Proposal for a multi-annual plan for horse mackerel in the North Sea

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Background

Scientific knowledge of the state of the horse mackerel stock in the North Sea has been rather limited. In contrast to other stocks, there has not been a scientific survey established for the specific purpose of monitoring stock abundance trends. As a consequence, ICES advice on catch limits was for over a decade consistently along the line that catches should not be more than the 1982-1997 average in order to avoid an expansion of the fishery until there would be more information available (ICES, 2007). Due to a number of circumstantial changes, improving the scientific basis for management has recently become more pertinent.

Alignment of management areas

One such circumstantial change was a European Council decision on new management area boundaries between the three (Western, Southern and North Sea) horse mackerel stocks, which came into effect on the 1st of January 2010. The management area boundaries previously did not match the biological stock boundaries that ICES utilised for its advice. In addition, the results of a research project (HOMSIR) suggested that a change in the management area boundaries would be appropriate (HOMSIR project, 2003). This particular decision by the European Council, which included a redistribution of quota among EU Member States, had a substantial impact on the operating conditions for fisheries targeting horse mackerel.

Data Limited Stocks advice by ICES

Another recent development that impacts the industry's fishing opportunities was the introduction by ICES of a new approach for the underpinning of Total Allowable Catch (TAC) advice for data limited stocks (DLS) (ICES 2012a and ICES 2012b). The main objective for this new DLS approach was to apply a more precautionary approach for exploitation of stocks where it is unknown whether their current catch levels are sustainable. In other words, rather than *rolling over* a particular TAC level in the absence of reasons for action otherwise, as was previously customary for TAC-setting for a substantial number of data limited stocks, it should become customary to take precautionary action by *reducing* the TAC if no information is available for action to be taken otherwise. This should both promote more sustainable exploitation levels in stocks for which little information is available as well as stimulate EU Member States to take action in improving the knowledge base for all commercially exploited fish stocks that their fishing industries have stakes in.

Development of a multi-annual plan

North Sea horse mackerel has been classified as a DLS in category 5 with only landings data available. This led to the advice for 2013 being a TAC which represented a reduction of 20% of recent landings as a precautionary measure. In response, the main stakeholder in the fishery - the Dutch Pelagic Freezer-trawler Association (PFA) - sought collaboration with IMARES to develop a multi-annual plan for this stock. The plan should specify a rationale for establishing TACs through a Harvest Control Rule (HCR) and it should stipulate how the stock could be 'moved up the ladder' of the DLS categories; ultimately aiming to progress it to become a data rich (category 1) stock. The current document presents a proposal for a HCR, which can be evaluated by ICES. Implementation of the plan should enable recovery of the stock in the short term. In addition – in line with the objectives of the reformed Common Fisheries Policy (European Union, 2013) – it should ensure achieving a Maximum Sustainable Yield (MSY) exploitation rate by 2015 if possible or at the latest by 2020.

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.

Total Allowable Catch

- 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 *x* years of the survey index
  I_{rec} = recent survey index = average of index values for the last *x* years
  I_{trig} = survey index trigger value

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

Strengthening the knowledge base

- Age information should be collected from horse mackerel caught in the third quarter International Bottom Trawl Survey (IBTS) in the North Sea

- Information should be obtained on potential mixing of catches of Western and North Sea horse mackerel in ICES area VIId

- The potential to utilise acoustic data from commercial vessels as a supplementary data source should be explored

Re-evaluation of the plan

- Considering the observed decrease in stock abundance, the primary aim of this plan is to reverse this trend. A re-evaluation of this plan to ensure long term high and stable yield should be conducted when:

    - The survey index value I has been above I_{tar} (to de determined) for three consecutive years, or;
    - New data becomes available, which will enable improvement of the assessment, or;
    - The exploitation pattern of the fleet changes substantially;
    - TAC uptake differs substantially from the scenario assumed in the MSE;
    - Latest in 2019.

Supporting information

The fishery

Catches by the Danish industrial fleet for reduction into fishmeal and fish oil formed the majority of North Sea horse mackerel catches throughout the 1970s and 1980s. Catches were taken in the fourth quarter mainly in Divisions IVb and VIId. The 1990s saw a drop in the value of industrial resources, limited fishing opportunities and steep increases in fuel costs. In 2001, an individual quota scheme was introduced in Denmark, which resulted in a rapid restructuring of the fleet. Since then the fleet size has been radically reduced and now numbers less than 20% that in the 1980s and Danish North Sea horse mackerel catches have diminished. Since the 1990's, a larger portion of catches has been taken in a directed horse mackerel fishery for human consumption by the Dutch freezer-trawler fleet.

