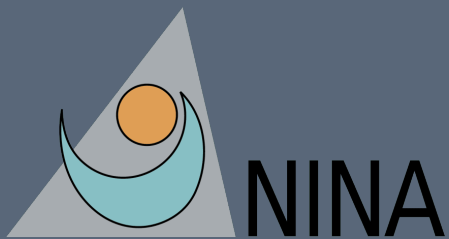


MARCIS

Marine Spatial planning and cumulative impact of blue growth on seabirds

Tone Kristin Reiertsen et al.

Offshore Norges Havvind og miljøseminar, 6. November 2025



[MARCIS \(nina.no\)](http://MARCIS(nina.no))

Overarching project aims

- **Trans-disciplinary collaboration**
- **Development of a CIA tool for seabirds**
- **New knowledge**



Cumulative impact assessment (CIA)

Halpern et al. 2008. Science

$$I(x, y) = \sum_{i=1}^n \sum_{j=1}^m P_i * E_j * \mu_{ij}$$

Impact
- Spatially explicit

Pressure
- OWF
- Fishery
- Climate
- Shipping
- Oil rigs

Environment
- Seabird distribution

Impact weight
- Seabird population impact



Annual variability of climate and fishery harvest data +
Annual timeseries data of demography
↓
Enables quantifications of stressors that varies in time

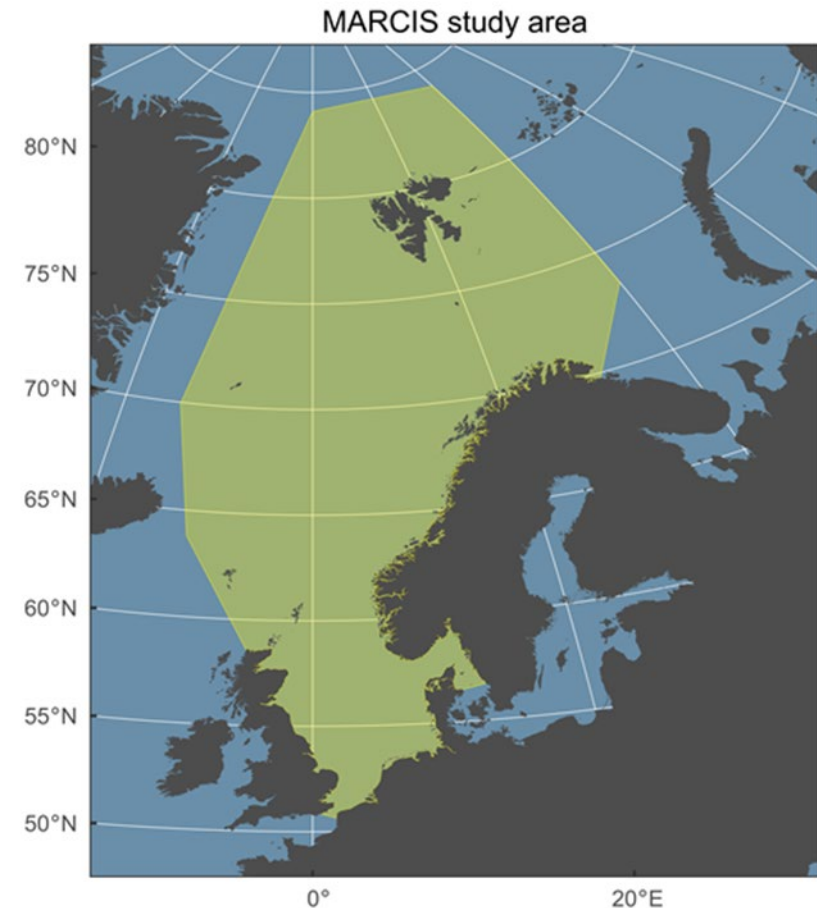
Demographic data
Demographic modelling
Activity data
IBMs

Receptors and input data

$$I(x, y) = \sum_{i=1}^n \sum_{j=1}^m P_i * E_j * \mu_{ij}$$

6 seabird species

- Distribution and activity data (GLS – SEATRACK)
 - Year-round distribution
 - Mass-change
 - Mortality
- Timeseries data of demography and population trends (SEAPOP)
 - Reflect seabirds' status in both breeding and non-breeding season
 - Adult survival and reproduction
 - Population trends
- Migratory birds
 - Behaviour near OWF (Radar)
 - Migratory routes and risks related to OWFs



Receptors and input data

$$I(x, y) = \sum_{i=1}^n \sum_{j=1}^m P_i * E_j * \mu_{ij}$$

- 6 seabird species

- Distribution and activity data (GLS – SEATRACK)

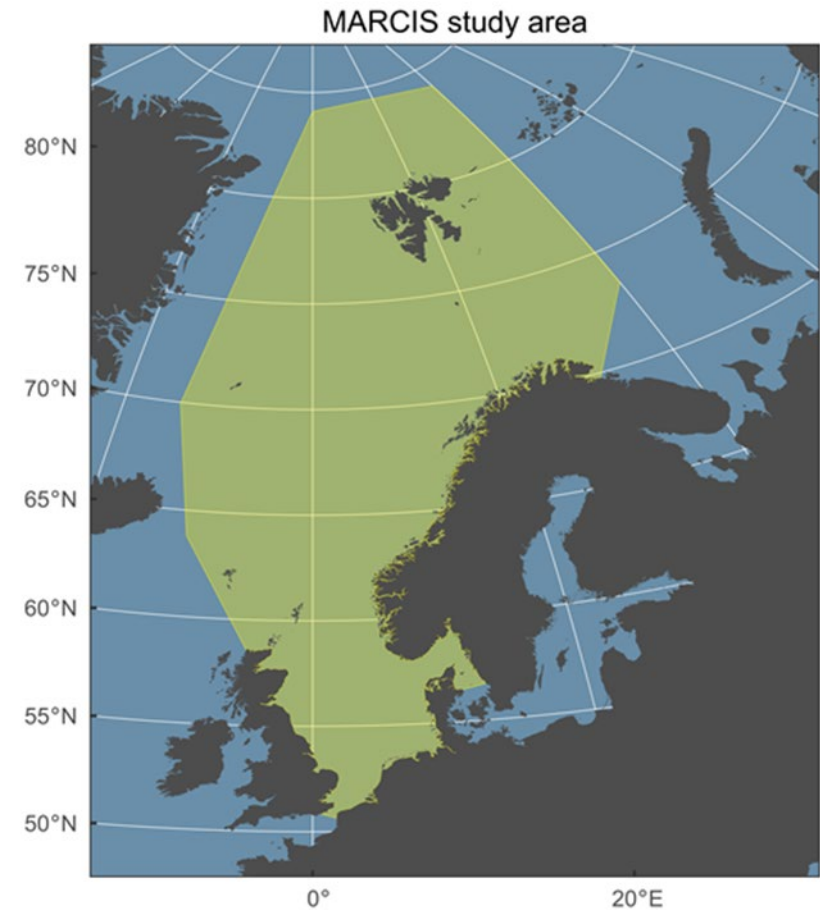
- All year distribution
- Mass-change
- Mortality

- Timeseries data of demography and population trends (SEAPOP)

- Both breeding and non-breeding season
- Adult survival and reproduction
- Population trends

- Migratory birds

- Behaviour near OWF (Radar)
- Migratory routes and risks related to OWFs



Receptors and input data

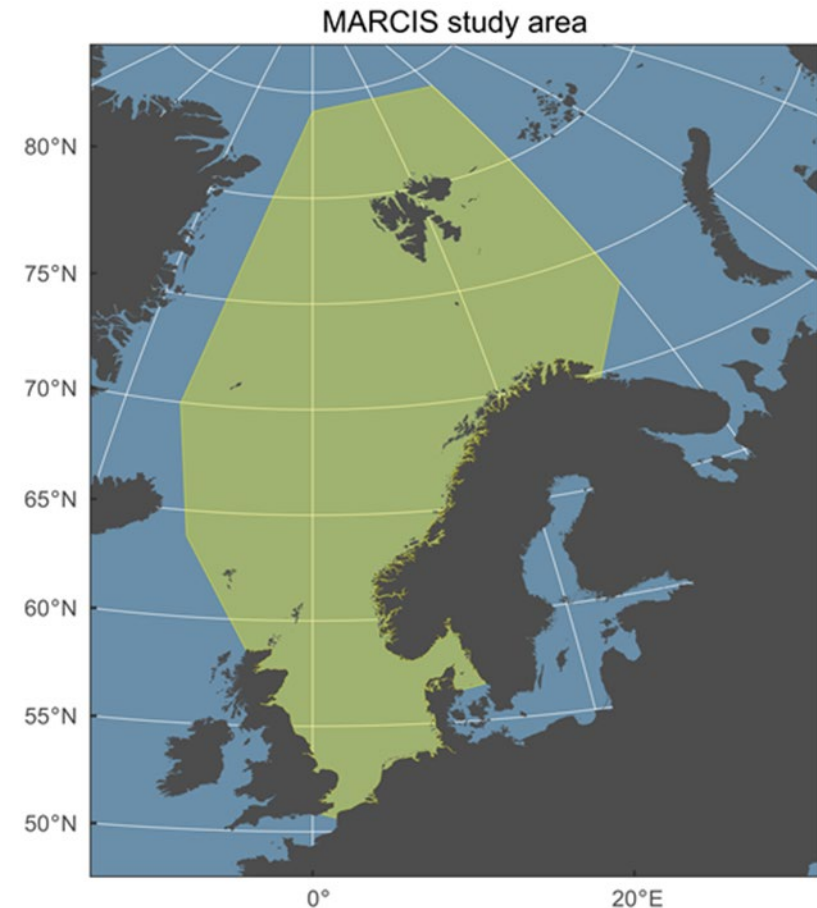
$$I(x, y) = \sum_{i=1}^n \sum_{j=1}^m P_i * E_j * \mu_{ij}$$

