ECOREGION **Bay of Biscay and Western Iberian Waters**
SUBJECT **EC request for evaluation of HCR for southern hake, anglerfish and *Nephrops***

Request

ICES is requested to:

1. *Develop Harvest Control Rules for the mixed fishery of S. hake, Nephrops and anglerfish in order to achieve F_{MSY} by 2015. Calculate P (F_{2015}<= F_{MSY})*

2. *Provide advice on an F policy with a 10% annual reduction, until F_{MSY} is reached.*

3. *Propose any other effort regime adaptation of the current one and evaluate its options, if appropriate.*

ICES' Advice

Request 1

None of the Harvest Control Rules (HCRs) considered by ICES achieve F_{2015}<= F_{MSY} if the TAC is overshot (i.e., exceeded). The TACs for southern hake and anglerfish have been exceeded every year since 2004 such that they do not seem to be effective in controlling the fishery. For these stocks, an effective control of the fishery is urgently needed if the management objective F<=F_{MSY} in 2015 is to be achieved.

ICES advises that HCRs with a multiplicative F reduction and either a ±15% or ±25% TAC constraint will not achieve F_{2015}<= F_{MSY} for the southern hake stock, in case of TAC overshoots. For anglerfish, in the absence of TAC overshoots, a 15% TAC constraint maintains F well below F_{MSY} for more than a decade, with the biomass above B_{MSY} and a loss in potential yield of anglerfish. A 25% TAC constraint results in less loss of anglerfish yield. ICES also considers a southern hake/anglerfish interaction in this response. Given the very low biomass of *Nephrops* FUs 25, 26-27 and 31, the catch in these functional units should remain as low as possible. Measures taken to reduce hake and anglerfish fishing mortality should also reducing fishing pressure on *Nephrops*.

Request 2

ICES advises that the EC's F policy with a 10% annual reduction will not achieve F_{2015}<= F_{MSY} for hake. For anglerfish, such a policy in combination with 15% or 25% TAC constraints will achieve F_{2015}<= F_{MSY} with at least a 0.95 probability if there is no TAC overshoot.

Request 3

Differences in the seasonality of the landings with respect to gear could be used in the management of the fisheries. Further, given that species selectivity differs by gear types, seasonal and/or area restrictions in the fishery could reduce the overall fishing mortality on hake by imposing fewer restrictions on fleets mainly targeting anglerfishes. The effects of changes in fishing patterns on estimates of F_{MSY} and long term yield would need to be considered. Separate management of the two anglerfish species could be achieved by area restrictions. These considerations were not evaluated quantitatively.

Basis of advice

Background and method

Southern hake, anglerfish and *Nephrops* are taken in mixed fisheries. The southern hake and anglerfish TACs have been exceeded every year since 2004 and are not effective in controlling the fishery. None of the *Nephrops* stocks in the Cantabrian Sea and western Iberian Peninsula have accepted analytical stock assessment or estimates of F_{MSY}. However, the available evidence indicates that the biomass of *Nephrops* in FUs 25, 26-27 and 31 is very low.

Development of a recovery plan for southern hake and *Nephrops* started in 2003 (Anon., 2003) at a meeting in Lisbon, where scientists from IEO and IPIMAR discussed the best strategy for achieving F_{2015}<= F_{MSY} for hake stock. At the time, there was no evidence of TAC overshoots. Recruitment was very low. The recommended strategy from amongst those tested was an annual 10% decrease in F from that of the previous year. The Recovery Plan (RP) was implemented in 2006, with some effort control measures already in place from 2005. Five years after the implementation of the RP, F does not appear to have been reduced towards F_{MSY} and the analyses performed in 2010, using updated data and more sophisticated modelling, show once again that a decrease in F is required, now at a pace of approximately 20% per year. Additionally, the present analysis clearly shows that failing to implement the suggested management strategy (i.e., adhere to the TAC) will result in a failure to achieve the desired objective.

Council Regulation (EC) N° 2166/2005 of 20 December 2005 established the rules for the recovery of the southern hake and *Nephrops* stocks in the Cantabrian Sea and western Iberian Peninsula; and amended Council Regulation (EC) N° 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. The plan aims at recovering the southern hake stock to a spawning stock biomass above 35 000 t and to reduce fishing mortality to 0.27 by 2015. The main elements of the plan are a 10% annual reduction in F and a ±15% constraint on TAC change from year to year, following the Policy statement's rules.

In 2010 ICES estimated F_{MSY} for southern hake and anglerfish (ICES, 2010a). For southern hake F_{MSY} = 0.24 while current F is about three times this value. For anglerfish, the F/F_{MSY} ratio for *L. piscatorius*, the species in the poorest condition, is estimated at ~1.5, whereas the ratio is below 1 for *L. budegassa*. The proposed F_{MSY} values are the best estimates at the present time and it is anticipated that estimates will be refined as ICES gains experience with the populations' dynamics when fishing in the region of F_{MSY}.

ICES analyzed the biological implications of management options within candidate HCRs and TAC overshoot scenarios. The analytical evaluations have all been undertaken on a stock by stock basis in the first instance. Subsequently, mixed fishery issues were investigated.

