SIXTH FRAMEWORK PROGRAMME

Project contract no. 003933

THRESHOLDS
Thresholds of Environmental Sustainability
INTEGRATED PROJECT

Priority 1.1.6 "Sustainable Development, Global Change and Ecosystems"
Sub-Priority 1.1.6.3 "Global Change and Ecosystems"

Stream 6 – D6.1.2
Feasibility evaluation of all case studies

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Executive Summary

In this report we present the results from ***Deliverable D6.1.2:*** *Feasibility evaluation of all case studies*. In the Description of Work (DOW) six case studies were proposed and we have since added a seventh case study (Table 1-1; cf. D6.1.1). The concept of this deliverable is to evaluate the feasibility of all case studies to be investigated by scenario analysis in WP6.3 according to the Impact Pathway Approach. This evaluation is based on a previous deliverable D6.1.1 *Determination of the terms of reference for case studies* and on face-to-face interviews. This report summarizes and concludes the activities of WP6.1.

Each of the case studies serves a different purpose with each case study having its own set of different drivers, pressures, state changes and impacts. Some of the case studies shall be analyzed with the full THRESHOLDS methodology, i.e., a comprehensive scenario analysis (conducted in WP6.3) including impact assessment in the coastal zone, whereas others will not. While in WP6.3 the scenarios by which the selected cases will be investigated will ultimately be defined, we will make an attempt to identify aspects to be analysed already in this document. This is necessary as the feasibility evaluation of the cases in terms of scenario analysis described in this document has not only to take into account the anticipated data and tool availability for each of the cases but to also consider the relevance of potential EU policy scenarios of each of the cases in order to better focus upcoming work (e.g., on emission data gathering and mitigation measure information compilation).

The approach consisted in a questionnaire circulated to all case study owners based on which face-to-face interviews were carried out. The results have been tried to be structured according to the driver-pressure-state-impact-response (DPSIR) approach.

The results of the feasibility evaluation are as follows.

The ***North Sea*** case study is the most elaborated case study, with almost all models and data already available. Depending on the effects that can be valued in monetary terms, various policy trends or aspects may be analyzed. Given the already adopted European Water Framework Directive (WFD) with a compulsory tertiary waste water treatment for agglomerations larger than 10000 inhabitants by 2015, it is definitely needed to perform scenario analysis beyond this year. This implies that the respective models need to be adapted to be able to be run until for instance 2020 if the implemented measures in the near future are not sufficient enough to reduce algal bloom occurrences to an acceptable level.

The ***Varna Bay*** case study is similar to the North Sea case in terms of investigating riverine loads to coastal ecosystems in which algal blooms and other species abundance shifts occur. At both sites, contingent valuation surveys will be carried out within WS1. The difference is the model availability in the Varna Bay case so that substantial model development and/or adaptation needs to take place before any type of scenario analysis can be performed. Another aspect is related to anticipated changes in policies in case Bulgaria joins the EU.

The impact pathway identified to be investigated for the ***Marine fish farms*** (i.e., the effect of deposition of feed and excrements to benthos on sea grass decline) is rather straightforward. The link between sea grass decline and identified and quantifiable impaired services is already available for CO_2 sequestration in the Mediterranean Sea. But efforts will be undertaken within THRESHOLS to provide relationships for further services. In addition to that, further threshold models such as for benthic fauna decline in the North Sea will be tried to be established within Stream 3. Aspects under which the scenario analysis shall be conducted relate to the trend of increasing demand for farmed fish and how this could be managed in an ecologically sound manner.

The most obvious and from a scientific point of view ‘beautiful’ threshold effect in the ***Ringkoebing Fjord lagoon*** is related to the water’s salinity which is driven by sluice management. Whether the sluice management of such a local scale phenomenon is apt to a policy analysis which is relevant at EU level, however, is at least debatable.

There is another point of concern with respect to this case. Even though it is acknowledged that there are many data and even two models in place for Ringkoebing Fjord held at RC, there is only little capacity in the consortium to do the necessary model development and/or run the models. This does not apply to the ecological lagoon model newly developed within THRESHOLDS by UU. However, when linking drivers (e.g., agriculture and residential or industrial activities) to pressures in the lagoon, the catchment model is needed.

This is not saying that there is no learning from this case study for the purpose of basic science under the aspect of thresholds effects which will be taken up in Stream 3 and/or WP6.1.

The impact pathways identified to be investigated for the ***Mallorca*** case study are rather straightforward. The missing links are clearly identified and will be provided based on efforts undertaken within THRESHOLDS. The aspects under which the scenario analysis shall be conducted focus on the impact of tourism and its regulation.

From the conducted analysis, it has become clear that there is no point in trying to have a contaminant case study on ***Thau Lagoon*** selected for scenario analysis unless one looks at pesticides. This is due to the emission data availability and the need for a rather large scale model or speciation model if POPs or heavy metals were to be included, respectively. Furthermore, the concentrations of these pollutants are so low at present that they are far from threshold levels observable at the ecosystem scale. Also, political thresholds or thresholds in the valuation function are estimated not to exist. The Thau Lagoon will therefore not be included in the scenario analysis exercise of WP6.3.

The most critical part of the ***Generalization case study*** will be the development of an indicator for thresholds effects applicable at rather large temporal and spatial scales. If this is not expected to be feasible, the concept of the whole case study may need to be reconsidered. This is particularly so as highly temporally resolved discharge etc. data at the European scale are not expected to be (readily) available.

The case studies identified for scenario analysis are the North Sea case, Varna Bay case, marine fish farms, Mallorca and the Generalization case. The existing models and data show rather different degrees of availability. Particularly, the North Sea case is almost already now ready for the analysis. For the cases 'Varna Bay' and 'Generalization', there are substantial model and/or data gaps identified. Efforts will be spent to fill these gaps.

As a result, tools will become available during the course of the THRESHOLDS project to perform the scenario analysis for five cases. The explicit scenarios to be investigated are still to be defined of which task 6.3.2 will be in charge.

Acknowledgements

The author wants to express their gratitude to all partners that have contributed to the compilation of this document. Most of the names are stated in the sections on the respective cases.

1 Introduction

In this report we present the results from ***Deliverable D6.1.2:*** *Feasibility evaluation of all case studies*. In the Description of Work (DOW) six case studies were proposed and we have since added a seventh case study (Table 1-1; cf. D6.1.1). The concept of this deliverable is to evaluate the feasibility of all case studies to be investigated by scenario analysis in WP6.3 according to the Impact Pathway Approach. This evaluation is based on a previous deliverable D6.1.1 *Determination of the terms of reference for case studies* and on face-to-face interviews. This report summarizes and concludes the activities of WP6.1.

Table 1-1 Case studies and responsible partners.

Case Study	Responsible Partner
River continuums and their coasts: The Southern Bight of the North Sea and its main river basins (Seine, Somme and Scheldt; "North Sea")	Josette Garnier, UMPC
Varna Bay	Snejana Moncheva, IO-BAS
Marine fish farms	Marianne Holmer, USD
Ringkoebing Fjord	Jens Würgler Hansen, RC
Mediterranean Island ("Mallorca")	Javier Lozano, UIB
Thau Lagoon	Joel Knoery, IFREMER
Generalization	Rainer Friedrich, USTUTT

The objective of Stream 6 is to test and apply the THRESHOLDS methodologies, tools and models developed in Streams 2 through 5 on different cases by an integrated approach. In principle, the models/tools developed in Stream 3 to 5 will describe the relationship between input of substances and the impact on/change of the ecology in the coastal zones, all studied in a ecosystem threshold perspective. Each model will be applicable for a selected coastal zone (or a type of coastal zones) and a certain problem/impact. The combination of coastal zone and impact is in the following referred to as 'case'. In Stream 6, results from different Streams, i.e., the findings in Streams 3 to 5 and the findings on monetary assessment in Stream 1, are combined with estimations of pressures, emissions and transport of pollutants and mitigation measures (compiled in this stream where possible) to build the case models. These will then be applied according to scenarios of different pressures developed in WP6.3 and estimate the resulting impacts in coastal zones. The findings will form the basis for decision-support tools such as Integrated Assessment Models (IAMs) needed to perform extended cost-benefit analyses. Such a tool will not be fully developed in Stream 6 but S6 has the clear goal to provide a good basis so that such a tool may be further and fully developed by projects funded at a later stage within this sub-priority.

Each of the case studies serves a different purpose with each case study having its own set of different drivers, pressures, state changes and impacts. Some of the case studies shall be analyzed with the full THRESHOLDS methodology, i.e., a comprehensive scenario analysis (conducted in WP6.3) including impact assessment in the coastal zone, whereas others will not. While in WP6.3 the scenarios by which the selected cases will be investigated will ultimately be defined, we will make an attempt to identify aspects to be analysed already in this document. This is necessary as the feasibility evaluation of the cases in terms of scenario analysis described in this document has not only to take into account the anticipated data and tool availability for each of the cases but to also consider the relevance of potential EU policy scenarios of each of the cases in order to better focus upcoming work (e.g., on emission data gathering and mitigation measure information compilation).

2 Methodology

The feasibility evaluation involved a number of stages. First, a questionnaire was developed and circulated to the case study teams (see Annex I of D6.1.1 on Determination of the terms of reference for case studies) This questionnaire formed the basis of interdisciplinary discussions (in the form of semi-structured interviews) between biologists, natural scientists and economists, where an initial identification of potential policies, impacts and possible valuation issues for each case study was made. This followed presentations of the case studies at meetings in Mallorca and Kalmar, where wider groups of scientists were able to raise particular issues with regard to the case studies. The interviews were conducted between September 2005 and February 2006.
Before the finalization of this deliverable, a workshop took place in Oslo on 18-19 May 2006 which resulted in a fine-tuned view on the feasibility of the EU policy scenario analysis the respective case study. It was decided to analyze and visualize the different steps of the impact pathway analysis according to the driver-pressure-state-impact-response (DPSIR) approach. Note that the response step is addressed neither in the text or tables, nor in the respective diagrams below. This is because the THRESHOLDS project will try to arrive at (policy) response recommendations by means of scenario analyses which are only to be conducted later in the project. The impacts have been distinguished into those affecting ecosystems and their functioning, and utility impacts.

2.1 Comments on the envisaged scenario analysis

Regarding the definition of scenarios as part of WP6.3, a reference scenario principally needs to be created which follows already adopted policies. This means that in the case of the Water Framework Directive all municipalities with more than 2 000 inhabitants should have already been connected to waste water treatment plants with secondary treatment by the end of 2005. For agglomerations with more than 10 000 inhabitants, it is decided that a tertiary treatment should be in place by 2015. Even though implementation may lack behind in some places, their realization cannot be considered an additional measure. As a first step, thus, it needs to be assessed in each of the case studies whether the considered effects putting an ecosystem into a less good ecological status will still occur beyond the year 2015. If the model predictions suggest that there will, additional measures to be taken should be identified and investigated in terms of their cost-efficiency or benefits. The scenarios to be analysed will then take into account anticipated trends in changing human activities (e.g., increased fish farming, changes in agricultural practice particularly due to change in policies) and/or additional mitigation measures to be taken (e.g., full compliance with current legislation where implementation lacks behind, adopted or additional regulations becoming effective in future). A maximum technologically feasible reduction scenario will in many cases be interesting to be investigated as it may demonstrate the potentially long time lag between taking measures and noting (positive) effects, especially related to nutrients released by agriculture. These will then lead into policy recommendations (mostly formulated as part of Stream 7).

3 Results

A first attempt has been made to identify methodological and/or data gaps in order to analyze each of the pressures on coastal zones according to the Impact Pathway Approach (see Figure 3-1) for each of the relevant case studies. The phrase “impact pathway” simply relates to the sequence of events linking a “burden” (or driver) to an “impact” (or effect) and subsequent valuation. The methodology, therefore, proceeds sequentially through the following pathway: The chain of causal relations starts from (1) the *emission of a burden* through (2) *transport and conversion* in the environment to the (3) *impacts on various receptors* such as on human beings and on the ecosystem. Based on exposure-response functions, physical impacts are calculated. Finally the resulting (4) *welfare losses* are transferred into (5) *monetary values* where possible based on the concepts of welfare economics.

In the following subsections on the respective cases, the results for each case study will be presented. The information provided on drivers, pressures and (ecosystem and utility) effects have been assembled by means of tables. In those cases in which the available information has not been sufficient to support the analysis according to the Impact Pathway Approach, an attempt is made to assess whether the missing data or tools would become available during the course of the study. If they are, the need for model development or data gathering is highlighted in yellow. If missing pieces are not expected to become available during the course of the IP, these are highlighted in grey. Finally, the impact pathways of each case study for which the knowledge base will be sufficient to sustain the scenario analysis in WP6.3 are drawn in conceptual diagrams.

