UK Research and Innovation

Funded by the European Union

A Simple Social-Ecological System Approach

Guidance Document

MARINE SABRES

Issued: **August 2025**

Version: **2025 Edition**

About this document

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This document was produced under the Marine SABRES Project: Marine Systems Approaches for Biodiversity Resilience and Ecosystem Sustainability. Funded by the European Union's Horizon Europe research and innovation programme under grant agreement no. 101058956 and the UK Research and Innovation Fund, UKRI Project no. 10050525.

CITATION

Smith, G., Elliott, M., Gregory, A.J., Atkins, J.P, Boyes, S., Costa, A, Dinis, A, Botelho, A, Martins, G, Parente, M, Ventura, M, Ruano, C, García, J, Haroun Tabraue, R, Benedetti-Cecchi, L, Mintrone, C, Ravaglioli, C, McGrath, A, Parretti, P, Woods, P, Olsen, M, Rybicki, S, Jurrius, L, Piet, G , Lusseau, D, Vastenhoud, D, Meirelles de Oliveira, B , and Borja, A., (2025). The Final Simple Social-Ecological Systems Guidance, Deliverable 3.4. Marine SABRES, European Union's Horizon Europe research and innovation programme under grant agreement no. 101058956. and the UKRI Project Number 10050525

DISCLAIMER

Contents

Introduction to the Simple SES Approach

OBJECTIVES:

The Simple Social-Ecological System (sSES) approach aims to support informed decision-making in marine management by providing a comprehensive understanding of the interconnectedness between human activities and the marine environment. To do this, the approach:

- promotes iterative learning about a social-ecological system;
- engages stakeholders with the management process;
- aims to identify the underlying causes of marine management challenges and potential Points for Management Intervention(s);
- informs the development and implementation of effective Response Measures that contribute to achieving desired environmental and societal outcomes.

DESCRIPTION:

The sSES is a marine management decision support tool comprised of multiple steps which uses systems thinking tools to frame the social-ecological system. It is based on the existing SES conceptual model of the Integrated Systems Analysis framework (Elliott, et al., 2020) and is adapted and expanded from other SES approaches. It uses the cause-consequence-response DAPSI(W)R(M) framework (Drivers, Activities, Pressures, State changes, Impacts (on Welfare), and Responses (as management Measures)) to structure the analysis of the social-ecological system.

The approach includes Causal Loop Diagrams as a tool, to visually represent complex relationships and feedback loops within the system. The approach is designed to be iterative, with outputs from one iteration informing the next, promoting both adaptive management and learning from experience.

WHAT ARE THE OUTPUTS OF THE APPROACH?

The sSES will provide a visual representation of the social-ecological system in the form of causal loop diagrams, highlighting key relationships, feedback loops, and potential points where management responses may be most effective. The use of causal loop diagrams in various applications has identified underlying causes of management problems and potential interventions based on system analysis (Barbrook-Johnson and Penn, 2022).

The recommendations for Response Measures, including specific actions, policies, and strategies can be developed from the sSES process to address the identified issues and challenges. Furthermore, this guidance document gives advice on outputs including reports and presentations that communicate findings and recommendations to stakeholders and decision makers.

WHO ARE THE INTENDED USERS?

The primary users of the sSES DST, for whom it has been designed, are marine managers and practitioners who are responsible for developing and implementing marine management plans and strategies. It will also support scientists and researchers who study social-ecological systems and contribute to marine management decision-making.

While other stakeholders may not directly use the guidance or the sSES approach, they would be consumers of its products. The sSES provides clear guidelines regarding how to communicate these findings to stakeholders who have an interest in, or who are affected by, marine management decisions, including industry representatives, NGOs, and local communities.

Introduction to the Simple SES Approach

WHAT PURPOSE WILL THIS APPROACH SERVE?

This approach will provide end-users with a structured procedure to analyse complex marine management issues, using the DAPSI(W)R(M) cause-consequence-response framework and systems thinking tools to reduce the perceived complexity. This approach includes creating causal loop diagrams that visually represent relationships and feedback loops within the system, and which in turn can be used as communication tools to enhance understanding by, and engagement with, relevant actors.

The approach facilitates identifying data gaps and encourages the use of various data sources, including scientific data, local knowledge, and expert judgment. Moreover, the approach supports stakeholder engagement throughout the Simple SES process, promoting collaborative decision-making and shared ownership.

WHAT ARE THE TIME COMMITMENTS?

The sSES process can be undertaken at a pace appropriate to available effort capacity. The minimum time commitment could be one week, to trial a model based on user knowledge and make a solely qualitative model based upon expert and stakeholder opinion. The number of people involved, resources of the users, and preferred style of conducting the approach may all determine the time duration of this process. Typically, the more time invested in applying the model, the more learning and understanding will be gained. In the space of three months, the three steps (Setting priorities, gathering data, and using the information) of the Simple SES could be completed, and response measures designed, based upon a data-informed approach.

FUNDAMENTS OF A 'SYSTEMS APPROACH':

Systems Thinking is a trans-discipline that embraces several fundamental concepts that represent a 'Systems Approach' (Reynolds and Howell, 2020). Whilst these underpinning concepts may vary and change in significance with different applications of Systems Thinking tools, in this approach we highlight some core principles to add the necessary context for users. Several fundamentals of Systems Thinking underpin the Simple SES approach including consideration of interconnections, boundaries of a system, feedback, emergence, communication, and holism. For more information regarding Systems Thinking, see Briefing Paper 9.

KEY CONSIDERATIONS:

Throughout the SimpleSES process, it is recommended that emphasis should be focused on three aspects:

- Iteration: each step should be revisited and refined as new information emerges;
- Confidence: consistently assess confidence levels in data and relationships;
- Reflection: regularly pause to evaluate assumptions and decisions.

HOW TO READ THIS DOCUMENT:

This guidance document centres on the use of overarching and individual Standard Operating Procedures (SOPs). To navigate this guidance document, the user should begin by reviewing the two overarching SOPs which together provide a comprehensive overview of the sSES: one covers the Process and Information Management System (PIMS), while the other details the Integrated Systems Analysis. The individual SOPs instruct each step of the PIMS and Integrated Systems Analysis. Figure 1 provides an overview of these two overarching SOPs.

Schematic of the Simple SES guidance

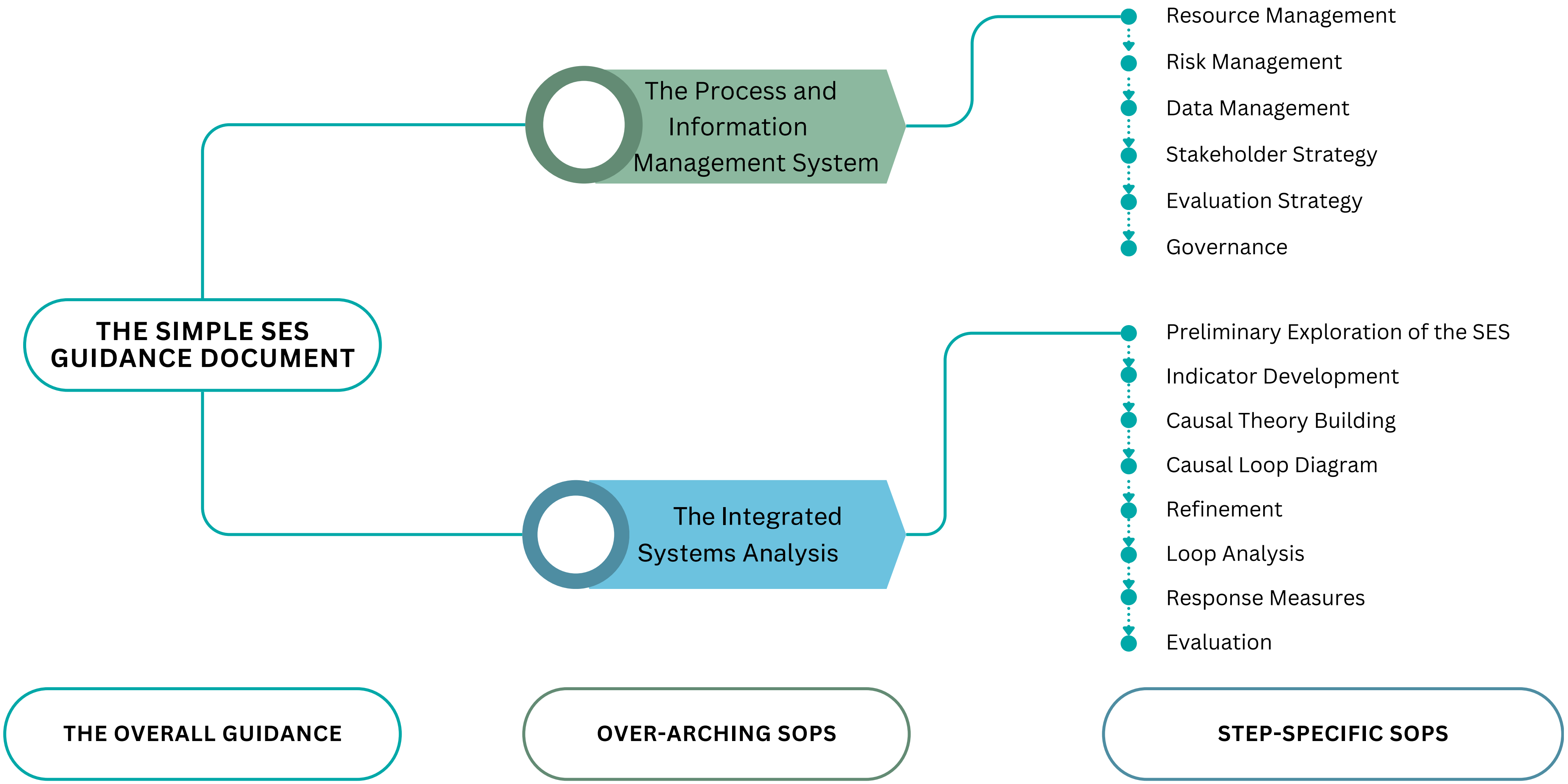


Figure 1: A schematic of the Simple SES guidance. Illustrating the two overarching Processes (the Process and Information Management Systems and the Integrated Systems Analysis), and the specific Standard Operating Procedures that contribute to the two Processes.

In the corner of each SOP you can track your progress of where you are in the Simple SES process by referring to this progress bar in the bottom right corner. The darker circle indicates your progress.

The Process and Information Management System

STANDARD OPERATING PROCEDURE 1.

SCOPE:

The Process and Information Management System (PIMS) is a preliminary component of the Simple SES (sSES) approach, designed to guide the logistical and multi-sectoral aspects of marine management. It provides the foundation for the analysis of a project (i.e. the challenge or circumstance being, or to be, addressed by management) by integrating priorities, governance, logistics and stakeholder considerations from the outset of the process. It aims to ensure key concerns are addressed, such as project management and stakeholder identification. The PIMS encompasses six key considerations, these are:

1. Project Management – this refers to the oversight of the activities in a project, ensuring that each phase of the project corresponds to its intended objectives.
2. Resource Management – this is centred on the strategic distribution and use of resources; this element ensures the process operates within its stipulated budget and time constraints, efficiently utilising resources, from scientific tools to human expertise.
3. Stakeholder Identification, Engagement and Communication – this involves actively involving all relevant stakeholders in a project, as well as seeking to create a dialogue that addresses their insights and reservations.
4. Data Provenance and Management – this underscores the importance of data integrity and traceability. It requires a structured approach to managing data in line with a Data Management Plan and respecting data protection standards such as General Data Protection Regulations (GDPR) (Regulation 2016/679).
5. Evaluation – this should comprise a continuous appraisal process that compares the project progression with predefined standards, enabling timely modifications to enhance the required outcome.
6. Governance – this relates to establishing and enforcing clear protocols, rules, and decision-making processes, ensuring the problem is addressed ethically, transparently and efficiently through the nation state having the appropriate legislation and administrations (Boyes and Elliott, 2014).

DEFINITIONS:

Term	Definition
Resource Management Plan	This outlines the efficient and effective deployment of necessary resources throughout the project lifecycle. These resources encompass a variety of assets, such as financial capital, inventory, human skills, production tools, information technology (IT), and natural resources. The plan includes all process phases: initiation, implementation and closure.
Risk Management Plan	This is a documented process that begins with identifying potential obstacles to achieving project deadlines, such as personnel changes or resource shortages. It involves recording and assessing these risks in a risk log. This plan may be integrated with issues management, which addresses concerns about the project raised by stakeholders, ensuring proactive responses to potential challenges and achieving project goals.
Data Management Plan	This is a written document outlining the plans for managing research data both during and after the project. It should address what types of data will be collected and how the data will be documented, stored, shared and preserved.
Stakeholder Strategy	This outlines how to identify and engage with relevant individuals and groups affected by, or who can influence decisions within, this complex system. It will define who is considered relevant and included within the scope of analysis.
Evaluation Strategy	This provides a structured approach to assess the effectiveness of interventions. It includes two key elements: process evaluation, examining the stakeholder engagement process itself, and outcome evaluation, measuring progress towards defined objectives using measurable indicators. This dual approach ensures that both the process and the outcomes contribute to successful and sustainable marine management.
Governance Analysis Guidance	This indicates the legislative instruments of the Social-Ecological System under study, and the Administrative bodies which govern the System.

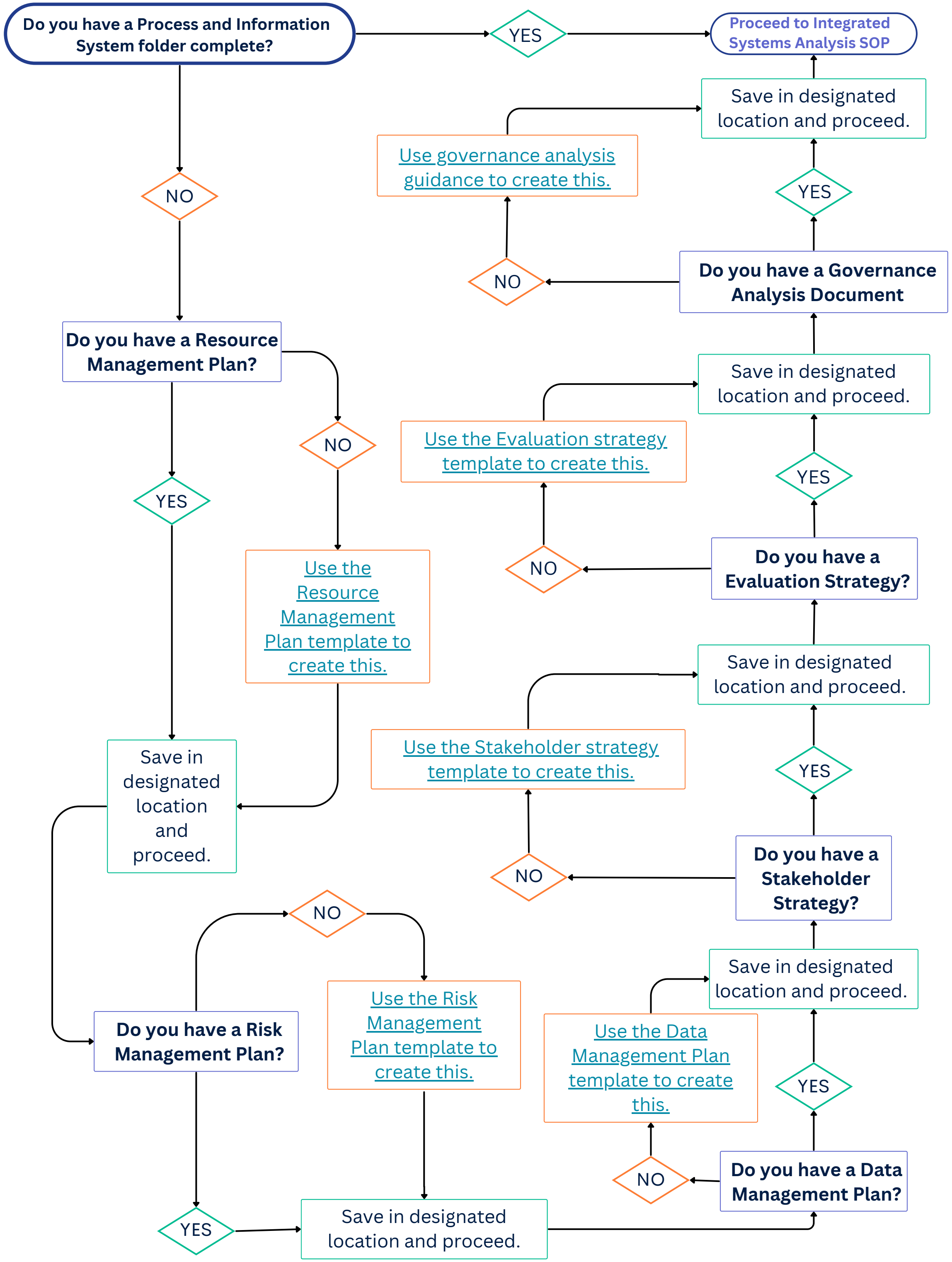


Figure 2: Decision tree guiding users to consider each of the required elements within the process and information management system.

PROCEDURE:

It is recognised that users of this tool may do so on behalf of their own institutions/organisations; hence, not all elements of the PIMS will require to be completed as their institutions/organisations may already have procedures and processes set-up that duplicate the PIMS. Users are directed to the decision tree (Figure 2) to assess which sections of the PIMS should be completed before beginning the Integrated Systems Analysis analysis.

The decision tree is designed to help you determine if you have the necessary PIMS elements in place. If not, see the templates section to download the relevant templates that you can use to create the required documentation. Once you have completed the templates, you can save them in a designated location for your project records.

SECTIONS AND TEMPLATES:

Annex 1 includes individual step-specific SOPs and accompanying templates of each PIMS section of the sSES. If required, each provided template should be completed after being saved as a new document.

The Integrated Systems Analysis

STANDARD OPERATING PROCEDURE 2.

SCOPE:

This SOP provides an overview of the Integrated Systems Analysis process, outlining the key stages of the approach. Individual step-specific SOPs will then follow this overview.

The Integrated Systems Analysis is the underpinning theoretical framework which is expanded and operationalised to create the Simple SES (sSES). This systems approach will structure the Marine Social-Ecological System to allow for understanding how the marine system under study is functioning and identify driving behaviours which influence the system overall functioning.

In addition to being used in data-rich areas where much of the necessary information already exists, the Simple SES approach can be used in data-poor areas, where an initial rapid iteration can help identify available information and user confidence levels. In this latter case, the initial iteration can motivate users to seek or create more robust data, leading to increased confidence and further iterations of the sSES process for continuous refinement and learning.

This SOP covers an overview of the Integrated Systems Analysis process, including:

- The three main parts: Setting priorities, getting information, and using information.
- Application of key cause-consequence-response frameworks such as DAPSI(W)R(M) and Causal Loop Diagrams
- Data collection, analysis, and visualisation procedures
- Stakeholder engagement and validation processes

Good management is based on having the best possible understanding of the system or systems that one is trying to manage but, given the multifaceted nature of marine and estuarine systems, no one stakeholder or stakeholder group has a privileged position that offers a holistic view. The view of each stakeholder is limited, and it is only by bringing stakeholders together to share their views of marine and estuarine systems that a more holistic and complete view can be achieved.

Consequently, the processes of identifying, engaging and enabling stakeholders to articulate and share their knowledge of the system (often referred to as issue structuring), critically manage information, and interrogate the prevailing governance become paramount and are reflected in the interpretation of the Integrated Systems Analysis approach detailed in this guide.

At the heart of the Integrated Systems Analysis approach is the DAPSI(W)R(M) model (pronounced dap-see-worm) (Elliott et al., 2017; see below.)

Drivers – the human needs and wants such as food, shelter, security, and life fulfilment.

Activities - the means of obtaining those human needs and wants, such as fishing for food or observing a scenic view.

Pressures - the mechanisms of change to the natural system emanating from the activities, such as physical disturbance to the seabed.

State changes - the degree of change on the natural system and ecology resulting from the pressures e.g. erosion and turbidity leading to reduced fish populations.

Impact - on human Welfare – A change in the goods and benefits society gains from the natural system e.g. reduction of fish catches per unit of effort.

Responses - using management Measures and the amendment or creation of policies, together with behavioural changes e.g. seasonal closure, changes in net size, and changes in consumer purchasing behaviour towards more eco-friendly goods.

This section is designed to enable practitioners to conduct a DAPSI(W)R(M) analysis in a step-by-step way and, in so doing, to generate the necessary data and information.

The DAPSI(W)R(M) framework is then used as the basis for a three-part process, an Action Learning Cycle (Zimmer, 2001), (Figure 3), to investigate and to improve the system under study, which is summarised as Part A – Setting priorities, Part B – Getting the information, and Part C – Using the information.

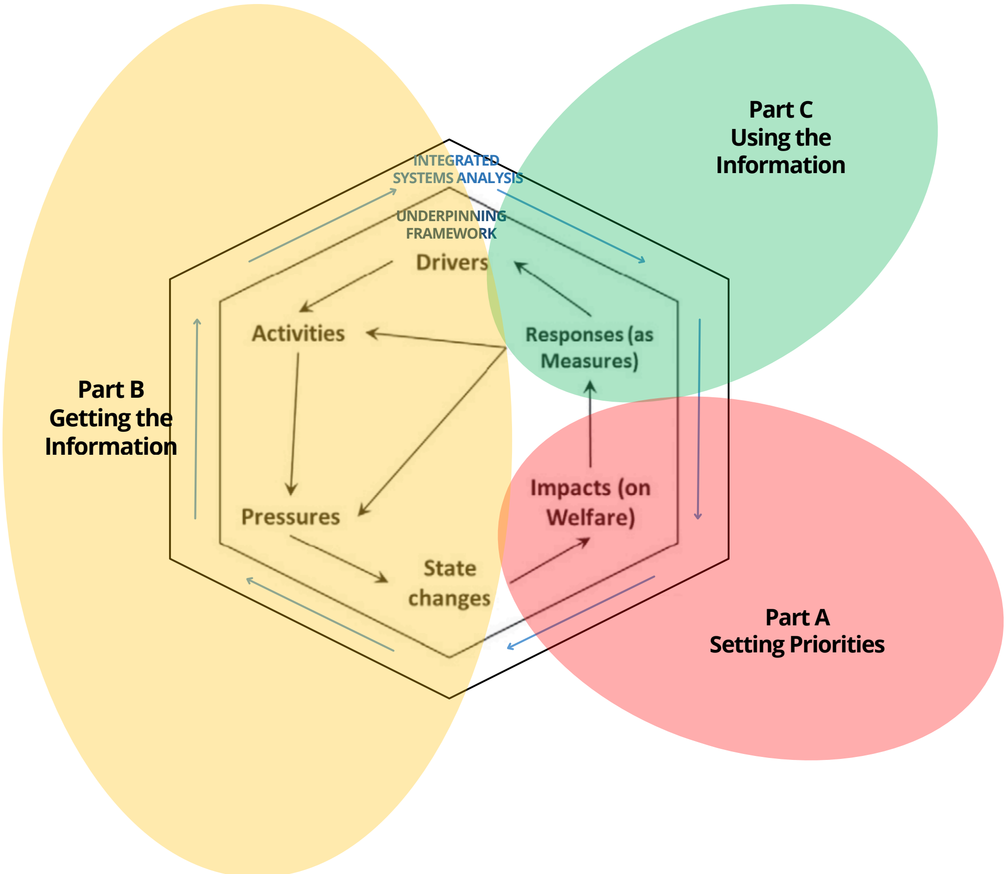


Figure 3:The DAPSI(W)R(M) based Action Learning Cycle (Gregory et, al. 2023).