Points 1 and 2 of the request:

ICES considered the following scenarios:

a) Set of candidate HCRs – ICES considered three HCRs and a *status quo* option (see below). The consequences for yield and risk to population should inform the choice of appropriate management plan.
b) Evaluation framework –Robustness of the HCRs was investigated. For hake, ICES examined the robustness of results from the HCRs with respect to alternative assumptions of recruitment in the projection years. The range of recruitment values in the projection years encompassed the range observed in the historic period used in the assessments. Given that southern hake and anglerfish TACs have been substantially exceeded since 2004, it is important to examine the performance of the HCRs under TAC overshoot scenarios.
c) To deal with mixed fisheries issues, common fleets or *métiers* across stocks were identified, together with their relative contribution to the landings of each stock. The seasonality of landings by fleet was also explored. However, consideration also needs to be given to the flexibility of the fleet/*métiers* exploiting each stock; i.e. what flexibility exists in the fleets' ability to catch particular species or deploy certain fishing methods.
d) The linkage between hake and anglerfish exploitation was explicitly considered.

None of the *Nephrops* FUs in Divisions VIIIc and IXa has an analytical assessment accepted by ICES which limits the ability to analyze options.

Harvest control rules – Three were considered; together with a *status quo* option:

HCR 0: F_{sq};
HCR 1: 10% annual decrease in F until F_{MSY} is reached
HCR 2: Percentage of annual decrease in F required to reach F_{MSY} in 2015
HCR 3: F_{MSY} from 2011

HCR 2 considers a gradual reduction in F to F_{MSY} by 2015 and HCR 3 considers an immediate reduction in F to F_{MSY} in 2011.

TAC constraints (maximum change allowed in the TAC between consecutive years):

HCR 0 is only examined under no TAC constraints, as it is just considered as a "control" case and not a real HCR.
HCRs 1-3 are examined under no TAC constraints and in combination with TAC constraints of ±15% and ±25%.

Under HCR 2, if a TAC constraint implies a different reduction in F from the one intended in a given year, the required percentage of annual decrease to reach F_{MSY} in 2015 is recalculated in the following year. If a TAC constraint forces F to be below F_{MSY} in a given year, the proposed F for the following year is F_{MSY} under any of the HCRs.

TAC overshoot – Two different overshoot options were considered:

The analyses explicitly distinguished between F_{HCR} and F_{real}, the former denoting the F corresponding to application of an HCR in a given year and the latter being the F value that actually occurs and according to which the population evolves. *TAC overshoots* corresponds to F_{real}>F_{HCR}. Two different overshoot options were considered. In one option, F_{real} in a given year is some value in between F_{HCR} in that same year and F_{real} in the previous year, reflecting a resistance for F_{real} to decrease. In the other option, landings are just assumed to exceed the TAC by some amount. Medium and very high TAC overshoot were explored under both mechanisms. So that a TAC overshoot does not prevent HCRs 1 and 2 from reductions in F as originally intended, HCRs 1 and 2 are defined based on F_{HCR} and not on the value of F_{real}.

Point 3 of the request:

The description of the fisheries is available in ICES (2010b) and an updated version in ICES (2010c), and also considerations of mixed fishery issues in relation to spatial management.

Results and conclusions

Points 1 and 2 of the request:

Initially, evaluations were performed separately for each stock and the single stock outcomes are summarised:

Southern hake in Divisions VIIIc and IXa: The EC's F policy with a 10% annual reduction (HCR 1) does not achieve F_{MSY} in 2015 (Figure 7.3.3.1.1). In addition, none of the HCRs considered by ICES achieved F_{MSY} in 2015 in the presence of TAC overshoot (Figure7.3.3.1.2). Conditioning a HCR to achieve F_{MSY} in 2015 with a multiplicative F reduction (HCR 2) and either a ±15% or ±25% TAC constraint led to similar probabilities of achieving F_{MSY} in 2015, but the ±15% TAC constraint produces slightly higher SSB in 2015 (Fig. 7.3.3.1.3).

Anglerfish in Divisions VIIIc and IXa (*Lophius piscatorius* and *Lophius budegassa*): Due to the starting conditions of *L. budegassa*, with F_{2009} below F_{MSY} (F_{2009}/F_{MSY} =0.45), all scenarios tested keep F below F_{MSY}. So the analysis of results is mainly focused on *L. piscatorius* - when no TAC constraint is applied in the scenarios investigated, the *L. piscatorius* biomass increases slowly towards B_{MSY}. The effect of TAC constraints (±15% and ±25% were explored) is dominant, all HCRs examined perform in the same way when the same TAC constraint is applied. This is because these TAC constraints force F_{2011} below F_{MSY}. In the absence of TAC overshoot, a 15% TAC constraint would force F to stay well below F_{MSY} for more than a decade, and the biomass to go above B_{MSY}, implying a loss of yield when compared with a 25% TAC constraint (Figure 7.3.3.1.4). TAC overshoot reduces the probability of F being equal to or below F_{MSY} in 2015 to levels below 95% (substantially lower if the TAC overshoot is very high; Figure 7.3.3.1.5) and slows down the recovery of the biomass.

Nephrops (FUs 28 and 29): In its June 2010 advice, ICES considers its stock assessment to be only indicative of historic trends that indicate that fishing mortality has decreased in the last five years, and is presently considered at a record low. The stock is likely to be underexploited in relation to any potential F_{MSY} target because *Nephrops* is caught in a crustacean fishery that mainly targets rose shrimp (Figure 7.3.3.16). For the future, an increase in F on *Nephrops* is likely to be expected if the rose shrimp abundance decreases and fleets stop targeting rose shrimp. It has been historically observed that *Nephrops* landings increase in years of low rose shrimp landings.