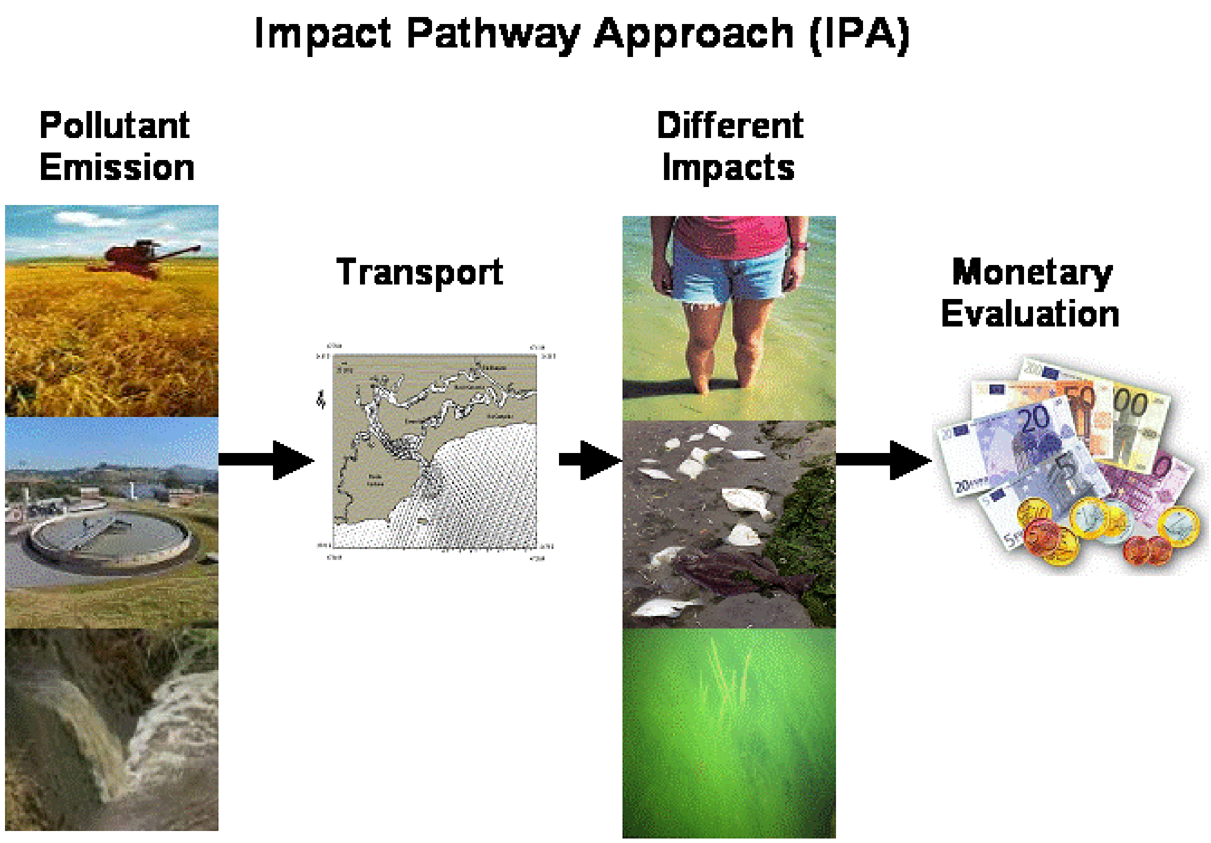

Figure 3-1 The Impact Pathway Approach (IPA) as exemplified for coastal zone impacts.

3.1 River continuums and their coasts: The Southern Bight of the North Sea and its main river basins (Seine, Somme and Scheldt; "North Sea" case study)

The southern bight of the North Sea case study will examine the river continuums of the Seine, Somme and Scheldt rivers. Existing ecosystem models describing nutrient transfer for the past, present and future conditions will be coupled with economic models to estimate costs of nutrient reductions and predicted responses in the coastal zone of the southern bight of the North Sea. The important ecosystem thresholds have not yet been identified.

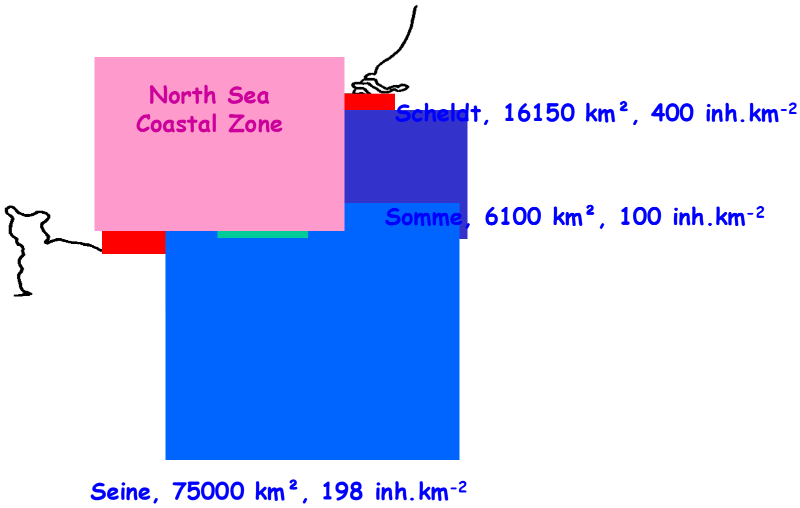

Figure 3-2: The North Sea case study area: its 3 drainage networks (3S) and the corresponding Coastal Zone.

3.1.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Josette Garnier and Gilles Billen (both UPMC), Christiane Lancelot (ULB-ESA), Véronique Choquette and Walter Hecq (both ULB-CESSE), and Till Bachmann (USTUTT) and later discussions is shown in tables 3-1 to 3-6.

Table 3-1 Information on driver-pressure relationships for the North Sea case study

Driver (activity/sources)	Data / model available	Pressure (releases of …)
Urban effluents	Yes / per capita load per year (emission factor approach)	N (different forms), P (different forms)
	Export to the coastal zone from the Seine river	Heavy metals, endocrine disruptors, PAHs, PCBs …
Agriculture	Yes / yes (4 categories of land use: forest, urban (sealed), pastures, crop land; export coefficient approach taking temporally resolved base flow and quick flow into account with a constant concentration; the constant concentration varies by base and quick and agricultural practice; the base flow concentrations can be derived from an available groundwater model) (UPMC)	N (different forms), P (different forms)
	USTUTT will try to provide estimates	NH_3 (g), heavy metals, pesticides …
Combustion processes and agriculture	Will be provided by USTUTT and taken indirectly into account in the river basin modelling approach	NO_x, NH_3
Hydrology, climate, morphology, management for shipment, water flow regulation etc.	Considered in the riverine dispersion model (UPMC)	n.a.

Table 3-2 Availability of pressure-induced pressure relationships for the North Sea case study

Pressure	Link	Induced pressure
N, P, Si inputs and releases from various sources	Seneque/Riverstrahler (UPMC)	N, P, Si loadings to river and the coastal zone

Pollutants other than nutrients	Not available/not planned	
N, P, Si loadings to the coastal zone from rivers	MIRO (ULB-ESA)	N, P, Si loadings in the coast
N, P, Si loadings to the coastal zone from land directly	MIRO does not assess direct releases from land to the coast	N, P, Si loadings in the coast
Climate change	Sensitivity analysis of different climate/hydrology changes can be done with Riverstrahler (UPMC) and MIRO (ULB)	Seasonally variable water quantities lead to variable risk of thresholds in terms of N, P and Si loadings to be exceeded
Weathering in catchment	Concentrations by lithology type; quick/base flow (Riverstrahler, UPMC)	Si loadings to the river
Atmospheric releases of NO_x and NH_3	EcoSense model (USTUTT)	Atmospheric deposition of N to the drainage basin(s) Concentration of N and secondary pollutants in air

Table 3-3 Availability of (induced) pressure-state relationships for the North Sea case study

(Induced) pressure	Link	State
N, P, Si loadings to river including ratios	Redfield ratios (Riverstrahler, UPMC)	Occurrence of algal blooms (above desirable levels) in rivers
Atmospheric deposition of N to the drainage basin(s)		
N, P, Si loadings to coast including ratios	Redfield ratios (MIRO, ULB)	Occurrence of algal blooms (above desirable levels) in coast
	Not expected to become available	Occurrence of harmful algal blooms (above desirable levels) in parts of the coast
Concentration of N and secondary pollutants in air	EcoSense model (USTUTT)	Human health changes

Table 3-4 Availability of state or ecological impact-(induced) ecological impact relationships for the North Sea case study

State or ecological impact	Link	(Induced) ecological impact
Occurrence of algal blooms (above desirable levels) in rivers	Riverstrahler, UPMC	Change in water quality (due to changes in P, N, Si concentrations and oxygen levels)
Occurrence of algal blooms (above desirable levels) in coast (with and without foam formation)	MIRO, ULB	Change in water quality (due to changes in P, N, Si concentrations and oxygen levels)
	Dinophysis (dinoflagelate); Pseudo-nitzschia (diatom) (principally contained in the food web model of MIRO but not the toxin producing species; conditions unknown as yet; no promise to be able to model these within the THRESHOLDS IP, discussion with WS3-1)	Shellfish are affected by toxic algal blooms (toxin of dinophysis only persists for a couple of days; while the one of Pseudo-nitzschia may persist at least a couple of weeks to months; at the Seine bight some scallops are forbidden to be caught around X-mas which is a habit to be eaten along the Atlantic coast then)
	Phaeocystis (colony-forming flagellate; non-toxic at the respective coast, in contrast to Northern strains; part of the	Shellfish asphyxia (dying from lack of oxygen) ; impact on shrimps is at present unknown

State or ecological impact	Link	(Induced) ecological impact
	foodweb model, ULB-ESA)	and will not be covered
	Phaeocystis (part of the foodweb model, ULB-ESA)	Change in water quality
	Not expected to become available	Snail (natural, no farming); problem of pollution more related to PCBs and HMs
	No data/model as yet; Christiane from ULB-ESA will try to do her best	Shrimps (traditional fishing with a horse in Belgium) and mussels
Algal blooms in the coast	MIRO, ULB	Food web changes in the coast
Food web changes in the coast	HAB, disruption of food web (part of the foodweb model up to copepods)	Reduction in biodiversity
	No model available	Jellyfish

Table 3-5 Availability of state or ecological impact-utility impact relationships for the North Sea case study

State or ecological impact	Link	Utility impact
Change in water quality in rivers (due to changes in P, N, Si concentrations and oxygen levels)	Water abstraction data are available at UPMC (direct abstraction from the river is more the rule than bank filtration)	Drinking water abstraction: changes in water treatment requirements (only nutrients and clogging, so far no problems related to toxicity)
	Fish population model is known to be available on the Seine but only loosely depends on Riverstrahler model outputs	Recreational fishing (even in Paris), there is a demand for bathing in the rivers
Food web changes in the coast	ULB-ESA will make an attempt (without promise) to include fish stock changes into the food web model, i.e. a relation between copepods and (undifferentiated) fish	Fisheries (no major evidence on impacts on fish catches, but potentially on cod larvae); see also net clogging above
Change in water quality in the coast	Expected to become available through WS1 (UBATH, UIB and ULB-CEESE)	Recreational activity (Tourism, Boating, swimming, walking along the coast, recreational fishing of snails, shellfish)
	Not expected to become available	Clogging of fishing nets. This means that fishermen may need to empty and bring out their nets more often
Reduction in biodiversity	Not expected to become available	Changes in levels of ecosystem services – including impacts on both marketed and non-marketed goods.
Human health changes	EcoSense model (USTUTT)	Health impairments

Table 3-6: Potential valuation of state changes and/or impacts for the North Sea case study

State change or impact	Expected importance	Valuation technique
Impediment or degradation of recreational activities	Middle	Hypothetical markets (choice experiment)
Impact on real estate value	Low	Documentary research
Impact on tourism (hotels, restaurants)	Low	Real markets / Documentary research
Impact on shrimp, mussel, scallops and other shellfish	Occasionally high (in the Seine bight)	Real markets / Documentary research
Impact on commercial fishing	Low	Real markets / Documentary research
Impact on ecosystem structure	Low	n/a (scientific data missing)
Impact on jellyfish occurrence	Low	n/a (scientific data missing)
Impact on drinking water abstraction	Low	Documentary research

Based on these tables, there are various impact pathways identified which could potentially be investigated within THRESHOLDS by means of scenario analysis (depicted in Figure 3-3). These link various drivers (agriculture, industry, habitation of residents and tourists, and combustion processes) through discharges of N, P and Si to various ecosystem impacts in both freshwaters and coastal waters. In the end, impacts on recreation and amenity, occasional shellfish toxicity episodes and impacts on commercial fisheries are identified as potentially monetizable. It needs to be seen whether also fisheries' income changes and additional expenses on drinking water treatment may also be valuable or obtainable, respectively.

There are only a few links/relationships which are presently not available for the envisaged impact pathways. Most of these are related to the valuation step (Stream 1) or the atmospheric input of N into the ecosystems mainly due to combustion processes and agriculture (USTUTT). It will be tried by ULB-ESA to find an implementable relationship between copepods and fish stocks.

