Aquat. Living Resour. 2026, 39, 17
© H. Drouineau et al., Published by EDP Sciences 2026
https://doi.org/10.1051/alr/2026010

Aquatic Living Resources
Available online at:
www.alr-journal.org

Research Article
Open Access

Trends in fishing opportunities in European fisheries following the last Common Fishery Policy reform

Hilaire Drouineau[1,*], Youen Vermard[2] and Michaël Gras[3]

[1] INRAE, UR EABX, 50 avenue de Verdun, 33612 Cestas Cedex, France
[2] DECOD (Ecosystem Dynamics and Sustainability), Institut Agro, IFREMER, INRAE, Nantes, France
[3] European Commission, Joint Research Centre (JRC), Ispra, Italy

Received 2 April 2025 / Accepted 11 May 2026

Handling Editor: Ralf Döring

Abstract – Since the end of the 20th century, the maximum sustainable yield (MSY) has been at the core of debates in the fisheries sector from a biological, economic, and geopolitical perspective. In theory, MSY aims to maximize fishery yields while preventing harmful declines in stock biomasses. However, MSY is primarily derived from monospecific population dynamics and does not necessarily achieve a suitable balance between exploitation, socioeconomic objectives, and foodweb and ecosystem functioning. Since the reform of the European Common Fisheries Policy (CFP) in 2013, FMSY has been the management target for European fisheries. Given the high prevalence of overexploited stocks at the time, fisheries theory suggests that, for those stocks, a reduction in fishing mortality should lead to an increase in biomass, which in turn should result in an increase in fishing opportunities. While some of the indicators calculated to monitor the effectiveness of the CFP show encouraging signs regarding stock status, the fishing industry, which in the meantime has also been affected by a series of crises, does not seem to perceive the expected benefits. Using a meta-analysis of 92 stocks assessed by ICES in the Northeast Atlantic, we examined how scientists' advice on fishing opportunities has evolved and whether it has responded to changes in F and SSB since the last CFP reform. While the analyses show that fishing opportunities have increased mainly in cases where fishing mortality and spawning stock biomass have changed the most, they also appear to be evolving more slowly, and the picture remains rather mixed. This may also reflect adverse signals of global change and the impact this may have on future fishing opportunities.

Keywords: Maximum sustainable yield / global change / overexploitation / fish stocks / total allowable catch / stock assessment / fishing mortality / stock depletion

1 Introduction

Overexploitation of natural resources is one of the five components of global change that threaten biodiversity (IPBES, 2019). In the oceans, the harvesting of fish for human consumption has already dramatically reduced the abundance of top predators (Christensen et al., 2003), impacted marine food webs (Cury et al., 2011; Hernvann and Gascuel, 2020), and had detrimental effects on ecosystems (Bastardie et al., 2021).

After decades of debate about whether marine resources were unlimited, the development of the first surplus production models in the mid-20th century (Schaefer, 1957) formalised the response of a fish population to increasing levels of fishing pressure: while fish biomass systematically declines as fishing mortality increases, catches display a dome-shaped response. Initially, catches increase with fishing pressure, up to a maximum, known as the maximum sustainable yield (MSY). However, if fishing pressure increases above F_{MSY}, the biological production of the stock is impaired by its low biomass and catches start to decline on average (Hilborn and Walters, 2013), a situation known as overfishing. The later development of analytical models refined the concept with the definition of growth and recruitment overfishing. The former defines a situation where fishing pressure prevents recruits from reaching a size that would maximise catch whereas the latter refers to a situation in which the depletion of the adult component of the stock hinders recruitment. Overexploitation or overfishing is a "lose-lose" situation, as it threatens the long-term viability of fish stocks and reduces fishers' socio-economic welfare (Gordon, 1954; Grafton et al., 2012).

Despite its well-known negative effects, overexploitation of fish stocks is widespread worldwide (FAO, 2024). In Europe, the Common Fisheries Policy (CFP) was adopted in

*Corresponding author: hilaire.drouineau@inrae.fr

1983 to promote sustainable fisheries, ensure the economic viability of Member States' fleets, and guarantee food security (EEC Council Regulation No. 170/83). Although considered one of the most integrated and prescriptive regulations in the European Union (Lado, 2016), the CFP did not prevent the overcapacity of European fleets (STECF, 2023a) nor the overexploitation of about 75% of stocks in the early 2000s (STECF, 2021). However, since its last reform in 2013 (EU Regulation No. 1380/2013), the CFP objectives have been expanded to include reducing the impact of fishing on marine ecosystems and achieving a situation of no overexploitation by 2020 in European waters. Harvesting at the "MSY", defined in the regulation as "the highest theoretical equilibrium yield that can be continuously taken from a stock under existing average environmental conditions without significantly affecting the reproduction process", therefore became the new management objective for all stocks managed under the CFP. Although this target has not yet been fully achieved (STECF, 2024), the reform has led to a significant reduction in fishing mortality and to a progressive rebuilding of fish population biomass (Froese et al., 2018; STECF, 2024).

Fishery science theory predicts that reducing fishing pressure on an overexploited population should lead to an increase in biomass, which in turn increases the biological production of the population and subsequently catch levels. Historically, this has been observed in Europe, for example, when a ban on the fishery targeting the depleted North Sea herring allowed the stock to recover and the fishery to reopen in the 1980s (Dickey-Collas et al., 2010). However, counter-examples also exist. For instance, the Canadian cod stock has shown limited signs of recovery despite decades of fishing bans or severe effort control (Schijns et al., 2021). This may be due to changes in environmental conditions and in food webs. Indeed, regime shifts occurring during periods of low population abundance may impair subsequent recovery (Blöcker et al., 2023; Möllmann et al., 2021). This risk may increase as climate change is expected to affect ocean catch potential (Pontavice et al., 2023; Pontavice et al., 2021).

About 10 years after the last CFP reform, at a time when the fisheries sector is facing multiple crises (e.g., Brexit and fuel costs (STECF, 2023b)) and when global change, including climate change as well as other components (e.g., habitat deterioration and contamination), is increasingly threatening marine ecosystems, this paper aims to explore whether efforts to reduce fishing pressure and rebuild fish populations have actually led to increased fishing opportunities in European waters, as predicted by theory. This article does not seek to assess the relevance of the MSY objective per se, but rather the implications of reducing F, given the significant overfishing that occurred in the late 2000s. It also examines why the biomass of certain stocks, and consequently fishing opportunities, has not recovered as expected following reductions in fishing mortality.

