Institution: Edinburgh Napier University

Unit of Assessment: 7 - Earth Systems and Environmental Sciences

Title of case study: Defining and sustaining healthy seas

1. Summary of the impact

Managing and conserving the marine environment requires defining what constitutes healthy ecosystems and understanding the effects of pollution. Edinburgh Napier University (ENU) research defining 'undesirable disturbance' allowed the United Kingdom (UK) to mount a successful defence at the European Court of Justice in 2009 against alleged infraction of UK obligations under the Urban Waste Water Treatment Directive. This saved UK taxpayers £6 billion in estimated additional costs. The European Union (EU) Marine Strategy Framework Directive uses a definition of good status for pelagic habitats derived from work at ENU, which benefits policy makers and marine stakeholders by facilitating the establishment of Marine Protected Areas.

2. Underpinning research

ENU has a long history of applied marine research including the first UK Master's degree in the biology of water resource management (1979), and early work on pollution in the Forth. Three related questions underpin this work from these origins until today: 1) How do we know what conditions are 'natural' or 'healthy'? 2) How can we detect changes from a healthy state? 3) How can we predict the impacts of pollution and disturbance on marine systems? Answering these questions for phytoplankton communities was the main focus of the group led by Professor Paul Tett (ENU, 1996 – 2009, when the research underpinning this case was conducted). Using modelling, field sampling and laboratory approaches, the Tett group explored the relationships between nutrient inputs and phytoplankton growth. They explained seasonal cycles under natural conditions in Scotland (e.g. with J. Lee, ENU, 1996 – 2002)[3.4] and in Northern Ireland (with E. Capuzzo, 2005 – 2011 funded by the Loughs Agency), and under conditions of enhanced nutrient inputs (with V. Edwards, 1997 – 2001, co-supervised with the Scottish Environment Protection Agency; (SEPA))[3.5].

This work modelled the 'assimilative capacity' of water bodies. The concept of assimilative capacity informs policy on pollution control. It assumes that there are acceptable quantities of pollution that can be absorbed by natural environments. Exceeding these limits results in detectable impacts that should be avoided. For example, inputs of nutrients that exceed limits can lead to eutrophication. The core predictive model developed and refined by the Tett team (with the Scottish Association for Marine Science, (SAMS)) is known as the CSTT (after the 'Comprehensive Studies Task Team' established by the UK Government). This predicts plankton biomass given nutrient and light conditions. Model predictions were validated, by ENU, SAMS and others, against observations from the Mediterranean to the Arctic in the European project OAERRE[3.3], and in Loch Creran by ENU-SAMS PhD student C. Laurent [3.2].

Applying biological understanding to policy required clear definitions of terms. The Urban Waste Water Treatment Directive (EEC 1991) gives the following definition of eutrophication: "The enrichment of waters by nutrients… causing an accelerated growth of algae… to produce an *undesirable disturbance* to the balance of organisms present in the water". Hence defining 'undesirable disturbance' is of crucial importance in applying this directive. Work led by Prof. Tett, funded by the UK Government (Department for Environment, Food and Rural Affairs; DEFRA) and with other permanent ENU staff (Mark Huxham, 1995 – present, Teresa Fernandes, 1994 – 2012 and Linda Gilpin, 1996 – present), and colleagues from SAMS, the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Hull University and elsewhere, produced a working definition of this term that has since been used by policy makers[3.1].

The latest developments in using phytoplankton science to inform policy have come from the Tett team's invention of the Phytoplankton Community Index (PCI). Work on *undesirable disturbance*

showed how biomass alone was an insufficient indicator: the balance of types of organisms is also crucial. The PCI applies life form theory to phytoplankton modelling which allows an understanding of when ecosystems are moving towards less desirable states, without the burdensome requirement to identify all taxa to species level.

3. References to the research

Selected peer reviewed papers:

3.1 Tett, P., R. Gowen, D. Mills, T. Fernandes, L. Gilpin, M. Huxham, K. Kennington, P. Read, M. Service, M. Wilkinson and S. Malcolm (2007) Defining and detecting Undesirable Disturbance in the context of Eutrophication. *Marine Pollution Bulletin* 55, 282-297.

