Skate and Ray Management Measures

Review and Recommendations

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Foreword

Skate and Ray Management Measures – Review and Recommendations was produced by MRAG for the purpose of providing the national fisheries and marine evidence team at Natural England with evidence-based management recommendations to support the development of the Southern North Sea and Channel Skates and Rays Fishery Management Plan (FMP) (2024; ICES Divisions 4.b, 4.c, 7.d, 7.e – English waters only) and the Celtic Sea and Western Channel Demersal FMP (2024-2025; ICES subarea and division 7.e, 7.f, 7.g, 7.h: Welsh and English waters only).

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Executive summary

This project investigates how skate and ray fisheries are managed in the UK and in temperate waters globally to review the feasibility, and potential for adoption within English fisheries. As part of Brexit, the UK developed a Joint Fisheries Statement, underpinned by the UK Fisheries Act (2020), outlining policy strategies to reform UK fisheries management and national legislation. This statement details eight fisheries objectives for future UK fisheries management and emphasises the importance of FMPs as a key tool for implementing these policies. Starting from 2022 and continuing through 2028, a series of FMPs will be collaboratively developed, with active participation from industry and other interested stakeholders, to restore and maintain sustainable fish stocks which are at risk of significant over-exploitation without management intervention. One notable group of species which meet these criteria are skates and rays.

Up to this point, UK fisheries management of skate and ray populations has been relatively limited, primarily relying on multi-species Total Allowable Catch (TAC) regulations that encompass all skate and ray species, with the exception of the \small-eyed ray and the endangered undulate ray which are managed under individual TACs. Additionally, management measures include gear restrictions and prohibitions on retaining and landing specific species. However, when compared to other target quota species, many of which have established minimum conservation reference sizes (MCRS) to safeguard juvenile populations, it becomes evident that skate and ray management is deficient. Action is needed to ensure the sustainability of commercial stocks, accompanied by enhancements in the collection of species-specific data to provide more robust protection for vulnerable and threatened species.

As a step to achieving better management for skate and ray fisheries, gaining insights into existing fisheries measures implemented beyond the UK is essential to understand how further management can effectively protect and restore skate and ray populations while sustaining fishery productivity. The findings from this review inform recommendations on how these measures could improve the sustainable exploitation of skate and ray populations in English waters.

During this project, particular attention was given to the seven species listed under the Southern North Sea and Channel Skates and Rays FMP, namely:

- thornback ray (*Raja clavata*)
- small-eyed ray (*Raja microocellata*)
- blonde ray (*Raja brachyura*)
- spotted ray (*Raja montagui*)
- cuckoo ray (*Leucoraja naevus*)
- undulate ray (*Raja undulata*)
- starry ray (*Amblyraja radiata*)

A series of literature searches were undertaken to review existing and proposed management measures for skates and rays in both target and non-target fisheries. In addition to reviewing fisheries management practices in the UK, this review expanded its

geographic scope to encompass countries and regions with comparable fisheries systems. Once the data had been collected, an analysis on the effectiveness of each management approach adopted within the researched countries / regions was carried out. The final list of candidate management measures was then analysed against the UK legal and regulatory framework to assess the practical applicability and likelihood of adopting these measures within English waters.

Based on the project's findings, the following nine recommendations are provided for enhancing the management of both target and non-target skate and ray fisheries in the English waters:

1. **Introduce species-specific Total Allowable Catches (TACs) to** provide more appropriate catch limits for specific species based on their life history and stock structure. Species-specific advice is already available, and the regulatory framework is in place, making this a high-priority conservation measure.
2. **Increase the minimum mesh size in static net fisheries to at least 266 mm (10.5 inch)** when skates and rays comprise more than 30% of catches.
3. **Increase the minimum cod-end mesh size to at least 100 mm in trawl mixed fisheries** that encounter skates and rays, improving post-release survivorship and selectivity.
4. **Implementation of a 45 cm disc width minimum conservation reference size (MCRS)** to safeguard juvenile individuals and ensure sexually mature skate species are landed. Further research is needed to develop species-specific MCRS based on life history traits.
5. **Establish move-on rules** for endangered or vulnerable species is proposed, triggered by bycatch limits. This rule can help reduce bycatch and protect threatened species and important seabed habitats.
6. **Develop species-specific bycatch measures** through research on species survivorship and life history traits.
7. **Create a best practice guide for handling skates and rays** to maximize post-release survivorship.
8. **Research and establish temporal and or spatial closures** which align with life history traits of protected species, such as spawning seasons and nursery grounds, to reduce fishing pressure on vulnerable populations.
9. **Enhance data collection** by improving observer coverage, implementing a national tagging program, and developing an identification guide for skates and rays. This will improve the accuracy and quality of species-specific landings data, fill knowledge gaps regarding the ecology, spatial distribution and movements of skate and ray stocks, and ultimately contribute to more effective and sustainable fisheries management.

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Introduction

Project background

The UK fishing industry is undergoing significant changes as the UK Government begins to reform its fisheries management and national legislation following its departure from the European Union in January 2020. The UK Fisheries Act (the Act), enacted in November 2020, established a legal mandate for fisheries policy authorities (the Secretary of State, Scottish Ministers, Welsh Ministers and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland) to publish a Joint Fisheries Statement (JFS) that outlines the overarching policy strategy to manage their fisheries. As set out in the Act, these policies must achieve, or contribute to the achievement of, eight fisheries objectives, namely sustainability, precautionary, ecosystem, scientific evidence, bycatch, equal access, national benefit and climate change. A key tool in the delivery of these policies will be the use of Fishery Management Plans (FMPs).

Since 2022 until 2028, multiple FMPs will be developed and implemented in a tranche approach to restore and or maintain the sustainable management of commercially important fish and shellfish stocks in UK waters. Each FMP will be prepared using the best available evidence and will require input from industry and other interested stakeholders to identify the most effective measures to deliver its policies, as well as directly relate to the objectives of the JFS relating to sustainability, the precautionary approach, scientific evidence, ecosystem impacts and equal access fisheries. Alongside these measures, each FMP must specify the relevant indicator(s) that fisheries managers will use to assess and monitor the effectiveness of the plan to achieving the long-term, sustainable harvesting of the target stock(s). Each FMP will likely be very different depending on the target stock(s), types of fishing or defined geographic area.

The criteria for determining whether a stock should be considered for inclusion in a FMP focuses mainly on the stock's risk of significant over-exploitation without management action, social and economic importance and contribution to coastal communities, and ecosystem significance. The list of FMPs is detailed under Annex A of the JFS, whereby skates and rays (*Rajidae*) are covered in the future Celtic Sea and Western Channel Demersal FMP (2025; ICES subarea and division 7.e, 7.f, 7.g, 7.h: Welsh and English waters only) and Southern North Sea and Channel Skates and Rays FMP (2024; ICES subarea and division 4.b, 4.c, 7.d, 7.e – English waters only).

In 2022, 2,017 tonnes of skates and rays were landed by the UK fishing fleet, valued at £3.67 million. This makes up only 0.3% of the total volume landed (640,000 tonnes), demonstrating that the UK contribution to the removals of skate and rays is negligible from an overall commercial perspective. Nonetheless, there are local fisheries where skates and rays make up a significant proportion of the catch composition, most notably in the Bristol Channel which is one of the UK's largest targeted fisheries (Enever *et al*., 2010). Skates and rays may also, in certain locations, be regarded as a choke species, those

species for which the available quota is reached before the quotas of other species caught together in a fishery.

Predominately landed as bycatch in mixed demersal fisheries, skates and rays are also targeted by local and seasonal otter trawl and longline fisheries, as well as large-mesh trammel and tangle nets (Enever *et al*., 2010). However, skates and rays are highly vulnerable to overfishing due to their life history traits, aggregating behaviour and large, flattened body shape, making them susceptible to capture by most fishing gears (Enever *et al.*, 2009; Ellis *et al.*, 2010). As a common mid-trophic level predator in marine benthic communities, skates and rays play a significant role in the community structure and function of marine ecosystems (Flowers *et al*., 2021). Therefore, their unregulated removal could have a negative impact on the environment altering predator-prey interactions and reducing food web complexity (Bănaru *et al.,* 2010; Amelot *et al*., 2021; Flowers *et al*., 2021).

In recent years, skates and rays have received increased management interest due to the disappearance of the critically endangered common skate (*Dipturus batis*; L. 1758)[1] and endangered white skate (*Rostroraja alba*; Lacépède 1803) from their former habitat in the north-east Atlantic- extending from northern Norway to Morocco- due to overfishing (Simpson and Sims, 2016; Ellis *et al.*, 2018). As a result, these species are now prohibited from being retained or landed in UK and European waters (Council Regulation (EC) No43/2009), as well as other species in certain areas, such as small-eyed ray (*Raja microocellata*) in ICES Subarea 4 & Divisions 2.a, 6.a-b, 7.a-c & 7.e, 7.h-k. However, the implementation of fisheries management for skates and rays has been slow. Given that landings were historically reported under the generic landings category “skates and rays” until 2009 (Council Regulation (EC) No 40/2008), there is a deficiency of data on population trends for specific species, making it difficult to implement evidence-based management for distinct stocks.

Up to this point, UK fisheries management of skate and ray populations has been relatively limited, primarily relying on multi-species Total Allowable Catch (TAC) regulations that encompass all skate and ray species with diverse life histories. Additionally, management measures include gear restrictions and prohibitions on retaining and landing specific species. However, when compared to other target quota species, many of which have established minimum conservation reference sizes (MCRS) to safeguard juvenile populations, it becomes evident that skate and ray management is deficient. Action is needed to ensure the sustainability of commercial stocks, accompanied by enhancements in the collection of species-specific data to provide more robust protection for vulnerable and threatened species.

[1] Since 2010, the common skate has been recognized as a complex of two species: common blue skate *Dipturus batis* and flapper skate *Dipturus intermedius*, both assessed as critically endangered by the IUCN.

As a step to achieving better management for skate and ray fisheries, gaining insights into existing fisheries measures implemented beyond the UK is essential to understand how further management can effectively protect and restore skate and ray populations while sustaining fishery productivity. This project investigates how skate and ray fisheries are managed in the UK and in temperate waters globally to review the feasibility, and potential for adoption within English fisheries. The findings of which inform recommendations on how these measures could improve the sustainable exploitation of skate and ray populations in English waters.

