ECOREGION **North Sea**
SUBJECT **The Netherlands request for evaluation of the proposal for a multi-annual plan for horse mackerel in the North Sea**

Advice Summary

ICES has evaluated the proposed harvest control rule for a multi-annual plan for horse mackerel in the North Sea using various plausible parameter options. Given that the stock is at its lowest since the early 1990s, some of the Harvest Control Rule parameter options suggest recovery of the stock to above the present level by 2020, but none of them with 95% probability. Therefore, ICES considers none of these options as being in accordance with the precautionary approach. It is suggested that managers discuss other options with ICES that might be more suitable, including a recovery phase to reverse the decline of the stock. ICES intends to provide 2015 catch options for this stock in the annual advice in October 2014.

Request

"The IMARES institute prepared a proposal for a multi-annual plan for horse mackerel in the North Sea. It was presented and discussed in the Pelagic RAC meeting early February 2014. … In short, it proposes a HCR that should help recover the stock, meanwhile work on strengthening the knowledge base and prepare for an evaluation by 2019 at the latest (if necessary leading to amending the plan).

The objective of this multi-annual plan is to provide a TAC setting basis that promotes recovery of the stock in the short term and ensures achieving a Maximum Sustainable Yield (MSY) exploitation rate at the latest by 2020. In addition, it should also stabilise inter-annual variation in catches. It further outlines a prioritized list of data issues that, when resolved, will benefit the knowledge basis for the management of this stock in the future.

- The TAC shall be revised annually based on the North Sea IBTS Q3 survey trend information

- In a TAC setting year, the TAC shall be set as follows:

$$TAC_{y+1} = TAC_y \times \left(min\left(\frac{I_{rec}}{I_{trig}}, 1\right) + \lambda Slp \right)$$

TAC = Total Allowable Catch; y = assessment year
λ = slope multiplier
Slp = slope of the log-linear regression for the last 3 or 5 years of the survey index
Irec = recent survey index = average of index values for the last 3 or 5 years
Itrig = survey index trigger value

- [Optional] The resulting TAC for year y +1 shall not deviate more that 20% from TAC in year y

The Netherlands would like to submit this "special request" to ICES ACOM for consideration and assess whether this proposal is precautionary (does it comply with ICES criteria), if it will deliver F_{MSY} by 2015 or 2020 at the latest."

Elaboration of the advice

This stock is data limited, with no benchmarked analytical assessment to assess the stock status and provide a formal basis for parameterising the evaluation. A stock assessment modelling framework was used to provide multiple plausible estimates of stock dynamics. According to all these estimates the stock is considered to be at the lowest level since the early 1990s. The set of plausible assessments was used as a basis for the evaluation of the proposed candidate Harvest Control Rule (HCR).

ICES tested a number of options for HCR parameters (λ, Slp, Itrig, TAC-stabilizing). The results of the evaluations presented here are based only on a limited but broadly reasonable selection of parameter options. Currently ICES has not had sufficient time to explore alternative HCRs, such as HCRs with a specific early 'stock rebuilding' phase.

To evaluate the harvest control rules, the standard ICES criteria were applied: a plan is considered to be precautionary if the probability of SSB falling below B_{lim} is less than 5%. ICES considers that a necessary condition for MSY exploitation is that the stock is within safe biological limits. In these evaluations, this was interpreted as a requirement

that SSB has less than 5% probability of being below B_{lim} by 2015 or 2020 at the latest as defined in the request. As there is currently no agreed assessment or reference points, B_{loss} (SSB in 2012 = 27 000 t) was used as a proxy for B_{lim}.

Initial evaluations were based on assumed catches in 2014 of 20 000 t (the TAC was set at 27 815 t). None of the parameter options tested meet ICES precautionary criteria, since with immediate application of the HCR tested from 2015 onwards none of the HCRs provide for an increase of the stock from 2012 (the most restrictive option in the short term leads to a probability that SSB_{2020} will be below B_{loss} of 0.55).

Additional evaluations were based on assumed catches in 2014 of 5000 t. These provide more optimistic results with the most restrictive option in the short term leading to a probability that SSB_{2020} will be below B_{loss} of 0.07, though this requires an effective closure of the fishery from 2016 onwards. This does not meet ICES precautionary criteria.

A potential candidate value for F_{MSY} is 0.12. Average F over the last 3 years (2010-2012) has been approximately 0.5. Assuming the catches in 2014 are no more than 20 000 t, the HCR options tested show that F does not reduce to F_{MSY} in 2015, or 2020. However, assuming the catches in 2014 are no more than 5000 t, the HCR options tested show that F is reduced to below F_{MSY} in 2015. However, none of these options will result in the stock being within safe biological limits by 2020.

