SEVENTH FRAMEWORK PROGRAMME
THEME 6

Environment (Including Climate Change)

Bologna Scenario Definition Workshop Report

Proposal Acronym: **MEECE**

Proposal full title: **Marine Ecosystem Evolution in a Changing Environment**

Grant agreement no: **212085**

Date of preparation of report: **06/2010**

MEECE scenario definition workshop
Bologna 8-9th June 2010

1. Introduction

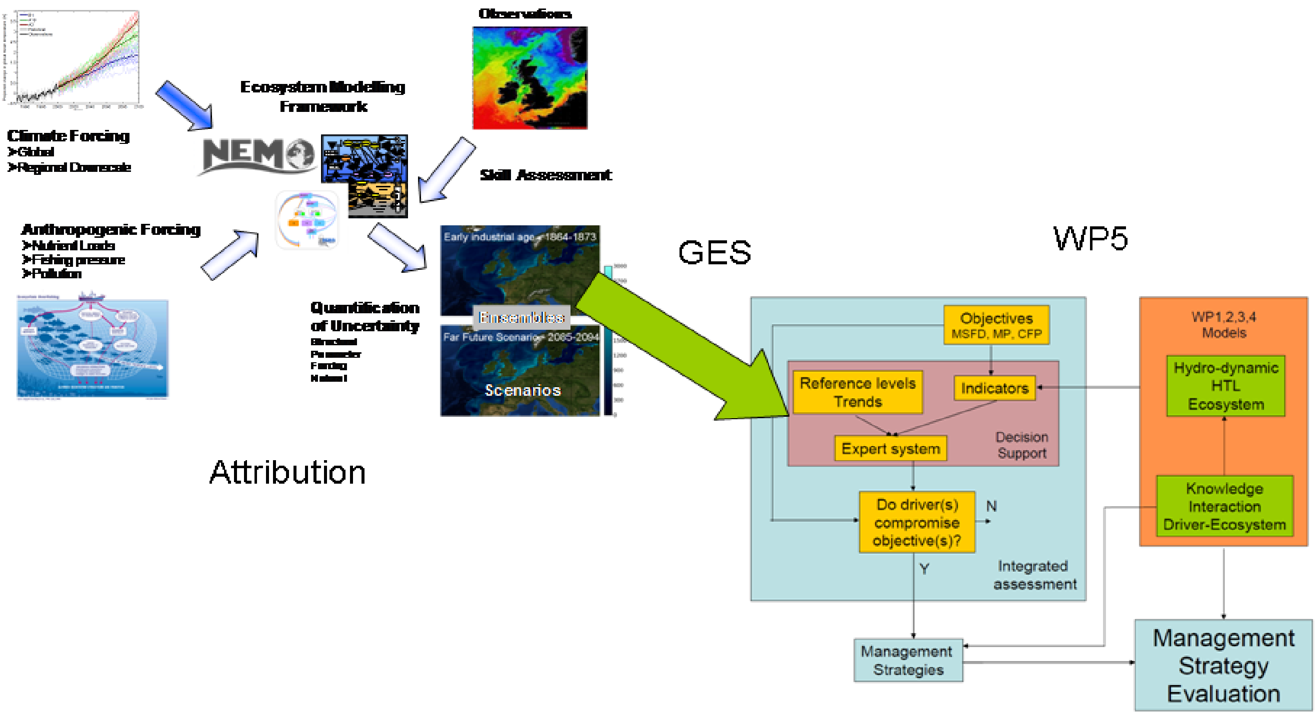
A two day workshop was held at the University of Bologna to help define the scenario to be run in WP3 and 4 of the MEECE project.

The goal of the meeting was to:

- To define and agree all the scenarios to be run in WP3 and WP4
- To establish a timetable for delivery of said scenarios
- To design experiments which allow the attribution of multiple drivers
- To select relevant indicators of GES for input to WP5 (with estimates of skill where possible)

