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Scientific, Technical and Economic Committee for Fisheries (STECF) Multispecies management plans for the Baltic (STECF-12-06)

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This report was reviewed by the STECF during its' 39th plenary meeting held from 16 to 20 April 2012 in Brussels, Belgium

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Multispecies management plans for the Baltic (STECF-12-06)

THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN BRUSSELS BELGIUM 16-20 APRIL 2012

REQUEST TO THE STECF

STECF is requested to review the report of the **EWG-12-02** held from March 26 – 30, 2012 in Rostock, evaluate the findings and make any appropriate comments and recommendations.

INTRODUCTION

The report of the Expert Working Group on Multispecies management plans for the Baltic (STECF-12-02) was reviewed by the STECF during its 39th plenary meeting held from 26 to 30 April, 2012 in Rostock, Germany. The following observations, conclusions and recommendations represent the outcomes of that review.

The development of regional, multi-stock long-term management plans are envisaged as an important element of the CFP. A series of expert groups has addressed TORs in relation to plans for a number of areas. In June 2011, the Commission and member states agreed that the Baltic cod plan should be replaced by a Baltic multi-species management plan which would take account of, for example, predation by cod on sprat and herring. The Baltic RAC also expressed support for such an approach. A meeting in Edinburgh (EWG 11- 15) was used to scope out work required towards developing a replacement plan. The expert Group (EWG 12-02) continued that work. This review by STECF considers both these meeting reports and draws on the single species evaluations from STECF EWG 11-07 in Hamburg 2011.In the Baltic Sea, the main fisheries are for cod, herring and sprat. Cod in the Eastern and Western Baltic are considered to be separate stocks. A long-term management plan has already contributed to the recovery of the stock of cod in the Eastern Baltic. There are a number of different herring stocks in the Baltic, with the main stock being in the eastern basin of the Baltic Sea and other stocks in the Gulf of Bothnia, the Gulf of Riga and the Western Baltic. An important issue to address when developing management plans for Baltic fish stocks that overlap in their distribution (Eastern Baltic cod, Eastern Baltic herring and sprat) is that cod are predatory, and their main prey is sprat and, to a lesser extent, herring. In addition, herring and sprat sometimes feed on the eggs of cod. This means that management of fisheries for cod can have an impact on fishing opportunities for sprat and herring, and vice versa. This is to be addressed by bringing all stocks into a single management plan where the objectives and harvest control rules are all designed to take account of these interactions between the different species.

STECF OBSERVATIONS AND CONCLUSIONS

STECF has reviewed the report and draws the following observations and conclusions for the stocks listed under the headings below:

Herring in Gulf of Riga, Bothnian Sea and Western Baltic

STECF endorses the modelling approach and supports the point exploitation Fmsy values and a range of B trigger options for the other stocks of herring in the Baltic. (EWG report Section 10.1.3)

Western Baltic cod

STECF considers that the report from EWG 11-07 provides acceptable single species MSY estimates for the Western Baltic cod stock(EWG report Section 6.1.1).

Eastern Baltic cod, Baltic sprat and Central Baltic herring

Work on these stocks formed the major part of the report. STECF commends the expert working group for the substantial work carried out in relation to the development of a multi-species management plan for these stocks (the significant input from DTU Aqua was particularly important). While this has not provided all the answers, it represents a major step forward and clearly identifies where future research effort should be directed.

In June 2011 EWG 11-07 extensively reviewed tactical approaches from the perspective of the utility of the different management methods such as total allowable landings (TAL), catch quota, effort control, closed areas and fishing gear regulations to control fishing mortality on cod in the Baltic. It was concluded for Baltic cod fisheries that since discarding was stable and relatively low, the current enforcement of the TALs appears to be sufficient to control the total outtake. In March 2012 a similar review of tactical approaches was considered also for herring and sprat fisheries and additionally in the context of effectiveness of control and enforcement. Based on considerations of the utility the various tactical options and their cost and effectiveness, STECF considers that simplifying the range of tactical approaches in the Baltic would be beneficial. STECF identified a number of specific points regarding the choice of tactics for Baltic finfish fisheries :

i) In the Baltic TALs or Catch quotas alone are more effective than catch and effort control combined;
ii) In the Baltic with a catch quota management system, regulatory gear technical measures may not be needed (except to exclude the use of gear for small pelagic fisheries to catch cod);
iii) In the Baltic spatial measures are considered to be easier to enforce than gear and mesh regulation if technical measures to control size or age selectivity are required.

The multi-species model used in this evaluation has been developed over many years and is accepted by ICES on many occasions for providing single species advice. The multi-species aspects depend on predation data from mainly the 1980s and there is an urgent need to update the information base. The values of cod cannibalism obtained are uncertain. The data come from before 1990s when the Baltic was under a different productivity regime, and overlap between adult and juvenile cod was different. The estimates of cannibalism depend on a few observed cases where cod have been found in cod stomachs, and because the data is so sparse the spatial differences that may be important have not been included in the model. Nevertheless the influence of these uncertain values when included in the model, suggest that Fmsy rises from 0.33 to 0.65. The uncertainty in these values is not included in the modelling and is not included numerically in the results.

Using the modelling framework selected a detailed evaluation of a range of exploitation F for central Baltic herring, Baltic sprat and Eastern Baltic cod are presented in this report. The evaluation indicates both single species and multi-species F MSY values for these three populations. In addition biomass and management trigger point values are proposed for these three species. The multispecies MSY evaluation indicates that MSY may be achieved at a higher F for all three stocks. The Fs which give maximum yield depend on the assumptions of the applied model and the use of some old diet data (pre 1990). Preliminary evaluations of growth effects in sprat and herring have been explored but are not yet substantiated. The most reliable model proposed as reviewed by ICES, (ICES WKMULTBAL Report) includes predation among cod, sprat and herring. Several different values of target F have are presented for these stocks and there is scope to explore tradeoffs in the exploitation of these species. Given the uncertainty of the estimates obtained from modelling and the lack of specific objectives at this stage, it is not possible to recommend specific multispecies MSY values for these three stocks.

Economic data were presented and simple projections involving static prices and cost structures were performed. Economic considerations suggest that there is little to be gained in value of landings from moving to higher fishing mortality rates. However, owing to the likely higher effort and increased costs of fuel etc. due to lower CPUE, lower Fs, which imply higher CPUE and greater stability, would most likely give more favourable outcomes.

In addition to the offshore fleets involved in the cod, herring and sprat fisheries, and some of the inshore cod-dependent fisheries, the Baltic Sea supports a number of inshore fleets which target other species (such as smelt, flatfish, eel, salmon and etc.) as well. The management plans under consideration here are not considered likely to affect the inshore fleets to the same extent as e.g. pelagic and demersal trawlers, which are targeting only the managed species.

Any improvement in the sectors' ability to plan will have positive benefits- not only in intangible social aspects such as improvement in the social environment (e.g. through minimizing stress) but also in concrete economic terms. The need for stability in order, for example, to get bank loans, improves the situation for the catching as well as ancillary sectors. A long term management plan creates the appropriate climate for this type of stability.

Based on the above work, a number of key observations can be made:-

- All the multispecies MSY F values for Eastern Baltic cod, Central Baltic herring and Baltic sprat are higher than the single species values.
- Considering the direct effects of F on the target stock: Changes in yield for cod and sprat due to higher Fs on these stocks give very similar yields on the long term and lead to lower SSBs. Simulated Fs of: F>0.65 for cod, F>0.5 for sprat or at lower Fs if TAC constraints of 15/20% are included in an HCR, run the risk of the stocks declining to lower biomass reference points that might be considered unacceptable. For Central Baltic herring Fs greater than the single species MSY value (F=0.16) give higher yields.
- Considering the indirect effects of target F on one stock affecting the other stocks: Changes in yield for sprat and herring are observed if F is changed on Eastern Baltic cod. Though higher Fs on cod give little increase in cod yield, they reduce consumption of sprat and herring by cod and give possibilities for higher yields from Baltic sprat and Central Baltic herring.
- Higher Fs than the estimated multispecies MSY values will carry even higher risks of SSB<lower biomass reference points.
- Since current multi-species modelling does not incorporate any structural uncertainty, associated with S-R relationships, predation and density dependence on growth, risks of decline in SSB will be higher than those estimated.
- The addition of year-year constraints in change in TAC increases the variability in stock size and the increases are greater in a multi-species system.
- Economic considerations suggest that lower Fs which imply greater stability and higher CPUE would give more favourable economic outcomes for the fleets evaluated.

The main conclusion to be drawn from the work is that target F values in the region of the single species Fmsy appear to be robust and could quickly be incorporated into a Baltic management plan.

STECF considers that there are broader considerations than were possible to fully address at the expert working group and that these should also be taken into account. The following paragraphs provide a summary of the STECF discussions.

The evaluations have concentrated on constant F based HCRs. The species interactions are driven by biomass considerations, and it is possible that HCRs with F dependent on biomass (increasing above the long term target at high biomass and decreasing at low biomass) may be more suitable and may deliver slightly higher yields, but so far there has not been sufficient time to explore these possibilities.

Both herring and sprat are food for cod and may be competitors for food. So far, tradeoffs between yield from sprat herring and cod have only been briefly considered. Currently there are no mixed species management objectives available to develop these options. If objectives could be stated, optimisation across species may be possible.

Currently the work in preparing this report has been limited by the request to deliver the STECF advice by April 2012. If the Commission finds that more detailed options are required or a biomass based management plan is preferred and does not need the advice before the autumn or next year, then with more time this would allow for additional modelling and a greater number of options to be considered. However, to do this effectively it is necessary for managers to enter into the dialog to develop a list of objectives allowing the work to be focused.

The work has generated interesting findings in relation to multispecies target values. The markedly higher F values are heavily driven, however, by predation data from 30 years ago and in particular by limited data on cannibalism in cod. Given that results so far suggest that at higher Fs the gains in yield are modest, that there is increased risk of depleted biomass and that the economic performance at higher F is likely impaired rather than enhanced, there does not seem to be a compelling reason to rapidly adopt a higher F strategy. STECF advises that before further consideration is given to the use of these multispecies Fmsy values in a future management plan, it is important that the supporting data is collected to allow more thorough evaluation of the model parameters. In particular there is an urgent need to collect predation data and information on the spatial overlap of the species and life stages. An EU call for tender issued recently provides a starting point for furnishing some of these data and in future further modelling based on the more up to date information from the tender and reviews of survey data should be possible.

The multispecies work conducted so far represents an important step towards an ecosystem approach to management, albeit for a limited range of interacting species and fisheries. STECF notes, however, that broader ecosystem considerations were not included and that these would need to be considered if a more holistic advice were to be sought. For example, it is unclear what effect increases in F values in the cod fishery (implying higher fishing effort) would have on the benthos or habitat integrity.

STECF also notes that environmental factors were not included in the modelling (apart from temperature in relation to sprat recruitment). It is possible that over longer time periods, significant effects leading to regime shifts may occur. The approaches adopted here assume reasonable stability in the system but when establishing plans going forward there is a need to be able to detect and make responses to any marked changes in environment which may render the management approach inappropriate. There is a need to extend the study to evaluate the sensitivity of the conclusions to some of the more uncertain assumptions on growth and predation.

Models can provide an indication of what might happen under different scenarios of management action but the question remains, ‘which is the most appropriate model’ or what is the ‘probability of other model structural options given the observations'. In the light of new data generated in the Baltic, the most appropriate models might be more easily identified. However, STECF advises that if the pursuit of improved multi-species models involves an 'experimental' approach to exploitation rate which encourages the adoption of higher fishing mortality rates, there is a danger that the health of stocks may be compromised. Moreover, such an approach may result in poorer economic outcomes for the fleets.

STECF is aware of further developments in multispecies work, *inter alia* the Framework 7 project MYFISH, COEXIST, VECTORS, SOCIOEC and the call for tender for collection and analysis stomach content data. It is anticipated that this work will help to remove some of the uncertainties discussed above.

STECF RECOMMENDATIONS

- STECF notes that the work carried out so far does not give a full range of risks and options and that currently only sparse data is available and models are limited. Nevertheless , STECF recommends that the current single species Fmsy values are sufficiently robust for use as F targets in a management plan for the main fisheries in the Baltic and that if managers wish to continue with exploitation at or below these values, this would be consistent with achieving high yield and low risk to stock productivity.

- If managers wish to understand the likely consequences of fishing at Fs higher than the single species FMSY values, there needs to be a dialogue involving managers, scientists and stakeholders to focus the work in the correct area. A sensitivity analysis is needed to understand the robustness of the higher Fs to the assumptions implied in the models. Furthermore, there are trade-offs between stock size, yield, and risks of stock decline to biological limit points among sprat, herring and cod stocks, which have only been examined superficially which could be explored further. In addition other approaches, for example incorporating biomass considerations into the HCR, could be explored.

REPORT TO THE STECF

EXPERT WORKING GROUP ON MULTISPECIES MANAGEMENT PLANS FOR THE BALTIC (EWG-12-02)

Rostock, Germany, 26-30 March 2012

1 EXECUTIVE SUMMARY

The EWG 111-02 met in Rostock, Germany to provide an impact assessment report for Baltic stocks of cod, herring and sprat. This Impact Assessment report provides exploitation Fmsy values and a range of B trigger options for herring in Gulf of Riga, Bothnian Sea and Western Baltic stocks. The report from EWG 11-07 provides single species MSY estimates for Western Baltic cod. The meeting concentrated mainly on the multispecies evaluation of Eastern Baltic cod, Central Baltic herring and Baltic sprat. Including both biological an economic studies.

The multispecies model used in this evaluation has been developed over many years and is accepted by ICES and on many occasions has provided single species advice. The multispecies aspects of the model were reviewed at ICES in February. A wide range of deterministic evaluations were carried out to indicate the range of Fs associated with MSY for the three species. From this a range of F values a small range were selected giving high yield for all three stocks. From this three specific scenarios were selected for stochastic evaluation.

There are some concerns regarding the possibility to model multispecies aspects predictably for the future. In particular the multi-species aspects depend on predation data from mainly the 1980s and there is an urgent need to update the information base. Also the current regime in terms of productivity and spatial distribution of fish stocks in the Baltic is different from the earlier period when predation data was collected.

The conclusions from the work are preliminary, but illustrate many of the main features for exploitation of the three stocks. All the multispecies Fmsy values for Eastern Baltic cod, Central Baltic herring and Baltic sprat are higher than the single species values. Particularly for cod and sprat higher Fs give very similar yields on the long term and will give lower SSBs and in some cases risks of stock decline to the lower biomass reference points. Model results indicate that although higher Fs on Eastern Baltic cod give little increase in cod yield they give higher yields from Baltic sprat and Central Baltic herring. As current modelling does not include any structural uncertainty, risks will be higher than those estimated. The addition of year-year constraints in change in TAC increases the variability in stock size and the increases are greater in a multi-species system. Economic considerations suggest that lower Fs which imply greater stability would give more favourable outcomes.

If management is to follow the higher Fs associated with multispecies interactions it is very strongly recommended that biological sampling to support the interspecific relationships be restarted.

2 CONCLUSIONS OF THE WORKING GROUP

The current evaluation provides point exploitation Fmsy values and a range of B trigger options for herring in Gulf of Riga, Bothnian Sea and Western Baltic stocks. The report from EWG 11-07 provides single species MSY estimates for Western Baltic cod. The model used in this evaluation has been developed over many years and is accepted by ICES on many occasions for providing single species advice. The multi-species aspects depend on predation data from mainly the 1980s and there is an urgent need to update the information base.

A detailed evaluation of a range of exploitation F for central Baltic herring, Baltic sprat and Eastern Baltic cod are presented in this report. The evaluation indicates both single species and multi-species F MSY values for these three populations. In addition biomass and management trigger point values are proposed for these three species. The multispecies MSY evaluation indicates that MSY may be achieved at a higher F for all three stocks. The Fs which give maximum yield depend on the assumptions of the applied model and the use of some old diet data (pre 1990). Preliminary evaluations of density dependent growth effects in sprat and herring have been explored but are not yet substantiated. The most reliable model proposed includes predation among cod, sprat and herring. Several different values of target F have are presented for these stocks. Given the uncertainty of the modelling and the lack of specific objectives it is not possible to recommend specific MSY values for these three stocks, however, a number of observations can be made:- All the multispecies MSY F values for Eastern Baltic cod, Central Baltic herring and Baltic sprat are higher than the single species values. For cod and sprat higher Fs give very similar yields on the long term and will give lower SSBs and in some cases risks of stock decline to the lower biomass reference points. For Central Baltic herring higher Fs give higher yields. Model results indicate that although higher Fs on Eastern Baltic cod give little increase in cod yield they give higher yields from Baltic sprat and Central Baltic herring. Higher Fs than those presented will carry even higher risks of SSB<lower biomass reference points. As current modelling does not include any structural uncertainty, risks of decline in SSB will be higher than those estimated. The addition of year-year constraints in change in TAC increases the variability in stock size and the increases are greater in a multi-species system. Economic considerations suggest that lower Fs which imply greater stability would give more favourable outcomes.

The evaluations have concentrated on constant F based HCRs. The species interactions are driven by biomass considerations, and it is possible that HCRs with F dependent on biomass (increasing above the long term target at high biomass and decreasing at low biomass) may be more suitable and may deliver slightly higher yields, but so far there has not been sufficient time to explore these possibilities.

Both herring and sprat are food for cod and may be competitors for food. So far tradeoffs between yield from sprat herring and cod have only been briefly considered. Currently there are no mixed species management objectives available to develop these options. If objectives could be stated optimisation across species may be possible.

Currently the work in preparing this report has been limited by the request to deliver the STECF advice by April 2012. If the Commission finds that more detailed options are required or a biomass based management plan is preferred and does not need the advice before the autumn or next year, then with more time this would allow for additional modelling and a greater number of options to be considered. However, to do this effectively it is necessary for managers to enter into the dialog to develop a list of objectives allowing the work to be focused.

If multispecies target values are to be use in any future management plan it is important that the supporting data is collected to allow evaluation of the model parameters. In particular there is an urgent need to collect predation data.

3 RECOMMENDATIONS OF THE WORKING GROUP

The EWG recognises that the work done so far does not give a full range of risks and options. The EWG recognises that currently only sparse data is available and models are limited. Nevertheless more work is possible to give better idea of the effects of exploitation at higher F. If managers do wish for whatever reason to run exploitation at Fs greater than single species Fmsy, then given appropriate lead in time of say 6-12 months the EWG can run through a more extended risks assessment. If managers wish to continue with exploitation at or below single species Fmsy then these values are sufficiently robust for use.

4 INTRODUCTION

Following a scoping meeting in Edinburgh (STECF EWG 11-15) it was decided to hold the Impact assessment meeting in Rostock 26-30 March. The timing for this meeting was delayed as much as feasibly possible in order to get the report to STECF plenary on 16 April. The work carried out and presented below forms a substantial modelling and exploitation development and draws on work from many years and the model evaluation carried out at ICES on 27 February 2012.

4.1 Terms of Reference for EWG-12-02

Hold a meeting 26 to 30 March in Rostock, Germany for preparation of Impact Assessments for multispecies management plans for the Baltic and review progress and the requirements to provide Impact Assessments on mixed fisheries plans for North Sea and Kattegat.

a) Impact Assessments for a new plan for cod, herring and sprat in the Baltic Sea, including Eastern and Western Baltic cod, Bothnian Sea, Bothian bay, Central Baltic, Gulf of Riga and Western Baltic Spring spawning herring and Baltic Sprat

b) Mixed fisheries plans for North Sea and Kattegat, including cod, haddock, whiting, saithe, plaice, sole, Nephrops,

- Describe and, where possible, quantify technical linkages between stocks in the area.
- Describe single species approaches and targets currently in force and consider if these need to be modified
- Identify and discuss approaches to incorporating the technical linkages into multi-annual management plans, and into MSY objectives for those plans.
- Consider how other objectives, relating to ecological and economic sustainability could be addressed within a management plan, and how progress towards these objectives might be evaluated.
- Identify candidate management measures that could contribute to the delivery of the objectives of the plan.
- Comment on the suitability of existing management measures for achieving MSY targets and where necessary suggest additional or alternative measures.

4.2 Participants

The full list of participants at EWG-12-02 is presented in section 13.

5 PROBLEM STATEMENT

Long-term management plans have become an important tool for fisheries management. These plans set-out clear conservation objectives for the fish stocks concerned and specify rules (known as harvest control rules HCRs) for how fishing opportunities on the stock are determined based both on the state of the stock and on the previous year's fishing opportunities. In this way, management plans provide a way of achieving conservation objectives while still allowing stability for the fishing industry. The use of long-term management plans in this way is strongly supported by stakeholders and member states.

In the Baltic Sea, the main fisheries are for cod, herring and sprat. Cod in the Eastern and Western Baltic are considered to be separate stocks. A long-term management plan has already contributed to the recovery of the stock of cod in the Eastern Baltic. There are a number of different herring stocks in the Baltic, with the main stock being in the eastern basin of the Baltic Sea. There are smaller stocks in the Gulf of Bothnia, the Gulf of Riga and the Western Baltic. The latter stock spawns in the Western Baltic, then migrates into the Skagerrak and the Eastern North Sea in order to feed. There is one stock of sprat in the Baltic.

An important issue to address when developing management plans for Baltic fish stocks is that cod are predatory, and their main prey is sprat and, to a lesser extent, herring. In addition, herring and sprat sometimes feed on the eggs of cod. This means that management of fisheries for cod can have an impact on fishing opportunities for sprat and herring, and vice versa. This could be addressed by bringing all stocks into a single management plan where the objectives and harvest control rules are all designed to take account of these interactions between the different species. This is the intention of the current initiative.

The initiative concerns fishery management, which is an area of Commission competence. The main impacts will be on stakeholders; primarily the fishing industry whose livelihood is determined by their fishing opportunities, but also conservation NGOs. The initiative should lead to more sustainable exploitation of Baltic stocks.

The current reform of the CFP anticipates more extensive use of long-term management plans, and states that: "Multi-annual plans should where possible cover multiple stocks where those stocks are jointly exploited". Such plans will also be more consistent with the ecosystem approach to fishery management, which is also anticipated under the reform. The multi-species management plan for the Baltic will be the first example of such a multi-stock plan, so it will make an important contribution to this aspect of the reform.

6 OBJECTIVES : GENERAL / SPECIFIC / OPERATIONAL

The current reform of the CFP (COM 2011/425) foresees several changes to the political framework for fisheries management that will have a direct or indirect impact on the scope and concept of long-term management plans and thus the respective needs for scientific advice.

Under the future policy a multiannual plan shall include:

(a) the scope, in terms of stocks, fishery and the marine ecosystem to which the multiannual plan shall be applied;

(b) objectives consistent with:

- the application of the precautionary approach to fisheries management ensuring exploitation that restores and maintains populations of harvested species above levels which can produce the maximum sustainable yield by 2015
- the implementation of the ecosystem-based approach to fisheries management to ensure that the impacts of fishing activities on the marine ecosystem are limited

(c) quantifiable targets expressed in terms of:

i) fishing mortality rates, and/or

ii) spawning stock biomass, and

ii) stability of catches.

(d) clear time frames to reach the quantifiable targets;

(e) technical measures including measures concerning the elimination of unwanted catches;

(f) quantifiable indicators for periodic monitoring and assessment of the progress related to achieving the targets of the multiannual plan;

(g) specific measures and objectives for the freshwater part of the life cycle of anadromous and catadromous species;

(h) measures to minimise impacts of fishing on the eco-system;

(i) safeguards and criteria activating those safeguards;

(j) any other measures suitable to achieve the objectives of multiannual plans.

7 IDENTIFIED TACTICAL METHODS

7.1 Options available

Past experiences show that it is important that a management plan includes options for actions to be taken in case the TACs are shown to be ineffective in limiting fishing mortalities. Managers should choose a minimum set of control measures that are thought to be appropriate at the time, but should retain the ability to relax or deploy additional tactical methods should the plan be failing to deliver its objectives.

7.1.1 Enforcement

In order for the plan to reach its objectives it is important that the effect on compliance and enforcement of the management measures is considered. From this perspective it is crucial that the measures are:

- harmonized over regions and MS as far as possible to avoid a perception of unfairness;
- kept to a minimum to avoid spreading limited control funds over a large number of measures;
- ensuring that the fishers bear the benefits of complying with the rules as well as the cost of non-compliance;
- carrying appropriate penalties for non-compliance. Failure to have sufficiently stringent penalties could incentivize non-compliance;
- considering the incentives for the fishers to comply with the rules;

It is important that the enforcement tools are applied in the most cost efficient way using the appropriate tools and intensity to control each management measures. Furthermore, the enforcement efforts need to be adaptive so that when irregularities are found the mix of enforcement tools and intensities can be changed accordingly.

7.1.2 Management through limitation of catches

From an enforcement perspective using both TACs and effort limitations to control the outtake, as is done in the current plan, is not efficient. The current enforcement of the TACs appears to be sufficient to control the total outtake in the Baltic. Discards of cod have been relative limited and stable in recent years. In the pelagic fisheries discards is not considered to be a problem, and the EWG therefore concludes that the current TACs have been effective in limiting fishing mortalities. F target based harvest control rules with catch calculated using a short term forecast and a percentage constraint on inter-annual change in TAC are considered appropriate in defining the TACs for all stocks considered.

Although discards appear at present not to be a problem in relation to limiting fishing mortality, a management plan should include explicit rules for addressing discards. This could be implemented by defining the TAC as total allowable catch and by ensuring that all catches (landings as well as discards) are counted against the TAC as for example in a fully documented fishery.

In a fully documented fishery scheme all catch have to be reported in the logbook as either catch or discard. Enforcing the rule could be done by using traditional enforcement tools such as at sea control and by analyzing species composition at landings. It could possibly also be done by equipping vessels with CCTV and sensors on the trawls in order to assess the quantity and species that are being lifted on board. Another management measure to regulate total allowable catch quotas would be to introduce a discard ban where all catches has to be landed. From an enforcement perspective it is very important that all species would be covered by the discard ban. If not, many control means would be powerless. For example, surveillance planes or patrol vessels cannot from a distance detect which species that are being discarded. Furthermore the enforcement activities should be risk-based and take fleet characteristics into account, as selective singles species fisheries will not require the same control intensity to control discards as for example for trawl multi-species fisheries.

If it is evident that recreational catches (see article 55.4 of the Council regulation (EC) 1224/2009) constitute a measurable and variable part of the total catches, catches from the recreational fisheries should be addressed in the management plan. A scheme to enforce recreational catches should, in the same way as is done in the professional fisheries, be risk-based rather than exhaustive.

7.1.3 Individual transferable quota concessions

As a mean to avoid race for fish, to allow fishers to obtain the right balance of quota and to directly benefit from selective fishing as well as bear the burden for unselective fisheries, a system of individual quota concessions could be introduced.

Within the system catch quotas for species would be set at European level but allocated at MS level to individual businesses or collectives, through direct allocation or TFC (Transferable Fishing Concessions) for a predetermined limited timeframe. In a multispecies fishery, fishers must have quota to cover the catch of the different species and vessels must cease to operate when their quota for one of the species is exhausted. Implementation implies allowing fishermen freedom to reconcile their single species quotas themselves provided no national quota is overshot.

This approach provides flexibility to the industry but is also demanding in terms of compliance requirements due to potential miss-match between quota allocation and catch. In case of small overshoot or surplus quota at the end of the year, some moderate (i.e. 10%) banking and borrowing between years and between MS and the Commission, could be used to deal with this.

Fishermen must accept that it is up to them to make the most of their opportunities while keeping within their quotas. It is their responsibility to avoid any miss-match between TFC and catch, either through TFC or spatiotemporal targeting/avoidance, or ceasing to fish. When designing the system it is important to investigate possibilities for introducing incentives for avoiding high grading and discarding.

Minor overquota catches could be dealt with by the borrowing and banking and possibly by fines. For serious and/or repeated infringements the authorities should have the possibility to withdraw the fishing concession with all the financial consequences that would follow.

7.1.4 Limitation of fishing effort

The evaluation of the present multiannual management plan, and the simulations presented in section 7 of the (EWG 11-07), indicate that rules for effort limitations are not currently required to meet the biological objectives, as long as the limitations in catches are effective in limiting the fishing mortality as intended.

7.1.5 Spawning closures

The impact on the present spawning closures on the stocks and the fisheries is unclear but the measures are unlikely to have had a limiting effect on the overall fishing mortality and EWG concludes that spawning closures are not required to meet the biological objectives as long as the TACs are effective in limiting fishing mortalities as intended.

If spawning closures are included in a future management plan it is recommended that it is ensured that the timing of the closures matches the spawning periods of the spawning components to be protected. From a control perspective time and area closures are to be preferred over gear rules (see section below) due to cost efficiency.

7.1.6 Other measures (gear rules, MLS, etc.)

A number of technical measures including gear rules, minimum landing size and maximum by-catch percentages currently included in the technical measures regulation affect the fisheries. These measures have little impact on the overall fishing mortality and are not required to meet the biological objectives as long as the limitations in catches is effective in limiting the fishing mortality as intended.

The measures may, however, have had a positive impact on the exploitation pattern on cod and as such a positive impact on the yield per recruit.

With a functioning catch quota management system, strong incentives for the fishery to reduce unwanted by catch could be created and thus improve selectivity. The present gear regulations put quite a burden on the both fishers and the inspection system and still only attempt to control parts of the issues related to the selectivity of a gear. By deregulating where plausible detailed gear regulation, a strong additional incentive could be created since the burden for fishers and inspectors would be eased. Despite these benefits there is a concern that smaller individuals could be targeted if gear rules are being abolished. Thus in the short term gear regulations in catch quota fisheries might be best suspended rather than removed in order to evaluate the impact of removal.

Furthermore, in a management system including a discard ban the minimum landing size as well as the maximum by-catch percentage would have to be abolished in order to reach the targets.

7.1.7 Incentives

In order to effectively delivering the objectives of the plan, including incentives as part of management needs to be addressed.

These could include:

- rewarding selective fishing practices by extra allocation of catch quotas.
- borrowing and banking to allow for flexibility between years.
- allocation of quotas to collectives: these should be carefully designed in order to create social peer pressure. For example, in order to receive extra quotas from selective fishing practices, none of the members can have breached the fisheries regulations.
- easing the number of controls of vessels/business where no infringement has been found for a predetermined timeframe.
- placing appropriate penalties: minor over-catch should be dealt with by banking and borrowing, while severe overshooting would be associated with fines in relation to the size of the infringement.

8 COST EFFECTIVENESS OF CONTROL AND ENFORCEMENT

In considering choices between options it is important to take into acount, that different options have important differences in implementation costs against the effectiveness in delivering the objectives of the plan. For example is one option able to deliver better conservation measures than another at comparable costs, or do both options have similar conservation properties with differing costs. There is currently no general methodology to provide a quantitative cost/benefit analysis of control and enforcement, however, some important aspects can be considered and described qualitatively.

The suggested management measures the following regarding the cost effectiveness of control efforts can be said:

- a discard ban that does not include all species is difficult to enforce effectively – in contrast it is cheaper and similar objectives can be met through enforcement of fully documented fisheries where all catches are reported as either landings or discards;

- control of recreational catches of cod – control needs to be risk based (relating risk to the stock and cost of enforcement) and cannot target all individuals;

- Enforcement of quotas vs. effort: using one method, effort or TAC, has enforcement cost gains especially if the one method is adequate;
- Implementation of catch traceability systems will most likely improve the cost efficiency of enforcing the TAC.

8.1 Enforcement issues

The working group has previously requested more information regarding the compliance rates of management measures in the Baltic.

As a part of the yearly risk assessment conducted at the European Fisheries Control Agency (EFCA) in Vigo data from national risk assessments in the MS are collected and compiled on the regional level. For each infringement type (for example misreporting, fishing in closed areas etc.) MS are asked to assess the perceived risk to the stock (in 5 levels from low to very high). In addition, the perceived frequency that the infringement occurs is reported. The national risk factor is calculated as this risk multiplied with the infringement frequency and weighted with the proportion of the TAC that is allocated to the MS by area and gear type (active or passive gears). The sum of the national risk factors gives a regional risk factor. Two areas were analyzed (ICES sub-division 22-24 and 25-32) because there are differences in fishing patterns.

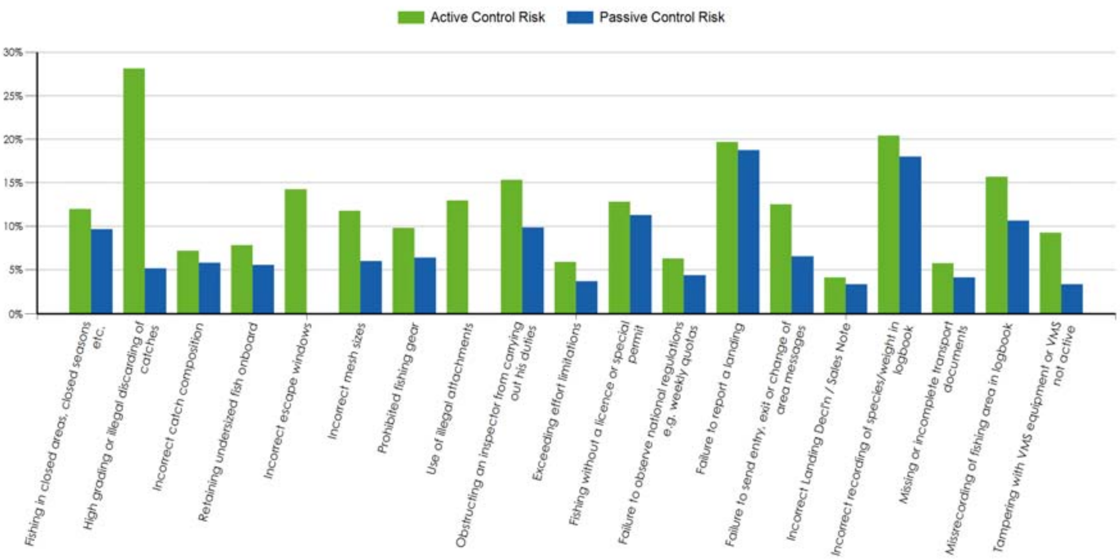


Figure 8.1 Regional risk for the second semester of 2012 in the Baltic Sea (sub-division 22-24) for Atlantic Cod.

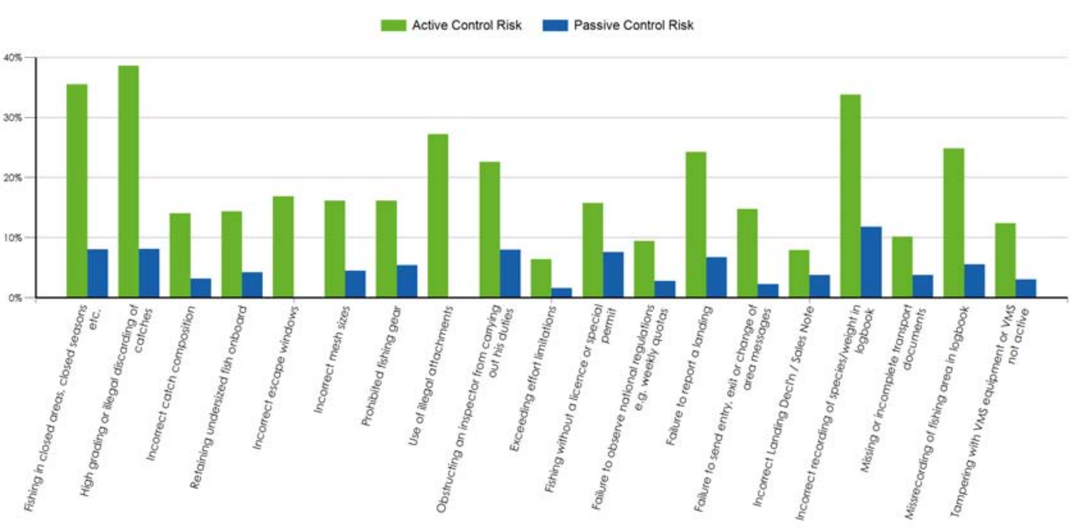


Figure 8.2 Regional risk for the second semester of 2012 in the Baltic Sea (sub-division 25-33) for Atlantic Cod.

The risk factor is higher overall in area 25-32 than in 22-24 (Figures 8.1 and 8.2. Furthermore, in both areas the active fleets have a higher regional risk factor. This is most likely however, the result of a larger allocation of quotas to these segments.

The infringement types with the highest regional risk factor are:

- High grading or illegal discarding
- Fishing in closed areas

• Incorrect recording of landings

Even though the national risk factors are calculated differently in each MS the analysis provides a good indication of the regional risk of non-compliance in the Baltic.

8.1 Pelagic species identification

For several years it is stated by ICES that: *"(…) The pelagic fisheries take a mixture of herring and sprat and this causes uncertainties in catch levels. The extent to which species misreporting has occurred is however not well known"*.

National experts were contacted and requested to describe the mixed pelagic fisheries on a national basis. The aim was to conclude if any further efforts should be taken to design a more elaborate sampling program to document species composition in mixed pelagic fisheries. A description of mixed pelagic fisheries was submitted by Denmark, Estonia, Finland, Germany, Latvia, Poland and Sweden (see Annex 1).

Conclusion

In most cases the sampling appears adequate

For some countries (i.e. Germany, Poland) it is difficult to get biological samples (length and age data) from the national fishing activities when a larger part of the herring/sprat catches are landed in foreign ports.

It would be beneficial to have a higher sampling coverage of the species composition of the small-mesh industrial fisheries targeting sprat in SDs 27-29 and SD 32 to decrease the potential of uncertainties in catch levels of herring and sprat.

Outlook

The outcome of the national description of the species composition in Baltic mixed pelagic Fisheries (see Annex 1) will be discussed during the next meeting of WGBFAS in April 2012. Further work is needed to get more details on the species composition in the mixed pelagic fisheries, focusing on how much of the herring/sprat catches (t) are taken by the industrial trawl fishery.

9 OVERRIDING CONSIDERATIONS OF THE MANAGEMENT METHODS

Most of the Baltic Sea and the vast majority of its marine living resources are managed under the EU common fisheries policy. It is the declared objective of the EU fisheries management to exploit these resources within safe biological limits and to restore and maintain the stocks at or above levels which can produce maximum sustainable yields not later than 2015.

Most ***pelagic resources*** of the Baltic are currently managed on the basis of the ICES/STECF advice, but – in the absence of an agreed management plan – recommended reductions in catches for sprat, central Baltic herring and western Baltic herring were not fully implemented. The ICES advice for the central Baltic resources is based on fishing mortalities as biomass reference points are not available for these stocks.

The two cod stocks – ***eastern and western Baltic cod*** – are managed according to a multiannual plan implemented in 2008 (EC Reg. 1098/2007). This plan aimed at reducing fishing mortalities gradually towards a minimum F by means of a reduction of fishing effort (in terms of days-at-sea) and total allowable catches. According to the regulation, the plan had to be evaluated 3 yrs after implementation. This evaluation was finalised by STECF in summer 2011 (EWG 11-07). The main recommendations of STECF following this evaluation for the management of the cod stocks in a single species context were:

- *Minimum target fishing mortalities:* Within the historical stock sizes exploitation of the two cod stocks at target fishing mortalities of 0.33 is consistent with the objective of MSY. If the stock sizes increase to a state where it influences the population parameters it may be necessary to adapt the target fishing mortalities to obtain MSY. This minimum target F is slightly higher than in the present plan for the eastern cod stock, and significantly lower for the western cod stock. Discards are included in the F_{MSY} evaluations and a possible discard ban is unlikely to affect the conclusions unless a ban will result in a major change in the exploitation pattern. A higher MSY could potentially be obtained for eastern Baltic cod by changing size selection towards harvesting cod >70 to77cm.

- *Limitation of catches:* The current enforcement of the TACs appears to be sufficient to control the total outtake. Discards have been relative limited and stable in recent years and the EWG concludes that the TACs have been effective in limiting fishing mortalities. However, the past experiences show that it is important that a management plan includes options for actions to be taken in case the TACs are shown to be ineffective in limiting fishing mortalities. F target based harvest control rules with catch calculated using a short term forecast and a percentage constraint on inter-annual change in TAC are considered appropriate in defining the TACs for both stocks – however, a 15% constraint on inter-annual variation in the TACs is not required to achieve the biological objectives.

Although discards appear at present not to be a problem in relation to limiting fishing mortality, a management plan should include explicit rules for addressing discards. This could be implemented by defining the TAC as total allowable catch and by ensuring that all catches (landings as well as discards) are counted against the TAC.

Recreational catches constitute, in certain areas, a measurable and variable part of the total catches and to ensure a proper limitation of total catches, catches of cod in the recreational fisheries should be addressed in the management plan.

- *Limitation of fishing effort:* Rules for effort limitations are not required to meet the biological objectives as long as the limitations in catches is effective in limiting the fishing mortality as intended. However, it might be useful to include options in a management plan allowing for limitations of the fishing effort in case the TACs prove not to be effective in limiting the fishing mortalities as intended.

Spawning closures: The impact on the present spawning closures on the stocks and the fisheries is unclear but the measures are unlikely to have had a limiting effect on the overall fishing mortality and EWG concludes that spawning closures are not required to meet the biological objectives as long as the TACs effective in limiting the fishing mortalities as intended. If spawning closures are included in a future management plan it is recommended that it is ensured that the timing of the closures matches the spawning periods of the spawning components to be protected.

