilnets) are cone-shaped nets inserted into standard trawls, which direct unwanted by-catch to an escape hole in the body of the trawl (Figure 9, Revill and Holst, 2004). Sievenets are proved to be more selective in reducing the catch of fish and other organisms >10 cm (Polet, 2003, Catchpole et al. 2008). However substantial numbers of 0-group fish is retained in the catches while using the sievenet (Catchpole et al, 2008). Especially the bycatch of juvenile (0-group) plaice is often raised as a concern (Neudecker and Damm, 2010). The Wadden Sea and adjacent coastal areas used for shrimp fishing are important nursery areas for plaice and other commercial important fish species like sole and dab (Zijlstra 1972, van Beek et al., 1989, Bolle et al., 1994). In the Netherlands exceptions for the use of the sievenet were granted from 15 April – 15 November (Quirijns et al, 2008). From 2009 onwards the exemption period on the use of the sievenet was gradually reduced from 8

[1] COUNCIL REGULATION (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms PB L 125/1. Article 25.

weeks in 2009 to no exemption at all in 2013. In Germany exceptions can still be granted between 1 May and 30 September.

The current report is a joint initiative to describe the methods and results of the monitoring of the brown shrimp fishery in the Netherlands and Germany within the European Data Collection framework in the years 2009 – 2012. The report is not a comparison between German and Dutch results, but aims to:

- provide an impression of the monitoring programmes in Germany and the Netherlands
- give (average) catch compositions based on the conducted monitoring in both countries
- give length distribution of the shrimp and other relevant species in the catches in both countries

1.1 Quality assurance

CVO operates under an ISO 9001:2008 certified quality management system (certificate number: 127538-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The certification was issued by DNV Certification B.V.

2. Methods

2.1 Sorting procedures of shrimp catch

In the process of separating marketable shrimp from undersized shrimp and bycatch, the catch is sieved three times; two times on board of the shrimp vessels (Figure 3) and one time at the auction.

1) The first sieve (I) separates the marketable sized shrimps from small non-marketable sized (below minimum landing size) shrimps, fish, benthic organisms, seaweed and shells. The shrimp sorting devices used in this step are coaxial sieving drums that make a rotating movement (Figure 4 left side) or trembling sieves (Figure 4 right side). The drums separate organisms based on their shape and size. Because marketable sized shrimps are separated based on their shape and size it is possible that species with similar body shape and size, e.g. goby or hooknose, are retained in this part of the catch.
2) Marketable sized shrimps are cooked in the boiling pot, after which another sieve (II) separates the retained small shrimps from the marketable shrimps (Figure 4 one the right). Some fish, like goby, dissolve in the cooking process. Fish or other organisms that do not dissolve in the cooking process are removed by hand, and clean shrimp ready for landing remains.
3) Ashore the landed shrimps are sieved into different size categories (at auctions in the Netherlands, at central sieving stations of the producer organisations in Germany), creating some extra runoff called “sievage” (in Dutch “ziftsel”, in German “Siebkrabben”; Neudecker et al. 2006).

2.2 Sampling procedures

The procedure to collect standardized scientific data from catches of commercial shrimp fishing vessel is developed in Germany. During the ICES working group on Crangon Fisheries and Life History (WGCRAN) in 2008 it was decided to use this procedure as a standard in each country (ICES, 2008). The sampling procedure in the Netherlands was based on the German procedure. However, comparison of the implemented procedures used in Germany and the Netherlands revealed differences between the procedures. Therefore, both sampling procedures are explained separately in the following sections.

2.2.1 Sampling procedure in the Netherlands

The sampling of discards on shrimp vessels is carried out by observers; usually two observers join a shrimp vessel. The aim is to conduct 8 trips per year and to equally spread the trips over the year and the Dutch fishing grounds. Most Dutch shrimpers are active in Dutch waters throughout the year, although fleet effort is lower during the winter period (Figure 10). The duration of a trip varies between one day and five days, and depends entirely on the fishing routines of the skipper; some skippers land their catch every day, some twice a week and some only after 4/5 days of fishing. Sampling is planned at the beginning of the year. A few weeks before a trip is planned a suitable vessel is approached (opportunistic and non-random). During the course of monitoring programme effort is put into the participation of an increasing number of different vessels in the observer programme through involvement of vessels which have not been sampled by observers before. Although this has been partially successful, not all vessels could be monitored due to impracticalities. Some vessels for example do not have suitable (sleeping) facilities to host two observers. At other vessels the sorting system is not suitable to carry out the whole monitoring procedure. Some fishers fish from Monday to Friday and the budget of the monitoring program does not allow for two observers to join one vessel for a week. Also, observers were refused by skippers without a given reason. Shrimp fishers depend on reasonable weather conditions to fish, and finding a suitable vessel in a pre-determined week can also be challenging in seasons with unpredictable weather.

During the trip observers sample as many hauls as possible during day and night time. For each haul information about date, time, position, distance, depth, wind direction, wind force, and landings is recorded. Sampling on board follows the procedure as illustrated in the schematic overview of the Dutch sampling procedure (Figure 5):

1. From each sampled haul the volume of the total catch (CV_h) is estimated in cooperation with the skipper or crew. The volume of the catch is expressed in number of baskets of 50L. A representative catch sample (Cv_h) of ½ basket is taken from the total catch.
2. The catch sample is sorted into shrimp (CSv_h) and by-catch (Dv_h). Debris (materials like stones and wood) is removed, but not measured. All species are categorized as by-catch except brown shrimp, *Crangon crangon*:
    a. Fish per species
    b. Benthic organisms per species
    c. Other organisms (like sepiola's, loligo's)
3. For each fish species numbers and lengths are determined. Fish is measured to the cm below *(e.g. 6.8=6)*. With the exemption of Clupeids, which are measured to the 0.5 cm below (e.g. 6.8=6.5).
4. Benthic and other species are counted.
5. First the total volume of shrimps in the sample (CSv_h) is determined. Secondly the shrimps are guided through the sieving drum (sieve I) to divide the shrimp into landings (LSv_h) and discards (DSv_h). Volumes of both fractions (commercial and discards) are determined. Fraction of discarded shrimp is usually calculated by subtracting the commercial sized shrimps from the total amounts of shrimp found in the sample ($DSv_h = CSv_h - LSv_h$).
6. A subsample is taken from the landings fraction of uncooked shrimp (Lsn_h) (ca. 200ml) and from the discards fraction of shrimp (Dsv_h) (ca. 150ml), total body lengths (to the mm below, e.g. 24.8=24mm) and numbers of these shrimps are measured. Other biological parameters e.g. sex and individual weight are not obtained.

2.2.2 Sampling procedure in Germany

The sampling of discards on shrimp vessels is carried by two observers. Similar to the Dutch programme the aim is to conduct 8 trips per year and to equally spread the trips over the fishing seasons and areas as much as possible. The fishing season in Germany starts usually in March/April and ends in November. Fishing activity is typically low during the first quarter of the year (Figure 10). The duration of the trip varies between one and three days, depending on the schedule of the skipper. Often, the fishing trip is undertaken by night and during daytime the vessel stays in the harbour. On these occasions, the observers will sample one or two night trips. Germany is trying to increase the number of participating vessels in the observer programme to include vessels which have not been sampled by observers before. Although this is partially successful, there are vessel owners refusing observers on board, this in particular the case for smaller vessels. In some cases security or workspace issues precludes the possibility of taking observers on board. Random sampling of the fleet is not yet implemented. At present sampling is opportunistic, taking sampling opportunities when they occur, even on boats which have sampled before, irrespective if they are planned or not.

The observers aim to take samples from all hauls. However, if this is not possible due to working hours or technical issues non-sampled hauls are not taken into account during raising procedures. During the trip, information for each haul about date, time, position, distance, depth, wind direction, wind force and total landings is recorded on a haul list. Weights are taken on board by electronic scales specifically designed for use on board fishing vessels.

Sampling on board follows the procedure illustrated in the schematic of German sampling overview (Figure 6):

1. From each sampled haul, a sample of the unsorted catch (Cv_h) is taken (usually ca. ½ basket).
2. The sample is sorted into brown shrimp (CSw_h) and by-catch / discards (Dw_h). By-catch are all species caught except brown shrimp, *Crangon crangon*:
    a. Fish per species
    b. Benthic organisms per species
    c. Other organisms (e.g. cephalopoda)
3. For each fish species numbers and lengths are determined. Fish is measured to the cm below. With the exemption of Clupeids, which are measured to the 0.5 cm below.
4. Benthic and other species are counted and total weight per species is measured.
5. The brown shrimp fraction of the sample (CSw_h) is thrown into the sorting grid, after sieving both the fractions are weighted by the observer. This results in a landing sample (LSw_h) and a discards sample of brown shrimp (DSw_h).
6. A subsample of LSw_h and DSw_h is taken for length measurements (total body length) and sex determinations (Lsw_h and Dsw_h).
7. The total landings of the haul are determined by the number of boxes of cooked brown shrimp in cooperation with the skipper.

2.3 Raising procedures

Likewise the sampling procedures on board, the method used to raise the data to haul level is different in Germany and the Netherlands. Both raising procedures are explained below.

2.3.1 Raising samples to haul level in the Netherlands

All haul components – shrimps landings weight and numbers, shrimp discards weights and numbers, by-catch species weight and numbers – are raised in relation to the estimation of the volume of the total catch (CV_h) and the sample of the catch (Cv_h). Numbers and weights per hour trawling were calculated based on trawl durations. A schematic overview of the Dutch raising procedure (from sample to haul level) is provided in figure 7.

<u>Fish, benthic and other species (n):</u>
Total number discards per species and haul ($DN_{h,s}$) has been calculated by multiplying the number of the species in the catch sample ($Dn_{h,s}$) by the ratio of the estimated total catch volume (CV_h) to the volume of the catch sample (Cv_h):

$$DN_{h,s} = Dn_{h,s} * (CV_h / Cv_h)$$

<u>Shrimp landings (n):</u>
Total number landing Shrimps per haul ($LSN_{h,s}$) has been calculated by multiplying the number of the species in the catch sample ($Lsn_{h,s}$) by the ratio of the estimated total catch volume (CV_h) to the volume of the catch sample (Cv_h) and the ratio of the volume of the landing sample (LSv_h) to the volume of the landing subsample (Lsv_h):

$$LSN_{h,s} = Lsn_{h,s} * (CV_h / Cv_h) * (LSv_h / Lsv_h)$$

<u>Shrimp discards (n):</u>
Total number landing shrimps per haul ($DSN_{h,s}$) has been calculated by multiplying the number of the species in the catch sample ($Dsn_{h,s}$) by the ratio of the estimated total catch volume (CV_h) to the volume of the catch sample (Cv_h) and the ratio of the volume of the landing sample (DSv_h) to the volume of the landing subsample (Dsv_h):

$$DSN_{h,s} = Dsn_{h,s} * (CV_h / Cv_h) * (DSv_h / Dsv_h)$$

From numbers to weights

Weights of fish and shrimp are estimated from measured lengths and the length-weight relationship of the various organisms (Coull et al, 1989). From benthos and other organisms only numbers are counted and thus no length measurements are available. Average weights per species from a Dutch self-sampling programme (described in Steenbergen et al, 2013) are used to measure total weights per species.

2.3.2 Raising samples to haul level in Germany

All haul components – shrimps landings weight and numbers, shrimp discards weights and numbers, by-catch species weight and numbers – are raised in relation to the total brown shrimp landings (LSW_h) given by the skipper. In the German raising procedure the first step is to obtain and calculate the total haul weights for each fraction in the catch. In the next step these weights are used to raise from numbers of each species per sample to total numbers of species per haul.

Numbers and weights per hour trawling were calculated based on trawl durations. A schematic overview of the German raising procedure (from sample to haul level) is provided in figure 8.

Weight of shrimp landings

The total weight of the shrimp landings that is provided are the weights of cooked shrimp estimated by the skipper.

