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Subject:	COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying the document PROPOSAL FOR A REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea

Delegations will find attached document SWD(2018) 60 final - PART 3/6.

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PART 3/6

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

PROPOSAL FOR A REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

Establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea

{COM(2018) 115 final} - {SWD(2018) 59 final}

ANNEX 4:
ANALYTICAL MODELS USED

Environmental impacts of the different policy option were modelled by the STECF. The analysis was based on management strategies evaluation (MSE) and on the JRC's a4a Initiative, using FLR framework.

A4a Management Strategy Evaluation algorithm, *by Jardim et al (2016)*[1]

1. METHODS

1.1 Notation and definition of variables

The following notation will be used for the defined variables, functions and indices. Variables in the Operating Model (OM) are always uppercase, whiles variables in the Management Procedure (MP) are lowercase, e.g. catch *C* in OM *c* in the MP. Quantities estimated within the MP, e.g. fishing mortality by a stock assessment model, will use the uppercase with a hat, e.g. ^F. The same will apply to functions which are estimated within the MP, e.g. the stock-recruitment function. The target value that results from a decision process, e.g. the application of a harvest control rule, is identified by a tilde, ~F. Indices will always use lowercase, with their maximum value represented by the corresponding uppercase letter, e.g. ages as *a* = 1...A. Table 1 presents the variables used in this document.

Indices	$a = 1...A$	age
	$t = 1...T$	years
	$i = 1...N$	iterations
	trg	target
Variables	N	population abundance in number of individuals
	R	recruitment in number of individuals
	F	fishing mortality rate
	M	natural mortality rate
	B	mature biomass in weight
	W	individual mean weight
	P	percentage of mature fish
	C	catch in number of individuals
	Y	yield in weight
	Q	feet catchability
	S	feet selectivity
	E	feet effort
Functions	G	stock-recruitment function
	J	hyper(hypo)stability function
	H	management decision function (aka harvest control rule)
	K	implementation function
	W	technical measures function
	LN	lognormal probability density distribution
Other	Θ	set of parameters
	ϕ	median
	σ^2	variance

Table A41 Variables, indices and function, and the notation used to refer to them in the text.

[1] Jardim et al (2016). A4a Management Strategy Evaluation algorithm. In Annex 3 of STECF – Multinnual plan for demersal fisheries in the western Mediterranean (STECF 16-21). Publications Office of the European Union, Luxembourg; EUR 27758 EN, 128 pp.

1.2 Operating model

The operating model includes the population dynamics at age (*a*) of the stock

$$N_{a+1,t+1} = N_{a,t} \exp(-F_{a,t} - M_{a,t})$$

while for the first age, recruitment is estimated following some function of the adult biomass G(*B*)

$$N_{0,t} = R_t = G(B)$$

which is in turn dependent on the proportion mature at age (*Pa*)

$$B_t = \sum_{a=1}^{A} W_{a,t} N_{a,t} P_{a,t}$$

Calculation of catch at age in numbers follows the standard Baranov equation

$$C_{a,t} = \frac{F_{a,t}}{F_{a,t} + M_{a,t}} N_{a,t}(1 - \exp(-F_{a,t} - M_{a,t}))$$

while total yield in weight is calculated as

$$Y_t = \sum_{a=1}^{A} W_{a,t} C_{a,t}$$

Fishing mortality at age is related to effort through selectivity-at-age, catchability and a (possibly non-linear) function (*J*)

$$F_{a,t} = S_{a,t} Q_t J(E_t)$$

1.3 Observation error model

1.3.1 Catch in number of individuals, $C_{a,t}$

Catch in numbers-at-age, generally derived from sampling of numbers-at-length and a growth model or age-length key, are observed with error,

$$c_{a,t} = C_{a,t} \exp \epsilon_c$$

where E_c is log-normally distributed

$$\epsilon_c \sim LN(\mu_c, \sigma_c^2)$$

1.3.2 Index of abundance, $d_{a,t}$

The relationship between the observed index of abundance and the stock abundance-at-age

$$d_{a,t} = N_{a,t} q_{a,t} \exp \epsilon_d$$

includes a log-normal error

$$\epsilon_d \sim LN(\mu_d, \sigma_d^2)$$

1.4 Assessment/Estimator of stock statistics

Input into the decision rule includes some indicator of current status (^V), given the available information, in this case catches (*c*) and an index of abundance (*d*)

$$\hat{V} = f(c_{a,t}, d_{a,t}|\theta_f)$$

transformed through some suitable function (*f*), for example an stock assessment. The precise inputs and the elements in θ will depend on the precise form of the HCR. In an age based system, for example, these would be estimates of F_t, B_t and C_t.

The stock assessment component of the status estimator might include a stock-recruitment relationship

$$\hat{N}_{0,t} = \hat{G}(\hat{B})$$

G is the stock recruitment relationship estimated within the MP and represents the perceived dynamics, which differs from that one (*G*) included in the OM.

1.5 Management decision/Harvest control rule

In this code it is assumed that management is carried out through changes in F, although the implementation of those changes can be done through a combination of systems: input control, output control and/or technical measures. A first decision is made about the target fishing mortality for next year. The result for this decision is afterwards translated into an implementation variable.

$$\tilde{F}_{a+1,t+1} = h(\hat{F}_{a-1,t-1}, \hat{F}_{trg}, t_{trg})$$

1.6 Implementation

This process translates the management decision into a regulation, for example fishing opportunities, or days at sea. It mimics the process used to formulate the advice from the scientific estimates of likely effects of different fishing mortality levels.

1.6.1 Input/effort management

$$\tilde{E}_{t+1} = k(\tilde{F}_{a+1,t+1}|\theta_k)$$

$$\tilde{E}_{t+1} = \tilde{E}_{t+1} \exp \epsilon_{\tilde{F}}$$

$$\epsilon_{\tilde{F}} \sim LN(\mu_{\tilde{F}}, \sigma_{\tilde{F}}^2)$$