3.2 Laurent, C., P. Tett, T. Fernandes, L. Gilpin and K. J. Jones (2006) A dynamic CSTT model for the effects of added nutrients in Loch Creran, a shallow fjord. *Journal of Marine Systems* 61, 149-164.

3.3 Tett, P., L. Gilpin, H. Svendsen, C. P. Erlandsson, U. Larsson, S. Kratzer, E. Fouilland, C. Janzen, J.-Y. Lee, C. Grenz, A. Newton, J. G. Ferreira, T. Fernandes and S. Scory (2003) Eutrophication and some European waters of restricted exchange. *Continental Shelf Research* 23, 1635-1671.

3.4 Lee, J.-Y., P. Tett and K.-R. Kim (2003) Parameterising a Microplankton Model. *Journal of the Korean Society of Oceanography* 38, 185-210.

3.5 Edwards, V. R., P. Tett and K. J. Jones (2003) Changes in the yield of chlorophyll a from dissolved available inorganic nitrogen after an enrichment event - applications for predicting eutrophication in coastal waters. *Continental Shelf Research* 23, 1771-1785.

3.6 Gowen, R.J., P. Tett, K. Kennington, D.K. Mills, T.M. Shammon, B.M. Stewart, N. Greenwood, C. Flanagan, M. Devlin and A. Wither (2008) The Irish Sea: is it eutrophic? *Estuarine, Coastal and Shelf Science* 76, 239-254.

Key grants related to research covered in this case study:

S.N.I.F.F.E.R. `Yield of marine phytoplankton chlorophyll from dissolved inorganic nitrogen under eutrophic conditions' ($35579 for 3 years from October 1997, a research studentship jointly supervised by P. Tett, K. Jones (Natural Environment Research Council Dunstaffnage Marine Laboratory) and R. Park (SEPA).

DEFRA `Understanding of Undesirable Disturbance in the context of eutrophication, and development of UK assessment methodology for coastal and marine waters' (£45,992 in 2004, to a consortium led by ENU: other members were, Heriot-Watt University, Liverpool University, CEFAS, and the Department of Agriculture and Rural Development).

DEFRA /CEFAS: `Research supporting the development of eutrophication monitoring and assessment' (CEFAS contract leader was Dr D. Mills, Subcontract ME2202 from CEFAS to ENU for £57,818, September 2004 to February 2007; extended into 2009, and used as a vehicle for providing advice to DEFRA in relation to the 'Scientific analysis and contributions to UK evidence and arguments concerning eutrophic status of estuaries and coastal waters in UWWTD case 1998/2265'.

DEFRA/CEFAS: `Development of a phytoplankton trophic index'. (CEFAS, CSA 6754 contract leader was Dr D. Mills; subcontract ME2204 to ENU for £35,700, December 2004 to March 2006).

4. Details of the impact

The most significant impact arising from this work was the role it played in determining UK policy in response to the Urban Waste Water Treatment Directive (UWWTD). Specifically, the work led by Professor Tett saved the UK approximately £6 billion (as estimated by the Environment Agency) with UK taxpayers as the ultimate beneficiaries.

The UWWTD governs how member states should treat sewage discharges into coastal waters. It requires the application of tertiary treatment to remove nutrients when discharges occur into

eutrophic waters. In 1999, the European Commission (EC) accused the UK of infracting the UWWTD by failing to identify certain coastal waters in England and Wales as eutrophic, and the case came before the European Court of Justice (ECJ) in 2007. Defending the case involved empirical work on the relationships between nutrients and algal growth and conceptual clarity around what was meant by the key term *undesirable disturbance* taken from the UWWTD definition of eutrophication.

In anticipation of this case, in 2004, DEFRA commissioned a review of 'undesirable disturbance in the context of eutrophication' from a group led by Tett. The group (see Tett *et al*., 2007)[3.1] concluded that '*an undesirable disturbance is a perturbation of a marine ecosystem that appreciably degrades the health or threatens the sustainable human use of that ecosystem'*, and proposed methods for detecting such disturbance. The methods were applied by a team including Tett and colleagues from SAMS, CEFAS, the Agri-Food and Biosciences Institute, and elsewhere, to show lack of undesirable disturbance in the Irish Sea, one of the contested areas (Gowen *et al*., 2008)[3.6].