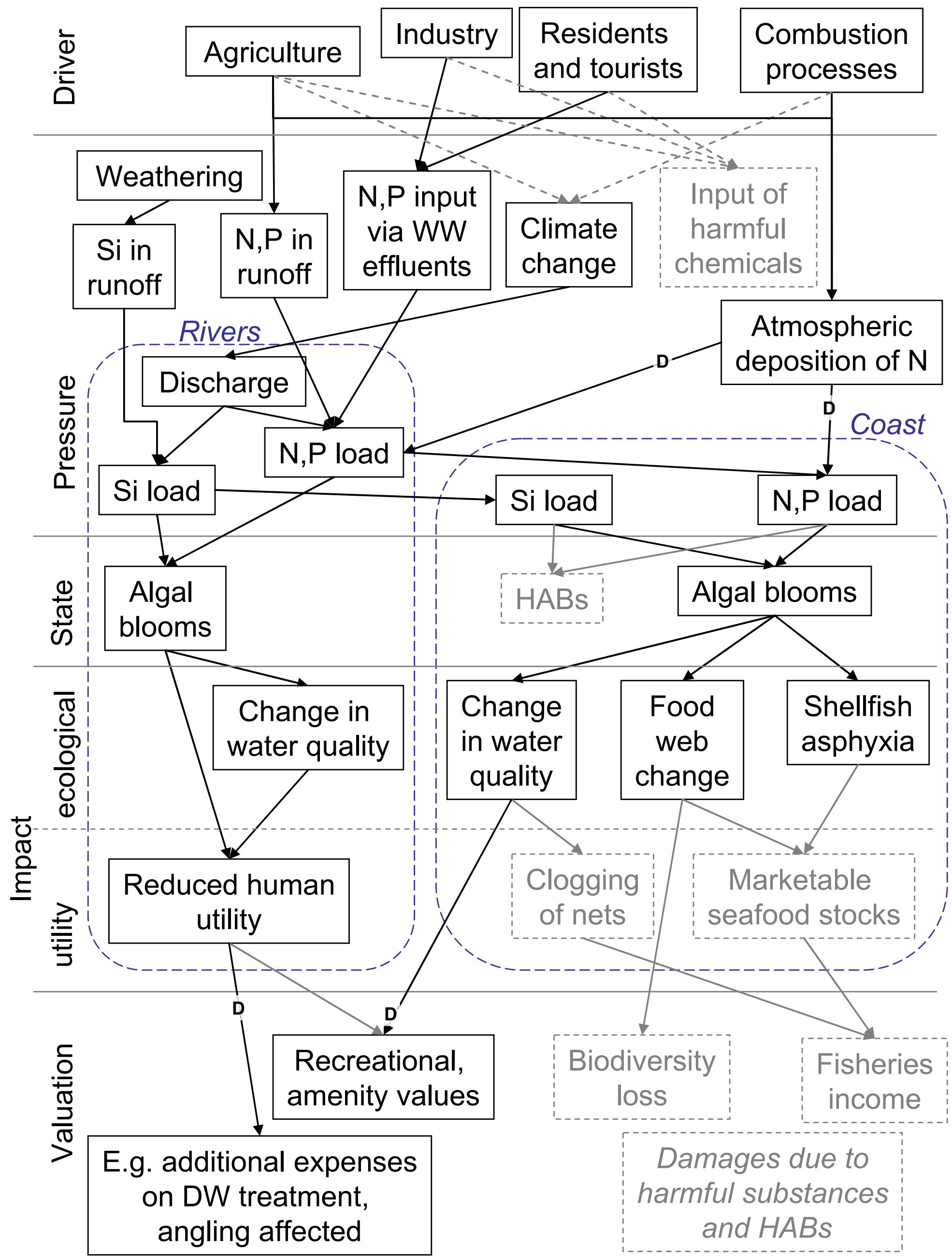

Figure 3-3 Impact pathways identified for the North Sea case study (D denotes need for development; impact pathways selected for scenario analysis are displayed in black; other

impacts or impact pathways are displayed in grey; assessment of ancillary impacts due to air pollution not shown).

3.1.2 Aspects for scenario analysis for the North Sea case study

For scenario analysis, the North Sea case study team is planning on assessing a series of selected policy options addressing N and P emissions from both urban wastewater and agricultural run-off. Ancillary impacts due to airborne emissions will also be assessed (carried out by USTUTT). It needs to be seen to what extent measures concerning industrial wastewater discharges will be considered with support from other partners.

The specific policy options beyond the currently effective policy (see general considerations on creating a reference scenario in Chapter 2) which will be included in the scenario analysis have not yet been selected. Even though implementation of some policies lacks behind in some places, their realization cannot be considered an additional measure. As a first step, thus, it needs to be assessed whether algal blooms will still occur in the North Sea coastal zone investigated beyond the year 2015. If the model predictions suggest that there will, additional measures to be taken should be investigated. For this, a preliminary list of potential measures has been drawn. Those referring to agricultural emissions have been consulted with an external expert in agronomy in the study area. So far, the measures that have been retained for potential inclusion in scenario analysis are the following:

(1) The building of new wastewater treatment plants;
(2) The upgrading of existing wastewater treatment plants from secondary to tertiary treatment;
(3) The introduction of nitrogen-trap crops (also called *winter covers*) on agricultural lands;
(4) The reduction of nitrogen fertiliser use below the levels recommended by the code of agricultural good practices;
(5) The conversion of arable lands back into prairies;
(6) The expansion of organic farming;
(7) The creation of wetlands on agricultural lands.

Ideally, there will be sufficient cost data available for all of these measures. Since no automated optimisation of the expenditures on such measures and improvement of the current status regarding algal blooms will be possible for the North Sea case study, different policy scenarios will be created which combine these measures to different extents (such as a Maximum Technically Feasible Reduction scenario which assumes an implementation of all different (non-mutually exclusive) mitigation options). Modifying this approach which combines the implementation of different measures at the same time, one could also conduct a technical-economic analysis from which one could derive a step-based cost-efficiency relationship, indicating both the economic costs and abatement efficiency of implementing each measure at various levels of intensity (e.g. on 10% of agricultural lands, 20%, 30%, etc.).

3.1.3 Conclusions with respect to the North Sea case study

The North Sea case study is presumably the most elaborated case study, with almost all models and data already available. Depending on the effects that can be valued in monetary terms, different policy trends or aspects may be analyzed (see previous section). Given the already adopted European Water Framework Directive (WFD) with a compulsory tertiary waste water treatment for agglomerations larger than 10000 inhabitants by 2015, it is definitely needed to perform scenario analysis beyond this year. This implies that the respective models need to be adapted to be able to be run well beyond the year 2015 due to the retention of nutrients in the subsurface. This, however, is only needed if the implemented measures in the near future are not sufficient enough to reduce algal bloom occurrences to an acceptable level by 2015. This needs to be explored. To what extent climate change effects can be considered for such longer term scenario runs needs to be explored.

3.2 Varna Bay

Initially, it was intended to address two different areas in the Northwestern Black Sea area. One is the Danube River-Northwestern Black Sea connection that has been the subject of a Framework IV (EROS2000) and a Framework V (DANUBES) research project. Clear ecosystem thresholds have been established, especially regarding shifts in ecosystem parameters. However, this case study suffers from a high complexity of the problem with lack of data regarding pressures and drivers. This is why the suitability of the second area (Varna Bay plus drainage basin; cf. Figure 3-4) as a case study is discussed in the following.

Figure 3-4: The Varna Bay case study area (without upstream catchment)

3.2.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Snejana Moncheva and Valentina Doncheve (both IO-BAS), Till Bachmann (USTUTT) and Tim Taylor (UBATH) and later discussions is shown in tables 3-7 to 3-12. It needs to be noted that similar to the North Sea case a line of investigation will consist in the analysis of ancillary impacts due to airborne pollutants. As these have been presented for the North Sea case study already, these shall not be presented in the following.

Table 3-7 Information on driver-pressure relationships for the Varna Bay case study

Driver (activity/sources)[a]	Data / model available	Pressure (releases of …)
Agriculture: application of fertilisers	MONERIS model (IO-BAS)	N, P in runoff
	Not expected to become available	OM in runoff
Wastewater effluents (domestic, tourist and	MONERIS model (IO-BAS)	N, P input via waste water effluents

Driver (activity/sources)[a]	Data / model available	Pressure (releases of …)
industrial)	Not expected to become available Not expected to become available	OM input via waste water effluents Coliforms in waste water
Illegal harvesting of rapana by trawlers[b]	Not expected to become available Not expected to become available	N and P load due decay of mussels thrown back into the sea as side-catch Re-suspension of sediments (fluffy layer) by the trawlers

[a] The drivers '(Unregulated) commercial use of fish' and 'shipping' are not shown here as they are not so much associated with pollutant inputs.
[b] Rapana is a snail that was introduced into the Black Sea in 1923. It then successfully naturalized. Originally, it was responsible for mussel field destruction in the Black sea (predator-prey consequence). Since 1996 it has become of commercial importance (exported to Japan). The activity has expanded also as a consequence of a fishery collapse after 1990.

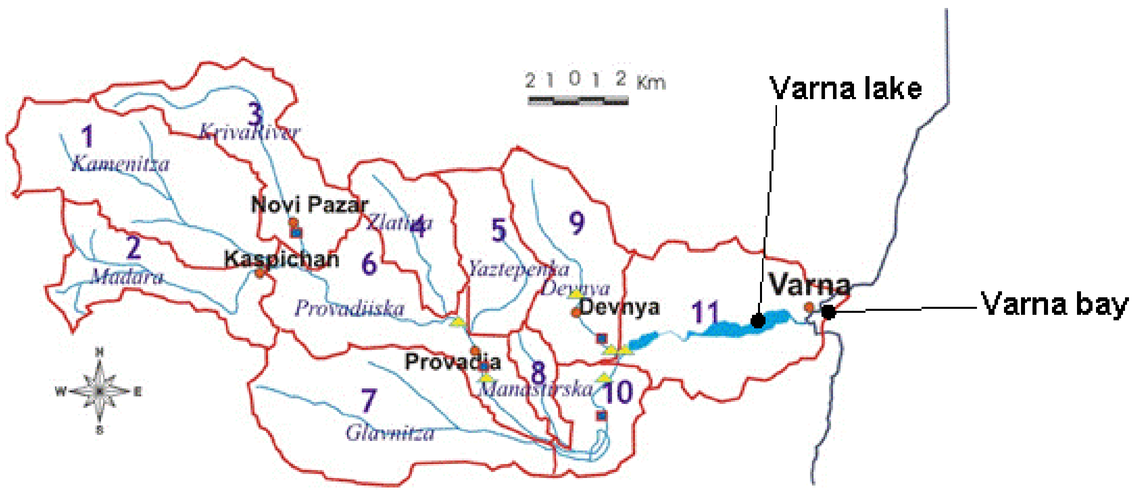

Figure 3-5: Spatial resolution of the Provadiiska river as represented in the MOdeling Nutrient Emissions in RIver Systems (MONERIS) model

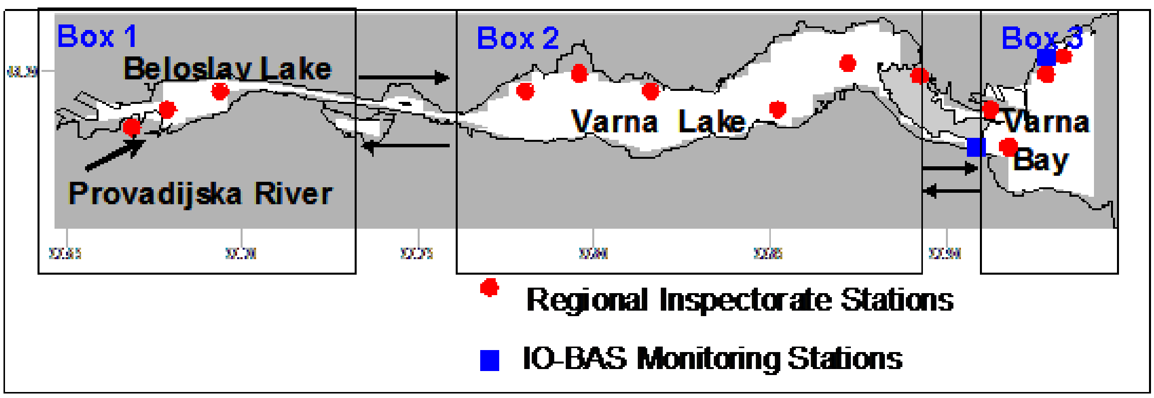

Figure 3-6: Spatial resolution into zones of the LOICZ Varna Bay model

Table 3-8 Availability of pressure-induced pressure relationships for the Varna Bay case study

Pressure	Link	Induced pressure
N, P in runoff	N/P balance: MONERIS[a]	N, P load to the Varna lake/Varna bay area

Pressure	Link	Induced pressure
	model available at IO-BAS	(considered as one zone with one water body)
N, P input via waste water effluents	N/P balance: MONERIS[a] model available at IO-BAS	N, P load to the Varna lake/Varna bay area (considered as one zone with one water body)
Coliforms in waste water	Not expected to become available	Coliforms in rivers and Varna lake
OM in runoff OM input via waste water effluents	Not expected to become available	Organic matter (OM) load
(Unregulated) commercial use of fish	Not needed to be modeled as this pressure occurred in the past and induced pressure prevails	Overfishing in the past
Shipping	Not needed to be modeled as pressure occurred in the past and induced pressure prevails	Invasion of jellyfish in the past

[a] Varna lake/Varna bay area are considered as one zone with just one water body (cf. zone 11 in Figure 3-5); IO-BAS will explore the feasibility to merge the MONERIS model for the Varna Bay case study with the LOICZ model adapted to this purpose (cf. Figure 3-6; http://data.ecology.su.se/mnode/Europe/Med_Aegean_BlackSea/Bulgaria/VarnaBay/VarnaBaybudget.htm)

Table 3-9 Availability of (induced) pressure-state relationships for the Varna Bay case study

(Induced) pressure	Link	State
N, P load in coastal waters	IO-BAS will make sure that an appropriate model is available IO-BAS will make sure that an appropriate model is available	Algal bloom/phytoplankton increase Change in species abundance
Invasion of jellyfish in the past	Covered by food web model to be set in place by IO-BAS	Change in species abundance

Table 3-10 Availability of state or ecological impact-(induced) ecological impact relationships for the Varna Bay case study

State or ecological impact	Link	(Induced) ecological impact
Algal bloom/phytoplankton increase	IO-BAS will make sure that an appropriate model is available Not expected to become available Not expected to become available	Food web disruptions Organic matter load in coastal waters Sea grass decline
Change in species abundance	IO-BAS will make sure that an appropriate model is available	Food web disruptions
Organic matter load in coastal waters	Not expected to become available	Hypoxia and Anoxia
Food web disruptions	IO-BAS will make sure that an appropriate model is available Not expected to become available	Fish stock changes Jellyfish stock changes
Coliforms	Not expected to become available Not expected to become available	Swimming leads to health impacts Swimming and mussel consumption in lake lost