2 Materials and methods

This study focuses on Northeast Atlantic stocks in European waters for which the International Council for the Exploration of the Sea (ICES) provides recurrent advice on fishing opportunities to the European Commission. For these stocks, we extracted from ICES advice, where available, the estimated fishing mortality (F), trends in spawning stock biomass (SSB), and annual catch or landing advice formulated by ICES, which corresponds to the level of catch/landings according to the management rules in force (e.g., MSY target and precautionary approach or management plans depending on the stock). ICES advice 2023 or 2022 was used, depending on availability when the dataset was built (the year of the advice is specified in supplementary material). To avoid any inconsistencies due to changes in stock definition or assessment methods, we collected the information from a single advice sheet so that catch advice, trends in F, and trends in SSB arise from the same assessment. For example, for the cod stock in the western Baltic Sea (cod.27.22-24), we used the 2023 advice (ICES, 2023a), extracted F and SSB time series from Table 9 ("Assessment summary"), and time series of catch advice from Table 6 ("ICES advice"). Among all these 92 stocks (a complete list of stocks is provided in the supplementary material), we filtered those for which at least 8 years of biomass and fishing mortality estimates and 8 years of catch/landing advice were available over the period 2013–2023. The 8-year threshold was chosen to avoid time series that are too short for trend tests to be meaningful or that potentially start too late after 2013. We only retained in the analysis years in which the scale of the advice remained consistent (e.g., no stock redefinition and no inclusion of additional population fractions). Given these data requirements, mostly stocks from ICES data categories (ICES, 2025) 1 ("stocks with quantitative assessments") and 2 ("stocks with analytical assessments") were used, although a few stocks from category 3 ("stocks for which survey-based assessments or exploratory assessment indicate trends") could also be included by using available proxies of biomass and fishing pressure (aru.27.6b7-1012, bsf.27.nea, fle.27.3a4, lem.27.3a47d, nep.fu.2829, spr.27.7de, usk.27.3a45b6a7-912b, and mur.27.3a47d).

For stocks for which advice changed from landing advice to catch advice (or vice versa), for instance, following the implementation of the landing obligation (Borges and Lado, 2019), we converted ICES landing advice to catch advice. To do so, we computed the average reported discard rate DR_s for each stock s in the ICES advice by dividing reported discards by the sum of discards and landings over the study period:

$$DR_s = \overline{\left(\frac{\text{discards}_s(y)}{\text{discards}_s(y) + \text{landings}_s(y)}\right)}.$$

Then, when for a given year, the fishing opportunities table in the ICES advice was specified as catch advice (conversely, landing advice), a corresponding landing advice was calculated as $\text{Landing advice}_s(y) = \text{Catch Advice}_s(y) \times (1 - DR_s)$ (conversely, $\text{Catch advice}_s(y) = \text{Landing advice}_s(y)/(1 - DR_s)$. The analyses were then carried out either on landings or on catches, using the series requiring the fewest conversions, which were considered to represent fishing opportunities.

This resulted in a subset of 92 stocks. For these stocks, we carried out three different analyses:

– Following the CFP monitoring protocol used by the Scientific, Technical, and Economic Committee for Fisheries (STECF) to assess CFP performance (Gras et al., 2023), we derived aggregated indicators of fishing opportunities using a state-space model as implemented in the JARA R package (Winker et al., 2020) to compare trends across ecoregions. Before fitting JARA, fishing opportunities for each stock were normalized by their average over the study period to focus on relative trends and avoid giving greater weight to stocks with larger opportunities. JARA fits an autoregressive smoother to each standardized stock time series, assuming that opportunities follow a log-normal distribution. JARA uses a Bayesian framework and is implemented using the runjags package (Denwood, 2016), with 3 chains run to produce 3,500 posterior samples each (burn-in: 2000 iterations; thinning rate: 2). For each stock and each year, this produces posterior standardized (by the mean) fishing opportunities, consisting of 10,500 (3×3500) samples. Finally, a bootstrap (with replacement) is performed across stocks to calculate mean fishing opportunities per year and the associated credibility intervals.

– At the stock level, Mann–Kendall trend tests were used to detect monotonic trends in F, SSB, and fishing opportunities. The Mann–Kendall test is a non-parametric rank-based test aimed at detecting the existence of monotonic (but not necessarily linear) trends in time series (Kendall, 1975). Historically overexploited stocks are expected to show a negative trend in F following the last CFP reform, leading to an increase in SSB and subsequently to an increase in fishing opportunities. For stocks for which trends in F and fishing opportunities were inconsistent with theory (i.e., a decrease in F accompanied by a decrease in fishing opportunities or an increase in F accompanied by an increase in fishing opportunities), we reviewed the literature and ICES working group reports to identify possible explanations.
– We carried out Chi-squared tests, which assess the association between two categorical variables (Pandis, 2016), to test whether trends in F, SSB, and fishing opportunities were significantly associated among stocks (e.g., whether stocks with decreasing F were significantly more frequently associated with increasing SSB or fishing opportunities).

3 Results

3.1 Overall trend in fishing opportunities

Figure 1 displays the sum of fishing opportunities across years and ecoregions. The sum of fishing opportunities appears to be increasing in the Bay of Biscay and along the Iberian coast, while it seems to be decreasing in the Baltic Sea and in the Celtic Seas. In the other ecoregions, no clear positive or negative trends can be identified.

The JARA model provided an indicator of the average trend in fishing opportunities. Fishing opportunities were first standardized by the mean for each stock to use a common scale, allowing equal weight to be given to each stock independently of its size and to focus on temporal trends. In contrast, Figure 1 sums the absolute values of fishing opportunities and is therefore primarily driven by stocks with the largest opportunities. The average trend in fishing opportunities indicates a general increase (Fig. 2–panel all stocks), which is visible in most regions, especially after 2020. In contrast, the Baltic Sea displays a different pattern, stable until 2018, followed by a decrease towards the end of the period.

3.2 Occurrence of significant trends in F, SSB, and fishing opportunities

Among the stocks, 38 significant trends in F were found, with a majority of decreasing trends (27 significant trends in F) (Fig. 3). For SSB, 44 significant trends were identified, of which 26 were increasing. This confirms the general decline in F and the gradual recovery in SSB. Only 30 significant trends were identified for fishing opportunity, of which 20 were positive. There are some differences among ecoregions, such as the absence of stocks with increasing fishing pressure in the Bay of Biscay & Iberian waters, while the number of stocks with significantly increasing F is greater than the number of stocks with decreasing F in the North Sea (though the number of stocks with a negative Kendall tau is greater than the number of stocks with a positive tau – tau corresponds to the correlation coefficient of the Mann–Kendall test; a negative value indicates a monotonous declining trend, while a positive value indicates an increasing monotonous trend).

Table 1 summarizes the stocks for which significant trends in fishing opportunities were detected.

3.3 Association between trends in F, SSB, and fishing opportunities

Chi-squared tests confirm a significant association between trends in F and SSB (*P*-value: 0.04) and between SSB and fishing opportunities (*P*-value: 0). In contrast, no significant relationship was found between trends in F and fishing opportunities (*P*-value: 0.88). This suggests a direct effect of trends in F on SSB, followed by an effect of SSB on fishing opportunities, whereas the link between F and fishing opportunities appears to be indirect and subject to a time lag, with SSB needing to recover first before fishing opportunities increase.

The residuals of the chi-squared tests confirm that, in line with theory, an increasing trend in SSB is more frequently associated with a decreasing trend in F and that an increasing trend in fishing opportunities is more frequently associated with an increasing trend in SSB (Fig. 4). In addition, stocks with both negative trends in F and SSB are rare, as are stocks with increasing fishing opportunities and decreasing SSB.