- 6 seabird species

- Distribution and activity data (GLS – SEATRACK)
 - All year distribution
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 - Mortality
- Timeseries data of demography and population trends (SEAPOP)
 - Both breeding and non-breeding season
 - Adult survival and reproduction
 - Population trends

- Migratory birds

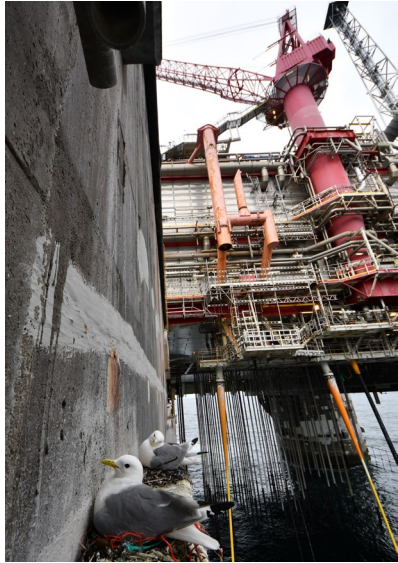
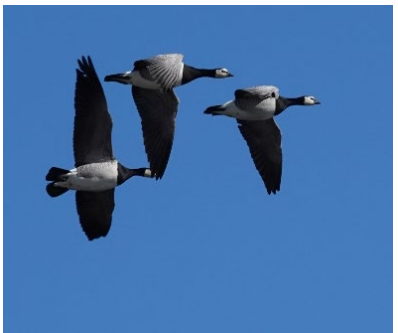
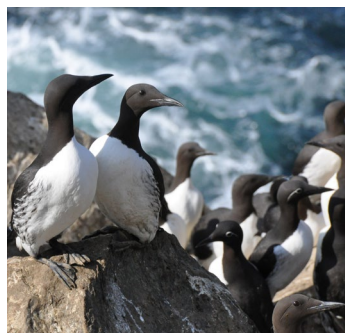
- Behaviour near OWF (Radar)
- Migratory routes and risks related to OWFs – ringing data



MARCIS – trans-disciplinary collaboration



MARCIS - a collaborative research project between research institutes, industry, management authorities, NGOs and interest groups.



Welcome to the MARCIS tool!

The MARCIS tool is a result of the [MARCIS research project](#).

The MARCIS tool assesses and visualizes cumulative impacts (CIA) on seabirds from blue growth and climate change and life cycle impacts (LCA) on migratory birds from offshore wind farms. CIA can be customized by species, scale, season, and stressors, while LCA can be tailored to collision, displacement, and disturbance impacts.

Scientific references

Halpern et al., 2008: "A Global Map of Human Impact on Marine Ecosystems". *Science*, 319(5865), 948-952.

Layton-Matthews et al., 2023: Development of a Cumulative Impact Assessment tool for birds in Norwegian Off-shore Waters: Trollvind OWF as a case study. NINA Report 2295.

Data attribution

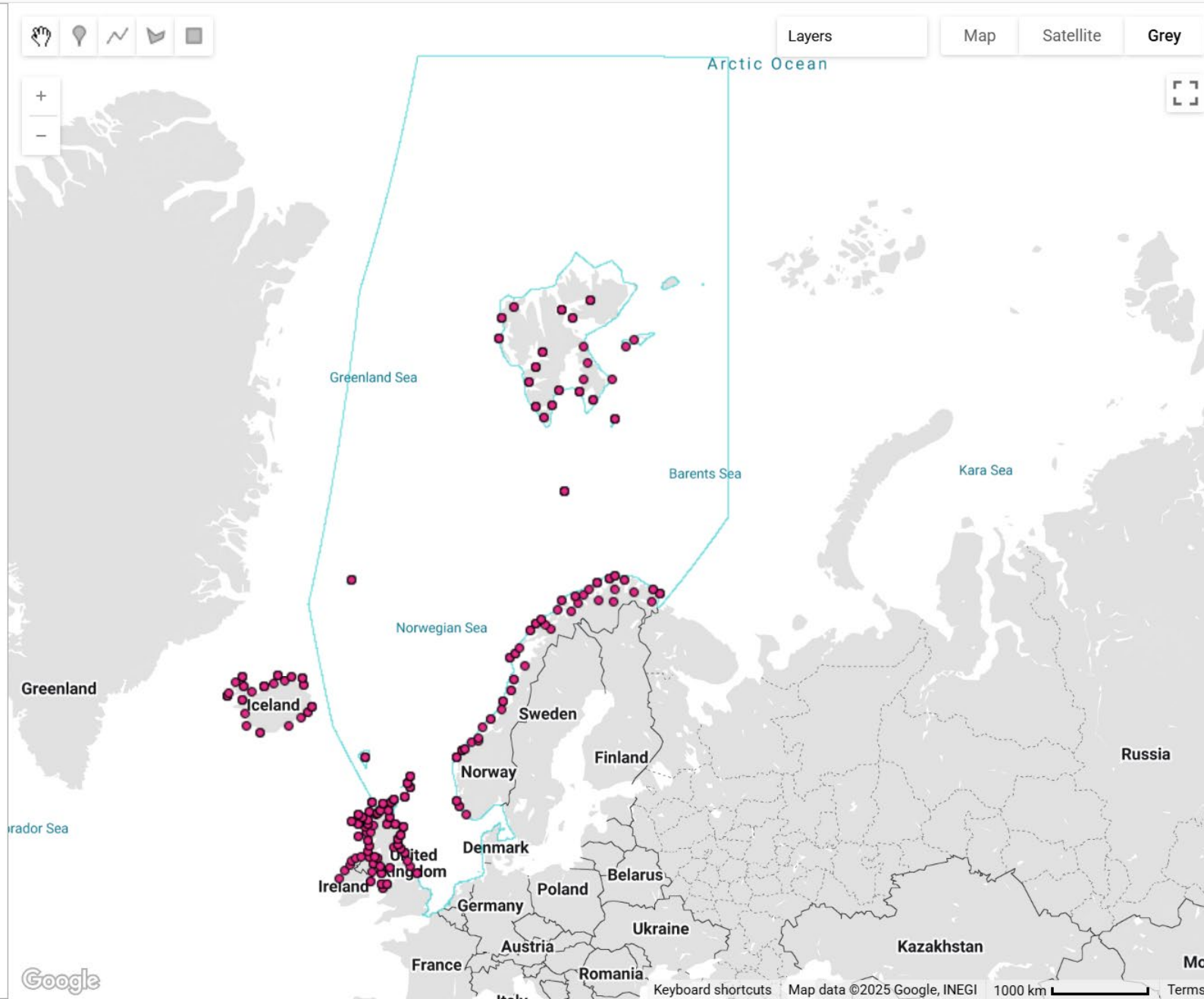
- Seabird colonies and distribution maps: [Seatrack](#)
- Life-cycle impact maps for migrating seabirds: [NINA](#)
- Stressor distribution maps: [EMODnet](#) and [SODIR](#).

Copyright© 2025, [NINA](#), tool licensed under [GNU GPL v. 3.0](#).

Modification and sharing of the source code of this tool is allowed under the terms of the GNU General Public License v.3.0., required that the MARCIS project and its partners are acknowledged. The tool is developed by NINA and intended for research and non-commercial use only, without warranties of any kind.

[Click here to assess single/cumulative impacts on seabirds](#)

[Click here to assess LCA impacts on migrating birds](#)



Single/Cumulative impacts on seabirds



In progress

Follow the workflow. Processing may take time due to the large data and area. If the browser shows 'Not responding,' it's still running in the cloud. Please wait until the map is loaded.

