WORKING GROUP ON CRANGON FISHERIES AND LIFE HISTORY (WGCRAN; outputs from 2024 meeting)

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H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editors

Lara Kim Hünerlage • Eva Maria Pedersen

Authors

Ulrika Beier • Annika Brüger • Lara Kim Hünerlage •Thomas Lanssens • Eva Maria Pedersen • Georg Respondek • Merten Saathoff • Torsten Schulze • Tamara Vallina • Bart Vanelslander

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Contents

i Executive summary

The Working Group on Crangon Fisheries and Life History (WGCRAN) investigates the population dynamics of the brown shrimp *Crangon crangon* and the factors that influence both the stock and the individual. A central aim of the group is to create a biological basis for recommendations and to identify ways of achieving sustainable management.

The report provides the annual international update on the landing statistics of brown shrimp for 2023, which shows the second lowest amount of brown shrimp landed in the history of the time-series, only surpassed by the year 1990.

The greatest decline in landings was found in the Dutch and Belgian fishery but also the German fishers experienced a decrease in the landings. The fishing effort was similar to previous years, resulting in a low LPUE for most countries with the exception of Denmark and United Kingdom. For the Netherlands, it was the lowest LPUE value of the country-specific time-series.

Since the introduction of the common workflow in 2022, the landing statistic data are queried and updated annually retroactively back to 2009 (data from DE, NL DK and BE) from the EFLALO database.

During the 2024 meeting, the transition (which started in 2023) towards using a common workflow for uniform data retrieval of international survey data from the ICES DATRAS database was continued. The transition also involves the inclusion of Belgian survey data; both tasks are still in progress but are to be implemented at the 2025 meeting.

To investigate a possible change in fishing effort at regional level, it was decided to analyse the time-series of the available VMS data of the individual countries, however due to data delivery issues the analyses had to be postponed until the next working group meeting.

All workflows of WGCRAN are stored and made accessible at GitHub.

ii Expert group information

Expert group name	Working Group on Crangon Fisheries and Life History (WGCRAN)
Expert group cycle	Multiannual fixed term
Year cycle started	2022
Reporting year in cycle	3/3
Chair(s)	Lara Kim Hünerlage, Germany
	Eva Maria Fenger Pedersen, Denmark
Meeting venue(s) and dates	21-23 June 2022, Bremerhaven, Germany (13 participants)
	13-16 June 2023, Oostende, Belgium (15 participants)
	18-20 June 2024, Lyngby, Denmark (12 participants)

iii Terms of References a) – g)

a) Stock status indicators

Report and evaluate population status indicators like recent landings and effort trends in the brown shrimp fisheries. Generate a standardized LPUE time-series and provide a detailed description of the process of collecting the dataseries effort, landings and LPUE for WGCRAN.

b) Logbook information and VMS analysis

Combine VMS, landings and effort data to gain a population distribution indicator and to monitor regional distribution and regional shifts in fishing effort.

c) Decision support tools

Develop and evaluate brown shrimp-specific management decision-support tools to evaluate strategies on how to sustainably and efficiently harvest the brown shrimp stock.

d) Research on bycatch

Review the status and results of research on bycatch time-series and consider the implications for management. Evaluate methods and procedures used on board for collecting data on bycatch. Gather, compile and evaluate information on the on board and ashore sieving fractions and processes and new national bycatch/discards data from e.g. DCF.

e) International survey data

Analysis of spatio-temporal trends of survey-based stock indicators (e.g. biomass, length distribution, mortality); Ground-truthing of VMS derived LPUE estimates.

f) Legislation, law and management

Information on national legislation, laws and management concerning the brown shrimp fisheries in the whole North Sea will be synthesized (e.g. Natura 2000, MSC process, landing obligation, ...).

g) Ongoing research and projects

Present and review ongoing brown shrimp research in the ICES area (impact studies, development of fishing gears, life cycle studies...) aiming at supporting international collaboration as well as evaluating management implications.

1 Stock status indicators (ToR a)

1.1 General development and overview

Since 1960, when the commercial fishery for brown shrimp (*Crangon crangon*) for animal feed was discontinued and converted to a fishery for human consumption, total landings have steadily increased, and from 2003 to 2015 total North Sea landings were consistently above 30 000 tons (Figure 1.1). Thereafter, although an exceptionally high biomass was landed in 2018 (46 931 tons = the highest landings in the entire time-series), the amount of biomass landed fell to around 25 000 tons from 2016 to 2022. In 2023, only 14 967 tons of brown shrimp were landed, which is the second lowest total landings in the time-series of WGCRAN (lowest total landings in 1990: 10 620 tons).

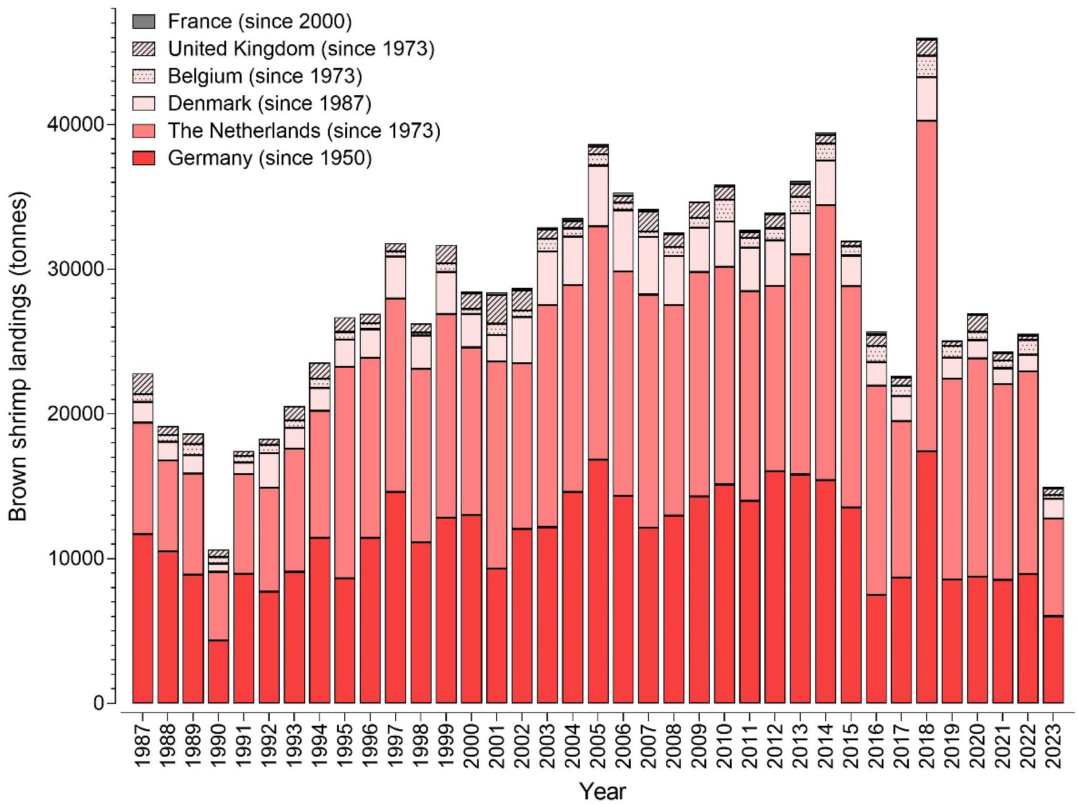


Figure 1.1 Total brown shrimp landed for human consumption (in tons) from the North Sea by country. The numbers in brackets give the year since data collection of the respective country started. For detailed countries' time-series, see Figure 1.5. *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

The annual total effort in the North Sea brown shrimp fishery showed, after a maximum in 2016, a decreasing trend (Figure 1.2): from 13.6 million horsepower days at sea (hpDAS) in 2016, over 12.6 million hpDAS in 2018 to a minimum of 8.5 million hpDAS in 2019. Thereafter, total annual effort remained at around 11 million hpDAS (10.8 million hpDAS in 2020, 11.6 million hpDAS in 2021, 10.7 million hpDAS in 2022) and dropped to 9.6 million hpDAS in 2023. Prominent factors influencing the effort were a fishing halt in 2019 due to storage bottlenecks in the processing industry caused by good catches in the previous year, the COVID-19 pandemic in 2020/2021 and high fuel prices resulting from the war in the Ukraine starting in 2022.

Of the 9.6 million hpDAS in 2023, Germany accounts for 3.41 million hpDAS, the Netherlands for 4.45 million, Denmark 0.47 million, Belgium for 0.28 million, the United Kingdom for 0.92 million and France for 0.05 million hpDAS (Figure 1.2 B).

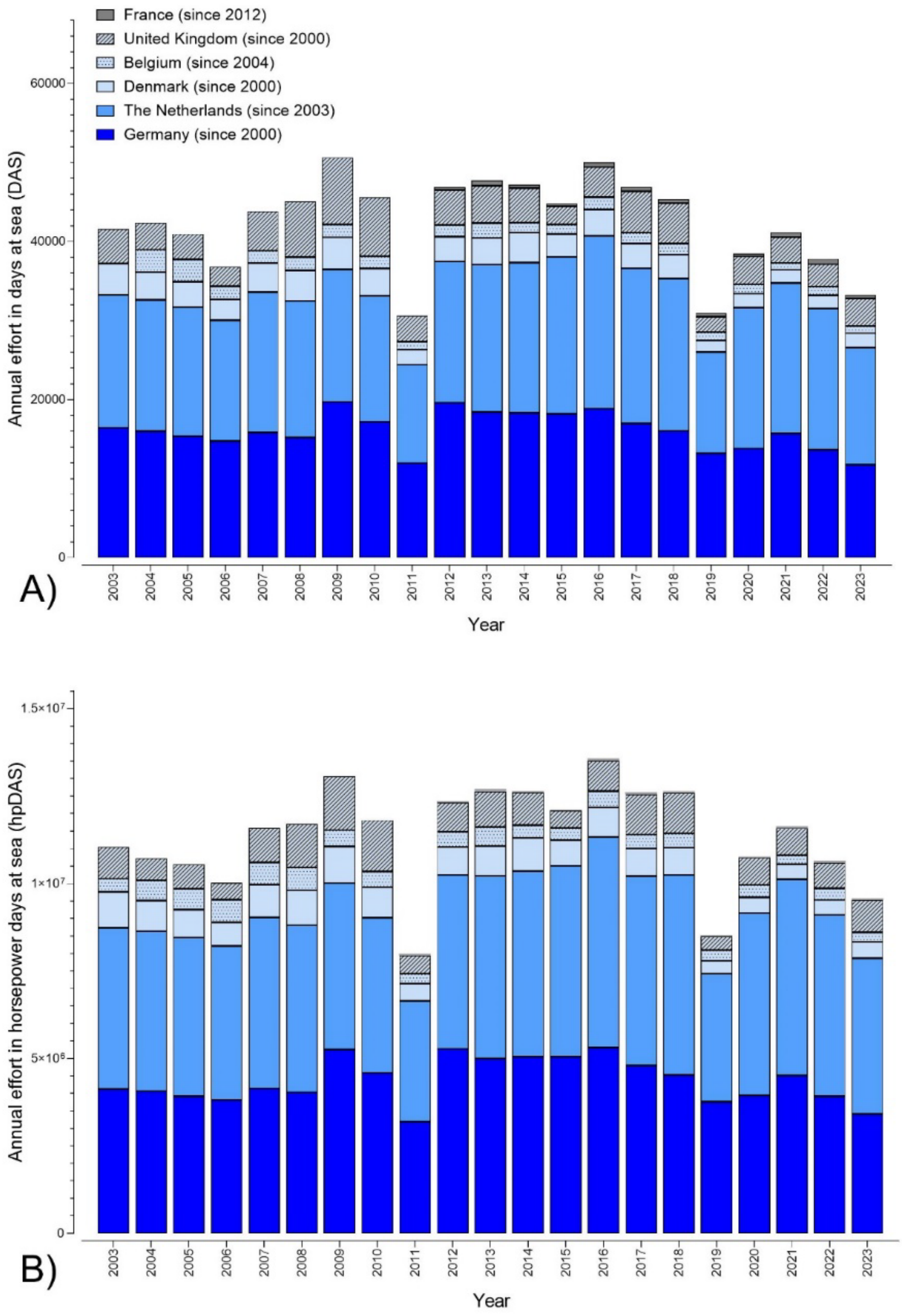


Figure 1.2 Total annual effort in A) days at sea (DAS) and B) horsepower days at sea (hpDAS) of the brown shrimp fishery by country. The numbers in brackets indicate the year since the data became available for WGCRAN. * Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

In order to get a more accurate estimate of the active fishing effort, total annual effort of the Netherlands, Germany and Denmark was further split into VMS recorded total fishing time and steam time (= total effort – VMS recorded total fishing time). The relation between steam time and fishing time is more or less stable for all countries and all years (Figure 1.3). However, since 2017, a decrease in steam time is observed for the Netherlands. This could indicate increased fishing effort near the Dutch national coast, resulting in less steaming time to the fishing areas.

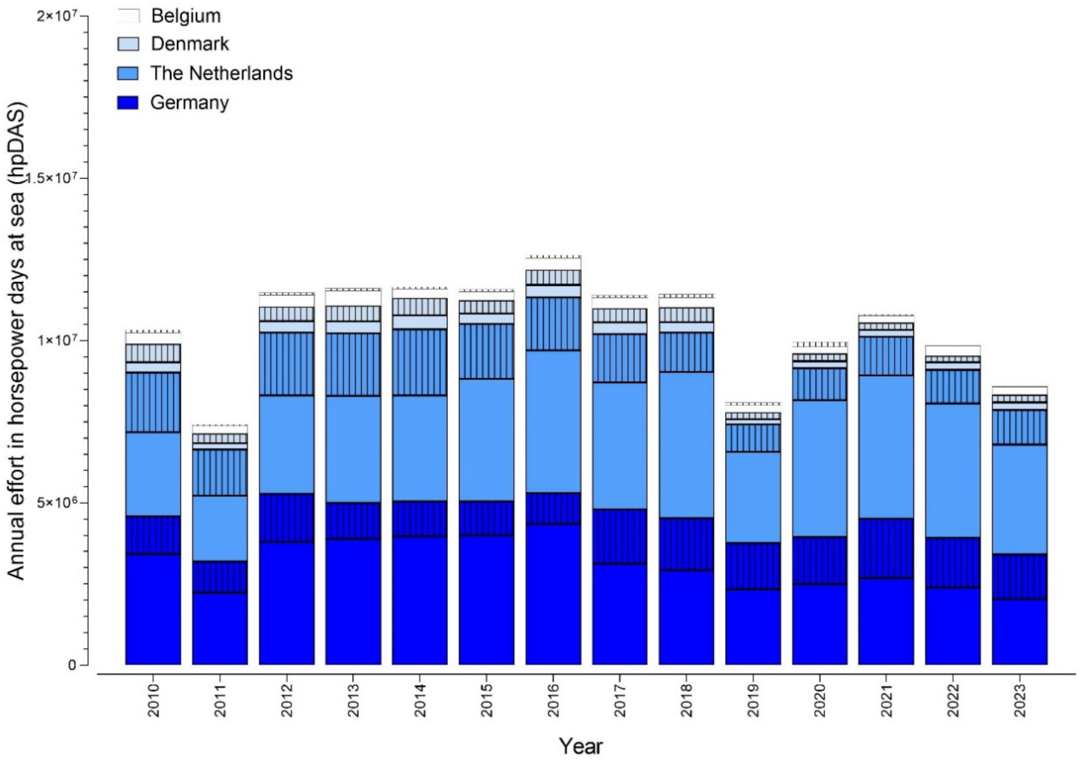


Figure 1.3 Total effort in horsepower days at sea (hpDAS) per country. Effort is split into fishing time and steam time (= striped). *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

The landings per unit effort (LPUE) over the years show similar trends for most of the countries (Figure 1.4). Lowest LPUE are generally given by the United Kingdom. Since the generally high LPUE in 2018, the values have decreased especially for the Dutch, German and Danish fleet and are in the lower range of the time-series. In 2023, annual LPUE (kg per hpDAS) were 1.5 for the Netherlands, 1.8 for Germany, 2.9 for Denmark, 1.0 for Belgium, 2.0 for France and 0.5 for the United Kingdom. It must be emphasized that Belgium and the Netherlands in particular had very low LPUE. For the Netherlands, it was even the lowest LPUE value of the country-specific time-series. For Belgium, it was comparable to the period from 2004–2009.