DEFINITIONS:

Term	Definition
Systems Approach	A method of examining complex issues holistically by considering how different parts of a system interact with each other, rather than looking at individual components in isolation. In marine management, this involves understanding the interconnections between social and ecological factors (Amissah, et al., 2020).
Action Learning Cycle	An iterative process of planning, action, and reflection used in the Integrated Systems Analysis. It involves setting priorities, gathering information, and using that information to inform decisions. The cycle then repeats, allowing for continuous improvement and adaptation of management strategies based on new knowledge and changing circumstances (Smith, et al. 2025).
Problem Structure Method	A systematic and participatory approach used to address complex issues by separating them into more manageable components (Mingers and Rosenhead, 2004). In the context of Integrated Systems Analysis, the DAPSI(W)R(M) framework can be used to structure the analysis of marine management problems, helping to identify key relationships and potential intervention points.
Indicator	"Indicators are measurable elements that show or communicate the status, condition, or trends related to a topic of interest" (Bennett, et al., 2021). In marine management, indicators might include attributes such as fish population abundance, water quality measurements, or economic data related to marine industries. They should be SMART (specific, measurable, achievable, realistic and time-bounded, and possibly SMARTIE with inclusivity and equity) and linked to monitoring thereby indicating what management is required or whether the management is successful (Elliott et al., 2025a).
Causal Loop Diagram	A visual representation of how different variables in a system are interrelated. It shows the causal relationships (or at least correlative relationships to inform expert opinion) between various factors, including feedback loops where the change in one variable affects others, which in turn influence the original variable (Haraldsson, 2004). In the sSES, these diagrams help to illustrate the complex dynamics of marine social-ecological systems and identify potential points for management interventions, where Points for Management Intervention(s) are specific operations or actions; this is likely to be included in the Programmes of Measures required under legislation such as the EU Marine Strategy Framework Directive.
Points for Management Intervention(s)	Points within the social-ecological system that are influencing key outcomes, hence are critical in the systems behaviour as a whole.

PROCEDURE:

As this SOP provides an overview of the Integrated Systems Analysis process, it details the steps in the procedure at a general level, hence, the detailed steps can be found in each corresponding step-specific SOP following this overview. The procedure fits into the overall Simple SES as in Figure 4.

Part A: Setting Priorities

1. Define the main issue(s) of concern and how it/they affect(s) people:
- Gather stakeholders to identify the most important issues relating to the focus of investigation;
- Capture the different views and promote dialogue;
- Clearly state the main problem(s) to be tackled.

2. Decide on the area and period to study:
- Choose the geographical area for the analysis;
- Decide how far into the past and future you will look;
- Think about the bigger picture, the focus area, and smaller parts within it and the bigger environment influencing it.

Part B: Gathering Information (relevant only to the issue(s) identified in Part A)

- Identify and document the goods and benefits within the scope of the systems as identified in Part A;
- Identify indicators to measure or represent the goods and benefits;
- Document data quality, quantity, and availability;
- Consider how these indicators are behaving over time, consider plotting this on a graph where time is along the x-axis;
- Following this, identify the associated changes in the natural environment. This includes ecosystem services and the marine processes and functions that support the services:

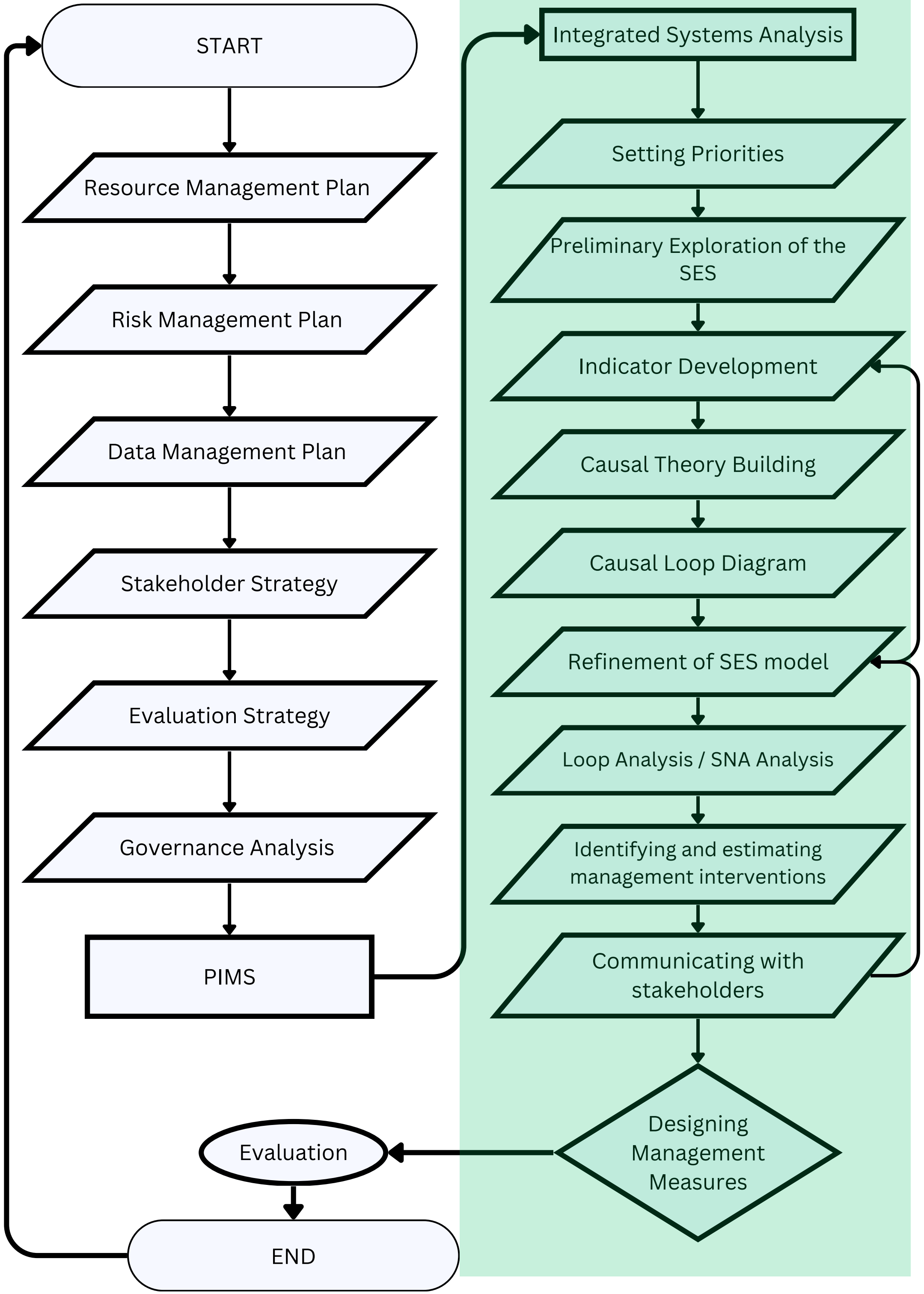


Figure 4: Overview of the Integrated Systems Analysis process within the Simple SES approach. (Acronyms: SES: Social-Ecological System, SNA: Social Network Analysis, PIMS: Process and Information Management System.)

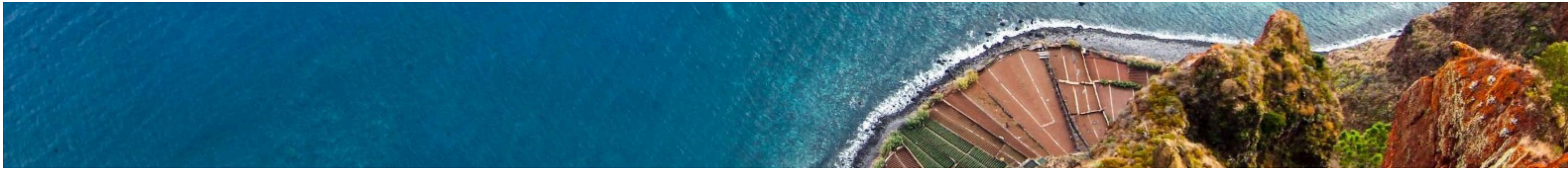
Part B Continued...

- Document the ecosystem services that ultimately lead to the societal goods and benefits identified after inputting human capital;
- Identify indicators to measure or represent the ecosystem services;
- Consider how these indicators are behaving over time, consider plotting this on a graph where time is along the x-axis;
- Complete an adjacency matrix linking goods and benefits to ecosystem services detailed in SOP 4:
  - Use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system.
- Repeat this process for the following elements of the system:
  - Marine Processes and functions;
  - Pressures;
  - Activities;
  - Drivers;
- Following the identification of indicators pertaining to drivers, close the loop by completing an adjacency matrix linking Drivers to the societal goods and benefits detailed in SOP 4.
- Review and refine:
  - Review the adjacency matrices to ensure all significant relationships are captured;
  - Identify any data gaps or uncertainties in the indicators or relationships;
  - Consider how these gaps might affect the analysis;
  - Plan for how to address these gaps in future iterations of the analysis.

Part C: Using the Information

Build Causal Loop Diagram(s):

- Create causal loop diagrams based on the adjacency matrices, as detailed in SOP 5;
- Visualise the data from the spreadsheets in a model through use of the Simple SES tool.
- Use data and/or expert judgement to refine and manage the complexity of the Model.
- Identify key points for Management Interventions:
  - Analyse the diagrams to find the most influential factors that can cause change or can respond to change;
  - Consider how strongly different factors are connected;
  - Add possible management responses to the diagrams;
  - Estimate the effects of potential management measures on the SES.
- Validate the Model with Stakeholders:
  - Prepare a clear diagram giving the level of detail and focus that is appropriate for the stakeholder group to review;
  - Explore the stakeholder understanding of the system and gather feedback and check if the models reflect the actual or perceived system;
  - Refine the model based on Stakeholder feedback.
- Design a Management Response Plan and evaluate progress:
  - Refer to the governance (legislation and administration) of the area to see what instruments are in place and who the governing authority is relating to them;
  - Create an ecosystem-based management plan to action the outcomes of the sSES approach.
- Implement interventions and evaluate progress alongside the ten-tenets (See SOPs 11 and 12 for detailed steps).



Preliminary Exploration of the SES

STANDARD OPERATING PROCEDURE 3.

PURPOSE:

This procedure facilitates an initial exploration of the SES and its components, to be considered throughout the Simple SES (sSES) process to set the scope for analysis and modelling. This step is critical in defining the geographical, temporal, and representational boundaries, and in ensuring the inclusion of relevant elements to address marine problems and focal issues of concern effectively.

By following this SOP, users will gain clarity on:

- The key issue(s) to address.
- The temporal and spatial scales of the analysis.
- The components/elements to be included in the system view.

SCOPE:

This exercise aims to define the boundaries for the sSES approach. It is intended to be undertaken in discussion as a group and will support users in establishing the focal issue(s), considering the scope of the analysis, and prioritising impacts on human welfare and policy implications.

DEFINITIONS:

Term	Definition
Boundary Setting	Boundary setting in sSES analysis defines the scope, focus, and limits of the system under study, including its spatial, temporal, stakeholder, and thematic dimensions, to ensure clarity, relevance, and manageability.
Causal Loop Diagram	Visual representation of how different variables in a system are interrelated. It shows the causal relationships between various factors, including feedback loops where the change in one variable affects others, which may in turn influence the original variable (Haraldsson, 2004).
System components	Tangible and Intangible parts of the system which are interacting with each other.
Mind-Map	A diagram in which information is represented visually, usually with a central idea placed in the middle and associated ideas arranged around it.
Rich Pictures	A diagrammatic representation of a complex situation that uses pictures, minimal text, symbols, and icons to illustrate the main elements and relationships (Bell, et al., 2016).

PROCEDURE:

- Document the purpose of this investigation. Consider what you are trying to explore, where this is spatially and temporally, and why you are undertaking this process. Ask yourself: what is the primary aim for this investigation?
- Gather a group of people who are involved in the system, this includes stakeholders, colleagues, policy makers, local businesses - essentially anyone with a interest in the issue you are exploring.
- As a group discuss each row in the Table 3 to address the relevant aspects to consider in your modelling approach.

Consideration	Description	Example
Key Issues	What are the key issues associated with your area?	The primary aim for this investigation is to manage overfishing in the North Sea.
Policy Implications	What are the expected outcomes of the exercise for policy development or decision-making?	To inform recommendations of what limits should be set for fishing in the North Sea EEZ for the next 10 years.
Geographical Boundaries	What are the geographical boundaries and limitations of the analysis? Specifies the spatial extent of the system being analysed.	Focusing on a specific marine area (e.g., North Sea) or a broader region (e.g., the entire Arctic Ocean).
Temporal Boundaries	Defines the timeframe over which the analysis will be conducted, including historical data and future projections.	Examining the impacts of overfishing over the past 20 years and forecasting implications for the next decade.
System Components	Determines which tangible (e.g., fish stocks, habitats) and intangible (e.g., cultural values, governance frameworks) elements of the SES are included.	Focusing on the fishing industry and its socio-economic impacts while excluding unrelated industries.
Stakeholder and Representational Boundaries	Sets the boundaries of stakeholder inclusion to ensure diverse but relevant participation.	Including local fishers, policymakers, and conservationists, but not global industries as irrelevant to the local context.

- For added value, you can visualise the considerations to explore what the system in focus includes using whatever methods are possible – e.g. mind maps, rich pictures, and qualitative causal loop diagrams; examples for each are found here.
- Once you are confident that you have identified the bounds of the investigation, this being temporal, spatial, and thematic, you can progress to the next SOP.

TEMPLATE/ EXAMPLES

Mind mapping

Brainstorm components and relationships within the system either with a pen and paper, whiteboard or in a virtual workspace. As illustrated in Figure 5, mind-maps usually have a central idea placed in the middle and associated ideas arranged around it, capture both tangible and intangible elements of the system in focus, ensuring stakeholder input.

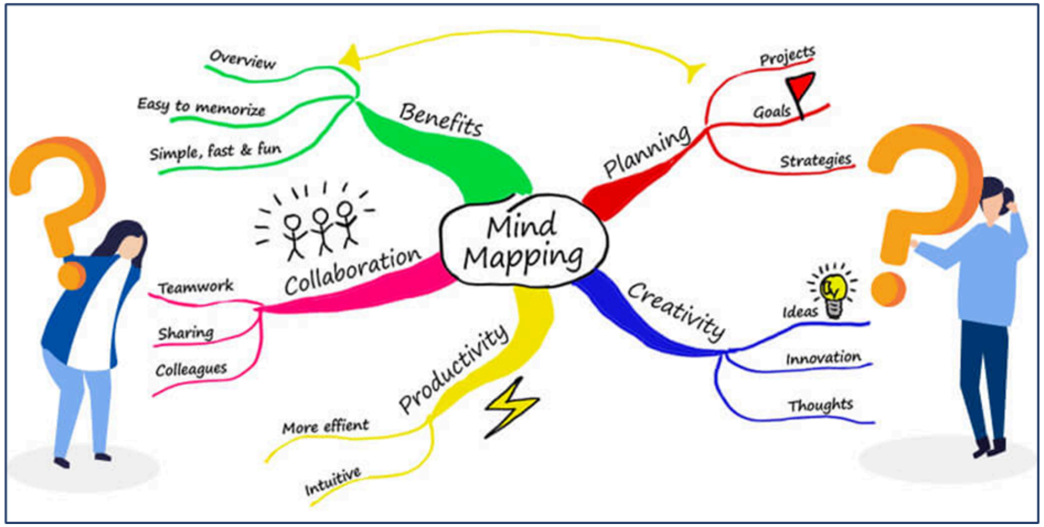


Figure 5: A mind map of a mind map (source: https://www.meistertask.com/blog/why-mind-mapping , 2019)

TEMPLATE/ EXAMPLES CONTINUED...

Qualitative Causal Loop Diagram

This diagram (Figure 7) is a visualisation of interrelations between system variables to view the system from an entirely subjective understanding. Creating a qualitative causal loop diagram can capture stakeholder perceptions on identified problems and translate them to an exploratory model.

Moreover, this activity can set foundations of a causal loop diagram model which will be developed further with available data, indicator development, and stakeholder input throughout the sSES instructed process. This can be undertaken by the user, following instructions in this link as a guide, or engaging with a group-model building expert facilitator to support this style of exploration.

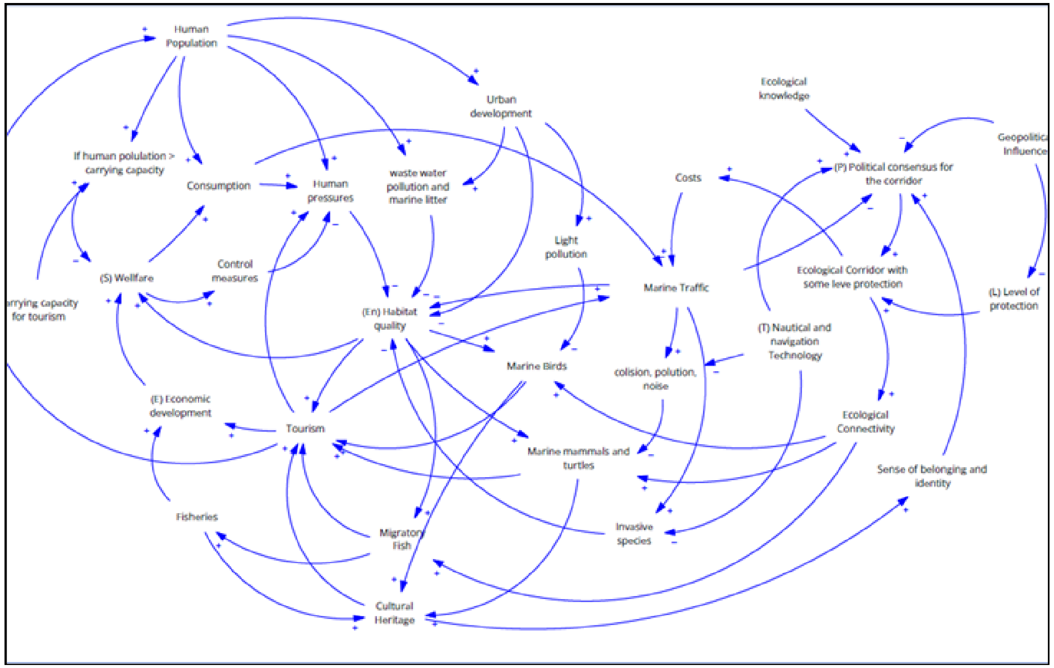


Figure 7: A qualitative causal loop diagram created in the Marine SABRES Project (Source: Borja, et al., 2024.).

Rich Picture Development

Illustrating the system's elements using diagrams to depict key components and their relationships. The use of 'Rich Pictures', cartoon-like and stakeholder-led expressions of the significant problem situation (Bell, et al., 2016). The aim is to use a minimum of text to convey the ideas (e.g. see Big Picture Thinking - The Art of Rich Pictures (8/8)). Exploration of a Rich Picture can facilitate discussions and guide stakeholders to confirm the priority issues of the SES in focus (Figure 6).

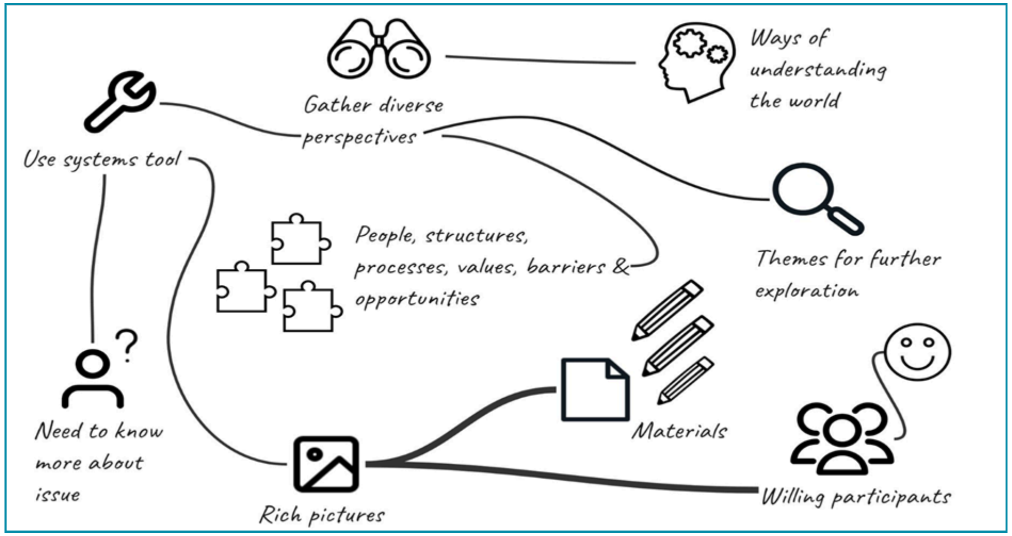


Figure 6: A Rich picture of the process involved in creating a rich picture.

Indicator Development and Causal Theory Building

STANDARD OPERATING PROCEDURE 4.

PURPOSE:

The purpose of indicator development is to select appropriate proxy measures that can be used to build a view of the system in focus at a later stage in the Simple SES (sSES) approach. This SOP will guide users to develop these indicators.

SCOPE:

Indicators are an integral part of monitoring and management of marine problems in reflecting the axiom 'you cannot manage unless you can measure' and that monitoring against such indicators indicates either what management is required or whether management has succeeded in its aims (Elliott and Wither 2024).

The DAPSI(W)R(M), as a linkage framework for causes-consequence-response chains, can be examined conceptually, qualitatively, or quantitatively and promote forward thinking to the process (Teixeira et al., 2016). Therefore, indicators for various aspects of the problem structuring framework can provide insight into the status of the component about the management objectives (Elliott, 2017); highlighting the need for indicators when making informed management decisions on which response measures are appropriate.

They are required for all elements of DAPSI(W)R(M), and guidance is required on their derivation and use in the causal loop diagram as well as the sSES approach. Indicators are a tool for determining change after understanding the complexity of a Social-Ecological System and to support management decisions and responses. They are also necessary for determining the efficacy of management measures.

Where possible, the indicators require to be quantitative and have SMART attributes (Specific, Measurable, Achievable, Realistic and Time-Bounded, and more recently Inclusivity and Equity have been added giving SMARTIE). Unless SMART, it is not possible to determine when an indicator has been reached/exceeded, etc.

Using indicators, the visualisation in Behaviour-Over-Time graphs can aid users in developing causal theories about how the system is interconnected. Behaviour-Over-Time Graphs provide a visual representation of how an element or indicator changes over time (analogous to time-series analysis).

A process of reflection is critical to the creation of such graphs and can also prompt users to reflect on the relationships between elements. It is emphasised that the focus of causal loop diagrams should be causality, not merely correlation. Theories about the causal relationships between elements can be recorded in an adjacency matrix which can provide the foundation for the creation of the Causal Loop Diagram in the next stage of the approach (Schoenenberger, et al., 2017). A process map of this SOP is depicted in Figure 8.

DEFINITIONS:

Term	Definition
Indicator	In general, an indicator consists of one or several parameters chosen to represent (indicate) a certain situation, attribute or aspect and to simplify a complex reality (CSWD 2020).
Behaviour over Time	Similar to a time series, behaviour over time refers to a visual trend for understanding the temporal dynamics of specific system variables (Kopainsky et al., 2015).
Adjacency Matrix	A tool that records the presence, direction, strength, and confidence of causal connections between elements in a system, enabling translation of information to a visualisation of the system interdependencies.
Expert Opinion	Expert opinion refers to the insights, assessments, or judgements provided by individuals with specialised knowledge or extensive experience in a particular field (e.g. the user and stakeholders of the Simple SES tool). In systems analysis, expert opinion is often relied upon to establish, validate, or interpret relationships within complex models when empirical data may be limited.
Causal Theory	Causal theories are the hypotheses from the user regarding how and why specific factors or variables influence each other in a system. It underpins the structure of causal models, guiding the identification of connections and expected outcomes based on assumed or observed cause-and-effect relationships.