Click here to return to the introduction panel

Atlantic puffin

All countries

All international regions

All international colonies

Non-breeding season

23. All stressors & future OWF & ocean warming

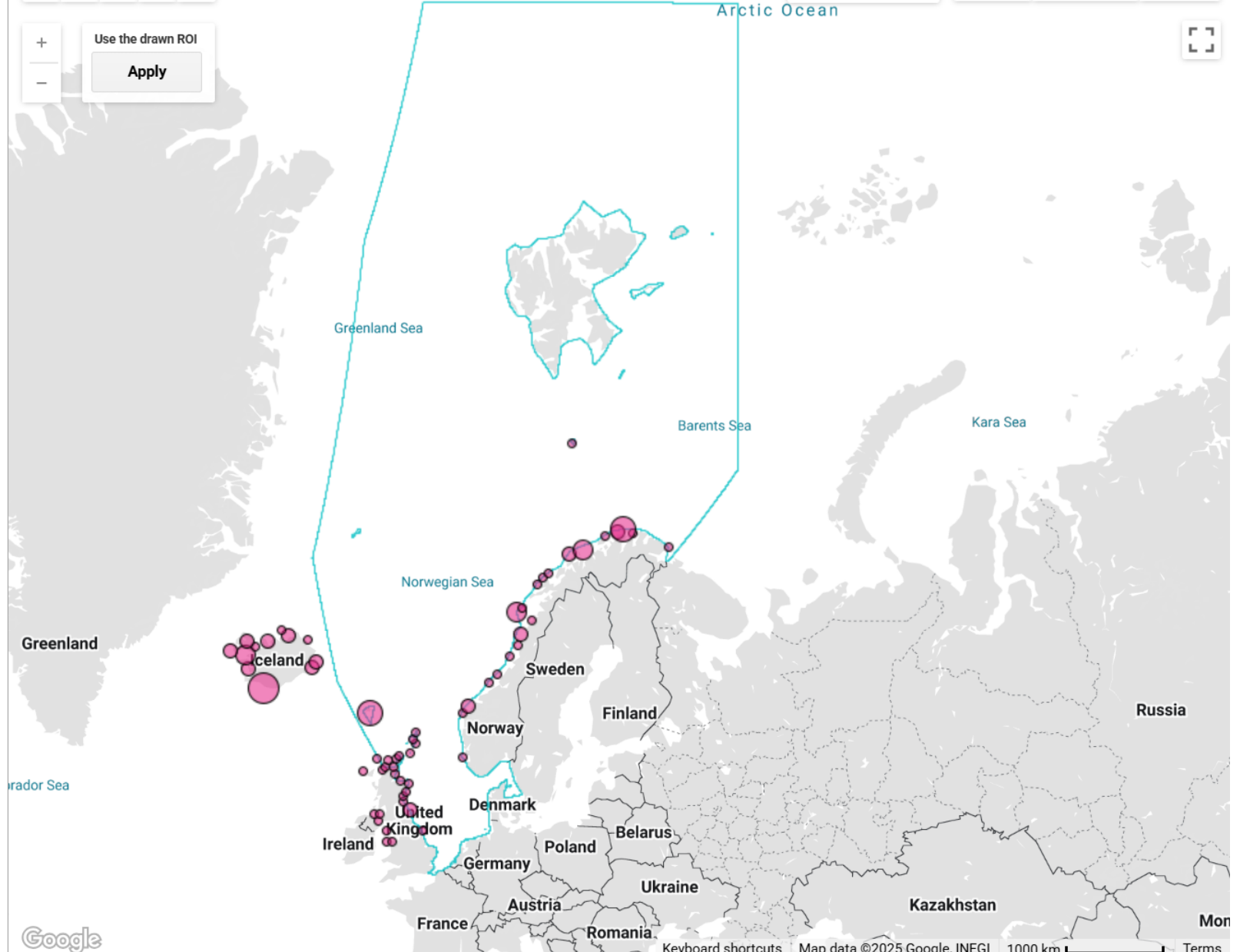
Start processing

Reset the panel

Map interaction tools: hand, location pin, line graph, bird icon, square icon.

Zoom controls: +, -, Use the drawn ROI, Apply

Layers | Map | Satellite | Grey



Single/Cumulative impacts on seabirds



Done

Follow the workflow. Processing may take time due to the large data and area. If the browser shows 'Not responding,' it's still running in the cloud. Please wait until the map is loaded.

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Start processing

Reset the panel



Show monthly overlap

Show applied weights

Show zonal statistics

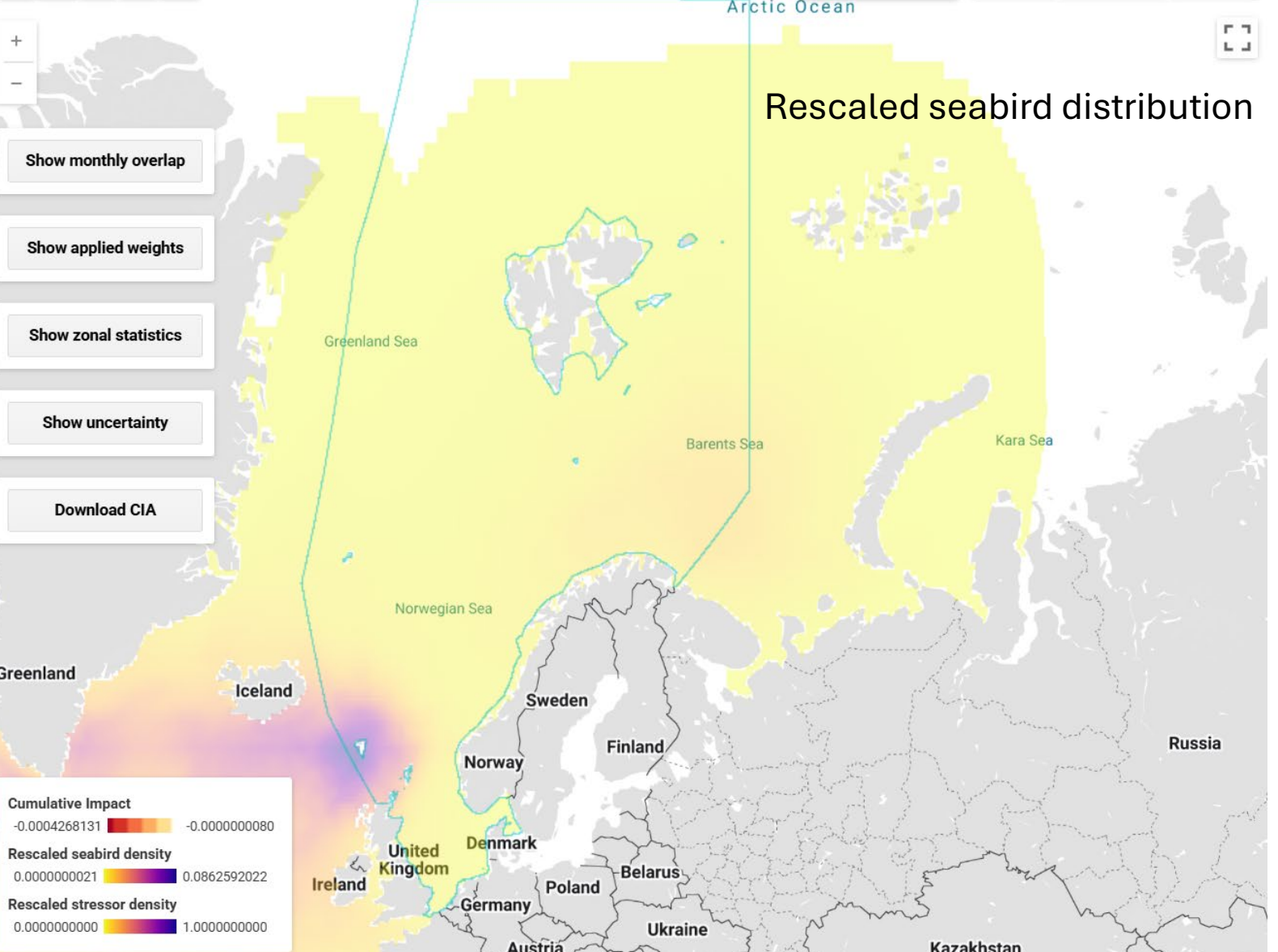
Show uncertainty

Download CIA

Layers | Map | Satellite | Base



Rescaled seabird distribution



Single/Cumulative impacts on seabirds



Follow the workflow. Processing may take time due to the large data and area. If the browser shows 'Not responding,' it's still running in the cloud. Please wait until the map is loaded.

