DECISION SPACE ANALYSIS

A method of visualising scale mismatches and communicating them more effectively to decision makers.

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WHAT

Understanding space and time scales

Decision Space Analysis provides an effective communication tool to illustrate mismatches in time and space scales of coupled (interlinked & connected) social and ecological systems.

Management task

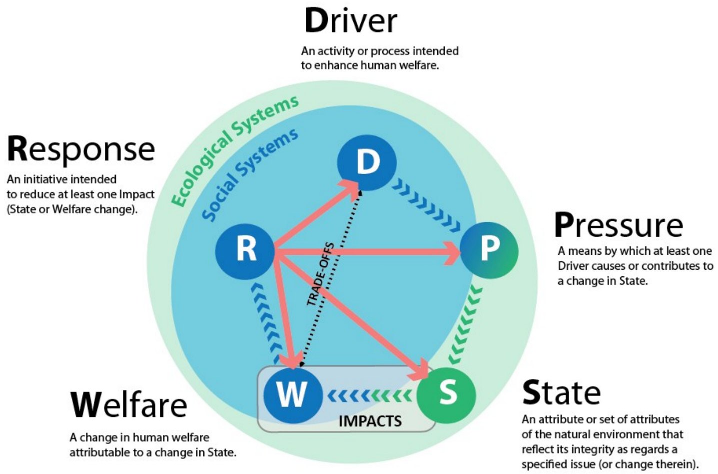
Identification of the stakeholders at each scale relevant to any particular problem/ issue (who causes which problem, who benefits and who pays the cost)

The MSFD requires decision-makers to follow an ecosystem approach to manage the marine environment as a coupled social-ecological system. But this is difficult because spatial and temporal scales of social systems frequently do not match those of ecological systems. The DPSWR framework analyses coupled social and ecological systems distinguishing between:

I. ***Drivers*** of change, the cost to human ***Welfare*** and policy ***Responses*** to reduce and/or compensate for impacts.

II. ***Pressures*** that drivers place on the environment and the resultant changes in the ***State*** of the status of species and/or ecosystems.

Decision space analysis (DSA) is a method for visually communicating scale mismatches between each element of the DPSWR framework effectively to decision makers. More on DPSWR **here**.



Human society is dependent on, and part of, ecosystems. The Ecosystem Approach to Management in the MSFD considers both social systems and the surrounding environment together as part of a whole.

DECISION SPACE ANALYSIS

Policy responses can make situations worse by overlapping in time and space. For coastal waters National policy has to assimilate the requirements of the Water Framework Directive (WFD) with those of the MSFD.

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Understanding space and time scales

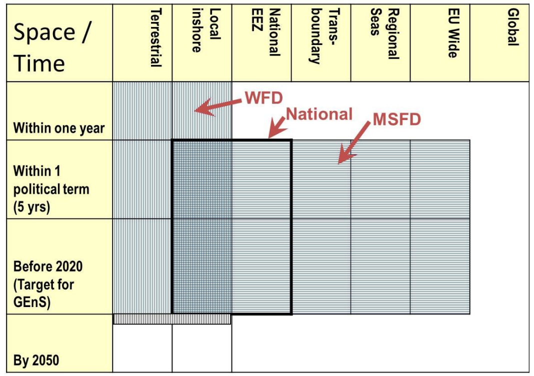
Policy decisions are a trade-off between human welfare costs (social and economic) and benefits derived from continued social and economic activity and damage to the environment.

Policy **R**esponses that seek changes to **D**rivers and **P**ressures often operate at a scale that is different in time and space from those of impacts to the **S**tate of the environment and **W**elfare of humans that the policy seeks to address, such that the:

1. Management jurisdiction of the policy response does not extend over the scale of ecosystem processes (e.g. commercially-exploited marine species caught in the open ocean dependent on coastal breeding and nursery habitats).

2. Management scale of the policy response is too large to cope with local ecosystem requirements (e.g. adjusting Europe-wide rules on eutrophication and wastewater treatment to the variety of local conditions).

The overlap in policy responses is intentional to promote joined-up thinking between local actions on the coast (responding to the WFD and the European Maritime Strategy) and those that operate from the coast to larger geographical scales (the MSFD) but can also result in confusion where this intention is not understood. There is need for pragmatic dialogue on this (e.g. when Nitrate Vulnerable Zones are beyond the 1 nautical mile coastal geographic boundary of the WFD but within the aegis of the MSFD). The distinction between inshore and offshore fisheries responds to other geographical limits and sovereignty described in the Common Fisheries Policy and this impinges on the designation of marine protected areas. The consequences are collapses in social systems (e.g. fisheries) and/or ecosystems (e.g. eutrophication).



A policy **R**esponse can be aimed to change a **D**river or **P**ressure but will only lead to effective management if its action leads to an improvement in the status of **S**tate and/or **W**elfare elements and/or a lessening of the impact caused.

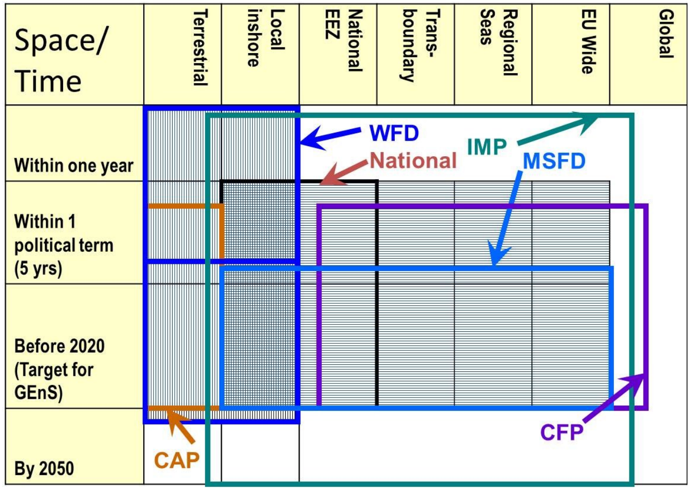
DECISION SPACE ANALYSIS

Policy should address not only direct benefits of an action (e.g. fish for consumption) but also indirect cost (e.g. reduced resilience of a system).

Understanding space and time scales

The DPSWR framework provides a systems approach that avoids considering individual sectors in isolation and allows an analysis of trade-offs between different policy areas.

The DPSWR framework provides a structure to analyse the spatial and temporal scales of both the MSFD and other policy instruments that impact regional and national (EEZ) marine areas. The figure shows how national-level policy and management has to consider not only the MSFD but a swathe of other EU policy instruments whose sphere of influence and implementation cycles impact the social and environmental fabric of the marine area. If international conventions were added to this figure, the picture would become even more complicated.



(WFD: Water Framework Directive, IMP: Integrated Marine Policy, MSFD: Marine Strategy Framework Directive, CAP: Common Agricultural Policy, CFP: Common Fisheries Policy)

There are important time dimensions to take into account as well. Some systems respond very slowly to change in drivers and pressures; often beyond the timescales set by policy-makers. Many actions planned in the current cycle of the MSFD will not be expected to produce tangible improvements in status or welfare until well within the next cycle. It is a mistake to set unreasonable expectations. Also, some issues can be framed better in terms of risk: the risk that inaction will have consequences for the state of the marine environment, its supply of ecosystem services and the welfare of those who depend on it.

The DSA provides a visual analysis of the sphere of drivers and pressures resulting from current policies and defines in space and time how trade-offs between their outcomes impact on environmental state and social welfare.

DECISION SPACE ANALYSIS

DSA communicates analysis of Drivers and Pressures on the marine environment and illustrates their impacts on State and Welfare components to determine appropriate scales of Policy response.

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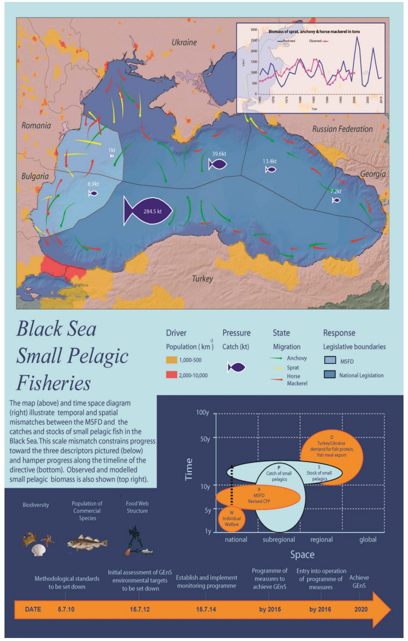
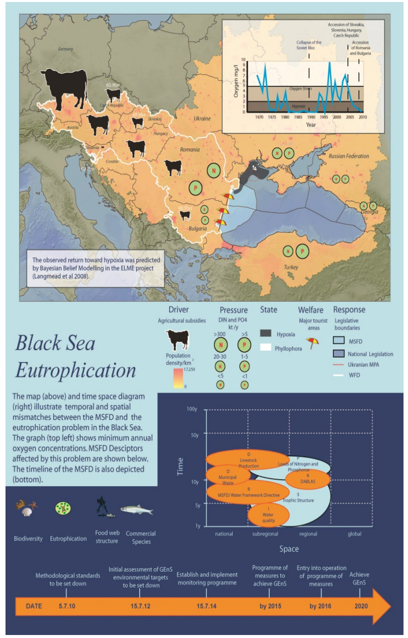
Understanding space and time scales

DSA helps examine available information, data and key current and emergent issues of the marine environment to help determine the most appropriate scale for their effective management.