Weight of shrimp discards

The weight of discarded shrimps from the haul DSW_h are calculated by dividing the weight of the landed shrimp from the haul LSW_h by the ratio of the landed shrimps from the sample LSw_h and the discarded shrimps from the sample DSw_h.

$$DSW_h = LSW_h / (LSw_h / DSw_h)$$

Weight of fish, benthic and other species

The weight of the discarded by-catch species by haul ($DW_{h,s}$) is calculated by dividing the weight of the landed shrimps from the haul LSW_h by the ratio of the landed shrimps from the sample LSw_h and the discard species from the sample $Dw_{h,s.}$

$$DW_{h,s} = LSW_h / (LSw_h / Dw_{h,s})$$

Number of shrimp landings

The number of landed shrimps from the haul LSN_h are calculated by multiplying the number of shrimps found in the subsample from the landings Lsn_h with the fraction from the total weight of the landings LSW_h and the weight of the subsample Lsw_h.

$$LSN_h = Lsn_h * (LSW_h / Lsw_h)$$

Shrimp discards

The number of discarded shrimps from the haul DSN_h is calculated by multiplying the number of discarded shrimp from the subsample Dsn_h with the fraction of the total weight of the discarded shrimps from the haul DSW_h and the weight from the discarded shrimps from the subsample $Dsw_{h.}$

$$DSN_h = Dsn_h * (DSW_h / Dsw_h)$$

Fish, benthic and other species

The number of discarded by-catch species by haul $DN_{h,s}$ is calculated by multiplying the number of the discarded by-catch species from the sample by the fraction of the weight of the discarded by-catch species from the haul $DW_{h,s}$ and the weight of the discarded by-catch species from the sample $Dw_{h,s.}$

$$DN_{h,s} = Dn_{h,s} * (DW_{h,s}/Dw_{h,s})$$

3. Results

3.1 Sampled trips

In the Netherlands a total of 26 trips were monitored, between 5 and 8 trips annually. During these trips 167 hauls were sampled in 44 days (Table 1a, Figure 11 for location of sampled trips). In Germany a total of 24 trips were monitored, between 5 and 8 trips annually. During these trips 167 hauls were sampled in 47 days (Table 1b, Figure 11 for location of sampled trips).

Sampling coverage in number of effort days was 0.1 % or lower for all years sampled, for both the Dutch and German sampling programme (Table 2ab).

3.2 Catch composition

Catch composition is stratified in five main components: shrimps landed, shrimps discarded, flatfish, roundfish and benthos. For these components average weight per hour were calculated per year per quarter and average per quarter, during period 2009 - 2012 (Figures 12 and 13). Overall the shrimp component of the catch, landings and discards, is larger than the fish and benthic component.

3.2.1 Shrimp

Netherlands
Over the complete sampling period (2009 – 2012) the average estimated landings rate of shrimp was 55 kg/hr with a minimum of 3 kg/hr and a maximum of 519 kg/hr of the sampled trips. On average 56 kg/hr shrimp were discarded, varying from 2 kg/hr to 397 kg/hr for all sampled trips (Table 3).

Lengths of shrimp in the landing fraction are between 39 and 75 mm with the maximum number of shrimp between 51 – 62 mm (Figure 14). Lengths of shrimp in the discard fraction are between 20 and 56 mm with the maximum number of shrimp between 39 – 44 mm.

Germany
Over the complete sampling period (2009 – 2012) the average estimated landing rate of shrimp was 61 kg/hr with a minimum of 7 kg/hr and a maximum of 172 kg/hr of all sampled trips. On average 105 kg/hr shrimp were discarded, varying from 2 kg/hr to 495 kg/hr of all sampled trips (Table 3).

Lengths of shrimp in the landing fraction are between 37 and 82 mm with the maximum number of shrimp between 50 – 60 mm (Figure 14). Lengths of shrimp in the discard fraction are between 18 and 62 mm with the maximum number of shrimp between 37 – 49 mm.

3.2.2 By-catch

Netherlands
The most abundant fish species in the by-catch is goby (*Pomatoschistus sp*.), the species is present in 92% of the hauls with an average catch rate of 1030 per hour; Plaice (*Pleuronectes platessa*, 86%, 798/hr), herring (*Clupea harengus*, 76%, 402/hr), whiting (*Merlangius merlangius*, 62%, 360/hr), dab (*Limanda limanda*, 51%, 69/hr), sole (*Solea solea*, 33%, 12/hr) are among the commercial species frequently caught (Table 4).

Germany
The most abundant fish species in the by-catch is goby (*Pomatoschistus sp*.) present in 95% of the hauls, with an average catch rate of 3719 per hour; plaice (*Pleuronectes platessa*, 85%, 2161/hr), herring (*Clupea harengus*, 51%, 135/hr), whiting (*Merlangius merlangius*, 65%, 173/hr), dab (*Limanda*

limanda, 40%, 270/hr), sole, (*Solea solea*, 39%, 49/hr) are among the commercial species frequently caught (Table 6).

Cod (*Gadus morhua*) was observed in 31% (with a catch rate of 10 per hour) of the catches (Table 6). In the Netherlands cod was observed only in 4% of all observed hauls during the period 2008 – 2012.

Plaice, dab and sole are the most abundant commercially interesting flatfish species. There was no observation of plaice individuals larger than 12 cm for both sampling programmes, whereas dab and sole the maximum length measured was 22 cm (Figure 15 en 16).

Other commercial species abundant in the discarded part of the catch are herring and whiting. Only small individuals of herring were observed in the catch, with 8 cm as the most abundant length category. The observed maximum length of whiting is 24 cm. (Figure 15 en 16).

4. Discussion

4.1 The two sampling methods

This report presents the results of both the Dutch and German sampling programme in 2009 - 2012 on board commercial shrimpers. The initiative, to present the results in one report, anticipates to work towards harmonised regional sampling of commercial fisheries as is foreseen in the (reformed) European Data Collection Framework. Likewise, results are presented together for the Dutch and German sampling programme on pelagic trawlers in European waters during 2011 and 2012 (van Overzee et al. 2013). Although the German protocol of 2008 was used as an example to develop the Dutch sampling protocol of Dutch shrimpers, there are differences in the sampling methodology used on board and the data raising procedures between the two countries. Therefore we made the choice to present the results of both sampling programmes separately. An important difference in the Dutch and German sampling method is that in the Netherlands samples are raised based on the estimated volume of the total catch and in Germany the samples are raised based on the weight of the landed shrimp. Based on the current analysis there is no indication that this affected the results for both programmes. For the future harmonisation of the two sampling programmes and comparability of the results e a common method for discards sampling should be used on board of shrimp vessels.

4.2 Representativeness of the data

The results presented here only provide an indication of the catches throughout the year and throughout the German and the Dutch fishing areas. Given the low sampling coverage, 0.1% or less, of total days at sea and the large variation between the sampled hauls, discard numbers that are presented in this report are not suitable to raise to the entire fleet. Moreover the vessel selection is based on ad-hoc non-random approach in both countries, depending on the vessel owners and scientists and the willingness to take an observer on board. In such an approach there is a considerable risk of biased data, and consequently not representative, for the whole fishery over the year(s).

The Dutch sampling effort is only congruent with the effort of the fleet in Dutch waters. Fishing activity beyond Dutch waters, e.g. German and Danish waters is not covered within the Dutch sampling programme. The same is true for Germany, where the sampling effort is only congruent with the German fleet with the exemption of the most northern fishing ground, west of the peninsular Sylt. Consequently, sampling effort of both countries is not equally distributed over the total fishing area. Also there is a temporal dissimilarity in sampling effort between Germany and the Netherlands, since in Germany the fishing season is generally starting in April, and, therefore, no trips are sampled in the first quarter of the year.

The Dutch landings presented in this report are an overestimation of the actual landings. During the sorting procedure on board of a shrimp vessel, shrimp is sorted twice; before and after cooking. This results in 3 shrimp fractions; discarded shrimp before cooking, discarded shrimp after cooking and landed (cooked) shrimp. The discarded shrimp after cooking is not measured in the current sampling procedure. In the Dutch method this fraction is included in the landings, hence the over estimation of the landings. In the German sampling procedure this fraction is not included at all. In the German sampling procedure the cooked shrimp are weighted. However, the difference in weight between cooked and uncooked shrimp is here not taken into account and therefore the presented landings figures are thought to be an underestimation. At the auction there is another sieving step which is not taken into account in this monitoring programme in both sampling programmes. Here, up to 30% of the landed shrimp is still sieved out and not recorded as official landings at the market (Neudecker & Damm, 2006 and ICES, 2012).

4.3 Composition of the catch

Estimated average landings of brown shrimp in kg per hour are similar in both countries. In contrast, the observed German discarded brown shrimp per hour are much higher than the Dutch estimates of discarded brown shrimp. A local increase in the abundance of juvenile shrimp during the summer period could explain the higher discard estimates for the German sampling programme (Temming and Damm, 2001). Moreover, in Germany more trips were sampled in the summer period.

In both sampling programmes fish by-catch is measured from a catch-sample. Most abundant fish species in the by-catch of both countries are gobies followed by plaice. The plaice observed in the catches were all juveniles <18 cm. Following the observations on the sampling trips and given the small sizes of the commercial fish in the catches, and the fact that shrimp fisheries is mainly a single species fisheries, one can assume that the vast majority of all by-catch in the brown shrimp fisheries is discarded.

Literature on the survival experiments on discards in the shrimp fishery indicate that discard survival is very variable. Boddeke (1989) indicates that the main causes of fish mortality were the sorting of the catch on board by means of mechanical sorting sieves and the duration of the catch on board, especially during warm sunny weather. He estimated mortality of juvenile plaice (*Pleuronectes platessa*) to range between 5% and 90%. Berghahn *et.al.* (1992) described a 100 % mortality rate for whiting (*Merlangius merlungus*), 10 % for bull-rout (*Myxocephalus scorpius*), hooknose (*Agonus catupbractus*), and viviparous blenny (*Zoarces viviparus*). Mortality of flatfish discards depended strongly on the species, the size of the individual fish and catch processing conditions, and ranged from 0 to 83%. No differences could be detected in the survival after sorting on different machines. However, due to better sorting efficiency, the rotary sieve may reduce mortality of fish in the by-catch (Berghahn *et. al.*, 1992). Mortality of shrimp discards in Dutch and German coastal waters is probably low. Gamito et all (2003) estimated mortality of brown shrimps in the beam trawl fishery in the Tagus estuary. Mortality was estimated to be 0% for water temperatures below 20°. For temperatures above 20° mortality increased considerable pending on temperature, fishing and sorting time.

4.4 Recommendations

With regard to improve the sampling of discards in Dutch and German Shrimp fisheries it is recommended that the sampling programmes and sampling procedures between both countries are harmonised. Further, profound methodologies to raise shrimp discard data to fleet level need to be developped, for example by increasing the sampling coverage and/or by the introduction of a statistically sound sampling scheme. The introduction of a statistically sound sampling scheme would reduce bias and, therefore, increase the representativeness of the data for the entire fleet. Statistically sound sampling includes defining the population of vessels and random selection of vessels from this population. A simple random or probability based sampling scheme will overcome the limitations of ad-hoc sampling (Van Helmond, in prep). However, practical issues, e.g. incomplete vessel registration lists, synchronizing selection procedures, seasonal fisheries and multipurpose vessels (switching fisheries between seasons or dependent on development of the shrimp market), vessel are encountered when implementing a truly random selection procedure and should be looked into carefully.

5. References

Beek, F.A. van, Rijnsdorp, A.D. and Clerck, R. de, 1989. Monitoring juvenile stocks of flatfish in the Wadden Sea and coastal areas of the southeastern North Sea. Helgoländer Meeresunters. 43: 461-477.

Berghahn, R., Waltemath, M. and Rijnsdorp, A.D. 1992. Mortality of fish from the by-catch of shrimp vessels in the North Sea. J. Appl. Ichthyol. 8: 293 – 306.

Boddeke, R. 1989. Management of the brown shrimp (*Crangon crangon*) stock in the Dutch coastal waters. In: (Ed. J.F. Caddy) *Marine invertebrate fisheries: their assessment and management*, pp. 35-62. Wiley

Bolle, L.J., Dapper, R., Witte, J.Y. and van der Veer, H.W., 1994. Nursery grounds of dab (*Limanda limanda* L.) in the southern North Sea. Neth. J. Sea Res. 32: 299-307.

