SEAWISE POLICY BRIEF ON

ECOLOGICAL EFFECTS OF FISHERIES

PURPOSE OF THIS BRIEF

Integrating scientific evidence on the broader ecological impacts of fishing is essential for Ecosystem Based Fisheries Management (EBFM). Though unintended, fishing impacts the broader marine ecosystem, beyond target species, affecting foodwebs and the health of marine wildlife and habitats.

This brief synthesises SEAwise's work examining the ecological effects of fisheries across European waters – detailing findings from our modelling of stocks, foodwebs and community diversity, bycatch, impacts to benthic habitats, and fisheries-related litter. Our work offers insights on how these impacts vary between fleets, different gear types, and across regions. Through modelling ecological dynamics under regulatory and climatic change, our work also provides an outlook on where management change and trade-offs may be required to safeguard the health of European seas and fisheries.

KEY RECOMMENDATIONS

- **Ensure catch advice does not exceed scientifically-recommended limits produced under Maximum Sustainable Yield (MSY) management**, with fishing effort limited at or below levels that provide MSY. Whilst our research highlights that not all unwanted impacts decrease under effort-reductions in line with FMSY-min, the lower fishing pressure improves the status and yield of the fished stocks and, in many cases, also reduces impacts on bycatch species and habitats.
- **Targeted effort reduction measures are essential for stock recovery to occur under climate change.** Our research points to the North Sea and Mediterranean as key regions where, for specific stocks, recovery remains possible, even under future warming, if fishing effort is reduced.
- **Regionally-specific, contextually-tailored approaches to management – including effort limitation and gear restrictions – are essential to deliver Good Environmental Status across fisheries.** SEAwise findings demonstrate that these measures must consider gear-, habitat- and species-specific impacts from fishing, and account for the variable impacts of climate across different stocks and ecosystem components.
- **Management measures may have impacts beyond that intended and should therefore be evaluated for impacts across objectives.** For example, protecting large areas offshore to reduce impacts on protected species (i.e sharks and dolphins) may cause the fisheries to reallocate to coastal areas with increased impacts on other species and habitats. Additionally, banning specific gear types (like benthic trawls) to decrease impacts on habitat without other regulations will lead to an increase in the use of static gears with a concurrent increase in impacts on other ecosystem components, such as seabirds and marine mammals.
- **Policymakers must support timely and responsive gear innovation and industry uptake to successfully navigate trade-offs.** Our research emphasises that such gear innovation is an essential addition to more conventional management measures when tackling issues such as bycatch risk.
- **Management must broaden its scope beyond a sole focus on catch and effort limitations focused on target species** and work to **integrate assessments of the broader ecosystem impacts of fisheries activities.** For example, supporting further development of indicator thresholds so as to facilitate the monitoring of ecosystem function and how it is impacted by fishing.

BACKGROUND

Though unintended, fisheries impact habitats and species beyond those directly targeted. Sensitive species, such as those classified as Endangered, Threatened or Protected species (ETPs), are accidentally captured as 'bycatch'. Fishing gear that is towed along, or otherwise interacts with, the seafloor has impact on benthic habitats. Keystone species, including those that act as top predators, are removed from the ecosystem through fishing and, resultantly, the functionality of foodwebs can be disturbed. Fisheries gear is sometimes lost but continues to pose a danger to marine species through entanglement or ingestion.

Seeking to comprehensively respond to this, both the Common Fisheries Policy (CFP) and Marine Strategy Framework Directive (MSFD) aim to deliver a more holistic approach to fisheries management through Ecosystem Based Fisheries Management (EBFM). EBFM aims, as SEAwise researchers phrase it, to deliver an "ecological safe space for fisheries" (1) – wherein the protection of marine ecosystems is balanced alongside sustainable use by policy makers, maintaining the societal and economic benefits derived from fisheries.

To deliver on EBFM implementation, up-to-date knowledge on exactly how marine ecosystems are impacted by fishing activities is critical. This evidence is essential for evaluating which management measures are best placed to mitigate these impacts, particularly in the face of climate change and other pressures on marine ecosystems.

