

Digital Twin of the Ocean

Workshop Summary Report



*UN Ocean Decade Theme Group 5 — Prediction & Management
Scenarios for Coastal Marine Systems*
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1. Purpose and Background

The workshop was organised by the UN Ocean Decade theme group on “Predictions and management scenarios for coastal systems” (Theme Group 5), which aims to build capacity for a Digital Twin of the Ocean (DTO) covering Denmark, the Faroe Islands, and Greenland. The theme group had recently mapped existing projects, tools, and services related to DTOs across the three territories (available at havetstiaar.dk). The purpose of the workshop was to bring this community together to identify knowledge gaps, opportunities, and barriers for further developing a shared DTO capability.

The morning session opened with introductions and a series of short presentations showcasing existing Digital Twin efforts, including DMI's contributions to EDITO (the EU's European Digital Twin of the Ocean), the Digital Twin of Danish coastal waters, Faroese coastal modelling with FarCoast, the Arctic ocean and sea-ice forecast, and a micro-siting tool for low-trophic aquaculture. The afternoon was dedicated to structured group work: three groups worked in parallel on the same three questions - opportunities, barriers, and knowledge gaps for a shared DTO - before reporting back in plenum.

This report consolidates the outputs of all three groups into a single framework, highlighting where the groups converged, where they diverged, and what this implies for next steps.

2. How the Groups' Input Was Combined

Each group worked from the same worksheet, covering three sections: (1) opportunities, placed on an impact-vs-effort grid; (2) barriers, each tagged by type and by who is best placed to address it; and (3) knowledge gaps and capacity-building needs. The sections below merge all three groups' entries into unified grids and tables. Each item is tagged with its group(s) of origin - (G1), (G2), (G3) - so the original source remains traceable. Only Group 1 completed the optional “top picks” summary; these are listed in the Appendix for reference.

3. Opportunities; Impact vs. Effort

Combining all three groups' entries into a single grid:

	← Low Effort	High Effort →
High Impact	- Establish shared data standards and formats (G1) - Clarify user needs — understand who the users are (G1) - Guidelines for transparency (G1) - Actively utilise EDITO; pursue small, coordinated EDITO calls/applications (G2, G3) - Add existing national services and tools into a shared inventory (G2) - Explore AI/LLM tools to lower the technical barrier to entry (G2, G3) - Improve documentation, metadata and quality control (G2) - Publish a joint paper on the national DTOs to raise visibility (G3) - Analyse the current DTOs on the homepage to identify need for new developments and covered topics (G3)	- Build one user-friendly interface/platform beyond EDITO (G1) - Homogenise models across DK, GL and FO (G1) - Expand EDITO with national DTOs, using EU Horizon Europe calls; EDITO seen as the most viable long-term platform (G3) - Diversify funding: IFD (with co-financing from companies/agencies), EU LIFE, NMR, Velux, HEU (G3) - Improve/expand Danmarks Miljøportal towards a digital twin, incl. land and water (G2)
Low Impact	Add existing services incrementally (G2)	- Wait and see what EDITO's output looks like before committing further (G1) - Expand Danmarks Miljøportal into a full DTO platform — seen here as a large, possibly disproportionate effort,

	since it was built to host monitoring data (G3)
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A point of disagreement worth flagging

Groups 2 and 3 placed the same idea - expanding Danmarks Miljøportal into a digital twin - in opposite corners of the grid. Group 2 saw it as a high-impact major project worth pursuing (including linking land and water data); Group 3 flagged it as low priority, arguing the portal was built to host monitoring data and would need substantial rework to serve as a DTO platform. This is a genuine open question for the theme group to resolve rather than a simple oversight, and may be worth a dedicated discussion: is Miljøportal a realistic long-term home for a DTO, or is EDITO (extended with national components) the more realistic path?

EDITO is, by design, much closer to a genuine DTO platform than Miljøportalen. It is an EU-funded, open infrastructure built specifically to combine live data (satellites, buoys, sensors, ships, and existing ocean models) with modelling, compute, and AI tools in a cloud "data lake," explicitly intended to support simulation, forecasting, and what-if scenario testing - the functions a digital twin actually needs, not just data publishing. It is interoperable and modular, meant to be extended with new regional or thematic components (such as national DTOs for Denmark, the Faroe Islands, and Greenland), and it is continuously funded and developed at EU level, which several workshop participants noted makes it easier to build on today than a few years ago. Its main limitations are practical rather than conceptual: a relatively steep technical entry bar for new users, and constrained compute allocation (e.g., only 8 CPUs per DTO), which restricts running larger or on-demand models. This suggests EDITO is a credible long-term home for the actual modelling and simulation engine of a shared DK-GL-FO DTO, provided the group invests in lowering its technical accessibility and secures additional compute (e.g., via HPC coupling), while a platform like Miljøportalen could complement it as a downstream data/dashboard layer rather than compete with it.

Danmarks Miljøportal is not, in its current form, a DTO platform, but it is a plausible foundation for parts of one. It is a well-established, actively maintained cloud platform with a large existing user base (over 100,000 direct users and 100+ connected external systems), a track record of adding new data domains, and an explicit strategy to adopt new technologies and partnerships. However, its stated purpose is data delivery and access - publishing, updating, and retrieving observational, spatial, and administrative data - rather than running numerical ocean models, forecasts, or "what-if" simulations, which is the core function a DTO needs. This suggests Miljøportalen could realistically serve as a public-facing data and dashboard layer (e.g., publishing DTO outputs, observations, or scenario results to citizens and authorities), but building genuine modelling and simulation capability into it would require new infrastructure and functionality it does not currently have, rather than being a natural extension of its existing service catalogue.