- *Other measures:* A number of technical measures including gear rules, minimum landing size and maximum by-catch percentages currently included in the technical measures regulation affect the fisheries on the cod stocks. These measures have little impact on the overall fishing mortality and are not required to meet the biological objectives as long as the limitations in catches is effective in limiting the fishing mortality as intended. The measures may, however, have had a positive impact on the exploitation pattern on cod and as such a positive impact on the yield per recruit.

Most of these recommendations appear to remain valid in a multispecies context, with the notable exception of the minimum target fishing mortalities. In addition the tactical choices can be summaries as follows:

- simplifying management control would be beneficial,
- TACs or Catch quotas alone are preferred to catch and effort control.
- Fully documented fisheries with catch quotas are preferred over discard bans.
- With catch quotas technical measures may not be needed
- Spatial measures are preferred over gear and mesh regulation if these are required.

10 ENVIRONMENTAL EFFECTS OF THE OPTIONS

This section presents the results of biological modelling in a multispecies context for Eastern Baltic Cod, Central Baltic herring and Baltic Sprat. A full description of the methods is contained in ICES 2012 a summary is presented below in section 10.1.1. All the other Baltic herring populations (Western Baltic, Gulf of Riga, Bothnia Sea) are modelled as single species populations, with the major effort being allocated to estimating appropriate range of Btrigger for exploitation at Fmsy (see section 10.1.3). Evaluations of Western Baltic cod were carried out in June/July 2011 and reported in the Baltic report from EWG 11-07. Reference should be made to this document for biological evaluation of Western Baltic cod.

10.1 Evaluation of the effects of the multi-annual plan options on the fisheries

10.1.1 Cod, Central Baltic herring and sprat combined area biological simulations

Methods

The ICES Workshop on Integrated Multispecies Advice for Baltic Fisheries (WKMULTBAL) (ICES, 2012) evaluated the SMS model used here and presented several configurations of the SMS model (Vinther and Lewy, 2012) for the eastern Baltic Sea. During the EWG meeting the “One-area, Constraint Uniform prey size selection” configuration was chosen as a starting point for further analysis as the EWG group considers that the available data for the alternative 4-area configurations presented by WKMULTBAL are insufficient to parameterise the model for fisheries advice. The 4-area configuration estimates predation mortality by sub-division from data on stock distribution and stomach data by subdivision. However the total number of stomachs sampled (~50 000) divided over areas seems too low to give an unbiased estimate of cod cannibalism by area. Cod cannibalism is a relatively rare event (250of 50,000 stomachs) which means that a lot of stomach samples for a given year, quarter and cod length class stratum have no observations of cod cannibalism. SMS does not use “zero-observation” in the likelihood for sub-model for predation, such that a very high proportion of zero-observations might bias the result seriously. The EWG considers that more analyses are needed to show that the split of stomach data does not bias the result seriously. In addition, the stock distribution model used in the 4-area model lacks the ability to predict future spatial distribution of the stock necessary for forecast which makes it less applicable for MSE purposes.

During the SG-MOS meeting the one-area model was further developed and tested and extended with the sub-model for density dependent growth of clupeid as outline in the WKMULTBAL report. There was not sufficient time to implement the model for cod growth suggested by WKMULTBAL.

10.1.1.1 Identification of potential target levels for fishing mortalities (F_{MSY}) talking multispecies interaction into account.

Candidates for FMSY were identified using the same approach as described by WKMULTBAL. In short, the method makes use of deterministic forecasts with no stochastic variability in recruitment based on a high number of combinations of F-values for the three species, cod, herring and sprat. Based on the estimated yield these runs, the range of F values giving high yield by species was identified (taking the F level and stock sizes on the other stocks into account simultaneously). Figure 10.1.1 presents the results for the default 1-area SMS model. In the simulations a wide range of F values, and probably unrealistic low and high values, has been used but the Figure to show clearly the higher yield region of F to allow selection of a narrower range of F-values.

Figure 10.1.2 presents the same results of the deterministic forecasts for this narrow range of F values around the F value that provided high yield in Figure 10.1.1. The highest yield of the individual species, without seriously impairing the stock sizes of other species, is obtained for an F around 0.60-0.65 for cod, 0.26 for herring and 0.46 for sprat. The associated deterministic levels of SSB and recruitment are presented in Figure 10.1.3 and Figure 10.1.4 respectively. Yield within this narrow near Fmsy range of F presented is rather constant for three species. For cod, the median yield is almost constant (in the range 70-73 kt), while SSB ranges 140-210 kt for F in the range of 0.4-0.7. The yields of herring of sprat vary by around 5% and 10% within the presented range of F, while SSB by species varies between 550 kt and 850 kt. The variation in yield of herring and sprat due to the stock size of cod and associated predation is at the same scale as the variation in yield due to the F range shown (Figure 10.1.2).

The results presented above are made with the assumption that the mean weights at age are constant in the forecast period. Higher FMSY proxies for herring and sprat are obtained when density dependent growth is assumed for the two species (Figure 10.1.5), as the stocks compensate by a higher growth at lower stock densities due to either higher fishing mortalities or predation. The estimated highest yield for sprat is obtained for F at 0.7 or higher, which seems to be a very high value. A similar exercise with density dependent growth, was done for sprat at the WGBFAS in 2011 using deterministic long-term projections. It showed that when the stock recruitment relation is fitted to years of high sprat recruitment (1991 onwards), F-MSY could reach level of 0.77-0.78 when cod predation mortality is low (WGBFAS 2011). This shows that the results presented in Figure 10.1.5 is not specific to this model but a general feature of modelling growth. For herring the FMSY proxy increased from 0.26 to 0.40 when density dependent growth is modelled. The method for estimating growth of clupeids is described in the WKMULTBAL report. Further discussion of the method made during the EWG meeting is presented in section 10.3. WGBFAS concluded that more work is needed to fully understand and validate the results of the estimated density dependent growth. The present EWG fully supports this conclusion; especially it should be evaluated to which extend the results are dependent on a number of environmental changes and not just clupeid abundance. Use of Fmsy values derived using density dependence is not currently recommended without further work.

10.1.1.2 MSE scenarios

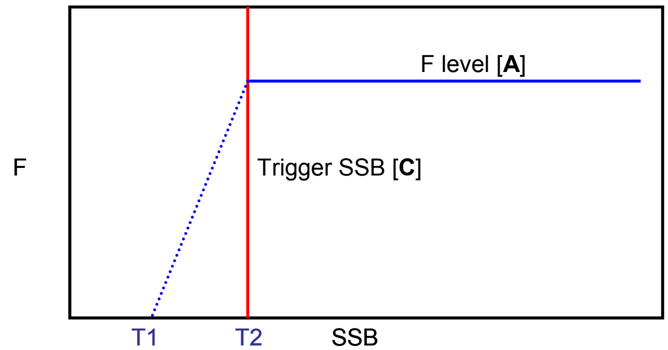
Due to time limitation, it was not possible for the EWG group to suggest or explore detailed candidates for harvest control rules to be applied for the eastern Baltic Sea. Instead three HCR simulations defined and carried out to illustrate the possible responses on a multispecies system from fisheries for a limited range of F that was though to highlight the main issues. All the scenarios presented in this section were made using the SMS software. The SMS approach to MSE mimics the full annual cycle of assessment and projection as done following ICES procedures. It is assumed that the true stock size can be “observed” with some bias and noise and it is this “perceived” stock that makes the basis for the use of HCR and estimation of a TAC. The true stock size is assumed know in the first projection year and is later updated annually by recruitment and catches derived from application of HCR on the "perceived" stock. Details about the method can be found in WKMAMPEL, (ICES 2009) and in Vinther and Lewy (2012). For all three species, it was assumed that the observation noise was log-normal distributed with a standard deviation at 0.20 with a correlation of one between age-groups. Though in practice this variability also may be considered to include variability in predicted mean weights and variability in catch/landings ratio. Such value represents a high "assessment uncertainty" only but may be more realistic when other factors are considered. For other variables that are kept constant in the projections, like mean weight at age, a twenty years average was used as a constant factor.

The basic settings for the three HCR scenarios investigated are listed below:

1. Existing plan/ single species F_{MSY}
    - Cod target F=0.3, +/-15% TAC constraint (similar to the existing management plan)
    - Herring target F=0.16 (preliminary single species F_{MSY} as estimated by ICES)
    - Sprat target F=0.35 (preliminary single species F_{MSY} as estimated by ICES)
2. Multispecies (deterministic) F_{MSY} proxies as identified in section 10.1.1.1
    - Cod target F=0.65
    - Herring target F=0.26
    - Sprat target F=0.46
3. As 3) TAC constraints applied and lower target F than used in 2).
    - Cod F=0.45 +/-15% constraint
    - Herring F=0.26 +/-15% constraint
    - Sprat F=0.40 +/-20% constraint

The scenarios were selected as follows: Scenario 1) mimics the existing management plan for cod and the default ICES approach to MSY management for herring and sprat. Scenario 2) investigates the robustness of the deterministic FMSY proxies to stochastic recruitment and to uncertainties in the assessment. Scenario 3) adds another layer of realism by adding TAC constraints, with levels currently already in use for Eastern Baltic cod and suggested by WKMAMPEL, 2009 for the pelagic stocks. The F-targets chosen for this scenario are slightly lower than the ones applied in scenario 2) as it is often seen that constraining TAC variability can increases variability in SSB this increasing risk. So to give comparable risks the F targets need to be slightly lower to obtain TAC stability. The actual F-values chosen are just a first guess, more work needs to be done. However, it should be noted that small changes in Ftarget within the range selected will give very small changes in mean yield

All the scenarios applied the same basic HCR (see figure below), where the F value is determined from SSB in the beginning of the TAC year. F is zero for SSB below the trigger value T1. For SSB larger than the trigger T2, F is at the target level F; between T1 and T2, F is linearly reduced.



Basic Harvest Control Rule

Likely candidates for the T1 and T2 were estimated from the stock recruitment relations for the three species (Figure 10.1.6). For cod, T1 was set at 50 kt (50% of the S/R breakpoint) and T2 at 150 Kt (150% of the breakpoint, to account for the assessment uncertainty). Bloss for herring is around 400 kt. T1 and T2 were set at 50% and 150% of that value. Sprat has a lower Bloss (~200T) than for herring, but 400 kt was also considered as the lower limit for a "safe" biomass, because recruitment has already decline significantly from the peak when SSB has declined to 400. T1 and T2 for sprat were set at 200 kt and 600 kt following the same logic as for herring.

For the three species the EWG group has set a "Low SSB" which is considered as a lower bound for SSB, for which the stock is not severely impacted. The LS values are set (in an *ad hoc* way) at a value where recruitment is not seriously impaired by low SSB. The actual "Low SSB" should be defined from more objectives than just avoiding impaired recruitment (see Section 10.3 on ecosystem).

The EWG group has chosen to present the results by species for scenario 3 in details and a more limited comparison of the other two scenarios with this one. Figure 10.1.7 presents the results for cod in scenario 3. The cod target F (0.45) is not reached in the start of the projection due to the TAC constraint. When target F is reached the stock is in a steep decline due to recruitments around a long term average and a high cannibalism on the recruits due to the high cod stock. Due to the TAC constraint the HCR does not allow the necessary steep decrease in F appropriate to such situation, and F becomes very high. This lead to a high risk for a SSB below the "Low SSB" limit defined for this species. The example illustrates that the dynamic of a cannibalistic species is different from a species with constant natural mortality (M). With fixed M, a higher SSB does not impair recruitment (except for extreme cases of Ricker S/R) and building up a SSB by use of a TAC constraint might be appropriate. This might not be the case for a cannibalistic species where a high SSB will impair recruitment and future stock size and the resulting decline in stock size is probably much greater than the lower bound in most inter-annual TAC constraints.

The predation mortality and eaten biomass of herring (Figure 10.1.8) follows closely the SSB of cod. Long term yield is around 150 kt, while the biomass eaten by cod is around 100 kt. The probability of SSB below "Low SSB" is lower than 5%.

For sprat (Figure 10.1.9) the overall picture is the same with respect to M2 and eaten biomass as for herring. Yield is approximately 50% higher than the eaten biomass. The probability of SSB below "Low SSB" is lower than 5%.

A comparison of results from the scenarios is presented in Figure 10.1.10-12 for the three species. For cod, the average yield is pretty much the same for the three scenarios, but the TAC constraint scenarios seems to deliver the most variable mean yield. An analysis of the individual trajectories is needed to see if this is also the case at that level, though this is to be expected as the increased variability is due to large stocks suffering from cannibalism and the phenomena will be observed on the individual case too. The risk of having SSB below the “Low SSB” threshold is high for scenario 3 and scenario 2 provides also SSB close to the “Low SSB” limit. Mean recruitment seems however just be impaired marginally by a low SSB, suggesting the lower limit is not inappropriate to avoid reduce recruitment.

Herring yield is considerable lower in scenario 1) compared to scenario 3 due to the low target F on herring in combination with the low F on cod and resulting large predator stock. The effect of the low cod F is also clear seen in the “Eaten biomass” plot where scenario 1) result in a considerably higher biomass devoured. None of the three scenarios result in a high risk with respect to the “Low SSB” limit. Mean yield depends highly on the size and the cod stock, such that a highly variable cod stock results in a highly variable herring yield.

The dynamic of the sprat stock in the three scenarios is very similar to the one for herring. The risk for SS below the “Low SSB” limit is however greater for sprat than for herring given the selected target Fs.

The three presented scenarios are all based on a traditional F based HCR. Due to time restrictions for the delivery of the report it was not possible to carry out move varied scenarios. However, it might be helpful to explore the use of HCRs based on biomass targets, “pruning” when biomass is high; that is to avoid very high stock biomasses (actually densities) for all the three species. Cod growth and condition factor are shown to be closely linked to the local density of cod (Eero et al, 2012) such that a high biomass (concentrated in sub-division 25) reduces growth and increases cannibalism, leading to a lower stock productivity and value of the catch. The analysis presented in this report concerning density dependent growth of clupeid does also show that a high biomass leads to a significantly lower growth of the two species. According to the model results, “pruning” of the stocks number will lead to a compensatory higher growth rate and mean weight at age which largely maintains the biomass. Though these results are dependent on a number of environmental assumptions so need to be tested carefully, the consequences of incorrect assumptions should also be evaluated.

10.1.1.3 Impact on landings by the plan options

The general conclusion from the scenarios presented above is that inclusion of biological interactions reduces the gains (higher landings and stock sizes) of using a lower F compared to models where the natural mortality and growth are assumed constant. When predation is included in the scenarios, the landings weight of cod applying the present target F at 0.3 on cod is pretty much the same as for target Fs in the range 0.4-0.6. The “cost” of a low cod F (and higher stock size) is however a significant loss of herring and sprat yield. The actual loss of yield from the pelagic stocks depends on the actual scenario, however the preliminary scenario results indicate losses up to around 25% for a high biomass cod stock.

The present cod plan operates with a TAC constraint at 15% which in combination with good recruitment in 2006-2008 have led to a relative high cod stock. This cod stock is now concentrated in SD 25 such that the cod density in that area is at a historical high level. Observations of decreasing cod mean weight at age and condition factors in the most recent years clearly show that the present F below target F has a negative effect on both the productivity of the cod stock, and landings quantity and value. Model results do also show that the presently high (and locally concentrated) cod stock will increase cod cannibalism and thereby decrease the survival of recruits and in the end decrease landings. This indicates that the present low F, below the target F, is not beneficial. Moreover, TAC constraint seems to have a detrimental effect, if the recruitment returns to the long term average level. These conclusions might be different if the cod stock was to expand over a wider area of the Baltic. TAC constraints on cod F will give a more variable stock size of cod and thereby a more variable yield of the cod prey, herring and sprat.

To conclude: The present management plan for cod operates with a low target F and a TAC constraint that although it is close to maximising yield of cod itself does not maximise yield from its prey species herring and sprat. Time constraints and lack of specific management objectives in particular do however, hamper specific suggestions for an alternative plan for cod and new plans for herring and sprat.

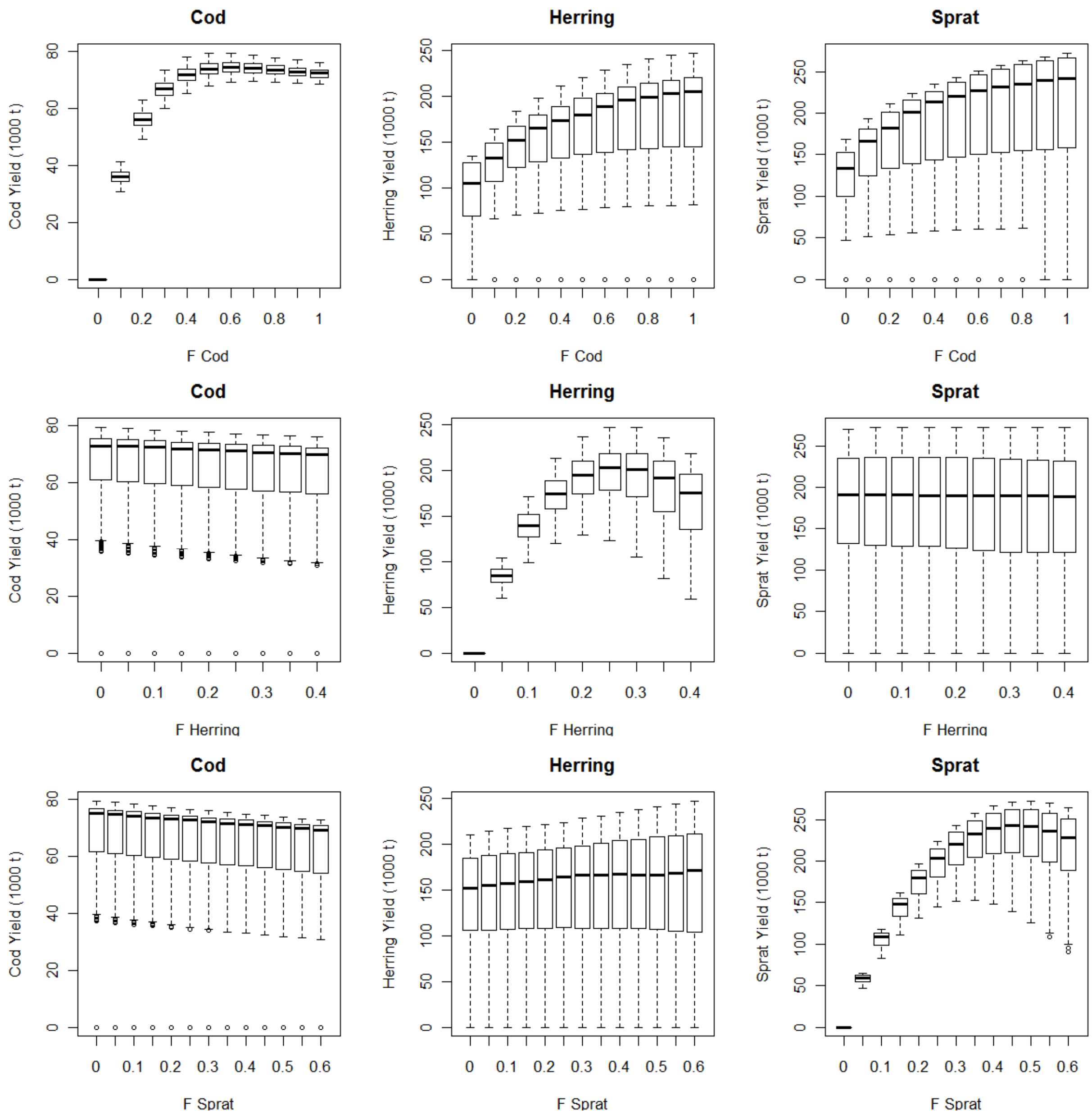


Figure 10.1.1. Equilibrium yield predicted for various levels of fishing mortality for cod (0.0 to 1.0 step 0.10), herring F (00.0 to 0.6 by 0.05) and sprat F (0.0 to 0.6 by 0.05). The boxplot by species shows the distribution of yields for the given F level shown on the X-axis taking into account to the range of F-levels for the other species. E.g. the yield of cod (upper left panel) has a median yield at 70 kt for cod F at 0.4. The variation in yield for F=0.4 is due to the varying F on sprat and herring and thereby the level of available food and related cod-cannibalism which affect the yield of cod.

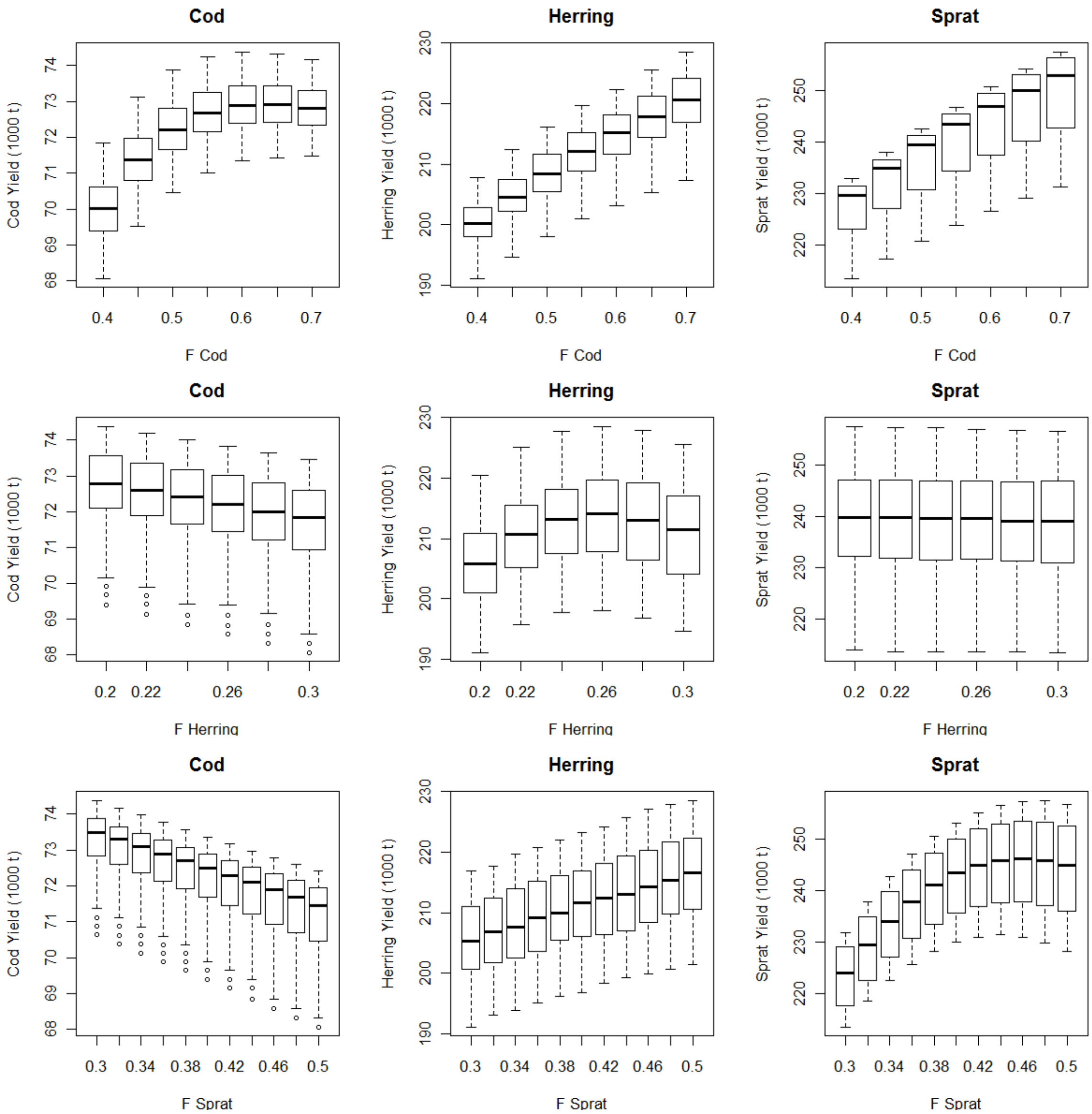


Figure 10.1.2. Equilibrium yield predicted for various levels of fishing mortality for cod (0.4 to 0.7 step 0.05), herring F (0.2 to 0.3 by 0.02) and sprat F (0.3 to 0.5 by 0.02).

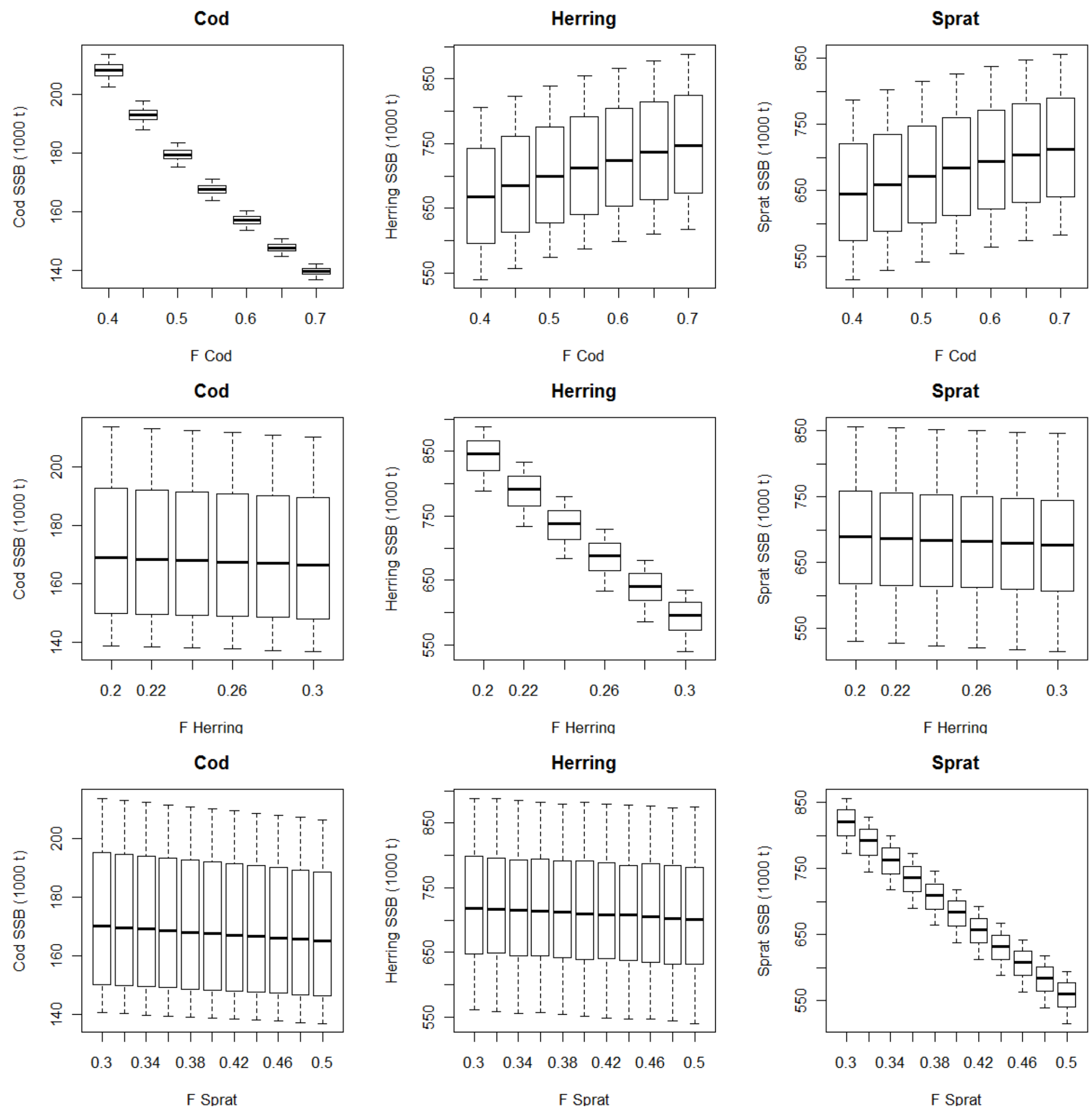


Figure 10.1.3. Equilibrium SSB predicted for various levels of fishing mortality as shown on the X-axes.

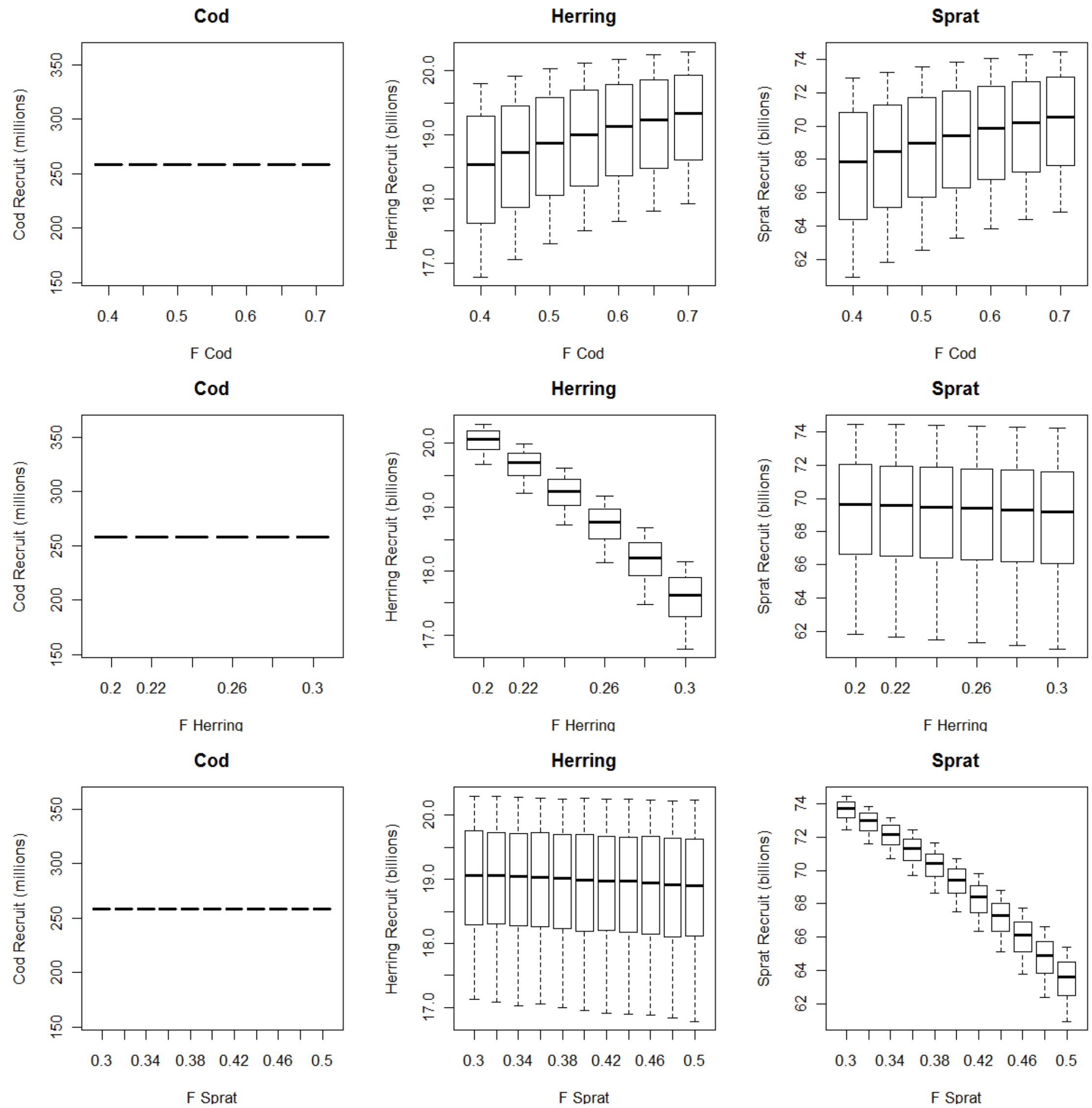


Figure 10.1.4. Equilibrium recruitment predicted for various levels of fishing mortality as shown on the X-axes.

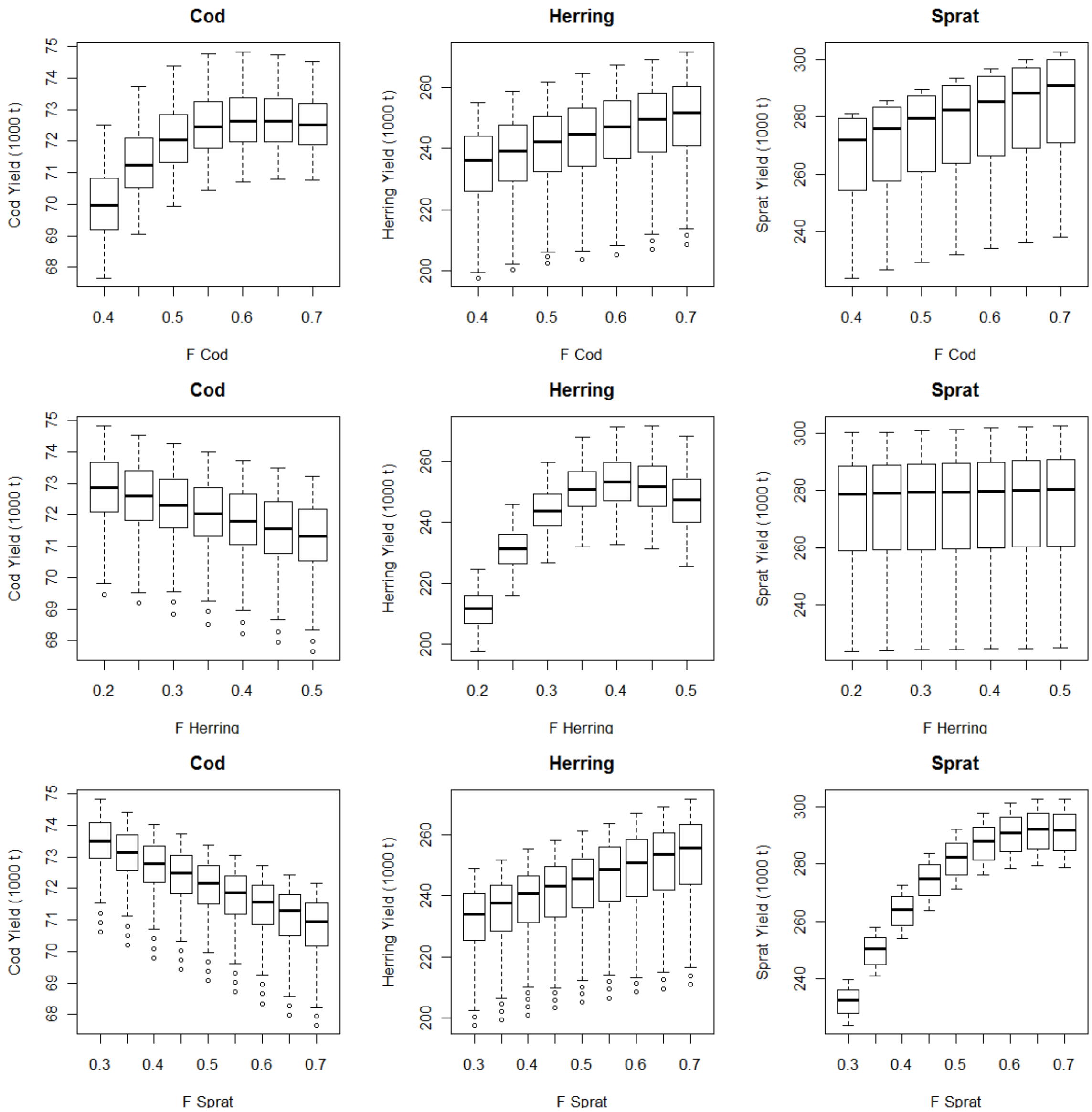


Figure 10.1.5. Equilibrium yield predicted for various levels of fishing mortality as shown on the X-axes. The model includes density dependent growth of Clupeids.

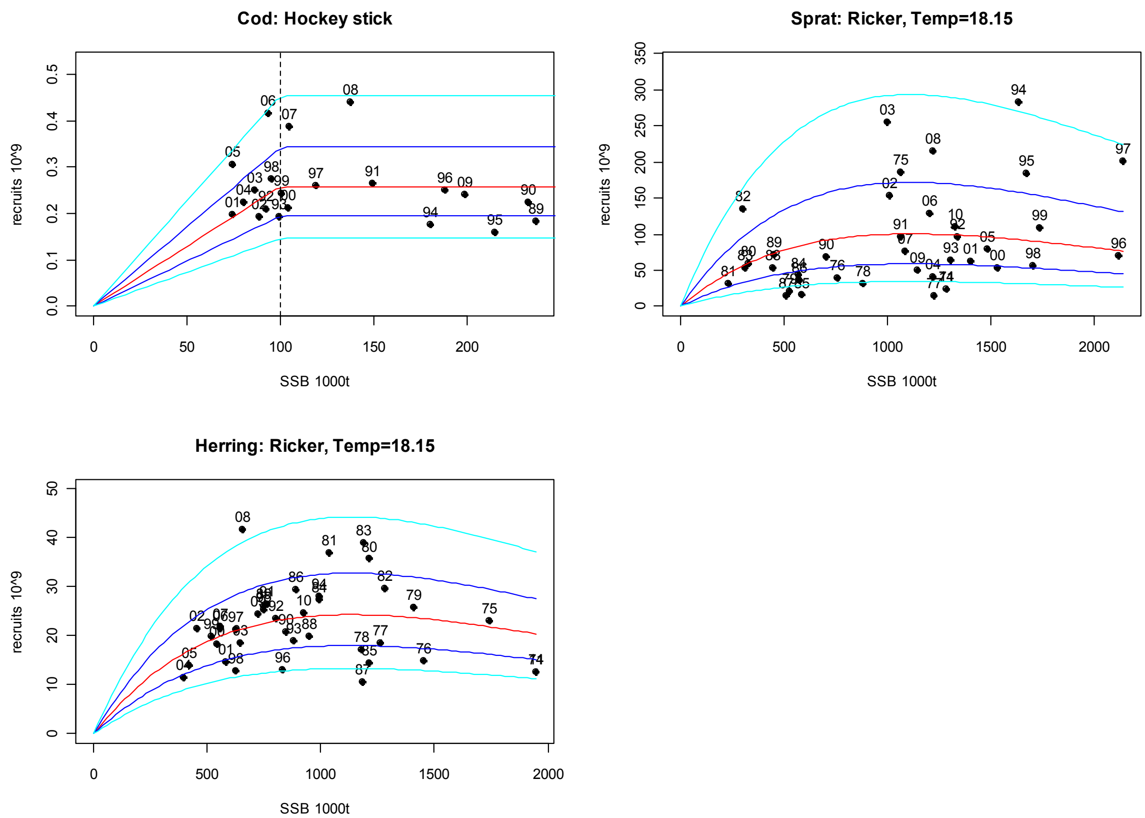


Figure 10.1.6. Stock recruitment relation as estimated by the default one-area SMS configuration. The red line show the median value. The blue lines show the median value +/- 1 and +/-2 standard deviations. For Herring and sprat, where recruitment is related to SST in August, the lines represent a situation with temperature 18.15 degree.