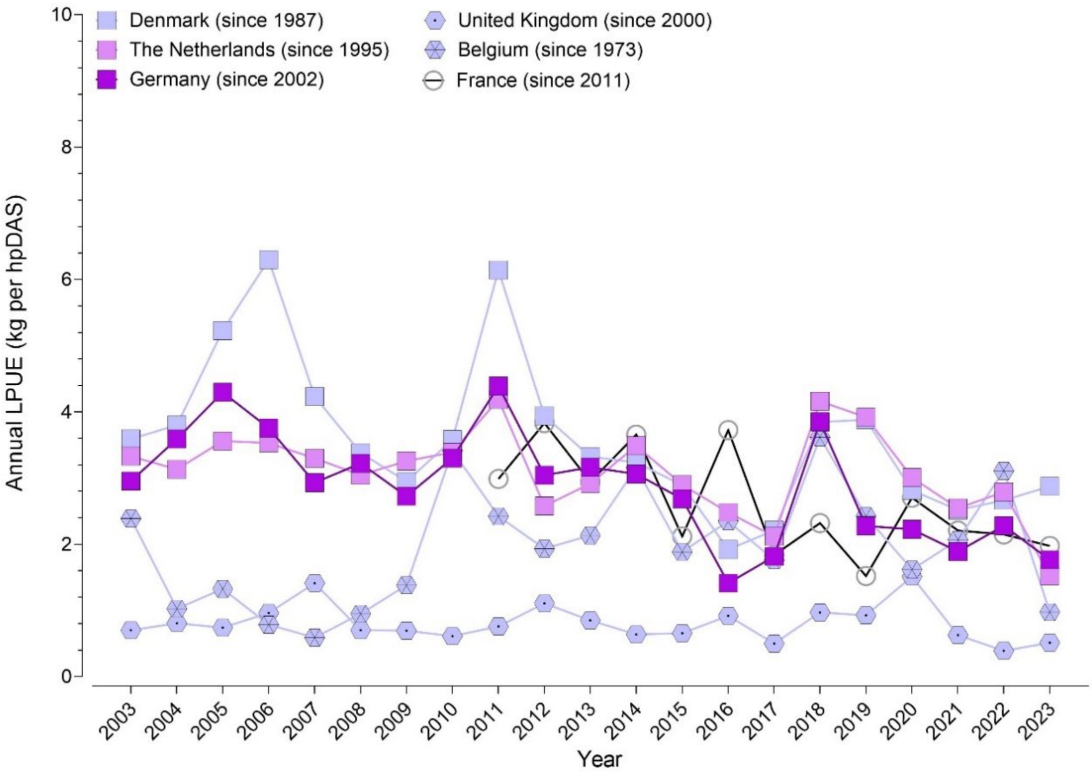


Figure 1.4 Annual landings per unit effort (LPUE) in kg per horsepower days at sea (hpDAS) of the brown shrimp fishery by country. The numbers in brackets indicate the year since the data became available for WGCRAN. *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

1.2 Landings and effort statistics 2023

1.2.1 National annual landings

In 2023, the largest share of the total *C. crangon* landings belonged to the Netherlands (45.3 %), followed by Germany (40.2 %), Denmark (8.9 %), United Kingdom (3.2 %), Belgium (1.8 %) and France (0.6 %; Figure 1.5).

Except for Denmark who landed a total of 1338 tonnes and the United Kingdom, who landed 471 tonnes, all countries showed a decline in brown shrimp landings. The Netherlands landed 6778 tonnes, which is less than half of the biomass landed annually since 1995. German landings had already decreased in the years before, but were further decreasing to 6018 tonnes in 2023. At 268 tonnes Belgium had its lowest annual landings since 1998 (189 tonnes). France landed 91 tonnes in 2023 (Figure 1.5).

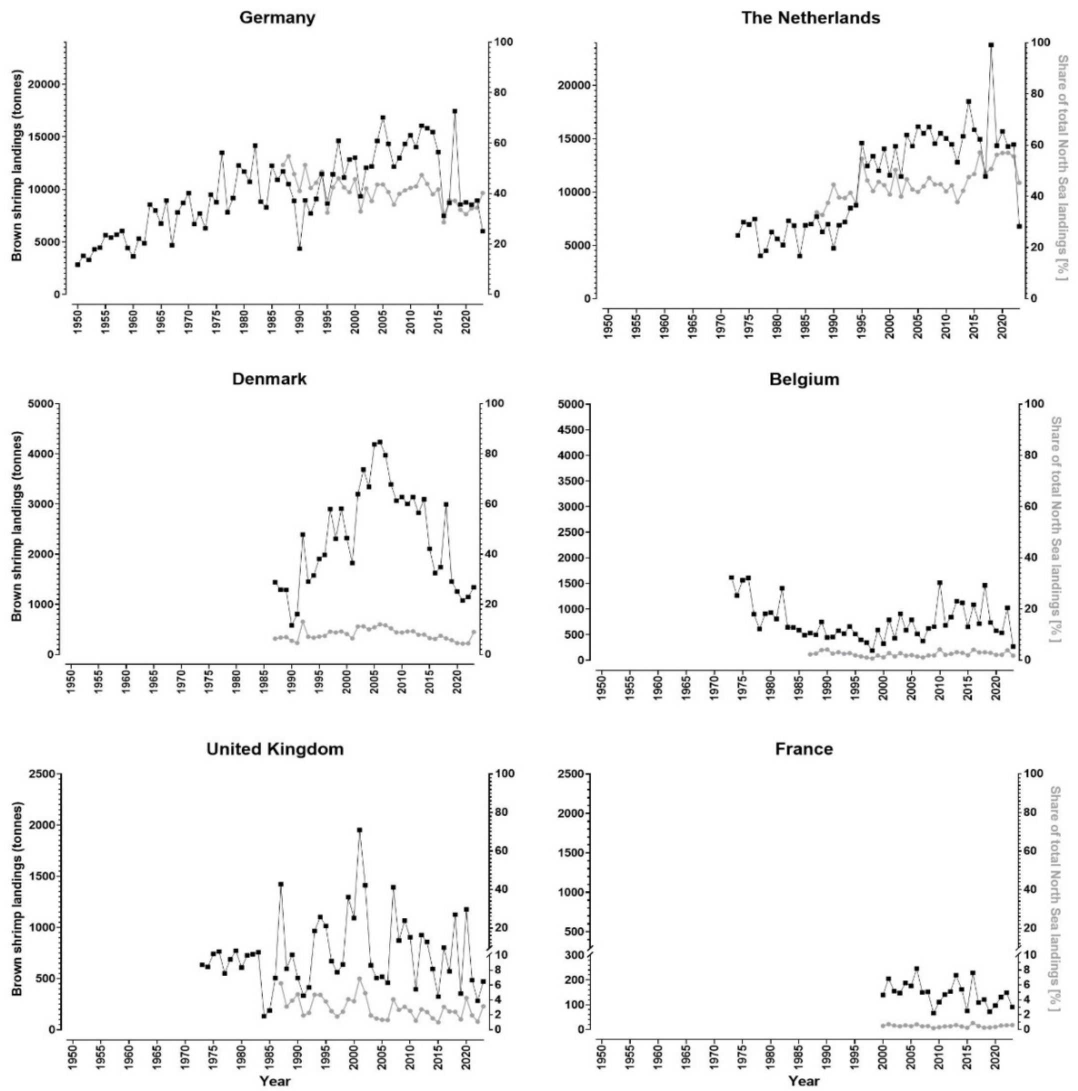


Figure 1.5 Country specific time-series of brown shrimp landed for human consumption (in tonnes). Data in grey give the percentage of landings in relation to total (whole North Sea, all nations). *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

1.2.2 National monthly landings, effort and LPUE

In 2023, both the monthly German landings and the monthly fishing effort were below the 10-year running mean (Figure 1.6 and Figure 1.7). Landings declined particularly from May to June and was accompanied by the same pattern of decline in fishing effort. The monthly LPUE values were below the 10-year running mean but within the respective standard deviation over the course of the year (Figure 1.8).

For the Dutch fleet, landings in 2023 (Figure 1.6) were well below the 10-year average from May onwards. As in Germany, the effort was below the 10-year running mean for most of the time (Figure 1.7). Combined with the low landings this still resulted in a Dutch LPUE that was well below the 10-year average, especially from June 2023 onwards (Figure 1.8). Comparing the two main fleets (Germany and the Netherlands), the monthly average patterns are similar, although in 2023 the German fleet achieved a higher LPUE relatively close to the country's 10-year average.

The Danish seasonal pattern of total landings in 2023 was below the 10-year average in most months, although it was always within the respective monthly standard deviations (Figure 1.6). As with the other countries, the effort in 2023 was mostly below the 10-year average (Figure 1.7), so the Danish LPUE value for 2023 generally followed the expected trend, although it was lower towards the end of the year compared to the 10-year average (Figure 1.8).

The Belgian landings in 2023 showed a strong deviation from previous years and the 10-year average, as landings remained at a very low level throughout the year and did not show the usual increase from July onwards (Figure 1.6). In the first half of the year, effort was above the 10-year average in some cases, but then did not increase any further (Figure 1.7). Comparable to the Netherlands, the Belgian LPUE values were well below the 10-year average from July onwards (Figure 1.8).

The landing pattern and magnitude in the UK fishery were as usual with a pronounced peak in autumn (Figure 1.6). In 2023, the peak was shifted by one month earlier which can be explained by a strong increase in fishing effort in August compared to the 10-year mean (Figure 1.6 and Figure 1.7). The LPUE values for UK in 2023 were stable on a low level during the entire year with a peak in July (Figure 1.8).

Despite the normal start to the year 2023 (even with higher landings in spring), monthly landings in France deviated strongly from the 10-year average and the last year's landings from summer onwards (Figure 1.6). Fishing effort was high in spring compared to the 10-year average and then fell below the average from July onwards (Figure 1.7). The French LPUE values for 2023 were above the 10-year average at the beginning of the year and then decreased steadily over the year. From November 2023, the level of the 10-year average was reached again (Figure 1.8).

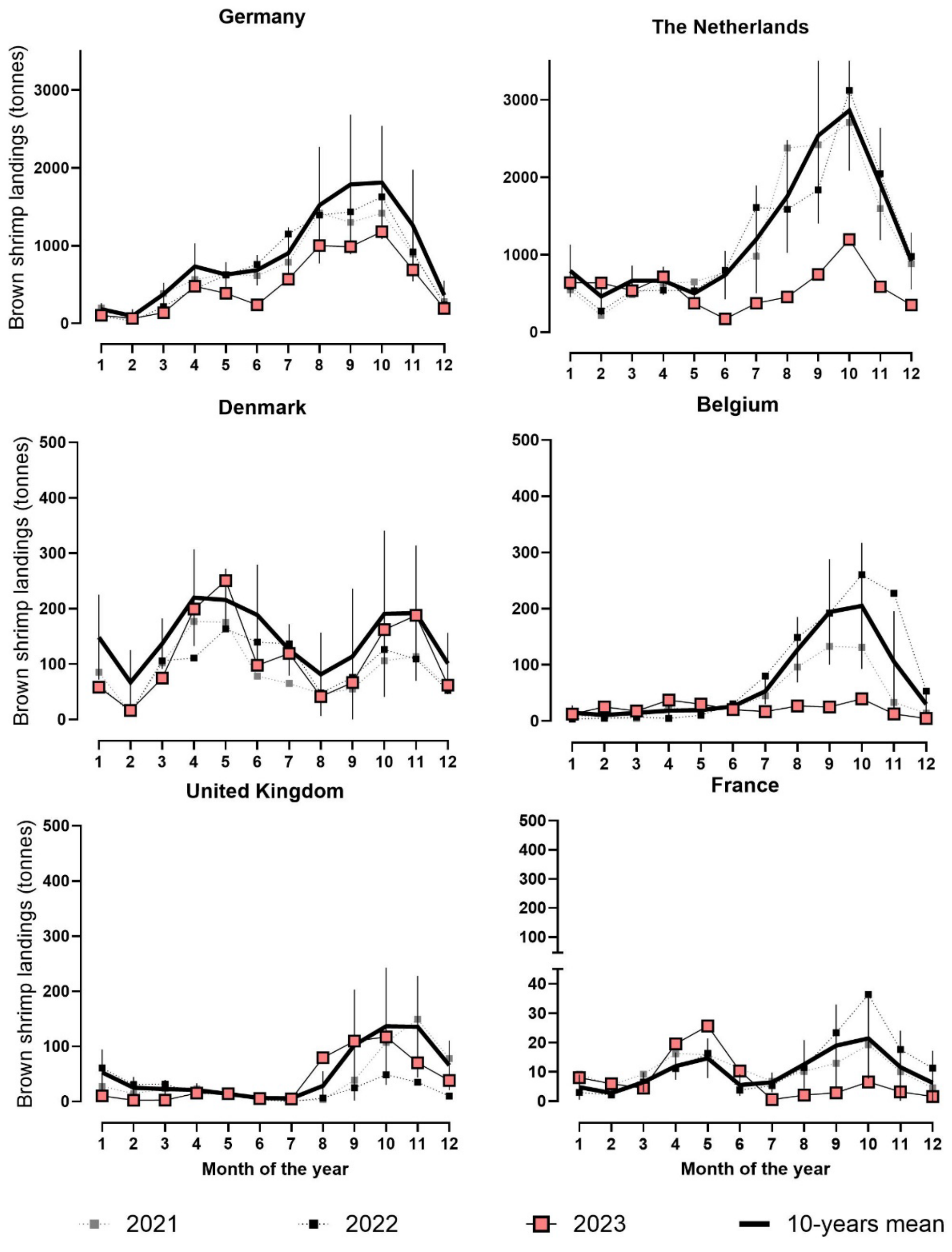


Figure 1.6 Monthly landings of commercial sized brown shrimp (in tonnes) per country in 2021, 2022, 2023 and the last 10 years 2014-2023 (10-years running mean +/- SD). *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

