Institution: University of the Highlands and Islands

Unit of Assessment: 7 Earth Systems and Environmental Science

Title of case study:

The CSTT model underpinning the UK defence in European Court of Justice

1. Summary of the impact (indicative maximum 100 words)

Eutrophication results from excessive nutrient discharge to a water-body, reducing water quality. Eutrophication status must comply with the Urban Waste Water Treatment Directive (UWWTD). As part of a consortium, UHI developed, validated and researched a model (CSTT) capable of screening a water-body for eutrophication. The model was used to defend the UK in the European Court of Justice (2009), against proceedings brought by the European Commission alleging infraction of UK obligations under the UWWTD. The model proved that British waters were not harmfully impacted by eutrophication, sparing the UK government ~£6 billion to implement tertiary sewage treatment across England and Wales.

2. Underpinning research (indicative maximum 500 words)

Eutrophication is the process by which a body of water acquires a high concentration of nutrients, especially Nitrate and Phosphate, promoting excessive growth of algae resulting in severe reduction in water quality. UHI research[1,2,3] shows that growth of algae may not occur where there is a lack of sunlight or where energy levels in the water are high enough to cause dispersion of the algae. The European Urban Waste-Water Treatment Directive (UWWTD) (1991) specifies that the amount of treatment required for discharge of urban wastewater depends, among other things, on the actual or potential level of eutrophication of the receiving water.

In response to the UWWTD, the UK government set up the Comprehensive Studies Task Team (CSTT) to produce guidelines for studies to check that British waters were not becoming eutrophic. To understand the potential of a water body become eutrophic, several factors have to be taken into consideration: water exchange and mixing relationships within the water-body, chlorophyll content and nutrient effects and light intensity.

Prof Tett proposed to the CSTT (1993) to develop a model which could accommodate all of these parameters to enable an effective means to screen a water body for eutrophic conditions. Model development and refinement took place from 1994-1997 during a number of collaborative research projects[2,3,4,5,6,7] of UHI, Napier University and University of Bangor.

The UHI component built on over 30 years of research into water exchange and mixing characteristics in sea-lochs and estuaries (Inall), phytoplankton growth theory (Droop) and nutrient effects on water quality (Gowen). This work was brought together with work on the other crucial parameters relating to photosynthetic efficiency and growth-related respiration in response to underwater light carried out at Napier University and University of Bangor, to develop the CSTT Model for Eutrophication.

The model uses the rate of exchange between water-bodies, the rate of addition of nutrients, and light levels to predict whether or not there will be eutrophication in a body of water under specified conditions and was published in the CSTT guidelines (1997).

From 1997-2003, the model was validated by UHI and Napier University during a joint PhD Studentship, against observations from the Mediterranean to the Arctic in the collaborative European project OAERRE[4]. Further tests were also carried out in Loch Creran by Napier-

SAMS PhD student Celine Laurent[5] (2002-2006). During this study, the CSTT model was applied to Loch Creran to assess the capacity of the loch to assimilate nutrients from fish-farms. Model simulations were found to retain a significant correlation with observations demonstrating the model's ability to replicate actual conditions of the water-body, in this case Loch Creran.

The model continues to be developed and adapted for wider use and with funding from the Scottish Aquacultural Research Forum (SARF, 2005–2011), UHI researchers led by Prof's Tett & Inall have been developing a new version of the model for predicting the environmental impacts of aquaculture in sea lochs[6] and has been developed further to the ACExR model for seasonal exchange and mixing in enclosed sea lochs.

3. References to the research (indicative maximum of six references)

1. CSTT (1997). Comprehensive studies for the purposes of Article 6 & 8.5 of DIR 91/271 EEC, the Urban Waste Water Treatment Directive, second edition. Report, pp. Edinburgh, Published for the Comprehensive Studies Task Team of Group Coordinating Sea Disposal Monitoring by the Department of the Environment for Northern Ireland, the Environment Agency, the Scottish Environment Protection Agency and the Water Services Association.
2. Gowen, R. J., **P. Tett** and **K. J. Jones**. 1992. Predicting marine eutrophication: the yield of chlorophyll from nitrogen in Scottish coastal phytoplankton. *Marine Ecology - Progress Series*, 85: 153-161.
3. 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.
4. **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.
5. 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.
6. **Tett, P**., E. Portilla, P. A. Gillibrand and **M. Inall** (2011). Carrying and assimilative capacities: the ACExR-LESV model for sea-loch aquaculture. Aquaculture Research, 42, 51-67.
7. Gillibrand, P. A., **M. E. Inall**, E. Portilla and **P. Tett** (2013). A Box Model of the Seasonal Exchange and Mixing in Regions of Restricted Exchange: Application to Two Contrasting Scottish Inlets. Environmental Modelling & Software, 43, 144-159.

