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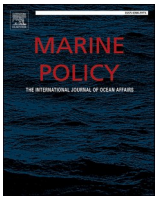

Institutional inertia in European fisheries – Insights from the Atlantic horse mackerel case

Esther Schuch [a,b,*], Silke Gabbert [b], Andries P. Richter [b,c]

[a] Institute for Advanced Sustainability Studies e.V. (IASS), Berliner Straße 130, 14467 Potsdam, Germany
[b] Environmental Economics and Natural Resources group, Wageningen University, P.O. Box 8130, 6700 EW Wageningen, The Netherlands
[c] CEES, Department of Biosciences, University of Oslo, P.O. Box 1095, Blindern, 3017 Oslo, Norway

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ABSTRACT

Fisheries management has to deal with uncertainty about the genetic composition and the location of fish stocks. If institutions are inert, i.e. unable to adapt to new insights, management may not be effective. This paper analyses fisheries management in Europe which relies on scientific advice feeding into the management decision process. The spatial boundaries of fish stocks define the scientific areas and management areas, which are not necessarily aligned. Even if new scientific information on the stock composition and location leads to changes in scientific areas, the management areas are usually not adjusted. This causes an institutional mismatch which violates the self-imposed good governance principles of the EU. We use the North Sea and the Western horse mackerel stocks to gain some insights in the process of renegotiating new management areas and national fisheries quotas. We find that distributional concerns around allocating quota are a key obstacle for an adjustment of management areas. We suggest to pre-define a transparent mechanism to facilitate adapting management areas to scientific areas.

1. Introduction

Marine systems are complex adaptive systems where both the ecological system and the governance system are changing over time. While the understanding of the mechanisms of ecological change has improved, relatively little is known about the institutional changes that govern marine social-ecological systems. Institutional dynamics can be slow and path-dependent, which is described by Young (2010) as follows: 'institutions are sticky; they often remain in place long after mismatches between regimes and the biophysical and socioeconomic settings with which they interact become severe and widely understood, at least among specialists' [88]. Such institutional inertia ensures stability and predictability within the governance system which can be seen as a positive trait. The problem occurs if institutions are resisting change even if this change is needed, e.g. due to climate change dynamics [56]. In fisheries, this institutional inertia may be problematic for at least two reasons. First, governance arrangements may adjust too slowly to respond adequately to environmental changes, which is particularly dangerous if certain thresholds have been passed, thereby endangering fish stock sustainability [35,54,73,84,89]. Second, there may occur a misfit, also called mismatch, between the governance mechanisms and ecosystem functioning [4,18,23,31,34,80]. This is particularly challenging in marine systems, where jurisdictional boundaries often do not align with boundaries of fish stocks [70]. In many of those cases, over time strategies have emerged on how to agree on the distribution of fish stocks among countries. However, climate change induces continuous range shifts, which alter historically observed spatial patterns of fish stocks. One example is that with rising water temperatures the stocks start to migrate out of their traditional habitats towards the poles [10,32,68–70,72]. These distribution shifts can challenge international cooperation on the management of fisheries and can even lead to conflicts between countries [59,70,76]. Also, new insights about the genetic composition may require a reconfiguration of the institutional setting. In this paper we focus on institutional inertia in European fisheries and which mechanisms are needed to overcome these.

The decision making system in the European Union (EU) is multi-institutional, multinational, and highly political. Even though the EU strives for ecosystem-based management, at the end of the day it still boils down to defining fishing quotas based on single stocks for individual countries. The main institutions involved in the decision-making process of the European Common Fisheries Policy (CFP) are the Council

* Corresponding author at: Institute for Advanced Sustainability Studies e.V. (IASS), Berliner Straße 130, 14467 Potsdam, Germany.
E-mail addresses: Esther.Schuch@iass-potsdam.de (E. Schuch), Silke.Gabbert@wur.nl (S. Gabbert), Andries.Richter@wur.nl (A.P. Richter).

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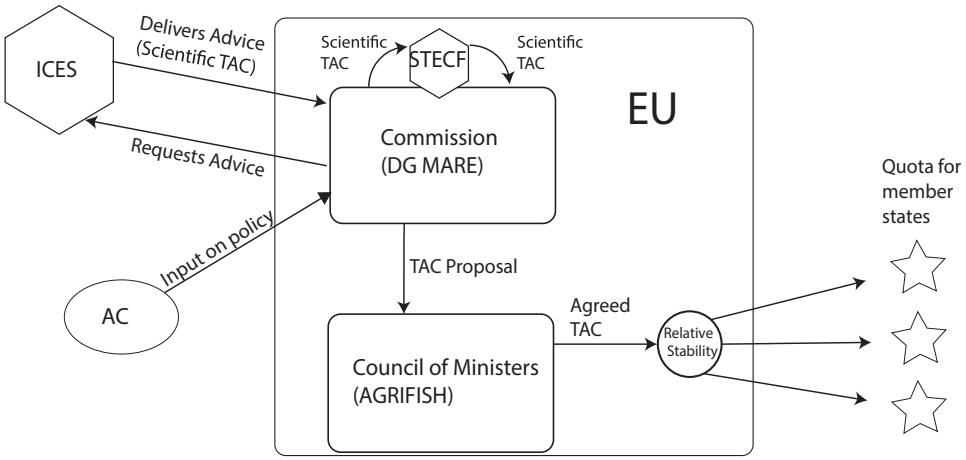

Fig. 1. EU Decision-making system for quota setting in the EU. Hexagons = scientific bodies, rectangles = political/administrative bodies, ellipse = stakeholder bodies, circle = institutional constraint, and star = policy outcome. ICES = International Council for the Exploration of the Sea, STECF = Scientific, Technical and Economic Committee for Fisheries, AC = Advisory Council.

of the European Union (Council), the European Commission (Commission) and – though to a lesser extent – the European Parliament. The Council encompasses the ministers from the EU member states and is the main legislator in the area of fisheries. The Commission can initiate, draft, and propose legislative acts in regard to the CFP. Any legislative measure proposed by the Commission has to be approved by the Council as well as by the European Parliament under the co-decision mechanism [39].

The CFP states that in order to achieve 'conservation and sustainable exploitation of fisheries resources' the 'best available scientific advice' has to be taken into account [29]. This scientific advice is produced by the International Council for the Exploration of the Sea (ICES), an intergovernmental scientific network [11,48].[fn1] The scientific advice delivered by ICES is based upon biological and ecological information, but the CFP also requires the consideration of technical and economic advice. The Scientific, Technical and Economic Committee on Fisheries (STECF), the Commission's (independent) scientific advisory committee, expands the advice of ICES by including socioeconomic considerations [11,77].

An essential obstacle in the fisheries-management process of the EU is that there exists a fundamental difference between scientific and management areas of a stock. Scientific areas refer to the geographical distribution of a stock. Hence, their location is to a certain degree flexible as areas are closely aligned with the stock, its genetic composition, and its potential spatial movement. The management areas, in contrast, are based upon biological and economic factors as well as on political and administrative constraints [72,83]. While the main constraint with regard to defining the scientific area is the validity of scientific information, the management area faces political constraints, which makes adjustments a difficult and time consuming process. As a consequence, scientific areas, which can be adjusted without having to consider political and economic consequences, are therefore not necessarily identical with the management areas. In 2000, roughly 50 out of about 150 cases existed where the management area did not match the scientific area [78].