PROCEDURE:

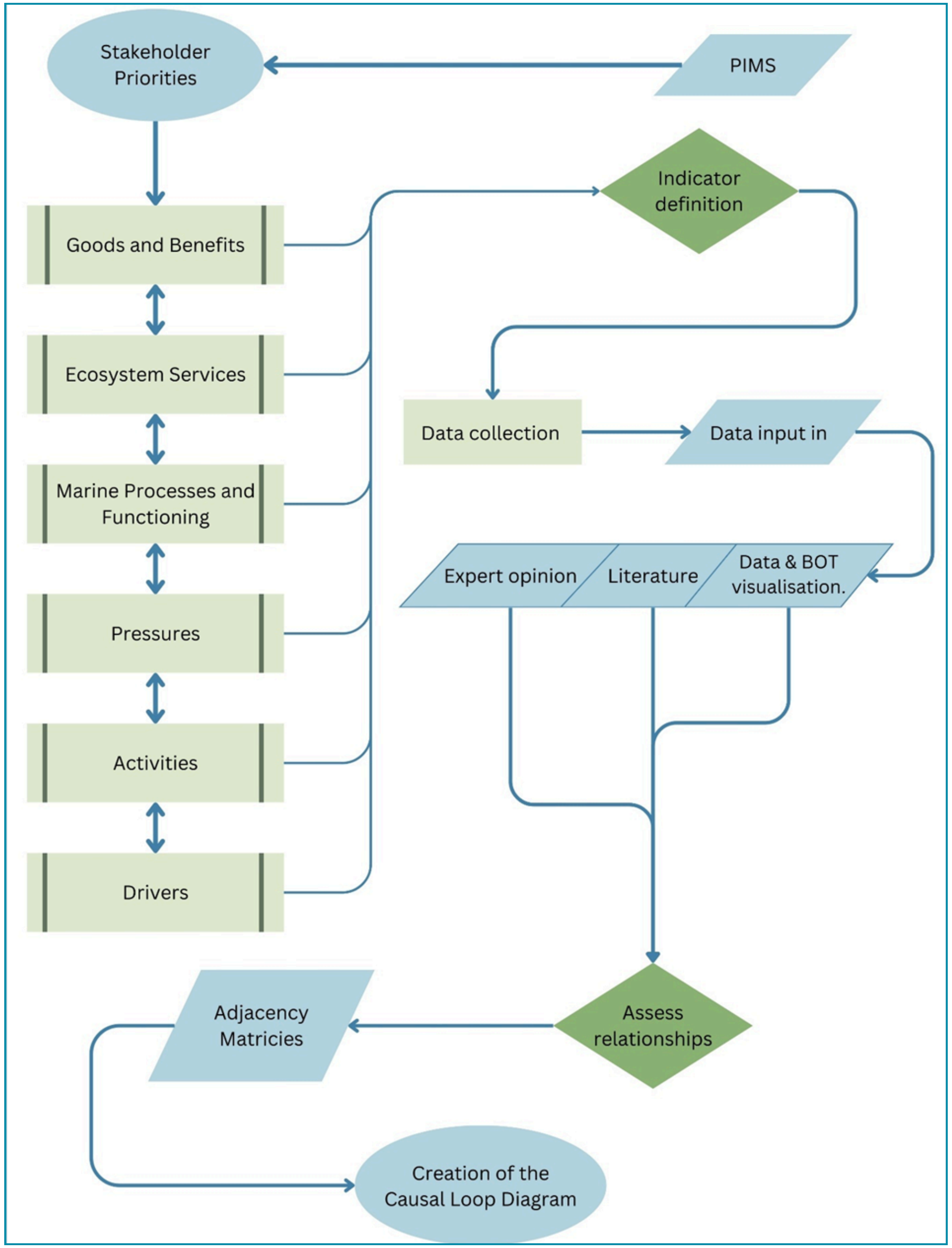


Figure 8: A process map illustrating the assessment of the SES elements, and the creating of causal theories which inform the Causal Loop Diagram (Acronyms: PIMS: Process and Information Management System, Behaviour-Over-Time).

Societal Goods and Benefits

- Using the priorities set in the previous SOP, identify indicators to measure or represent the goods and benefits.
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. With the data, consider how these indicators are behaving over time, you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Following this, identify the associated changes in the natural environment. This includes ecosystem services and the marine processes and functions that support the services.

Ecosystem Services: Changes in the Natural System

- Determine actual or a proxy measurements (indicator) representative of the ecosystem services that ultimately lead to the societal goods and benefits identified after inputting complementary (built, human and social) capital (Elliott, 2023).
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. With the data, consider how these indicators are behaving over time; you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Complete the adjacency matrices linking ecosystem services to the societal goods and benefits (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Marine Processes and Functioning: Changes in the Natural System

- Determine actual or proxy measurements (indicator) representative of the marine processes and functioning (including the structure of the natural system).
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. With the data, consider how these indicators are behaving over time; you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Complete the adjacency matrices linking marine processes and functioning to the ecosystem services (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Pressures: on the natural System

- Determine actual or proxy measurements (indicator) representative of the pressures in the SES.
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. With the data, consider how these indicators are behaving over time; you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Complete the adjacency matrices linking pressures to the marine processes and functioning (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Activities

- Determine actual or a proxy measurement (indicator) representative of the activities in the SES.
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. Also, document the scale of their activity (local, national, or international level). With the data, consider how these indicators are behaving over time; you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Complete the adjacency matrices linking activities to the pressures (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Drivers: Why we need to use the natural environment

- Determine an actual or a proxy measurement (indicator) representative of the Drivers.
- If possible, gather data to measure the indicator and document data quality, quantity, spatiality, and availability. With the data, consider how these indicators are behaving over time; you may choose to plot this on a graph where time is along the x-axis and the indicator behaviour on the y-axis (a Behaviour-Over-Time Graph).
- Complete the adjacency matrices linking Drivers to the Activities (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Closing the cycle:

- Complete the adjacency matrices linking the Goods and Benefits to the Drivers (use expert opinion, available data, and relevant literature to create these causal theories of interconnections within the system).

Review:

Review the Adjacency Matrices and reflect on the below questions and amend the matrices accordingly. Once complete, proceed to model building (SOP 5).

- *How confident are we in our conclusions?*
- *What additional validation is needed?*
- *What improvements could be made?*

Key Considerations:

<u>Building a causal loop diagram is iterative:</u> it relies on the ability to gather more information or insights, revisit your matrices and adjust your connections, strengths, and confidence levels accordingly.

<u>Collaboration:</u> It is recommended to work in a team, encourage discussion and debate while completing the matrices. This helps to identify uncertainties and potential biases.

<u>Visualisation:</u> The confidence levels you assign can be visually represented in your causal loop diagram by assigning weight to connections based on confidence. Be explicit in how you are determining the connection, strength and confidence and promote consistency in this application. Once visualised, this aims to enhance transparency and understanding of the sSES model.

<u>Data rich and data poor environments:</u> The availability of data significantly influences the confidence levels that can be assigned to the causal links. In data-poor environments, initial connections may be based on intuition, expert opinion, or anecdotal evidence. It is important to acknowledge this uncertainty explicitly in your confidence matrix and hence assign lower confidence scores to reflect the limitations of your knowledge and evidence.

TEMPLATES:

In documenting the above procedures, users will need to detail the indicators, the data availability, confidence in this data, and other relevant information. This should be completed for each of the Drivers, Activities, Pressures, Marine Processes and Functioning, Ecosystem Services, and Societal Goods and Benefits. A template for each element of DAPSI(W)R(M) can be found in the downloadable excel file on the sSES tool webpage. Examples in Table 4 below provides an outline for this.

Table 4: Examples of the data sheet for documenting relevant indicators and associated information.

	Location specific Indicator	Indicator name Quality/Quantity	Name to be presented in the model (what is this representing)	Indicator Data Source (Organisation and/or Named Individual) or Data Gap	Indicator Behaviour over time				Comment on Behaviour over time/Trend
					What is the relevant period to assess indicator change? (Unit is always years)	Previous states (T-1, T-2,…)?	Current state (T0)?	Data confidence level (5 highly certain-0 highly uncertain)	
Recommendations	*Description of the indicator.*	*Name to summarise the indicator.*	*Use 4 words or less.*	*Where the data are from.*	*The period that will be suitable to assess change in this indicator.*	*Year: State*	*Year: State*	*Based upon the information in this table, what is the confidence level?*	*How is the element behaving – increasing? Decreasing? Or in a stable fluctuation.*
Example 1: Activity.	Number of potential Vessel anchorages in the area.	Anchorages	Anchorages	EMODNET (Leisure craft vessel density in the MPA)	5y	*2017: 193, 2018: 226, 2019: 342, 2020: 484, 2021: 453.*	*2022: 1150*	3	Increasing - Poor control on anchorages sites; few or no alternatives to anchorages (no dedicated moorings); no monitoring of the impacts.
Example 2: Ecosystem Service.	Biomass (kg) of reef fishes in 100m2 transects	Coastal and Marine Biota	Marine Species.	UNIPI (biomass in kg of fishes in 100m2 transects in MPA)	5y	2005-2008: 24.16, 2009-2013: 43.48	2020-2022: 53.19	4	Slowly increasing

When creating and suggesting causal links, it will be valuable for users to consider the behaviour of an element over time. The template below and Figure 9 provides a structure and an example of this.

Template:

Element Name	
Time	**Data**

Example:

Number of available Vessel anchorages in the area.	
Year	**Vessel Anchorages**
2017	193
2018	226
2019	342
2020	484
2021	494
2022	1140

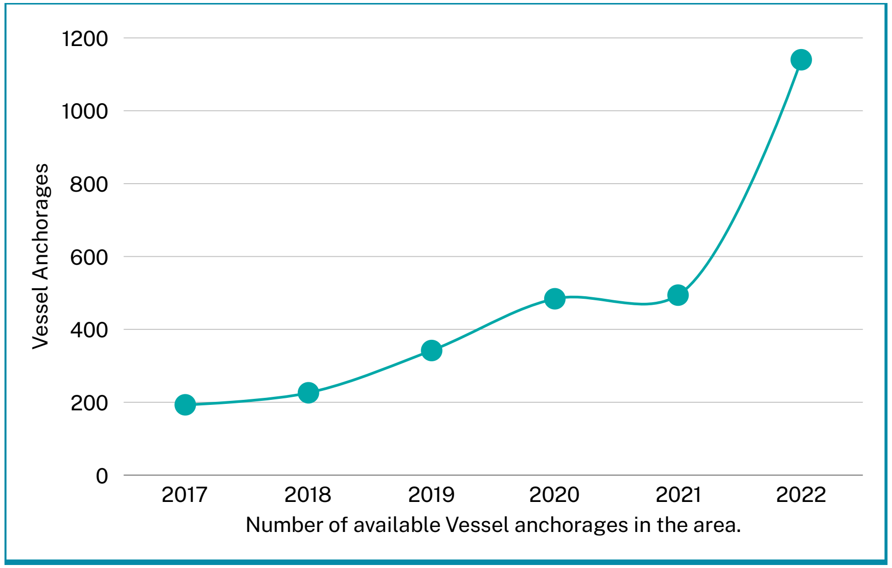


Figure 9: Example of a Behaviour-Over-Time graph

Assessing relationships in the Adjacency Matrices:

To consider how the elements interact within the system, adjacency matrices are suggested to assign connections based upon these causal perceptions, their strength and the confidence users have in their theory.

Connections assigned between indicators will include a positive connection (the two indicators increase), a negative connection (as one indicator increases, the other decreases), or left empty if there is no evidence to suggest a causal theory between two indicators. Connections are either:

(+) The indicators move in the same direction. An increase/decrease in one indicator will cause the same increase/decrease in the corresponding indicator.

(−) The indicators move in opposite directions. An increase/decrease in one indicator will cause the opposing increase/decrease in the corresponding indicator.

		Linked DAPSI(W)R(M) category				
		Indicator	Indicator	Indicator	Indicator	Indicator
DAPSI(W)R(M) category	Indicator	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*
	Indicator	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*
	Indicator	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*
	Indicator	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*
	Indicator	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*	*+/-/empty*

Assessing relationships in the Adjacency Matrices: Strength of the connection

The strength of this connection in the previous adjacency matrix is to be recorded as a Strong, Medium, or Weak (positive or negative) influence on other indicators.

		Linked DAPSI(W)R(M) category				
		Indicator	Indicator	Indicator	Indicator	Indicator
DAPSI(W)R(M) category	Indicator	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*
	Indicator	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*
	Indicator	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*
	Indicator	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*	*Strength of connection (Strong, Medium, or Weak) Positive or Negative.*

Assessing relationships in the Adjacency Matrices: Confidence in the connection

Relating to the previous adjacency matrices, the confidence of the users' causal theory is recorded here with '1' being not confident and '5' being extremely confident in the causal relationship between indicators.

		Linked DAPSI(W)R(M) category				
		Indicator	Indicator	Indicator	Indicator	Indicator
DAPSI(W)R(M) category	Indicator	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*
	Indicator	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*
	Indicator	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*
	Indicator	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*	*Confidence in this connection (1-5)*

Causal Loop Diagram Model Building

STANDARD OPERATING PROCEDURE 5.

PURPOSE:

A Causal Loop Diagram serves multiple purposes as it is a tool that reflects and enhances expert dialogue, generating research questions and hypotheses essential for data collection and theory building. As a knowledge management tool, it integrates existing insights, highlighting how elements interact within the broader SES. causal loop diagrams also serve as diagnostic tools, identifying policy gaps and operational Points for Management Intervention(s) for targeted interventions (Haraldsson and Bonin, 2021). Importantly, the value of a causal loop diagram lies largely in its creation process, fostering holistic thinking about an SES and its behaviour, with most of its value embedded in this process and only small part in the final diagram (Liebovitch et al., 2020).

SCOPE:

This SOP provides the methodology to standardise the causal loop diagram creation process for SES analysis, ensuring a structured, transparent, and efficient approach to understanding, visualising, and managing complex ecological and social interdependencies. It instructs users on how to visualise the SES as a whole.

DEFINITIONS:

Term	Definition
Node/ connection	A node and its linked connections represent a causal relationship between indicators within the system. They indicate that a change in one element (the cause) will lead to a change in another (the effect), based on available evidence or expert judgement.
Causal Loop Diagram	Visual representation of how different variables in a system are interrelated. It shows the causal relationships between various factors, including feedback loops where the change in one variable affects others, which may in turn influence the original variable (Haraldsson, 2004).
Connection Strength	This refers to the intensity of influence that one element has on another within the system, based on available evidence or expert judgement.
Confidence	A negative link represents an inverse relationship between two elements, where an increase in the cause leads to a decrease in the effect and vice versa.
Negative Link	A diagrammatic representation of a complex situation that uses pictures, minimal text, symbols, and icons to illustrate the main elements and relationships (Bell, et al., 2016).
Positive link	A positive link indicates a direct relationship between two elements, where an increase in the cause leads to an increase in the effect (or a decrease leads to a decrease).

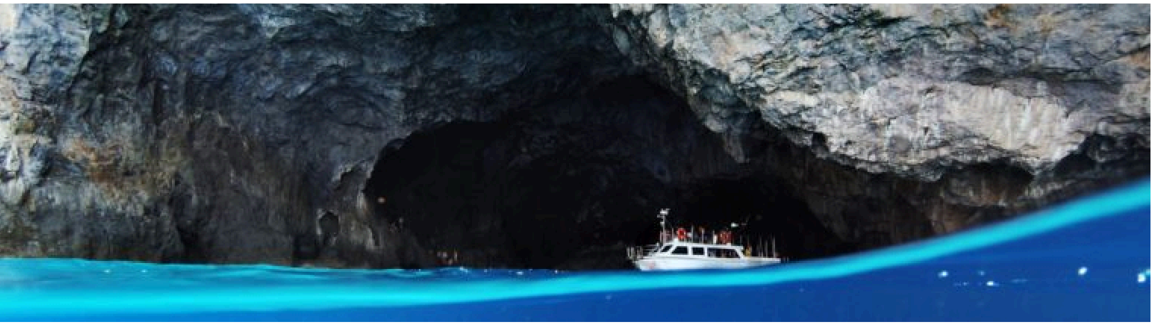
CONSIDERATIONS:

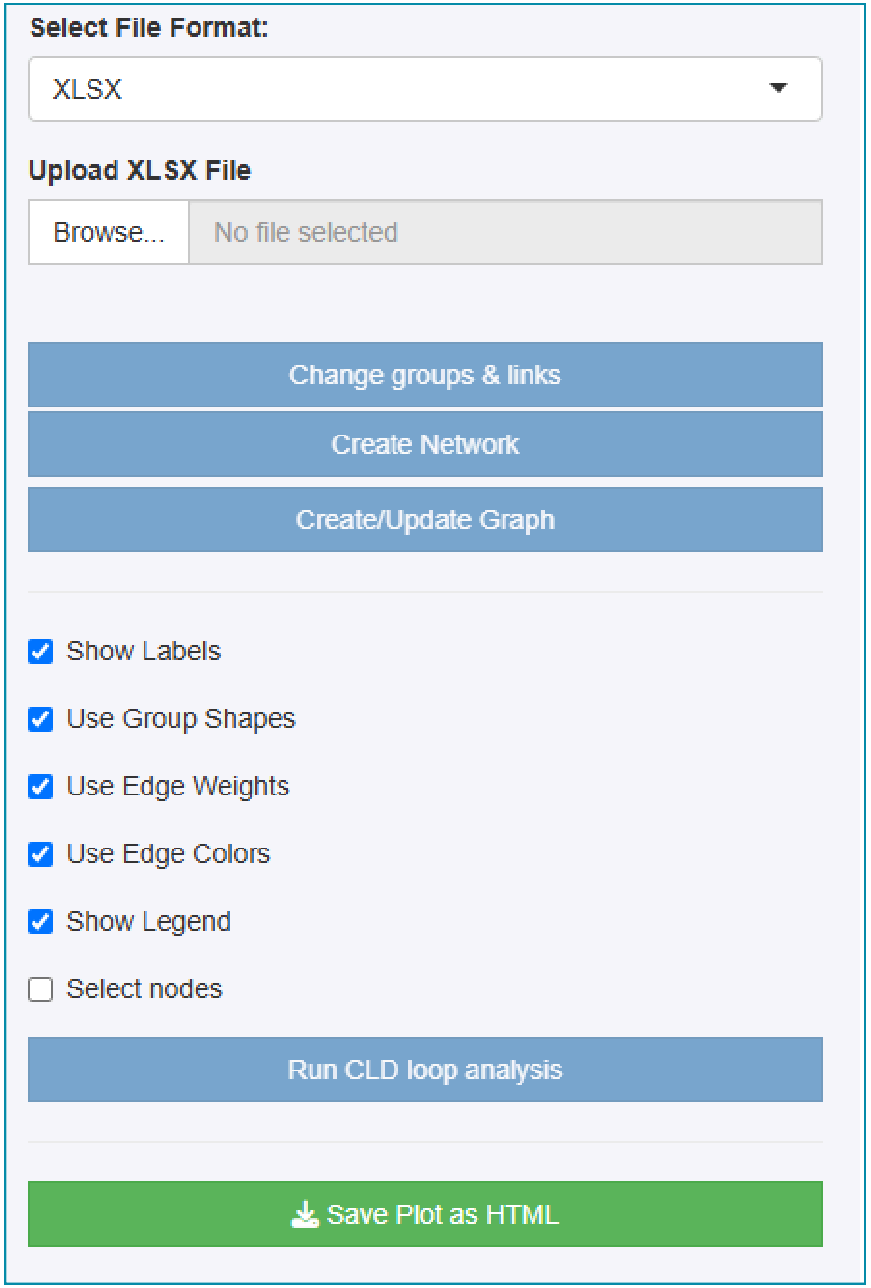
When causal loop diagram model building, there is a balance between including relevant elements and adding clarity to the model, together with increasing the complexity of the model.

There is a threshold whereby including so much relevant detail increases the complexity to too high a level thereby possibly obscuring important details with minor details. Hence, as a user, this consideration is paramount throughout the Simple SES modelling process.

PROCEDURE:

- Select the appropriate format for the file that contains the indicators and connections that you have created throughout the previous standard operating procedures.
- Click the to the 'create network' button the on Simple SES tool.
- Once your graph has loaded, begin to pull the elements to a format that make sense to you as a user.
- Begin to trace the pathways and sense check the narratives present in the model.
- Using a trial and error approach, explore the various functions on the decision support tool and familiarise yourself with the visualisation of your social-ecological model..





Refinement of the SES model

STANDARD OPERATING PROCEDURE 6.

PURPOSE:

The Issue-based causal loop diagram is likely to be highly complex with many elements and connections. Whilst the model may be seen to represent the complexity of the management issue to be resolved, it is likely to be somewhat difficult to interpret and there is a need to focus on creating a simpler, more basic working model. This SOP will guide users to refine their sSES model to both reflect and manage complexity.

SCOPE:

The modelling of this approach is iterative in nature; hence, a dedicated critical review procedure is necessary to improve the validity and robustness of the Simple SES model on which to base management decisions. Most of the value of model comes from building it rather than just interrogating the final diagram; despite this, the refined model should synthesise our understanding of the SES for communication with Stakeholders. The focus remains on creating a simplified yet representative model that reflects both expert judgement and stakeholder input whilst maintaining scientific rigour. This SOP provides guidance to review and refine the SES model, the considerations are illustrated in Figure 10.

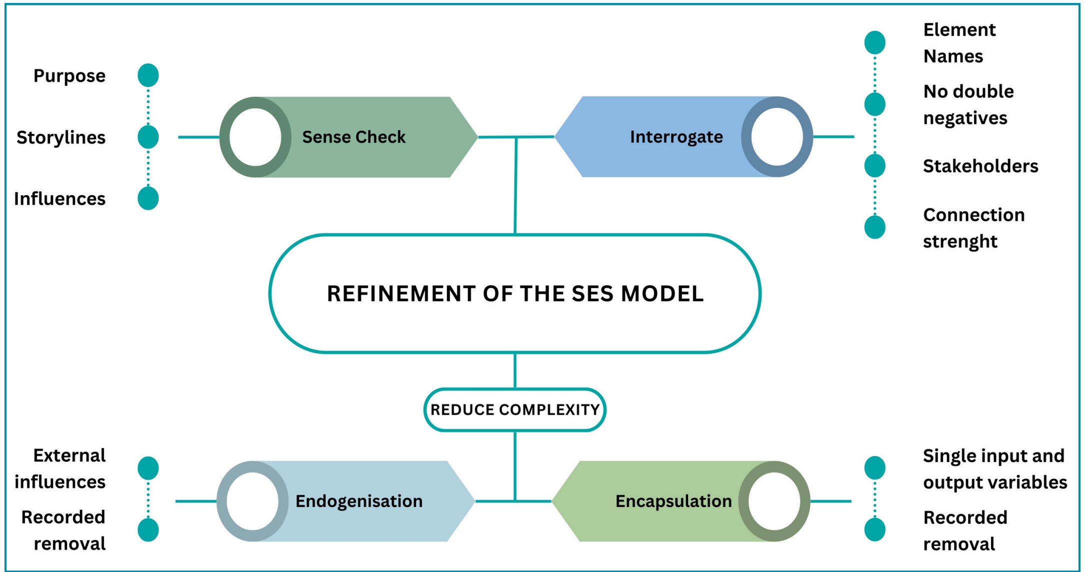


Figure 10: Key considerations in refining the user's SES model.