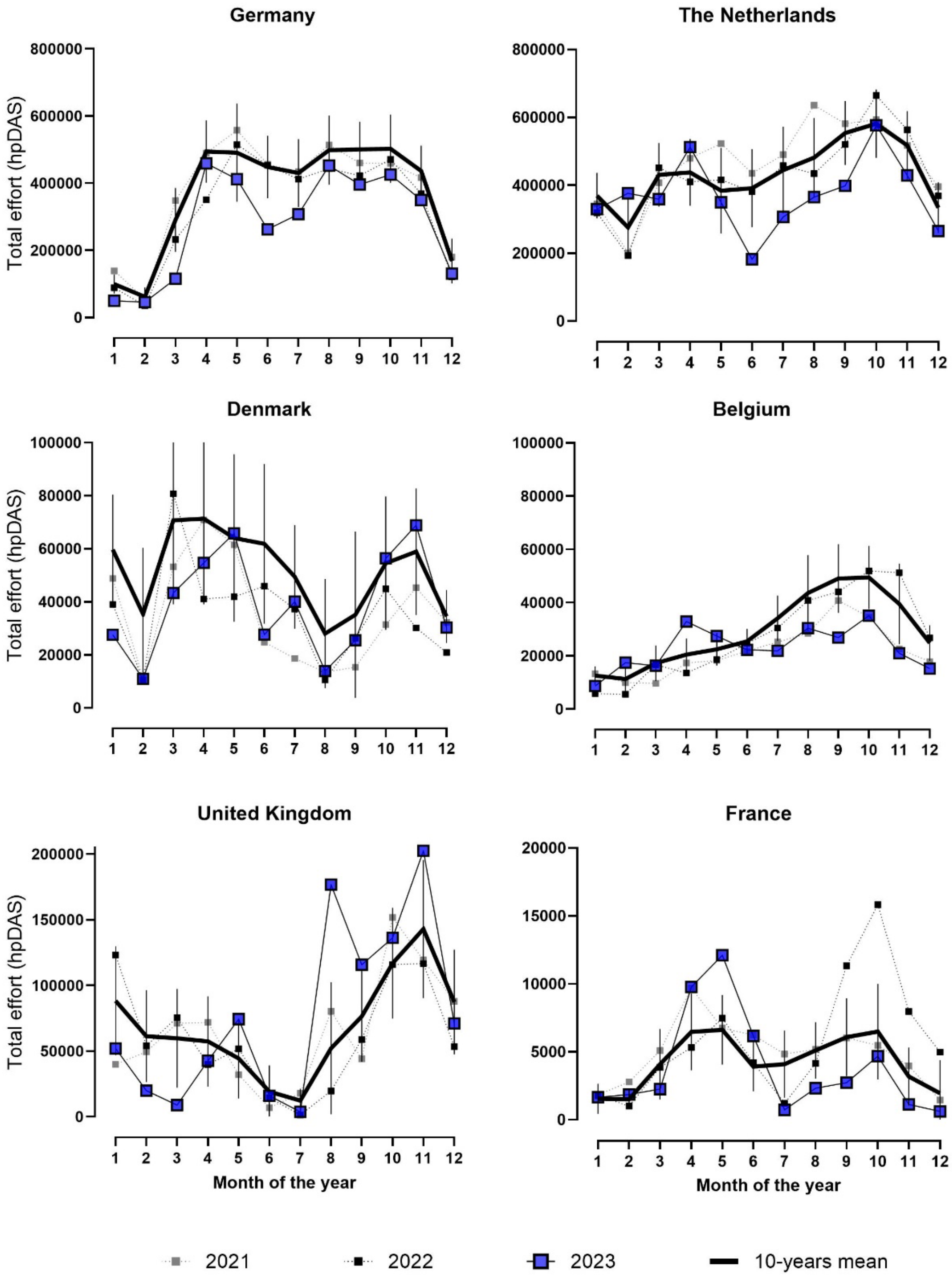


Figure 1.7 Monthly total fishing effort on commercial sized brown shrimp per country in 2021, 2022, 2023 and the last 10 years 2014-2023 (10-years running mean +/- SD). Effort is given as horsepower days at sea (hpDAS). *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, NL, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

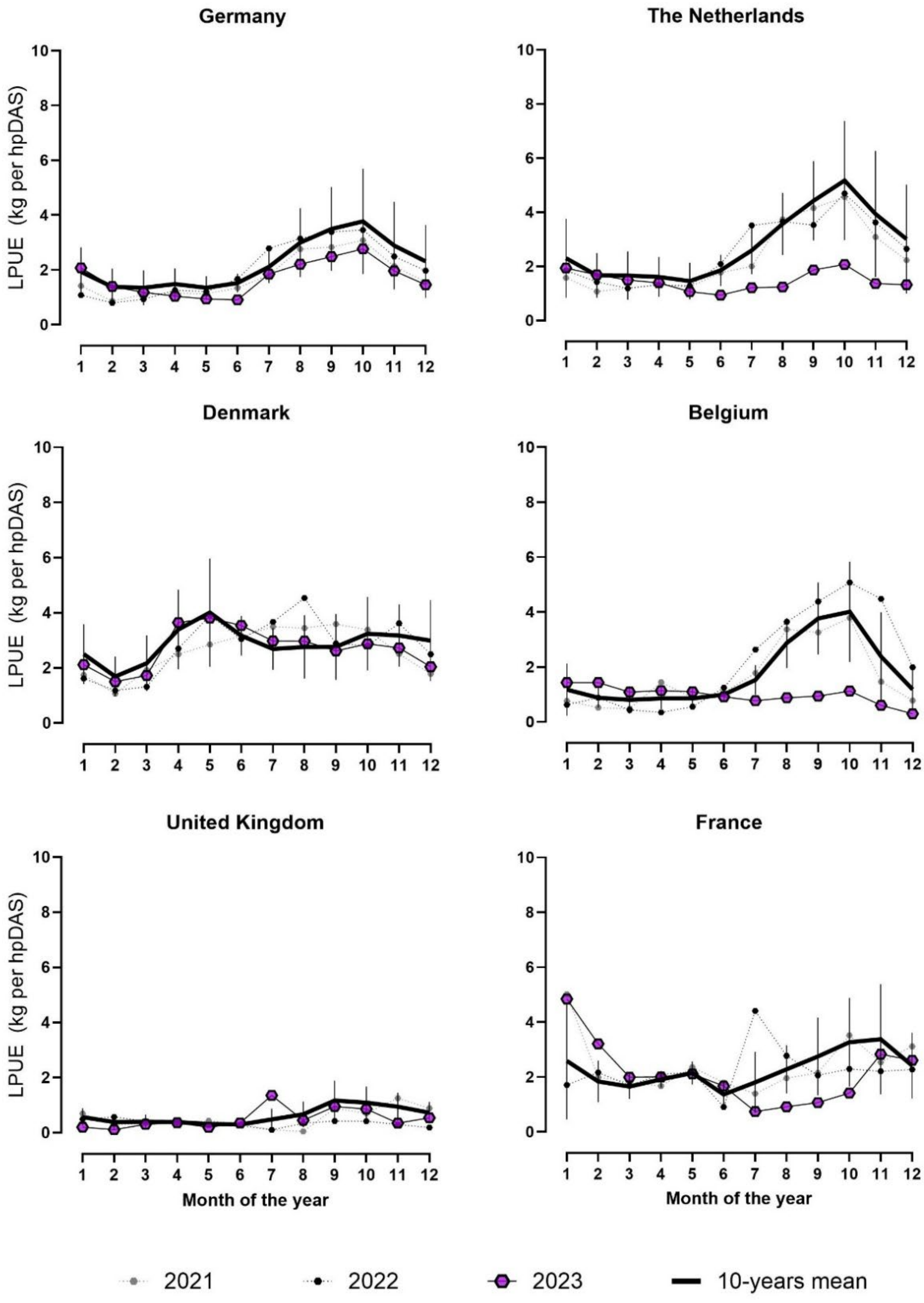


Figure 1.8 Monthly commercial sized brown shrimp landings per unit effort (LPUE) per country in 2021, 2022, 2023 and the last 10 years 2014-2023 (10-years running mean +/- SD). LPUE is given as in kg per horsepower days at sea (hpDAS). *Note: Since the introduction of the common workflow (WGCRAN Meeting 2022), the data are queried and updated annually retroactively back to 2009 (data from DE, DK and BE) from the EFLALO database. This may result in minor deviations compared to figures/values of previous reports.

2 Logbook information and VMS analysis

During the WGCRAN meeting, the group discussed a (possibly) different increase in winter fishing activity between countries and its possible negative affect the North Sea stock, especially in recent years. In this context, the already known influence of the warm winter temperatures of recent years was also discussed (Siegel *et al.,* 2005). To investigate a possible change in fishing effort at regional level, it was decided to analyse the time-series of the available VMS data of the individual countries. Due to problems with the timely delivery of the VMS data, the analyses had to be postponed until the next working group meeting at the latest.

The future workflow for this VMS/logbook analysis is described in Figure 2.1.

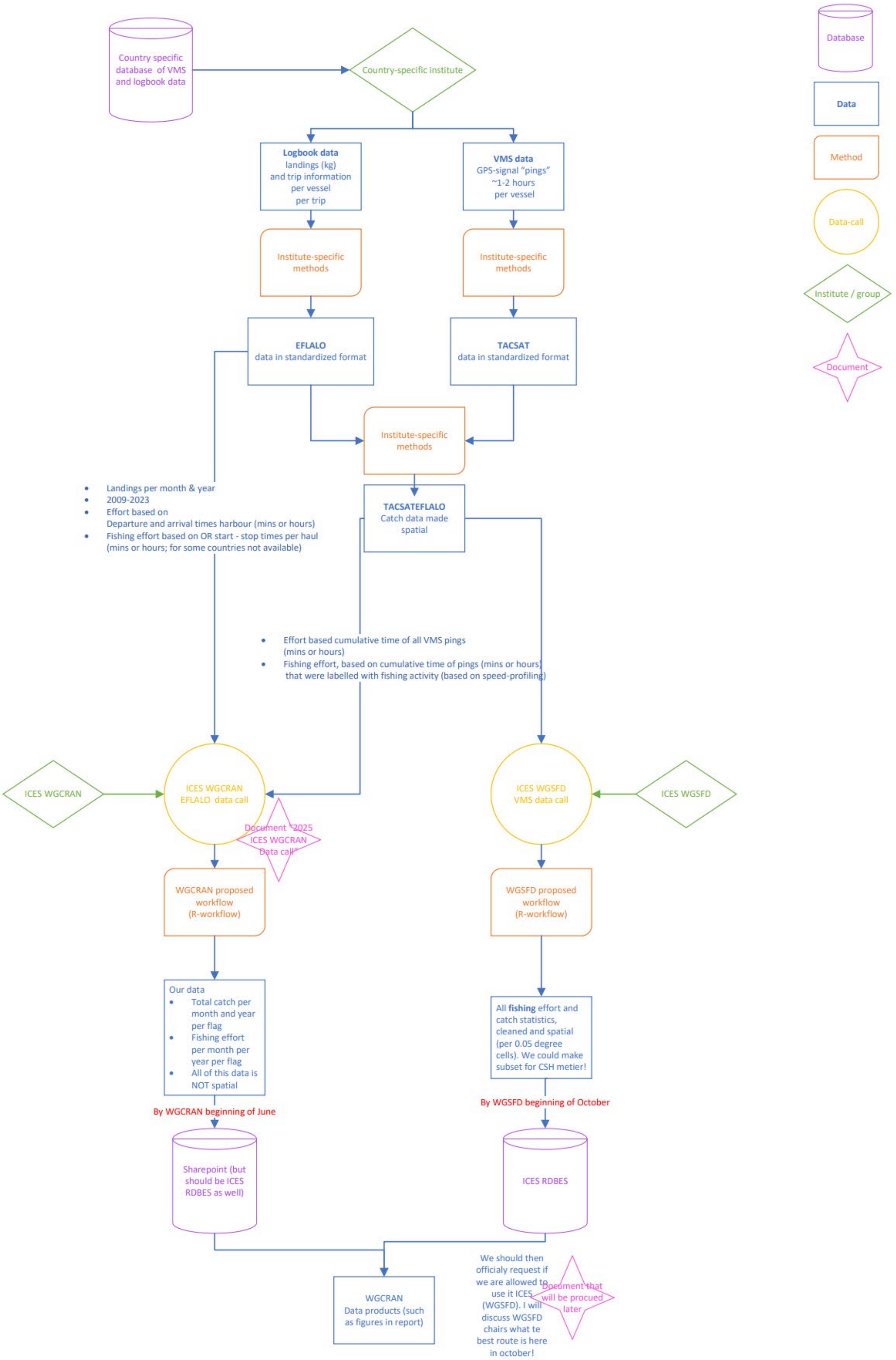


Figure 2.1 Workflow diagram describing data requirements and methods needed to create VMS/logbook data maps/figures.

3 Development of decision support tools (ToR c)

3.1 Simulating the effectiveness of the Harvest Control Rule (HCR) with a population model

The population model as described in Temming *et al.* (2017) was used in an updated version, based in effort, landings and temperature for the years 2013–2020. Effort and landings for the German EEZ were taken from combined VMS and logbook data as described in Respondek *et al.* (2021) and updated during the WGCRAN meeting in 2021 (ICES, 2022). Although the model runs on a daily basis, the results of landings etc. are calculated based on monthly effort values. The values for landings, biomass and egg production in the fourth year of the simulation were used for the evaluation of the HCR, after reaching a stable state.

3.1.1 Conversion of reference values for the simulation

The reference values as used in the Management plan are calculates as 70% of the mean LPUE of the years 2002 and 2007, based on landings in kilograms (kg) and effort in hours at sea (HAS) of the German fleet. The input effort for the model is in fishing hours at sea (fihas), resulting in the LPUE from the simulation being in kg/fihas. To compare the LPUE from the model with the reference values from the management plan, a conversion factor was used.

3.1.2 Decision building in the simulation model

The LPUE from the simulation is calculated on a monthly basis. If the LPUE falls below the (adjusted) reference value, the effort is limited in the first two full weeks of the following month, depending on the reference value (Figure 3.1). The LPUE is of this month is calculated again, and if it is still below the reference value, the restriction is extended by another two weeks. If at least the last week with effort limitation is in a month with an LPUE above the reference value, the restriction is withdrawn.

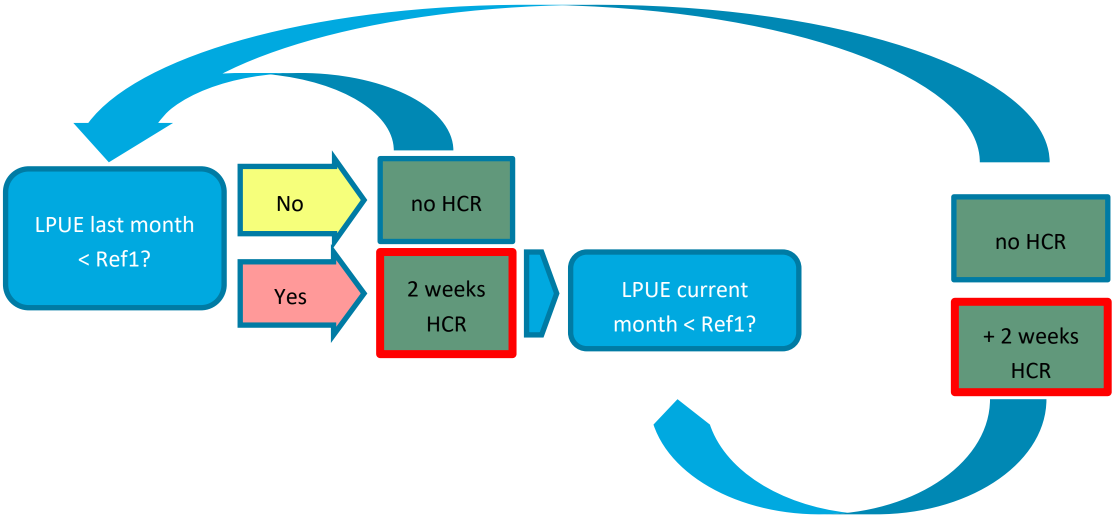


Figure 3.1 Decision model used for the HCR simulation.