Project objectives

MRAG were commissioned to conduct a review of the current and proposed fisheries management methods for skates and rays within fisheries systems relevant to the UK, including temperate regions with robust enforcement capabilities. From the review, MRAG undertook an analysis of the applicability and feasibility of measures collated within English fisheries. Providing evidence-based recommendations on how these measures could be implemented successfully to improve the sustainability of exploiting skate and ray populations, in particular, this study provides evidence to feed into the development of the Southern North Sea and Channel Skates and Rays FMP.

For this project, the objectives were twofold:

Task 1: Literature review on the current and proposed management measures for skate and ray fisheries; and

Task 2: Analysis of the effectiveness of management approaches adopted by relevant fisheries systems and likelihood of successfully applying management approaches in English waters.

Methodology

Task 1: Literature review

A series of literature searches were undertaken to review existing and proposed management measures for skates and rays in both target and non-target fisheries. This review was intended to collate measures implemented by relevant fishery authorities to support the development of future management measures to protect or improve the sustainable exploitation of skate and ray fisheries in English waters. To achieve this, the review assessed a wide range of existing input and output control measures, focusing on gear types and species relevant to UK fisheries. In particular, due consideration was given to several species known to be commercially important in UK fisheries, as well as listed under the Southern North Sea and Channel Skates and Rays FMP:

- thornback ray (*Raja clavata*)
- small-eyed ray (*Raja microocellata*)
- blonde ray (*Raja brachyura*)
- spotted ray (*Raja montagui*)
- cuckoo ray (*Leucoraja naevus*)
- undulate ray (*Raja undulata*)
- starry ray (*Amblyraja radiata*)

However, when relevant, management approaches for other species of skate and ray were also considered.

In addition to reviewing fisheries management practices in the UK, this review expanded its geographic scope to encompass countries and regions with comparable fisheries systems. These were focussed on temperate waters characterised by effective fisheries management practices. This broader scope included the European Union, Iceland, Norway, USA, Canada, New Zealand, Australia, South Africa and the Falkland Islands.

Literature searches were conducted in Google Scholar, allowing access to both peer-reviewed and grey literature. Searches used Boolean logic to combine key search terms relating to fishery management measures and the associated skate and ray species, using both their common and scientific name. Additional search terms specifying the geographic location were also included to identify literature of greater relevance to the study. For example, [species name]" OR "[scientific name]" AND "[measure]" AND "[location]".

The resultant evidence was collated and saved using open-source reference management software Zotero. References were saved by geographic region in individual subcollection folders. These search databases were then combined and duplicated references (n= 15) removed, leaving 224 unique references. Unique references were screened on review of 'type' excluding press releases, speeches or opening remarks and website extracts (n = 9). The remaining 216 references were then screened first by title, then the abstract to ensure all the literature was relevant to the scope of work (all retained). The final

references were deemed to be of direct relevance to this review and were examined in full to extract the relevant information. The literature selection process is depicted in Figure 1.

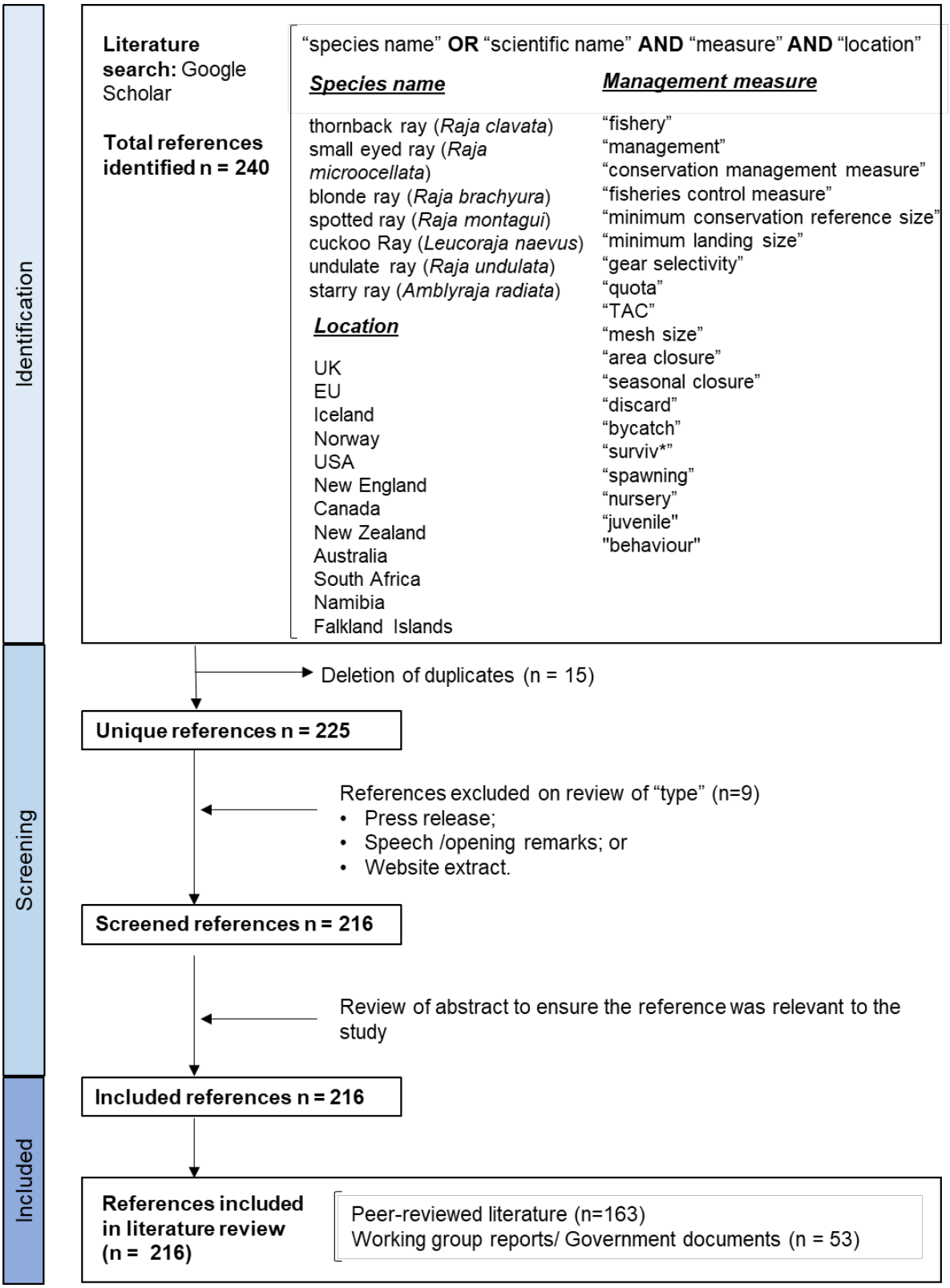

Figure 1 Flow diagram of the literature search and selection process.

The literature review in Google Scholar, was supported with additional information sources including the International Union for Conservation of Nature (IUCN) Red List, FishBase and the Marine Life Information Network (MarLIN). These sources provide information on skate and ray life history traits, such as geographic distribution, length at sexual maturity and breeding seasons.

A summary of the skate and ray species referred to in this report is provided in Table 1.

Table 1 List of skate and ray species included in this report.

Species Code	Common name (English)	Scientific Name
BYF	Alaska skate	*Bathyraja parmifera*
SRR	Antarctic starry skate	*Amblyraja georgiana*
RJL	Barndoor skate	*Dipturus laevis*
JRI	Big skate	*Beringraja binoculata*
RFL	Biscuit skate / spotted skate	*Raja straeleni*
RJH	Blonde ray	*Raja brachyura*
BZB	Broadnose skate	*Bathyraja brachyurops*
RJB	Common skate / Blue skate	*Dipturus batis*
DYP	Cowtail stingray	*Pastinachus sephen*
RJN	Cuckoo ray	*Leucoraja naevus*
BEA	Eaton’s skate	*Bathyraja eatonii*
DRJ	Flapper skate	*Dipturus intermedius*
BYG	Graytail skate	*Bathyraja griseocauda*
JAH	Longnose skate	*Beringraja rhina*
RJO	Longnosed skate	*Dipturus oxyrinchus*

BHY*	Multispine skate	*Bathyraja multispinis*
DPQ	New Zealand smooth skate	*Dipturus innominatus*
JAD	Norwegian skate	*Dipturus nidarosiensis*
SKA	*Raja rays nei*	*Raja spp*
DHY	Reticulate whipray (Honeycomb stingray)	*Himantura uarnak*
JAT	Rough skate	*Zearaja nasuta*
$---	Roughskin skate	*Dipturus trachyderma*
RJE	Small-eyed ray	*Raja microocellata*
RJS	Smooth skate	*Malacoraja senta*
RJM	Spotted ray	*Raja montagui*
RJR	Starry ray / skate	*Raja (Amblyraja) radiata*
RJC	Thornback ray	*Raja clavata*
RJU	Undulate ray	*Raja undulata*
JRV	White joined-fins skate	Bathyraja cousseauae
RJA	White skate	*Raja (Rostroraja) alba*
BHY*	White-dotted skate	*Bathyraja albomaculata*
DPV	Yellownose skate	*Dipturus chilensis*

* No species-specific species code within the ASFIS (Aquatic Sciences and Fisheries Information System) list (FAO. 2023), within Europe these species are assigned as "*Bathyraja Nei*" which has been applied here. $ No species-specific species code within the ASFIS list (FAO. 2023), and no alternative code could be identified.

Furthermore, national regulatory and management portals for each country / region of interest were also mined for relevant legislation or fishery management plans related to skate and ray fisheries. For example, the Marine Management Organisation (MMO), European Commission, National Oceanic and Atmospheric Administration (NOAA), Fisheries New Zealand (FNZ) and relevant Regional Fisheries Management Organisations (RFMOs). Finally, general searches also generated publications from regional technical working group reports (e.g. the Scientific, Technical and Economic Committee for Fisheries (STECF) under the European Commission), International Council for the Exploration of the Sea (ICES) Working Group on Elasmobranch Fishes (WGEF) and ICES advice on fishing opportunities, catch and effort for skates and rays.

Task 2: Analysis

Once the data had been collected, an analysis on the effectiveness of each management approach adopted within the researched countries / regions was carried out.