SEAwise addressed this through conducting **a comprehensive analysis of the ecological effects of fishing** across the Baltic Sea, North Sea, Western Waters region, and the Mediterranean Sea (see figure 1); modelling alternative management strategies **to understand where management change is required to mitigate the impact of fishing activity and support stock recovery and ecosystem health under climate change.**

This brief offers a summary of this work, highlighting key management-relevant findings and recommendations to support the implementation of EBFM and realise efforts towards more sustainable, biodiverse fisheries systems into the future.

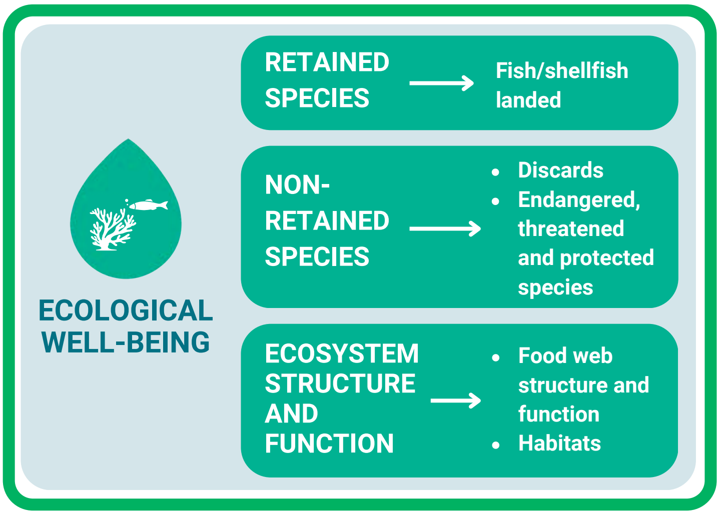

Figure 1: Scope of SEAwise work on fisheries' ecological effects.

SEAWISE AT A GLANCE

Involving 24 universities and research organisations from across Europe funded under Horizon2020, the **SEAwise project has worked to deliver the knowledge needed to support fishers, managers, and policy makers in the practical implementation of Ecosystem Based Fisheries Management (EBFM)** across European waters.

Building on the recognition that societal and ecological objectives are interdependent under EBFM, SEAwise has assembled a new knowledge base that captures the social, economic and ecological complexity of European fisheries. Drawing on this to develop predictive models, tools, and ready-for-uptake advice, SEAwise's work enables stakeholders to evaluate the potential trade-offs of management decisions and forecast their long-term impacts.

Through this, SEAwise has laid the foundation for a whole-ecosystem approach to management in Europe – one that would equip both fisheries and management with the resilience needed to successfully navigate future challenges and change.

SEAWISE'S CLIMATE AND ALTERNATIVE MANAGEMENT SCENARIOS

MANAGEMENT SCENARIOS:

- **Status Quo:** A continuation of current fishing effort levels.
- **FMSY-min:** Fishing according to a strict Maximum Sustainable Yield approach, whereby fleets must stop fishing once the first species in their target mix reaches FMSY levels.
- **PGY (Pretty Good Yield):** Fishing according to a more flexible MSY approach consistent with the Multiannual Plans for fisheries, whereby fishing can continue until, for example, an upper range of FMSY is reached. This approach aims to mitigate the 'choke effects' induced by the Landing Obligation.
- **Case-specific:** Entailing region-specific measures relating to changes in active versus passive gear allocations, and closed areas.

CLIMATE SCENARIOS:

Scenarios were tested under both current conditions and future climatic projections to examine how severe (RCP8.5, equivalent to around 5 degrees of warming) and moderate (RCP4.5, equating to around 2.5 to 3 degrees of warming) scenarios, and resulting changes in fish productivity, might alter outcomes.

RETAINED SPECIES

Though improvements have been made over recent years, many commercially important stocks are still fished above FMSY and many stocks remain outside of safe biological limits, often due to combined impacts of fishing and climate change (2). Across all examined fleets and regions, the proportion of yield derived from stocks in Good Environmental Status is less than 80%, with the exception of the large-scale fleets in the Bay of Biscay and the large-scale passive gear fleets in the Celtic Sea (2).

To support management approaches that address this, SEAwise has assessed the potential outlook for stocks under a range of climate and management scenarios (see box above).