Table 3-11 Availability of ecological impact-utility impact relationships for the Varna Bay case study

Ecological impact	Link	Utility impact
Algal blooms – visual	Human perception (WS1, UBATH)	Recreational and Amenity values
Fish stock changes	IO-BAS will make sure that an appropriate model is available	Fish stocks (local fishery depleted)
Jellyfish stock increase	Not expected to become available	Closure of beaches, other recreational impacts
Algal Bloom	Rotting of organic material from the bloom on beaches (valuation WS1, UBATH)	Odour (possible tourism/amenity/recreation)
Sea grass decline	Not expected to become available	Amenity due to odour due to sea grass rotting on beaches

Table 3-12: Potential valuation of state changes and/or impacts for the Varna Bay case study

State change or impact	Valuation Technique
Invasive species – jellyfish dominance (link to shipping)	WTP for recreational swimming – not likely to be able to value in Thresholds
Recreational and amenity values	Valuing in WS1: Questionnaire to Residents and Tourists, UBATH
Fish stocks (local fishery depleted)	Depends on whether recovery likely => market value of fish, UBATH
Odour (possible tourism/amenity/recreation)	Valuing in WS1: Questionnaire to Residents and Tourists, UBATH
GHG reduction/increase	Social Cost of Carbon, UBATH
Algal bloom/phytoplankton increase	Valuing via indirect impacts on tourism. Other impacts - small (eg acquaculture not yet developed to any great scale), UBATH
Hypoxia and Anoxia	Potentially to be valued via fish stocks, UBATH
Fish stocks	Market value of fish, UBATH
Swimming and mussel consumption in lake lost	Not valuing unless recovery of lake to good quality => likelihood under scenarios. If value => WTP values and market values, UBATH
Swimming leads to health impacts	Transfer of health valuation studies if possible.
Tourism	Impact on tourism to be evaluated if possible => scenarios with different environmental quality, UBATH

Based on these tables, there are various impact pathways identified of which one main impact pathway will be analysed relating N and P emissions from agriculture and sewers via algal blooms to recreational impacts (depicted in Figure 3-7). A second line of investigation which also has the nutrient load as the main (assessible) pressure investigates monetizable fish stock changes due to food web disruptions. For this second impact pathway, there are more development needs identified so that it is not ascertained that the corresponding impacts could be assessed. For the first line of investigation, it still needs to be made sure that the riverine model is consistent with the not yet available model predicting algal blooms in the coastal zone. For both impact pathway branches, the approaches to value the utility impacts are to be provided by Stream 1. The analysis of the impact pathway related to the pressure of coliform presence in the water column is hampered due to lack of human health impact models as well as release estimates.

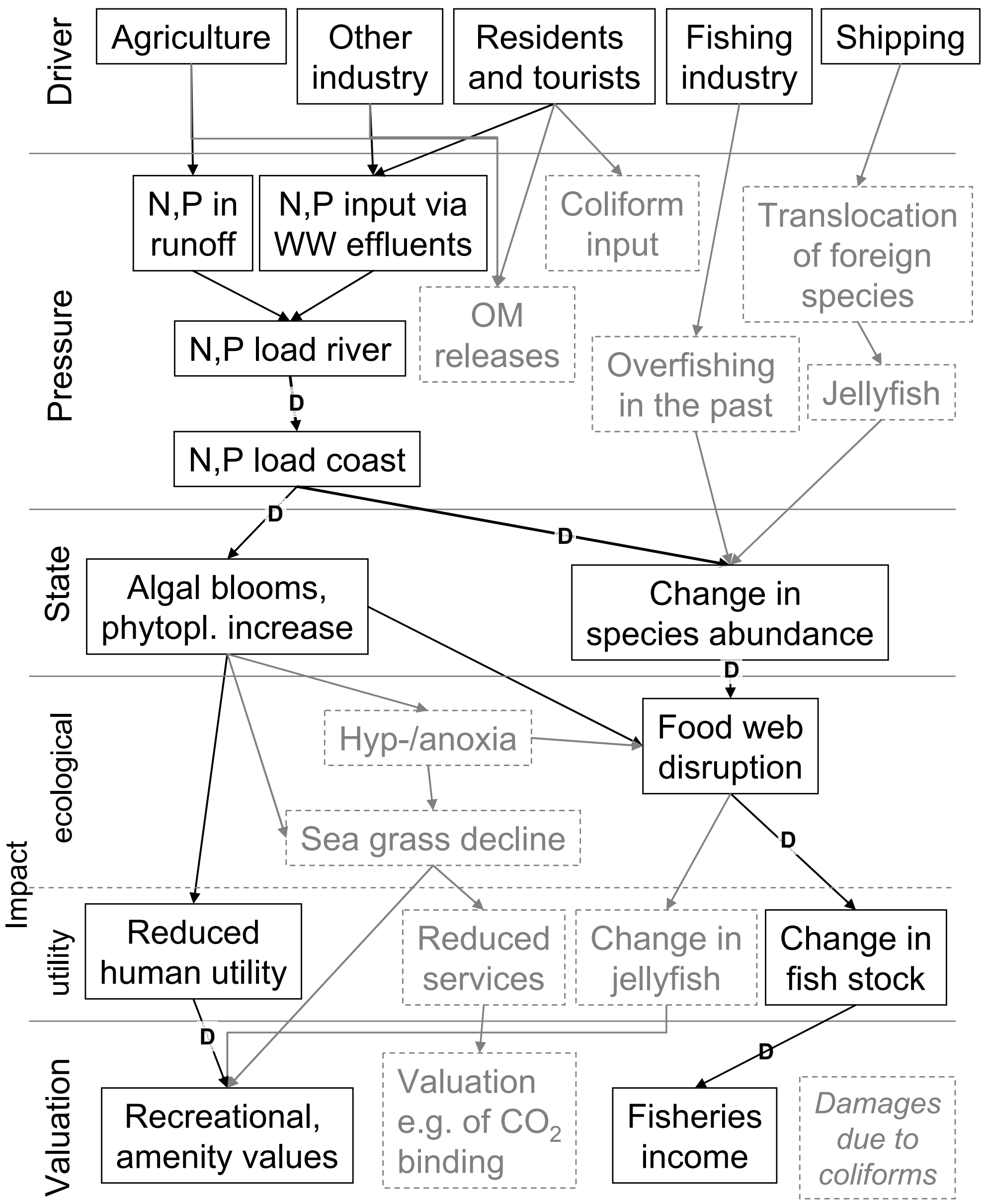

Figure 3-7 Impact pathways identified for the Varna Bay case study (D denotes need for development; impact pathways selected for scenario analysis are displayed in black; other impacts or impact pathways are displayed in grey; assessment of ancillary impacts due to air pollution not shown).

3.2.2 Aspects for scenario analysis of the Varna Bay case study

Given the conceptual similarity of the Varna Bay case to the North Sea case, analogous aspects of analysis are envisaged. Particularities lie in the circumstance that Bulgaria is a candidate country to join the EU. This means that some EU policies have not yet been fully adopted and/or implemented and that subsidies particularly in agriculture are not yet warranted. An increase in agricultural activity may therefore result which may even overcompensate compulsory measures to be taken under the Water Framework Directive in terms of waste water treatment.

Thus, when creating scenarios one first has to find a reference scenario in which the implications of Bulgaria joining the EU need to be considered. One needs to consider, furthermore, that in many instances the policy is already in place but implementation and/or control lacks behind (regulation on rapana harvesting, stock and capabilities of STPs). On top of that, further scenarios need to be created which consider mitigation measures to be enforced by legislation affecting the main drivers such as tourism, effluents from STP, agriculture and rapana harvesting. Again a maximum technologically feasible reduction scenario will be interesting to be investigated, also demonstrating the potentially long time lag between taking measures and noting (positive) effects.

3.2.3 Conclusions with respect to the Varna Bay case study

The Varna Bay case study is similar to the North Sea case in terms of investigating riverine loads to coastal ecosystems in which algal blooms and other species abundance shifts occur. At both sites, contingent valuation surveys will be carried out within WS1. The difference is the model availability in the Varna Bay case so that substantial model development and/or adaptation needs to take place before any type of scenario analysis can be performed. Additionally, the available models for the drainage basin are particularly different in terms of their temporal resolution. While in the case of the North Sea case study a seasonal resolution is achieved in which Si is considered beside N and P, only 5 year averages are predicted by the riverine models available for Varna Bay, without modelling Si. It would be good to include Si correspondingly. In terms of the coastal zone, UU will develop an ecological coastal zone model applicable to Varna Bay if data are provided. The anticipated changes in policies in case Bulgaria joins the EU constitute one aspect for scenario analysis.

3.3 Marine fish farms

Marine fish farms in the Atlantic and Mediterranean will be investigated for threshold responses in eutrophication (WP3.4). Atlantic and Mediterranean fish farms provide a good contrast between ecosystem types, species used in fish farms and projected responses on the environment. Significant threshold effects have been observed in bottom communities surrounding fish farms. Waste products of marine fish farms are found either as dissolved or particulate compounds. As most farms are located at locations with rapid water exchange, it is often difficult to detect effects on water quality, whereas the settling of particulate waste products in rates much higher than natural background levels leads to impacted sediments underneath the net cages (cf. Figure 3-8). In the Mediterranean, where the water transparency is high and seagrasses are found to large depths, also seagrass meadows may be threatened by the sedimentation of waste products.

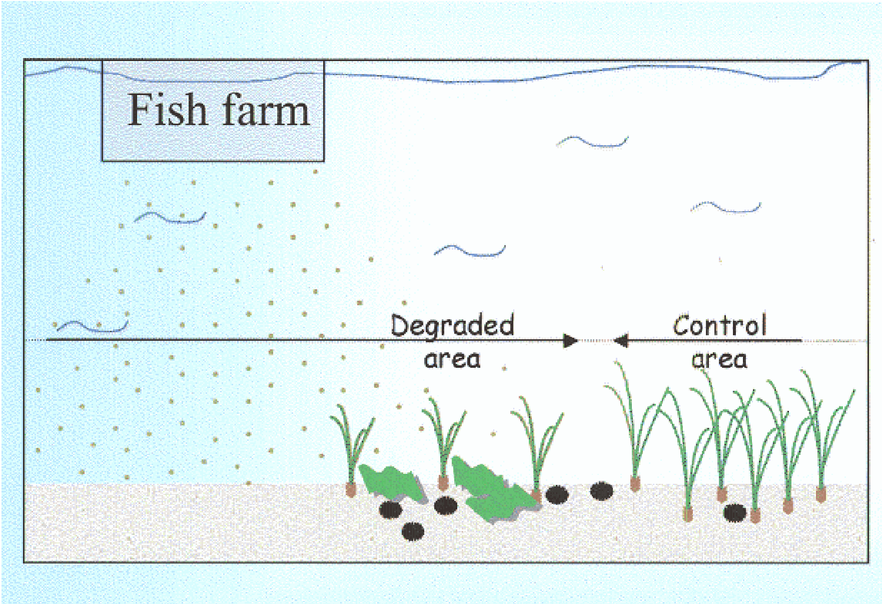

Figure 3-8: Example of a marine fish farm with seagrasses in surroundings, as found in the Mediterranean. Due to the rapid settling of particulate waste products the seafloor is degraded near the net cages.

3.3.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Marianne Holmer (USD), Till Bachmann (USTUTT) and Tim Taylor (UBATH) and later discussions is shown in tables 3-13 to 3-18.

Table 3-13 Information on driver-pressure relationships for the Marine fish farms case study

Driver (activity/sources)	Data / model available	Pressure (releases of …)
Feed to farmed fish	Yes / yes[a]	Feed to farmed fish (organic matter)
Fish protection	Not expected to become available	Antibiotics
Farmed fish keeping	Not expected to become available	Farmed fish escapes

[a] $\dot{M}_{OM} = \frac{M_{OM}}{M_{feed}} \cdot \frac{M_{feed}}{M_{fish\ yield}} \cdot \dot{M}_{fish\ yield}$ where M is mass [kg] and OM stands for organic matter

Table 3-14 Availability of pressure-induced pressure relationships for the Marine fish farms case study

Pressure	Link	Induced pressure
Feed to farmed fish (organic matter)	USD holds the data	Deposition of feed and excrements to benthos
Fish protection	Not expected to become available	Antibiotic input/contents

Table 3-15 Availability of (induced) pressure-state relationships for the Marine fish farms case study

(Induced) pressure	Link	State
Deposition of feed and excrements to benthos	USD holds the data	Excessive organic matter load to benthos
Feed to farmed fish	Not expected to become available	Change in wild fish stocks

(Induced) pressure	Link	State
(organic matter)		
Farmed fish escapes	Not expected to become available	Change in wild fish stocks
Antibiotic input/contents	Not expected to become available	Excessive antibiotics level

Table 3-16 Availability of state or ecological impact-(induced) ecological impact relationships for the Marine fish farms case study

State or ecological impact	Link	(Induce) ecological impact
Excessive organic matter load to benthos	USD (IMEDEA already holds a model)	Seagrass decline in the Mediterranean
	Potentially becoming available in the last third of the THRESHOLDS project; whether this is early enough to be included in the scenario analysis is to be seen (USD responsible)	Impact on benthic fauna particularly in the North Sea/Atlantic
Excessive antibiotics level	Not expected to become available	Impacts on aquatic non-target organisms (including increased antibiotic levels)
Change in wild fish stocks	Not expected to become available	Change in biodiversity

Table 3-17 Availability of ecological impact and other 'disturbances'-utility impact relationships for the Marine fish farms case study