The meeting began with an overview of the progress in WP3 and 4 by Marco Zavatarelli followed by a keynote talk from John Pinnegar (Cefas) on scenario design. Gerjan Piet then presented WP5 and the links of model output to indicators of good ecological status for the MSF (Fig 1). Each of the partners then presented the progress of each individual group. All of the presentations are posted on the MEECE website (http://www.meece.eu/meetings/bologna/scenarios.html). The rest of the meeting was devoted to mapping indicators onto model outputs and scenario definition. A spreadsheet summarising this activity has been prepared and will be used to define key model outputs for the scenarios. The scenarios will use the SRES AR4 storylines (Fig. 2, as interpreted by the ELME project – www.elme-eu.org; Appendix 2) to define our scenarios for fishing, nutrients and pollution (Appendix 1). The storylines follow the four-quadrant approach, whereby the future 'possibility-space' is divided, based on two axes or dimensions. The approach has become commonplace following its earlier adoption by the Intergovernmental Panel on Climate Change (IPCC). The basis of the 4-quadrant model is the identification of the two driving forces with the greatest importance and the highest uncertainty. Many existing scenario exercises seem to have also chosen similar criteria to define their 'possibility-space', with an axis representing 'local to global' and an axis representing 'community to consumerism'. Summaries of these scenarios follow.

Figure 1. Summary diagram of approach and linkages in WP's 3, 4 &5 in MEECE



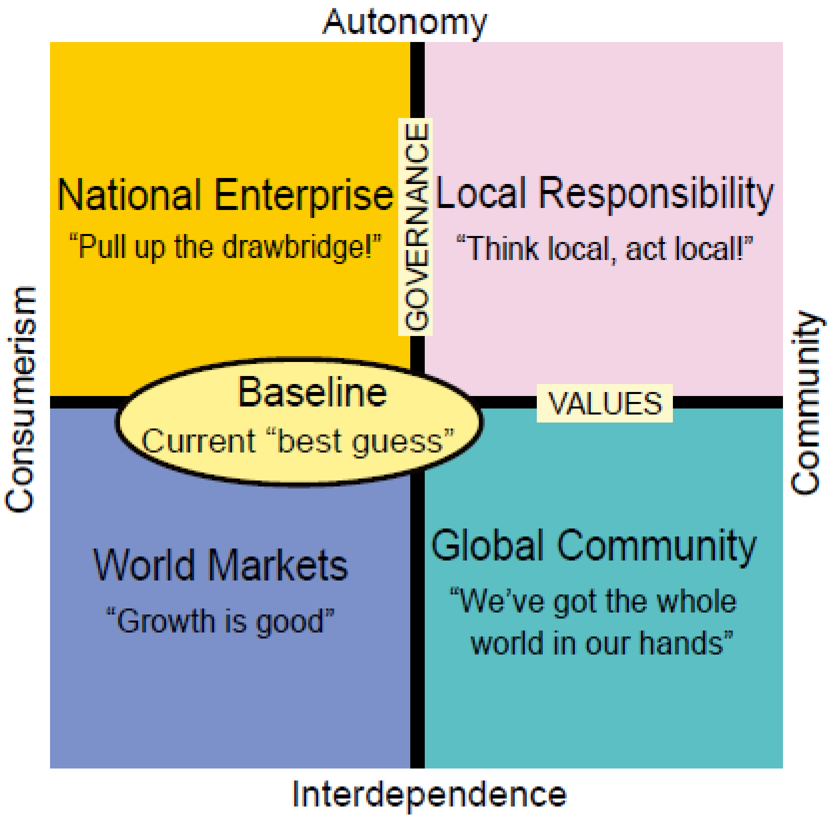


Figure 2. Schematic of the ELME interpretation of the AR4 storylines.

A1: World markets: *Technology and markets fail to deliver sustainable solutions*

- People aspire to personal independence, material wealth and greater mobility, all of which have a negative effect on wider societal and environmental goals.
- Pressure grows to reduce taxes, and more public services are privatized or privately managed.
- Social and environmental governance is achieved through international legal frameworks setting minimum standards, and through market-based approaches.
- Marine ecosystems are heavily degraded by human activity.
- Increased pressures are placed on marine biological resources, either through utilization or through increasing levels of 'stressors' (for example, loss of habitats and changes in water quality).

A2: National Enterprise: *National identity gets in the way of global sustainability*

- People aspire to personal independence and material wealth but within a national cultural identity.
- The balance of opinion favours increased national isolation and independence in economic, foreign and defence policy.
- Long-term economic growth is limited by government policies, which protect important national industries.
- By 2020, marine ecosystems come under greater pressure than at present.

- Efforts to reduce the effects of human activity are abandoned where they conflict with issues of national self sufficiency.
- Large-scale, environmentally damaging projects such as tidal barrages and wide-scale oil exploration develop under the Fortress Britain scenario.
- Governments fail to deal with global problems.