Under today's climate, this modelling indicates that alternative management approaches (fishing effort reduction in line with FMSY-min or PGY) would improve stock biomass and fishing mortality indicators (2). Across most case study regions, implementing FMSY-min or, in some cases, PGY would lead to over 90% of stocks being in Good Environmental Status (2). In the North Sea, alternative management approaches were projected to increase yields by up to 26% across both small- and large-scale fleets, with the recovery of North Sea cod allowing for improved catch (2). However, elsewhere, management change would deliver decreased yields - for example, in the Western Waters region, yield was projected to severely decline under these alternate management approaches (2). **These findings raise salient questions for policy makers and managers about navigating trade-offs when management change enhances ecological status but decreases direct socio-economic benefit.**

Photo credit: LTapsaH, Pixabay

Under climate change, across most regions, projected management change to FMSY-min or PGY would increase stock biomass but decrease yield even further than under current management (2). Further, continued status-quo management in some regions results in a smaller decline in catch levels under climate change, when compared against FMSY-min and PGY (2). This is due to the reduced productivity of many species under climate change, hindering the recovery of commercially important stocks such as hake in the Mediterranean and cod and saithe in the North Sea. The exception to this was across the North Sea and the sub-region of the Adriatic and western Ionian Sea, where FMSY-min or PGY had larger yields under future climate than status-quo fishing (2). However, in both regions, the future yields were substantially below current levels.

Overall, **our findings reaffirm the need for catch advice to be set at or below FMSY.** Beyond this, they support **a regionally-tailored approach to management, particularly under climate change** – with advice that is grounded in up-to-date science on the health of specific stocks and assessment of how likely stock recovery is under climate change.

Photo credit: Cavan Images, Getty Images

FOODWEBS AND COMMUNITY DIVERSITY

Developing knowledge on and measuring how fishing impacts the broader marine ecosystem is fundamental to ushering in the more holistic approach to management enshrined in EBFM. This includes understanding foodweb dynamics (i.e. who eats who within an ecosystem) and the diversity of species within them (aka 'community diversity').

To establish suitable indicators that allow decision-makers to monitor the impact of fisheries on ecosystem functionality, SEAwise modelled foodweb dynamics and ecosystem interactions within the northeast Atlantic and Mediterranean Sea (1).

Our modelling work demonstrated that the number of apex predators within an ecosystem typically declined due to fishing (1). Further, we found that when the proportion of large individuals in demersal fish communities declined, the risk of interruptions in ecosystem functioning increased (1). This highlights **a need for management measures that allow individuals to grow to large (often more fertile) sizes.** Other relationships between ecosystem indicators and fishing pressure were found to be less clear, with variability in community diversity levels on account of the intensity of fishing effort and between different gear types (1). These findings highlight the **need for fisheries management to be contextually-tailored**, with there being **no one-size-fits-all solution that can be uniformly applied across EU fisheries**.

Utilising these findings, we explored how set indicators responded under different management scenarios (1). Across future climate and management scenarios, most food web indicators were found to be in good status (2) – with exceptions including apex predator biomass being below provisional thresholds in the North Sea under continued status-quo management and climatic warming (2). Through this, SEAwise identified ecological indicators that show common predictable responses to fishing, such as the biomass of top predators or size-based indicators of fish communities (1). Continued research is needed to establish agreed risk thresholds for many indicators, to ensure they are fit-for-purpose and suitable for tactical use within management advice. However, once these thresholds are set, **the indicators identified by SEAwise are likely to be most useful to managers, enabling the risk posed to ecosystem function, foodwebs, and community diversity from fishing to be actively monitored.**

BYCATCH RISK

Identifying the bycatch risk of sensitive, endangered, threatened or protected (ETP) species is key to mitigating the unintended effects of fisheries activities. By evaluating the efficacy of management measures designed to reduce bycatch risk – such as gear restrictions, effort reduction, or area-based closures – this knowledge can be integrated to enable effective implementation of EBFM.

Having estimated species' vulnerability to bycatch, SEAwise assessed the sustainability of bycatch levels of sensitive or ETP wildlife populations to identify areas and gears with highest bycatch risk across SEAwise's case study regions (2, 3).

Species found to be impacted at unsustainable levels include the critically endangered Balearic shearwater in the Bay of Biscay sub-region, harbour porpoise in the Western Waters region, the North Sea and the Baltic Sea, and the critically endangered bull ray and blue shark in the Mediterranean Sea (2, 3). Species determined to be sustainably impacted by bycatch include the loggerhead turtle in the Mediterranean Sea and the undulate ray in the Western Waters region and North Sea (2, 3).

