North Sea Energy Nature-inclusive hub design Workshop 2 - report

March 19th, 2024, 9:00 – 16:30
Location: Dutch Marine Energy Centre, Hellingweg 11D, The Hague
Participants: see appendix.
Programme and presentations: see slide deck (separate document).

Welcome and introduction

Anne-Mette Jørgensen (MSG) welcomes the participants to the workshop and introduces the programme of the day. Benjamin Lehner (DMEC) welcomes everyone to the location and briefly introduces DMEC's activities around ecology and the nature-inclusive design of offshore energy technologies.

Roos Bol (ARK) describes the Seawilding Approach, which is the basis for this workshop (see the attached slides). Harmen Slot (TNO) describes the characteristics of Hub North according to the scenario used in the workshop (see the attached slides).

Questions and remarks:

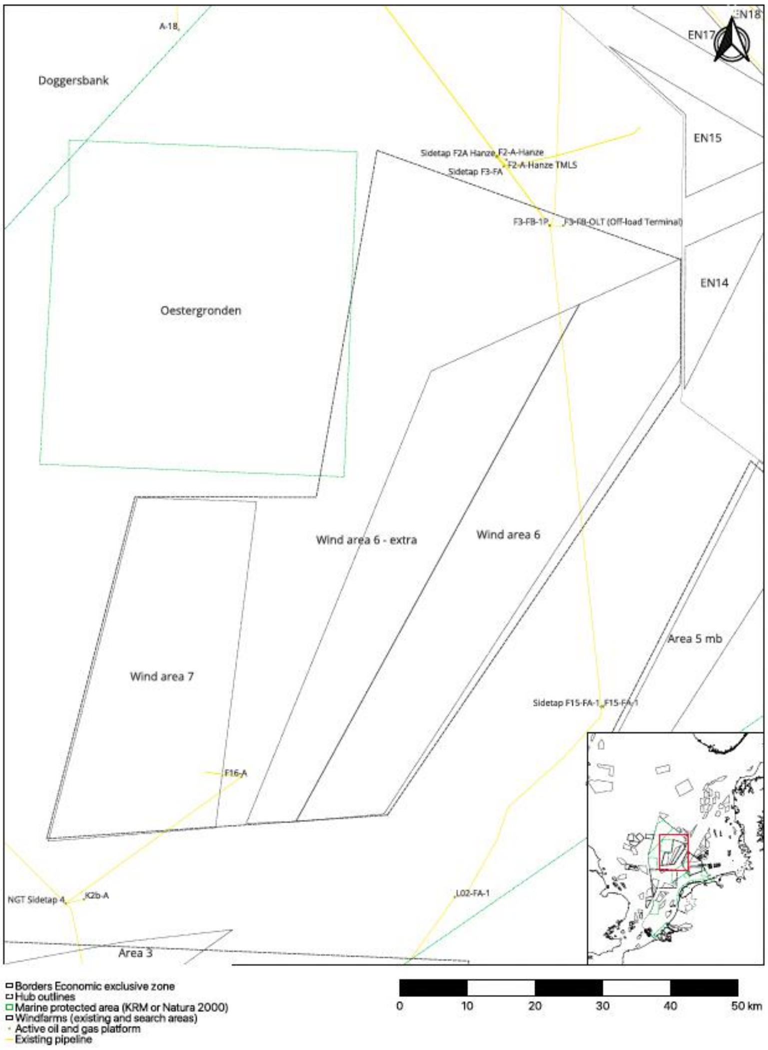
- Why was Hub North chosen for the nature-inclusive design? The intention was to jointly pick a hub during the first workshop, but there was no clear consensus. Based on the outcomes, the NSE-Ecology work package team chose Hub North for the following reasons: Of the three NSE hubs, this is the one where large-scale offshore hydrogen production is planned and it offers opportunities to discuss the scale effects of large volumes of wind and hydrogen production. It is also an ecologically sensitive area, which means that any developments taking place here will have to be nature-inclusive in design, and the area offers opportunities for both mitigation and restoration interventions. Finally, decision making regarding energy developments in this area are in a stage that allows us to have an impact by contributing to the process around of the Partial Revision of the North Sea Programme. Exploring a nature-inclusive design for Hub North in this workshop does ***not*** imply that participants endorse the idea of an energy hub in this particular area.
- Are the relevant ministries involved? Representatives from various ministries have been invited and are interested in the results but preferred not to participate. The ministries are more generally involved in the NSE programme through the Sounding Board. The NSE programme also contributes to the Energy Infrastructure Plan North Sea (EIPN). A major difference in its scope is that EIPN does not look at spatial synergies, whereas this is at the core of NSE.
- Will the cumulative impacts (also of other human activities in the area) be taken into account in the comparative assessment? Yes, they will be. The focus of this workshop is on energy activities, but we also prepared materials on other activities, such as vessel density and fishing intensity.
- Why is carbon capture and storage (CCS) not included in the hub design? CCS in the area in Hub North is not ruled out but has not been included in the current scenario as the other hubs seem more logical for it at this stage. For this workshop we had to limit ourselves to just one scenario for the hub. A different work package within NSE is refining this scenario and will also develop other scenarios that may include CCS.

Design workshop

For the workshop, participants split into four groups. Groups A and B were requested to focus on the large-scale spatial design of the energy hub and interventions related to it (macro-level). Groups C and D were requested to focus on local interventions related to specific structures (micro-level). Group C focused on electricity-related structures (windfarms and cables), while group D focused on hydrogen-related structures (electrolysers and pipelines). The main results of the group discussions are summarised below, with the input from all four groups combined per step in the Seawilding approach. Detailed reports from each group are included at the end of this report.

1. Seascape scope

The scope of the seascape was defined by the project team before the workshop. The map below shows the area of Hub North.