4. Details of the impact (indicative maximum 750 words)

Eutrophication is a process involving the excessive build-up of nutrients in a water body leading to the deterioration of the water quality. Whilst eutrophication can happen naturally, human impacts such as sewage discharge can greatly enhance the process. As such, eutrophication status is controlled by The European Urban Waste Water Treatment Directive (UWWTD) of 1991. The UK set up the Comprehensive Studies Task Team (CSTT) to produce guidelines for studies to check that British waters were not becoming eutrophic. However, despite these guidelines, 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. This accusation led to a court case in the European Court of Justice, which was finally decided in the UK's favour in 2009[7]. The CSTT model, developed by UHI, Napier University and University of Bangor was key to the UK's successful defence[1].

The UK was brought before the Court in 2007, and presented its defence in writing over the next two years, culminating in a hearing in Luxembourg in April 2009. Prof. Tett contributed written and oral evidence during this period and attended the hearing in person as an expert advisor, supporting the UK government solicitors and Defra officers.

The defence included data showing lack of undesirable disturbance due to nutrient enrichment of UK waters, and made the argument, based quantitatively on the CSTT model, that many of our coastal waters and estuaries were light-limited, and therefore not eutrophic[1].

As part of the judgement, the Court ruled that eutrophication comprises four linked steps: (1) enrichment with nutrients; (2) accelerated growth of algae, etc.; (3) an undesirable disturbance to the balance of organisms; (4) an undesirable disturbance to water quality; and that, for eutrophication to be proven, a causal relationship between each step must be demonstrated[1].

It was agreed that the relevant waters in question were nutrient-enriched (step 1), but the UK claimed that accelerated algal growth (step 2), was often prevented by turbidity. Results from the CSTT model were put forward to show that this was the case[1].

In December 2009 it was announced that the UK had won the relevant part of its case[1]. The CSTT model provided the scientific evidence which helped to uphold the reputation of British scientific research and save the British government and taxpayers a hefty bill for additional water treatment. A similar case was lost by the French government in 2004[2], resulting in heavy fines and the expensive obligation to build extra sewage treatment plants. Enforcement of the directive, if the UK had lost the case, would have required the installation of nutrient-stripping treatment systems to all waste water discharges identified as being eutrophic – affecting every major city and town from the east of England up to Liverpool, an area with a resident population of around 20 million. This tertiary level of sewage treatment would have cost on the order of £6 billion to implement, accounting for initial capital costs of installation, running costs and maintenance over a 20-year period[1]. It is assumed these extra water treatment costs would have been passed down to consumers.

Other impacts of the research include:

- The Centre for Environment, Fisheries and Aquaculture Science (Cefas) (with funding from the Environment Agency) continues research to combine the CSTT model with their *'combined macroalgae and phytoplankton model'* (CPM), for use in evaluating the trophic status of shallow coastal water bodies such as Poole harbour. UHI collaborates on this evaluation project[3].
- In 2011, Prof. Tett was invited to serve on a European Task Group set up by International Council for the Exploration of the Sea and the EC Joint Research Committee, chaired by Dr. João Ferreira, to provide guidance to the European Commission on implementing 'Qualitative Descriptor' 5, Eutrophication, of the Marine Strategy Framework Directive. Prof. Tett led clarification of the definition of eutrophication (Ferreira et al., 2011)[4].
- Further developments of the model by UHI for use in aquaculture by Profs. Tett & Inall (2005-2011 SARF (Scottish Aquacultural Research Forum) funded research) have been transferred to Marine Science Scotland and Scotland's Environment Protection Agency (SEPA) and reported to the industry at the Association of Scottish Shellfish Growers Conference in 2011. A report on the Development of Assimilative Capacity and Carrying Capacity Models for Water Bodies utilized for Marine Bivalve and Caged Fish-farming, was prepared by Prof. Tett on behalf of SARF and published on the SARF website to provide a guide to the model system and advice on model software

for businesses and regulators[5].

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. 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). http://curia.europa.eu/juris/document/document.jsf;jsessionid=9ea7d2dc30db12af24355e0046d080a3c6903dd5e118.e34KaxiLc3qMb40Rch0SaxuLc390?text=&docid=76787&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=497124

2. ECJ (2004). Commission of the European Communities v French Republic. Judgement of the European Court of Justice (2nd chamber) on 23 September 2004, in case C-280/02, concerning: Failure of a Member State to fulfil obligations - Directive 91/271/EEC - Urban waste water treatment - Article 5(1) and (2) and Annex II - Failure to identify sensitive areas - Meaning of 'eutrophication' - Failure to implement more stringent treatment of discharges into sensitive areas.

3. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) continue to use the CSTT model in collaboration with UHI. For more information contact named individual from Cefas as reported to the REF submission Team, or details are available from the UHI REF audit contact.

4. Ferreira, J. G., J. H. Andersen, A. Borja, S. B. Bricker, J. Camp, M. Cardosa da Silva, E. Garces, A. S. Heiskanen, C. Humborg, L. Ignatiades, C. Lancelot, A. Menesguen, P. Tett, N. Hoepffner and U. Clausen (2011). Overview of eutrophication indicators to assess environmental status within the European Marine Strategy Framework Directive. Estuarine, Coastal and Shelf Science, 93, 117-131.

5. SARF commissioned report http://www.sarf.org.uk/cms-assets/documents/48900-379750.sarf012a.pdf