The evaluations show that because of the current poor state of the stock, short term considerations that stop stock decline outweigh any potential long term performance, as current catches are not thought to be sustainable. With the limited data used in the assessment and the uncertainty associated with the resulting stock dynamics (stock recruitment relationship in particular), longer term implications are highly dependent on the assumptions made in the assessment model and forecast model. Nevertheless the immediate concern is to decrease fishing mortality and prevent further decline of the stock.

Suggestions

In the absence of an agreed assessment and associated F_{MSY} targets it is suggested that managers consider a 2-3 year initial phase with significantly reduced catches during which ICES would aim to continue to improve the assessment, evaluate reference points and develop a better understanding of the origin of fish caught in Division VIId. Following this a new range of HCRs, looking towards long term management considerations, could be explored. Based on the work already done ICES would hope to be able to suggest 2-3 year catch advice options for this stock in October 2014.

Recovery of the stock could be aided by reductions in catch and by reducing the targeting of young fish to prevent both recruitment and growth over-fishing.

Generally speaking, any long-term management plan is most effective when its measures apply to all fisheries exploiting the stock and when catches can be identified as originating from that stock with some certainty. Considering the potential of mixing between Western and North Sea horse mackerel occurring in Division VIId, better insight in the origin of catches from that area will be a major benefit, if not crucial, for improvement of the quality of future scientific advice and thus management of the North Sea horse mackerel stock. One way of possibly distinguishing between individuals of the two stocks is with the GCxGC-MS (Gas chromatography x Gas chromatography–mass spectrometry). A pilot project aimed at determining whether this technique could be used for distinguishing between Western and North Sea horse mackerel is currently underway and should be pursued further depending on initial results.

Basis of advice

North Sea horse mackerel is currently a data limited stock (DLS) and no analytical assessment is carried out. Advice for 2014 was based on a precautionary reduction in catch (category 5).

Exploratory stock assessment

Full details about the stock assessment model and management strategy evaluation framework can be found in ICES, 2014.

In order to evaluate the HCR, an age-based separable model using catch at age and a 2+ survey biomass index is used. Two options for the IBTS biomass indices for horse mackerel were derived using different methods: General Linear Models (GLM) and the delta lognormal approach (DLN). Catch at age data are available for a large part of the fleet and total catch estimates for the stock are obtained from the ICES database.

Rather than developing a 'best' assessment, alternate assumptions, i.e. on natural mortality, choice of index and the weighting of input data, are used to create six alternative plausible model fits for use in testing the robustness of candidate management scenarios (Table 6.2.3.3.1). Uncertainty in assessment parameters is estimated from Monte

Carlo – Markov Chain (MCMC) analysis. The stock biomass in 2013 is estimated from each of these MCMC iterations and these estimates are used as starting values for the Management Strategy Evaluation (MSE).

The MSE works by projecting the stock forward and calculating observed index values based on stock size and historic uncertainty in survey estimates. These observed index values are then used in an HCR to determine future TACs. The simulations then project the stock forward again, removing the catch associated with the advised TAC and adding recruitment calculated from two types of stock-recruit relationships (Ricker and hockey-stick) including variability. This results in twelve options (six assessment models with two stock-recruit relationships) which are combined with equal weight to give overall summary statistics. The framework is also used to determine a candidate value for F_{MSY} through long term simulations applying various fixed fishing mortality rates.

It is assumed that the observation uncertainty present in the survey has been constant over time, and will remain constant in the future. The evaluation of the HCR candidates is done assuming catches are taken exactly. Translating the catches values into appropriate TACs needs careful consideration given the recent low uptake to TACs. This is not addressed in these evaluations.

Results

Assessment results

The available data suggest that the North Sea horse mackerel stock is currently at a low biomass in relation to levels in the late 1990s. Recent IBTS surveys have had low cpues and a high proportion of hauls without horse mackerel catches. Both methods of calculating the index from the raw data indicate that the stock is near the lowest level observed. All exploratory assessment models fit to these data estimate that SSB in 2012 is near the lowest observed (Table 6.2.3.3.1). Fishing mortality has been well above fishing mortality levels suggested for F_{MSY} (proxies), especially in the recent past.

Table 6.2.3.3.1. Comparison of the recent values of spawning stock biomass (SSB) and mean fishing mortality (ages 2-8) from the six assessment models used in the reference set. Absolute values are given for 2012 and values relative to equilibrium biomass and F at F= $\mathbf{F_{MSY}}$=0.12 are shown. See ICES (2014) for further details on the stock assessment fits.

