The Plaice Box: data inventory

Morgane Amelot

WAGENINGEN UNIVERSITY & RESEARCH

Introduction

This document presents an inventory of the data available to assess the Plaice Box (PB) performances and impacts. These data are (1) fisheries related data: landings, discards, and fleets information; (2) biological data: plaice (Pleuronectes platessa), demersal, benthic, and top predator species; (3) environmental data. Finally, to understand what kind of new analysis and experiments might be designed to assess the PB performances and impacts, recent updates on fishing impacts on ecosystem function are presented trough a short literacy review.

Fishing effort, landings, and discards

Five countries were involved in the fisheries occurring in the PB during the last evaluation: Germany, Denmark, the Netherlands, United Kingdom and Belgium. The data required to estimate the PB impacts includes landings, discards and efforts from all fleets currently fishing in the PB and surrounding area. Data from fleets that could be fishing in the PB, if this one reopens to all vessels, may be considered too.

During the last evaluation, the fishing effort was analysed based on 7 fleet categories (1) Beam trawlers using 16-31mm meshes (2) Beam trawlers using 80-99mm meshes (3) Beam trawlers using > 99mm meshes (4) Otter trawlers using 80-99mm meshes (5) Otter trawlers using > 99mm meshes (6) Gill or trammel netters and (7) 'Others'.

Table 1. Landings, discards and effort data availability and coverage

Data	Scale and resolution	Countries	Time series length	Source	Resource person
Landings					
Total	Aggregated	All fleets	1957-2021	ICES/ logbooks VISSTAT	Chen Chun
Spatial	ICES statistical rectangle	Dutch	2009-2021	VMS VISSTAT	Niels Hintzen
Discards					
Total	Aggregated (Euro cutters and large cutters)	All fleets	1996-2021	ICES/logbooks VISSTAT	Chen Chun
Total	Fleet level (Shrimp fishery missing)	Dutch	2009-2021	Self-sampling program FRISBE	Harriet van Overzee
Effort					Niels Hintzen

Data	Scale and resolution	Countries	Time series length	Source	Resource person
Fleets	ICES statistical rectangle	All fleets/Dutch	2009-2021	Logbook/VMS VISSTAT	ICES OSPAR request
Plaice fisheries		North Sea	~2000-2021	ICES	Plaice benchmark

Limitations

<u>Fleet</u> No or sparse information on shrimp fishery discards (a pilot study was abandoned due to a lack of data and representativity from the reference fleet, new projects are currently building up).

<u>Scale</u> The finest spatial scale available during the last evaluation was the ICES rectangle. However, the PB limits do not fit exactly ICES rectangle borders. The effort allocated to the rectangles being both in and out of the PB were previously attributed to the one or the other based on VMS data.

<u>Time</u> Data are not available for the entire time period (before/after PB implementation).

Distribution and Spawning Stock Biomass trends

In previous evaluation the estimation of the plaice distribution and Spawning Stock Biomass (SSB) were based on several surveys data. All bottom trawl surveys occurring in the area (IBTS/BTS/DFS/SNS) give insights on the general distribution of plaice, including younger age classes.

Dedicated surveys might help to acquire data fitting the PB borders better. The PB survey occurred in 1996 and 1998, this survey data were used during the second evaluation only. However, these data were so far not digitalized.

Table 2. Plaice distribution and abundance data availability and coverage

Data	Scale and resolution	Time series length	Source	Resource person
Distribution and abundance	Hauls coordinates	Survey dependent	Surveys	Ingeborg de Boois
IBTS		1965-2021	DATRAS/ FRISBE	
BTS		Q3 1985-2021	Q1 2006-2021 DATRAS/ FRISBE	
DFS		1967-2021	DATRAS/ FRISBE	
SNS		1969-2021 (no data in 2003)	DATRAS/ FRISBE	
Plaice Box Survey		1996 and 1998	FRISBE	

Limitations

Spatial There is no reference zone and dedicated survey (apart from the PB survey in 1996 and 1998) to assess PB effects. This does not allow to compare the effects of the different fishing pressures in and out the PB areas.

Environmental variables

During the last evaluation, the data used to analyse environmental variables were based on Helgoland station monitoring. It followed the recommendation from the ICES Working Group Oceanography and Hydrography (ICES, 2008). These data are still the closest and more precise 'unprocessed' data available for the PB. 'Unprocessed' data from several Dutch authorities' water monitoring stations are close to the PB (Rijkswaterstaat) and could be used as well.

Recent model-based approaches such as Copernicus or ERSEM (European Regional Seas Ecosystem Model) allows the estimation of environmental parameters in non-monitored areas.