Catchpole, T.L., Revill, A.S., Innes, J., Pascoe, S., 2008. Evaluating the efficacy of technical measures: a case study of selection device legislation in the UK *Crangon crangon* (brown shrimp) fishery. ICES Journal of Marine Science 65:267-275

Coull, K.A., Jermyn, A.S., Newton, A.W., Henderson, G.I., Hall, W.B., 1989. Length/weight relationships for 88 species of fish encountered in the north east Atlantic. p. 81.

Gamito, R., and H. Cabral. 2003. Mortality of brown-shrimp discards from the beam trawl fishery in the Tagus estuary, Portugal. Fisheries Research Volume 63, Issue 3, September 2003, pp 423-427

ICES, 2008. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN). 27-29 May 2008. Texel, Netherlands. ICES CM 2008/LRC:12. REF ACOM

ICES, 2012. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN). 5–7 June 2012. Porto, Portugal. ICES CM 2012/SSGEF:09 REF. SCICOM

ICES, 2013a. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN). 3-7 June 2013. ICES HQ, Copenhagen, Denmark. ICES CM 2013/SSGEF:12

ICES, 2013b. Report of the Workshop on the Necessity for Crangon and Cephalopod Management (WKCCM). Copenhagen, Denmark. ICES CM 2013/ACOM:82

Neudecker, Th., Damm, U., Kühnhold, W.W., 2006. Fang, Anlandungen, Discard und Bestand der Nordseegarnelen (*Crangon crangon L.*). Catch, landings, discard and stock of the brown shrimp (*Crangon crangon L.*). Inf. Fischereiforsch. 53 80-81, 2006.

Neudecker, Th., Damm, U., 2010. The by-catch situation in German brown shrimp (*Crangon crangon* L.) fisheries with particular reference to plaice (*Pleuronectes platessa* L.). J. Appl. Ichthyol. 26 (Suppl. 1) (2010), 67–74.

Polet., H., 2003. Evaluation of bycatch in the Belgian brown shrimp (*Crangon crangon L.*) fishery and of technical means to reduce discarding. University of Gent

Quirijns, F.J., van Giels, J., Dijkstra, E.S., 2008. Garnalenvisserij: pilots voor verbetering discardsoverleving. IMARES report C116/08.

Respondek, G.; Gröger, Joachim Paul; Floeter, Jens; Temming, Axel (2014). Variability of fishing effort for the German brown shrimp (*Crangon crangon*) fishing fleet: influencing factors, and seasonal and spatial patterns. ICES journal of marine science, doi:10.1093/icesjms/fsu016

Revill, A.S., Holst, R., 2004. The selective properties of some sieve nets. Fisheries Research 66 (2004) 171–183

Steenbergen, J., van der Hammen, T., Rasenberg, M., Tulp, I., 2013. Tussenrapportage onderzoek "Effecten van garnalenvisserij" – onderdeel bijvangst. Rapport / IMARES Wageningen UR Nr. C047/13.

Temming, A., Damm, U., 2002. Life cycle of Crangon crangon in the North Sea: a simulation of the timing of recruitment as a function of the seasonal temperature signal Fish. Oceanogr. 11(1): 45-58.

Tulp, I, Leijzer, T, van Helmond, E., 2010. Overzicht wadvisserij: deelproject A bijvangst garnalenvisserij: eindrapportage. Rapport / IMARES Wageningen UR Nr. C102/10.

Ulleweit, J., Stransky, C., Panten, K., 2010. Discards and discarding practices in German fisheries in the North Sea and Northwest Atlantic during 2002-2008. J. Appl. Ichthyol. 26 (Suppl. 1) (2010), 54–66.

Van Helmond, E., Chun, C., Uhlmann, S., in prep. Implementing a statistically-sound sampling design for commercial fisheries: using Dutch shrimp trawlers as a case study. Imares report.

Van Overzee, H.M.J., van Helmond, A.T.M., Ulleweit, J., Panten, K., 2013. Discard sampling of the Dutch and German pelagic freezer fishery operating in European waters in 2011 and 2012. CVO Rapport 13.013, 68 p.

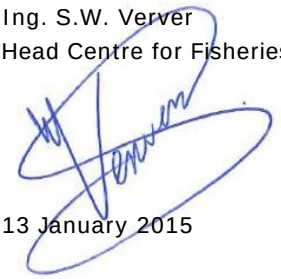
Zijlstra, J.J., 1972. On the importance of the Wadden Sea as a nursery area in relation to the conservation of the southern North Sea fishery resources. Symp. zool. Soc. Lond. 29: 233-258.

Justification

CVO report number : 15.003
Project number : 4311213005

Approved by: Ing. S.W. Verver
Head Centre for Fisheries Research

Signature:



Date: 13 January 2015

Appendix: tables and figures

Table 1a, b. Overview of sampled trips directed on brown shrimp in the Netherlands (a) and Germany (b) 2009 to 2012 per quarter (Q). Departure data and arrival date are defined as day.out and day.in. Vessel length in meters (m). Engine size in horse power (HP). The sievenet is a technical adaptation of the net to reduce the unnecessary capture of unwanted marine organisms (Catchpole, et. al., 2008); Y = sieve net is used during; N = sieve net is not used; n.a. = information on sieve net was not registered by observer. Number of days sampled and number of haul sampled.

a

The Netherlands

year	Q	day.out	day.in	Length vessel (m)	Hp vessel (HP)	Sievenet	# days	# hauls sampled
2009	3	2009-07-01	2009-07-02	20.3	209	Y	2	6
2009	3	2009-09-28	2009-10-01	23.9	300	Y	4	12
2009	4	2009-10-07	2009-10-07	18.8	188	Y	1	7
2009	4	2009-10-12	2009-10-13	22.0	300	Y	2	11
2009	4	2009-11-11	2009-11-11	18.8	300	N	1	5
Tot 2009							**10**	**41**
2010	2	2010-06-07	2010-06-07	18.8	188	Y	1	7
2010	2	2010-06-23	2010-06-23	23.8	299	N	1	8
2010	2	2010-06-28	2010-06-28	19.0	299	N	1	4
2010	3	2010-08-18	2010-08-19	20.2	256	Y	2	10
2010	4	2010-10-11	2010-10-11	18.8	188	Y	1	6
2010	4	2010-10-26	2010-10-26	22.0	250	N	1	5
2010	4	2010-11-22	2010-11-22	24.0	299	Y	1	6
Tot 2010							**8**	**46**
2011	1	2011-03-23	2011-03-23	18.8	188	Y	1	5
2011	2	2011-05-30	2011-05-30	23.9	299	Y	1	8
2011	2	2011-06-27	2011-06-28	20.2	256	Y	2	11
2011	3	2011-07-26	2011-07-27	19.5	300	Y	5	2
2011	4	2011-10-17	2011-10-17	20.3	209	Y	1	5
2011	4	2011-11-21	2011-11-23	23.2	300	Y	3	11
Tot 2011							**13**	**42**
2012	1	2012-03-05	2012-03-05	18.8	188	Y	1	5
2012	2	2012-04-16	2012-04-17	23	300	Y	2	9
2012	2	2012-06-06	2012-06-07	23.7	300	Y	2	8
2012	3	2012-07-09	2012-07-11	20.3	209	Y	3	8
2012	4	2012-11-06	2012-11-07	23.5	300	Y	2	8
Tot 2012							**10**	**38**

b

Germany

year	Q	day.out	day.in	Length vessel (m)	Hp vessel (HP)	Sievenet	# days	# hauls sampled
2009	2	2009-04-01	2009-04-02	18.2	184	Y	2	10
2009	2	2009-06-17	2009-06-18	17.0	221	n.a.	2	3
2009	3	2009-07-28	2009-07-28	19.4	221	n.a.	1	6
2009	3	2009-08-04	2009-08-07	18.2	184	Y	4	12
2009	4	2009-12-01	2009-12-03	19.4	221	n.a.	3	6
Tot 2009							**12**	**37**
2010	2	2010-04-19	2010-04-20	18.2	184	Y	2	7
2010	2	2010-06-16	2010-06-17	15.9	146	n.a.	2	4
2010	3	2010-08-04	2010-08-05	17.0	221	n.a.	2	6
2010	3	2010-09-12	2010-09-14	19.0	221	n.a.	3	11
Tot 2010							**9**	**28**
2011	2	2011-04-11	2011-04-12	18.2	184	Y	2	6
2011	2	2011-05-30	2011-05-30	16.6	221	n.a.	1	7
2011	2	2011-06-27	2011-06-28	18.2	184	Y	2	8
2011	3	2011-07-12	2011-07-12	15.9	146	n.a.	1	4
2011	3	2011-07-26	2011-07-27	15.1	221	n.a.	2	6
2011	4	2011-10-13	2011-10-13	11.7	169	n.a.	1	1
2011	4	2011-11-02	2011-11-02	15.1	221	n.a.	1	6
Tot 2011							**10**	**38**
2012	2	2012-04-14	2012-04-17	19.9	221	Y	4	14
2012	2	2012-05-22	2012-05-22	18.2	184	Y	1	6
2012	2	2012-06-07	2012-06-07	15.1	221	n.a.	1	6
2012	3	2012-07-10	2012-07-10	15.1	221	n.a.	1	6
2012	3	2012-08-01	2012-08-03	19.9	221	Y	3	10
2012	3	2012-08-15	2012-08-16	18.2	184	Y	2	8
2012	4	2012-10-10	2012-10-12	17.0	221	n.a.	3	11
2012	4	2012-10-12	2012-10-12	15.9	146	n.a.	1	3
Tot 2012							**16**	**64**

Table 2a, b: Overview of total fleet effort in days at sea (DAS), sampled number of trips, sampled days at sea (DAS) and sampling coverage (%) based on ratio between sampled effort (DAS) and total fleet effort (DAS) in the brown shrimp fisheries in the Netherlands (a) and Germany (b) during the period 2009 – 2012. Total fleet effort in the Netherlands in 2009 could not be calculated because the data have been transferred to a new database. Source: data DAS WGCRAN, ICES.

a

Netherlands	*No. sampled trips*	*DAS Sampled*	*DAS fleet*	*Coverage (%)*
2009	5	10	n.a.	
2010	7	8	17568	0.046
2011	6	13	13594	0.096
2012	5	10	19799	0.051

b

Germany	*No. sampled trips*	*DAS Sampled*	*DAS fleet*	*Coverage (%)*
2009	5	12	14752	0.081
2010	4	9	12874	0.070
2011	7	10	8918	0.112
2012	8	16	20803	0.077

Table 3. Mean Dutch and German catches of brown shrimp (*Crangon crangon*) in numbers of individuals per hour and weight (kg) per hour (L = landings, D = discards, hr = hour), minimal and maximum values and standard deviation (sd). *Because of high variability in the data and the limited number of trips sampled, extrapolations to fleet level will be very uncertain. Therefore, it is undesirable to raise these estimates to fleet level.*

	Netherlands				Germany			
name	**mean**	**min**	**max**	**sd**	**mean**	**min**	**max**	**sd**
L_number_hr	38946	1944	351120	351120	41702	4919	137525	137525
D_number_hr	103584	4343	727834	727834	204998	3465	1201836	1201836
L_weight_hr	55	3	519	519	61	7	172	172
D_weight_hr	56	2	397	397	105	2	495	495

Table 4. Estimates of discarded fish species in Dutch brown shrimp fishery in the period 2009-2012. Observed occurrences in samples. Average numbers per hour observed in sampled hauls and standard deviations (SD). *Because of high variability in the data and the limited number of trips sampled, extrapolations to fleet level will be very uncertain. Therefore, it is undesirable to raise these estimates to fleet level.*