Nephrops (FU 30): In the absence of an analytical assessment, it is not possible to assess the distance from current F to a potential F_{MSY}. Given that the bottom trawl fleet of the Gulf of Cadiz consists of only one, highly multi-specific *métier*, any F reduction measures applied to the fleet catching hake should also cause a reduction on the fishing pressure applied to *Nephrops*. The strong seasonality of the *Nephrops* fishery, with most of the landings between April and September (Figure 7.3.3.1.7), should be taken into account when devising management measures, ensuring that any measures applied to reduce effort also include these months.

Nephrops (FUs 25, 26-27 and 31): In the absence of an analytical assessment, it is not possible to assess the distance from current F to a potential F_{MSY}. Given the very low biomass of *Nephrops* in these functional units, the catch should remain as low as possible, but the mixed nature of the Spanish bottom trawl fishery, for which *Nephrops* is no longer a target species, makes this difficult to accomplish. Nonetheless, measures taken to reduce F for hake and anglerfish should have the effect of also reducing fishing pressure on *Nephrops*. The strong seasonality of the *Nephrops* fishery, with most of the landings between May and August (Figure 7.3.3.1.8), should be taken into account when devising management measures, ensuring that any measures applied to reduce effort also include these months.

Subsequently, mixed fisheries issues were investigated explicitly for Southern hake and anglerfish:

Southern hake/anglerfish linkage – Since most fleets catch both hake and anglerfish, an interaction between their exploitation can be considered. Hake requires a stronger reduction in F than anglerfish in order to reach F_{MSY}. If all fleets underwent for both hake and anglerfish the reduction in F required for hake, long-term F values for anglerfish would be well below F_{MSY}, resulting in sub-optimal exploitation of anglerfish. Management of anglerfish might use the fact that there is one gillnet fleet in Spain (*Rasco* with minimum mesh size of 280 mm) that does not catch hake. Approximately 35% of the *L. piscatorius* landings and 5% of the *L. budegassa* landings are from the *Rasco* fleet. If the partial F corresponding to the *Rasco* fleet was not reduced at all, while the remaining fleets that catch both hake and anglerfish followed the annual F reductions required for the hake stock to reach F_{MSY}, the long-term probability that F for anglerfish is less than or equal to F_{MSY} would be 0.78 for *L. piscatorius* and certainty for *L. budegassa*. To increase this probability for *L. piscatorius*, F of the *Rasco* fleet must also be reduced from current level, but the reduction does not need to be as strong as for the other fleets which also catch hake. Applying to the *Rasco* fleet any reduction consistent with driving anglerfish on its own (*i.e.* without consideration of hake) to F_{MSY}, while the remaining fleets that catch both hake and anglerfish followed the annual F reductions required for the hake stock to reach F_{MSY}, would ensure that long-term F of anglerfish is below F_{MSY}. Further detailed analyses would be required to determine an optimal strategy which ICES is willing to pursue if requested. Using hake as the key driver for the management of the mixed fisheries would have an impact on species such as, megrim, horse mackerel and blue whiting, in addition to anglerfish and *Nephrops*. This is not part of the request to ICES and the extent of this impact has yet to be quantified.

Point 3 of the request:

Description of the fisheries and seasonality of landings – There are differences between the seasonality of the Portuguese and Spanish catches. In general, the trawl fleets are concentrated in the second and third quarters, while gillnets show no clear seasonality in catches. For long-liners catches are concentrated in the second quarter. Examining the catch composition of the different fleets at different times of the year could allow for differentiated management with regards to sizes and species composition in the mixed fishery. A possible way to improve the impact of static gears could be to enforce continuous closed periods so that fishermen will have to bring their gear ashore and stop fishing during certain periods.

Spatial management of anglerfish - Anglerfish occur in a wide range of depths, from shallow waters to at least 1000 m. Information about spawning areas and seasonality is scarce and the stock structure remains unclear. The percentage of *L. piscatorius* in the commercial catches of anglerfish, is very high in the Cantabrian coast (Division VIIIc) and decreases southwards from the Galician to Portuguese west coast (Division IXa). On the south coast of Portugal the percentage of *L. piscatorius* is almost null and the proportion of *L. budegassa* is more than 90%. This spatial distribution could allow managing each species separately, but additional research will be required before developing this further.

Discussion

ICES has started the evaluation of Harvest Control Rules that comprise the mixed fishery of southern hake, *Nephrops* and anglerfish and presents one option in its advice. Additional work is advocated to further identify optimum solutions to the management of this mixed fishery.

The current effort regime sets an annual 10% reduction in the number of fishing days for some selected gears. No effort data have been presented to ICES that allow an evaluation of the efficiency of this control measure but STECF has recently reviewed both regulated and effective fishing effort (STECF, 2010). ICES notes that fishing mortality has not been reduced for southern hake, while for the two anglerfish species the latest assessment indicates a reduction since 2006.

The difference in species and size selectivity among the gear types used in the mixed fishery for hake, anglerfish and *Nephrops* could be examined further in order to determine optimal management regimes that take account of the differences in stock status. However, this will require more information on catches from the various gears. A quick look at the catch composition of different fleets is a good initial step as it might point to the solutions that need to be implemented. An attempt to quantify the contributions of the various fleets' activities to the exploitation of the stocks under considerations would be feasible.

For future work more sophisticated simulations would be of value, perhaps some kind of Management Strategy Evaluation (MSE). What would be interesting to model is the discard process. Will the discards be reduced or increased with reduced TAC, or in other words do reduced landings lead to reduced F?

Sources

Anon. 2003. Report of the subgroup on management objectives (SGMOS) of the Scientific, Technical and Economic Committee for Fisheries (STECF) for recovery plans of southern hake and Iberian Norway lobster stocks. 9 – 13 June 2003, IPIMAR, Lisbon, 107 pp.