Environmental and social scientists have very different traditions such that collaboration between them is notoriously difficult. Scientific interpretation of data and its translation into language that can be grasped by decision makers is a major challenge for both scientists and policymakers. The DSA provides a tool to facilitate this necessary discussion in a language all can understand. Analysis of fisheries and eutrophication in the Black Sea provides an example of the policy challenges and the application of the DSA.

Click here to see examples of DSAs for different issues for the Black Sea





The major feature of Decision Space Analysis is the user does not need to be an expert in order to understand the key messages of how policy affects drivers and pressures leading to impacts on social and environmental components of a system, and the conflicts these lead to.

DECISION SPACE ANALYSIS

This DSA shows a temporal and spatial mismatch between the influence of the MSFD and CFP and Black Sea stocks and catch of small pelagic fish.

Click here to see the poster in full screen

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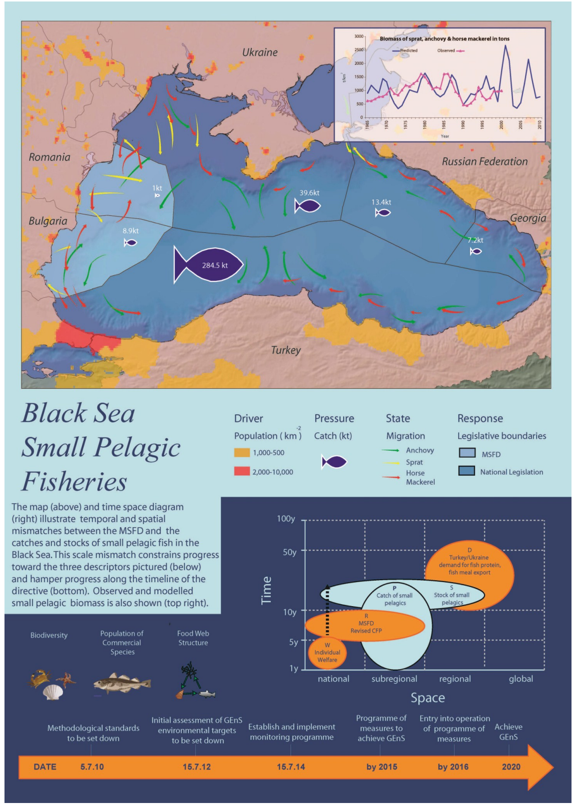
Decision Space Analysis — Example 1

A DSA to illustrate where the EU policy instrument (MSFD & CFP) cannot match the scale of the issue, which operates at the regional sea level, the majority of which is outside the jurisdiction of the EU.



This analysis shows a:

- Temporal mismatch— the time to deplete the stock (P) and time for recovery (S) is longer than the legislative Responses provided by the MSFD affecting the welfare of EU fishers (see time and space diagram).
- Spatial mismatch - the legislative Response cannot address Stock levels (P) and their recovery (S) because the majority of the fishery occurs outside of EU waters (see map and graph of trends).

For both scales the driver (global demand for fish protein) is beyond the influence of EU legislation. What this means is that the ability of the EU countries Bulgaria and Romania to reach a GES of maximum sustainable yield by 2020 for the fishery (see Indicators, timeline and T&S diagrams) is undermined by the limits of influence of EU EEZs and individuals trading-off short term welfare over long term stability of the ecosystem.

The DSA illustrates that fisheries management for the Black Sea requires cooperative agreement for the fishery beyond the scope of EU legislation otherwise both short term welfare for EU fishers as well as long term sustainability are lost.

DECISION SPACE ANALYSIS

This DSA shows that legislation under one directive (CAP) produces impacts that have to be managed by another piece of legislation (MSFD).

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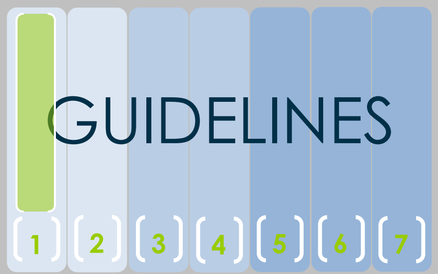
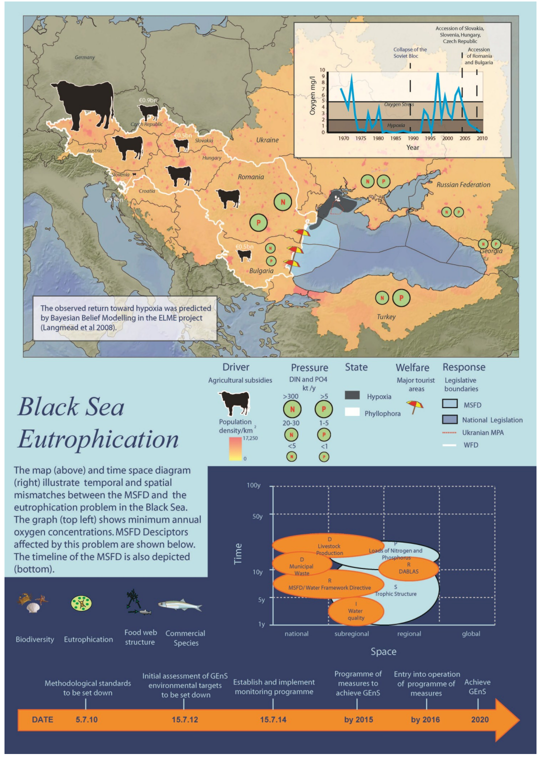


DSA

Decision Space Analysis — Example 2

A DSA to illustrate where there is conflict in the scales of two EU policy instruments (the MSFD and CAP) where the drivers and pressures arise from one (CAP) but the impact (eutrophication) has to be managed by another (MSFD).



The analysis shows a:

- Temporal and spatial mismatch between European legislation (R) and the sub-regional to regional pressures of nutrient loading (P) originating from the river basins (see map and T&S diagram) producing a State change (eutrophication) distant from the source of the cause.
- A temporal scale mismatch of environmental changes that can shift more rapidly than the legislative framework can respond, whilst recovery processes of the environment can be over much longer time scales than policy cycles of the legislation.

Some pressures are under EU jurisdiction but covered by legislation (CAP & WFD) that does not extend to where the problem is managed by the MSFD. The problem is compounded by pressures that originate from outside the EU EEZ over which it has limited control/influence.

The lack of a comprehensive and formalised institutional structure to make the necessary societal choices and the potentially long timeframes required to develop such a functional framework represent a serious constraint to management of Regional seas.

DECISION SPACE ANALYSIS

There are nine possible visual elements to a DSA, which can feature all nine components or a subset depending on the information that needs to be conveyed.

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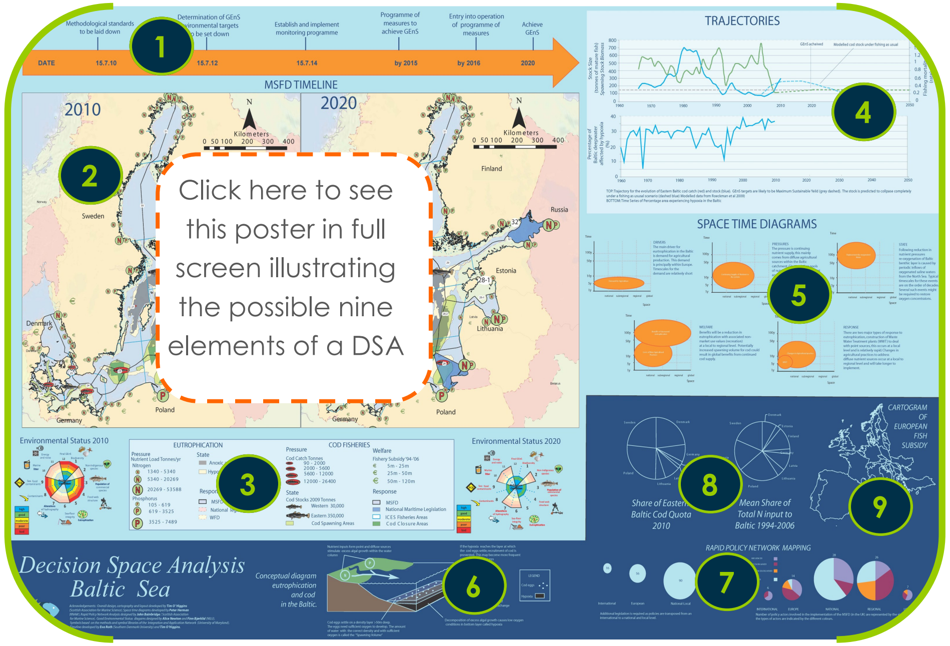
Components of a Decision Space Analysis

Communicating an understanding of spatial and temporal mismatches to decision makers is key to effective implementation of the ecosystem approach.



