Poole Harbour: Defining trends, thresholds and tipping points in transitional aquatic ecosystems.

Bournemouth University

VALUING NATURE PROGRAMME

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Introduction

Concern about abrupt and potentially irreversible ecosystem tipping points is growing rapidly, as they may have significant implications for natural capital and human wellbeing. Evidence indicates that explicitly addressing tipping points leads to improved management outcomes.

What do we mean by a tipping point?

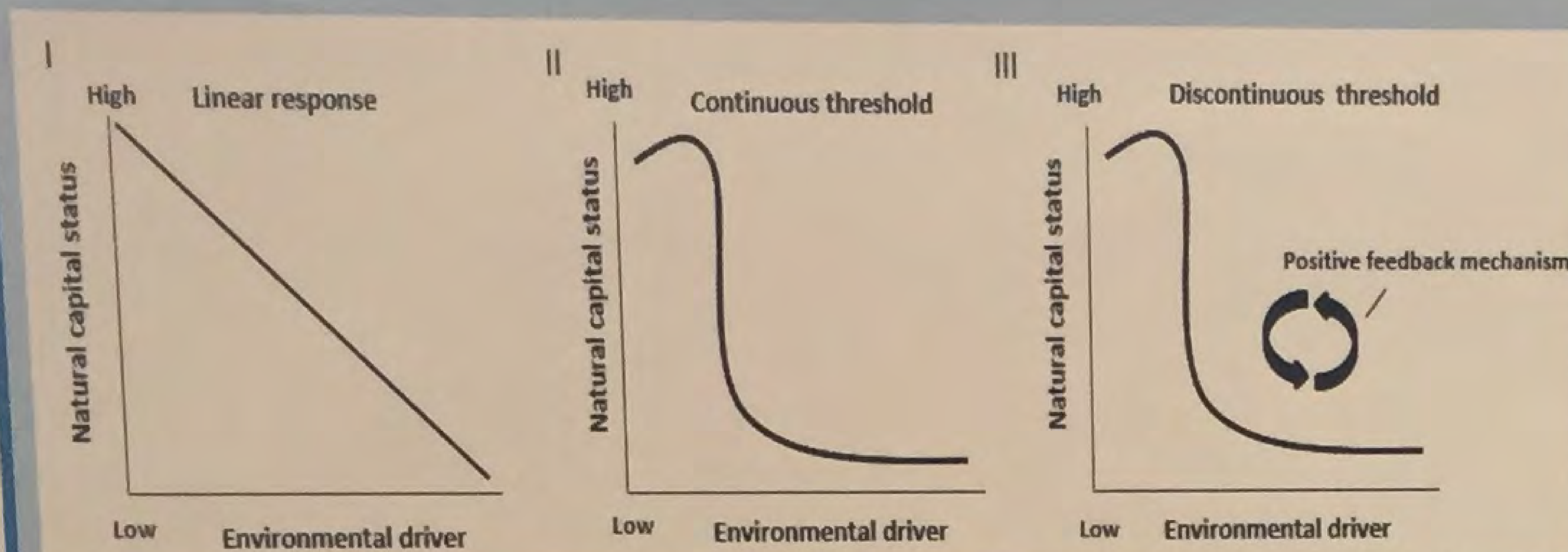

Figure 1: Alternative forms of natural capital status–driver relationships. I. Linear II. Abrupt non-linear III. Non-linear and strong positive feedback within an ecosystem often leads to hysteresis/irreversible change and is often referred to as a discontinuous threshold or a "tipping point".

Case Study

Poole Harbour is a large natural harbour of nearly 4,000 ha (located on the coast of Dorset in southern England. Despite its high conservation value, the harbour has experienced a significant decline in many of its natural assets over the last few decades with rising levels of nitrate and other inorganic nitrogen compounds in harbour waters, increasing events of invasive species and numerous threats from climate change all acting concurrently to reduce important biota that help to provide services to the surrounding catchment and wider economy.