2. Current state

In preparation for the workshop, the project team compiled a factsheet with information on the current state of the seascape and on the potential developments in case an energy hub would be developed. Based on this information, the groups describe the current state as follows:

- **Trophic complexity: medium**. The primary production is in a relatively good state. Benthic complexity is a lot lower than it historically was – the area used to be covered with flat oyster banks, which have been destroyed by intensive fisheries – but compared to other areas, such as the Southern North Sea, benthic diversity is relatively high including some long-living species. Also, pelagic complexity is relatively high, providing enough food for schools of tuna and large number of birds to forage here.
- **Dispersal (connectivity): medium**. Benthic connectivity is relatively low. Currents are not very strong and there is little hard substrate for species to use as stepping stones, meaning connectivity to the surrounding MPAs is limited. Pelagic connectivity is higher, as indicated by Tuna visiting to the area.

- **Random disturbances: medium**. If abiotic processes are governed by natural dynamics, this score is higher. For the hub area, it is relatively low for the benthic zone, mostly because of fisheries impacts, and higher for the pelagic zone.

3. Constraints

Current constraints identified include:

- Some fishing activity in limited parts of the area, but much less than in areas closer to the coast.
- Increasing seawater temperatures due to climate change.
- Noise from shipping lanes, but much less than further south, e.g. around Hub West.

Constraints created by the construction or presence of an energy hub include:

- Sediment & turbidity disturbance due to construction of wind turbines, platforms, cables and pipelines, which may continue for several years.
- Impulse noise and vibrations during construction as well as continuous noise, from wind turbines and H_2 compressors.
- Vessel movement, both during construction and in the operational phase. This includes both noise and artificial light. Mitigation of potential impacts on migrating guillemots might take the form of halting construction activities during the July-October period.
- Habitat disturbance resulting from physical disturbance and noise.
- Brine disposal from H_2 production and salt cavern excavation for H_2 storage.
- O_2 release.
- Shadow effects (blocking light) from platforms and offshore solar panels.
- Collisions and barrier effects on birds, in the air (wind turbines) as well as on the water (turbines, platforms).
- Changes in stratification due to monopiles and other structures.
- Introduction of hard substrate; scour protection and steel piles.
- Cables (electromagnetic fields).
- Cooling water intake for and emissions of warm, polluted water from H_2 production.

An important note to be made is that the ecological effects of many of the potential impacts are poorly understood, especially when occurring at a large scale. This, in combination with significant knowledge gaps regarding the functioning of the current ecosystem in the area, makes it difficult to assess which impacts could be seen as constraints and which ones might (also) function as enabling conditions.

4. Enabling conditions

Potential enabling conditions on which a nature-inclusive design for the energy might make use of include:

- Introduction of hard substrate; scour protection and steel piles.
- (Limited) O_2 release may be an enabling condition, especially in oxygen depleted areas developing near the seabed.
- Creation of no-fishing areas.
- The presence of platforms with large complexity might facilitate dispersal of certain species and serve as a safe haven for juveniles and bird species normally nesting on cliffs.
- The presence of scouring protection and gravel beds around platforms and pipelines may facilitate restoration of oyster reefs and improved breeding conditions for sharks and rays.
- Reduced seabed disturbance and protection/strengthening of benthic and reef-building species in the area. This could occur only after all energy infrastructure has been constructed, as the construction itself will temporarily increase seabed disturbance and turbidity. It is uncertain to what extent existing benthic species would be able to survive a long period of disturbing construction activities.
- The structural complexity of energy installations might be able to function as a safe haven for juveniles and to support connectivity for other species. These functions might be enhanced by the design and location of installations.

5. Potential state

Participants felt the following ecological state could be feasible, though not necessarily in combination with an energy hub:

- Trophic complexity: medium-high. Restoration of oyster banks and reduction of fisheries pressure could result in more habitat diversity and higher trophic complexity.
- Dispersal (connectivity): medium. Wind farms and platforms will even in optimistic scenarios function as barriers for some migrating birds, hence reducing connectivity. The presence of additional hard substrate may increase connectivity for benthic species that need hard substrate, including exotic (potentially invasive) ones.
- Random disturbances: medium. Noise pressure will increase significantly. Turbidity will first increase and then return to more natural levels (after the construction phase). Stratification patterns will remain changed.

For specifying what type of ecosystem(s) the potential state might include, the suggestion is to look at reference areas inside and outside of the hub area.

6. Interventions

Creating the right conditions

Optimizing enabling conditions for nature restoration and minimizing negative impacts starts out with proper understanding of the current state and potential of the ecosystem and careful planning of activities, considering the cumulative impact of all activities and processes, such as climate change. Planning needs to consider locations as well as timelines for development taking a full life-cycle approach.

Improving our understanding: Monitoring, research and education

Lack of detailed knowledge about the presence of certain species and habitats and the functioning of the ecosystem as a whole is currently a major barrier to defining effective measures for nature-inclusive development of the Hub North area. Interventions to improve our knowledge could include:

- National monitoring plan and mandatory monitoring around new developments: In order to fill knowledge gaps and improve future decision making a national monitoring programme could be developed, including mandatory monitoring of ecological impacts for all new (infrastructural) projects in the North Sea.
- Such a plan could include a roadmap for monitoring **that starts monitoring now.** This would facilitate learning on the way (with and without interventions) and adaptive management.
- To increase monitoring and data-sharing we could obligate data-sharing (windfarm lifetime) and use fishermen and maintenance vessels as data gatherers, so the learning curve increases instead of becoming stagnant and human capacity is optimally used.
- Use existing gas platforms (F16, F15, F2, F3) to research/monitor potential for biodiversity on/around platforms in the area and start experimenting with nature-enhancing measures within their safety zones. If the platforms turn out to be able to support ecosystem restoration, it might be considered to leave parts of them in place as artificial reefs.
- A North Sea Ecology (NSE) research program could further study the expected impacts of the expected developments on the North Sea, beyond the mandatory monitoring at projects.
- Use H2 production pilots 1 and 2 to monitor potential impact on birds, in particular guillemots and their predators (large gulls), and to experiment with different solutions for disturbances caused by brine and heat emissions.
- Micrositing with a focus on identifying highly biodiverse areas. These areas could then be excluded from wind farm and other infrastructural developments. Also looking for areas with shipwrecks, WWII artefacts (quite often are biodiverse because untouched).
- In order to improve the knowledge on ecology by engineers/geologist/other non-ecologist we could create a standard course, so the various people involved in the whole chain of process know better what an ecosystem is, how it works and why it is important.