Denmark has traded parts of its quota with the Netherlands for fishing opportunities for other species, however due to the structure of the Danish quota management set-up only a limited amount of quota can be made available for swaps with other countries. These practical implications of the management scheme largely explain the consistent underutilisation of the TAC (approximately 50% in 2010-2012) in recent years (see Figure 1).

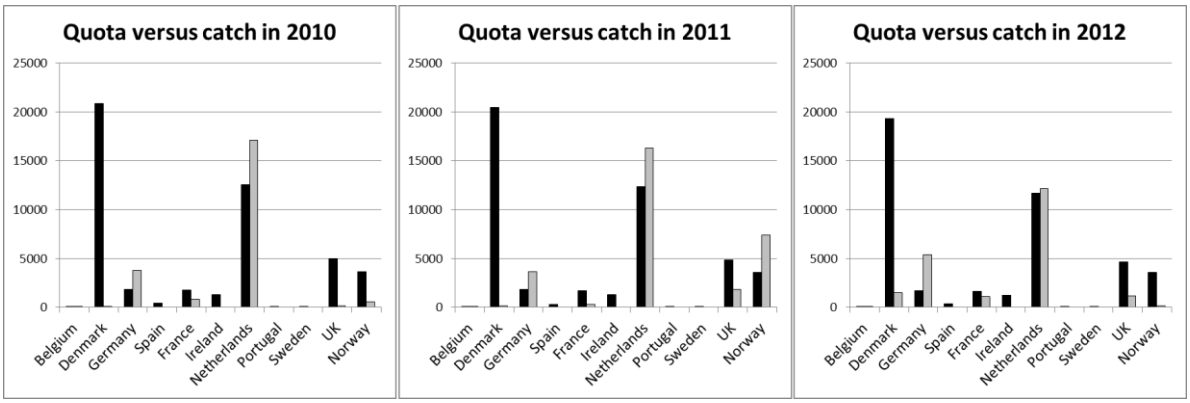

Figure 1. Quota and landings by country in recent years, showing the substantial differences in utilisation of available quota by different countries. The black bars are quota (before international swaps) and the light grey bars are reported landings.

IBTS survey data

The International Bottom Trawl Survey (IBTS) started in the 1960's directed at juvenile herring (as the International Young Herring Survey (IYHS)). In 1990 ICES decided to combine international and national surveys into the IBTS, which was fully standardised across countries in subsequent years. The fishing method and gear (GOV trawl) are described in the IBTS manual (Anon, 2004).

Horse mackerel is abundantly caught in the North Sea IBTS survey. Survey data are available as numbers of fish (individuals) caught per hour (cpue) by length classes of 10 mm. Fish between 1-14 cm correspond to 0-year old fish and 15-19 cm correspond approximately to 1-year old fish and 20 cm and larger to 2-year old fish and older. Figure 2 shows the spatial distribution of horse mackerel catches in the survey for two grouped length classes roughly corresponding to 0-year and 1-year old juveniles (left panel) and 2-year old and older individuals, which are mostly mature (middle panel). Examination of annual distribution maps showed that juvenile fish are found in highest concentrations in the South Eastern part of the North Sea (in area IVb and IVc), along the Dutch, German and Danish coast. These fish are found often in more aggregated densities. 2-year and older fish are found somewhat more dispersed throughout the North Sea, while some concentrations are found around the Orkney Islands as well.