Table 3 Environmental variables data availability and coverage

Data	Method	Scale and resolution	Time series length	Source	Resource person
Temperature (surface and bottom)/ nutrients/ salinity/ (phyto-plankton)	***Model-based***	World 0.083*0.083 degrees	1993-2021	Copernicus https://marine.copernicus.eu/	
		North Sea	Depends on the simulation	ERSEM	Jan Jaap Poos
Temperature / salinity	***Station-based***	North Sea (1 station)	1960-2021	Biologische Anstalt Helgoland (PANGAEA)	
Temperature / chlorophyl		The Netherlands (2-4 stations near or in the PB)	2015-2021	https://www.rijkswaterstaat.nl/en	Jan Tjalling van der Wal
		The Netherlands	sparse	https://www.pdok.nl/	Jan Tjalling van der Wal

Species Communities

Apart from plaice, three groups of species could be of interest to assess (1) the PB impacts, (2) the external processes that might have impacted the PB performances. These groups are benthic species, other demersal species, and top predator species. PB regulations might have had direct impacts on them. Furthermore, these groups own trends could have impacted the plaice stock dynamics considering their status of prey, competitors, and predators for plaice.

Table 3 Species communities data availability

Data	Scale and resolution	Time series length	Source	Resource person
Benthic				
Species composition and abundance	North Sea	1986	North Sea benthos Survey VLIZ http://www.vliz.be/vmdcdata/nsbs/	Johan Craeymeersch
	North Sea	2000	North Sea benthos project VLIZ http://www.vliz.be/vmdcdata/nsbp/datasets.php W:\IMARES\Yerseke\Common\Algemeen\JohanCraeymeersch\NSBS_NSBP.accdb	
	North Sea hauls coordinates	IBTS 1965-2021	FRISBE/ DATRAS	Ingeborg de Boois
		BTS Q1 1985-2021 Q3 2006-2021		

Data	Scale and resolution	Time series length	Source	Resource person
Demersal				
Species composition / Abundance	ICES statistical rectangles	1957-2021	Logbooks VISSTAT	
Abundance	North Sea Hauls coordinates	IBTS 1965-2021	FRISBE/ DATRAS	Ingeborg de Boois
		BTS Q1 1985-2021 Q3 2006-2021		
		DFS 1967-2021		
		SNS 1969-2021		
Top predators				
Seals (grey and harbour) abundance and distribution	Wadden Sea	2021	Project-base modelling	Geert Aarts
Cormorants	Wadden Sea and North Sea	20 years	National Bird counts, ICES (JWGBIRD)	Hans Verdaat/ Leopold Mardik
		20 years	Breeding colonies counts, ICES (JWGBIRD)	

Limitations

Benthic As for plaice biomass the benthic biota composition and abundances were not assessed through an experimental design allowing comparison of trends in and out the PB area.

Demersal As for plaice biomass the demersal species abundances were not assessed through an experimental design allowing comparison of trends in and out the PB area.

Top predators Cormorants numbers were estimated based on breeding colonies that included birds feeding in the North Sea and Wadden Sea. To estimate the number of cormorants feeding in the PB area assumptions will need to be done. The seal population was estimated for the Wadden Sea only.

Theoretical framework on impact of fishing on ecosystem function

Fisheries, especially bottom trawling fisheries, due to their seabed penetration, have direct impacts on species apart from those they target (Figure 1, Van Denderen et al., 2013). Several hypotheses have been proposed along the last decades on the positive and negative impacts of bottom trawling on benthic communities' diversity and abundance. Fisheries have direct effects on the relative availability of benthic species to predators.

In the North Sea, fishing has been taking place for centuries (Engelhard, 2008). Consequently, there is no knowledge on the pristine state of the local ecosystem (Barett et al., 2004). However, the fishing pressure did vary with the evolution of fishing technologies and fishing effort (Engelhard, 2008). Fishing effort in the North Sea reached a peak in the 90’s and decreased until now (Couce et al., 2020).

Currently, North Sea fisheries are mainly composed of otter trawl and bottom trawl, considered together they represented more than 50% of the total kW day at sea in 2016 (ICES, 2018). They constituted an average effort larger than 100 000 kW days at sea in 2016 (ICES, 2018). The PB fishing effort was driven by the PB regulations. The fishing effort decreased after the PB was implemented for vessels with engine power over 221kW while it increased for smaller vessels such as shrimp trawlers. However, the general fishing pressure from all vessels combined, decreased from 1989 to 2010 (Beare et al., 2010). The pressure exerted by fisheries on the local PB ecosystem in 2010 was driven by beam trawls and otter trawls as well (Beare et al., 2010). It is likely that the current fishing pressure in 2021 is still exerted by the same fleets.

