To manage or not to manage?

Discussion Paper on brown shrimp (Crangon crangon) fisheries

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The underlying paper is a reflection of an internal discussion held at IMARES, it describes possible routes for management and their rationale. This document has to be treated as a starting point for a broader (international) discussion about the management of shrimp fisheries. Although it was the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I) that assigned IMARES to write this discussion paper, the authors want to emphasize that it is by no means a reflection of the opinion of the ministry.

Background

In the beginning of 2011 IMARES held an internal discussion about possible routes for management of shrimp fisheries. This discussion was triggered by the current developments of shrimp fisheries in the Netherlands; economically the situation of shrimp fishers has worsened and at the same time the attention for the industry has been broadened towards more ecological discussions about MSC and the measures that need to be taken in relation to Natura 2000.

Current situation

Currently there is an overcapacity of shrimp fisheries in European coastal waters; increased landings of shrimp have led to sequential reduction of the shrimp prices in the last years. As a consequence, economically, the shrimp fisheries industry of the Netherlands has been close to unprofitable in recent years. Vessels smaller than 191 kW still made a slight profit, but the 221 kW vessels were generally operating at a loss. Although the total landings of the shrimp were higher in 2009 when compared to the years before, this did not compensate for the low prices (Taal et al, 2010).

Besides licenses there are no regulations to control either effort nor landings of brown shrimp fisheries in Europe, apart from the use of selective gear for reducing discards (the sievenet; Catchpole et al, 2008; Steenbergen et al; 2011). In the Netherlands there are ca. 230 licences for brown shrimp (*Crangon crangon*) fisheries of which 90 are for the Wadden Sea only.

Attempts by the industry to control landings nationally has led to fines from the Dutch Consumers Authority (NMA). At present the NMA keeps a close watch on the developments within the industry. As a consequence producers organisations or other groups representing shrimp fishers are not allowed to make agreements about prices, market and landing amounts. Within producers organisations this is allowed (EU 104/2000); however due to the 'prisoners dilemma' (a.o. Hardin 1968) this is not effective. Despite repetitive attempts of the industry to make the fisheries more profitable, for example by reducing fishing days, the prices of shrimps in autumn 2011 are lower than ever before.

Not only in the Netherlands, also in Germany the economic situation of the shrimp fishers has worsened due to the reduced shrimp prices. In May 2011 a round table discussion about the shrimp fisheries between the Dutch Ministry of Economic Affairs, Agriculture and Innovation and the German Ministry of Food, Agriculture and Consumer Protection was organized. Both countries agreed that a close cooperation is important in order to jointly find solutions for the future of the shrimp fisheries (source: website Dutch government).

Natura2000 & MSC

The fishery on shrimp takes place in an area which for a large part has been designated as a Natura 2000 area. Fishing activities of the Dutch, German and Danish shrimpers are confined to the coastal areas and the Wadden Sea (Figure 1, ICES 2010). In the Dutch coast for example, these fishing activities overlap for a great deal with designated reserve area's for Natura 2000 (Figure 2). Depending on the measures taken it will either lead to fishing within a protected area or will lead to displacement. At the same time the industry is striving for the MSC certificate for sustainable fisheries. It is in this light that information on the effect of the fisheries on the shrimp stock and the ecosystem is requested. Also the industry is asked to come up with an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable, according to the 3 principles of MSC (MSC, 2010). These developments bring to the fore the question what the exact effect is of shrimp fisheries on the stock, what the role is shrimp plays in the ecosystem and which wider ecosystem effects the fishery has.

Three possible routes

Until now management of the shrimp fisheries on ecological grounds was seen as unnecessary and unwelcome due to the often expressed opinion that brown shrimps are 'the weed of the sea' and overfishing of this species is thus impossible. Therefor the discussion about shrimp fisheries tend to focus on the economic situation of the industry. Whether or not this idea holds true, is yet to be seen. It is in this context all the more relevant to evaluate possible management options and measures to ensure a sustainable fishery. Therefore the expression that shrimps are 'the weed of the sea', has been reassessed by a group of experts of IMARES which has resulted in this paper that describes three possible routes to management, based on ecological and biological grounds. The routes looked into are stock management, foodweb-based management and ecosystem management.

(Single species) stock management

Looking at trend data from the yearly demersal fish survey (DFS), the brown shrimp stock does not seem to decline. Therefore is no reason to believe that this stock is in impediment danger. The Demersal Fish Survey (DFS) data, show a slight, but significant increase of shrimp biomass in the area covered by the DFS survey during the last decade (Figure 3). However, between the years and also between different areas there is a lot of variability, with sometimes opposing trends in subareas (Tulp et al, in prep; Figure 4). The 40 year period showed distinct regional trend differences in estuarine areas: the Western Dutch Wadden Sea (increase), the Eastern Dutch Wadden Sea (decrease) and the Oosterschelde (decrease). Additionally periods with significant changes were identified in the period 1972-1980 in the Voordelta (increase) and the Westerschelde in 1992-1996 (decrease; Tulp, in prep).