3.4 Unexpected associations

In theory, a long-term increase in F should lead to a decrease in SSB, which would consequently reduce fishing opportunities. However, some stocks show trajectories that do not follow this expected pattern. Among the stocks exhibiting a positive trend in fishing opportunities while F is increasing (her.27.nirs, lez.27.6b, and sol.27.7e) or shows no significant trend (ane.27.8, bli.27.5b67, nep.fu.16, nep.fu.2829, nep.fu.8, ple.27.21-23, ple.27.24-32, rju.27.7de, sol.27.20-24, and

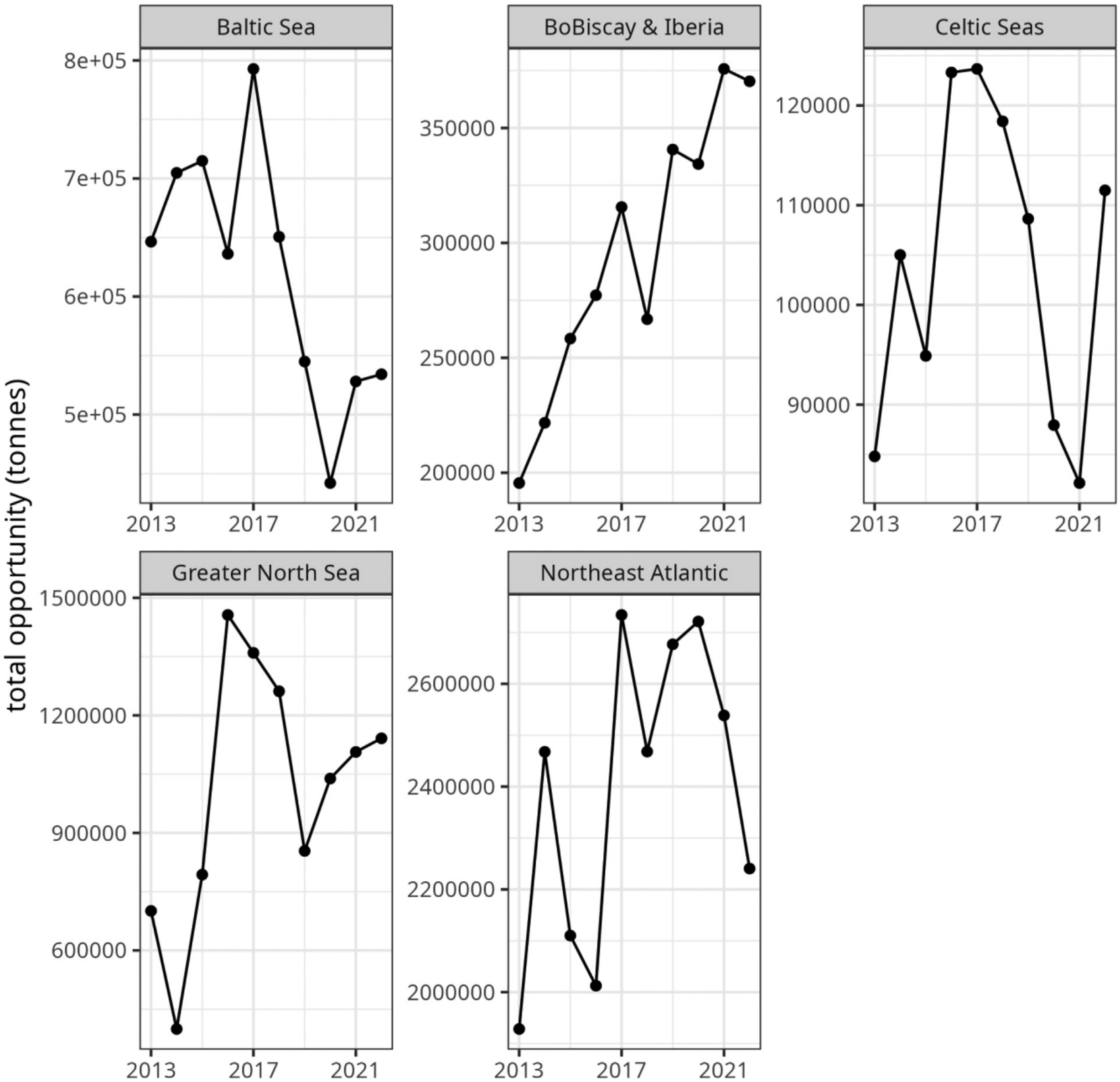

Fig. 1. Sum of fishing opportunities per ecoregion. The diagram ends in 2022 since some advice was not available for the latest years. For consistency, only stocks for which fishing opportunities were available each year from 2013 to 2022 were kept. "Northeast Atlantic" refers to widely distributed stocks.

sol.27.7a), a closer examination of ICES advice and stock assessment working group reports shows that F is generally below F_{MSY} (Tab. 2). Moreover, SSB does not appear to decrease for these stocks and is even increasing for 9/13 stocks. For many of these stocks, this may reflect recovery following a period of overexploitation prior to the study period ($F/F_{MSY} > 1$ for 8/13 stocks).

Conversely, theory predicts that a long-term decrease in F should lead to an increase in SSB and subsequently to higher fishing opportunities. Some stocks exhibit the opposite pattern, with a decrease in fishing opportunities despite a decrease in F (cod.27.24-32 and lem.27.3a47d) or despite the absence of a significant trend in F (cod.27.7e-k, her.27.20-24, her.27.irls, lin.27.5b, nep.fu.13, nep.fu.22, and pok.27.3a46). For two of these stocks, SSB is even decreasing despite the absence (cod.27.7e-k) or the presence of a decreasing trend (lem.27.3a47d) in F. Among these stocks, six out of the seven for which F_{MSY} is available (F_{MSY} was not estimated for cod.27.24-32 and lem.27.3a47d) remain overfished. For six of those stocks, a period of low recruitment values was observed (cod.27.24-32, cod.27.7e-k, her.27.20-24, her.27.irls, lin.27.5b, and pok.27.3a46), which does not necessarily result from low SSB. Notably, ICES reports detrimental effects of other environmental drivers for many of these stocks:

- a potential effect of climate change (cod.27.24-32, cod.27.7e-k, and her.27.20-24);
- habitat degradation (cod.27.24-32, her.27.20-24, and her.27.irls);