Name	English name	Dutch Name	# Hauls Present	Mean nr/hr	SD
Pomatoschistus sp.	Goby	Grondels	154	1030	2436
Pleuronectes platessa	Plaice	Schol	144	798	1779
Clupea harengus	Herring	Haring	127	402	1438
Syngnathus sp.	Pipefish sp.	Zeenaalden	123	203	473
Agonus cataphractus	Hooknose	Harnasmannetje	110	42	78
Merlangius merlangus	Whiting	Wijting	103	63	127
Osmerus eperlanus	European smelt	Spiering	97	148	339
Limanda limanda	Dab	Schar	85	69	160
Sprattus sprattus	European sprat	Sprot	85	155	437
Myoxocephalus scorpius	Bull-rout	Gewone zeedonderpad	71	31	68
Ciliata mustela	Fivebeard rocklin	Vrijfdradige meun	57	10	22
Solea solea	Sole	Tong	55	12	32
Callionymus lyra	Common dragonet	Gewone pitvis	46	27	81
Liparis sp.	Seasnail sp.	Slakdolf	43	24	80
Zoarces viviparus	Viviparous blenny	Puitaal	43	12	33
Platichthys flesus	Flounder	Bot	38	13	42
Buglossidium luteum	Solenette	Dwergtong	36	21	74
Hyperoplus lanceolatus	Greater sand eel	Smelt	34	7.7	39.9
Arnoglossus laterna	Scaldfish	Schurftvis	29	6.1	20.5
Trisopterus luscus	Bib	Steenbolk	18	4.4	20.0
Pholis gunnellus	Rock gunnel	Botervis	17	2.5	11.3
Microstomus kitt	Lemon sole	Tongschar	16	2.9	13.3
Gasterosteus aculeatus	Three-spined stickleback	Driedoornig stekelbaarsje	14	0.9	3.4
Dicentrarchus labrax	European seabass	Zeebaars	11	1.1	4.5
Trachurus trachurus	Atlantic horse mackerel	Horsmakreel	10	1.6	8.3
Trigla lucerna	Tub gurnard	Rode poon	9	1.0	5.3
Eutrigla gurnardus	Grey gurnard	Grauwe poon	8	0.4	2.1
Gadus morhua	Cod	Kabeljauw	7	0.5	2.8
Echiichthys vipera	Lesser weever	Kleine pieterman	5	0.3	1.6
Callionymus reticulatus	Reticulated dragonet	Rasterpitvis	4	0.3	2.4
Gymnocephalus cernuus	Ruffe	Pos	4	1.0	9.6
Lampetra fluviatilis	River lamprey	Rivierprik	4	0.2	1.7
Mullus surmuletus	Surmullet	Mull	4	0.3	2.5
Ammodytes sp.	Sand eel sp	Zandspieringen	3	0.9	7.6
Scophthalmus rhombus	Brill	Griet	3	0.4	2.9
Trisopterus minutus	Poor cod	Dwergbolk	3	0.4	3.2
Cyclopterus lumpus	Lumpsucker	Snotolf	2	0.2	1.5
Enchelyopus cimbrius	Fourbeard rockling	Vierdradige meun	2	0.2	1.8
Perca fluviatilis	European perch	Baars	2	0.3	3.0
Scophthalmus maximus	Turbot	Tarbot	2	0.2	2.3
Alosa fallax	Twaite shad	Fint	1	0.2	2.8
Atherina sp.	Sand smelt	Koornaarvissen	1	0.1	0.8
Belone belone	Garfish	Geep	1	0.1	1.1
Gaidropsarus vulgaris	Three-bearded rockling	Driedradige meun	1	6.6	84.6

Name	English name	Dutch Name	# Hauls Present	Mean nr/hr	SD
Gobius niger	Black goby	Zwarte grondel	1	0.1	1.2
Lipophrys pholis	Shanny	Gewone slijmvis	1	0.1	0.8
Petromyzon marinus	Sea lamprey	Zeeprik	1	0.2	2.8
Scomber scombrus	Atlantic mackerel	Makreel	1	0.1	1.1

Table 5. Estimates of discarded benthic species in Dutch brown shrimp fishery in the period 2009-2012. Observed occurrences in samples. Average numbers per hour observed in sampled hauls and standard deviations (SD). *Because of high variability in the data and the limited number of trips sampled, extrapolations to fleet level will be very uncertain. Therefore, it is undesirable to raise these estimates to fleet level.*

Name	English name	Dutch Name	# Hauls present	Mean nr/hr	SD
Carcinus maenas	Common shore crab	Strandkrab	116	194	398
Liocarcinus holsatus	Flying crab	Gewone zwemkrab	114	532	1645
Ophiuridae	Brittle stars	Slangsterren	47	28	77
Loligo sp.	Loligo	Loligo	44	15	64
Anthozoa	See anemones	Zeeanemonen	26	7	36
Pagurus sp.	Hermit crabs	Heremietkreeften	24	3.2	11.9
Ensis sp.	Razor clams	Scheermessen	20	19	149
Mytilus edulis	Blue mussel	Blauwe mossel	17	12	69
Cerastoderma edule	Cockle	Kokkel	8	0.6	3.7
Macoma balthica	Baltic macoma	Nonnetje	7	15	188
Sepiola sp.	Bobtail squid	Sepiolas	7	0.5	2.9
Echinocardium cordatum	Sea potato	Zeeklit	6	0.8	6.1
Pleurobrachia pileus	Sea gooseberry	Zeedruif	6	19	154
Ascidiacea	Sea squirts	Zakpijpen	5	1.1	7.4
Palaemon sp.	Caridean shrimp	Steurgarnaal	8	4	48
Liocarcinus marmoreus	Marbled swimming crab	Gemarmerde zwemkrab	3	0.2	1.5
Macropodia	Spider crabs	Hooiwagenkrabben	3	0.2	1.4
Necora puber	Velvet swimming crab	Fluwelen zwemkrab	3	0.2	1.3
Palaemon sp.	Caridean shrimp	Palaemon sp.	3	4	48
Spisula sp.	Spisula	Spisula	2	0.2	1.7
Pandalus sp.	Pandalus	Pandalus	2	0.2	2
Cancer pagurus	Brown crab	Noordzeekrab	1	0	0.04
Cephalopoda	Cephalopods	Cephalopoden	1	0.07	0.9
Corystes cassivelaunus	Helmet crab	Helmkrab	1	0.06	0.7
Eriocheir sinensis	Chinese mitten crab	Wolhandkrab	1	0.1	1.6
Hinia sp.	Whelks	Wulken	1	0.03	0.4
Isopoda	Isopods	Isopoden	1	0.01	0.2
Liocarcinus depurator	Harbour crab	Blauwpootzwemkrab	1	0.55	7.1
Nereis sp.	Nereis	Zagers	1	0.04	0.6
Pholadidae	Piddocks	Zagers	1	0.2	1.9
Portumnus latipes	Pennant's swimming crab	Breedpootkrab	1	0.1	1.3
Psammechinus miliaris	Shore sea urchin	Gewone zeeappel	1	0.06	0.8
Thia scutellata	Thumbnail crab	Nagelkrabbetje	1	0.06	0.8

Table 6. Estimates of discarded fish species in the German brown shrimp fishery in the period 2009-2012. Observed occurrences in samples. Average numbers per hour observed in sampled hauls and standard deviations (SD). *Because of high variability in the data and the limited number of trips sampled, extrapolations to fleet level will be very uncertain. Therefore, it is undesirable to raise these estimates to fleet level.*

Name	English name	German Name	# Hauls present	Mean nr/hr	SD
Pomatoschistus sp.	Gobies	Grundel	158	3719	13850
Pleuronectes platessa	Plaice	Scholle	142	2161	7705
Osmerus eperlanus	European smelt	Stint	142	785	1355
Syngnathus sp.	Pipefish sp.	Kleine Seenadel	138	286	551
Agonus cataphractus	Hook-nose	Steinpicker	134	258	475
Merlangius merlangus	Whiting	Wittling	109	173	347
Sprattus sprattus	Sprat	Sprotte	104	175	424
Liparis sp.	Seasnail sp.	Scheibenbauch	87	166	650
Clupea harengus	Herring	Hering	85	135	515
Limanda limanda	Dab	Kliesche	67	270	836
Solea solea	Sole	Seezunge	65	49	136
Callionymus lyra	Common dragonet	Gestreifter Leierfisch	60	42	111
Platichthys flesus	Flounder	Flunder	56	36	128
Myoxocephalus scorpius	Bull-rout	Seeskorpion	52	15	32
Ciliata mustela	Fivebeard rockling	Fuenfbaertelige Seequappe	44	18	41
Arnoglossus laterna	Scaldfish	Lammzunge	38	12	28
Buglossidium luteum	Solenette	Zwergzunge	37	26	77
Ammodytes sp.	Sand eel sp	Sandaal	32	10	29
Gadus morhua	Cod	Kabeljau	31	10	62
Microstomus kitt	Lemon sole	Limande	29	25	107
Pholis gunnellus	Rock gunnel	Butterfisch	28	8.2	28.2
Zoarces viviparus	Viviparous blenny	Aalmutter	24	5.6	17.8
Callionymus reticulatus	Reticulated dragonet	Ornament-Leierfisch	15	4.2	19.6
Trigla lucerna	Tub gurnard	Roter Knurrhahn	11	2.1	10.4
Trachurus trachurus	Atlantic horse mackerel	Stoecker	10	5.6	32.9
Lampetra fluviatilis	River lamprey	Flussneunauge	10	1.6	7.8
Gasterosteus aculeatus	Three-spined stickleback	Dreistacheliger Stichling	8	1.6	10.1
Eutrigla gurnardus	Grey gurnard	Grauer Knurrhahn	6	0.9	5.3
Scophthalmus maximus	Turbot	Steinbutt	6	0.8	5.9
Alosa fallax	Twait shad	Finte	6	0.7	4.6
Anguilla anguilla	Eel	Flussaal	4	0.01	0.10
Trisopterus luscus	Bib	Franzosendorsch	3	0.5	4.2
Callionymus maculatus	Spotted dragonet	Gefleckter Leierfisch	2	0.5	4.3
Hyperoplus lanceolatus	Greater sandeel	Grosser Sandaal	1	0.2	3.1
Echiichthys vipera	Lesser weever	Vipernqueise	1	0.2	2.7
Salmo salar	Atlantic salmon	Lachs	1	0.03	0.43
Alosa	Shad sp	Maifische	1	0.00	0.05

Table 7. Estimates of discarded benthic species in the German brown shrimp fishery in the period 2009-2012. Observed occurrences in samples. Average numbers per hour observed in sampled hauls and standard deviations (SD). *Because of high variability in the data and the limited number of trips sampled, extrapolations to fleet level will be very uncertain. Therefore, it is undesirable to raise these estimates to fleet level.*

Name	English name	German Name	# Hauls present	Mean nr/hr	SD
Portunidae	Swimming crabs	Familie der Schwimmkrabben	144	3321	9601
Carcinus maenas	Common shore crab	Strandkrabbe	110	293	633
Pandalus sp.	Pandalus	Rote Garnele	84	257	996
Asterias rubens	Common starfish	Gemeiner Seestern	61	22	46
Ophiuridae	Brittle stars	Schlangensterne	58	1447	7303
Crangon allmanni	Crangon allmani	Furchengarnele	49	5528	17585
Pagurus sp.	Hermit krabs	Einsiedlerkrebse	36	11	33
Crangon allmanni	Crangon allmani		21	113	484
Anthozoa	Sea anemones	Seeanemone	20	103	632
Alloteuthis subulata	Common squid	Gepfriemter Zwergkalmar	13	18	120
Macropodia	Spider crabs	Gespensterkrabben	9	7.6	60.9
Mytilus edulis	Blue mussel	Miesmuschel	6	49	319
Hyas sp.	Hyas species	Seespinne (kleine)	5	2.9	18.2
Ensis sp.	Razor clams	Messerschneide	5	1.3	9.0
Loligo sp.	Loligo species	Kalmar	4	0.7	4.71
Asteriidae	Starfish species	Familie der Seesterne	3	2.6	20.7
Cancer pagurus	Brown crab	Taschenkrebs	3	0.01	0.08
Cephalopoda	Chephalopods	Tintenfische	2	1.6	14.7
Aphrodita aculeata	Sea mouse	Seemaus	2	0.8	9.7
Corystes cassivelaunus	Helmet crab	Antennenkrebs	2	0.6	6.9
Astropecten irregularis	Sand sea star	Nordischer Kammstern	2	0.4	4.6
Liocarcinus depurator	Harbour crab	Ruderkrabbe	1	0.6	8.0
Eriocheir sinensis	Chinese mitten crab	Wollhandkrabbe	1	0.5	6.2
Sepiola sp	Bobtail squid	Atlantische Zwergsepia	1	0.1	1.6