ICES. 2010a. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM), 5-11 May 2010, Bilbao, Spain, ICES CM 2010/ACOM:11.

ICES. 2010b. Report on the evaluation of HCR for the establishment of a management plan for the Iberian mixed fisheries of hake, anglerfish and *Nephrops* aiming to achieve F_{MSY} by 2015. Jardim, E., C. Silva, R. Alpoim, F. Cardador and M. Azevedo. ICES CM 2010/ACOM:56.

ICES. 2010c. ICES Workshop on Iberian mixed fisheries management plan evaluation of Southern hake, *Nephrops* and anglerfish 22-26 November 2010, Lisbon, Portugal. ICES CM 2010/ACOM:63.

STECF. 2010. Report of the Sub-group on Management Objectives and Strategies (SGMOS 10-06). Part d) Evaluation of multi-annual plan for hake and Nephrops in areas VIIIc and Ixa. 18-22 October 2010, Vigo, Spain.

Table 7.3.3.1.1 Probability F_{real} (2015) <= F_{MSY} for southern hake, with three recruitment scenarios (high, average and low).

HCRs	TAC constraint option	High recruitment				
		No TAC overshoot	TAC Overshoot: Type 1		TAC Overshoot: Type 2	
			Medium	Very high	Medium	Very high
HCR0	No constraint	0	Not applicable	Not applicable	Not applicable	Not applicable
HCR1	15%	0.24	0	0	0.01	0
	25%	0	0	0	0	0
	No constraint	0	0	0	0	0
HCR2	15%	1	0.03	0	0.01	0
	25%	1	0	0	0	0
	No constraint	1	0	0	0	0
HCR3	15%	1	0.92	0	0.49	0
	25%	1	0.8	0	0.26	0
	No constraint	1	0	0	0	0
HCRs	**TAC constraint option**	**Average recruitment**				
		No TAC overshoot	TAC Overshoot: Type 1		TAC Overshoot: Type 2	
			Medium	Very high	Medium	Very high
HCR0	No constraint	0	Not applicable	Not applicable	Not applicable	Not applicable
HCR1	15%	0.12	0.01	0	0	0
	25%	0	0	0	0	0
	No constraint	0	0	0	0	0
HCR2	15%	1	0.03	0	0.01	0
	25%	1	0	0	0	0
	No constraint	1	0	0	0	0
HCR3	15%	1	0.78	0	0.29	0
	25%	1	0.5	0	0.1	0
	No constraint	1	0	0	0	0
HCRs	**TAC constraint option**	**Low recruitment**				
		No TAC overshoot	TAC Overshoot: Type 1		TAC Overshoot: Type 2	
			Medium	Very high	Medium	Very high
HCR0	No constraint	0	Not applicable	Not applicable	Not applicable	Not applicable
HCR1	15%	0	0	0	0	0
	25%	0	0	0	0	0
	NA constraint	0	0	0	0	0
HCR2	15%	1	0	0	0	0
	25%	1	0	0	0	0
	No constraint	1	0	0	0	0
HCR3	15%	1	0.65	0	0.1	0
	25%	1	0.17	0	0.01	0
	No constraint	1	0	0	0	0

Table 7.3.3.1.2 Probability F_{real} (2015) ≤ F_{MSY} for *L. piscatorius*. For *L. budegassa* this probability is 1 in all scenarios.

HCRs	TAC constraint option	No TAC overshoot	TAC Overshoot: Type 1	
			Medium	Very high
HCR0	No constraint	0.11	Not applicable	Not applicable
HCR1	15%	0.98	0.9	0.37
	25%	0.97	0.76	0.28
	No constraint	0.72	0.11	0.1
HCR2	15%	1	0.88	0.35
	25%	0.99	0.76	0.27
	No constraint	1	0.11	0.1
HCR3	15%	1	0.93	0.35
	25%	0.99	0.75	0.28
	No constraint	1	0.11	0.1