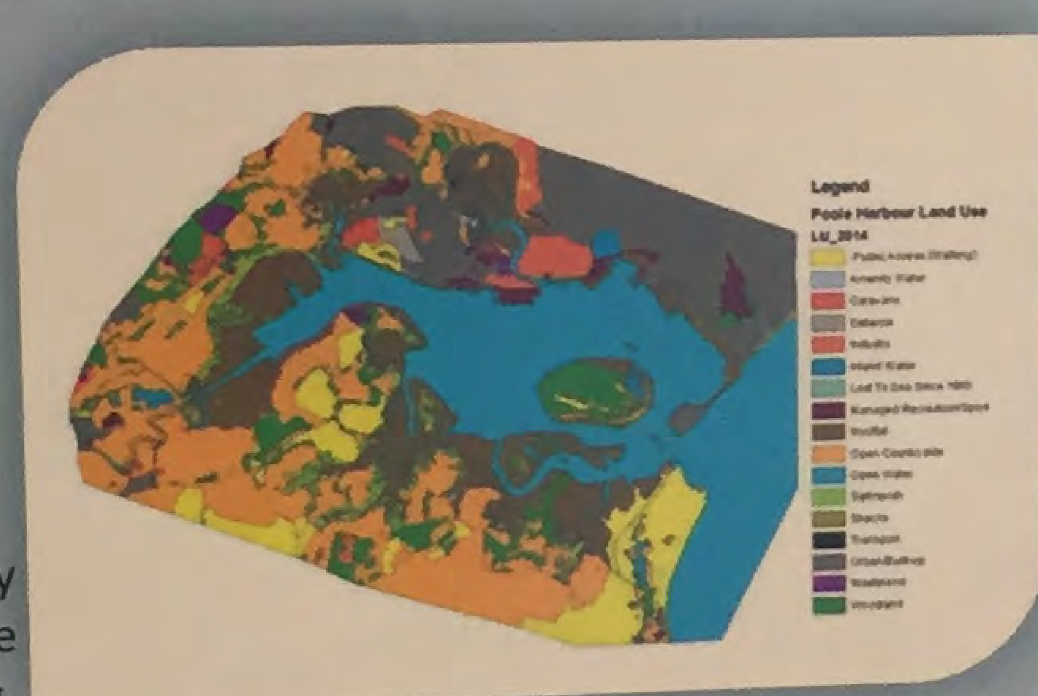

Figure 2 Pool harbour and its surrounding land use.

Aims

1. To investigate and provide statistical evidence for non-linear thresholds in Poole Harbours natural assets.
2. Identify possible pressure–natural asset state relationships.

Materials and Methods

To advance the science and application of ecosystem thresholds in resource management, we tested two statistical methods, change point analysis (STARS, Rodionov.,200) and generalized additive models (GAMs). Using these exploratory approach, threshold response patterns could be related to ecologically sound hypothesis of underlying mechanisms of cause and effect.

Data for provisioning, regulating and cultural services were represented by a wide range of natural assets collected from across the harbour . Assets of interest were chosen were of immediate importance for conservation (e.g. saltmarsh and mudflat area or wader numbers) but also those of considerable commercial (e.g. Manila clam) and regulatory importance (e.g. macroalgal mats). Data for possible drivers in the harbour were also sourced from monitored instrument records.

Reference: Rodionov, S. N. (2004). A sequential algorithm for testing climate regime shifts. *Geophysical Research Letters*, *31*(9).

Results

1. Time series (Change point analysis)

Time series for Poole Harbour (Figure 3) provide empirical evidence of recent environmental degradation.

Drivers
Coliform bacteria
Fishing pressure
Nutrient loading (Nitrates & Phosphates)
Riparian water flows
Water temperature

Thresholds identified

Type I:
Intertidal mudflat

Type II:
Macroalgal mats (Area)
Macroalgal mats (Condition)
Saltmarsh
Wildfowl and waders