3.1.3 Potential effort reduction of the fleet(s)

The implementation of the management in 2016 did already result in first effort restrictions in the following years. To get a value for the unrestricted effort per vessel and week, we used the logbook data for the German fleet from 2002 to 2015 as reference fleet. We summed up the effort for each vessel, week and year and restricted the effort of those vessels with more than first 72, then 60, 48 and 36 HAS to this limit. The mean of the difference of the restricted to the unrestricted year resulted in one value for potential effort reduction per week. For the simulation purposes, the fishing mortality for weeks with effort restrictions in place was reduced by the respective potential effort reduction (Lim1-Lim4, Figure 3.2). One of the alternative HCRs tested was a two-weeks closure when the first reference value was missed (HCR99). Only a small test-fishing would have to be allowed in this case, to get actual LPUE values. This approach was simulated by reducing the effort by 99% for two weeks. In this case, the model could still produce some landings for LPUE calculation. The resulting effort reduction per week and effort limitation are shown in Figure 3.2.

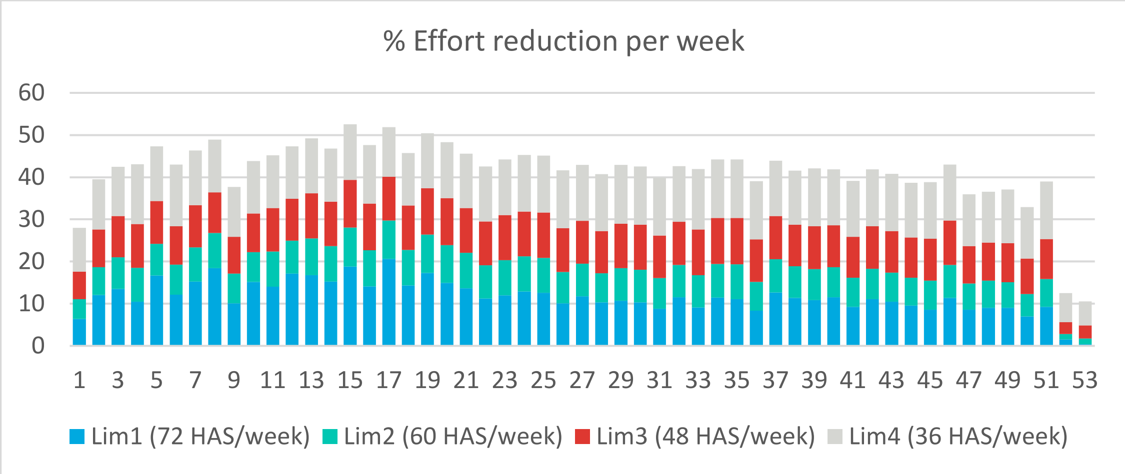


Figure 3.2 Percentage of effort reduction per week when different limits in hours at sea apply to the German reference fleet. Lim1-Lim4 were used to reduce the fishing mortality in the simulation when breaching the relevant reference value triggered the HCR action.

3.1.4 Scenarios for stock reduction

The model output of the SRIII is shown in Figure 3.3. The fourth year was used to calculate the LPUE based on the mean effort for the German EEZ 2013-2020. Two low abundance scenarios were simulated:

1. Stock reduction to 70%
2. Egg-loss November-December

For Stock reduction to 70%, the initial number of starters at the beginning of the modelling were reduced to 70% of the SRIII value. For Egg-loss November-December, the number of eggs starting to develop were reduced by 50% in the calendar days 206 to 365 (November and December) in year 3 of the simulation.

3.1.5 Stock reduction to 70%

In the scenario with the stock reduction to 70%, the landings in the last year were reduced (Figure 3.3). The LPUE fell below the reference value 1 in April and below the reference value 2 in May and June (Figure 3.3 and Table 2). As the first reference value was breached in April, this resulted in a first effort reduction to 72 hours at sea in the first two weeks of May (18 and 19) in the HCR72 scenario (Table 3.1). After applying this reduction, the LPUE in May was still below the second reference value. As result, the effort was restricted to 60 hours per week in the next two weeks of May (weeks 20 and 21). After that, the LPUE did increase above the second but still below the first reference value in May, leading to an additional restriction of the effort to 72 hours in the weeks 22 and 23. The following restriction of the effort to 72 hours for the weeks 24-25 did not result in raising the LPUE above the reference values. After the first two weeks of July (26 and 27), the effort restriction was lifted (Table 3.1).

When the effort related to the first reference value was reduced to 60 hours per week, the effort had to be reduced from week 18 to week 23. The LPUE in June did increase above the first reference value and no further effort limitation did apply (Table 3.1).

In the HCR design with an effort reduction at the first reference value to 48 hours per week, already the first effort reduction in weeks 18 and 19 did lead to an increase of the LPUE in May above the second reference value. Another four weeks of effort limitation did result in the June LPUE being above the first reference value and the effort restrictions were lifted.

When the HCR is designed with breaching the first reference value results in a two-week reduction of the effort by 99%, the fishery is closed in weeks 18 and 19 (Table 3.1). Afterwards, the LPUE in May did already rise above the first reference value, such that the effort restriction is lifted.

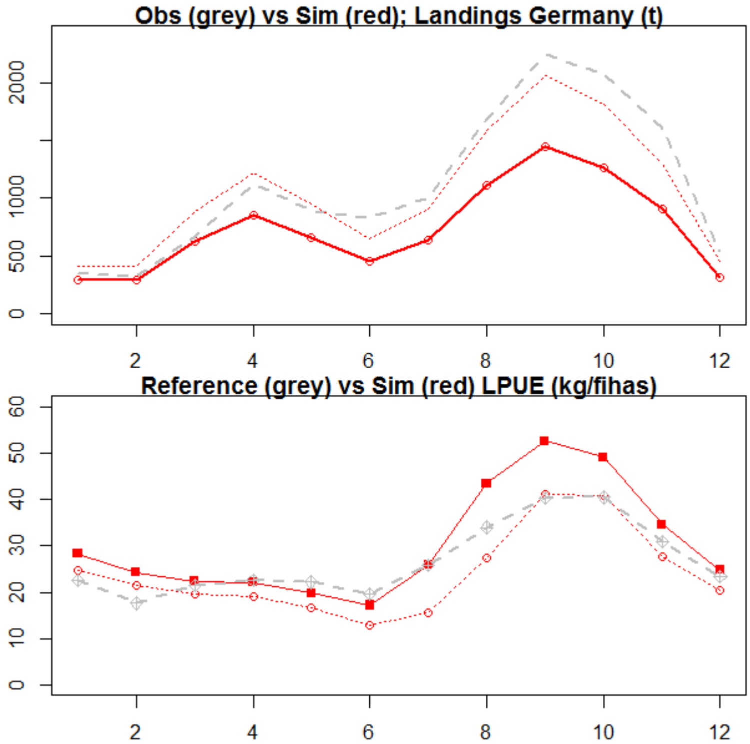


Figure 3.3 Year four of the simulation. Above: observational landings from VMS and logbook data (dashed grey line) the SRIII (dashed red line) and simulated landings (red solid line). Below: simulated LPUE (red solid line) and adjusted reference values (dashed grey line). The dashed red line shows the simulated LPUE of consumption shrimps.

Table 3.1 Effort restrictions and resulting LPUE values as stepwise implementation by the decision model. The effort was reduced by the relevant % regarding Lim1, Lim2, Lim3 or by 99% per week when the first reference value was missed. The column name displays the effort reduction (e.g. "Lim1") per week (e.g. "18_19"). The colour of the cell refers to the reference value that has been missed in each case. The bold numbers mark the final run for this scenario and the applied HCR.

Month		**HCR72**	**HCR60**	**HCR48**	**HCR99**
	no HCR	**18:27 Lim1**	**18:23 Lim2**	**18:23 Lim3**	**18:19 99%**
1	28.37	**28.37**	**28.37**	**28.37**	**28.37**
2	24.23	**24.23**	**24.23**	**24.23**	**24.23**
3	22.29	**22.29**	**22.29**	**22.29**	**22.29**
4	22.07	**22.09**	**22.10**	**22.11**	**22.19**
5	19.78	**20.81**	**21.37**	**21.81**	**23.71**
6	17.16	**19.13**	**19.98**	**20.79**	**20.82**
7	25.92	**28.29**	**28.08**	**28.72**	**28.43**
8	43.56	**45.23**	**44.93**	**45.34**	**45.01**
9	52.73	**53.80**	**53.50**	**53.73**	**53.50**
10	49.27	**49.97**	**49.75**	**49.90**	**49.79**
11	34.63	**35.07**	**35.00**	**35.12**	**35.21**
12	24.79	**25.18**	**25.20**	**25.32**	**25.53**

3.1.6 Egg-loss November-December

The recruitment failure, simulated by reduced eggs starting in November and December in year three, leads to lower landings in autumn year four. The LPUE breaches the second reference value from July to August and October to December and the first reference value in September (Figure 3.4).

Autumn season starts directly with the second reference value breached in July (Table 3.2, Figure 3.4). This resulted in a first effort reduction to 60 hours in the weeks 32 to 37 at the beginning of September and led to an increase in September LPUE above Ref1. In October, the LPUE did fall below Ref1 again, resulting in an Effort reduction from November on to 72 hours. The LPUE did stay below Ref1 until the end of the year, resulting in the weeks 45-52 being restricted to 72 hours per week.

When HCR60 is applied and the effort is reduced 48 hours in weeks 32 and 33, the LPUE in August increases above Ref2 but is still below Ref1. Thus, the effort is reduced to 60 hours in the weeks 34 and 35, leading to a further increase in LPUE above Ref1 in September. In October, the LPUE falls below Ref1 again, and Lim2 reduces the effort in the first two weeks of November (45 and 46) again. The LPUE did not rise above Ref1 until the end of the year again, leading to finally the weeks 45 to 52 being restricted.

In the HCR48 design the breaching of Ref2 in August leads to an effort reduction to 24 hours in the weeks 32 to 33. In course of this reduction, the LPUE rises above ref2, but stays below Ref1 in August. After two more weeks (weeks 34 and 35) with effort reductions to 48 hours, the LPUE of September is above Ref1 and the effort limits are lifted. In November, the LPUE falls below Ref1 again and the effort in the first weeks of December (49 and 50) is reduced to 48 hours. This limitation does not result in increasing the LPUE above Ref1, and the effort reduction stays in place until the end of the year. When the HCR is designed with a 99% reduction in effort when the first reference value is breached, the reduction in weeks 32 and 33 let the LPUE increase from below Ref2 to above Ref1 in August. The LPUE stays above Ref1 in September and October. In November, the LPUE falls below Ref1 again. An additional reduction of the effort in weeks 49 and 50 by 99% results in an increase above Ref1 in December (Table 3.2).

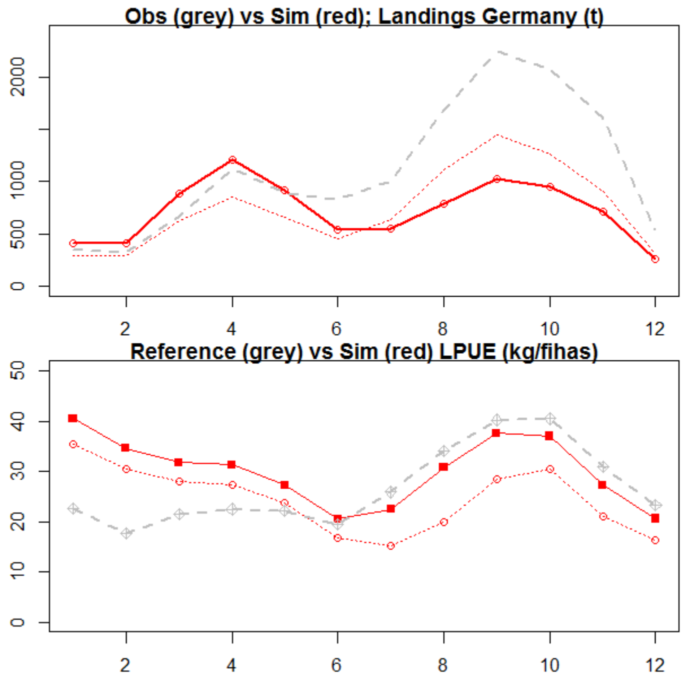


Figure 3.4 Year four of the simulation. Above: Observational landings from VMS and logbook data (dashed grey line) the SRIII (dashed red line) and simulated landings (red solid line). Below: Simulated LPUE (red solid line) and adjusted reference values (dashed grey line). The dashed red line shows the simulated LPUE of consumption shrimps.

Table 3.2 Effort restrictions and resulting LPUE values as stepwise implementation by the decision model. The effort was reduced by the relevant % regarding Lim1, Lim2, Lim3 or by 99% per week when the first reference value was missed. The column name displays the effort reduction (e.g. "Lim1") per week (e.g. "32:33"). The colour of the cell refers to the reference value that has been missed in each case. The bold numbers mark the final run for this scenario and the applied HCR.

		HCR72	**HCR60**	**HCR48**	**HCR99**
Month	no HCR	**32:37, 45:52**	**32:35, 45:52**	**32:25, 49:52**	**32:33, 49:50**
1	40,53	**40,53**	**40,53**	**40,53**	**40,53**
2	34,60	**34,60**	**34,60**	**34,60**	**34,60**
3	31,80	**31,80**	**31,80**	**31,80**	**31,80**
4	31,37	**31,37**	**31,37**	**31,37**	**31,37**
5	27,34	**27,34**	**27,34**	**27,34**	**27,34**
6	20,58	**20,58**	**20,58**	**20,58**	**20,58**
7	22,44	**22,44**	**22,44**	**22,44**	**22,44**
8	30,81	**31,45**	**31,90**	**32,36**	**36,15**
9	37,66	**40,92**	**40,48**	**42,04**	**43,27**
10	37,04	**40,07**	**39,32**	**40,58**	**41,52**
11	27,31	**29,50**	**29,27**	**29,41**	**29,93**
12	20,61	**22,45**	**22,65**	**22,18**	**23,65**

When the results of the different approaches for the full year are compared (Table 3.3), the effect on the landings is below 1% for all approaches. The effect on the biomass is the largest for the HCR99 approach, with an increase in biomass of 3.17% for the 30% stock reduction case and 2.99% for the recruitment failure case. The increase in the yearly egg production is also largest for the HCR99 approach with 12.23% respective 5.66% more eggs compared to the no HCR approach. The effort reduction for the full year is largest for the HCR99 approach, too; with 5.23% respective 5.9% less effort than in the no HCR approach (Table 3.3).

Table 3.3 Final results of all runs and scenarios. The scenario without HCR was used as 100% base case, the percentages in the columns HCR72 – HCR 99 display a surplus or reduction compared to the scenario without HCR.

