

Modeling fisheries responses to North Sea closures using DISPLACE

March 17 2026

Justen Steenberg, Peter Persoon, Chrisoph Okello, Katell Hamon, Bea Deetman



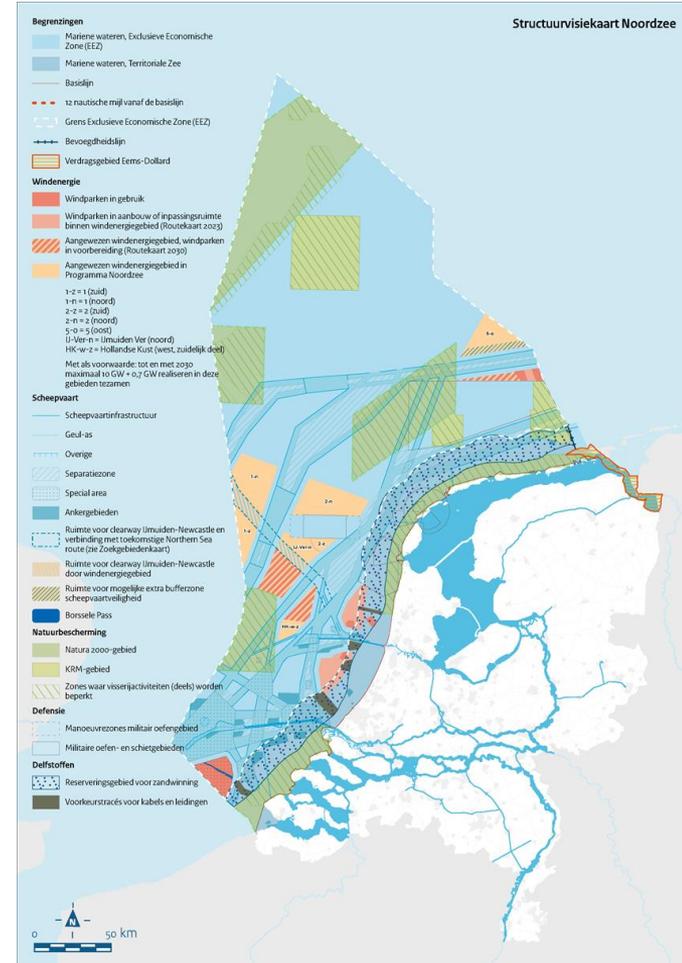
Overview

1. The challenge
2. Short overview DISPLACE
3. Validation
4. Visualisation
5. Initial results



The challenge

How do increasing maritime area closures impact the spatial distribution of Dutch fisheries?



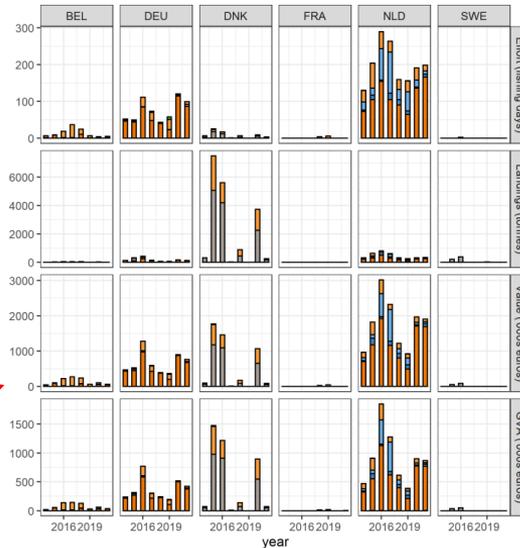
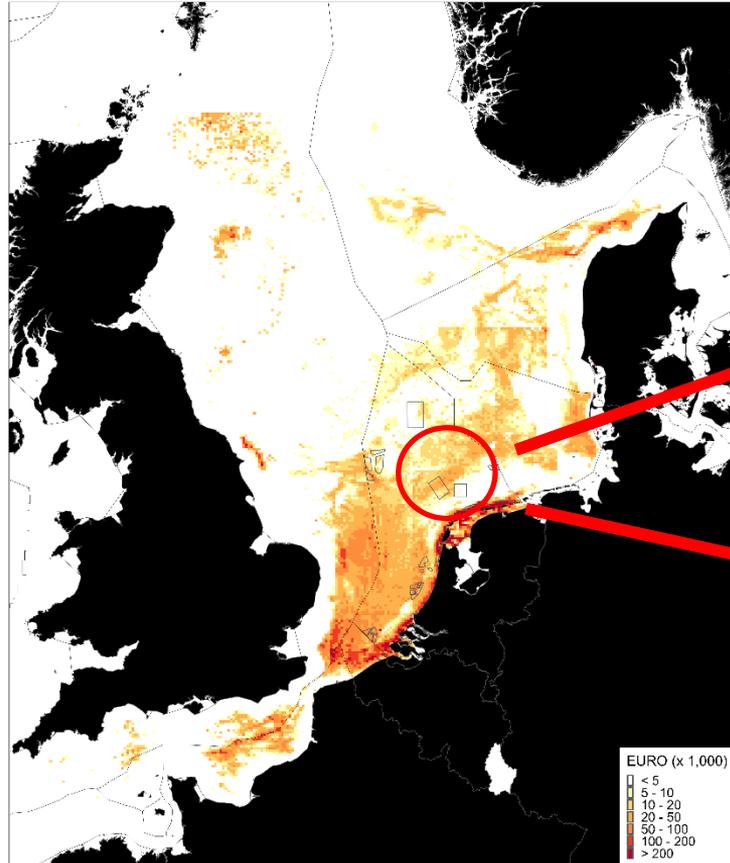
DISPLACE

- Geography specific ABM where fisheries and stocks INTERact
- **Not reinvent the wheel → existing model**
- With track record for advice within EU
- Technical criteria
 - Spatial
 - Flexible scale of aggregation (fleet, community, gear/metier)
 - Explicit behaviour (location choice, effort intensity, gear/metier choice, quota trading*, entry/exit*)
- Drawback
 - Steep learning curve

From dependency analysis...