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Reset the panel



Show monthly overlap

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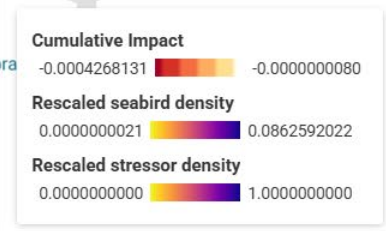
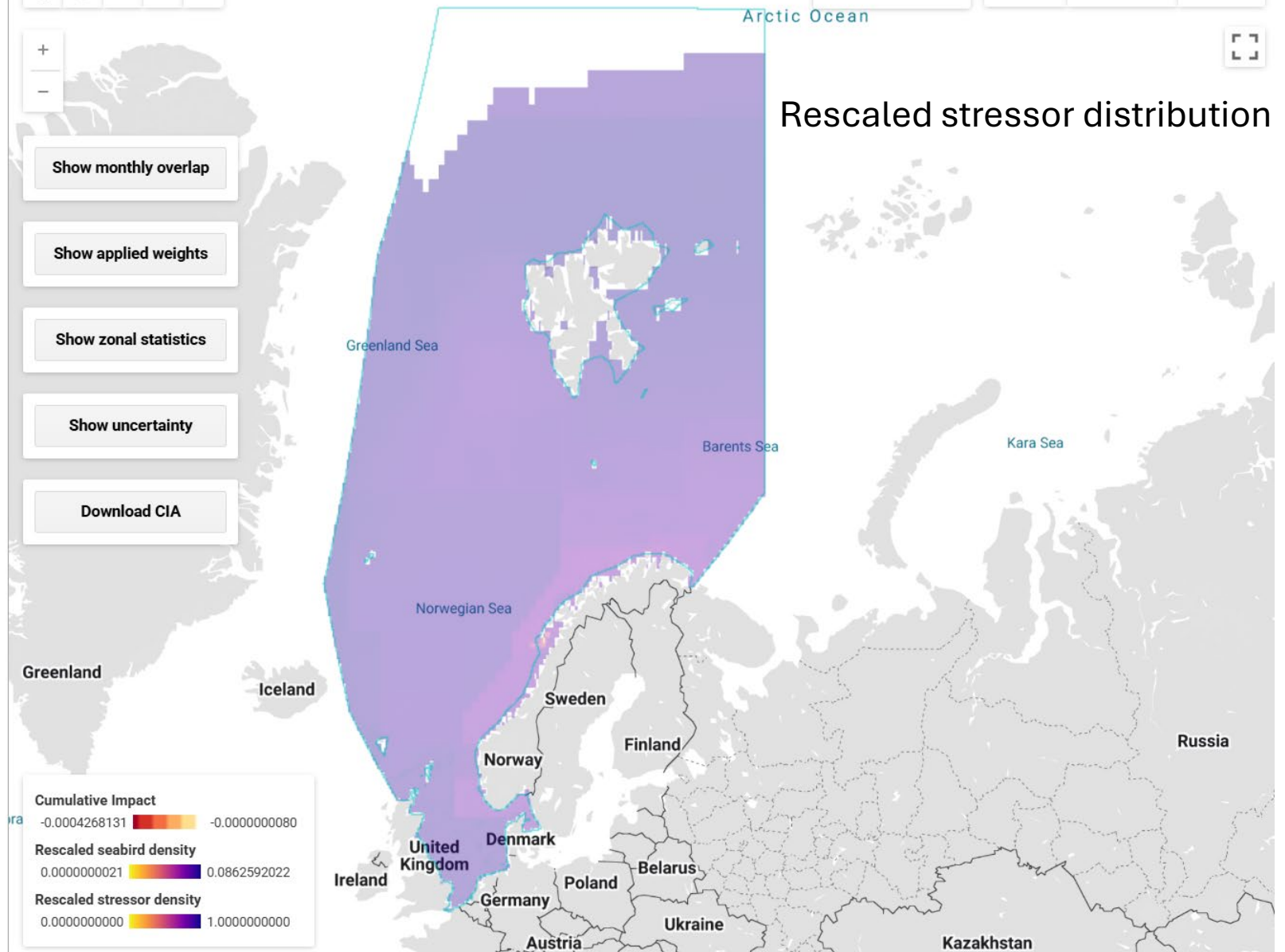
Show uncertainty

Download CIA

Layers Map Satellite Base



Rescaled stressor distribution



Single/Cumulative impacts on seabirds



Done

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Show monthly overlap

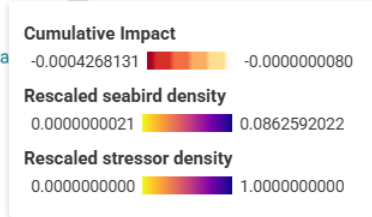
Show applied weights

Show zonal statistics

Show uncertainty

Download CIA

Layers Map Satellite Grey



[Click to download file:](#)
[CIA \(GeoTIFF, 50 km px, EPSG:3857\)](#)
 Tip: If blocked, right-click → "Open link in new tab" or allow pop-ups.

Single/Cumulative impacts on seabirds



Done

Follow the workflow. Processing may take time due to the large data and area. If the browser shows 'Not responding,' it's still running in the cloud. Please wait until the map is loaded.

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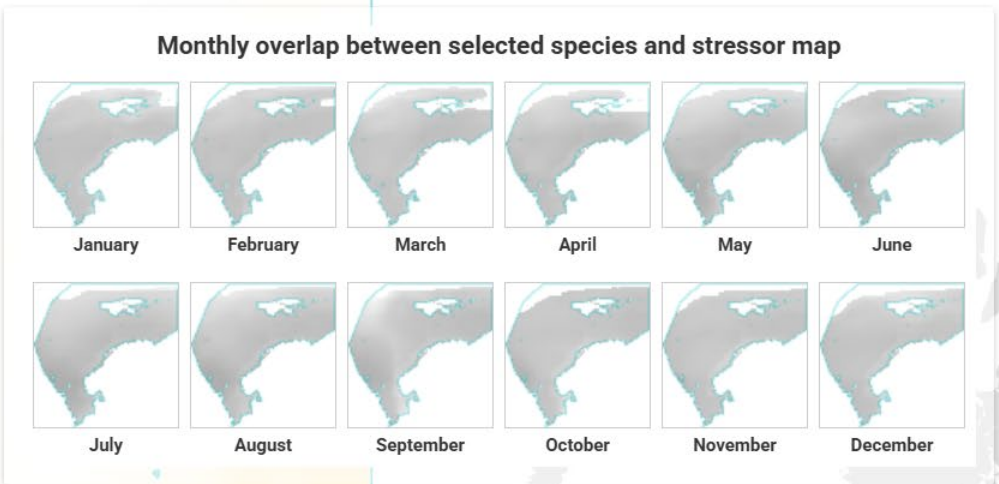
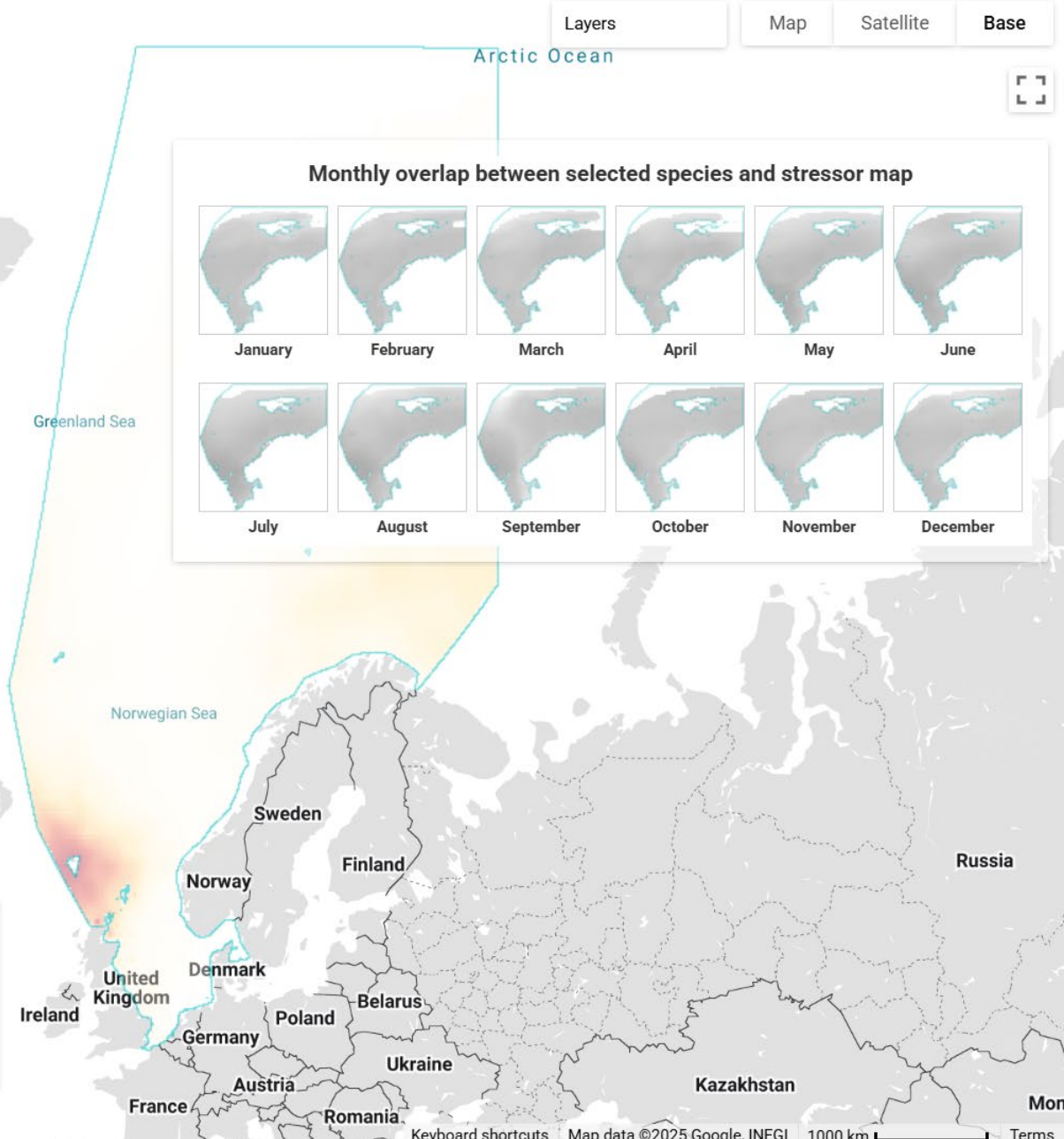
Hide monthly overlap

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Single/Cumulative impacts on seabirds