Evaluation of the effectiveness of each measures/overall fishery

Firstly, each measure was identified under an exhaustive list of input and output control measures classified to four levels of description based on the categorisation developed under a recent series of European Commission projects addressing the Ecosystem Approach to Fisheries Management (EAFM) (European Commission, 2022). This made sure all the terms used to describe the control measure were standardised and that a complete set of potential measures were considered. Measures were broken down into a clear tree structure. The initial breakdown of three levels, separated input controls (e.g. effort limits such as kW hours or mesh sizes), output controls (e.g. quotas) and “Alternative governance and economic instruments” (e.g. Payments for ecosystem services/alternative fishing method).

The complete list of measures can be found in Annex 1. These measures were then categorised by type to showcase if it was an operational or technical measure and if these measures contributed to monitoring, reporting and evidence, and education / outreach. A detailed description of each measure was provided and, where possible, the scientific evidence or rationale for implementing each measure was explained. This was also supported by evidence extracted from the literature review.

Secondly, a preliminary evaluation was undertaken to ascertain the effectiveness of the implemented measures and their contribution to improved stock or species management. Recommending management measures that do not yield positive outcomes serves no purpose, so it is crucial to ensure that these recommendations are based on measures which have shown to be effective and successful in achieving their fisheries objectives within these fisheries systems.

Ideally, a management measure should have an objectively verifiable indicator (OVI) to monitor and evaluate the performance of a measure towards meeting its fisheries objectives. However, where an OVI was not identified, a collective assessment of how the

measures contributed to a well-managed fishery was carried out. During these assessments, where available, evidence from the literature review, such as ICES stock assessments, was used to underpin the assessment findings.

Applicable management measures for English fisheries

The final list of candidate management measures was then analysed against the UK legal and regulatory framework to assess the practical applicability and likelihood of adopting these measures within English waters.

To assess the feasibility of adopting the measure under national legislation, the JFS states that, "*the design and structure of FMPs directly relate to the sustainability, precautionary, scientific evidence, ecosystem and equal access fisheries objectives by delivering sustainable fisheries, the collection and use of scientific evidence and application to all vessels fishing in the area covered*". Therefore, each identified measure was assessed on whether it met one or more of these objectives which would help inform the likelihood of potential adoption in English fisheries (see Table 2). In addition, similar examples of where these measures are already integrated into the existing legislative frameworks to manage other fish stocks were provided. This contributed to the overall assessment of the likelihood of successful implementation, promoting more effective and streamlined fisheries management practices.

Furthermore, consideration of the potential risk of non-compliance is given to support the likelihood of stakeholders from the fishing industry and regulatory bodies accepting the implementation and enforcement of these measures.

Table 2 Description of Fisheries Objectives set out under Article 1 of the Fisheries Act 2020.

Objective	Description
Sustainability	(a) fish and aquaculture activities are environmentally sustainable in the long term, and managed so as to achieve economic, social and employment benefits and contribute to the availability of food supplies, and (b) the fishing capacity of fleets is such that fleets are economically viable but do not overexploit marine stocks.
Precautionary	(a) the precautionary approach to fisheries management is applied, and (b) exploitation of marine stocks restores and maintains populations of harvested species above biomass levels capable of producing maximum sustainable yield.
Scientific evidence	(a) scientific data relevant to the management of fish and aquaculture activities is collected, (b) where appropriate, the fishery policy authorities work together on the collection of, and share, such scientific data, and (c) the management of fish and aquaculture activities is based on the best available scientific advice.
Ecosystem	(a) fish and aquaculture activities are managed using an ecosystem-based approach so as to ensure that their negative impacts on marine ecosystems are minimised and, where possible, reversed, and (b) incidental catches of sensitive species are minimised and, where possible, eliminated.
Equal access	the access of UK fishing boats to any area within British fishery limits is not affected by – (a) the location of the fishing boat's home port, or (b) any other connection of the fishing boat, or any of its owners, to any place in the United Kingdom.

Review of UK management measures in skate and ray fisheries

Throughout the UK, fisheries management for skates and rays is minimal. This has largely stemmed from long-standing data gaps in species-specific ecology, stock assessments and the absence of species-specific reported landings. These deficiencies have hindered the establishment of evidence-based management for distinct stocks. In the UK, skates and rays are predominately caught and landed as bycatch from mixed fisheries. However, there are some localised and seasonal fisheries which target skates and rays throughout the year, using a range of gear types such as otter trawl, longline, large-mesh trammel and tangle nets (Ellis *et al.* 2010; STECF 2017; Thys *et al.*, 2023).

To date, existing UK fishing regulations concerning commercially exploited skates and rays in both targeted and non-targeted fisheries have primarily revolved around quota limitations, gear restrictions and EU legislation to address discarding. The subsequent section provides a detailed discussion of the various input and output controls in place.

Quota Restrictions

Fishing effort for skates and rays in the north-east Atlantic has primarily been regulated by annual 'Total Allowable Catch (TAC)'= restrictions, commonly known as quotas. TACs are set by fisheries policy managers in, typically annual, negotiations at an international level. In relation to UK skate and ray stocks, this is done as a bi-lateral agreement with the EU under the EU-UK Trade and Cooperation Agreement (2020). The level of the TAC is set taking into account ICES advice as to the estimated catches which can be removed from a stock whilst maintaining a sustainable stock size relative to fishery reference points, or in data deficient situations, as is the case with many skate and ray species, relative to the precautionary approach. Noting that negotiated TAC may not follow the ICES advice.

The first TAC for skates and rays in 1999, located within the North Sea (ICES Subarea 4 and Division 2.a) marked the beginning of regulatory efforts of these species (Council Regulation (EC) No 48/1999). Noting pre-Brexit up to 2020, TACs were set as a result of annual negotiations by the European Union Council of Ministers of which the UK was party. Initially set at 6,060 tonnes, these TACs encompassed all skate and ray species caught in target and non-target fisheries. In subsequent years, the TAC gradually decreased, but it was rarely reached until 2009 when the TAC was set at 2,755 tonnes and it has been reached almost every year since. This pattern highlights that the initial decade of management failed to alleviate fishing pressure to safeguard skate and ray stocks. Consequently, the current quota restrictions for this area have only proven effective since 2009 (Thys *et al.*, 2022).

At the same time, additional combined TACs for skates and rays were established in specific ICES regions in 2009, along with new EU fisheries legislation to report skate and

ray landings to species level (where possible) (Council Regulation (EC) No 40/2008). Improved accuracy in data reporting has led to better understanding of spatial distribution and fishing pressure on distinct stocks. Consequently, species specific landing advice is now available for multiple species through ICES assessments, developed upon request from ICES clients (European Union, NASCO, NEAFC, Iceland, and Norway). Nevertheless, problems related to misidentification persist, and in some cases, landings are still reported at the family level or confounded with other species, most notably species in the genus *Dipturus*, such as blue skate (*D. batis*), flapper skate (*D. intermedius*), Norwegian skate (*D. nidarosiensis)* and longnosed skate (*D. oxyrinchus*) (Garbett *et al.,* 2023). Consequently, data accuracy and quality of species-specific information related to catch rates, spatial distribution and stock structure is affected, hampering the ability to perform stock assessments and implement effective management.

In response to the declining populations of specific skate and ray species, the EU (including the UK at the time) implemented a regulation that imposed a prohibition on EU vessels for "fishing for, retaining on board, transhipping, or landing" certain species within designated ICES areas (Council Regulation (EC) No 43/2009).This conservation measure was implemented to prevent further depletion and fragmentation of declining stocks, encompassing critically endangered species like the common skate (now termed the common blue skate *D. batis* and flapper skate *D. intermedius*) in ICES Divisions 2.a, 3.a, 7.d & Subarea 4, as well as other endangered species within ICES Divisions 6.a-b & 7.a-c, e-k: undulate ray (*R. undulata*), common skate, Norwegian skate (*D. nidarosiensis*) and white skate (*Rostroraja alba*). There is also a ban on targeting starry ray (*Amblyraja radiata*) in subareas 2 and 4 and Division 3.a and a zero TAC is in place (ICES, 2023a). However, specific TACs were allocated to some endangered species like undulate ray (*R. undulata*) and small-eyed ray (*R. microocellata*) in specific ICES areas due to localised abundances. Under the TAC and Quota Regulation, these species are not to be targeted and landings are restricted to the catch quota. To ensure English vessels adhere to the set catch limits, a bycatch allowance exists for undulate ray in ICES Areas 7.d and 7.e, while landings are strictly prohibited elsewhere. Similarly, small-eyed rays may only be caught in ICES Areas 7.f and 7.g and a special condition exists for which up to 5 % of the quota may be fished in ICES Areas 7.d, with a prohibition to retain small-eyed ray still in place in ICES Division 7.e.

At the time of writing, skates and rays are now regulated under five regional TACs, either referring to a group of several species or individual stocks of concern within a localised area (see Table 3). For example, small-eyed ray and the endangered undulate ray were assigned stock specific TACs in 2017 and 2018 respectively (Johnston and Clarke, 2019). While the stock status is unknown for the majority of skate and ray species around the UK, there is evidence that some populations, including thornback ray, spotted ray and cuckoo ray, are increasing. Furthermore, populations of endangered undulate ray in the English Channel (7.d and 7.e) have shown a consistent increase in biomass index and significant decrease in fishing effort, indicating the population is recovering (STECF, 2015). This is also reflected in an increased TAC from 58 tonnes in 2019 to 1,051 tonnes in 2023. This is also reflected in the increased bycatch allowance for English vessels fishing in ICES Areas

7.d and 7.eto no more than 200 kg of undulate ray in live weight may be retained or landed per fishing trip, an increase from 70 kg in 2019 (MMO, 2019).

In 2022, there was a notable shift in ICES advice for skate and ray landings in 2023 and 2024, particularly stocks in the North Sea and eastern English Channel as a result of a benchmark assessment for species such as thornback ray, blonde ray and spotted ray, meaning there is greater certainty in the accuracy of the data (ICES, 2023b). As a result, 2022 marked the first time ICES provided catch advice according to the Maximum Sustainable Yield (MSY) approach, replacing the previous precautionary advice method. The new benchmarked assessments rely on stock indicators derived from survey-based biomass indices or SPiCT models (stochastic production model in continuous time) to estimate stock status relative to MSY reference points. The adoption of the MSY approach can likely be attributed to the increased availability of stock-specific data which has substantially enhanced the reliability of ICES assessments, thereby providing more robust estimations to guide TAC negotiations.