		NO HCR	HCR72	HCR60	HCR48	HCR99
1) Stock reduction to 70%	Landings [1000 kg]	100%	0.43%	0.24%	0.32%	0.36%
	Landings consumption [1000 kg]	100%	0.66%	0.40%	0.52%	0.49%
	Effort [fihas]	100%	-3.53%	-3.95%	-4.99%	-5.23%
	Biomass [1000 kg]	100%	1.82%	2.02%	2.62%	3.17%
	Egg-production [1 Mio.]	100%	8.19%	9.13%	11.81%	12.23%
		NO HCR	HCR72	HCR60	HCR48	HCR99
2) Egg-loss November-December	Landings [1000 kg]	100%	-0.59%	-0.93%	-0.02%	-0.41%
	Landings consumption [1000 kg]	100%	0.07%	-0.30%	0.85%	0.82%
	Effort [fihas]	100%	-3.31%	-3.69%	-3.66%	-5.90%
	Biomass [1000 kg]	100%	1.75%	1.67%	2.09%	2.99%
	Egg-production [1 Mio.]	100%	2.40%	2.45%	3.61%	5.66%

3.2 Summary and outlook

The data used as basis for landings and effort have several limitations, as described in detail by ICES (2022) and Respondek *et al.* (2021). Specifically minor landings of other species than *C. crangon* cannot be ruled out totally, and the estimation of the effort based on fishing pings and logbook entries may lead to some under- or overestimation of the "real" fishing effort. However, those limitations are well-known, and the data are the best available estimate up to date.

The yield-per-recruit model used in this analysis can only display a stable state of the stock. It cannot yet be used to forecast stock development, nor can it yet be used to simulate long-term stock development or display stock–recruit effects (see Temming *et al.*, 2017 for details).

However, the model is used here to compare the effect of variations in one single variable on the stock in a stable state environment. Therefore, the deviations from the observed values are considered to be of minor importance regarding the conclusions drawn from the simulations. The model is used to simulate an exemplary year for the shrimp fishery, not to simulate any specific year and fishery.

Some behaviour, which has been observed in the field, cannot be simulated with this approach. For example, the first time the fishing effort was limited by the HCR, the fishers responded by fishing closer to the coast, essentially decreasing steaming time and leaving more time for fishing (ICES, 2019).

Nevertheless, it can be assumed that the conclusions drawn from this simulation exercise are the closest we can get to understanding the mechanizms behind the brown shrimp stock and its fisheries at the moment. Clearly, it can be deduced from the results that a short and sharp reduction of effort is the wisest approach – at least according to the modelling results. Although the differences may be not in the range to influence any decision on an economic basis, it should be discussed that a full closure of the fishery instead of on effort reduction leads to higher LPUEs, larger numbers of eggs released and, in the end, higher returns of investment compared to the approach followed by now. The current design of the HCR did not manage to raise the LPUE values above the reference values again.

4 Research on bycatch (ToR d)

The results of the trilateral co-sampling programme (2019–2022) were reported to the Scheveningen Group, and evaluated by the Scientific, Technical and Economic Committee for Fisheries (Beier *et al*., 2023; ICES, 2023). As a result, the "*de minimis* exemption for all species subject to catch limits in the fishery for brown shrimp" was further prolonged from 2024 to 31 December 2027. (CDR 2023/2459; STECF, 2023). The current legal text is as follows.

"*in the fisheries for brown shrimp by beam trawls using a mesh size of at least 22 mm and equipped with a sorting grid, sieve net or any other device that is approved by the Commission in accordance with Article 15(2) of Regulation (EU) 2019/1241, in the Union waters of ICES divisions 4b and 4c: a quantity of all species subject to catch limits, which shall not exceed 5 % of the total annual catches of all species subject to catch limits made in those fisheries*;" (CDR, 2023)

To support future bycatch estimations, observer-trips under the Data Collection Framework (DCF) are carried out in the Danish and German brown shrimp fishery, but since 2018 not in the Dutch shrimp fishery. Furthermore, Germany has continued their co-sampling programme whereas Denmark has begun a resumption of the co-sampling programme. The Dutch government has called to a meeting in January 2025 to discuss possibilities for renewed bycatch sampling in the Netherlands.

5 International survey data (ToR e)

5.1 Biological stock status indicators

5.1.1 Present and future work

The stock status indicators and biomass production estimation methodology described by Tulp *et al.* (2016), is currently applying different calculation modules (SAS scripts, R scripts, Excel files) in a step-by-step manner. These calculations have been based on national input data collected annually (not through DATRAS but submitted directly). The WGCRAN group is currently merging these different calculations into a unified R script, leveraging DYFS survey data on *C. crangon* available in DATRAS. This new approach improves data quality and reliability by using DATRAS, which incorporates corrections and updates over time. Additionally, the R script will be stored on the WGCRAN SharePoint, transitioning from the previously person-dependent procedures housed at individual institutes.

The R script streamlines biomass production estimation workflows for WGCRAN, enhancing data-driven insights into shrimp populations across the North Sea. It includes extended cleaning and quality-check procedures, as well as the allocation of hauls to specific subareas. Following the DYFS spatial subareas, coastal waters in Belgium, the Netherlands, Germany, and Denmark are divided into distinct WGCRAN subareas to facilitate regional production estimates. For hauls with missing WGCRAN area designations, spatial analysis of haul coordinates was used for allocation in R. Similarly, missing depth data were imputed using spatial analysis combined with a bathymetric map. The R script also checks for errors in length distributions, such as incorrect units (e.g. millimetres instead of centimetres), and corrects them accordingly.

WGCRAN plans to extend the biological stock status indices by incorporating Belgian DYFS data. This addition will provide insights into southern fishing areas relevant to *C. crangon* fisheries. The Belgian DYFS, part of the international Demersal Young Fish and Brown Shrimp Survey (Beier *et al.*, 2024), conducts an annual autumn (quarter three) survey in Belgian coastal waters to assess juvenile flatfish, primarily plaice (*Pleuronectes platessa*) and sole (*Solea solea*), as well as *C. crangon* abundance. Since 1973, 33 fixed sampling stations (Figure 5.1) have been surveyed using a standardized shrimp beam trawl (6 m beam length; 22 mm codend mesh size, no tickler chains) at 3 knots against the tide. These stations align with key flatfish nursery grounds along the Belgian coast.

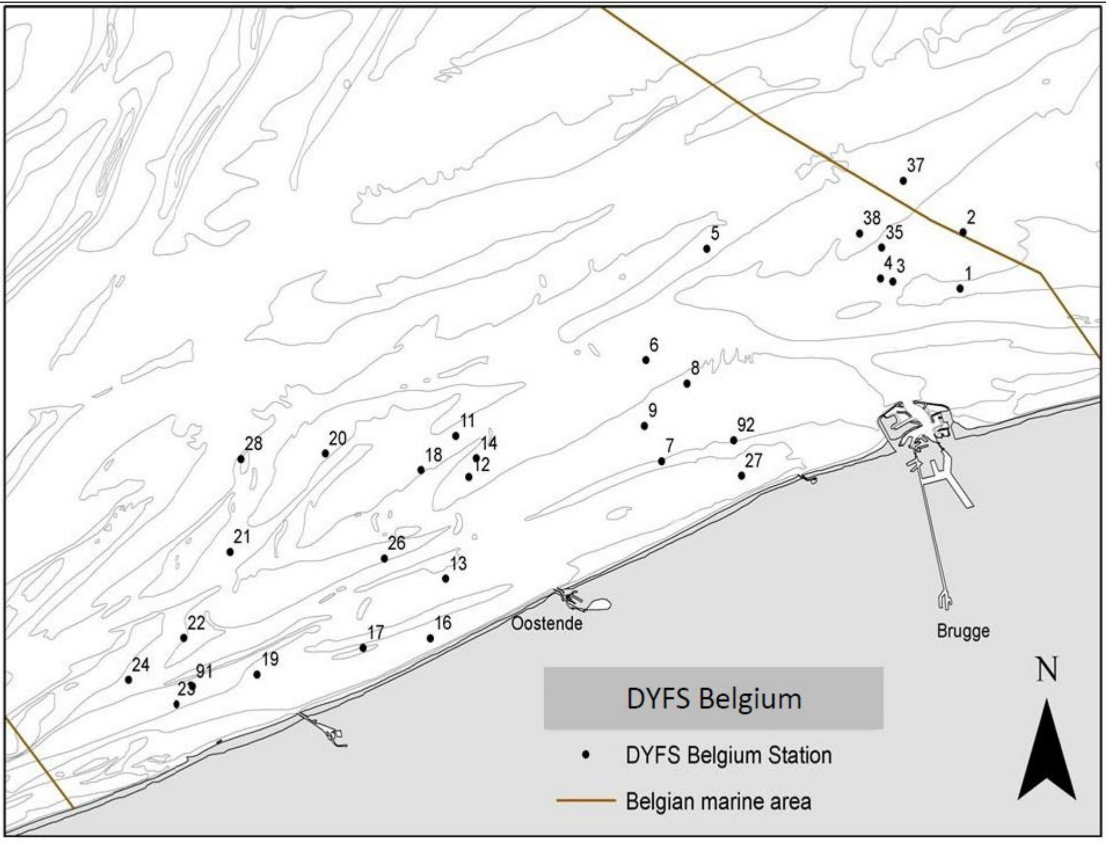


Figure 5.1 DYFS sampling stations in the Belgian coastal waters.

WGCRAN will compare the new R-based procedure using DATRAS data with the existing methodology, which relies on applying SAS scripts, R scripts, and Excel files on annually collected national input files (outside DATRAS). Initial comparisons will focus on Dutch and German data before incorporating Belgian data. The present stock indices are length-based, and preliminary analyses point to potential problems regarding differences in data collection methods across countries. Belgian data, for instance, exhibit a larger proportion of large shrimp, likely due to differences in length measurement protocols. The Belgian DYFS includes various sieving fractions and employs an automated image analysis system developed by ILVO, unlike in Germany and the Netherlands (Beier *et al.*, 2024). WGCRAN aims to harmonize these length distributions by potentially developing conversion factors, and by comparing non-sieved and sieved samples in the Belgian dataset.

The WGCRAN group has identified several areas for further development to refine biomass production estimation methodologies and improve data harmonization:

- **Imputation of missing haul distances:** Develop methods to calculate missing haul distance, based on haul duration and speed, or by using start and end locations.
- **Taxonomic consistency in DATRAS:** Resolve inconsistencies in species codes in DATRAS, where three different WoRMS AphiaIDs for 'brown shrimp' are found, to ensure standardized species allocation.
- **Validation of outlying DYFS haul coordinates:** Review and verify coordinates of DYFS hauls located outside defined WGCRAN subareas in collaboration with WGBEAM and national DYFS survey coordinators.
- **Comparison of national datasets and DATRAS inputs:** Conduct a comprehensive comparison between the historical national datasets and the DATRAS-derived data to assess differences and identify potential improvements.

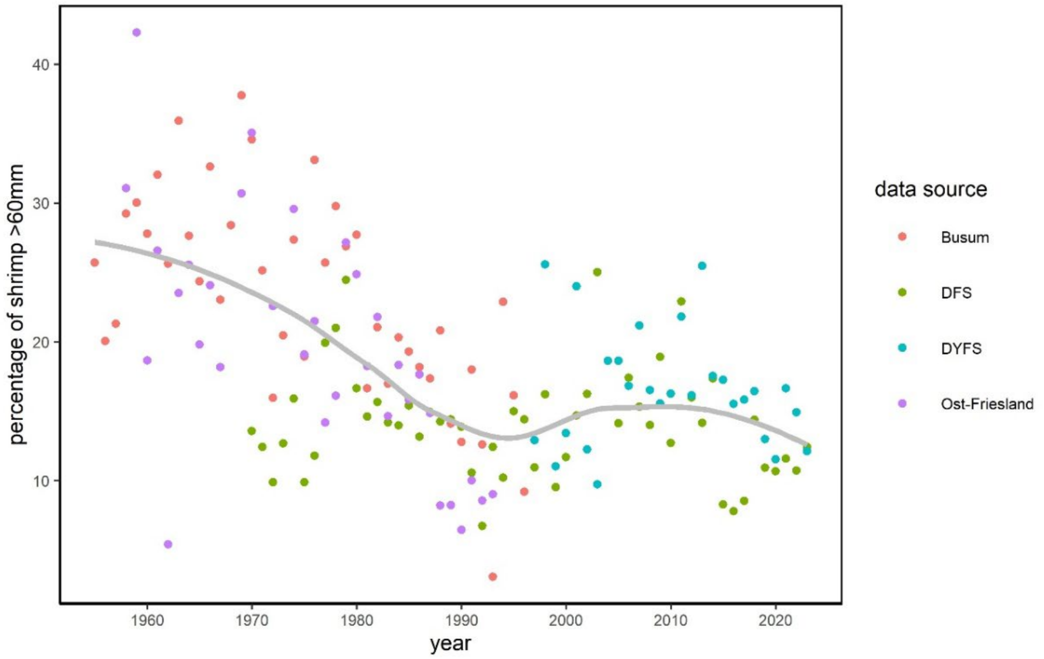
- **Impact of sieving on length distributions:** Investigate the effects of sieving on length distributions through statistical tests and evaluate field tests comparing sieved an non-sieved samples.
- **Mortality calculations:** Extend the current biomass production workflow with a dedicated script to calculate mortality rates.
- **Incorporation of Belgian DYFS data into stock indices:** Expand the biomass production indices to include southern fishing areas.
- **Integration of multiple surveys:** Explore methods to combine different survey datasets into a unified survey index, following approaches used by WGNSSK, to improve robustness and comparability. Hereby, effects of different gears and vessels used in the different surveys may be accounted for.
- **Exploration of SPiCT model feasibility:** Once a unified survey index is developed, explore the applicability of a Stochastic Production Model in Continuous Time (SPiCT) for *C. crangon*. This model could provide further insights into stock dynamics, productivity, and exploitation rates.

5.1.2 Fraction of large shrimps

The fraction of shrimps > 60 mm during 1955–2023 caught in different surveys conducted during autumn showed a decreasing trend over time until about 1990 (Figure 5.2). However, the decreasing overall trend may partly be explained by different dataseries, where bycatch time-series data (Büsum and Ost-Friesland) were collected 1955–1996, and coastal scientific surveys (Dutch and German DYFS) time-series data collection started later within the included period. The proportion of large shrimp decreased in both bycatch time-series (Büsum and Ost-Friesland), and the proportion of shrimp >70 mm stabilized in the 1990s. The proportion of shrimps >60 mm in the scientific surveys showed a moderately increasing trend from 1990 until about 2010, during which period it varied from 10 to 25% (Figure 5.2). Since 2016, survey data indicate that the fraction of large shrimp is more stabilized at lower levels. In the Dutch data, the fraction of large shrimp was exceptionally low during 2015–2017, and since 2018 the fraction of large shrimp has been comparatively low in both the Dutch and German data.

5.1.3 Estimated mortality

After a continuous increase in total annual mortality (Z) during 1955–1995, there has been strong annual variation (Figure 5.3, for methods see Hufnagl *et al.* (2010)). From 1994, there was a decreasing trend until 2008, thereafter there was no clear trend until 2019, when the estimated total mortality was similar to the previous maximum level in the early 1990s. However, from 2019 (when the estimated mortality was unusually high) and onwards, the mean estimated annual total mortality (Z) was 5.7 $year^{-1}$, i.e. slightly higher than the mean during the whole period (5.5 $year^{-1}$). The estimates of total mortality may be affected by circumstances, e.g. seawater temperature, limited fishing effort in periods etc., which may affect the proportional contributions from winter and summer cohorts in the survey data. It is desirable to complement the estimated mortality with standardized length distributions to support the interpretation. The aim is to do this in future, in connection to the new procedure to calculate biological stock status indicators, which is under development.