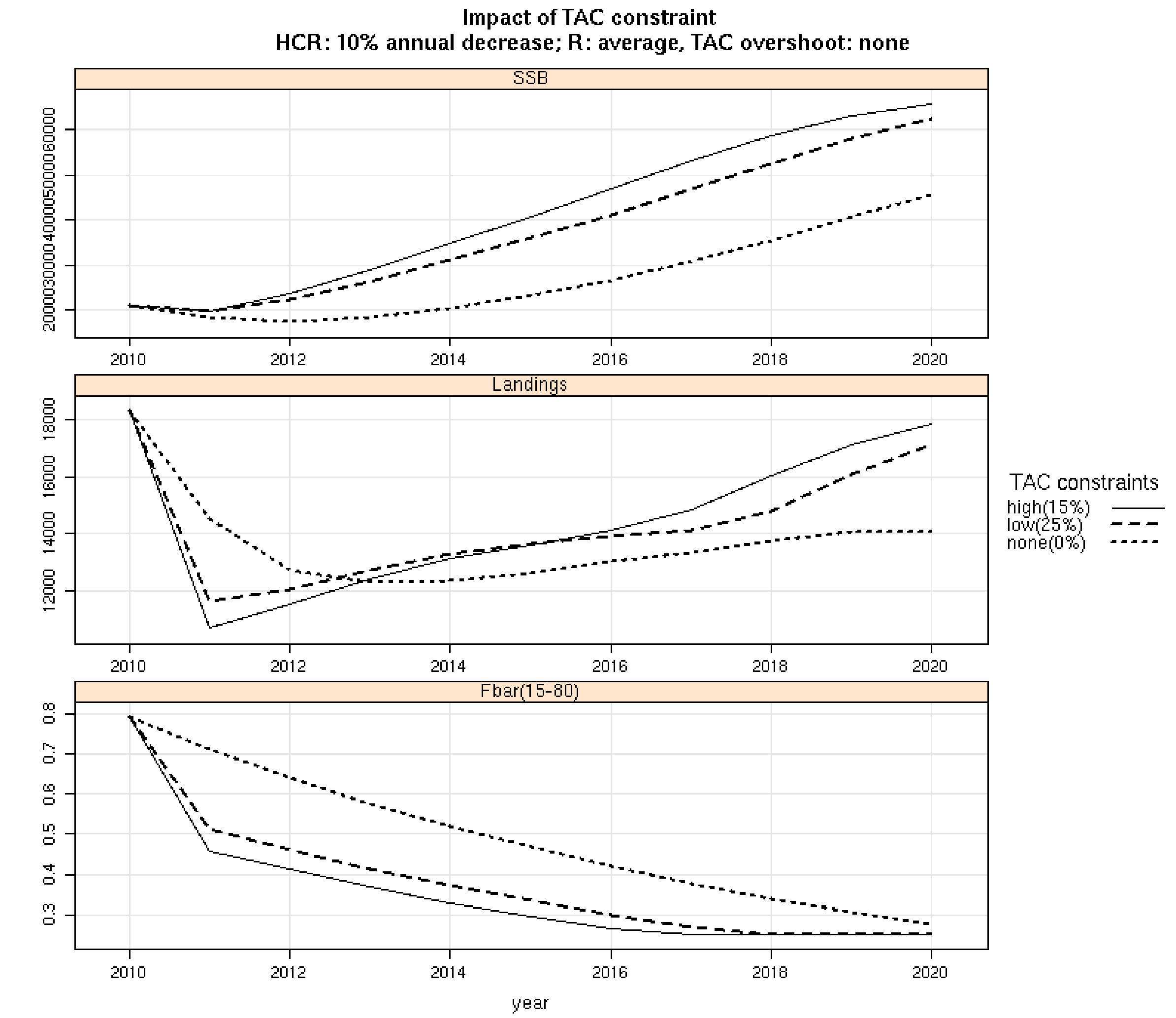

Figure 7.3.3.1.1 Effect of TAC constraint on performance of HCR 1 on southern hake.

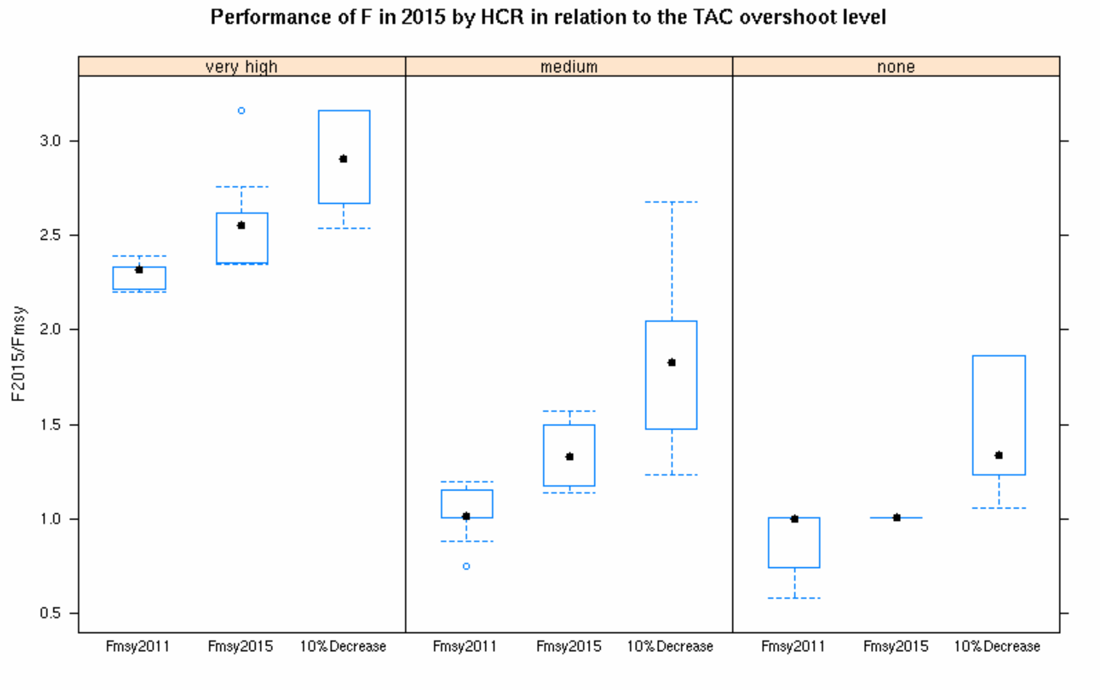

Figure 7.3.3.1.2 Impact of different TAC overshoots on southern hake $F_{real}(2015)/F_{MSY}$ for the different HCRs. Each panel corresponds to a TAC overshoot level. Within each panel, HCRs displayed in order 3, 2, 1, from left to right. (all TAC constraints, recruitment scenarios and the two types of TAC overshoot merged)