Spatial planning & policy measures

As there is still much we do not know about potential impacts, we need to develop the area in an adaptive manner: develop wind farms (and H_2 platforms) in small pieces and start monitoring of potential constraints and enabling conditions now as suggested above. Considering that energy developments in the area will probably not start until after 2035, there is time enough to significantly increase our knowledge about the area and possibly to take measures to improve enabling conditions/restore nature before developments take place. That way, ecosystems may become more resilient to new developments.

- Start restoration processes earlier than planned commissioning (potentially with reef kickstart functions). E.g. already close certain areas now (MPAs).
- Consider energy developments as part of an integrated plan for the area, in which the cumulative pressure on the ecosystem is reduced or at remains 'neutral: in order to restore seabed integrity, we could, for example, implement a no-fishing zone in the area.
- Strategical Marine Spatial Planning: In order to avoid affecting stratification regimes, decisions could be made in MSP to strategically designate areas to refrain from development.
- Spatial design of infrastructure areas from a nature-first perspective, so that disturbances of natural processes are minimized as much as possible
- Strengthening ecosystem resilience by designating additional protected areas, also outside the hub area (so that the overall ecological carrying capacity is increased).
- Plan for modular development and adaptive management: In order to deal with uncertainty, we could improve flexibility by developing the hub in pieces over time and continuously monitor so that negative effects can be identified and mitigated. This process should be sufficiently flexible as to be able to stop developments in case of severe negative impacts.
- Diversify infrastructure type: In order to reduce bird mortality and reduce the risk of potential effects on stratification, we could diversify infrastructure type by partially replacing wind turbines with solar & wave energy structures. NB. To do so, we need to know more about how birds respond to alternative renewable energy technologies and about how such structures may affect stratification.
- In order to reduce underwater noise levels and optic disturbance**,** we could plan for refuge (no-go) zones spread across the wind/solar farm areas that limit activities and allow for passive restoration.
- In order to minimize disturbance by noise, we could concentrate disturbances, by placing H_2 platforms at the edge of Hub North and next to the shipping lanes**,** so the largest area of the Hub retains low noise levels.
- Plan timeline for construction phase to facilitate the effects of nature-strengthening measures: In order to avoid mismatches between construction activities and the effectivity of building with nature interventions, timelines for construction could be adapted.
- In order to improve the processes of designing nature-strengthening measures, inside and outside tender processes, maps and ecological reference information could be shared and Chinese walls between ecologists working on different projects removed.
- Adapt policies regarding decommissioning in order to facilitate protection of nature value as well as circularity: In order to avoid limiting positive impacts to the short term we could investigate the possibilities for enabling partial decommissioning in plans so that ecological values that develop on and around infrastructure may be protected also after decommissioning.
- In order to collaborate, coordinate and have an owner we could educate, communicate and disseminate better what is going on by assigning a minister of the North Sea so the governance of this all is well arranged.

Mitigating negative impacts

H_2 production:

- It is absolutely key to develop a closed cooling system for elektrolysers in order to avoid the impacts of a 'huge vacuum cleaner' sucking up large amounts of water (including marine life) and emitting it again in a form where it is polluted with biocides and other chemicals needed to keep the interior of the cooling system and the elektrolysers clean.
- To reduce the impact of heat production on the marine ecosystem, cooling techniques could be diversified, using air as well as water for cooling.

- Possibly, produced heat might also be used for some form of multi-functional use of the platform, e.g. algae production (oxygen, heat, water and nutrients from bird poop?) or living quarters on the platform (potentially also reducing noise from maintenance vessels).
- To reduce the overall spatial footprint solar panels could be mounted on H_2 platforms.

Wind farm design:

- Design windfarms with a focus on circularity and limiting resource use by:
    - Extending lifetime so as to minimize ecosystem impact through change and prolong the kickstarting effect.
    - Keep decommissioning in mind to prevent taking out biodiversity after operation.
    - Re-use windfarm components (e.g., scour protections / part of foundations) on site or in other areas.
- Partly replace wind by solar so that:
    - the total affected surface area is reduced/
    - the total amount of wind turbines is reduced (further research is needed on the relative impacts of solar to wind, but a mix may well result in lower negative impacts overall).

Impact on Birds:

- Bird corridor in deeper area: In order to reduce habitat loss, collisions and barrier effects for birds, we could enable connectivity, by creating a North/South Corridor in the deeper area of the Hub North (which birds already tend to use and where fixed installations would be more challenging and costly anyway), so the birds can migrate undisturbed between the Oyster Grounds and Frisian Front.
- Adjust wind turbine design: In order to reduce bird collisions an optimal turbine tip height and distance to sea-level, painted blades and NIDs should be developed as a standard.
- Explore possibilities for using electrolyser platforms to create a safe flight corridor for birds migrating e.g. between the Doggerbank and the Frisian Front. And more generally exploring opportunities for using platforms to divert birds away from wind turbines in order to reduce the collision risk.

Stratification:

- Streamlining (wind turbine) foundations and other infrastructural obstructions**,** so wake effects are minimized could help to reduce impacts the effect on stratification.
- Replace (partly) wind by solar > small area of light/solar radiation limitation vs big de-stratification effects
- For enabling stratification: decreasing the number of structures, creating east-west corridors to account for hydrodynamics, modularity(?) and hotspots (?).

Noise:

- In order to keep fish and mammals unaffected, we could reduce underwater noise levels and optic disturbance, by concentrating disturbances (layout), reducing duration of impacts (efficient operations), choosing optimal timings for required disturbances (windows) and finally reducing the intensity of impacts (slow sailing, mitigation screens), so the behaviour and health of the species is not adversely affected.

Electromagnetic fields:

- In order to avoid electromagnetic field disturbance to shark and rays, we could optimize cable routing, by allowing for corridors, burying the cables deeper, remove IAC crossings / nodes, aligning cables closer to each other, so the possible ecosystem disturbance is minimized.