For various reasons, the European fisheries-management system in its current form has been working sub-optimally. A key obstacle has been the interplay between scientific and policy institutions in the EU fisheries-management system. For instance, Delaney and Hastie (2007) and Schwach et al. (2007) argued that scientific institutions such as ICES and the STECF, and policy and administrative institutions such as the Council, operate under different role identities, causing them to prioritise different aspects in the entire management process [22,74]. This has hampered scientists to effectively explain research results, to learn from past experience and to further adapt the advice system. Furthermore, it has induced a shift in the 'ethos of science', moving from traditional academic science towards contextualized, policy-driven science [52,55]. The large uncertainties underlying crucial parameters such as stock growth and species mortality were identified as major cause of the insufficient transformation of scientific knowledge into practical outcomes, in particular fishing quotas [6,20].

The focus of this paper is on the implications of the inert reactivity of governance institutions to new scientific information regarding stock location and genetic composition. One factor driving these developments is climate change. Under climate change, fish stocks will continue to move towards the poles in the coming years. Consequently, an increasing divergence of the location of fish stocks and management areas is to be expected. Specifically, this will be the case if climate change alters the composition of the stock, which is typically revealed by genomics research. If fish stocks shift faster than governance institutions can adapt, an institutional mismatch may occur, which may lead to unsustainable exploitation of stocks, which could even cause fisheries management in Europe to collapse [58]. While there are ample studies documenting how fish stocks may respond to climate change, evidence how this may affect the functioning of institutional systems is largely lacking. The aims of this paper are, therefore, twofold. First, we analyse how new scientific insights can affect the functioning of institutions if these are unable to adapt within sufficient time. In particular, we focus on problems in the institutional system for setting total allowable catch (TAC) in the EU that could lead to inadequate responses to distribution shifts of fish stocks. We use the EU as an example for a supranational management system in which there is a system to cooperatively manage fisheries which is not adequately equipped to deal with new insights regarding genetic composition or location of stocks, and we show that the self-imposed good governance principles by the EU can be violated as a result of an institutional mismatch. Second, we look at the different parts of the fisheries-management system in the EU and explore their ability to flexibly adjust management areas and the corresponding allocation of national fishing quotas. We use horse mackerel in the North Sea and the Atlantic as an illustrative case study since, to our knowledge, these are the only stocks where the management areas were adjusted. Scrutinizing the realignment process provides information on potential obstacles in the management process which need to be overcome, given the need for continuous readjustment of management areas, which is

[1] ICES produces the scientific advice on catch limits (total allowable catch) in the North Atlantic. ICES does not provide catch limits for the Mediterranean and Black Sea which are mainly managed via input controls [11].

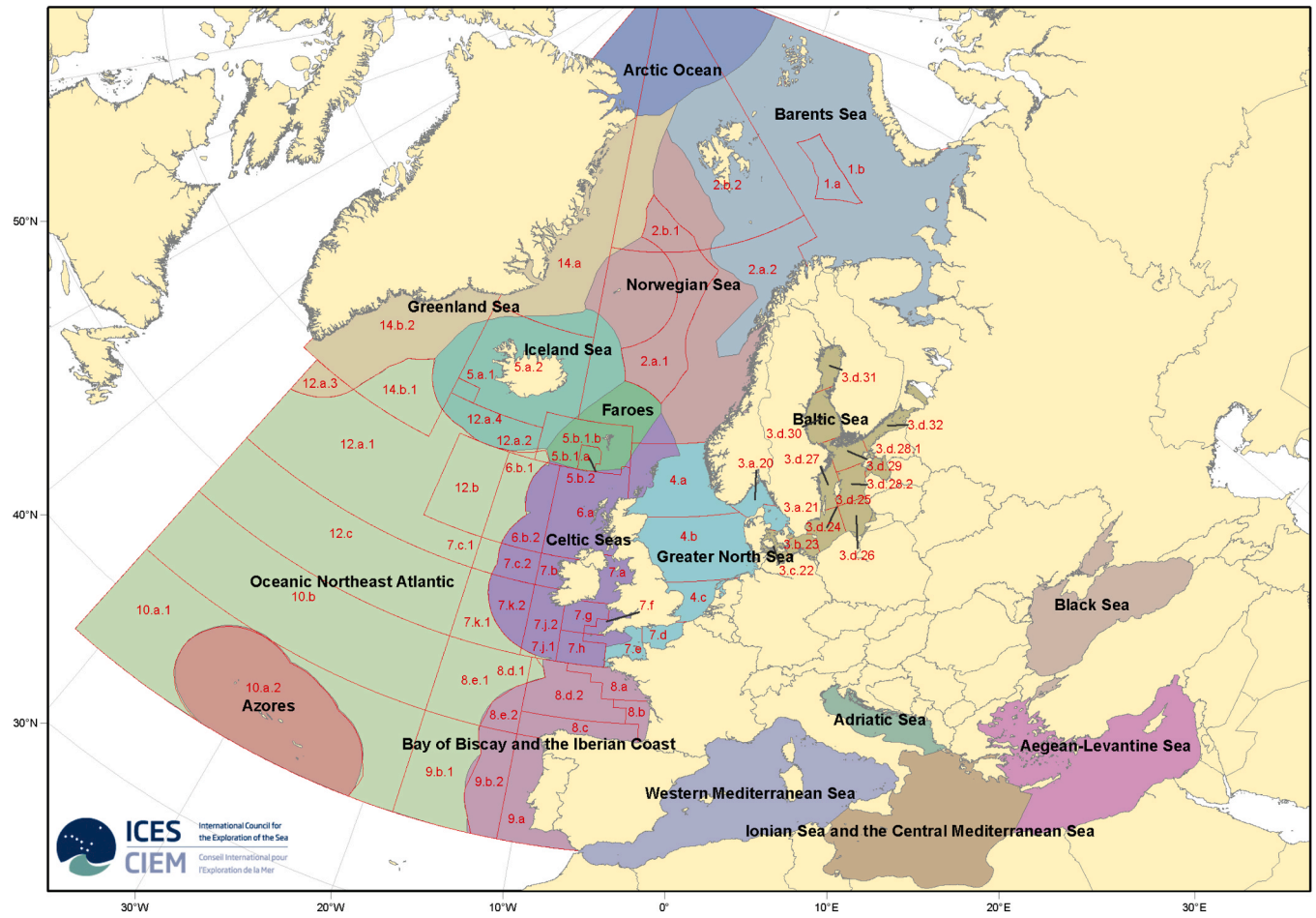

Fig. 2. Division of scientific areas (red) straight lines and ecoregions (coloured regions) taken from the ICES homepage [45]. ICES provides management advice based upon these scientific areas in form of a scientifically determined total allowable catch (TAC). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

expected to be aggravated by climate change.

2. Scientific advice and the relative-stability principle

The EU's Common Fisheries Policy (CFP) rests on the principles of good governance. Management measures include setting fishing opportunities and monitoring their efficiency in delivering policy objectives and targets [28]. In a nutshell, scientific information within the CFP is generated as follows. First, biological information about stocks is provided by ICES which STECF then complements with information about the economic and societal impact of TACs[fn2] (see Fig. 1). The scientific TACs are communicated to DG MARE[fn3] (the department within the European Commission dealing with maritime affairs and fisheries) who consults advisory committees (AC) and negotiates with non-EU states. Based upon their input DG MARE proposes TACs which can be used for management decision-making [7,42,83]. The proposed TACs are sent to the EU Council who decides upon the final size of the TACs to be implemented which we refer to as the 'agreed TAC'[fn4] [77].