It has become increasingly evident that the current approach to managing skate and ray catches through one generic TAC is not appropriate. For example, species-specific ICES assessments have stated that “management of the catches of skates and rays under a combined TAC prevents effective control of single-stock exploitation rates and could lead to overexploitation of some species” (ICES, 2023c). By grouping skates and rays under one TAC, the various species-specific biological traits and conservation status of individual species are ignored, resulting in different vulnerabilities to exploitation. Therefore, consideration should be given to the development of a species-specific approach to better safeguard the more vulnerable species included within the group complex.

In the recent fisheries consultation held between the UK and European Union in November 2022, delegates acknowledged the existing TAC management approach provides limited protection to vulnerable stocks. Consequently, it was mutually agreed to explore alternative management options, including the possible introduction of individual TACs for key stocks, with a view to any agreed alternative being implemented as soon as possible (Written Record of fisheries consultations between the United Kingdom and the European Union for 2023). During this consultation, it was agreed the setting of the group TACs for 2023 should be calculated by summing up the ICES species-specific advice included under the combined TAC for skates and rays in ICES Divisions 6.a-b, 7.a-c & 7.e-k; European Union waters of 8 and 9; and, to an extent, in ICES Division 7.d. Table 3 lists the agreed TACs and associated UK share of quota for skates and rays stock areas which overlap in English waters, alongside the specific conditions for fishers to comply with, as stated in the Written Record of fisheries consultations between the United Kingdom and the European Union for 2023.

Table 3 Agreed EU TACs set for skate and ray fisheries for 2023.

Stock area	Species	TAC (Tonnes)	UK share (Tonnes)	% share	Conditions
ICES Division 2.a & Subarea 4	Skates & rays	1,764	1,202	68.14	1,2,3,4
ICES Divisions 6.a-b, 7.a-c & 7.e-k	Skates & rays	9,797	2,937	29.98	5,6,7,8
ICES Division 7.d	Skates & rays	1,537	240	15.64	1,9,10
ICES Divisions 7.d & 7.e	Undulate ray (*R. undulata*)	3,192	1,051	32.94	11
ICES Divisions 7.f & 7.g	Small-eyed ray (*R. microocellata*)	86	43	49.58	12

[1] Catches of blonde ray in United Kingdom and European Union waters, cuckoo ray, thornback ray and spotted ray shall be reported separately.

[2] Bycatch allocation. These species shall not comprise more than 25 % by live weight of the catch retained on board per fishing trip. This condition applies only to vessels over 15 metres' length overall. This provision shall not apply for catches subject to the landing obligation as set out in Article 15(1) of Regulation (EU) No 1380/2013 and UK retained Regulation (EU) No 1380/2013.

[3] Shall not apply to blonde ray in United Kingdom waters of 2a and small-eyed ray in United Kingdom and European Union waters of 2.a and 4. When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[4] Special condition: of which up to 10% may be fished in United Kingdom and European Union waters of 7d (SRX/*07D2.), without prejudice to the prohibitions set out in Articles 14 and 51 of the EU TAC and Quota Regulation 2022 and relevant prohibitions in UK law for the areas specified therein. This special condition shall not apply to small-eyed ray and undulate ray.

[5] Catches of cuckoo ray, thornback ray, blonde ray, spotted ray, sandy ray (*Leucoraja circularis*) and shagreen ray (*Leucoraja fullonica*) shall be reported separately.

[6] Shall not apply to small-eyed ray, except in 7.f and 7.g. When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species. Within the limits of the above-mentioned quotas, no more than the quantities of small-eyed ray in 7.f and 7.g (RJE/7FG.) provided below may be taken.

[7] Shall not apply to undulate ray. Catches of this species in 7.e shall be counted against the quantities provided for in that separate TAC (RJU/7DE). When accidentally caught in 6.a, 6.b, 7.a-c and 7.f-k, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[8] Special condition: of which up to 5 % may be fished in European Union waters of 7.d (SRX/*07D.), without prejudice to the prohibitions set out in Articles 14 and 51 of the EU TAC and Quota Regulation 2022 and relevant prohibitions in UK law for the areas specified therein.

[9] Special condition: of which up to 5 % may be fished in United Kingdom and European Union waters of 6.a, 6.b, 7.a-c and 7.e-k (SRX/*67AKD).

[10] Special condition: of which up to 10% may be fished in United Kingdom and European Union waters of 2.a and 4 (SRX/*2AC4C).

[11] This species may only be landed whole or gutted. This is without prejudice to the prohibitions set out in the EU TAC and Quota Regulation 2023 and relevant prohibitions in UK law for the areas specified.

[12] 5 % may be fished in European Union waters of 7d and reported under the following code: (RJE/*07D.). This special condition is without prejudice to the prohibitions set out in Articles 16 and 52 of the EU TAC and Quota regulation and relevant prohibitions in UK law for specified areas.

Landing Obligation

In 2014, the reformed EU Common Fisheries Policy entered into force and introduced a phased discard ban or landing obligation for all fisheries in EU waters (and retained in UK law), as set out in Article 15(1) of Regulation (EU) No 1380/2013. The Landing Obligation (LO), which requires the landing of species subject to a catch quota or size regulation, came into full effect from 1 January 2019, with the aim of reducing unwanted catch. As a result, all relevant catches must be landed and deducted from the vessel's quota. Once the vessel's quota is reached of any specific stock, all fishing must stop within that area, this is commonly referred to as a "choke event" and can be a constraint on fishing activities.

Due to the large size and morphology of skates and rays, these species are highly susceptible to capture in non-target fisheries, such as demersal trawl fisheries for mixed fish, as well as static net fisheries targeting sole (*Solea solea*) and plaice (*Pleuronectes platessa*) in the Eastern English Channel (Ford *et al.*, 2020). As a result of their aggregating nature, skates and rays can rapidly dominate a vessel's catch, resulting in skates and rays being considered a "choke species" due to their typically low quota and unfavourable (low) commercial value. This issue is exacerbated where skate populations are locally abundant. Since 2019, skates and rays have been temporarily exempt from the LO under the high discard survival exemption (Commission Delegated Regulation (EU)2019/2239). Studies have shown various species exhibit high survival rate, although this is dependent on the gear type and handling methods (Catchpole *et al.*, 2007; Ellis *et al.*, 2008; Enever *et al.*, 2009, 2010; Catchpole *et al.*, 2017; Ellis *et al.*, 2018; Van Bogaert *et al.*, 2020). For example, based on captive observations of species caught in beam trawls in ICES area 7.d, 4.c, the discard survival is estimated at 54% for thornback ray; 67% for blonde ray; 27% for spotted ray; 58% for undulate ray (Van Bogaet *et al.*, 2020). In other areas, cuckoo ray discard survival is estimated at 34-35% for the ICES area 7.e beam trawl fishery, based on modelled results (Catchpole *et al.*, 2017). For other gears, similar results were calculated for thornback ray survival in the Eastern English Channel (ICES area 7.d) trammel net fishery, estimated at 95% by Catchpole *et al.* (2017) in a tagging survey; 94% by Ribeiro Santos *et al.* (2021, as cited in Catchpole *et al.,* 2021) and 99% by Van Bogaet *et al.* (2020) based on captive observations.

The differences in species survival are likely influenced by fish size, with larger individuals typically assessed in better health condition after capture than smaller rays, such as cuckoo ray, spotted ray and small-eyed ray (Alves *et al.*, 2019, cited from Catchpole *et al.,* 2021). In addition, the fishing gear type can have a significant impact on the condition of rays before discarding, with otter trawls more likely to damage rays than static and longline gears. However, on the whole, the biological features of skate and ray species, such as effective respiratory system; rough, protective skin made of denticles which prevent skin trauma; and absence of a swim bladder (reducing the risk of barotrauma when the gear is hauled from different depths), increase survival potential and supports the exemption of skates and rays from the Landing Obligation (Ellis *et al.*, 2018; Whitley, 2019). However, further research to understand survival rates is needed to understand if the exemption under the LO is appropriate to cover all commercial skate and ray species, as there is a

wide range of estimate discard survival of 27 – 99% across different species and fisheries (Van Bogaet *et al.*, 2020). Species specific survivorship has been identified as a key evidence gap by Cefas and more data on discards should be made available to better assess the overall discarding rate and levels of fishing mortality on different skate and ray species.

Catchpole *et al.* (2017) recommended future studies to use electronic tagging technologies over captive observation methods to quantify post-release survival for target and non-target ray species. In addition, survival of skates could be further improved by developing appropriate handling guides which minimise the stress imposed on skates and encourages quick release back to the sea when discarding. In September 2015, the MMO published a Code of Conduct on best practice advice for handling and discarding undulate ray, a prohibited species in most UK waters (MMO, 2015).

Minimum Conservation Reference Sizes (MCRS)

For those skate and ray species allowed to be landed, there are no official minimum conservation reference size (MCRS) in place under EU or UK law. However, there are specific fishing restrictions for undulate ray which apply specifically to all English fishing vessels. Undulate rays must be landed whole or gutted and must not measure less than 78 cm or more than 97 cm from the tip of the snout to the tip of the tail (MMO, 2018). These restrictive measures stipulate a minimum and maximum landing size, protecting both the juveniles and larger mature adults which have greater reproductive potential, with the intention of helping to maintain the stock.

Regional measures exist within three of the ten English Inshore Fisheries and Conservation Authorities (IFCAs) which mandate a disc width (wing tip to wing tip) MCRS from 40 cm (Kent and Essex IFCA) up to 45 cm (North Western IFCA) for all skates and rays. Nonetheless, although this measure would provide safeguarding for local populations within the IFCA district, its influence is limited to the IFCA boundaries and, consequently, offers no broader-scale protection. In addition, minimum size restrictions may be limited in their efficacy as some skate and ray species are not mature at this size. This is supported by Philips *et al.* (2020) demonstrating that when disc width is converted to total length, 45 cm is largely below the length at maturity of most coastal skate and ray species. For example, on average, Philips *et al*. (2020) calculated that a disc width of 40 – 45 cm equated to estimated total lengths of 61.0 – 68.7 cm, although it was reported there were species-specific differences in the total length-disc width relationship. Available biological information for targeted species reports 50% of males and females mature (L_{50})[2] at a total

[2] L_{50} represents the length at which 50% of the females or males of a particular species have reached reproductive size, as such a fish caught below its L_{50} size would most likely not have had a chance to reproduce.

length of 65.4 cm and 83.9 cm, respectively, for thornback ray; 78.2 cm and 85.6 cm respectively, for blonde ray; and 69 cm and 77.1 cm, respectively, for small-eyed ray (McCully *et al.*, 2012). Spotted ray, cuckoo ray and starry ray were the only species examined here to attain L_{50} by 41 cm disc width (Philips *et al.*, 2020). However, cuckoo ray and starry ray are typically found offshore between 50 – 200 m in depth, and therefore this inshore measure would unlikely benefit these populations. Existing MCRS may therefore not offer adequate protection of juvenile populations, particularly of larger bodied skates. This highlights the need for species-specific data collection and management considerations of the interspecific differences in the morphometrics and life history traits of skate and ray species caught in UK waters (Thys *et al.*, 2023).