Gemiddelde opbrengst Nederlandse visserij

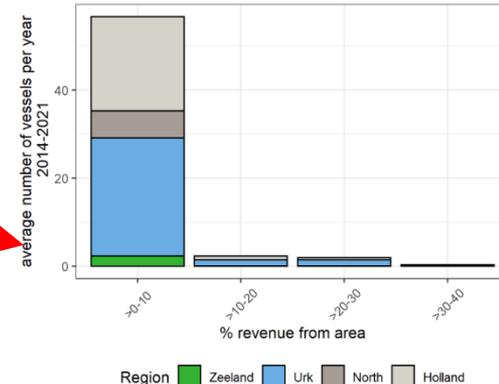
Periode: 2016-2019, Tuig: Alle, Vissoort: Alle



Gear

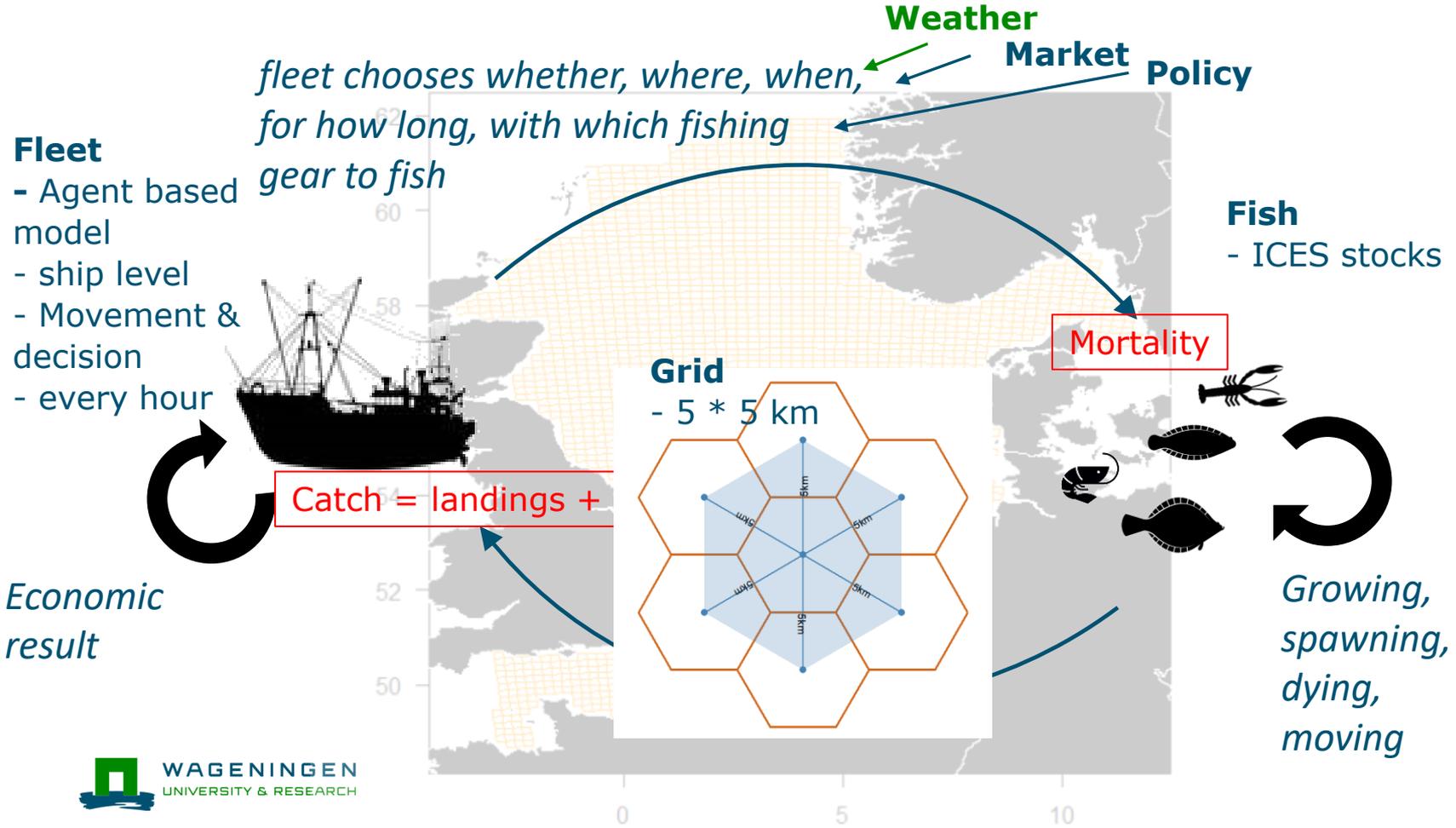
- FPO
- GNS
- OTB
- OTM
- OTT
- SDN
- SSC
- TBB
- Other

Old model:
Looking back,
static, no
feedback between
stocks and
fisheries,
individual areas



Example Frisian front Hamon & Klok 2023

DISPLACE – model structure



DISPLACE – Dutch application

1 Vessel selection:

2023 NL flagged cutterfleet
after decommissioning :

217 vessels

- ship level
- Movement & decision
- every hour



2 Metier selection

- Important for the ships
- Aggregated based on gear/mesh size/target species/rules