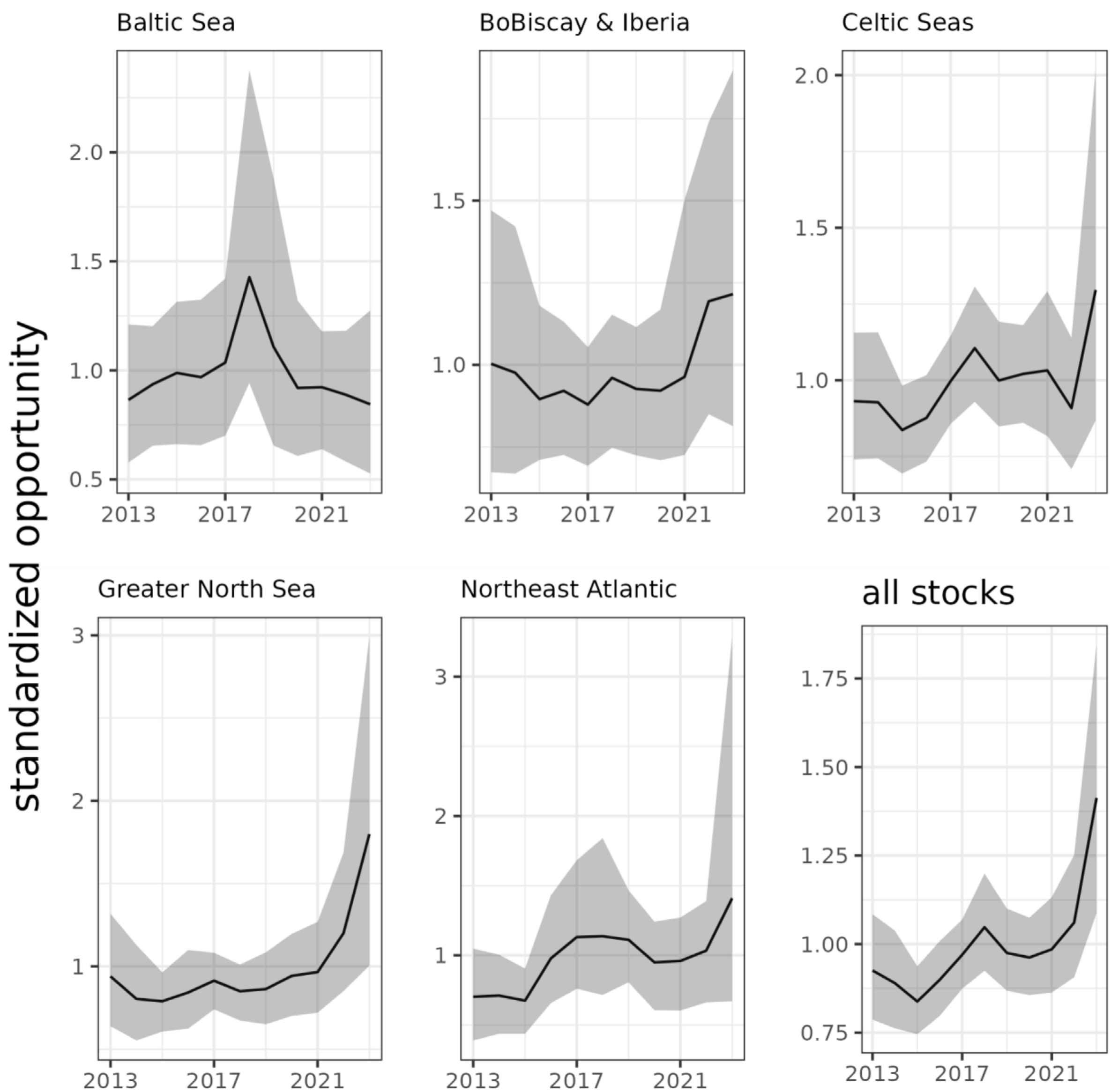

Fig. 2. Average trend in fishing opportunities per ecoregion and across all stocks according to JARA model estimates. Values were standardized by the average fishing opportunities for each stock so that a value of 1 indicates a value above the average while a value less than one is below the average. "BoBiscay & Iberia" refers to the Bay of Biscay and Iberian waters. "Northeast Atlantic" refers to widely distributed stocks.

– a potential low productivity regime affecting the stock–recruitment relationship of pok.27.3a46 (ICES, 2024);
– Lloret et al. (2021) report the effect of temperature on the dynamics of ling stocks, including lin.27.5b.

For other stocks, the decrease in fishing opportunities appears to be linked to the lack of SSB recovery following reduction in F and may be due to a lag in recovery time (her.27.irls and nep.fu.22).

4 Discussion

Global change has dramatically modified natural ecosystems (Steffen et al., 2018) and is threatening biodiversity (IPBES, 2019). Fisheries, the harvesting of a natural and renewable resource, used to be the main anthropogenic driver affecting marine ecosystems, with overexploitation being almost a worldwide norm for decades (Drouineau et al., 2023; FAO, 2024). However, the environment has also played a role in the dynamics of many fish populations (Hernvann and Gascuel, 2020), and climate change is expected to be a major threat in the coming decades (Cheung, 2018). In this context, a critical question is whether appropriate management measures to regulate fishing pressure can ensure the recovery of depleted fish populations (Blöcker et al., 2023). Based on a comprehensive dataset of stocks in the Northeast Atlantic, this meta-analysis shows how the reduction in fishing pressure since the last reform of the European CFP (EU Regulation No. 1380/2013) has enabled stock recovery and an increase in