Across species and region, gear types posing the highest risk (medium or high) of bycatch were trammelnets, gillnets, and beam trawls; for other gear types, including longlines or bottom otter trawls, bycatch risk was regionally- and species-specific (2, 3). Overall, we found no clear relationship between the status of the species (i.e. how endangered it is) and its bycatch risk. As such, our work highlights a need to **assess both species-specific vulnerability and area- and gear-related bycatch risk when producing management advice – ensuring that management is targeted where it is needed most**.

SEAwise also explored the effects of management measures on bycatch risk. Generally, we found spatial measures, such as area closures, to have a minimal effect on bycatch risk (2, 4). In contrast, changes to fishing effort, from current management to FMSY-min or PGY, could reduce the risk to unsustainably impacted ETP species by at least 23% (2). In some cases, such as the blue shark in the Adriatic and western Ionian, it was only FMSY-min that led to a decrease in unsustainable bycatch risk (2). For other species, like the common dolphin in the Bay of Biscay sub-region, our results indicate that bycatch risk can only be mitigated through more extensive, tailored measures (see box above).

SPECIES-SPECIFIC CLOSURES IN THE BAY OF BISCAY

In the Bay of Biscay, bycatch risk to the common dolphin is currently unsustainable and, therefore, management change to mitigate the present impact of a large-scale, active gear fleet is vitally needed (2).

Our findings suggest that changes to fisheries management, in the form of FMSY-min and PGY, will have little impact on reducing bycatch of the species (2). The introduction of a dolphin closure together with PGY was projected to reduce common dolphin bycatch risk by an additional ~20% compared to a PGY scenario without closures, while the number of bottom habitats excessively negatively impacted by fishing were projected to double (2). The PGY scenario led to substantial declines in fisheries yields, while the addition of a closure led to minor further declines (2). In contrast, closures of coastal areas to protect Balearic shearwater had both positive impacts on Balearic shearwater and very limited impacts on fisheries (5).

Our modelling here exemplifies **the importance of policy support for timely, responsive, and fit-for-purpose gear innovations to reduce bycatch risk from both passive and active gears alongside more conventional effort-based restrictions**; with guidance and support for industry to assist uptake of innovations that help reduce fleets' impact on vulnerable species in a way that is socially fair.

Again, our findings underscore **the importance of setting catch limitations in line with scientific advice, at or below FMSY** – with the potential benefits of such management change not only tangible for target stock health, but offering the dual benefits of mitigating bycatch risk and habitat degradation (see section below). More broadly, our research emphasises that **management must broaden its scope beyond a sole focus on catch limitations and work to integrate assessments of the broader ecosystem impacts of fishing activities.**

BENTHIC HABITATS

Fishing gears that contact the seafloor inevitably have an effect on 'benthic habitats' – that is, the seabed and the communities of organisms found in and upon it. Quantifying the risk of negative impacts on benthic habitats from fishing, alongside how this might vary over space and time, is key to devising management strategies that protect or restore these habitats so that they can support healthy ecosystems and fish stocks.

Across our case study regions, using a preliminary definition of negative impact, we found the total area across all habitats that was negatively impacted by fishing to be less than 36% (2). In the North Sea and northern Western Waters region, for example, we found 20% of the total area was negatively impacted by fishing (2). Nonetheless, across all regions assessed (bar the western Ionian Sea), we identified specific habitats which were negatively impacted in more than 25% of their extent, exceeding the sustainability threshold determined by TG Seabed (2, 6). The most negatively impacted habitats were found to vary between regions, between fleets operating with different gear types, and with the spatial and temporal distribution of fleets' fishing activities (2). Our findings therefore affirm that **management measures aiming to attain Good Environmental Status, such as gear restrictions, should be both regionally-tailored and habitat-specific** (2).

SEAwise also explored the impact of catch- and effort-based management approaches on reducing

Photo credit: Pablo Joanidopoulos, Shutterstock

benthic impacts. Across regions, both FMSY-min and PGY management were projected to reduce the area negatively impacted by fishing, when compared against a continuation of the status-quo (2) – with the strongest reduction found under the FMSY-min scenario. Conversely, case study-specific scenarios, including area-based closures, led to a greater area negatively impacted – likely due to fishing effort being displaced from current areas to other areas with a higher sensitivity to fishing, with this being especially true at larger scales (2, 7).