1. **Timeline**
2. **Decision Space Maps**
3. **GES status diagrams**
4. **Trajectories of parameters required for GES**
5. **Space Time Diagrams for DPSWR**
6. **A conceptual diagram**
7. **Rapid Policy Network Mapping results**
8. **Summary pie charts**
9. **A cartogram**

A Decision Space Analysis can illustrate :

1. Quantitative information about the spatial and temporal scales of phenomena pertaining to the ecosystem is illustrated by elements 1 to 5.
2. Information that provides a more general context is illustrated by elements 6 to 9.

Treated academically, the issue of scale mismatches may appear to be highly theoretical. DSA provides a more practical means of communicating these important concepts.

DECISION SPACE ANALYSIS

The MSFD places a scientific burden and strict time constraints on EU member states to achieve Good Environmental Status (GES) by 2020. Communicating the science base to decision makers is a critical element of the MSFD.

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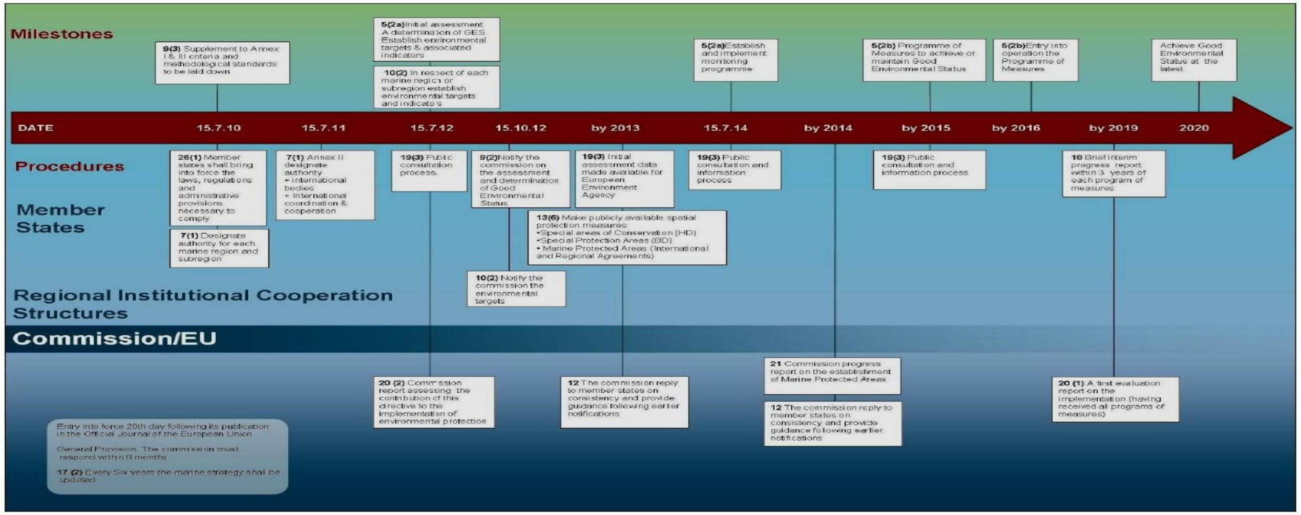
Understanding space and time scales

It is important that decision makers are aware of the timeline for milestones in the management process that they must meet and the procedures they should adhere to.

1. Timeline

There are five major steps that make up the process of achieving final delivery of Good Environmental Status (GES) in 2020 , these are: input, output and spatial control measures; management coordination measures; measures to improve traceability of pollutants; economic incentives; mitigation measures and methods for communication and stakeholder involvement.



Because the key criterion of the MSFD is reaching GES the timeline shows clearly the deadlines for scientific milestones that must be reached by each member state under the directive, which can be compared with the trajectories required to reach GES.

Incorporating a realistic timeframe for biological issues and legal processes, coupled with understanding scale mismatches, is an important element to set feasible targets for GES.

DECISION SPACE ANALYSIS

Maps provide a means of rapidly communicating large amounts of different types of information to decision makers. Knowledge is presented in a summary and visual form that a non-expert can understand.

Understanding space and time scales

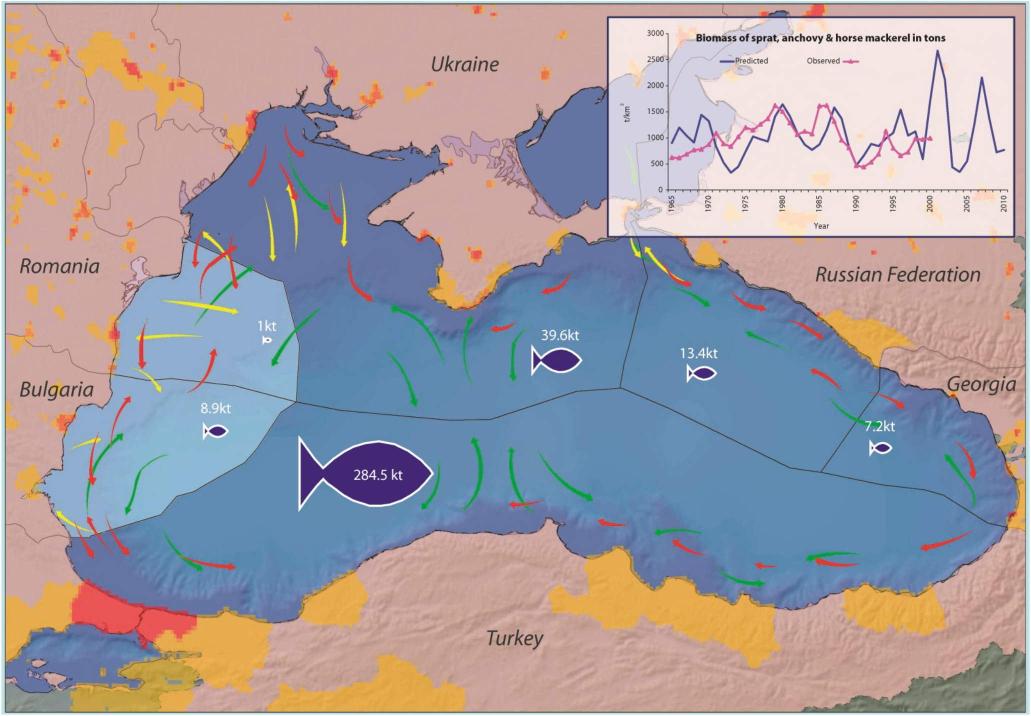
A decision space map presents the DPSWR elements in the context of the area of interest and communicates mismatches in their spatial and temporal scale.

2. Decision Space Maps

A map serves as a decision support tool, allowing easy, reliable and informative visualisation of the geographic scope and scale of problems as well as the sphere of influence of the relevant legislation.

Knowledge is presented in a summary and visual form that a non-expert can understand. The use of symbols rather than words avoids misinterpretation and language differences, as well as helping discussion and engagement with the story they reveal.

(The map illustrates a temporal and spatial mismatch between the MSFD, CFP and Black Sea stocks and catch of small pelagic fish)



A map helps communicate the complex interactions between the physical and biological systems with social systems to apply an ecosystem approach to management.

DECISION SPACE ANALYSIS

Each descriptor of GES has a set of criteria and indicators that describe features to make them concrete and quantifiable.

Click here for a breakdown of GES terminology (N.B. External website)

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Understanding space and time scales

The MSFD sets out eleven high level descriptors of Good Environmental Status (GES) that describe what the environment will look like when GES has been achieved.

3. GES diagrams

GES means that different uses made of marine resources are conducted at a sustainable level, ensuring their continuity for future generations. A first key milestone is when each member state identifies which descriptors are relevant for issues (e.g. fisheries, eutrophication) affecting their marine waters and the target status that each descriptor will need to be at in 2020 in order to achieve an overall classification of GES.

The status diagram provides a means of displaying which criteria and indicators for each descriptor are relevant to the issues in an area that are to be used to assess GES, and illustrates the status of the descriptors at any time using a simple traffic light scheme for GES or Not GES. This includes several categories for descriptors which are also in the WFD.