The agreed TAC is the total quantity of biomass to be fished in the management area and has to be converted into quotas for the individual EU member states. The process of allocating the agreed TAC in a particular area among EU member states, is determined by the 'relative-stability' principle. The relative-stability principle determines the shares of an agreed TAC that each member state receives. The relative-stability principle is based on three aspects, (i) historical catches, (ii) the maintenance of fisheries-dependent communities as established in the 'Hague preferences', and (iii) the compensation of jurisdictional losses after the introduction or extension of Exclusive Economic Zones (EEZ) by non-members [7,39,41,57].[fn5] Apprehending that it may be impossible to reach a new agreement once the negotiations are opened the relative-stability principle has been considered an 'untouchable institutional principle' [42]. At the same time, it has been acknowledged that the relative-stability principle is an impediment to a better management system [50].

Due to the relative-stability principle the management areas are

[2] While scientific information in the fisheries management system has traditionally been biological information this has been recognised as being too narrow. For a discussion on further aspects to be included see Foley et al. [30] and the ICES working group on Balancing Economic, Social and Ecological Objectives [82].

[3] The scientific TACs are publicly available on the ICES homepage (http://ices.dk/advice/Pages/Latest-Advice.aspx).

[4] The agreed TAC is, just as the scientific TAC, publicly available. The agreed TAC can be accessed on the homepage of the EU (https://ec.europa.eu/fisheries/cfp/fishing_rules/tacs_en).

[5] The historic catches are based on the reference period from 1973 to 1978. The Hague preferences refer to preferential treatment of regions whose dependence upon fishing is above average [7,39,41,57].

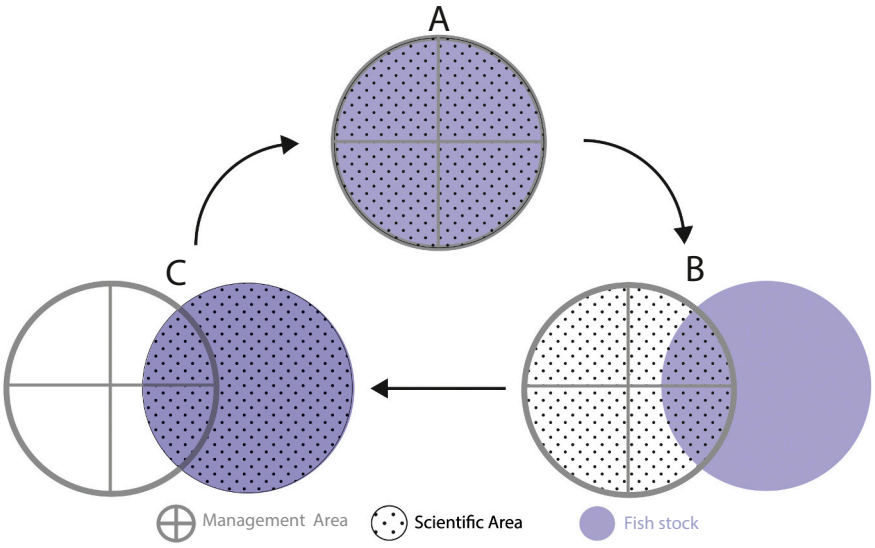

Fig. 3. Institutional mismatch. The black dotted area depicts the scientific area, the grey circle the management area and the purple area indicates the location of the fish stock. The division of the management area represents the sharing of the TAC according to the relative stability key. (A) Perfect alignment of scientific area, management area, and fish stock. (B) Management and scientific area are aligned but fish stock is not completely covered. (C) Scientific area matches the fish stock, but mismatch with management area occurs. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

paramount to the fisheries-management process in the same way as the scientific areas are essential to the provision of scientific advice. The TACs provided by ICES, referred to as 'scientific TACs, are based upon predefined areas (see Fig. 2) which we refer to as 'scientific areas'.[fn6] The underlying principle is to deliver 'best available science', and it is of course open to interpretation what this definition entails [85]. There is the very basic expectation to provide the most accurate stock assessment upon which the scientific TAC is based, which will, ultimately, be converted into best management practices. Still, a broader spectrum of considerations are being discussed within ICES, as part of the strategic initiative on human dimensions, and working groups (e.g. WGBESEO - 'Balancing economic, social and ecological objectives).

3. Institutional mismatch

3.1. Reasons for changing the scientific area

As discussed above, the management areas used in European fisheries management result from a transformation of scientific areas accounting for economic and political factors. Yet, fish populations adapt to changing environments. One of the biggest drivers for changes in ecosystems is climate change [70,71]. Climate change can impact fish populations in multiple ways such as e.g. distribution shifts, recruitment failure and increased productivity [32,68,72]. While the speed and degree of distribution shifts differ between stocks, there is ample evidence that all marine stocks shift towards the poles [32,69,70]. Even fish stocks that are less affected by temperature will likely move north eventually following their prey [51]. These spatial changes inevitably affect fishing grounds and fishing management in the EU.

In addition to the spatial distribution of stocks, new insights regarding the genetic composition of a stock may emerge [72]. Scientific advances in genomics allow for clear differentiation between genetically different stocks which used to be considered as one fish stock. New insights from genomics and distribution shifts due to climate change are the main factors calling for a modification of scientific and management areas. Genomics has developed rapidly in recent years and may have lead to modification of scientific areas [38]. Understanding the genome of a fish stock gives important information about the stock structure, which may allow for more precise stock assessments and also more sustainable management of stocks [9].

Distribution shifts of fish stocks as well as changes in the stock composition can induce a revision of scientific areas. Yet, adjusting scientific areas comes at a cost to ICES since there are clear path-dependencies. Stock assessment working groups are reluctant to change the scientific area since all the previous data refers to this specific area. Hence, there is a trade-off between adjusting the scientific area to the best available knowledge and lowering the value of previously collected data. Yet, while ICES clearly displays some institutional inertia, we still see changes in the scientific areas.[fn7]

3.2. Institutional inertia and the corresponding mismatch in the management system

New information about stock location and stock structure may motivate a change in scientific area, which also calls for an adjustment of the management area. If this does not happen, the scientific and the management areas diverge. Such mismatch occurs if (i) scientific area, (ii) management area, and (iii) fish stock location are not aligned, i.e. congruent. Fig. 3 shows schematically three different possible situations of the fisheries-management system that are relevant when discussion institutional inertia. In the ideal case (A), the scientific and the management area are aligned and the fish stock is also in that area. In this case, the scientific TAC can be easily converted into national fishing quotas. New information may indicate that the fish stock is not completely in the scientific and management area, but these two areas are aligned (B). This would, for example, be the case if a fish stock shifted polewards due to climate change. In this case, the national quotas are still determined via the relative-stability principle even though the stock is partially located outside that area and can, therefore, not be harvested by national fleets. However, the rigid structure of relative stability lacks a mechanism to flexibly adapt to 'an unpredictable but continuously changing ecosystem' [74]. Situation (C) depicts the case where the scientific area is adapted to match the location of the fish stock, but the management area is not, due to the inflexibility caused by institutional and political constraints. As a result, the scientific TAC needs to be converted into the agreed TAC and it is unclear how to divide the quota over countries. This paper focuses on case (C) and what is

[6] The main part of the recurring advice are single stock assessments, which is the focus of this paper. In addition, the advice also includes information on mixed-fisheries and ecosystem-based approaches [46].

