ECASA - Model description template

1	Name of model	*Reporter/Institute (email address)*
1.a	***MERAMOD***	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). Univariate macrobenthic indicators: Species, Abundance, Biomass, Shannon Weiner, Simpson, Redox Eh
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 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. 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 univariate indices. Sediment content (g kg^{-1}) of a particulate component, such as a medicine, can also be predicted.
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 for the species being modelled (default and recommended values available for bass and bream)
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.

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 univariate indicators, 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:*	MERAMOD was developed from the DEPOMOD model (Cromey et al. 2002) and validated for sea bass and bream farms in the Eastern Mediterranean.
4.b	*Present status of model, including scientific basis of claimed robustness and key matters still needing study:*	Validation of MERAMOD can be divided into three stages: (i) validation of the particle tracking model using solids flux (AFDW – ash free dry weight) in 57 sediment traps at MD8 was undertaken. This study was 13 days in length and sampled across a range of flux values (65 – 7535 g AFDW m^{-2} yr^{-1}) from under cage to intermediate field (50 m). (ii) validation of the particle tracking model using solids deposition (TDS – total dry solids) in a series of six 24 hour sediment trap studies from the spring and autumn 2002 cruises (MD1 (3 experiments), MD5 (2 experiments), MD3 (1 experiment)). These studies concentrated on the high flux zone underneath the cages and included different depths of sediment traps within the same experiment, including traps directly attached to the cage (net) bottom. (iii) validation of the benthic response model using benthic community data from six sites. This established relationships between modelled flux and numerous descriptors (species (S), abundance (A), biomass, A/S, Shannon Weiner, Simpson, Eh (4 cm)) allowing the model to be used for planning and monitoring scenarios. Useful relationships were also found between modelled flux and relative abundance of indicator species and families *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:*	Modelling of the impact of sea bass and sea bream farms in the Eastern Mediterranean; the use of this model is not restricted to this environment or farmed species. Users 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 bream and bass and other species farmed in the Mediterranean. 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. The model TROPOMOD is being developed for modelling of Milkfish and Tilapia fish farms in the tropics under the EU PHILMINAQ project.

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. 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 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*	A summary of all sediment trap validation experiments data as summarised in 4b (i) and (ii) gave a model accuracy of ± 49%. Accuracy of the benthic response model can be determined from the graphs included in the model documentation.

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., 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., et al. (2004). MERAMOD (version 1.4). Model for predicting the effects of Mediterranean fish farms. EU Project Q5RS-2000-31779. See URL: http://meramed.akvaplan.com/download (seen 11th September 2007)

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.

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.

Magill, S.H., Cromey, C.J., Treasurer, J., Nickell, T.D., Thetmeyer, H. (2006). Essential faecal properties of gilthead sea bream (Sparus aurata), Sea Bass (Dicentrarchus labrax), Atlantic Cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) and implications for management. Poster presentation at AQUA 2006, Florence, Italy. May 9-13, 2006.