Using enabling conditions to strengthen and enrich nature

Hard substrate and connectivity:

- In order to restore oyster reefs, we could introduce several connected stepping stones spread in the area to assist larval introduction, dispersal and settlement, by designing new scour protections, reuse existing hard substrates and finally introduce new tailored ecological substrates that support seeding of adult oysters, spat-on-shell and proper settlement chemical cues (calcium-rich), so a continuous oyster reef can grow leading to a recovery of the species and a stable population in the long term.

- Designing windfarms/cable layer/crossing in a way that they stimulate dispersal and connectivity may play a role here. This would demand improved insight into the distances that relevant species can travel and of the general connectivity between MPAs.
- In combination with the above, in order to restore a continuous oyster reef that spans across and even extends further than the Hub North area, we could minimize seabed disturbance activities, by designation of proper MPAs that run through Hub North and connect it with the Oyster Grounds, Frisian Front and Doggerbank, so that a continuous oyster reef can form and more local active restoration activities are allowed to take on a large scale effect.
- In order to give oysters the chance to thrive we could have a biological layer on hard substrates, and by placing these substrates in certain areas, so the oysters can grow better.
- In order to increase potential habitat diversity, we could work with different types and sizes of hard substrate by using small rocks, big rocks, cravets, gravel, etc, so the different species and size-classes can grow, life and reproduce.
- In order to enhance ecosystem connectivity, we could connect MPAs, by creating stepping stones and other effective area-based conservation measures (OECMs), so the wider area will have a higher carrying capacity and the wider ecosystem is taken into account, and upscaling of biodiversity enhancement from more local active restoration efforts is possible.

Habitat diversity:

- In order to increase habitat diversity, we could work habitat specific and make sure certain habitats are left untouched, so the system as a whole becomes more robust, stabile and resilient.
- Create diversity in size and structural design of energy installations in the area in order to facilitate different habitats suitable for different species. Avoid ‘monoculture’. This might also help to reduce impacts on abiotic factors like stratification.
- In order to facilitate biodiversity, platforms could be developed with resting/nesting places for seabirds, fish hotels, reef-enhancing scouring protection, gravel beds for the eggs of rays and sharks to attach to, artificial reefs supporting the reintroduction of flat oysters, etc. These measures are seen as no-regret measures that could be experimented with already now in the safety zones of existing platforms in the area.

One remark made by a participant who was not present at this particular workshop is that the discussions may have overestimated the potential for oyster restoration. The area has low productivity and strong summer stratification. This means the growth speed for oysters and other reef builders is very low and reef restoration may take a very long time. Increasing species richness in the upper water layers may well further lower the carrying capacity for oysters in the area.

7. Connecting the dots

“What’s next” will be discussed during the third workshop.

Conclusions

The four group leads briefly presented the main results of their groups. Before leaving, participants were also asked to fill out a form with three questions. The general outline of their answers is included below.

Anne-Mette thanked all participants for their active participation and valuable insights. The results of this workshop will form the foundation for the products the NSE team will deliver: a nature-inclusive design for the energy hub; a comparative assessment of the ecological impacts of this design and those of a non-nature-inclusive design; and a whitepaper with general recommendations for nature-inclusive design. All participants will be invited to a third workshop in the autumn (date to be determined), during which we will discuss drafts of these products.

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Appendix: Results by group

This appendix includes a more extensive description of the discussion of the four sub-groups. Please note that these results have already been included in summarized form in the main report.

Group A: spatial design

1. Current state

- Trophic complexity — Medium
- Dispersal (connectivity) — Medium
- Random disturbances — Medium

The primary production is in a good state, the visiting tuna are good and the current area dynamics are relatively natural (mild human pressure) but there is impact from damage from the past (e.g., no oyster reefs) and the complexity of benthos could be higher. There are active fisheries and there are still knowledge gaps. In term of dispersal there seems to be more influx than outflux in this area. In terms of knowledge gaps, it is unclear what climate change will do to the area and whether Lanice reefs are present.

2. Constraints (↓) and 3. enabling conditions (↑)

A number of constraints identified were:

1. Sediment & turbidity disturbance — ↓ environmental trigger
2. Impulse and continuous noise (also from H_2 compressors) and vessel movement/artificial light — ↓ environmental trigger
3. Habitat disturbance / hard structures — ↓↑ interacting infrastructure
4. Brine — ↓ environmental trigger
5. O_2 release (with a clear sidenote on the amount of O_2) — ↓↑ environmental trigger
6. Light blocking — ↓ interacting infrastructure
7. Collisions — ↓ interacting infrastructure

It was discussed within the group that vessel movement might be an underestimated impact of offshore wind farms.

Idea bank

No.	What is the idea or intervention?	How does it influence the ecosystem?
1.	Enable partial decommissioning in plans so that biodiversity can be stimulated and supported after removal of infra	- Stimulation of biodiversity in area during and after operation - Function as stepping stone for biodiversity
2.	Concentrate noise of electrolysers close to shipping lane	Only localised effects of noise on birds/mammals
3.	Wind turbine generator layout optimized for currents (stratification) next to wind extraction	Prevent negative effects on stratification and primary production

4.	Nature-inclusive designed scour protection along/on top of pipelines / cable crossings	Act as stepping stone
5.	Create corridors for cables and electromagnetic fields, put cables next to existing ones as much as possible and bury cables deeper	Prevent EMF disturbance on e.g. sharks and rays
6.	Design windfarms with a focus on circularity to: - extend the lifetime = minimize ecosystem impact through change, prolong kickstarting effect - keep decommissioning in mind to prevent taking out biodiversity after operation - Re-use windfarm components (e.g., scour protections / part of foundations) and prevent ecological damage in other areas	Reduces overall ecological impact
7.	Replace (partly) wind by solar > small area of light/solar radiation limitation vs big de-stratification effects	Reduce stratification disturbance Reduce overall area that is impacted
8.	Refuge areas with passive restoration & no activities (no take zone)	Stimulate biodiversity and natural processes
9.	Start restoration processes earlier than planned commissioning (potentially with reef kickstart functions). E.g. already close certain areas now (MPAs).	Ensure that positive effects happen during the operating phase. Nature takes more time than wind farm installation.
10.	Slow sailing zones + silent shipping + multi-purpose sailing	Prevent/limit noise disturbance and keep areas available for animals
11.	Use maintenance vessel for monitoring	Increase knowledge to help take better measures
12	Put solar panels on H_2 platforms	Minimize space needed