[7] Two examples are plaice in the North Sea and the Baltic where the scientific areas changed in 1992, 2013, and 2016 while the management area stayed the same and haddock in the North Sea with changes in the scientific area in 1997 and 2015.

needed within the management system to overcome institutional inertia to achieve situation (A) again.[fn8]The mismatch between the scientific and the management area and the spatial position of the stock as illustrated in case B and C has clear implications for fisheries management: A change of the scientific area requires consensus among scientists involved in the provision of the scientific advice. Given the potential impact of changes in stock assessments on the allocation of the TAC, changes in stock assessments are usually adopted only if scientific evidence is sufficiently robust. Also, different working groups with their own working culture, tradition and composition of scientists having various roles lead to complex institutional dynamics [19]. Still, there is an ongoing discourse about modification of scientific areas.

Due to climate change there are continuous distribution shifts to be expected. As such, the scientific as well as the management area need to be adjusted continuously as well. While the adjustment of scientific areas has its own problems with path-dependencies it is reasonable to expect scientific areas to change before management areas. The change of the management area is convoluted given that it has immediate implications for national fishing quotas and requires a renegotiation of the relative stability key. Since the relative-stability principle is the backbone of the common fisheries policy, decision makers are reluctant to open this sharing rule up for discussions since there is a risk of not agreeing on a new sharing rule [42]. Also, the time frame is an important factor, since the renegotiation process of the management area takes most likely even more time than the changing of the scientific area. Hence, there is a risk of science outpacing the political realm. Since there is no defined mechanism indicating when and how management areas are adjusted, responsible institutions in the EU (AGRIFISH (fisheries and agriculture ministers of the member states in the council) and DG MARE) are lacking an effective and efficient procedure of resolving a mismatch.

3.3. Consequences of the mismatch

A mismatch between the scientific and the management area may impact the (perceived) quality of governance, i.e. the principles how decisions are adopted [36]. The EU has defined five principles for good governance, namely transparency, participation, accountability, effectiveness, and coherence. These principles also apply to the CFP [37]. Good governance in the CFP requires a clear definition of responsibilities at Union, regional, national and local level, the use of best available scientific advice, following a long-term perspective, administrative cost efficiency as well as taking into account regional disparities and consistency with other EU policies [29]. In the following part we analyse how a mismatch between scientific and management area may violate the principles of good governance in different respects.

3.3.1. Loss of transparency and coherence

Transparency refers to a policy process that can be followed and understood by the public, while coherence implies consistency across sectoral boundaries [36,40]. A mismatch as discussed in section 3.2 requires that – under defined conditions – the scientific TAC needs to be converted into the agreed management TAC. Since the areas are not equivalent, it needs to be decided how to calculate and allocate the TAC from the scientific area. So far, there is no clearly defined process how this should be done. So far, the conversion process occurs behind closed doors in the AGRIFISH meetings. Thus, it remains a black box which factors steer the conversion. Agreement on the conversion can involve trading political favours between countries within the realm of fisheries. Since the AGRIFISH meetings are between fisheries and agricultural ministers of the member states [8] such trading can also extend to other policy areas such as agriculture. This, in turn, goes at the expense of transparency and coherence. It also violates the principle of clear separation of responsibilities between member state and the EU. Ultimately, the lack of transparency and the deviation from predefined institutional rules may, in the long term, hamper cooperation between member states. Moreover, it can undermine public trust in the functioning of EU institutions [21].

3.3.2. Loss of accountability

Given the opaque process of converting the scientific TAC into the agreed TAC, and the risk of mismatches between both, it remains intransparent for the public who is responsible for the setting of the agreed TAC. The accountability of the distribution of quotas is further reduced if member states of the EU engage in quota swapping. Quotas assigned to one country through the relative stability key can be swapped with other member states. There are rules on how this is to be done but the process is still complex and therefore difficult to follow for outsiders [41]. This is further convoluted by the fact that the quota that is agreed on on paper is higher than the potential catch in that area, often referred to as 'paper fish'. If an assigned quota is not fished by the country because it is too high to be profitable, countries use them to swap with other countries or use them as currency to negotiate additional quotas for different fish stocks. It is expected that a potential mismatch of scientific and management area aggravates the problem of 'paper fish', and also undermines accountability. While the quota swaps satisfy principle of administrative cost efficiency in the short run, there is a risk that they undermine accountability and also trust in the long run.

3.3.3. Reduced effectiveness of sustainable fisheries management

The CFP has the clear goal to manage fish stocks sustainably, so policies should be implemented in a timely and effective manner. There are various reasons why fisheries management is expected to be less effective if there is a mismatch between areas. The management of fish stocks is based on reference points which typically set management targets as well as safe biological limits of harvesting. These reference points are calculated for a given stock in a fixed geographical location. If the fish stock shifts out of this predefined area the reference points are no reliable tools for management anymore. As a result, there is a risk of either overexploiting or underexploiting the stock, both leading to economic losses in the long run [53]. In particular, if the fish moves out of a management area, there is a risk of overfishing, as the stock can now also be caught outside that area. This could imply that the quotas are fully fished in the management area and on top of that fished in neighbouring management areas [69].

The EU introduced a landing obligation in 2015 which means that all catches of regulated commercial species also need to be landed [5]. This has implications for mismatches between scientific and management areas, since stocks that migrated into another region might be caught there as by-catch. Since the quota in these areas may be low, stocks can become a 'choke species'. This implies that vessels either have to halt fishing activity even if they still have quota for the target species, or discard the fish illegally [2,3]. If the stock is located outside the management areas, fishers may be inclined to catch the stock in the part of the scientific area that is not covered by the management area. In such case, they would still have to take 'accounting trips' to the management area in order to camouflage that the catch was fished outside that area. These actions of behaviour impede a successful long-term management of the fish stocks. They also undermine the principles of effectiveness, accountability, as well as transparency and coherence.

4. Resolving the institutional mismatch – The horse mackerel case

In European fisheries management mismatches between scientific

[8] Clearly, the three cases depicted in Figure 1.3 do not claim to be exhaustive, several other cases may exist where the scientific and the management area do not (fully) match the position of the stock, keeping also in mind that stock assessments are subject to considerable data and model uncertainty.