However if we strictly follow the ICES-MSY approach, a reduction of catches may be needed. To give an indication; we can use the "MSY" notion from a crude assessment model of the population dynamics of shrimp (van der Hammen & Poos 2010). Given the assumptions made in the model, the 95% confidence interval for the MSY ranged between 27 000t and 39 000t. The total landings of shrimp have increased in the last years to 36.000t (Figure 6). In other words, based on this crude assessment model, the current fisheries has reached the MSY-limits.

In many cases research into stock management only starts when it is clear that a stock is in danger. It can be argued however that a better knowledge base of the species will allow for more informed management and prompt action, should the stock ever fall into trouble. One can think of unforeseen circumstances; sudden shocks or effects of more lengthier processes such as climate change. These factors in combination with heavy fishing pressure could potentially lead to (local) collapses.

<u>Implementation</u>

This route follows the common used ICES MSY-approach. For shrimp there are two possible routes within this approach: follow the guidelines for short lived species or follow the guidelines for stocks without population estimates (annex 3).

1. In order to implement the ICES guidelines for short lived species, a population size estimate is required (annex 3). An assessment model that deals with the population dynamics and life history characteristics of shrimp should still be developed. For brown shrimp it is difficult to quantify the population structure of the population, because of its complicated population dynamics (two main reproduction periods, short life span of 2-3 years, high P/B ratio; Kuipers & Dapper 1984, Henderson and Holmes, 1987; In: Tulp et al, in prep). The initial assessment model by van der Hammen and Poos (2010) should be carefully scrutinized. The WGCRAN expert group of ICES is probably the best platform to do this.

2. For stocks without population estimates, ICES practice has been to base advice on recent average catches when there is no quantitative or qualitative evidence of declining abundance (annex 3). Fishery catch per unit effort data or resource survey abundance information may be used to assess population trends, taking into account uncertainty. Age or size composition data are often useful for assessing the status of the fishery relative to FMSY.

Shrimp biomass should periodically be evaluated in order to readjust the TAC if necessary. Such an evaluation of the shrimp biomass could be done by means of assessment models, or by Catch per Unit of Effort (CPUE) indicators from a combination of a scientific survey and an industry self-sampling program. Given that shrimp has such a short generation time, in this case the CPUE should be regularly monitored.

From other (mixed) fisheries it is known that TAC management without accompanying effort management may lead to discarding, and as a result the TACs may limit landings, but do not necessarily limit catches. Therefore, in addition to the TAC management based on the stock assessment, in this case it might also be wise to adjust fishing effort simultaneously. One could also think of technical measures to avoid catching small size shrimp (e.g. increased mesh size).

Required activities:
- Annual scientific survey
- Year-round monitoring of CPUE by the fishing industry
- Annual stock assessment
- Development assessment model

Required measures:
- Total Allowable Catch (TAC)
- Effort reduction
- Technical measures

Foodweb-based management

Brown shrimp fulfils a key role in the ecosystem as a predator of larvae and juvenile stages of several fish and benthic species (Hamerlynck et al., 1993). At the same time it forms an extensive food source for a large number of fish and epibenthic species, some of them commercially important (gadoids like cod, whiting; Kuhl & Kuipers, 1978, Berghan, 1996, in: Welleman & Daan, 2001). It is conceivable that if the shrimp population is managed purely on the basis of the shrimp stock, natural predators of shrimp will suffer from lack of food. In food web-based management, the aim is to determine the amount of shrimp which can be safely harvested, while preventing such food shortages for predators. There are several examples of management of species that fulfil a similar key role in the ecosystem, including krill management in the Antarctic according to the Convention on the Antartic Marine Living resources and shellfish fisheries management in The Netherlands (ICES, 2011, Constable 2011, Bult et al, 2000). If we extent these examples to brown shrimp, then the fishery would be directed at harvesting the 'surplus', which is not needed to fuel other parts of the food web. This is the essence of foodweb-based management.

A quick calculation shows that possibly 15-55% the total annual shrimp stock is extracted by fisheries. In the past decade, landings in the North Sea shrimp fishing increased from around 20 to over 30 million kilos per year (Figure 6). The total annual production of shrimp > 50 mm is calculated to be on average *54 – 208 mln kg*[1] (years 1970 – 2010; Figure 5). This means that with an annual landing of 30 million kilo's per year, potentially 15-55% of the total annual production of shrimp is extracted from the ecosystem. These percentages are not insubstantial, and indicate that further research may be needed.

Implementation

To compare total shrimp consumption to the standing stock a reliable stock (production) estimate is required, the calculation of which is prone to large uncertainties (high turnover, P/B ratio of 4–8; ICES, 2011). For successful food web-based management of shrimp it is crucial to find out what proportion of shrimp is eaten by predators, because the rest, all the productivity which is not eaten by predators, is largely available for harvesting, put simply: TOTAL SHRIMP PRODUCTION – *FOOD FOR PREDATORS* = SURPLUS FOR HARVEST. Hereby (local) density dependent factors (e.g. minimum density of prey required for the predator to still be able to find its food) should also be taken into account.