State or ecological impact	Link	Utility impact
Existence of fish farms	WS1 UBATH	Visual amenity (tourism, residents; likely irrelevant)
	WS1 UBATH	Odour (only in the vicinity, tourism, residents; likely irrelevant)
	Not expected to become available	Disease spreading between neighbouring cages and between farms and wild stocks (rather hypothetical)
	It is not expected that a model will become available	Increase wild stocks; positive effect on angling/fishing (Machias et al. 2004, 2005, Pitta et et al. 2005)
	Not expected to become available	Contamination of marketed fish with PBTs
	May also be relevant for the Mediterranean; not expected to become available for the North Sea (USD)	Cultivated fish escape: interference with wild species (inbreeding, destruction of spawning grounds, anglers pay less) according to Carr et al. 1997, Miggiano et al. 2005, Roberge et al. 2006)
Sea grass decline (Mediterranean)	Carbon capture/loss (IMEDEA)	CO_2 binding reduced, additional CO_2 releases
	Not expected to become available	Reduced biodiversity, Loss of spawning grounds, Loss of fish/fauna shelter Increased erosion of sea floor
Impact on benthic fauna (Atlantic)	Possible impact on marketed species (eg fish, USD)	Possible reduced fish harvests and other ecosystem services (eg carbon capture) provided by benthic fauna.
	Not expected to become available	Reduced biodiversity
Excessive antibiotics level in target and non-target species	Not expected to become available	Impacts humans
Change in wild fish stocks	Not expected to become available	Impacts on fishing/angling

State or ecological impact	Link	Utility impact
Change in biodiversity	Not expected to become available	Impacts on ecosystem services provided – including market and non-market values

Table 3-18: Potential valuation of state changes and/or impacts for the Marine fish farm case study

State change or impact	Valuation technique
Visual amenity (tourism, residents)	UBATH will look for studies on valuing visual amenity from fish farms, but unlikely. Transferability questionable.
Odour (only in the vicinity, tourism, residents)	Not likely to value.
Disease spreading between neighbouring cages and between farms and wild stocks	Loss of stocks can be valued through market prices. Additional cost of treatment can be valued, UBATH
Increase wild stocks; positive effect on angling/fishing	WTP for wild angling can be assessed through transfer of fish angling studies potentially, UBATH.
Contamination of marketed fish with PBTs	Health impacts => value using benefit transfer or Cost of Illness. If can't sell fish => market price, UBATH.
Cultivated fish escape (irrelevant in Med.): interference with wild species (inbreeding, destruction of spawning grounds, anglers pay less)	Likely difficult to value. But avertive expenditure by fishermen gives min WTP. Some suggestion of action by anglers to catch invasive species in fish ladders.
CO_2 binding reduced, additional CO_2 releases	Social cost of carbon, UBATH
Shellfish	Bioeconomic model - transfer from ECOHARM project, UBATH
Water clarity	Recreational and amenity values (transfer) , UBATH
Reduction in biodiversity	Depends on species. For marketed => use market value. Services provided by species, UBATH.
Tourism	Valuation likely possible through transfer of studies valuing water quality, UBATH
Boating, swimming, walking along the coast	Valuation likely possible through transfer of studies valuing water quality, UBATH
Fisheries	Bioeconomic model - transfer from ECOHARM project, UBATH

There is only one impact pathway for which a full analysis is expected to be feasible within the course of the project (depicted in Figure 3-9). As can be seen from the tables above, the utility impact of reduced carbon sequestration due to sea grass decline caused by fish farms in the Mediterranean Sea can readily be assessed once the link between ‘sea grass decline’ and ‘impact on CO_2 sequestration’ is made available by IMEDEA. To what extent also the impact of benthic fauna decline will be able to be analysed is to be seen later on in the project. In any case, it shall be strongly emphasized that the investigated utility impacts are estimated to be only small compared to the overall impact caused by marine fish farms (cf. the other impacts given in Figure 3-9) which presently cannot be valued to the extent desirable in order to conduct a comprehensive cost-benefit analysis and support a well-informed policy-decision.

The impact pathway due to antibiotic inputs to the fish farm is hampered due to lack of application data and an impact assessment approach for marine organisms and humans.

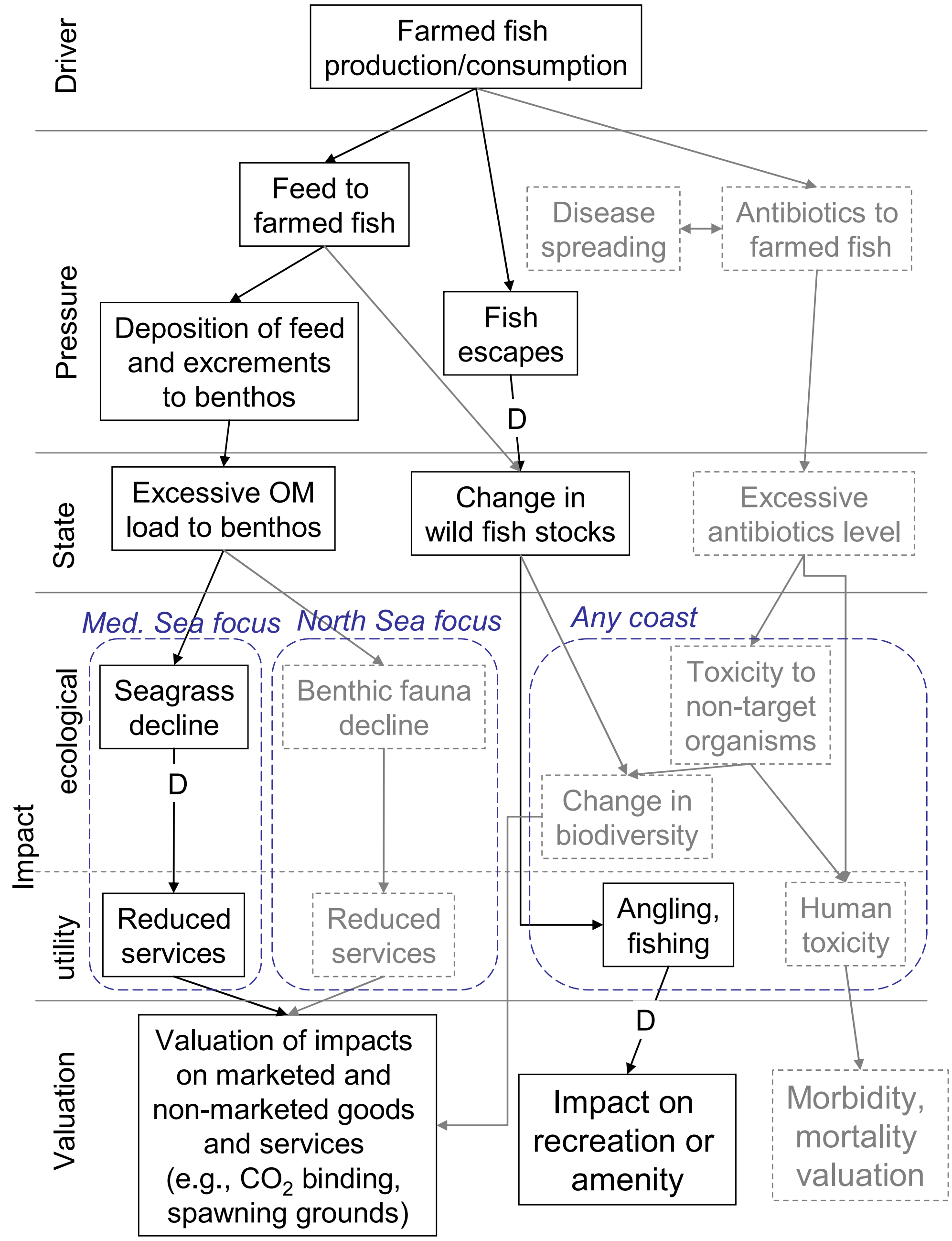

Figure 3-9 Impact pathways identified for the Marine fish farms case study (D denotes need for development; impact pathways selected for scenario analysis are displayed in black; other impacts or impact pathways are displayed in grey).

3.3.2 Aspects for scenario analysis of the Marine fish farm case study

Capture fisheries are declining, whereas the demand for fish is increasing in particular in countries with a fast economic growth rate such as China. Aquaculture production of fish is expected to fill this gap, a trend which has been seen during the past two decades. This will increase the pressures on the coastal zones, such as the sea grass meadows in the Mediterranean unless some mitigation measures are taken.

At present, it can be anticipated that the practice of running fish farms will develop towards polycultures or the cultivation of other species, more sustainable feed (also in order to avoid antibiotics by the use of probiotic feed), improved digestibility and minimised feed losses.

Sustainable feeds are being developed by reducing the use of wild fish stocks and instead using agricultural products such as soy bean oil.

Potential mitigation measures to be considered are fallowing, i.e., regularly shifting of cages from one place to another, and limitation on farm size, water depth at which to install the farms and flushing of water (‘dispersion’). An optional scenario of course is also to do without fish farms.

When defining a reference scenario to be investigated for European policy support, all of these trends and mitigation measures should ideally be considered, i.e., how marine fish farming in Europe will most likely develop in terms of both its quantity (amount of fish farmed) and quality (the way fish farming is achieved). The respective impact on the benthic community should be assessed. As a comparison, one or more scenarios will be formulated that takes a more environmentally benign way of fish farming will be developed and its costs should be assessed. It is, however, noted that the capacities to get respective data, and develop and run appropriate models may not be sufficiently available within the THRESHOLDS IP so that alternative scenarios may be investigated in the end.

3.3.3 Conclusions with respect to the Marine fish farm case study

The impact pathway identified to be investigated (effect of deposition of feed and excrements to benthos on sea grass decline) is rather straightforward. The link between sea grass decline and identified and quantifiable impaired services is already available for CO_2 sequestration in the Mediterranean Sea. But efforts will be undertaken within THRESHOLDS to provide relationships for further services. The loss of breeding/nursery areas for fish when sea grass meadows are affected is estimated to be particularly important. In addition to that, further threshold models such as for benthic fauna decline in the North Sea will be tried to be established within Stream 3. Aspects under which the scenario analysis shall be conducted relate to the trend of increasing demand for farmed fish and how this could be managed in an ecologically sound manner. Thereby, a particular focus should be laid on the geographic distribution and expansion of the farms in relation to the benthic community. This should at least be done qualitatively.

3.4 The lagoon Ringkoebing Fjord

In the late 1970s, the lagoon, Ringkoebing Fjord, Denmark (Figure 3-10) shifted from a clear to a turbid state, driven by increases in nutrient loading. In the mid-1990s, Ringkoebing Fjord has undergone a significant threshold response due to changed sluice practice and reduced nutrient loading shifting from a turbid system with massive algal blooms to an ecosystem that is characterized by relatively clear water and considerably lower algal biomass than before (which is still higher than in many other water bodies). A slight change in salinity with alteration of sluice practices allowed a filter feeding clam (*Mya arena*) to establish a high biomass in the estuary, filtering the water of algae. This case study has historical data, extensive monitoring data, regional data, ecological models, models for the catchment area and socio-economic valuation studies.

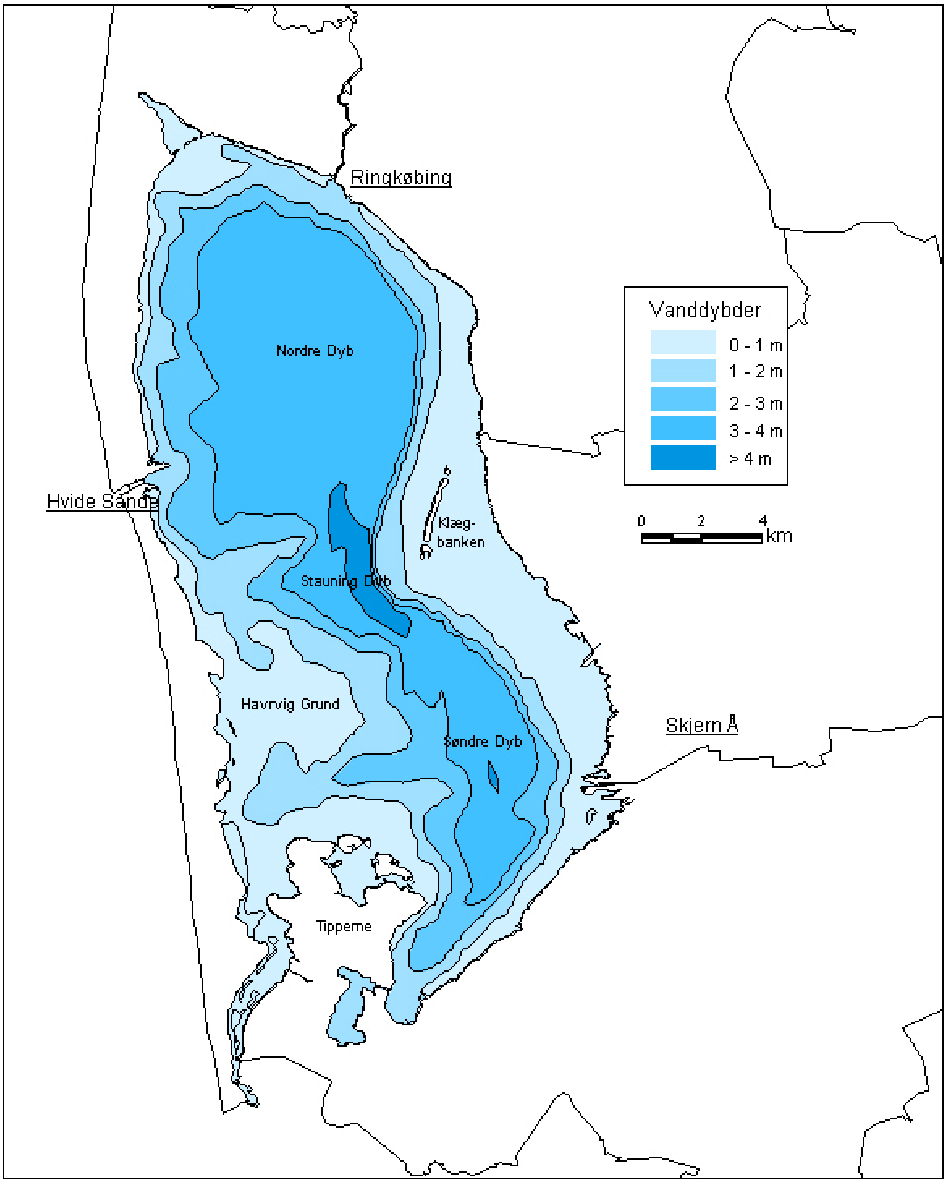

Figure 3-10: The lagoon Ringkoebing Fjord

3.4.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Jens Würgler Hansen (RC), Till Bachmann (USTUTT) and Tim Taylor (UBATH) and later discussions is shown in tables 3-19 to 3-24.