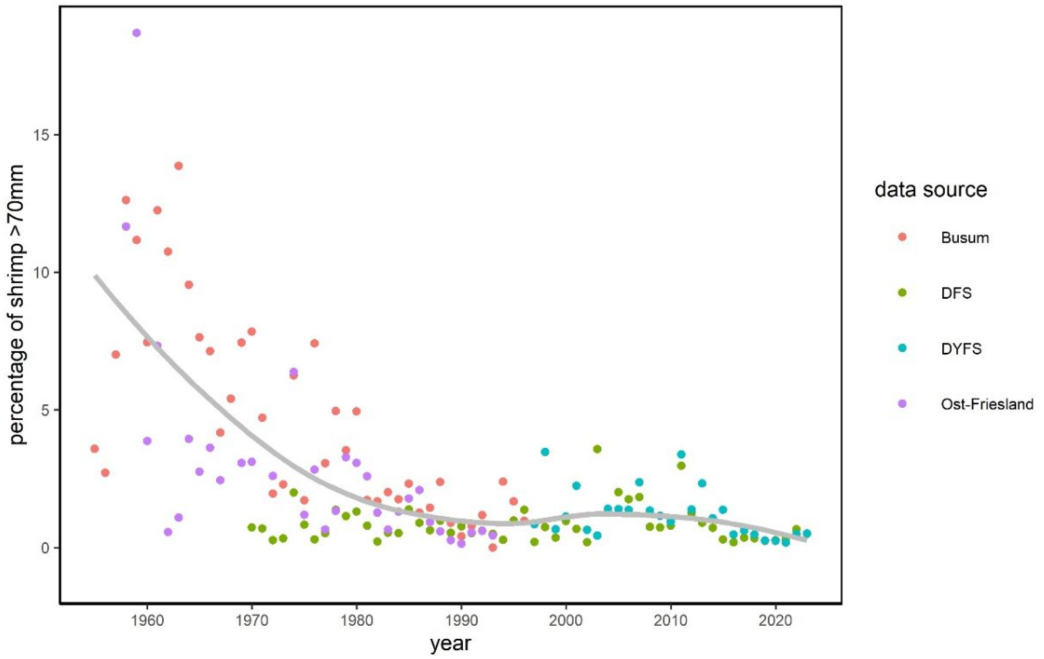


Figure 5.2 Time-series of proportion of large brown shrimp, >60 mm (top), and >70 mm (bottom), in four different survey programs. 'DFS' (the Netherlands; equivalent to DYFS) and 'DYFS' (Germany) are fishery-independent coastal surveys; Büsum and Ostfriesland are German bycatch time-series. Percentages are expressed as fractions (numbers) of all shrimp >45 mm. The grey line is a Loess smoother.

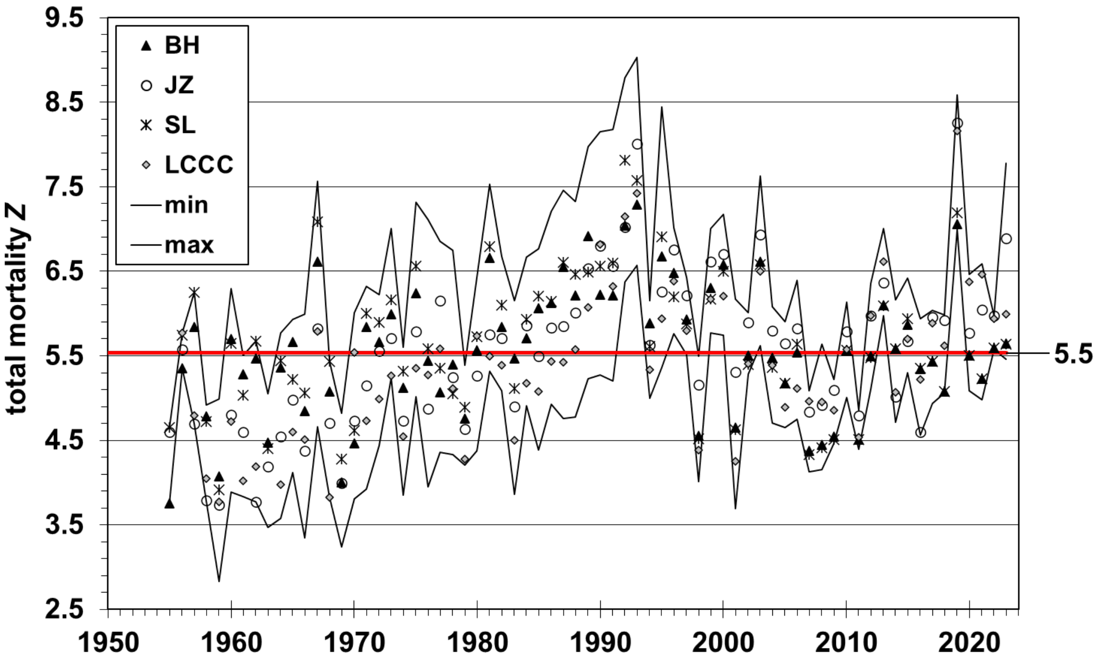


Figure 5.3 Total annual exponential mortality rate Z [year^{-1}] estimated for 1955-2023 using length-based methods, including Dutch and German survey data (DYFS). Four different methods were used (represented by the different symbols): Beverton and Holt (BH), Jones and van Zalinge (JZ), Ssentongo and Larkin (SL) and Length Converted Catch Curve (LCCC). Red line=mean during the whole period; methods and validations are presented in Hufnagl *et al*. (2010).

5.1.4 Swept-area biomass estimate

A swept-area biomass index of *C. crangon* combining the Dutch and German DYFS was used to compare stock indices with annual landings data (Tulp *et al.*, 2016). In Tulp *et al.* (2016) total biomass production was also calculated based on the swept-area estimate of brown shrimp biomass. In this report we include the swept-area estimate (Figure 5.4), not the full biomass production estimate (taking mortality estimates as well as various assumptions into account). During the period 2010–2020 the swept-area biomass index varied from approximately seven to 14 thousand tonnes. Since 2020, the average swept-area biomass was estimated to approximately eight thousand tonnes, with a somewhat decreasing trend in the latest years (Figure 5.4).

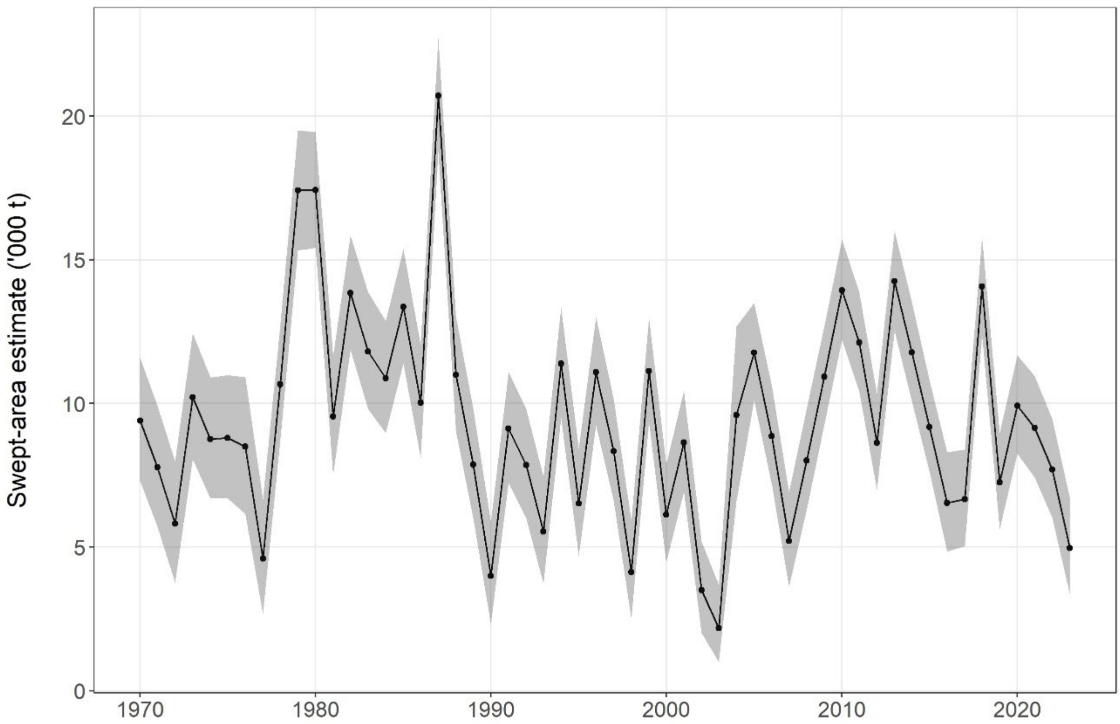


Figure 5.4 Time-series 1970–2023 and 95% confidence limits (grey area) of the swept-area biomass estimate of large-sized brown shrimp ≥ 50 mm calculated according to Tulp et al. (2016) based on Dutch and German DYFS survey data.

6 Legislation, law and management (ToR f)

6.1 MSC

In order to achieve a high long-term sustainable yield, the first MSC management plan for brown shrimp (MSC, 2015) aimed for a gradual increase in mesh size from 22 mm (in 2016) to 26 mm (in 2019). Over time, further adjustments were made to the implementation, so that in 2019 the mesh size was increased to 24 mm and in 2023 it was only increased to 25 mm instead of 26 mm. As a compensation for the smaller mesh size than originally planned, a reduction in fishing effort was agreed in order to meet the management objectives (MSC, 2014). The conditions for Germany, Denmark and the MSC certified fishers from the Netherlands can be found in Table 6.1.

A number of Dutch fishers decided in 2024 to withdraw from the MSC certification.

Table 6.1 Effort reduction plan for the MSC certified brown shrimp vessels in the Netherlands (CVO), Germany (MSC-GbR) and Denmark (DFPO) source (North Sea Brown shrimp management plan V 2.1).

CVO	
Measure period:	Calendar week 1 to 9
Reduction scheme:	W1. Max. 768 hours at sea to be filled in freely within the reduction period (reduction of 204 hours at sea) *or* W2. Max. 84 hours at sea per week to be filled in freely within each week; stacking of hours from multiple weeks not possible (reduction 24h per week)
Measure period:	Calendar week 25 to 36
Reduction scheme:	Z1. Max. 84 hours at sea per week to be filled in freely within each week; stacking of hours from multiple weeks not possible (reduction 24h per week) *or* Z2. Two weeks of seven consecutive days without any effort. This scheme is only possible with advance registration of chosen weeks before 17.06.2024 *or* Z3. Max. 864 hours at sea (36x24h) to be filled in freely within the reduction period (reduction 432h)
MSC-GbR	
Measure period:	Calendar week 1 to 8
Reduction scheme:	The sea time per vessel in weeks 1-8 is limited to a max. of 650 h (50% limit: 8x168h = 1344h).
Measure period:	Calendar week 26 to 35
Reduction scheme:	Two weeks of seven consecutive days without any effort. This scheme is only possible with advance registration of chosen weeks. *or* No shrimp fishing on Saturday and Sunday in these weeks.
DFPO	
Measure period:	1st of January to 31st of December
Reduction scheme:	Vessels are allowed to fish using 25mm meshes and will have a reduction period in fishing effort in week 26-35. Specifically, fishing is prohibited from Friday 9.00 until Sunday 18.00 in all weeks.
Measure period:	1st of January to 31st of December
Reduction scheme:	Vessels are allowed to fish using 24mm meshes and will have two reduction periods in fishing effort. The two periods with restrictions are: 1. Fishing is prohibited from Friday 9.00 until Sunday 18.00 in weeks 26-35. 2. No fishing is allowed from week 4-8 (both weeks inclusive).

6.2 Denmark

From 01 January 2025 the Danish government is applying a CO_2 toll on fuel used in the fishery. In the years 2025–2029 there will be a partly compensation until it's fully implemented in 2030 (Lov, 683).

6.3 The Netherlands

The Dutch Natura2000 areas each have a yearly maximum allowed amount of total collective fishing hours for the shrimp fleet, estimated from using VMS data. If the maximum allowed hours (based on a reference value) is reached, the fishery in that area is stopped. In some of the Natura2000 areas the effort during the later years have not reached the maximum allowed amount, but in other areas they have (de Vries *et al.*, 2023).

The nature permits for shrimp fishing in Natura 2000 areas are expected to be given in July 2025 for a multiyear period. So far there have been approximately 170 requests for renewed licenses. One requirement for obtaining a license is that a Black box device is mounted and in working order on the vessel. This equipment collects more detailed data on shipping routes, speed etc. compared to what is collected by VMS and can identify when actual fishing is taking place. Furthermore, the Dutch national limitations regarding nitrogen emissions have led to catalytic converters being installed on board many vessels. In connection to renewed nature permits, this will also be taken into account.

In 2021, 19 licences out of the Dutch shrimp fishing fleet were decommissioned (Hamon *et al.*, 2023). There is governmental investigation taking place regarding possible further decommission, with the aim to reduce fishing effort to ensure ecological and economic sustainability. The potential fleet reduction runs in parallel with other potential management adjustments, within a trajectory to form a future vision for the Dutch shrimp fishery.

6.4 Belgium

For Belgian commercial shrimp fishers with TBB in areas IVb and IVc, a 5% *de minimis* rule applies to all demersal species relative to the total catch. This is valid with a mesh size of at least 22 mm and gear equipped with a sorting grid, sieve net, or other EC-approved devices.

Vessels using TR3 (otter trawling for shrimp) must be equipped with a sieve panel year-round.

Belgian Sieve net Requirements for shrimp beam trawlers (01 December –31 May):

- Mandatory for trawls with a mesh size of 16–31 mm.
- Should allow marine organisms and debris to escape through an opening in the net.
- Maximum sieve net mesh size: 70 mm.
- Escape opening: at least 15 open meshes, placed max. 30 meshes before the codend.
- Secondary codend (optional): mesh size ≥80 mm, positioned at least 50 meshes before the primary codend.

7 Ongoing research and projects in the period 2022–2024 (ToR g)

For an informative overview, all (inter-) national *Crangon* related projects known to the working group are listed in the following table (Table 7.1). Information on the German 'Innovation Program' (sub-chapter 7.1), the Danish 'REDUCE GAS SHRIMP' (sub-chapter 7.2) and the German 'CRANMAN' (sub-chapter 7.3) can be found in the following sections.

Furthermore, a description of a project on marine spatial planning, which focuses on a better understanding of the impact of increasing wind energy area needs (= the Greater North Sea Basin Initiative 'GNSBI'), can be found in sub-chapter 7.4.

Table 7.1 Overview in alphabetic order of projects in the period 2022–2024 related to *Crangon crangon* (fishery) research.