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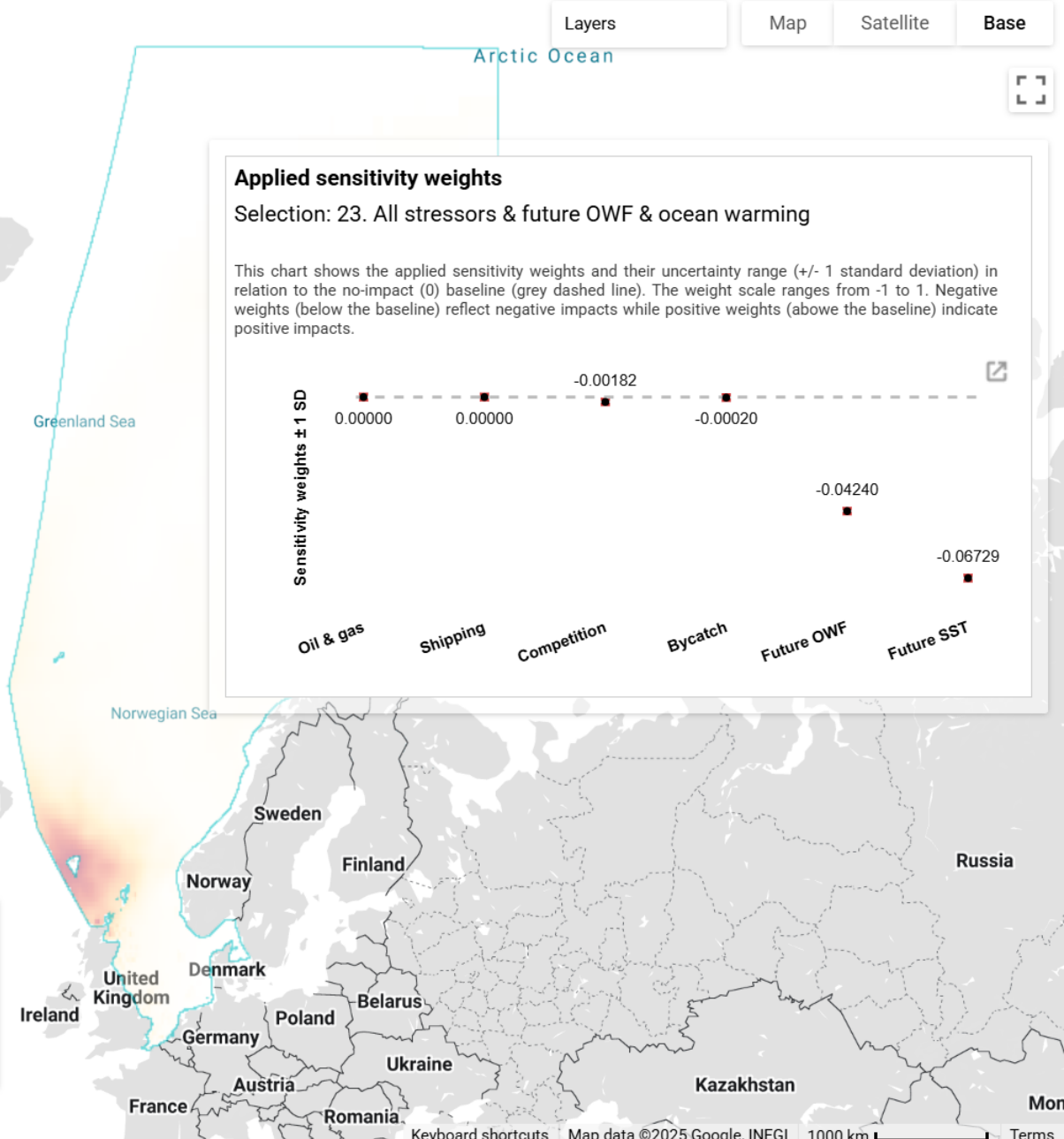
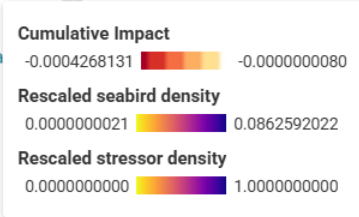
Show monthly overlap

Hide applied weights

Show zonal statistics

Show uncertainty

Download CIA

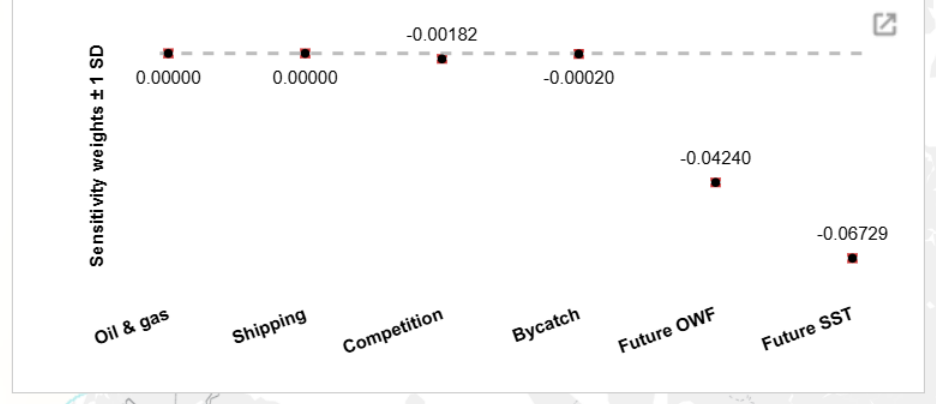


Layers Map Satellite Base

Applied sensitivity weights

Selection: 23. All stressors & future OWF & ocean warming

This chart shows the applied sensitivity weights and their uncertainty range (+/- 1 standard deviation) in relation to the no-impact (0) baseline (grey dashed line). The weight scale ranges from -1 to 1. Negative weights (below the baseline) reflect negative impacts while positive weights (above the baseline) indicate positive impacts.



Single/Cumulative impacts on seabirds



Done

Follow the workflow. Processing may take time due to the large data and area. If the browser shows 'Not responding,' it's still running in the cloud. Please wait until the map is loaded.

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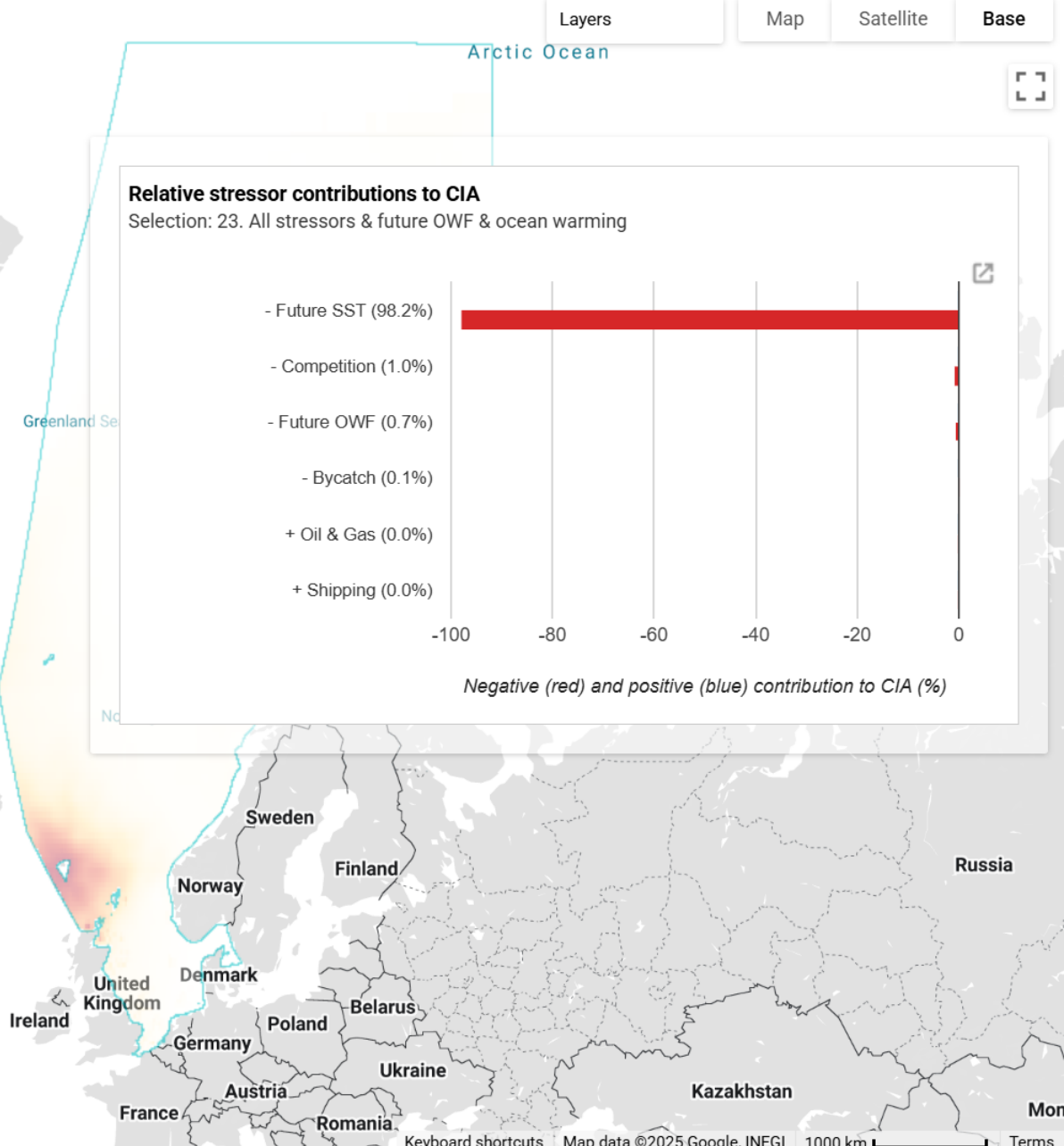
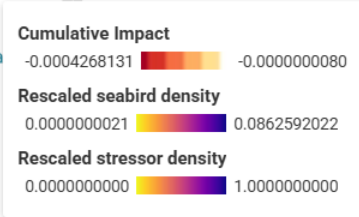
Show monthly overlap