B1: Global Community: ***International co-operation towards global sustainability***

- People aspire to high levels of welfare and **a healthy environment**, the best way to achieve these aims is through **international co-operation**.
- Sustainability is seen from a global viewpoint, including: **maintaining biodiversity**, **protecting global commons** and providing **fair access** to environmental resources.
- Policies are co-ordinated at the European Union and international level. This is a **high taxation** scenario.
- Major **investment in offshore renewable energy** projects.
- **Internationally agreed control measures** reduce the amount of pollution released into the marine environment.
- The health of the oceans across the world improves, although it is necessary to sacrifice some local areas for development.

B2: Local Responsibility: ***Tailored solutions for local problems***

- Public policies aim to promote economic activities that are **small scale and regional.**
- **Sustainable development** is a major aim of this scenario.
- An important focus is on using technology and new ideas to make the best use of **local and regional resources**. By 2020, this leads to **varied outcomes** in different parts of the UK.
- **Local communities** manage the marine environment.
- There are fewer invasive species, oil spills and less damage due to port development.
- Action is taken to reduce the effects of human activity at a local level, and this results in **a cleaner marine environment overall**.

We also need to consider the timeframes of the scenarios: In WP3 we focus on climate impacts. Climate impacts are only clearly demonstrated statistically in the forcing beyond 2040/2050, therefore we focus on time-slices for the period 2080-2100 to ensure we see a climate signal. In WP4 we focus more on anthropogenic drivers. The window of policy relevance is the next 20-30 years hence we focus on a time-slice 2030-2040.

Note: we are **ONLY** considering these scenarios to define direct anthropogenic perturbations. The basic emissions scenario we are using remains A1B (see below). We can justify using a fixed emission scenario on the basis that the SRES scenarios do not diverge strongly during the time frame of the WP4 experiments.

2. Summary of the scenarios

WP3: slightly revised from the discussion in SETE

To define the envelope of response to climate and circulation drivers of marine ecosystem function both on a global and a regional scale. Analyze the impact on ecosystems end to end of changes in:
temperature, circulation, mixing, acidification, and light, focusing on physics, biogeochemistry and ecosystem productivity and on higher trophic levels

The sub objectives are:
· To define common metrics and scenarios
· To run/analyze base-line and ensemble scenarios
· To synthesize results
· To contribute to knowledge transfer activities in WP6
These simulations are run with the drivers defined in WP4 set to their 'present-day values', so match the WP 4 reference simulation.

WP3.3 Plankton models (+OA module for WP2)

- Hindcast simulation (ERA40, IOP data forcing, MEECE river database)
- Time slices scenarios: IPSL climate model (see www.meece.eu)
- Recommended: 1980-2000; 2080-2100; A1B, A2, E1 (LUA2R2)
- ***Minimum: 1980-2000; 2080-2100; A1B (use member LUA1B2)***
- ***Key outputs as defined in indicators spreadsheet***

WP3.4 End to End (physics-plankton-HTL model) see table

- Hindcast simulation (ERA40, IOP data forcing, MEECE river database)
- Time slices scenarios: IPSL climate model (see www.meece.eu)
- Recommended: 1980-2000; 2080-2100; A1B, A2, E1 (LUA2R2)
- ***Minimum: 1980-2000; 2080-2100; A1B (use member LUA1B2)***
- ***Key outputs as defined in indicators spreadsheet***

The climate forcing data can be downloaded at
Hhttp://dods.extra.cea.fr/data/p48bopp/MEECE/IPSL_PISCES/

WP4

WP4 OBJECTIVES

- To define the envelope of response to combinations of direct anthropogenic drivers on marine ecosystem on a regional scale.
- Impact on ecosystems end to end of changes in pollution, fishing effort, fluvial nutrient and CDOM inputs.
- Focus on physics, biogeochemistry, ecosystem productivity, higher trophic levels.