Therefore the implementation of food web-based management can be summarized in 3 essential steps:

1. Determine how much and in which density shrimp is required by its predators

   This step requires detailed insight into which species eat shrimp, when, where and why. This goes beyond merely finding out in whose stomachs the shrimp end up: many predators are opportunistic, and simply eat what is there. This does not automatically mean that they *require* shrimp. On the other hand, there may be species which only eat shrimp as a small fraction of their total diet, but do rely heavily on it *in certain periods* of the year when alternative prey is scarce. Such patterns in time can also be different in different areas, depending on the other available prey. A spatio-temporally resolved picture of which species require shrimp is needed. Furthermore, a projection of how numerous these predators are going to be is needed. The

[1] This production is based on a swept area estimate in the area covered by the DFS survey (ICES 2008, 2010, 2011) and taking catchability and P/B ratio into account. The range in the average is caused by two uncertainties. The catchability, or the amount of shrimp caught during the survey, versus the amount of shrimp present is either 35% (ICES, 2008) or 66% (Bart Verschueren, pers. comm.). Then the P/B ratio of shrimp ranges from 4 or 8 (Hufnagl et al. 2010). Assuming a catchability of 66% and a P/B ratio of 4, then the average annual production is 54 mln kg. Assuming a catchability of 33% and a P/B ratio of 8, then the average annual production is 208 mln kgs.

combination of the two then leads to the requirements in terms of quantity, per location and time, for shrimp.

2. Determine the expected shrimp production

   Shrimp is a fecund species with a short generation time. The population can hence be expected to be fairly quick to recover from large external sources of mortality (such as for example starvation). This means that short-term (within-year) fluctuations can be large, requiring substantial monitoring effort, such as a combination of a scientific survey and an industry self-sampling program. A model can then be developed which estimates the production of shrimp in the North Sea one year ahead, on the basis of oceanographic predictions for temperature and primary production. Models for predicting the growth and reproduction of individual shrimp based on food availability and temperature are available from the literature. An extension of these models such that they also predict population size development will need to be developed.

3. Determine the surplus which is available for harvesting

   A careful assessment of production minus requirement gives the amount of shrimp which can be harvested. The combination of the spatiotemporal shrimp requirements by predators, and the modelled spatiotemporal patterns of shrimp production form the basis of a system of quota connected to a certain location and period during the year (real-time openings rather than real-time closures). Fishing at a CPUE threshold may be a useful measure to ensure the minimum density of shrimp required for predators.

Required activities:

- Investigate which species eat shrimp, when, where and why
- Development of brown shrimp production model
- Monitoring developments in shrimp stock by a scientific survey and self-sampling by the fishing industry
- Calculation of surplus shrimp available for fishery, as basis for Total Allowable Catch (TAC)
- Calculation of minimum required density of shrimp for shrimp dependant predators

Required measures:

- Spatio-temporal TAC
- CPUE threshold

Ecosystem based management

Effects of shrimp fisheries on bottom ecosystem cannot be excluded. Although current information for effects of shrimp trawls on the habitat is limited, these effects are also largely unexplored (ICES, 2011). Within the implementation of Natura2000 areas will be closed for fisheries.

Another impact of the shrimp fisheries on the ecosystem is the by-catch and discarding of unwanted marine organisms. Sievenets are proved to be effective in reducing discards of fish >10 cm (Catchpole et al, 2008). However, although sievenets are used and present to reduce the capture of unwanted marine organisms, this gear is least effective at reducing 0-group plaice, which make up the largest component of the bycatch (Catchpole et al, 2008; Steenbergen et al, 2011). By-catch and discarding of juvenile (flat)fish species, in particular plaice (*Pleuronectes platessa*) in the brown shrimp fishery is extensively reported and a well-recognized problem (Revill and Holst, 2004; Catchpole et al, 2008). The main fishing areas for brown shrimp also correspond to the nursery grounds of plaice (Zijlstra, 1972, van Beek et al., 1989). Small mesh size and the location of the fishery in the nursery grounds cause a large bycatch of juvenile fish. Further also undersized shrimp is being discarded; monitoring of bycatches in Dutch Shrimp-fisheries show that from 2008 -2010 on average 50% of the total shrimp catches (in kg) where discarded (Tulp et al, 2010).

In September 2011 a 3 year research project has started at IMARES. Within this project as well the (direct) impact of the fisheries on the bottom ecosystem as the bycatch of unwanted species is examined. The output of this research will provide useful extra information for further exploration of this route.

As a cause of these measurements Dutch shrimpers will partly lose their fishing grounds. If however the capacity stays the same, it implies that fishing pressure in other areas will increase which may be undesirable. Given the protection status of the areas involved, and the possible displacement of the fishery this route deserves further exploration.

<u>Implementation</u>

This route aims at a sustainable fisheries with a minimal impact on the ecosystem. The management is designed in such a way that:

1. Closing of vulnerable habitats for fisheries

1. Impact on the bottom is limited: impact on the bottom is minimalized by increased fishing efficiency. Fishing is only allowed if the CPUE is above a set threshold.

2. Unwanted bycatch is avoided: unwanted discards of (flat)fish can be avoided by real time closures when high abundances of juvenile plaice are recorded.