Project name	Country	Time	Description
Bycatch reduction in the North Sea brown shrimp beam trawl fishery	DK	2019-2023	Document and reduce bycatch of fish with special emphasis on juvenile TAC species. This includes the development of a BRD and a co-sampling programme for the Danish *de minimis* exemption
CRANIMPACT	DE	2018-2023	Impact of shrimp fishery on the seabed
CRANMAN	DE	2018-2022	Scientific studies on the biology and fisheries of the common brown shrimp *CRANgon crangon* as the basis for an efficient self-MANagement System
CRANMAN II	DE	2023-2026	Follow-up project: Scientific studies on the biology and fisheries of the North Sea shrimp *CRANgon crangon* as the basis for an efficient self-MANagement system
Co-sampling shrimp fishery	DE	Since 2019	Estimating discard percentages of TAC species in the German shrimp fishery for a *de minimis* exemption
Co-sampling shrimp fishery	NL	2021-2023	Estimating discards of quota species in the Dutch shrimp fishery for a *de minimis* exemption - https://research.wur.nl/en/publications/a-co-sampling-program-to-asses-bycatch-in-the-dutch-brown-shrimp-
Future vision for shrimp fisheries	NL	2024-2025	For the development of a future vision for shrimp fisheries in the Netherlands, WMR has provided compiled information on effects of shrimp fisheries on issues in connection to nature conservation, e.g. as basis for advice to a "shrimp commission" (started in 2024). Report and plan for future research due Q1 2025.
Innovation Program	DE	2020-2025	Studies to improve fishing gear based on ideas from the fishery, e.g. to reduce bycatch and environmental impact
IRC shrimp	NL	2019-2023	International Research Cooperation Shrimp; development of an international platform for stakeholders (WP1) and data collection on bycatch in Dutch shrimp fishery (WP2). Report due Q1 2025.

Project name	Country	Time	Description
iSeal	DE	2021-2024	Investigation of the effects of **climate change**, **fisheries** and **invasive species** on the Wadden Sea National Parks of Lower Saxony and Schleswig-Holstein
LED there be light, SYMAPA, OPTITOG	BE	2018-2023	Trials using LED light and OPTITOG laser beam technology in brown shrimp fishery
Management scenarios of shrimp fisheries	NL	2022-2023	Investigating ecological and economic effects of three main management scenarios using modelling approaches, project for the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature Ecologische en sociaaleconomische effecten van alternatieve beheerscenario's voor de garnalenvisserij - Research@WUR
Passive shrimp fishing in the Wadden Sea	NL	Since 2023	Shrimp fishing using passive gear in the Dutch Wadden Sea https://research.wur.nl/en/publications/projectvoorstel-passieve-garnalenvisserij-op-de-waddenzee
REDUCE GAS SHRIMP	DK	2023-2026	The aim of the project is to reduce bycatch and emission of climate gases in the Danish brown shrimp fishery through gear changes/adaptations.
SepCran	BE	2018-2022	Selectivity studies to minimize bycatch in shrimp fishery.
SHRIMPBREED	BE	2020-2023	Study on the technical and economic feasibility of brown shrimp (*Crangon crangon*) farming for product diversification.
Socio-economic impact analysis of fisheries	NL	2022-2023	Implementing the landing obligation - what costs are involved for the shrimp fisheries sector? Implementing the landing obligation - what costs are involved for the shrimp fisheries sector? : a brief overview - Research@WUR
Socio-economic impact analysis of fisheries	NL	2021-2022	Economic impact analysis of management measures on the shrimp fishery Decommissioning of Wadden Sea shrimp fishing licences: Impact analysis of management measures on the fishery - Research@WUR
Structural Change Coastal Fisheries	DE	2021-2027	https://www.thuenen.de/en/cross-institutional-projects/structural-change-in-coastal-fisheries

7.1 The "Innovation Program"

7.1.1 Gear development - Discovering new ideas with the German shrimp fishery

The shrimp fishery in Schleswig-Holstein, Germany, is a traditional profession with over a century of history. Currently, shrimp fishing remains an essential economic and cultural cornerstone of the region, with around 78 vessels operating along the state's west coast, focusing primarily on the North Sea shrimp (*Crangon crangon*), with approximately 3975 tonnes landed in 2022.

However, the fishery faces significant challenges, particularly the high energy demands and fuel costs associated with the widely used beam trawls. Moreover, this fishery requires small mesh sizes to efficiently catch shrimp, leading to high levels of bycatch—unwanted marine organisms, including fish, invertebrates, and debris such as algae, wood, and stones. The bycatch is in most cases mechanically sorted onboard, often subjecting organisms to high stress and mortality, which raises ecological concerns.

To address these challenges, the "Innovationsprogramm Krabbenfischerei Schleswig-Holstein"(IPK) was initiated under the guidance of the "Krabbenfischereibeirat Schleswig-Holstein". This programme empowers fishers to develop and test their own solutions for reducing environmental impact. By encouraging innovative approaches within the industry, the IPK aims to harmonize traditional fishing practices with sustainability goals, ensuring the long-term viability of shrimp fisheries in the region. By combining the expertise and practical experience of fishers with scientific support, traditional fishing should be able to continue working in a future-orientated way with modern ideas. The core of the IPK is to provide fishers with a framework for fast-track development and testing of their own technological solutions to tackle present challenges in the fishery. Subsequently, there is an opportunity to further develop promising ideas or apply them comprehensively to the fishing industry.

To make fishing more sustainable, changes can be made to the fishing gear itself, for example, as well as to the sorting devices used. The fishers' ideas can also focus on reducing drag resistance and the resulting energy consumption, as well as on reducing interaction with the surrounding environment. To be active part of the project, the fishers are required to submit their innovation in a brief proposal to the management of the "Krabbenfischereibeirat" for funding under the IPK. They receive scientific support from the Thünen-Institute of Baltic Sea Fisheries as early as the development of the experimental setup and the application process. In addition to assistance with the application for financial support, the development and realization of ideas is also supported, as well as comprehensive instruction in data collection on board. The results and impressions of the fisher are then documented in a report for each project.

Data collection plays a decisive role in the implementation and testing of the individual innovative ideas. Data are collected as systematically as possible to allow comparisons to be made between the various projects at an annual workshop where the individual reports and the fishers experiences are shared among stakeholders. As a basis for the development of a relevant testing and data collection strategy, the desired objectives are identified for each innovation project prior to implementation and testing. The data are collected at sea during tests, mainly using self-sampling protocols under a detailed instruction by the scientific support team from the Thünen-Institute. Sea trials for testing new gear innovations are often arranged as paired-gear experiments, where a beam trawl with the targeted modification is towed besides a conventional beam trawl taken as reference. The nets used should be as identical as possible so that the catches and handling of both nets can be directly compared. Any differences in the catch quantity or its composition can thus be attributed to the modification made.

Overall, ten small fishers projects were successfully completed in 2023. These included, for example, modifications of the netting, technological alternatives to dolly ropes, or better sorting systems for bycatch mitigation. The technological progress being made under the Innovation programme has not slowed down in 2024, with some projects still running to date. The communication of those results is a key aspect of the project. Therefore, regular workshops are held, where stakeholders can exchange ideas and discuss results. The fishers have the opportunity to share the progress of the projects, as well as experiences and results, and to stimulate further discussions. As a result of previous workshops, additional ideas for future projects emerged. For the upcoming year 2025, a deeper exploration of the IPK will take place, focusing on projects previously carried out by the fishers that yielded promising results. The main goal is to further improve these ideas if necessary or to apply them commercially in fisheries.

Based on the evaluation of the projects conducted so far, a very positive overall conclusion can be drawn regarding the innovation program. The program has facilitated the establishment of many connections with commercial fishers who are highly interested in making fishing practices more sustainable. During the exchange of results and experiences, it became clear, that the innovation program is well-suited to provide an initial impression of the ideas and to assess their functionality. At the same time, it was evident that the short duration of each project limits the interpretability of the results. However, this trade-off between ease of implementation and the scientific validity of the results has already been incorporated into the design of the innovation program for shrimp fisheries.

There remains a significant need for further research in various focus areas, such as energy consumption, interaction with the seabed, and bycatch selection. From a scientific perspective, continuing the innovation program is highly valuable, as this form of transdisciplinary research benefits both science and the fishing industry.

7.2 REDUCE GAS SHRIMP (2023–2026)

7.2.1 Reduced climate gas emission in the Danish brown shrimp fishery

The aim of the project is to reduce emission of climate gases in relation to the catch of brown shrimp by the Danish fishing fleet. This will be accomplished by a reduction of the fuel consumption during the fishing trip and by a diminished benthic impact that that will lessen the diffusion of substratum bound CO2 and methane. Gear changes/adaptations also aims at reducing the bycatch, potentially giving higher yield per trip compared with the traditional gear setup in the Danish brown shrimp fishery.

All the gear changes that will be tested are either known/developed by the participating fisher, in other fisheries or from other nations and will adapt to the conditions of the Danish brown shrimp vessels and the fishery. The tested changes include but is not restricted to; inserts of large mesh panels (>= 100 mm), a lighter operated rolling beam, and a reduction in the numbers and a changed construction of the bobbins in the "ruller". The larger brown shrimp fishing nations Netherlands and Germany have many different ongoing experiments and if they find positive results within this project period it will be valuable to test this under Danish conditions. In addition, a reduction in the bycatch of other species is expected without a loss of landing size shrimps.

The project is co-funded in the period 2023–2026 by the European Union through the Danish Maritime, Fisheries and Aquaculture Programme (EMFAF).

7.3 CRANMAN (2018-2022)

7.3.1 Seasonal growth variability of common brown shrimp *Crangon crangon*

In the course of the CRANMAN project (2018–2022), a set of growth studies of separately kept individuals, revealed significant differences in growth potential within the season, under controlled laboratory conditions. In animals between 20 and 70 mm in length, a peak in growth potential was observed, which appeared at different points in the season depending on the animal size. While juvenile shrimp (20–35 mm) showed their maximum growth rates at equal laboratory conditions (ad libitum feeding/ 17°C / 12-12h light regime) in early summer (May to July), adult shrimps (>50 mm) grew significantly better towards the end of summer (Sep to Oct). Poorer growth rates observed before and after the peak in the respective length class indicated, that it is primarily winter egg recruits, that are responsible for the particularly good growth performance, whereas overwintered-, and summer egg recruits sampled in the same year show poorer growth potential. It is also winter egg recruits that make up the majority of commercially landed shrimp in autumn, which is why particular attention should be paid to this cohort in future conservation measures. A publication on this is in preparation.

7.4 CRANMAN 2 (2023–2026)

The work planned in the CRANMAN 2 project builds upon findings from the previous CRANMAN project regarding shrimp fisheries. While insights from the analysis of VMS data on shrimp recruitment and connectivity of the years 2009 to 2018 offer a solid foundation, a detailed examination of the years following 2018 is necessary due to significant disturbances caused by an unusually productive year and the COVID-19 crisis. Specifically, the project will analyse regional and seasonal variations from 2019 onward to assess the persistence of negative trends in LPUE (Landings per Unit Effort). Preliminary analyses indicate a significant relationship between winter fishing efforts in southern areas and catch rates in northern regions the following season. This suggests that overfishing in certain subareas could affect recruitment levels, necessitating a longer temporal perspective from 2009 to 2024. Focus will be placed on the northern spawning areas, which exhibited declines without significant correlations to winter fishing, raising questions about potential overfishing effects on recruitment. To investigate larval drift, data from various environmental factors will inform a multivariate approach scrutinizing seasonal and regional fish production. A particular emphasis will be on the ecological conditions around the Sylt-Rømø Basin, where existing data will be used to understand shifts in foodweb structure and potential trends affecting shrimp populations. Additionally, the project will delve into the discard mortality phenomenon, particularly examining the "wolf pack effect" to determine how congested fishing areas affect shrimp survival rates. Efforts will also be made to improve growth and mortality models to allow better predictive insights into shrimp populations under various management strategies. Finally, enhanced stakeholder collaboration through fisher surveys will support the development of management recommendations, ensuring economic viability and transparency in regulatory practices. The integration of fisher observations will be crucial in addressing issues of overfishing and recruitment sustainability.

7.5 Greater North Sea Basin Initiative (GNSBI)

For a better understanding of the impact of increasing wind energy area needs on the marine areas and actors within (cross sector, cross borders), the ministries of North Sea neighbouring countries started the Greater North Sea Basin Initiative (GNSBI). Within this initiative six work tracks aim to elucidate the different aspects of impact:

- **Governance:** Explores current and needed arrangements for the GNSBI to function properly
- **Nature restoration and conservation:** Setting up a program for cooperation regarding conservation, enhancement and restoration of nature
- **Multiple use of space:** Setting up criteria and sharing best practices on co-use and decommissioning/circularity of offshore wind energy
- **Cumulative impacts:** find a common approach on cumulative impact assessments based on existing work to identify and observe ecological boundaries and options for enhancement and protection of the marine environment.
- **Long-term perspective of fisheries:** Creating insight in key fisheries areas and socio-economic/food impacts of spatial developments at North Sea scale

- **Knowledge sharing:** Coordinating the exchange of best practices, (scientific) information, data, plans and assessments. The result of this work could be incorporated into the already established compendium

The aim of the work track Long-term perspective of fisheries is

1. Describing the spatial pressure through new and/or expanded anthropogenic activities on fisheries, e.g. by assessing their overlap with current fishing areas and to create a common evidence base:

   1.1 The 1st step is to achieve a common North Sea wide mapping of important fisheries areas linked to other indicators of importance e. g. volumes, value, [jobs offshore and onshore,] ports

   1.2 The second step is to forecast the roll-out of other anthropogenic activities by 2030 and overlay those with the mapped fishing areas to establish areas of conflict potential between fisheries and other anthropogenic uses.

2. **From this evidence base,**

   2.1 Develop recommendations how to better incorporate fisheries into the MSP process, and secure a long-term perspective for North Sea fisheries

   2.2 (Re)position fisheries in the wider range of human activities and environmental issues in the MSP process and/or develop other support/remedial measures, including by looking at possible opportunities/synergies arising from these new developments.

The workflow of point 1.1 (North Sea wide mapping) is organized in five steps (Figure 7.1.).

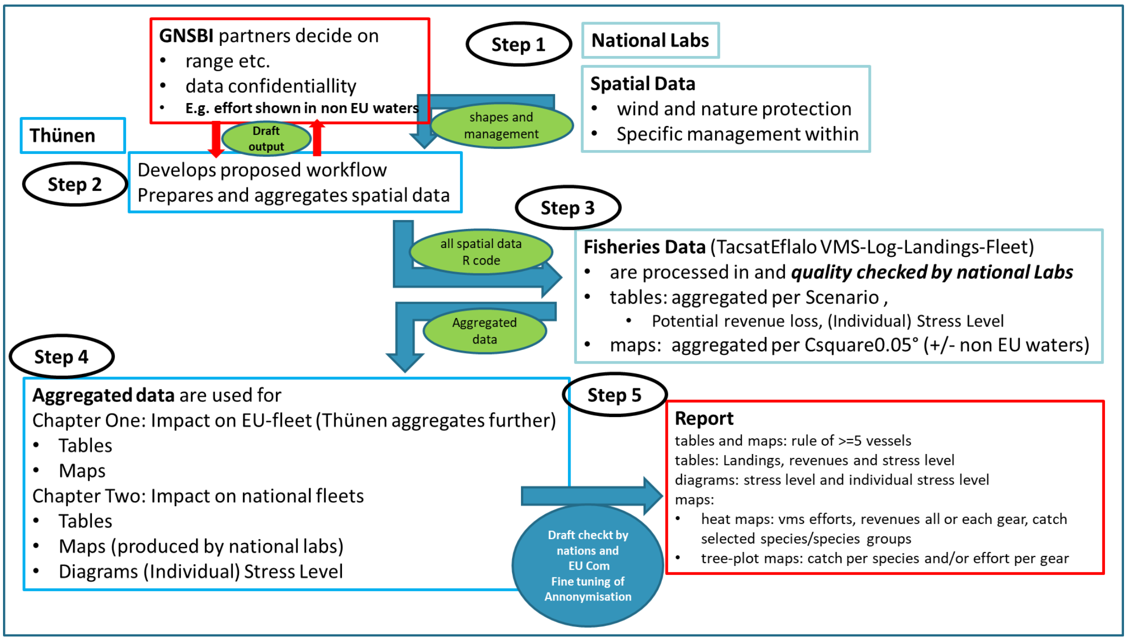


Figure 7.1 GNSBI work track "Long-term perspective of fisheries" workflow. The GNSBI area comprises northern waters from Ireland over Channel, Southern North Sea, German Bight up to Norwegian waters (Figure 7.2).

