

What are thresholds?

Ecological thresholds imply non-linear changes in ecosystems. The consequences of ecological thresholds include the following:

- ▶ The state of coastal areas can change drastically almost without warning;
- ▶ Significant economic cost can arise and increase rapidly due to loss of valued services;
- ▶ Costs can be avoided by maintaining pressures well below critical levels;
- ▶ Remedial action can be difficult and costly when systems have passed “points of no return”;
- ▶ Adaptive solutions based on science are needed in order to embrace the variability and uncertainties related to thresholds.

Tools to identify and anticipate potential thresholds are developed in the project THRESHOLDS. The research has revealed the complexity of the changes: different parts of the system are connected and when one component passes a threshold, effects can be observed in other components too.

Why do thresholds matter?

When a threshold is exceeded significant social and economic consequences frequently arise. Harmful algal blooms related to excessive amounts of nutrients are a case in point. ▶ Figure 1 shows how the days when mussels cannot be harvested due to Diarrhetic Shellfish Poisoning increase with an increased level of winter phosphate in Danish coastal waters, and how the amount of algal bloom varies with nitrate levels in the North Sea.

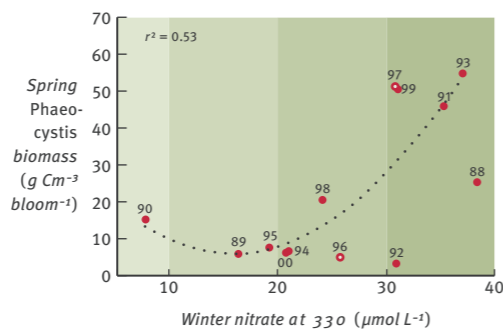
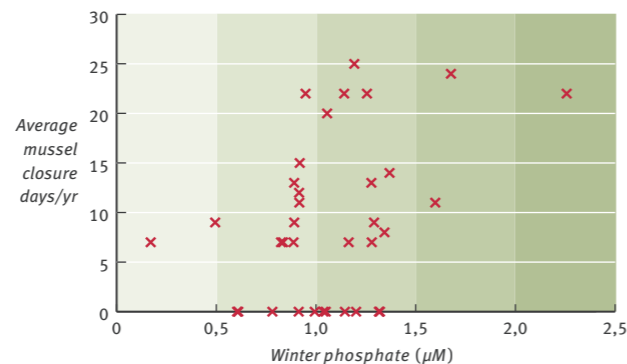


Figure 1

Top Average number of when mussels cannot be harvested in study areas and the average surface concentration of phosphate in winter.
Bottom Relationship between spring Phaeocystis colony bloom (g C m⁻³ bloom⁻¹) and winter nitrates at a North Sea station in different years.

In the Mediterranean, seagrass meadows formed by *Posidonia oceanica* are declining, with potential adverse consequences for many other marine species, including commercially valuable fish. Organic and nutrient loading has been identified as an important cause of seagrass decline, and thresholds of sedimentation leading to this loss can be identified. ▶ Figure 2 illustrates how the change in the growth rate of seagrass declines slowly as phosphorous input rises, but after a certain level of phosphorous, the decline accelerates.

Chemicals from industrial and other activities have caused severe problems for marine organisms. For example, organic tin compounds in antifouling paint led to widespread reproductive anomalies in molluscs and PCBs were identified as a key culprit for reproductive failures in seals and birds of prey. Chemicals or combinations of chemicals and other causes of stress can thus disrupt coastal and marine ecosystems.

The economic and social consequences of passing a threshold are difficult to manage. If a threshold of adverse effect is passed the recovery is a long and expensive process. Efforts to clean up even small patches of polluted sediments have been extremely costly.

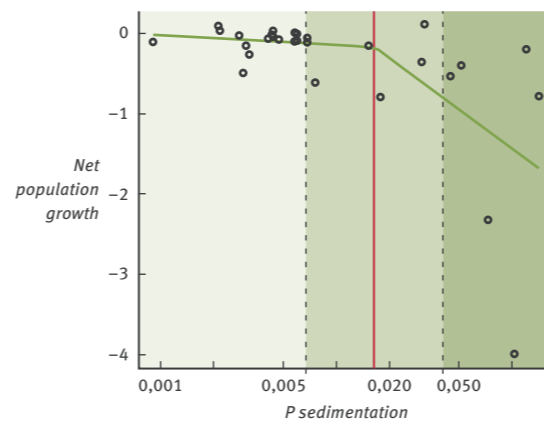


Figure 2 Relationship between phosphorus input rates (*P* sedimentation, g m⁻² d⁻¹) and *Posidonia oceanica* net population growth rate (net population growth, yr⁻¹).

When the state of the environment changes, human activities have to adapt at a cost. Therefore there is also a willingness to pay for improvements. Preliminary results show that recreational users in Belgium are willing to pay more than €16 per person to ensure low levels of algal blooms. Previous studies have shown willingness to pay of between €23 and €41 to avoid toxic algal bloom events. Other impacts of algal blooms may include impacts on the fishery industry. Maintaining water quality well below thresholds of algal blooms clearly provides economic benefits.

Policy Brief— THRESHOLDS

An integrated project under the European Union’s FP6 (Contract N. 003933) website: www.thresholds-eu.org



How can thresholds be tackled in management?

Although thresholds appear as sudden changes they do not come out of the blue. Changes in the structure and function of coastal ecosystems are related to changes in variables such as salinity and temperature, nutrient concentrations, and toxic substances. One can use models to explore management strategies that can avoid critical thresholds. Several THRESHOLDS models provide tools for the management of coastal ecosystems that are affected by nutrients.