Click here for more on GES

GEnS not acheived	GEnS not acheived	GEnS	DESCRIPTOR	GEnS not acheived
X			1. Biodiversity	X
✓			2. Non-inigenous species	✓
✓			3. Populations of commercial species	✓
X			4. Food Web Structure	X
X			5. Eutrophication	X
✓			6. Sea Floor Integrity	✓
✓			7. Alterations to hydrography	✓
X			8. Contaminants	X
X			9. Sea-food Contaminants	X
X			10. Marine Litter	X
✓			11. Energy and Noise	✓

The use of symbols and recognisable colour codes facilitates science communication with decision makers and help highlight areas where new policy and/or management will be required.

DECISION SPACE ANALYSIS

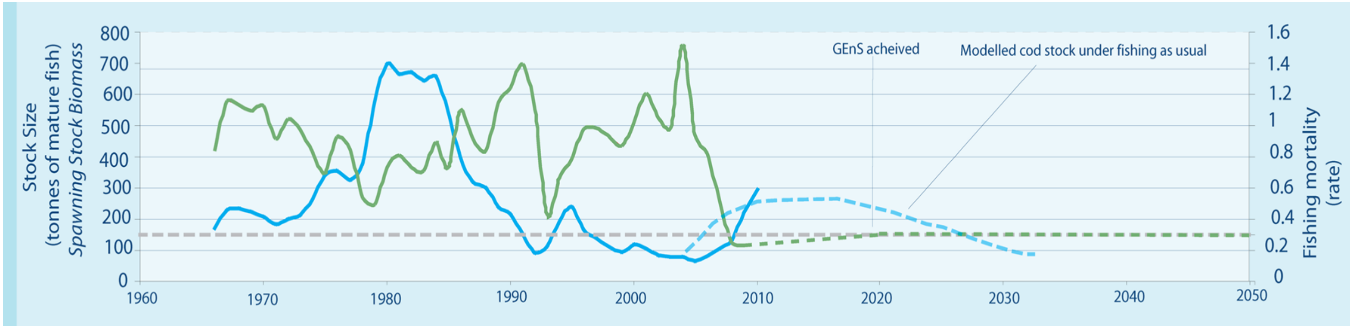
Targets set for descriptors of GES will be achieved not only by policy responses, but also from the legacy of patterns of change in the past, which could have their origins in natural cycles and/or human activities.

Understanding space and time scales

Trajectories can show both past changes in an ecosystem element and likely consequences of business as usual and policy responses based on past trends of natural cycles and/or previous policy interventions.

4. Trajectories of parameters required for GES

Often policy responses designed today to improve future states must take into account historical legacies, otherwise there is a risk a management decision might worsen existing trends.

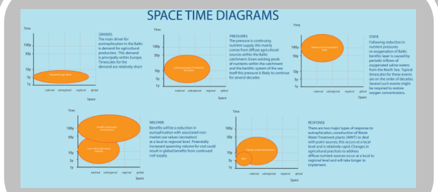


The figure shows a time series of historical data for cod stock size (blue line) and catch (green line) along with a projected future trajectory of stock size under a fishing as usual scenario (dashed blue line). The dashed grey line indicates Maximum Sustainable Yield which is the proposed indicator of GES. This trajectory shows that a gradual increase in fishing pressure over the next decade may achieve GES (dashed green line) but that this might not ensure the persistence of the Eastern Baltic cod stock over time, which is predicted to collapse completely under a fishing as usual scenario (dashed blue line drops beneath dashed green line).

Trajectory diagrams illustrate the trends of key drivers and can show 'business as usual' scenarios as well as the planned impact of policy responses.

DECISION SPACE ANALYSIS

Click on the diagram below for an example of time and space boundaries of DPSWR elements for the Baltic Sea.



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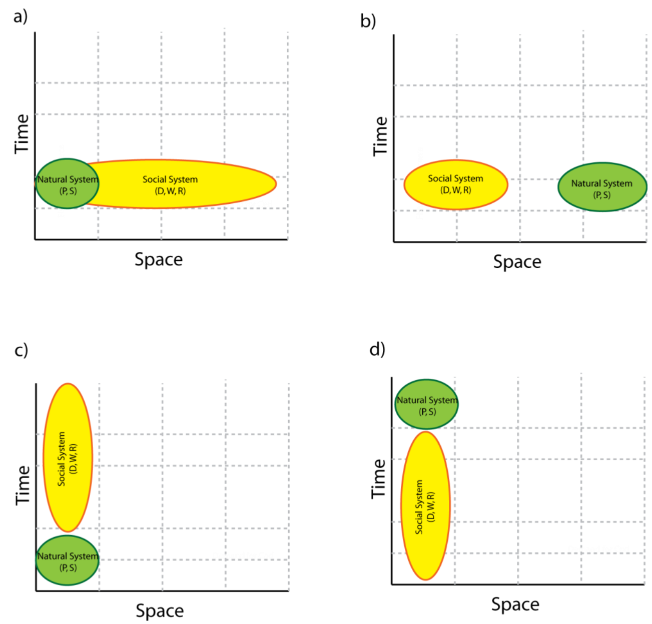
Understanding space and time scales

Policy failures can often be traced to mismatches between the scales of pressures, state changes of the natural system, welfare impacts and responses of governance systems in terms of intensity, space and time.

5. Space Time Diagrams for DPSWR

Management of social-ecological systems is disrupted when there are mismatches in scale and alignment between environmental variation and social organization. Space time diagrams for the DPSWR elements allow rapid understanding of the vastly different time and space scales for different aspects of the system. Mismatches in space can arise when social institutions work at a spatial scale that is broader than the ecological processes they seek to control (a) or in terms of the area covered by the data, such as when the authority of a social institution's function does not cover the whole of the area to be managed (b).



Time scale mismatches occur when rates of social, institutional and environmental change differ sufficiently such that management is unable to integrate the social and ecological parts of the system. The working of social institutions can be slower (c) or faster (d) than the changes in natural systems they seek to manage. Information from different sources can relate to different scales in relation to the geography of space and the time over which different social and natural systems work; this can be difficult for a non-expert to grasp.

Space time diagrams provide spatial and temporal context for a particular issues represented graphically; comparison of the scales of pressures, states and responses can help in identifying major gaps and mismatches for management interventions.

DECISION SPACE ANALYSIS

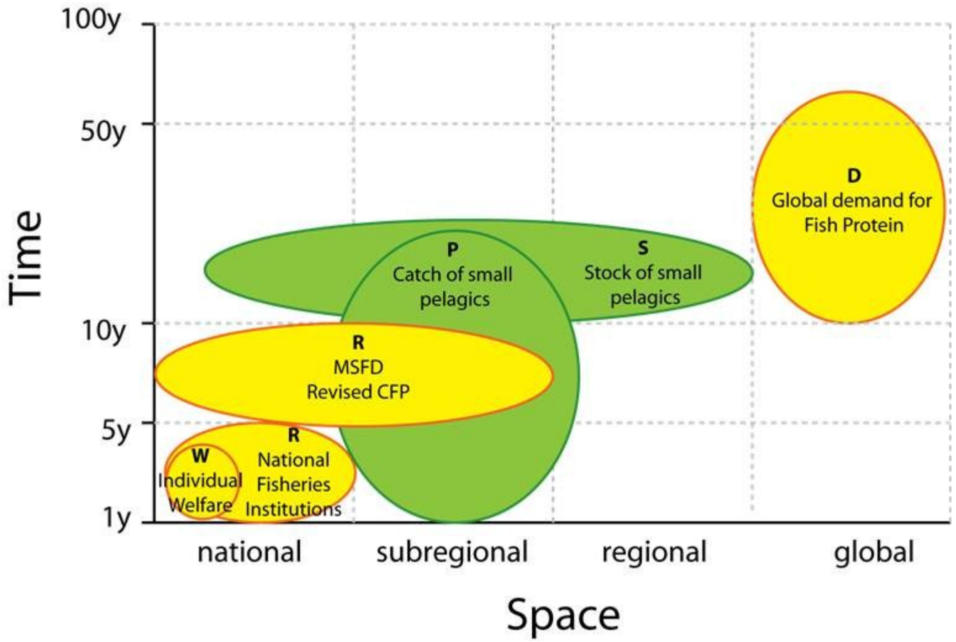
It is difficult to represent spatial and temporal scales of important processes (human and natural); how to visualise the scales of drivers (e.g. demand for fisheries products), or the time scale of responses (e.g. fishery policy initiatives).

Understanding space and time scales

A decision space map presents the DPSWR elements in the context of the area of interest and communicates mismatches in their spatial and temporal scale.