The MEECE direct anthropogenic drivers (i.e. Drivers originating from a direct human pressure on the Marine environment:

- Eutrophicating substances (nutrients)
- Toxic substances (e.g: herbicides, antibiotics)
- Optically active substances (CDOM)
- Exploitation of living marine resources (Fishery)
- Introduction of invasive species

Table 4 (DoW)

Sub task	Region	Leader	Participants	Drivers
4.2.1	Barents sea	IMR	UNIFOB	Fisheries impact and inorganic pollutants
4.2.2	NW European Shelf	POL	PML	Eutrophication, sediment mediated optics and demersal trawling.
4.2.2	North Sea	CEFAS	POL DIFRES UNIFOB	Eutrophication and fisheries.
4.2.3	Baltic Sea	UNIFOB	DIFRES,	Eutrophication, dissolved organic matter, organic and inorganic pollutants, alien invasive species and fisheries
4.2.4	Biscay Bay	AZTI	IRD	Fishing
4.2.5	Black Sea	IMS-METU	CEFAS	Eutrophication, pollution and invasive species.
4.2.6	Adriatic	UNIBO	IRD	Eutrophication, land based inputs of dissolved organic matter, organic pollutants and fisheries
4.2.7	North Aegean Sea	HCMR	UNIBO, IRD	Eutrophication, land based inputs, organic pollutants and fisheries
4.2.8	Benguela	IRD	AZTI	Fishing.

Scenarios:

4.1. Hindcast scenarios to test driver sensitivity

Reference climate scenario for anthropogenic drivers: IPSL-CM4 A1B + Present Day drivers: 2030-2040.
Hhttp://dods.extra.cea.fr/data/p48bopp/MEECE/IPSL_PISCES/

Hindcast simulations of driver sensitivity (as appropriate for each region see table 1)

a) Eutropication + ERA40 + range of driver sensitivity: 5 years
b) Pollution; ERA40 + range of driver sensitivity: 2 years (copper, herbicides etc.)
c) Fishing: ERA40 + range of driver sensitivity: 5-20 years
d) CDOM: ERA40 + range of driver sensitivity: 2 years?

These hind cast simulations should be where possible for the most data rich period for each region. A subset of the main 45 yr hindcast should be run to explore the sensitivity of each region to specific drivers. The timescale have been chosen to reflect expected scales of response for each driver. These may need to be iterated.

4.2: Multiple Driver Scenarios

Climate + all regional drivers: 2030-2040 *Compulsory scenarios in bold.*

- **IPSL-CM4 A1B + SC1 world market (A1)**
- **IPSL-CM4 A1B + SC2 global commons (B1)**
- IPSL-CM4 A1B + SC3 Fortress nation (A2)
- IPSL-CM4 A1B + SC4 local stewardship (B2)

The exact perturbation of each driver to be guided by the ELME interpretations of each driver under these scenarios (http://www.elme-eu.org/ELME_Results.pdf). The sign of the perturbation should follow the trend of the relevant pressure/driver evidenced by the outcomes of ELME (the synoptic tables of the regional BBN models and/or the extended tables showing regional trends for the drivers in the different scenarios; **see annex 1**) while the magnitude of the perturbation could to be defined according to historical trends and/or natural variability.
Further work is required to finalise the details.

It was recognised the there is a tension between the storylines and the policy requirements of the EC particularly where the CFP is concerned. One suggestion is that the compulsory scenarios should be CFP relevant. In this case, an appropriate choice would be to choose Maximum Sustainable Yield scenarios and scenarios for limiting the by-catch and discarding of non-target species.

Appendix 1: ELME scenarios

Summary tables of the outcomes of the ELME interpretation of the 4 scenarios follow. The signs of these responses should be used to define the direction of change in the multiple driver scenarios. Full details can be found at http://www.elme-eu.org/ELME_Results.pdf

North-East Atlantic

Scenario outcomes

Outcomes of the Baseline scenario and four alternative scenarios from the North Sea simulation model are shown below. The driver component determines the conditions that forced the simulation for each scenario, while pressures and states are the responses to these combinations of drivers. Arrows indicate the direction of changes relative to the current situation.

