1	Name of model	*Reporter/Institute (email address)*
1.a	***TRIMODENA-HYDRO***	Julien Mader AZTI - Tecnalia Unidad de Investigación Marina / Marine Research Division, Herrera kaia portualdea z/g 20110 Pasaia (Gipuzkoa), Spain email: jmader@pas.azti.es Tel. +34 943 004 800
1.b	*date this form was completed or updated*	27 September 2005

2	Short DESCRIPTION of model	
2.a	*Main state variables:*	3D Current velocity field
2.b	*Scale to which applicable:*	A, B & C The mesh of the model can be adapted to make the tool able to simulate the gradient effect on benthic (Scale A, A+) and dilution processes at the water body scale (Scale B). It would be possible to apply the model at scale C (with another numerical mesh) and it can be useful to obtain border conditions if the hydrodynamic forcing at larger scale is relevant in the area.
2.c	*General description.*	TRIMODENA-HYDRO is a 3D finite element numerical model. This software contains two hydrodynamical modules that have been used in many projects, in terms of the numerical hydrodynamic simulations (González et al., 1995) of dispersive processes (González et al., 1998) and marine pollution (Mader et al., 2001; Gonzalez *et al.*, 2004), including cage fish aquaculture impacts. The current (speed and direction) and water level simulations are performed using the following codes: (a) *ECADIS*, which calculates density and wind-induced currents (Espino, 1994); and (b) *MAREAS*, which simulates the astronomical tidal propagation and estimates the currents and water levels induced (González, 1994). ECADIS and MAREAS solve the Shallow Water Equations (SWE), by means of the Finite Element Method (FEM) with quasi-3D approximations (Zienkiewicz and Heinrich, 1979). ECADIS (Espino, 1994) processes the stationary part of the SWE, using the macro-element technique and the penalty function (Fortin and Fortin, 1985). The model MAREAS (González, 1994) solves the tidal propagation equations, expressed as a sum of a finite series of harmonic constituents (Walters, 1986), using a horizontal Q1/P0 discretisation and

		vertical spectral decomposition.
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 viscosity coefficients and tidal components parameters.
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.*	The measurements needed for calibrating the hydrodynamic model to the local conditions are: - Wind data - Tidal components parameters - Bathymetry - Current data (1 month is a good series) - Hydrographical measurements (Temperature, Salinity…)
2.f	*Restrictions to use of model*	The model is stationary and requires calibration with field data.

3	**possibly relevant INDICATORS and example EcoQOs**	
3.a	***D**river*	Aquaculture
3.b	***P**ressure*	Organic matter inputs
3.c	***S**tate*	Flux, organic matter load, AMBI, dissolved oxygen, etc.
3.d	***I**mpact*	Hypoxia, benthic communities degradation
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:*	The first version of TRIMODENA was developed by the Laboratory of Marine Engineering (LIM-Barcelona), together with AZTI, within the framework of the PACOS project of the EU- ESPRIT Programme.
4.b	*Present status of model, including scientific basis of claimed robustness and key matters still needing study:*	The two hydrodynamic modules of TRIMODENA have been validated first in simple cases with analytical solutions and then calibrated in a large number of oceanographic applications. At present, TRIMODENA-HYDRO equations have been developed in order to reach a maximum number of 20 free degrees.
4.c	*Present use:*	TRIMODENA has been used in several Environmental Impact Studies of Mediterranean and Atlantic Spanish cage aquaculture, (González *et al.*, 2002). *http:/aquatic.unizr.es/N3/art1304/azti2.htm* List of recent projects including studies on aquaculture for tuna, sea bass and sea bream:

		"Estudios para la instalación de una granja marina en San Pedro de Pinatar (Murcia)" **Contractor:** Pedro Martínez Baños (1999). *"Estudio hidrodinámico y de dispersión frente a San Pedro de Pinatar previo a la instalación de jaulas para el cultivo de dorada y lubina"* **Contractor:** Antonio Belmonte (1997-98) *"Estudios para la instalación de una granja marina frente a punta Algas en la costa del Mar Menor (Murcia)"* **Contractor:** Antonio Belmonte (1999) *"Estudios para la instalación de una granja marina para engorde de lubina y dorada en las proximidades de la Punta de la Isleta (Almería)"* **Contractor:** Acuisleta (1998-99) *"Estudios para la instalación de una granja marina de atún entre la Punta de Calnegre y la Punta de Ciscar en el Golfo de Mazarrón (Murcia)"* **Contractor:** Atunes de Mazarrón (1998-99) *" Estudios para la instalación de una granja marina frente a Punta Parda (Murcia)"* **Contractor:** Antonio Belmonte (1998) *"Estudios para la instalación de una granja marina frente a Aguadulce (Almería)"* **Contractor:** Piscifactorías de Aguadulce, S. L. (1999-2000) *"Estudios para la instalación de una granja marina en el Hornillo (Murcia)"* **Contractor:** Antonio Belmonte (2000) *"Estudios para la instalación de una granja marina en Punta Galera (Murcia)"* **Contractor:** Antonio Belmonte (2000) *"Dinámica marina y modelización para una explotación de piscicultura en la Bahía de Ávila (Lanzarote)"* **Contractor:** Ricardo Fuentes e hijos (2000) *"Estudios de corrientes y modelización para unas jaulas de piscicultura en la Bahía de Adeje (Tenerife)"* **Contractor:** Antonio Belmonte (2000, en curso)
4.d	*Potential use and development in ECASA :*	The use of TRIMODENA-Hydro can be necessary for open sea applications at scale B or C (such as tuna cages in the Mediterranean Sea).

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 Fortran 77 running under Windows 98 or later. Source code available for AZTI to modify as part of the ECASA project.
5.b	*State of documentation* *(which describes how to use an implementation as well as giving model theory)*	No real manual available
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 AZTI.

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.*	The measurements needed for calibrating the hydrodynamic model to the local conditions are as in 2.e.: - Wind data - Tidal components parameters - Bathymetry - Current data (1 month is a good series) - Hydrographical measurements (Temperature, Salinity…)
6.b	*Criteria for model rejection*	Very local application without horizontal variation in the study field

7	OTHER models	
7.a	*Used explicitly or implicitly with this model*	TRIMODENA-LPT and TRIMODENA-RECODE
7.b	*Similar models (which might serve roughly the same purpose in relation to mariculture)*	DEPOMOD

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

Espino, M. -1994. Estabilización de la superficie libre en la solución de ecuaciones de Shallow-Water por Elementos Finitos. Aplicaciones oceanográficas. Ph. D. thesis, UPC, Barcelona.

Fortin, M. and A. Fortin. -1985. A generalization of Uzawa´s Algorithm for the solution of the Navier-Stokes Equations. *Communications in Applied Numerical Methods*, 1: 205-208.

González, M. -1994. Un modelo numérico en Elementos Finitos para la corriente inducida por la marea. Aplicaciones al Estrecho de Gibraltar. Tesina de especialidad. UPC, Barcelona.

González, M., M. A., García, M., Espino and A., S.- Arcilla. -1995. Un modelo numérico en Elementos Finitos para la corriente inducida por la marea. Aplicaciones al Estrecho de Gibraltar. Revista Internacional de Métodos Numéricos para Cálculo y Diseño en Ingeniería, 11 (3): 383-400.

González, M., A. Uriarte, L. Motos, Á. Borja and A. Uriarte, 1998. Validation of a numerical model for the study of anchovy recruitment in the Bay of Biscay. *Oceans'98 IEEE-OES, Nice,* 3: 1313-1318.

González, M., J., Mader, P., Gyssels, A., Uriarte and S., Sorhouet. -2001. Estudio numérico de propagación de la marea astronómica en el Golfo de Vizcaya. VI Congreso de Ingeniería de Puertos y Costas de España. Palma de Mallorca: 97-98.

González, M, A. Uriarte, A. Fontán, J. Mader and P. Gyssels. -2004. Marine dynamics. In: Borja, A. and Collins, M. (eds.), *Oceanography and Marine Environment of the Basque Country*, Elsevier Oceanography Series nº 70:27-50, Elsevier, Amsterdam.

Walters, R. A. -1986. A Finite Element Model for tidal and residual circulation. *Communications in Applied Numerical Methods*. 2, 393-398.

Zienkiewicz, O.C. and J.C., Heinrich. -1979. A unified treatment of steady state shallow water and two-dimensional Navier-Stokes equations-finite element penalty function approach. *Computer Methods in Applied Mechanichs and Engeenering*. 17-18: 673-698.