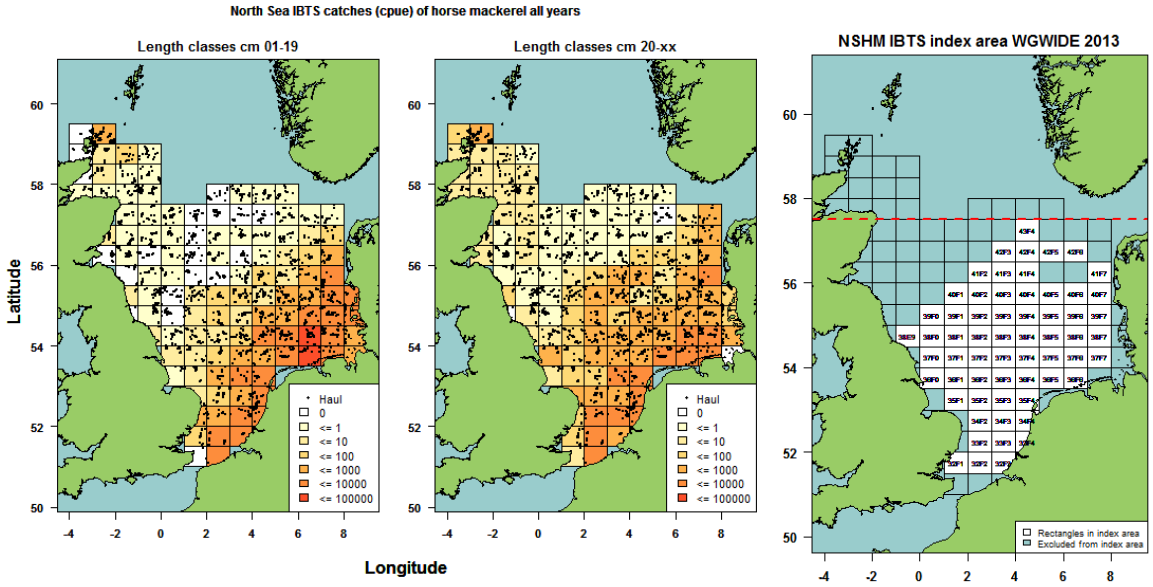

Figure 2. Horse mackerel caught in the third quarter North Sea IBTS survey. 0- and 1-year old juveniles (left panel); 2-year old fish and older (middle panel) and agreed index area (right panel).

Rückert et al (2002) described these North-West and South-East concentrations of abundance as two separate stock components in the North Sea. Results from the HOMSIR project suggested that the North Western concentrations are likely horse mackerel originating from the Western stock, migrating into area IVa (HOMSIR project, 2003). The statistical rectangles that should be included in the index area for the survey index for the stock was agreed by WGWIDE in 2013 (ICES, 2013). It excludes the rectangles in the North-Western corner of the North Sea and some rectangles that have not been consistently covered by the survey over the years (see Figure 2, right panel).

The survey index

The IBTS is an bottom trawl survey targeting primarily ground fish (gadoids), but also catching pelagic species (e.g. herring, sprat, mackerel and horse mackerel). The standard method used to derive abundance indices consists in computing a mean CPUE per ICES rectangle, and take the mean of these values over the area representative of the stock of interest (ICES DATRAS technical description including indices calculation[1]).

This approach is designed for dispersing ground fish and is probably not appropriate for dealing with a species that displays schooling behaviour for two reasons. First, by taking the mean of the CPUEs, it assumes that the data is normally distributed. With species that display schooling behaviour, such as horse mackerel, the proportion of zeros (absence in the trawl haul) may be high, in which case an assumption of normal distribution is not appropriate.

The second problem is that even though survey trawl hauls are supposed to be directly comparable, there still may exist differences in catchability of this species between vessels. If the proportion or the geographical distribution of the data collected by the different vessels varies among years, then it is necessary to check for a vessel effect, and account for it in the computation of the abundance index.

Using a generalized linear model (GLM) approach accounts for the above mentioned issues in establishing an appropriate survey index. Catches from the survey can be modelled as a linear function of explanatory variables, which may be continuous (e.g. depth) or factors (e.g. year, vessel, gear type)

1 http://www.ices.dk/marine-data/Documents/DATRAS/Indices_Calculation_Steps_IBTS.pdf

and offer the possibility to specify a distribution different from the normal distribution. The abundance index (corrected for the other potential effects such as vessel effects) can then be obtained from the estimated year effects. Figure 3 shows the estimated abundance index for North Sea horse mackerel based on the application of a GLM on the IBTS survey data. Sensitivity tests suggested that the index is robust to the inclusion of new years of data.