Restriction of effort could be used in order to minimize the effects of the displacement of the fisheries due to the implementation of Natura2000. At the same time, the development of innovative new gear techniques with less bottom contact and preferably less bycatches (f.i. the pulse trawl) should be promoted.

Required activities:

- Further development of knowledge on fishing impact on bottom
- Set a threshold for minimum CPUE
- Monitoring ratio by-catch/shrimp landings by means of self-sampling in the fishing industry

Required measures:

- Closed areas
- Minimum threshold for CPUE
- Real time closures

Combination of management routes

One could also think of a combination of the three routes. It is an opportunity to implement an ecosystem based approach in brown shrimp fisheries management instead of a conventional single-species management. In short this ecosystem approach to managing fisheries aims to ensure that target stocks are maintained at productive levels, that their dependent and related species are maintained and that any impacts are short-lived with recovery in two to three decades after the cessation of fishing (Constable, 2011).

Conclusion

Given the important role of shrimp in the ecosystem, both as a food source and a predator, the low predictability of the stock, the indirect ecosystem effects of the fisheries in combination with increased fishing pressure, an argument can be made for additional measures to manage shrimp fisheries. Initial ideas presented in this paper were discussed at the WGCRAN, the ICES working group on shrimp fisheries in May 2011 and the following concerns raised by IMARES were also recognised by the WGCRAN (ICES, 2011; Annex 2):

- shrimp biomass in relation to the predation of shrimp by gadoids
- by catches of undersized flatfish which can be periodically high
- possibly negative effect of the fisheries on the bottom

When the possible routes for management are summarized it becomes clear that although rationale between the three routes differ from each other there are similarities in the implementation (Table 1). Routes 1 and 2 have measures as TAC setting – albeit calculated in a different way; and routes 2 and 3 are directed at including spatial information and threshold of CPUE. However each route also requires extra information, information which is at the moment not always readily available. In order to have a better understanding of the developments of the stock we need to make use of all available data sources: CPUE, self-sampling and surveys. Furthermore the knowledge base of the effect of the fisheries on the ecosystem needs to be further improved.

It has become clear that still a lot is unknown, however this paper can be seen a starting point for a wider (international) discussion on whether and how brown shrimp fisheries in Europe should be managed. Previous requests for management advice have rarely been sent to WGCRAN (ICES,2011). As a first step, it was suggested to discuss the options at the NSRAC, which is scheduled for 27 October 2011. With sufficient support membership countries could approach ICES to ask an advice; if, in their opinion, from an ecological perspective management for brown shrimp is necessary and if so, which management route they would advise.

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ANNEX 1 figures

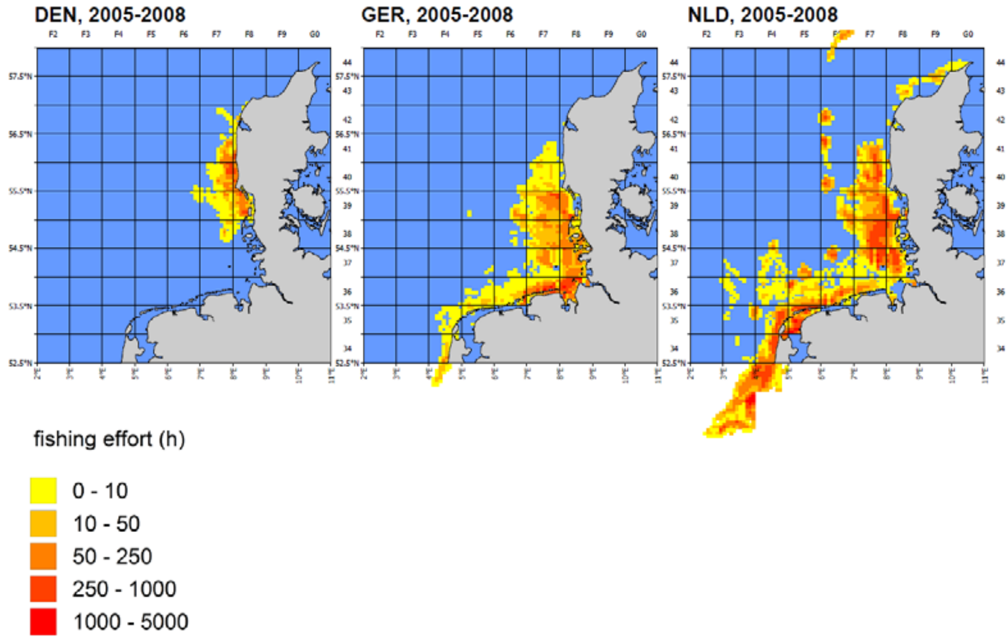

Figure 1. Distribution of fishing effort (hours) of the Danish (DEN), German (GER) and Dutch (NLD) shrimp fisheries in 2005 to 2008. Effort distribution of beamtrawls -31mm mesh size <= 221kW. Based on VMS data, resolution: 3 x3 nm squares. Misclassification due to wrong logbook data may have occured (e.g. see effort of Dutch shrimpers in off shore areas). (ICES, 2010).

