ECASA - Model description template

1	Name of model	*Reporter/Institute (email address)*
1.a	***DEPOMOD***	Chris Cromey Scottish Association for Marine Science (SAMS), Oban, Argyll. PA34 4AD. UK. email: chris.cromey@mapandmarine.co.uk Skype username: philminaqcjc
1.b	*date this form was completed or updated*	31st January 2008

2	Short DESCRIPTION of model	
2.a	*Main state variables:*	Particulates (total solids, carbon, tracer or other particulate component) and Infaunal Trophic Index (ITI)
2.b	*Scale to which applicable:*	local to discharge, scale A
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 particle tracking model used for predicting flux of particulate waste material (with resuspension) and associated benthic impact of fish farms. Simulated particles sink and are displaced by currents and random-walk eddy disperion. Shear in the water column can be represented by layers in the model. Resuspension is a function of near-bed currents. Net depositional flux is predicted in g m^{-2} yr^{-1} on a 2-D grid beneath a cage. Benthic community impact is predicted by an empirical relationship between depositional flux and the ITI. Sediment content (g kg^{-1}) of a particulate component, such as a medicine, can also be predicted. DEPOMOD is a major component of the AutoDEPOMOD modelling software.
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*	Locally-relevant horizontal and vertical dispersion coefficients Water content and digestibility of the food to be used at the stage of the growing cycle to be modelled, feed wastage estimations; food and faecal settling velocity data (default and recommended values available for salmon) Resuspension model predictions from default parameters should be verified by checking predicted with observed benthic impact.
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.*	A current velocity timeseries is needed for an area close to the fish farm site, together with some knowledge of the vertical structure of the water column; Bathymetry, either from a site survey or from an Admiralty chart of the area, and number and dimensions (length, width and depth) of cages and the proposed/existing positions of these cages. Feed input data (kg food d^{-1} for the whole farm) and mean fish size for the intended scenarios

2.f	*Restrictions to use of model*	Model found to work well for soft sediment and low to moderately dispersive sites. Model requires further testing in dispersive, hard sediments areas. Plus see note in 2d above relating to resuspensive sites

3	**Possibly relevant INDICATORS and example EcoQOs**	
3.a	***D**river*	
3.b	***P**ressure*	Loading of site with POM or fin fish medicine
3.c	***S**tate*	
3.d	***I**mpact*	Change in the benthic impact index, Infaunal Trophic Index, from which critically impacted zone dimensions can be assessed
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:*	A. Edwards (SMBA) for fish farms; UK 'Comprehensive Studies Task Team' (CSTT, 1994) for urban waste water discharges
4.b	*Present status of model, including scientific basis of claimed robustness and key matters still needing study:*	To validate near–field, sea surface to sea bed particle tracking algorithms, a 24 hour sediment trap study was undertaken at the two sites. For the dispersive site, model predictions of flux (g m^{-2} d^{-1}) generally agreed well with field data and an accuracy of ±20% was achieved. At the depositional site, an improved accuracy of ±13% was achieved. The resuspension model was validated in a study with UV fluorescent particles with similar settling characteristics to salmonid faeces and food. Tracer was introduced to the seabed and sediment samples taken on days 0, 3, 10, 17 and 30 to measure the horizontal and vertical distribution of tracer in sediments. The bulk of the deployed tracer initially deposited in an area 25 m radius from the release point and was observed to steadily decrease to zero over a period of 30 days. The validated model generally gave good predictions of total mass budgets (±7% of total tracer released) particularly where tracer concentrations were high near the release point. Correlations between predicted solids accumulation (g m^{-2} yr^{-1}) and observed Infaunal Trophic Index (ITI) and total abundance have been established using data from several fish farm sites. Envelopes of Acceptable Precision (EAP) have also been established. These allow predictions of indices to be obtained where the width of the EAP reflects natural variability of the benthic data measured for duplicate samples. *Key matters needing study:* The model is primarily validated