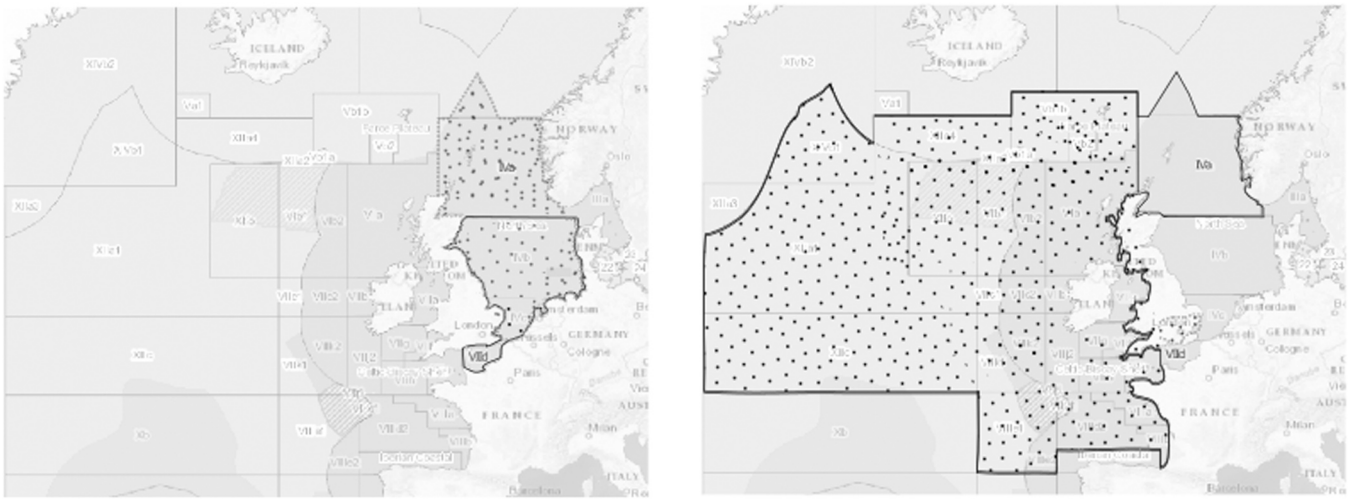

Fig. 4. The mismatch between management and scientific areas for the North Sea (left) and the Western stock (right) of horse mackerel in 1999. The black dotted areas indicate the scientific areas and the black solid lines indicate the management areas. The areas that need to be realigned are IIa and IVa (from the Western stock to the North Sea stock) and VIId (from the North Sea stock to the Western stock).

and management areas are not uncommon [8]. Moreover, as discussed above, they can be expected to become more relevant in the future due to climate change [69]. So far, there has been, to the best of our knowledge, only one case in the EU – i.e. the case of horse mackerel – in which the management area has been adjusted to the scientific area. The main reason for a mismatch of the scientific and the management area in this case was new genetic information. It became apparent that two stocks of the same species had been genetically misspecified. We use this case as an example to evaluate the process and to exemplify different obstacles associated with resolving the mismatch between the management and the scientific area (the change from situation C to A in Fig. 3). We focus only on the adjustment of the management areas to the scientific areas and assume for simplicity that the fish stock area is covered by the scientific area. We discuss the process in light of the governance principles introduced before.

4.1. Background of the mismatch

The two horse mackerel stocks for which the management areas were adjusted are the North Sea stock (along the coasts of France, Germany, Denmark, Sweden, Norway, and the United Kingdom) and the Western stock (along the coasts of France, Norway, Ireland, and the United Kingdom).

The first scientific assessment that became publicly available for those stocks is from 1999 in which ICES pointed out that the management areas for the North Sea as well as the Western stock do not match the scientific areas[fn9][44]. There was also some uncertainty about the exact biological division of the two stocks, i.e. the fish stock area. Fig. 4 provides an overview of the three divisions which were to be changed to realign scientific and management areas. The management area for the North Sea stock did not cover divisions IIa and IVa while the scientific area did. At the same time, the management area of the Western stock did not encompass division VIId while the scientific area did. With regard to division IIa and IVa there was no scientific dispute whether these should be part of the North Sea management area or not. However, scientific assessments were less conclusive regarding division VIId. Comparing the scientific and the management areas of the Western as well as North Sea stock one can see that division IIa and IVa should have had to be added to the Western stock management area and division VIId to the management area of the North Sea stock (Council of the European Union 1999, ICES 1999b, Council of the European Union 1998). In contrast, management considered divisions IIa and IVa to be part of the North Sea stock area and VIId to be part of the Western stock area. Hence, the first publicly available assessments for the North Sea and the Western stocks[fn10] illustrate a mismatch between the scientific and the management area, reflecting lacking effectiveness in the transformation of scientific advice into quotas.

The status of the North Sea stock was a concern in 1999. ICES stated clearly that the rising exploitation rate of the stock, and the extensive fishing of juveniles, was problematic for the sustainability of the stock. Moreover, it was noted that the stock was migrating out of the North Sea and into divisions IIa and IVa [43]. The Western stock was also considered to be outside safe biological limits. Specifically, there was a major concern about the increased fishing of juveniles in the areas VIIe&f. Similar to the case of the North Sea stock, the overfishing of the Western stock was partly due to a distribution shift which lead to an increased fishing pressure since new fleets started to also fish the Western stock [44].

From 2000 onwards, efforts were made to disentangle the horse mackerel stocks with the aid of genetic markers and biological tags [1]. While the differences between the northern boundary of the Western stock and the North Sea stock were clearly defined, uncertainty about the southern boundaries (division VIId, English Channel) of the two stocks remained because of a lack of samples [1]. In 2015, 2016, and 2017 genetic samples were taken to clearly differentiate the Western from the North Sea stock and a full genome sequencing was initiated but so far there are no conclusive results [47]. Thus, the scientific areas were considered to be aligned with the location of the fish stocks (division VIId as part of the Western stock) to the best of current (uncertain)

[9] The management area also did not cover the Western part of division IIIa, but this division was of no major concern to any party involved.

[10] While the exact reason for this mismatch remains elusive given the publicly available data, the stocks were clearly affected by genetic issues as well as northward distribution shifts [43,44].

Table 1
Timeline of the main steps from the first official mismatch between scientific and management area for the North Sea and the Western stocks of horse mackerel to the aligned areas and accepted quotas.

1999	2005	2006	2007	2008	2009	2010
First official record of mismatch between management and scientific area.	Advisory Council (AC) Initiative to align areas as part of a multiannual management plan.	AC discussions on how to align areas.	Proposal of alignment sent to European Commission and ICES.	Biggest problem of implementation of management plan: consolidation of scientific and management area. European Commission asked AC for advice, but AC refused to discuss quotas.	European Commission sent proposal of aligned areas to European Council without redistributed quotas. Commission circulated proposal for recalculation of quotas asking for input of member states. Several member states voiced concerns and provided alternative solutions.	First record of aligned management and scientific area with new quotas.
Involved Actors						
EU, ICES	AC	AC	AC, EU, ICES	AC, EU	EU, France, UK, Netherlands, Spain, Ireland	EU

knowledge. Yet, the lack of conclusive evidence turned out to be a big hindrance in the realignment of the management areas.

4.2. Process of the renegotiation

The alignment of the scientific and management area was a lengthy process, starting in 1999 and ending in 2010 with aligned areas and recalculated national quotas. Table 1 provides a brief overview over the process and the involved actors. The EU upheld the principle of participation by involving stakeholders such as the industry seated in the Advisory Councils (ACs). In the following, we focus on the main steps that were taken over the years, and in particular on the recalculation of the national quotas. Note that during this process the management system continued to distribute fishing quotas based on outdated management areas. Further, while part of the mismatch was caused by distribution shifts this has not lead to a change of scientific areas since 1999 [17].