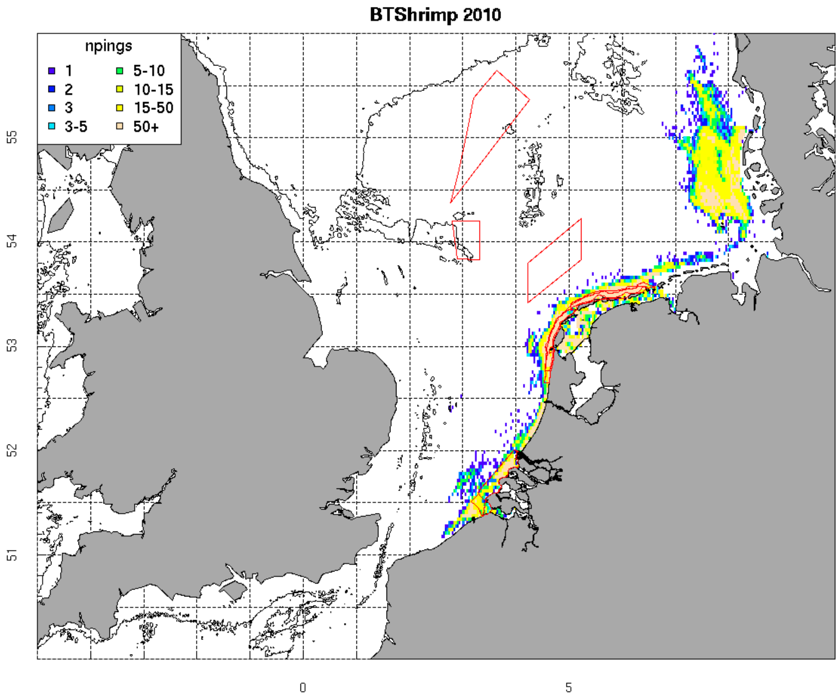

Figure 2. distribution of shrimp fisheries in the North Sea in 2010 (Dutch vleet) based on VMS data and Dutch natura2000 designated areas (red boxes). (Doug Beare, IMARES).

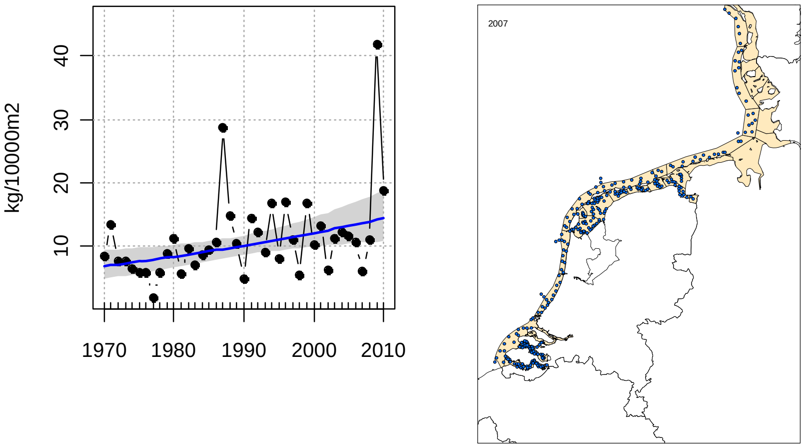

Figure 3. Mean overall density (kg/ha) of brown shrimp in the DFS area (depth-stratified). The area covered by the DFS on the right (Ingrid Tulp, IMARES). The DFS survey takes place in autumn.

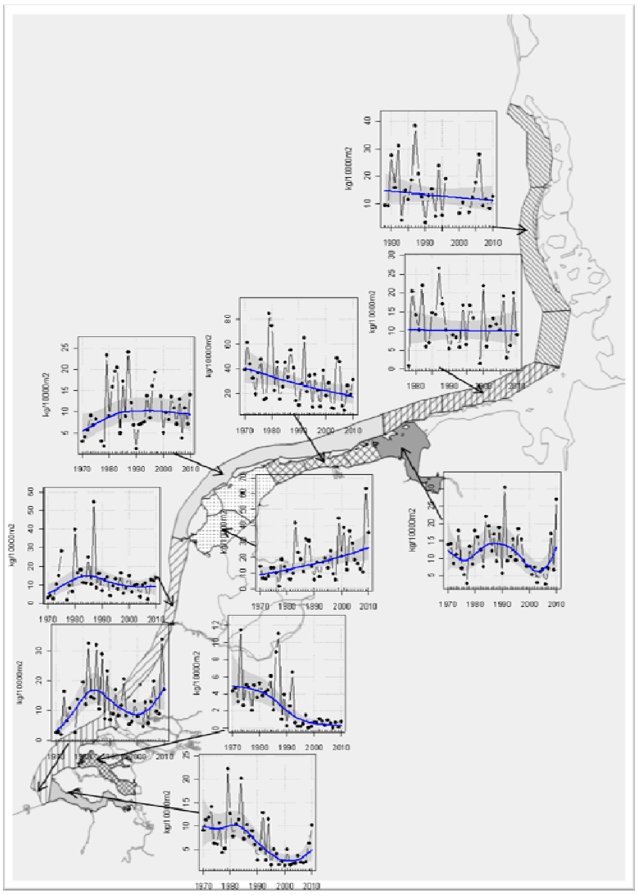

Figure 4. density (kg/ha) of brown shrimp in the DFS area per sub-region (depth-stratified).