Type III:
Manila Clam
(*Tapes philippinarum*)
Subtidal sediment

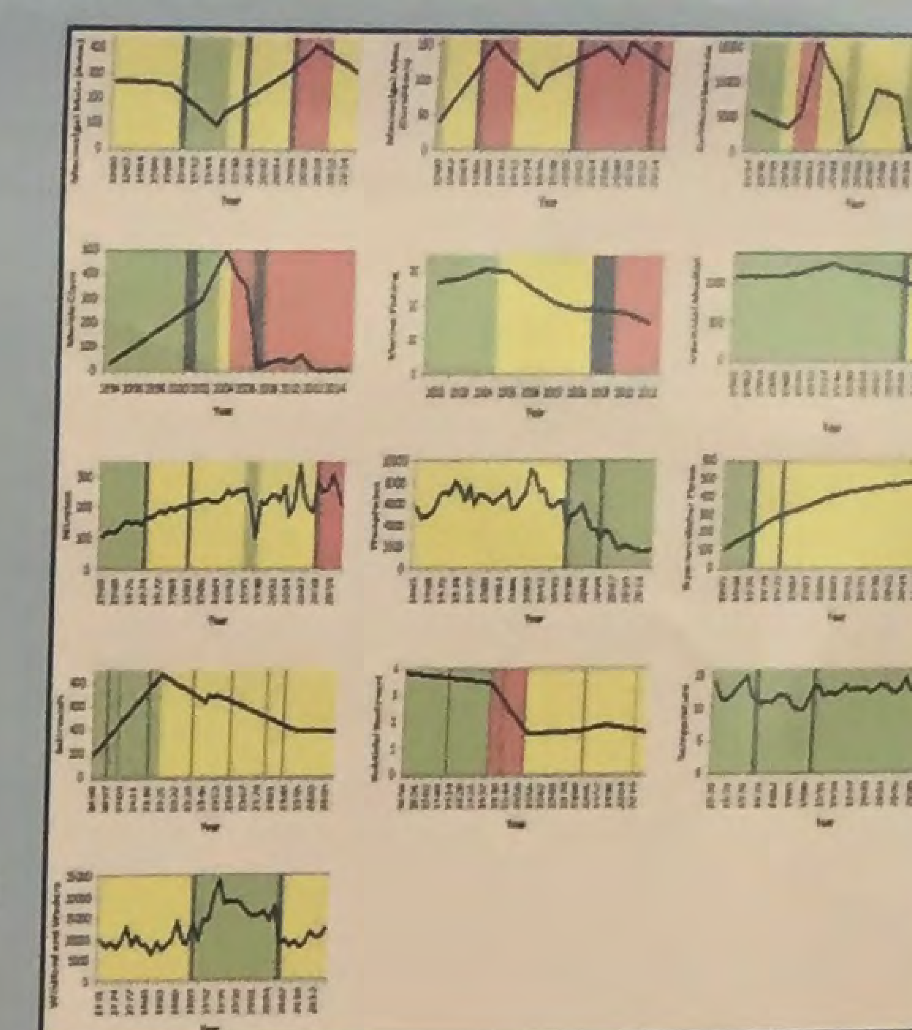

Figure 3: Long term time series of natural assets and environmental drivers in Poole Harbour for the period 1890-2015. Grey lines represent statistically significant ($p \leq 0.01$) breakpoints. Colour coded segments show historical changes: Favourable (green), Unfavourable-Inadequate (yellow) and Unfavourable-Bad (red).

2. Interactions between drivers and natural assets (GAMs)

Of the 22 possible GAM models among ecological indicators manila clam, saltmarsh and waders and wildfowl, 9 were significant ($p < 0.05$).

Significant results
Asset vs drivers

Manila Clam vs
Fishing pressure
Temperature
Subtidal sediment

Saltmarsh vs
Riparian water flows
Macroalgal mats (Condition)

Waders and wildfowl vs
Macroalgal mats (Area)
Macroalgal mats (Condition)
Saltmarsh

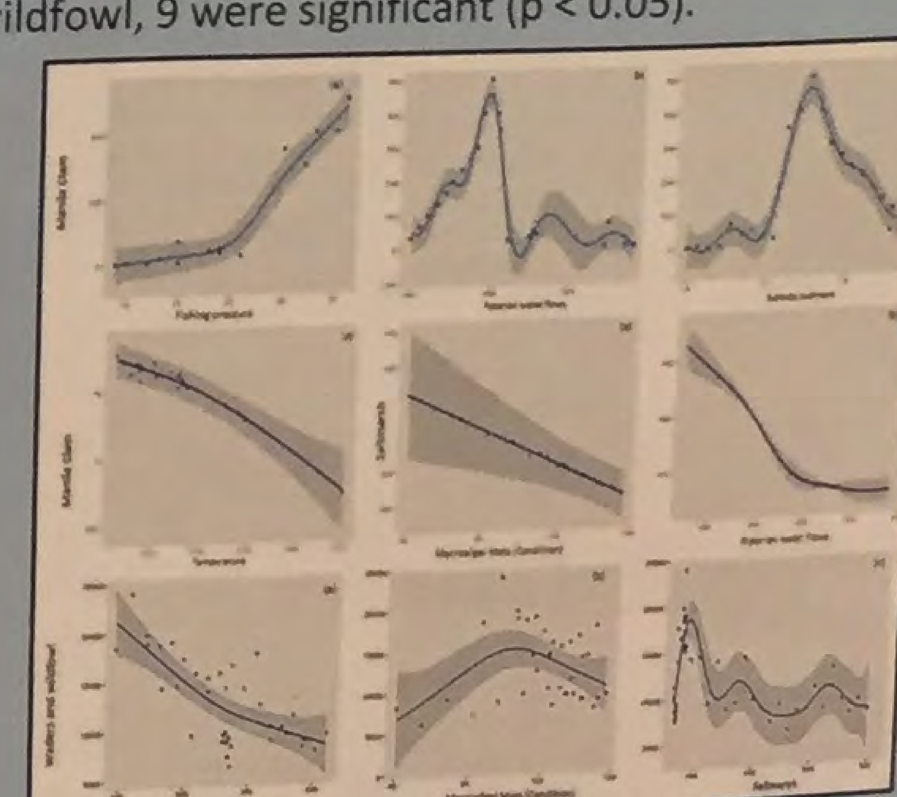

Figure 4 GAMs of Manila Clam, saltmarsh, wildfowl and wader's. Blue line represent significant positive or negative trends, the grey polygon represents 95% confidence intervals, points represent the raw data

Conclusions

- Non-linear trends were the most common threshold type (II) identified in from our time series analysis.
- Fishing activity combined with other stressors have strongly modified the population dynamics of Manila clams resulting in a type III tipping point.
- Increased attention is still needed to reduce nitrogen fuelled pressures such as algal mats and bring the catchment back to "Good Status" by Water Framework Directive standards (WFD) .
- Several novel non-linear pressure–state relationships were identified from GAMs with potential utility for an ecosystem based management approach to the harbour.