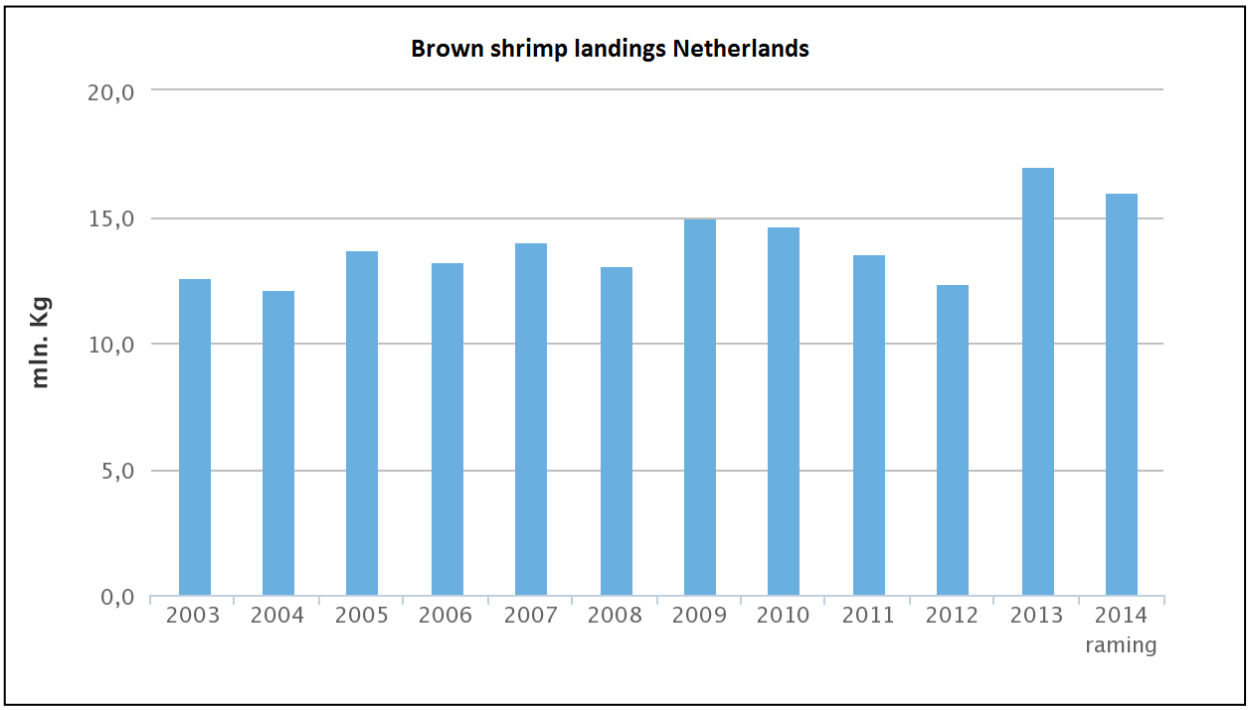


Figure 1. Total annual landings of shrimp (weight in million kg) in the Netherlands during the period 2003 – 2013, the estimate for 2014 is a prediction. Source: LEI, 2014.

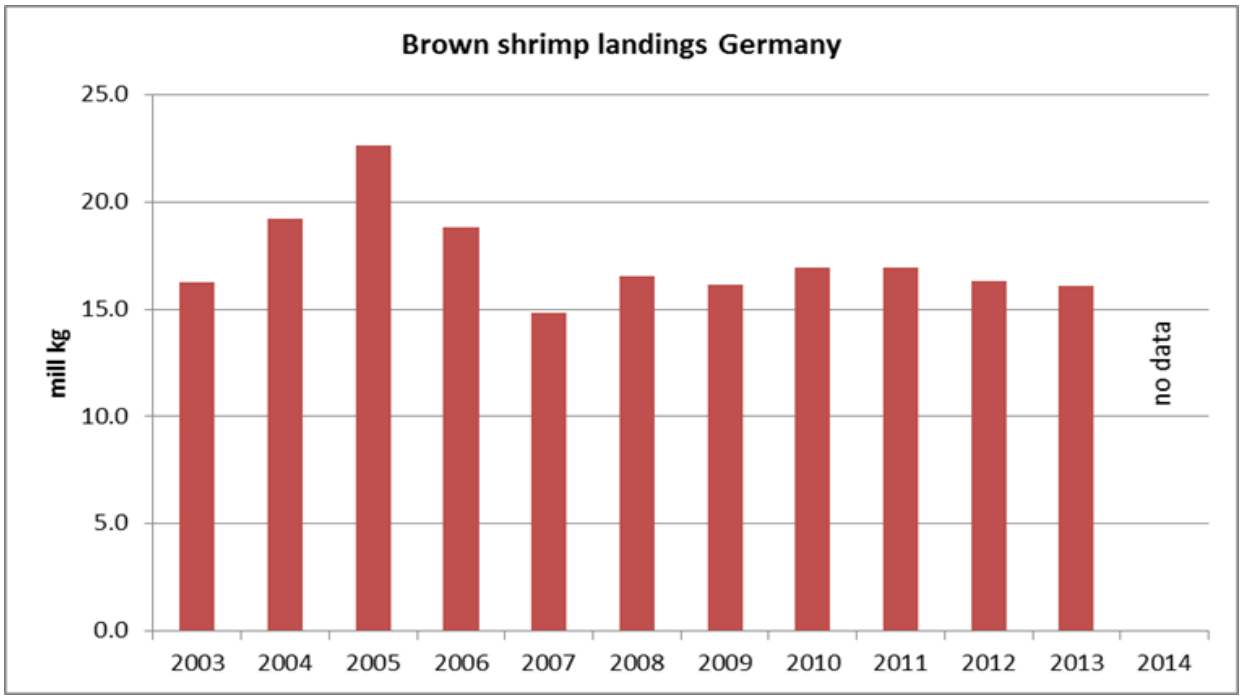


Figure 2. Total annual landings of shrimp (weight in million kg) in Germany during the period 2003 – 2013. Source: Thünen Institute for Sea Fisheries, 2014.

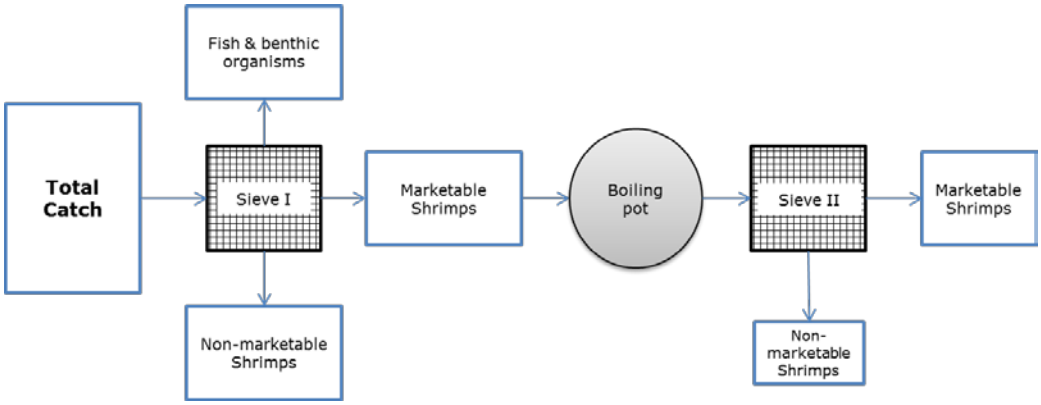


Figure 3. The sorting procedure of shrimp on board of shrimp vessels (Tulp et al, 2010)

Figure 4. Sieving devices on board of shrimp vessels: coaxial sieving drums (left), trembling sieve (right).

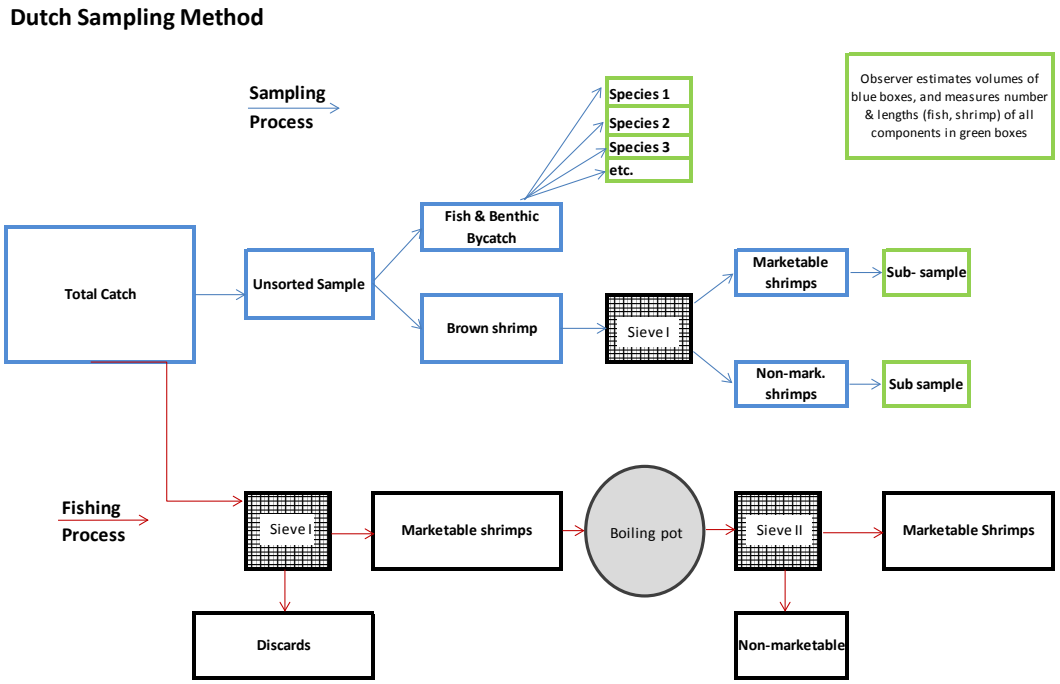


Figure 5. The Dutch sampling procedure.

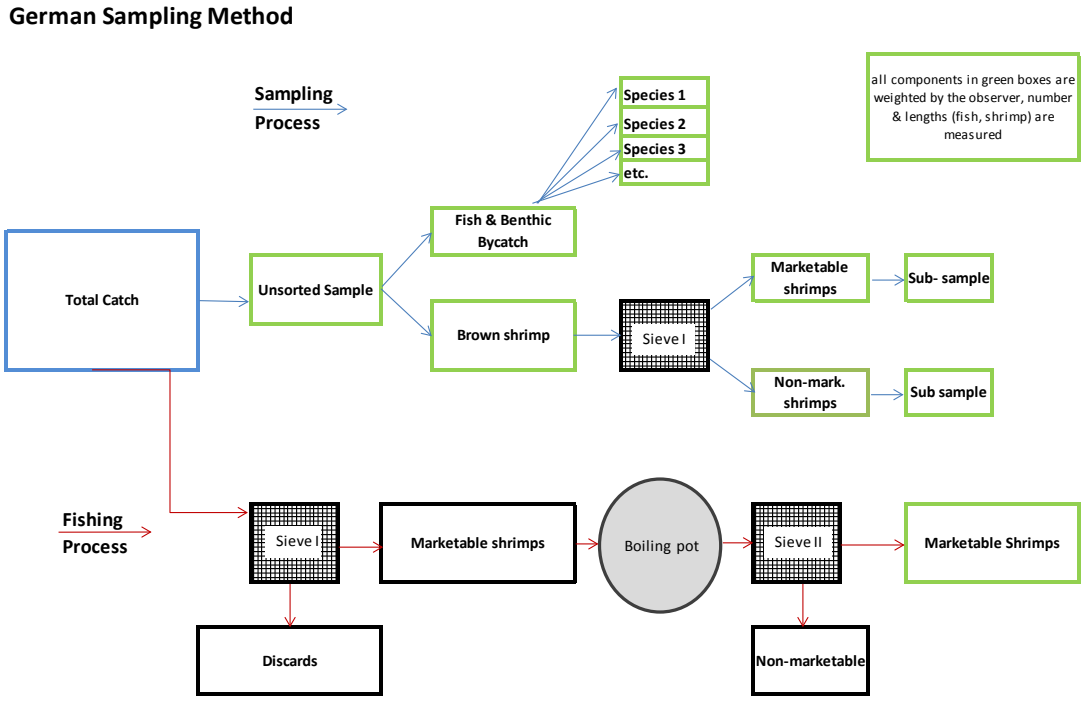


Figure 6. The German sampling procedure.