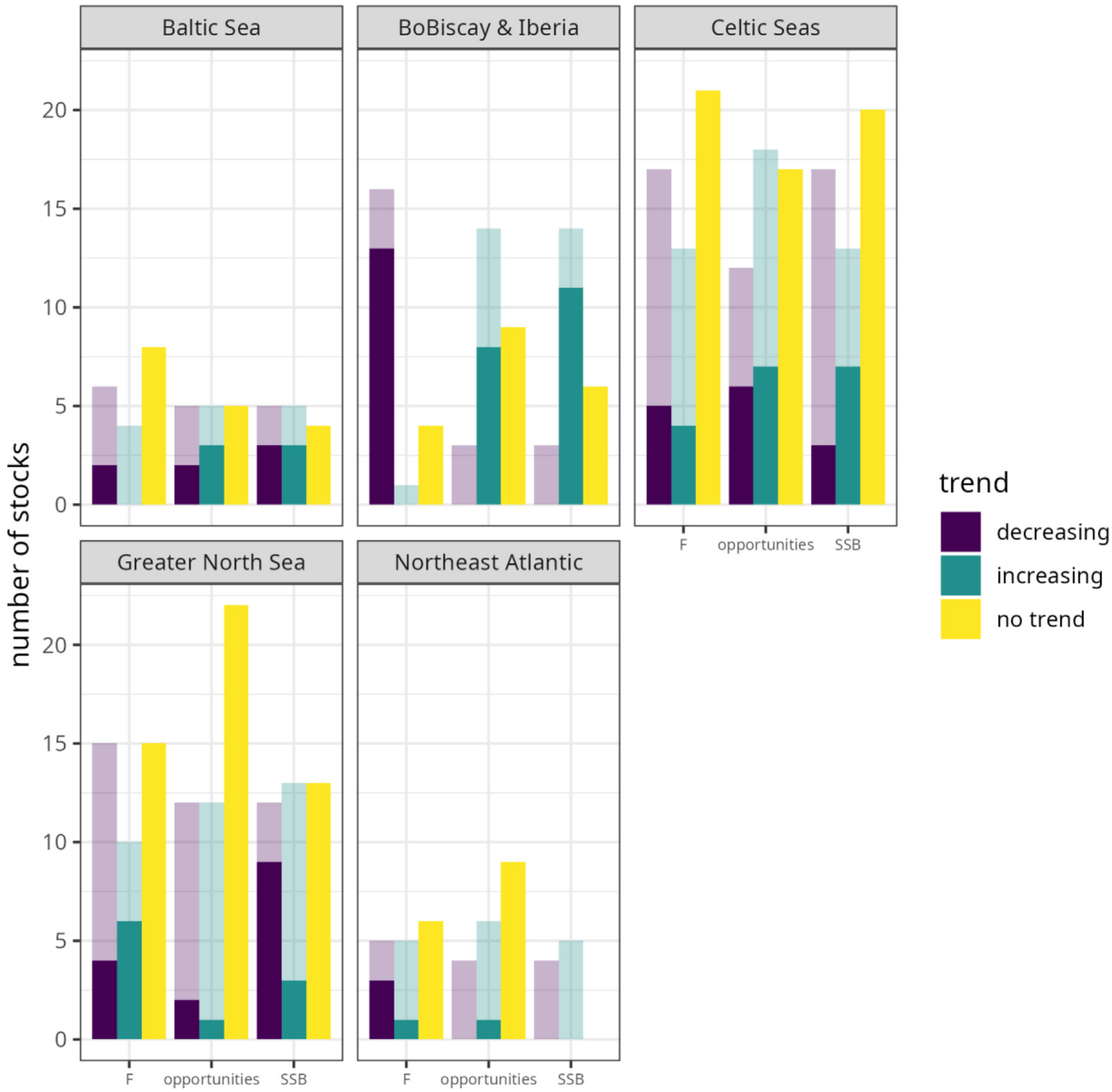

Fig. 3. Number of stocks showing significant increasing, decreasing, or no trend in F, SSB, and fishing opportunities per ecoregion (dark bars). The light bars indicate the total number of stocks with positive or negative Kendall tau, whether they are significant or not. On the x-axis, opportunities refer to the fishing opportunities as estimated in ICES advice. "BoBiscay & Iberia" refers to the Bay of Biscay and Iberian waters. "Northeast Atlantic" refers to widely distributed stocks.

Table 1. Table of stocks for which a significant increasing or decreasing trend in fishing opportunities was found per ecoregion over the study period. "BoBiscay & Iberia" refers to the Bay of Biscay and Iberian waters. "Northeast Atlantic" refers to widely distributed stocks.

Ecoregion	Increasing trend	Decreasing trend
Baltic Sea	ple.27.21-23, ple.27.24-32, sol.27.20-24	cod.27.24-32, her.27.20-24
BoBiscay & Iberia	ane.27.8, ank.27.78abd, bss.27.8ab, hom.27.9a, ldb.27.8c9a, meg.27.7b-k8abd, meg.27.8c9a, nep.fu.2829	
Celtic Seas	her.27.nirs, lez.27.6b, nep.fu.16, rju.27.7de, sol.27.7a, sol.27.7e, whg.27.6a	cod.27.7e-k, her.27.irls, lin.27.5b, nep.fu.13, nep.fu.22, whg.27.7b-ce-k
Greater North Sea	nep.fu.8	lem.27.3a47d, pok.27.3a46
Northeast Atlantic	bli.27.5b67	

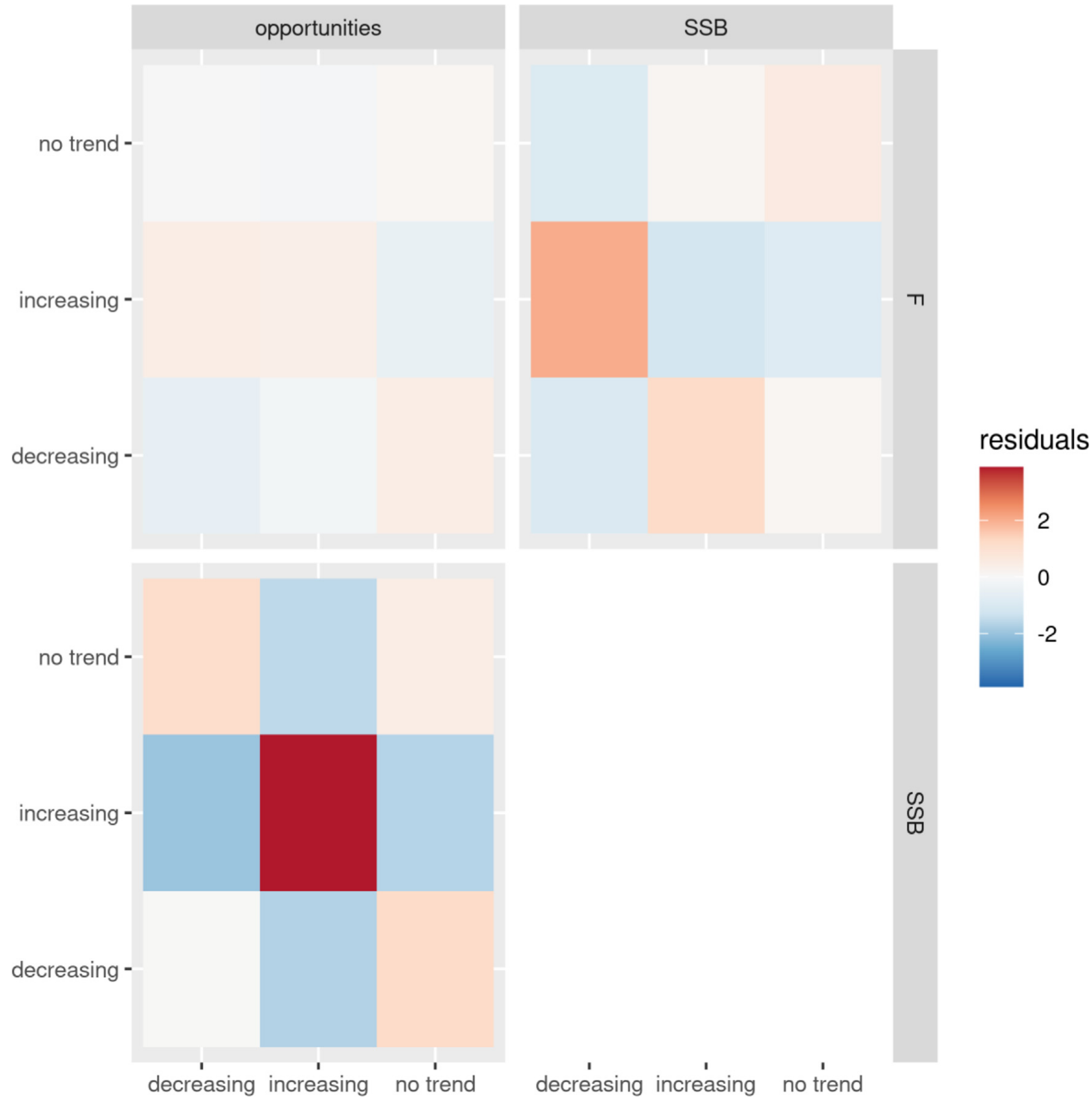

Fig. 4. Residuals of the different chi-squared test. Positive residuals mean that the association of the two trends is more frequent than expected if the variables were independent, while a negative value indicates that the association is less frequent. Here, "opportunities" refer to the fishing opportunities as estimated in ICES advice.

fishing opportunities, as predicted by fisheries science theory. Such feedback, based on a wide diversity of fish species and ecosystems, is essential to assess whether field observations bear out theory but also to demonstrate the potential benefits of fisheries regulations to managers and stakeholders at a time when fisheries face multiple crises and must prepare for climate change adaptation.

