ECASA - Model description template *(do not exceed 4 pages)* (v3: PT, Aug 05)

1	Name of model	*Reporter/Institute (email address)*
1.a	***CSTT eutrophication screening model***	Paul Tett / Napier University email: p.tett@ichrachan.u-net.com
1.b	*date this form was completed or updated*	18 August 2005

2	Short DESCRIPTION of model	
2.a	*Main state variables:*	nutrient S and chlorophyll X concentrations
2.b	*Scale to which applicable:*	water body, scale B
2.c	*General description.* *NB: if the model is complicated, or has easily distinguishable components (such as a physical and a biological sub-models) that can be, or have been, used separately, it may be easier to complete one form for each of the main components.*	A model for a 'well-mixed box' of volume V, which solves for 'equilbrium concentration enhancement' (ECE) of nutrient and converts this into a worst-case chlorophyll concentration. E, exchange rate (proportion of box volume exchanged daily with the boundary conditions S_o and X_o), parameterizes all relevant water movements. Main equations: $S_{eq} = S_o + (s_i/(E.V))$ (nutrient concentration); $X_{max} = X_o + q.S_{eq}$ ((maximum) chlorophyll conc.); X_{max} only possible if $\mu(I) > (L+E)$, where light-limited growth rate $\mu(I) = \alpha.(I-I_c)$; in this, submarine mean illumination $I \approx m.I_o/(K_d.h)$, where h is box depth.
2.d	*Key semi-universal parameters and example values (which should apply at least regionally or for at least one type of water body); summarize any restrictions or reservations about these parameters*	q, yield, 1.1 mg chl from 1 mmol (assimilated) nitrate; α, photosynthetic efficiency, 0.006 d^{-1} ($\mu E\ m^{-2}\ s^{-1}$)$^{-1}$ I_c, compensation irradiance, 5 $\mu E\ m^{-2}\ s^{-1}$ Values apply to N-limited coastal phytoplankton in summer and assume the presence of microheterotrophs.
2.e	*Main forcing data needed - initial values of state variables; boundary conditions; inputs; imposed environmental conditions; generalized loss terms. State whether single values or time-series needed.*	Local data needed for: E; V; h; seasonal medians and maxima of S_o and X_o; typical seasonal value of PAR diffuse attenuation coefficient, K_d adjusted for worst-case chlorophyll; nutrient input (s_i, amount d^{-1}) from all local (natural and anthropogenic) diffuse and point sources (except recycling and the trans-boundary input given by $E.V.S_o$). Regional value needed for typical 24-hr mean surface PAR, I_0 . L is local loss rate to grazing etc; a default value of 0.1 d^{-1} could be used in absence of local data.
2.f	*Restrictions to use of model*	Should only be used at sites where 'mixed-box' and 'steady-state' assumptions roughly correct.

3	**possibly relevant INDICATORS and example EcoQOs**	
3.a	***D**river*	
3.b	***P**ressure*	nutrient loading as ECE: $s_i/(E.V)$ *(not to exceed 50% of background* S_o *in Scottish assessment of sites)*
3.c	***S**tate*	
3.d	***I**mpact*	maximum chlorophyll, X_{max} *(not to exceed 10 mg chl* m^{-3} *in Summer - CSTT, 1994)*
3.e	***R**esponse*	

4	**STATUS of model** *NB: refers to scientific theory and equation set; distinguish from implementation*	
4.a	*Origin(ator) of model concept and initial formulation:*	UK 'Comprehensive Studies Task Team' (CSTT, 1994; 1997; Tett, 2000) based on Gowen *et al.* (1992)
4.b	*Present status of model, including scientific basis of claimed robustness and key matters still needing study:*	Parameterization improved and model tested (against observed X_{max}) during OAERRE project (Tett *et al.*, 2003). Values of q under N-limitation based on microcosm experiments by Edwards (2001) and Edwards *et al.* (2003, 2005), which need repeating for phosphorus. Box definition and estimation of E currently under study for Scottish fjords and coastal waters (in collaboration with SAMS). Improvements needed in procedures for estimating value of L.
4.c	*Present use:*	Identifying 'less sensitive' and 'sensitive' waters for the UWWTD and Nitrates Directive.
4.d	*Potential use and development in ECASA :*	Estimating eutrophication risk from fish farm nutrients, and hence waterbody capacity to assimilate these nutrients.