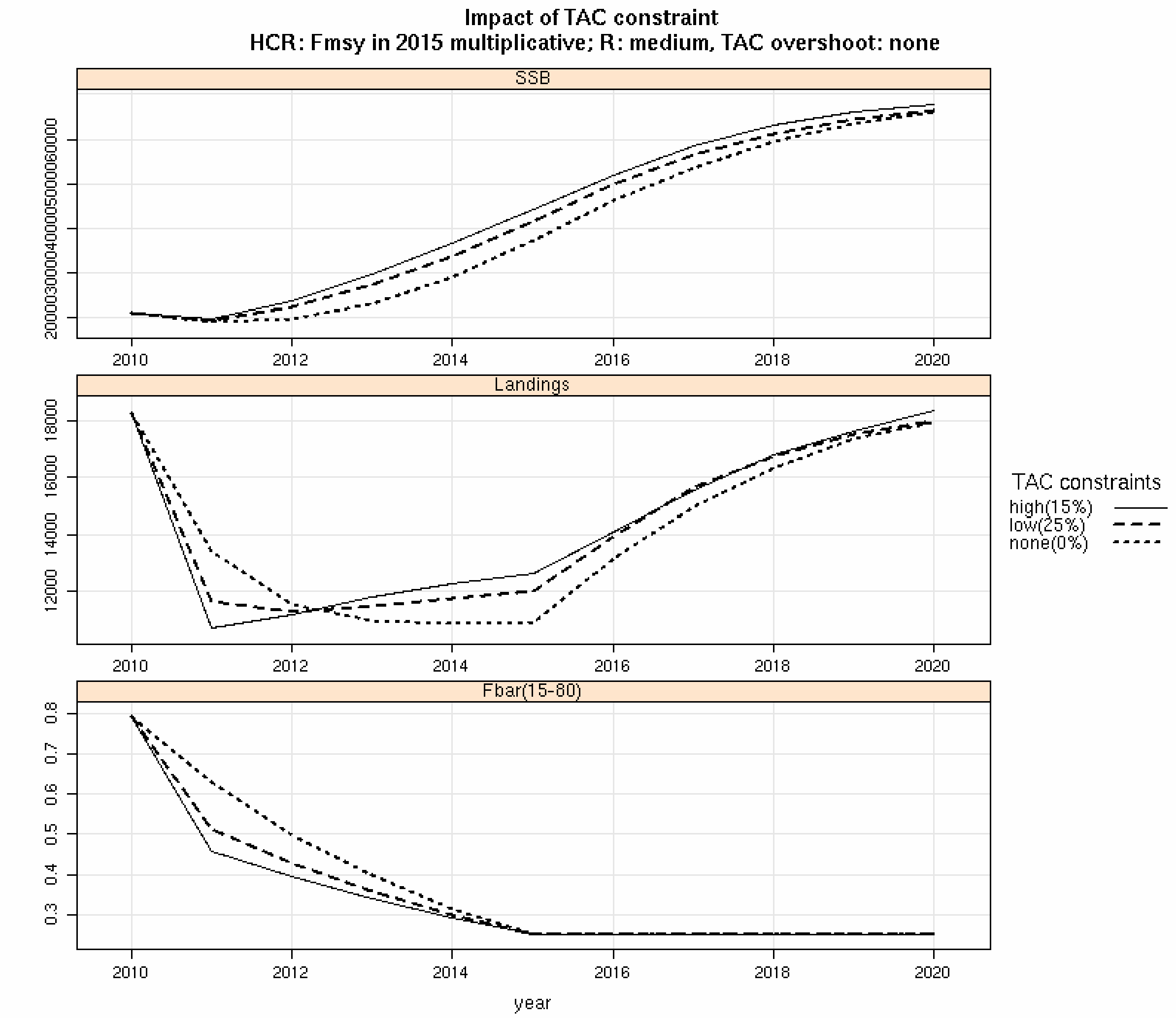

Figure 7.3.3.1.3 Effect of TAC constraint on performance of HCR 2 on southern hake.