It should be noted that in this study, we used the catch/landing advisories formulated in scientific advice as a proxy for fishing opportunities. We therefore did not take into account differences between scientific advice and the quota ultimately implemented, which, for some stocks, may have been subject to top-ups following the introduction of the landing obligation. In general, the gradual introduction of the landing obligation following the CFP reform affected scientific advice by progressively shifting the focus from landing to catch advice. This may have affected our analysis. For example, we had to convert landings to catch advice and assumed that discard rates had remained constant throughout the study period. This assumption is supported by reports assessing the effectiveness of the landing obligation, which show that this measure has had limited impacts on discard rates (AZTI-Brta et al., 2021; European Climate, Infrastructure and Environment Executive Agency (European Commission) et al., 2025). Another important consideration concerns the periodic benchmark process conducted under the ICES quality assurance framework. During these benchmarks, key components of the stock assessment – including input data, assessment models, and reference point estimations – are peer-reviewed and, where necessary, revised; in some cases, stock definitions themselves may be redefined. This process inevitably introduces a degree of temporal inconsistency in

Table 2. Status of the stocks that display unexpected associations of fishing opportunities (Opp) and F trends. R stands for the geometric mean of recruitment from 1999 to 2023 over the whole time series; F/FMSY and B/MSY Btrigger are the average values in the study period (2013-2023) or before (b) the study period (2000-2012).

Opp	F	SSB	Stock	R	F/FMSY	B/MSY Btrigger	F/FMSY (b)	B/MSY Btrigger (b)
↘	↘	↘	lem.27.3a47d					
		-	cod.27.24-32	0.63				
	-	↘	cod.27.7e-k	0.20	3.61	0.61	3.19	1.32
		-	her.27.20-24	0.36	1.10	0.49	1.58	0.74
			her.27.irls	0.41	1.82	0.54	0.97	1.30
			lin.27.5b	0.21	1.64	1.67	1.81	1.20
			nep.fu.13	-	1.02	3.09	1.18	2.90
			nep.fu.22	-	0.93	1.11	1.00	1.26
			pok.27.3a46	0.42	1.08	1.18	1.15	1.49
↗	↗	↗	sol.27.7e	1.14	0.87	1.50	1.03	1.05
		-	her.27.nirs	2.08	0.84	1.95	0.91	1.56
			lez.27.6b	-	0.57	2.45	1.37	0.96
	-	↗	ane.27.8	2.25				
			bli.27.5b67	1.20	0.39		1.01	
			nep.fu.16		0.78		0.51	
			nep.fu.8		0.96	2.69	1.38	2.20
			ple.27.21-23	2.42	1.33	2.06	2.54	1.03
			ple.27.24-32		0.29	3.05	1.08	1.02
			rju.27.7de		0.10	2.45	0.91	0.49
			sol.27.7a	0.71	0.69	0.60	1.90	0.58
		-	nep.fu.2829		0.30		0.56	
			sol.27.20-24	0.55	0.74	0.89	1.18	0.98

catch advice, as advice issued in a given year reflects the assessment model and reference points that were current at that time, both of which may have subsequently changed. However, there is no a priori reason to expect such revisions to systematically bias catch advice in either direction – upward or downward. We therefore argue that the time series of catch advice used in this study remains a valid representation of the best available scientific knowledge at the time each advisory output was issued.

Two main take-home messages arise from this meta-analysis. First, in a majority of cases, observations are consistent with fisheries science theory. The decrease in fishing pressure observed since 2013 has promoted an increase in SSB for 50/91 stocks (positive Kendall tau, 24 statistically significant), confirming the average increase already highlighted by STECF (2021). In many cases (55/92 stocks with positive trends in fishing opportunities, including 20 that were statistically significant), this has also led to an increase in fishing opportunities. In other words, as expected, reducing fishing pressure on overexploited stocks generally generates positive feedback for both fish populations (increase of the biomass) and fisheries (increased catches). The case of the Bay of Biscay and Iberian waters illustrates the benefits of reducing F, an important message in a period of crisis for the fishing industry (Gascuel, 2019; Symes, 2023).

Of course, this generally positive picture conceals a diversity of situations, as fishing pressure does not decrease and biomass does not increase for all stocks across European waters (STECF, 2021). Among all stocks for which ICES has provided advice, 9% were still under zero catch advice in 2023 (a slight improvement compared to the 16% in 2013). In our analysis, we did not account for differences in stock importance in terms of landing volumes or economic value. For example, a substantial part of the increasing trend in total fishing opportunities in the Bay of Biscay & Iberian coast (Fig. 1) is driven by increased opportunities in horse mackerel (hom.27.9a), a species of moderate economic value. In contrast, sole (sol.27.8ab), one of the most important species for fleets operating in the Bay of Biscay (Prellezo, 2019), shows an alarming trend with a drastic reduction in total allowable catch (TAC) in 2022 and the implementation of measures to compensate for economic losses (ICES, 2023b).

The results also suggest that positive outcomes should be expected with a time lag following reductions in fishing pressure. Further investigation of this time-lag effect would be valuable, particularly for the development of rebuilding plans. However, two issues may hinder such analyses. First, introducing time lags mechanically reduces the length of already short time series, thereby decreasing the power of the Kendall test. Second, if a time lag exists, the relationship between F and fishing opportunities is likely non-monotonic (the nature of the relationship is likely to change when the reduction of F starts to have an effect on the fishing opportunities), violating the assumption of Kendall tests. Exploring more flexible metrics of dependence between variables such as MIC (Albanese et al., 2018; Reshef et al., 2011) or qAD (Griessenberger et al., 2022) may be an option to overcome this issue. Transitional periods will represent a critical challenge for managers, particularly in regions like Europe, where fleet overcapacity persists (STECF, 2023a), where required fishing pressure reduction will come at the cost of temporary fishing opportunity reductions.

The second key take-home message is that, for many stocks exhibiting dynamics inconsistent with theory, environmental factors are likely to play a significant role. In more than half of these cases, periods of low recruitment were observed. Early life stages of fish are particularly sensitive to environmental conditions (Houde et al., 2009). Habitat degradation and climate change, two other components of global change, are thought to act synergistically with fishing pressure, explaining, for example, the current low recruitment of herring in the Western Baltic (her.27.20-24 (Moyano et al., 2023)). Climate change is also suspected by ICES to be a driving factor for several "inconsistent" stocks (cod.27.24-32 (ICES, 2023c), bli.27.5a14 (ICES, 2022a), cod.27.7e-k (ICES, 2022b), and her.27.20-24 (ICES, 2023d; Moyano et al., 2023)). Environmental change is known to impair the recovery of depleted stocks (Blöcker et al., 2023; Möllmann et al., 2021). This underlines the urgency of rebuilding stocks before irreversible climate-drive impacts occur.