↑ Large increase
↗ Increase
→ Stable
↘ Decrease
↓ Large decrease

		Current Trend	Baseline Scenario	Scenarios (relative to current)			
				National Enterprise	Local Responsibility	World Markets	Global Community
DRIVERS	UWWT	↗	↗	→	↗	→	↗
	Industrial discharge	↘	↘	→	↓	↓	↓
	Fossil fuel en. gen.	↘	↗	↑	↘	↑	→
	N fertiliser use	↘	→	↗	↘	↗	→
	P fertiliser use	↘	↘	→	↓	→	↘
	Livestock prod.	↗	→	→	↘	→	→
	Dredg. & spoil disp.	↗	↗	→	↘	↑	↗
	Dredg. & trawl effort	↘	→	↗	↘	→	↘
	Fishing effort	↘	→	→	↘	↗	→
PRESSURES	[PCB] seawater	↘	↘	→	↓	↘	↓
	[Cd] seawater	↘	↘	↗	↓	↗	↓
	Total nitrogen	↘	↘	↗	↘	↗	↘
	Total phosphorus	↘	↘	→	↓	→	↘
	TSS	↘	→	↗	↘	→	↘
	Demersal catch	↘	↘	→	↓	↘	↓
	Pelagic catch*	→	→	→	↗	↘	→
STATES	[PCB] mussels	↘	→	→	→	→	→
	[Cd] mussels	↘	↘	↗	↓	↗	↘
	Eutrophication	↗	↗	↘	↑	↘	↑
	TWB status	↗	↗	↘	↗	↑	↑
	Waterfowl abund.	↘	↘	→	↘	↓	↓
	Submarine sediment hab.	↘	↘	↘	↗	↓	↘
	Demersal stocks	↘	↗	→	↑	↗	↑
	Seabird abundance	↘	→	→	↗	↘	→
	Pelagic stocks*	→	→	→	↗	↘	→

*trend for sandeels is ↗ and herring ↘

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Mediterranean Sea

Scenario outcomes

Outcomes of the Baseline scenario and four alternative scenarios from the Mediterranean Sea simulation model are shown below. The driver component determines the conditions that forced the simulation for each scenario, while pressures and states are the responses to these combinations of drivers. Arrows indicate the direction of changes relative to the current situation.

↑ Large increase
↗ Increase
→ Stable
↘ Decrease
↓ Large decrease

		Current Trend	Baseline Scenario	Scenarios (relative to current)			
				National Enterprise	Local Responsibility	World Markets	Global Community
DRIVERS	Recreat. anchoring	↗	↗	→	→	↑	→
	Dredge & trawl effort	↘	↘	→	↓	↘	↓
	Fishing effort	↘	→	→	↘	↗	→
	UWWT	↗	↗	→	↗	→	↗
	Aquaculture prod.	↗	↗	↑	↗	→	→
	Livestock prod.	↗	↗	↗	→	↗	↗
	Fertiliser use	↘	↗	↑	→	↑	→
	Tourism	↗	↗	→	→	↑	→
	Urbanisation	↗	↗	→	↘	↑	→
PRESSURES	Demersal catch	↗	↗	→	↑	→	↗
	Small pelagic catch	↗	→	→	↘	↗	→
	Large pelagic catch	↘	→	→	↗	↘	→
STATES	Sed. shore hab.	↘	↘	→	↗	↓	→
	Caulerpa taxifolia	↗	↗	↑	↘	↘	↘
	Coastal eutrophic.	↗	↗	↑	↗	↗	↗
	Seagrass hab.	↘	↘	↓	↗	→	→
	Fish com. structure	↘	↗	→	↑	↘	↗
	Apex predators	↘	→	→	↗	↘	→

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Scenario outcomes

Outcomes of the Baseline scenario and four alternative scenarios from the Baltic Sea simulation model are shown below. The driver component determines the conditions that forced the simulation for each scenario, while pressures and states are the responses to these combinations of drivers. Arrows indicate the direction of changes relative to the current situation.

↑ Large increase
↗ Increase
→ Stable
↘ Decrease
↓ Large decrease

		Current Trend	Baseline Scenario	Scenarios (relative to current): National Enterprise	Local Responsibility	World Markets	Global Community
DRIVERS	Industrial discharge	→	↘	→	↓	↓	↓
	Fishing effort	↗	↘	↗	↗	↑	↓
	UWWT	↘	↘	→	↘	→	↘
	Agricultural activity	→	→	↗	↘	↗	→
	Fossil fuel en. gen.	↘	↘	→	↓	→	↓
	Shipping activity	↗	↗	→	→	↑	↗
	Livestock prod.	↗	↗	↗	→	↑	↗
PRESSURES	P Load	↗	↘	↗	↓	↗	↓
	N Load	→	↘	↗	↓	↗	↓
	Total P	↗	↗	↑	↑	↑	↑
	Total N	→	↘	↗	↓	↗	↓
	Atmos. N depos.	→	↘	↗	↓	↗	↓
	P from sediment	↗	↗	↑	↗	↑	↗
	N fixation	→	↗	↑	↑	↑	↑
	Turbidity	↗	↘	→	↘	↗	↘
	Recruitment	↘	↘	↗	↗	↓	↘
	[Contam.] seawater	↗	↘	↗	↓	↗	↓
STATES	Zoobenthos	→	↘	↗	↗	↗	↓
	Zooplankton	→	↘	↓	↓	↗	↓
	Macrophytes	↘	↘	↘	↑	↘	↑
	Filament. algae	↗	↗	↑	↑	↑	↑
	Cod stocks	↘	↗	↘	↘	↓	↗
	Sprat stocks	↗	↘	↗	↗	↑	↓
	Toxins in fish	↗	↘	↗	↓	↗	↓