DEFINITIONS:

Term	Definition
Endogenisation	This is the process of identifying, documenting and, if appropriate, removing exogenous elements (those that influence the system but are not influenced by it) from the causal loop diagram to focus solely on elements that are mutually interactive within the system that management can control. By endogenising, the model retains only those components that have reciprocal relationships, simplifying the causal loop diagram and enhancing clarity for the purpose of this process.
Encapsulation	Encapsulation involves identifying Single-Input-Single-Output (SISO) elements in the causal loop diagram and merging them by directly linking the input to the output. This process simplifies the model by bypassing intermediate steps, making it easier to understand primary relationships and system dynamics without losing critical influence or polarity. For example, nutrient run-off from a land-based source may lead to increased phytoplankton growth, which can then fuel harmful algal blooms HABs, in this instance if only one connection to phytoplankton growth was in the model for nutrient run-off, this would be a SISO element, and could be removed, and the nutrient run-off can be linked directly to HABs.
Model Interrogation	These considerations relate to sense checking in a functional sense that the element names are accurate to demonstrate what the user is intending to show, to ensure they are clear, concise and understandable by stakeholders. This may include reviewing and refining the strength and confidence assigned to the links between elements in the model.
Sense-Checking	This is the process of systematically reviewing each element, connection, and assumption within the causal loop diagram to ensure logical consistency and alignment with stakeholder priorities and expert understanding. Sense-checking verifies that the model accurately represents the system's intended dynamics, helping to identify and correct any errors or inconsistencies.
Aggregation	A process that involves combining similar or related elements within the causal loop diagram to reduce complexity.
De-aggregation	De-aggregation involves breaking down a single, broad element into more specific sub-elements within the causal loop diagram. This can clarify distinct relationships or interactions that may be obscured in a general category.

PROCEDURE:

It is acknowledged that the composite model is likely to be complex, with many interconnected elements. While this may accurately reflect the system complexity and the complexity of the issue under investigation, a more simplified version may often be more effective for communication, understanding, and application.

If working as a team, it will be necessary to gather to collaboratively assess the causal loop diagram; if working individually, remotely consult with stakeholders to critically evaluate the model. Examine each element and connection in the composite causal loop diagram to confirm their relevance and accuracy, distinguishing between endogenous and exogenous elements. In addition, one should acknowledge the cognitive limits of the group by seeking a balance between detail and clarity. The questions in Table 5 can help to guide to reflect on the current model.

1. Interrogate the Current Model, check the following factors:

- Verify that element names clearly represent their roles within the system.
- Check for double negatives, as these may obscure meaning when represented in the causal loop diagram.
- Confirm that elements and connections align with stakeholder priorities and perceptions as established in earlier engagements.
- Consider whether they adequately reflect expert opinions regarding the system key dynamics.
- Ensure that the strength of each connection reflects the user confidence level, so influence and uncertainties are accurately represented in the model.
- Identify any duplicate explanations of variables, combining elements where appropriate (e.g., consolidating 'Artisanal' and 'Commercial Fisheries' into 'Fishing Activities').

It is suggested that a simplified, fundamental version of the model is likely to provide more value at this stage than a highly detailed one . Hence, it is recommended to retain each iteration of the causal loop diagram model as you may need to de-aggregate ('unpack' the simplification undertaken) when considering the design of management measures.

Table 5: Helpful questions to analyse and reflect upon the causal loop diagram. Modified from Williams (2021).

Purpose:	**What thoughts do you now have about the purpose of the causal loop diagram?**
Temporal, Spatial, and Scale considerations:	What conclusions can you draw from the context of the causal loop diagram?
	What was included in the causal loop diagram and what has been excluded?
	Can you estimate the delays to assess the timescale of each feedback loop?
	What might be any differences if you expand or reduce the scale and scope of the causal loop diagram?
Connections:	Are any connections missing between elements?
	Does the strength of each connection reflect the corresponding confidence level, thereby accurately representing influence?
	Do elements and connections align with stakeholder priorities and perceptions as established in the exploratory exercises?
Data:	What kind of data did you use to construct the causal loop diagram?
	Where did the data come from?
	What data were privileged and what data were excluded or marginalised?
	What might be the implications of this for the conclusions?
Events, States and Variables:	What events, states or variables were excluded from the causal loop diagram?
	For what reason were these excluded, and how appropriate was that?
	What assumptions were made about the relative 'power' of the relationships between events, states or variables?
Learning:	What have you learned?
	What have you confirmed?
	How confident are you that the assumptions were correct?
	What are the consequences for the conclusions if those assumptions were incorrect?

2. Use the following techniques, if appropriate, to reduce the model complexity:

Endogenisation:

- Identify and list all exogenous elements within the causal loop diagram, which are those influencing other elements but not affected by anything within the system (e.g., 'sunlight' impacting marine photosynthesis).
- Record the influences of each exogenous element before removing them, if appropriate, to simplify the model. This removal focuses the model on elements with internal connections that can be impacted by management interventions, thereby increasing the model interpretability and coherence.

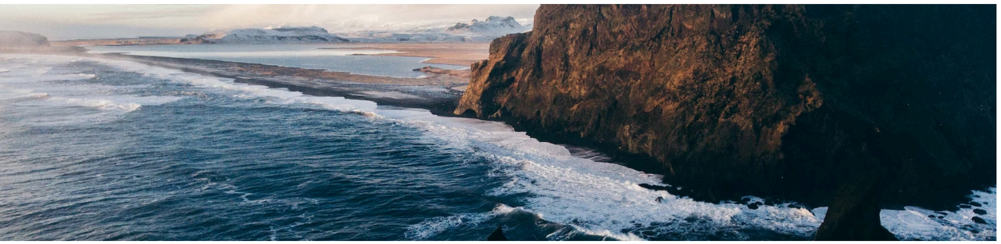
Encapsulation:

- Identify Single-Input-Single-Output (SISO) variables within the causal loop diagram, i.e. those which have only one input and one output .
- Bridge these SISO elements by removing the intermediate variable, directly connecting the input to the output while preserving the polarity of the link based on the number of negative polarities.

When you merge two indicators you need to answer to these 5 questions:

1. *What indicators are we grouping?*
2. *Why are we grouping these indicators?*
3. *What is the new name?*
4. *What connection are we deleting? and why?*
5. *Do these modifications change the model?*

After simplification, review the adjusted causal loop diagram to ensure it captures the main connections and influences within the system, without excessive detail. Document the endogenised and encapsulated elements as well as the simplification rationale for future reference, ensuring the model remains informative and accessible for analysis and decision-making.



TEMPLATES:

When making refinement changes to the SES model using endogenisation and encapsulation techniques, the templates below provide a structure for recorded amendments/ removal.

Recording Endogenisation:

Element Removed	Reasoning	Associated information / Data

Recording Encapsulation:

SISO Variable	Elements Merged		Reasoning	Changes in link polarity

Loop Analysis and Social Network Analysis (SNA) Indicators

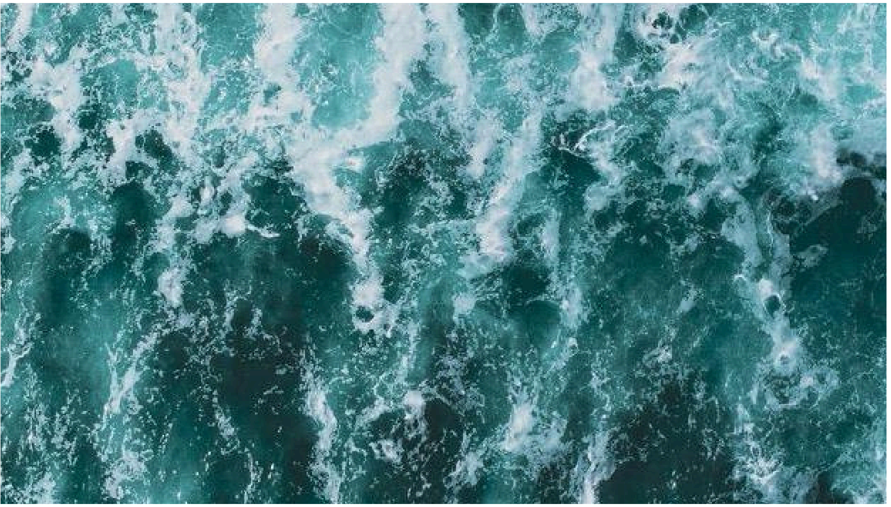
STANDARD OPERATING PROCEDURE 7.

PURPOSE:

The purpose of loop analysis within this approach is to identify and understand feedback mechanisms in the system, which are crucial for interpreting dynamic interactions among elements.

SCOPE:

By classifying loops as either reinforcing (supporting growth or decline) or balancing (stabilising or regulating behaviour), loop analysis enables insights into emergent system behaviours. This understanding supports identifying leverage points for potential interventions that could reinforce desirable feedback or disrupt problematic cycles, ultimately helping to guide targeted, effective management strategies.



DEFINITIONS:

Term	Definition
Causal Loop	A circular chain of causation that either reinforces or balances a change in the system (Garrity, 2018).
Loop Analysis	The process of examining the feedback loops within a system to understand how they contribute to the systems behaviour.
Loop Polarity	A characteristic of feedback loops represented by a positive (+) or negative (−) sign that indicates whether a loop is a reinforcing (positive) or balancing (negative) one. Loop polarity is the algebraic product of all signs around a loop (Ford, 2019).
Reinforcing loop	A reinforcing loop amplifies changes within a system, either accelerating growth or driving decline. In a reinforcing loop, a change in one variable leads to further change in the same direction, making it self-reinforcing.
Balancing loop	A balancing loop stabilises the system by counteracting changes. In this type of loop, a change in one direction leads to an opposite response that brings the system back towards equilibrium.
Loop Dominance	In systems with multiple feedback loops, loop dominance refers to the feedback loop that has the strongest influence on system behaviour. The dominant loop can shift over time, leading to changes in system dynamics.
System Behaviour	System behaviour is the overall pattern or trend that emerges from interactions among elements and feedback loops within a system. Analysing system behaviour helps to understand whether the system is in a state of growth, stability, or decline.

PROCEDURE:

- Identify and Categorise Feedback Loops

Start by carefully examining the causal loop diagram to identify all feedback loops. Classify each loop as either a reinforcing loop (which amplifies changes, driving growth or decline) or a balancing loop (which regulates and stabilises the system). Reinforcing loops are often areas where changes can accelerate outcomes, while balancing loops help to maintain stability. This categorisation is crucial, as it reveals the system underlying mechanisms, helping to determine where small changes could lead to significant impacts.

- Walk Through the Major Feedback Loops

Begin by reviewing the primary feedback loops, categorising each as either reinforcing (driving growth or decline) or balancing (regulating behaviour). Simplify each loop to its core process to clarify how it shapes system behaviour. This initial examination provides an overview of the system dynamic structure, highlighting key processes and potential points of influence.

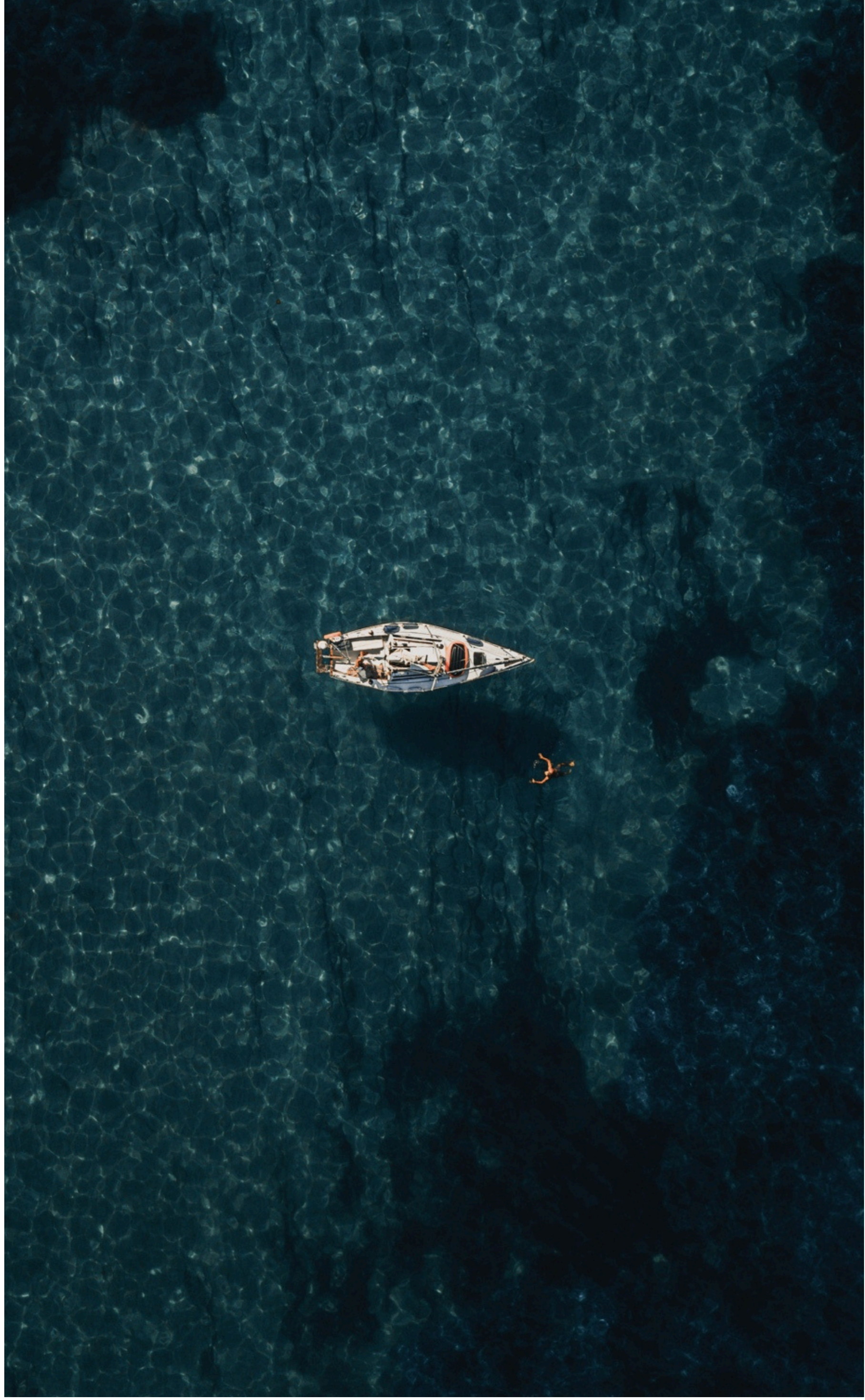
- Estimate Delays and Timescales

Assess any delays within each feedback loop to gauge its timescale, as these delays influence how quickly the loop affects the system. Understanding timescales is essential for predicting the speed of changes and potential impacts from interventions, especially in complex systems where rapid shifts may have different outcomes compared to gradual changes.

- Identify Dominant Elements and Loops

Identify which elements and feedback loops exert the most influence on the system, focusing on those with multiple inputs and outputs. These dominant areas often serve as leverage points where small changes can create significant impacts, making them ideal targets for intervention.

With the learning from the loop analysis, identification of leverage points can take place to find points in the system where management measures may be most appropriate.



Identifying Points for Management Intervention(s)

STANDARD OPERATING PROCEDURE 8.

PURPOSE:

The purpose of this SOP is to provide a structured method for identifying leverage points within Causal Loop Diagrams to inform effective management interventions.

SCOPE:

Leverage points are critical locations within a system where small adjustments can lead to significant shifts in system behaviour. This SOP guides users in pinpointing these high-impact points through systematic analysis of feedback loops, element interactions, and system dynamics. This SOP applies to analysts, modelers, and decision-makers using causal loop diagrams to understand complex marine SESs.

DEFINITIONS:

Term:	Definition:
Leverage Point	An element or connection within a system where an intervention can lead to significant changes in system behaviour.
Delays	The time lag between an action and its effect in a feedback loop, impacting the timing and stability of system responses.
Mental Model	A mental model is an internal framework of assumptions and beliefs that shape the individual understanding of how a system works, guiding decisions and actions.

PROCEDURE:

1. Examine Potential Leverage Points within Loops

Use Identified elements and feedback loops which exert the most influence on the system, focusing on those with multiple inputs and outputs. These dominant areas often serve as leverage points where small changes can create significant impacts, making them suitable places for effective intervention.

Analyse feedback loops contributing to undesirable outcomes or blocking goals, considering how to weaken, break, or counteract them. Adjusting or disrupting problematic loops can address the causes of system issues.

2. Reinforce Supporting Loops

Identify feedback loops that promote positive outcomes and consider actions to strengthen or replicate them. Enhancing supportive loops can reinforce beneficial behaviour within the system.

3. Evaluate Delays and Instabilities for Adjustment

Review feedback loops for sources of inertia or volatility. Evaluate whether delaying or accelerating these loops would help achieve stability or responsiveness as required. Modifying delays or instabilities offers control over how quickly or stably the system responds to interventions.

4. Adjust Influencing Parameters and Challenge Mental Models

Determine the key parameters driving feedback loops, exploring adjustments to encourage the desired behaviour. Re-examine the underlying mental models and assumptions within the causal loop diagram, considering if revising these could yield better insights.

Adjusting parameters and refining mental models can clarify causal relationships and reveal new points for intervention.

5. Document Findings and Recommendations

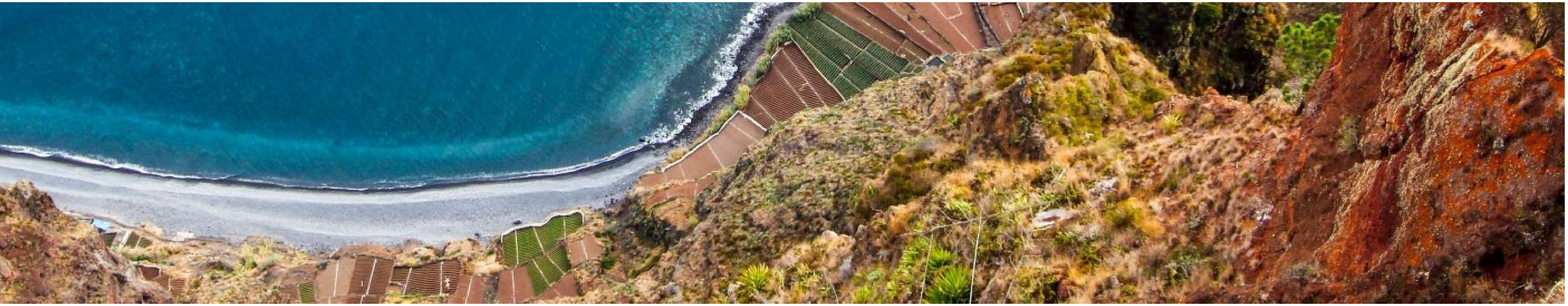
Record identified leverage points, the reasoning behind each, and recommended interventions. Include insights into delays, loop dominance, impediments, and any potential side effects to guide future decision-making.

Comprehensive documentation ensures transparency and provides a reference for evaluating intervention outcomes. The Leverage Points Table Template here can aid in structing this documentation.

TEMPLATE:

Leverage Points Table Template.

Leverage point		**Description**	**Potential Response measures**
Type of Element (Driver, Activity, etc...)	Element		



Estimating the effect of potential measures on the SES model

STANDARD OPERATING PROCEDURE 9.

PURPOSE:

Management measures aim at changing the way people act in their environment or react to factors in a social, economic, and ecological landscape. With ‘semi-quantitative analyses’ we can generate an insight as to whether some outcomes of the SES will be reached based on the network of interactions in the SES that has been qualified by the user.

The analyses can help to understand of the behaviour of the system, i.e. whether it can reach a ‘sustainable’ state in the long term, but also of individual components that the user has highlighted as components for which they would like to track the fate.

Management measures can be included into the analysis, to evaluate whether these might have the desired effect on the system.

SCOPE:

Measures can be introduced as changes to the SimpleSES as changes to the sign and values of existing effects, by introducing new effects (new lines) between existing components, or by introducing new components (Measures as responses).

To ensure simplicity all measures are introduced as described in DAPSI[(W)]R(M), as new components which may be triggered by impacts to affect any of the other component types in the system (“R”). The user can manually implement a measure in a given system and define the connection strength between the measure and other system elements.

DEFINITIONS:

Term	Definition
Management measure	Management measures target stressors and receptors, i.e. they mitigate the anthropogenic pressures (from current or past human activities) or enhance the ecosystem components toward the achievement of the societal goals (See D5.3)
System state	The state in which the SES finds itself. That is, the values that the ensemble of components exhibits.
Component state	The state in which a component of the SES finds itself. That is, the value that the given component exhibits
Attractor	As the system reaches this given state it cannot escape it, without external pressures being applied to meaningfully adversely effect the system or component from this attractor. The pressures needed to dislodge the system from an attractor directly relate to the resilience of the attractor.

PROCEDURE:

1. Define ‘desirable outcomes’

As a user you need to provide an a priori view on what constitute a desirable outcome for the system model. For example, it may be that given the logical statement by which “States” are defined, a desirable outcome is that all “States” are progressing ‘positively’ (e.g. increasing, ameliorating, improving).

2. Apply a simulation-based analysis

To apply the simulation-based analysis, you will need to press ‘play’ – there is no additional information necessary beyond the graph that the user wants evaluated. We can simulate the outcome of the propagation of small changes through time given initial conditions using projection simulations.

Simulations are practical ways to understand both the short-term (reactivity and resilience) and long-term (state and stability) of the system. We project the input matrix for 1000 time steps (sufficient for the system states to escape initial conditions).

After application of this analysis you will obtain text-based output that reports whether or not if the system is sustainable or not, and to what elements the system is most sensitive. If desired outcomes are provided by the user (as per instruction 1), the user will also obtain information on the links that have the largest influence on the desirable outcomes. The influences (or matrix elements) are ranked according to their importance to the emergence of desired outcomes.

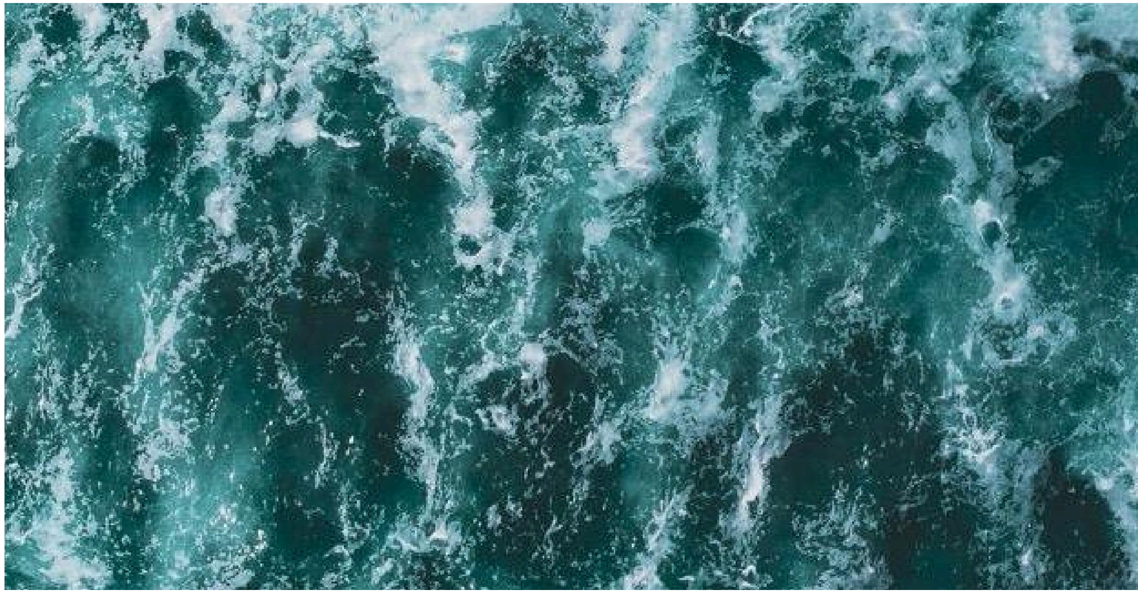
The user can also choose to obtain a visualisation of the system behaviour over time as it settles from initial conditions after the disturbance to its long-term behaviour.