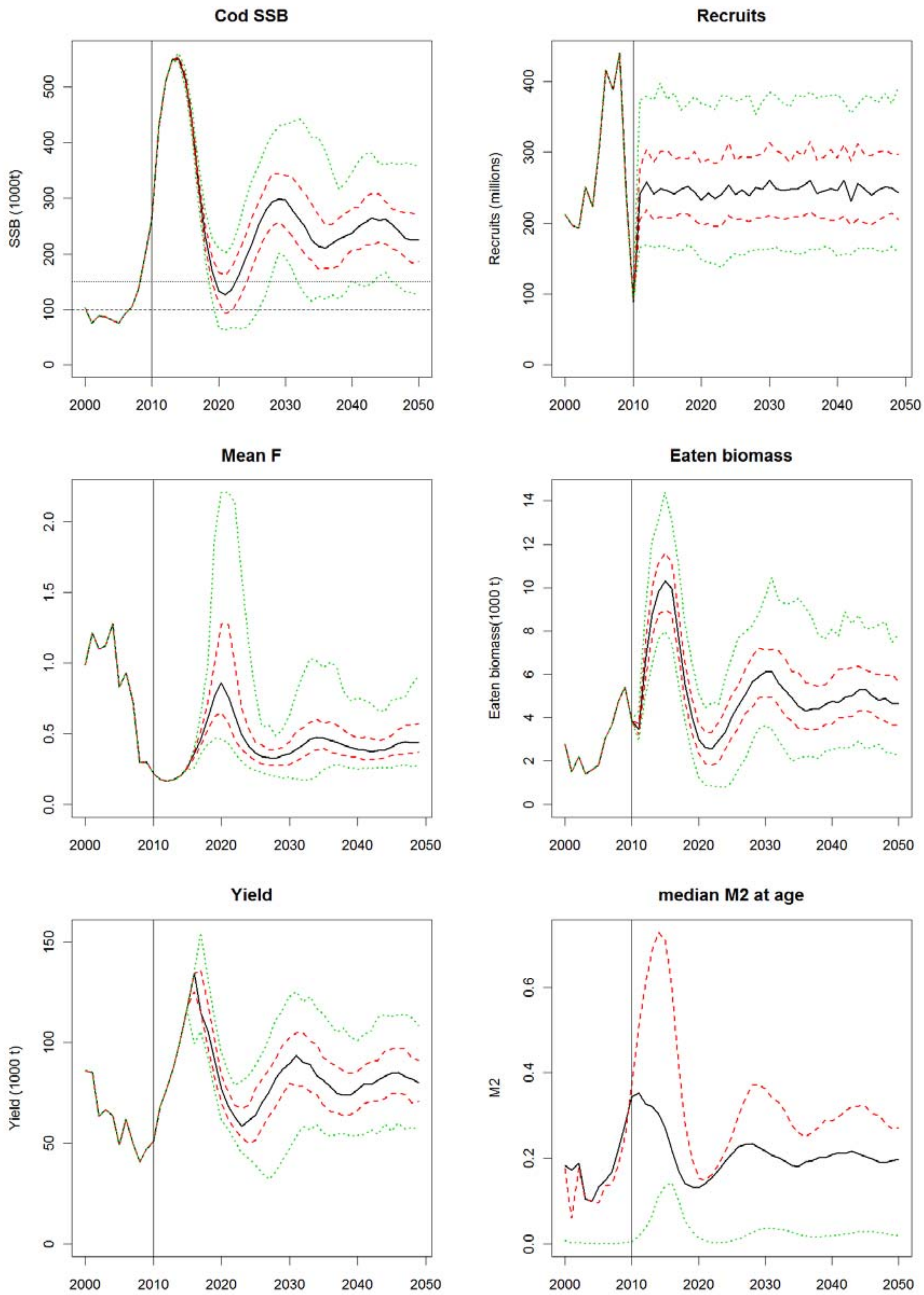


Figure 10.1.7. Scenario 3) results for cod. For all the plots except the "median M2 at age" plot the lines show the 95%, 75%, 50%, 25% and 5% percentiles of the values from 200 iterations. The M2 plot shows M2 by age (age0 (half yearly)=black, age1=red, and age 2=green**).**

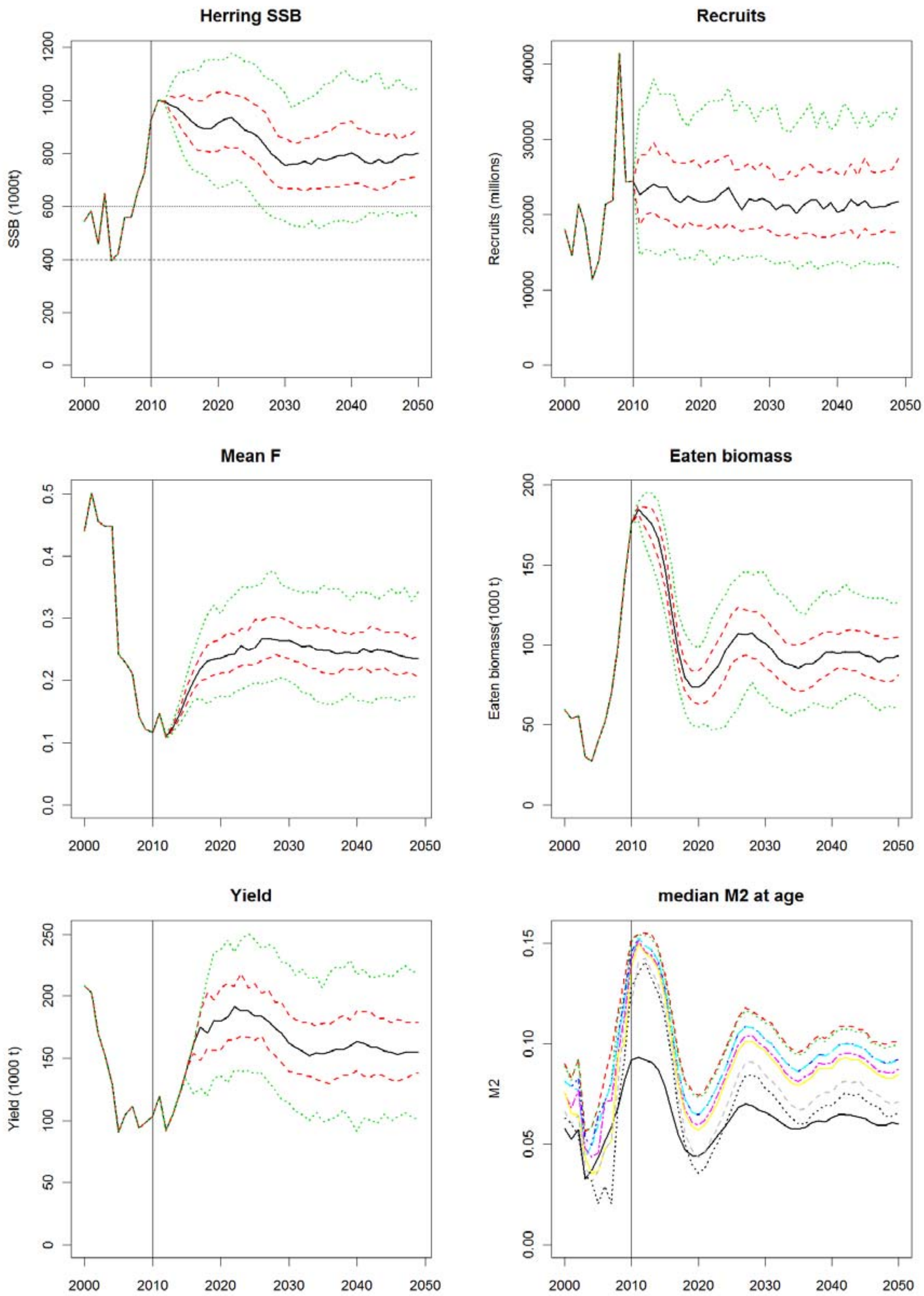


Figure 10.1.8. Scenario 3) results for herring. For all the plots except the "median M2 at age" plot the lines show the 95%, 75%, 50% , 25% and 5% percentiles of the values from 200 iterations. The M2 plot shows M2 by age (age0 (half yearly)=black, age1=red, and age 2=green).

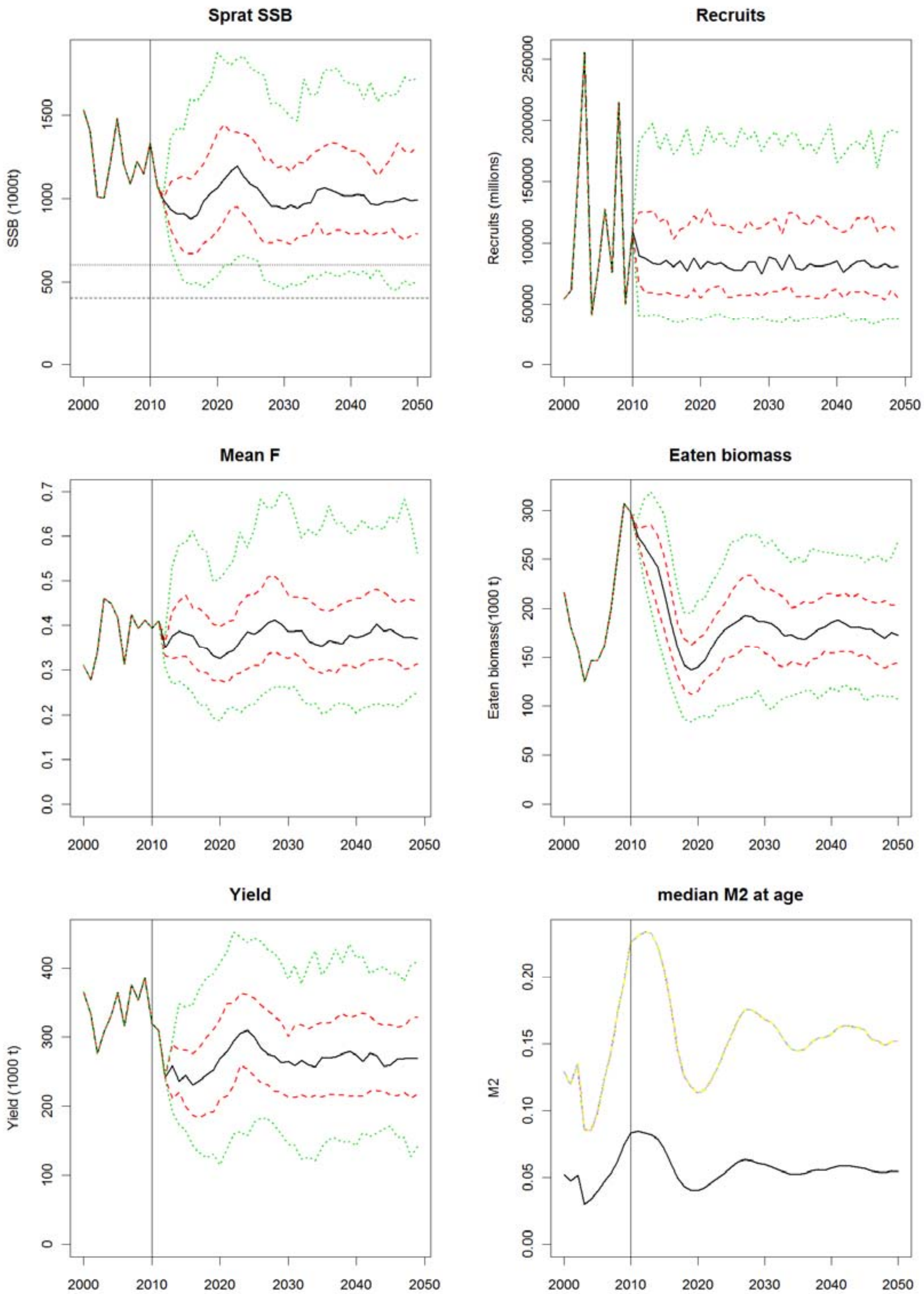


Figure 10.1.9. Scenario 3) results for sprat. For all the plots except the "median M2 at age" plot the lines show the 95%, 75%, 50%, 25% and 5% percentiles of the values from 200 iterations. The M2 plot shows M2 by age (age0=black, age1=red, and age 2=green ….).

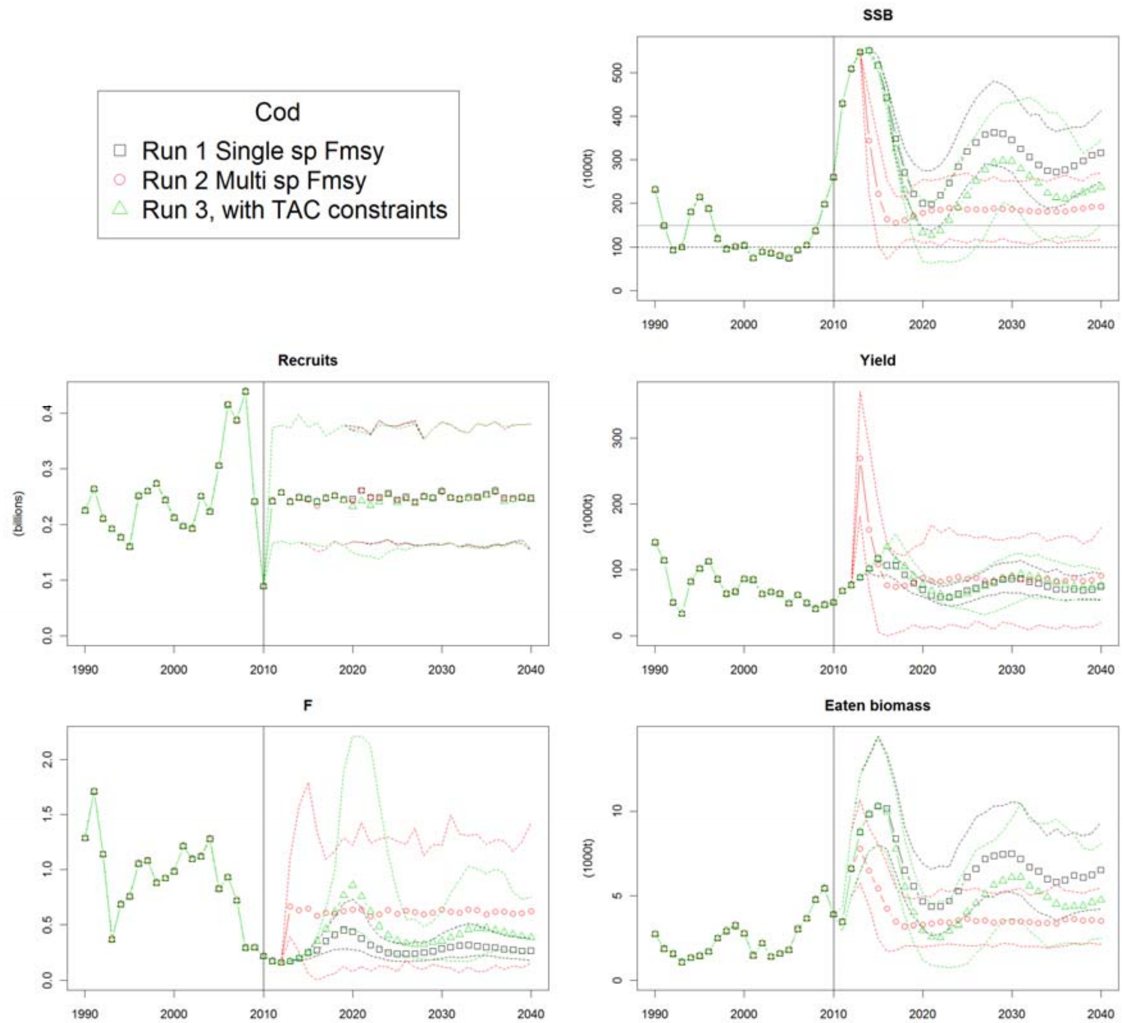


Figure 10.1.10. Cod: Comparison of results for the three example scenarios. For each scenario, the median value and the 5% and 95% percentiles shown. "Eaten biomass" includes just the species presented.

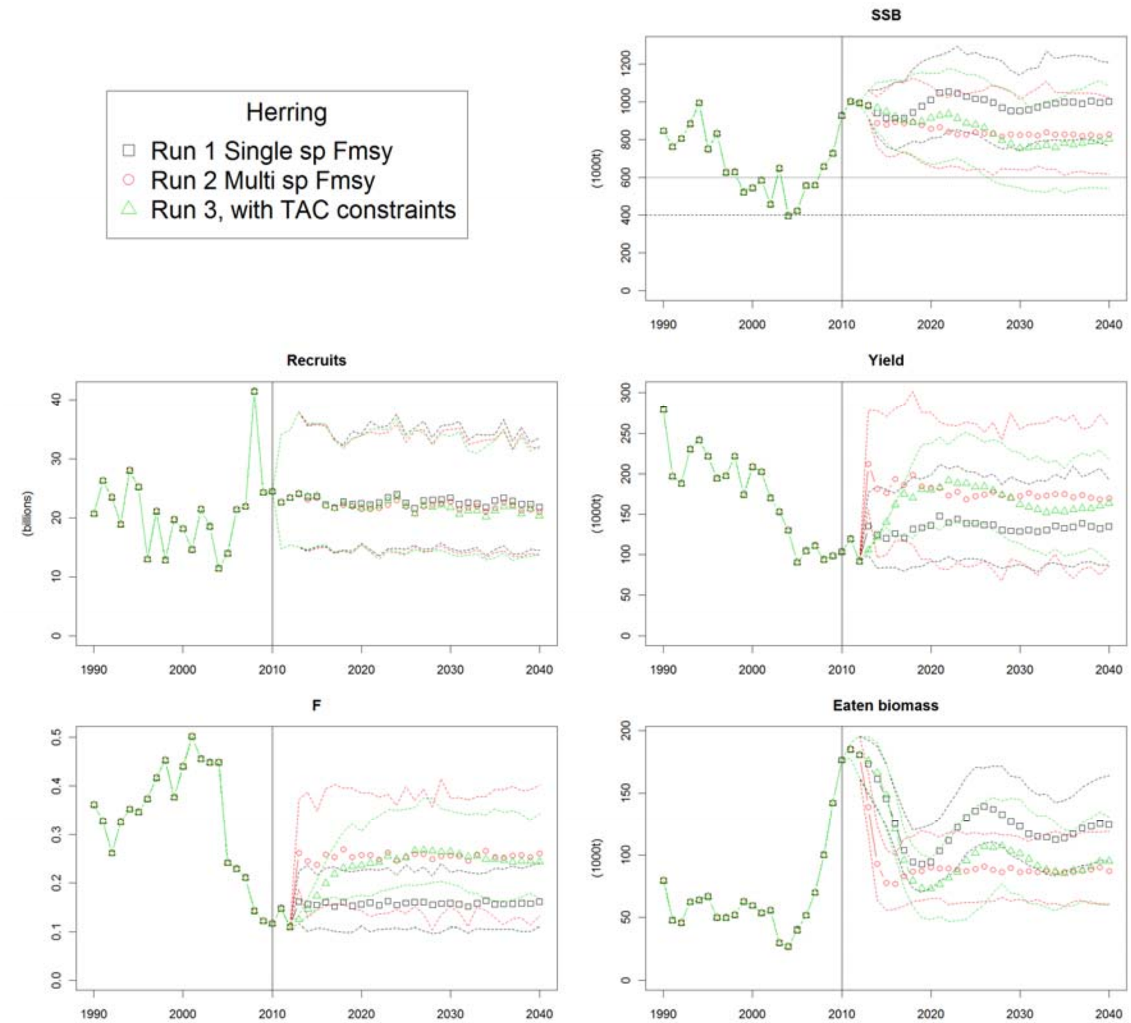


Figure 10.1.11. Herring: Comparison of results for the three example scenarios. For each scenario, the median value and the 5% and 95% percentiles are shown. “Eaten biomass” includes just the species presented.

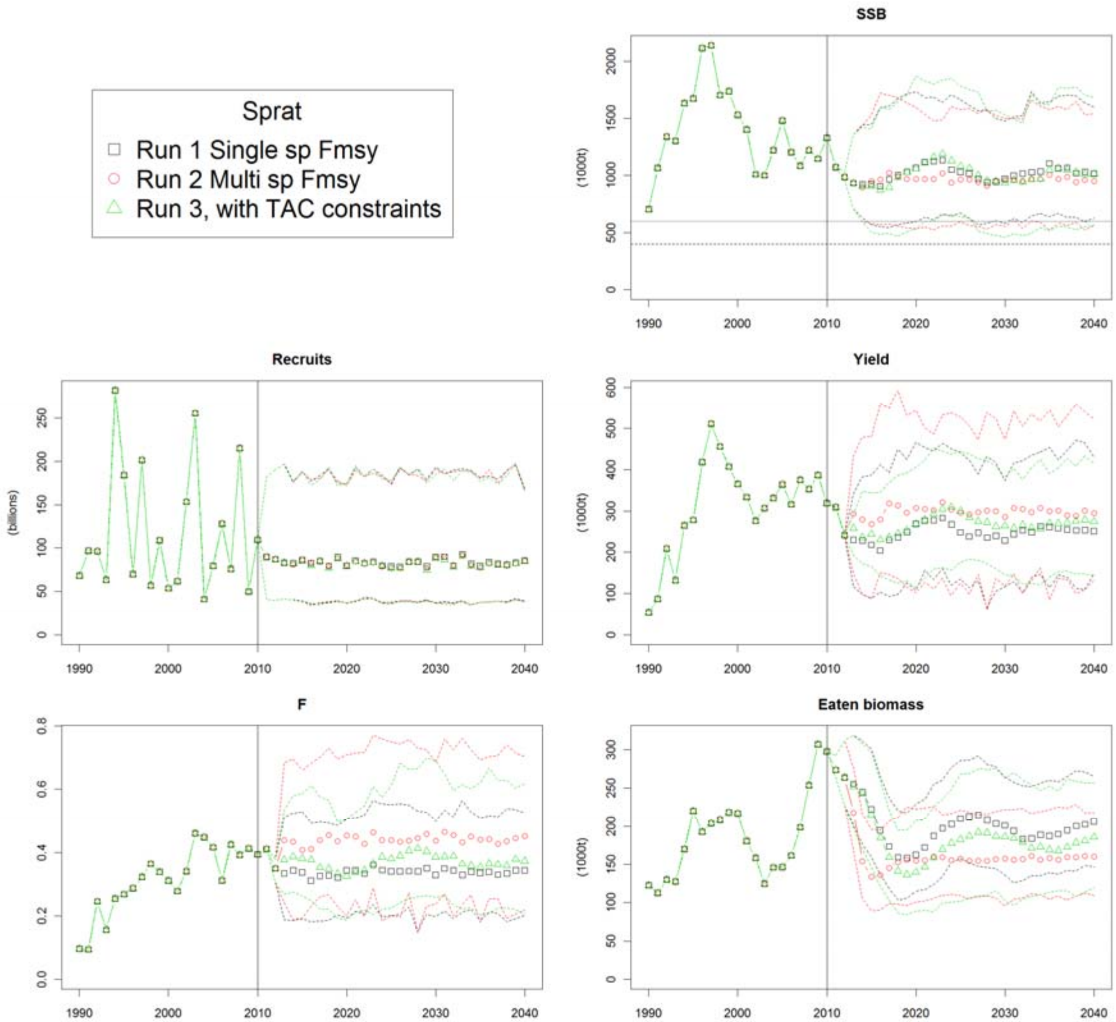


Figure 10.1.12. Sprat: Comparison of results for the three example scenarios. For each scenario, the median value and the 5% and 95% percentiles are shown. “Eaten biomass” includes just the species presented.

10.1.2 Cod, Central Baltic herring and sprat multi area bio-economic simulations

In addition to the SMS model a bioeconomic model (Annex 3) based on similar stock dynamics but using fleet specific exploitation rates and spatial distribution of stock was used. The model assumes recent spatial distribution and catch rates will be observed into the future. This approach allows some estimation of the impact on individual fleets. The biological aspects come from the SCMs model, and the economic aspects of the fishing sector are drawn from economic data from the Annual Economic Report

Figures 10.1.13-15 provides comparisons of landing by species by fleet for the : scenario 1 is in red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 in green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints. The results from bioeconomic model described in Section 10.1.2 are provided by fleet by country and by major gear type for selected fleets a:"den.otter", b:"den.ptrawl", c:"den.static", d:"pol.otter", e:"pol.ptrawl", f:"pol.static", g:"swe.otter", h:"swe.ptrawl", i:"swe.static",j:"lat.otter", k:"lat.ptrawl", l:"lat.static", m:"lit.otter", n:"lit.static", o:"est.ptrawl".

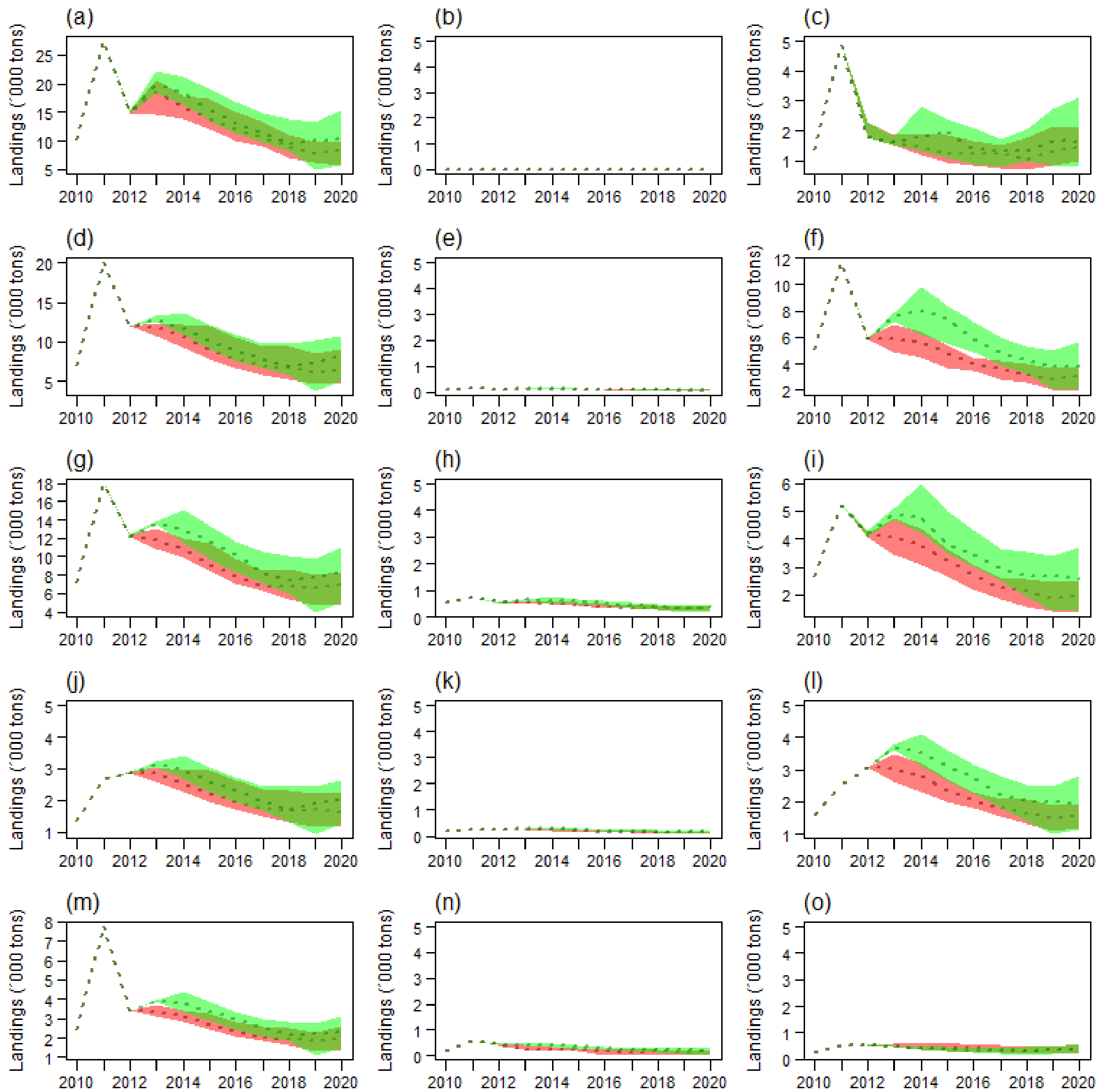


Figure x10.1.13: Landing of cod by fleet for the : scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints for selected fleets :"den.otter", b:"den.ptrawl", c:"den.static", d:"pol.otter", e:"pol.ptrawl", f:"pol.static", g:"swe.otter", h:"swe.ptrawl", i:"swe.static",j:"lat.otter", k:"lat.ptrawl", l:"lat.static", m:"lit.otter", n:"lit.static", o:"est.ptrawl"

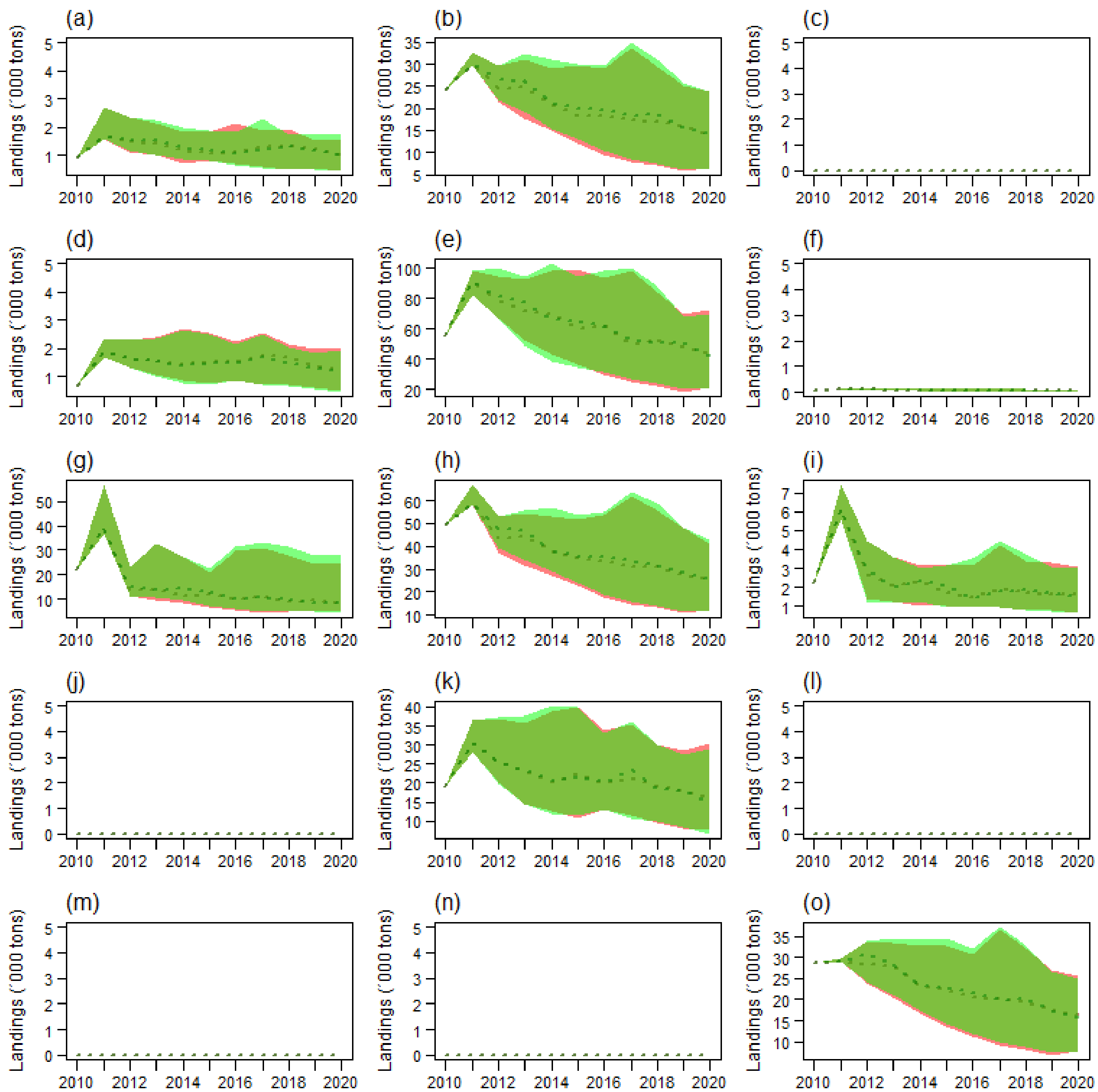


Figure 10.1.14: Landing of sprat by fleet for the : scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints for selected fleets a:"den.otter", b:"den.ptrawl", c:"den.static", d:"pol.otter", e:"pol.ptrawl", f:"pol.static", g:"swe.otter", h:"swe.ptrawl", i:"swe.static",j:"lat.otter", k:"lat.ptrawl", l:"lat.static", m:"lit.otter", n:"lit.static", o:"est.ptrawl"

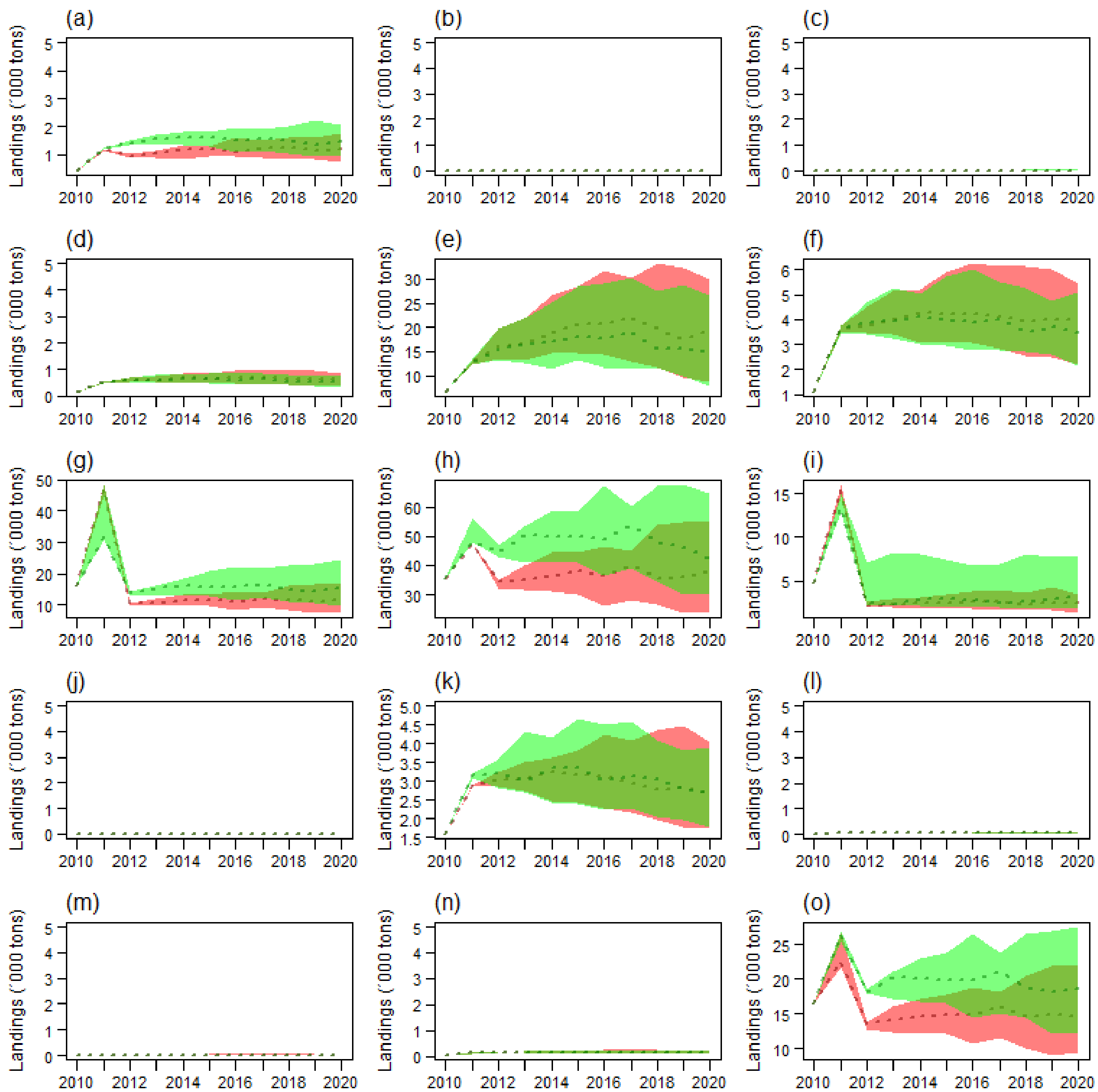


Figure 10.1.15: Landing of herring by fleet for the : scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints for selected fleets a:"den.otter", b:"den.ptrawl", c:"den.static", d:"pol.otter", e:"pol.ptrawl", f:"pol.static", g:"swe.otter", h:"swe.ptrawl", i:"swe.static",j:"lat.otter", k:"lat.ptrawl", l:"lat.static", m:"lit.otter", n:"lit.static", o:"est.ptrawl"

10.1.3 Sprat and herring Btrigger values

The STECF EWG 11 15 requested tests on the robustness of the target fishing mortality (F_{target}) and biomass trigger ($B_{trigger}$) used on the harvest control rule (HCR) of the Baltic pelagic stocks. This section summarizes the work was to test with simulations the robustness of the reference points for use in the HCR of the pelagic stocks' in the Baltic, with regards to their ability to keep the stock above the biomass trigger and exploited at the foreseen level of fishing mortality.

This work used the assessments performed by HAWG 2011 (ICES 2011/ACOM:06) and WGBFAS 2011 (ICES 2011/ACOM:10) for Baltic sprat, Bothnian Sea herring, Gulf of Riga herring, Central Baltic herring and Western Baltic spring spawning herring. The assessment results were taken as a starting point for state of stock and biological characteristics (weights and maturities) . The stock-recruitment (S/R) model used conformed to the decisions made by WKMAMPEL 2009 (ICES/ACOM:38) about using a segmented regression with pre specified break point values. Recruitment above the break point was taken as the geometric mean over the time series (see Annex 2a).

Details on the stock simulation are given in Annex 2a The harvest control rule (HCR) applied is described below. Considering the objective of the work, only one HCR was tested with distinct parameters.

$F_{y+1} = F_{target}$ if $SSB_{y+1} > B_{trigger}$

$F_{y+1} = F_{target} SSB_{y+1} B^{-1}_{trigger}$ if $SSB_{y+1} < B_{trigger}$

Scenarios were defined based on distinct values of $B_{trigger}$, F_{target}, implementation error and variability on [F] and [N]. The scenarios are described below for each stock.

Simulations scenarios				
Stock	**F_{target}**	**$B_{trigger}$ (1000 t)**	**F and N CV**	**Impl. Error**
Baltic Sprat	0.3, 0.35, 0.4, 0.42, 0.43, 0.44	0, 400, 600, 800	0.1, 0.2, 0.3	1, 1.05, 1.1, 1.2
BS Herring	0.14, 0.16, 0.19, 0.21	0, 100, 200, 250, 300, 400	0.1, 0.2, 0.3	1, 1.05, 1.1, 1.2
CB Herring	0.15, 0.16, 0.20, 0.25	0, 500, 700, 900, 1100, 1300	0.1, 0.2, 0.3	1, 1.05, 1.1, 1.2
GoR Herring	0.20, 0.25, 0.30, 0.35, 0.40	0, 50, 60, 70, 80	0.1, 0.2, 0.3	1, 1.05, 1.1, 1.2
WBSS Herring	0.20, 0.25, 0.30, 0.35, 0.40	0, 100, 120, 140, 160, 180, 200	0.1, 0.2, 0.3	1, 1.05, 1.1, 1.2

The same simulations were run using other S/R relationships, Ricker and Beverton and Holt. A preliminary analysis showed the results to be similar to the Segmented regression S/R.
Details on the results are given in Annex 2a and Annex 2b/Table 1-5.

Most of the differences are concerned with selecting Btrigger values that keep the stock above Blim/Bloss and deliver the desired F exploitation. Given a seleted F then recruitment is maximised if the stock is kept above Blim. The results in terms of the probability of Dropping below Btrigger or Blim/Bloss are discussed in section 10.2.3

10.2 Evaluation of the effects of the options on the stocks

10.2.1 Cod, Central Baltic herring and sprat combined area biological simulations

The results of exploitation following the three HCRs described in section 10.1.1. Changes in stock are best seen in Figures 10.1.10 -13. For cod (Figure 10.1.10.)SSB rises until 2013 for all scenarios, and then declines, If a TAC constrain is included the decline is slower, but if combined with a higher F (scenario 3) deeper. If F is increased quickly (scenario 2) the stock declines due to the fishery. For all scenarios the model indicates that predation will cause the stock to decline anyway by 2020, though the level to which it declines depends on the F. The probability of cod SSB declining below the biomass reference points depends on the target F and the TAC constraint. Generally higher Fs and more constrained TACs carry higher risks. The real risks are higher than those illustrated as the models do not contain structural uncertainty in S-R relationships or predation.

The predation mortality and eaten biomass of herring (Figure 10.1.8) follows closely the SSB of cod. For all three scenarios (Figure 10.1.11) the probability of SSB below “Low SSB” is lower than 5%.

For sprat (Figure 10.1.9) the overall picture is the same with respect to M2 and eaten biomass as for herring. For all three scenarios (Figure 10.1.12) the probability of SSB below “Low SSB” is lower than 5%, though they are greater than those for herring because of the higher Fs.

10.2.2 Cod, Central Baltic herring and sprat multi area bio-economic simulations

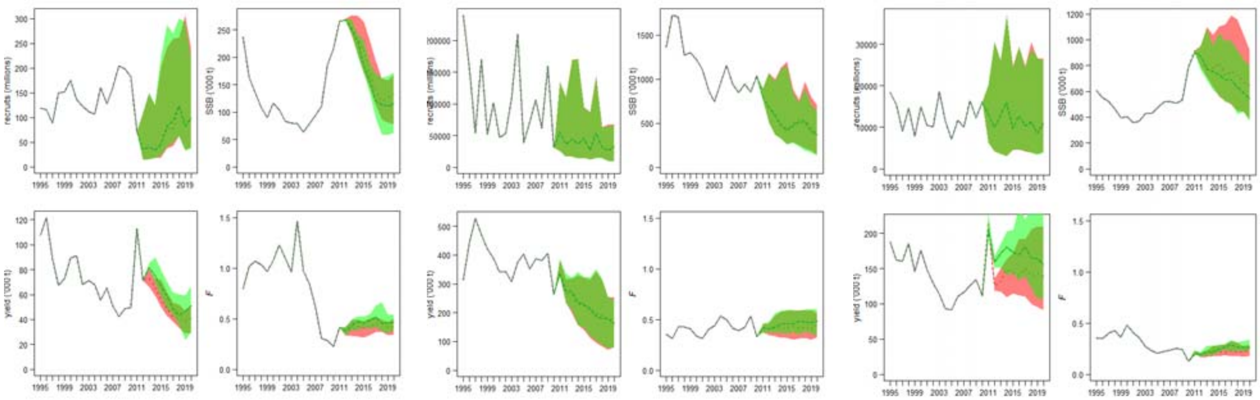


Figure 10.2.1: Single species MSY scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints for selected fleets - Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment (age 2, 1 and 1 for cod, spr and her, resp.), top-right: SSB, bottom-left: Yield, bottom-right: species specific Fbar). 15 stochastic stocks have been simulated where the solid line gives the median trajectory and the dashed line the 5 and 95% percentiles.