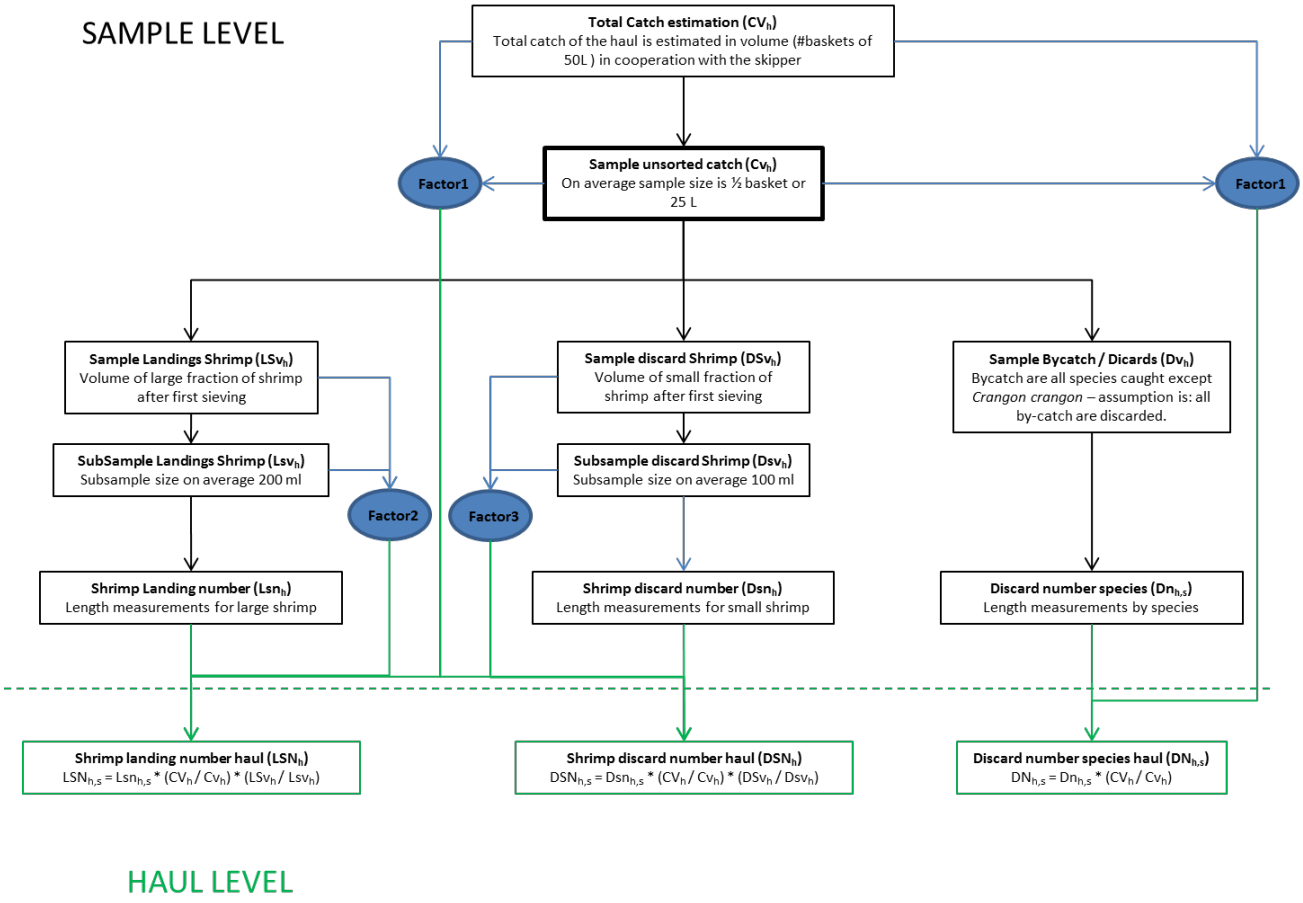


Figure 7. The Dutch raising procedure (from sample to haul level).

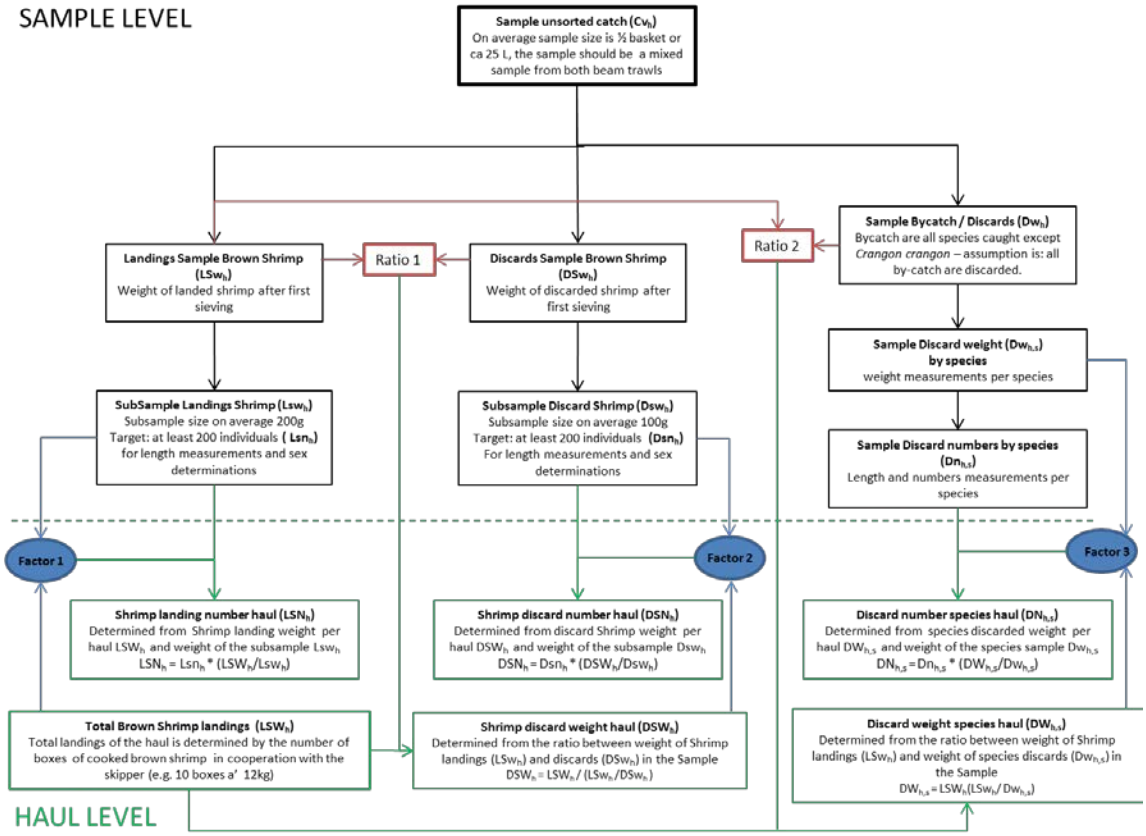


Figure 8. the German raising procedure (from sample to haul level).

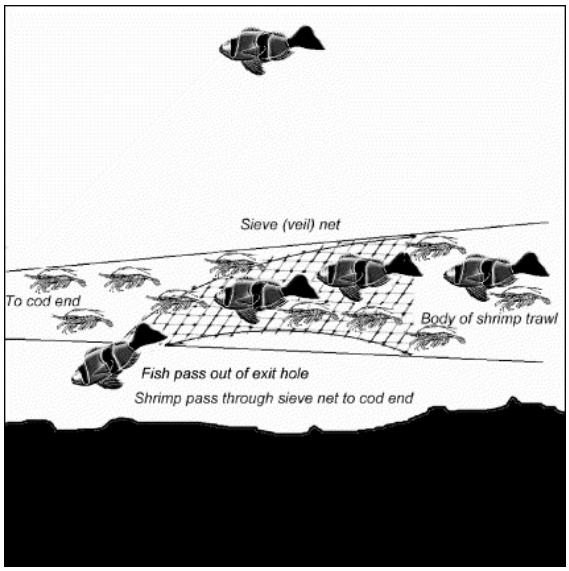
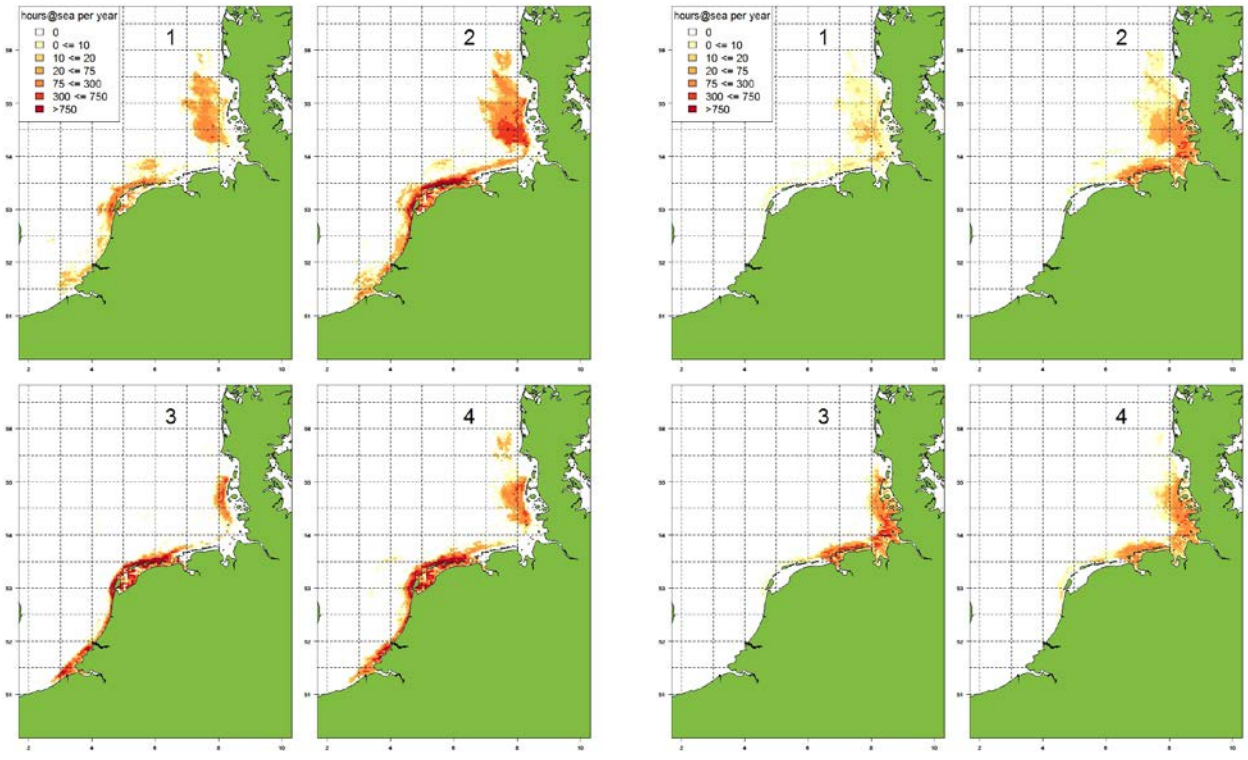


Figure 9. Schematic drawing of the sieve net (Revill and Holst, 2004).