3. Introduce management interventions

The user can manually introduce new management measures in the graphical interface of the system, by creating new system elements and their links with the system.

Management interventions formalised in SES qualitative models essentially create new loops in the system model and therefore offer the scope to stabilise the system. However, they do not guarantee that the system state they create will lead the system towards an attractor that has desired outcomes.

Currently, we have no general method to predict that a given management intervention will meet desired outcomes in a SES model when those span multiple components. Therefore, management measures can be tested by again applying a simulation-based analysis again. After the simulation, the user can evaluate whether the management measure had the desired effect.



Communicating Outputs

STANDARD OPERATING PROCEDURE 10.

PURPOSE:

The purpose of this SOP is to guide the effective communication to stakeholders of findings derived from the Simple SES (sSES) process, including the Causal Loop Diagrams, ensuring that the information is accessible, accurate and can be actioned. Moreover, maintaining active communication with stakeholders ensures they feel included, which increases the likelihood of their engagement with potential recommendations and successful uptake of project outputs.

SCOPE:

This SOP aims to help users tailor the complexity of causal loop diagrams to the stakeholder audience, validate findings through stakeholder input, and refine the model based on feedback to ensure clarity, relevance and alignment with stakeholder knowledge. This also ensures greater transparency and defensibility of the process.

DEFINITIONS:

Term	**Definition**
Stakeholder	Any actor with any role in influencing nature, activities and/or management of the marine system in an area.
Stakeholder typology	The separation of stakeholders into inputters (those placing materials or infrastructure in the marine system), extractors (those removing materials or space), regulators (those involved in managing an area), affectees (those affected by the activities), beneficiaries (those benefitting from the activities), and influencers (those advisors, educators or researchers influencing the other groups) (Newton and Elliott, 2016).
Governance	This involves the interactions between formal institutions (such as government bodies) and informal arrangements (such as community groups or industry associations). It also includes universities, research institutions, and individual scholars who engage in systematic investigation and study to discover or revise facts, theories, and applications. Governance is also carried out by business administrations in the act of 'governing' their business.
Public audience	The public audience may include coastal communities, recreational users of marine environments, consumers, and the general populace concerned with environmental conservation
Individual and collective action	Collective action involves coordinated efforts by multiple individuals or organisations to achieve a common goal, for instance, a community-led beach clean-up or a coalition of non-governmental organisations advocating for stronger marine protection policies.
Industry and private sector	This stakeholder group encompasses all businesses and commercial enterprises, ranging from small and medium-sized enterprises to large multinational corporations.
Economy and finance	This stakeholder group is comprised of individuals, groups, and organisations whose financial and economic interests, activities or investments are intertwined with the marine environment.
Public authorities	This stakeholder group includes official bodies and institutions that are part of local, regional, national, or international government and have the legal power to enforce laws and regulations. Alongside regulating and evaluating the effectiveness of management interventions.
Academia, Science and innovation	This stakeholder group provides the scientific knowledge base necessary for understanding marine ecosystems, assessing the impacts of human activities, developing new technologies for monitoring and conservation.

PROCEDURE:

1. Prepare the causal loop diagram for communication with stakeholders.

When presenting the causal loop diagram to stakeholders, it is important to accommodate the abilities of the audience (Barbrook-Johnson and Penn, 2022). It is imperative not to discourage or confuse any section of stakeholders by large causal loop diagrams, or those causal loop diagrams with multiple interacting feedback loops. The aim should be to produce a causal loop diagram of the minimum complexity necessary and presented in the most appropriate way; it may be necessary to introduce the impact causal loop diagrams first before presenting the issue-based composite causal loop diagram that emerge from the refinement process.

2. Summarise Findings and Key Take-away Messages

Prepare a summary that highlights the main Impediments, Points for Management Intervention(s) and implications identified within the causal loop diagram, focusing on areas of interest for the stakeholders and with an appropriate language and set of terms. Include any key recommendations for actions or next steps based on the refined model and present these in a way that encourages informed decision-making and continued engagement.

3. Validate the findings with stakeholders.

Stakeholder dialogue is the most popular method to validate causal loop diagrams simply by asking stakeholders questions such as:

- *Does this make sense?*
- *Are we missing anything important in this section of the diagram?*
- *Is there anything that you feel should be removed from the diagram?*
- *Is this part of the system supported by the existing knowledge?*
- *Are appropriate system variables represented? If not, what variables are missing or should any be removed?*
- *Are appropriate in- and out-flows represented? If not, what flows are missing or should any be removed?*
- *Is the polarity of in- and out-flows accurately represented? If not, what changes would you make?*
- *Are delays in the system represented appropriately according to our knowledge of behaviour over time? If not, what delays are missing, and should any be removed or changed?*

4. Revisit the causal loop diagram model to ensure this is amended following the learning achieved by consulting with stakeholders.

- Incorporate stakeholder feedback into the causal loop diagram model, adjusting elements, connections, polarities or delays as suggested to enhance accuracy and relevance. Always cross-verify the new information with existing sources.
- Verify that all changes are correctly implemented and that the causal loop diagram remains logically consistent after adjustments.
- Document any changes made during this refinement process and record the rationale, ensuring transparency and providing a reference for future stakeholder consultations.

Key Considerations:

Consider the terminology used in your communication. Ensure all information is clear and concise and use accessible terms.

Allow dialogue between stakeholders and you, as the user, to ensure any confusions can be understood and clarified, or learnt from.

Designing a Management Response

STANDARD OPERATING PROCEDURE 11.

PURPOSE:

Management responses are required to fulfil the central aim of protecting and maintaining the natural system, its ecological structure and functioning, while allowing that system to create ecosystem services from which society can gather goods and benefits after inputting human capital (Elliott, 2023).

Following the previous SOPs, we will design management Response (measures). These are typically underpinned by policy instruments and are carried out by stakeholders who either are designated (statutory) competent authority, the business management authority (e.g. from an activity) or an informal body (e.g. NGOs). Hence, in addition to formal management responses created by statutory and competent bodies, operational management responses are performed by marine industries to either fulfil legal obligations or satisfy their business demands (Elliott et al., 2025a).

SCOPE:

This SOP focusses on the governance and operational management required to design management responses linked to Ecosystem-based Management necessary to prevent undesirable State changes and resultant Impacts on human Welfare which occur as the consequence of societal Activities and their Pressures. As such, the management responses accommodate many of the DAPSI(W)R(M) elements see Figure 1 and (Piet et al., 2015).

Policy can generally be described as an instrument, a set of decisions, principles or guidelines designed to influence (guide, steer) (collective) decisions in a particular area of concern and achieve specific outcomes. An Ecosystem-based Approach gives the policies and overall approach underpinning management whereas Ecosystem-based management are the operationalised mechanisms to achieve Ecosystem-based Approach (Elliott et al., 2025b). Policies underpin environmental management and are not confined to public administration, but also emerge among non-state institutions, actors (including marine users) and processes. Policy may be broader than the political system (e.g. policy established within business) and refer to the political institutional system and legislative and regulatory frameworks (Cormier et al., 2017).

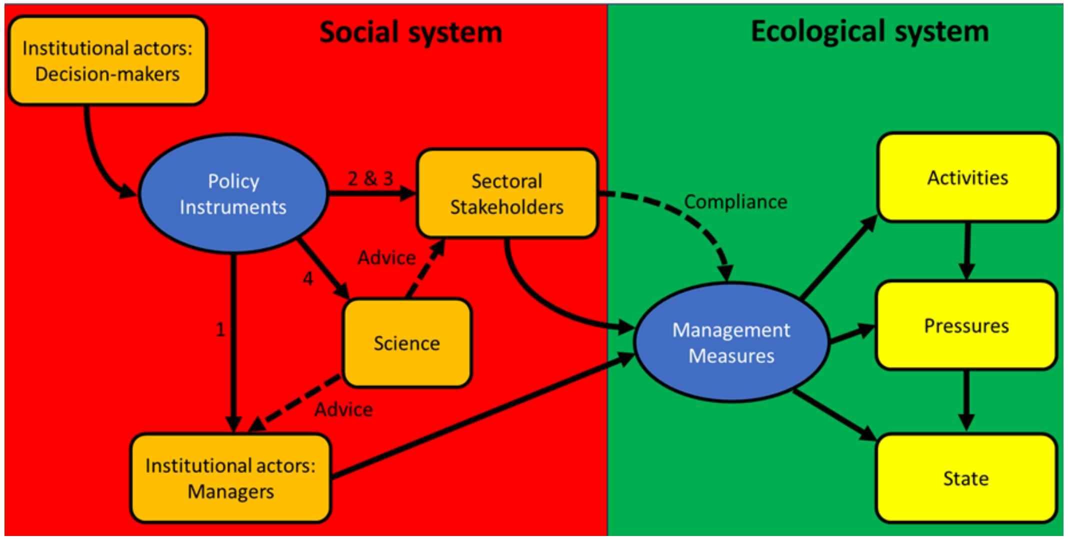


Figure 1. The statutory governance of the marine SES, its main actors and relevant processes in relation to the proposed Ecosystem-based Management plan consisting of policy instruments and management measures. Key: policy instrument categories (1) Legal and regulatory instruments; (2) Voluntary agreements and information instruments; (3) Economic incentive-based instruments (including market-based instruments); (4) Research and development (knowledge base) (see Table 1). The arrows indicate clear cause-effect linkages, in case of dashed lines this is uncertain.

Formulated and adopted policies are arranged through various instruments defined as interventions “in the governance arrangements often covering the advisory and decision-making processes intended to facilitate the implementation and/or enforcement of management measures” (CINEA EBFM). The implementation of the whole Ecosystem-based Management plan can be regarded as an intervention. Addressing specific issues requires individual actions or comprehensive strategies and programmes within four commonly applied categories of policy instruments which are: Legal and Regulatory Instruments (also referred to as command-and-control), Voluntary agreements and information instruments, Economic incentive-based instruments (including, but not limited to, market-based instruments), and Research and development (knowledge base) (see Table 1).

A policy then requires concrete management actions (e.g. programmes, measures, procedures and controls) needed to reach the defined policy objectives (Cormier et al., 2017). Policy instruments target specific agents to induce societal behavioural change and/or contribute to achieving policy goals. They directly affect the natural environment management measures, programmes and controls; for example, a top-down policy such as the MSFD Programme of Measures.

Management measures are specific interventions to target human activities and their pressures and/or receptors (the ecosystem components as habitats, species or species-groups) to achieve policy objectives or societal goals. For example, fisheries management measures are "specific elements of fisheries control which are embodied in regulations and which become a focus for surveillance activities" (EBFM CINEA). Statutory measures are implemented by sectoral competent authorities 'that are accountable to implement the measures that are designed to manage their specific operations' (Cormier et al., 2017; Elliott et al., 2025b).

This Ecosystem-based Management framework and ecosystem-based approaches are underpinned by the five-step policy-cycle process (Table 2) (Altvater, 2019), which is aligned with the ten-step cycle for MSP (Ehler, 2009). An Ecosystem-based Management plan, consists of interlinked the operational (technical) management measures and policy instruments. This considers two SES components, i.e. the enabling governance arena and statutory management measures, which requires science advice to be adopted, and the process overlaid by operational management measures from marine users.

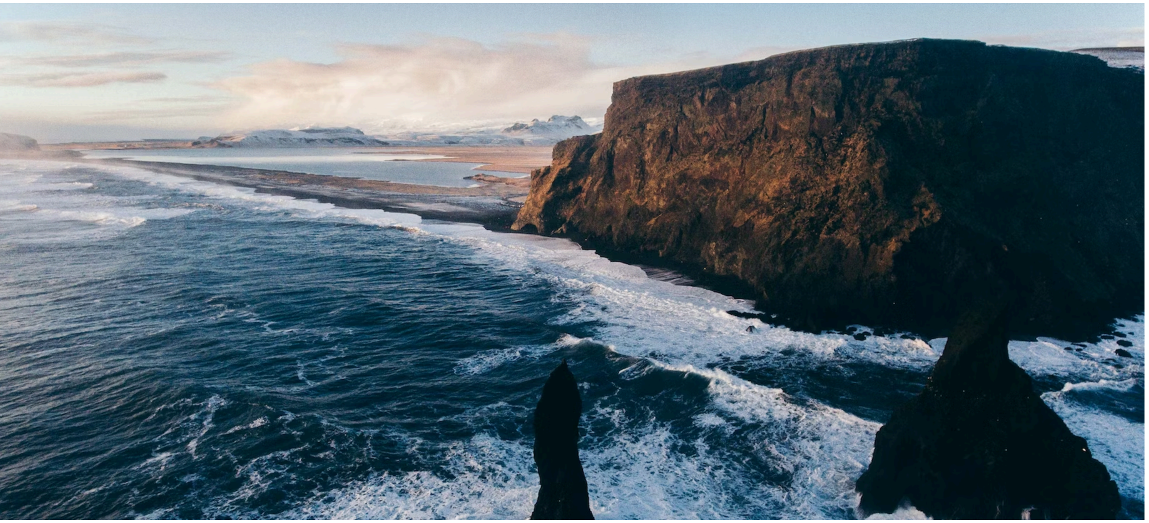


Table 1: Examples of policy instrument categories and types.

Categories	Types
1. Legal and regulatory instruments	1.1. Standards/limits/requirements
	1.2. Supervision/enforcement
	1.3. Treaties
	1.4. Targets/policy development
	1.5. Bans
2. Voluntary agreements and information instruments	2.1. Codes of Conduct
	2.2. Certification schemes
	2.3. Awareness campaigns/education
	2.4. Labelling
	2.5. Nudging (shaping public opinion)
3. Economic incentive-based instruments (including market-based instruments)	3.1. Subsidies and grants
	3.2. Tariffs
	3.3. Deposit-refund schemes
	3.4. Taxes (relief) and charges
	3.6. Liability schemes
	3.7. Individual Tradeable Quota/cap-and-trade
4. Research and development (knowledge base)	4.1. Research (monitoring/investments/programmes)
	4.2. Impact assessments
	4.3. Evaluation

Table 2: Five-step Ecosystem-based Management process in a SES context.

Step	Policy Instruments	Management measures
1	Ecosystem-based Approach defines the policy framework for Ecosystem-based Management, defining the frame for Ecosystem-based Management, starting with its aim to achieve specific policy objectives and ecological and societal/economic goals within the social and environmental context, including the legal setting. Strong or weak sustainable exploitation across these aspects is the overriding goal and Ecosystem-based Management is assumed to be	
	Agenda setting (Scoping the governance - institutional (administrative) setup, potential policy instruments)	Scoping the relevant human activities, their pressures and ecosystem components of concern. Identification of the existing management measures leading to operational (technical) measures adopted and implemented by marine users (activities) to fulfil business, societal and licence requirements.
2	Policy formulation	Developing the knowledge base (with scientific as well as indigenous knowledge) driven by the policy objectives and/or societal and economic goals to be achieved, the different human activities and their pressures operating in that ecosystem with the species or species groups of concern and potential Ecosystem-based Management measures.
3	Policy adoption	Assess and weight the Ecosystem-based Management measures in terms of their expected performance using the knowledge base and appropriate tools.
	A synergy test to assess how the various management interventions (policy instruments and statutory and operational management measures) can reinforce each another, e.g. a measure intended to achieve a policy, business or societal objective may also contribute to achieving other objectives or the same policy instrument may initiate several management measures and/or strategies.	
4	Implementing the Ecosystem-based Management plan based on informed decision-making guided by best practices together with a fit-for-purpose monitoring and enforcement programme.	
5	Follow-up to evaluate both the Ecosystem-based Management process (i.e. the preceding steps), as well as its performance in achieving the specific policy objectives or societal goals.	

DEFINITIONS:

Term	Definition
Governance	The sum of policies, politics, administrative bodies and legal instruments; the processes and structures by which laws, policies, norms and institutions are developed, implemented and adapted to guide behaviour, resolve conflicts and achieve goals. Governance involves the interplay between actors, networks, power dynamics and organisational systems in political, ecological and social contexts. Governance is also carried out by business administrations in the act of 'governing' their business.
Policy Instrument	An intervention from administrative bodies under governance arrangements often covering the advisory and decision-making processes intended to implement and enforce management measures.
Ecosystem-based Approach	Ecosystem-based Approach gives the policies and overall approach underpinning management whereas Ecosystem-based management are the operationalised mechanisms to achieve Ecosystem-based Approach (Elliott et al., 2025b).
Horizontal integration	Integrating management responses across the various marine sectors (fishing, navigation, renewable energy, etc) necessary in a complex marine area and to accommodate cumulative pressures.
Vertical integration	Integrating policy responses from local, through national and regional, to global (e.g. see Cormier et al., 2022).
Management measure	Specific interventions on the ecological system that may target the stressors and/or receptors to achieve policy objectives or societal goals and on the way society uses the marine system
Ecosystem-based management plan	All the policy instruments and management measures combined. For the plan to be effective possible synergies need to be considered leading to an internally consistent plan.
Programme of measures	The total of management responses required to achieve a desired environmental and ecological status [as in Good Environmental Status](e.g. as required by the EU Marine Strategy Framework, Water Framework and Habitats and Species Directives).
Operational (technical) management responses	Measures carried out by an industry or other marine user necessary to both create a successful and sustainable operation and also to comply with regulatory demands (e.g. licence conditions) (see Elliott et al., 2025b).

PROCEDURE:

Assessing the effectiveness of management measures and providing guidance for the implementation of Ecosystem-based Management requires six major actions: Spatio-temporal distribution control, Input control, Output control, Remediation, Restoration and other Nature-based solutions (NbS) (Table 3). Hence the procedure is to:

1. Identify the relevant policy objectives and/or societal goals and prioritise those that need to be advanced through the Ecosystem-based Management plan.

2. Identify the main human activities and their pressures that need to be prevented, mitigated and/or compensated to achieve the selected policy objectives and/or societal goals; where required, restore the receptors (species and habitats).

3. Identify the most effective management measures to achieve policy objectives and/or societal goals.

4. Identify the most effective operational management measures undertaken by the activity/industry/developer to satisfy licence, business and/or societal demands.

5. Identify the most effective policy instruments to implement those management measures.

6. Combine the final management measures and policy instruments to create an Ecosystem-based Management plan internally consistent and fulfilling external demands (i.e. horizontally and vertically integrated).

7. Implement an adequate monitoring programme, realising that monitoring is not a management response but a means of indicating whether management responses are required or were effective.

8. Determine whether the selected policy objectives and societal goals were achieved.

Table 3: Management measure categories and types

Management measure categories	Proposed definition	Management measure types	Marine Examples
Spatio-temporal distribution control	Prevention and/or mitigation of the extent in space and time of the activity and/or pressure(s)	**Spatial closure/ restriction**	Marine Protected Area (MPA), no-take zones (Grorud-Colvert et al., 2021). Restrictions can also be considered spatial input or output measures, e.g. area to discharge ballast water. Other Effective area-based Conservation Measures (OECMs) (Jonas, 2023)
		Seasonal closure/ restriction	Closure of season (March-June) for sole fisheries
Input control	Prevention and/or mitigation of the activity	**Capacity**	Capacity reduction by decreasing size of fleet (decommissioning)
		Effort	Effort reduction of fishing in days-at-sea
		Technical Conservation Measures	Gear-based, e.g. meshsize, sorting grids, escape panels
Output control	Prevention and/or mitigation of the pressure(s)	**Output control**	Reduction of catch through TAC/Quota, bycatch through landing obligation, ban on littering
Remediation	Intervention to reduce the pressure from past activities	**Remediation measure**	Collection of litter (Fishing for Litter), beach cleaning, retrieval of lost fishing gear, cleaning pollution from offshore drilling operations
Restoration	Intervention to enhance the state of the ecosystem component(s), biotic or abiotic; passive restoration by removing the pressure and allowing the natural system to recover, or active restoration by restoring areas through geo- or eco-engineering	**Biotic community, species or stock restoration**	Breeding programme seabirds, Rebuilding of stocks
		Abiotic (physical) habitat restoration	Greening of grey hard infrastructure, e.g. Nature-inspired surfaces, Shoreline protection.
Nature-based solutions	Novel (configuration of) activities expected to enhance the ecological state	**Enhance ecosystem state**	Artificial reefs
		Multi-use	Co-existence, Co-location, Symbiotic use, Multi-purpose, Multi-functional instead of single-use
		Replace existing activities	Lower-trophic aquaculture, Wind-powered shipping

Evaluating Management Responses

STANDARD OPERATING PROCEDURE 12.

PURPOSE:

Marine environmental management aims to achieve the central objective of protecting and maintaining ecological structure and functioning which can deliver ecosystem services thereby leading to societal goods and benefits after inputting human capital (Elliott, 2023).

Successful marine management based on implementing response measures is therefore gauged quantitatively and qualitatively against this overall main objective. To achieve this, marine management statutory controls and technical and operational measures are widely adopted, e.g. by the EU MSFD or by industries needing to both have a successful business and fulfil the societal, environmental and statutory demands (Elliott, et al., 2025a).

SCOPE:

The management response can be evaluated as two stages:

A. An evaluation of the current management in place in terms of achieving the selected policy objectives and societal goals;

B. Building on A to give an evaluation of a proposed or an implementable Ecosystem-based Management plan in terms of its potential performance to achieve the selected policy objectives and societal goals.

There are several elements in or linked to a management plan: definition of targets and operational objectives, stakeholder engagement, governance framework, human activities and their effects, monitoring and evaluation, environmental status (conservation, protection and restoration), ecosystem structure and functioning, future scenarios, and approaches (tools and methods).

An Ecosystem-based Management plan is needed to achieve certain policy objectives reflecting relevant societal goals for a specific ecosystem. It determines the degree to which objectives and goals are met within a policy cycle (Elliott et al., 2025b). Management can be regarded as being successful if the objectives are met, the actions are carried out, the outputs are produced, the outcomes are achieved and the vision is satisfied.

The policy and planning cycle is iterative, i.e. an adaptive management cycle, to eventually fulfil all policy objectives. It is desirable to evaluate the performance of an Ecosystem-based Management plan which can be judged by monitoring programmes and associated calculated indicators. If (some of) the assessed policy objectives are not achieved, then this sets the baseline against which the next Ecosystem-based Management cycle must be adapted in order to improve the Ecosystem-based Management plan performance. Determining the success or otherwise of marine management requires to be gauged against indicators and key results (KPI, KCI, KRI and OKR – see definitions).