The change of target from single-species FMSY to multi-species FMSY has only a limited effect on the simulation trajectories in the present model settings. At a constant target, TACs are lower and lower likely because of change in the exploitation pattern (e.g. for cod, less age 2 available due to predation and cannibalism interaction) that affects the short-term forecast. TACs decided by the management procedure are slightly higher than in the baseline situation according to the higher F targets, but even if the TAC is fully taken, the fixed spatial effort allocation makes no possible displacement toward area with bigger catches in size. Therefore the overall exploitation pattern is only affected by the underlying change in relative abundance per age.

Plots of the probability of biomass being below Biomass reference points by stock are given in Figures 10.2.2, the probability of being above or below single and multispecies Fmsy targets are given in Figure

10.2.3.

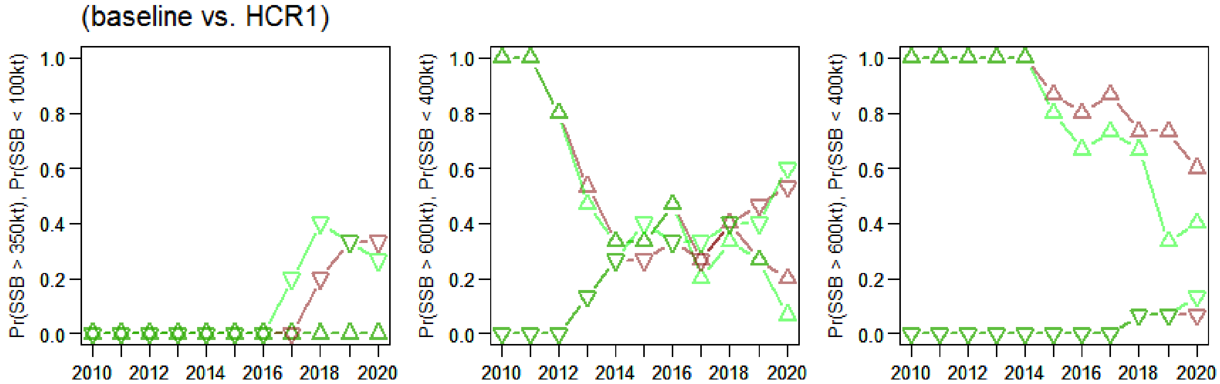


Figure 10.2.2: Probability plots of spawning stock biomass SSB being below (triangle) or above (triangle) biomass reference points for 2 by 2 comparisons for scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints for cod, sprat and herring (from left to right).

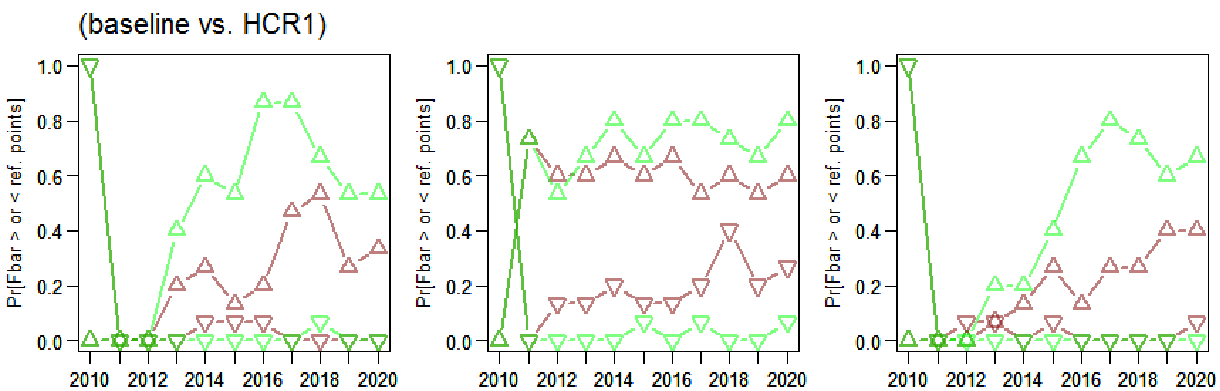


Figure 10.2.3: Probability plots of fishing mortality Fbar being below (lower triangle, single FMSY) or above (upper triangle, multi-species FMSY) F reference points for 2 by 2 comparisons (baseline SMS in green vs. baseline SMS + HCR1 in red) for cod, sprat and herring (from left to right).

10.2.3 Sprat and herring Btrigger values

The HCR tests described in Section 10.1.3 showed that if the exploitation objective drives SSB below $B_{trigger}$ management is not robust if the selected Btrigger mismatches with the stock's productivity. In such case the HCR is not able to bring the stock above its level. A safe mechanism is to choose a higher $B_{trigger}$ so that it controls fishing mortality at higher biomass, resulting in an effective fishing mortality below the target. The approach taken here was to choose values of $B_{trigger}$ and F_{target} that give high probability of meeting the objectives, by looking for pairs that resulted in low probabilities of having F above the target and SSB below the trigger, simultaneously. Another mechanism is to increase the slope of the HCR so that the decrease in F is sufficient to bring SSB above $B_{trigger}$ (see section 10.1.1). The results of these analyses based on single species exploitation modeling are given below by stock.

Baltic sprat results show that a F_{target} of 0.35 and $B_{trigger}$ of 600 000 t have a high probability of achieving the objectives without jeopardizing the sustainability of the stock and maintaining SSB away from the region of impaired recruitment.

Bothnian Sea herring doesn't show a clear pair of HCR parameters that have a high probability of meeting the objectives. The problem comes from the dynamics of the stock that don't seem very consistent. The break point of the S/R looks too high and all exploitation levels tested drive the stock to the slope of the curve (see Annex 2a). In that sense only a very high $B_{trigger}$ (~400 000 t) brings the SSB to levels above the break point but at costs of driving fishing mortality to levels ~0.12.

For **Central Baltic herring** all pairs of values presented in the table (Annex Xb/Table 3) guarantee that SSB will stay above the break point of the S/R. The most consistent parameters are F_{target} of 0.16 and $B_{trigger}$ of 900 000 t. These values are robust to 20% over-catch regarding keeping the SSB above the area of impaired recruitment.

The **Gulf of Riga herring** results show (Annex Xb/Table 4) that a F_{target} of 0.35 may not be consistent with the stock dynamics once that it drives the SSB to levels very close to the S/R break point. Our simulations show that values of exploitation above 0.3 can produce SSB levels below the lowest observed historical value. Pushing $B_{trigger}$ to values above 60 000 t, in order to keep SSB away from the break point, lower F at levels ~0.3 should be selected. With an F_{target} of 0.3 $B_{trigger}$ should be at least 70 000 t to avoid SSB dropping close to 60 000 t. This combination of parameters shows a good match between the objectives and the realized F and SSB, in our simulations (see Annex 2a).

The **Western Baltic spring spawning herring** shows a wide range of values that can be used for the HCR. The projections show that for a range of values of F between 0.2 and 0.35, SSB has values between 350 000 t and 190 000 t, while cumulative catches range between 1 400 000t and 1 700 000t for a period of 19 years. None of these exploitation values drives the stock to regions of impaired recruitment.

10.3 Evaluation of the effects of the multi-annual plan on the ecosystem.

10.3.1 General ecosystem effects

A general observation made by the group was that no matter what Fmsy target is for the different species, it is the change in SSB that will have consequences on the other species in a multispecies context, and on the whole ecosystem.

A plan with higher cod F would decrease cod SSB, increasing the SSB of both herring and sprat, especially sprat. This would increase the inter- and intra-specific competition among clupeids reducing their body growth and condition (Casini et al. 2006, 2010). High biomasses of planktivorous fishes (especially sprat) would, via grazing, decrease the zooplankton biomass increasing the risk of algal blooms and therefore eutrophication symptoms (Casini et al. 2008, Möllmann et al. 2008). Recent studies have also shown a close link between the M74 syndrome in Baltic salmon and the amount of sprat in their diet, which increases when sprat stock size is high (Mikkonen et al. 2011, Keinänen et al. 2012). Therefore, a plan with higher cod F, decreasing cod SSB, would have negative consequences on several fish physiological processes and other components of the ecosystem.

On the other hand, a plan with lower cod F will likely produce an inverse chain of cascading effects on the Baltic ecosystems, with lower clupeid biomass (especially sprat), higher clupeid growth rates and condition, higher zooplankton biomass, and lower risk for intense algal blooms.

A plan with higher sprat F will likely have the same consequences of a plan with lower cod F. Low sprat abundances, however, could have the effect of decreasing the individual growth of cod through food limitation.

Considerations about the spatial distribution of the interacting species is however crucial to envisage the impact of the different plans. During the past 10 years, cod has been mainly concentrated in the southwest Baltic, whereas clupeids in the northeast (Casini et al. 2011). Due to the present clearly non-homogenous distribution of the three stocks in the Baltic, estimation of the trade-offs between species at different exploitation rates should take the overlap between the species into account. The present distribution pattern implies that an increase in F on cod, not necessarily will result in increasing Baltic wide clupeid stock sizes, and conversely a decrease in F on cod will not necessarily result in a decrease of the Baltic clupeid stock size if it will not be accompanied by a cod expansion to northern areas. On the other hand, a reduction of clupeid F in Sub-division 25 will likely improve growth and condition of cod as well as reduce cannibalism. An increase in clupeid F in northern areas (SDs 27-32) will likely not have a negative effect on cod, since this will not affect the stock component distributed in southern areas (SD 25-26). Further, a higher F on clupeids in northern areas would likely reduce density dependence and improve the growth and condition of clupeid stocks (WKMULTBAL 2012).

The Baltic Sea is dominated by the three species considered in our multispecies context, and therefore the effect of different plans on other, non-target species, could be considered minor.

A decrease in cod F, and the consequent increase in SSB and reproductive potential, could enhance discarding practices in the nursery if this will be accompanied by increased recruitment

10.3.2 Changes to other indicators such as MSFD type

The Commission Decision of September 2010 establishes 3 criteria that must be considered in order to assess the current status with respect to GES:

- Criterion 3.1 (level of pressure of fishing activity),
- Criterion 3.2 (reproductive capacity of the stock),
- Criterion 3.3 (population age and size distribution).

The Commission Decision states that achieving or maintaining GES requires that F≤FMSY in Criterion 3.1, whereas for Criterion 3.2 full reproductive capacity corresponds to $SSB \geq SSB_{MSY}$. However, due to possible interactions between species, SSB_{MSY} may not be attained for all stocks simultaneously and further research is needed to address this fact (like Baltic cod-Baltic herring-sprat interactions). The Commission Decision also states that if SSB_{MSY} cannot be reliably estimated, a precautionary biomass value could be used instead.

All the Baltic stocks included in the actual multispecies context (Eastern Baltic cod, Central Baltic herring and Baltic sprat) have currently only fishing mortality reference points. Therefore any stock fished sustainably (F < Fpa or Fmsy) will fulfil the criteria for Good Environmental Status (GES) according to the MSFD Descriptor 3. Biomass and age/size distribution reference points are undefined for these species. Therefore changes in the indicators for full reproductive capacity cannot be evaluated.

The indicators suggested by MSFD Descriptor 4 (Food-webs) may be, on the other hand, related to the temporal development of the stocks' size. A high F on cod would decrease cod biomass, and increase the biomasses of sprat and herring. This would decrease the proportion of big fish in the community and therefore impact the "proportion of large fish" indicator of the MSFD Descriptor 4. The abundance/biomass of ecosystem key species (defined as targeted by the fishery, habitat-defining, tightly linked to other trophic levels) is also a suggested indicator of Descriptor 4. In the Baltic ecosystem, cod, herring and sprat are all key species and their stock development can be used as indicators of food-web structure and functioning.

10.3.3 Uncertainties in ecosystem modelling

<u>Cod cannibalism</u>

Because cod are numerically much less abundant than sprat or herring, the occurrence of an individual cod in the stomach of a cod implies a much higher preference for juvenile cod relative to the occurrence of individual herring or sprat.

Cod cannibalism in the Eastern Baltic Sea has been estimated to be most intense in 1978-1984, a period with high juvenile abundance and large adult stock size. Multispecies modelling predicted about 60% of the 0-group and 30% of the 1-group cod were consumed by adult cod (Neuenfeldt & Köster 2000). Subsequently, cod recruitment and adult stock decreased, and especially sprat, the main fish prey for cod, became significantly more abundant. Estimated predation rates on 0-group cod in the fourth quarter of the year and annually on 1-group cod decreased to 23% and 9%, respectively. No stomach data has been collected since 1993, however, model predictions predict that since 2003, when cod stock size has increased again, predation on the 0-group increased, too. However, predation on the 1-group has increased more slowly, because to consume 1-group cod, the individual adult cod have to grow larger first.

The ICES database on cod stomachs contents contains data from 62 427 cod, collected between 1977 and 1994 and is kept at DTU Aqua. Out of these stomachs, about 250 contained juvenile cod in the length range 5 cm to 35 cm. The database includes data from examination of 11647 individual stomachs which were collected between 1981 and 1994. These stomachs were extracted to do an exploratory analysis on the frequency of cod in cod stomachs (Figure 1). Both freshly ingested and further digested cod occurred in the stomachs, but not simultaneously in one stomach. Out of the 64 stomachs with cod present, the number of digested cod was still identifiable in 29 stomachs. The remaining 35 stomachs contained further digested fragments. From the 29 stomachs with identified number of digested cod, 26 contained 1 cod, 2 contained 2 cod, and 1 contained 3 (very small) cod.

In conclusion, the main sources of uncertainty in the estimation of cod cannibalism are:

(i) Uncertainty in the availability of juvenile cod. Nowadays, cod spawning period is delayed as compared to the late 70s early 80s. Therefore, the overlap between juvenile cod and adult cod might have changed. The earlier period is sampled, however, no stomach samples are available since 1994. It is hence urgently important to collect new stomachs of large cod to update the database on cod cannibalism;

(ii) Uncertainty in the estimated cannibalism. Cod cannibalism is occurring in the stomach samples at very low numbers. Therefore, given the number of stomachs sampled the rates compted have a large uncertainty in the estimated cannibalism rates.

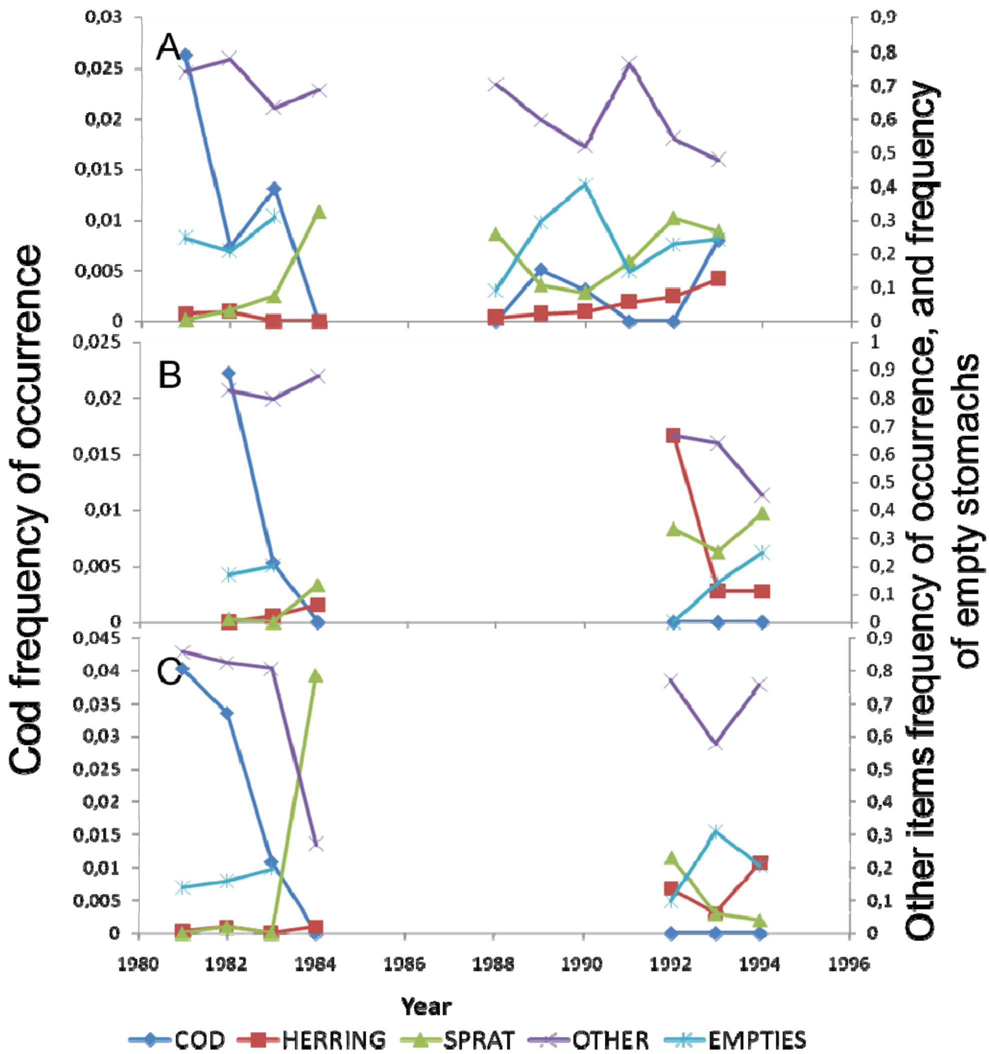


Figure 10.3.1: Frequency of occurrence of cod and other prey items in the stomach database sub-set consisting of individual stomachs. A) ICES Sub-division (SD) 25, B) SD 26, C) SD 28.

<u>Cod growth</u>

Weight at age in eastern Baltic cod increased with decreasing stock size throughout the 1980s, and it continued to decrease throughout the 1990's despite continuously low stock size. This trend continued in the early 2000s. However, the slopes of the growth curves over the whole period fitted to different cohorts did not differ significantly. Starting from about 30 cm total length, the cod diet changes from being almost exclusively based on benthic food to a mixture of benthos and fish, mainly clupeids.

For these reasons, the analysis and modeling of cod growth consisted of two stages: first a model for age 3 weight at age dependent on clupeid availability, and second a model for growth in age groups 3+. The sub-models are still under development, and have not yet been integrated in SMS predictions. It is of note that simultaneously the consumption sub-model has to be changed from constant to weight-specific. Consumption rate depends on predator weight. Predictions of prey-specific consumption rates will hence be biased without coupling dynamic growth to a dynamic consumption rate.

The correct term for clupeid availability has been discussed during WKMULTBAL (ICES 2012). Two trials, one with total number of clupeids and one with total number of clupeids divided by number of age-group 2 cod, have been conducted in advance of the workshop. However, it was decided to try also regressions with clupeid biomass, and sums of age 2 and age 3 cod in the denominator. The latter because it was argued that age 2 cod alone (in clupeids per cod) might not adequately represent the sum of competing cod. Adding the neighboring age-group with similar size fits the observation that cod are most times caught in the vicinity of similar sized conspecifics.

The model fit might be improved by using sub-area specific clupeid and cod abundances, instead of aggregate abundance over the whole Eastern Baltic Sea. This was unfortunately impossible in advance of the workshop. Another shortcoming in the model at its present stage is that weight in the sea actually comes from commercial catch data. Hence, selectivity of the gear has to be taken in to account as well as difference in the usage of specific gears during the different season. It is to expect that accounting for the greater weight at age 2 in the catches as compared to weight in the stock, due to selective fishing of heavier and faster growing age 2 individuals, the intercept will decrease. However, if the bias is constant in the absence of changes in gear selectivity and fishing patterns, the shape of the relation probably remains unaffected.

The growth of age groups 3 to 7 is well describe by von Bertalanffy growth parameters (WKMULTBAL) as can be seen in cohort-based Ford-Walford plots. Deviations from linearity in some years have to be investigated for the effect of differing prey availability to the cod.

The growth pattern of the cod during one year has changed substantially. Cod egg surveys indicated that the change is most probably due to a shift in the cod spawning period.

During the period with relatively early spawning, the cod were able to make up for the weight loss due to spawning in the fourth quarter of the year. On the other hand, when spawning was later in the year, the cod were not able to compensate the weight loss and carried a weight deficit into the next year. However, it is of note that the data are based on commercial catches. The different timing of trawl and gillnet fisheries has not been accounted for, yet.

This weight deficiency tendency is still visible for the spawning age groups in the period 2006 to 2010. Actually, the weight deficiency at the end of the year is, according to the data, to be compensated for during the first quarter of the following year.

In conclusion, variable cod weight has not been included in the model.

<u>Herring and sprat growth</u>

Density-dependence in clupeid body growth was implemented in some SMS runs. The rational for this is that when clupeid abundance/biomass increases, the individual growth of sprat and herring slow down, likely because of food competition (WKMULTBAL 2012). As result, the weight-at-ages of both species are lower. Conversely, in the case of reduced stock size, the clupeids compensate by increasing their individual growth. As density-dependent factor we used the total abundance of clupeids (sprat + herring). Using only sprat abundance as density-dependent factor gave very similar results, but since the statistics were somewhat worse, the total clupeid abundance (sprat + herring) preferred and the resulting formula used was:

w(t+1)=a+b*w(t)+c*Clupeid abundance

where w(t) is the weight-at-age at year t.

According to this formulation the weight-at-age at year (t+1) is an effect of the weight-at-age the previous year and of the total abundance of clupeids. The model uses the mean weight in the previous year to estimate mean weight in the following year. This is a sensible assumption, but as the model parameters are estimated given the (fixed) historical observations of mean weights, the predictive power of estimating growth (and mean weight) might be limited. To test the performance of the model, sprat mean weights were predicted using a fixed mean weight at the youngest age, and the estimated model parameter and SMS estimates of clupeid abundance. The observed and predicted mean weight (Figure 10.3.2) fit quite well showing a good predictive power of the model. A similar result was obtained for herring.

The SMS stock simulation model outputs show that cod Fmsy could be around 0.6. This value is similar to the value estimated by the models were clupeid density-dependence was not included. This is not surprising since sprat and herring do not exercise any feedback effects on the cod. On the other hand, Fmsy for both herring and sprat were much higher than those estimated without density-dependence. For herring the estimated Fmsy is around 0.4, and for sprat higher than 0.65. These may seem very high values but similar values were obtained from by WGBFAS 2011 using deterministic long term-projections, when S-R was fitted only to years of high sprat recruitment (1991 onwards).

WGBFAS concluded that more work is needed to fully understand and validate the results of the estimated density dependent growth. The present EWG fully supports this conclusion; especially it should be evaluated to which extend the results are dependent on a number of environmental changes and not just clupeid abundance. Also, more analyses could be done using only sprat as density-depended factor, because there are indications that sprat abundance affects both herring and sprat growth, whereas herring abundance has not a large effects on clupeid growth rates.

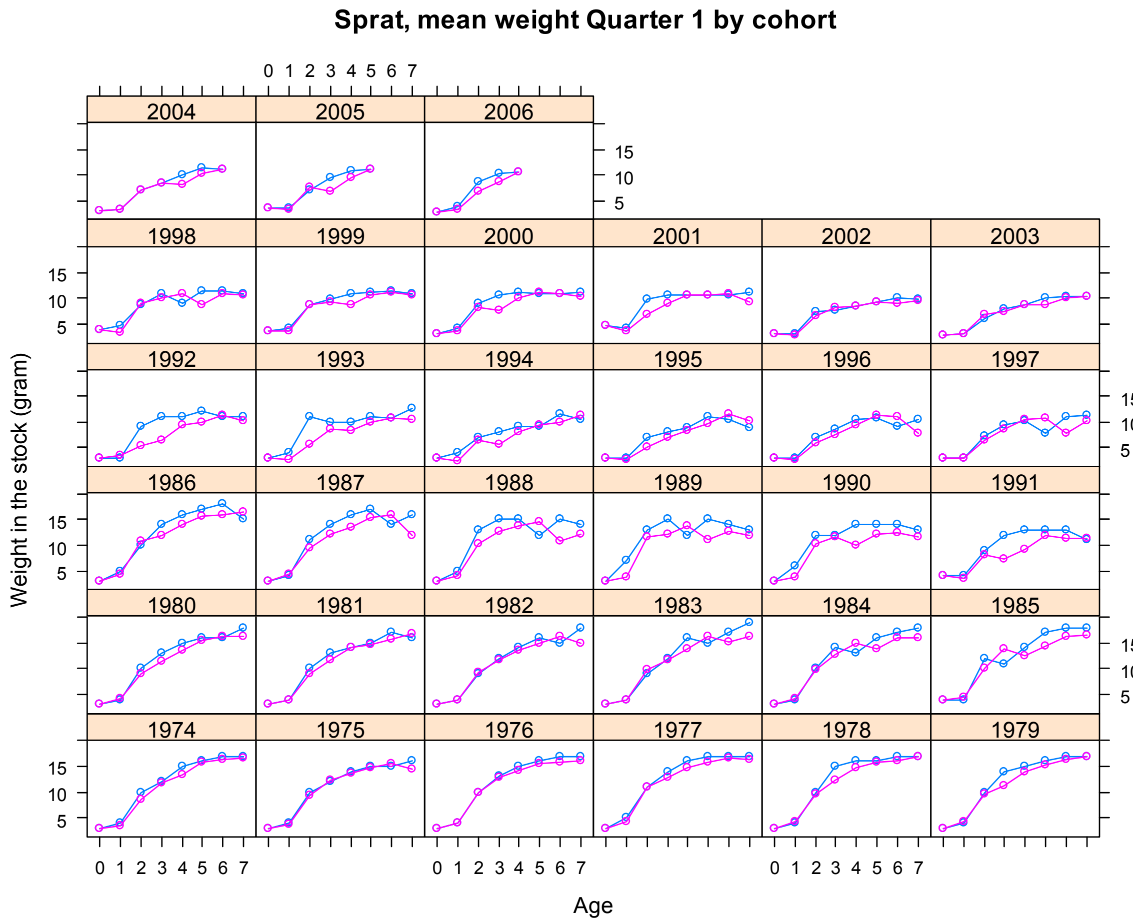


Figure 10.3.2. Observed (blue line) and predicted (red line) mean weight for sprat Quarter 1, by cohort. The predicted values are derived using a fixed mean weight at age 0, Quarter 3, the estimated model parameters and the estimated clupeid abundance.

<u>Predation on cod eggs and competition for food between cod larvae and sprat</u>

It is of note that the change in the timing of spawning might have consequences for predation on cod eggs and larvae, and food competition between cod larvae and mainly sprat might also have changed. Both of the issues necessitate a new sampling program for cod, herring and sprat stomachs. The latest data are from 1994. Currently, predation on cod eggs is not included in the model.

<u>Spatial considerations</u>

Currently, it is assumed in the SMS model that the overlap between cod and clupeids is taken as the mean for the whole area. At present spatial distribution of the stocks, the overlap between cod and clupeids are to a large extent limited to SD 25; with less interaction in SD 26 and almost no overlap between cod and clupeids in the north eastern areas (SD 28-32). In SD 25, there are indications that cod is suffering from food limitation, with a high predation pressure on sprat and herring in this area. In a Baltic wide scale, the impact of cod predation on sprat is limited, as the highest densities of sprat occur in north eastern areas, where cod is rare. Also for herring, the overall predation mortality in SD

25-32 is estimated relatively low. In north eastern areas, the density dependent processes on sprat and herring growth are more pronounced, related to high densities of clupeids in these areas.

In conclusion, due to the present clearly non-homogenous distribution of the three stocks in the Baltic, estimation of the trade-offs between species at different exploitation rates should take the overlap between the species into account (WKMULTBAL 2012). Not taking spatial overlap into account constitutes an extra source of uncertainty.

11 Social and Economic Effects of the Plan

11.1 Economic Data and Indicators

Economic status of fisheries

For the economic assessment of the Baltic Sea fleets economic data were used which was provided by Member States to the Joint Research Centre and analysed in the 2011 Annual Economic Report on the EU Fishing Fleet (STECF EWG 11-16). As it is difficult to attribute costs to specific areas in case of Germany, Sweden and Denmark where fishing activities are executed in North Sea and Baltic Sea, particularly for coarser fleet segmentation under the DCR, therefore only DCF data has been used but this has limited the analysis of the economic performance of Baltic fleets to the period 2008–2009.

During the scoping meeting it was agreed to make economic projections for 2010, using the same approach which been applied during STECF SG-MOS 10-06 and elaborated by STECF EWG 11-18. However, due to lack of time and insufficient data, only existing data has been analysed in this report.

To simplify the analysis and reduce the number of segments, all cluster names been changed in accordance to the first segment name (e.g. Swedish segments DTS-DRB-PMP-PS and DTS-DRB-PS been changed to DTS*). The overall number of fleet segments, operated in 8 Baltic States (Denmark, Germany, Finland, Estonia, Lithuania, Latvia, Poland and Sweden) has been reduced from 84 to 37 using few selection criteria's (volume and/or value of the fish landed in the Baltic Sea had to be more than 1% of total landings done by all fleets). However due to incompleteness of economic data the number of segments been further reduced to 34. The representativeness of selected fleets is presented in Figure 11.1

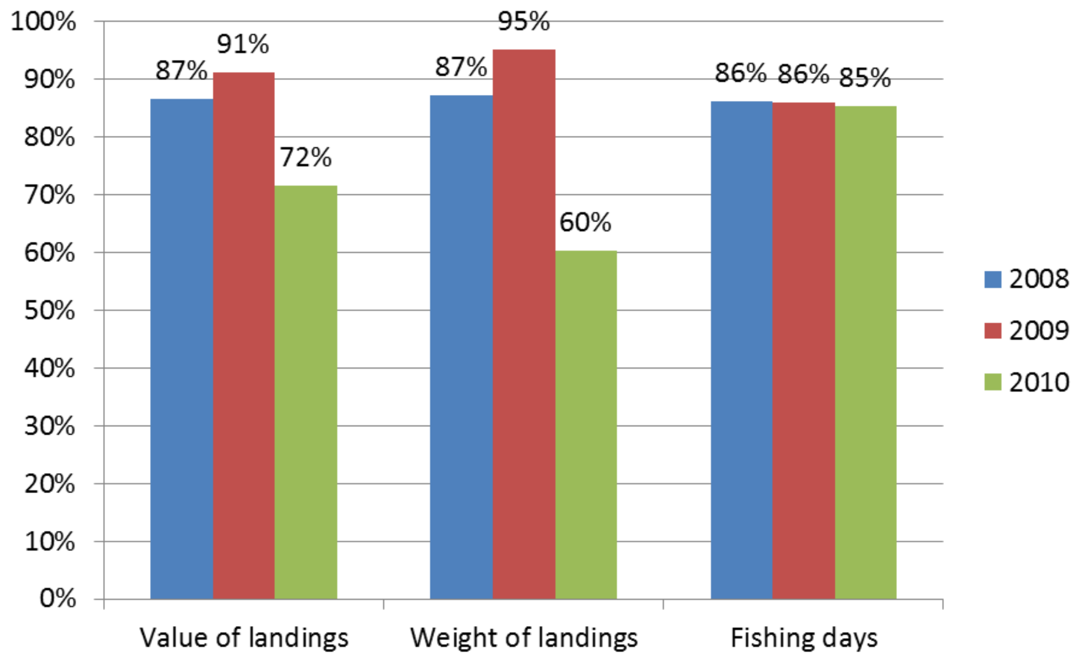


Figure 11.1. The representativeness of selected fleets for economic analysis compared with total Baltic Sea.

Due to the time lag needed to collect, proceed and analyze economic data an analysis of the economic performance of selected fleets for 2010 was not possible. It was possible to make projections, however, available 2010 data on value and weight was not sufficient to make reliable conclusions.

The coverage per species caught in the Baltic Sea by selected fleets varied as well and is presented in Figure 11.2.

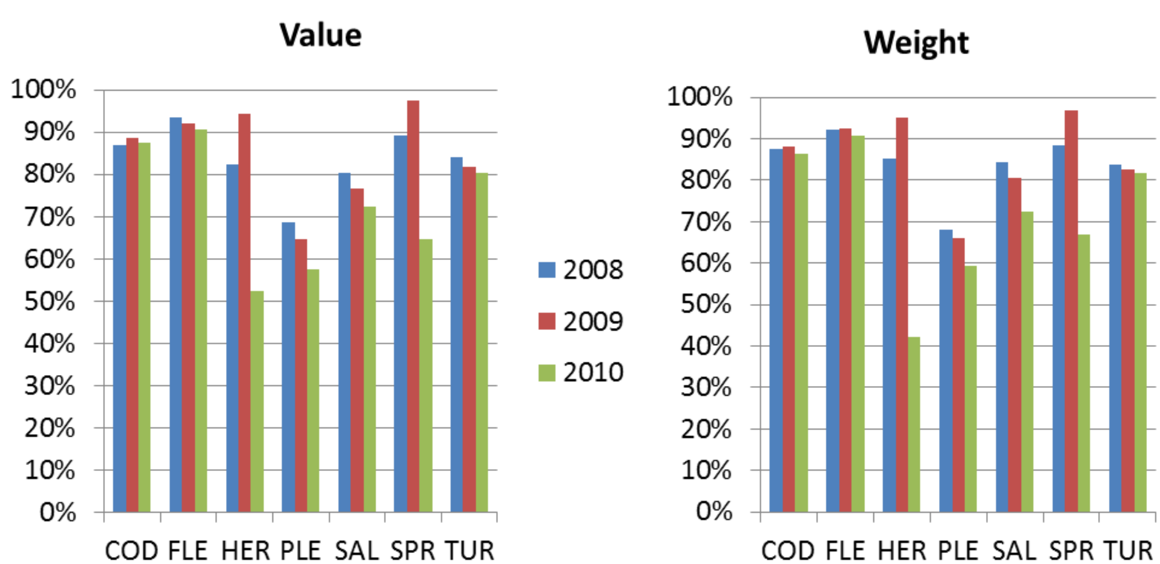


Figure 11.2. The economic analysis coverage per main species landed in the Baltic Sea

There were 16 fleets operating in both Baltic and North Sea (Danish, German and Swedish), selected for the analysis. To compile a pure Baltic Sea region analysis these fleets economic data been disaggregated, using two main disaggregation criteria's:

- *Value of landings* (for crew costs, costs for fishing rights and all income indicators)
- *Effort* (for fuel costs, repair and maintenance costs, depreciation and variable and non variable costs; employment indicators)

Due to disaggregation of these fleets between regions, the economic performance is affected as income indicators were attributed in accordance to the value of landings, while main costs indicators in accordance to effort. Selected fleets spend more fishing days in the Baltic receiving less money (overall effort in the Baltic is more than twice higher then value of landings).

The analysis shows high dependency of drift and fixed netters (DFN) as well as demersal trawlers (DTS) on the cod catches, while coastal fisheries (PG - Polyvalent gears) are more heterogeneous, targeting more diverse and valuable fish species (see Figure 11.3). The pelagic fishery (TM) is mostly targeted sprat and herring; however demersal fish species provide about 10% of value of landings. On the other hand, some demersal fleets are fishing pelagic species presumably during the closure of cod fishing seasons.

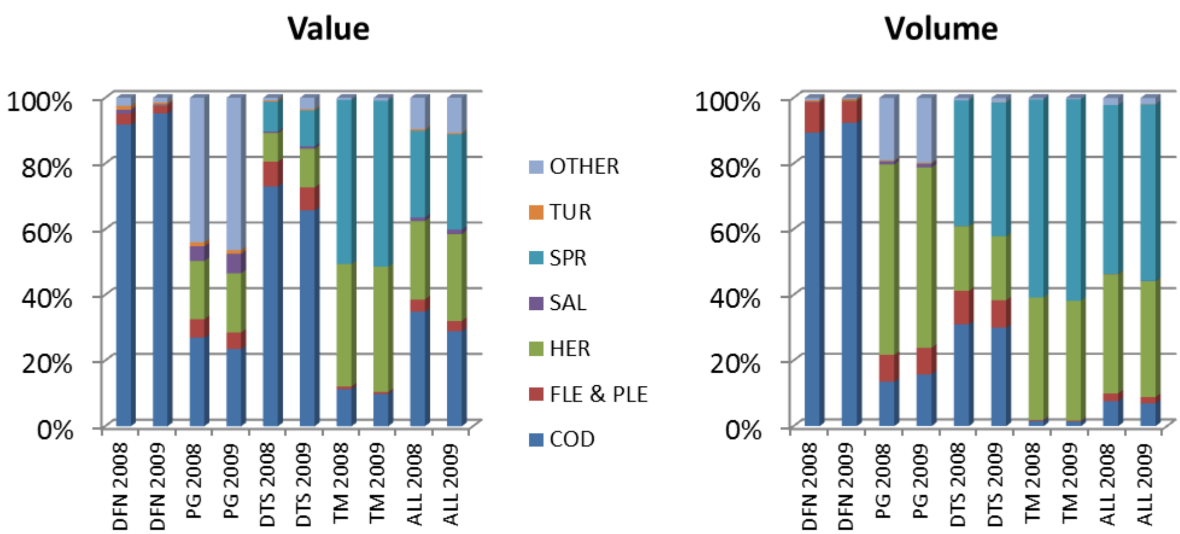


Figure 11.3. The composition of landings by species within selected fleet groups in the economic analysis.

For the analysis of economic performance of the Baltic Sea fleets main economic indicators agreed during STECF EWG 15-11 has been used for the assessment of current economic situation of the Baltic fleets. The results are showing decreased profitability in 2009, which mostly been affected by reduction of prices for most fish species in the Baltic due to the general economic crisis. However trawlers has been less affected due to decrease of fuel prices and other costs indicators.

The Baltic Sea costal fleet (see PG Figure 11.4) is representing about 69% of persons employed as well as 77% of vessels and 24% of kW of the selected fleets. They accounted for more than 50% of economic profit in 2009, while income and gross value added reached about 25% of the selected fleets.

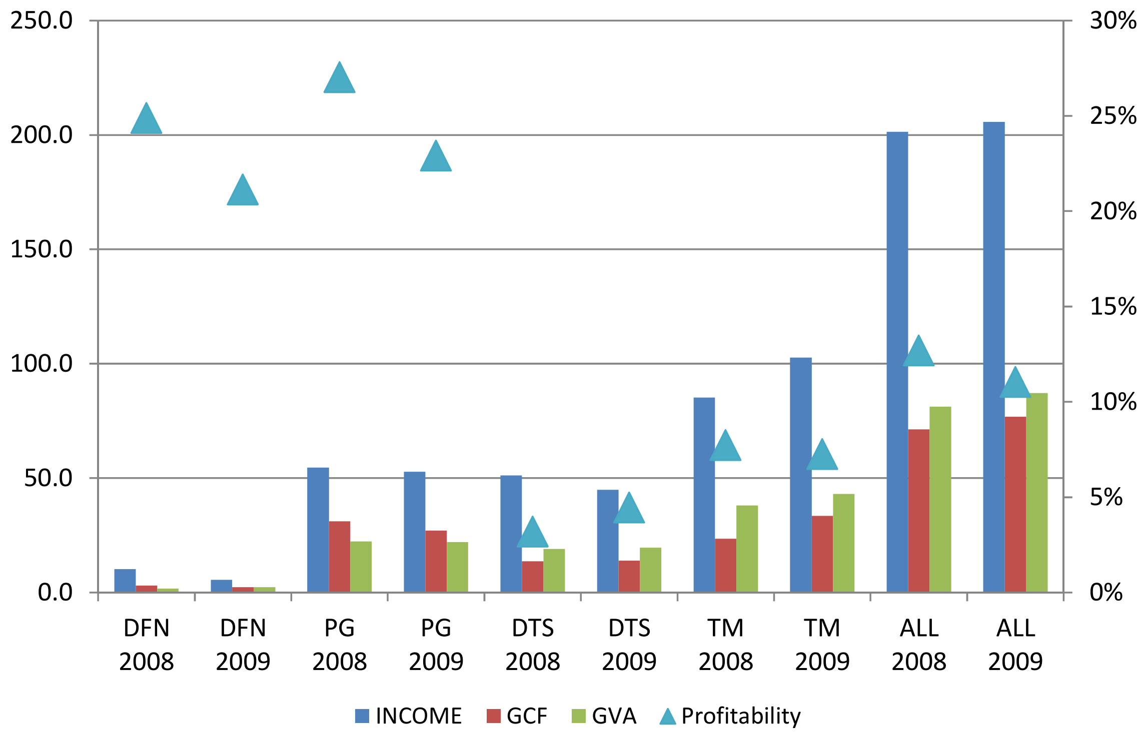


Figure 11.4. Economic performance of selected Baltic Sea fleets.

Evaluation of changes in 2008-2009 (See Figure 11.5) shows an increase of gross value added and gross cash flow overall and in the trawl fishery, the labour productivity (value of landings per FTE) grew as well. However capacity and overall employment in the Baltic Sea fishery decreased. The reduction of capacity through the decommissioning schemes and economic instruments, as individual transferable quotas is observed in most of MS fishing in the Baltic Sea since 2005.