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Single/Cumulative impacts on seabirds



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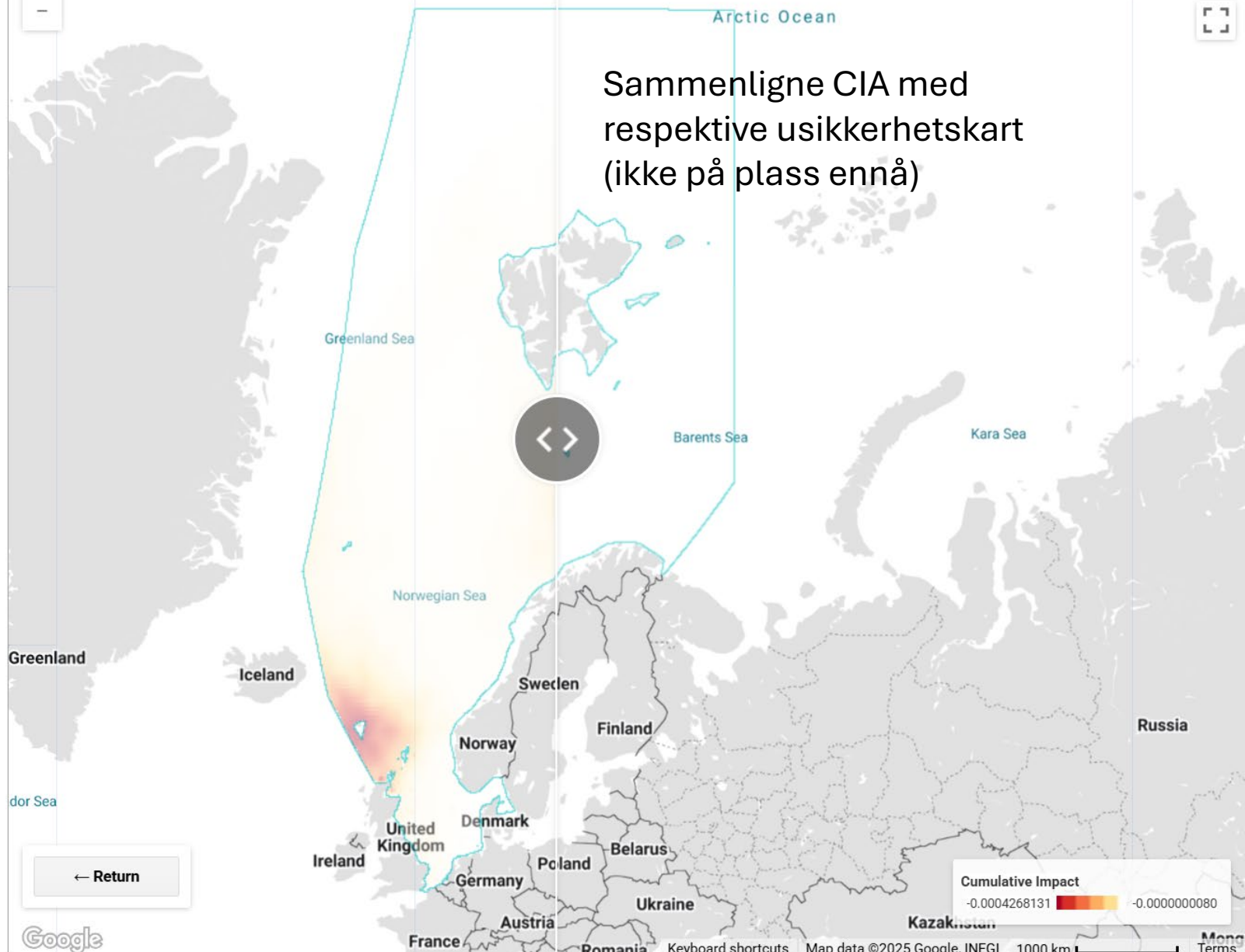
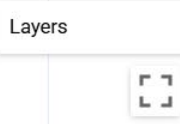
23. All stressors & future OWF & ocean warming

Start processing

Reset the panel



Compare the single/cumulate impact map with the stressor uncertainty maps



Return



Offshore wind impacts on migratory birds

Follow the requested workflow to perform your assessment. The results will automatically be added to the map and the layer list.