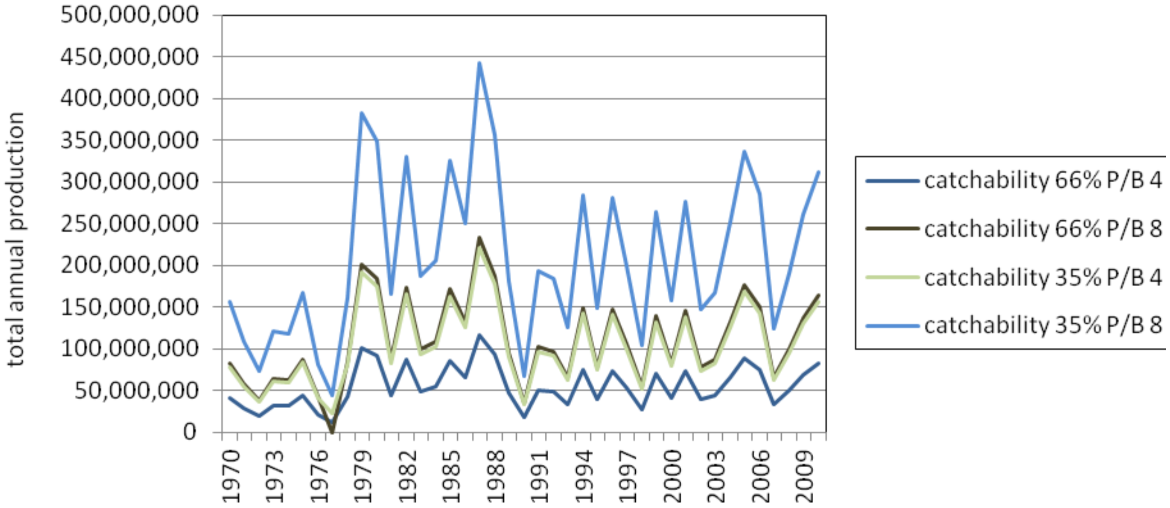

Figure 5. Estimated total annual production of shrimp > 50 mm in the area covered by the DFS survey based on a swept are estimate, taking catchability into account (the amount of shrimp caught versus the amount of shrimp present) of 35% (Martin 2007) or 66% (Bart Verschueren pers. comm.) and a P/B ratio of 4 or 8 (Hufnagl et al. 2010)

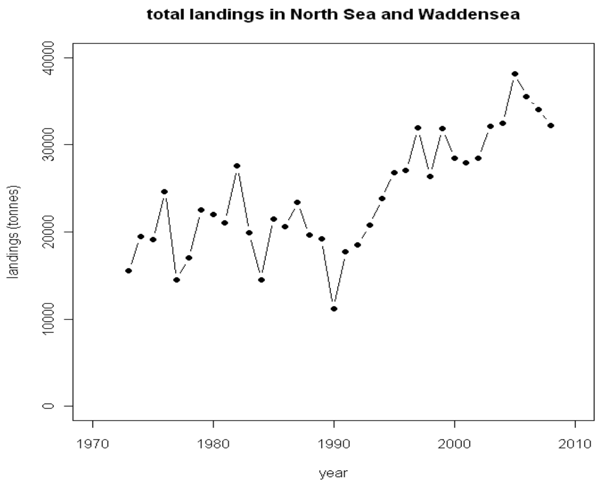

Figure 6. Sum of the commercial landings from the Netherlands, Germany, UK, France and Denmark (Hammen en Poos, 2010)

Table 1. Summary of the 3 possible routes for shrimp management

Required activities:	Required measures:
Stock management	**Stock management**
Annual scientific survey	Total Allowable Catch (**TAC**) at MSY level
Year-round monitoring of CPUE by the fishing industry	Effort management
Annual stock assessment	Technical measures
Development assessment model	
Foodweb-based management	**Foodweb-based management**
Investigate which species eat shrimp, when, where and why	Spatio-temporal **TAC** based on surplus shrimp calculation
Development of brown shrimp production model	Minimum CPUE threshold
Monitoring developments in shrimp stock by a scientific survey and self-sampling by the fishing industry	
Calculation of surplus shrimp available for fishery, as basis for Total Allowable Catch (TAC)	
Calculation of minimum required density of shrimp for shrimp dependant predators	
Ecosystem based management	**Ecosystem based management**
Further development of knowledge on fishing impact on bottom	Closed areas
Set a threshold for minimum CPUE	Minimum CPUE threshold
Monitoring ratio by-catch/shrimp landings by means of self-sampling in the fishing industry.	Real time closures

ANNEX 2: Opinion of WGCRAN

Reflection of discussion on the need of a management plan (copied from: ICES, 2011)