4. Potential state

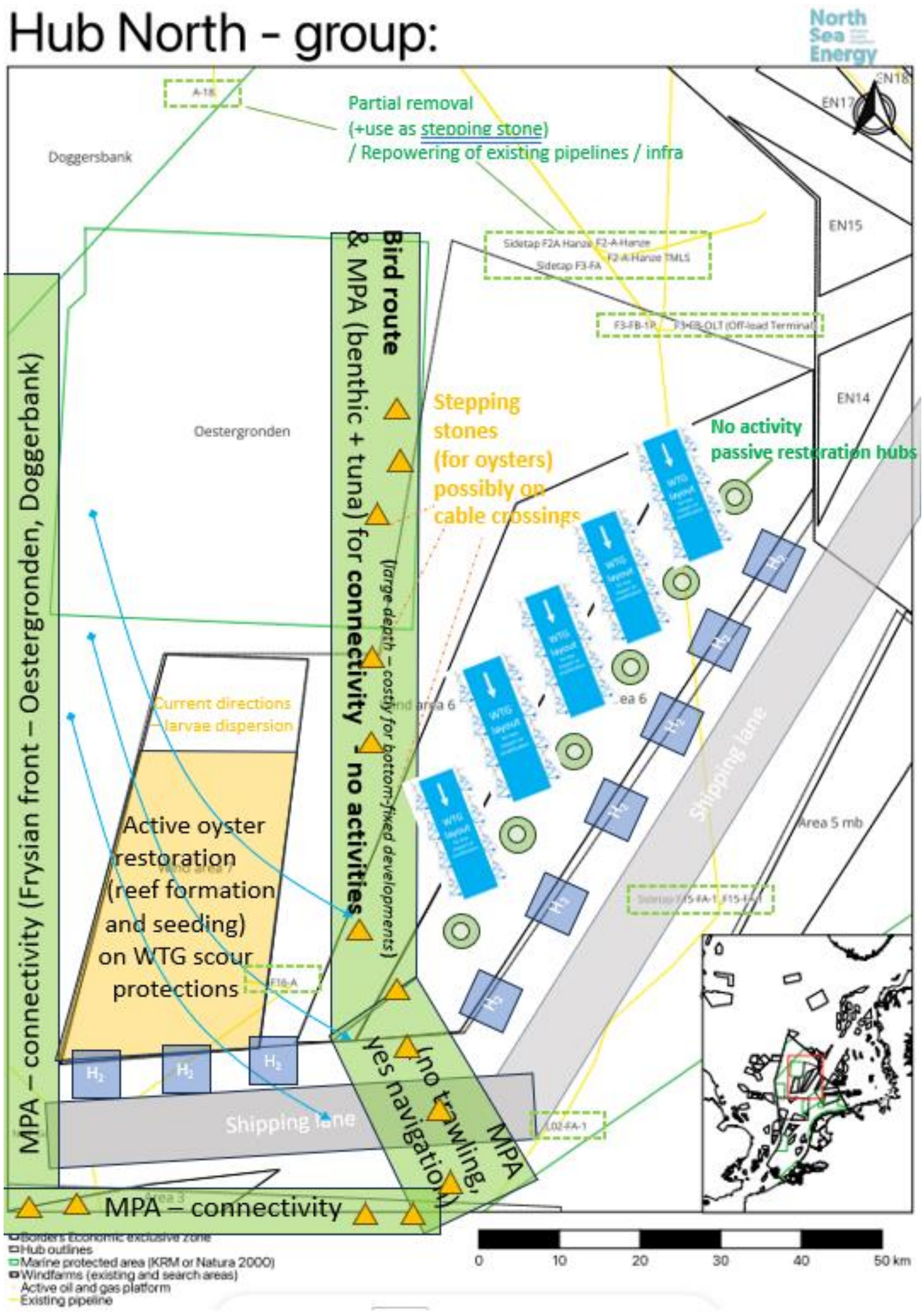
- Trophic complexity — Medium - High
- Dispersal (connectivity) — Low - Medium
- Random disturbances — Low – Medium

We can see a shift in the triangle (see picture), but the area stays approximately the same. A number of causes we see for this are:

- ↓ The offshore wind farms will always cause some blocking of bird migration
- ↓ There will always be more blocking of migration and more human impact with the introduction of infrastructure
- Natural processes are very important to form the basis of an ecosystem
- ↑ If oyster banks can be kickstarted this will generate more biodiversity and trophic complexity
- ↑↓ more hard structures and settling areas will also provide opportunities for new (invasive exotic) species
- ↑ fisheries pressure will reduce
- ↑ all turbines will have fish and cod hotels
- ↓ noise pressure will increase

5. Interventions

A potential spatial design is recommended, in which a number of high-priority interventions and layout choices from ecological perspective are outlined, accounting for the presence of wind and solar energy production, hydrogen and shipping in Hub North (in rough priority order elaborated also below).



1a. **In order to** restore oyster reefs, **we could** introduce several connected stepping stones spread in the area to assist larval introduction, dispersal and settlement**, by** designing new scour protections, reuse existing hard substrates and finally introduce new tailored ecological substrates that support seeding of adult oysters, spat-on-shell and proper settlement chemical cues (calcium-rich)**, so** a continuous oyster reef can grow leading to a recovery of the species and a stable population in the long term.

1b. **In order to** reduce habitat loss, collisions and barrier effects for birds, **we could** enable connectivity**, by** creating a North/South Corridor in the deeper area of the Hub North (where bottom-fixed installations would be more challenging and costly)**, so** the birds can migrate undisturbed between the Oyster Grounds and Frisian Front.

2. **In order to** reduce impacts on ambient water quality and primary production, **we could** reduce the effect on de-stratification**, by** streamlining (wind turbine) foundations and other infrastructural obstructions and partly replace wind by solar**, so** wake effects are minimized while also keeping light and (solar radiation) temperature to a minimal as well.