Click here to return to the introduction panel

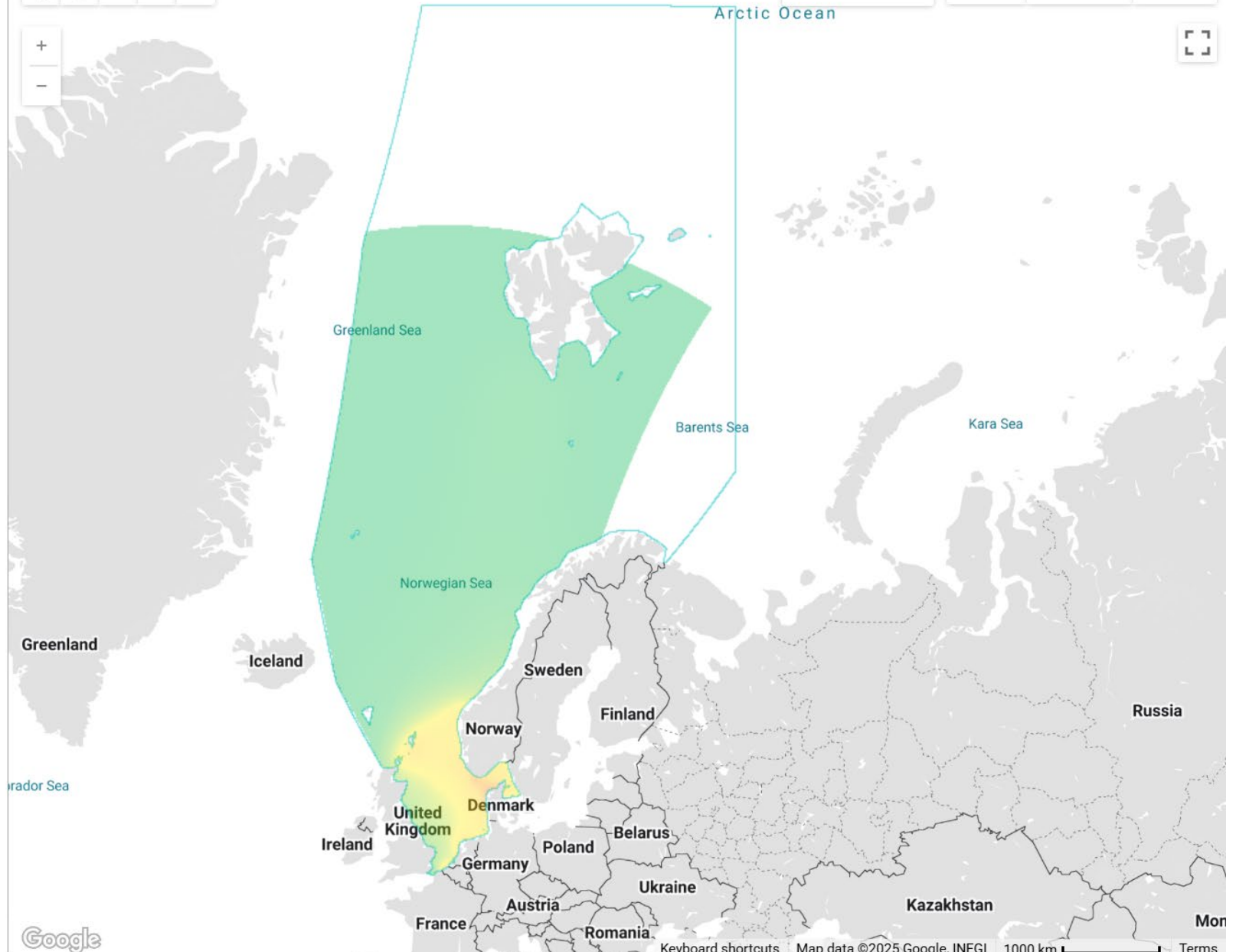
All impacts on all bird groups

All species groups

Reset the panel



Layers Map Satellite Base



Offshore wind impacts on migratory birds

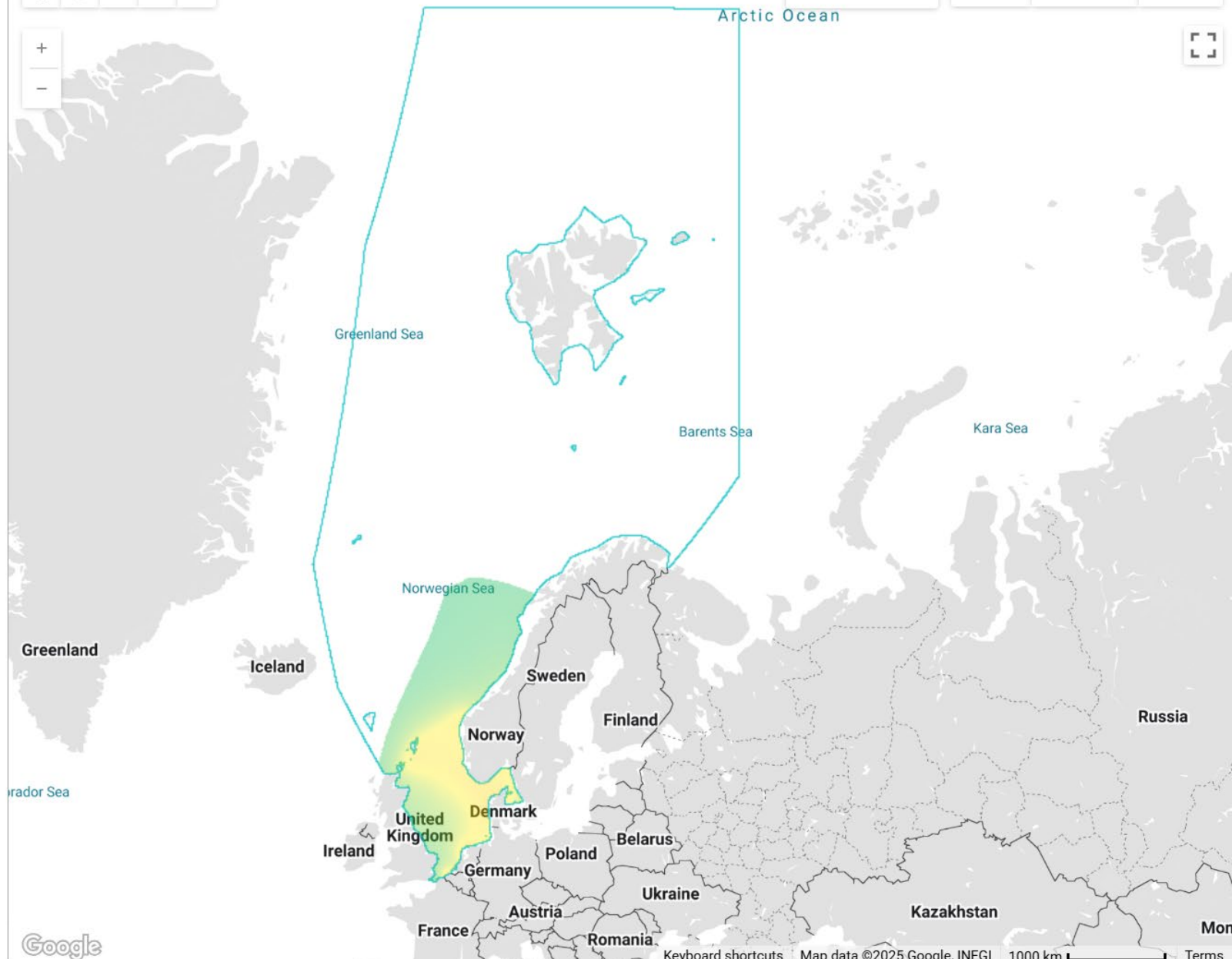
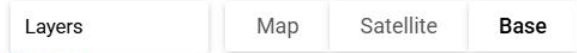
Follow the requested workflow to perform your assessment. The results will automatically be added to the map and the layer list.

Click here to return to the introduction panel

Barrier impacts on all bird groups (upper level)

All species groups

Reset the panel



Offshore wind impacts on migratory birds

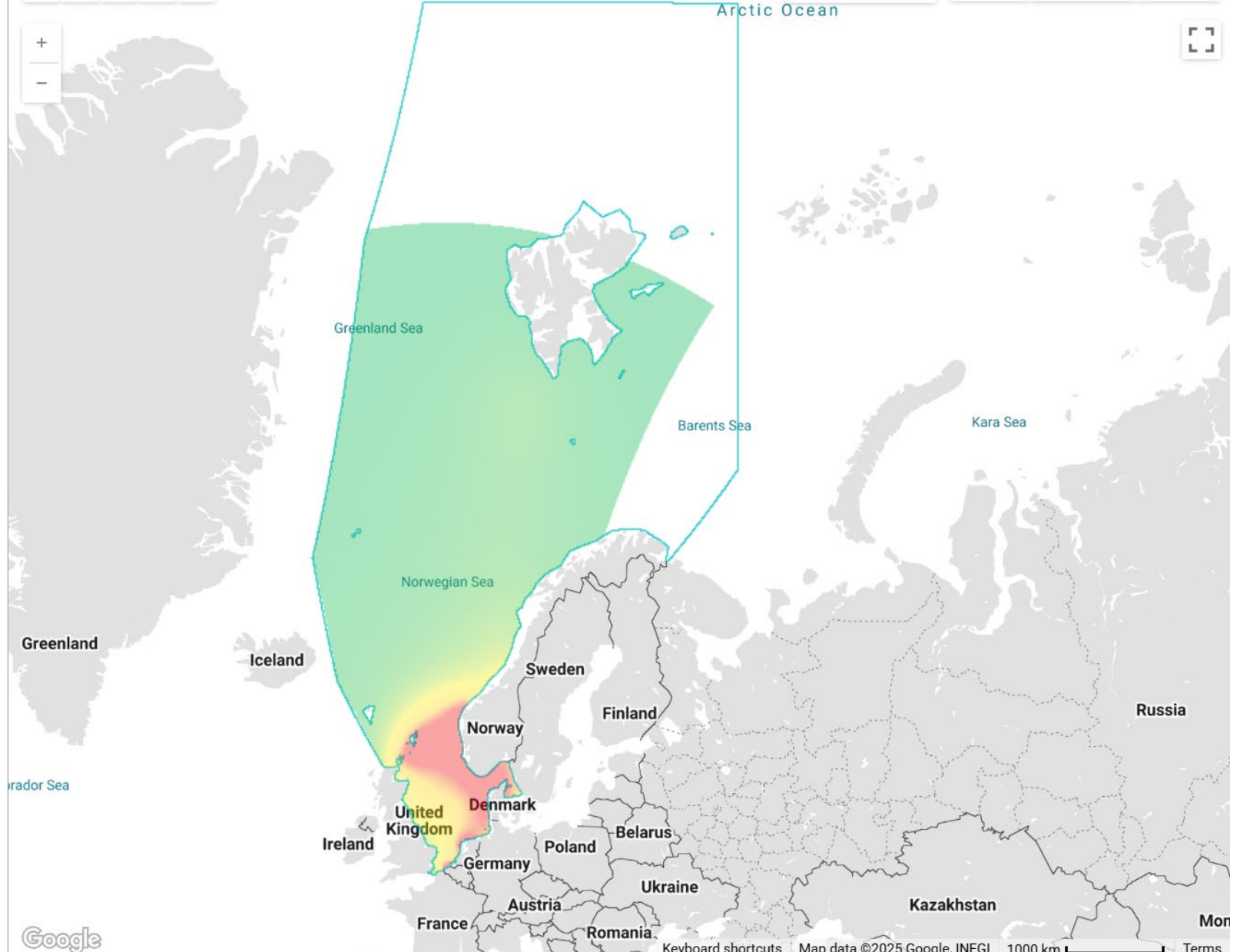
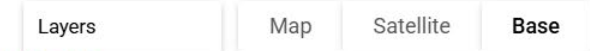
Follow the requested workflow to perform your assessment. The results will automatically be added to the map and the layer list.