FISHERIES-RELATED LITTER

SEAwise also explored the impact of marine litter, responding to stakeholders identifying this as a key area of concern (8).

Among findings, we identified that **between 2012 and 2021, plastic and fisheries-related litter almost doubled in European waters**, resulting in a corresponding increase in the risk of entanglement and ingestion of commercial species (2, 9). Our work also demonstrated that plastic and fisheries-related litter occurs in 40-90% of scientific trawls across our case study regions (9). According to our analysis, there was some degree of overlap between fishing activity and fisheries related litter, however further research is needed here (9). **Though mandated under the MSFD, measures for acceptable litter levels – or threshold values – remain lacking across European waters.**

GEAR-SPECIFIC ECOLOGICAL IMPACTS

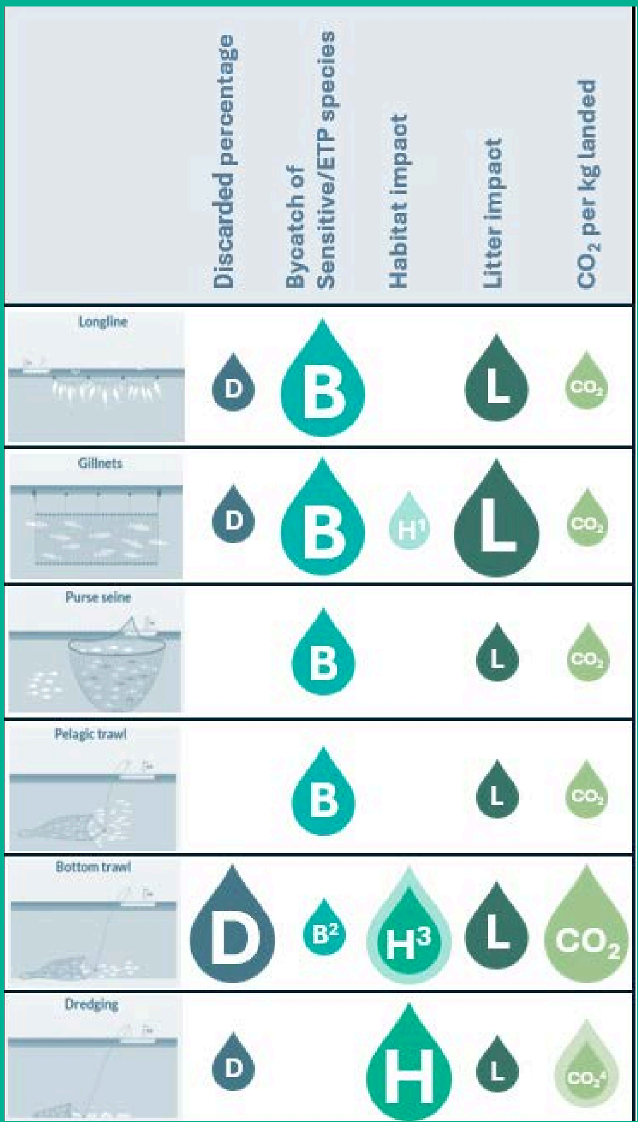

Figure 1: Consolidation of SEAwise's findings regarding the impact of various gear types on different ecosystem components.

Across SEAwise's work theme on the ecological effects of fisheries, we explored the impact of fisheries on a broad range of ecological components. As part of this, we explored the impact of various gear types on the ecosystem, looking beyond a sole focus on retained species.

Our results here illustrate the diverse impacts different gears have on different aspects of the ecosystem (2)-- highlighting the need for gear-specific approaches to management that account for these differences. Beyond this, these results highlight the potential for trade-offs between different ecological management priorities which must be addressed as part of effective EBFM going into the future (2).

Figure footnotes:
1: Habitat impacts may occur for gillnets where the bottom of the gear touches the seafloor.
2: Bycatch of sensitive fish is frequent.
3: Habitat impacts are large for beam trawls and less for bottom trawl gear.
4: CO2 and habitat impact per kg landed is low for mussels and other species occurring at high densities.