3. **In order to** protect species, **we could** reduce underwater noise levels and optic disturbance**, by** planning refuge (no-go) zones spread across the wind/solar farm areas that limit activities and allow for passive restoration**, so** there is sufficient space for the ecosystem.

4. **In order to** enhance ecosystem connectivity, **we could** connect MPAs**, by** creating stepping stones and other effective area-based conservation measures**, so** the wider area will have a higher strengthening capacity and the wider ecosystem is taken into account, and upscaling of biodiversity enhancement from more local active restoration efforts is possible.

5a. **In order to** minimize disturbance by noise, **we could** concentrate disturbances**, by** placing H_2 platforms to the edge of Hub North and next to the shipping lanes**, so** the largest area of the Hub retains low noise levels.

5b. **In order to** keep fish and mammals unaffected, **we could** reduce underwater noise levels and optic disturbance**, by** concentrating disturbances (layout), reducing duration of impacts (efficient operations), choosing optimal timings for required disturbances (windows) and finally reducing the intensity of impacts (slow sailing, mitigation screens)**, so** the behaviour and health of the species is not adversely affected.

6. In combination with 2, **in order to** restore a continuous oyster reef that spans across and even extends further that the greater Hub North area, **we could** minimize seabed disturbance activities**, by** designation of proper MPAs that run through the Hub North and connect it with the Oyster Grounds, Frisian Front and Doggerbank**, so that** a continuous oyster reef can form and more local active restoration activities are allowed to take on a large scale effect.

7. **In order to** avoid electromagnetic field disturbance to shark and rays, **we could** optimize cable routing**, by** allowing for corridors, burying the cables deeper, remove IAC crossings / nodes, aligning cables closer to each other**, so** the possible ecosystem disturbance is minimized.

Extra notes

We also had a brief discussion on centralized vs decentralized placement of infrastructure. Some arguments mentioned where that centralizing noise impacts leads to more freely available area elsewhere. However, for wind turbines and platforms this could lead to very big wake effects and secondary impacts on stratification. Clustering H_2 platforms to form a bird island could work IF there is not too much noise IF the island is undisturbed IF there is no decommissioning IF there is a clear flyway past turbines and IF there is a clear target species. For instance, black-legged kittiwakes are known to use abandoned platforms for nesting, but they seem to avoid active platforms. This of course would be hard to achieve with an active hydrogen production plant. The advantages of decentralization are dispersed impacts of brine and O_2 and the option to place platforms strategically for wake effects. There also was a discussion about centralized versus dispersed brine release (linked to this discussion), O_2 release and the strategic placement of platform pillars and what would be best also in view of the de-stratification from the disturbance of the hydrodynamics. These discussions are how/why we thought of aligning everything next to the shipping lane. To find the best compromise between centralized and decentralized.

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Group B: spatial design

Current state

- Trophic complexity Medium
- Dispersal (connectivity) Medium
- Random disturbances Low-Medium

Due to fisheries the benthic complexity is low-medium. Even though the area is suitable for oysters, they are hardly present in the area. However, in the pelagic the trophic complexity is higher. This is partially shown by tuna returning to the area again. Overall, the trophic complexity is currently at an intermediate state. Furthermore, there are quite a few knowledge gaps of the trophic complexity at Hub North. It is unknown which benthic reef builders are currently present in the area.

Constraints

The following constraints were identified for the commissioning and operational phase.

Commissioning phase

- Seabed disturbances
- Noise
  - Impulsive sound
- Movement of ships
  - Continuous sound
  - Light

Operational phase

- Change in stratification regime due to presence of monopiles and other structures
- Impact on birds (collision and barrier effects)
- Fishing activity (especially bottom trawling)
- Introducing hard substrates (attraction of unwanted species)
- Increase in salinity, due to brine

The largest constraints at Hub North are, potentially, the fishing activity and a change in stratification. By placing structures in the water, an increase in mixing of warm and cold water occurs which decreases the chance on summer stratification. The effects of a decrease or absence of summers stratification on the ecosystem are unknown.

Enabling conditions

To enable stratification, or decrease the chance in a shift of stratification regime, the following enabling conditions could help:

- Decrease the amount of structures
- Consider the hydrodynamics (east – west corridors)
- Modularity
- Hotspots

Furthermore, the following conditions to decrease the impact of the structures and Hub in general were thought off:

- Marine Spatial Planning (where to start the construction?)
- Which area is most suitable to start at?
- Flexibility of assets

Potential state

- Trophic complexity — High
- Dispersal (connectivity) — Higher than current state but hard to pinpoint.
- Random disturbances — Medium

The trophic complexity increases as there is more variability in habitats and systems in the potential state. This variability is caused by the potential presence of different species of reef builders, especially if flat oyster reefs can be kickstarted.

Due to the presences of structures the connectivity for benthic species will be higher. However, for birds the connectivity decreases due to wind turbines. The hard structures also provide opportunities for invasive exotic species.

Interventions

A variety of interventions can be used to either decrease the impact on the ecosystem of improve the potential ecosystem:

- Adaptive design: In order to deal with uncertainty, we could improve flexibility by rolling out the hub over time and monitor so the negative effects can be identified and managed, and future decision making can be improved.
- No fishing-zone: In order to retore seabed integrity we could implement a no-fishing zone so the pressure on the seabed is removed and the trophic complexity can be increased
- Strategical Marine Spatial Planning: In order to not affect stratification regimes, we could make decisions in MSP by strategically choosing areas to refrain from development so the mixing by structures doesn’t take place.
- Monitoring plan: In order to improve future decision making we could set-up a national monitoring programme by making it mandatory to monitor when implementing new projects in the North Sea so the system knowledge is improved and knowledge gaps can be filled.
- Adjust wind turbines: In order to reduce bird mortality, we could avoid collisions by having an optimal turbine height and paint blades and include NIDs.
- Diversify infrastructure type: In order to reduce bird mortality, we could diversify infrastructure type by including more solar + wave energy structures so the birds have to dodge fewer obstacles.

Group C: windfarms and cables

1. Current state

- Trophic complexity — Low-Medium
- Dispersal (connectivity) — Medium
    - Benthic — Low
    - Pelagic — Medium-High
- Random disturbances — Medium
    - Benthic — Low (excl. fisheries)
    - Pelagic — Medium-High

The overall ecological state is a bad shape due to the intensive fishing activities.