4. Barriers

Barriers raised by the three groups, grouped by theme:

Technical / Data

Barrier	Type	Who can address it
Different data security policies across institutions/countries (G1)	Technical/Data	Cross-border, political mandate, EU
Large data volumes; choosing the “best” data is itself a challenge (G1)	Technical/Data	—
Loss of traceability (G1)	Technical/Data	—
Lack of data integration, harmonisation (e.g. differing data formats) and FAIR practice (G1, G3)	Technical, capacity, finance	Cross-border, political mandate, EU
Near-real-time integration and forecasting is difficult when NOVANA data is delayed — CMEMS may help fill some forecast gaps (G3)	Technical	CMEMS makes operational use easier
High technical expertise required to implement new DTOs into EDITO (G2, G3)	Technical/Capacity	Easier access, tutorials, AI-assisted search; training

Legal / Governance

Barrier	Type	Who can address it
Intellectual property rights with respect to the EU (G1)	Legal/Governance	EU level
Is it realistic — or even desirable — to build “one twin that rules them all”? (G2)	Organisational/Governance	—
Harmonising DTO strategy across group members/institutions, which each have their own internal strategies that can conflict (G3)	Organisational, financial	More group collaboration; recognize shared benefits

Financial

Barrier	Type	Who can address it
Applications are project-based; no clear route to funding long-term maintenance once a project ends (G2)	Financial	—

Capacity / Skills

Barrier	Type	Who can address it
Securing consistently high quality across contributions (G2)	Capacity/Skills	Standardised, quality-checked documentation and metadata
Keeping up with adaptation to new technologies (G2)	Capacity/Skills	Better communication across the community

5. Knowledge Gaps and Capacity Building

Knowledge gap / capacity need	Why it matters	Suggested next step
Satellite coverage gaps, e.g. Greenland fjords (G1)	Fill data gaps	—
Sampling limitations in rural/remote areas (G1)	Fill data gaps	—
Balancing broad user needs against practical implementation (G1)	Moving from research to application; addressing different user types	—
Bridging the value of model data with the legal framework built around in-situ measurements (G1)	Important for communicating results credibly	—
Building a genuinely robust, useful platform (G2)	It won't be adopted if it doesn't work reliably	—

Uncertainty about long-term technical direction (G2)	Unclear whether today's solution will still be relevant in 5 years	—
The land–coast–sea continuum needs more focus (G3)	Coastal waters are strongly dependent on land use and runoff	Collaboration across research communities and funding bodies
EDITO's compute capacity is limited (8 CPUs per DTO) (G3)	Restricts running larger models or on-demand simulations	Couple to HPC infrastructure (e.g. LUMI) that can provide more CPU time; training
Difficult to couple models in near real time (G3)	Needed for more realistic, end-to-end service chains	Training, collaboration
Uncertainty and limitations are not yet systematically addressed (G3)	Needed to give advice with higher confidence	Estimate and report confidence levels

6. Cross-Cutting Themes Across All Groups

Reading the three groups' outputs together, several themes recur independently across groups, suggesting they are priorities for the theme group as a whole rather than one group's individual concern:

- EDITO as the shared foundation: all groups that discussed a platform (G2, G3) converged on EDITO as the most promising base to build on, but also flagged it as a barrier due to its technical entry bar and limited compute allocation.
- Data harmonisation and standards: raised as both a quick-win opportunity (G1) and a persistent barrier (G1, G3), indicating agreement on its importance but no agreed path yet on how to achieve it.
- Sustainable funding beyond the project phase: both the financial barrier (G2) and the funding-opportunity discussion (G3) point to the same underlying issue — maintenance and continuity funding, not just development funding.
- One shared twin vs. federated national twins: G2 explicitly questioned whether “one twin to rule them all” is realistic, while G1 argued that DK/GL/FO's differing oceanography means standards - not necessarily a single model - are what enables interoperability, and G3's approach (expand EDITO with national DTOs plugged in) is itself a federated model. This is a governance question the theme group has not yet settled.
- The land–sea (and land-use) connection: both G2's wish to “include both land and water” and G3's land–coast–sea continuum knowledge gap point to the same missing link.

- Lowering the technical barrier via AI: G2 and G3 both raised AI/LLM tools - both as a quick win to make platforms more accessible, and as a capacity-building need for using EDITO.
- Trust and communication: G1's emphasis on understanding user needs and bridging model data with legal frameworks, and G3's emphasis on communicating uncertainty and confidence levels, both point to the same challenge - making DTO outputs trustworthy and usable for non-specialist decision-makers.

7. Suggested Next Steps

Based on the combined input, the following next steps emerge as reasonable priorities for the theme group. These are drawn directly from the groups' own suggestions rather than new proposals:

- Use EDITO as the modelling/compute back-end and treat Miljøportal (or similar) as a possible public-facing dashboard layer downstream of it - not as competing DTO engines. EDITO has continuous EU funding and development behind it.
- Agree a minimal shared data standard across DK, GL and FO as a near-term, low-effort, high-impact action (G1).
- Coordinate small, joint EDITO applications/calls across the group rather than pursuing this individually (G3).
- Investigate HPC coupling (e.g. LUMI) to address EDITO's compute constraints for larger or on-demand simulations (G3).
- Explore AI/LLM-assisted interfaces to lower the technical bar for both using EDITO and building new services (G2, G3).
- Address the funding-for-maintenance gap explicitly in future funding applications, rather than treating DTOs as one-off development projects (G2, G3).
- Write a joint paper describing the national DTOs to raise visibility and support future funding cases (G3).
- Give the land-coast-sea continuum a dedicated place on the theme group's agenda, given it was raised independently by two groups (G2, G3).
- Make an analysis of the existing DTOs on the Havets Tiår homepage and identify knowledge gaps

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