3 Grid

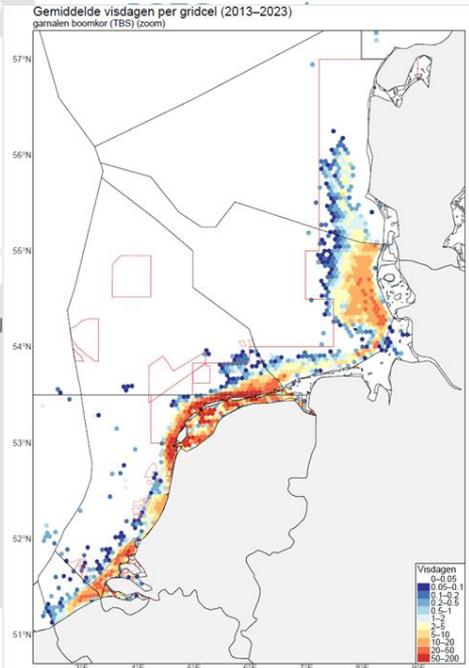
Where metiers active:
North Sea, Skagerrak and Channel

discards



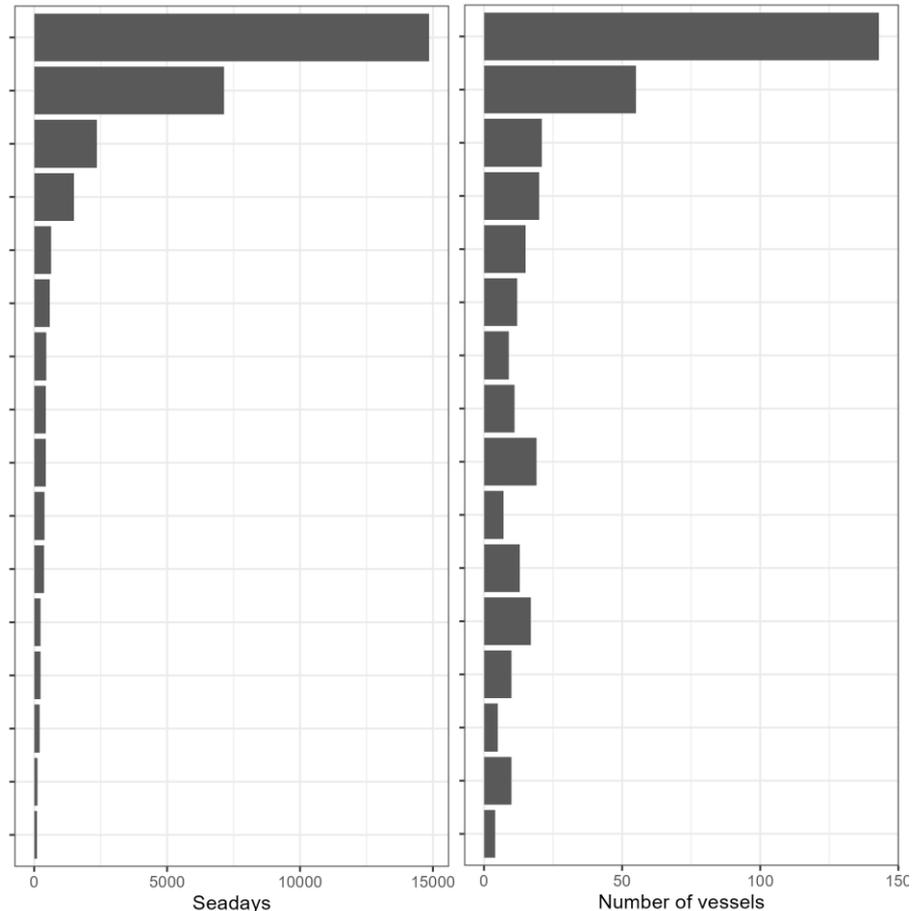
4 Fish Stock selection

- Covers the value of catch well
- Every metier covered



Metiers

1. TBB_CRU_16-31
2. TBB_DEF_80-89 $\geq 300\text{pk}$
3. SSC_DEF_80-99
4. OTB_CRU_70-99
5. OTB_DEF_<70
6. TBB_DEF_ ≥ 120
7. TBB_DEF_100-119
8. SSC_DEF_<80
9. OTB_DEF_100-119
10. TBB_DEF_80-89 $< 300\text{pk}$
11. OTB_MCD_70-99
12. OTB_DEF_70-99
13. OTB_MCD_100-119
14. OTB_DEF_ ≥ 120
15. SSC_DEF_100-119
16. SSC_DEF_ ≥ 120



Species

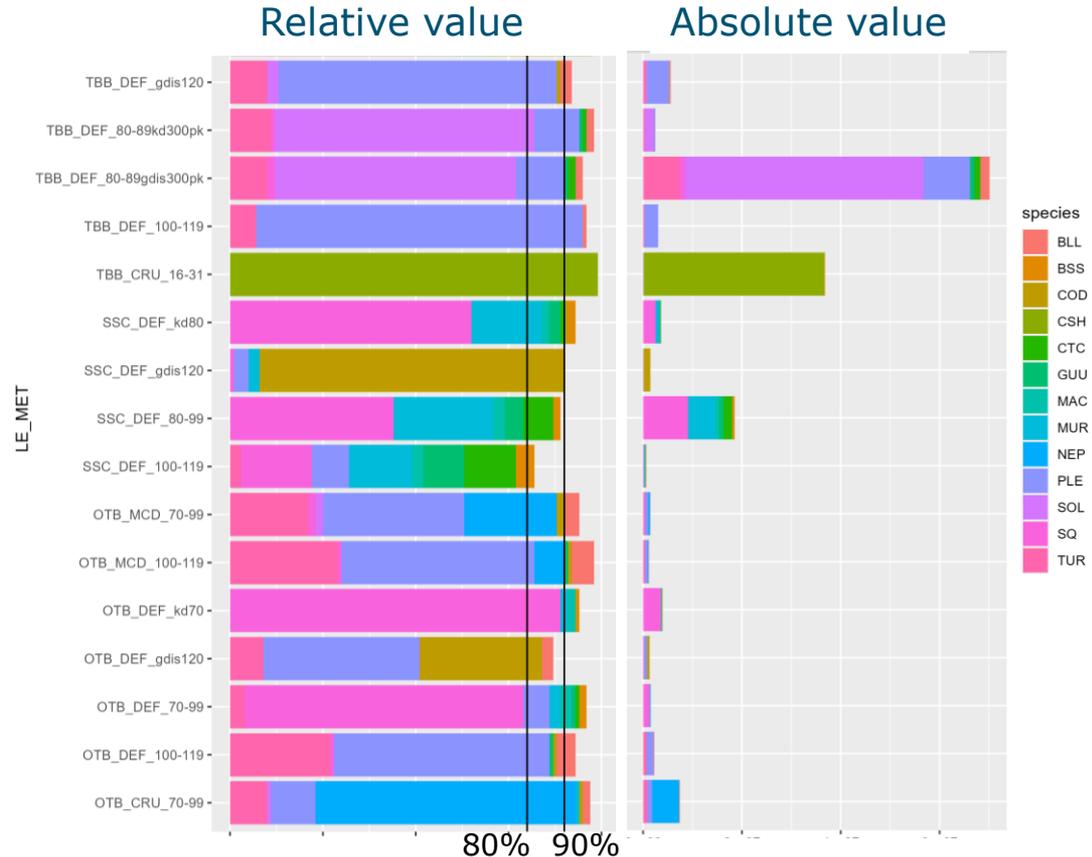
- Top 13 species covering > 80% value of landings per metier
- Most >90%
- 13 species → 18 stocks