	SSB		**Mean F (ages 2-8)**	
Assessment model description	**2012 (t)**	**Relative to Bmsy**	**2012**	**Relative to F_{MSY}**
GLM index, Catch weighted	41002	0.32	0.44	3.67
GLM index, WHM M	40773	0.32	0.43	3.58
GLM index, SHM M	39620	0.31	0.44	3.67
GLM index, Index weighted	40033	0.31	0.35	2.92
DLN index, WHM M	25636	0.20	0.75	6.25
DLN index SHM M	24930	0.19	0.76	6.33

Reference points

Considering B_{loss} as a proxy for B_{lim}, F_{MSY} was determined based on calculations using equilibrium yield and SSB at different F from stochastic projections of the stock at constant F (Figure 6.2.3.3.1). Based on these calculations, F_{MSY} is estimated at 0.12. This target value is considered precautionary since the probability that SSB will reduce to below B_{loss} is lower than 0.05. Biomass is expected to fluctuate around 130 000 t (B_{MSY}) at this level of F, with catches at equilibrium fluctuating around 20 500 t.

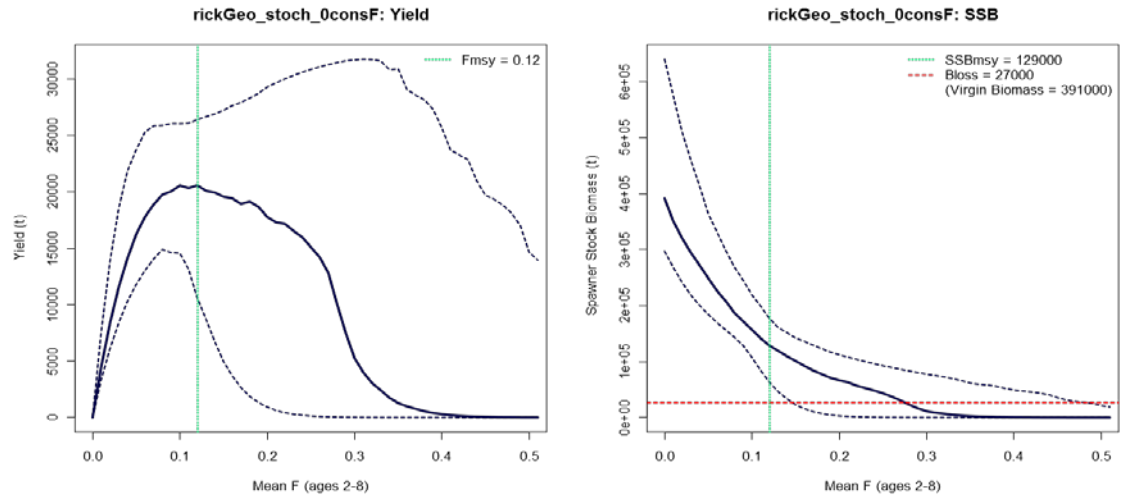

Figure 6.2.3.3.1. Yield and spawning stock biomass (SSB) at stochastic equilibrium. Medians (solid lines) and 5th and 95th percentiles are plotted. The vertical lines show F_{MSY} (green) and the horizontal line in the SSB plot shows B_{loss} (red).

Harvest control rule evaluations

The presented options of HCR parameters evaluated are shown in Table 6.2.3.3.2.

Table 6.2.3.3.2. HCR parameter options presented.

HCR parameterisation		TAC 2014	Slp	λ	TAC
Option	**Name**	**(kt)**	**(slope)**	**(slope multiplier)**	**change limits**
1	LL5_lam1	5 / 20	Log-linear 5yr	1	-
2	LL3_lam2	5 / 20	Log-linear 3yr	2	-
3	LL3_lam1 (chngLim)	5 / 20	Log-linear 3yr	1	+/-20%
-	Zero_fishing	0	-	-	-

Initial evaluations were based on assumed catches in 2014 of 20 000 t (the TAC was set at 27 815 t). None of the parameter options tested meet ICES precautionary criteria (Table 6.2.3.3.3), since with immediate application of the HCR tested from 2015 onwards none of the HCR options provide for an increase of the stock from 2012 (the most restrictive option in the short term leads to a probability that SSB_{2020} will be below B_{loss} of 0.55). The HCR option 1 and 2 (using a 3 or 5yr slope with lambda=1 or higher, no change limits) prevent the collapse of the stock through rapid reduction in catch, option 2 allows SSB to increase more in the medium term, at the cost of closing the fishery. Introduction of catch change limits (option 3) leads to a crash of the stock in the short term by preventing the catch from decreasing rapidly.