Table 3-19 Information on driver-pressure relationships for the Ringkoebing Fjord case study

Driver (activity/sources)	Data / model available	Pressure (releases of …)
Agriculture	Data available but it is difficult to separate anthropogenic and background loads	N,P,OM load from manure/slurry
Wastewater treatment (domestic and industrial)	Data available at RC	N,P,OM load due to residential and industrial sewage
Aquaculture (trout)	Estimates on the loadings from aquaculture exists	OM, N and P
Authority regulation affecting fjord / sluice	Data available – long time series	Salinity

Driver (activity/sources)	Data / model available	Pressure (releases of …)
management		
Aquaculture and other industry	Load data from main river, content in clams and sediment available since 1998	Heavy metals [a]
Dredging (sand collection)	Outside boundaries of case study	Disruption to spawning grounds for fish stocks
Tourism	Not expected to become available	Boating
Fishing industry	Not expected to become available	(Unregulated) commercial use of fish

[a] deemed irrelevant

Table 3-20 Availability of pressure-induced pressure relationships for the Ringkoebing Fjord case study

Pressure	Link	Induced pressure
N,P load from manure/slurry	N/P ecological model (UU, RC), N model for the catchment area (RC)	Nutrient load in the lagoon
N,P load due to residential and industrial sewage		
OM load from manure/slurry	No model available, but there are estimates of organic load which can be split up into sources – one being open land/diffusive source consisting of the natural input and input from agriculture production	Organic matter load in the lagoon
OM load due to residential and industrial sewage		
Boating	Not expected to become available	Tributyltin releases
(Unregulated) commercial use of fish	An ecopath/foodweb model is being established (UU: benthic decline-fish stock link)	Overfishing

Table 3-21 Availability of (induced) pressure-state relationships for the Ringkoebing Fjord case study

(Induced) pressure	Link	State
Sluice management	3D ecological model and mass balance model, RC Mass balance model (UU)	Salinity change inducing a change in species abundance
Nutrient load	N/P ecological model (RC) Mass balance model (UU)	Algal bloom (macroalgae)
Organic matter load	3D ecological model and model for catchment area, RC	Turbidity and change in sediment conditions.
Overfishing	Not expected to become available	Change in species abundance
Tributyltin releases	Not expected to become available	Tributyltin concentration change
Heavy metal releases	Emission to water (WATSON, USTUTT)	Increased heavy metal concentrations in environmental media and organisms

Table 3-22 Availability of state or ecological impact-(induced) ecological impact relationships for the Ringkoebing Fjord case study

State or ecological impact	Link	(Induced) ecological impact
Algal bloom	3D ecological model, RC Mass balance model (UU)	Water quality deterioration
Turbidity	3D ecological model, RC Mass balance model (UU)	Change in water quality

State or ecological impact	Link	(Induced) ecological impact
Change in water quality	Models relating water quality to food webs and, thus, fish stocks (UU, ecopath model being established)	Food web change
Salinity change	Above certain threshold: clam invasion (WS3, NERI)	Clam occurrence
	Not expected to become available	Salmon and trout occurrence
Clam occurrence	3D ecological model, RC Mass balance model (UU)	Change in water quality (filtration of water, 95% algae removal)
Change in water quality, salinity change	Not expected to become available	Benthic system change
Tributyltin concentration change	Not expected to become available	Gender issues in snails
Change in species abundance	Models relating water quality to food webs and, thus, fish stocks (UU)	Food web change
Increased heavy metal concentrations in environmental media and organisms	Not expected to become available for fish; available for clams	Ecotoxicity

Table 3-23 Availability of ecological impact-utility impact relationships for the Ringkoebing Fjord case study

Ecological impact	Link	Utility impact
Benthic system change	Food decline for bird feeding and spawning grounds destruction	Bird stocks decline: duck hunting, recreation Fish stocks (local fishery)
Food web change	Ecopath model being established by another institution in DK. Models relating water quality to food webs and, thus, fish stocks (UU)	Fish stocks (local fishery)
Water quality changes	Perception of environmental improvement. Transfer from other water quality studies might be possible (UBATH)	Recreation – swimming, tourism, boating, walking, amenity benefits – residential property
Salmon and trout occurrence	There is no model for the movement of pikes, but it is known from past experience that they will enter the lagoon if salinity is lowered	Recreational anglers
Macroalgae	Rotting on the beach	Odour (possible tourism/amenity/recreation)
Sea grass recovery/development	Carbon capture (IMEDEA)	GHG reduction
Clam occurrence	Not being exploited/most likely not possible without major disturbance	Income
Increased heavy metal concentrations in environmental media and organisms	Not expected to become available for fish; available for clams	Human toxicity

Table 3-24: Potential valuation of state changes and/or impacts for the Ringkoebing Fjord case study

State change or impact	Valuation
Algal bloom (macroalgae)	Indirect odour impacts not to be valued. Direct ecological impacts likely

	small. Clogging of fishing nets.
Fish stocks	Social economic report (RC) Ecopath model being established
Clams (economic value)	Not being exploited/most likely not possible without major disturbance
Benthic system disruptions	Indirect impacts to be valued. UBATH
Sexual disturbance in snails	Likely small value, but difficult to estimate as it depends on if/how information is distributed and if/how tourists react to such information.
Bird decline => duck hunting, recreation	WTP to hunt: Revealed Preferences: Licence Fee. Stated Preference: Transfer of hunting values/recreation value. Need number of hunters. (Unlikely to value)
Local economy impacts => value of fish landing	Social economic report exists (RC)
Recreation – swimming, tourism, boating, walking, amenity benefits – residential property	Transfer of values from existing water quality studies (Norway, UK, new studies) Issue: use levels and data availability, UBATH
Impact on salmonid and trout => recreational anglers	Transfer of values from existing studies or revealed preference in DK, UBATH
Odour (possible tourism/amenity/recreation)	Some amenity values of odour starting to emerge in literature but primary study in Denmark on this impossible. WS1 includes odour issues, transferability will be addressed.
GHG reduction	Social Cost of Carbon estimates, UBATH

Based on these tables, there are various impact pathways identified which could potentially be investigated within THRESHOLDS by means of scenario analysis (depicted in Figure 3-11). These link various driving forces (agriculture, fishing, aquaculture and other industry, habitation of residents and tourists, and other tourist activities, authority regulation) through discharges of N, P and organic matter as well as through fishing and introduction of more or less amounts of saline waters to various ecosystem impacts. In the end, impacts on recreation (particularly angling and hunting) and amenity, ecosystem services (such as CO_2 sequestration) and marketable food items are identified as monetizable. The analysis of the impact pathway related to the pressure of heavy metal and tributyl tin releases is deemed irrelevant.

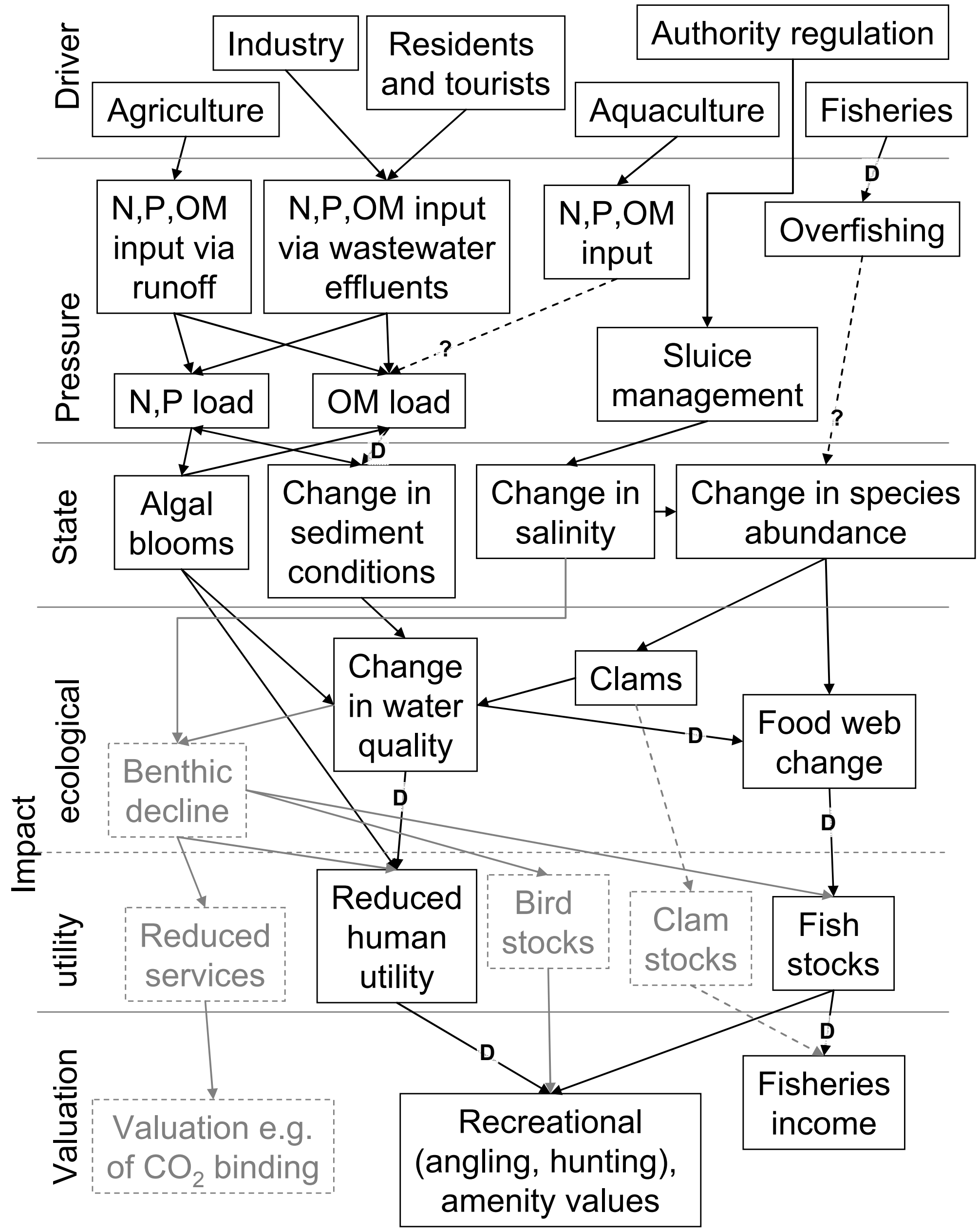

Figure 3-11 Impact pathways identified for the Ringkoebing Fjord case study (D denotes need for development; impact pathways selected for scenario analysis are displayed in black; other impacts or impact pathways are displayed in grey; dotted lines indicate gaps for which it is estimated that no model will become available; impacts due to releases of toxic substances such as heavy metals and airborne pollutants, and tributyl tin are not shown).

3.4.2 Aspects for scenario analysis of the Ringkoebing Fjord case study

There is no scenario analysis envisaged for this case study (for reasoning see below).

3.4.3 Conclusions with respect to the Ringkoebing Fjord case study

The most obvious and from a scientific point of view 'beautiful' threshold effect in the Ringkoebing Fjord lagoon is related to the water's salinity change which is driven by sluice management. Whether the sluice management of such a local scale phenomenon is apt to a policy analysis which is relevant at EU level, however, is at least debatable. However, this demonstrates the difficult requirement from a policy point of view that coastal zone regulations at the EU level need to be flexible enough to accommodate all sorts of rather distinct management measures and/or options. This should be kept in mind when deriving policy recommendations as done in Stream 7 of the THRESHOLDS IP.

There is another point of concern with respect to this case. Even though it is acknowledged that there are many data and even two models in place for Ringkoebing Fjord (one for the catchment and one for the lagoon) held at RC, there is only little capacity in the consortium to do the necessary model development and/or run the models. This does not apply to the ecological lagoon model newly developed within THRESHOLDS by UU. However, when linking drivers (e.g., agriculture and residential or industrial activities) to pressures in the lagoon, the catchment model is needed.