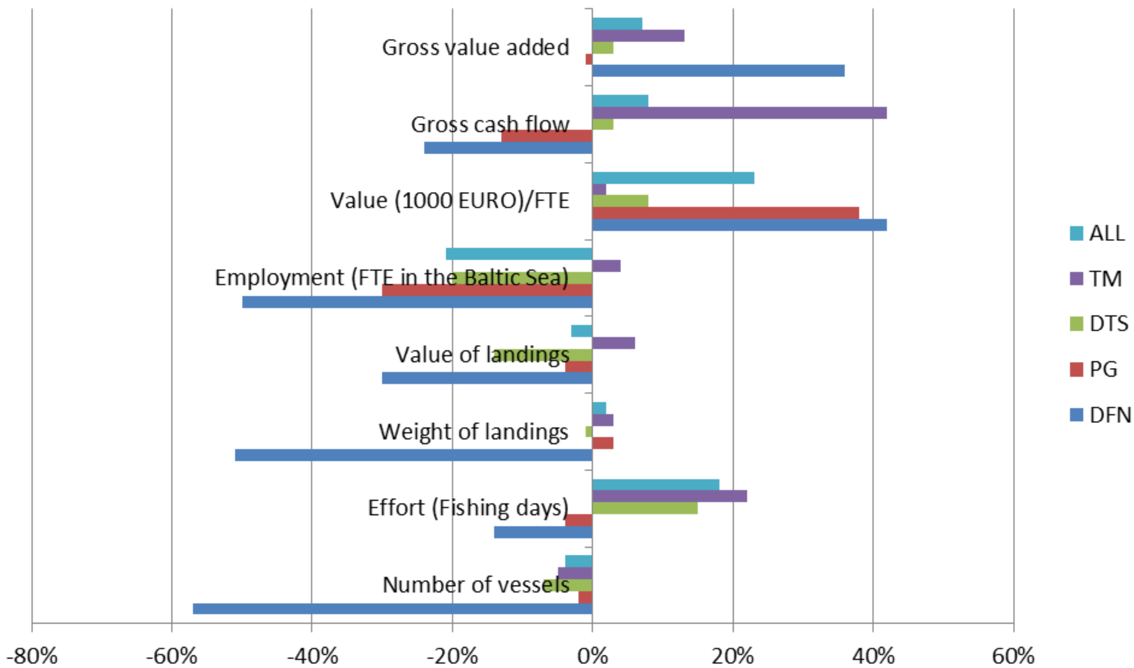


Figure 11.5. Changes in the performance indicators 2009 compared with 2008.

The economic performance of fleets is usually affected more by external factors, like fuel prices and fish prises which are driven mostly by overall price levels and consumption. The changes in fuel prices are likely to affect trawl fishery more than coastal or nets fishery (see Figure 11.6.). The past experience shows a decrease of energy costs in the overall cost structure in 2009, affecting economic profit as well. The overall deterioration of economic situation in 2009 leaded the decrease of crew costs in some segments.

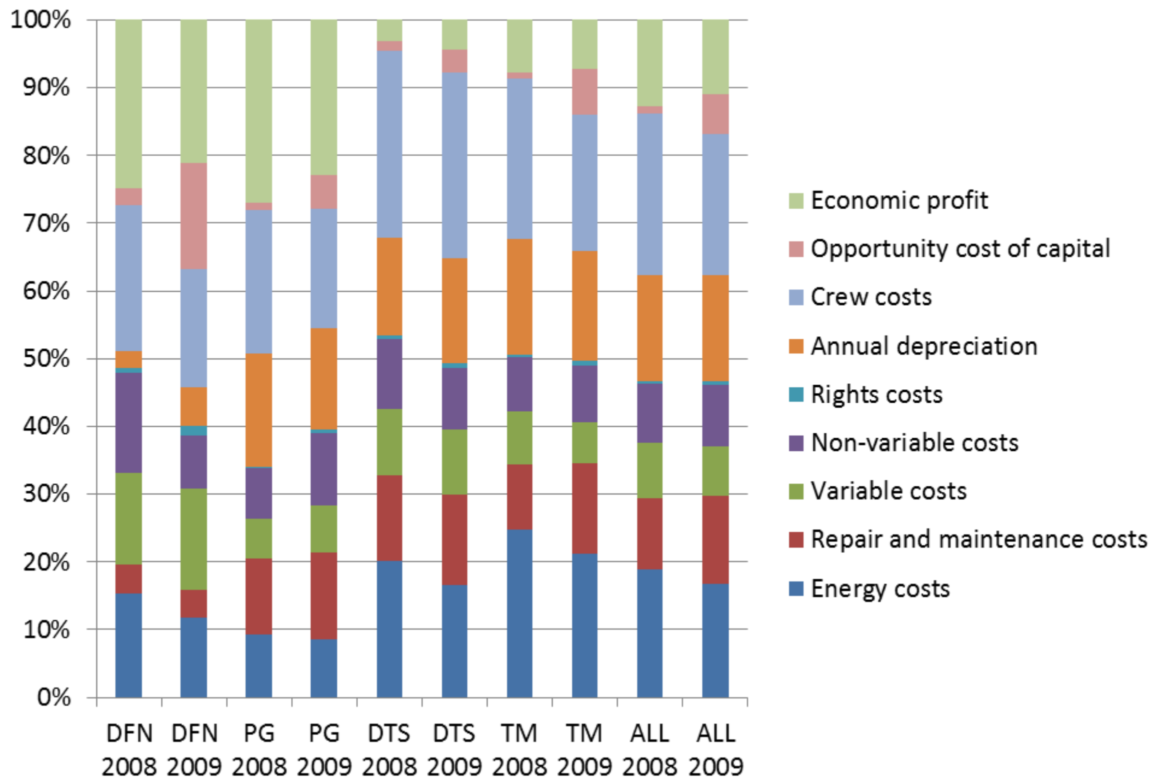


Figure. 11.6. Profitability and Costs structure of main Baltic Sea fleets.

11.2 Medium term projections

Simulation results from the models described in section 10.1.2 and in Annex 3 are given in terms of GVA for selected fleets in Figure 11.7

The simulations for different fleet segments are showing a few relative general trends. Fleet segments fishing on demersal stocks (basically left side) or using static gear (mixed catches, basically right side) are improved over the recent years and GVA will further grow for one or two more years. Afterwards due to the decrease in cod stock size and yield GVA will decrease. The situation for the pelagic segments (basically in the middle and (o)) is different as they already show more or less negative GVA which will not improve until 2020. This is probably an unrealistic development as fishermen will react on this situation by switching to other fisheries (if possible) or by leaving the fishery. As the sprat quota was already cut by 55% over the last two years a further large decrease is not expected following the simulations. This means that a more or less stable situation for the pelagic fleet segments may follow but with less vessels involved. The same development is likely for the demersal fleet segments. As the expected yields will stabilize on a lower level the fleet may further decrease. However, increasing fuel costs and in general a tendency of decreasing fleet sizes without the influence of a new management plan may lead to a smaller fleet in the Baltic Sea anyway (as stated other external factors are often more relevant for the economic outcome than the effects of management decisions).

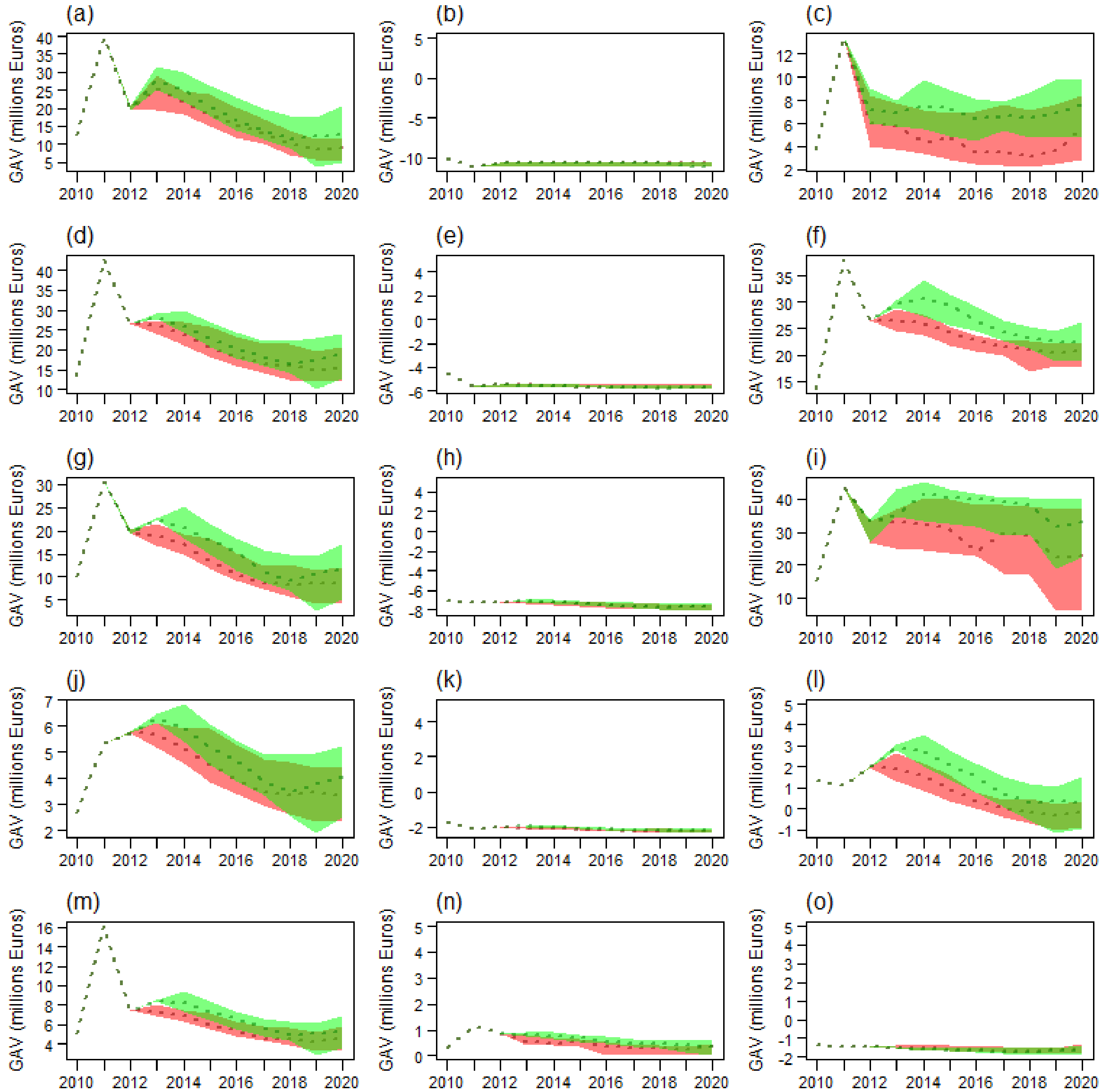


Figure 11.7: Gross value added (GAV) for selected fleets for scenario 1 red (FMSYcod=0.3 tac+/-15%, FMSYsprat=0.35 tac+/-20%, FMSYherring=0.16 tac+/-15%) with Scenario 3 green (FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15%) based on multi-species interactions and including TAC constraints a:"den.otter", b:"den.ptrawl", c:"den.static", d:"pol.otter", e:"pol.ptrawl", f:"pol.static", g:"swe.otter", h:"swe.ptrawl", i:"swe.static",j:"lat.otter", k:"lat.ptrawl", l:"lat.static", m:"lit.otter", n:"lit.static", o:"est.ptrawl"

The problems of these simulations are that the assumptions are too static. The costs increase/decrease linearly with the development of the fishing effort. In reality the sector will react on negative or positive economic development by investments or divestments. Increasing fuel costs will lead to a search for more efficient ways to catch fish like lower speeds or the switch to static gear.

The medium and longer term social aspects related to these simulation scenarios would also need to be taken into account. A long period of losses in a fleet segment would not only carry a reduction of the number of vessels in both demersal and pelagic segments, but also of employment in fisheries and auxiliary industries. Additionally, a search for more efficient ways to fish in order to compensate for higher fuel costs could have different effects on work conditions and/or wages that would need to be analysed in a longer term.

The effect on employment in the processing sector related to the pelagic segments depends on the type of processing industry. The characteristics of processing sector are different across member states, in particular the acceptance of a supply of alternative species as inputs for the different types of industries. Fishmeal industries can use many different kinds of small species and buy on a low price, therefore they are not so affected by the situation in the Baltic stocks because they can buy their inputs in the global market. Smaller, local fish processing industries depend on the catches of Baltic Sea herring and sprat and cannot use other species because they do not match their customers´ demand. Long periods of low availability of herring and/or sprat affect the profitability of these industries and in the longer run it may lead to a reduced industry size and lower employment.

11.3 Social aspects

The social impact of the plan is being analyzed using three indicators: engaged crew per vessel as an indicator of the level of employment provided by each segment (labour intensity), engaged crew per full time equivalent as an indicator of the quality of the work (full time/part time) and value of landings per full time equivalent as an indicator of remuneration, given that in the Baltic the income of the crew is mainly based on crew share.

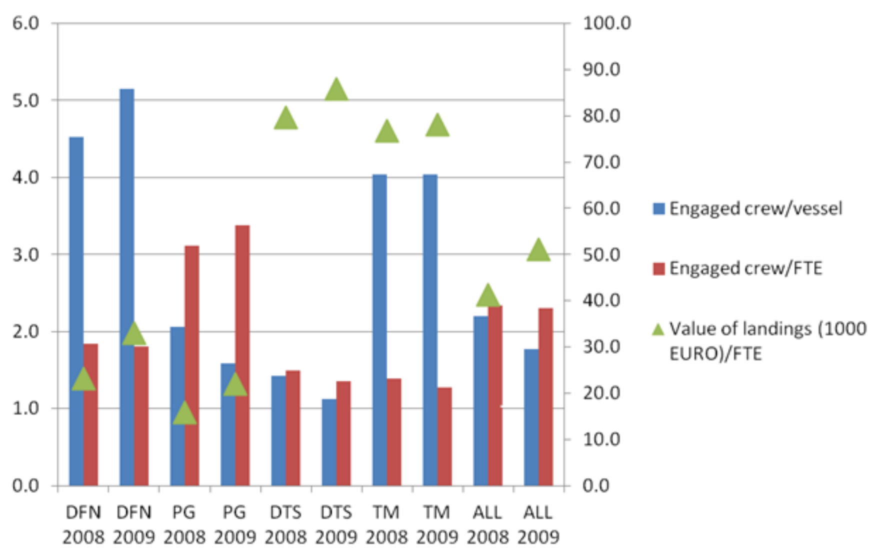


Figure. 11.8 Value of social indicators for main segments, 2008-2009

During the management plan, the employment per vessel has increased in the netter segment and remained stable in the pelagic trawlers, but it has decreased both in the coastal fisheries segments and in the pelagic trawlers. The level of employment has thus increased or maintained in the segments with the highest employment but it has decreased in those segments that had already a low level of employment per vessel. The value of the indicator for the coastal fisheries is also due to the fact that they are smaller vessels, for the value for the demersal trawlers there are some data issues (see below).

The quality of employment indicator shows an overall decrease for all segments, whic shows that the type of employment is moving towards full time. The overall quality (and thus attractiveness) of jobs depends among others on stability (part time vs full time/full season) and remuneration. The degree to which a job in the Baltic is full time may depend on effort restrictions and crew share remuneration depends on catches also restricted by quota , and therefore according to these indicators the management plan would make current employment in the fishing sector in the Baltic overall less attractive.

The management plan affects not only current employment, but also employments expectations. For example, a decreasing trend in employment in the coastal fisheries, those with the lowest remuneration indicator already, creates negative employment expectations. These expectations can also be affected by external factors as the economic crisis , that can make employment in certain segments more attractive with relation to other economic activities, and the existance of adecuate training programmes for young people. This would be the case for those segments with higher remuneration, as both trawler segments, with examples of this pattern being referred in Denmark

Some data issues regarding the social indicators include short length of the data series, lack of updated data at the meeting, limitations on FTE, engaged crew and number of vessels data availability (affecting in various ways all three indicators) and the effect of data allocation influencing mainly the indicators for the demersal trawlers. The latter is due to the fact that the large demersal trawlers can operate in different areas, switching between the Baltic and the North Sea and their effort (days at sea) in the Baltic is lower than that of the other segments. On the allocation of social variables between ecosystems the values of both engaged crew and FTE are therefore lower when compared with the other segments . Thus their crew is artificially divided giving rise to unrealistic values of some indicators such as approximately 1.5 crew per vessel for a large trawler. A more realistic estimate for this important segment would require more information on operation patterns (the same/different crew in each ecosystems, higher/ lower job quality on the vessels that switch) and/or alternative allocation criteria. for social indicators.

11.4 Conclusions to socio/economic aspects of impact assessment

Economic performance of fleets is likely to be more affected by external factors as fuel prices, fish meal and fish oil prices in the world as well as general consumption level and competition between Asian and European production. However increase of stocks and catch ability in the future could increase volume and value per fishing efforts, leading to the improvement of economic situation of the fleet.

2008-2009 data showing the importance of coastal fleets in the economic performance of Baltic Sea fishery and it seems that in most of MS these fleets are supported by EFF or reserving part of the quota. These fleets are more dependent on the other fish species and would be less affected by management plan then offshore demersal and pelagic fleets.

12 CONCLUSIONS TO THE IMPACT ASSESSMENT

12.1 Comparison of Options

The current impact assessment provides point exploitation Fmsy values and a range of B trigger options for herring in Gulf of Riga, Bothnian Sea and Western Baltic herring stocks.

The report from EWG 11-07 provides single species MSY estimates for Western Baltic cod.

This report has a detailed evaluation of a range of exploitation F for central Baltic herring, Baltic sprat and Eastern Baltic cod. This report identifies a range of potential target Fs are for the different stocks. The lower limits of these ranges correspond to the single species MSY values. Based on the current analysis it is not possible to give a list of candidate HCRs, however, the work provides some general guidance on the likely changes associated with the upper and lower ends of the range of target Fs.

The upper limits of the F target range are rather uncertain and depend heavily on assumptions of growth and predation. The current modelling is conditional on the current perceptions of the Baltic ecosystem, especially the low productivity of cod, long term changes in ecosystem productivity have been seen to occur in the past and may change again in the future. The conclusions here are conditioned on the current regime and may need to be reconsidered if the regime changes.

There are a number of important considerations in selecting specific values for exploitation from within this target range.

> Fishery yields for cod do not increase substantially with increasing F above single species MSY target values.
>
> The higher F targets are associated with short term increases in yield but not significant long term increases in yield.
>
> Increased fishery yields for Cental Baltic herring and Baltic sprat may result from higher Fs on cod.
>
> Fs at the lower end of the range are associated with economic stability and lower cost structures.
>
> Current knowledge requires that biomass limits are respected in order to keep stocks within safe biological limits. Increasing F has higher risks of depleting biomass. The modelling does not include structural uncertainty in the models, even though this is very uncertain particularly for cod predation, Thus higher Fs carry even greater risks than those illustrated.
>
> Including a restriction on inter-annual change in TAC on cod increases stock fluctuation for both cod and the prey species.

12.2 Effectiveness: best placed to achieve the objectives (select appropriately just to relate to the objectives given above)

Increasing F targets will probably imply increased effort and may have increased impact on the ecosystem in general. Discards of other species may rise as will Fs on any other species caught by within the same fisheries.

Important cod cannibalism rates are uncertain and are based almost entirely on data before 1984. Thus new data is urgently needed to verify current predation levels.

Changing the F targets upwards substantially without an inter-annual TAC constraint may increase catches of in the short term effecting market conditions unfavourably.

Lower Fs can be associated with lower growth rates for all species, that can reduce the product quality.

12.3 Efficiency: cost-effectiveness

The fish processing industry is generally not dependent on domestic production from the Baltic Sea (see STECF Report on the fish processing sector (STECF 2012)). However, there are countries, especially the Baltic States, or branches of the industry, like the fishmeal and –oil sector or small processing facilities, which can be dependent on domestic production (including buying raw material from other countries around the Baltic Sea). In the past the loss of landings in certain areas led to the close down of local processing facilities and landings currently have to be transported to facilities further away from landings ports with increasing costs for transports.

Nevertheless, generally it is possible to buy raw material from other sources in cases where domestic production decreases. With the decreasing cod quota several years ago the processing plants needed to find other sources for raw material and this was relatively easily possible.

For the processing industry stability of supply, which is associated with lower Fs is preferable.

The EWG was not able to fully assess possible effects of the management options/scenarios on the auxiliary industry.

From the scenarios (ch. 11.2) we can assume that the changes in benefits/losses for the fleet segments are rather small as for the pelagic fleet the cuts in quota over the last years are unlikely to continue. Increase in cod catches seem likely over the next few years and will lead to higher value added and profits in the cod fishery, however, these increases may not be sustained in the medium term. Therefore, the benefits may exceed the costs from a societal perspective but fleets are effected differently. For the demersal sector there appear to be benefits , for the pelagic sector pelagic losses).

12.4 Consistency: limiting trade-offs across the economic, social and environmental domains

At the moment with increasing cod stocks and a decreasing sprat stock we have tradeoffs between different fleets by having both fisheries reaching the target of Fmsy. The 55% decrease in the TAC for sprat, however, is a huge negative change for the pelagic fleet especially in Sweden and the Baltic States. On the other hand the demersal trawlers and several other segments targeting at least partly cod benefit from the increase in the cod stocks. The objective to reach Fmsy for all stocks may mean that cod catches will not further increase (maybe even decrease slightly) and that sprat catches will also not further decline or may increase above current levels.

From an overall perspective it seems reasonable to move into a relative stable situation with a low risk to overfish (lower range of F target) and then optimize the economic and social outcome of the fisheries. Higher stock levels are for example lead to lower costs for the fishing fleet and shall also increase the probability that processing facilities and auxiliary industry can stay in rather remote areas.

There seems to be a good opportunity to reach a relative stable situation for fleets in the Baltic Sea in the coming years. It may mean that several restricting regulations like the effort limitation can be removed particularly if countries were to introduce IFCs on a national level and these are seen to control catch. Fishermen are then able to invest or disinvest as necessary to stay profitable in the long run and be able to cover capital costs and pay the resource rents to the owner of the resources (governments can recover management costs from the sector).

Lower fishing mortalities with increased stability have the potential for simpler regulation implying less costly control from both industry and control agency perspectives.

12.5 Forward look to Evaluation

Research needs to support the implementation of multi-stock management plans

- Research on cod cannibalism. The predation data of large cods on juveniles are based on sampling from the period late 1970s-early 1990s. New sampling effort is required to analyse the potential changes in juvenile availability for adult cod and the adults' food preferences.

- Cod cannibalism is occurring in the stomach samples at very low numbers. Therefore, the number of stomachs sampled results in a large uncertainty in the estimated cannibalism rates. Different stochastic methods could be used to estimate the level of uncertainty in cannibalism estimates, and to separate between sampling-based uncertainty, and uncertainty due to the food selection model chosen for the estimation of cannibalism rates.

- Research on the strength of clupeid predation on cod eggs, and food competition between clupeids and cod larvae, in different areas and seasons.

- Research on the factors regulating cod growth. There are some evidences that cod growth has been density dependent in some periods (especially when its stock size was high), and recently food limited and regulated by the amount of available clupeids as prey.

- Research on the implications of density-dependence in clupeid growth on the Fmsy estimations and simulations. When clupeid density-dependent growth is included in the models, the estimated Fmsy for both sprat and herring become very high. More modelling work is needed to understand the reasons of these outcomes.

- Research on the long-term changes in the spatial distribution of the interacting species, in different seasons, to better understand the interaction strength between the species. The drives and implications of these changes must be better understood. More data could be potentially collated.

- Further research on the stock-recruitment relationships of all the species included in the multispecies context.

- Comparison of different multispecies models and their outcomes. Potential candidate models to be compared with SMS are BALMAR, Ecopath, but also others. This will provide a sort of sensitivity analyses on the effect of different management plans using different independent models.

- Research on multispecies HCR. To explore and develop management decisions considering species interaction.

- Accompanying the different model calculations (Ecopath, SMS) with assessment of socio-economic effects. For Ecopath this may be possible by improving the economic module (see Blenckner et al. 2011).

- It was not possible to run FishRent for this IA but this may be possible in the future if the model will be developed further (part of several EU FP 7 projects).

- Especially the assessment of social indicators has to be further developed. In the FP 7 project SOCIOEC this will be a key issue and may improve the possibilities for assessments in the future as well.

- Research on using fisheries profiles as a tool in the impact assessment process for multi-stock management plans

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15 List of Background Documents

Annex 1. Walther, Y. & Casini, M. (SWE), Gröhsler, T. & Krumme, U. & Strehlow, H. (GER), Horbowy, J. (POL), Kornilovs, G. (LAT), Pönni, J. (FIN), Raid, T. (EST), Storr-Paulsen, M. (DK). Species measurement error for pelagic species in the Baltic Sea– an overview

Annex 2 E. Jardim, I. Mosqueira, C. Millar & C. Osio. 2012. Testing the robustness of HCRs applied to Baltic pelagic stocks. Working Document in support to the STECF Expert Working Group 12-02 Management Plans - part 1. JRC Tech. Note 69877, 56 p.

Annex 3 Francois Bastardie, Morten Vinther, Rasmus Nielsen. 2012 Impact assessment (IA) of alternative HCRs to the current multiannual Baltic Sea plan on the bio-economy of fleets – coupling the SMS model to the FLR Baltic model, Working Document to STECF EWG 12-02

ANNEX 1 SPECIES MEASUREMENT ERROR FOR PELAGIC SPECIES IN THE BALTIC SEA– AN OVERVIEW

Walther, Y. & Casini, M. (SWE), Gröhsler, T. & Krumme, U. & Strehlow, H. (GER), Horbowy, J. (POL), Kornilovs, G. (LAT), Pönni, J. (FIN), Raid, T. (EST), Storr-Paulsen, M. (DK)

For several years the WGBAS has concluded that the estimates of species composition of herring and sprat in the mixed pelagic are not well/sufficiently known (ICES 2011). The landings provided are in most cases based on logbooks and landing declaration, which for various reasons may not be giving a correct estimate. In some cases the landings are recalculated by national experts based on additional information gathered by onboard sampling, fisheries control estimates or adjusted according to acoustic data in the area.

This document is the effort of national experts on herring trying to point at the problem by describing the mixed pelagic fisheries on a national basis and efforts to perform supplementary sampling. The aim is to conclude if any further efforts should be taken to design a more elaborate sampling program to document species composition in mixed pelagic fisheries.

The main problem lies not in the de facto separation of species by identification but how precise the estimates are documented in logbooks and sales slips. The errors may be caused by non voluntary errors caused by the fishermen's visual estimate of the catch when no other measurements are required or also a deliberate misreporting depending on TAC for the species and fishing possibilities.

We tried to answer the following questions by country:

- Do the landing figures submitted to assessment WG (e.g. WGBFAS) stand for official national landing figures?
- If they are changed by the national expert on what basis is it done? Describe e.g. national on board sampling programme or harbour sampling, adjustments based on acoustic survey data etc.
- Describe the fisheries; are there incentives (now or previously) for species misreporting in pelagic fisheries of your country? Do the fishermen performing pelagic fishery have fishing quotas for both species.
- Is correct reporting of species composition of the catches required and controlled?

GERMAN HERRING AND SPRAT LANDING FIGURES IN THE BALTIC SEA (SUBDIVISIONS 22-32)

Tomas Gröhsler, Uwe Krumme and Harry Strehlow, vTI-OSF

Description of the fisheries from 2008-2011 (all values given below represent means for this period)

Since 2008 the landings of herring and sprat decreased by 59 % and 62 %, respectively. This decrease was caused by a continuous year by year reduction of the corresponding TAC/quota system (German quota in 2011, herring: 8,763 t for Subdivisions (SDs) 22-24 & 627 t for SDs 25-27, 28.2, 29 and 32; sprat: 18,046 t for SDs 22-32). The German fishing fleet tried to compensate these quota reductions of herring and sprat by means of quota transfer with other countries around the Baltic Sea.

The German fishing fleet in the Baltic - where all catches for herring and sprat are taken in a directed fishery - consists of two parts:

- Coastal fleet with undecked vessels (rowing/motor boats ≤ 12 m and engine power ≤ 100 HP). The fishing is mostly conducted with passive gears (gillnet and trapnet), which are exclusively catching herring.
- Cutter fleet with decked vessels and total lengths between 12 m and 40 m. The fishing is mainly carried out with trawls (pair trawlers) catching herring (minimum mesh-size >32 mm in SDs 22-27 and >16 mm in SDs 28-32) and sprat (minimum mesh-size >16 mm).

Within the herring fishery 64, 34, and 3 % of the total catches were taken by trawl, gillnet and trapnet fishery, respectively. All sprat are generally caught in the trawl fishery.

The main fishing season for herring was in spring (quarter 1: 59 % and quarter 2: 28 %); a minor part was taken in quarter 4 (10 %). Most of the sprat catches were taken in the first quarter (60 %); quarter 2 (18 %) and quarter 4 (22 %) were of minor importance.

Most herring landings originated from SD 24 (76 %) and SD 22 (10 %). The fishing activities are in accordance to the quota system, which allocates more than 90 % of the herring quota to SD 22-24. The German herring fishery involves several hundred fishing vessels. The highest fishing activities for sprat were recorded in SD 28 (36 %), followed by SD 26 (20 %), SD 29 (16 %) and SD 27 (15 %). The sprat fishery in these areas was only conducted by four larger fishing vessels.

The allocated quota for herring and sprat (incl. overall positive or negative quota transfer from other countries) were almost fully exploited (96 - 100 %).

Virtually all sprat catches were landed abroad (94 %, in Skagen/DK and in Vastervik/SWE), whereas only about a quarter of the herring catches were landed in foreign ports (24 %, e.g. Köge/DK).

Herring is mostly used for human consumption, only a minor part is used for industrial purposes. In contrast, sprat is mostly used for industrial purposes (fish meal and mink food for Finland) and only a small part is used for human consumption.

1.1 Description of the national monitoring system

Information on the German fishery is derived from sales slips and logbooks. This information is sent to the fishery department of the corresponding federal states (Länder). After checking the reported catch and landing data, they are forwarded to the national state authority (Federal Centre for Agriculture and Food, BLE) and stored in a computer system. The data are compiled according to the type of fishery, fish species, and the fishing area and are submitted monthly, quarterly and annually to the EU Commission (DGXIV) (catch report A). Other EU member states (MS) report their landings by submitting logbook sheets and sales slips directly to the authority of the responsible state. These catches are compiled and transferred monthly to the EU Commission (catch report B). Catch data from German fishing vessel landings in other MS are transferred by these states to the responsible state authority in Germany.

In January 2012 a new regulation has been implemented, replacing the previous reporting system (catch reports A and B). The new regulation requires all MS to sample the entire information regarding their national fishing fleets; this now also includes the landings of the national fleet in foreign ports.

In the Baltic region, German fishing vessels $\geq$ 8 m are obliged to fill in a logbook. The logbooks contain fishing information on quoted fish species (date, gear used, rectangle, and landings in kg). Catches of fishing vessels < 8 m are required to provide monthly sales slips, which are submitted to the respective fishery department.

Catches and landings are monitored at sea, by control vessels of the federal and state governments of Schleswig-Holstein and Mecklenburg-Vorpommern (fishery board, customs, marine police)

In harbours, by the port control of the state fishery board (13 check points along the Baltic coast) and by the fishmaster.

1.2 Reliability of herring/sprat landing figures

There are numerous steps in the data collection that can limit the reliability of herring and sprat landings (e.g. logbook information, misreporting, mixed catches). To detect possible deviations from the official landing figures an evaluation of the herring and sprat figures was performed. The landing figures submitted to the ICES Baltic Fisheries Assessment Working Group (WGBFAS) and the Herring Assessment Working Group for the Area South of 62° N (HAWG) during the last years was identical to the officially reported landings. They were regarded as reliable due to the following reasons:

- All catches taken with gillnet and trapnet are exclusively catching herring with no by-catch of sprat (mean 2008-2011: 37 % of the total landings). However, some species mixing of herring and sprat may occur in the trawl fishery.
- The landings in the herring fishery are mainly taken in SD 24 and to some minor extent in SD 22 (mean of SD 24 + SD 22 in 2008-2011: 86 %). There is almost no spatial overlap with the fishing activities for sprat, which is mainly conducted in SDs 26-29 (mean 2008-2011: 87 %).
- The logbooks – which in certain areas and to certain times of the year only contain rough estimates of the species composition in the pelagic trawl fisheries – are cross-checked and, when necessary, corrected by the information from the corresponding sales slips. Landing data based on sales slips is fairly reliable because it is based on the sorting and weighing process carried out in the factories with standardized equipment. The product weight is also used for cross-checking by applying a correction factor to get an estimate of the original landing figure. The quota is charged for the final landing species composition of a trip.
- The German quota for herring and sprat from the Baltic was fully taken during the last years. This may have resulted in incentives for misreporting. However, the low spatial overlap of the herring and sprat fishery - where herring is mainly caught in SD 24 + SD 22 and sprat in SDs 26-29) - is not supporting the incentives of misreporting. It may, however, occur that vessels with open quota for North Sea herring and nearly depleted quota for Baltic herring have trips with minor catches in the North Sea and major catches in the Baltic Sea but declare the entire catch as North Sea herring to conserve the Baltic Sea quota. The scale of this misreporting is unknown.

- The scientific sampling system, which also covers the trawl fishery catching herring and sprat is characterised by low sampling intensities since most trawl catches are landed abroad. However, the analysis of the few sampled landings suggests that no correction of the official landings figures is needed.
- Since most herring landings are used for human consumption, the trawl fishery intends to catch pure samples of herring with minor by-catch of sprat. This also guarantees the highest landing prices.

2 The Danish sampling system

Marie Storr-Paulsen

Denmark is having two sampling system in the pelagic fishery. The first is conducted by the Danish control were the species composition is measured. The second sampling system is conducted by DTU Aqua as part of the DCF regulations and here species composition, length, weight and age are measured. At present Denmark is only using the samples from the control to calculate the species composition in the landings, however there is a possibility to also include the samples from DTU Aqua and thereby increase the total number of samples. There will be some overlap between the vessels from where the samples have been taken and therefore it is not possible to just add the number of samples from the two sources.

Species compositions have been calculated since 1989 for the Skagerrak, Kattegat and North Sea, data are available also for the Baltic area in this time frame.

Data on species composition are sampled and can be reported by square and month. An example from 2010 is included.

We do not consider species identification by the control or by DTU Aqua staff to be a very large problem.

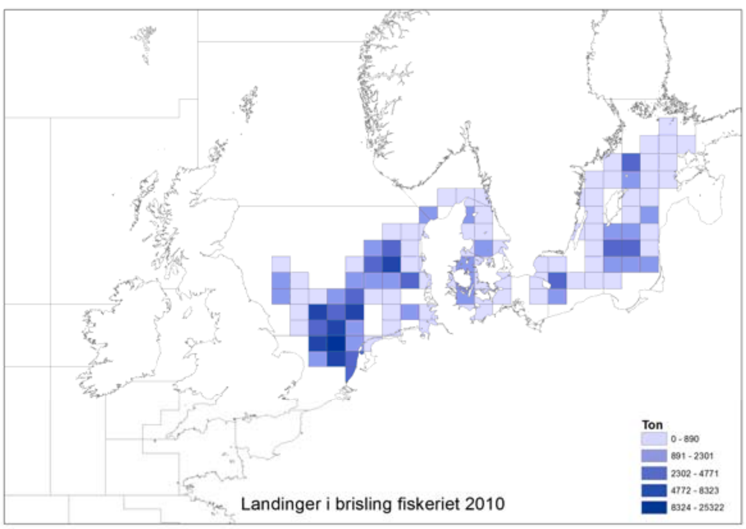


Figure 1 Annual Danish sprat landings by square in 2010

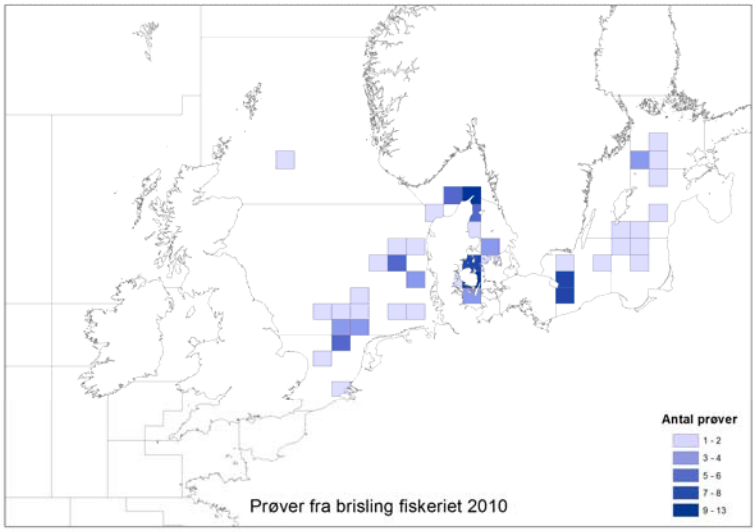


Figure 2 Annual numbers of DTU Aqua samples by square in 2010

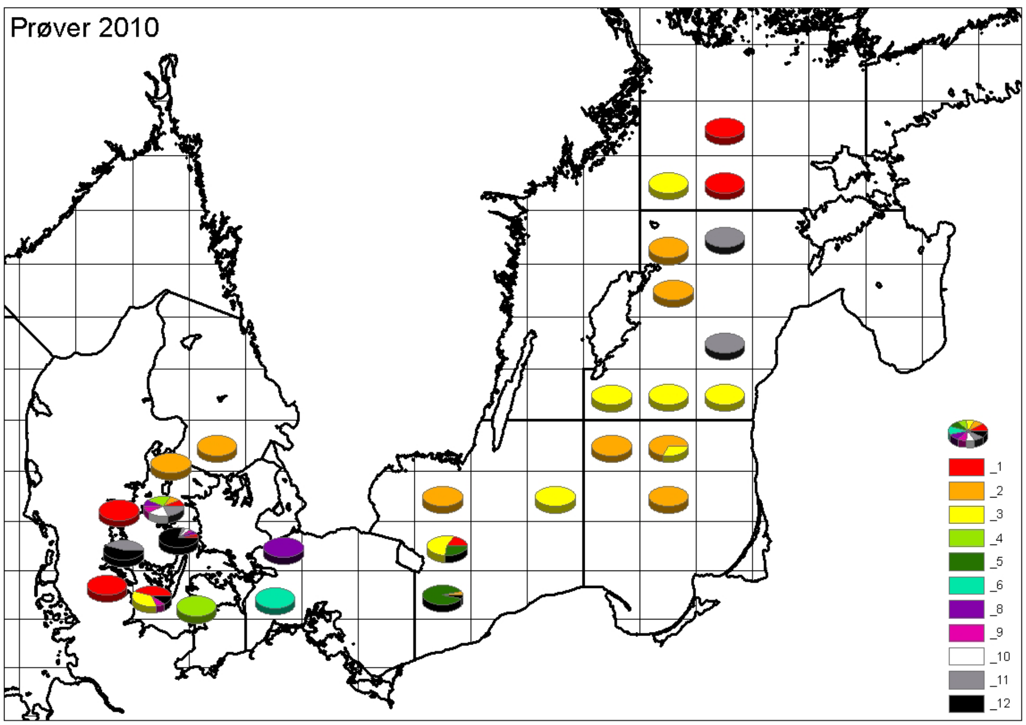


Figure 3 Annual numbers of control samples by square in 2010

Table 1 Control samples by square in 2010.

Sum of Number of Samples			
square	Total	square	Total
32f3	1	40g9	1
34f2	2	41f6	1
35f3	6	41f7	1
36f3	3	41g1	4
36f4	3	41g8	1
37f2	1	41g9	1
37f3	1	42g0	1
37f4	1	42g8	1
37f6	1	42g9	2
37f7	1	43f8	2
38f4	1	43g0	5
38g0	4	43h0	1
38g5	7	44f9	6
39f7	3	44g0	13
39f9	2	45h0	1
39g0	12	46f0	1
39g5	8	46g9	3
40f5	1	46h0	1
40f6	5	47h0	1
40g0	8		
40g1	1		
40g5	1		
Grand Total			121

3 Herring and sprat in mixed fishery (Estonia)

Tiit Raid

The mixed fishery occurs mostly in the open sea areas of Subdivisions 28.2, 29 and to a lesser extent also in the Gulf of Finland, particularly in its western part (Subdivision 32) by the pelagic trawls. The abundance of sprat is low in the Gulf of Riga and its share in pelagic landings from that Gulf marginal.

The vast majority of catches are landed in only a few fishing ports (Lehtma , Veere, Mõntu, Dirhami, Haapsalu, Paldiski, Pärnu, Tallinn, Toila), where the landing process is permanently monitored.

The herring and sprat is landed for human consumption (smoking and canning industry).

No discarding and/or sorting take place in Estonian Baltic pelagic fishery. The proportion of clupeid species in all landings is checked in the fishing ports by the local inspectors of Environmental Inspectorate. The results of those inspections serve, together with logbook information, as the basis for estimation of the amounts of both species landed. These estimations serve as a basis for the official catch (landing) figures. Additionally, the species composition is checked on a monthly basis by the observers (data collectors) from the Estonian Marine Institute during the regular monitoring of the structure of landings under the DCF.