Stock: Until recently the general belief was that the brown shrimp stock could not be easily overfished and that natural mortality was significantly higher than fishing mortality (i.e. exploitation is low). This belief was based on the observation that after the absolute low of 1990 the stock rebuilt itself within one year thereafter (WGCRAN reports) and on the evaluation by Welleman & Daan (2001) who quantified that the magnitude of the total annual shrimp landings amounted to 5 to 10% of the total mortality caused by cod and whiting. However gadoid stocks have since declined as demonstrated by the total annual landings which are much lower (ca. 5–10 000 tonnes, versus 16 000 tonnes). At the same time the total annual brown shrimp landings have increased from approx. 20 000 tonnes to 36 000 tonnes. If the gadoid stocks would rebuild, total natural mortality on brown shrimp would increase. It is thought that the stock-recruitment relationship for this species is particularly weak based partially on the observation that the lowest observed stock in 1990 was able to rebuild itself by the next year. If a very poor stock-recruit relationship is typical for brown shrimp fisheries the possibility of recruitment overfishing is reduced. It can, however, be quite misleading to contrast the total predation with the landings, since both figures refer to different size ranges of the species. While most of the predation refers to sizes below the commercial size of approximately 50 mm, the landings refer to shrimp above this size only. On the other hand quite a large component of the landings are sieved out (the ‘crushed shrimp’) at the time of landing (up to 40%). A modified estimate is required that addresses this aspect directly. Welleman & Daan (2001) based their conclusions on data from 1981 and 1991, the only years with available information on predator stomach contents. The high predation figures of other years were then calculated based on the assumption that both the consumption and the share of Crangon in the consumed food remain constant. Given the lack of more recent stomach content data the working group has discussed an alternative way to estimate the ratio of F/M, using independent information on the total mortality, the total commercial catch and a swept area biomass estimate. The swept area estimate requires a standardisation between Dutch and German data as well as a number for the gear efficiency. On both issues good progress was made during the WG and this sets the foundation for an application of a Crangon specific yield per recruit (Y/R) model, which was developed in the frame of a national German research program. Depending on the finally estimated F/M (fishing mortality/natural mortality) ration either a MSY strategy or the F0.1 approach can be applied to the Crangon stock. (The value of F0.1 equals the fishing mortality rate when the increase in yield per recruit from adding a single unit of effort is only 10 percent of the increase achieved by going from zero to one unit of effort).

Bycatch of undersized flatfish: Fish (especially flatfish), undersized shrimp and other benthos are taken by the gear. An overview of all discard studies is presented in (Doeksen 2006). In 1996 an European project (RESCUE) was carried out (van Marlen et al. 1998, van Marlen et al. 2001) during which bycatches were analysed in the German, Belgian, UK and Danish fleet. Germany has a long tradition in bycatch data (since the 1950s), Neudecker and Damm (2010) which have been published in several studies (Tiews 1983, Berghahn & Purps 1998). In the UK several studies have been carried out and bycatch rates reported (Revill et al. 1999, Revill & Holst 2004). Since 2002 the use of sieve nets (a net with a mesh size of 5 to 6 cm fitted inside the shrimp trawls) to prevent larger fish from entering the cod end is mandatory under certain circumstances. This works well in reducing the bycatch of fish

>10cm and in-vertebrates but not for fish <10 cm (Polet 2003, Catchpole et al. 2008). Since 2008 discard monitoring has become part of the Data Collection Framework (DCF EC no. 199/2008) and a discard program has been put in place in The Netherlands and Germany (ICES 2009, Tulp et al. 2010). At this point of the discussion WGCRAN did not sum up the different reported bycatch rates, however, in general bycatch rates of undersized Crangon and juvenile fish are quite variable although notably much higher in spring and summer (Neudecker & Müller 2011). This especially applies to those segments of the fleet that operate in the shallow coastal and estuarine areas which fulfil a nursery function, especially in the spring and summer seasons (and maybe less so to the fisheries around Sylt in winter. Fish bycatch in the shrimp fisheries has been estimated to reduce plaice, sole, cod and whiting spawning stock by 10%, 1%, 1% and 1% (Revill et al. 1999).

Effect on the bottom: A shrimp beam trawl has relatively light gear and is operated without tickler chains (different to the gear used in the flatfish fishery), exerting relatively low pressure on the sea bottom. In addition brown shrimp prefer to inhabit relatively mobile substrates which are prone to natural disturbance. Nevertheless, the passage of a beam trawl and the net may alter the topography and structure of the seabed by displacing sediment and potentially damaging biogenic and biological substrata, ultimately smoothing and flattening the seabed. In addition direct and in-direct effects on benthic organisms could be expected. However, the number of studies actually measuring the effect of shrimp trawling on the bottom and benthos is limited, but Doeksen (2006) provides an overview. In essence there is no scientific based agreement on the effect of shrimp trawl on the bottom due to the fact that the few studies that have been carried out in the relevant habitat have looked at different time scales and different T-zero situations (not fished versus recently fished (Riesen & Reise 1982, Berghahn & Vorberg 1997)).

For both the discard rates as well as the bottom impact, any reduction in effort would directly translate into a reduction of the negative impacts. Therefore, a management strategy should target at the lowest fishing effort that still allows a profitable fishery.

