

ECASA - Model description template

1	Name of model	<i>Reporter/Institute (email address)</i>
1.a	<i>Ecophysiological model based on the DEB theory</i>	Aline Gangnery / Ifremer email: Aline.Gangnery@ifremer.fr
1.b	<i>date this form was completed or updated</i>	5 September 2007

2	Short DESCRIPTION of model	
2.a	<i>Main state variables:</i>	Structural volume, reserves and gonads of an organism.
2.b	<i>Scale to which applicable:</i>	Individual (fish or shellfish).
2.c	<p><i>General description.</i></p> <p><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>	<p>The DEB (Dynamic Energy Budget) model describes the energy flows through an organism and also changes in the environment with varying food densities and temperature. The model allows to simulate individual growth rate and reproduction. Energy acquisition is represented by food uptake, which is proportional to the surface area of the feeding apparatus of the organism and which is converted into reserves. These reserves are then used and allocated to growth, maintenance & reproduction according to a generic rule. A fixed fraction, K, is allocated to somatic maintenance and growth while the remainder (1-K) is allocated to maturity maintenance & development or reproduction. Maintenance can be interpreted as the metabolic cost to maintain somatic & reproductive tissues.</p> <p>The DEB model relies on 10 primary parameters which control energy acquisition and allocation within the organism. Some extra parameters can be added.</p>
2.d	<p><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></p>	<p>Some of the parameters (<i>i.e.</i> volume specific cost of maintenance and volume specific cost for growth) can be eventually considered as semi-universal in the way they are close for related species.</p>
2.e	<p><i>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.</i></p>	<p>* Temperature and food concentration (<i>e.g.</i> chlorophyll a) are the main forcing functions.</p> <p>* Initial value of structural mass, reserves and gonads should be known.</p>
2.f	<i>Restrictions to use of model</i>	None

3	possibly relevant INDICATORS and example EcoQOs	
3.a	<i>Driver</i>	
3.b	<i>Pressure</i>	
3.c	<i>State</i>	
3.d	<i>Impact</i>	Assessment of ingestion flux from organisms.
3.e	<i>Response</i>	Modifications of individual growth rate and reproduction in response to environmental changes (e.g. eutrophication, warming of water).

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>	Theoretical background of the DEB theory can be found in Kooijman (2000 - 2 nd edition). First applications on bivalves were done by Ross and Nisbet (1990) and van Haren and Kooijman (1993) on the mussel <i>Mytilus edulis</i> .
4.b	<i>Present status of model, including scientific basis of claimed robustness and key matters still needing study:</i>	DEB theory has gained increasing popularity and several applications were successfully done on different aquatic (Cardoso et al. 2001, van der Veer et al., 2001, Ren and Ross, 2005) and non aquatic species. A large work was recently dedicated to the application of DEB theory and validation of the model for several bivalves species, among them the Pacific oyster <i>Crassostrea gigas</i> (see the special Volume 56 Issue 2 of the Journal of Sea Research: The DEBIB project: Dynamic Energy Budgets in Bivalves).
4.c	<i>Present use:</i>	Assessment of growth and reproduction energy fluxes in fish and shellfish species (when limited to aquatic organisms). Assessment of standing stock and marketable production of oyster when DEB model is coupled with an IBM population dynamics model. Assessment of carrying capacity when DEB is coupled with a 0D ecological model.
4.d	<i>Potential use and development in ECASA :</i>	Can be coupled with 2D ecosystem and/or population dynamics models in order to assess interactions between aquaculture and environment.

5	IMPLEMENTATION of model	
5.a	<i>State of implementation : (This refers to realization of model theory in numerical algorithms, spreadsheets, computer programs, etc. to</i>	Model algorithm is programmed in Matlab 7.0.1 and STELLA 8.1.

	<i>provide solutions of the model equations when supplied with appropriate forcing data.</i>	
5.b	<i>State of documentation (which describes how to use an implementation as well as giving model theory)</i>	DEB theory is largely detailed in Kooijman (2000). Different papers present a summary of the model as well as a list of parameters and their values for each species tested (van der Veer et al., 2006, Pouvreau et al., 2006).
5.c	<i>Intellectual property concerns - if none stated here, model and implementation will be deemed to freely available on request</i>	ECASA participants have a free access to these tools, which is restricted to be used when carrying the tasks identified within the ECASA contract. The use of the most recent set of parameters concerning the species <i>Crassostrea gigas</i> requires the written consent of IFREMER.