7 Explicit

North Sea plaice
Plaice Channel
North Sea sole
North Sea turbot
Cod (South North Sea)
Cod (viking)
Mackerel

11 Implicit

Sea bass
Shrimp
Squid
Norwegian lobster
Cuttlefish
Turbot Skaggerak
Red North Sea
Mullet channel
Rub gurnard
Sole Skagerrak
Brill



Decision trees

- Fishing Decisions
 - Métier choice
 - To go fishing or not to go fishing
 - Fishing grounds selection :
Fishing grounds by métier of historical data and measures
 - How long to fish
 - To other fishing grounds
 - To the port or keep fishing

Probability based on historical proportions

Decision trees

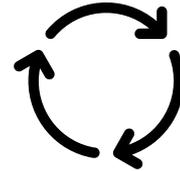
Validation process

Step 1 by ourselves

Check: 2023 simulation and 2023 logbooks, VMS and economic data

We found/find:

- Bugs in input data
- Bugs in model assumptions



Step 2 with fishers

- Check: Check our assumptions
- Better understanding of (special) context
- Identifying changes in fisheries/metiers

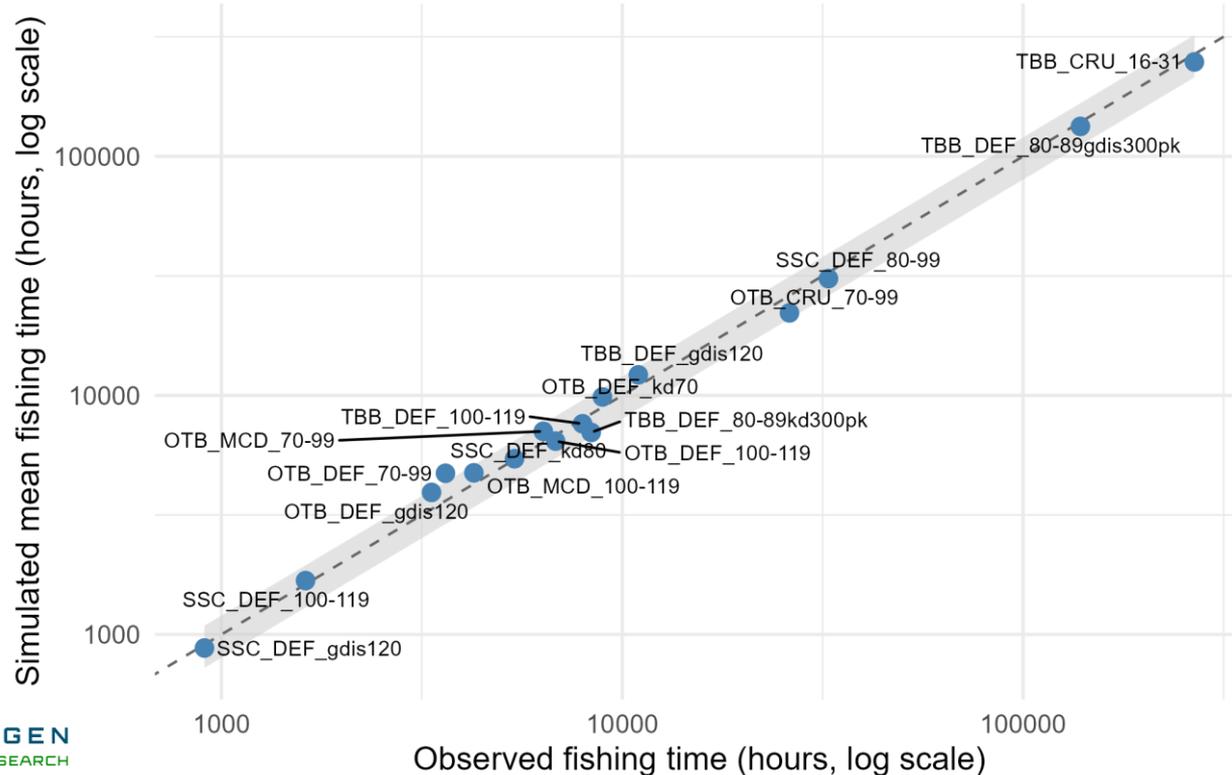
Current state - validation

- 2023
- Current closures
- 10 simulations
- Validation on
 - effort
 - landings

Fishing time

Observed vs simulated fishing time by métier

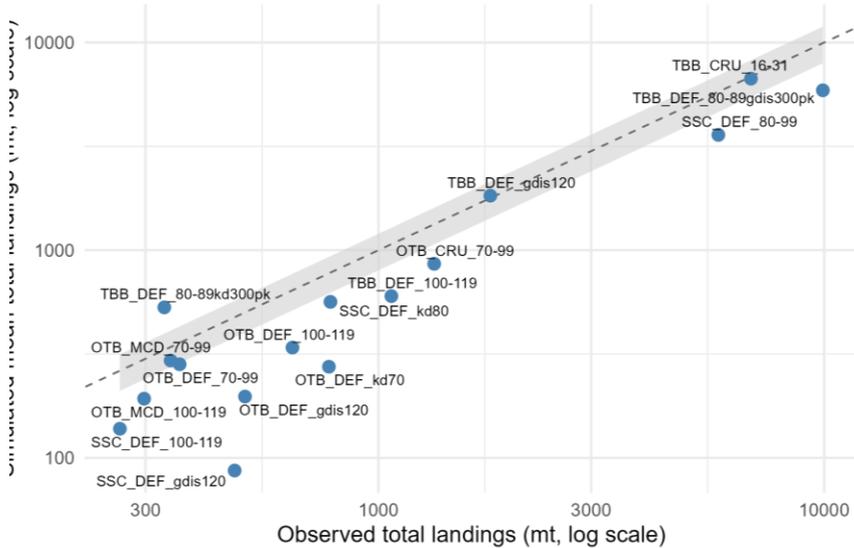
Shaded area shows $\pm 20\%$ deviation from 1:1



Aggregated landings

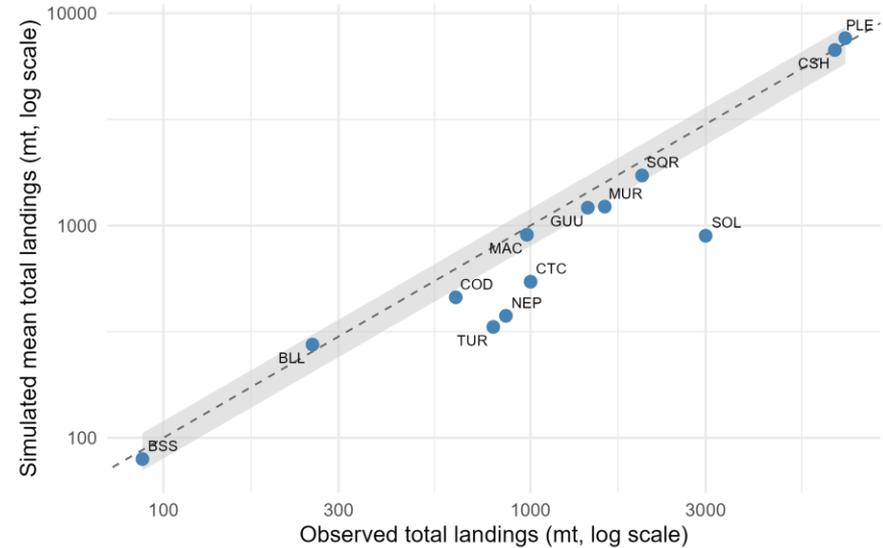
Observed vs simulated total landings by métier

Shaded area shows $\pm 20\%$ deviation from 1:1



Observed vs simulated total landings by species

Shaded area shows $\pm 20\%$ deviation from 1:1