Additional evaluations were based on assumed catches in 2014 of 5000 t. These provide more optimistic results with the most restrictive option in the short term leading to a 0.93 probability of an increase of the biomass to above B_{loss} by 2020, though this requires an effective closure of the fishery from 2016 onwards. All HCR options have an average catch of <5kt in the short term.

None of the HCR options lead to higher catches in the medium term (2017-2026) compared to the short term (2015-2018). This is due to both inertia in the HCR options not allowing for rapid increases in catches once the stock starts to recover and short term catches not guaranteeing enough recovery of the stock to allow for an increase in catches.

To evaluate the plans ICES has standard ICES Management plan criteria of the >5% probability of SSB>candidate B_{lim}. ICES considers that a necessary condition for MSY exploitation is that the stock is within safe biological limits. In these evaluations, this was interpreted as a requirement that SSB has less than 5% probability of being below B_{lim} by 2015 or 2020 at the latest as defined in the request. As there is currently no agreed assessment or reference points, B_{loss} (SSB in 2012 = 27 000 t) was used as a proxy for B_{lim}. In conclusion, ICES considers that none of the HCR options tested meet ICES precautionary criteria.

The conclusions are dominated by the performance in the short-term. This suggests a recovery clause is required in the management plan. Recovery of the stock is needed before a long-term HCR can be evaluated. Recovery can be defined by the probability > 95% of the stock being above B_{loss}, by using the stock assessment framework used for this evaluation.

Table 6.2.3.3.3. Performance statistics of the HCR options, assuming either an initial 20 or 5kt of catch in 2014.

Catch 2014	HCR parameters	Catch 2015	Catch 2016	Catch 2017	Catch 2018	Average catch (2014-2018)	Average catch (2017-2026)	Absolute average inter-annual variation in catch (2017-2026)	SSB 2015	SSB 2020	Probability $SSB_{2020} < B_{loss}$	F 2015	F 2020	F_{2020}/F_{MSY}
20000	1. LL5_lam1	16145	8831	3800	1407	10036	522	18	15892	6772	0.78	0.66	0	0
20000	2. LL3_lam2	8043	2	1	1	5610	2	17	15892	27082	0.55	0.31	0	0
20000	3. LL3_lam1 (chngLim)	16000	12800	9099	4165	12413	1666	48	15892	324	0.91	0.99	1.85	15.39
5000	1. LL5_lam1	4501	3800	2833	1907	3608	1366	9	26426	57875	0.12	0.09	0.02	0.15
5000	2. LL3_lam2	2428	3	3	3	1488	6	15	26426	64811	0.07	0.05	0	0
5000	3. LL3_lam1 (chngLim)	4000	3408	3419	3072	3780	2729	13	26426	53639	0.21	0.12	0.04	0.33
0	0. Zero_fishing	0	0	0	0	0	0	0	30346	79494	0.02	0	0	0

