**High Level Recommendations**

**THEME 1: Continued engagement with key stakeholders**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 16:](#_RECOMMENDATION_16_-) Develop proactive engagement with data custodian stakeholders who weren’t fully involved in the review | Do next “major project” |
| [RECOMMENDATION 25:](#_RECOMMENDATION_25:_Ensure) Ensure future governance of marine data management in Scotland | Do next “major project” |

**THEME 2: Clarifying and streamlining data flows**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 3:](#_RECOMMENDATION_3_-) Adopt primacy of affiliated data submission routes | High “quick win” |
| [RECOMMENDATION 4:](#_RECOMMENDATION_4_-) Map out marine data flows holistically | Low priority |
| [RECOMMENDATION 5:](#_RECOMMENDATION_5_-) Adopt primacy of Marine Recorder Online | High “quick win” |
| [RECOMMENDATION 7:](#_RECOMMENDATION_7_-) Agree a single, central route for casual records | High “quick win” |
| [RECOMMENDATION 9:](#_RECOMMENDATION_9_-) Formalise data flows between DASSH and the NBN Atlas | Do next “major project” |
| [RECOMMENDATION 11:](#_RECOMMENDATION_11_-) Clarify workflow responsibilities for mobilising benthic records to NBN Atlas | High “quick win” |
| [RECOMMENDATION 20:](#_RECOMMENDATION_20_-) Provision of biodiversity records collected under licence or for consent into the MEDIN Data Archive Centre network | High “quick win” |

**THEME 3: Improving the quality of existing data management**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 6:](#_RECOMMENDATION_6_-) Clarify responsibility for tagging of records of conservation importance | High “quick win” |
| [RECOMMENDATION 8:](#_RECOMMENDATION_8_-) Each record submitted to have a persistent identifier (PID) to prevent duplication | High “quick win” |
| [RECOMMENDATION 12:](#_RECOMMENDATION_12_-) Progress a verification protocol for imagery derived data that complements the existing NMBAQC scheme component for grab and core sediment derived data | Do next “major project” |
| [RECOMMENDATION 15:](#_RECOMMENDATION_15_-) Plan for and fund the management and sharing of all new data being collected | High “quick win” |
| [RECOMMENDATION 21:](#_RECOMMENDATION_21_-) Maintain data version control through encouraging active custodianship | High “quick win” |
| [RECOMMENDATION 22:](#_RECOMMENDATION_22_-) Optimise re-use of data through adherence with FAIR Data Principles | High “quick win” |

**THEME 4: Investing in infrastructure and resource (people skills and funding)**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 2:](#_RECOMMENDATION_2_-) Scottish (and UK) Government recognise and resource key skills and infrastructure across the full data lifecycle | Do next “major project” |
| [RECOMMENDATION 19:](#_RECOMMENDATION_19_-) Invest in data engineers and allocate resource for system decommissioning | Do next “major project” |

**THEME 5: Improving existing and creating new data infrastructure**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 1:](#_RECOMMENDATION_1:_Undertake) Undertake a UK-wide marine biodiversity data infrastructure assessment | Do next “major project” |
| [RECOMMENDATION 10:](#_RECOMMENDATION_10_-) Develop infrastructure to support viewing and download of habitat records | Do next “major project” |
| [RECOMMENDATION 13:](#_RECOMMENDATION_13_-) Provide infrastructure and data management support for citizen science marine biodiversity recording | Do next “major project” |
| [RECOMMENDATION 17:](#_RECOMMENDATION_17_-) Develop simplified user interfaces onto repositories to support wider data submission | Do next “major project” |
| [RECOMMENDATION 23:](#_RECOMMENDATION_23_-) Develop existing portal infrastructure to support efficient searching, data display and dataset collation | Do next “major project” |
| [RECOMMENDATION 24:](#_RECOMMENDATION_24_–) Embed marine expertise in, and interoperability of, the National and Regional (LERC) hubs infrastructure in Scotland | Medium “Do later” |

**THEME 6: Simplifying existing and creating new guidance**

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| **Recommendation** | **Prioritisation score** |
| [RECOMMENDATION 14:](#_RECOMMENDATION_14_-) Simplify the requirements for submitting data into DASSH whilst maintaining data quality | Medium “Do later” |
| [RECOMMENDATION 18:](#_RECOMMENDATION_18_-) Develop guidance on optimal data submission pathways | High “quick win” |

**Full Recommendations Summary**

## RECOMMENDATION 1: Undertake a UK-wide marine biodiversity data infrastructure assessment

The UK Monitoring and Assessment Reporting Group (MARG) should expedite a UK-wide marine biodiversity data infrastructure assessment to inform development and agreement of a strategic and integrated technical road map that will simplify the data flow and connectivity of infrastructure.