Current state - validation

- 2023
- Current closures
- 10 simulations
- Validation on
 - Effort - checked
 - landings - Almost ok, better understanding still needed

Look and feel

DISPLACE
File Graph Editor Parameters Model Utilities Windows

Model Objects
[1] simu1
- Layers
 OpenStreetMap
 Seamark
 Entities
 Graph
 Graph Edges
GIS Shapefile Layers
+ Environmental Forcing
- Monthly Output Layers
 Abundance (PopValues TotalN)
 Biomass (PopValues TotalW)
 Impact (PopValues Impact)
 Catches Per Pop (PopValues CumCatches)
 Benthos Biomass (FuncGroups bNTot)
 Benthos Number (FuncGroups bN)
 Benthos Mean Weight (FuncGroups bMeanW)
 Fishing Effort (NodesStat CumFTime)
 Swept Area (NodesStat CumSwA)
 Subsurface Swept Area (NodesStat CumSubSurfSwA)
 Catches (NodesStat CumCatches)
 Catches With 70% Threshold (NodesStat CumCatchesThreshld)
 Discards (NodesStat CumDiscards)
 Discards Ratio (NodesStat CumDiscardsRatio)
 Nb choked stocks (NodesStat NbChokedStks)
+ Monthly Fishing Tariffs
+ Nodes
+ Fish Populations
+ Fish Size Groups or Age
+ Benthos
+ Benthos Functional Groups
+ Fishing Nations
+ Fishing Firms
+ Fishing Metiers
+ Fishing Harbours
+ Fishing Vessels
+ Commercial Shipping

Commands
Start
Stop
Setup

Simulation Status
Simulation step:
4199/4199
D 174 [sun] Wk 24
Mt 5 Yr 0
23:00 h

Map Data:
Name: at_sea id: 8715
Coords: 54.0717 2.76072
Landscape: 5
Init Benthos Biomass: 1
Init Benthos Number: 1
Code Area: 0
Tariffs
Fishing Effort (hours): 167