During the defence, the UK was able to cite the undesirable disturbance work and the arguments were accepted by the Court (e.g. para. 330, 332 - they refer to the paper as the Gowen report 2007)[5.1,5.2]. In addition, evidence from Tett and Gowen on the biology of phytoplankton growth was presented orally to court in April 2009. This drew on the CSTT work and demonstrated that most UK coastal waters were light limited because of turbidity, which was crucial in winning the case[5.1]. In December 2009, it was announced that the UK had won the relevant part of its case (ECJ, 2009), thus avoiding fines, and the necessity for very expensive tertiary sewage treatment plants. The work has influenced other areas of UK response to EU legislation, for example the EU's Marine Strategy Framework Directive (adopted in June 2008). This aims to protect the marine environment across Europe by achieving 'good environmental status' of the EU's marine waters by 2020, and to protect the resource base upon which marine-related economic and social activities depend. As in the case of the UWWTD, implementing the legislation requires conceptual clarity about key terms and the scientific tools and procedures to measure the relevant variables. In particular, it requires that the commission should lay down criteria and methodological standards to allow consistency of approach in evaluating the extent to which Good Environmental Status (GES) is being achieved. The Commission established Task Groups of experts to achieve this for each of the descriptors in the directive. Task group 5 reported on eutrophication in 2010[5.3]. It included Tett as one of the expert authors, and drew on the work on undesirable disturbance and the plankton community index to establish standards that will be used in implementing the directive across the EU, thus helping to maintain and enhance the health of the marine environment within the EU.

Impacts of the work in defining assimilative capacity and undesirable disturbance included policy on aquaculture, in particular on the siting of finfish and shellfish farms[5.4]. Tett and Fernandes were authors on the Huntington *et al*. 2006 report to the Directorate-General for Fish and Maritime Affairs of the EC on 'Some Aspects of the Environmental Impact of Aquaculture in Sensitive Areas'. This has been used by the EC to inform policy on aquaculture. It has also informed the application of the Marine Stewardship Council (MSC) sustainable fisheries certification in Scottish waters. For example, the Shetland and Scottish Mainland Rope Grown mussel Enhanced fishery was certified by the MSC in April 2012, using Huntington *et al.* 2006 to support their 'principle 2 – ecosystem sustainability'[5.5]. This industry is growing rapidly, with more than 7,000 tonnes produced in 2010. Its further growth will be supported by the MSC accreditation.

Hence, the ENU work on healthy seas has established a strong tradition of interpreting fundamental ecological concepts, such as ecosystem health, and facilitating their application by policy makers in settings from pollution control to ecosystem restoration.

5. Sources to corroborate the impact

[5.1]Corroboration from key individual: Science Leader at CEFAS. This person can corroborate the impacts of the UWWTD related work.

[5.2]ECJ (2009). Commission of the European Communities v United Kingdom supported by Portuguese Republic. Judgement of the European Court of Justice (3rd chamber) on 10 December 2009, In Case C-390/07, under Article 226 EC for failure to fulfil obligations, pursuant to Articles 3(1) and (2) and 5(1) to (3) and (5) of, and Annex II to, Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment (OJ 1991 L 135, p. 40).

A link to this judgement from the European court – note paragraphs 330 and 332 as examples of references to the work described here:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:62007CJ0390:EN:NOT.

[5.3]Report of the Marine Strategy Framework Directive task group 5 on eutrophication, with Tett as an expert author:
http://ec.europa.eu/environment/marine/pdf/5-Task-Group-5.pdf.

[5.4]Programme manager for Marine Spatial Planning with Marine Science Scotland. This individual can corroborate the importance of the aquaculture impacts and siting work.

[5.5]For evidence of the use of assimilative capacity in aquaculture see, e.g. p 94 from the Marine Stewardship Council accreditation documents:

http://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/north-east-atlantic/shetland_and_scottish_mainland_rope_grown_mussel_enhanced_fishery/assessment-downloads-1/20120503_FR.pdf.