2. Constraints and 3. Enabling conditions

Several constraints identified were:

- Sediment & turbidity disturbance ↓ environmental trigger
- Pulling/jacket?
- Impulse and continuous noise
- And vessel movement/artificial light ↓ environmental trigger
- Habitat disturbance / hard structures ↓ environmental trigger
- Cables ↓↑ interacting infrastructure
- Scour protection
- Light disturbance ↓ environmental trigger
- Collisions ↓ environmental trigger
- Birds & bats ↓ interacting infrastructure

Other enabling conditions that were unclear on how to fit in the concept figure are:

- Required monitoring.
- Surveys
- Sonars
- Include fishermen in doing this.
- Stopping of fishing activities

It was discussed within the group that vessel movement might be an underestimated impact of offshore wind farms.

Idea Bank

Taking along fishermen in the transition to a different North Sea → data fishing (monitoring), aquaculture, co-ownership
How does it influence the ecosystem?
Generate support base.

Finding highly biodiverse areas → excluding them from search areas windfarms. Also looking for areas with shipwrecks, WWII artefacts (quite often is biodiverse because untouched)
How does it influence the ecosystem?
Create a more diverse system.

4. Potential state

Highest potential ecological state:
Trends in more habitat diversity
Trends in increasing species / trophic complexity → (multiple pathways to higher trophic levels, multiple predatory species, more long-living species)
Trends in increasing connectivity

This results in a dynamic, robust, and stabile ecosystem (not only looking at reefs).

Note: important to get to this state is to use references areas (both inside and outside).

- Trophic complexity — Medium-High
- Dispersal (connectivity) — Medium-High
  - Benthic — Medium
  - Pelagic — Medium-High
- Random disturbances — Medium
  - Benthic — Medium
  - Pelagic — Medium-High

5. Interventions

1. In order to fill the knowledge gap of interventions and/or monitoring we could create a roadmap of monitoring **and start monitoring now** by learning on the way (with and without interventions) so the actors (us) can adapt on the way.

2. In order to give oysters the chance to thrive we could have a biological layer on hard substrates, and by placing these substrates in certain areas, so the oysters can grow better.

3. In order to increase habitat potential diversity we could work with different sort and sizes of hard substrate by using small rocks, big rocks, cravets, gravel, etc, so the different species and size-classes can grow, life and reproduce.

4. In order to increase connectivity we could use the cable and pipeline scour protection and by designing the windfarms/cable layer/crossing in a way that they stimulate dispersal and connectivity so the different populations can be connected in a better way.

5. In order to improve the knowledge on ecology by engineers/geologist/other non-ecologist we could create a standard course, so the various people involved in the whole chain of process know better on what ecology is, how it works and why it is important.

6. In order to increase habitat diversity we could work habitat specific and make sure certain habitat are left untouched, so the system as a whole becomes more robust, stabile and resilient.

7. In order to collaborate, coordinate and have an owner we could educate, communicate and disseminate better what is going on by assigning a minister of the North Sea so the governance of this all is well arranged.

8. In order to have better alignment between commissioning and nature interventions we could optimize building with nature and avoid mismatches so the nature can thrive better and your building with nature interventions are most efficient.

9. In order to improve the tender process we could share maps, remove the Chinese walls between ecologists, by taken apart the ecological reference info so the ecological value for the energy transition program increases.

10. In order to learn more, increase monitoring and data-sharing we could obligate data-sharing (windfarm lifetime) and use fishermen as data gatherers so the learning curve increases instead of becoming stagnant and human capacity is optimally used.

11. In order to avoid limiting positive impacts to the short term we could investigate changing the decommissioning phase, so the process is not a steady state.

Group D: electrolysers and pipelines

1. Current state

- Trophic complexity: Medium
  Relatively high diversity of benthic species, incl. long-living ones, large number of birds and also larger predators present (tuna, harbor porpoise)
- Dispersal (connectivity) Medium
  - Benthic Low
  - Pelagic Medium-High
- Random disturbances Medium
  - Benthic Low (excl. fisheries)
  - Pelagic Medium-High

Overall state: medium quality. Though there is a relatively large amount of trophic complexity, the area is in an alternative stable state than it could be due to the loss of historical oyster reefs.
The area is surrounded by MPAs that are not in a very good state: it is important to beware of how developments in this area may impact those MPAs.

2. Constraints & 3. Enabling Conditions

Commissioning Phase:

In this phase, **constraints** relate to:

- Increased activity and related noise from construction vessels. This may disturb guillemots (father-chick-combinations) migrating to the Frisian Front. Probably construction activities would have to take the sensitive period (July – October) into account in planning, which may significantly lengthen the overall construction period (>5 years?).
- Cable & pipeline laying, wind turbine and platform installation and removal of existing infrastructure may temporarily increase turbidity. Considering the long construction period, this may have a significant impact on all species. Maybe include pauses in turbidity-increasing activities, that allow water to clear up in between?
- Construction activities also create vibrations that will disturb a range of species.
- Creation of underground hydrogen storage in salt caverns may involve significant discharges of brine.

Operational Phase:

In this phase, **constraints** relate to:

- The major impacts of offshore H_2 production relate to water intake for cooling (±99%) and H_2 production (in total estimated at some 360.000 l/hour), emissions of brine, emissions of polluted water from cooling (containing chlorine, sulfuric acid, halogens and other anti-fouling chemicals) and the transfer of heat from elektrolyser & cooling system to the surrounding water. (In case of an open cooling water system, the constraints related to the suction (intake) of cooling water remain).
- There is a need to develop scenarios for water intake/outflow and brine disposal in great detail and to explore the impacts of various scenarios. Also, development of the need for cooling over time needs to be considered: the expectation is that cooling needs may dramatically increase over time as a result of tear and wear of the electrolysers.
- Independently of hub developments, the temperature of the seawater is likely to increase, which may in itself impact stratification and living conditions for temperature-sensitive species.
- The presence of platforms making noise (from compressors) may function as a barrier to certain species, a.o. guillemots.
- The regular shipping (service vessels) necessary for maintenance and operation of the platform causes disturbance in turbidity, light penetration, emissions and noise.
- The use of anti-fouling and/or antinodes introduces new (synthetic) elements in the water.