Model results, shown by various indicators

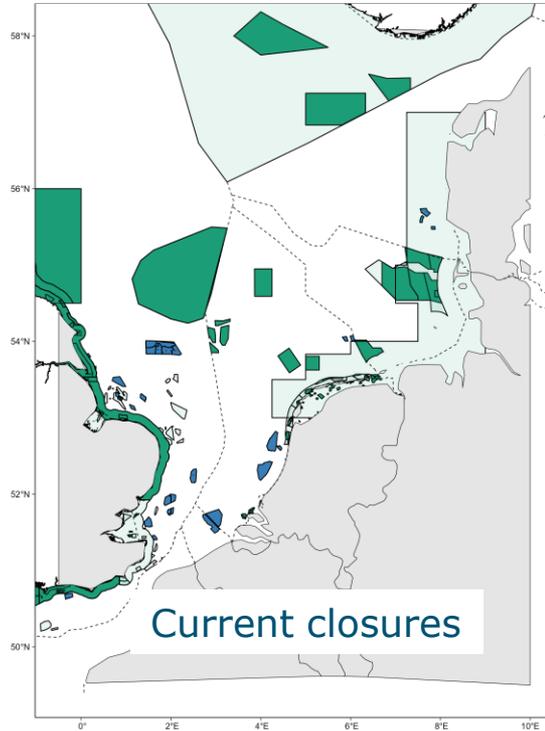
- The model can be used to compare the consequences of management scenario's
 - What if..? (we close this area)
- We can present these results in different ways and from different perspectives:
 - Biology (i.e. effect on *implicit* fish stocks) Biomass, fishing mortality
 - Ecology (i.e. effect on the bottom) swept area ratio
 - Economy (i.e. effect on landings/livelihoods) Landings, revenue, GVA
 - Safety/collision risk (i.e. how busy area x will become)
 - Social (i.e. effect per region)
- Changes compared to the baseline situation/baseline scenario

Closure scenarios

Ruimtelijke maatregelen – Noordzeegebied 2024

Groen = natuurgebied | Blauw = windgebied

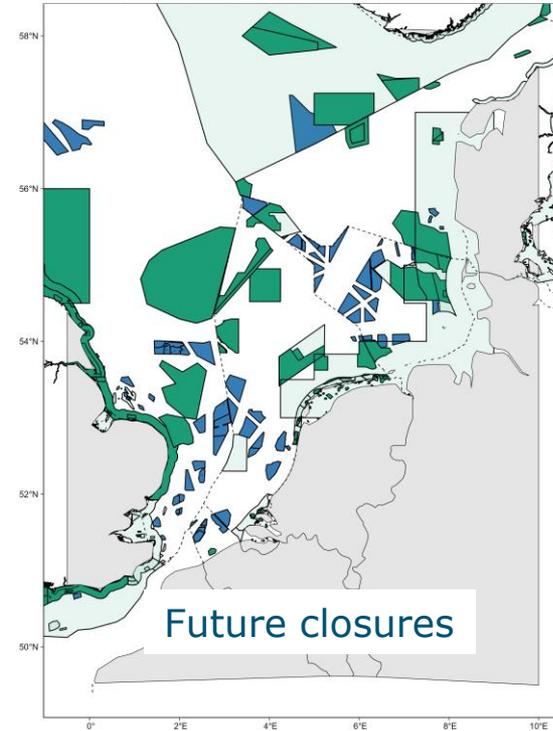
Donker = alle tuigen verboden | Licht = specifieke tuigen (voor zover gespecificeerd door lidstaten)



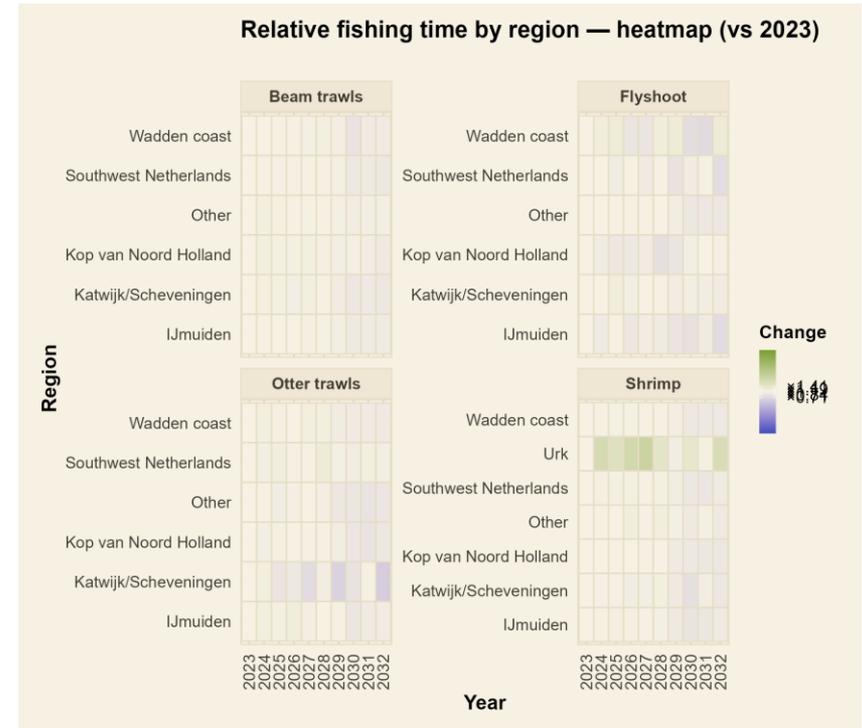
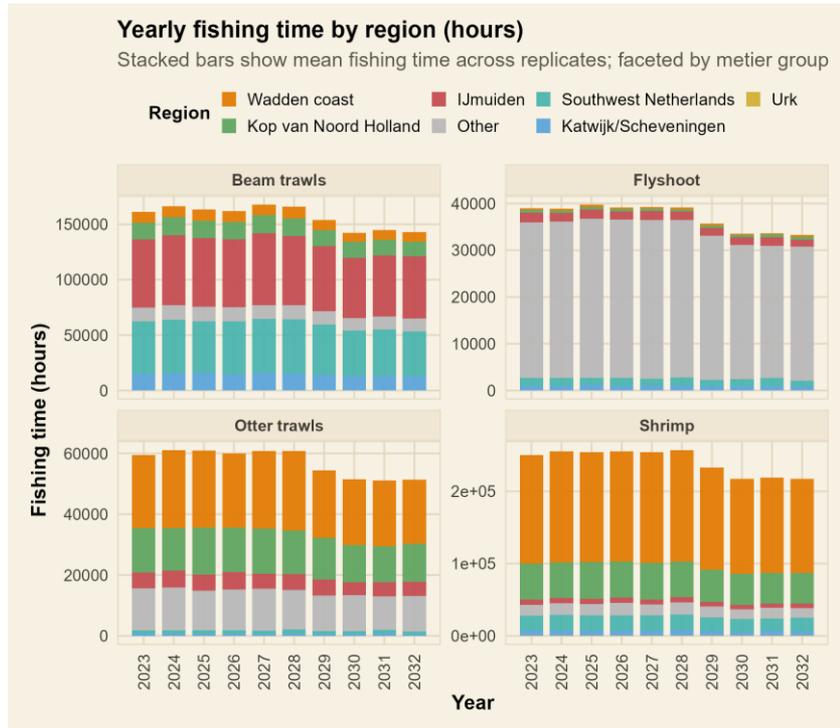
Ruimtelijke maatregelen – Noordzeegebied 2030