a b

Figure 10a,b. Effort of Dutch (a) and German (b) shrimp fishers per quarter (in hours at sea per 1/64 ICES square, average of 2010-12)

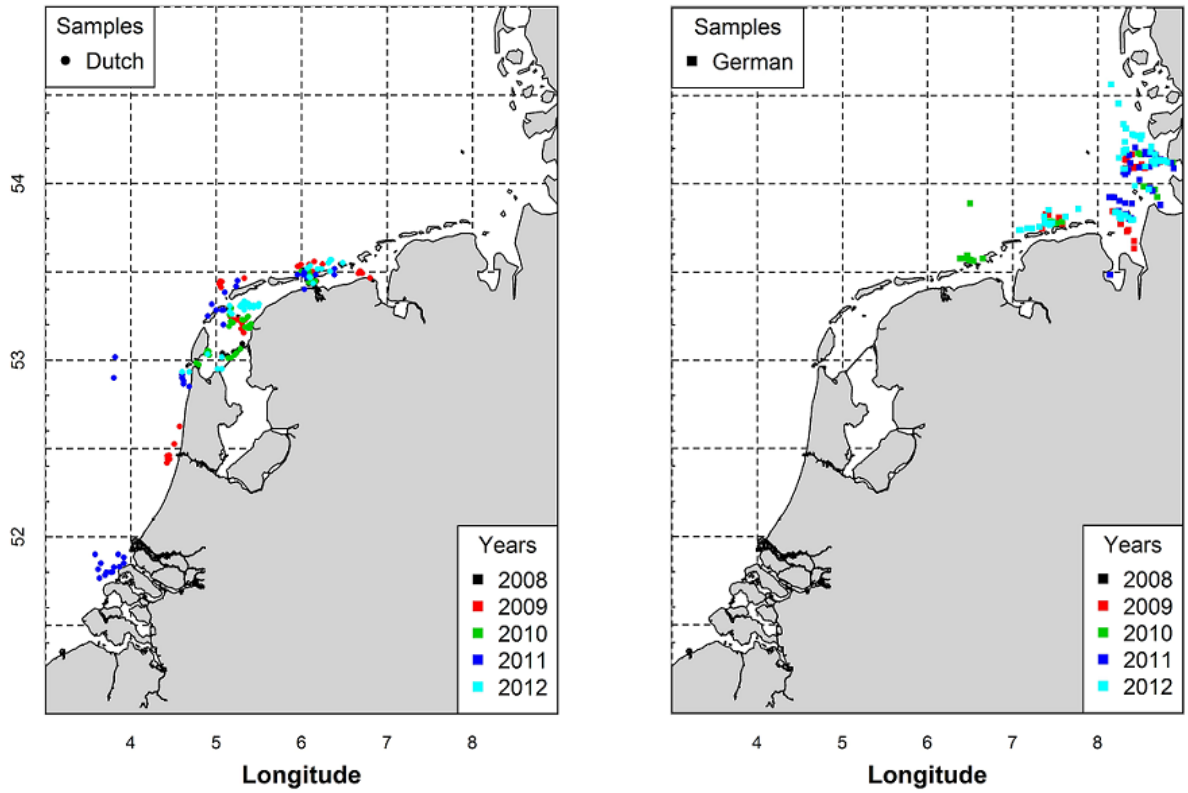


Figure 11. Positions of sampled hauls during the discard monitoring programme of the Dutch (left panel) and German (right panel) brown shrimp fishery in the years 2009 – 2012.

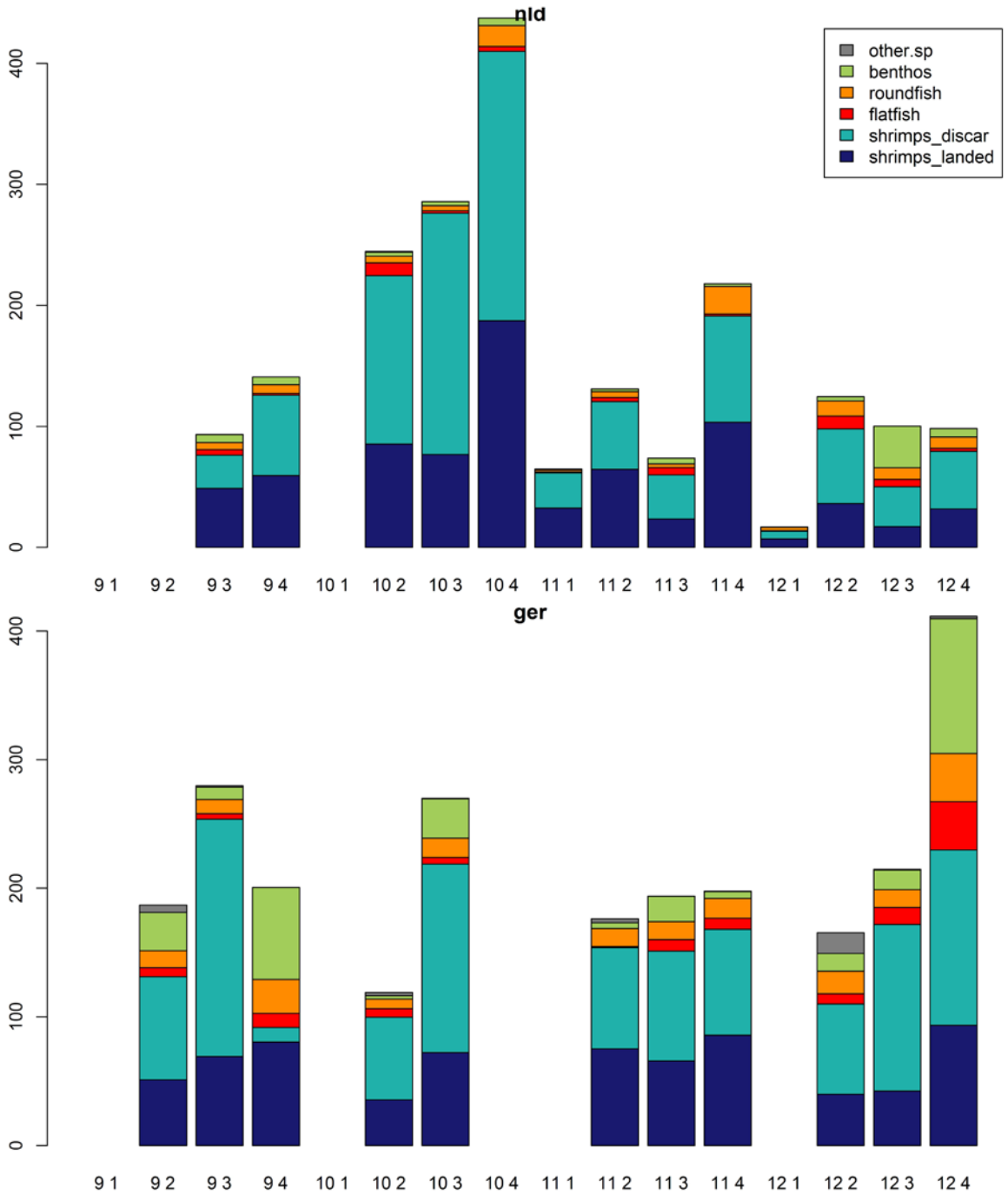


Figure 12. Composition of the catches: average weight (kg) per hour per year and quarter for the catch components: shrimps landed, shrimps discarded, flatfish, roundfish and benthos. Upper panel: the Netherlands, lower panel: Germany.

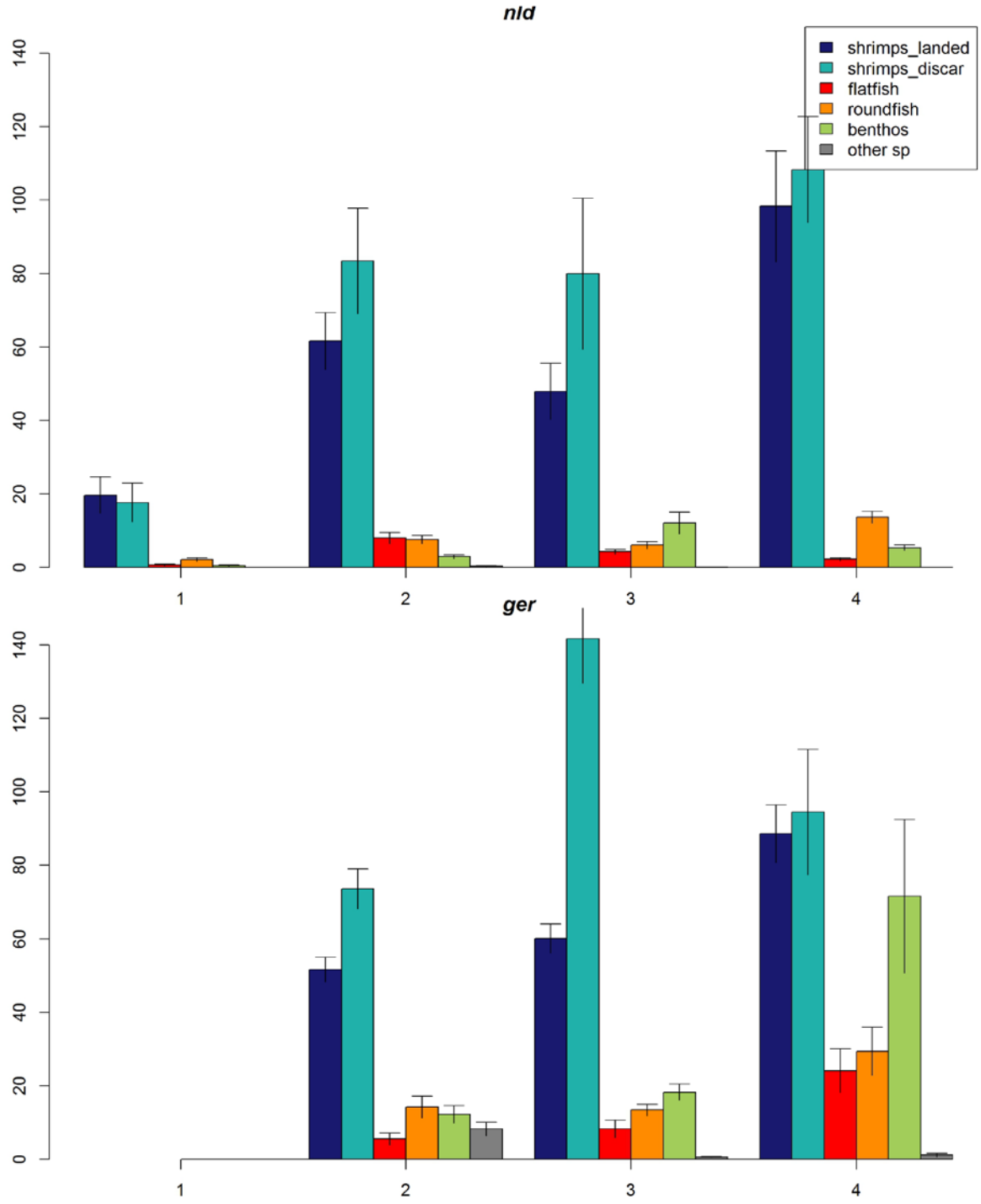
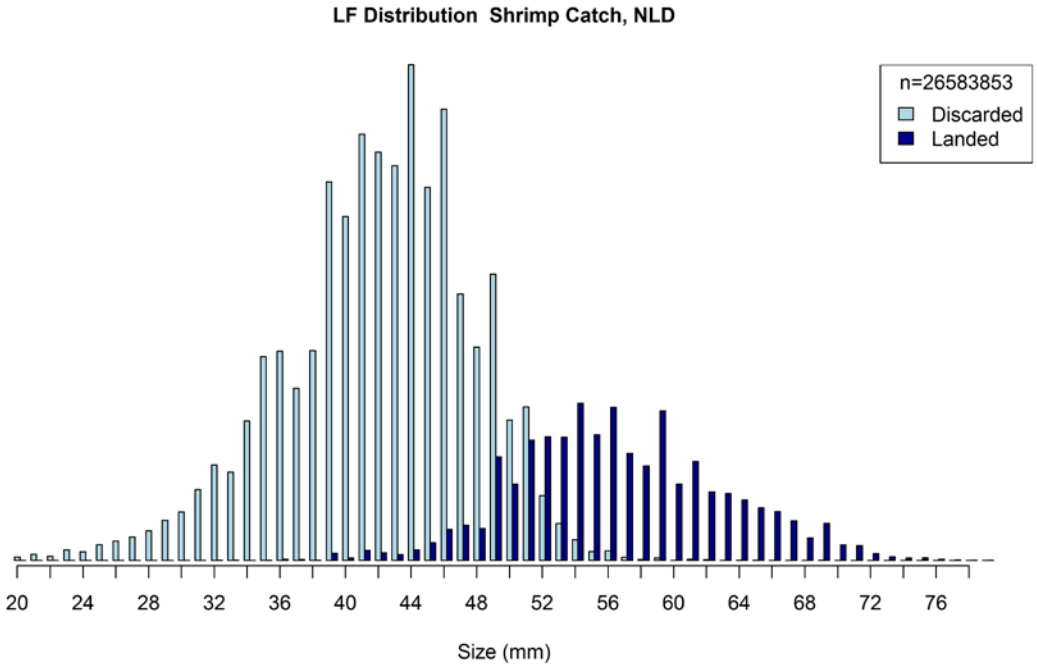


Figure 13. Composition of the catches: average weights kg per hour per quarter all sampling years combined (2009 – 2012) for the catch components: shrimps landed, shrimps discarded, flatfish, roundfish and benthos. Upper panel: the Netherlands, lower panel: Germany.