To our knowledge, such a meta-analysis has never been conducted at this scale. We believe that a regular monitoring of the trends in fishing opportunities would be a valuable tool for assessing the performance of fisheries management measures and for detecting potential issues, possibly related to environmental changes. This could be a valuable tool to help managers to adapt their measures to the observed dynamics and to anticipate potential issues. This could also be a valuable supporting tool to communicate on the benefits of fishing pressure reduction to stakeholders and to the public. The annual CFP monitoring exercise and ICES fisheries overviews provide valuable insights into fishing pressure (e.g., F and landings) and stock status (e.g., SSB). In this study, we have taken this a step further by exploring the links between these families of indicators to show how stocks respond to fisheries restrictions. When comparing the results of the CFP monitoring and ICES overviews with this analysis, two aspects must be borne in mind. First, we did not consider the absolute values of the indicators, focusing on their trends. For example, in our analysis, stocks with significant trends have the same weight, regardless of the fishing pressure level. We did so because we wanted to explore whether the trend in F has an effect on trends in SSB and fishing opportunities on each stock. On the other hand, the CFP monitoring and ICES fisheries overviews average F or SSB after scaling them to a common reference point (e.g., F_{MSY} and MSY $B_{trigger}$) to monitor an average pressure at the ecosystem scale. Furthermore, our focus here is on stocks for which significant trends have been identified, while CFP monitoring and ICES overview indicators are averages across all stocks, regardless of any significant trend tests. Given the limited length of the time series and the fact that stocks may exhibit non-monotonic relationships, the Kendall test we used might be restrictive (see Fig. 3). These differences may explain, for example, why we detect a higher number of stocks with a significant increasing F in the Greater North Sea while the other exercises indicate an overall decrease in fishing pressure in this ecosystem. Despite these differences due to slight differences in objectives, our analysis and the CFP monitoring analysis provide complementary results that support an overall decrease in F and an increase in SSB.

Like any meta-analysis, this exercise has some pros and cons. An asset of any meta-analysis is that the large number of case studies allows one to derive general rules and theories (Arnqvist and Wooster, 1995; Fagard et al., 1996; Stewart, 2009). In our case, this was relevant to check that observations are generally consistent with the fishery science theory. However, as previously acknowledged, meta-analysis can hide a diversity of situations (Arnqvist and Wooster, 1995; Stewart, 2009), and it is difficult to analyze in detail each specific case study. Meta-analysis should not prevent further analysis at the case study scale. Other drivers might, for example, be more important than the fishery to explain the dynamics of some stocks. Still, such a meta-analysis helps to pinpoint relevant case studies for further analysis. In our case, we explored in greater detail the stocks that were identified as contradictory with the theory.

Data availability statement

The research data associated with this article are included in the article.

Supplementary material

The following table displays the stocks that were included for the analysis.

The Supplementary Material is available at https://www.alr-journal.org/10.1051/alr/2026010/olm

References

Albanese D, Riccadonna S, Donati C, Franceschi P. 2018. A practical tool for maximal information coefficient analysis. *Gigascience* 7: giy032.

Arnqvist G, Wooster D. 1995. Meta-analysis: synthesizing research findings in ecology and evolution. *Trends Ecol. Evol.* 10: 236–240.

AZTI-Brta, Centre for Environment Fisheries and Aquaculture Science, European Climate Infrastructure and Environment Executive Agency (European Commission), Federal Research Institute of Rural Areas Forestry and Fisheries, Marine Institute, MRAG, National Marine Fisheries Research Institute, Research Institute for Agriculture and Fisheries, Spanish Institute of Oceanography, Stichting Wageningen Research, Swedish University of Agricultural Sciences and Institute of Food Safety Animal Health and Environment, Technical University of Denmark, Thünen-Institute, Wageningen Marine Research, Heinrich J. 2021. *Synthesis of the landing obligation measures and discard rates*. Publications Office of the European Union.

Bastardie F, Brown EJ, Andonegi E, Arthur R, Beukhof E, Depestele J, Döring R, Eigaard OR, García-Barón I, Llope M, Mendes H, Piet G, Reid D. 2021. A review characterizing 25 ecosystem challenges to be addressed by an ecosystem approach to fisheries management in Europe. *Front. Mar. Sci.* 7: 629186.

Blöcker AM, Gutte HM, Bender RL, Otto SA, Sguotti C, Möllmann C. 2023. Regime shift dynamics, tipping points and the success of fisheries management. *Sci. Rep.* 13: 289.

Borges L, Penas Lado E. Discards in the common fisheries policy: The evolution of the policy, in: S.S. Uhlmann, C. Ulrich, S.J. Kennelly (Eds.), *The European Landing Obligation: Reducing Discards in Complex, Multi-Species and Multi-Jurisdictional Fisheries*, Springer International Publishing, Cham, 2019, pp. 27–47.

Cheung WWL. 2018. The future of fishes and fisheries in the changing oceans. *J. Fish Biol.* 92: 790–803.

Christensen V, Guenette S, Heymans JJ, Walters CJ, Watson R, Zeller D, Pauly D. 2003. Hundred-year decline of North Atlantic predatory fishes. *Fish Fish.* 4: 124.

Cury PM, Boyd IL, Bonhommeau S, Anker-Nilssen T, Crawford RJM, Furness RW, Mills JA, Murphy EJ, Österblom H, Paleczny M, Piatt JF, Roux J-P, Shannon L, Sydeman WJ. 2011. Global seabird response to forage fish depletion—one-third for the birds. *Science* 334: 1703–1706.

Denwood MJ. 2016. Runjags: An R package providing interface utilities, model templates, parallel computing methods and additional distributions for MCMC models in JAGS. *J. Stat. Softw.* 71: 1–25.

Dickey-Collas M, Nash RDM, Brunel T, van Damme CJG, Marshall CT, Payne MR, Corten A, Geffen AJ, Peck MA, Hatfield EMC, Hintzen NT, Enberg K, Kell LT, Simmonds EJ. 2010. Lessons learned from stock collapse and recovery of North Sea herring: A review. *ICES J. Mar. Sci.* 67: 1875–1886.

Drouineau H, Moullec F, Gascuel D, Laloë F, Lucas S, Bez N, Guillotreau P, Guitton J, Hernvann P-Y, Huret M, Lehuta S, Léopold M, Mahévas S, Robert M, Woillez M, Vermard Y. 2023. Food for thought from French scientists for a revised EU Common Fisheries Policy to protect marine ecosystems and enhance fisheries performance. *Mar. Policy* 148: 105460.