		for soft sediments and depositional to dispersive sites, and has not been extensively tested in offshore or very dispersive sites, coarse/hard sediments (e.g. bedrock, sand), sites with underwater cliffs, shallow sites dominated by wind–wave resuspension. Flocculation or dissaggregation behaviour of particles are not included. Current in the grid is horizontally homogenous, therefore accuracy decreases at increasing distance from farm in areas of complex topography/bathymetry. See below for references.
4.c	*Present use:*	Regulation of sea lice treatment chemical discharges from Scottish fish farms; regulation of maximum biomass for new applications. See: SEPA (2005a). User can validate their own local version of the model by measuring benthic impact indicators for their local environment and then establishing a relationship between predicted flux and benthic impact.
4.d	*Potential use and development in ECASA :*	Estimating benthic impact of organic waste and medicines from farming of Salmon (primarily), cod and mussels in North Atlantic + other macro tidal and fjordic areas. Development of model to establish correlations between predictions (e.g. solids flux) and any indicators short listed in WP2. Coupling to hydrodynamic models of larger areas for determination of scale B effects. Development of model to establish relationships between solids flux and readily measurable biochemical indicators such as sediment free sulphide and sediment oxygen consumption.

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.*	Algorithms programmed in Borland Delphi 7 running under Windows 98 or later. Compiled, executable code is the usual form distributed.
5.b	*State of documentation* *(which describes how to use an implementation as well as giving model theory)*	Electronic user manual complete with software. Detailed documentation for use of the model in regulation of Scottish farms is given by SEPA (2005b). Training workshops in model use are available either in person or online (contact the author).
5.c	*Intellectual property concerns - if none stated here, model and implementation will be deemed to freely available on request*	Model algorithms, source and executable code for implementation are property of SEPA and SAMS. Software is sold under license to external bodies and source code is not distributed with license. Software in form of executable code available to ECASA partners for non-commercial use.

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.*	Observations needed for model testing: hydrography, bathymetry, cage layouts, detailed husbandry data as in 2.e. Some or all of the following in order of preference are required for validation: benthic macrofaunal univariate indices distributions; solids flux (from sediment traps); some other tracer which can be used as signature for fish farm wastes = biochemical variables (e.g. free sediment sulphide measurements, sediment oxygen consumption) along organic gradient
6.b	*Criteria for model rejection*	Model predictions have an EAP (Envelope of Acceptable Precision) which was established during validation and reflects variability of observations and predictions. Expect 88 % of data to fit in the EAP and this can be tested for a transect of sampling stations (e.g. 0, 25, 50 and possibly 75 m). Model rejected if less than 88 % of observations are not contained within the model EAP for comparative studies.

7	OTHER models	
7.a	*Used explicitly or implicitly with this model*	None, but the model could make use of output from a hydrodynamic model.
7.b	*Similar models (which might serve roughly the same purpose in relation to mariculture)*	TRIMODENA (Partner AZTI); KK3D (Partner RBI)

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

Cromey, C.J., Black, K.D., Edwards, A. & Jack I.A. (1998). Modelling the Deposition and Biological Effects of Organic Carbon from Marine Sewage Discharges. Estuarine Coastal and Shelf Science, 47, 295–308.

Cromey, C.J., Nickell, T.D. & Black, K.D. (2002). DEPOMOD - modelling the deposition and biological effects of waste solids from marine cage farms. Aquaculture, 214, 211-239.

Cromey, C.J., Nickell, T.D., Black, K.D., Provost, P.G., Griffiths, C.R. (2002). Validation of a fish farm waste resuspension model by use of a particulate tracer discharged from a point source in a coastal environment. Estuaries, 25, 916-929.

Cromey, C.J. and Black, K.D. (2005). Modelling the impacts of finfish aquaculture. In: B.T.Hargrave (ed.) Environmental effects of marine finfish aquaculture. The Handbook of Environmental Chemistry (volume 5, part M): Water Pollution, 129-155, Springer Verlag, ISSN 1433-6863.

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SEPA (2005a). Aquaculture: modelling. Scottish Environmental Protection Agenecy. Web page(s), URL: http://www.sepa.org.uk/aquaculture/modelling (seen 11 September 2007).

SEPA (2005b). Regulation and Monitoring of Marine Cage Fish Farming in Scotland: Annex H : Methods for Modelling In-feed Anti-parasitics and Benthic effects. Issue No: 2.3 Issue date: 18 May 2005. Available at: http://www.sepa.org.uk/pdf/guidance/fish_farm_manual/annex/H.pdf (seen 11 September 2007)