The landing figures presented to the WGBFAS by Estonia are the official ones.

4 Description of Latvian pelagic fisheries

Georgs Kornilovs

There are two main metiers targeting pelagic species in Latvia: trawlers targeting sprat in the Baltic Proper (mainly Sub-divisions 26 and 28.2) and trawlers targeting herring in the Gulf of Riga. It should be highlighted that the Latvian Fishing Rules allow only sprat targeted fishery in the Baltic Proper and only herring targeted fishery in the Gulf of Riga.

4.1 Sprat targeted fishery in the Baltic Proper

The Latvian Fishing Rules allow only sprat targeted fishery in the Baltic Proper because the Latvian national herring quota in the Baltic Proper is small in comparison with the sprat quota. The fishing firms which obtain the sprat quota receive proportional herring quota. Fishery is performed by trawlers mainly belonging to the length segment of 24-40 m. The number of ships performing sprat directed fishery has significantly decreased in recent years. Since 2005 forty one vessels have been scrapped and in 2011 there were 44 active vessels left in this fishery.

The landing figures of sprat and herring in the Baltic Proper submitted to the assessment working group WGBFAS correspond to the official national landing figures of Latvia. In the frames of National data collection programme regular monthly one-two day onboard sampling of sprat fishery is performed to estimate the species composition in this fishery. The by-catch of herring varies from 0% till 20% but on average the percentage of herring by-catch corresponds well to the proportion of herring in the total official landings of pelagic fishes. In general there could be incentives of misreporting herring as sprat in this fishery, because the herring quota is relatively low in comparison with sprat quota and fishermen could try to avoid overshooting the herring quota. On the other hand the main receiver of pelagic fish landings is the sprat processing industry therefore fishermen are not interested in the by-catch of herring and in general could avoid by-catch of herring. The Fisheries inspection pays attention to the correspondence of reported and actual species composition in the landings.

4.2 Herring targeted fishery in the Gulf of Riga

The Latvian Fishing Rules allow only herring targeted fishery in the Gulf of Riga because in the Gulf of Riga sprat is less abundant than in the Baltic Sea and could be caught only as by-catch. The fishing firms which perform trawling in the Gulf of Riga obtain the herring quota for the Gulf of Riga and receive proportional sprat quota. Fishery is performed by trawlers mainly belonging to the length segment of 12 -24 m. The number of trawlers in the Gulf of Riga has significantly decreased in recent years. Since 2005 thirty four vessels have been scrapped and in 2011 there were 28 active vessels left in this fishery. Herring directed fishery is performed also by trap-nets during April-July. This could be regarded as a clean herring fishery with no by-catch of sprat.

The landing figures of herring in the Gulf of Riga submitted to the assessment working group WGBFAS have been increased in comparison with the official national landing figures of Latvia. It has been done on the basis of interviews with the fishermen and the obtained information of unallocated landings of herring. The percentage of increase has been gradually reduced due to significant decrease of the fishing fleet and evident balancing of the fishing possibilities with the fishing capacity. In the frames of National data collection programme sampling of herring fishery is performed in the harbours of the Gulf of Riga. During the IBSSP project there was also an intensive on-board sampling and it was concluded that misreporting by species and discarding is not characteristic for this fishery. In general incentives for species misreporting are not evident. The Fisheries inspection pays attention to the correspondence of reported and actual species composition in the landings.

5 Poland

Jan Horbowy

Polish quantities of Clupeid landings (herring and sprat), submitted to WGBFAS, are the official landings of herring and sprat based on the data from logbooks, distributed into species by national experts in herring and sprat.

There exist two types of Clupeids catches in the Polish fishery:

a) catches for human consumption

b) industrial catches.

In catches for the human consumption species shares are well separated by using different mesh size of codend in the catches of herring and sprat and use of mechanical sorting equipment. Statistics of these landings and their sampling are of good precision. However there exists the problem of bycatch of juvenile herring in sprat landings, which is solved by sorting and biological sampling both in harbour landings and at sea. As the result the official quantity of herring landings received from logbooks is increased by its bycatch in sprat landings and official sprat landings are decreased by this quantity.

Landings of Clupeids for industrial purposes concern mixed catches, done using trawl with sprat codend mesh size, and aren't sorted for species. These landings are done as industrial sprat and noted in logbook under the sprat species. Only in few logbooks shares of herring and sprat are estimated. Majority of these landings, done by Polish ships, take place in harbours of Denmark (Bornholm) and Sweden. The statistics, concerning this type of fishery, is created basing on landings documents. These catches are sampled directly at sea for species composition and collection of biological material. Results of sampling are extrapolated for landings of the whole fleet. Sampling is insufficient in case of far areas (Sub-divisions 27, 28, 29) and for cutters not entering the Polish ports for the longer time. In this case only the quantity of landing is reported to WGBFAS, based on logbook.

In 2011 Total Allowable Catch determined for Sub-divisions 25-27, 28.2, 29 and 32 of Baltic Sea might be used by ship-owners without dividing it for each fishery ship. In case of herring from subdivisions 22-24 of Baltic Sea distribution of allowable catch is done for ships which owners had the quota of “western herring” in years 2007, 2008 or 2009 and caught it in at least one of these years.

In 2011 distribution of Total Allowable Catch of sprat in Sub-divisions 22-32 of Baltic Sea was done without dividing for individual ships, giving the yearly limits by length class of the ship (Journal of Laws of the Republic of Poland Nr 240, Regulation of the Ministry of Agriculture and Rural Development Nr 1607).

6 Finland

Jukka Pönni

The landing figures submitted to assessment WG (e.g. WGBFAS) stands for official national landing figures.

Previously there has been no reason to believe misreporting. Now that (mixed) trawl fishery is regulated (because of smaller sprat quota), there is a hypothetical possibility that fishermen would report sprat as herring. Both species have quotas, but the very small sprat quota is a problem for the fishery of both species.

Correct reporting of species composition is required. Controlling needs to have a suspect of crime, so it is not done regularly.

7 Sweden

Yvonne Walther, Michele Casini

The Swedish fisheries for pelagic can be divided into four categories:

- Trawlers catching herring with a minimum mesh size of 32 mm. This fishery is for human consumption.
- Trawlers catching sprat with a minimum mesh size of 16 mm. A small part of the landings is used for human consumption. Most of the landings are used for industrial purposes. Herring is caught as by-catches in this fishery.
- Coastal fishery for herring with gillnets. This fishery is for human consumption.
- Purse seine fishery near the coast for spawning herring in the second quarter of the year. This fishery is also for human consumption.

It is mainly in the trawl fisheries that the proportion between herring and sprat is unknown.

Sweden regularly collects samples of approximately 5 kg from the pelagic fisheries catch for biological parameter. These samples are recorded also for species composition but evaluated to be large enough to reflect the species composition.

Sweden gets information about the pelagic landings from logbooks and sale slips and then tries to evaluate the species composition by including information from additional sampling. The total landing of herring and sprat is then accordingly adjusted to give more plausible figures for assessment.

The strategy has prior to 2005 been to try to use available sampling made by the Swedish Coast Guard. Currently this sampling had been taken over by the Fisheries control which takes 2-4 samples from pelagic fisheries and has not been used for adjustments. There may be a possibility to cooperate and try to evaluate the statistical accuracy of this sampling.

In the last few years the acoustics from BIAS quarter 4 has been used for adjustment in SD 25, 27, 28 and 29. The acoustic values are compared to logbooks and applied by quarter. Adjustments in quarter 4 can be 30-40% but on average for a whole year less than 10%

8 Conlusion

Overviews of species measurements of pelagic fisheries were kindly provided by Denmark, Germany, Poland, Estonia, Latvia, Finland and Sweden

Overall the national experts are well informed about the fisheries and possible caveats in the estimates of landings.

The official herring and sprat landing figures are based on logbooks, sales slips, fishery control and sampling information. In no case there is a concern that the sampling is impaired by identification of herring and sprat.

Most sprat and herring landing figures submitted to the ICES Baltic Fisheries Assessment Working Group (WGBFAS) stand for official national landing figures. Only Latvia increased the official landing figures for herring caught in the Gulf of Riga during the past years.

Some adjustments of the official landings and species composition were applied before submitting the data for assessment. The adjustment concerned the overall division between herring and sprat landed by industrial fisheries (i.e. Poland and Sweden).

Herring in the Baltic is caught by active (pelagic trawl and purse seiners) and passive gears (gillnet and trapnet), respectively, whereas sprat is only caught within the pelagic trawl fishery.

Only the pelagic trawl fishery takes a mixture of herring and sprat. All passive gears as purse seiners, which are directed for human consumption, can be regarded as an almost clean herring fishery.

The landing figures taken within small-mesh (minimum mesh size >16 mm) industrial trawl fisheries, which are directed to catch sprat, can be considered as the most uncertain ones.

Previous investigations showed that bycatch of herring is larger in SD 27 and 28 compared to 25 and 26 but it is not confirmed if this pattern is stable.

The overall biological sampling (length and age data) seems to be sufficient. However, for some countries (i.e. Germany, Poland) it is difficult to monitor the national fishing activities since a larger part of the herring/sprat catches are landed in foreign ports.

Overall, it would be beneficial to have a higher sampling coverage of the species composition of the small-mesh industrial fisheries targeting sprat in SDs 27-29 and SD 32 to decrease the potential of uncertainties in catch levels of herring and sprat.

9 Outlook

The outcome of the national description of the species composition in Baltic mixed pelagic Fisheries (see Annex X) will be discussed during the next meeting of WGBFAS in April 2012. Further work is needed to get more details on the species composition in the mixed pelagic fisheries, focusing on how much of the herring/sprat catches (t) are taken by the industrial trawl fishery.

10 Reference

ICES 2011, ICES WGBFAS Report 2011 ICES Advisory Committee on Fishery Management. ICES CM 20011/ACOM:10.

Annex 2 E. Jardim, I. Mosqueira, C. Millar & C. Osio. 2012. Testing the robustness of HCRs applied to Baltic pelagic stocks. Working Document in support to the STECF Expert Working Group 12-02 Management Plans - part 1. JRC Tech. Note 69877, 56 p.

Annex 2 is published separately and is available from JRC web site.

ANNEX 3. IMPACT ASSESSMENT (IA) OF ALTERNATIVE HCRS TO THE CURRENT MULTIANNUAL BALTIC SEA PLAN ON THE BIO-ECONOMY OF FLEETS – COUPLING THE SMS MODEL TO THE FLR BALTIC MODEL, WORKING DOCUMENT TO STECF EWG 12-02

Francois Bastardie, Morten Vinther, Rasmus Nielsen

The simulations have been performed with an existing age-structured multi-stock and multi-fleet bio-economic model (mixed fisheries and technical interactions), which have already been published and applied for the Baltic cod stocks and fisheries (fishery library in R, FLR Baltic model in Bastardie et al. 2010a, b). This model explicitly includes the dynamics of underlying harvested stocks in order to integrate over time the combine effects of fishing activities and regulations on the dynamics of stocks, within a management strategy evaluation framework (MSE). The model is further coupled with the stochastic multispecies (SMS) model to refine and correlate the stock dynamics in order to now include species interaction between cod, sprat and herring when projecting forward future abundances.

In practice, the SMS model is encapsulated into the FLR Baltic model in place of the single-species operating model (OM) used so far. The SMS OM (see Morten Vinther and Stefan Neuenfeldt 2012 working document for details) is then run every year y of the simulation and uses the aggregated catches at y-1 (catches issued from the simulated activities of the set of fleet segments included in the simulations) to predict the abundances at y.

The fleet modelling is performed on a disaggregated seasonal and spatial scale (ICES statistical rectangle and quarterly time step) using the spatial and seasonal explicit application of the FLR Baltic model. Incorporating the spatial scale into the more elaborated stochastic fleet-based forecast model was planned to integrate potential effects of the population dynamics and the age-specific spatial distribution of the population together with the spatial and temporal allocation of fishing effort also including the heterogeneity of fishing practices.

Coupling with the area-based OM SMS, time and spatial scales are an issue. While the dynamic of the cod, sprat and herring stocks is simulated by applying the SMS model on a yearly time step, the removals from fleets are applied by quarter by rectangle. The OM SMS is however a new version of the SMS model which now incorporates space and time dimensions (ICES subdivision and quarter) for parameterisation. With this approach, in this current application, the SMS uses quarter catches of sprat, herring and cod per ICES subdivision to predict next year total abundances of each of these stocks. These total abundances are further distributed in space by using a quarter-specific spatial allocation key previously built from scientific surveys analyses (see the Eero et al 2012 working document for details), assuming constant stock distribution in future.

Previous simulations using the FLR Baltic model covered evaluation of different management instruments such as TAC regulation under different relative annual variability constraints either alone or together with effort regulation, as well as effort regulation alone. Simulations were applied to the Eastern Baltic cod stock (one stock) and management area. The current simulations focus on testing implications of different FMSY values for the three main Eastern Baltic stocks (cod, sprat and herring), including dynamic interactions between the three stocks. As the three stocks are not targeted by the same fisheries, relative change in total effort between pelagic and demersal fleet-segments is also tested by increasing effort by 10%, one fishery after the other.

This model has been updated with information from (i) the STECF effort and economic working groups (Effort and Economic 2010 data calls) used to define and parameterize the fleet activity occurring in the (East) Baltic Sea into different and sensible fleet-segments, (ii) the SMS runs used to parameterize the initial starting population abundances and the level of recruitment variability and observation errors, and (iii) the ICES WGBFAS 2011 (ICES 2011) used to parameterize the stock assessment settings currently in use, if necessary.

The evaluations are performed and organized as follows:

- Runs 1: calibration
- Runs 2 (Baseline): single-species biological operating model, multi-fleet operating model, current LTMP (TAC +/- 15% for cod and herring and +/-20% for sprat, associated with effort reduction by 10% each year for T90mm fleet-segments), XSA and observation error on the catch matrix of 0.3, single species (current) FMSY for the three stocks i.e. FMSYcod=0.3, FMSYsprat=0.35, FMSYherring=0.16.
- Runs 3 (Baseline SMS): multi-species SMS OM model, multi-fleet operating model, current LTMP (TAC +/- 15% for cod and herring and +/-20% for sprat, associated with effort reduction by 10% each year for T90mm fleet-segments), observation error on true N from variance-covariance matrix given by SMS, single species (current) FMSY for the three stocks i.e. FMSYcod=0.3, FMSYsprat=0.35, FMSYherring=0.16.
- Runs 4 (multi-species FMSY) Baseline SMS and proposals for alternative set of FMSY values i.e. FMSYcod=0.45, tac+/-15% FMSYsprat=0.40, tac+/-20%, FMSYherring=0.26 tac+/-15% based on multi-species interactions (refer to the SMS runs).
- Runs 5: Baseline SMS + alternative FMSY values + 10% effort more for *pelagic* fleet segments
- Runs 6: Baseline SMS + alternative FMSY values + 10% effort more for *demersal* fleet segments

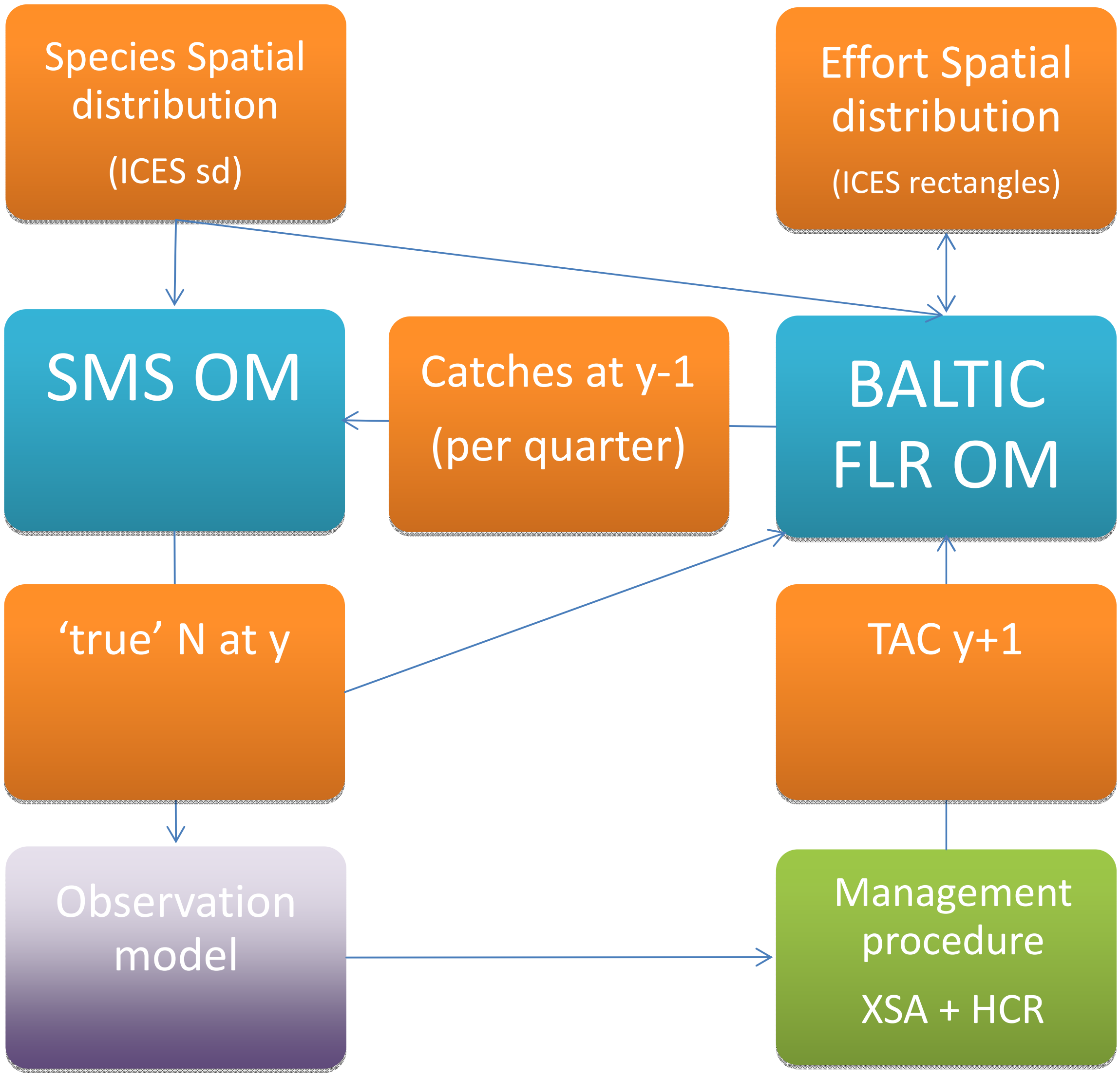


Figure xx: Conceptual view of the coupling between SMS and the Baltic FLR multi stock multi fleet models. 'OM' stands for Operating Model.

<u>Work plan outlined in November 2011(STECF EWG Edinburgh)</u>

To reduce the work load and meet the deadline, it has been decided to limit the evaluation to the Eastern Baltic as a first step.

- Obtain the up to date catch data (e.g., effort catch and landings per DCF fleet-segments, see section 5.5 and table below)
- FLR/SMS coupling: replace the existing biological operating model by SMS (accounting for species interactions via the M2 matrix) and inform with the relative spatial distribution of the three stocks (distributions assumed constant in the forecast)
- Implement the candidate HCRs (previously drafted from the SMS outcomes).

- Make the DCF Fleet-segments consistent with economic AER ones (see table below).
- Obtain and introduce with economic data in the model (variable and fixed costs and price formation).
- Decide on uncertainty ranges for stochastic simulations (from SMS simulations), including year correlation in assessment error.
- Run the baseline forward, measure the performance and plot the multidimensional outcomes for cod, sprat and herring.
- Run alternative 'what if' scenarios (robustness to errors and alternative HCRs) e.g. compare HCRs with single stock MSY targets vs. HCRs with multi-species MSY targets.

1. Parameterization

The entire parameterization has been done mostly using data on fishing activities and stock levels from the year 2010. Fleet data were available at the correct resolution for Poland, Denmark, Sweden, Germany, Estonia, Lithuania and Latvia. Finland provided data that were not per ICES rectangle and assumptions had then to be done here (i.e. effort and landings evenly distributed inside subdivision 29). In the Eastern Baltic Sea, the advised TAC corresponds to the EU TAC plus the Russian quota. Unfortunately, no Russian data were available at the time of the evaluation. Landings from Russia were however also accounted for (by adding a small piece of additional landings to each of the simulated fleet-segment).

As fleets should be identifiable for management purpose, the definition of fleets is in agreement with the DCF segments. Avoiding too numerous categories, aggregation has however been done to reduce the total number of simulated entities (i.e. activities less that 800 days at sea over 2009-2011 have been pooled into an "other" category). It should be care that the model should not suffer from an "averaging" problem (occurring when aggregation is too high) that makes the calibration difficult because meaningless fleet-segments.

The sometimes diverging fleet categories between biological and economic data led to put some assumptions ahead e.g. fishing technology categories into economic data have been aggregated (fleet segments with less than 10 vessels, due to confidentiality issues) in a way that make difficult/impossible the link with the category JRC defined for the effort table (Gear coding- Appendix 3 of EFFDC-Official letter.pdf) , for example seiners are mixed with trawlers, while otter trawls are not really discriminated, etc.

<u>Fleet related data needed for Baltic FLR multispecies MSE</u>

DATA	PURPOSE	AVAILABILITY	DESCRIPTION	REMARKS
Effort	To Inform the effort per fleet/metier allocation model	JRC –Effort data call - Baltic countries in STECF effort data call for 2010 Per DCF segments (DCF Appendix IV)	Effort (in fishing hours) per country per DCF vessel size , gear and mesh size, per ICES rectangle per quarter	Use of 2010 data. Not available for Finland.
Landings (weight)	To Standardize the nominal effort per fleet/metier from specific sprat herring and cod catch rate	JRC –Effort data call - Baltic countries in STECF effort data call for 2010 Per DCF segments (DCF Appendix IV)	Landings (in weight) per species per country per DCF vessel size, gear and mesh size, per ICES subdivision per quarter	Use of 2008-2010 data.
Landings (value)	To Inform the additional revenue from "other" species (i.e., excl. sprat,	JRC –Economic data call -Baltic countries in STECF economic data call for 2010 Per DCF segments (DCF Appendix	Landings (in value) per species per country per DCF vessel size, gear and mesh size, per ICES	Vessel length and fishing techniques (gear) categories are clustered if less than 10 vessels in the

	herring and cod) by computing VPUE per DCF fleet-segment	IV)	subdivision per quarter.	category for confidentiality purpose. Fishing techniques naming are not consistent with the effort call ones. Merged with effort data to compute VPUEs
Capacity	To compute properly the DCF segment - specific fixed costs (because fixed costs are per vessel)	JRC Economic data call Per DCF segments (DCF Appendix III)	Number of (active) vessels per country per vessel size category, per DCF category. per quarter	
Variable costs	Inform running cost per day	JRC Economic data call Per DCF segments (DCF Appendix III)	Costs per DCF segments (for year 2010): costs depending on total revenue (e.g. sales costs and crewshare in % of revenue) costs for operating (e.g. fuel cost, ice, maintenance, etc. in cost per unit effort in day)	Need to be split per region using method from EWG 11-18 i.e. according to the respective effort (e.g., Denmark, Germany between North Sea and Baltic Sea)
Fixed costs (i.e. annual cost per vessel that do not depend on its running activity)	Inform fixed cost per vessel	JRC Economic data call Per DCF segments (DCF Appendix III)	Insurance cost, etc.	Need the capacity to be properly informed
Price	Compute gross revenue from landings of sprat, herring and cod	Average price per species or Price equation per species (accounting for price flexibility)		Evidences for price flexibility is weak (Ernesto). Mean price per species per DCF segment (Landings value divided by landings weight) has been used so far. Accounting for commercial categories would be a valuable refinement.

Based on the data requirements described on the table above, JRC has provided the data in December 2011. The table below summarizes the information provided, the level of aggregation required and provided and the source of information.

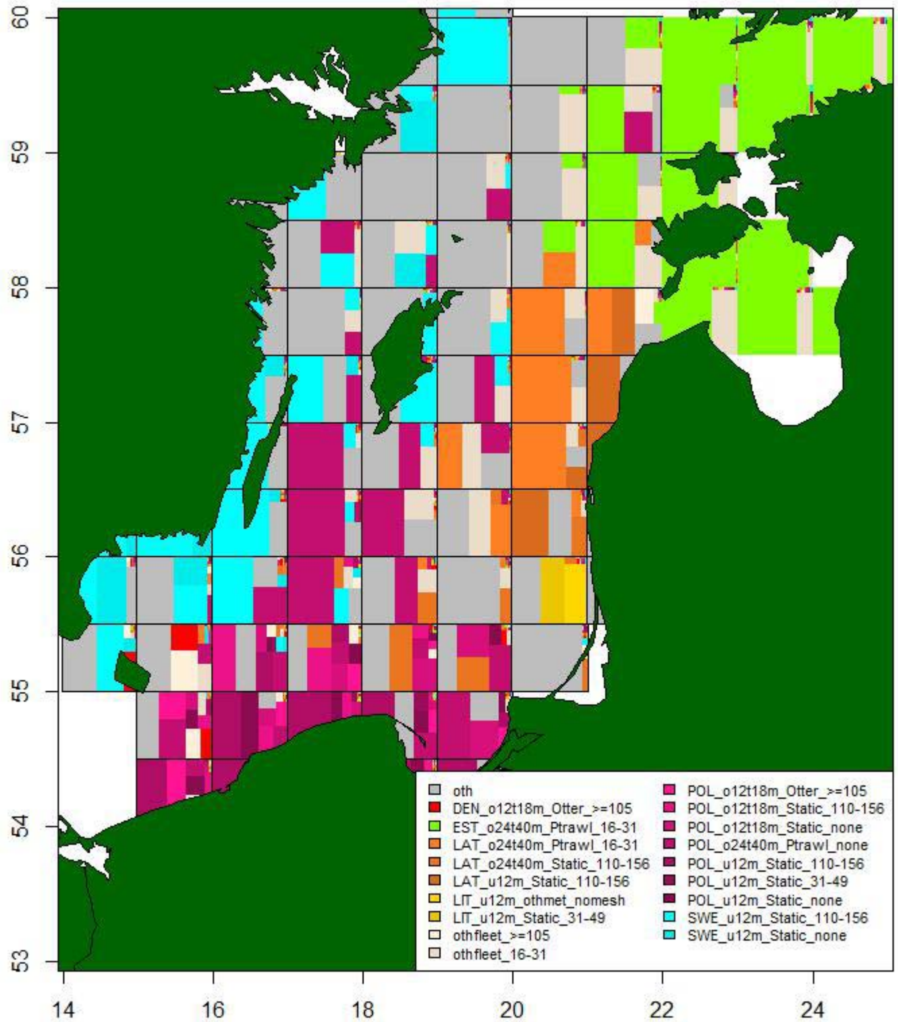


Figure xx: Effort proportion per ICES statistical rectangle in the Eastern Baltic Sea (presented as a squarified tree map i.e. in each ICES rectangle, a given colored area is proportional to the total effort in days at sea in this rectangle) for the main fleet-segments.

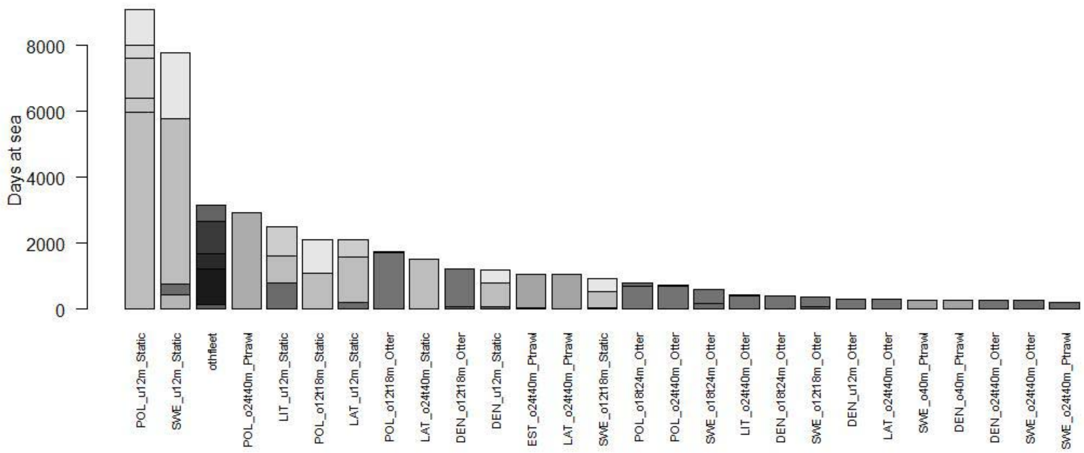


Figure xx: Days at sea in 2010 per fleet-segment (bars are further split per metier, no legend given here).

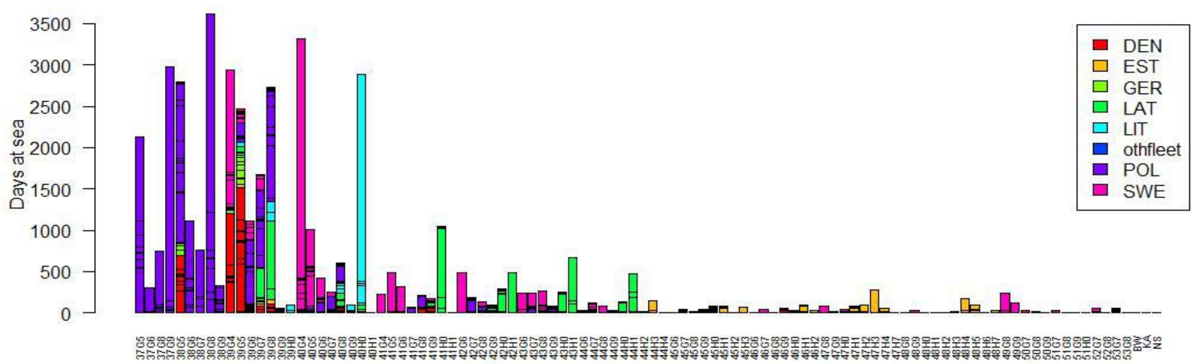


Figure xx: Days at sea in 2010 per ICES rectangle (belonging to Eastern Baltic Sea) for aggregated fleet-segment per countries (bars are further split per metier, no legend given here).

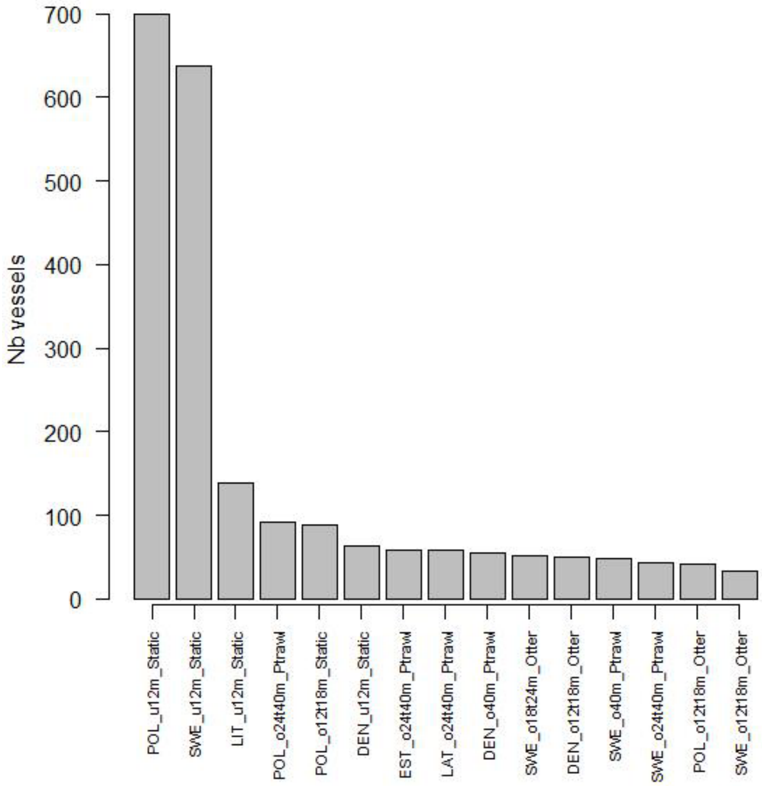


Figure xx: Capacity in terms of number of vessels (active in Eastern Baltic Sea) for aggregated fleet-segment per countries. (Top 15 fleets only, other fleets are omitted).

Table xx: Catching power (C.P.) and landings in tons (L.) per fleet-segment per species. C. P. coefficients were obtained from the application of a poisson regression on LPUE data (i.e. lpue(i) ~ beta1 x fleet_segment(i) + beta2 x year(i)+ beta3 x quarterSD(i)). A C.P. of 1 indicates the reference fleets while each reference fleet relates to different species. Reference fleets are basically the fleets contributing the most to the total landings. Catching power calculation intends to characterize relative productivity of each fishing effort unit.

FLEET-SEGMENTS (METIERS)	C.P. COD	C.P. SPR	C.P. HER	L. OTH	L. COD	L. SPR	L. HER
SWE_o18t24m_Otter_>=105	1	0	0	42	4331	>1	
DEN_o24t40m_Otter_>=105	0.85195232	0	0	12	2574	>1	
LIT_o24t40m_Otter_>=105	0.75675027	0	0	1	1980	>1	
othfleet_>=105	0.66568927	0.4216791	0.00027	401	4785	>1	
SWE_o24t40m_othmet_nomesh	0.62762269	2.1660525	0.750518	19	2338	14330	26
EST_o24t40m_othmet_nomesh	0.57656296	0	0	>1	266	>1	
LAT_o24t40m_Otter_>=105	0.55155331	0	0	58	2414	>1	
SWE_o12t18m_Otter_>=105	0.51945693	0	0	28	1589	>1	
DEN_o18t24m_Otter_>=105	0.47135513	0	0	33	2055	>1	
othfleet_nomesh	0.42973328	0.4189161	0.5855496	11	14	1705	
DEN_o12t18m_Otter_>=105	0.35395482	0.0026215	0.000303	493	4331	>1	
POL_o24t40m_Otter_>=105	0.26427469	0	0	1494	2413	>1	
LAT_o24t40m_othmet_nomesh	0.25966238	0.0211322	0	0	>1	>1	
POL_o12t18m_Otter_>=105	0.21024562	0	0.0004103	3320	2478	1	
POL_o24t40m_othmet_nomesh	0.20824874	1.1058846	0.0388172	0	28	>1	

POL_o18t24m_Otter_>=105	0.19292271	0	0.0002906	1679	1470	>1	
DEN_u12m_Otter_>=105	0.17097241	0	0.0003908	41	526	>1	
othfleet_110-156	0.14731252	0	0.0003908	2	701	>1	
DEN_u12m_Static_none	0.12620463	0	0.0004575	65	272	>1	
LAT_o24t40m_Static_110-156	0.12263145	0	0	3	2298	>1	
POL_o12t18m_Static_110-156	0.12241446	0	0	258	1304	>1	
EST_o24t40m_Ptrawl_16-31	0.08899244	0.8152202	0.1619491	0	>1	17072	43
DEN_u12m_Static_110-156	0.08706095	0	0.0004287	52	467	>1	
DEN_u12m_othmet_nomesh	0.08239877	0	0.0004113	19	18	>1	
POL_u12m_Static_none	0.08110458	0.0011865	0.0004828	59	1257	>1	
LAT_o24t40m_Ptrawl_16-31	0.07944877	0.8309636	0.0399928	6	136	3506	42
SWE_u12m_Static_none	0.06809135	0.053484	0.0037461	85	350	11	
POL_o12t18m_Static_none	0.04412642	0	0	280	182	>1	
POL_u12m_Static_110-156	0.04313036	0	0	2631	2219	>1	
othfleet_none	0.04228419	0.3066172	0.038512	94	>1	646	3
othfleet_16-31	0.03949208	1.8925408	0.2365067	1	61	7683	47
SWE_o12t18m_Static_110-156	0.03652831	0	0.0003415	4	214	>1	
SWE_u12m_Static_110-156	0.02883735	0	0.0003389	74	953	>1	
SWE_o12t18m_othmet_nomesh	0.02739994	1.6440415	0.6919565	1	>1	1597	2
SWE_o12t18m_Static_none	0.01902747	0	0	46	83	>1	
LIT_u12m_othmet_nomesh	0.01803318	0	0	10	33	>1	
SWE_u12m_othmet_nomesh	0.01717807	0.0025702	0.0978374	31	22	538	
SWE_o18t24m_othmet_nomesh	0.01175715	1.9706297	0.4691221	12	7	2871	3
LIT_o24t40m_othmet_nomesh	0.01067612	0	0.0980208	0	>1	22	
LAT_u12m_Static_110-156	0.00836909	0	0.0001897	37	92	>1	
DEN_o24t40m_othmet_nomesh	0.00820803	4.9798028	0.7406536	0	>1	382	
OTH_u12m_Static_none	0.00774068	0.0005161	0.001183	1473	44	6384	
LIT_u12m_Static_110-156	0.0076895	0	0	8	102	>1	
DEN_o12t18m_othmet_nomesh	0.00558804	0.5867104	0.2331953	0	1	879	
SWE_u12m_Static_>=220	0.00473899	0	0.0001621	20	1	>1	
POL_u12m_Static_60-69	0.00455409	0	0.0004511	138	2	4	
POL_o24t40m_Ptrawl_none	0.00412509	1	0.0802795	4	57	20026	54
POL_o18t24m_othmet_nomesh	0.00350651	0.0517289	0.0350458	0	>1	213	
LAT_u12m_Static_31-49	0.00348459	0	0.0003471	6	>1	14	
LAT_u12m_othmet_nomesh	0.00305867	0	0.0001132	10	>1	>1	
POL_u12m_Static_31-49	0.00261956	0	0.0380609	200	6	1787	
POL_o12t18m_othmet_nomesh	0.00240087	0.0629407	0.0503245	6	>1	208	
POL_u12m_Static_157-219	0.00229466	0	0.0002906	59	1	>1	
DEN_o18t24m_othmet_nomesh	0.00215556	1.0587758	0.5429886	0	>1	21	
SWE_o40m_Ptrawl_16-31	0	3.2153176	1	0	>1	22097	44
DEN_o40m_Ptrawl_16-31	0	2.2966675	0	0	>1	>1	24
DEN_o40m_othmet_nomesh	0	2.0268082	0	0	>1	>1	
SWE_o40m_othmet_nomesh	0	1.4288546	1.1559978	0	>1	178	
LIT_u12m_Static_31-49	0	0	0.001717	0	>1	71	

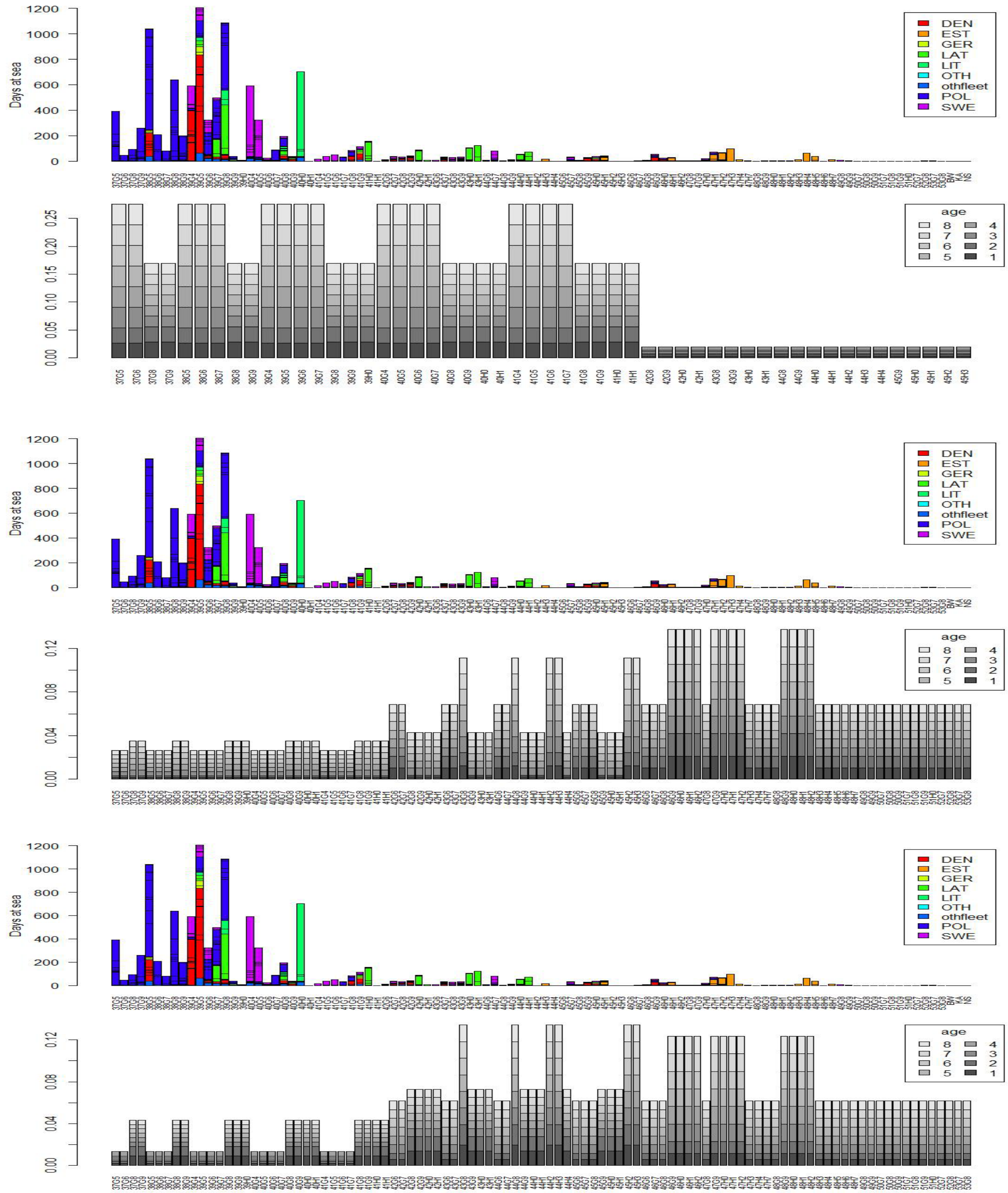


Figure xx: Fishing effort per aggregated fleet-segment and relative stock availability per age (see the text for details, no unit but sum up to 1 per age per quarter) per ICES rectangle during the 1st quarter of the year (average over the period 2005-2010?) for cod, sprat and herring.