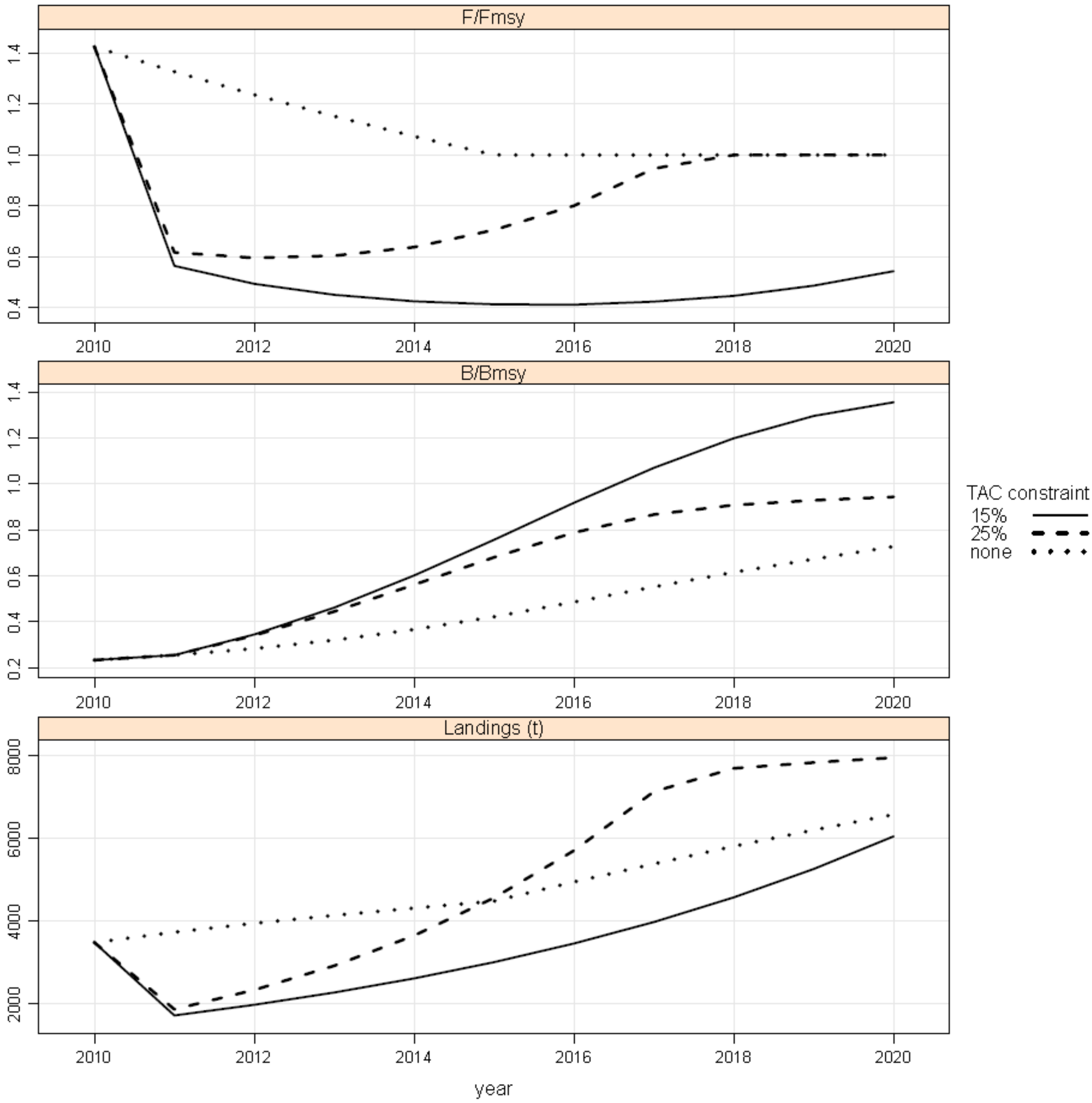

Figure 7.3.3.1.4 Effect of TAC constraint on performance of HCR 2 on anglerfish (under no TAC overshoot). Trends in median F/F_{MSY} for *L.piscatorius*, B/B_{MSY} for *L. piscatorius* and landings for both anglerfish species combined.

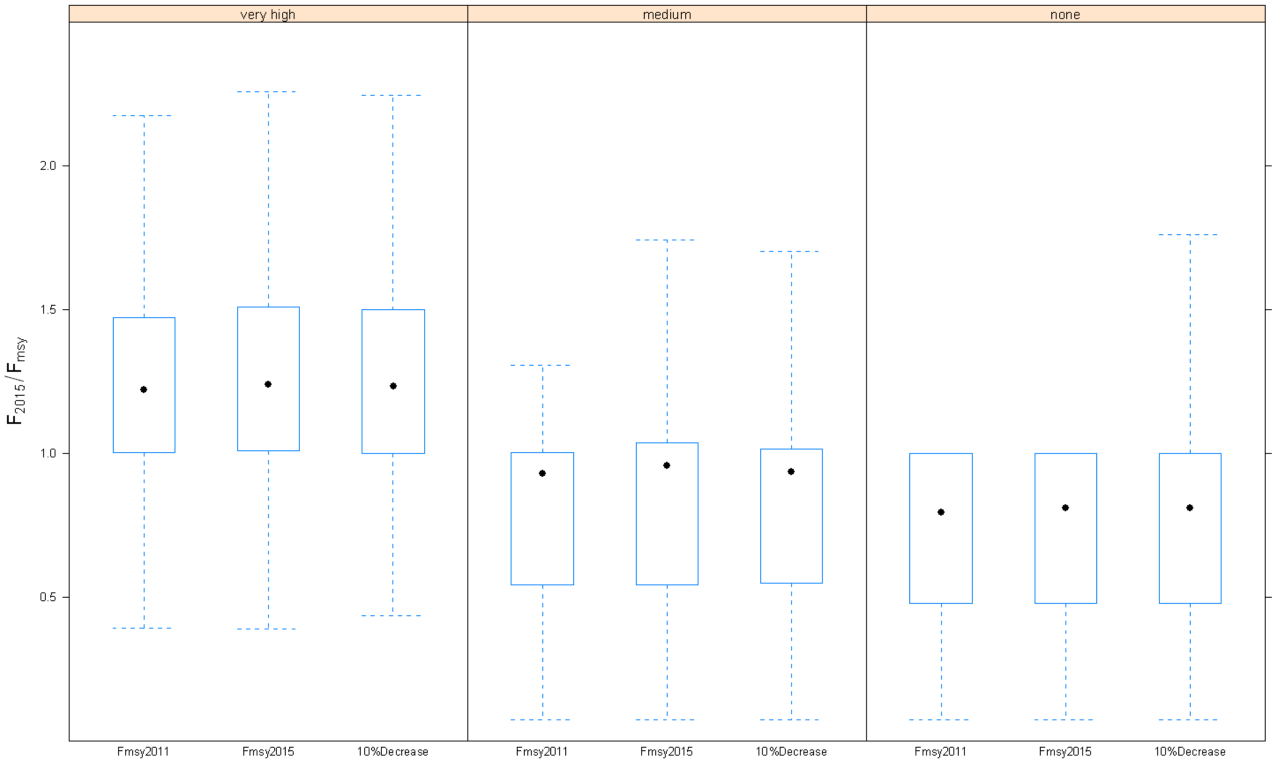

Figure 7.3.3.1.5 Impact of different TAC overshoot levels on *L. piscatorius* $F_{real}(2015)/F_{MSY}$ for the different HCRs. Each panel corresponds to a TAC overshoot level. Within each panel, HCRs displayed in order 3, 2, 1, from left to right (all TAC constraints merged).