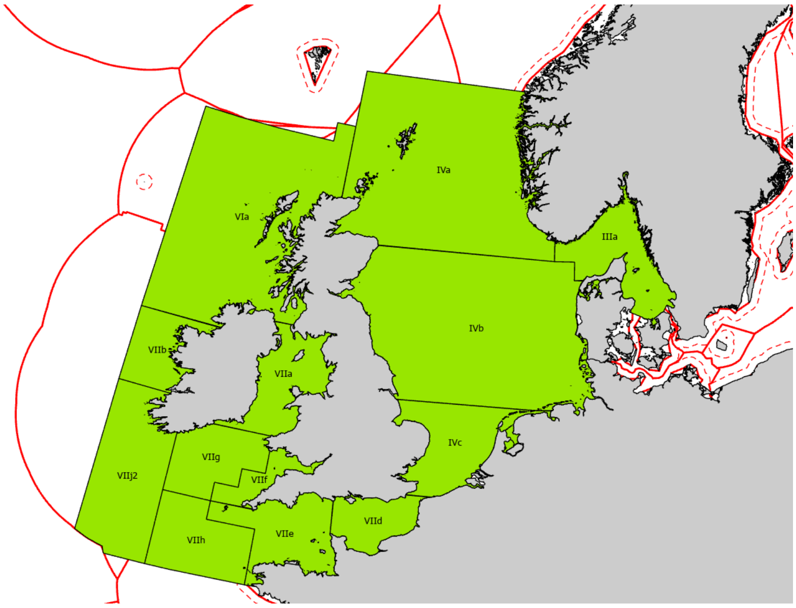


Figure 7.2 GSNBI area in green.

Due to the importance of the brown shrimp fisheries the effort, catch and revenues, and also the potential impact of wind farms and nature protection areas on the fisheries, is analysed separately.

The work is ongoing (January 2025) and the aim is to produce the report until summer 2025.

Reference list

Beier U., Chen C., Huenerlage K., Mosegaard H., Neitzel S., Nielsen A., Pedersen EM. (2023). Bycatch of TAC-species in the North Sea brown shrimp fishery. Results from trilateral co-sampling programmes. Appendix for the Scheveningen Group Brown Shrimp exemption report (March 2023).

Beier, U., de Boois, I. J., Haslob, H., Raat, H., and Vrooman, J. (2024). ICES Survey Protocols – Inshore beam trawl surveys, coordinated by Working Group on Beam Trawl Surveys (WGBEAM). *ICES Techniques in Marine Environmental Sciences* Vol. 70. 55 pp. https://doi.org/10.17895/ices.pub.25382437

Commission Delegated Regulation (EU) 2023/2459 of 22 August 2023 supplementing Regulation (EU) 2018/973 of the European Parliament and of the Council by specifying details of the landing obligation for certain fisheries in the North Sea for the period 2024-2027.

de Vries, P., & van de Pol, L. (2024). Garnalenvisserij in Natura 2000 gebieden: Een update tot en met het jaar 2023. (Wageningen Marine Research rapport; No. C085/24). Wageningen Marine Research. https://doi.org/10.18174/680479

Hamon, K.G., Giesbers, E., Hoekstra, F.F., Klok, A., Kraan, M., van der Veer, S., Verschuur, X., Deetman, B., 2023. Decommissioning of Wadden Sea shrimp fishing licences: Impact analysis of management measures on the fishery. Wageningen Economic Research, Report 2023-2023-032. 46 pp.; 13 fig.; 6 tab.; 21 ref. ISBN 978-94-6447-640-8 https://doi.org/10.18174/590257

Hufnagl, M., A. Temming, V. Siegel, I. Tulp en L. Bolle (2010). Estimating total mortality and asymptotic length of *Crangon crangon* between 1955 and 2006. *ICES Journal of Marine Science* 67(5): 875-884. https://doi.org/10.1093/icesjms/fsq003

ICES (2019). Report of the Working Group on *Crangon* Fisheries and Life History (WGCRAN), 9–11 October 2019, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/EPDSG:06. 68 pp.

ICES (2022). Working Group on *Crangon* Fisheries and Life History (WGCRAN; outputs from 2021 meeting). ICES Scientific Reports. 4:14. 77 pp. http://doi.org/10.17895/ices.pub.10056.

ICES (2023). Working Group on *Crangon* Fisheries and Life History (WGCRAN). ICES Scientific Reports. 5:93. 48 pp. https://doi.org/10.17895/ices.pub.24220471.

LOV nr 683 af 11/06/2024 https://www.retsinformation.dk/eli/lta/2024/683

MSC (2015) BROWN SHRIMP MANAGEMENT PLAN Version 1.0 (adopted 01.12.2015, in force from 01.01.2016) http://www.granatfischer.de/dokumente/MSC-Managementplan-01-01-2016.pdf

MSC (2024). NORTH SEA BROWN SHRIMP MANAGEMENT PLAN Version 2.1 (adopted 17.06.2024) https://garnalenvisserij.com/wp-content/uploads/2024/09/North-Sea-Brown-Shrimp-Management-Plan-V2.1_EN.pdf

Respondek, G., Günther, C., Beier, U., Bleeker, K., Pedersen, E. M., Schulze, T., & Temming, A. (2022). Connectivity of local substocks of *Crangon crangon* in the North Sea and the risk of local recruitment overfishing. Journal of Sea Research, 181, 102173.

Siegel, V., Gröger, J., Neudecker, T., Damm, U., & Jansen, S. (2005). Long-term variation in the abundance of the brown shrimp *Crangon crangon* (L.) population of the German Bight and possible causes for its interannual variability. *Fisheries Oceanography*, *14*(1), 1-16.

STECF (2023). Scientific, Technical and Economic Committee for Fisheries (STECF) - Evaluation of Joint Recommendations on the landing obligation and on Technical Measures Regulation (STECF-23-04 & 23-06). Publications Office of the European Union, Luxembourg, 2023.

Temming A., Günther C., Rückert C., Hufnagl M. (2017). Understanding the life cycle of North Sea brown shrimp *Crangon crangon*: a simulation model approach. Mar Ecol Prog Ser 584:119-143. https://doi.org/10.3354/meps12325

Tulp, I., C. Chen, H. Haslob, S. K., V. Siegel, J. Steenbergen, A. Temming en M. Hufnagl (2016). Annual brown shrimp (*Crangon crangon*) biomass production in Northwestern Europe contrasted to annual landings. *ICES Journal of Marine Science* 73(10): 2539–2551. https://doi.org/10.1093/icesjms/fsw141

Annex 1: List of participants

2024 Participants

Name	Institute	Country (of institute)
Annika Brüger	Thünen-Institute of Baltic Sea Research	Germany
Arlene Encendencia	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Bart Vanelslander	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Eva Maria Pedersen	DTU Aqua, National Institute of Aquatic Resources	Denmark
Georg Respondek	Institute of Marine Ecosystem and Fishery Science	Germany
Henrik Mosegaard	DTU Aqua, National Institute of Aquatic Resources	Denmark
Lara Kim Hünerlage	Thünen-Institute of Sea Fisheries	Germany
Merten Saathoff	Alfred-Wegener-Institute Wadden Sea Station	Germany
Serra Örey	Thünen-Institute of Sea Fisheries	Germany
Tamara Vallina	Wageningen University and Research	Netherlands
Thomas Lanssens	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Torsten Schulze	Thünen-Institute of Sea Fisheries	Germany
Ulrika Beier	Wageningen University and Research	Netherlands

2023 Participants

Name	Institute	Country (of institute)
Arlene Encendencia	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Claudia Günther	University of Kiel - Research and Technology Centre West Coast	Germany
Daniel Stepputtis	Thünen-Institute of Baltic Sea Research	Germany
Eva Maria Pedersen	DTU Aqua, National Institute of Aquatic Resources	Denmark
Georg Respondek	Institute of Marine Ecosystem and Fishery Science	Germany
Heleen Raat	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Henrik Mosegaard	DTU Aqua, National Institute of Aquatic Resources	Denmark
Jasper van Vlasselaer	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Lara Kim Hünerlage	Thünen-Institute of Sea Fisheries	Germany

Mattias van Opstal	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Serra Örey	Thünen-Institute of Sea Fisheries	Germany
Thomas Lanssens	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Tobias van Kooten	Wageningen University and Research	Netherlands
Torsten Schulze	Thünen-Institute of Sea Fisheries	Germany
Ulrika Beier	Wageningen University and Research	Netherlands

2022 Participants

Name	Institute	Country (of institute)
Anna-Marie Winter	Wageningen University and Research	Netherlands
Arlene Encendencia	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Eva Maria Pedersen	DTU Aqua, National Institute of Aquatic Resources	Denmark
Georg Respondek	Institute of Marine Ecosystem and Fishery Science	Germany
Heleen Raat	The Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
Henrik Mosegaard	DTU Aqua, National Institute of Aquatic Resources	Denmark
Julia Friese	Institute of Marine Ecosystem and Fishery Science	Germany
Lara Kim Hünerlage	Thünen-Institute of Sea Fisheries	Germany
Margarethe Nowicki	Institute of Marine Ecosystem and Fishery Science	Germany
Paul Müller	Hamburg University of Applied Sciences	Germany
Serra Örey	Thünen-Institute of Sea Fisheries	Germany
Sophie Neitzel	Wageningen Environmental Research	Netherlands
Stefanie Kurbjuweit	Hamburg University of Applied Sciences	Germany
Tiago Malta	DTU Aqua, National Institute of Aquatic Resources	Denmark
Torsten Schulze	Thünen-Institute of Sea Fisheries	Germany
Ulrika Beier	Wageningen University and Research	Netherlands

Annex 2: Resolutions

2021/FT/EPDSG05 The **Working Group on *Crangon* fisheries and life history** (WGCRAN), chaired by Kim Hünerlage, Germany, and Eva Maria Pedersen, Denmark will work on ToRs and generate deliverables as listed in the table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2022	21–23 June	Bremerhaven, Germany	Interim e-evaluation	
Year 2023	13–16 June	Oostende, Belgium	Interim e-evaluation	
Year 2024	18–20 June	Lyngby, Denmark	Final report by August 2024 to SCICOM	

ToR descriptors

ToR	Description	Background	Science Plan Codes	Duration	Expected Deliverables
a	Data collection of the status of the *Crangon* stock.	Report and evaluate population status indicators like recent landings and effort trends in the brown shrimp fisheries. Generate a standardized lpue time-series and provide a detailed description of the process of collecting the dataseries effort, landings and lpue for WGCRAN.	1.1; 2.1	year 1,2,3	A time-series analysis of the standardized stock indicators will be delivered by all WGCRAN members within the annual report(s)
b	Compilation of Logbook information and VMS analysis	To combine VMS, landings and effort data to develop a spatial indicator of shrimp distribution based on LPUE and to monitor regional distribution and regional shifts in fishing effort.	2.1; 2.4; 3.5; 5.4	year 1,2,3	Results will be presented in the annual report(s)
c	Development of decision-support tools for brown shrimp harvesting	To develop and evaluate brown shrimp-specific management decision-support tools to evaluate strategies on how to sustainably and efficiently harvest the brown shrimp stock.	2.1; 2.2; 5.1; 5.4 6.1	year 1,2,3	Results will be presented in technical reports, summarized in a peer-reviewed paper and included in the annual report(s)
d	Assessment of brown shrimp bycatch	Review the status and results of research on bycatch time-series and consider the implications for management. Evaluate methods and procedures used on board for collecting data on bycatch. Gather, compile and evaluate information on the onboard and ashore sieving fractions and processes and new national bycatch/discards data from e.g. DCF.	3.1; 3.2	year 1,2,3	Results as well as updates on the development of sampling procedures will be presented in the annual report(s)
e	Analysis of spatio-temporal trends of survey based stock indicators	Analysis of German, Belgian and Dutch scientific survey data to assess spatio-temporal trends of survey based stock indicators (e.g. biomass,	3.1; 3.2	year 1,2,3	Results will be presented in the annual report(s)

		length distribution, mortality); Ground-truthing of VMS derived lpue estimates.			
f	Overview of Legislation, Law and Management	Information on national legislation, laws and management concerning the brown shrimp fisheries in the whole North Sea will be synthesizesynthesized (e.g. Natura 2000, MSC process, landing obligation,...).	7.1	year 1,2,3	An overview and update of relevant information on legislation, law and management will be included in the annual report(s)
g	Overview of ongoing research	Present and review ongoing brown shrimp research in the ICES area (impact studies, development of fishing gears, life cycle studies...) aiming at supporting international collaboration as well as evaluating management implications.	6.1	year 1,2,3	The summaries of updates on ongoing research will be included in the annual report(s)

Summary of the Work Plan

Year 1	Stock status indicators will be updated and harmonized between countries (ToR a). German and Dutch survey data will be analysed and reported, Belgian data will be included in the analyses (ToR e). Data used for the compilation of manuscripts in support of ToR b and c will be made available. Information and updates on national legislation, laws and management concerning the brown shrimp fisheries will be summarized (ToR d and f). New information generated from ToR g will be reported.
Year 2	Stock status indicators will be updated and harmonized between countries (ToR a). German, Belgian and Dutch survey data will be analysed and reported (ToR e). Data used for the compilation of manuscripts in support of ToR b and c will be made available. Information and updates on national legislation, laws and management concerning the brown shrimp fisheries will be summarized (ToR d and f). New information generated from ToR g will be reported.
Year 3	Stock status indicators will be udated and harmonized between countries (ToR a) as well as German, Belgian and Dutch survey data will be analysed and reported (ToR e). Data used for the compilation of manuscripts in support of ToR b and c will be made available. Information and updates on national legislation, laws and management concerning the brown shrimp fisheries will be summarized (ToR d and f). New information generated from ToR g will be reported.

Supporting information

Priority	*Crangon* fisheries are economically important with landings value ranking this species among the top three species caught from the North Sea. The priority of WGCRAN is to understand the interactions between the brown shrimp population (structure and abundance) and human behaviour (mainly fishing effort), the environment, and the ecosystem. One important aspect is and will be the monitoring, investigation and development of population status indices. WGCRAN is the only expert group to evaluate the Brown Shrimp Fisheries Management Plan which was developed by the industry in the course of the MSC certification.
Resource requirements	The research programmes that provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The group is normally attended by some 10 members and guests.
Secretariat facilities	Standard EG support.

Financial	No financial implications.
Linkages to ACOM and groups under ACOM	WGCRAN aims at a permanent linkage with ACOM after year 2 when sound and proven stock indicators and tools to evaluate management strategies have been developed (ToR a, b, c).
Linkages to other committees or groups	There is a linkage to WGBEAM through the international scientific surveys (DFS and DYFS). WGINOSE by providing data for the integrated assessment. WGSAM as the SMS key runs will be used to estimate natural mortality of brown shrimp. Members of WGCRAN are also members in these groups.
Linkages to other organizations	CWSS = Common Wadden Sea Secretariat; TMAP = Trilateral Monitoring and Assessment Programme; RCM – NSEA