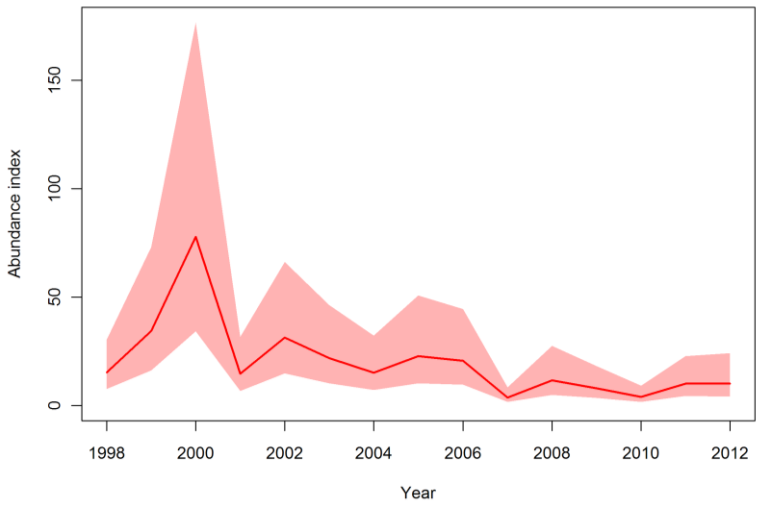

Figure 3. North Sea horse mackerel abundance index. The shaded area indicates the 95% confidence intervals for the estimated index values.

Basic assessment model

The GLM abundance index can be used to fit a simple age based model. The assessment model used follows the approach first presented to the WGMHSA (ICES, 2007). It is an age-based model that is fit by comparing trends in age 2+ abundance with the GLM-derived IBTS index, since the index approximates 20cm+ fish (primarily age 2 or older). 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. It is a separable model that assumes constant selectivity of the fleet over time and does not assume that catch is known exactly. Alternate assumptions, e.g. on natural mortality and the validity of input data, can be used to test sensitivity of the model's results to uncertainties.

Management Strategy Evaluation (MSE)

This assessment model, or variants thereof, provides a basis for conditioning a set of operating models to simulate the future performance or alternate HCRs. This allows for the selection of satisfactory parameters in the HCR (e.g. number of years to calculate the index slope and λ) and allows for the comparison of the performance of alternate HCRs in terms of trade-offs between stock development, catch and inter-annual variation in catch.

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 a stock-recruit relationship (including variability). See Figure 4. This framework can also be used to determine a candidate value for F_{msy} through long term simulations applying various fixed fishing mortality rates.

The performance of candidate HCRs can be compared over the short and medium term. Given 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 likely to be highly dependent

on the assumptions made in the assessment model. Also, given the apparent poor condition of the stock, the immediate goal of any HCR should be to halt decline in the short term. A new HCR should be proposed once more data informing on the status of the stock become available or the stock displays reasonable recovery from the current condition.

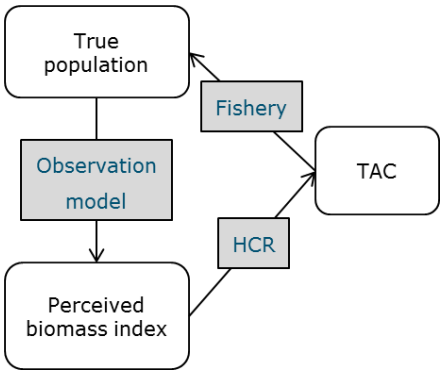

Figure 4. A Schematic of the basic procedure modelled in the MSE simulations.

Preliminary exploration

A preliminary exploration using the MSE framework provides some insight in the stock's performance. It should be noted that this is a preliminary result and no conclusions about the robustness of the HCR can be drawn until a full evaluation has taken place. Figure 5 shows an example of an assessment result and an example of the projected catch for one candidate HCR. The HCR could be considered to provide reasonable performance (in terms of the median):

- Landings are maintained at similar levels or slightly decreased
- The declining trend in SSB is halted (it stabilises around the estimated level of SSB in 2013)
- Landings are not very variable from year to year