4.2.1. Alignment of the scientific and the management areas

In 2004 the Council of the EU established the Advisory Councils (ACs) to allow for stakeholder participation in the CFP [12]. In 2005, the Pelagic AC agreed with ICES that the management area should be changed to match the scientific area [61]. The alignment of scientific and management area was to be part of a longterm management plan for horse mackerel for which the Pelagic AC kept pushing [63]. In November 2006 the first unofficial draft of a management plan for horse mackerel was discussed and one of the main issues to be solved was the discrepancy between scientific and management area [62,65]. In July 2007 the Pelagic AC proposed the management plan to the European Commission which was based upon the scientific areas, thus assuming that management and scientific areas are aligned but without discussing the implications for the national quotas [64]. Stakeholders as well as ICES agreed on the need to increase the effectiveness of the CFP by aligning the areas.

The implementation of the management plan proved difficult since the question of how to adjust national quotas due to a change in management areas had not been solved [66]. The Commission wrote a non-paper,[fn11] an unofficial and non-binding discussion paper, in which it discussed the calculation of new national quotas for the changed management areas. The Pelagic AC was asked to provide input but declined since they considered this a 'political issue, which should be left to the Member States to be resolved' [67]. The Commission stressed that 'relevant stakeholders' would have to get involved in the coming weeks to find a solution but since there was no agreement on the new distribution key yet, the TAC and the corresponding management area for 2009 would be the same as in 2008 [25].

In April 2009, the Commission sent the proposal for the multiannual management plan of horse mackerel to the Council of the EU without having solved the recalculation of national quotas. The proposal stated that 'the management TAC shall be calculated taking into account recent scientific advice on appropriate catch levels' [26]. In the annex of the proposal, the Commission presented the problem of the mismatch. The Commission pointed out that science-based management of the fish stocks was impossible given the mismatch. Moreover, the proposal stated which divisions had to be reassigned to other management areas to be in line with the scientific areas. The Commission also presented the changes in the agreed TAC (the TAC for the Western stock will be increased while the one for the North Sea stock will be reduced). However, the Commission did not address how this would translate into national quotas [26]. Thus, while the Commission acknowledged that the mismatch was undermining the good governance principles of effectiveness and the use of the best available science, and ultimately also the long-term management strategy, there was still no clear path on how to solve the issue.

4.2.2. Recalculation of the quotas

While the official proposal did not quantify the new national quotas, the Commission circulated a non-paper (DS 621/09) among the member states in which the exact calculation was discussed. The Commission proposed to use the 10 year period between 1997 and 2006 as basis for the calculations. The North Sea stock was used to clarify the process.

The recalculation of the quota for each member state meant that agreement needed to be reached on a new sharing rule of the agreed TAC which proved to be complex. While the Commission stated that it 'calculates the fishing possibilities that each MS [member state] has in the average catches in the division to be transferred', this principle was not

[11] A non paper often starts with a disclaimer such as "This draft has not been adopted or endorsed by the European Commission. Any views expressed are the preliminary views of the Commission services and may not in any circumstances be regarded as stating an official position of the Commission. The information transmitted is intended only for the Member State or entity to which it is addressed for discussions." [28]

Table 2
Changes in the relative stability key for the North Sea stock and the Western stock. Numbers indicate percentage of total quota per fish stock and year (rounded). We use the official quotas to calculate the relative stability key for the years 2008 [13] and 2010 [14]. We see that while there were changes in the single stock distribution, the relative share for both stocks did not change much (biggest difference DK loosing 1.6%).

	North Sea		Western		Stocks combined		
Country	2008 %	2010 %	2008 %	2010 %	2008 %	2010 %	Δ
Belgium	0.156	0.109	0	0	0.028	0.024	-0.004
Denmark	67.709	47.601	9.073	9.938	19.714	18.126	-1.589
Germany	5.106	4.202	7.252	7.755	6.863	6.982	0.119
Spain	0	0.885	9.904	10.577	8.107	8.470	0.363
France	0.107	3.949	4.792	3.991	3.942	3.982	0.040
Ireland	3.930	2.994	23.610	25.826	20.039	20.863	0.824
Netherlands	10.983	28.659	34.601	31.114	30.315	30.580	0.265
Portugal	0	0.100	0.958	1.019	0.785	0.819	0.035
Sweden	2.015	0.171	0	0.428	0.366	0.372	0.006
United Kingdom	9.995	11.328	9.808	9.352	9.842	9.782	-0.060
Agreed TAC (in t)	37,230	43,854	167,920	157,881	205,150	201,735	

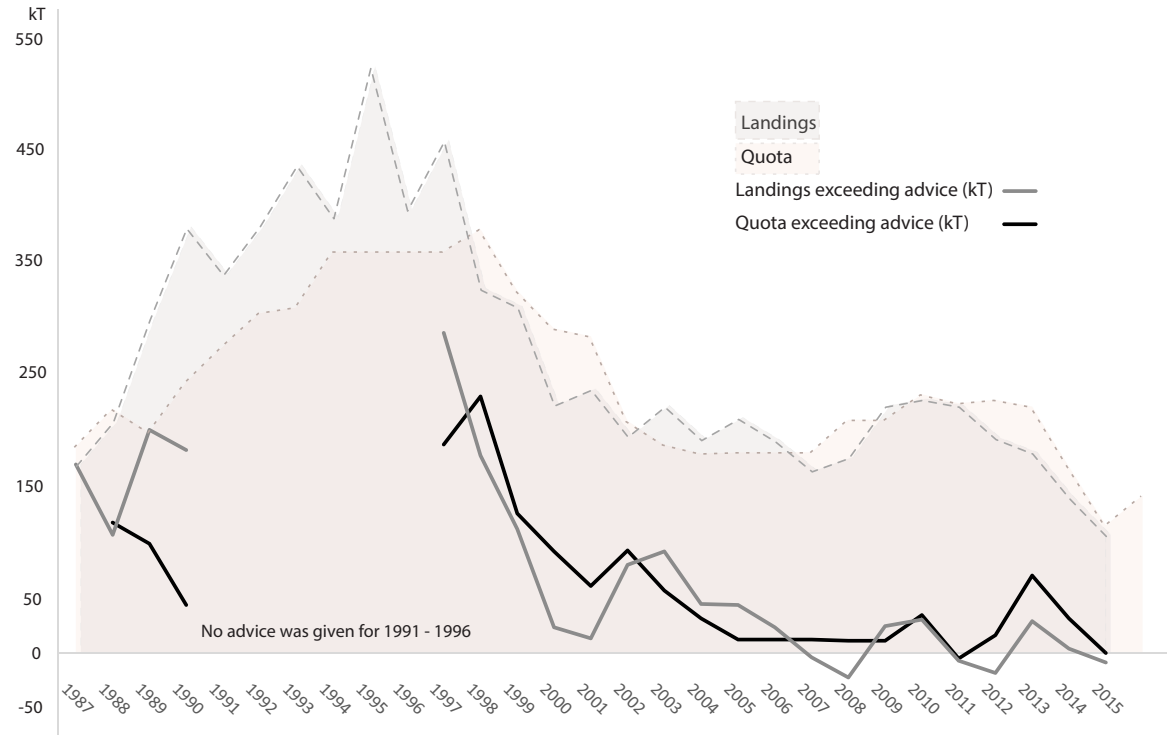

Fig. 5. Overview over management of North Sea and Western horse mackerel. Data from Pastoors [60].

applied. The benchmark of what was fished under the old management regime could be based on either calculating the average quota per country, or average catch, which were different (see Table A.1). Using catches as a benchmark for calculating the new relative stability key would probably have been more transparent, since it would reflect the catches after quota-swapping and without quota that only existed on paper, the so-called 'paper fish'. Using the average quota as a basis would ensure that the new sharing rule was closer to the old one and perhaps easier to implement. While the realignment of the areas would increase transparency and effectiveness of the CFP, the recalculation of the relative stability key was still a hurdle that needed to be taken.