DEFINITIONS:

Term	**Definition**
Governance	The sum of policies, politics, administrative bodies and legal instruments; the processes and structures by which laws, policies, norms and institutions are developed, implemented and adapted to guide behaviour, resolve conflicts and achieve goals. Governance involves the interplay between actors, networks, power dynamics and organisational systems in political, ecological and social contexts. Governance is also carried out by business administrations in the act of 'governing' their business.
Policy Instrument	An intervention from administrative bodies in the governance arrangements including advisory and decision-making processes intended to implement and enforce management measures.
Management measure	Specific interventions on the ecological system that may target the stressors and/or receptors with the aim to achieve policy objectives or societal and environmental goals.
Operational / technical management measure	Actions and operations performed by marine activities/industries in order to satisfy a successful business model, fulfilling their economic, societal and environmental responsibilities.
Ecosystem-based management plan	All the policy instruments and management measures combined. For the plan to be effective possible synergies need to be considered leading to an internally consistent plan and externally coherent with vertical and horizontal integration (respectively from local to global and across sectors).
Monitoring plan / programme	A structured spatial and/or temporal assessment designed to indicate what management is required or whether a management measure was successful; not a management measure per se.
Ten-tenets	A set of quantitative and qualitative indicators against which management success should be judged; while not mutually exclusive, all are required for successful and sustainable management.
Input and output controls (*1)	Management measures that influence respectively the amount of a human activity that is permitted, and the degree of perturbation of an ecosystem component that is permitted.
Spatial and temporal distribution controls (*1)	Management measures that influence where and when an activity is allowed to occur including measures to improve the traceability, where feasible, of marine pollution.
Management coordination measures (*1)	Tools and other measures to ensure that management is coordinated and including communication, stakeholder involvement and raising public awareness.
Economic incentives (*1)	Management measures which make it in the economic interest of those using the marine ecosystems to act in ways which help to achieve the good environmental status objective.
Prevention, mitigation and remediation tools (*1)	Management tools which control human activities to prevent, reduce or restore damaged components of marine ecosystems.
OKR – Objectives and Key Results (*2)	A goal-setting framework that helps individuals and teams focus on the most important aspects, align their efforts, and track progress towards achieving their objectives. In the case of the EU MSFD, the objective is to achieve GES and the Key result would be achieving it as shown by indicators.
KPI – Key Performance Indicators (*2)	Quantifiable measures of performance over time for a specific objective. KPIs provide targets at which to aim, milestones to measure progress, and information for better decision-making; e.g. MSFD 2008/56 Annex I descriptors of good environmental status; UN SDG targets, but as yet these are aspirational goals and visions and need to be made SMART to show successful management.
KCI – Key Control Indicators (*2)	Metrics showing the extent to which a given operational risk control is meeting its intended objectives; e.g. MSFD 2008/56 Annex VI Output controls for each of the MSFD 2017/845 Table 2a entries: Anthropogenic pressures on the marine environment; these must be SMART to be operational and informed by the Programmes of Measures for the MSFD and other Directives.
KRI – Key Risk Indicators (*2)	To provide an early signal of increasing potential risk exposures to the continuation of the activity or project. They differ from a KPI which measure how well something is being done while KRI indicate the possibility of future adverse impact. SFD 2017/845 Table 2 Anthropogenic pressures, uses and human activities in or affecting the marine environment; these must be SMART to be operational; this is shown by the risk and hazard typology (Elliott and Kennish, 2024).
*1 - Controls and measures for successful marine management (from the MSFD, European Commission (2008) Annex VI); *2 modified from Elliott et al., 2025a.	

PROCEDURE:

The proposed, adopted or implemented marine management plan should be tested against a set of elements covering both natural and societal aspects. These should structure new, or unravel existing, management plans by separating them into categories/types of management measures and policy instruments. The elements could be prioritized for implementation based on their likely performance, either in absolute terms or relative to existing management measures and policy instruments. However, the priorities for statutory bodies will differ from those of industries/activities (Elliott et al., 2025a).

The management plan should then be judged on its expected performance in achieving a broad suite of policy objectives and societal goals. The criteria for sustainable and successful management are based on the 10-tenets a suite of criteria (Elliott, 2013). These criteria apply to the statutory policy instruments and industry/activity management measures and are embedded in the whole SES.

Evidence for the compliance of the 10-tenets are given in the table together with information on guide the selection/evaluation of the most appropriate management measures and/or policy instruments. Where possible and indicated, this evaluation should be based on quantitative information but if this is lacking or not applicable, there are normative definitions based on value and expert judgement possibly using quantitative scoring for compliance (ordinal or as a binary) (see Barnard and Elliott, 2015).

Criterion	Evidence and normative definitions of compliance
Ecologically sustainable (quantitative/ predominantly numerical)	Assess using ecological indicators relative to a baseline and determine if the measure caused one or more indicators to show an improved environmental status, e.g. Good Environmental Status (GES); preferably for State, both ecological structure and functioning, but also pressure indicators, e.g. fishing effort or levels of contaminants, showing a decline. Determine the degree to which the measure reduces pressures and safeguards or recovers ecosystem components and services to achieve specific ecological goals (e.g. GES). For example, the marine, coastal and estuarine areas should be in favourable or good ecological, environmental, chemical status, e.g. they fulfil EU Directives.
Economically viable (quantitative/ predominantly numerical)	This should be assessed using cost-benefit analysis of productivity and other economic indicators reflecting how efficiently inputs (investments, natural resources, raw materials) are used to produce output (goods and services); preferentially use management measures causing the biggest productivity increase for the supply of most goods and services. Check compliance against indicators such as (1) Net Present Value, the sum of discounted future benefits minus costs, (2) Benefit-Cost Ratio, or (3) Internal Rate of Return which is the discount rate at which the NPV is zero; check if monetary returns outweigh the costs or investments in the short- and long-term. Financial aspects should be secured in the long-term for both the planning and implementation of the plan by both regulators and industries.
Technologically feasible (quantitative/ predominantly numerical)	As related more to operational measures by developers/ operators, determine whether the methods, techniques, technology or equipment are available and effective to support the proposed management measure to address comparable activity and its pressures; industry KCIs should be achieved including relying on BATNEEC (Best Available Techniques Not Entailing Excessive Cost); e.g. the marine habitats have been recreated/created/rehabilitated, and Nature-based solutions are successful; contamination is reduced.
Legally permissible (quantitative/ predominantly numerical)	Determine (by creating a legislative horrendogram) the degree to which the regional, national and/ or international agreements and/or statutes currently in place are expected to enable and enforce the proposed management; determine whether prosecution is avoided as relevant either by the individual or company, or, in the case of an EU state, by avoiding infraction proceedings at the ECJ; determine that all parties are fulfilling all relevant legal instruments, especially by fulfilling the MSFD, WFD and other relevant directives for marine areas.
Administratively achievable (quantitative/ predominantly	Determine (via an administrative organogram) that the existing statutory (administrative) bodies and their policy instruments can successfully implement the preferred management measures; assess whether the KPIs of the administrative bodies have been achieved; i.e. the bodies deliver their required duties to satisfy the users and uses of the marine area.
Politically expedient (qualitative/ narrative)	Determine whether the proposed management and its underlying philosophies agree with nationally and internationally declared aims (environment plans, strategies, manifesto commitments) and the prevailing political climate and have the explicit support of political leaders; ensure that supporting drivers for the proposed management are documented (for example within policy statements at the national or international level).
Socially Desirable/ tolerable (qualitative/ narrative)	Use indicators of social well-being involving drivers of basic human needs, e.g. health, job security, education, social and civic engagement, equality, and well-being. Qualitative indicators from happiness surveys can be supplemented with quantitative indicators, such as job creation and life expectancy. Determine whether societal wishes and aspirations are satisfied, as the result of democratic processes; check if the marine area produces the goods and benefits required by society and is of the required aesthetic status.
Morally correct / Ethically defensible (qualitative/ narrative)	Determine whether the wishes and practices of individuals potentially affected by the management have been fully respected in decision-making with no single sector or group being unduly favoured; determine that the proposed management, including the future costs, are acceptable on moral or ethical grounds and that there are no present conflicts or no future adverse legacy, ensuring that costs of management, remediation, etc., are not disproportionately placed on future generations, that just communities are promoted and that management through justice removes systemic barriers thereby preventing inequity.
Culturally inclusive (qualitative/ narrative)	Determine whether decision-making ensures all types of groups and stakeholders are satisfied, equity and justice are achieved, including explicitly for gender, local communities and indigenous peoples; check that there is promotion of equal communities being supported by equality in management; ensure local customs and practices (including aboriginal/first-nation rights) are fully considered, defended and not adversely affected and that local needs are embedded within the proposed management.
Effectively communicable (qualitative/ narrative)	Use all means of communication, including ocean literacy, across horizontal links and vertical hierarchies of governance and decision-making to ensure the consequences of adopting or rejecting proposed instruments and measures are readily appreciated by all stakeholders including the public; employ effective stakeholder interaction and participation to ensure that all parties are aware that management has been successful and sustainable.

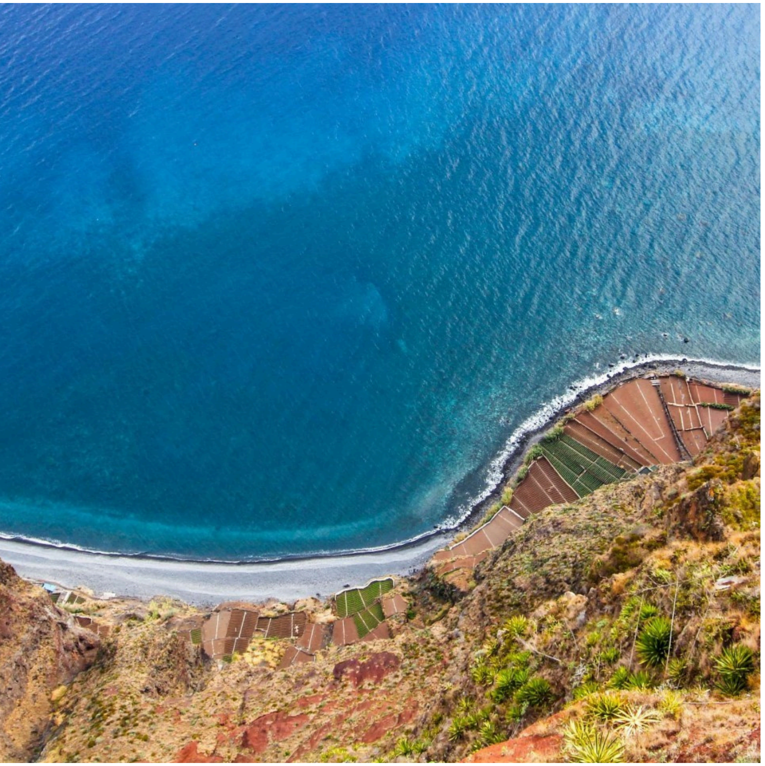
TEMPLATE:

Use the template table to evaluate your management response measures against each of the ten tenets.

Rank these on a scale from 1-5 in terms of their compliance with the ten tenets.

Reflect on these rankings and consider how future management measures may be improved to increase these rankings for future instances.

Users should note that the tenets are not equally weighted, ecology is the highest weighted and then communication, with the remaining tenets being equally weighted. However, the weighting depends on who is doing it (Elliott et al., 2025b).



Criterion	Compliance ranking (1-5)	Evidence and normative definitions of compliance
Ecologically sustainable (quantitative/ predominantly numerical)		
Economically viable (quantitative/ predominantly numerical)		
Technologically feasible (quantitative/ predominantly numerical)		
Legally permissible (quantitative/ predominantly numerical)		
Administratively achievable (quantitative/ predominantly numerical)		
Politically expedient (qualitative/ narrative)		
Socially Desirable/ tolerable (qualitative/ narrative)		
Morally correct / Ethically defensible (qualitative/ narrative)		
Culturally inclusive (qualitative/ narrative)		
Effectively communicable (qualitative/ narrative)		

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Annex 1: The PIMS Standard Operating Procedures.

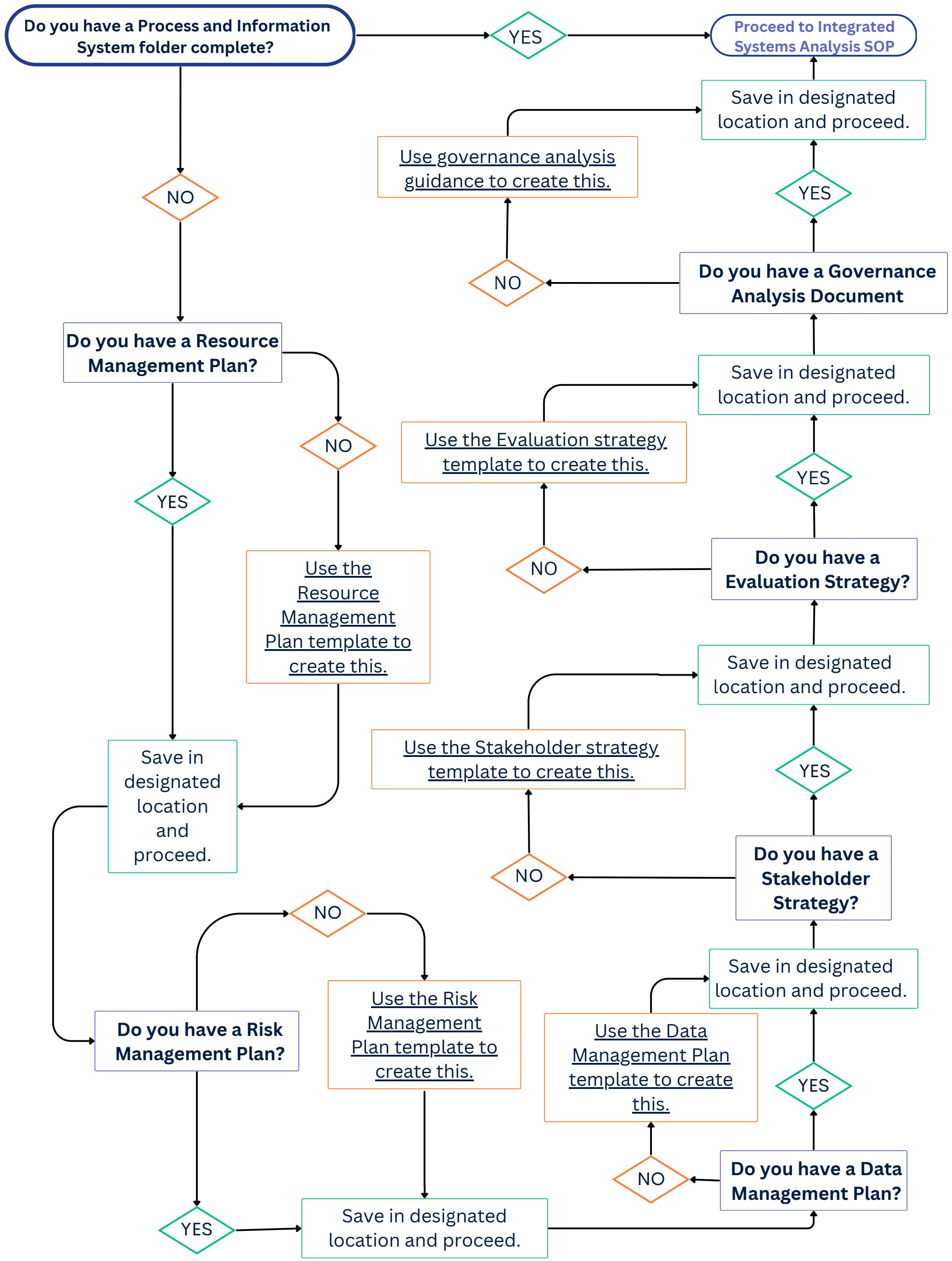
PROCEDURE:

It is recognised that users of this tool may do so on behalf of their own institutions/organisations; hence, not all elements of the PIMS will require to be completed as their institutions/organisations may already have procedures and processes set-up that duplicate the PIMS. Users are directed to the following decision tree (Figure 1) to assess which sections of the PIMS should be completed before beginning the Integrated Systems Analysis analysis.

The decision tree is designed to help you determine if you have the necessary PIMS elements in place. If not, see the templates section to download the relevant templates that you can use to create the required documentation. Once you have completed the templates, you can save them in a designated location for your project records.

SECTIONS AND TEMPLATES:

This Annex includes all step-specific standard operating procedures for users to ensure the Simple SES process is built upon good foundations.



Resource Management Plan

PIMS STANDARD OPERATING PROCEDURE 1A.

PURPOSE:

To ensure the strategic distribution and efficient use of resources within stipulated budget and time constraints for undertaking the Simple SES approach.

SCOPE:

The scope of a resource management plan includes:

- People and Skills, the allocation of expertise and personnel to specific tasks.
- A breakdown of financial resources for each phase of tackling the issue requiring management (hereafter termed 'the process').
- Other resources to be accounted for, i.e. the inventory and allocation of scientific tools and technologies.
- Communication and Monitoring for this management plan.
- Review commitments to assess the distribution of resources and if this requires amending as the project progresses.

PROCEDURE:

Using the template below, make explicit the people and skills, financial resources, other resources, communication monitoring, and reallocation adjustment relevant to the process of using the sSES to address management questions.

Once complete, save in a secure folder and revisit when necessary throughout the project.

More information can be found in Briefing Paper 10: The Process and Information Management System.

TEMPLATE:

People/Skills	*What are their roles and responsibilities?*	*Completed?*	*Date*
	Who is responsible for completing in and updating the Excel sheets (PIMS and Data Sheet)/ Kumu interface/storage management of the different files?	*Completed?*	*Date*
	What tasks are they to be undertaking and when?	*Completed?*	*Date*
	Where is this information to be stored? Do all team members have access to this file?	*Completed?*	*Date*
	How often will this information be reviewed?	*Completed?*	*Date*
	Who is responsible for monitoring the financial resources?	*Completed?*	*Date*

Financial Resources	*What is the budget for the project? How is this to be spread among the phases of the project?*	*Completed?*	*Date*
	Where is this information to be stored? Do all team members have access to this file?	*Completed?*	*Date*
	How often will this information be reviewed?	*Completed?*	*Date*
	Who is responsible for monitoring the financial resources?	*Completed?*	*Date*
Other Resources (e.g., IT, natural resources)	*What other resources are essential to the undertaking of the project (for example, online data storage and computer software)?*	*Completed?*	*Date*
	Where is this information to be stored? Do all team members have access to this file?	*Completed?*	*Date*
	How often will this information be reviewed?	*Completed?*	*Date*
	Who is responsible for monitoring the financial resources?	*Completed?*	*Date*
Communication and Monitoring	*Where is this information to be stored? Do all team members have access to this file?*	*Completed?*	*Date*
	How often will this information be reviewed?	*Completed?*	*Date*
	Who is responsible for monitoring overall resources, including reallocation and adjustment?	*Completed?*	*Date*
Reallocation and Adjustment	*Are any resources necessary to be reallocated?*	*Completed?*	*Date*
	Document here which resources are to be reallocated/adjusted.	*Completed?*	*Date*
	When are these to be reviewed?	*Completed?*	*Date*

Risk Management Plan

PIMS STANDARD OPERATING PROCEDURE 1B.

PURPOSE:

To identify, assess, and mitigate potential risks that could impact the success of the Simple SES process.

SCOPE:

The risk management aims to account for:

- Identify potential risks across all the process and their impacts.
- Evaluation of the likelihood and potential impact of each identified risk.
- Notes to mitigate the risks identified.
- Identifying a team member responsible for addressing these risks as the process progresses.
- Risk Monitoring: Ongoing process to track identified risks and detect new ones.

PROCEDURE:

1. User(s) are to consider the possible risks that may inhibit the application and success of the Simple SES process.
2. Complete the table in the template, considering the level of impact, probability and priority; alongside planning for mitigations these risks.
3. Once complete store this file, update it as necessary and refer to this throughout the Simple SES process.

Once complete save in a secure folder and revisit when necessary throughout the project.

More information can be found in Briefing Paper 10: The Process and Information Management System.

TEMPLATE:

Risk Description	Impact description	Impact Level	Probability level	Priority level	Mitigation notes	Person Responsible	Date
What risks could have a negative impact upon the team's ability to	*What impact would this have on the project?*	*1-5 score (1 being low impact and 5 being high impact)*	*1-5 score (1 being low probability and 5 being high probability)*	*1-5 score (1 being low priority and 5 being high priority)*	*Notes on how this will be addressed.*	*Team member completing Risk assessment*	

Data Management Plan

PIMS STANDARD OPERATING PROCEDURE 1C.

PURPOSE:

To ensure data integrity, traceability and compliance with data protection standards in undertaking the Simple SES approach.

SCOPE:

The data management plan accounts for the following aspects:

- Collecting data from various sources (e.g., field studies, satellite imagery, traditional knowledge).
- Secure and accessible storage for project data.
- Procedures for cleaning, validating and integrating data from different sources.
- Methods and tools for analysing and interpreting project data.
- Protocols for sharing data with stakeholders and other researchers.
- Long-term preservation of project data for future reference and use.

The principles of Findability, Accessibility, Interoperability and Reusability (FAIR) should be considered in data management practices. This ensures that data generated and processed using the Simple SES approach are not only robust and reliable but also contribute to broader understanding. Specifically, the SOP will address FAIR principles by:

- Findability: Implementing clear and consistent file naming conventions and documenting data provenance.

- Accessibility: Defining clear access protocols for data sharing, ensuring that data can be accessed by authorised users, and considering long-term accessibility, if applicable.

- Interoperability: Employing open file formats where possible, documenting data structures and variables, and considering the use of controlled vocabularies to enable data integration and reuse.

- Reusability: Providing comprehensive documentation and adhering to quality assurance procedures to maximise the potential for data reuse.

More information can be found in Briefing Paper 10: The Process and Information Management System

TEMPLATE:

Team member responsible for Data Management Plan			Date
Category	Key Points	Data management actions	
File Types and Formats	What types of files will be created as part of the project? Will data be transformed and/or transferred as part of the process of analysis? Outlining all the types, sources, and estimated size of data being collected and analysed will help you identify potential issues relating to storage, sharing, and preservation.	List the characteristics of the data to be collected (e.g. quantitative, text, audio, video, code, etc.)	
		Include the file formats/software and if they are open or proprietary. List relevant physical formats such as lab notebooks here.	
		Outline the file types you'll be creating or transforming during collection and analysis.	
		What is the anticipated size of data? Will they require additional resources?	
Documentation	It is important to document how files are being managed as you may want to or be expected to share the data, and someone may want to verify, replicate, or reuse the data. Describe the documentation and quality assurance strategies for each type of data during collection and analysis. Consider using a file naming convention and using built-in documentation capabilities, such as taking notes in code scripts.	Outline what documentation you will create here.	
		Describe workflows for systematic capture of study information.	
		How will you add, update and maintain the data and documentation? Who will be responsible for this management?	
		How will you track multiple files or versions?	
		How will non-digital documentation be handled?	
		Establish whether there is a relevant disciplinary standard for documentation and metadata* you could use.	
		Consider what documentation will be needed for shared/preserved data.	
		Consider creating a README document for shared/preserved data you'll use during collection and analysis. Where will this be stored?	
Storage, Security and IP	Storage location, data safety and access control. In almost all cases, research data should be kept in secure storage. Avoid using local hard drives, portable storage devices, laptops and tablets for storage to reduce the risk of accidental loss.	Describe where you will store the data at every stage of collection and analysis (be specific about the journey the data will take).	
		Determine how you will keep the data safe to prevent accidental loss and unauthorised access	
		Decide if you will transfer data from a collection tool to do the analysis, e.g. voice recorder, field measurements, or online survey	
		How and when will you do this? Every week? After data collection ends?	
		Identify any ethical, legal or commercial issues with the data, e.g. identifiable data, copyright materials, patents, etc. How will you protect the data? (This could include transforming, de-identifying, or anonymising the data).	