The five actions below should build on the mapping analysis work done in this current Scottish marine biodiversity data review and work done by the JNCC on UK Marine Strategy indicator data flow mapping to achieve a UK-wide assessment.

1. Provide a clear definition of each of the key components and tools in the marine species and habitats data infrastructure. *This would assist in improving the automated harvesting of records and integration of standalone system data flows;*
2. Clarify the linkages between data repositories, portals, aggregators, DACs etc. *This would ensure that data providers are secure in the knowledge of where their records will be available for use and where they can aid decision-making;*
3. Endorse the key roles each portal and repository fulfils. *This would maximise inter-operability, coordination and ease and speed of data flow into and from the MEDIN DACs and from EU / international portals directly receiving data. It would also promote the endorsed portals and repositories as those supported by the wider marine community and help to encourage more extensive uptake and use;*
4. A single central directory of all Scottish / UK affiliated data submission routes should be developed and maintained by MEDIN. *This would facilitate streamlined data submission into the MEDIN data archive centre network, via affiliated routes (e.g., repositories). A link from SEWeb (or its re-developed form) could also be made to sign-post the directory in future.*
5. Map out the current and future capabilities of organisations with an interest in the data flow pathway. *This would ensure that: the organisations involved have appropriate workforce skills, resource and funding to undertake recommended improvements; the data infrastructure / data flow is joining up; and that system integration is being improved.*

## RECOMMENDATION 2 - Scottish (and UK) Government recognise and resource key skills and infrastructure across the full data lifecycle

The key components of the Scottish marine data flow landscape should be recognised and resourced as:

* Core/central database management systems (e.g., Marine Recorder Online; JCDP);
* MEDIN data archive centres (e.g., DASSH);
* Scottish specific and UK-wide marine data portals (e.g., NBN Atlas, NMPi Portal).

*Each component should have a clearly defined role, enabling them to work together as a collaborative, connected network.*

This links to: a task under [Recommendation 1](#_RECOMMENDATION_1:_Undertake) - a clear definition of each of the key components and tools in the marine species and habitats data infrastructure; and [Recommendation 3](#_RECOMMENDATION_3_-) – primacy of affiliated data submission routes.

## RECOMMENDATION 3 - Adopt primacy of affiliated data submission routes

Marine species and/or habitats records should be submitted into the appropriate established database where the database remit permits (e.g. benthic species and habitat occurrence data into Marine Recorder Online, cetacean at-sea effort-related vessel and aerial sightings transect data into the JCDP); as the recognised data entry point to the data flow network, and channelled to a MEDIN DAC (e.g. DASSH) via standard, affiliated workflows for onward dissemination to the NBN Atlas and other data aggregators (e.g. EurOBIS/EMODNet).

*This will help avoid duplication of effort and indirect data flows. It would also reduce the complexity of collating records for individual/organisation purposes and help prevent version control and/or record duplication issues.*

Links with a task under [Recommendation 1](#_RECOMMENDATION_1:_Undertake) – a directory of all affiliated Scottish / UK data submission routes maintained by MEDIN.

## RECOMMENDATION 4 - Map out marine data flows holistically

A holistic picture of the Scottish data flow landscape (e.g., seabed, mammal, fish and bird data) should be mapped out.

*The mapping should build on the individual receptor data flows mapped for Scotland in this current analysis review.* This would clearly outline the infrastructure that a data provider would be faced with when deciding where to submit their dataset into the data network to the relevant receptor database or repository.

This links with [Recommendation 18](#_RECOMMENDATION_18_-) – development of guidance on optimum data submission routes.

## RECOMMENDATION 5 - Adopt primacy of Marine Recorder Online

Government bodies in Scotland (NatureScot, JNCC, Marine Scotland and SEPA) should adopt Marine Recorder Online, once it is available in 2022, as the data management and storage solution for benthic species and habitats data.

This links with [Recommendation 3](#_RECOMMENDATION_3_-) – primacy of affiliated data submission routes.

## RECOMMENDATION 6 - Clarify responsibility for tagging of records of conservation importance

Responsibility for tagging records of conservation status (Priority Marine Features and Annex 1 habitats) in Scotland should remain with JNCC / NatureScot. Marine Recorder Online should be used as the mechanism to do this for benthic data.