The Commission proposed to calculate the average fishing possibilities per member state and division. The idea was to transfer national fishing possibilities per division to the new management area (fishing possibilities of VIId are added, fishing possibilities of IVa and IIa are deducted from the average quota in the old North Sea management area)

[24]. The Commission asked for input of the member states. Depending on the fishing behaviour of a country there was a clear preference for either catches or quotas as basis for the calculations. Countries that did not fish their full quota advocated for quota as basis for the calculation while countries engaged in quota swaps to increase their national quotas advocated for using catches as the basis for calculation (see Table A.2 for input by member states). Basing the calculation on catches instead of quotas would have had the advantage that the new relative-stability key would be based on fish that had actually been caught by the countries. Thereby, 'paper fish' would be eliminated which would increase transparency considerably. In contrast, basing the new quotas on the old quotas would keep the original relative-stability key. The main concerns in regard to the proposal referred to the scientific accuracy of the division of the two stocks and whether quotas or catches should be used as a basis. In regard to VIId, several countries proposed a flexibility clause to be able to catch part of the Western under the North Sea quota and/or part of the North Sea quota under the Western quota, depending on the time of the year. This request was granted as a political compromise, though it reduced transparency of the CFP. The role division VIId played in the negotiations highlights the importance of robust scientific advice for the management and its adaptation.

4.3. Final relative stability key

The first official quotas for 2010 were made public in January 2010 [16]. France, Germany, the Netherlands, and United Kingdom had the right to declare 5% of their quota for the North Sea stock fished in division VIId under the quota for the Western stock. Denmark, Germany, France, Ireland, the Netherlands, Sweden, and the United Kingdom had the possibility to declare up to 5% of their quota for the Western stock fished in division IIa and IVa under the North Sea stock [15,27].

The redistribution of the divisions IIa, IVa, and IIVd were not without consequences for the relative stability key. Table 2 shows the changes for the individual stocks. The main part of the TAC for the North Sea stock was and still is the quota for Denmark. Yet, the relative size of the Danish quota was reduced by around 20% points. In contrast to Denmark, the Netherlands' share of the North Sea TAC was increased by about the same amount. The other countries kept their share more or less constant with maybe a 1 or 2% point change. The changes to the relative stability key in the Western stock were smaller. While Ireland increased its share by about 3% points, the Dutch share decreased by about 5% points.

Combining the two quotas it becomes apparent that the relative stability key remained more or less stable (table 2). The biggest decrease in quota shares was experienced by Denmark with − 1.589% points while Ireland was the country with the biggest increase in quota (+ 0.248% points). So while we do see an adjustment in the management areas to match the scientific areas, none of the countries had to give up a big share of its quota for horse mackerel. It seems that the guiding principle was 'to focus most on minimizing short-term losses and maintaining agreed quota shares' [74]. The final compromise was accepted, so it can be seen as a success, though it was also a missed opportunity to establish a more transparent and effective system on how to handle adaptations within the system.

While the adjustment of the management areas missed the opportunity to establish a system to adjust management areas it was a clear success for sustainable management of the two stocks. Fig. 5 highlights the development over time. While overfishing was high in 1999 we see a trend towards less overfishing. The discussions on a multiannual management plan and the realignment of the areas started in 2005 which correlates with greatly reduced overfishing. The discussions might have heightened the awareness of the mismatch implications. Quotas as well as landings are closer to the scientific advice than before since aligned areas take away the opportunity to exploit the "rule of thumb" redistribution between the management areas.

The horse mackerel case could, finally, be resolved because it only required a division of biomass (North Sea and Western horse mackerel combined) into two quotas. As we saw there were no real losers, rather the countries received overall the same amount of quota for horse mackerel as before, although officially they are fishing a different fish stock now. Given the inertia of the institutions involved, a case which also involves a re-distribution of quotas between countries thus generating winners and losers will likely be much more challenging.

5. Discussion

So far, the common fisheries policy of the EU has been relying on a rather static governance system. While this means it adheres to the good governance principles of administrative cost efficiency and provides consistency, the question is how the system deals with situations where the static governance fails. It has become clear that the EU lacks a clear and transparent mechanism of adjusting the management TAC when new information on the genetic composition and location of stocks has become available. This institutional inertia can induce a mismatch between the scientific and the management area. Besides hampering EU institutions to adequately react to ecological changes with sufficient flexibility, it can also negatively affect the relations between EU member states and other countries. For instance, with stocks shifting towards the poles, conflicts about fish can arise with non-EU countries such as Norway and Iceland.

Obviously, overcoming the institutional inertia is challenging in several respects. However, this paper has provided several important lessons that may help overcoming those challenges. First, information can reflect most recent scientific insights but is less valuable to decision makers in the policy arena. Hence, a change of the scientific area may be considered 'best' by researchers (e.g. in ICES) but be qualified 'suboptimal' in terms of management goals and policy preferences. As the horse-mackerel case illustrates, changing procedures such that the management area is adjusted based on new scientific advice is very time- and resource consuming since the adjustments are adopted on a case-by-case basis rather than through a predefined process. This is neither efficient, nor does it ensure good long-term planning. The challenge is to broaden the ambition of providing 'best' science towards providing 'most useful' advice that is tailored to governance needs, which could imply that novel insights regarding stock structure may not always be incorporated in scientific advice.

Second, defining a mechanism for adjusting management areas also requires a debate about when new information should trigger adjustments. Considering that even the best and most up-to-date scientific knowledge remains subject to different types of uncertainty, and considering the distributional impacts of adjustments of management areas, new information has to be sufficiently robust to warrant a change in the management system. However, the level of robustness is often subjective and open for interpretation.

Third, the expected distributional impacts of any changes, i.e. change in quota, have been the overriding institutional constraint,

potentially stalling any meaningful attempts to create a system where individual countries are worse off even if it is collectively beneficial. Especially in a multi actor setting like the EU, establishing predefined rules would help to not get bogged down in lengthy negotiations and unclear responsibilities as laid bare in the horse mackerel case. ICES could play a larger role in making distributional implications transparent in their advice, which may be helpful to inform any change in the management system.

Fourth, a predefined mechanism bears the risk to create one-size fits all solutions and ignore their context-dependence. This requires to think ahead about which components of such mechanism should be kept flexible and which should be cast in stone. Closely related to this, and as illustrated by the horse mackerel case, countries tend to argue opportunistically, trying to create the most beneficial agreement for their national fishers. Hence, a system for flexible adjustments of management areas should contain a 'veil of ignorance', i.e. EU member states should adopt decision rules without knowing whether it will apply to a fish stock in their own portfolio. In general, using catches as basis for the calculations would improve transparency since it would respect the idea of giving rights to those who have been traditionally fishing, and avoiding the problem with 'paper fish', i.e. quota that only exists on paper. A mechanism to compensate losers of a potential change may help to come to an agreement that avoids too severe distributional repercussions.