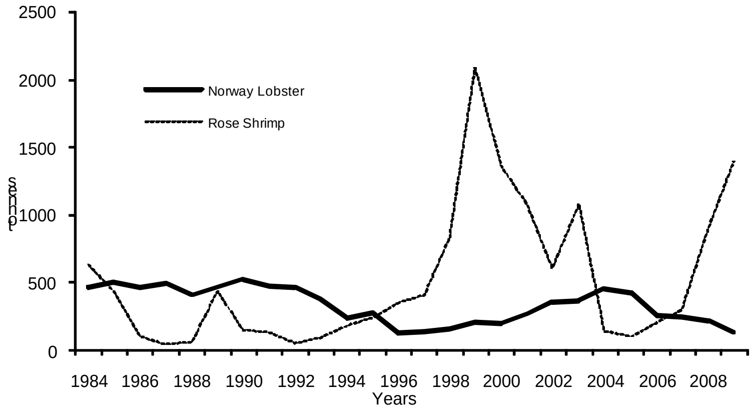

Figure 7.3.3.1.6 *Nephrops* and rose shrimp Portuguese landings in the period 1984-2009.

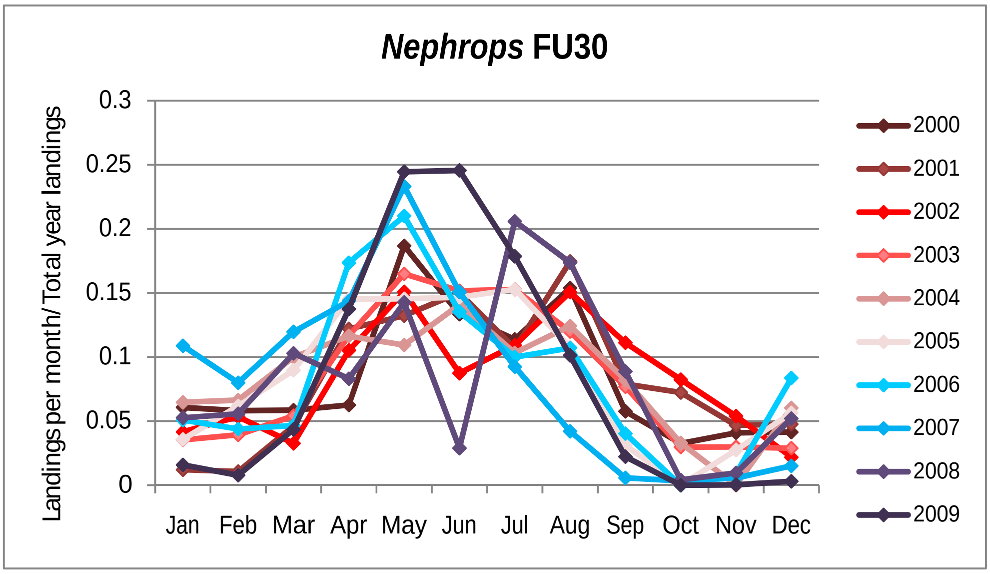

Figure 7.3.3.1.7 Seasonal pattern of *Nephrops* FU30 landings (Landings per month/ Total year landings for 2000-2009 period).

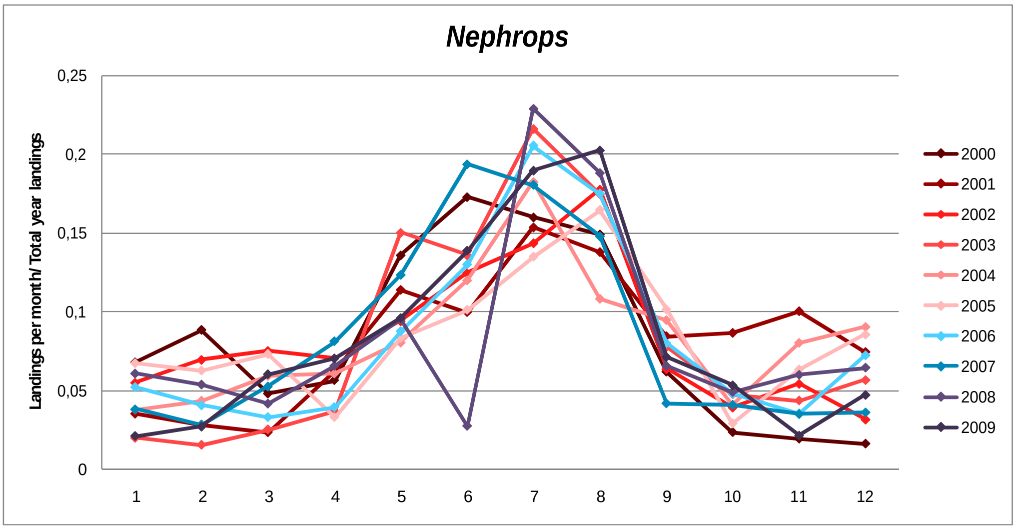

Figure 7.3.3.1.8 Monthly percentage of annual landings of the northern Spanish bottom trawl fleet, for *Nephrops* FUs 25, 26-27 and 31 combined.