Key questions that can be tackled using the models are:

- 1 How would a coastal area respond to a significant reduction in tributary inflow? and
- 2 How would this reduction influence important variables such as algal biomass, water clarity or oxygen concentration in the deep-water zone regulating the survival of benthic animals?

For local pollution problems managers can use thresholds in a relatively straight forward way. For example, thresholds determined by models can be used to set water quality targets that ensure seagrass stability around fish farms and other point sources of pollution.

For managers it is important to understand why thresholds or regime shifts appear, and why compensatory effects may prevent them from materialising. For example, not even large cuts in nutrient inputs lead to immediate response in medium-sized and large catchments ▶ Figure 3, right. Thresholds research can explain why management measures sometimes succeed and sometimes fail.

Monitoring provides important information and in THRESHOLDS monitoring data is analysed with novel multivariate techniques to identify indicator values of individual species or groups of species.

The usual way to deal with (eco)toxicological effects of environmental pollutants is to look for acute toxicity. THRESHOLDS aims at identifying a harmonised methodology that allows toxic effects to be determined at ecosystem level.

Despite data deficiencies the identification of potential risks helps to develop monitoring programmes and assessments of risk caused by hazardous substances. The results of this work are already helping the implementation of the Water Framework Directive where the THRESHOLDS partners are actively involved in the Chemical Monitoring Activities.

For the management of ecosystems with regime shifts time lags are important. The systems seldom react immediately on changes in pressures. Often the level to which the pressure must be reduced in order for the system to recover is well below the level that caused the adverse change. It is generally far more expensive to reduce pressures to very low levels than to maintain pressures below a threshold level. Therefore managers can avoid substantial economic cost by preventing the pressures from exceeding threshold levels in the first place.

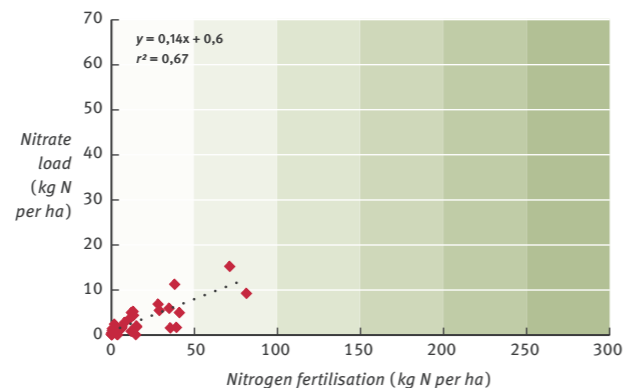


Figure 3 Patterns and relationships at large scale (left panel) are not necessarily present at smaller scales (right panel)

How should policies reflect thresholds?

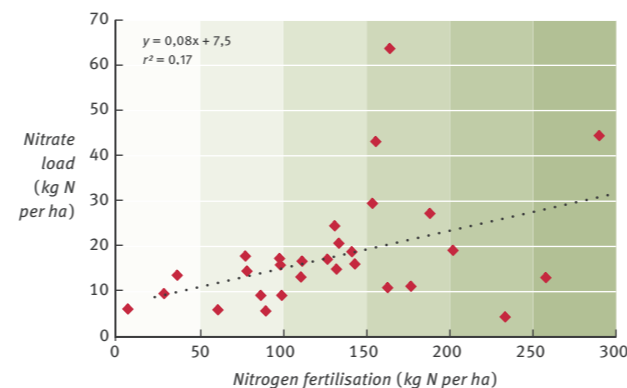
According to the Water Framework Directive (WFD) lakes, streams, rivers, estuaries, coastal water and other water bodies should achieve good ecological status by 2015. The first review of the River Basin Management Plan should take place in 2021. The WFD classification scheme for water quality includes five status categories: high, good, moderate, poor and bad.

According to the Thematic Strategy on the Protection and Conservation of the Marine Environment good environmental status of the EU's marine waters should be achieved by 2021 and the resource base upon which marine-related economic and social activities depend should be protected.

Three overarching questions can be identified in these policies:

- 1 what is 'good environmental status' for a coastal/marine area,
- 2 how do coastal and marine waters change between the different categories of status, particularly, is this change smooth or abrupt?, and
- 3 how can one hinder deterioration, or achieve a desired change when needed?

The results of THRESHOLDS show that failure to recognise the risk and possibility of a sudden shift may



have serious economic and social consequences. The results also show that thresholds, and related adverse or beneficial sudden changes, depend on time and place specific conditions.

The complexity has important implications for governance in the EU. It is not generally advisable to define legally binding limit values based on thresholds at a pan-European level. Such limit values reduce flexibility in planning and management measures in Member States and regions. Instead EU-level regulation should focus on the creation of management frameworks, which encourage production of new information and support adaptive implementation.

For contaminants, it is possible to set legally binding limit values in EU-level policies. For contaminants the key questions are the level of the safety factors and the side effects of setting general limit values. Erroneously specified limit values may have severe undesired economic and social side effects.

The uncertainty caused by thresholds and the potential side effects of too rigid policies suggest that policy development should stress adaptive solutions. THRESHOLDS supports this by developing methods that are capable of reacting on relatively weak signals of adverse change and potential discontinuities. It is also essential to learn how long it can take to detect a response to changes and implemented measures. Such information allows realistic goals to be established in dialogues between authorities, stakeholders and civil society at large.

The implementation of policies for coastal and marine waters should be intimately linked with research so that scientific knowledge is translated into knowledge that can be used in management and policy questions are translated into research questions. THRESHOLDS assists this two way dialogue by delivering results on key the aspects of changes in the coastal zones using an impact pathway approach ▶ See cover.

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