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Baltic Sea

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Scenario outcomes

Outcomes of the Baseline scenario and four alternative scenarios from the Black Sea simulation model are shown below. The driver component determines the conditions that forced the simulation for each scenario, while pressures and states are the responses to these combinations of drivers. Arrows indicate the direction of changes relative to the current situation.

↑ Large increase
↗ Increase
→ Stable
↘ Decrease
↓ Large decrease

		Current Trend	Baseline Scenario	Scenarios (relative to current): National Enterprise	Local Responsibility	World Markets	Global Community
DRIVERS	Dredge & trawl effort	↘	↗	↑	→	↗	→
	Shipping activity	↗	↗	→	→	↑	↗
	Fishing effort	↘	↗	↑	→	↗	→
	Drainage/land claim	↗	↗	→	→	↑	→
	Municipal waste	↘	→	↗	↘	→	↘
	Livestock prod.	↘	↗	↗	→	↑	↗
	N fertiliser use	→	↗	↑	→	↗	→
	P fertiliser use	↘	→	↗	↘	→	↘
	UWWT	↗	↗	→	↗	→	↗
PRESSURES	Total P	↘	→	↗	↓	↗	↓
	Turbidity	↗	↗	↑	↘	↑	↘
	Dead zone	↘	↗	↑	↘	↗	↘
	N:P ratio	↗	→	↘	↗	↘	↗
	Invasive species	↗	↗	→	→	↑	↗
	Demersal catch	↘	↘	↓	→	↘	→
	Pelagic catch	→	↘	↓	→	↘	→
STATES	*Cystoseira* hab.	↗	↘	↓	↗	↗	→
	Seagrass hab.	↗	↘	↓	↗	↓	↗
	Phyllophora hab.	↘	→	↘	↗	→	↗
	Pelagic predators	↘	↘	↓	→	↘	→
	Pelagic stocks	↘	↘	↓	→	↘	→
	Wetlands hab.	→	↘	↓	↗	↓	↗
	Demersal stocks	↘	↘	↓	→	↘	→
	Zoobenthos	↘	↘	↓	↗	↘	↗
	Phytopl. com. comp.	↘	→	↗	↘	↗	↓

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Black Sea

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Appendix 2: Definitions and codes for scenarios

ERA40: ERA-40 is a ECMWF re-analysis of the global atmosphere and surface conditions for 45-years, over the period from September 1957 through August 2002. Many sources of the meteorological observations were used, including radiosondes, balloons, aircraft, buoys, satellites, scatterometers. This data was run through the ECMWF computer model at a 40km resolution. As the ECMWF's computer model is one of the more highly-regarded in the field of forecasting, many scientists take its reanalysis to have similar merit. The reanalysis was done in an effort to improve the accuracy of historical weather maps and aid in a more detailed analysis of various weather systems through a period that was severely lacking in computerized data.

The Special Report on Emissions Scenarios (SRES) was a report prepared by the Intergovernmental Panel on Climate Change (IPCC) for the Fourth Assessment Report (AR4) in 2007 (http://en.wikipedia.org/wiki/Intergovernmental_Panel_on_Climate_Change) , on future emission scenarios to be used for driving global circulation models to develop climate change scenarios. Because projections of climate change depend heavily upon future human activity, climate models are run against scenarios. There are 40 different scenarios, each making different assumptions for future greenhouse gas pollution, land-use and other driving forces. Assumptions about future technological development as well as the future economic development are thus made for each scenario.

AR4 scenario definitions: AR4 stands for Assessment Report #4 of the Intergovernmental Panel on Climate Change (IPCC). There were 4 SRES scenario families defined by the IPCC 4th assessment report; A1 World Markets; A2, National Enterprise; B1 Global Community and B2 Local Responsibility, each of which gives a range of response for global average surface warming (A1 1.4-6.4 C, A2 2.0 – 5.4 C, B1 1.1 – 2.9 C, B2 1.4-3.8 C). Within the A1 scenario there are several sub-groups, A1T, A1B, A1F1). Each of these scenarios was run in ensemble mode to quantify the range of response. In MEECE we use the ensemble member LUA1B2 of the A1B scenarios run by the IPSL (Institut Pierre Simon Laplace). This is chosen because it represents a mid range warming response, assuming a balanced emphasis on all energy sources. There is an additional scenario E1 which represents stabilization of atmospheric CO_2 at 450 ppm.