Gear restrictions

In mobile fisheries, fishing vessels of 10 m length overall or more deploying towed gear to target skates and rays must have a mesh size of at least 80 mm cod-end, 90 mm square mesh panel and 140 mm headline panel (EU Regulation 2019/1241). In static fisheries, catches of skates and rays must be taken within a minimum mesh size of 220 mm (8.5 inch mesh) if over 30% of the catch is comprised of skates and rays (Council Regulation (EC) 850/98).

These gear restrictions are technical measures designed to minimise the capture of juvenile populations. Whitley (2019) reported local vessels fishing in ICES area 7.e typically deployed gillnets with larger mesh sizes between 10.5 and 12.5 inch (267-317mm) to selectively target adult skates and rays. Observer data showed 96% all skate caught in nets with 10.5 inch mesh size were above the locally enforced minimum conservation reference sizes (MCRS), set at 40 cm by the Southern IFCA. This reduced the number of skate discards, as well as the accidental bycatch of other demersal species. Wider research into the impact of introducing an increased mesh size for skate and ray fisheries management is recommended to promote increased gear selectivity and reduce discards.

Spatial and or temporal management

Across the UK, there is a lack of legal legislation which enforces any spatial or temporal management measures to protect skates and rays. This is largely due to the lack of information on ecologically important habitats for these species, such as spawning and nursery grounds, which limits the development of potential spatio-temporal management measures. Nevertheless, since 2005, local fishers from the North Devon Fishermen's Association (NDFA) have partnered with the Welsh and Belgian fishing fleet to voluntarily close a known skate nursery area in the Bristol Channel (from 1st December to the 31st May) to allow spawning to take place. Locally known as the "Ray Box", the area covers over 300 square kilometres north of Lundy Island and avoids the use of mobile fishing gear (mainly trawling) to protect juvenile skate populations, such as blonde ray and thornback ray, as well as other breeding stock.

However, for some endangered species, such as undulate ray, species-specific management measures do exist to protect species from commercial fishing in English waters. Statutory guidance for licence holders is provided on the MMO website which stipulates various fishing restrictions for undulate ray. This includes the prohibition to retain or land undulate ray in any ICES area, with the exception of ICES 7.d and 7.e. Within these areas, undulate ray can be caught between the hours of 00:01 on 1st January and 23:59 on 30th April; and 00:01 on 1st September and 23:59 on 31st December, leaving a four-month closed season to protect spawning and juvenile populations. This temporal restriction applies to all categories in licence schedules and is part of a wider set of management measures designed to protect and conserve undulate ray populations. In addition, spatial management regulations exist for small-eyed rays in the western Channel (ICES area 7.e) where a non-retention policy prohibits the landings of this species.

In contrast to the limited spatial management in England, there are Marine Protected Areas (MPAs) in Scotland designated to protect resident populations of the critically endangered flapper skate. This includes the Loch Sunart to the Sound of Jura Nature Conservation MPA and Red Rocks and Longay urgent MPA which was temporarily established in March 2021 following the discovery of the largest flapper skate nursery in Scotland (Dodd *et al.,* 2022; Garbett *et al.,* 2023). Following a consultation, this area was permanently designated under the Red Rocks and Longay Marine Conservation Order 2022[3] and came into force from the 9th February 2023, prohibiting all fishing activity within the MPA, except hand diving for king and queen scallops. This protected area is now recognised as a site of national importance for the conservation of flapper skates.

The results from recent studies provide sufficient evidence that spatio-temporal measures could improve the management of skate and ray species (Hunter *et al.*, 2006; Sousa *et al*., 2019; Thorburn *et al.*, 2021). For example, many studies have reported several species, such as thornback ray, small-eyed ray, blonde ray, spotted ray, flapper skate, white skate to exhibit a high degree of site fidelity in coastal areas, particularly during important life history stages such as the mating season (Chevolot *et al.*, 2006; Wearmouth and Sims, 2009; Ellis *et al.*, 2011; Neat *et al.*, 2015; Sousa *et al.*, 2019; Simpson *et al.*, 2020; Bird *et al*., 2020; Papadopoulo *et al.,* 2023). This is supported by mark-recapture tagging studies demonstrating that skates express philopatric behaviour, with individuals shown to return to the same site during spring and summer every year, likely associated with breeding cycles (Hunter *et al.*, 2005; Papadopoulo *et al.*, 2023). The increased presence and abundance of skate aggregating at these preferred sites increases their risk to fishing mortality, potentially leading to localised depletion of mature spawning stock if overfishing occurs (Chevolot *et al.*, 2006). In addition, juvenile populations for many skate and ray species are predominately non-migratory, inhabiting inshore nursery grounds in shallow coastal, estuarine and tidal flat areas during their early life history before moving offshore

[3] The Red Rocks and Longay Marine Conservation Order 2022

when older (Martin *et al.*, 2012). This ontogenetic shift in habitat utilisation is common, however, after maturation, species exhibit different migratory behaviour, with some species, such as the cuckoo ray, moving to greater depths beyond 200 m, while other species tend to remain in coastal waters, such as thornback ray and small-eyed ray.

Based on these behaviour traits, the implementation of temporal closed areas to coincide with seasonal migrations to known spawning and nursery grounds would act as an effective conservation measure to protect vulnerable populations at certain times of year (Hunter *et al.*, 2006). Tagging programmes and DNA analyses should be considered for future species-specific research to identify sites where large numbers of juveniles and spawning populations are likely to aggregate to inform spatio-temporal conservation measures and ensure effective management. This would be preferable to the implementation of permanent closures, such as marine protected areas, which would be ineffective at protecting a group of species which exhibit clear differences in habitat preference, depth range and home range during their migrations offshore (Martin et., 2012; Simpson *et al.*, 2020) and would likely result in greater trade-offs for fisheries, due to the resultant displacement and reduced skate catches for the fisheries (Hunter *et al.*, 2006).

Global fisheries systems relevant to the UK

With over 600 species worldwide, skates and rays inhabit much of the world's seas and oceans from the tropics to polar regions. This extensive global coverage is reflected in their exploitation throughout global fisheries. This task reviews the management systems and strategies for skates and rays applied elsewhere across the globe that may be relevant to the UK.

UK Southwest Atlantic Territories (The Falkland Islands and South Georgia)

Skates and rays are caught in the fisheries of both the Falkland Islands and South Georgia to varying degrees. Both island groups are found in the Southwest Atlantic Ocean and catch species of skate as either bycatch or, in the case of the Falklands, in a targeted fishery. South Georgia's fishery targets Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*Dissostichus mawsoni*) using bottom set longlines, and mackerel icefish (*Champsocephalus gunnari)* using pelagic trawls. These fisheries are subject to the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), however their management standards exceed those set by CCAMLR. While bycatch of skates and rays does occur from bottom set longlines, particularly of Eaton's skate (*Bathyraja eatonii*) and Antarctic starry skate (*Amblyraja georgiana*), these catches are typically low with a bycatch limit of 110 tonnes for skates and rays in the Patagonian toothfish fishery in 2019, and a limit of 3 tonnes for the Antarctic toothfish fishery in 2018 (SGSSI Government, 2017, 2019). Similarly, the mackerel icefish pelagic trawl fishery has low associated skate and ray bycatch, with bottom trawling banned throughout the South Georgia and the South Sandwich Islands (SGSSI) Maritime zone.

Across the SGSSI maritime zone there are ten distinct areas closed to all benthic fishing, with the West Gully Benthic Closed Area (BCA) being one of them. This was established to protect skate and has since been shown to have a high overall abundance of skate and the presence of juveniles (Cefas, 2016). It should be noted that, while the SGSSI fisheries demonstrate how certain measures may protect skate and ray populations, the fisheries around the SGSSI are relatively simple to manage, with a low vessel count and fishing effort as well as healthy funding for scientific research and effective monitoring, control, and surveillance (MCS) including 100% observer coverage. Furthermore, the fishing method employed in the region that generates the most skate and ray bycatch (bottom set longlining) is rarely utilised in the UK.

As was outlined above, CCAMLR, has its own conservation measures for fisheries operating in the CCAMLR Regulatory Area. These set skate and ray bycatch limits of varying sizes depending on the subarea or division being addressed and range from 3.2 to 169 tonnes for skates and rays in non-target fisheries. For new and exploratory fisheries this limit is set at 5% of the catch limit of toothfish (*Dissostichus* spp.). CCAMLR has implemented a move-on rule for bycatch in finfish fisheries, including the fishery for *Dissostichus* in subarea 48.4 (waters surrounding the South Sandwich Islands). This is

triggered when the bycatch of skates and rays exceeds 5% of the *Dissostichus* species catch in any one haul, and the vessel must move to another location at least 5 nautical miles (nm) from the previous location. The vessel may not fish within that 5 nm radius for a period of at least five days. CCAMLR also has a tagging program in place for skates in exploratory fisheries with a set of dedicated guidelines for the tagging of skate. All recaptured tagged skate that are caught are not re-released and biological measurements are taken by observers.

The Falkland Islands fisheries catch skates and rays in both target and non-target fisheries. The current licensing system has eight distinct licence types. Of those eight, one authorises the catching of all species of the *Rajidae* skate family ('F' licence), with three other licences authorising the catching of a combination of finfish and squid with bycatch of skates ('A', 'G', and 'W' licences). All four of these licence types permit fishing within the Falkland Conservation Zones (FCZ). Most commercially targeted skate catches are of the broadnose skate (*Bathyraja brachyurops*), white-dotted skate (*B. albomaculata*), graytail skate (*B. griseocauda*), and yellownose skate (*Dipturus chilensis*), while joined-fins skate (*Bathyraja cousseauae*), multispine skate (*B. multispinis*), and roughskin skate (*Dipturus trachydermis*) represent commercially valuable bycatch. Typically, small, and juvenile skate that survive hauls are discarded.