Click here to return to the introduction panel

Disturbance impacts on all bird groups (upper level)

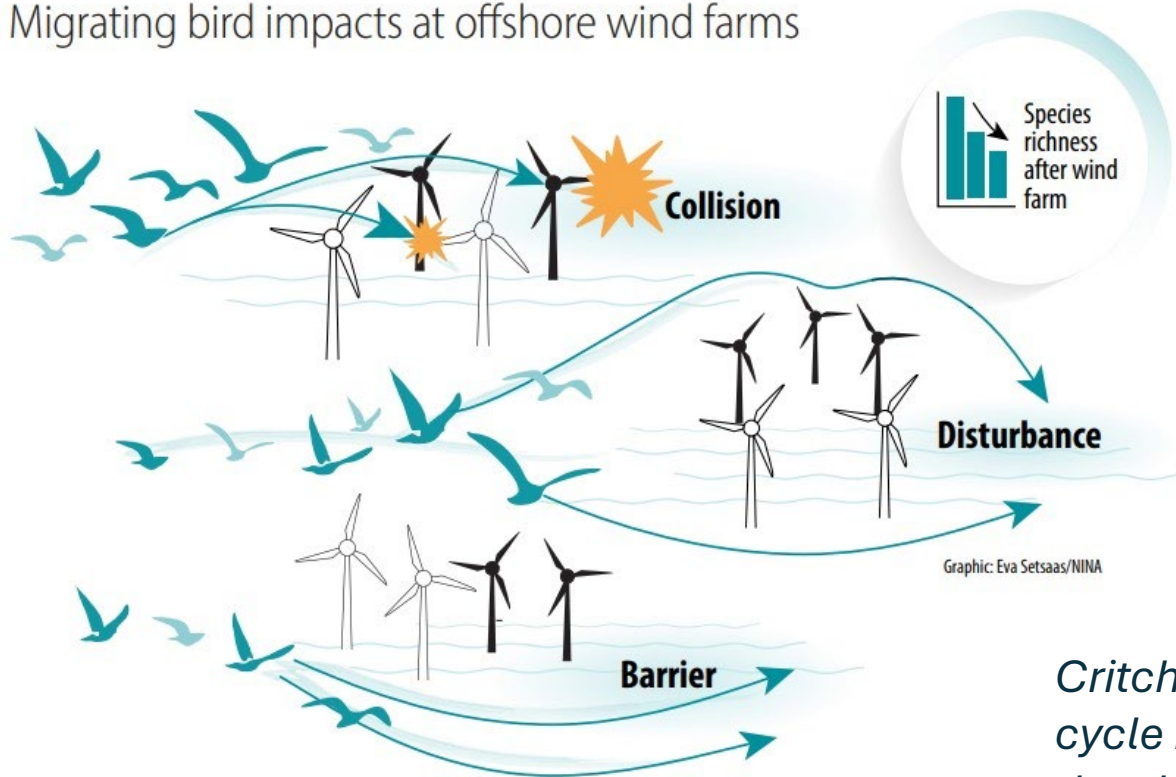
All species groups

Reset the panel



New knowledge: How offshore wind energy affects migratory bird diversity in the North Sea

Migrating bird impacts at offshore wind farms

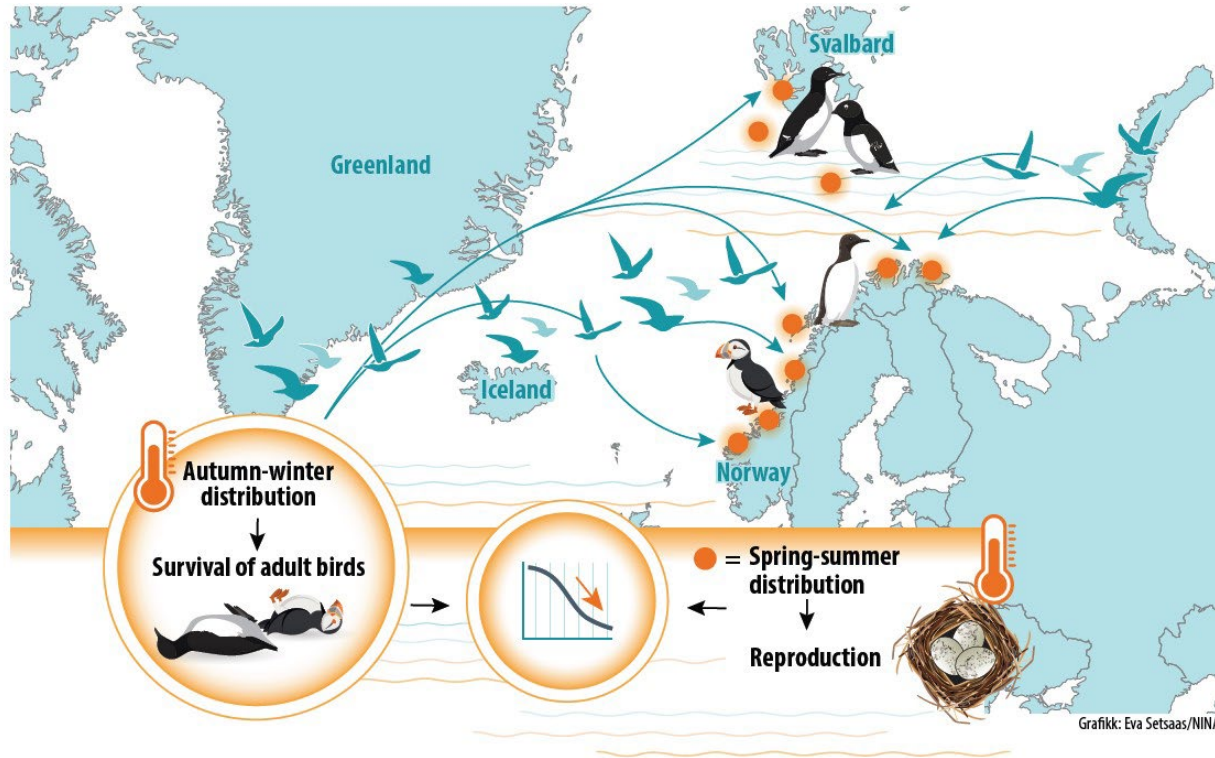


- Only impact from OWF
- Long-term ringing data
- 123 species --> 12 groups
- Life-cycle impact analysis
 - Calculated loss of species richness

Critchley, E.J., Nilsson, A., Helberg, M., May, R., 2025. Life-cycle impact assessment of offshore wind energy development on migrating bird diversity in the North Sea. Journal of Applied Ecology, 62(6).

<https://doi.org/10.1111/1365-2664.70087>

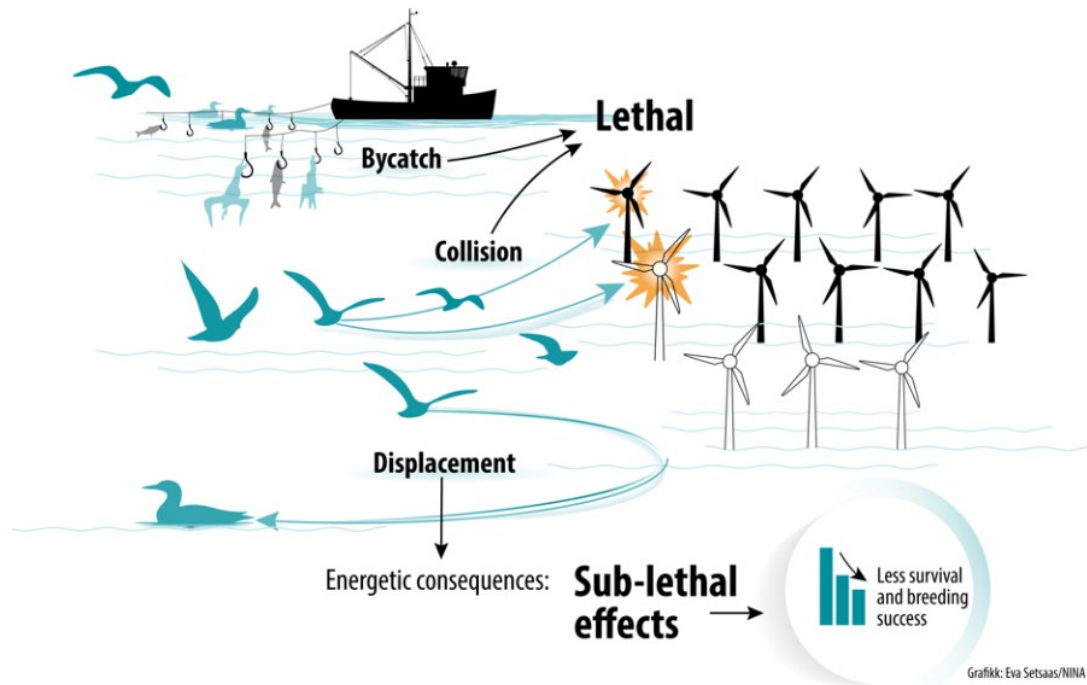
New knowledge: Seabird populations affected differently from ocean warming



- Affected through different demographic pathways
- Affected through different areas and seasons during non-breeding season
- Shows the importance of combining tracking and demographic data

Layton-Matthews, Regan, Ballesteros, Hodges, Descamps, Tycho Anker-Nilssen, Benjaminsen, Daunt, Barrett, Buckingham, Bråthen, Christensen-Dalsgaard, Dehnhard, Erikstad, Fayet, Helgason, Kjellstadli Johansen, Lorentsen, Lorentzen, Moe, Systad, Strøm, Searle, Reiertsen. Seabirds in hot water: are ocean warming hotspots associated with population decline? (Submitted, PNAS)

New knowledge: combined impacts of bycatch and offshore wind farms



- Modelled with IBMs
- Mortality or change in body mass

Buckingham, L., Masden, E.A., Layton-Matthews, K., Bringsvor, I.S., Bråthen, V.S., Dehnhard, N., Fauchald, P., Lorentsen, S.-H., Reiertsen, T.K., Tarroux, A., Searle, K.R., Christensen-Dalsgaard, S., An individual-based model to quantify the non-breeding season impact of wind farms on seabirds. (In Revision Ecological Solutions and Evidence)

Usefulness of the MARCIS tool

- Marine spatial planning related to cumulative impact on seabirds
- Can also be used for future EIA
 - Case specific
- Framework can be further developed
 - Other data, more species, expand area etc

Launch event of the MARCIS tool – 4. December

Stay tuned!



Takk til alle
prosjektdeltakere,
partnere og
interessenter!