*This would streamline the dissemination of records of conservation importance to Marine Scotland’s NMPi Portal to inform marine planning and management decisions.*

## RECOMMENDATION 7 - Agree a single, central route for casual records

DASSH should be recognised as the single, central route for the submission of casual Scottish marine biodiversity records/datasets that are not submitted directly to NBN Atlas via apps such as iNaturalistUK and iRecord.

This links with [Recommendation 9](#_RECOMMENDATION_9_-) – formalise the data flow between DASSH and the NBN Atlas.

## RECOMMENDATION 8 - Each record submitted to have a persistent identifier (PID) to prevent duplication

Disciplined implementation of PIDs should be adopted (i.e., not altered or prefixed by different systems throughout its lifetime) by each data entry point system. PIDs should be allocated at every level of the survey hierarchy by data repositories at the point of data submission by recorders to prevent record duplication in data collations by enabling easy linking/identification of the same record shared to aggregators from different organisations.

*The allocation of PID's (inc DOIs) would help with Findability and Interoperability in terms of dataset versioning and also contribute to data provenance to ensure it is fully traceable (Reusable).*

## RECOMMENDATION 9 - Formalise data flows between DASSH and the NBN Atlas

DASSH and NBN Trust should maintain the established workflow of records from DASSH to the NBN Atlas, and formalise the existing ad hoc workflow from the NBN Atlas into DASSH into an automated workflow, to create an efficient two-way exchange of records.

*This would facilitate collation, mobilisation and archiving of marine species records (and habitats in due course) that are submitted directly to the NBN Atlas by recorders, e.g., via iNaturalistUK, iRecord.*

This links to, and relies on successful implementation of, [Recommendation 8](#_RECOMMENDATION_8_-) – persistent identifiers (PID).

## RECOMMENDATION 10 - Develop infrastructure to support viewing and download of habitat records

Resource should be prioritised by (or additional provided to) MEDIN and the NBN Trust, respectively, to:

* Develop the DASSH species mapper infrastructure so that it is capable of also supporting habitats data, with the ability to access both species and habitats data through an API.
* Develop the NBN Atlas infrastructure so that it supports both species and habitats occurrence records, and ensuring that API access covers both species and habitat data.

*This would help to deliver the infrastructure required to enable end users of data to efficiently navigate, browse, find and download available species and habitat data resources (complete datasets). There is a need to clearly define the niche and purpose of each system to streamline data flow and avoid duplication.*

Links to [Recommendation 9](#_RECOMMENDATION_9_-) – formalise the dataflow between DASSH and the NBN Atlas; and [Recommendation 23](#_RECOMMENDATION_23_-) - Develop existing portal infrastructure to support efficient searching, data display and dataset collation.

## RECOMMENDATION 11 - Clarify workflow responsibilities for mobilising benthic records to the NBN Atlas

DASSH should become the responsible organisation for mobilising Scottish benthic species (and habitats in due course) records to the NBN Atlas, on behalf all Marine Recorder Online custodians with records relating to Scotland’s seas (e.g., NatureScot, JNCC, Seasearch); utilising the [developing] automated workflow from Marine Recorder Online to DASSH.

*This arrangement should supersede the existing arrangement whereby Marine Recorder data custodians (e.g., NatureScot, JNCC, Seasearch) are responsible for publication of their own species data to the NBN Atlas, simplifying and streamlining the data workflow.*

This links with: [Recommendation 3](#_RECOMMENDATION_3_-) – primacy of affiliated data submission routes; and [Recommendation 5](#_RECOMMENDATION_5_-) - primacy of Marine Recorder Online.

## RECOMMENDATION 12 - Progress a verification protocol for imagery derived data that complements the existing NMBAQC scheme component for grab and core sediment derived data

This supports the NMBAQC’s existing commitment to develop a component of the scheme for epibiota via implementation of the UK Benthic Imagery Action Plan and JNCC’s Big Picture work.

This links to an action within[Recommendation 12](#_RECOMMENDATION_12_-) -progress a verification protocol for citizen science stakeholders**.**

## RECOMMENDATION 13 - Provide infrastructure and management support for citizen science marine biodiversity recording

A targeted piece of analysis should be undertaken to fully understand the priorities for investment and/or infrastructure necessary to better support the flow of citizen science data into the marine evidence base.

This should include:

1. Assessing the need for provision and update of data management protocols, technical guidance and clear sign-posting of data submission routes available to citizen scientists.
2. Identifying the key data ‘types’, species groups, methods of data capture (apps, web forms etc), and spatial data visualisation tools to inform the priorities for investment.
3. Development of a verification protocol(s) with key citizen science stakeholders in the verification process, which aligns to current and future verification requirements and technologies. The protocol(s) need to cover the broad range of citizen science data collection methods and expertise. The resources required to support implementation of the protocol and capacity building should also be identified.