There are several conservation measures in place for skates and rays. Firstly, no vessel may target skate under an F license in the FCZ south of 51°S. This exclusion zone was established in 1996 in response to decreasing catch trends (Wakeford *et al.,* 2005). For vessels targeting skates and rays a particular mesh and net configuration is required with a minimum mesh size of 400 mm (diamond shape), no use of top chafers, and no lifting straps that are smaller than the circumference of the cod-end with the meshes stretched (FIFD, 2005). The 400 mm diamond mesh size was recently introduced in 2021 (Arkhipkin *et al.*, 2021) to reduce the bycatch of small and juvenile rays. Currently, the catches of the skate fishery are managed via a total allowable effort (TAE) where licensed vessels are given a certain number of fishing days per year. In 2022, 158 "F" (fishing) licence vessel days were available for the skate fishery however there have been recommendations from fisheries managers that a TAC be set at 500 tonnes.

Despite the Falklands Islands skate assemblage containing up to 15 species, catch reporting of skate is completed under a single code for all skate. The regulation of bycatch of both the skate fishery and the finfish fishery are standard across the FCZ. There is a move-on rule in place for all vessels licensed to catch finfish or skate which is triggered when a vessel's catches of non-permitted species exceed 10% of all permitted species catches. Where this occurs, the surrounding area defined by a grid defined on the FCZ in which the vessel was fishing is closed to that vessel for 10 fishing days.

Dwindling catches and the tightening of conservation measures have meant the Falkland Islands skate fishery has shrunk significantly. While licences are still held and stakeholder interest remains, the management over the years has been unsustainable, with skate biomass thought to have decreased by 61% overall since 2013 (Winter and Arkhipkin, 2023). This is also likely due to a lack of bycatch measures specific to skate bycatch in the finfish fishery.

Europe

The European Union manages skates and rays under several different TACs. Most of these are regional and encompass a number of different species with ICES providing catch advice for each of these. Five of these regional TACs exist: North Sea and Norwegian (Division 2.a and Subarea 4, SRX/2AC4-C), The Kattegat/Skagerrak (Division 3.a, (SRX/03A-C.), the Eastern English Channel (Division 7.d, SRX/07D), the Celtic Seas (subareas 6 and 7, SRX/67AKXD) and the Biscay and Iberia ecoregion (subareas 8 and 9, SRX/89-C). There are also three stocks that are treated individually with their own TAC, these are: the common skate complex in the Celtic Sea, undulate ray in the Celtic and North seas, and the starry ray, often referred to as the thorny skate, in the North Sea (STECF, 2022). Landings of various skate species are typically reported by ICES and then allocated to their respective ecoregion. Where stocks straddle more than one ecoregion, the advised TAC is split to partition across both regions. TACs are set each year using stock-specific advice which is then packaged to provide a regional TAC for an ecoregion.

When advising stock TACs, ICES classifies stocks into six categories based on the available information and knowledge about that stock. Category one stocks have full stock assessments and forecasts based on biological models, while category six stocks have very little landings or bycatch data available[4]. The ICES category into which a stock is placed determines how management measures will be applied by ICES when advising on a TAC. An issue with the current quota system for skates and rays was identified by STECF, in that regional TACs contained stocks with varying ICES categories. STECF found trends in how different ICES category stocks were exploited, with category 5 and 6 stocks of skates and rays being overexploited, and category 3 stocks being underexploited. One of STECFs recommendations to the EU was to further breakdown regional TACs into common ICES categories. The same STECF report recommended the phasing in of single-stock TACs from 2025 (STECF, 2022). However, as is outlined in the previous section, in 2022 the ICES advice for skate and ray landings for 2023 and 2024 shifted to provide species-specific landings advice for skates and rays based on the MSY approach. While this has not seen a change to species-specific TACs for skates and rays yet, it is now far more feasible with these changes made to ICES advice.

There are relatively few EU technical measures that apply to skates and rays. These are outlined in the current fisheries regulations (2019/1241) set out by the European Parliament. The only mesh size regulation for a directed skate and ray fishery is in place for North Sea skate and ray fisheries where vessels must use nets with a minimum mesh size of 80 mm. A review of other demersal fisheries which may present a bycatch risk to skates and rays showed mesh size regulations of between 35 mm (enforced in the wedge sole fishery in Southwestern EU waters) and 100 mm (enforced in the North Sea plaice

[4] ICES Technical Guidelines

and sole trawl and seine fisheries). Typically, demersal fisheries' minimum mesh size was 80 – 90 mm (EU, 2019). Often, these fisheries will be required to use square mesh panelling of up to 180 mm in the anterior part of the trawl net, or to use square mesh panelling at the cod-end of up to 120 mm. Sorting grids may also be used, for example in the *Nephrops norvegicus* fishery (EU, 2019).

Two species of *Rajidae* are prohibited in EU fisheries: the Norwegian skate (*Dipturus nidarosiensis*) in ICES subareas 6 and 7 (Western British Isles and the English Channel) and white skate (*Rostroraja alba*) in ICES subareas 6 to 10 (all western waters of the British Isles and Atlantic Southern Europe, including the Azores and mid-Atlantic). There are numerous closed areas throughout European waters, however none of these are in place specifically to alleviate fishing pressure on skate. Although, one seasonal closure of the Norway lobster during May off the west coast of Ireland does alleviate bycatch pressure on skates and rays (EU, 2019).

Eastern North America

Commercial target fisheries of skates and rays along the east coast of the USA and Canada typically target winter skate (Leucoraja ocellata) and little skate (Leucoraja erinacea), while other species are largely taken as bycatch. Fisheries in this area are managed through the Northwest Atlantic Fisheries Organization (NAFO) and nationally in the USA by the New England Fisheries Management Council (NEFMC), and in Canada by Fisheries and Oceans Canada (DFO).

In the Canadian EEZ, there is no target fishery for skates or rays. However, the ground fish fishery operating in the area does catch several skate species as bycatch. These species include little skate, barndoor skate, smooth skate, winter skate, and thorny skate. Bycatch limits are set for all non-target species at 10% where no species-specific limits exist. This is the case for skates and rays, meaning skate landings may not exceed 10% of all landings and may not exceed landings over previous years. When this occurs, the fishery will be temporarily closed. There is currently a possession prohibition in place for thorny skate in these waters. Skate populations are tracked on a three-year average from survey biomass levels. Where populations fall below a limit reference point in a given fishing area, the live release of that species is enforced in that area. No net mesh regulations are in place for the Canadian ground fish fishery, however the use of separator panels in otter trawl nets is enforced and a reduction in yellowtail flounder fishing effort has reduced skate capture (DFO, 2023). Currently, the biomass indices for a number of species are below the fishery limit reference point (thorny skate, smooth skate, and winter skate). While there does seem to be some sound management in this fishery, more specific TACs would improve the species-specific management within the bycatch of the fishery.

The NEFMC manages all species of skate as a multispecies complex with its own fishery management plan. This management plan sets an annual catch limit of 37,236 metric tons and total allowable landings (TAL) of 21,142 metric tons for both skate wing and bait fisheries (NEFMC, 2021). The fishery season is split (May to August and September to

April) with TALs for each period. In-season monitoring of landings informs any closure of either the skate bait or wing fishery. While there are no quotas for individual species, there are possession limits set for certain species such as barndoor skate (Dipturus laevis) and a possession prohibition in place for thorny skate (Amblyraja radiata). There are no NEFMC technical measures in place that are specific to the skate fishery, with all vessels being required to comply with regulations for the Northeast multispecies fishery. However, NAFO enforces a 280 mm mesh size in the cod-end and 220 mm in other parts of the trawl net. There are also no minimum conservation reference size limits for skates or rays from either NAFO or the NEFMC. However, there is a move-on rule implemented by NAFO that is triggered when bycatch comprises the largest percentage of the total catch in a single haul. There are several closed areas in NAFO and NEFMC waters including five seamounts, the western Gulf of Maine, Cashes ledge, Eastern Maine, and Jeffrey's bank. These are all closed to mobile bottom fishing gear and are designated as Habitat Management Areas (HMAs) (NAFO, 2019). Work by Kneebone et al. (2020) assessed thorny skate habitat use and spatial dynamics. This found them to be largely sedentary, meaning the Gulf of Maine groundfish closure is likely an effective conservation measure (Kneebone et al., 2020).

The NEFMC sets stock status on the basis of a three-year moving average of survey indices, with spring surveys researching little skate and autumn surveys researching all other skate species in the region. NEFMCs skate annual monitoring report states that one stock in the council management area is overfished – the thorny skate (Amlyraja radiata), named the starry ray in UK waters. This stock is 19 years into the rebuilding period, with survey biomasses showing no signs of significant improvement despite reported NAFO landings of 0.004 metric tons (NEFMC, 2022; NAFO, 2021). All other stocks of skates and rays managed by the NEFMC are currently not deemed to be overfished. With the exception of the thorny skate stock, most stocks in the NAFO region have survey biomass indices that are stable (NAFO, 2021).

Western North America

Fisheries along the west coast of the North America are managed by the Pacific Fisheries Management Council (PFMC) where they fall in USA waters south of Canada, and Fisheries and Oceans Canada (DFO) where they fall in Canadian waters. Alaska and the Bering Sea fisheries are managed by the North Pacific Fisheries Management Council (NPFMC). Skate fishing occurs off the coast of California, Oregon, Washington, British Columbia, Alaska, and the Aleutian Islands. Several species of skate are caught throughout the region, with longnose (*Beringraja* rhina) and big skate (*Beringraja binoculata*) representing the majority of catches. Both species have their own quota limits in the Canadian fishery (74,590 lbs (33,833 kg) for longnose skate and 23,267 lbs (10,554 kg) for big skate). DFO set out minimum mesh sizes for various fishing areas, ranging from 108 mm and 152 mm for the groundfish fishery, but nothing specific to skates and rays.

In the US waters south of Canada, the PFMC has implemented TACs for both big skate and longnose skate. In 2011, the PFMC transitioned to an Individual Fishing Quota (IFQ)

program to manage these species. This change meant deducting both retained and discarded catch off an individual quota for a species. This potentially reduces fishing effort as the quota limit is approached and reduces the bycatch of some species of non-managed elasmobranchs in the fishery (Jannot *et al.*, 2021).