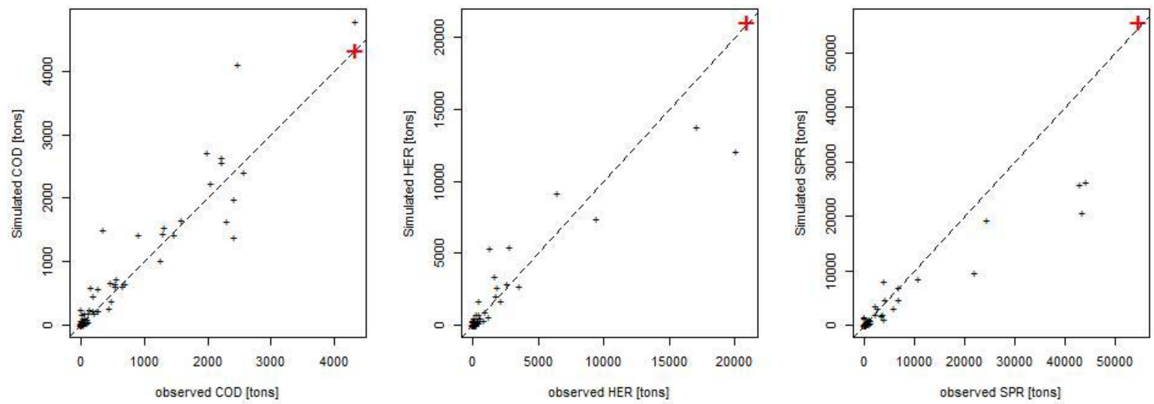


Figure xx: Comparison between observed and simulated landings in tons for the calibration year (2010) for cod, herring and sprat, respectively. The line 1:1 is given in dashed line. Each cross is a fleet-segment. The particular red crosses are the 3 fleet-segments of reference (one reference per stock i.e., SWE_o18t24m_Otter_>=105, for cod, POL_o24t40m_Ptrawl_none for sprat, SWE_o40m_Ptrawl_16-31 for herring).

Table xx: Comparison between observed and simulated 2010 landings in tons per species for the simulated landings, the official TAC for 2010 (EC No 1226/2009) and the actual landings (ICES WGBFAS 2011). The goodness of fit of the calibration is given by comparing the simulated landings with the actual landings.

cod

COUNTRY	sim	quota	actual_land
DEN	11064	11777	10739
GER	4628	4685	3908
SWE	10604	11932	10169
LAT	3273	4379	5001
LIT	3219	2885	3140
POL	14623	13561	11433
EST	762	1148	796
FIN	0	901	826

spr

COUNTRY	sim	quota	actual_land
DEN	31711	37480	34900

GER	16111	23745	15900
SWE	66008	72456	68800
LAT	28132	52565	45900
LIT	8456	19015	9190
POL	60840	111552	56600
EST	39139	43522	47900
FIN	1573	19620	24400

her

COUNTRY	sim	quota	actual_land
DEN	5023	2780	5367
GER	3213	737	2235
SWE	58610	42268	50037
LAT	2951	3504	3903
LIT	3351	3689	1492
POL	15093	31486	25028
EST	20214	14198	17915
FIN	10975	27714	21602

The calibration phase is critical to mimic:

The total amount of landings that will link to the population removals in the feedback loop between fleet and stocks dynamics

The amount of landings per fleet-segments (e.g., at the country level) that will link with fleet-specific economic indicators

2. Runs

The results are presented yearly by aggregating the quarterly estimates.

2.1 Population/harvesting indicators

2.1.1 Baseline 1

To illustrate the response of the current fishery to Long Term Management Plan (LTMP) and current HCR for pelagic stocks, baseline runs were carried out with the simulation settings as follows:

<u>Effort application</u>

Spatial and temporal effort allocation per segment is kept constant (i.e. identical to the 2010 calibration year, unless TAC is exhausted for certain species and reallocation occurs)

Possible reduction/increase of effort per vessel on a year to year basis given the changing allowed effort per vessel decided by the cod plan (for segments with mesh size >90mm only as specified in the plan)

Constant capacity in terms of number of vessels: no entry/exit

Constant capacity in terms of number catching power: no technological creeping

Exploitation pattern from ICES XSA, the same for all segments

Populations

Constant spatial and seasonal stock-specific distribution

Constant SMS parameterisation (i.e. diet, weight at age, etc.)

Management

Either XSA assessment from WGBFAS 2011 + observation error at 0.3 on catches

Or mimicked assessment using var-covar matrix and multinomial distribution to add noise on true N

Fmsy=F target at 0.3 for cod, 0.35 for sprat and 0.16 for central herring

TAC interannual stability criteria of +/-15%

TAC share from relative stability

Effort reduction according to the cod plan, i.e. applied to T90mm fleet-segments.

Fleet reaction

Discard and effort displacement in case of exhausted TAC

Bio-economy

ad hoc fixed price (cod= 2 euro/kg, spr=0.5 euro/kg, herring= 0.5 euro/kg)

Constant fleet capacity therefore constant fixed costs

Variable costs vary depending on effort per vessel

No dynamic/feedback effects on fleet reaction from fleet economic indicators

No dynamic/feedback effects on price of stock unit

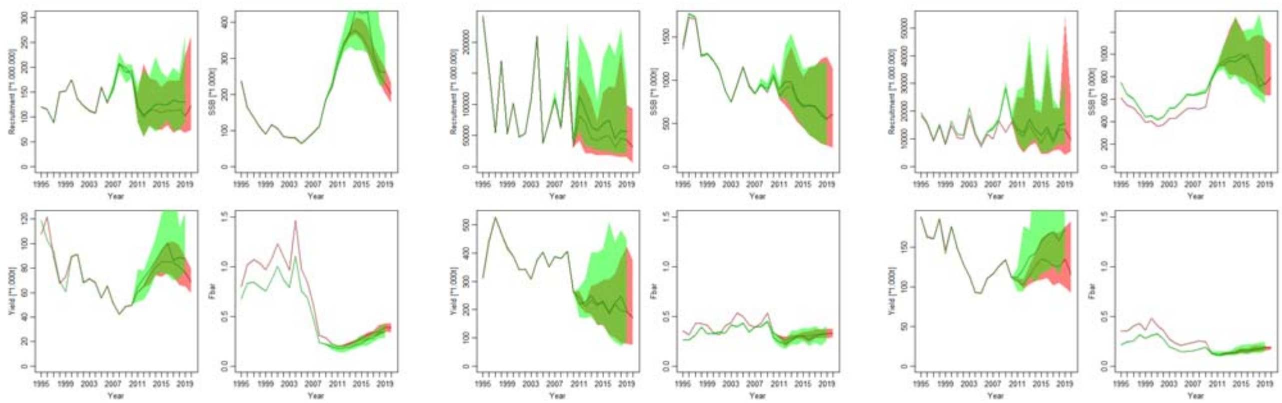


Figure xx: Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment, top-right: SSB, bottom-left: Yield, bottom-right: Fbar). 100 stochastic stocks have been simulated for this baseline scenario where the solid line give the median trajectory and the dashed line the 5 and 95% percentiles. Perceived stock in green, true stock in red.

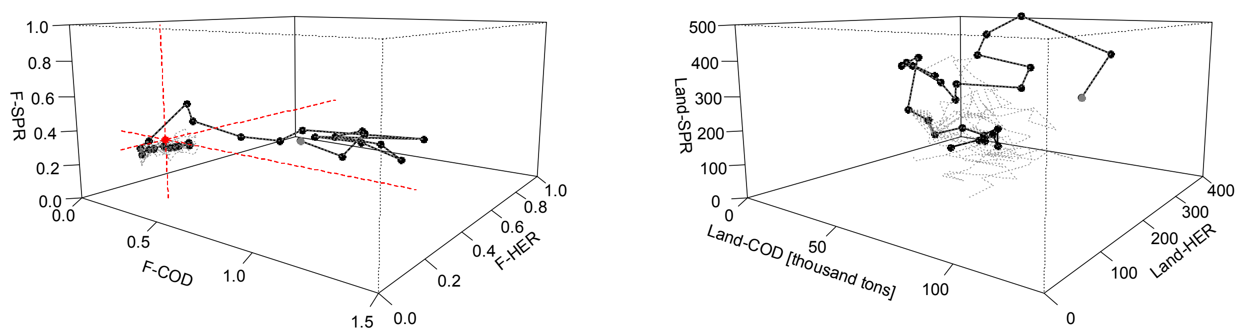


Figure xx: 3d line plot of a- the fishing mortality (Fbar) and b- the landings (in thousand tons) in the three species space (cod, sprat and herring). The solid line gives the median trajectory of the set of runs while the dotted grey lines give individual trajectories. The intersection of the three F Targets is given in red.

2.1.2 Baseline SMS

The baseline SMS (i.e. run 3) is identical to baseline 1 unless incorporating the SMS OM in place of the default single-species oriented OM.

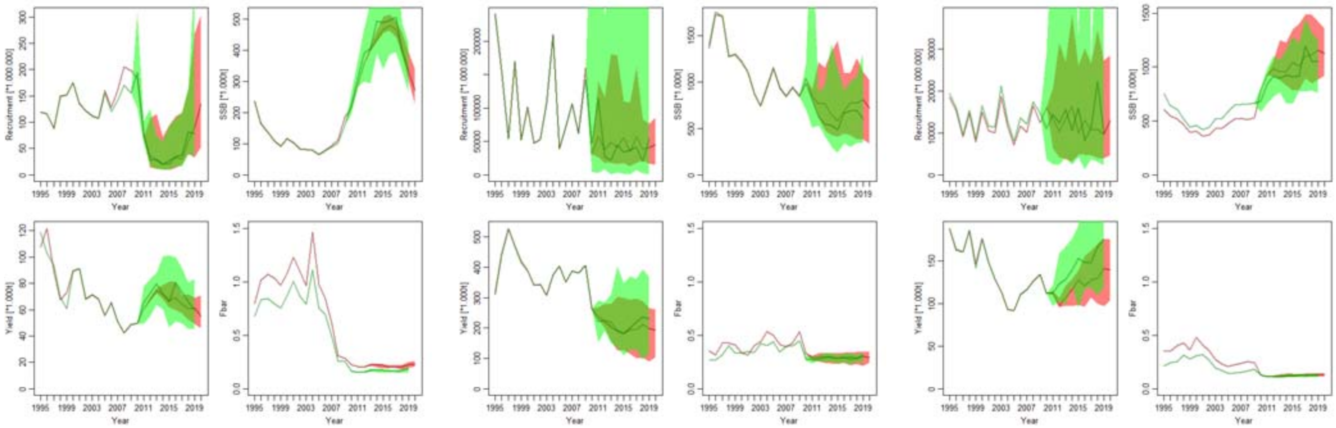


Figure xx: Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment (age 2, 1 and 1 for cod, sprat and herring, resp.), top-right: SSB, bottom-left: Yield, bottom-right: Fbar). 100 stochastic stocks have been simulated for this baseline scenario where the solid line give the median trajectory and the dashed line the 5 and 95% percentiles. Perceived stock in green, true stock in red.

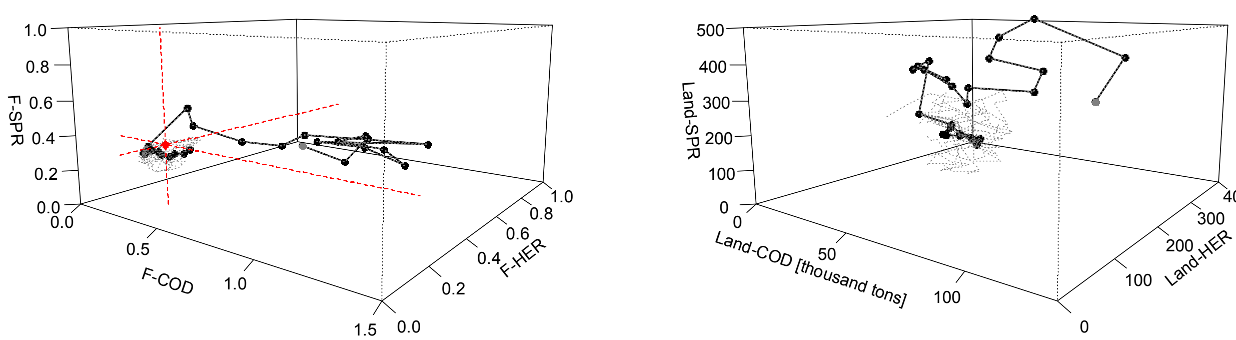


Figure xx: 3d line plot of a- the fishing mortality (Fbar) and b- the landings (in thousand tons) in the three species space (cod, sprat and herring). The solid line gives the median trajectory of the set of runs while the dotted grey lines give individual trajectories. The intersection of the three F Targets is given in red.

2.1.3 baseline vs. baseline SMS

Plot OM on the same graph window

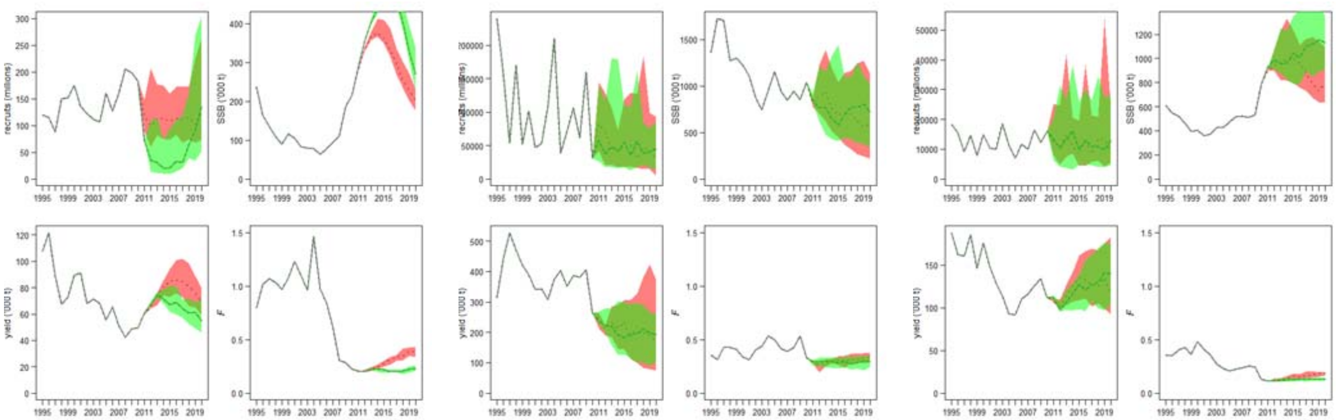


Figure xx: Baseline 1 (runs 2, red) vs. baseline SMS (runs 3, green) - Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment, top-right: SSB, bottom-left: Yield, bottom-right: Fbar). 100 stochastic stocks have been simulated for this baseline scenario where the solid line gives the median trajectory and the dashed line the 5 and 95% percentiles.

The main difference between the two runs is the abundance in age 2 for cod (recruitment for fishery) which is lower for SMS due to predation associated to a larger cod stock. This led to a lower cumulated yield while SSB is the same.

2.1.4 Baseline SMS (single species FMSY) vs. HCR1 (multi-species FMSY)

Plot on the same graph window

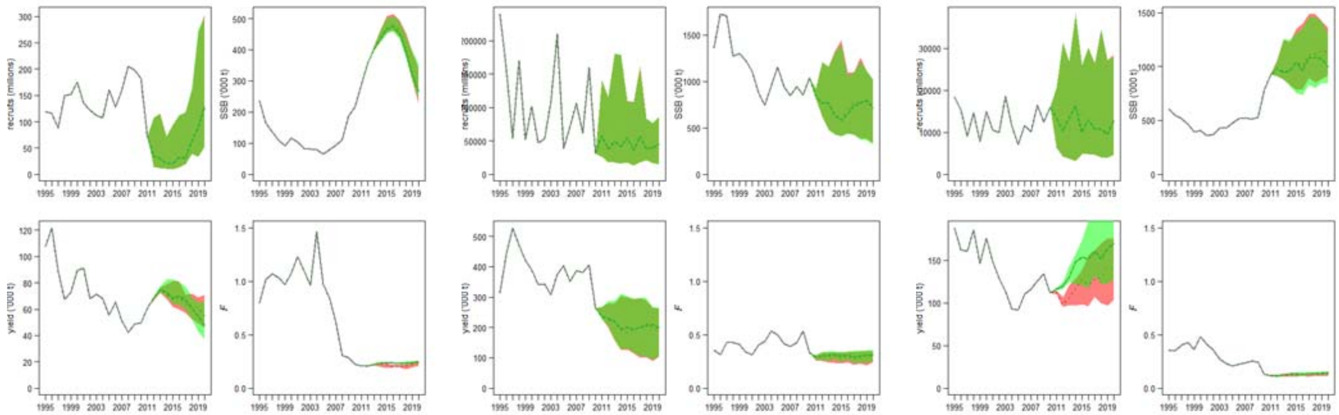


Figure xx: baseline SMS (runs 3, red) vs. HCR1 (runs 4, green) - Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment, top-right: SSB, bottom-left: Yield, bottom-right: Fbar). 100 stochastic stocks have been simulated for this baseline scenario where the solid line gives the median trajectory and the dashed line the 5 and 95% percentiles.

The change of target from single-species FMSY to multi-species FMSY has almost no effect on the simulation trajectories in the present model settings. Even if TACs decided by the management procedure are increasingly higher than in the baseline situation, the model calibration and fixed spatial effort allocation makes fleets hard time to increase their own catches, also likely because of change in the exploitation pattern (e.g. for cod, less age 2 available). Therefore TAC are not fully taken for some given countries.

2.1.5 Relative effort change

Plot on the same graph window

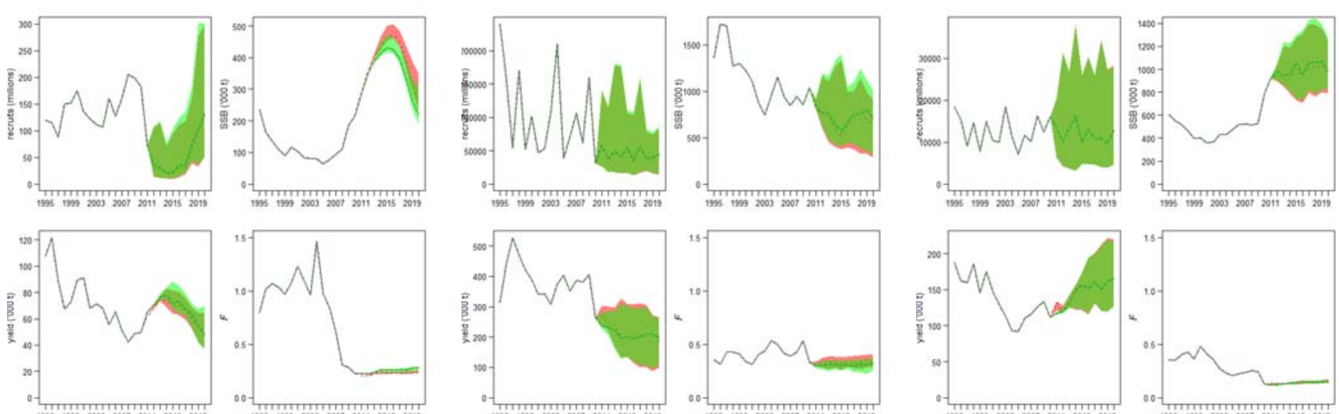


Figure xx: Pelagic effort +10% (runs 5, red) vs. Demersal effort +10% (runs 6, green) - Panels of indicators for a- cod, b- sprat, and c- herring projected over the period 2010-2020 (On each panel, top-left: Recruitment, top-right: SSB, bottom-left: Yield, bottom-right: Fbar). 100 stochastic stocks have been simulated for this baseline scenario where the solid line gives the median trajectory and the dashed line the 5 and 95% percentiles.

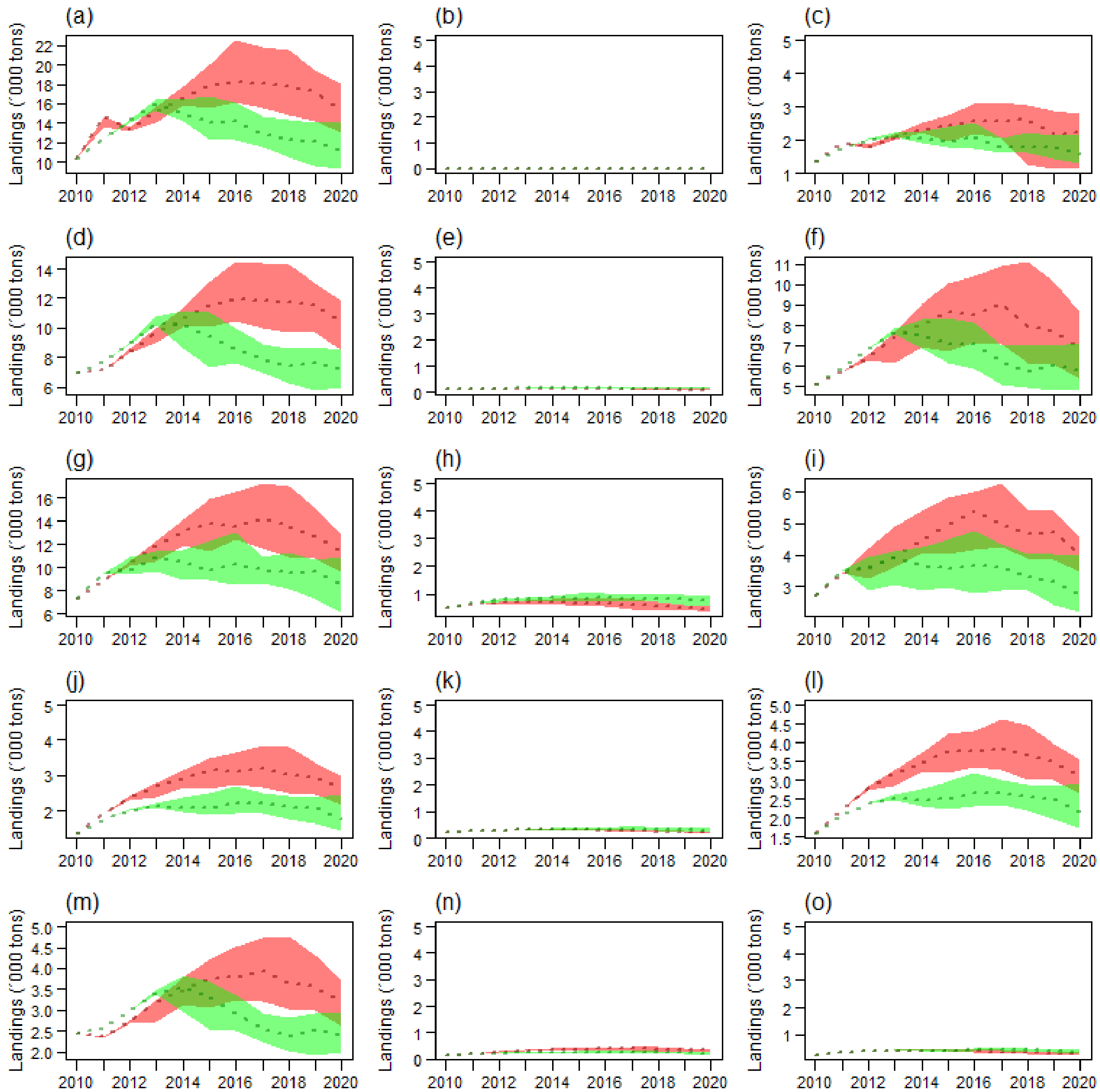
No striking difference at this aggregated level.

2.2 Bio-economic indicators

2.2.1 Baseline 1 vs. baseline SMS

Selected fleets a to o:

```
c("den.otter", "den.ptrawl", "den.static",
  "pol.otter", "pol.ptrawl", "pol.static",
  "swe.otter", "swe.ptrawl", "swe.static",
  "lat.otter", "lat.ptrawl", "lat.static",
  "lit.otter",               "lit.static",
  "est.ptrawl")
```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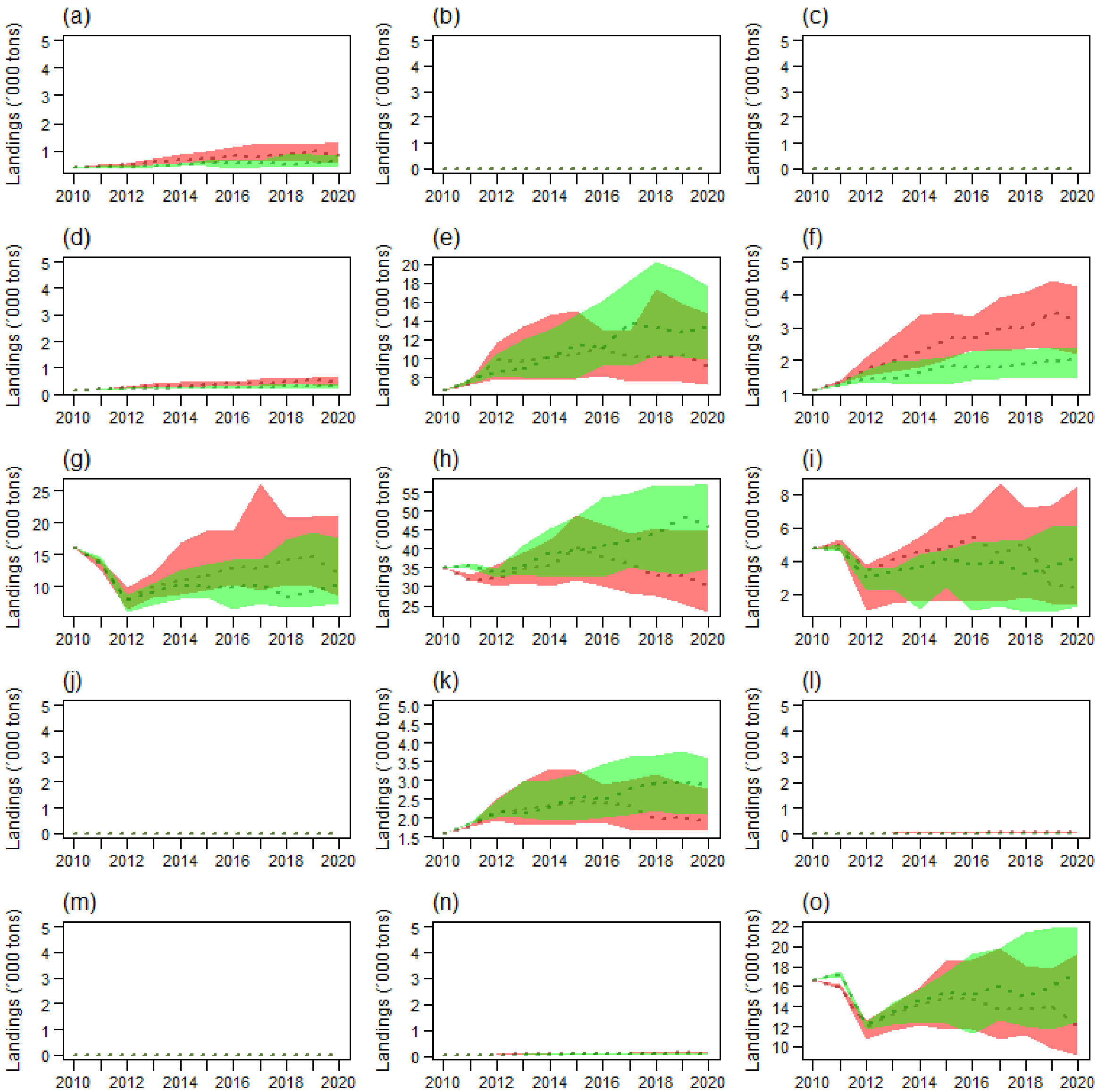
Landings ('000 tons)
2010
2012
2014
2016
2018
2020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Landings ('000 tons)
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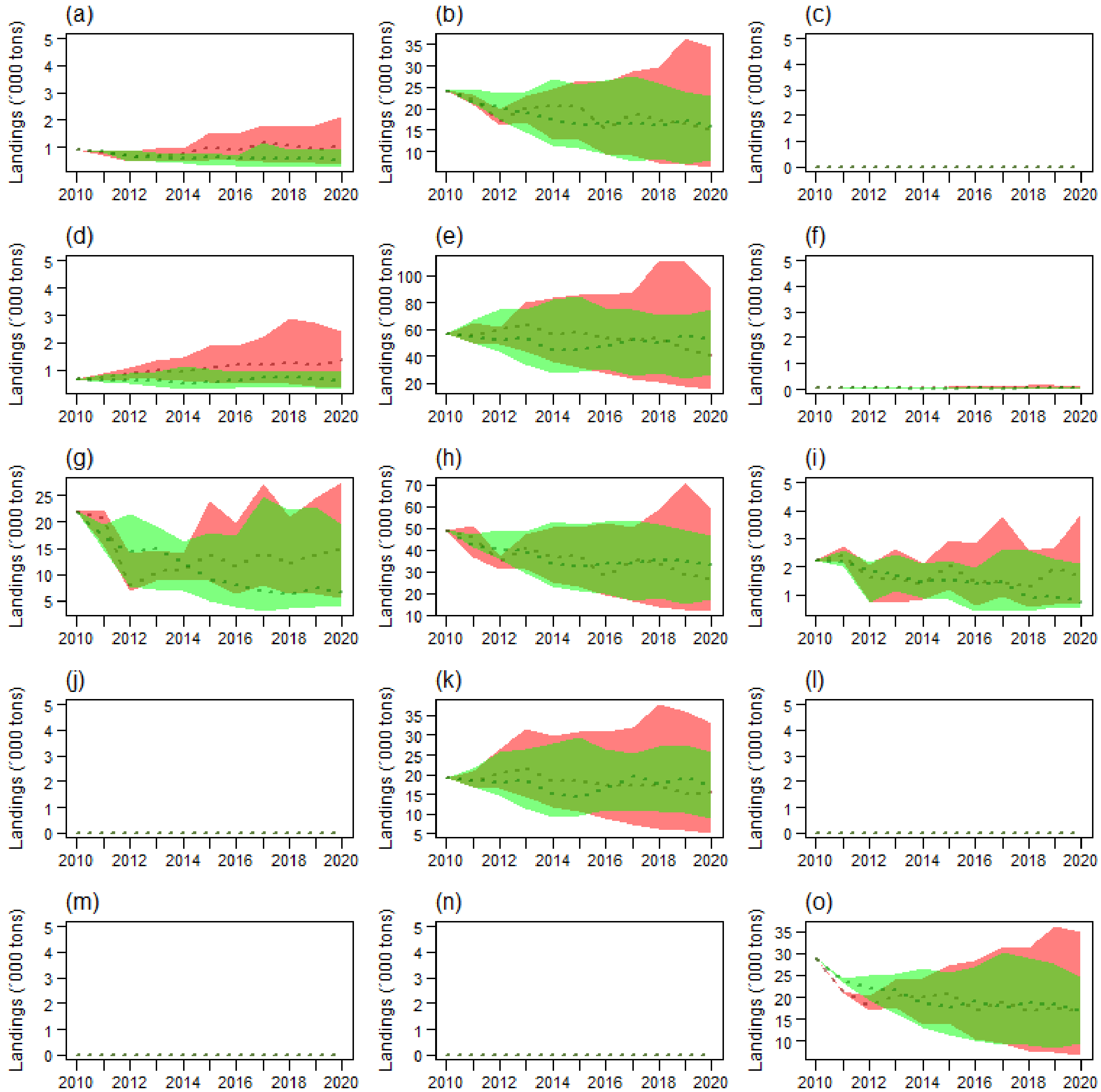
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Landings ('000 tons)
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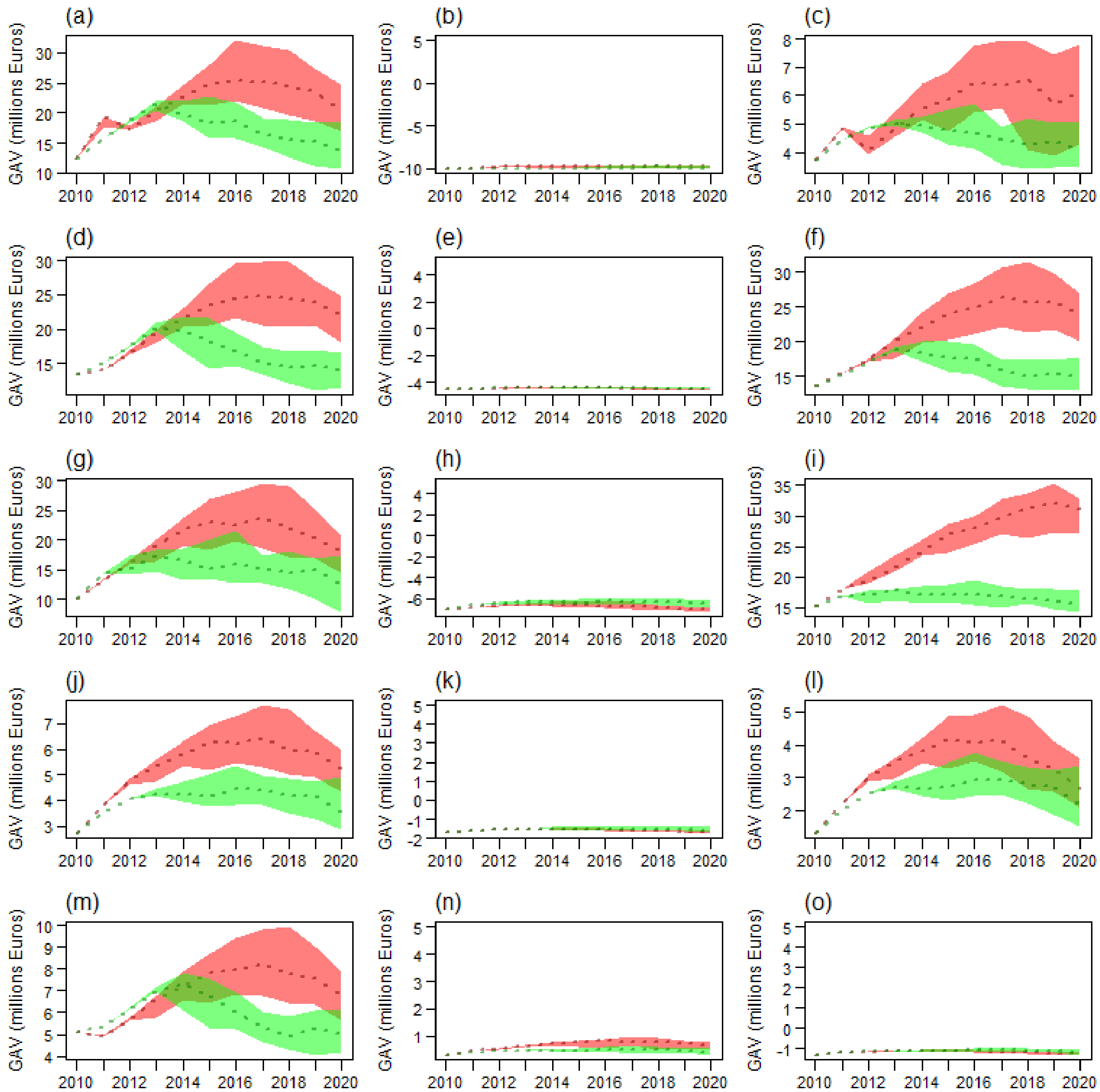


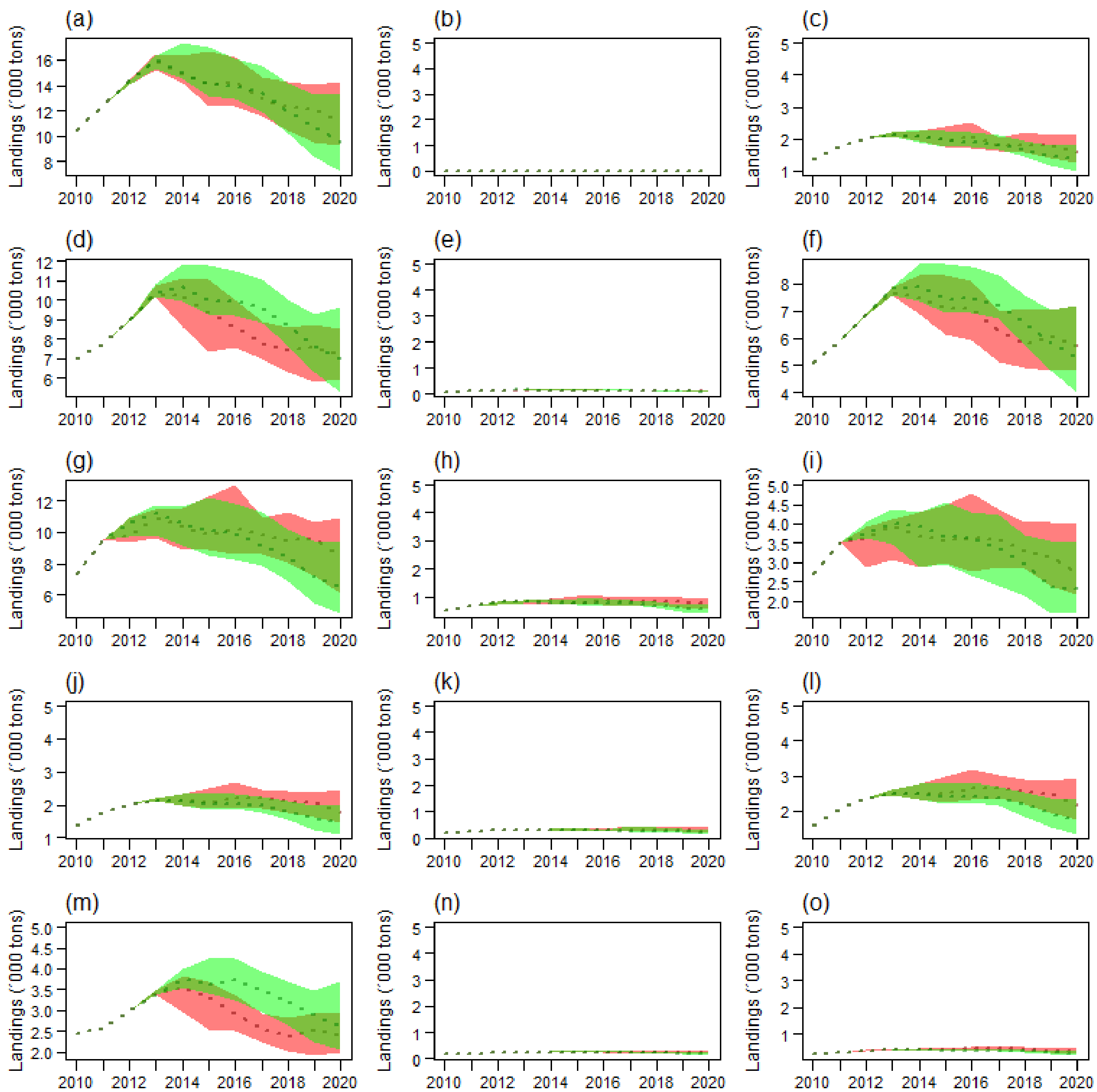
Figure xx: Landings for cod for selected fleets a to o