Appendix 3: Workshop agenda

Scenario Definitions Workshop
8-9 June 2010

Hosted by Alma Mater Studiorum Università di Bologna, Bologna

Workshop Goals:
Define of scenarios; so that by the end of the workshop each modelling group will know which scenarios to use and have agreed a timetable for delivery.

Tuesday

Session 1: Setting the Scene – Zavatarelli (Chair)

9.00 Introduction and goals of the workshop (Icarus Allen, PML)

9.15 Background to WP3 and WP4, review of Sete agreements (Marco Zavatarelli, UNIBO)

9.35 Updated on WP5 progress (GerJan Piet, IMARES)

9:50 Another perspective on marine/maritime scenarios (John Pinnegar, Cefas)

10.20 Discussion

11.00 Coffee

Session 2: Progress of work around MEECE scenarios - Allen (Chair)

11.00 Downscaling of the A1B climate scenario to the South African region; Preliminary results (Simone Russo, CNRS, Brest)
11.10 ECOSMO (North and Baltic Sea); Comparing the impacts of different atmospheric forcings (Ute Daewel, UiB)
11.20 Climate downscaling on the NW European Shelf (Jason Holt, NERC)
11.30 Update on WP3/WP4 (Momme Butchenson, PML)
11.40 Fishing Driver: 2015 and beyond (Steve Mackinson, Cefas)
11.50 Progress of Work around MEECE scenarios (Laurent Bopp, CNRS (IPSL/LSCE)
12.00 Status of models and scenarios (Kostas Tsiaras, HCMR)
12.10 Progress towards MEECE objectives for the Black Sea region (Heather Cannaby, IMS-METU)
12.20 Bay of Biscay (Sonia Sanchez, AZTI)
12.30 WP3 & 4 Scenarios for Adriatic Sea (Marco Zavatarelli, UNIBO)
12.40 Total consumption of *Calanus finmarchicus* by planktivorous fish in the Norwegian Sea, estimated from a fully coupled model system (Kjell Utne, IMR)
12.50 Scenarios Definition Workshop – model status and plans (Maciej Tomczak, DTU)

13.00 Lunch

14:15 **Session 3: Discussion** (plenary or break out as appropriate) – ***GerJan Piet (Chair)***
Which GES indicators to be focused on in each region, links with WP5

Coffee included

19:30 **Workshop Dinner**

Wednesday

9:00 Summary of previous day – Icarus Allen

Session 4: Plenary discussion - Jason Holt (Chair)
Session began with a couple of relevant presentations

FISHING and CLIMATE drivers (slides presented on behalf of Yunne-Jai Shin and Lynne Shannon, IRD and UCT)
Fishing as a Driver: Meta-Data Analysis (Chris Smith, HCMR)
The ELME Framework (Yuri Artoli, PML)

Scenarios definition discussions

13:00 Lunch

14.15 ***Session 5: Synthesis and Task definition.*** *(Plenary or breakout)* – ***Chair I. Allen***

Appendix 4: List of participants

Icarus Allen (PML, Project Coordinator)
Yuri Artioli (PML)
Laurent Bopp (LSCE,
Momme Butenschön (PML)
Heather Cannaby (IMS-METU)
Emanuela Clementi (UNIBO)
Clare Coughlan (Cefas)
Ute Daewel (UiB)
Jessica Heard (PML, Project Manager)
Reinier Hille Ris Lambers (IMARES)
Jason Holt (NERC-POL)
Steve Mackinson (Cefas)
Nadia Papadopoulou (HCMR)
Gerjan Piet (IMARES, WP5 Leader)
John Pinnegar (Cefas)
Simone Russo (CNRS, Brest)
Sonia Sanchez (AZTI)
Chris Smith (HCMR)
Maciej Tomczak (DTU-Aqua)
Kostas Tsiaras (HCMR)
Kjell Rong Utne (IMR)
Sarah Wakelin (NERC-POL)
Marco Zavatarelli (UNIBO, WP4 Leader)