5. Space Time Diagrams for DPSWR continued

The example shows the scale of DPSWR elements for the small pelagic fisheries of the North-western shelf of the Black Sea. It shows that management of the demand for fish protein (**D**) is beyond the remit of existing EU legislation, so that management (**R**) operates on relatively short timescales compared to demand and pelagic fish stocks that recover on relatively long timescales (**S**). It also shows there is currently a mismatch between welfare (**W**) and stocks (**S**) because the timescale of welfare encourages short term gain without consideration of the longer timescale that will be required for the stocks to replenish. Management for this means that the requirement to reach Maximum Sustainable Yields (MYS) under the MSFD is undermined by the need to trade-off short term welfare over long term stability of the ecosystem.



A management Response may be directed towards any of the other elements (D, P, S or W) to achieve a balance between benefits of economic and social development and ecosystem costs.

DECISION SPACE ANALYSIS

Policy-making informed by scientific evidence requires both scientists and policy-makers to share a common understanding of the contextual setting to a problem in order to provide a baseline and foundation for dialogue.

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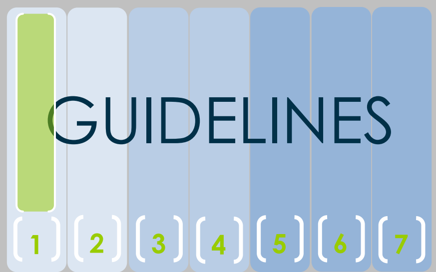


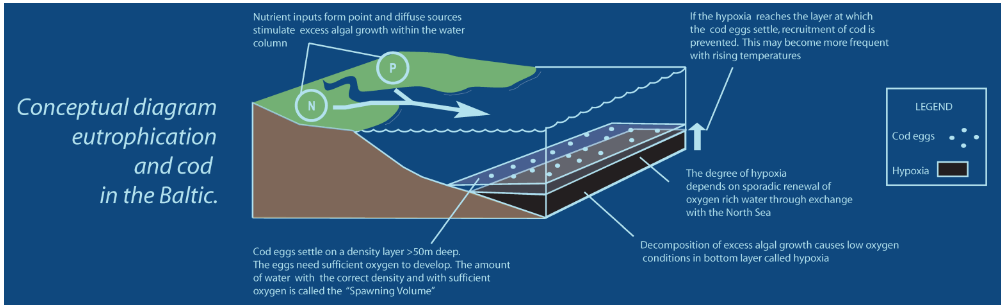
DSA

Understanding space and time scales

Context promotes enhanced and ongoing engagement between scientists and policy-makers to maximise the impact of the science evidence.

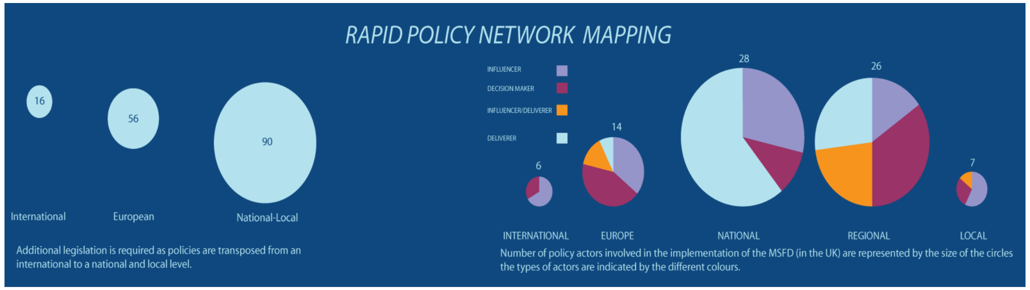
6. Conceptual diagram

A conceptual diagram is a visual representation of how a system works. This Figure summarises the relationship between eutrophication and cod spawning in the Baltic. It highlights the general functioning of the system and includes nutrient inputs, eutrophication and hypoxia as well as the concept of spawning volume.



7. Rapid Policy Network Mapping

Rapid Policy Network Mapping (RPNM) illustrates policy context, including policy instruments and the role of actors in implementing policy decisions. The example shows that the amount of legislation increases as policy is passed from International to local levels, and number and type of institutions involved at different institutional levels from local to international.



Context needs to be presented in a visual form to overcome barriers of expert mysticism and/or inaccessible terminology.

DECISION SPACE ANALYSIS

Decision Space Analysis overcomes communication barriers through provision of relevant information in an accessible format that graphically conveys the spatial and temporal characteristics of the DPSWR for a given system.

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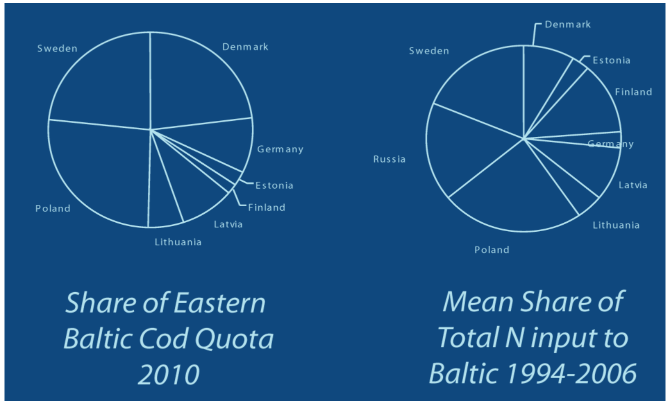
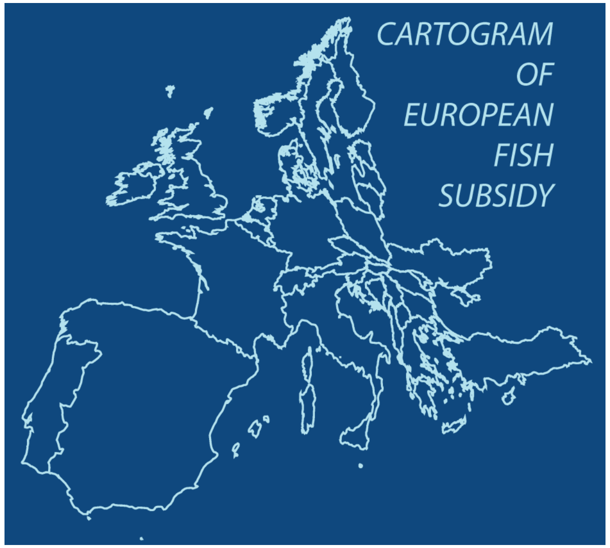
Understanding space and time scales

Comparison between elements of a visual representation can show mismatches between, for instance, contributors and beneficiaries to an issue.

8. Summary pie charts

Any relevant statistical figures can be displayed as pie charts that give an immediate idea of the likely degree of interest in the issue as well as showing the relative inputs that different contributors make to a problem.