European Climate Infrastructure and Environment Executive Agency (European Commission), Davie S, Wakeford RC, Whitley C, van den Berg P, Rimpler A, Burke A, Verschuur X, Oudmaijer S, Kraan M, Chai SM, Pearce J, Peat W, Stacy R, Ligas A, Sartor P, Pulskens A, Vallina T, Aranda M, Basterretxea M. 2025. *Study supporting the evaluation of the landing obligation: Common fisheries policy: Final report*. Publications Office of the European Union.

Fagard RH, Staessen JA, Thijs L. 1996. Advantages and disadvantages of the meta-analysis approach. *J. Hypertens.* 14: S9.

FAO. 2024. *The State of World Fisheries and Aquaculture 2024*. FAO.

Froese R, Winker H, Coro G, Demirel N, Tsikliras AC, Dimarchopoulou D, Scarcella G, Quaas M, Matz-Lück N. 2018. Status and rebuilding of European fisheries. *Mar. Policy* 93: 159–170.

Gascuel D. Pour une révolution dans la mer: De la surpêche à la résilience. *Éditions Actes Sud*, 2019.

Gordon HS. 1954. The economic theory of a common-property resource: The fishery. *J. Polit. Econ.* 62.

Grafton RQ, Kompas T, Che TN, Chu L, Hilborn R. 2012. BMEY as a fisheries management target. *Fish Fish.* 13: 303–312.

Gras M, Vasilakopoulos P, Pierucci A, Kupschus S, Mantopoulou P, alouka D, Winker H, Konrad C. *Protocol for the monitoring of the common fisheries policy—version 5.0*. Luxembourg, 2023.

Griessenberger F, Trutschnig W, Junker RR. 2022. Qad: An R-package to detect asymmetric and directed dependence in bivariate samples. *Methods Ecol. Evol.* 13: 2138–2149.

Hernvann P-Y, Gascuel D. 2020. Exploring the impacts of fishing and environment on the Celtic Sea ecosystem since 1950. *Fish. Res.* 225: 105472.

Hilborn R, Walters CJ. *Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty*. Springer Science & Business Media, 2013.

Houde ED, Steele J, Thorpe S, Turekian K. Fish larvae. In: *Marine Ecological Processes: A Derivative of the Encyclopedia of Ocean Sciences*. Academic Press, Burlington, Vermont, 2009, pp. 286–292.

ICES. 2022a. *Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)*.

ICES. 2022b. *Celtic Seas ecoregion Ecosystem Overview.*

ICES. 2023a. Cod (*Gadus Morhua*) in subdivisions 22–24, western Baltic stock (western Baltic Sea) (report). ICES Advice: Recurrent Advice.

ICES. 2023c. Cod (*Gadus morhua*) in subdivisions 2432, eastern Baltic stock (eastern Baltic Sea).

ICES. 2023d. *Baltic Fisheries Assessment Working Group (WGBFAS)*.

ICES. 2023b. *Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) (Report)*. ICES Scientific Reports.

ICES. 2024. *Benchmark workshop on selected haddock and saithe stocks (WKBGAD) (report)*. ICES Scientific Reports.

ICES. 2025. *Advice on fishing opportunities (2025) (report)*. General ICES Advice guidelines.

IPBES. 2019. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany, IPBES secretariat.

Kendall MG. 1975. *Rank Correlation Methods*. 2nd impression. Charles Griffin and Company Ltd., London and High Wycombe.

Lado EP. 2016. The Common Fisheries Policy: The Quest for Sustainability. John Wiley & Sons.

Lloret J, Serrat A, Thordarson G, Helle K, Jadaud A, Bruno I, Ordines F, Sartor P, Carbonara P, Rätz H-J. 2021. The poor health of deep-water species in the context of fishing activity and a warming climate: Will populations of Molva species rebuild or collapse? *J. Fish Biol.* 98: 1572–1584.

Möllmann C, Cormon X, Funk S, Otto SA, Schmidt JO, Schwermer H, Sguotti C, Voss R, Quaas M. 2021. Tipping point realized in cod fishery. *Sci. Rep.* 11: 14259.

Moyano M, Illing B, Akimova A, Alter K, Bartolino V, Börner G, Clemmesen C, Finke A, Gröhsler T, Kotterba P, Livdane L, Mittermayer F, Moll D, von Nordheim L, Peck MA, Schaber M, Polte P. 2023. Caught in the middle: Bottom-up and top-down processes impacting recruitment in a small pelagic fish. *Rev. Fish Biol. Fish.* 33: 55–84.

Pandis N. 2016. The chi-square test. *Am. J. Orthod. Dentofacial Orthop.* 150: 898–899.

Pontavice H du, Gascuel D, Kay S, Cheung WWL. 2023. Climate-induced changes in ocean productivity and food-web functioning are projected to markedly affect European fisheries catch. *Mar. Ecol. Prog. Ser.* 713: 21–37.

Pontavice H du, Gascuel D, Reygondeau G, Stock C, Cheung WWL. 2021. Climate-induced decrease in biomass flow in marine food webs may severely affect predators and ecosystem production. *Glob. Change Biol.* 27: 2608–2622.

Prellezo R. 2019. Exploring the economic viability of a mesopelagic fishery in the Bay of Biscay. *ICES J. Mar. Sci.* 76: 771–779.

Reshef DN, Reshef YA, Finucane HK, Grossman SR, McVean G, Turnbaugh PJ, Lander ES, Mitzenmacher M, Sabeti PC. 2011. Detecting novel associations in large data sets. *Science* 334: 1518–1524.

Schaefer MB. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. *Bull. Inter-Am. Trop. Tuna Comm.* 2: 245–285.

Schijns R, Froese R, Hutchings JA, Pauly D. 2021. Five centuries of cod catches in eastern Canada. *ICES J. Mar. Sci.* 78: 2675–2683.

STECF. 2021. Monitoring the performance of the common fisheries policy. Luxembourg.

STECF. 2023a. Assessment of balance indicators for key fleet segments and review of national reports on member states efforts to achieve balance between fleet capacity and fishing pportunities. Luxembourg.
STECF. 2023b. The 2023 annual economic report on the EU fishing fleet. Luxembourg, Publications Office of the European Union.
STECF. 2024. Monitoring the performance of the common fisheries policy. Luxembourg.
Steffen W, Rockström J, Richardson K, Lenton TM, Folke C, Liverman D, Summerhayes CP, Barnosky AD, Cornell SE, Crucifix M, Donges JF, Fetzer I, Lade SJ, Scheffer M, Winkelmann R, Schellnhuber HJ. 2018. Trajectories of the Earth system in the Anthropocene. *Proc. Natl. Acad. Sci. U.S.A.* 115: 8252–8259.
Stewart G. 2009. Meta-analysis in applied ecology. Biol. Lett. 6: 78–81.
Symes D. Fishing Europe's Troubled Waters: Fifty Years of Fisheries Policy. Routledge, 2023.
Winker H, Pacoureau N, Sherley RB. 2020. JARA: Just Another Red-List Assessment. bioRxix.

Cite this article as: Drouineau H, Vermard Y, Gras M. 2026. Trends in fishing opportunities in European fisheries following the last Common Fishery Policy reform. *Aquat. Living Resour.* 39: 17. https://doi.org/10.1051/alr/2026010