Figure xx: Landings for spr for selected fleets a to o

Figure xx: Landings for her for selected fleets a to o

Figure xx: Gross value added (GAV) for selected fleets a to o

2.2.2 baseline SMS vs. HCR1



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Landings ('000 tons)
2010
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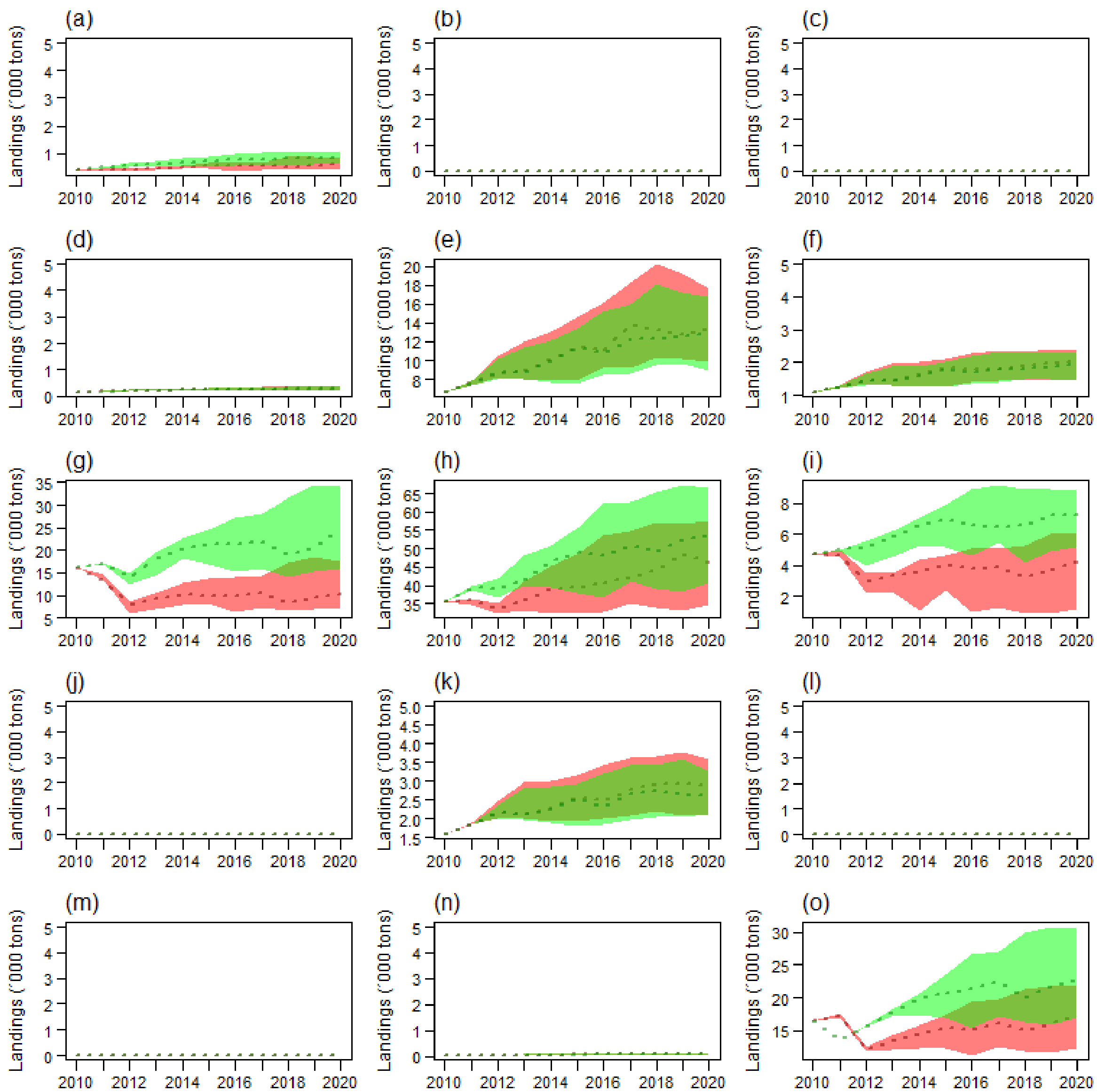
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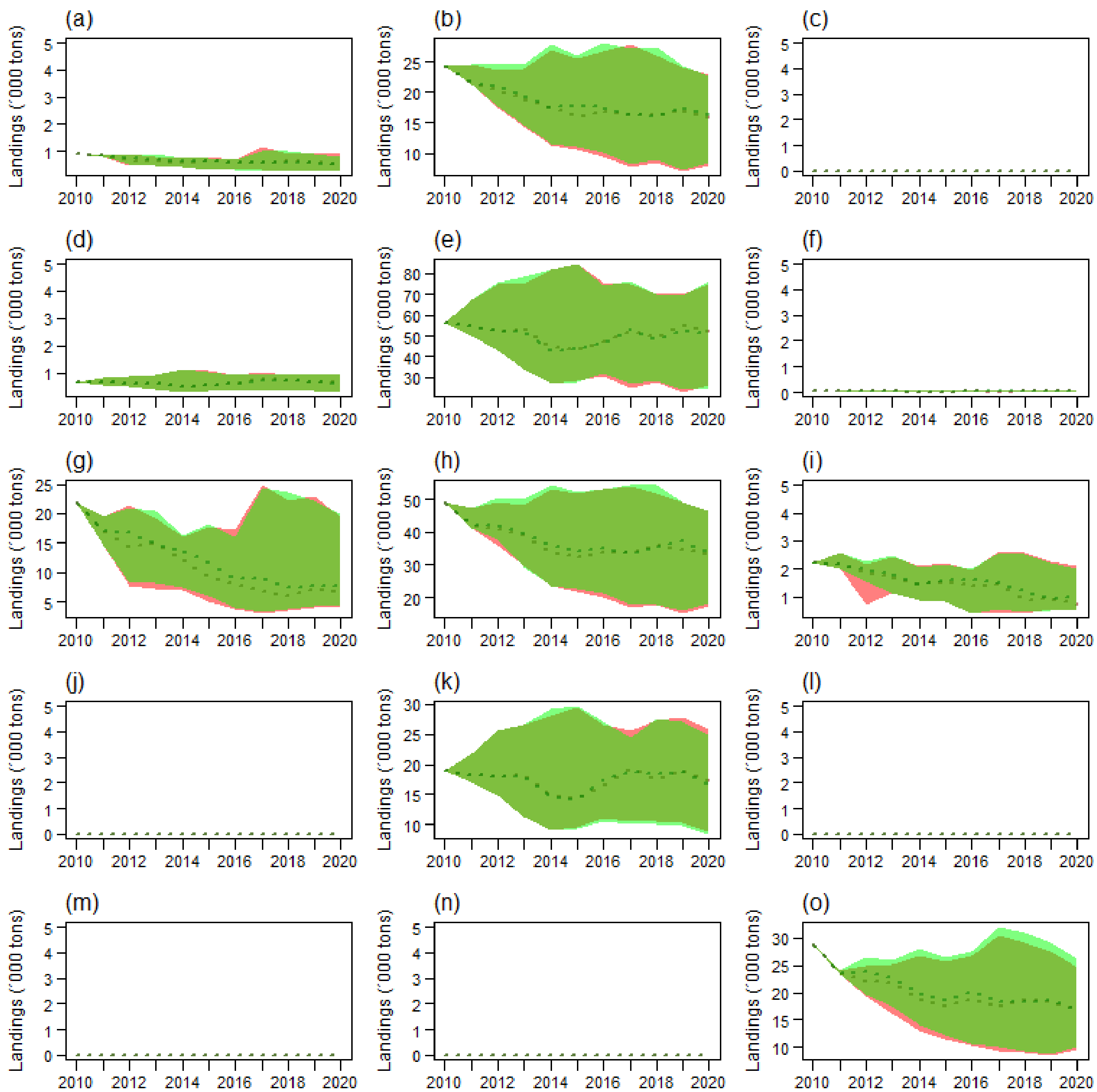
Landings ('000 tons)
2010 2012 2014 2016 2018 2020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Landings ('000 tons)
2010
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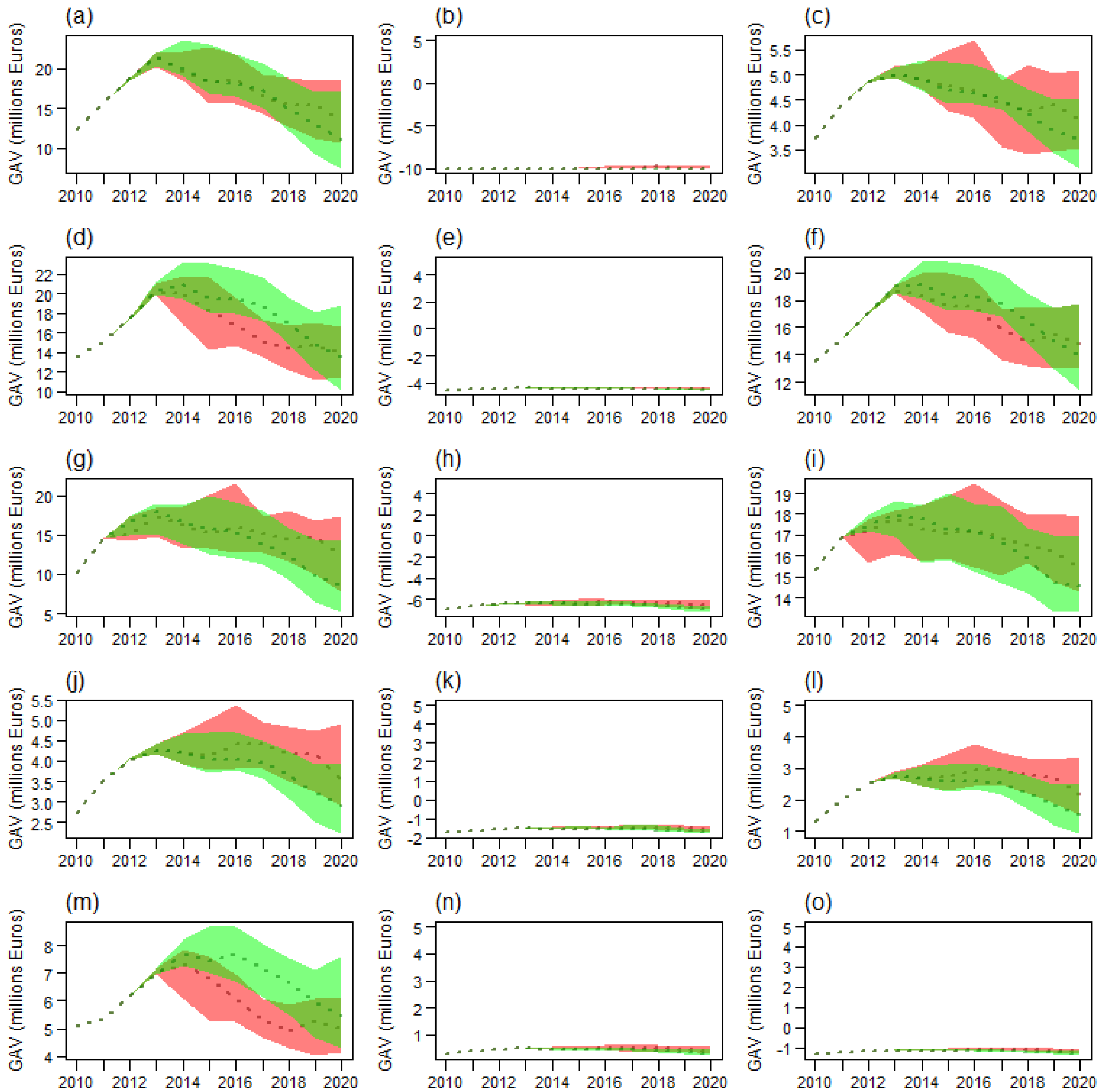

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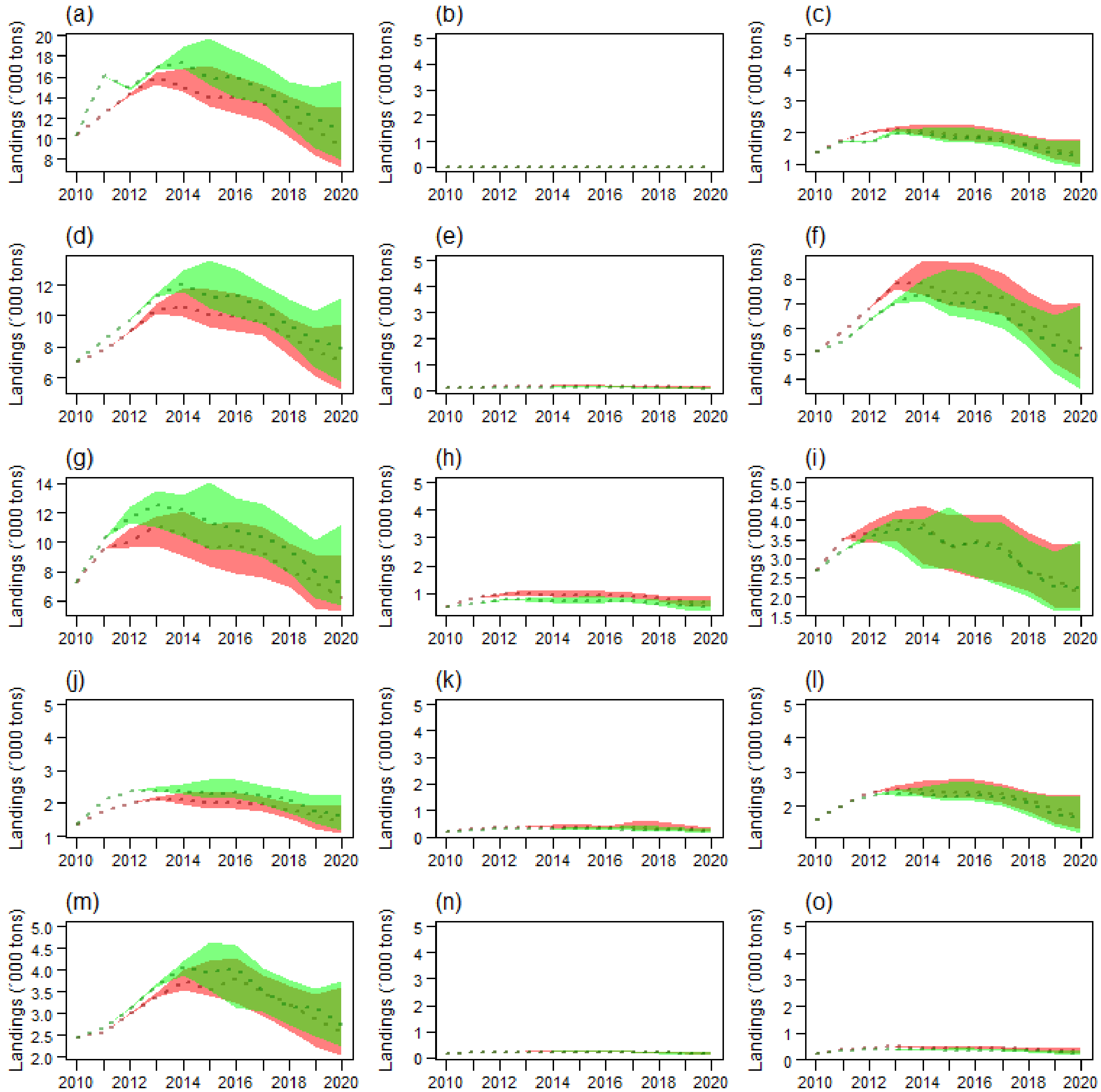
2.2.3 Effort: 10% pel vs. 10% demersal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Landings ('000 tons)
2010
2012
2014
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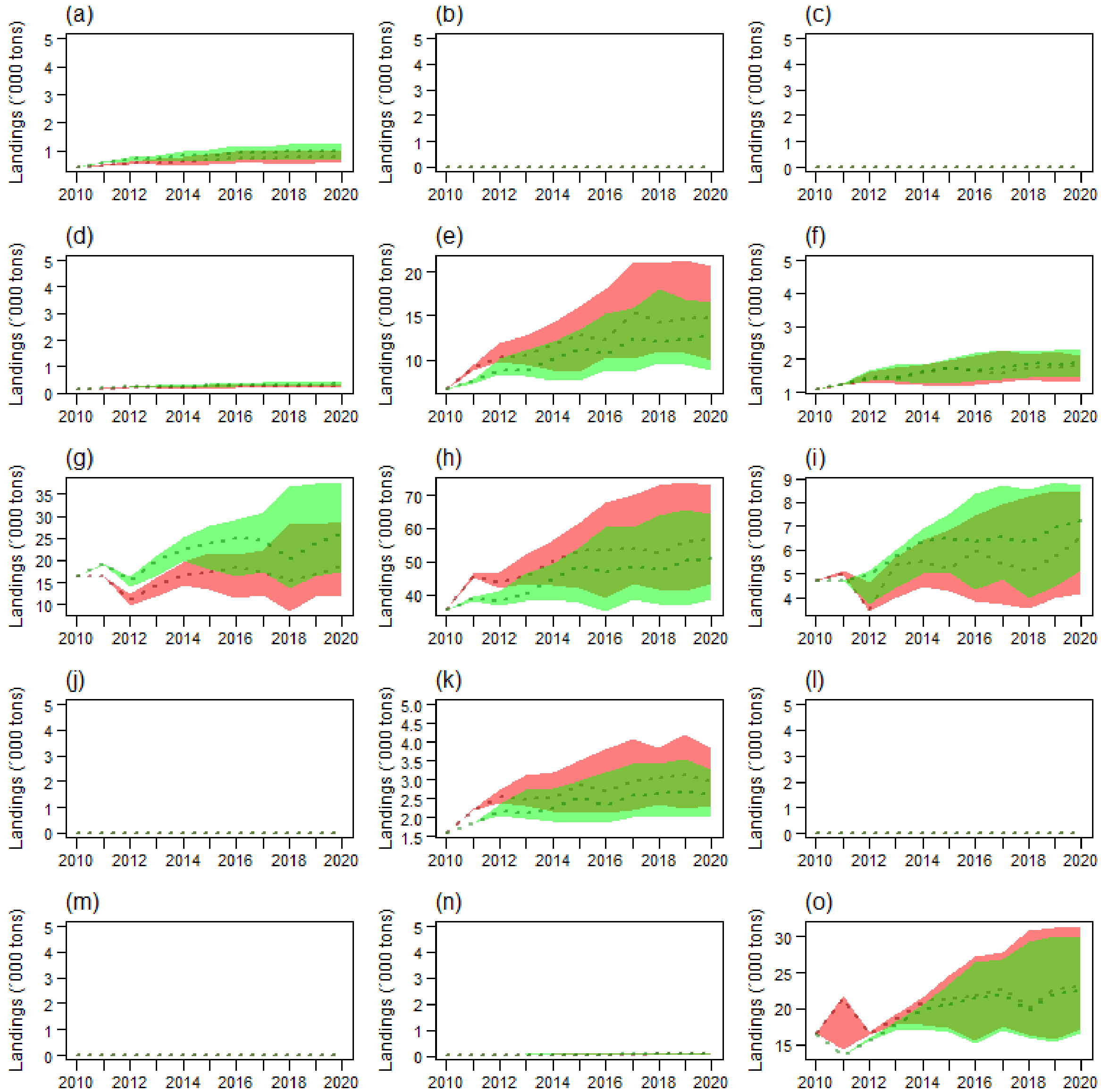
2020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Landings ('000 tons)
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2012
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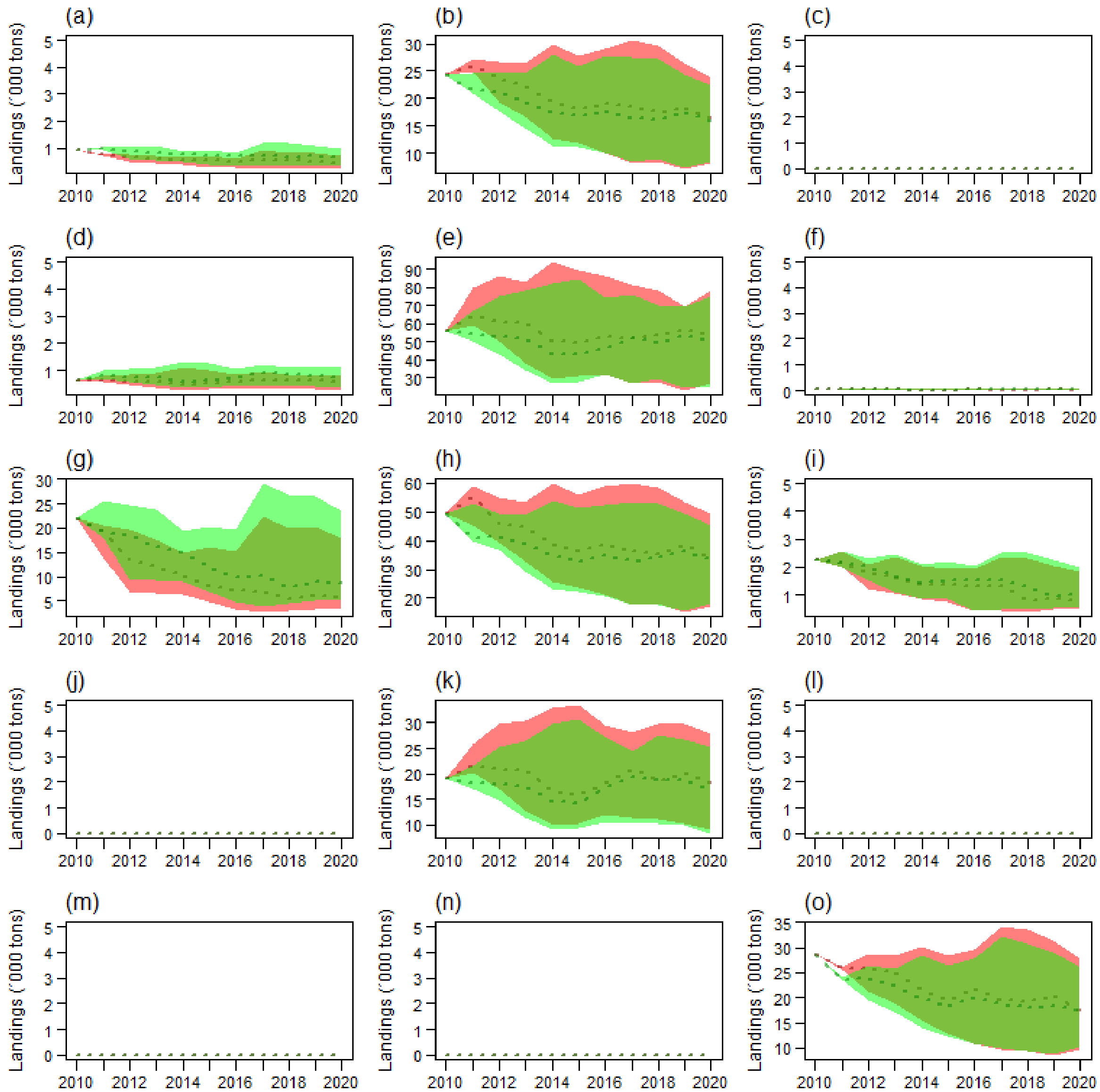
2016
2018
2020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Landings ('000 tons)
2010
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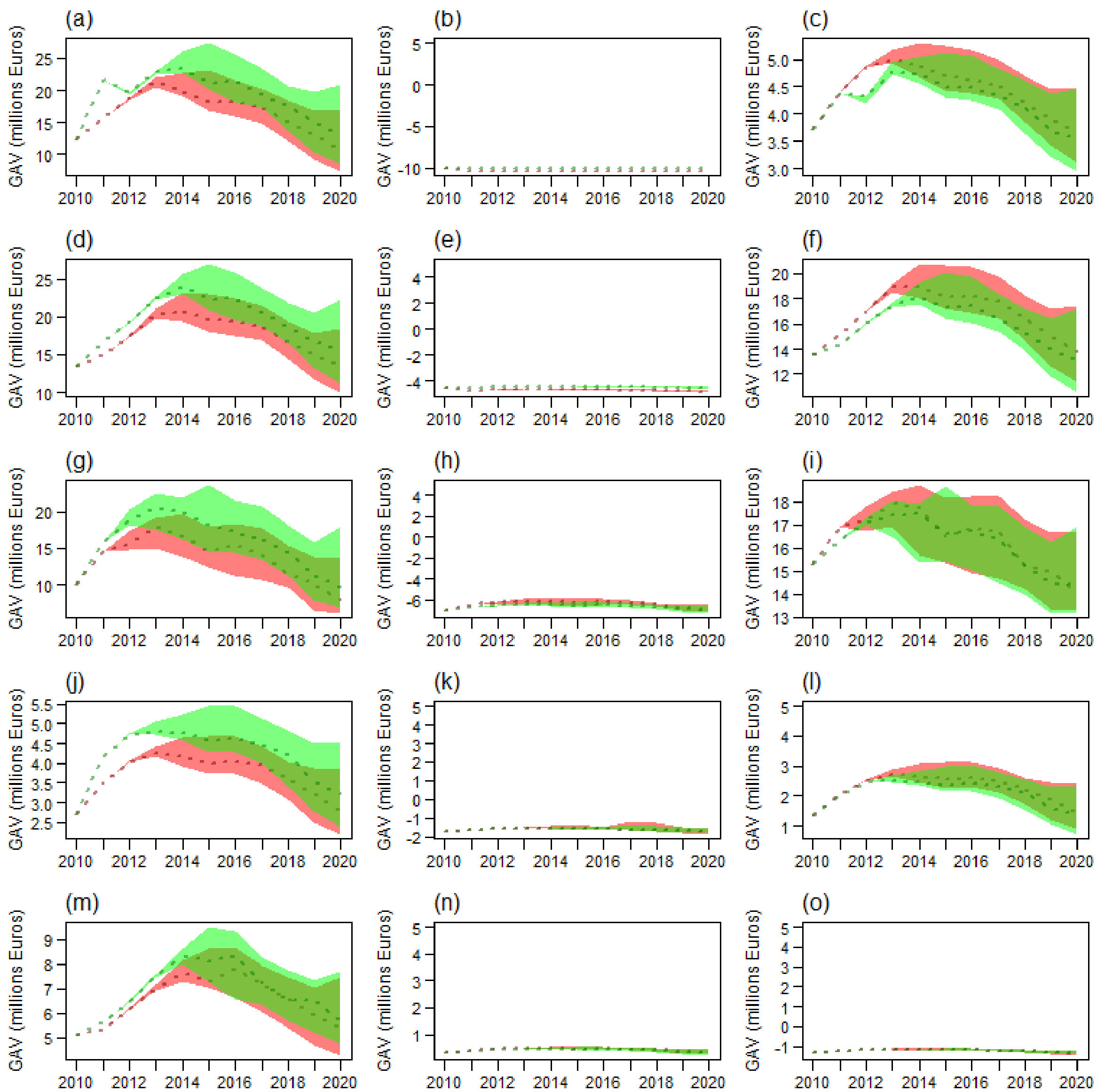
2018
2020



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(o)
GAV (millions Euros)
2010
2012
2014
2016
2018
2020

Probability plots

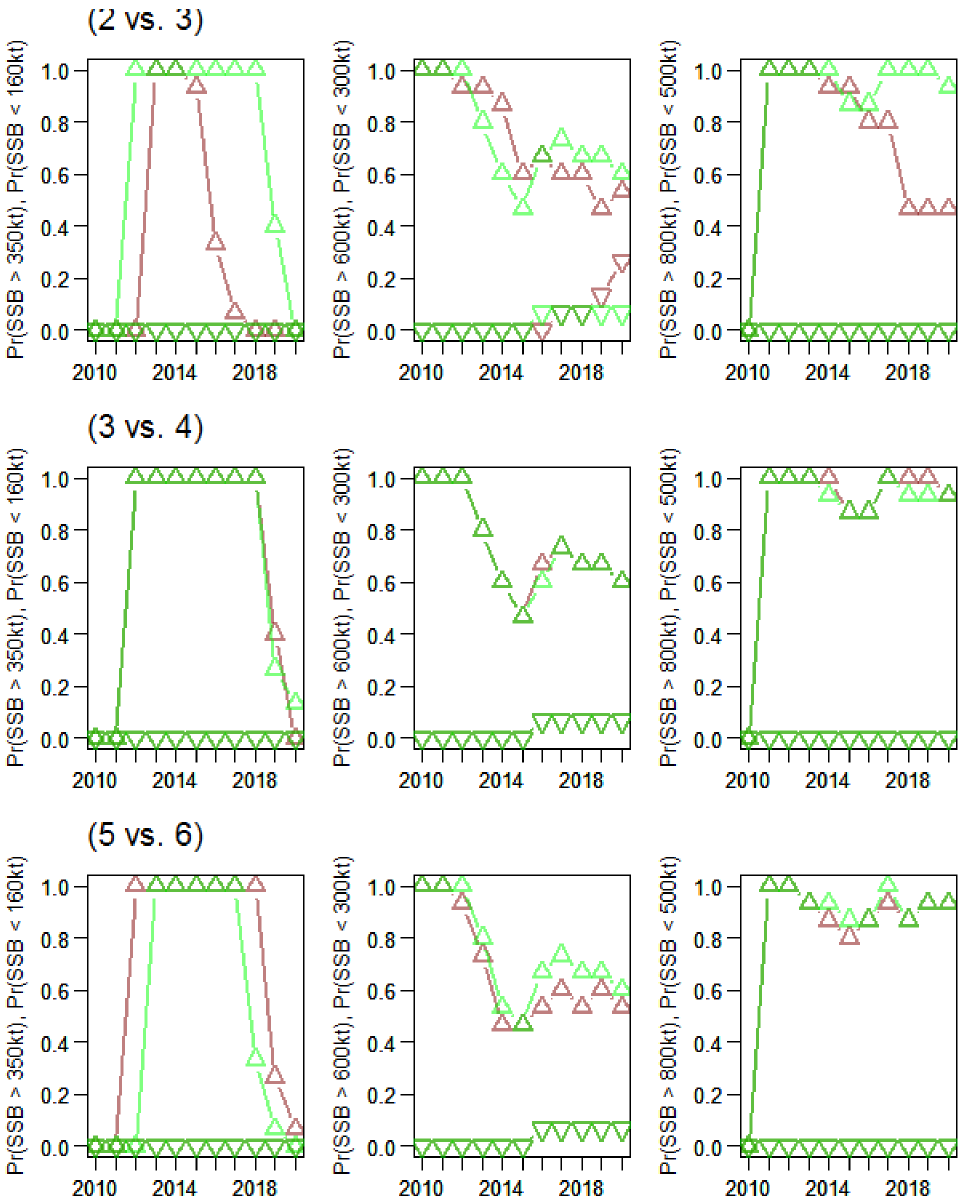

Figure xx: Probability plots of spawning stock biomass SSB being below (triangle) or above (triangle) biomass reference points for 2 by 2 comparisons (green vs. red) for cod, sprat and herring (from left to right).

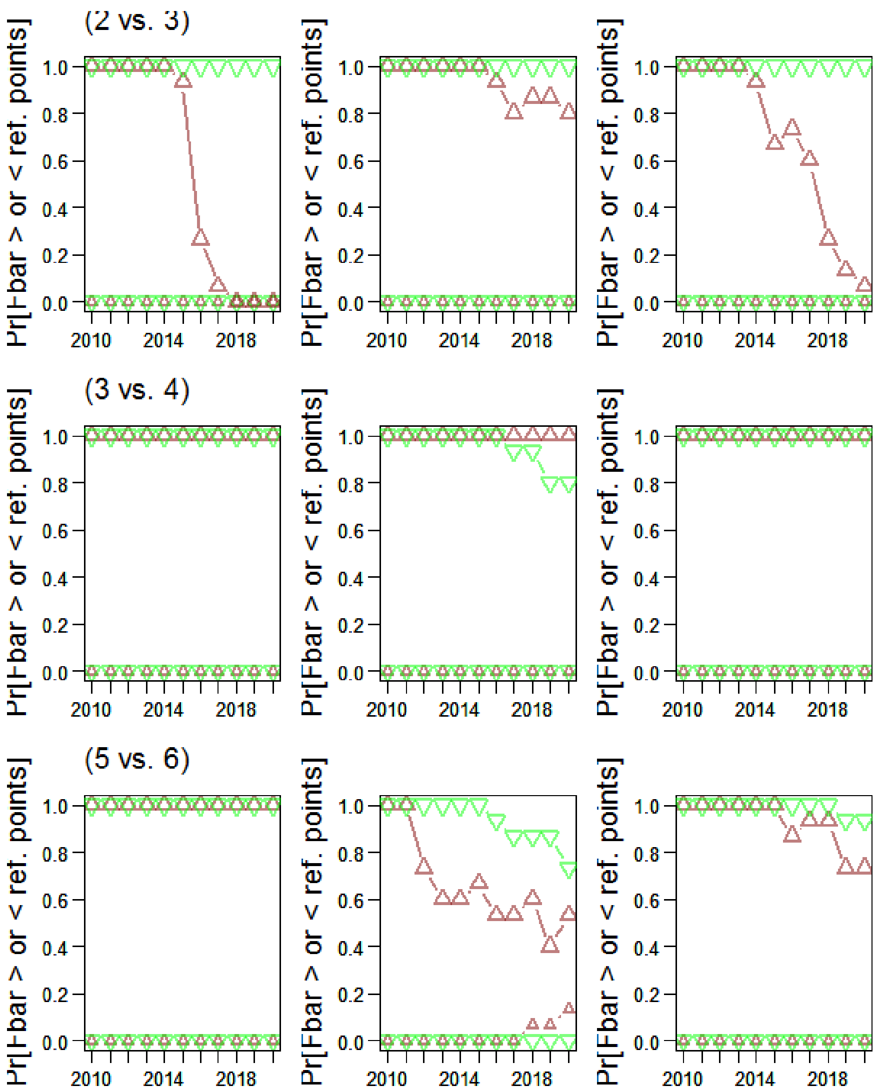

Figure xx: Probability plots of fishing mortality Fbar being below (lower triangle, single FMSY) or above (upper triangle, multi-species FMSY) F reference points for 2 by 2 comparisons (green vs. red) for cod, sprat and herring (from left to right).

References

Bastardie, F., Nielsen, J. R., and Kraus, G. 2010a. The eastern Baltic cod fishery: a fleet-based management strategy evaluation framework to assess the cod recovery plan of 2008. – ICES Journal of Marine Science, 67: 71–86.

Bastardie, F., Vinther, M., Nielsen, J. R., Ulrich, C. and Storr Paulsen, M. 2010b. Stock-based vs. fleet-based evaluation of the multi-annual management plan for the cod stocks in the Baltic Sea, Fisheries Research, 101: 188–202.

Annex A – FLR Baltic Model short description

It has been acknowledged that single fleet and non-spatial fishery modelling approaches might lead to bias in the outcomes of MSEs by ignoring the effect of heterogeneity of fishing practices and spatial effort allocations on various components of the stocks. Stress may be put on the spatial dimension of the exploitation of harvested stocks and dynamically integrate the combined effect of fleet, stock and management dynamics and to project the relative effect of different 'what if' scenarios. The resulting relationship F-stock is the conjunction between the diverse spatio-temporal fleet activities and the variable spatio-temporal stock availability.

Details that concerns the linkage between the population and the fisheries dynamics are provided in Bastardie et al. (2010) where the development of a fleet- (métier-) based bioeconomic model evaluating the 2008 cod management plan in the Baltic Sea within a Management Strategy Evaluation framework (MSE) is reported. The application has been used for impact assessments of Baltic cod so far, but it the procedure can be extended to apply for the sprat and herring stocks. Modelling of fisheries dynamics can also be done.

1- The modelling of effort is explicit, so that the overall stock-F is an aggregation of fleet-specific Fs, knowing fleet specific catchability and spatio-temporal allocation of fishing effort,

2- The age-structured population is spatially explicit and age-specific migration occur within the year.

Briefly, the relationship between the spatially disaggregated *E* and the resulting *F* is the core of the operating model OM, linking the population dynamics and the fishery. A linear relationship is assumed:

$F_{fl,ag,se,ar} = Q_{fl,ag} E_{fl,se,ar}$ Equation 1

The dimensions are fl for a fleet segment (i.e. a combination of a country co, a vessel category vc, and a gear component gr and mesh sizes, consistent with DCF fleet segments e.g. DNK_18-u24_OTB_DEF_70-99), ag for fish age, ar for area, and se for season. The catchability composite term, *Q*, quantifies factors other than fish availability (abundance), which can impact the catch rates:

$Q_{fl,ag} = q \, Sel_{ag} Pow_{fl}$ Equation 2

Relative catching power (Pow) per fleet segment [Equation (2)] is deduced by applying generalized linear models on cpue data (for a given period of time) as a way to standardize the nominal effort. Catching power indices are calculated relative to the catching power of reference fleets, those having the higher landings for the respective species. An overall ogive for selectivity Sel is deduced from the overall exploitation level given by the assessed *F*. *F*-at-age is scaled to the maximal *F* over the 3 years before the start of projection. Gear-specific discard ogives might play a minor role in our application because discards are mainly of cod aged 1 whereas our population recruits to the fishery at age 2. Unless data is provided, the discard ogive will reflects the observed situation for a given year assumed to be representative for the entire period covered. The calibration factor *q* [Equation (2)] is set at a given fixed value, i.e. the factor that scaled the simulated landings in for the calibration year to the observed ones for the fleet of reference.

The effort allocation model assumes so far a constant allocation of the effort between the fleet-segments, space and time. The total effort (per vessel) is then scale up/down according to available fishing opportunities. Routines for altering/reallocating the effort allocation have been/are to be developed according to given scenarios (e.g. spatial closure, directed reallocation) and/or presumed responses of the fleet-segments to stocks fluctuations and/or regulations.

The respective stock dynamic of the sprat, herring and cod will be interlinked (accounting for species interactions M2) by incorporating the SMS model (see section 5.5.1) into the fleet-based framework. In brief, the fleet-based model could predict the yearly area-based Fs (e.g. ICES Baltic subdivision) from spatial and temporal fleet-segment activities (at the end of the year) to be input into the SMS model to draw the next N-at-age for the coming year of each of the stocks, also accounting for observation and stock assessment errors. Implementation error is still up to the fleet-based model.

Choosing the fleet definition to incorporate into the model is an issue when conducting the economic impact assessment because the DCF fleet-segments do not have the same level of sampling for economic or the fleet activity variables (The Commission Decision (2008/949/EC) of the 6 November 2008 describes in detail the Multiannual Community Programme to support the DCF). DCF economic fleet-segment (Appendix III - Fleet segmentation by region) are at a more aggregated level than the DCF fleet-segment for activity (Appendix IV- Fishing activity ( ) by region). In this context it expected that disaggregation chosen will be at the most disaggregated level available (the fishing activity Level6 per fleet) at the level and aggregate in the model when combining the economic aspects.

Furthermore, the fleet definition for the pelagic fisheries may not be sufficient to separate some activities targeting one species at the time, unless the DCF level6 (mesh size) is enough to inform on the target species (The ideal case would have been to use trip-based data where the targeted species can be identified), however, currently this is not available and may not be accessible on the anticipate timescale for the work.

When a given TAC is exhausted: discard and effort reallocation

European Commission

EUR 25312 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Scientific, Technical and Economic Committee for Fisheries. Multispecies management plans for the Baltic (STECF-12-06).

STECF members: Casey, J., Abella, J. A., Andersen, J., Bailey, N., Bertignac, M., Cardinale, M., Curtis, H., Daskalov, G., Delaney, A., Döring, R., Garcia Rodriguez, M., Gascuel, D., Graham, N., Gustavsson, T., Jennings, S., Kenny, A., Kirkegaard, E., Kraak, S., Kuikka, S., Malvarosa, L., Martin, P., Motova, A., Murua, H., Nord, J., Nowakowski, P., Prellezo, R., Sala, A., Scarcella, G., Simmonds, J., Somarakis, S., Stransky, C., Theret, F., Ulrich, C., Vanhee, W. & Van Oostenbrugge, H.

EWG-12-02 members: Arina Motova, Clara Ulrich Rescan, Jenny Nord, John Simmonds, Nick Bailey, Sarah Kraak, Ralf Doring, Willy Vanhee Alexander Kempf, Christopher Zimmermann, Francois Bastardie, Jan Jaap Poos, Johan Stal, Katell Hamon, Michele Casini, Leyre Goti, Ludvig Krag, Morten Vinther, Stefan Neuenfeldt, Tomas Gröhsler, Ernesto Jardim,

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ISBN 978-92-79-24799-6

doi:10.2788/25697

Abstract

This document forms the report and STECF opinion of EWG 111-02 which met in Rostock, Germany to provide an impact assessment report for Baltic stocks of cod, herring and sprat. This Impact Assessment report concentrated mainly on the multispecies evaluation of Eastern Baltic cod, Central Baltic herring and Baltic sprat and includes both biological an economic studies. The document also provides exploitation Fmsy values and a range of B trigger options for herring in Gulf of Riga, Bothnian Sea and Western Baltic stocks. The report presents a wide range of deterministic evaluations were carried out to indicate the range of Fs associated with MSY for the three species. From this a range of F values a small range were selected giving high yield for all three stocks. From this three specific scenarios were selected for stochastic evaluation. The report presents some concerns regarding the possibility to model multispecies aspects predictably for the future. In particular the multi-species aspects depend on predation data from mainly the 1980s and there is an urgent need to update the information base. Also the current regime in terms of productivity and spatial distribution of fish stocks in the Baltic is different from the earlier period when predation data was collected.

LB-NA-25312-EN-N

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

Publications Office

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