6.	TESTING of model	
6.a	<i>Summary of conditions and measurements needed: Refer back to 2.e if necessary. Highlight observations needed for model testing.</i>	Times series of forcing functions are needed (water temperature and food density). Parameterization of the model needs to be carefully done for each species even if some parameters can be close for related species.
6.b	<i>Criteria for model rejection</i>	No specific rejection criteria were set.

7	OTHER models	
7.a	<i>Used explicitly or implicitly with this model</i>	An IBM population dynamics model was recently coupled to a DEB model for oysters cultivated in Thau Lagoon (Bacher and Gangnery, 2006).
7.b	<i>Similar models (which might serve roughly the same purpose in relation to mariculture)</i>	Other ecophysiological models have been developed based on the SFG theory (Scope For Growth) (e.g. Barillé et al. 1997, Ren and Ross 2001 for the Pacific oyster <i>Crassostrea gigas</i>). Presently, the more achieved model of this type is probably SHELLSIM, also proposed as a modeling tool in ECASA (Hawkins et al., 2002).

8.	REFERENCES cited	<i>show in bold the most important paper describing the model</i>
	Bacher, C., Gangnery, A. 2006. Use of dynamic energy budget and individual based models to simulate the dynamics of cultivated oyster population. J. Sea Res. 56, 140-155.	
	Barillé, L., Héral, M., Barillé-Boyer, A.L., 1997. Modélisation de l'écophysiologie de l'huître <i>Crassostrea gigas</i> dans un environnement estuarien. Aquat. Living. Resour. 10, 31-48.	
	Cardoso, J.F., van der Meer, J., van der Veer, H.W., 2001. Interspecies comparison of energy flow in some North Atlantic bivalve species by means of dynamic energy budget. J 43. C. ICES.	
	Hawkins, A.J.S., Duarte, P., Fang, J.G., Pascoe, P.L., Zhang, X.L., Zhu, M. 2002. A functional simulation of responsive filter-feeding and growth in bivalve shellfish, configured and	

- validated for the scallop *Chlamys farreri* during culture in China. *J. Exp. Mar. Biol. Ecol.* 281, 13-40.
- Kooijman, S.A.L.M., 2000. Dynamic energy and mass budgets in biological systems, Cambridge University Press, Cambridge.**
- Pouvreau, S., Bourles, Y., Lefebvre, S., Gangnery, A., Alunno-Bruscia, M. 2006. Application of a dynamic energy budget model to the Pacific oyster, *Crassostrea gigas*, reared under various controlled conditions. *J. Sea Res.* 56, 156-167.**
- Ren, J.S., Ross, A.H., 2001. A dynamic energy budget model of the Pacific oyster *Crassostrea gigas*. *Ecol. Model.* 142, 105-120.
- Ren, J.S., Ross, A.H., 2005. Environmental influence on mussel growth: a dynamic energy budget model and its application to the greenshell mussel *Perna canaliculus*. *Ecol. Model.* 189, 347-362.
- Ross, A.H., Nisbet, R.M., 1990. Dynamics models of growth and reproduction of the mussel *Mytilus edulis* L. *Func. Ecol.* 4, 777-787.
- Van der Veer, H.W., Kooijman, S.A.L.M., van der Meer, J., 2001. Intra- and interspecies comparison of energy flow in North Atlantic flatfish species by means of dynamic energy budgets. *J. Sea Res.* 45, 303-320.
- Van der Veer, H.W., Cardoso, J.F., van der Meer, J. 2006. Estimation of DEB parameters for various North Atlantic bivalve species. *J. Sea Res.* 56, 107-124.**
- Van Haren, R.J.F., Kooijman, S.A.L.M., 1993. Application of a dynamic energy budget model to *Mytilus edulis* (L.). *Neth. J. Sea Res.* 31, 119-133.