*This recommendation provides the opportunity to explore funding options, including via the Scottish Marine Environmental Enhancement Fund (SMEEF). The recommendation also has synergy with the SBIF Better Biodiversity Data (BBD) Project\* proposed to improve the management and long-term sustainability of LERC citizen science data.*

*\*Currently terrestrial and freshwater species focussed.*

This links to: [Recommendation 12](#_RECOMMENDATION_12_-) - Progress a NMBAQC scheme component for imagery derived data;[Recommendation 14](#_RECOMMENDATION_14_-) - Simplify the requirements for submitting data into DASSH; [Recommendation 17](#_RECOMMENDATION_17_-) – develop simplified user interfaces onto repositories; and [Recommendation 18](#_RECOMMENDATION_18_-) – guidance development on optimal data submission pathways.

## RECOMMENDATION 14 - Simplify the requirements for submitting data into DASSH whilst maintaining data quality

DASSH should simplify the existing requirements that need to be met by recorders in order to submit their datasets, whilst maintaining the quality of data submitted. This should be through provision of support to users of the formal data guidelines to translate and produce practical step-by-step guidance for their peers to facilitate submission of new data.

*This will help:*

* *Maintain data quality by ensuring that MEDIN requirements are met, but make it easier for users to share their data;*

* *Encourage more organisations and individuals to submit their data currently stored on publicly inaccessible hard-drives or servers into the data network;*
* *Increase the volumes of data made available in standard formats;*
* *Wider application of FAIR data principles and facilitate the integration potential of marine data from different disciplines and sectors (including private sector).*

## RECOMMENDATION 15 - Plan for and fund the management and sharing of all new data being collected

Funding providers should stipulate that a requirement of funding will be the development and execution of a data management plan that assures datasets are provided in accordance with FAIR data principles and shared within a timely manner, following embargo periods [e.g., a requirement for research projects receiving public funds to share data that they generate with MEDIN, via affiliated data flows, to contribute to the Scottish / UK marine evidence base].

*Further collaboration and discussion with the organisations that fund the collection of data will be fundamental to achieving this.*

This links with: [Recommendation 3](#_RECOMMENDATION_3_-) – affiliated data submission routes; and [Recommendation 18](#_RECOMMENDATION_18_-) – developing guidance on optimal data submission pathways.

## RECOMMENDATION 16 - Develop proactive engagement with data custodian stakeholders who weren’t fully involved in the review

Further targeted engagement should be undertaken with stakeholders (including eNGOs, commercial sector) in an endeavour to increase the flow of biodiversity records into the marine data infrastructure.

*This further engagement would support and facilitate the wider cultural step-change required to increase data sharing and availability.*

## RECOMMENDATION 17 - Develop simplified user interfaces onto repositories to support wider data submission

The development of simplified user interfaces onto repositories should be encouraged to support the submission of data by citizen science initiatives.

This links with [Recommendation 14](#_RECOMMENDATION_14_-) - simplifying the requirements for submitting data into DASSH.

## RECOMMENDATION 18 - Develop guidance on optimal data submission pathways

Guidance should be developed with stakeholders to clarify the optimal pathways for submitting biodiversity records into Scottish / UK marine data repositories, in accordance with FAIR data principles.

*For example, developing guidance with academic researchers* *would aim to provide reassurance to the academic sector that their data submitted at a Scottish / UK level would flow to the appropriate EU / international portals (with likely timelines); data flow into UK infrastructure in the first instance would make research data more readily available for use in a Scottish/UK policy context.*

This links to [Recommendation 13](#_RECOMMENDATION_13_-) – infrastructure to support citizen science record submission.

## RECOMMENDATION 19 - Invest in data engineers and allocate resource for system decommissioning

Data engineers should be funded to input ‘loose’ data stored in file storage on networked drives into systems; complimented by short-term resource (monetary and/or effort) made available to government organisations to enable legacy data management system decommissioning so that and the benefits of cloud-based system technology can be fully adopted.

*This would reduce technical debt and longer-term data management staff resource requirements associated with non-automated workflows and duplication of effort, by facilitating full adoption of automated workflows and the benefits of new cloud-based system technology.*

## RECOMMENDATION 20 - Provision of biodiversity records collected under licence or for consent into the MEDIN data archive centre network

It should be a statutory requirement for records collected by commercial developers through the licensing and consenting system to be provided, via affiliated data submission routes (i.e., established databases), into the UK MEDIN archive DASSH. This would enable onward publication to the NBN Atlas and other international portals.