Source imagery adapted from Hanna Ritchie, OurWorldinData.org.

Photo credit: AliLooney, Getty Images

CONCLUSIONS

SEAwise's research demonstrates the significance of catch limits being capped at or below levels consistent with MSY. Our findings suggest that beyond stock-specific benefits (including a greater number of stocks with Good Environmental Status), **management in line with FMSY-min would likely deliver ecosystem-wide benefits – including in respect to reducing bycatch risk and mitigating fisheries' impact on benthic habitats.**

Nonetheless, **decision-makers must be cognisant of the trade-offs involved** with such an approach, particularly under climate change. Our work highlights that FMSY-min has the potential to result in large declines in yields across all regions, due to either the climate-independent effect of choke species or as a result of climate-induced declines to stock productivity. While the latter is difficult to mitigate, the impact of choke species can potentially be mitigated by fishing with gears or in locations and times that allow for the avoidance of choke species.

Further, the species-, habitat-, gear- and regionally-specific nature of many of our findings **reinforces the importance of a tailored approach to management**, informed by best available science that captures the dynamics at play 'on-the-ground'. Beyond this, **across work areas and regions, our research emphasises that management must broaden its scope** beyond a sole focus on instating catch limitations for target species or protecting a single ecosystem element. **Instead, management must seek to integrate consideration and assessment of the broader ecosystem impacts of fisheries activities.**

REFERENCES

1. Lynam, C., et al. (2023). SEAwise Report on the effects of fishing on food webs and community diversity aimed at populating the MSFD Descriptor 4 and based on food web and end-to-end modelling. Technical University of Denmark. https://doi.org/10.11583/DTU.25158746
2. Rindorf, A., et al. (2025). SEAwise synthetic summary report of the findings of WP4 on changes to the ecosystem impacts of fishing in response to spatial management for online tool. Technical University of Denmark. https://doi.org/10.11583/DTU.29235029
3. Astarloa, A., et al. (2023). SEAwise Report on the bycatch mortality risk of potentially endangered and threatened species of fish, seabirds, reptiles and mammals. Technical University of Denmark. https://doi.org/10.11583/DTU.25041257
4. Astarloa, A., et al. (2024). SEAwise Report on changes in bycatch of fish, seabirds, reptiles and mammals in response to spatial management. Technical University of Denmark. https://doi.org/10.11583/DTU.28078955
5. Bastardie, F., et al. (2025). Anticipating how spatial fishing restrictions in EU waters perform to protect marine species, habitats, and dependent fisheries. *Front. Mar. Sci.*, 12. https://doi.org/10.3389/fmars.2025.1629180
6. Technical Group on Seabed Habitats and Sea-floor Integrity (TG SEABED) 2023. Setting of EU Threshold Values for extent of loss and adverse effects on seabed habitats. Recommendations from the Technical Group on Seabed Habitats and Sea-floor Integrity (TG Seabed). Accessible here.
7. Van Hoey G., et al. (2024). SEAwise Report on changes in the spatiotemporal benthic effects of fishing on benthic habitats relative to suggested reference levels, both with respect to area impacted and impact intensity in response to spatial management. Technical University of Denmark. https://doi.org/10.11583/DTU.28078970
8. Beukhof, E., et al. (2022). SEAwise Report on the key species and habitats impacted by fishing. Technical University of Denmark. https://doi.org/10.11583/DTU.21269298
9. Spedicato, M.-T., et al. (2023). SEAwise Report on the pressure induced by fisheries related litter on key species groups. Technical University of Denmark. https://doi.org/10.11583/DTU.23284649

This policy brief has been produced as part of SEAwise's work theme on 'Ecological Effects of Fisheries'. For further information on this work and to dive into our findings in-depth visit: https://tinyurl.com/EcolEffectsOfFisheries.

This work theme was led by Prof. Anna Rindorf, Technical University of Denmark (DTU), as part of the broader SEAwise project also coordinated by Prof. Anna Rindorf.

This brief sits as part of a broader series of six policy briefs offering an overview of SEAwise's research, coinciding with the culmination of the project in September 2025. These briefs can be found here: https://tinyurl.com/SEAwisePolicyBriefs.

info@seawiseproject.org

seawiseproject.org

SEAwise Project

MINDFULLYWIRED

SEAwise has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000318