In this phase, potential **enabling conditions** relate to:

- Oxygen production from electrolyser might help to reduce the risk of oxygen depleted areas developing near the seabed as a result of temperature rise.
- The presence of platforms with large complexity might facilitate dispersal of certain species and serve as a safe haven for juveniles and bird species normally nesting on cliffs.
- The presence of scouring protection and gravel beds around platforms and pipelines may facilitate restoration of oyster reefs and improved breeding conditions for sharks and rays.

Spatial considerations:

- With more decentralized hydrogen production (smaller platforms) disturbance and risks are distributed, but also smaller, whereas the steppingstone function of platforms may be of value to a larger range of species.
- With more centralized hydrogen production, disturbance and other impacts will be larger, but more limited in spatial reach.
- Centralized solutions will have a smaller cumulative material footprint than decentralized solutions.

4. Potential state

Ideally the potential state might be one in which the original oyster banks have returned, turbidity decreased and connectivity with reef habitats elsewhere in the North Sea have been increased. Enabling conditions could include:

- Reduced seabed disturbance and protection/strengthening of benthic and reef-building species in the area. This would occur only after all energy infrastructure has been constructed, as the construction itself will temporarily increase seabed disturbance and turbidity. It is uncertain to what extent existing benthic species would be able to survive a long period of disturbing construction activities.
- The structural complexity of energy installations might be able to function as a safe haven for juveniles and to support connectivity for other species. These functions might be enhanced by the design and location of installations.
- The growth of energy related and shipping activities in the area might significantly increase the level of noise – above and under water – in the area. This could form a major barrier to various birds (incl. migrating guillemots) and underwater species.

5. Interventions

- The major impacts of offshore H_2 production relate to water-intake for cooling (±99%) and H_2 production, emissions of brine, emissions of polluted water from cooling and the transfer of heat from elektrolyser & cooling system to the surrounding water. Interventions should in the first place focus on how to mitigate these impacts:
  - It is absolutely key to develop a closed cooling system for elektrolysers in order to avoid the impacts of a ‘huge vacuum cleaner’ sucking up huge amounts of water (including marine life) and emitting it again in a form where it is polluted with biocides and other chemicals needed to keep the interior of the cooling system and the elektrolysers clean.
  - To reduce the impact of heat production on the marine ecosystem, cooling techniques could be diversified, using air as well as water for cooling.
  - Possibly, produced heat might also be used for some form of multi-functional use of the platform, e.g. algae production (oxygen, heat, water and nutrients from bird poop?) or living quarters on the platform (potentially also reducing noise from maintenance vessels).
- In order to facilitate biodiversity, platforms could be developed with resting/nesting places for seabirds, fish hotels, reef-enhancing scouring protection, gravel beds for the eggs of rays and sharks to attach to, artificial reefs supporting the reintroduction of flat oysters, etc. These measures are seen as no-regret measures that could be experimented with already now in the safety zones of existing platforms in the area.
  - A specific measure in this area would be to explore possibilities for using platforms to create a safe fight corridor for birds migrating e.g. between the Doggerbank and the Frisian Front.

And more generally exploring opportunities for using platforms to divert birds away from wind turbines in order to reduce the collision risk.

- As there is still much we do not know about potential impacts, we need to develop the area in an adaptive manner: develop wind farms (and H_2 platforms) in small pieces and start monitoring of potential constraints and enabling conditions now. Some short-term suggestions are to:
    - Use existing gas platforms (F16, F15, F2, F3) to research/monitor potential for biodiversity on/around platforms in the area and start experimenting with nature-enhancing measures within their safety zones. If the platforms turn out to be able to support ecosystem restoration, it might be considered to leave parts of them in place as artificial reefs.
    - Use H_2 production pilots 1 and 2 to monitor potential impact on birds, in particular guillemots and their predators (large gulls), and to experiment with different solutions for disturbances caused by brine and heat emissions.
- To support migration of pelagic and benthic species between MPAs (inside and outside of the Dutch NS), ‘steppingstones’ or hiding places could be created at strategic locations along pipelines/cables and at platforms and wind turbines. This would demand improved insight into the distances that relevant species can travel and of the general connectivity between MPAs.
- Create diversity in size and structural design of energy installations in the area in order to facilitate different habitats suitable for different species. Avoid ‘monoculture’. This might also help to reduce impacts on abiotic factors like stratification.

Appendix: Participants

The following people attended the workshop:

- Anne-Mette Jørgensen (MSG)
- Antonios Emmanouil (Deltares)
- Astrid Groot (DMEC)
- Audrey Roustiau (EBN)
- Benjamin Lehner (DMEC)
- Cas Dinjens (Arcadis)
- Debby Barbe (RWE)
- Ella Zahra (Oceans of Energy)
- Fokko van der Goot (Boskalis)
- Harmen Slot (TNO)
- Hein Sas (Native Oyster Restoration Alliance)
- Heleen Vollers (Stichting de Noordzee)
- Isabel Gerritsma (Deltares)
- Ivo de Klerk (MSG)
- Jelle Rienstra (Deltares)
- Joep Breuer (TNO)
- Joris Koornneef (TNO)
- Justé Motuzaité (ARK Rewilding)
- Karel van den Wijngaard (ARK Rewilding)
- Kees Stiggelbout (NWEA)
- Luuk van der Heijden (Deltares)
- Maartje Hofker (Gasunie)
- Madelaine Halter (TNO)
- Mart van der Linden (TNO)
- Nazila Fotoohi (EBN)
- Niels Verdoodt (DEME)
- Reinier Hille Ris Lambers (BP)
- Rien van Leeuwen (ARK Rewilding)
- Robbert Becker (Element NL)
- Roos Bol (ARK Rewilding)
- Sarina Versteeg (Arcadis)
- Tim van Ooijen (Vogelbescherming)
- Uyen Phuong Le (DMEC)
- Walter Sieval (Van Oord)