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| 1 | Name of model | <i>Reporter/Institute (email address)</i> |
| <i>1.a</i> | ESV water body assimilative capacity model | Paul Tett / Napier University email: p.tett@ichrachan.u-net.com |
| <i>1.b</i> | <i>date this form was completed or updated</i> | 27 October 2005 |

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| 2 | Short DESCRIPTION of model | |
| <i>2.a</i> | <i>Main state variables:</i> | Concentrations of particulate organic matter in microplankton <i>B</i> and detritus <i>C</i> , dissolved oxygen <i>O</i> , several nutrients <i>S</i> , and chlorophyll <i>X</i> in two types of phytoplankton |
| <i>2.b</i> | <i>Scale to which applicable:</i> | water body, scale B |
| <i>2.c</i> | <i>General description.</i> <i>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.</i> | <p>A dynamic model for a water body containing 1, 2 or 3 layers, each well-mixed and in continuous or intermittent exchange with the sea. Change within each layer is described by the following equation, which applies to the set of state variables here represented by <i>Y</i> (replace by <i>B</i>, <i>C</i>, etc):</p> $\left\{ \frac{\partial Y}{\partial t} = -\nabla \vec{\phi}_Y + \beta_Y \right\}$ <p>The first right-hand term is the physical flux divergence for each layer, and will be called the <i>physical model</i>. The second right-hand term is the <i>biological model</i>, and is expanded for the example of diatom chlorophyll:</p> $\beta_X = \mu(I, {}^N S, {}^{Si} S)^D X - L \cdot D X - \frac{w}{h} \cdot D X$ <p>A <i>bio-optical model</i> provides estimates of layer irradiance, <i>I</i>.</p> <p><i>ESV</i> abbreviates Ecosystem State Vector, which is the set of states of the variables <i>Y</i> at any given time.</p> <p><i>q</i>, yields (of flagellate or diatom chlorophyll from assimilated DAIN, of diatom chlorophyll from assimilated dissolved silica), e.g. 1.1 mg chl (mmol DAIN)⁻¹;</p> <p>α, photosynthetic efficiency, e.g. 0.006 d⁻¹ (μE m⁻² s⁻¹)⁻¹</p> <p><i>I_c</i>, compensation irradiances, e.g. 5 μE m⁻² s⁻¹</p> <p>... and others; restrictions under consideration.</p> |
| <i>2.d</i> | <i>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</i> | |
| <i>2.e</i> | <i>Main forcing data needed - initial values of state variables; boundary conditions; inputs; imposed environmental conditions; generalized loss</i> | Local data needed for: <i>E</i> ; <i>V</i> ; <i>h</i> ; seasonal medians and maxima of <i>S_o</i> and <i>X_o</i> ; typical seasonal value of PAR diffuse attenuation coefficient, <i>K_d</i> adjusted for worst-case chlorophyll; nutrient input (<i>s_i</i> , amount d ⁻¹) from all |

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| | <i>terms. State whether single values or time-series needed.</i> | 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_o . 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 | <i>Restrictions to use of model</i> | Should only be used at sites where 'mixed-box' and 'steady-state' assumptions roughly correct. |

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| 3 | possibly relevant INDICATORS and example EcoQOs | |
| 3.a | <i>Driver</i> | |
| 3.b | <i>Pressure</i> | nutrient loading as ECE: $s_i/(E.V)$ (not to exceed 50% of background S_o in Scottish assessment of sites) |
| 3.c | <i>State</i> | |
| 3.d | <i>Impact</i> | maximum chlorophyll, X_{max} (not to exceed 10 mg chl m^{-3} in Summer - CSTT, 1994) |
| 3.e | <i>Response</i> | |

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| 4 | STATUS of model <i>NB: refers to scientific theory and equation set; distinguish from implementation</i> | |
| 4.a | <i>Origin(ator) of model concept and initial formulation:</i> | Paul Tett and SEPA assimilative capacity working group in 2003-4, with roots in the 'Riley+' and 'MP' models of Tett & Wilson (2000) |
| 4.b | <i>Present status of model, including scientific basis of claimed robustness and key matters still needing study:</i> | Under SARF-funded development for Scottish fjords, voes and coastal waters (in collaboration with SAMS and FRS). |
| 4.c | <i>Present use:</i> | Intended for use in estimating the capacity of zone B water bodies to assimilate nutrients and organic waste from fish farms |
| 4.d | <i>Potential use and development in ECASA :</i> | Estimating eutrophication risk from fish farm nutrients, and hence waterbody capacity to assimilate these nutrients, at a wide range of sites for which physical models can be provided. Link to shellfish model to provide simple method for carrying capacity. |

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| 5 | IMPLEMENTATION of model | |
| 5.a | <i>State of implementation :</i> <i>(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.</i> | Being developed as Matlab script(s). |
| 5.b | <i>State of documentation</i> | Not yet available. |

(which describes how to use an implementation as well as giving model theory)

5.c **Intellectual property concerns** - if none stated here, model and implementation will be deemed to freely available on request

Model implementation and specific algorithms are the property of FRS, NUE, SAMS and SARF according to a contractual agreement. Permission will be sought from SARF to make these available for research purposes within ECASA

| 6. | TESTING of model | |
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| 6.a | <p><i>Summary of conditions and measurements needed:</i></p> <p><i>Refer back to 2.e if necessary. Highlight observations needed for model testing.</i></p> | <p>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_0 and X_0 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).</p> |
| 6.b | <p><i>Criteria for model rejection</i></p> | <p>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 <i>for a given site</i> if $\hat{X}_{max}[i] > X_{max}[i]$ is false. The model will be deemed to have failed <i>for any single hydrodynamically-defined water type</i> if (given reliable forcing data) the test is failed at more than 1 in 10 sites of that type.</p> |
| 7 | OTHER models | |
| 7.a | <p><i>Used explicitly or implicitly with this model</i></p> | <p>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 <i>et al.</i>, 2003; Tett & Wilson, 2000; Tett <i>et al.</i>, 2002). Physical models have been used to quantify exchange (see also Gillebrand, 2001) and an astronomical-atmospheric model to provide PAR.</p> |
| 7.b | <p><i>Similar models (which might serve roughly the same purpose in relation to mariculture)</i></p> | <p>The FjordEnv model of Stigebrandt (2001). The 'Riley+' (Tett & Wilson, 2000) and 'dynamic CSTT' (Laurent <i>et al.</i>, 2005) models.</p> |

8. REFERENCES cited

show in bold the most important paper describing the model

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