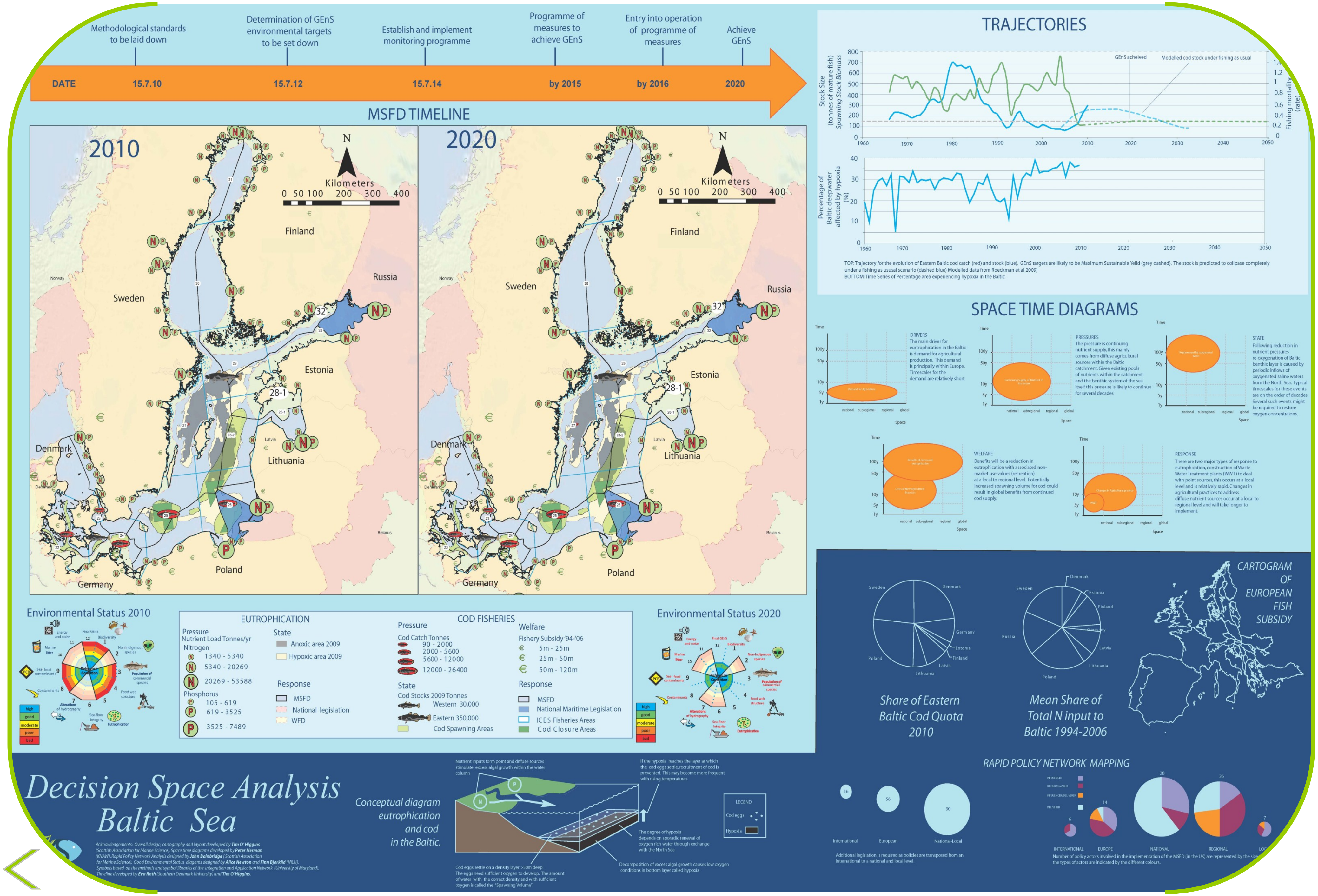


9. A cartogram

A cartogram represents the geographical distribution of statistical data on a map with each element scaled according to the statistical data rather than their actual area. The distortion of shape and size of a country, compared to its actual shape and size, can give a continent wide perspective on the relative size of, for instance, the fishery subsidy in each nation; this gives a broader context to the issue in the particular regional sea.

Decision space analysis is an important step towards integration and communication of data required to implement the MSFD and to understand the spatial and temporal mismatches which can obstruct the process.

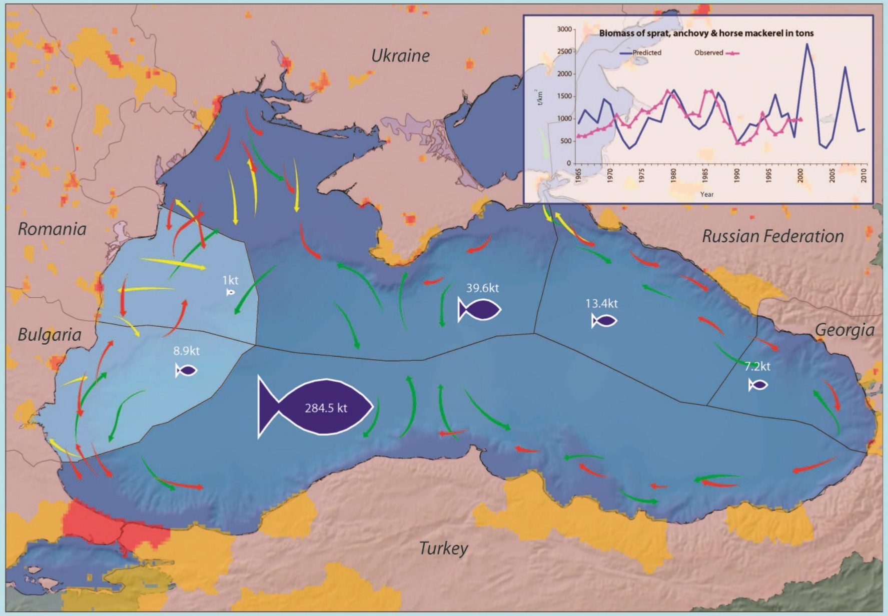
Click on arrow below to go back to all guidelines


Methodological standards to be laid down
Determination of GEnS environmental targets to be set down
Establish and implement monitoring programme
Programme of measures to achieve GEnS
Entry into operation of programme of measures
Achieve GEnS
DATE
15.7.10
15.7.12
15.7.14
by 2015
by 2016
2020
MSFD TIMELINE
2010
2020
N
Kilometers
0 50 100 200 300 400
Finland
Sweden
Russia
Estonia
Lithuania
Denmark
Poland
Germany
TRAJECTORIES
Stock Size (tonnes of mature fish) Spawning Stock Biomass
Fishing mortality (rate)
GEnS acheived
Modelled cod stock under fishing as usual
Percentage of Baltic deepwater affected by hypoxia (%)
TOP: Trajectory for the evolution of Eastern Baltic cod catch (red) and stock (blue). GEnS targets are likely to be Maximum Sustainable Yeild (grey dashed). The stock is predicted to collpase completely under a fishing as usual scenario (dashed blue) Modelled data from Roeckman et al 2009)
BOTTOM: Time Series of Percentage area experiencing hypoxia in the Baltic
SPACE TIME DIAGRAMS
DRIVERS
PRESSURES
STATE
WELFARE
RESPONSE
Time
Space
national subregional regional global
Environmental Status 2010
EUTROPHICATION
Pressure
Nutrient Load Tonnes/yr
Nitrogen
1340 - 5340
5340 - 20269
20269 - 53588
Phosphorus
105 - 619
619 - 3525
3525 - 7489
State
Anoxic area 2009
Hypoxic area 2009
Response
MSFD
National legislation
WFD
COD FISHERIES
Pressure
Cod Catch Tonnes
90 - 2000
2000 - 5600
5600 - 12000
12000 - 26400
State
Cod Stocks 2009 Tonnes
Western 30,000
Eastern 350,000
Cod Spawning Areas
Welfare
Fishery Subsidy '94-'06
5m - 25m
25m - 50m
50m - 120m
Response
MSFD
National Maritime Legislation
ICES Fisheries Areas
Cod Closure Areas
Environmental Status 2020
high
good
moderate
poor
bad
CARTOGRAM OF EUROPEAN FISH SUBSIDY
Share of Eastern Baltic Cod Quota 2010
Mean Share of Total N input to Baltic 1994-2006
RAPID POLICY NETWORK MAPPING
International
European
National-Local
Additional legislation is required as policies are transposed from an international to a national and local level.
INTERNATIONAL
EUROPE
NATIONAL
REGIONAL
Decision Space Analysis Baltic Sea
Conceptual diagram eutrophication and cod in the Baltic.
Nutrient inputs form point and diffuse sources stimulate excess algal growth within the water column
If the hypoxia reaches the layer at which the cod eggs settle, recruitment of cod is prevented. This may become more frequent with rising temperatures
The degree of hypoxia depends on sporadic renewal of oxygen rich water through exchange with the North Sea
Cod eggs settle on a density layer >50m deep. The eggs need sufficient oxygen to develop. The amount of water with the correct density and with sufficient oxygen is called the "Spawning Volume"
Decomposition of excess algal growth causes low oxygen conditions in bottom layer called hypoxia
LEGEND
Cod eggs
Hypoxia

GEnS

DESCRIPTOR	GEnS not acheived	GEnS acheived	GEnS
1. Biodiversity			X
2. Non-inigenous species			✓
3. Populations of commercial species			✓
4. Food Web Structure			X
5. Eutrophication			X
6. Sea Floor Integrity			✓
7. Alterations to hydrography			✓
8. Contaminants			X
9. Sea-food Contaminants			X
10. Marine Litter			X
11. Energy and Noise			✓

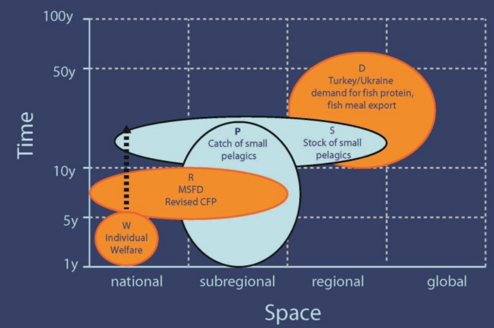
A "Mondrian" diagram (named after the style of artist Piet Mondrianis) is used to depict the 11 descriptors of **G**ood **En**vironmental **S**tatus. Each descriptor is represented by a unique visual symbol based on symbols developed by the Integration and Application Network (ian.umces.edu). Under the MSFD there are two possible classifications for a water body, GES is either "achieved" or "not achieved". This status under the MSFD for each descriptor is shown by the black X for "GES not achieved" or √ for "GES achieved". Other EU environmental directives relating to the marine environment do not use this simple binary classification. For example, under the Habitat directive there are three possible categories, favourable conservation status, inadequate status and bad status that are also accommodated in the Biodiversity descriptor on the Mondrian diagram. Under the Water Framework Directive there are five possible categories of environmental status, high, good, moderate, poor and bad that are also accommodated in the eutrophication descriptor on the Mondrian diagram. The relationships between the categories of environmental descriptors in different directives is set out in the Common Understanding Document.