5	**IMPLEMENTATION of model**	
5.a	*State of implementation :* *(This refers to realization of model theory in numerical algorithms, spreadsheets, computer programs, etc. to provide solutions of the model equations when supplied with appropriate forcing data.*	Equations and standard parameter values listed in Tett *et al.* (2003); also available as (Microsoft Excel X, compatable with Excel 97 through 2001) spreadsheet.
5.b	*State of documentation (which describes how to use an implementation as well as giving model theory)*	Report (CSTT, 1997) describes application for purposes of UWWTD; paper by Tett *et al*. (2003) gives current estimates of parameter values as well as describing model theory; web pages (Tett, 2005) explain and guide application.
5.c	*Intellectual property concerns - if none stated here, model and implementation will be deemed to freely available on request*	Original CSTT model (CSTT 1997) and OAERRE application (Tett *et al.*, 2003) in public domain. Spreadsheet freely available (needs appropriate Excel to run) but without warranty and on condition of

citation of source.

6.	**TESTING of model**	
6.a	*Summary of conditions and measurements needed:* *Refer back to 2.e if necessary. Highlight observations needed for model testing.*	For each site, a box must be identified, and corresponding values of *E, h* and *V* found. This is usually easy for 'regions of restricted exchange', but account should be taken of stratification (box confined to surface layer); in open coastal waters box may be defined (for appropriate timescale) from tidal movements, residual flows, or dispersion. Sufficient observations of S_o and X_o are needed to provide statistics for season. K_d must be estimated locally (from Secchi depth or PAR profiles), and local inputs of nutrient quantified. Surface PAR can be measured locally, or estimated from latitude, time of year, and estimated cloud cover. **Sufficient observations of chlorophyll concentration (*X*) are needed to give reliable estimate of the statistic X_{max}** (during appropriate season).
6.b	*Criteria for model rejection*	Given $\hat{X}_{\max}[i]$ from model for site *i* and corresponding $X_{\max}[i]$ from upper 95%ile of observations of *X* at site, the model fails *for a given site* if $\hat{X}_{\max}[i] > X_{\max}[i]$ is false. The model will be deemed to have failed *for any single hydrodynamically-defined water type* if (given reliable forcing data) the test is failed at more than 1 in 10 sites of that type.

7	**OTHER models**	
7.a	*Used explicitly or implicitly with this model*	The CSTT model includes a nutrient ECE model (Gillebrand & Turrell, 1997), and requires a water column optical model (e.g. Tett, 1990) to estimate K_d. Values of α and I_c derive from a microplankton model, which takes account of planktonic microheterotrophs (Lee *et al.*, 2003; Tett & Wilson, 2000; Tett *et al.*, 2002). Physical models have been used to quantify exchange (see also Gillebrand, 2001) and an astronomical-atmospheric model to provide PAR.
7.b	*Similar models (which might serve roughly the same purpose in relation to mariculture)*	The FjordEnv model of Stigebrandt (2001). The 'Riley+' (Tett & Wilson, 2000) and 'dynamic CSTT' (Laurent et al., 2005) models. The 'Strategic fjord simulation model' of Ross *et al.*(1993, 1993, 1994).

8. REFERENCES cited *show in bold the most important paper describing the model*

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Tett, P. (1990). The Photic Zone. In *Light and Life in the Sea* (eds P.J. Herring, A.K. Campbell, M. Whitfield & L. Maddock), pp. 59-87. Cambridge University Press, Cambridge, U.K.

Tett, P. (2000). Marine eutrophication and the use of models. In *Science and Environmental Decision Making* (eds M. Huxham & D. Summer), pp. 215-238. Addison Wesley Longman/Pearson Education, London.

Tett, P. (2005) Sustainable Catchement Management: Predicting Eutrophication with the CSTT model. http://www.lifesciences.napier.ac.uk/teaching/SCM/CSTT04.htm

Tett, P., Arístegui, J., Barton, D., Basterretxea, G., De Armas, J.D., Escánez, J.E., Hernández León, S., Lorenzo, L.M., & Montero, N. (2002) Steady-state DCM dynamics in Canaries waters. Deep-Sea Research II, 49, 3543-3559.

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