Groen = natuurgebied | Blauw = windgebied

Donker = alle tuigen verboden | Licht = specifieke tuigen (voor zover gespecificeerd door lidstaten)



Times series – effort per landing region current closures



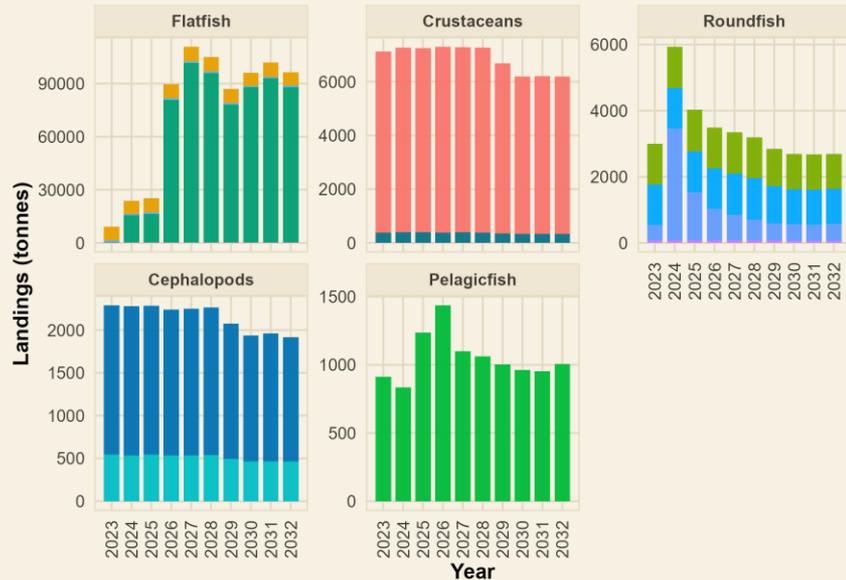
Time series – landings by species current closures

Yearly landings by species (tonnes)

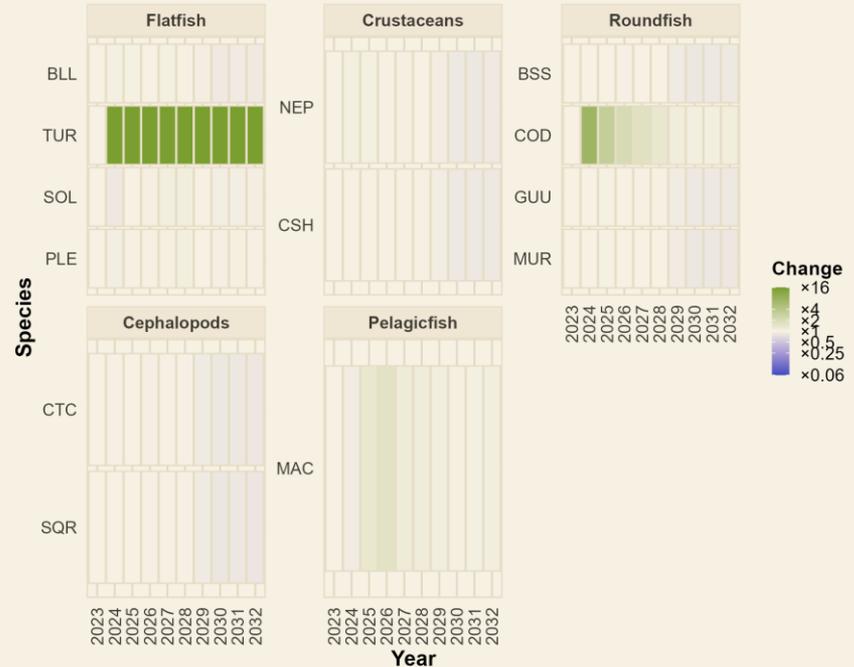
Stacked bars show mean landings across replicates; DISPLACE catch: Tonnes

Species

- PLE
- CSH
- SQR
- MUR
- GUU
- MAC
- SOL
- CTC
- COD
- NEP
- TUR
- BLL
- BSS



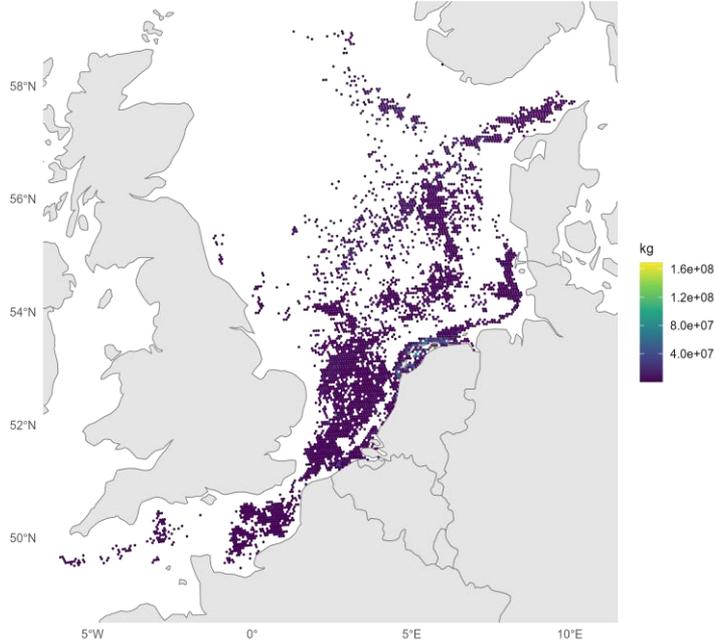
Relative landings by species — heatmap (vs 2023)