Data Sharing	Data sharing for verification and reuse is an increasingly important marker of research integrity. The plan should identify what data will or will not be shared from the project and, for data that cannot be shared, you should include a justification for why not. For shareable data, you should outline where, when, and how others can access it. Often data are released following publication or at the close of a project. Be aware: some funders and publishers require data to be shared within specific timelines (what is the expectation on this project?).	Make sure the consent forms do not prohibit sharing/retention and, even better, ensure that they mention that de-identified data will be shared in an open repository	
		Is there non-digital data that needs to be made available? How will people request access (e.g. a publicly discoverable metadata record)?	
		Will you transform the data? (e.g. de-identify or convert to an open format)	
		Identify how you will share the data, such as depositing in a repository	
		Consider applying a Creative Commons license to the shared data or code	
		Check out the FAIR principles of data sharing (https://www.go-fair.org/fair-principles/)	
		Best practice is to deposit the data into a suitable data repository. Repositories provide the best visibility, tracking and safe keeping for the data (what is recommended for this project?).	
		Identify a suitable repository. Consider a discipline specific repository that is most appropriate for the data. Check out the PLOS list of recommended repositories (https://journals.plos.org/plosone/s/recommended-repositories) or Scientific Data recommended data repositories (https://www.nature.com/sdata/policies/repositories).	
		Restricting access to bona fide researchers or on a case-by-case basis	
		Outlining terms of access and/or applying for a copyright licence	
		Only allowing access for verification of findings and subject to a non-disclosure agreement	
		Creating a public metadata record outlining what data is held and why it cannot be shared	
Preservation	Retaining data is an important part of the research process. Even if data cannot be shared now, they may still have important historical value for future researchers. You should identify what data will be retained, where they will be stored, and who will oversee the safekeeping in the longer term.	Identify which data should be preserved. This should be anything that underpins the conclusions of the project and any published works	
		Identify what documentation you will include with the data to facilitate verification/reuse	
		Consider transforming the data to an open format for preservation	
		Identify where and who will be preserving the data and for how long	
		If you shared the data in a repository, it may have a preservation policy you can link/refer to.	

Stakeholder Strategy

PIMS STANDARD OPERATING PROCEDURE 1D.

PURPOSE:

To identify, engage, and effectively communicate with all relevant stakeholders in the Simple SES approach, ensuring diverse perspectives are integrated into decision-making processes.

Effectively engaging with stakeholders requires giving attention to how stakeholders are identified and engaged. It also means considering what information is disseminated, to whom and in what form, and about recognising political/power alliances and identity impact on the construction of understandings of the context, focal issues and stakeholder interactions.

SCOPE:

A stakeholder strategy is multifaceted; hence, this includes:

- Stakeholder identification, all potential stakeholders, from local communities to policymakers.
- Assessment of stakeholder interests, influence and potential impact on the process.
- Planning for how to engage different stakeholder groups. To create clear and effective methods for two-way communication with stakeholders.

Logistical considerations for engaging stakeholders should include:

- When they are contacted: ideally after ethical considerations, but sufficiently early to be included throughout the process.
- Why they are contacted: through written communication to gain their consent and advise how communication will take place throughout the process.
- How they are contacted: considerations for minimising the time used of stakeholders, the design of communication should account for stakeholder fatigue by proper planning and considering compiling questionnaires and limiting the number of workshops.

More information can be found in Briefing Paper 13: Stakeholders and Stakeholder Communication.

PROCEDURE:

- Using template 1, consider the types of stakeholders in the marine environment. It is to be noted that some stakeholders may fit into two groups.

- Using the four quadrant grid in table 2, consider what information is disseminated, to whom and in what form, and about recognise political/power alliances and identity impact on the construction of understandings of the context, focal issues and stakeholder interactions.

- Using template 3, acknowledge that different stakeholder groups have different communication traditions and preferences and plan how to deal with this throughout the project.

TEMPLATES:

Template 1: Stakeholder Identification

Type of Stakeholder	Stakeholder
Extractors (e.g. fishers, resource removers)	*List stakeholders here.*
Inputters (e.g. dischargers, polluters)	*List stakeholders here.*
Beneficiaries (those acquiring the benefits)	*List stakeholders here.*
Affectees (e.g. society, those paying the costs)	*List stakeholders here.*
Regulators (e.g. government, legislators, decision-makers)	*List stakeholders here.*
Influencers (e.g. expert groups, politicians, NGOs)	*List stakeholders here.*

Template 3: Stakeholder Communication

Communication type	Stakeholders
Smaller communication methods; Sound bites, headlines, Tweets and one-page briefing notes.	*List stakeholders here.*
More in-depth and larger communication methods; Theses, reviews, scientific papers, and consultant reports.	*List stakeholders here.*

Template 2: Stakeholder Management

The four quadrants of the grid can be seen as defining four categories of stakeholders.

Stakeholders in the upper two categories (Figure 1) are those with the most stake (i.e., most 'interest') in the issue but with varying degrees of power: those to the right-hand side enjoy more power, i.e. they have 'influence', but may or may not actually be concerned about the issue. 'Players' are those interested stakeholders who also have a high degree of power to support (or to sabotage) the outcome of the intervention, whereas 'Subjects', while interested, have less influence. The two lower categories can perhaps be seen more as 'potential' stakeholders who have not (yet) displayed much interest in the issue. 'Context setters' may have a high degree of power over the future of the issue, particularly in terms of influencing the future context within which responses (plans, policies, etc) will need to operate. The last quadrant, the 'Crowd', (currently) exhibits neither interest in nor power to influence the issue of concern.

Figure 1. The stakeholder management table.

	SUBJECTS	**PLAYERS**
	List stakeholders here who are interested in the project but have little influence over the outcomes (e.g. local individuals).	*List stakeholders here who are interested in the project and have a high influence over the outcomes (e.g. large industry in the area, local environmental groups).*
Interest	**CROWD**	**CONTEXT SETTERS**
	List stakeholders here who currently exhibit neither interest nor power to influence the issue of concern (e.g. general public of the country).	*List stakeholders here who may have a high degree of power over the future of the issue, particularly in terms of influencing the future context within which responses will need to operate (e.g. local governing bodies; marine planning authorities).*
	Power	

Evaluation Strategy

PIMS STANDARD OPERATING PROCEDURE 1E.

PURPOSE:

To provide a continuous appraisal process that compares the project progression with predefined standards, enabling timely modifications to enhance outcomes via the Simple SES approach and cycle.

SCOPE:

The scope of the evaluation strategy encompasses both outcome evaluation – did we achieve what we set out to do? And process evaluation – What did we learn and improve upon from this application and experience? In considering these evaluations, these evaluations account for:

- Establishment of initial conditions and benchmarks.
- Development of clear, measurable indicators aligned with project objectives (SMART Goals).
- Regular evaluation of project goals and standards.
- Mechanisms for incorporating evaluation results into project management and decision-making within this instance and future instances

More information can be found in Briefing Paper 10: The Process and Information Management System.

TEMPLATES:

Template 1: Outcome evaluation

The scope of the objectives			
What is the overall management goal?			
Goal	**Objectives**		**Indicator/Target**
	Is this objective Specific, Measurable, Achievable, Realistic and Time-bound?	*What is the scale of this objective (local, national, regional)?*	*The desired final state and the date at which it should be assessed, with appropriate intermediate assessments to check progress if appropriate, should be specified.*
	Is this objective Specific, Measurable, Achievable, Realistic and Time-bound?	*What is the scale of this objective (local, national, regional)?*	*The desired final state and the date at which it should be assessed, with appropriate intermediate assessments to check progress if appropriate, should be specified.*
	Is this objective Specific, Measurable, Achievable, Realistic and Time-bound?	*What is the scale of this objective (local, national, regional)?*	*The desired final state and the date at which it should be assessed, with appropriate intermediate assessments to check progress if appropriate, should be specified.*
	Is this objective Specific, Measurable, Achievable, Realistic and Time-bound?	*What is the scale of this objective (local, national, regional)?*	*The desired final state and the date at which it should be assessed, with appropriate intermediate assessments to check progress if appropriate, should be specified.*
	Is this objective Specific, Measurable, Achievable, Realistic and Time-bound?	*What is the scale of this objective (local, national, regional)?*	*The desired final state and the date at which it should be assessed, with appropriate intermediate assessments to check progress if appropriate, should be specified.*

Template 2: Process evaluation

Focussing on the group option analysis session, to what extent do you agree or disagree with the following statements:						
		Strongly Disagree	Disagree	Agree	Strongly Agree	Neither
Communication	a. There was a good exchange of ideas and viewpoints between participants					
	b. All participants contributed to the discussion					
	c. A shared language was being used					
	d. Some participants dominated discussions which prevented some other participants from contributing					
	e. Participants understood and were focussed on the options analysis task					
Consensus	a. Participant opinions converged as they discussed options for their respective positions					
	b. Participants became aware that there were more options than they originally thought					
	c. Participants did not reach agreement on the analysis of the options					
	d. The approach to analysing options helped participants communicate their ideas to others					
Commitment	a. There was a strong belief and recognition of the value of the options analysis exercise					
	b. Participant level of engagement with the analysis exercise was low					
	c. There was a strong desire to achieve an analysis of the options which was both correct and complete through the exercise					
Take-Aways	**Focussing on the process in its entirety, to what extent were the following delivered:**					
		Fully Agree			Fully Disagree	Not sure
	a. Understanding of opportunities for…					
	b. Clarification of drivers and barriers to change					
	c. An opportunity to engage in a discussion about…					
	d. Greater appreciation of a range of stakeholder views on…					
	e. Action to achieve.					

Governance Analysis

PIMS STANDARD OPERATING PROCEDURE 1F.

PURPOSE:

Governance considerations within the scope of this SES look to the structures and processes in that people in societies make decisions and share power, create the conditions for ordered rule and collective power (Folke et al., 2005); more specifically the sum of the policies, politics, administration and legislation required in adaptive environmental management (Cormier et al., 2022).IT also includes governance of activities by their operators through business administration (Elliott et al., 2025a).

SCOPE:

The scope of a governance analysis within the Simple SES is to inform upon what 'rules' (legislative instruments) are in place relating to the SES, and who administers these rules governing the system. This SOP provides a set of instructions and templates to complete both a legislation (Procedure 1) and administration (Procedure 2) audit to determine the governance of the area to be managed.

Within the EU, various initiatives have been developed to promote sustainable marine management, such as maritime spatial planning, protecting marine habitats, and encouraging cross-border cooperation. Hence, the scope of consideration includes:

- Analysis of relevant international, national and local laws and regulations.
- Mapping of organisations and bodies involved in marine governance for the area.

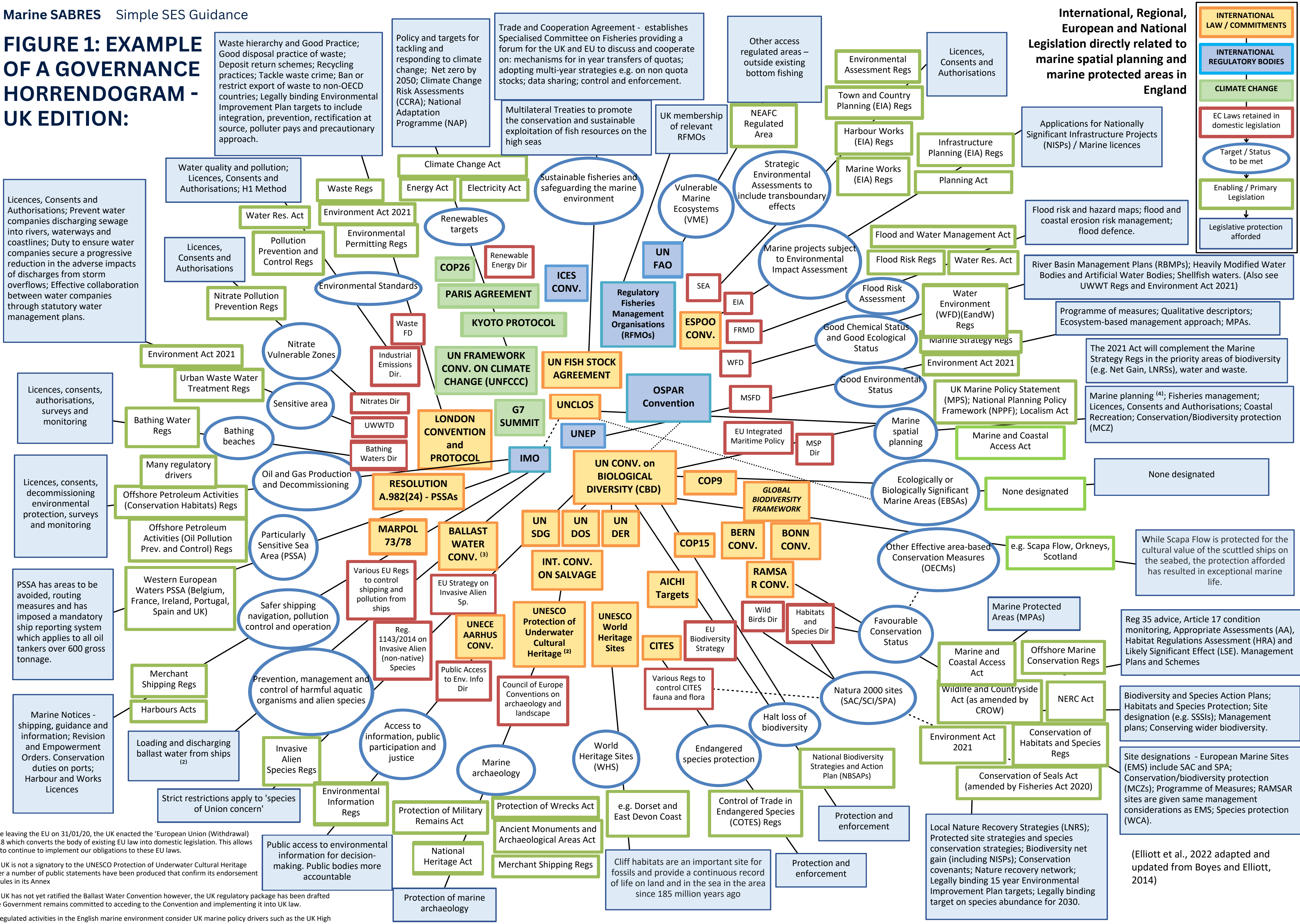
The procedure for undertaking a statutory governance analysis involves two main components: a legislation audit (creation of a horrendogram) and an administration audit (creation of an organogram). An example of the output of the legislation horrendogram is given in Figure 1 and the administrative organogram in Figures 2a and 2b.

More information can be found in Briefing Paper 9: Marine Governance Briefing Paper.

DEFINITIONS:

Term	Definition
Governance	The sum of the policies, politics, administration, and legislation required in adaptive environmental management; It also includes the governance of activities by business administrations.. It encompasses the structures and processes designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity, and inclusiveness in environmental decision-making.
Legislative Framework Analysis ('Horrendogram')	A systematic analysis and often visual mapping of the complex web of legislative and policy instruments influencing a system, showing vertical integration (e.g., from international conventions down to national statutes) and horizontal linkages across sectors
Administrative Structure Analysis ('Organogram')	A systematic analysis and often visual mapping of the organisations, government departments, agencies, and other bodies responsible for implementing, managing, and enforcing the legislative framework within the system.
Statutory Body	Statutory bodies are those who have been established under national, regional or local legislation as competent authorities and are working to meet policy objectives.
Competent Authority	A competent authority is one that has a specific remit under the legislation; EU Directives specifically refer to competent authorities. These management bodies are likely to be found by searching on government websites, in policy documents and relevant literature.

FIGURE 1: EXAMPLE OF A GOVERNANCE HORRENDOGRAM - UK EDITION:



(1) Since leaving the EU on 31/01/20, the UK enacted the 'European Union (Withdrawal) Act 2018 which converts the body of existing EU law into domestic legislation. This allows the UK to continue to implement our obligations to these EU laws.

(2) The UK is not a signatory to the UNESCO Protection of Underwater Cultural Heritage however a number of public statements have been produced that confirm its endorsement of the rules in its Annex

(3) The UK has not yet ratified the Ballast Water Convention however, the UK regulatory package has been drafted and the Government remains committed to acceding to the Convention and implementing it into UK law.

(4) All regulated activities in the English marine environment consider UK marine policy drivers such as the UK High Level Marine Objectives 2009, the UK Marine Policy Statement and various National Policy Statements

(Elliott et al., 2022 adapted and updated from Boyes and Elliott, 2014)

FIGURE 2A: EXAMPLE OF A GOVERNANCE ORGANOGRAM - UK EDITION:

The UK Government marine organogram (predominantly for England) indicating the main bodies and their predominant competencies (updated from Elliott et al., 2022).

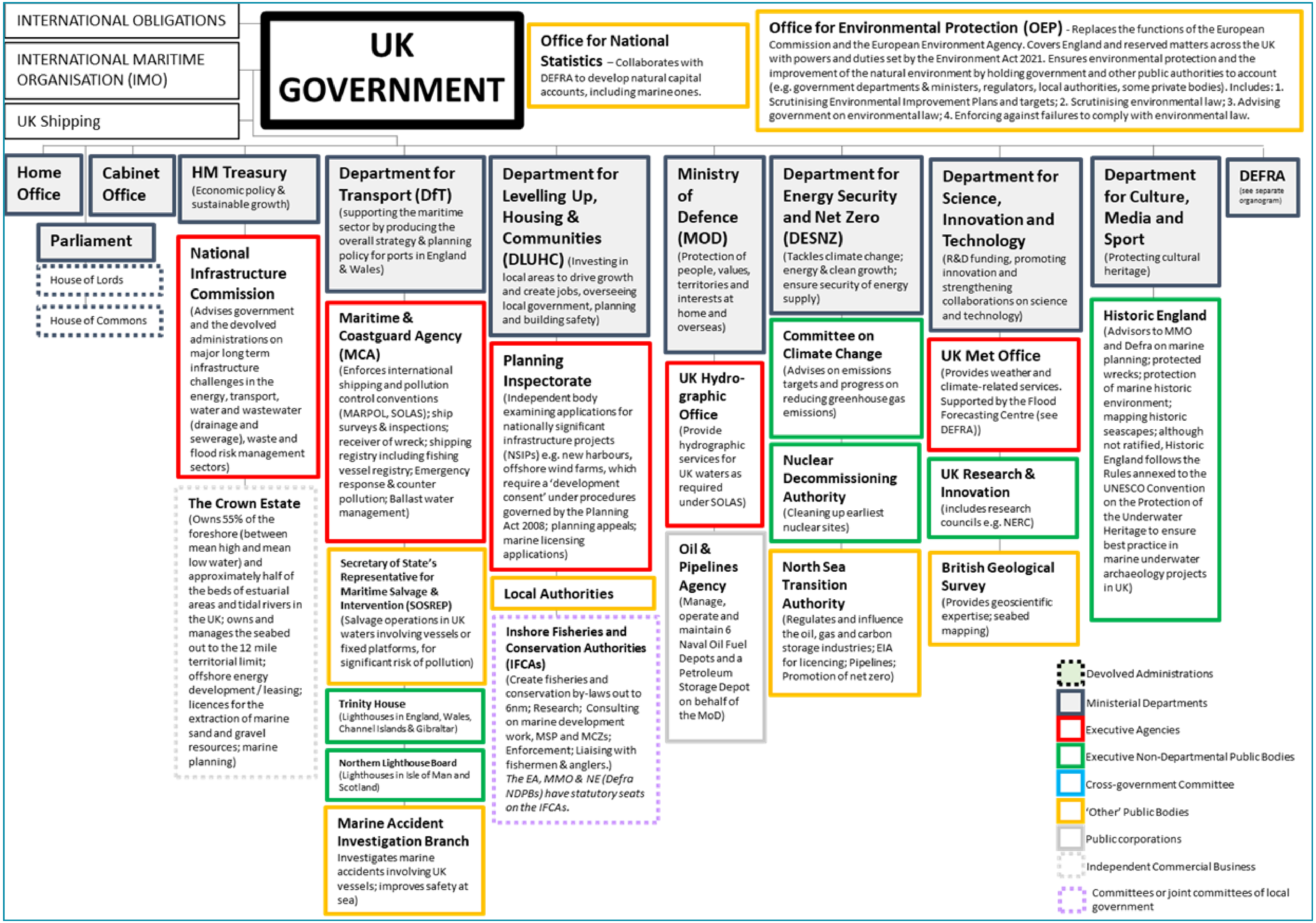
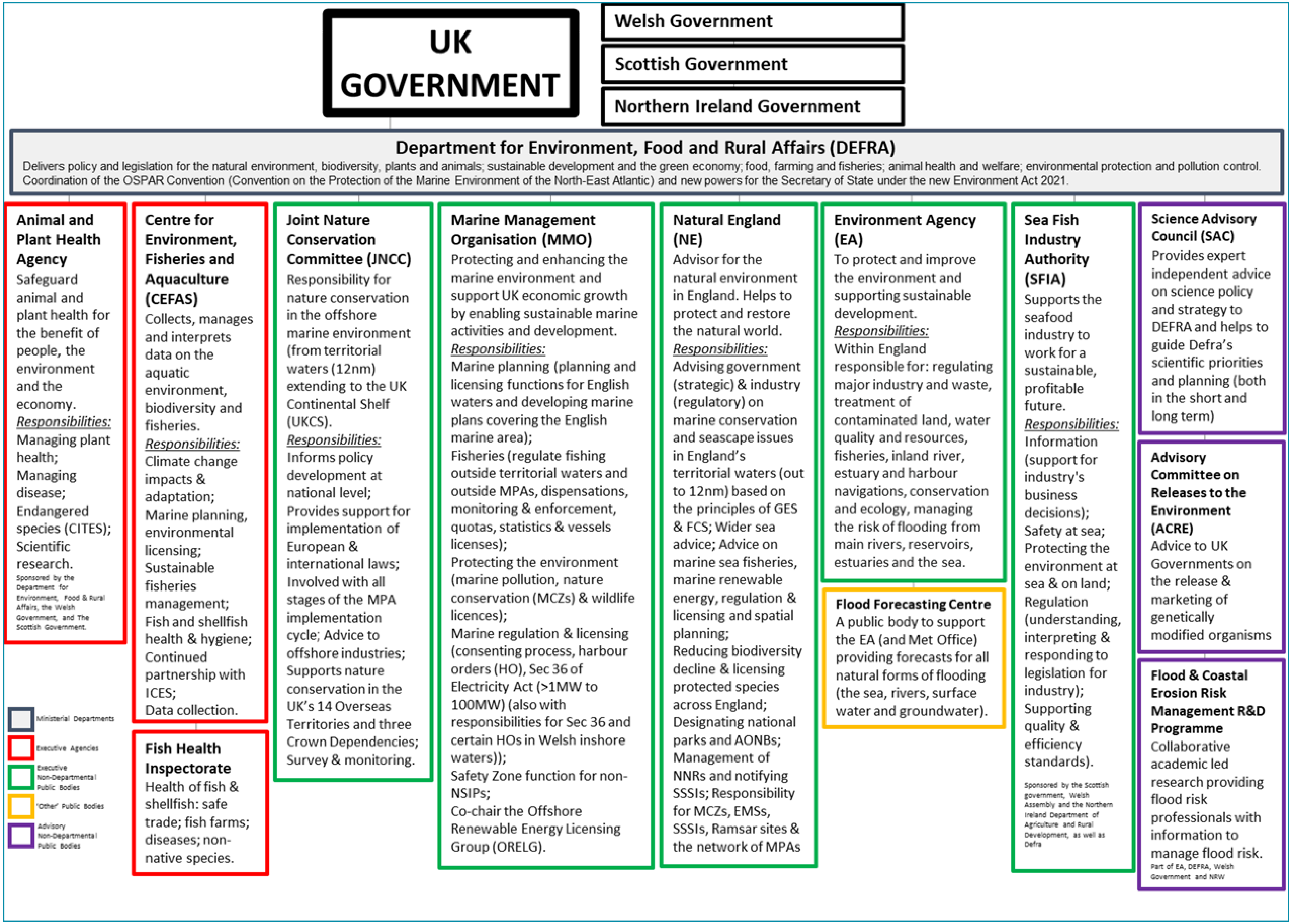


FIGURE 2B: EXAMPLE OF A GOVERNANCE ORGANOGRAM - UK EDITION:

Organogram specially detailing the agencies and bodies under DEFRA.