This links to [Recommendation 3](#_RECOMMENDATION_3_-) – primacy of affiliated data submission routes.

## RECOMMENDATION 21 - Maintain data version control through encouraging active custodianship

Data custodians should perform checks to determine whether the version of data in portals is true to source, and ensure that portals harvest updated data, in addition to re-archiving.

*Re-harvesting of* *data by Data Archive Centres (e.g., DASSH from MRO), either periodically or on request following active management of data, would help ensure that data are up-to-date and robust throughout the data network.*

## RECOMMENDATION 22 - Optimise re-use of data through adherence with FAIR Data Principles

All organisations should champion open data and FAIR data principles: use of Open Government Licensing for all data commissioned by public bodies and Creative Commons (by attribution) (CC-BY) licences for industry, eNGO volunteer recording and academia should be encouraged; clear licensing conditions; and easy to access descriptions of the dataset (metadata).

*The generation, management, collation and sharing of data should be based on FAIR Data Principles to make marine species and habitat data in Scotland Findable, Accessible, Interoperable and Reusable (FAIR) throughout the data flow network.*

## RECOMMENDATION 23 - Develop existing portal infrastructure to support efficient searching, data display and dataset collation

DASSH, Marine Scotland and the NBN Trust should prioritise investigation and requirements gathering to fully understand DASSH’s species mapper, NMPi portal and the NBN Atlas’ existing and future customer needs against the current and planned work to respective portal interfaces; i.e., what stakeholders need access to and how, and where the highest value lies for each customer\*.

\*There are a wide range of user groups with different needs / expectations.

This could include:

* A discovery phase, prior to undertaking user needs research, to clearly understand and articulate each systems niche and its purpose within the data network to avoid duplication. See Annex D (in report) for description of existing key system purposes relevant to Scottish data.
* Understanding what is working well and what can be improved in the existing user interfaces of these platforms, the mapping tools functionality, download services and use of APIs. This would help to deliver the infrastructure required to facilitate efficient searching, harvesting and collation of records. This links to [Recommendation 10](#_RECOMMENDATION_10_-) – infrastructure to support habitat records.
* Enabling the querying, visualisation and download of multi-disciplinary datasets for use in end-user systems, via cross-DAC re-aggregation of data.

## RECOMMENDATION 24 – Embed marine expertise in, and interoperability of, the national and regional (LERC) hubs infrastructure in Scotland

* The NBN Trust should require, where possible, marine ecological expertise and/or marine data management expertise in at least one of the role holders recruited for the SBIF Better Biodiversity Data (BBD) Project, i.e., for one of the roles to be located in the National Hub for Scotland being established by that project.
* The infrastructure of National and Regional Hubs (i.e., the Scottish LERC infrastructure) should be scoped and developed to enable interoperability with the existing and developing marine data infrastructure; including Marine Recorder Online, the JCDP, and the MEDIN biodiversity data archive centre DASSH, so that data are made openly available for others to reuse under licence terms. This is in alignment with MEDIN’s ethos of FAIR data.
* There is a need to further tease out the relevance to the LERC model (which is based on charging developers for ‘value added services’) to marine biodiversity data; if marine data submitted to LERCs flows efficiently into MEDIN DACs there would likely be little call on LERCs for ‘value added services’ as most enquiries about marine data would likely end up with e.g., DASSH (coastal data is possibly an exception).

*This would enable incorporation of marine species and habitat data products into the ‘value-added service’ available, e.g., to industry and local authorities, through the Scottish Hub for use in coastal (terrestrial / freshwater-marine interface) planning and development. It would also facilitate the integration of existing marine data management infrastructure with the future Hub infrastructure to ensure that any marine data submitted into the LERCs flows into the wider marine data network.*This links with [Recommendation 10](#_RECOMMENDATION_10_-) – infrastructure to support habitat records.

## RECOMMENDATION 25: Ensure future governance of marine data management in Scotland

A Scottish / UK advisory group should be formed to facilitate continued cross-sector stakeholder engagement and collaboration and guide implementation of the recommendations.

The group’s role should involve:

* Guiding the development of an ‘Implementation Plan’; this should follow an agile approach, focussing on priority areas and areas of highest value/benefit first.
* Within the ‘Implementation Plan’, develop a benefits dependency network diagram for the marine community, identifying the case for change:
  + Drivers of change
  + Change objectives
  + Benefits of change
  + Business changes needed
* Oversee / monitor and provide leadership to progress, find solutions to, and implement the Review’s recommendations.
* Ongoing and iterative collaboration between stakeholders.