There are no specific groundfish restrictions on mesh size that are specific to skate, with generic mesh sizes set for all trawl nets operating in the PFMC fishing areas.

In USA waters off Alaska, a directed skate fishery developed in 2003 in the Gulf of Alaska (GOA) with fishing vessels retaining skate caught in trawls and by rod and line. Amid conservation and management concerns, skates were moved to the species management category in 2004 (NPFMC, 2020). Today, directed skate fishing for skates is prohibited. However, incidental catches are high enough for skate to be considered part of the fishery. Each regulatory area of the NPFMC has its own dedicated TAC for longnose, big skate, and “other skates”. In 2016, the Alaska Regional Office reduced the maximum retainable amount for all skates in the GOA from 20% to 5% (Ormseth, 2019a). In-season management of fisheries occurs through the constant tracking of catches towards TACs, indicating whether the season’s overfishing limit may be reached before the season ends. Fisheries may be closed in-season where prohibited species catch limits are reached.

There are no predefined limits on the number of licences granted for the ground fish fishery off Alaska, however the NPFMC has the right to limit access where it sees fit. Since 2017, stock biomass estimates for big skate have increased in the GOA while longnose skate have decreased. The estimated biomass of all other skates has also decreased continually since 2013. In response to this, the overfishing limit and the acceptable biological catch have both been reduced (Ormseth, 2019a). This fishery appears to be actively managed, responding to biological estimates with stricter measures where required.

The skate fishery in the Bering Sea and Aleutian Islands is managed with similar measures, however this management is split between the Alaska skate (*Bathyraja parmifera*) and all other skates. Both stocks have seen slight declines in survey biomass estimates in the east Bering Sea, while in the northern Bering Sea Alaska skate biomass estimates increased in 2019. Exploitation rates of Alaska skate have risen slightly since 2015 (Ormseth, 2019b), however this fishery appears to be well managed and monitored.

Australia

There are no Australian fisheries that target skate species. Skates and rays may be caught as bycatch in gillnet, trawl, or longline fisheries. Limited evidence was found for management strategies in place for skates and rays. However, the Australian Fisheries Management Authority (AFMA) has a best practice handling guide for bycatch species. Within this guide, there are specific instructions regarding the handling of rays. Current measures in place for species of stingray such as cowtail stingray (*Pastinachus sephen*) and reticulate whipray (*Himantura uarnak*) include possession prohibitions and the use of turtle excluder devices and fisheye bycatch excluder devices on trawlers, however these

gear restriction measures are not specific to elasmobranchs (Patterson and Tudman, 2009). While no specific fishery management measures are in place for skate, a 183m depth closure on longlining and gillnetting, primarily aimed at safeguarding schooling sharks, may inadvertently offer some protection to skate species (AFMA, 2023).

Due to a lack of unique management measures specific to skates and rays, Australia was not considered a relevant case study in this report, and so is not included in the following analysis section.

New Zealand

In New Zealand, the primary skate species caught in commercial fisheries are rough skate (*Zearaja nasuta*) and smooth skate (*Dipturus innominatus*). Both species are often referred to collectively as barndoor skate and are typically caught as bycatch by both the trawl and longlining fisheries around New Zealand. Historically there have been problems managing both species due to identification issues. Since 2003, initiatives to improve the identification of both species may have led to the collection of more accurate data on their abundances. TACs for both species of skate were introduced under the quota management system (QMS) in the 2003 fishing season. Since then, reported catches have rarely exceeded TACs. Relatively little is known about the stock structure of both species, with no reference biomasses available for numerous fishing areas around New Zealand's waters (Fisheries New Zealand, 2022a. Both species of skate may be discarded if the skate is deemed likely to survive on its return, and if the return takes place as soon as is practicable (Fisheries New Zealand, 2022b).

The literature review did not identify any specific gear restrictions used to limit the incidental catch of either rough skate or smooth skate. Moreover, the review found no evidence of management measures specific to skate and ray fisheries in New Zealand. Consequently, New Zealand was not included in the analysis phase of the report.

South Africa

Approximately half of South Africa's commercial fisheries harvest elasmobranchs as either target species or as bycatch. The most targeted skate throughout these fisheries is the biscuit skate (*Raja straeleni*). Directed fisheries include the demersal shark longline fishery, line fisheries, and gillnet fisheries. Skate bycatch is seen in both the Agulhas sole fishery and the commercial trawl fishery with broad estimated catches released by the Department of Agriculture, Forestry and Fisheries (DAFF, 2016).

The literature review did not reveal any Total Allowable Catches (TAC) or direct management measures specifically designed for skates or rays. Consequently, South Africa was not included in the analysis phase of the report.

Other Nations

The literature review also investigated management measures in both Norway and Iceland for reference to skates and rays. In Norway, where 90% of its stocks are shared with other states (Norwegian Ministry of Fisheries and Coastal Affairs, 2007), most regulations are not specific to Norway, with any skate species that might bear relevance to UK fisheries being managed bi- or tri-laterally with the EU (e.g. Norwegian skate) and the UK. In Iceland, the review did not identify targeted Icelandic skate and ray fisheries, with only blue skate (*Dipturus. cf. flossada*) forming part of a wider bycatch TAC (ICES, 2021). While grey skate (*Dipturus batis*) and starry skate (*Amblyraja radiata*) are caught as a small proportion of bycatch, no TACs are applied to them (Government of Iceland, 2023).

Given these findings, the review of Iceland and Norway did not yield further insight for the management of skates and rays. Consequently, they were excluded from the analysis section.

Analysis of management approaches

UK South Atlantic Territories

Measure	Class	Description	Assessment	Effective
Total allowable effort	Operational measures (effort limits)	Falkland Islands: the skate fishery has been regulated by total allowable effort (TAE) of licensed vessels, with the number of skate fishing licences or 'F' licence days limited to 144 vessel days (VUs) in 2021 and 158 in 2022. However, the number of licences purchased since 2017 have decreased as catches have fallen.	Objectively verifiable indicator (OVI): YES (Fishing vessel days versus effort limit) For this measure, the number of allocated fishing licences will be used to assess compliance with fishing effort regulations. A review into the skate fishery found that the speculative use of F license in recent years has made the VU protocol impractical and is not in keeping with other management measures such as the change in regulatory mesh size.	Yes
Mesh size changes	Technical measures (gear restrictions)	Falkland Islands: the minimum mesh size of 400 mm was enforced from 1st January 2021. The 110 mm diamond mesh cod end, standard in other Falkland Islands trawl fisheries, caught large quantities of finfish as well as undersized and non-commercial skates. The minimum cod-end	OVI: YES (Mesh size versus minimum mesh size limits) For this measure, discard and retention rates reported by observers would indicate if mesh size changes were reducing the bycatch of juvenile populations and other	Yes

Measure	Class	Description	Assessment	Effective
		mesh size was set at 350 mm measured using a standard metric tape across the long diagonal of the mesh opening (approximately 400 mm between the centres of knots of the mesh). Concurrently, minimum mesh of the net excluding cod end was set at 230 mm (Arkhipkin *et al.*, 2023).	unwanted catch. Prior to its implementation, the effects of mesh size increases were assessed by Falkland Islands Fisheries Department. Larger mesh cod-ends were found to decrease finfish by up to 98%. Additionally, trawls with a mesh size of 400mm mesh size significantly decreased bycatch of low value small skate species that experience high discard mortality (Arkhipkin et a., 2023). Recently low fishing effort under skate licences in Falkland Islands' waters mean this measure has not been assessed since its implementation in 2021.	
Mesh configuration changes	Technical measures (gear restrictions)	Falkland Islands: no cod-end net liners are permitted. A 400 mm cod end mesh must be inserted a minimum of 6 metres and a maximum of 8 metres from the codline. The mesh panel should be at least 2 metres in length and must not have straps around it, reducing the size of the mesh panelling.	OVI: YES (Mesh configurations must be adhered to) For this measure, discard and retention rates reported by observers would indicate if net configuration changes were reducing the bycatch of juvenile populations and other unwanted catch. This measure can be treated the same as a mesh size change, given it attempts to reduce bycatch and the landing of juvenile skate. Where cod end mesh insertions are not sufficiently long, or	Yes

Measure	Class	Description	Assessment	Effective
			net liners reduce the effective mesh size of the trawl net, bycatch levels and juvenile catch rates are expected to be relatively higher. Recently low fishing effort under skate licences in Falkland Islands' waters mean this measure has not been properly assessed since its implementation in 2021.	
Closed area	Operational measures (Effort Caps); Education/ outreach	Falkland Islands: the skate licenced fishery was initially permitted throughout the entire FCZ. Declining catch trends meant the zone south of 51 degrees south latitude was closed for conservation in 1996. Catches stabilized around 3500-6000 tonnes from 1994 to 2016. Since 2017, catches have fallen to around 1400 t. Alternatively in South Georgia, as well as having depth limits, the South Georgian Patagonian toothfish fishery has seven closed areas designed to minimise the capture of skates.	OVI: YES (Closed areas) For this measure, catch rates and spatio-temporal data from catch reports and observer data will be used to ensure a zero-catch rate from the specified area and or during the specified time. Overall, the outcome would be a reduction in fishing mortality for skate. Longer term assessment might include fisheries independent demersal surveys assessing population densities of previously targeted skate species against those in fished areas.	Yes
Move-on rules	Operational measures (Effort Caps);	Falkland Islands: if, during the course of a directed fishery, the bycatch in any one haul is equal to, or greater than 2 tonnes of skate and rays, then the fishing vessel shall	OVI: YES (Catch rates compared to bycatch limit)	Yes

Measure	Class	Description	Assessment	Effective
	Education/ outreach	not fish using that method fishing at any point within 5 square nautical miles of the location where the bycatch limit was exceeded for a period of at least five days.	For this measure, catch reports would indicate if the bycatch threshold was reached. Subsequently, logbook and observer reports would indicate if the vessel had left the area of high skate bycatch and if the required minimum distance was met. High observer coverage is important for this measure to ensure no illegal discarding takes place to maintain bycatch levels below the set move-on threshold. Random searches by fisheries authorities would also achieve the monitoring required where observer coverage is low. This is an effective measure as it aims to promote more sustainable fishing practices by reducing the unintentional capture of non-targeted species and helps to safeguard the overall health and diversity of marine ecosystems.	
Bycatch measures	Operational measures (Effort Caps); Monitoring, reporting	CCAMLR: for new and exploratory fisheries, bycatch of skates and rays is limited at 5% of all Patagonian toothfish catches, however certain subdivided areas do have different bycatch limits for skate and ray. In South Georgia, skate bycatch in the longline Patagonian toothfish is mostly	OVI: YES (Catch rates compared to bycatch limit) For this measure, catch landings and discard and retention rates reported by observers would be monitored to notify fishery managers when relevant bycatch	Yes