Apart from their direct impact on target species, beam trawls do have an impact on benthic communities (Hiddink et al., 2017). These impacts are highly variable and depend on several fisheries related factors: trawling intensity, duration, gear used, species targeted. In European waters the trawling intensity (number of times a cell of one latitude minute and one longitude minute is trawled per year) varied from 0.5 to 8.5 year-1 (Eigaard et al., 2017). In the North Sea the average intensity exerted by the ten main metiers is estimated to 2.77 year-1 (Rijnsdorp et al. 2020). Secondly, the trawling methods used also have different impacts on the seabed. Recent studies compared the relative impacts of different metiers on benthic biota. There is no consensus on which metiers impact benthic species the most, and the relative impacts of the different methods are dependent of the resolution considered (gear, metiers, etc.). Studies at the gear level demonstrated a lower impact of otter trawls in comparison to beam trawls (Hiddink et al., 2017). However, at the metier level otter trawls targeting demersal species are estimated to have the higher impacts than shrimp beam trawls (Rijnsdorp et al., 2020). Furthermore, trawling impacts could be quantified as short as well as mid- or long-term effects. For example, brown shrimp beam trawls have been estimated to have short term impacts only on the total number of species. Nevertheless, this fishery was estimated to have mid- long-term impacts on the community diversity (Pielou’s eveness) only (Tulp et al., 2020). In the PB flatfish beam trawlers were the most common gear before the PB implementation, while the shrimp trawler effort increased after the PB implementation (Beare et al., 2010). This has led to different pressures over time, likely impacting different characteristics of the benthic biota. Finally, historic fishing intensity may have shaped benthic community structure and thereby result in altered ecosystem resilience. It is likely that species present in areas exploited for centuries are more adapted to fisheries pressure than species present in less exploited areas (Boethius et al., 2020). This makes the PB area hard to compare to other areas that might have been exploited for a shorter period.

The benthic communities present in a fishing area could have variable abundance, diversity, and resilience to bottom trawl pressure. Conclusions of recent studies seems to indicate that longer-lived species are less resilient to bottom trawl than shorter-lived species (Rijnsdorp et al., 2018). Filter feeders' abundance usually decreased when trawling intensity increased (van Denderen et al., 2015) while deposit feeders abundance increased (Lokkeborg, 2005). However, these effects do not seem to be consistent between studies. Species from comparable ecological niche could demonstrate variable reactions to bottom trawl (McConnaughey et al., 2000). These differences in individual species vulnerabilities while having the same ecological niche, might be linked to our ability to correctly assess these vulnerabilities (sampling design) as well as undetected covariables (benthic biota initial status). Furthermore, the food web structure could also impact individual species resilience to bottom trawl. The ecosystem regulation type (bottom-up, top-down, etc.) and the impact that bottom trawling has on the different compartments of this ecosystem, could create new equilibrium states (Wolfshaar et al., 2020).

Obviously the PB has led to comparable changes in benthic biota composition and abundance. How these changes have impacted the specific PB area were not assessed through a dedicated experimental design. Future changes in regulation might be monitored through dedicated experimental design to adequately identify these changes. The changes in benthic biota might have had positive impacts, such as an increase in abundance and diversity of prey available to plaice. Though, if plaice were adapted only to the prey in place before the implementation of the PB, the PB could have led to a reduction of food availability for plaice (Hinz et al., 2017). Furthermore, an increase in food availability might have increased plaice growth rate. However, the North Sea plaice stock has been the object of several

Fisheries Induced Evolution studies that showed a decrease in the length at maturity (Mollet et al., 2016, 2015, Walraven et al., 2010, Grift et al., 2003). Finally, density dependent phenomena have been shown for plaice juveniles (Van der Sleen et al., 2018). Food availability and growth rate changes could have impacted the plaice density and caused negative feedbacks due to density dependent phenomena such as juvenile competition.

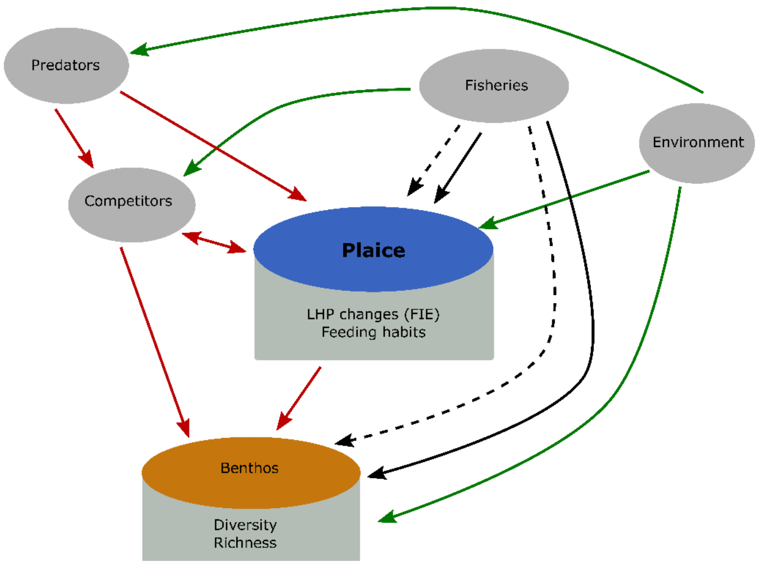

Figure 1. Direct and secondary effects of fishing effort variations on plaice (*Pleuronectes platessa*)

General perspectives

The PB effects have always been assessed taking into account the current environmental conditions. Global environmental changes such as warming water, nutrients availability variations or eutrophication might modify the long term PB effects. Furthermore, other species population trends and/or invasive species arrival and their potential impact should also be explored in the future.

Resource person: Tobias van Kooten, Ingrid Tulp

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