Black Sea Small Pelagic Fisheries

Driver	Pressure	State	Response
Population (km^{-2})	Catch (kt)	Migration	Legislative boundaries
1,000-500		Anchovy	MSFD
2,000-10,000		Sprat	National Legislation
		Horse Mackerel	

The map (above) and time space diagram (right) illustrate temporal and spatial mismatches between the MSFD and the catches and stocks of small pelagic fish in the Black Sea. This scale mismatch constrains progress toward the three descriptors pictured (below) and hamper progress along the timeline of the directive (bottom). Observed and modelled small pelagic biomass is also shown (top right).

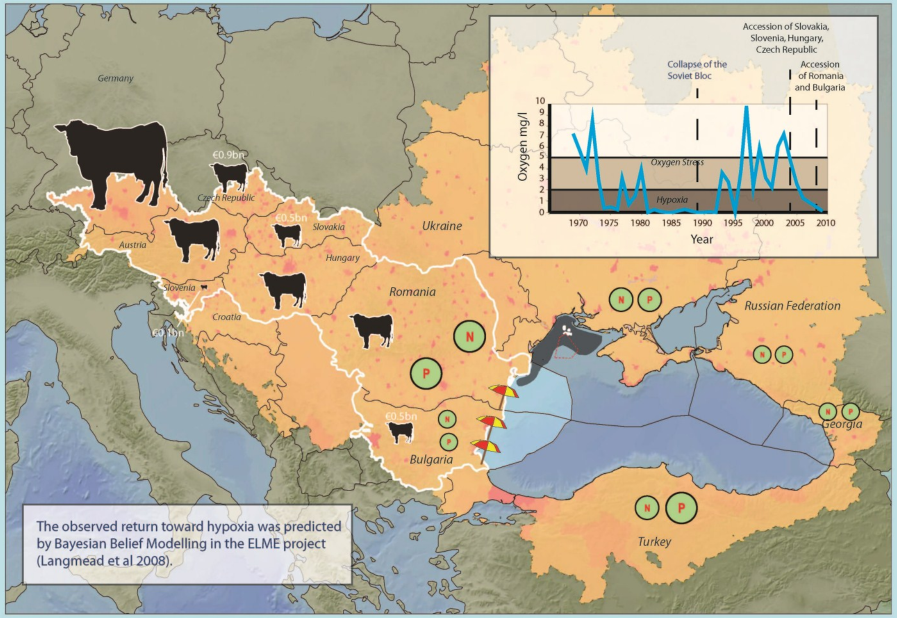


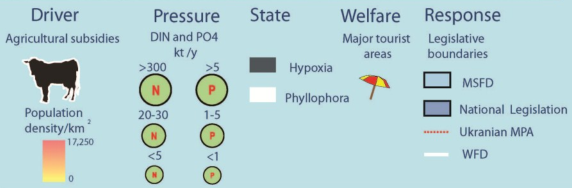
Biodiversity

Population of Commercial Species

Food Web Structure

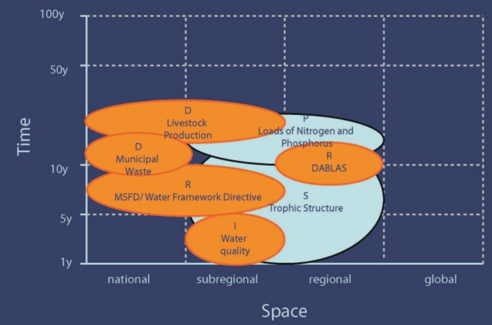
DATE	5.7.10	15.7.12	15.7.14	by 2015	by 2016	2020
	Methodological standards to be set down	Initial assessment of GEnS environmental targets to be set down	Establish and implement monitoring programme	Programme of measures to achieve GEnS	Entry into operation of programme of measures	Achieve GEnS





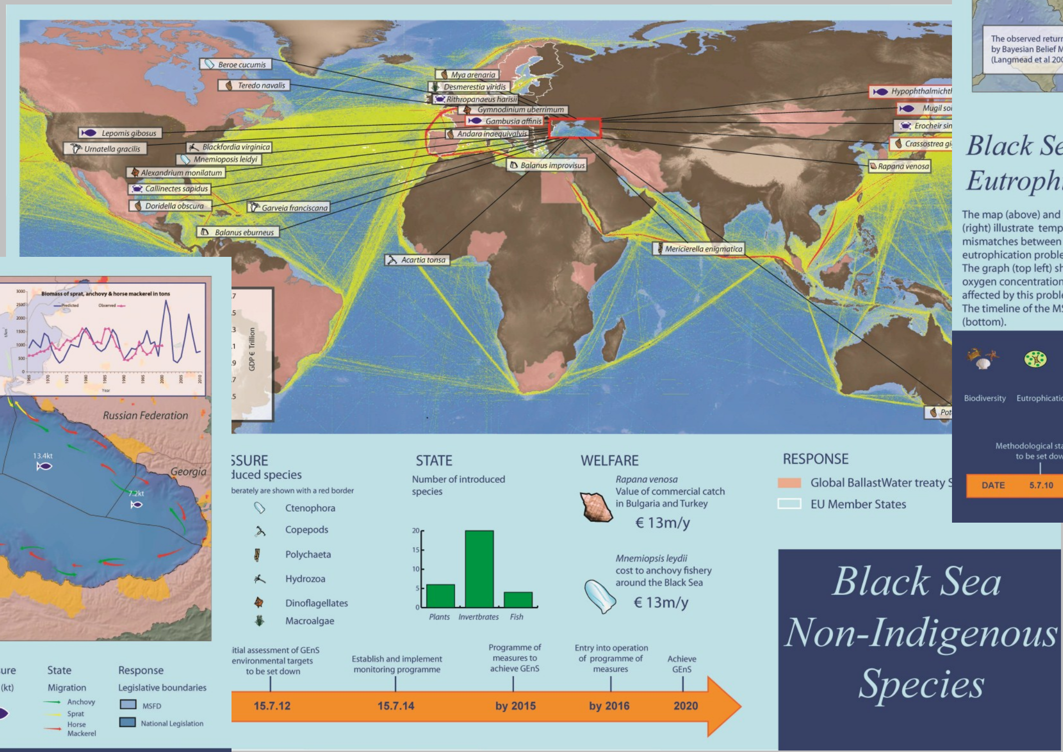
Black Sea Eutrophication

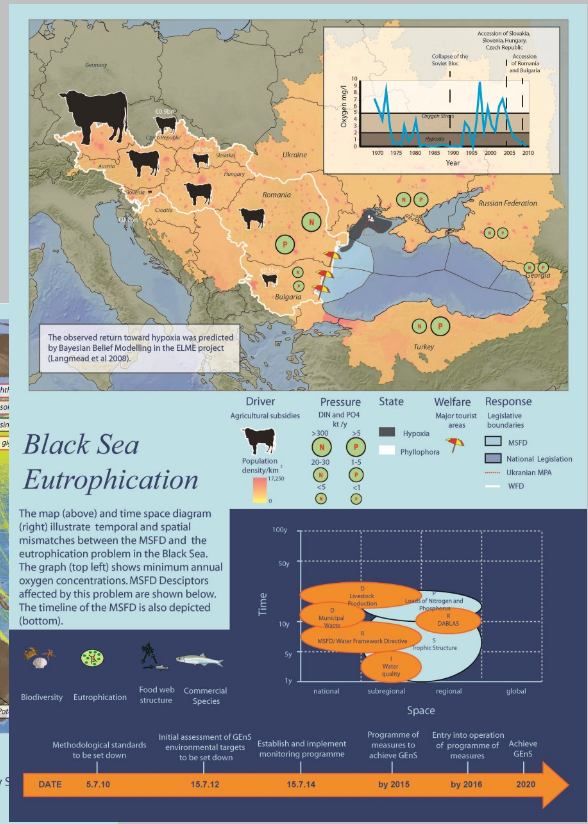
The map (above) and time space diagram (right) illustrate temporal and spatial mismatches between the MSFD and the eutrophication problem in the Black Sea. The graph (top left) shows minimum annual oxygen concentrations. MSFD Desciptors affected by this problem are shown below. The timeline of the MSFD is also depicted (bottom).