Towards an integrated management of the shrimp fisheries

The working group discussed what options might provide an effective management plan. Accepting the given arguments as a justification for the need of a fishery management, in the view of WGCRAN there are three possible options:

1) Stock management:

In addition to last year's advice (ICES 2010) an additional possibility could be: as explained above, once the F/M ration is calculated, the Y/R model could be applied to explore the possible use of maximum sustainable yield (MSY) or F0.1 strategies. In any case the model can be used to estimate the likely loss of landings in relation to seasonal closures to minimise flatfish discards in summer. Likewise the model can address scenarios of increases in mesh sizes of cod ends and sorting devices to minimise the discard of the target species.

2) Food web based management:

This route has been successfully applied to shellfish fisheries management in The Netherlands, where a calculation is made of the ecological food requirements of shell-fish eating birds, and this quantity is subtracted from the total stock, to arrive at the quantity available for fisheries. That amount is still difficult to quantify for brown shrimp. Shrimp are an important food source for many fish and other species, including those for which we have no information on e.g. population size or food requirements. To compare total shrimp consumption to the standing stock a reliable stock estimate is required, the calculation of which is prone to large uncertainties (high turnover, P/B ratio of 4–8). Potentially this could be a very useful route and this re-search topic could be one of the priority tasks on the list of WGCRAN's agenda.

3) Habitat:
Current information for effects of shrimp trawls on the habitat is scarce but these effects are also largely unexplored. However, given the protection status of the areas involved, this route might be an important one and deserves further exploration. We recommend that more study on the effect of shrimp fisheries on the bottom sea bed is carried out. New fishing techniques as e.g. electric beam trawls may be very useful in that direction. However, such new techniques might also increase the efficiency of the gear and this will lead to a higher fishing mortality at the same nominal effort levels. The effects of such efficiency changes should also become a research priority prior to the permission of such gear in the commercial fishery.

Suitable management should take into account the above mentioned routes, as they represent important components related to these fisheries. Previously requests for management advice have rarely been sent to WGCRAN which may change in near future due to current developments in the shrimp fishery.

ANNEX 3: ICES guidelines for Fisheries advice

Short lived stocks with population size estimates

The future size of a short-lived fish stock is sensitive to recruitment because there are only a few age groups in the natural population. Incoming recruitment is often therefore the main component of the fishable stock. In addition, care must be given to ensure a sufficient spawning stock size as the future of the stock is highly dependent on annual recruitment. For short-lived species, estimates or predictions of incoming recruitment are typically very imprecise, as are any catch forecasts.

For short-lived stocks, the ICES MSY approach is aimed at achieving a target escapement (BMSY-escapement, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach. The catch corresponds to the stock biomass in excess of the target escapement. No catch should be allowed unless this escapement can be achieved.

For some short-lived species, assessments are so sensitive to incoming recruitment that the amount of biomass in excess of the target escapement cannot be reliably estimated until data available just prior to the fishery or during the fishing year have been analysed. Therefore, an adaptive framework may be applied as follows:

1. Set a preliminary TAC such that there is high likelihood that the target escapement will be achieved or exceeded. This preliminary TAC is likely to be considerably below the final TAC (step 3).
2. Assess the stock just before or during the fishing year, typically based on a survey or an experimental fishery.
3. Adjust the TAC based on the assessment in step 2 assuring that escapement is at or above the target.

The escapement level should be set so there is a low risk of future recruitment being impaired, similar to the basis for estimating Bpa in the precautionary approach. In short-lived stocks, where most of the annual surplus production is from recruitment (not growth), BMSY and Bpa might be expected to be similar. Therefore Bpa is a reasonable initial estimate of BMSY-escapement.

Stocks without population size estimates

For many fish stocks, the data available are inadequate to estimate the current population size and the catch resulting from fishing at a desired F. However, other data may be available to allow ICES to assess the intensity of fishing relative to a desired level.

For stocks without population estimates, ICES practice has been to base advice on recent average catches when there is no quantitative or qualitative evidence of declining abundance. The ICES MSY approach calls for a determination of the status of exploitation relative to FMSY (overfishing or no overfishing) and consideration of the stock trend. The following table is the framework for advice for stocks without population size estimates.

	No overfishing	**Overfishing or unknown exploitation status**
Decreasing stock trend	Reduce catch from recent level at rate of stock decrease	Reduce catch from recent level at rate greater than the rate of stock decrease

Stable stock trend	Maintain catch at recent level	Reduce catch from recent level
Increasing stock trend	Increase catch from recent level at rate of stock increase	Maintain catch at recent level

Fishery catch per unit effort data or resource survey abundance information may be used to assess population trends, taking into account uncertainty. Age or size composition data are often useful for assessing the status of the fishery relative to FMSY. However, there are situations where even this type of information is not available. In such cases, it might still be possible to give advice but the basis for this advice cannot be prescribed in advance. This approach is intended to move in the direction of MSY, but this is unlikely to be achieved without additional or more complete information.

In summary the brown shrimp just falls in between the above two categories. If we would simply the table above we would probably arrive at the box on the right in the middle or the lower box (depending on how we interpret the time trends in the survey data)