This is not saying that there is no learning from this case study for the purpose of basic science under the aspect of thresholds effects. Thus, aspects of investigation within Stream 3 or WP6.1 comprise:

- Ex-post evaluation of salinity increase
- Salinity decline scenario
- Nutrient flow scenarios
- Existing scenarios only consider low salinity conditions which might be overcome by the new model developed at UU
- Restoration of benthic vegetation may lead to a significant increase in bird numbers (within 5 years)

A further aspect is that the water bodies across Europe need to be classified with respect to their ecological status according to the Water Framework Directive. Ringkoebing Fjord might actually be classified to be in a good status according to the criteria set out (so far). However, the (scientific) functional knowledge of this ecosystem suggests that it is rather vulnerable. Correspondingly, the researchers working on Ringkoebing Fjord (such as RC and UU) are encouraged to examine possible breaking points to occur in the future (e.g., by assuming the same nutrient inputs or increased inputs, changes in salinity, and/or investigating potential impacts of climate change) in the frame of Stream 3 or WP6.1 activities. If then a baseline scenario to be created and investigated gives evidence that the respective ecological thresholds are exceeded, further scenarios should be investigated in order to come up with a suggestion on how a future sustainable development should take place. Respective learnings will be communicated to partners involved in Stream 7 who will further disseminate these findings.

3.5 Mediterranean Island Case Study ("Mallorca")

The Mediterranean coastal zone is highly dependent upon sustained integrity and recreational values of the littoral zone ecosystems and accounts for a large percentage of gross domestic production. However, rapid economic growth in the development service sector (tourism) has placed significant burdens on the functioning of coastal island ecosystems. This case study will focus on a coastal zone and corresponding drainage basin on a Mediterranean island (Sta Ponça Bay, Mallorca, Spain) and will evaluate this area in terms of sustainable ecosystem integrity and recreational values.

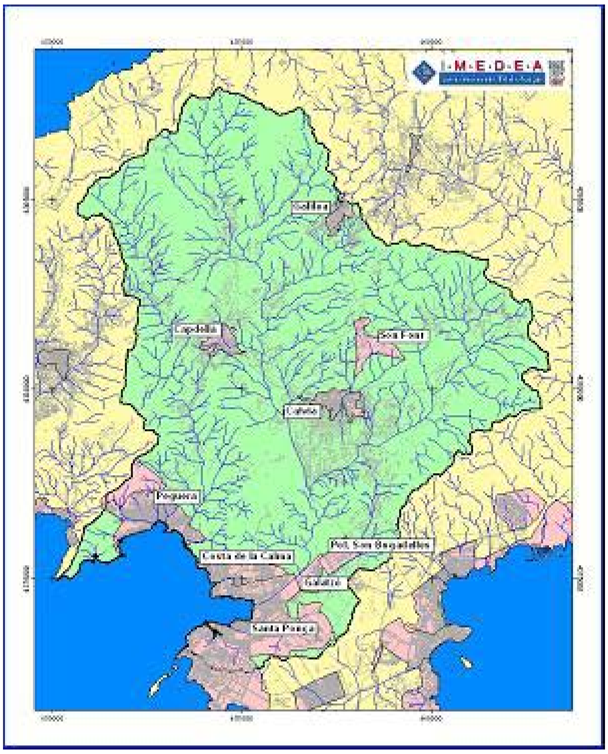

Figure 3-12: The Mallorca case study

3.5.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Javier Lozano (UIB), Till Bachmann (USTUTT) and Tim Taylor (UBATH, part time) and later discussions is shown in tables 3-25 to 3-30.

Table 3-25 Information on driver-pressure relationships for the Mallorca case study

Driver (activity/sources)	Data / model available	Pressure (releases of …)
Urban population (residential and tourists, always dominating): - Treated sewage (WWTP) - Urban runoff - Partly residents are not connected to the WWTP	Best data for WWTP loads (monthly for several years; direct output of water and concentration on nitrates and phosphates); Treated water is used for two purposes: irrigation of golf course and agriculture; no data on people not connected to WWTP as yet (septic tanks, or just discharges to the ground); population evolution scenario will be derived; WWTP: secondary treatment; UIB will check whether the urban runoff is treated in a WWTP	N, P input via wastewater effluents
	Not expected to become available	Coliforms input via wastewater effluents
Tourism (including Mallorcan residents e.g. from Palma): Boating	Not expected to become available	N, Coliforms input to coastal waters
Agriculture	33% are agricultural land, 0.5% of watershed is irrigated, fertilizer use data are not available at present; but estimates on nitrates (no ammonia, no phosphate, no nitrite) emissions from groundwater to the sea at UIB	N, P input via runoff
Industry (construction companies, mineral	See above (no distinction between industry and people possible/available; trying to contact the	N input due to treated wastewater

Driver (activity/sources)	Data / model available	Pressure (releases of …)
extraction, services to tourism)	companies for data)	
Combustion processes and agriculture	There are no site-specific emissions from two oil-fired power stations on Mallorca (Palma, Alcudia); the EcoSense model (USTUTT) can cover regional scale emissions (e.g. from the Spanish mainland)	Atmospheric N emissions

Table 3-26 Availability of Pressure-induced pressure relationships for the Mallorca case study

Pressure	Link	Induced pressure
N, P releases from sewer systems (tourists and residents; with or without urban runoff)	Deriving a relationship within THRESHOLDS (e.g. amount of N / P discharge per additional capita) (TERRAQUAT's responsibility)	N, P load in torrent (data on concentration in the coast also for coliforms available)
Coliforms input via wastewater effluents	Not expected to become available	Coliform load in torrent
N, P input via runoff	Hydrochemistry data from local authorities will be gathered as far as possible. Water Samples and analysis will be done at key spots, where necessary. Contacts will be established through UIB / IMEDEA. Data compilation, sampling and valuation by TERRAQUAT.	N, P load in torrent
N input due to treated wastewater	Hydrochemistry data from local authorities will be gathered as far as possible. Water Samples and analysis will be done at key spots, where necessary. Contacts will be established through UIB / IMEDEA. Data compilation, sampling and valuation by TERRAQUAT.	N load in torrent
N, P load in torrent	Hydrochemistry data from local authorities will be gathered as far as possible. Water Samples and analysis will be done at key spots, where necessary. Contacts will be established through UIB / IMEDEA. Data compilation, sampling and valuation by TERRAQUAT.	N, P load in coastal waters
N input into coastal waters	Hydrochemistry data from local authorities will be gathered as far as possible. Water Samples and analysis will be done at key spots, where necessary. If these data are available, they can be used to validate the mass balance assumptions derived from the above inputs. Contacts will be established through UIB / IMEDEA. Data compilation, sampling and valuation by TERRAQUAT.	N load in coastal waters
Atmospheric N emissions	EcoSense model (USTUTT)	Atmospheric N depositions to coastal waters and the catchment

Table 3-27 Availability of (induced) pressure-state relationships for the Mallorca case study

(Induced) pressure	Link	State
N, P load in the coast	Goal: deriving such a relationship within WS3, IMEDEA	Algal blooms and, thus, turbidity ("increased occurrence of suspended solids, microalgal growth"); during summer; not frequently; no beach closures; mostly a visual effect
Coliforms in the coast	Not expected to become available	Presence of coliforms
Atmospheric N	EcoSense model (USTUTT)	Changes in human health

(Induced) pressure	Link	State
depositions to coastal waters and the catchment		

Table 3-28 Availability of state or ecological impact-(induced) ecological impact relationships for the Mallorca case study

State or ecological impact	Link	(Induced) ecological impact
Algal blooms	Goal: deriving such a relationship within WS3, NERI Relationship provided by WS3 (NERI)	Turbidity increase ("increased occurrence of suspended solids, microalgal growth") Posidonia meadow decline

Table 3-29 Availability of state or ecological impact-utility impact relationships for the Mallorca case study

State or ecological impact	Link	Utility impact
Turbidity increase	Expected to become available through S1 activities (UBATH)	Less tourism in the area in terms of swimming, boating
	Not to be developed	Decrease in house prices and hotel prices
Changes in human health	EcoSense model (USTUTT)	Health impairments
Presence of coliforms	Not expected to become available	Impacts on human health

Table 3-30: Potential valuation of state changes and/or impacts for the Mallorca case study

State change or impact	Valuation technique
Transparency loss and water quality deterioration caused by algal massive blooms	Attribute-Based methods (State Preference). Choice experiment approach.

There is one main effect to be analyzed for the Mallorca case study which is algal blooms and the consequently induced turbidity of the coastal waters. Three activities may be held responsible for this effect to occur (depicted in Figure 3-13): agriculture, industry, and leisure activities and habitation of residents and tourists. The algal bloom and induced turbidity may lead to sea grass decline as well as to reduced recreational value of the coastal zone. As can be seen from the tables above, there is still a need for model development with respect to a few links. As regards the relation between activities and N and P load, a joint effort by UIB, IMEDEA and TERRAQUAT is envisaged to be undertaken. The development of a coastal zone model to predict algal blooms as well as sea grass decline is subject of Stream 3. As for the Marine fish farm case study, IMEDEA will provide CO_2 sequestration estimates.

The impact pathway due to coliform inputs to the Sta Ponça Bay is hampered due to lack of an impact assessment approach for humans.

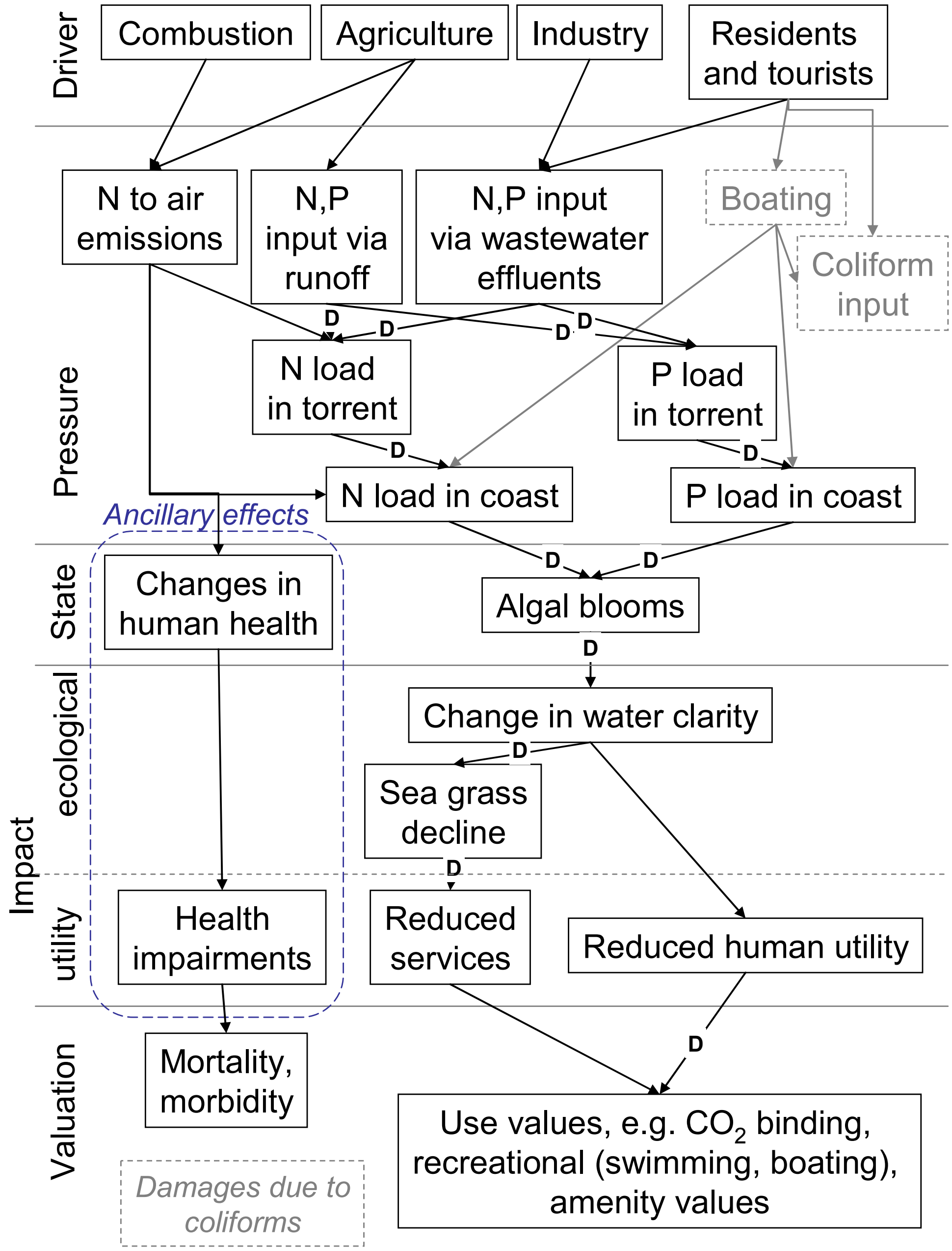

Figure 3-13 Impact pathways identified for the Mallorca case study (D denotes need for development; impact pathways selected for scenario analysis are displayed in black; other impacts or impact pathways are displayed in grey).

3.5.2 Aspects for scenario analysis of the Mallorca case study

The area of study is characterized by a high pressure of human presence in the coastal line due to activities related to tourism. Conditioned on the availability of data to complete the impact pathway, the scenario analysis of the Mallorca case study will focus on considering different floating and permanent population levels in the area. The design of the different scenarios should be guided by current trends and legislation while at the same time considering that simple trend extension does not seem valid for a highly volatile industry such as the tourist industry (e.g. due to dependency on the oil price). The mass balance model for the nutrients of concern will reveal which human activity is most relevant to focus the scenario analysis. The good ecological status defined by the WFD should be considered as a reference point to evaluate those scenarios.

3.5.3 Conclusions with respect to the Mallorca case study

The impact pathways identified to be investigated for the Mallorca case study are rather straightforward. The missing links are clearly identified and will be provided based on efforts undertaken within THRESHOLDS. The aspects under which the scenario analysis shall be conducted focus on the impact of tourism and its regulation.