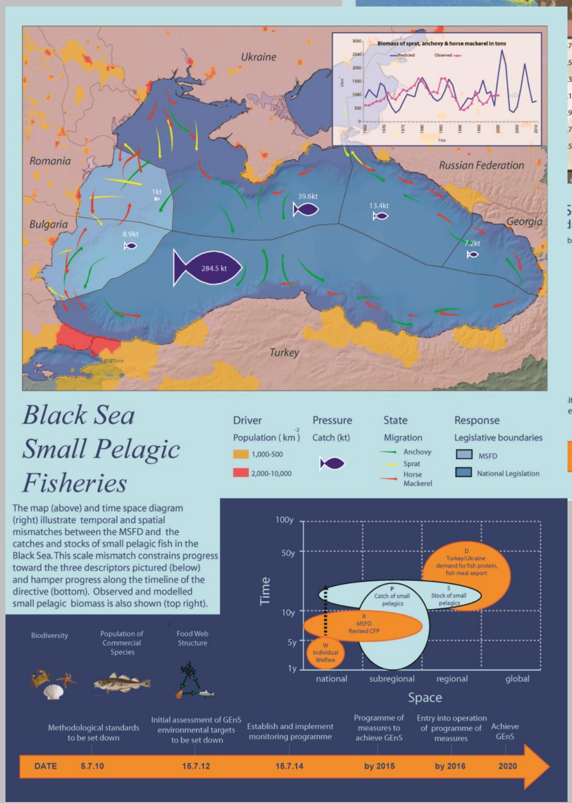


Black Sea DSA

Only DSA components that best convey the key policy relevant scientific information are included as seen in this Black Sea example.







A framework for the analysis of environmental problems and sustainable development that reveals the complexity in social ecological systems is the Driver-Pressure-State-Impact-Response (DPSIR) approach. Confusion arises over the term 'Impact' which is often described in terms of changes to the environment when it is really meant to reflect changes in **human welfare**. For this reason **Knowseas** has proposed using Driver-Pressure-State-Welfare-Response (DPSWR) where:

[D]

Drivers are changes to social and environmental systems and are largely economic and socio-political (industrial or agricultural development, trade, regulations, subsidies, etc.) and often reflect the way benefits are derived from ecosystem goods and services.

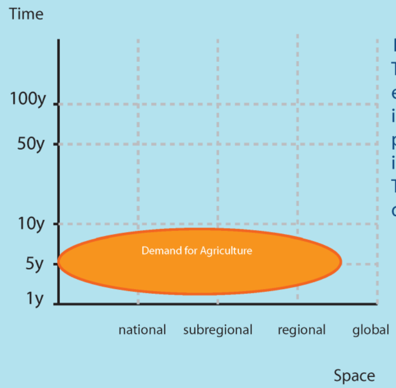
[P]

Pressures are the ways these Drivers burden the environment (agricultural run-off of nutrients, pollution discharges, bottom trawling, introduction of alien species, etc.).

[S]

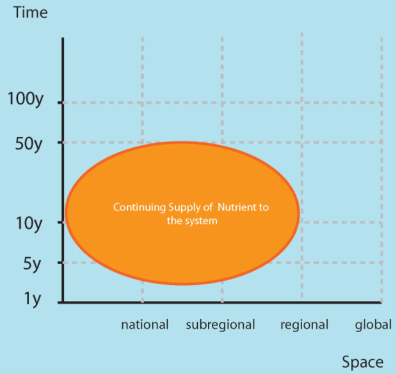
State change is a measure (or proxy) of the consequences of Pressures on species or ecosystems.

SPACE TIME DIAGRAMS



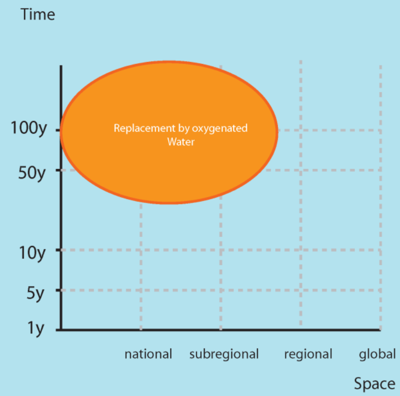
DRIVERS

The main driver for eurtrophication in the Baltic is demand for agricultural production. This demand is principally within Europe. Timescales for the demand are relatively short



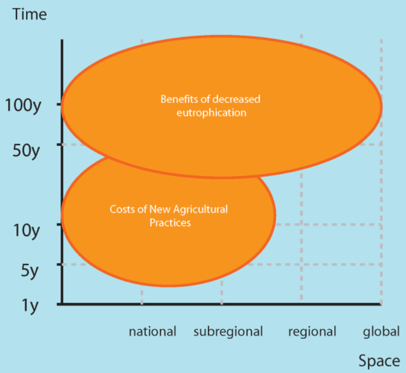
PRESSURES

The pressure is continuing nutrient supply, this mainly comes from diffuse agricultural sources within the Baltic catchment. Given existing pools of nutrients within the catchment and the benthic system of the sea itself this pressure is likely to continue for several decades



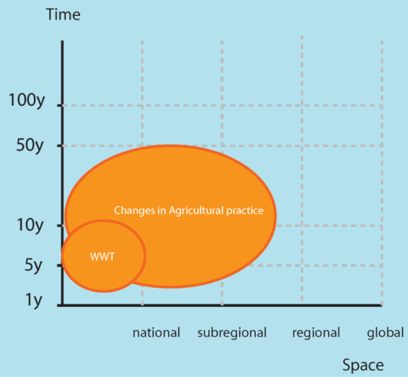
STATE

Following reduction in nutrient pressures re-oxygenation of Baltic benthic layer is caused by periodic inflows of oxygenated saline waters from the North Sea. Typical timescales for these events are on the order of decades. Several such events might be required to restore oxygen concentraions.



WELFARE

Benefits will be a reduction in eutrophication with associated non-market use values (recreation) at a local to regional level. Potentially increased spawning volume for cod could result in global benefits from continued cod supply.



RESPONSE

There are two major types of response to eutrophication, construction of Waste Water Treatment plants (WWT) to deal with point sources, this occurs at a local level and is relatively rapid. Changes in agricultural practices to address diffuse nutrient sources occur at a local to regional level and will take longer to implement.

[W]

Welfare is a measure of changes (the "costs") to human welfare as a result of State changes (including indirect effects such as the knowledge that a species is endangered).

[R]

Response is the way society attempts to reduce Impact or compensate for it through a policy response that is directed to addressing the causes of a problem, and which can be directed at any element (D, P, S or W) in an effort to achieve a balance between the benefits of economic and social development and the ecosystem costs.

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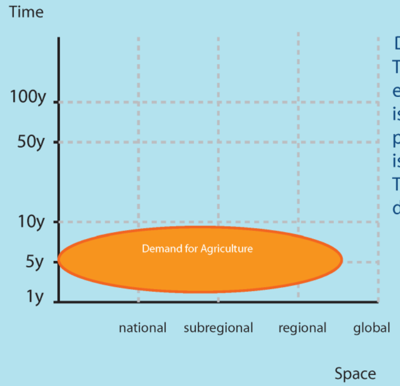
SPACE TIME DIAGRAMS - A DPSWR analysis in the Black Sea



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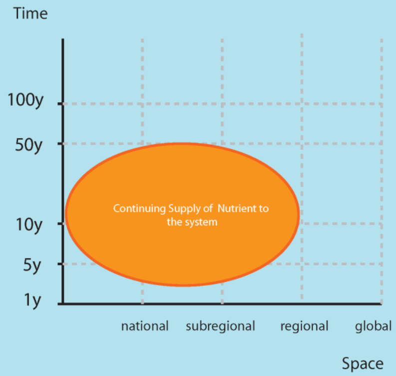

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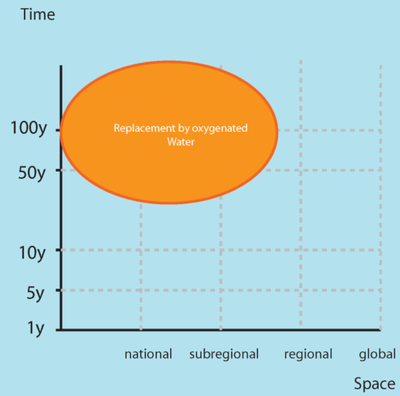

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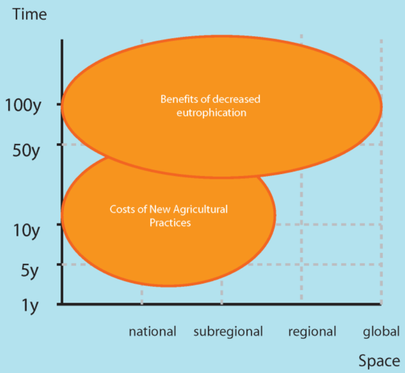

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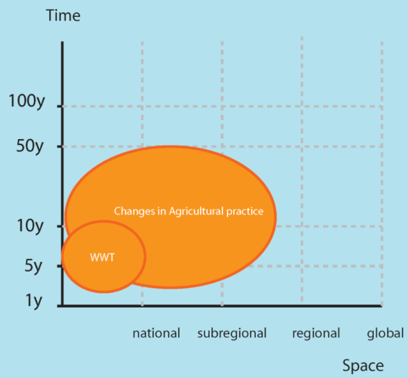

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