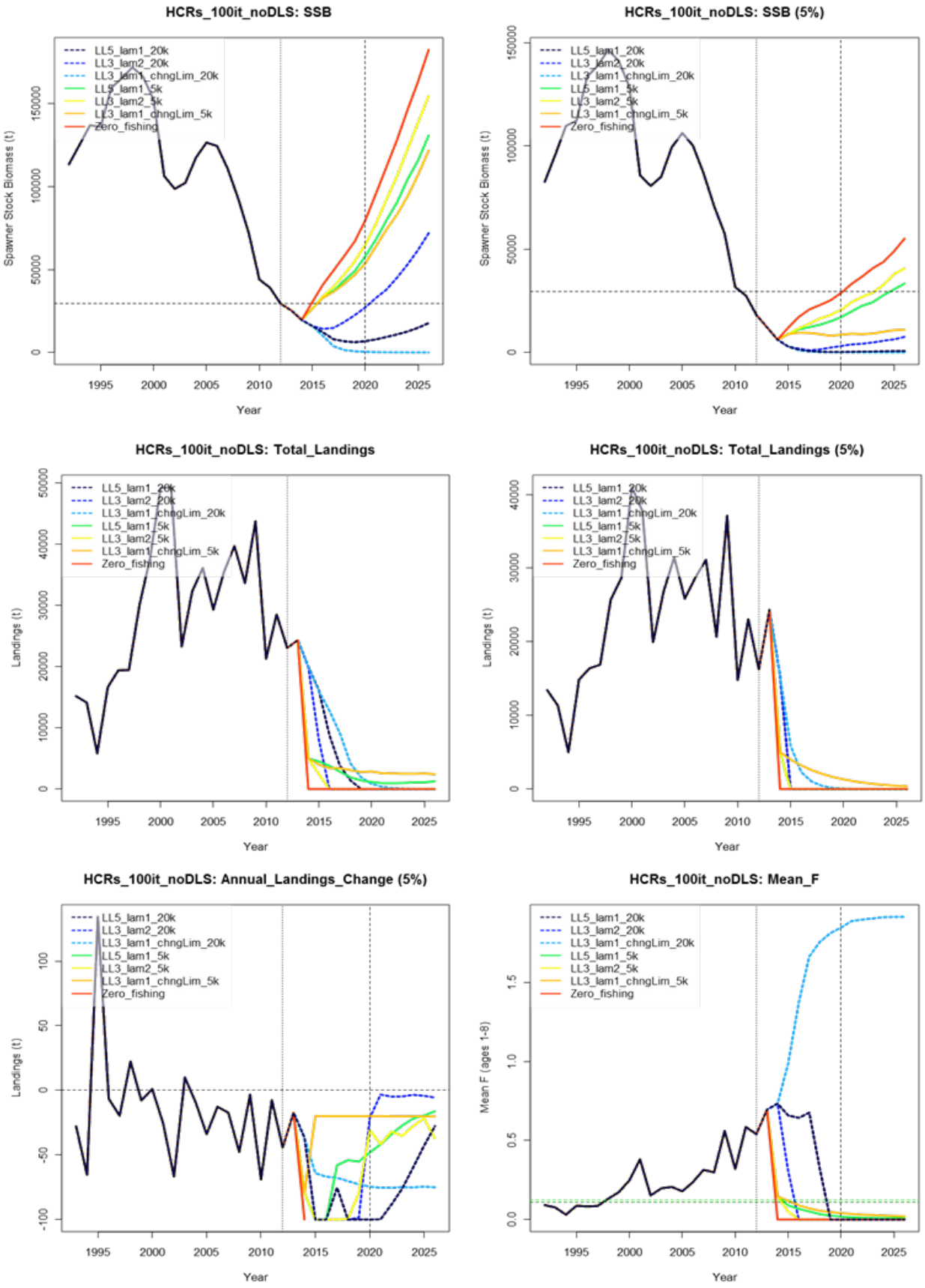

Figure 6.2.3.3.2 Median results of harvest control rule (HCR) projections. Landings (median, top left; and lower 5th percentile, top right), SSB (median, middle left; and lower 5th percentile, middle right), annual change in catch (=landings; bottom left) mean fishing mortality (ages 2-8, bottom right). Vertical lines indicate 2012 (reference biomass point, dotted) and 2020 (target year for recovery, dashed). In the SSB plot the horizontal line indicates the median SSB in 2012; in the mean F plot the horizontal green line represents F_{MSY}.

Uncertainties

MSE projections are highly sensitive to the assumed catches in the first few years. This makes the evaluation of long term performance of candidate HCRs difficult, since any initial short term recovery depends largely on the assumptions made in the simulation model. Therefore a recovery clause is required in the management plan.

There are numerous difficulties fitting an assessment model for this stock: unclear stock boundaries, difficulty aging horse mackerel and lack of strong cohort signals in the catch at age data. The IBTS survey used to develop indices for this stock is a bottom trawl survey targeting primarily ground fish (gadoids), but also catching pelagic species (e.g. horse mackerel). This survey does not cover the full distribution area of the stock, it covers the area of the North Sea where the population is thought to be in Quarter 3, but does not cover Division VIId where the majority of the fishery occurs.

Fish caught in the English Channel are of uncertain origin. It is possible that a variable proportion of the Division VIId catches are of fish from the western horse mackerel stock. Likewise, a variable proportion of catches in Division VIIe could be of North Sea origin. If influx of the western stock occurs, this may sustain a higher fishery than indicated by these evaluations, conversely, if the proportion of western fish in Division VIIe decreases, depletion of the North Sea stock may occur more quickly. This is not taken into account in the evaluation.

There is some anecdotal evidence, both from scientific and fishery sources, suggesting that one or more relatively strong year classes may have been produced in recent years in the North Sea. If this is a true reflection of actual events, then this may lead to a more rapid recovery of the stock than the results of the current study suggest. This should then be measurable in the IBTS survey data in upcoming years, in which case management measures can be revised accordingly.

Sources

ICES. 2014. Evaluation of a multi-annual plan including an index based HCR for North Sea horse mackerel, 17-18 June 2014, IJmuiden, the Netherlands. ICES CM 2014/ACOM:55.