3.6 Thau Lagoon

The Thau Lagoon in France was added after the description of work (DOW) was written. The Thau Lagoon suffers from severe eutrophication in addition to contaminants. The interactions between eutrophication and contaminants make this case unique.

3.6.1 Interview results and identified impact pathways to be analysed

The result of the brainstorm during the interview between Joel Knoery (IFREMER), Josef Manuel Zaldivar (JRC), Till Bachmann (USTUTT) and Tim Taylor (UBATH) resulted in the conclusion that the focus of the Thau lagoon case will be the scientific investigation of contaminant thresholds. The level of analysis including model building will occur below the ecosystem level. As it is this level at which a sensible scenario analysis for policy support could be carried out, one would be particularly interested in threshold effects to occur at the ecosystem level. However, threshold effects are only expected to occur at the organism level and below. Hence the pressure is not large enough to be policy-relevant, though it will provide useful insights into the science of contaminant thresholds to be investigated in WS4. In addition to this drawback, there is hardly any human activity-related emission data of all relevant sources available so that assuming different types of measures to be taken would become a rather hypothetical exercise.

For this reason, no attempt is made to show the same type of tables and a corresponding diagram as for the other cases.

3.6.2 Aspects for scenario analysis for the Thau Lagoon case study

There is no need to consider aspects for scenario analysis given the scientific basis (available models) and expected effects to occur. Work in future projects could examine issues relating to pesticides and heavy metals at higher levels of concentration than are found in Thau Lagoon. In particular, a cost-benefit analysis of various controls on pesticides may be worth examining in future projects.

3.6.3 Conclusions with respect to the Thau Lagoon case study

From the conducted analysis, it has become clear that there is no point in trying to have a contaminant case study on the Thau Lagoon selected for scenario analysis unless one looks at pesticides. This is due to the emission data availability and the need for a rather large scale model or speciation model if POPs or heavy metals were to be included, respectively. Furthermore, the concentrations of these pollutants are so low at present that they are far from threshold levels observable at the ecosystem scale. Also, political thresholds or thresholds in the valuation function are estimated not to exist. The Thau Lagoon will therefore not be included in the scenario analysis exercise of WP6.3.

3.7 Generalization case study

One of the objectives of the THRESHOLDS IP is the development of "a target-setting procedure, encompassing both the environmental and the socio-economic dimensions required to formulate robust policies ensuring sustainable development" (DOW, p. 6). THRESHOLDS IP is a project funded by the European Commission which is why this target-setting procedure should be applicable at the European scale. The generalization case study therefore seeks to take a broader perspective and to evaluate all impacts within and outside the drainage basin of the respective coastal zones.

This would start from the OMEGA tool and connect (a) several if not (b) all European coastal zones to this tool. In case of (a), 'simply' the other case studies would be taken as exemplary coastal zones and evaluated for their overall impacts and potential mitigation measure options across Europe. In case of (b), one would make use of the 'eutrophication risk index approach' by the JRC, which has previously classified all European coasts. It was concluded to explore these options in more detail until the end of task 6.1.1.

3.7.1 Interview results and identified impact pathways to be analysed

The result of the discussions between Till Bachmann and Rainer Friedrich (USTUTT) and later discussions is shown in tables 3-31 to 3-36.

Table 3-31 Information on driver-pressure relationships for the Generalization case study

Driver (activity/sources)	Data / model available	Pressure (releases of …)
Agriculture	Yes, from the other case study areas or efforts undertaken by tasks 6.2.1, otherwise estimated by USTUTT Principally available at USTUTT, but need for refinement	N, P releases to water (directly and indirectly via soil) N releases to air
Combustion processes	Yes / yes available at USTUTT	N (and S) releases to air
Municipal wastewater	Yes, from the other case study areas or efforts undertaken by tasks 6.2.1, otherwise estimated by USTUTT Incomplete data available at USTUTT, but need for refinement (no promise)	N, P releases to water N releases to air

Table 3-32 Availability of pressure-induced pressure relationships for the Generalization case study

Pressure	Link	Induced pressure
N, P releases to water	WATSON tool (USTUTT) needs to be extended in terms of multi-species, groundwater and costal zones (potentially also a higher temporal resolution); in order to facilitate an extension to coastal zones, UU is expected to provide a costal zone typology including volumes and flushing rates	N, P load to European rivers and coasts
N (and S) releases to air	EcoSense model (USTUTT)	Atmospheric deposition of N to European rivers and coastal waters, concentration changes of N and S in air
Atmospheric deposition of N to European rivers and coastal waters	EcoSense model (USTUTT)	N, P load to European rivers and coasts

Table 3-33 Availability of (induced) pressure-state relationships for the Generalization case study

(Induced) pressure	Link	State
N, P load to European rivers and coasts	(Preferably long-term) indicator for thresholds exceedances to be developed by WS 5 (UT)	Thresholds exceedance in coastal waters (and potentially rivers)
Concentration changes of N and S in air	EcoSense model (USTUTT)	Human health changes

Table 3-34 Availability of state or ecological impact-(induced) ecological impact relationships for the Generalization case study

State or ecological impact	Link	(Induced) ecological impact
Thresholds exceedance in coastal waters (and potentially rivers)	(Preferably long-term) indicator for thresholds exceedances to be developed by WS 5 (UT)	Dependent on the effect to be assessed by means of the (long-term) indicator

Table 3-35 Availability of state or ecological impact-utility impact relationships for the Generalization case study

State or ecological impact	Link	Utility impact
Dependent on the effect to be assessed by means of the (long-term) indicator	To be seen (UBATH and/or USTUTT)	Different utility impacts may be valued
Human health changes	EcoSense model (USTUTT)	Human health impairments

Table 3-36: Potential valuation of state changes and/or impacts for the Generalization case study

State change or impact	Valuation technique
Assessed utility impact(s)	To be seen (UBATH and/or USTUTT)
Human health impairments	Results from previous contingent valuation studies; cost-of-illness

The case study links various sources (i.e., agriculture, industry, residents and tourists, and combustion processes) to riverine and ultimately coastal loads of nutrients. These may then lead to an effect (to be decided upon) that can be valued in the end. Of the data and models needed, several need still to be developed or adapted. Particularly the runoff, discharge and coastal zone model needs to be built, thereby preferably building on the water and soil fate model of the WATSON tool (Bachmann, 2006) which is extended by a groundwater and coastal zone compartment. UU is in charge of developing the coastal zone model for the whole of Europe, while USTUTT is responsible for the other fate parts. The effect indicator is expected to become available from WP5.2 (UT). Depending on the effect assessed, WS1 will try to provide monetary values (UBATH).

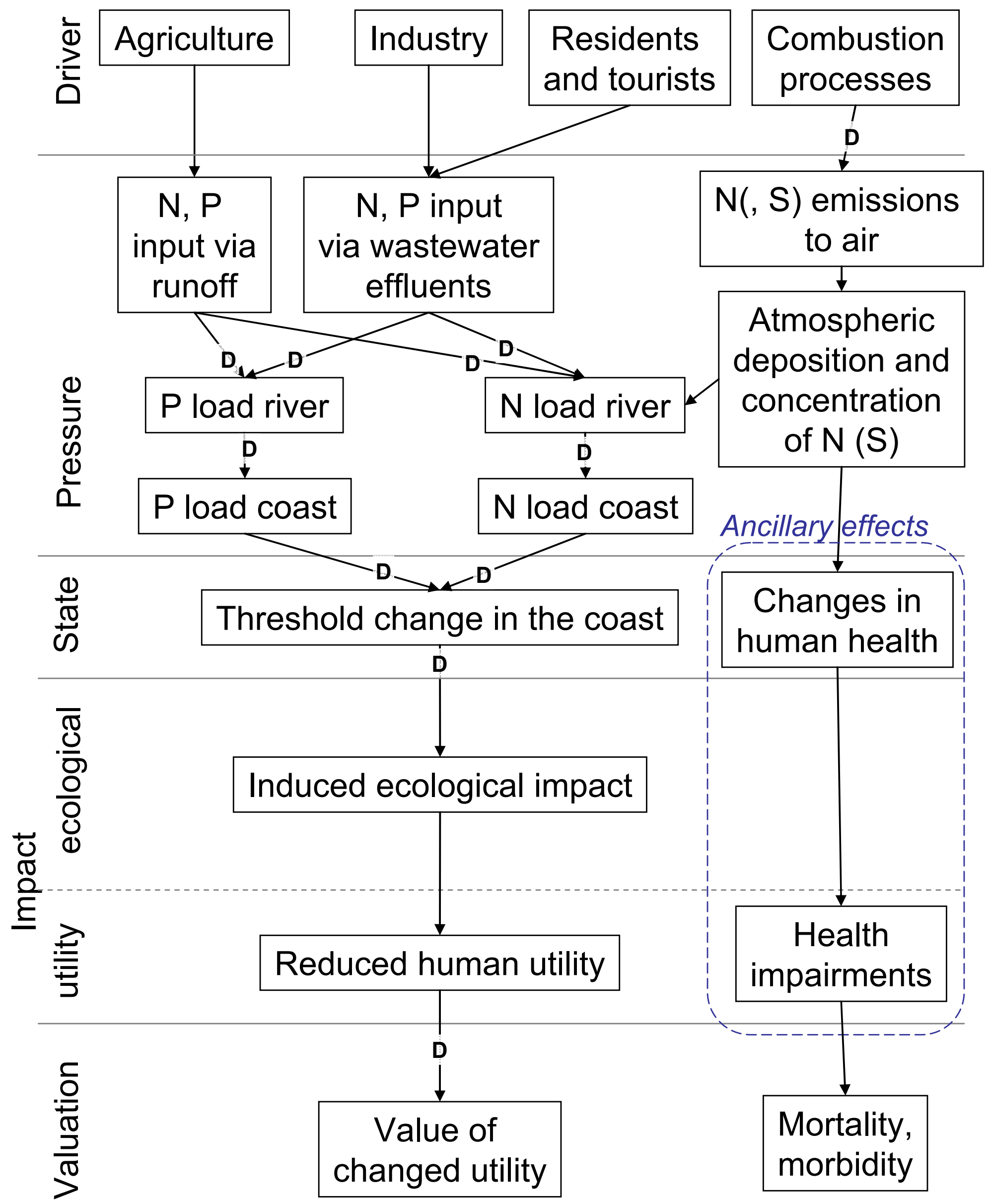

Figure 3-14 Impact pathways identified for the generalization case study (D denotes need for development; other potential impacts or impact pathways are not displayed).

3.7.2 Aspects for scenario analysis of the Generalization case study

It is assumed that the threshold effect indicator to be identified for modelling purposes at EU level will help assessing whether a given water body is in 'good ecological status' as aimed at in the WFD. Thus, the Generalization case study may be able to analyse the coastal waters in their European diversity as to whether current legislation is sufficient to bring these into good ecological status. If not, specific cost-efficient measures to be taken across Europe for each of the respective drainage basins will be analysed. As for other case studies, a maximum technically feasible reduction scenario will be used as one extreme case which will try to demonstrate the time horizons that one may have to deal with when trying to reduce riverine and coastal nutrient concentrations by changing agricultural practice in particular.

Given the fact that the actual degree of implementation of existing regulations may not be known at the European scale and is anticipated to be rather heterogeneous, one may consider to assume for the reference scenario that all facilities comply with current regulations (i.e., all municipalities larger than 2000 inhabitants have secondary waste water treatment in place right now).

3.7.3 Conclusions with respect to the Generalization case study

The most critical part of the Generalization case study will be the development of an indicator for thresholds effects applicable at rather large temporal and spatial scales. If this is not expected to be feasible, the concept of the whole case study may need to be reconsidered. This is particularly so as highly temporally resolved discharge etc. data at the European scale are not expected to be (readily) available. A fall-back solution would be to rely on work for instance by Josette Garnier (UPMC) and co-workers which have suggested an effect model based on Redfield ratios at the river mouth. In any case, not only N but also P needs to be addressed. Additionally, the Generalization case study needs a pan-European coastal zone classification and a coastal zone model for the same geographical area which are expected to be produced by UU.

4 Discussion and conclusions

The case studies identified for scenario analysis are the North Sea case, Varna Bay case, marine fish farms, Mallorca and the Generalization case (see the respective conclusion sections of the case study chapters in this document). The existing models and data show rather different degrees of availability and of resolution in both time and space. Particularly the North Sea case is almost already now ready for the analysis. For the cases 'Varna Bay' and 'Generalization', there are substantial model and/or data gaps identified. Efforts will be spent to fill these gaps in order to allow for scenario analysis.

Of the missing links, there are a few that show up in more than just one case study. For instance, the 'service' by sea grasses of CO_2 sequestration occurs in a few studies. This link, therefore, only needs to be provided once, maybe dependent on the involved sea grass species. The same applies to the valuation of different effects which is to large extents subject of Stream 1.

As a result, it is expected that tools become available during the course of the THRESHOLDS project to perform the scenario analysis for five cases. The explicit scenarios to be investigated are still to be defined of which task 6.3.2 will be in charge. The efforts to compile missing emission data and corresponding mitigation measure information can now be fully initialised (tasks 6.2.1 and 6.3.1, respectively).

A last note shall be given on the DPSIR approach. It is sometimes difficult to be applied to the different steps within an impact pathway. This is because one cannot clearly distinguish between pressures, states and impacts. For instance, the increased N load in rivers (state) is the result of N emissions to rivers (pressure) but at the same time it is also responsible (as a pressure) for the increased N load in coastal water (state). Furthermore, it is debatable whether the occurrence of algal blooms needs to be classified as a state (occurrence vs. non-occurrence of algal blooms) or an impact due to a change in nutrient concentrations.

5 References

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