As a subset, because of its importance for the marine environment, Figure 2b shows the dominant lead marine body in the UK (Department for Environment, Food and Rural Affairs (Defra)) and its associated agencies for marine management.



PROCEDURE 1: DEVELOPING THE HORRENDOGRAM

The majority of the International agreements and EU Directives shown in the centre of the governance diagram (Figure 1) should be common to many countries. However, differences may exist if your country has not ratified a Convention or is not a member of the EU, however, some similar legislative instruments may be in place influenced by bilateral agreements. The template table corresponds to the blank boxes on Figure 1b and requires you to complete the following actions

- Firstly, state how the EU Directives are currently implemented through the own country legislation. In EU countries then these may be adopted through Regulations rather than Acts of Parliament whereas other countries will need sovereign Acts.
    - You may be familiar with these already, but if not, then you may need to interrogate official government agency websites, marine planning documents or marine literature. Given that this is official information, then it should be publicly available without having to contact individuals.
    - Think about the protection that a particular piece of legislation specifically provides for maritime spatial planning, marine protected areas and the MSFD and add it to the template.

- Once the legislation implementation audit has been completed, add the information to the corresponding boxes on the horrendogram figure.

- If any of these legislative aspects do not apply to your focus area, then you can state this in Table 2 and the corresponding boxes can be deleted from the figure.

- The template asks you to consider other forms of marine area-based protection measures. These include Ecologically and/or Biologically Significant marine Areas (EBSAs), World Heritage Sites (WHS), Other Effective area-based Conservation Measures (OECMs), Particularly Sensitive Sea Areas (PSSA) and Vulnerable Marine Ecosystems (VME).
    - Although not formally designated under International or European legislation, they can provide additional maritime protection to important marine ecosystems (see BP11 for information on Governance terminology). Should you not include these additional measures, then please delete the relevant boxes from the horrendogram figure.

- If the country has additional protection measures beyond the International, Regional and European laws already considered in the horrendogram figure, there is the opportunity of adding boxes to complete the legislative landscape.

- This information should be added at the end of this table before including it on the figure.

TEMPLATE - PROCEDURE 1 HORRENDOGRAM TABLE:

BOX on the template	LEGISLATION	COMPLETE THIS COLUMN TO STATE THE NATIONAL IMPLEMENTATION and THE PROTECTION IT AFFORDS	Added to Figure (Y/N)
Regional Sea Convention			
Box 1	Insert the Regional Sea Convention in the central area (highlighted in yellow) e.g. OSPAR, HELCOM, Barcelona or Bucharest.	e.g. UK - OSPAR	
EU Marine Strategy Framework Directive (MSFD)			
Boxes 2a and 2b.	Under which piece of national legislation is the MSFD implemented? (If just one main act or regulation, then delete the second box).	e.g. UK – Marine Strategy Regulations; Environment Act	
Box 2c.	Do you have any nationally implemented legislation which also helps to achieve GES?		
Box 2d	State what specific protection this legislation gives the Demonstration Area.		
EU Marine Spatial Planning Directive (MSPD)			
Box 3	Which piece(s) of national primary/enabling legislation implements the MSPD in the country?		
Box 3a	State what components or sub-area this act/regulation specifically protects in the MarineSABRES Demonstration Area.		
CBD COP9 - Ecologically or Biologically Significant Marine Areas (EBSAs)			
Box 4	Do you use this term and if so, do you have any designated EBSAs? If so, name the area.		
Box 4a	What specific protection does this concept/designation give to the Demonstration Area?		
CBD Global Biodiversity Framework - Other Effective Area-Based Conservation Measures (OECMs)			
Box 5	Do you use this term and do you have any designated OECMs? If so, name the area.		
Box 5a	What specific protection does this concept/designation give to the Demonstration Area?		

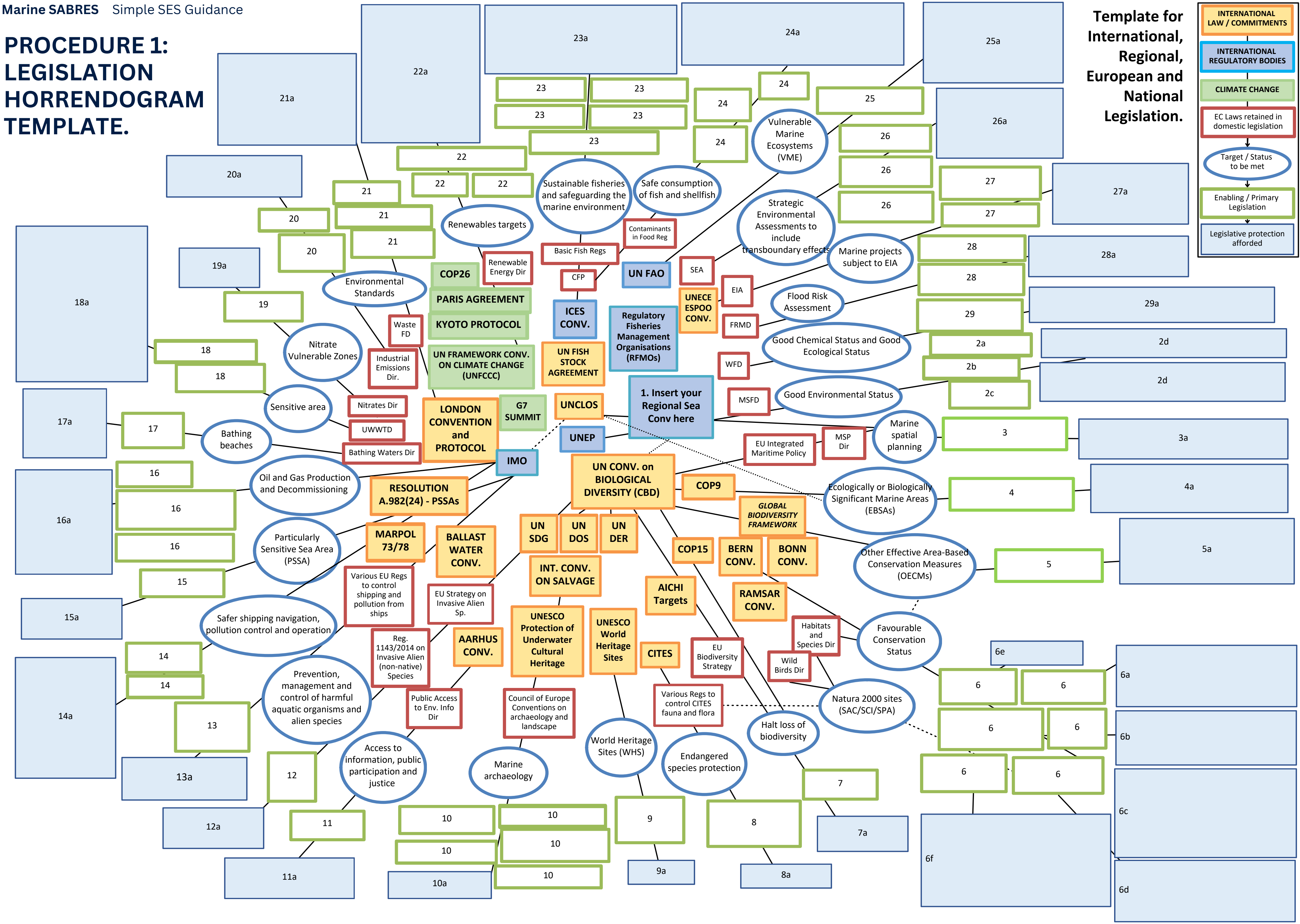
EU Habitats Directive			
Box 6	List any national legislation implementing the Habitats Directive in the country. There may be other pieces of legislation which also fill that role which can be added to the additional box		
Boxes 6a-f	What component(s) does each piece of legislation specifically give protection to in the Demonstration Area?		
	e.g. protected areas, a certain species e.g. *Posidonia*, *Zostera*, fish sp.		
AICHI targets through the EU Biodiversity Strategy			
Box 7	State the main national legislation or actions used to implement the AICHI targets		
Box 7a	What specific protection do these give to the Demonstration Area?		
CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)			
Box 8	How is CITES implemented in the country?		
Box 8a	What specific protection does it give to marine species?		
UNESCO – World Heritage Sites (WHS)			
Box 9	Do you have any coastal/marine WHS in the country and, if so, what is the main reason for designation?		
Box 9a	What specific protection do these give to the Demonstration Area?		
UNESCO – Protection of Underwater Cultural Heritage			
Box 10a	If the country is a signatory - how is this implemented in the country and what specific protection does it give? What components/aspects are protected?		
Box 10b	If the country is not a signatory (as with the UK) how does the country give protection to marine archaeology?		
EU Public Access to Environmental Liability Directive			
Box 11	State how this Directive has been implemented in the country.		
Box 11a	What protection is provided?		

EC Regulation 1143/2014 on Invasive Alien Species (IAS)			
Box 12	State how this has been implemented in the country.		
Box 12a	What specific protection is provided?		
IMO Ballast Water Convention			
Box 13	If a signatory - how is this implemented in the country and what specific protection does it give?		
Box 13a	If you have not ratified it, does the country provide equivalent protection?		
MARPOL Annexes and Regulations			
Box 14	What national legislation do you have to implement MARPOL Annexes and Regulations?		
Box 14a	Does this provide any specific protection to marine habitats and species in the marine area?		
IMO – Particularly Sensitive Sea Areas (PSSAs)			
Box 15	Do you have any designated PSSAs? If so, name the area.	e.g. The Baltic Sea area, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden	
Box 15a	What specific protection does this give to the Demonstration Area?		
IMO and Regional Sea Conventions - Oil and Gas Production and Decommissioning			
Box 16	What are the main regulatory instruments relating to oil and gas extraction and decommissioning?		
Box 16a	What kind of management/ protection do those instruments provide?		
EU Bathing Waters Directive			
Box 17	Which piece of national primary/enabling legislation implements the Bathing Waters Directive in the country?		
Box 17a	State if and how this act/regulation specifically gives protection to the Demonstration Area.		

EU Urban Waste Water Treatment Directive (UWWTD)			
Box 18	Which piece(s) of national primary legislation and/or regulations implement the UWWTD?		
Box 18a	State how these act(s)/regulation(s) specifically give protection to the Demonstration Area		
EU Nitrates Directive			
Box 19	Which piece(s) of national primary/enabling legislation implements the Nitrates Directive in the catchments?		
Box 19a	State how these acts/regulations specifically give protection to the Demonstration Area.		
EU Industrial Emissions Directive			
Box 20	Which piece(s) of national primary/enabling legislation implements this Directive?		
Box 20a	State how this act/regulation specifically gives protection to the Demonstration Area.		
EU Waste Framework Directive			
Box 21	Which piece(s) of national primary/enabling legislation implements this Directive?		
Box 21a	State how this act/regulation specifically gives protection to the Demonstration Area.		
EU Renewable Energy Directive			
Box 22	Which piece(s) of national primary/enabling legislation implements this Directive?		
Box 22a	State how this act/regulation specifically gives protection to the Demonstration Area.		
Common Fisheries Policy (CFP) - Fisheries Management – Various regulations			
Box 23	Which piece(s) of national primary/enabling legislation implements the CFP and Basic Fisheries Regs?		
Box 23a	State how these national acts/regulations specifically give protection to the Demonstration Area.		

EU Contaminants in Food Regulations			
Box 24	Which pieces of legislation are used to implement this Directive to ensure the safe consumption of shellfish?		
Box 24a	What specific protection do these pieces of national legislation give to the Demonstration Area?		
UNFAO Vulnerable Marine Ecosystems (VME)			
Box 25	Do you have any VME designated areas? Please name the area.		
Box 25a	What specific protection does this give to the Demonstration Area?		
EU Strategic Environmental Assessment Directive (SEA)			
Boxes 26	Which piece(s) of national primary/enabling legislation implements the EU SEA Directive? (delete/add boxes as required)		
Box 26a	State how these acts/regulations specifically give protection to the Demonstration Area.		
EU Environmental Impact Assessment Directive (EIA)			
Boxes 27	Which piece(s) of national primary/ enabling legislation implements the EU EIA Directive? (delete/add boxes as required)		
Box 27a	State how the act/regulation specifically gives protection to the Demonstration Area.		
EU Flood Risk Management Directive (FRMD)			
Boxes 28	Which piece(s) of national primary/enabling legislation implements the EU FRMD? (delete/add boxes as required)		
Box 28a	State how this act/regulation specifically gives protection to the Demonstration Area.		
EU Water Framework Directive (WFD)			
Box 29	Which piece(s) of national primary/enabling legislation implements the EU WFD?		
Box 29a	State how this act/regulation specifically gives protection to the Demonstration Area.		
OTHER REGIONAL LEGISLATION SPECIFIC TO THE COUNTRY / DEMONSTRATION AREA NOT ALREADY CONSIDERED ABOVE			

PROCEDURE 1: LEGISLATION HORRENDOGRAM TEMPLATE.



PROCEDURE 2: DEVELOPING THE ORGANOGRAM

This procedure helps to identify and characterise the number of statutory organisations and agencies that have a strategic role governance in the area. The outputted figured should show that a country can have many government departments with a marine competency, not only the more obvious ministries and departments such as environment and trade, but also defence, foreign affairs and transport. You may have to indicate department/ministries that have joint responsibility, for example with a remit for climate change and the environment. The organogram table will help you to identify organisations which play a role in the management of the Area. This should be done by completing the following actions:

- List the statutory organisations who have an active role in managing the marine environment.
- If you have many agencies, it may be useful to identify them on an activity by activity basis. This could be done by working clockwise around the horrendogram, consider;
  - Which agency/body takes the lead for the designation, management and enforcement of that particular sector (e.g. marine spatial planning, nature conservation, shipping, water quality, EIA, SEA, fisheries, oil and gas, renewables, etc.).
  - Are there any other agencies who also have a role?
- Consider hierarchy: If you have listed an agency or subsidiary body, please state under which government department they operate and to whom they report.
- Describe the overall aim and vision of that organisation in relation to marine management.
- In the appropriate column, describe the specific role of each agency/body in relation to MPAs, MSP and MSFD.
- You may find it easier to regroup/sort the rows if you have numerous agencies/bodies who operate under one main government department.
- Now use the information collated to create an organogram using the Organogram template.

PROCEDURE 2: ADMINISTRATIVE AUDIT TEMPLATE

<table>
<tr><td rowspan="3">Statutory Organisation</td><td>Hierarchy</td><td>Overview</td><td colspan="3">Responsibilities</td></tr>
<tr><td>If an agency/body – under which department do they operate</td><td>Describe the vision of the organisation</td><td colspan="3">Description of their specific role in relation to:</td></tr>
<tr><td></td><td></td><td>Maritime Spatial Planning (MSP)</td><td>Marine Protected Areas(MPAs)</td><td>Marine Strategy Framework Directive(MSFD)</td></tr>
<tr><td rowspan="3">e.g. Marine Management Organisation (MMO), England</td><td>Statutory.</td><td rowspan="3">Protecting and enhancing the marine environment and supporting UK economic growth by enabling sustainable marine activities and development.</td><td>Marine planning (planning and licensing functions for English waters and developing marine plans covering the English marine area);</td><td rowspan="3">Protecting the environment (marine pollution, nature conservation (MCZs) and wildlife licences).</td><td rowspan="3">Assists Defra to deliver the UK Marine Policy Statement by taking measures to improve the state of the UK's marine environment and achieve GES under the MSFD.</td></tr>
<tr><td>Executive Non-Departmental Public Body working under the Department of Environment, Food and Rural Affairs (Defra) in England and Wales</td><td>Marine regulation and licensing (consenting process, harbour orders (HO), Sec 36 of Electricity Act (>1MW to 100MW) (also with responsibilities for Sec 36 and certain HOs in Welsh inshore waters));</td></tr>
<tr><td></td><td>Fisheries (regulate fishing outside territorial waters and outside MPAs, dispensations, monitoring and enforcement, quotas, statistics and vessels licenses).</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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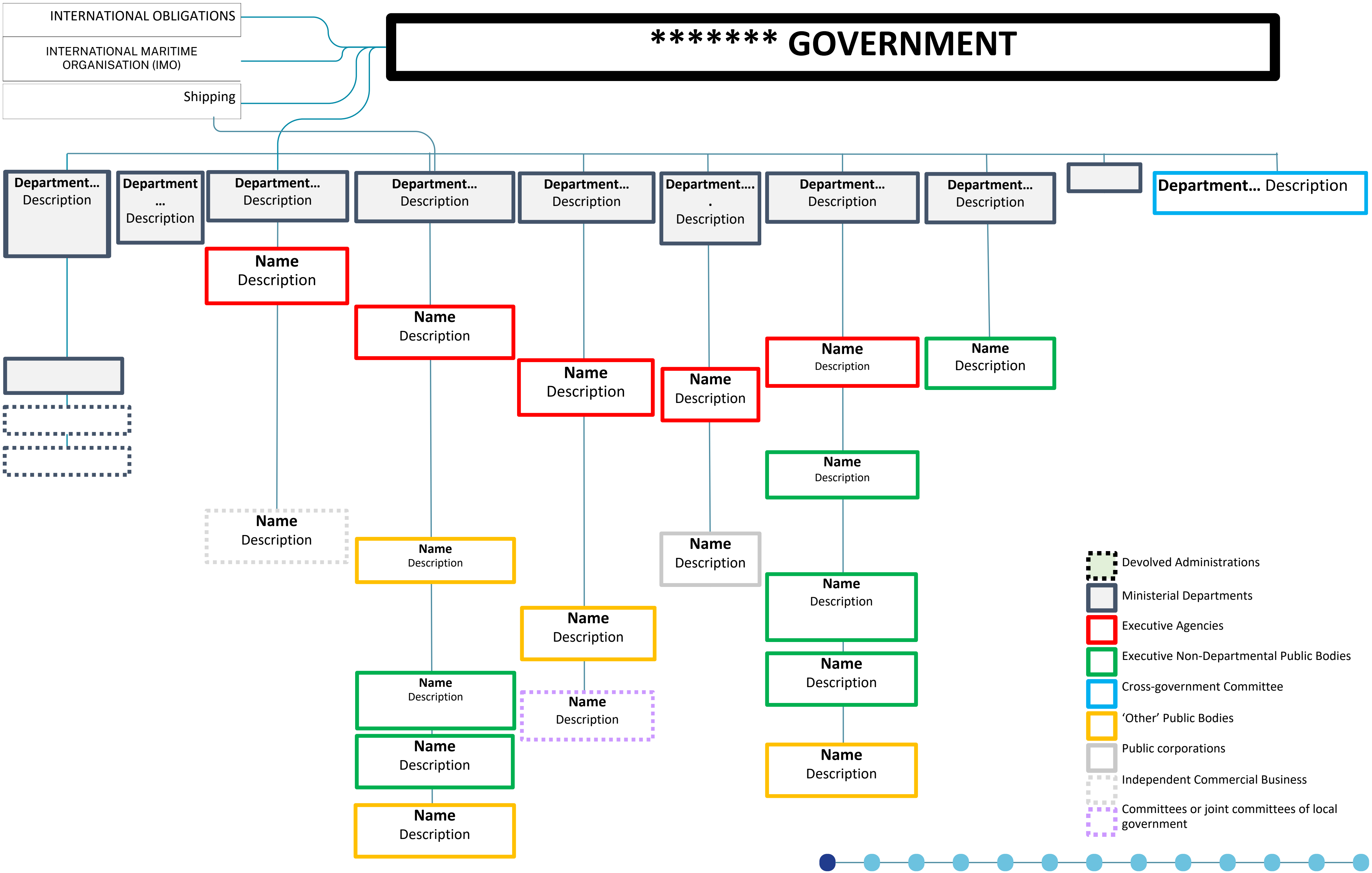
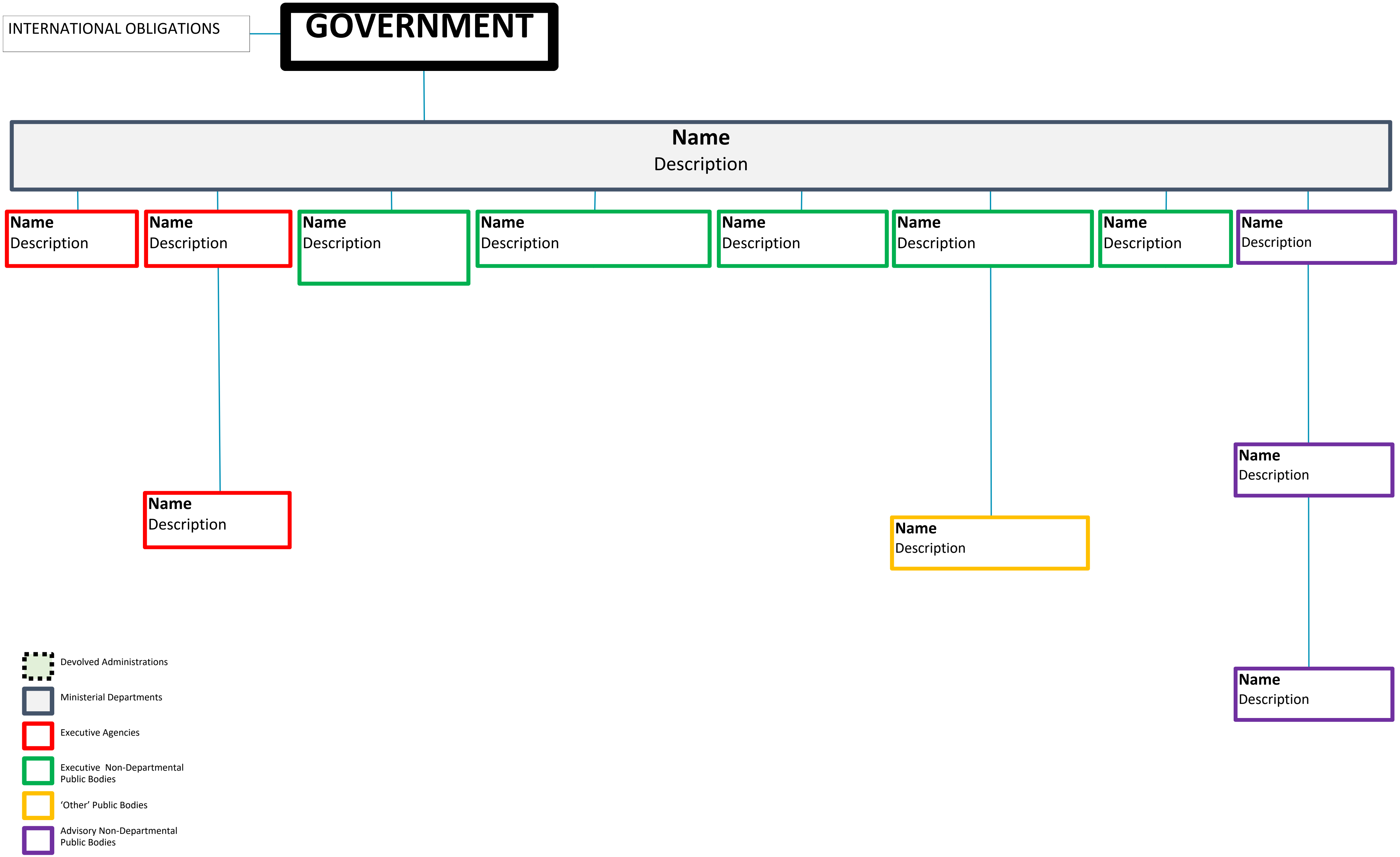
PROCEDURE 2: ADMINISTRATION ORGANOGRAM TEMPLATE.



PROCEDURE 2: SUBSET ORGANOGRAM TEMPLATE.



MARINE
SABRES