Change in fishing distribution – future closures

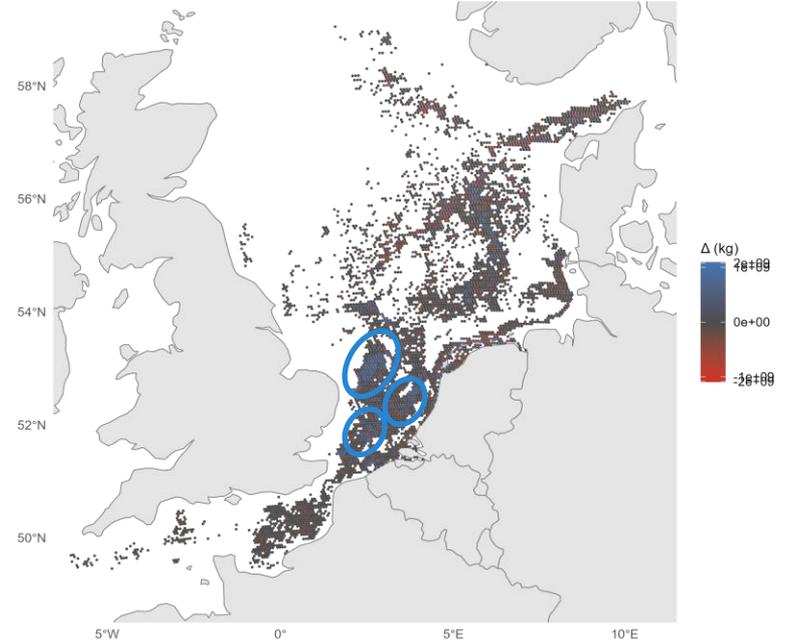
Landings — Cumulative (end of 2023) [2024 scenario]

CUMULATIVE up to end of 2023 | snapped boundary: 2024-01-01 01:00 UTC (tstep=8761) | ensemble mean across 9 runs



Landings — Δ vs 2023 (Independent 2032 – 2023) [2030 scenario]

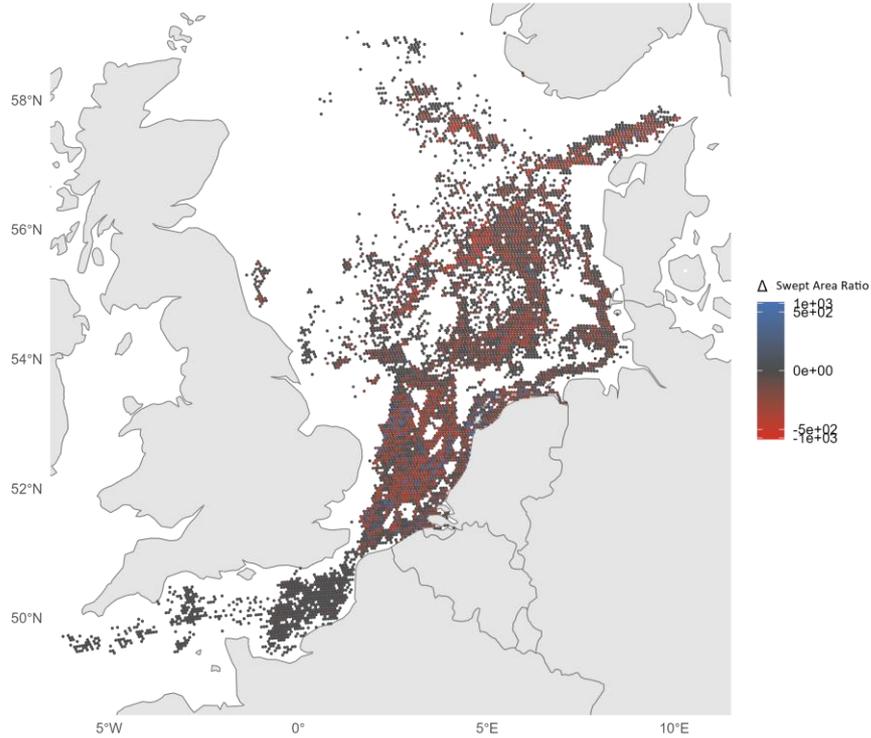
Δ vs 2023: Independent(2032) – Independent(2023) | missing treated as 0



Change in swept area ratio

Swept area ratio — Δ vs 2023 (Independent 2030 – 2023) [2030 scenario]

Δ vs 2023: Independent(2030) – Independent(2023) | missing treated as 0



Change in swept area ratio to assess impact on (bottom) ecology

Take home message

- Model validation on 2023:
 - Fisher's behaviour – checked
 - Fish stocks – Almost ok, better understanding still needed
- Social, economic and ecological trade-offs of policy options can be shown in a diverse and visually attractive way
- DISPLACE best option... with a steep learning curve

Questions/comments?

justen.steenbergen@wur.nl

Dank aan collega's Justen Steenbergen, Hans van Oostenbrugge, Peter Persoon, Chrispoh Okello, Marc Robert, Alba Pulskens, Marloes Kraan en Nathalie Steins.