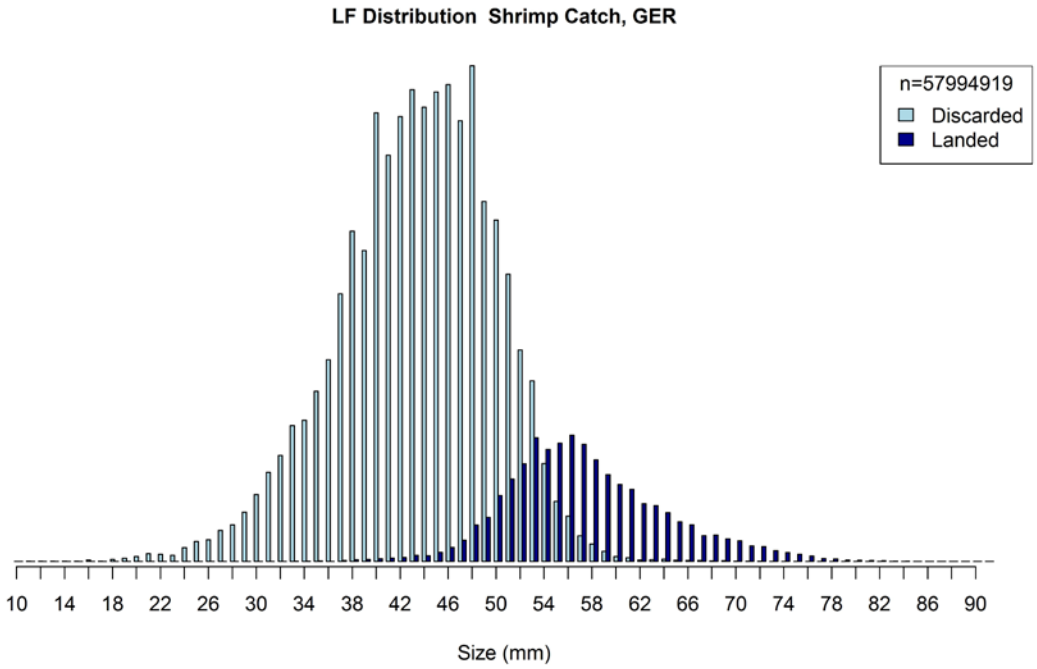


Figure 14. Relative length frequency distribution of landed (dark bars) and discarded (light bars) brown shrimp (*Crangon crangon*) in the Netherlands (upper graph) and Germany (lower graph) for all sampled years combined. Length classes in mm.

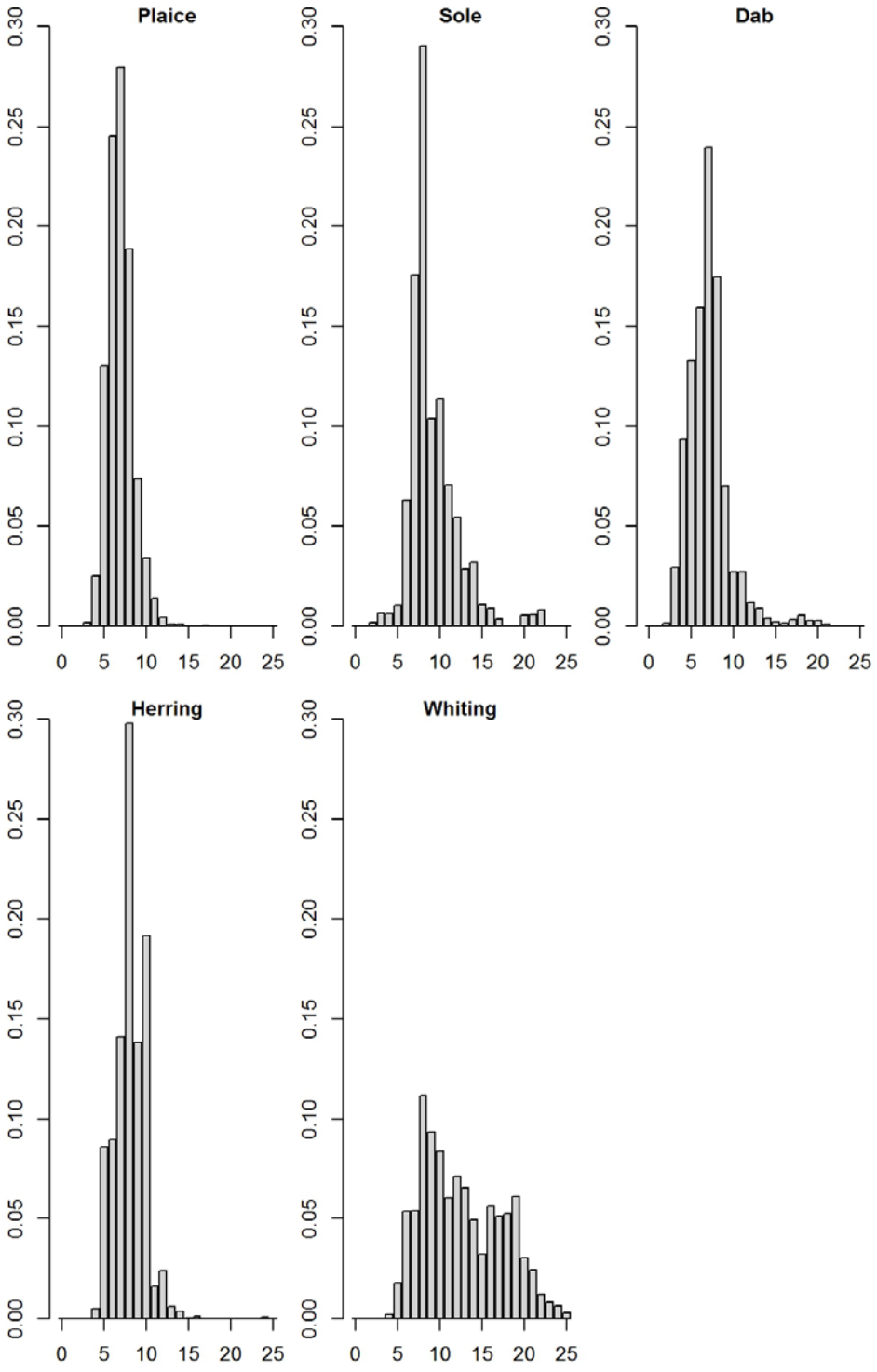


Figure 15. Relative length frequency distribution of the most important commercial flat- and roundfish species discarded in the Dutch shrimp fishery during 2009 -2012. Length classes in cm.

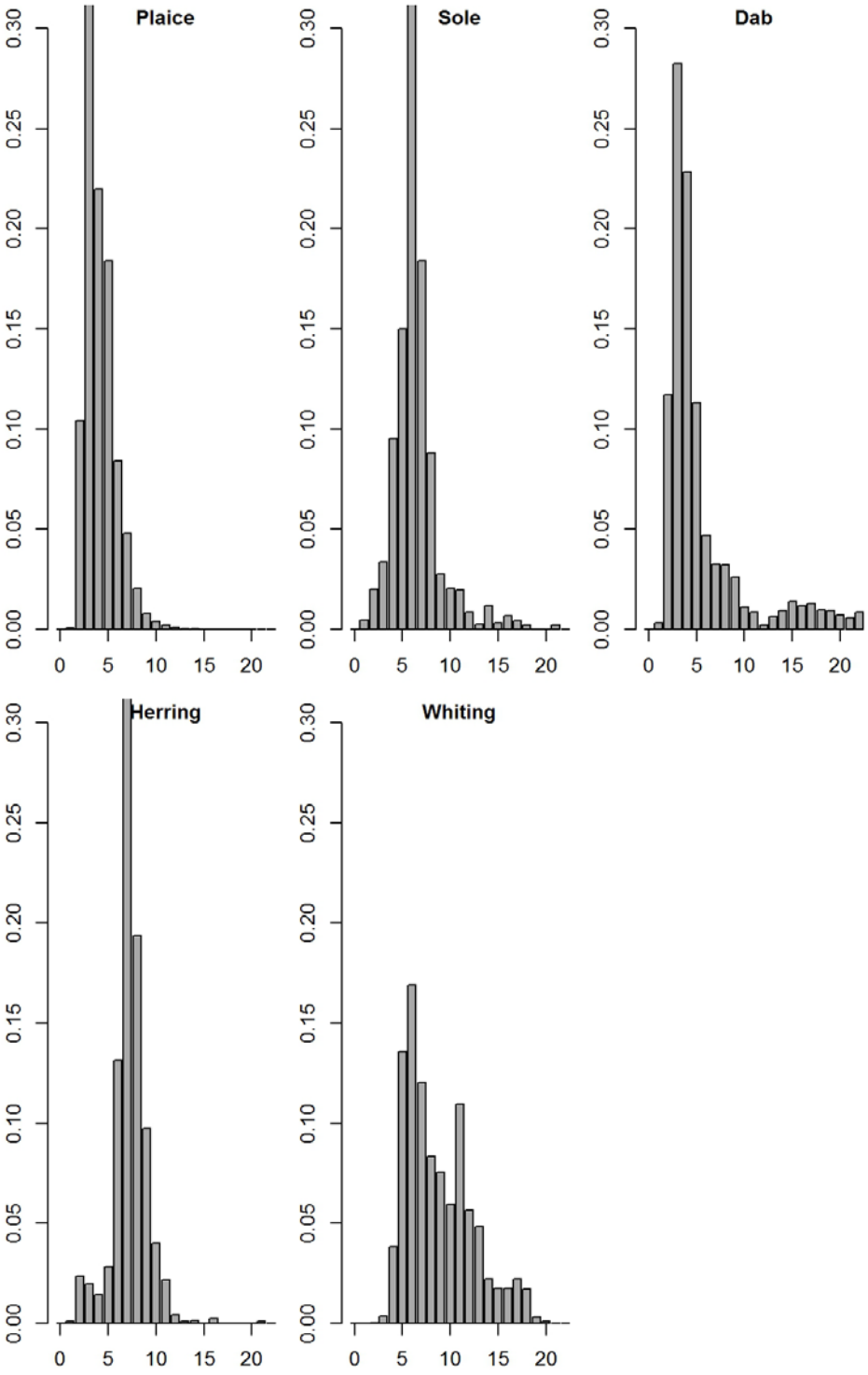


Figure 16. Length frequency distribution of some commercial flat and roundfish species found in the shrimp by-catches in Germany during 2009 -2012.