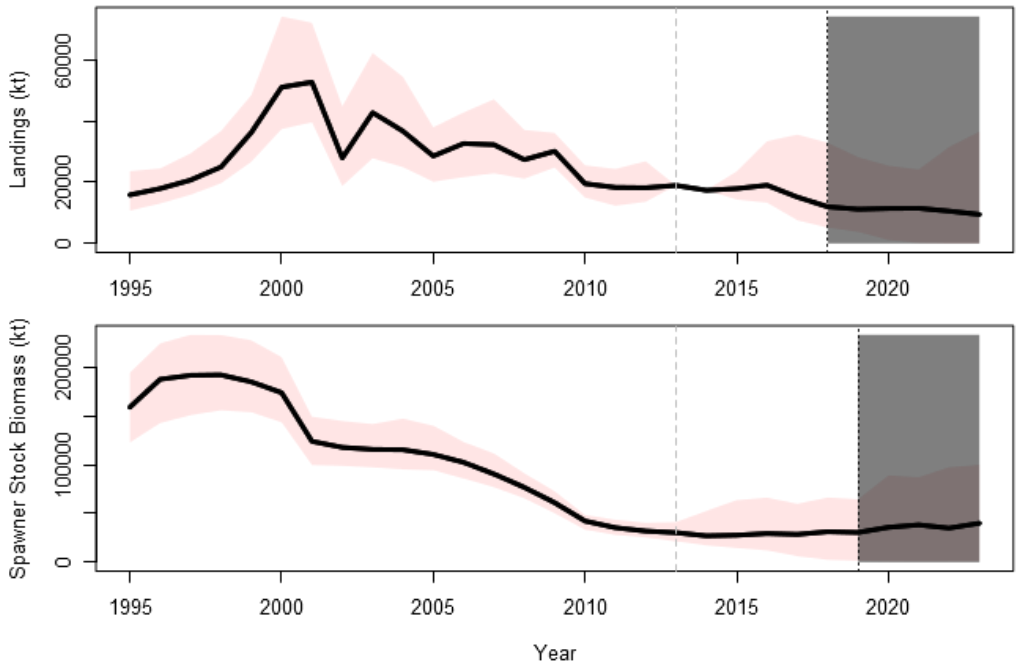

Figure 5. Projections of landings (top) and SSB (bottom) for an example HCR based on the basic assessment. The red shaded areas represent 5% and 95% confidence intervals. Projections start in 2013. The results in the grey shaded area should be regarded with extra caution due to high uncertainty in the population dynamics.

Issues for consideration in the full evaluation

Evaluation should make it possible to choose the optimal HCR parameters by exploring:

- A range of years (*x)* over which the trend in the survey (*Slp*) is determined **[candidate values: 3, 5]**
- A range of values for λ (slope multiplier) **[candidate values: 0.75, 1, 1.25]**
- I_{trig} = survey index trigger value **[candidate value: I_{2012}]**
- Stabiliser on inter-annual variation of the TAC **[candidate values: no stabiliser, 20%]**
- Starting TAC

Robustness of the candidate HCR should be tested using a reference set of biological and fleet operating models. Sensitivity of the assessment results to model assumptions and validity of input data should be tested:

- Stock-Recruitment function
- Natural mortality
- Selectivity of the fleet
- Percentage of utilisation of the TAC
- Uncertainty on origin of catches from area VIId

Evaluation criteria that should be included (no exhaustive list):

- SSB
- Fishing mortality (F) in 2015 and in 2020
- Landings
- Inter-annual variation in the TAC
- Length/age distribution in the population (optional)

References

European Union 2013. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC

HOMSIR project 2003. Final report: a multidisciplinary approach using genetic markers and biological tags in horse mackerel (*Trachurus trachurus*) stock structure analysis. (EU funded project: qlk5- ct1999-01438)

ICES 2007. Report of the Working Group on the assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). 4 - 13 SEPTEMBER 2007. ICES CM 2007/ACFM:31

ICES 2012a. Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). 13–17 February 2012, Lisbon. ICES CM 2012/ACOM:36.

ICES 2012b. Report of The Workshop to Finalize the ICES Data-limited Stock (DLS) Methodologies Documentation in an Operational Form for the 2013 Advice Season and to make Recommendations on Target Categories for Data-limited Stocks (WKLIFE II). ICES CM 2012/ACOM:79.

Rückert, C., Floeter, J., and Temming, A. 2002. An estimate of horse mackerel biomass in the North Sea, 1991–1997. – ICES Journal of Marine Science, 59: 120–130.

ICES 2013. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 27 August–02 September 2013, ICES Headquarters, Copenhagen, Denmark. ICES CM 2013/ACOM:15.