Fifth, having a predefined mechanism that steers the redistribution of the newly agreed TAC among EU member states would eliminate the need for deals behind closed doors in the AGRIFISH meetings. Being able to pinpoint on who is responsible within the system would increase trust in the institution and thus establish a stronger sense of legitimacy of the policy. Also, establishing a dynamic system that continuously aligns the management area to the scientific area would eliminate incentives to mask fishing outside designated locations, which may happen if the best fishing locations are not where vessels hold their quota. The horse mackerel case – as complex and convoluted as it was – has been the only case in the EU where the management areas have finally been adjusted. In the context of climate change dynamics future cases will probably be even more complex and difficult if the current regime will be maintained. While we can only speculate about the overall welfare effects, a predefined mechanism for adjusting management areas would increase transparency, decrease administrative costs, and would therefore improve the efficiency and effectiveness of the CFP. This is a prerequisite for building trust in the European fisheries policy and long-term management.

6. Conclusion

Fisheries are social-ecological systems, where the fish stock dynamics are guided by complex biological processes in response to external drivers. Yet, institutions may be inert and do not respond swiftly and appropriately to new scientific insights. In this paper, we investigate the case of a potential mismatch between scientific areas and management areas in European fisheries. Striving for the most detailed knowledge on a fish stock is well-intended and – in an ideal world – also the knowledge needed for the management system to run smoothly. Also, the principle of separating scientific advice from the realm of politics and management (see Fig. 1) was well intended, as it strengthens transparency and the independence of advice, and is an important cornerstone of sustainable fisheries management. However, in this paper we have indicated a potential weakness, as there is no mechanism in place to ensure that institutions co-evolve with the ecosystem that is governed. As a result, over time, new scientific insights have emerged that cannot be translated into management because of institutional inertia. Such inertia leads to a violation of the self-imposed principles of good governance, especially effectiveness, transparency, and accountability. The biggest direct danger is probably the erosion of trust of stakeholders and the broader public in the fisheries system, which is notoriously difficult to build and almost impossible to recover if lost.

We used the realignment of the management areas of the North Sea and Western horse mackerel stocks as a case to gain some insights in the process and the associated obstacles of changing management areas. We see that the negotiations are slow (ten years from the first officially documented mismatch between scientific and management area) and primarily driven by distributional questions about how to divide the total quota.

Considering that the EU provides a framework for countries to cooperate on fisheries management with the declared aim of achieving sustainability, it is plausible that adapting to new insights and stock shifts is even harder to manage in areas where such an institutional setting is missing. It is also clear that the current system is too static to deal with the challenges future distribution changes may bring in a coherent and transparent way. What would be urgently needed, therefore, is a streamlined process on how to adapt management and scientific areas and the corresponding national quotas following-up on new and better knowledge on stock composition and spatial distribution.

CRediT authorship contribution statement

Esther Schuch: Conceptualization, Methodology, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Silke Gabbert:** Conceptualization, Methodology, Writing - review & editing. **Andries Richter:** Conceptualization, Methodology, Writing - review & editing, Visualization.

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Declaration of Interests

None.

Appendix A

See Table A.1 and Table A.2

Table A.1
Commission proposal on how to calculate the new quotas for the agreed TAC of horse mackerel in the North Sea [24].

	Average Quota in the initial North Sea stock management area (including division VIa & IIa without VIId) (tons)	Quota to be transferred from Western area (average catches VIId)	Quota to be transferred to Western area (division IVa)	Quota to be transferred to Western area (division IIa)	Net transfer, adding the ratios of the transfer quotas to 52,599 t	New quotas for the new management area (IVbc and VIId)	New quota key
NL	5896.35	6838.808	3034.995	92.258	7.06%	9607.902	21.61%
IE	2109.2199	4666.556	1085.667	33.002	6.75%	5657.106	12.72%
ES	0	1957.565	0	0	3.72%	1957.565	4.40%
FR	57.858	947.198	29.781	0.905	1.74%	974.370	2.19%
PT	0	189.447	0	0	0.36%	189.447	0.43%
DE	2740.407	1433.436	1410.555	42.878	-0.04%	2720.411	6.12%
DK	36,345.909	1793.377	18,708.134	568.693	-33.24%	18,862.459	42.41%
UK	5365.098	1938.610	2761.548	83.946	-1.72%	4458.214	10.03%
BE	84.158	0	43.3184	1.316	-0.08%	39.523	0.09%
Total	52,599	19,765	27,074	823	-15,46%	44,467	100%

Table A.2
Summary of the comments of the member states on the proposed changes to the management areas and quotas for horse mackerel.

Country	Comments
France	France questioned whether the redistribution of VIId is really scientifically warranted by referring to the somewhat inconclusive results of HOMSIR [87]. France advocated a quota that is more in line with these results. France proposed that divisions IVa and VIId should be regarded as "exchange areas". This would mean that IVa would be fished under the North Sea quota in the first half of the year and under the Western quota in the second half. This flexibility would be granted to Member States with a catch history in the area. Fishing in VIIId could be fished under the Western and the North Sea quota during the whole year, again this flexibility only applies to countries with a catch history in the area. Another option France puts forward is having separate TACs for the division IVa and VIId, so avoiding the complication of having to definitely assign them to a specific TAC [33].
Ireland	Ireland disagrees with the calculation of the new quota distribution proposed by the Commission. The method proposed by the Commission would mean that Irish fishers have to fish their North Sea quota in the divisions IVb, IVc, and VIId where Irish fishers usually do not catch fish. The quota for the North Sea was caught exclusively in IVa and IIa. The redistribution would result in a situation where Ireland has a high quota in areas where they do not fish while the quota for the regions they are fishing is lowered. Hence, Ireland proposed a method for recalculation that is based on historical catch patterns. Only the countries fishing in the divisions that need to be reattributed would be affected. By focusing on the historical catch instead of quota, the new quotas would account already for quota swaps which the member states frequently engage in. Also, 'paper fish' would be avoided. The relative stability key over the two management areas would remain unchanged. Lastly, Ireland also supported the call for flexibility in divisions IIa/IVa and VIId [49]. Ireland proposed that 5% of its quota for the North Sea which is fished in VIId could be accounted for under the Western TAC [86].
Spain	Spain advocated for a redistribution based on quota instead of actual catches. If catches were used the relative stability key per division is changed. Also, using catches favours Member states with inward quota swaps in comparison to Member States with outward quota swaps. Spain did not agree on the method of the Commission, since this calculation would result in Spain having quota in the North Sea stock, where Spanish fishermen do not operate [75].
United Kingdom	In line with France and Ireland, the United Kingdom requested flexibility in division VIId due to the inconclusive science. Another concern was that the reorganisation could impact fishing patterns. The main focus of the United Kingdom was to keep the fishing in division VIId as close as possible to the status quo to ensure that the fishery remains undisturbed [81].
Netherlands	The Netherlands advocated for flexibility in the redistribution of catches. The Netherlands requested that 5% of its quota for the Western stock are accounted for in VIId [79,86].

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