Measure	Class	Description	Assessment	Effective
	and evidence	Antarctic starry skate. CCAMLR sets catch limits arbitrarily at 5% of all toothfish catches. Skate that are still alive and considered to have a high probability of survival are cut off the lines and released.	threshold was reached. All catch and bycatch levels are monitored in-season by the CCAMLR Secretariat using a forecast model to minimise the likelihood of either limit being inadvertently exceeded. When bycatch limits are exceeded a fishery closure in the relevant fisheries management area is implemented for the remainder of the season.	
Tagging programme	Monitoring, reporting and evidence; Education/ outreach	Falkland Islands: for new and exploratory fisheries, all skates and rays must be brought on board or alongside the vessel to be checked for tags and for their condition to be assessed. Recaptured tagged skates and rays, as per Conservation Measure 41-01, Annex 41-01/C, paragraphs 2(vii) and (ix), should not be re-released. Unless otherwise specified by scientific observers, all other skates and rays caught alive and with a high probability of survival should be released alive, by vessels, by cutting snoods, and when practical, removing the hooks, and the number should be recorded and reported to the Secretariat. Exploratory fisheries tagging skate should follow specific protocols developed during 'Year-	OVI: YES (Number of tag deployments and recoveries) The level of successful tag recovery indicates the effectiveness of this measure. Where tag recovery is high, data output from the tagging program will be higher, leading to better informed management strategies.	Yes

Measure	Class	Description	Assessment	Effective
		of-the-skate'. All skate must be double-tagged and released alive. Tags must be sourced from FIG secretariat. All skates shall be brought onboard or alongside the vessel to be checked for tags and for their condition to be assessed. Recaptured tagged fish (i.e. fish caught that have a previously inserted tag) shall not be re-released, even if at liberty for only a short period. In South Georgia, a Rajid tagging program has been in place since 2006, tagging more than 7,600 skates and rays between 2006 and 2013.		
Identification guide	Education/ outreach	Falkland Islands: the fisheries department of FIG (Falkland Islands Government) has developed an identification guide for key species of Rajidae found in the Falkland Islands waters (Bizikov *et al.*, 2003). This aims to help fishers assess and correctly identify their catches to minimise the risk of misreporting and enhance the collection of species-specific landing data.	OVI: YES (Identification guide developed to aid identification) For this measure, increased identification of skate landings at species level would indicate if the identification guide has been successful. This would be assessed from both catch reports and observer reports.	Yes

Europe

Measure	Class	Description	Assessment	Effective
TAC controls	Operational measures (Catch limits)	Catches of skates and rays are currently regulated through five regional Total Allowable Catches (TACs) in commercial EU fisheries. Since 2009, skates and rays have been managed under a single multi-species TAC, although specific quotas are established for stocks of concern with localized areas of abundance, such as undulate ray (*R. undulata*) and small-eyed ray (*R. microocellata*). TACs are set annually by the European Union, based on scientific advice provided by ICES. Every TAC covers several stocks so that various methods may be applied to aggregate ICES advice for individual stocks into a multi-stock TAC.	OVI: YES (Catch levels versus TAC as target) For this measure, catch rates from landings data will be used to assess compliance with fishing effort regulations. The annual review of skate harvest limits ensures stocks are fished at sustainable levels. However, the setting of a multispecies TAC has been deemed as an unsuitable method for protecting individual species that may require reductions in fishing mortality and conversely may limit catch opportunities for stocks in good condition. In addition, the implementation of a multi-species TAC is also recognised as adversely affecting EU fisheries due to the overall mixed quota may allow some species to be caught above safe levels. Also fishing opportunities for EU vessels due to the high potential volume of discarding. Alternative approaches to the current TAC system are being explored, such as the establishment of species-specific TACs for key stocks, recognising the different vulnerabilities of species to fishing pressure to better address the conservation requirements of each species.	No

Measure	Class	Description	Assessment	Effective
Mesh size changes	Technical measures (gear restrictions)	The only directed mesh size restriction for skate and ray fisheries in the EU is for North Sea skate and ray fishing where mesh size must be a minimum of 80 mm. Other demersal fisheries which may have significant skate or ray bycatch have mesh size regulations of between 35 mm (Wedge Sole fishery in Southwestern EU waters) and 100 mm (North Sea Plaice and Sole Otter and beam trawlers and seines), with 80-90 mm minimum mesh size being most common. Often these fisheries will either enforce square mesh panelling of up to 180 mm in the anterior part of the trawl net or will enforce square mesh panelling at the cod-end of up to 120 mm, sorting grids may also be used (*Nephrops norvegicus* fishery). In gillnet fisheries, catches of skates and rays must be taken with a minimum mesh size of 220 mm (8.5 inch mesh) if over 30% of the catch is comprised of skates and rays (Council Regulation (EC) 850/98).	OVI: YES (Mesh size versus minimum sizes) For this measure, discard and retention rates reported by observers would indicate if mesh size changes were reducing the bycatch of juvenile populations and other unwanted catch. Sample biological data (e.g. length of disc width and total length) could be assessed to ensure only the mature stock was being targeted. The implementation of gear restrictions, alongside a regulatory mechanism to adjust the mesh size in response to monitoring and conservation efforts, is important to promote proactive management of fish stocks. As skate is often caught as bycatch in demersal mixed fisheries and gillnet fisheries, changing the mesh size is an effective measure to reduce unwanted bycatch.	Yes

Measure	Class	Description	Assessment	Effective
Prohibited species	Operational measures (Effort Caps)	According to EU fishing regulations, various species of skates and rays are on the prohibited list in certain ICES areas. For example, common skate and complex cannot be targeted in ICES Divisions 2a and Sub-areas 3, 4, 6, 7, 8, 9 and 10, while Norwegian skate are prohibited in ICES subareas 6 and 7 and white skate are prohibited in ICES subareas 6-10. Additional species with EU prohibitions in place include thornback ray, undulate ray, blonde ray, small-eyed ray and starry ray. These prohibitions were put in place as a conservation measure due to declining populations.	OVI: YES (Catch rates by species for prohibited species). For this measure, catch rates of prohibited species would be monitored to ensure a zero-catch rate. In addition, evidence of increasing stock abundance is a key indicator to monitor the effectiveness of implementing prohibition measures. For the common skate complex, recent scientific trawl surveys have reported increased catch rates since the prohibition was established in 2009, suggesting the measure has contributed to the recovery of the stock (ICES, 2020).	Yes
Minimum conservation reference size (MCRS)	Technical measures (gear restrictions)	Under EU legislation, where catches of undulate ray is not subject to the landing obligation set out in article 15 of Regulation (EU) 1380/2013, no undulate ray which measures less than 78 cm and more than 97 cm from the tip of the snout to the tip of the tail shall be retained on board or landed. This measure is in place to protect juvenile and mature spawning stock of endangered undulate ray.	OVI: YES (Size data versus reference sizes) For this measure, the landed size of undulate ray, where permitted, should be monitored to ensure catches are between 78 – 97 cm.	Yes

Measure	Class	Description	Assessment	Effective
Bycatch measures	Technical measures (gear restrictions)	To reduce the discarding of unwanted catch, the EU Common Fisheries Policy introduced a phased discard ban or landing obligation for all fisheries in European Union fisheries. Under Landing Obligation (LO) all catches have to be kept on board, landed and counted against quotas. Exemptions to LO exist, if a high survival rate has been demonstrated for the species concerned. Evidence of high survival rate of skate species post discard has been reported in various tagging and catch observation studies. Based on this evidence, skates have been temporarily exempted from the LO under the exemption of high discard survival (EU Delegated Regulation 2019/2239).	OVI: NO (Catch rates versus reference fleet to ensure catch is being landed). For this measure, it is difficult to monitor the impact of the LO exemption due to the unaccounted mortality rate of discard skates. Further research into discard survival is needed to support the evidence that the exemption should apply to all skates for all gear types, or on a species basis further separated by gear type.	No
Closed area	Operational measures (Effort Caps)	Directed fishing for Norway Lobster (*Nephrops norvegicus*) and associated species (including skates and rays) is prohibited from 1st May to 31st May in an area off the southwest coast of Ireland. There is also a prohibition to retain small-eyed ray from ICES area 7.e.	OVI: YES (Fishing activity in closed areas) For this measure, catch rates and spatio-temporal data from catch reports and observer data will be used to ensure a zero-catch rate from the specified area and or during the specified time period. Overall, the	Yes

Measure	Class	Description	Assessment	Effective
			outcome would be a reduction in fishing mortality for skate. Longer term assessment might include fisheries independent demersal surveys assessing population densities of previously targeted skate species against those in fished areas.	

Eastern North America

Measure	Class	Description	Assessment	Effective
Total Allowable Catch	Operational measures (Catch limits)	NEFMC: manages all skate species under the Northeast Skate Complex FMP. Under the FMP, fishing mortality for seven species (barndoor, clearnose, little, rosette, smooth, thorny, and winter skate) is managed through a single complex-wide quota. This includes an ACL, an ACT and a fishery-level TAL, with current harvest limits for 2023-2024 being 21,142 metric tons TAL, covering both skate wing (14,059 metric tons; 66.5%) and bait (7,082 metric tons; 33.5%). Annual skate harvest limits are reviewed annually, based on stock biomass. The fishery is managed seasonally (Season 1: May 1 and August 17; Season 2: August 18 and April 30) with procedures in place to reduce possession limits if catches reach 85% of the quota before the end of the season. For example, if 85% of the skate wing season 1 quota (57 percent of the annual skate wing TAL) is projected to be landed between May 1 and August 17, the skate wing possession limit will be reduced to the incidental limit of	OVI: YES (Catch versus ACL, ACT and TAL targets) For this measure, catch rates from landings data will be used to assess compliance with fishing effort regulations. The annual review of skate harvest limits ensures stocks are fished at sustainable levels. In contrast to the EU, the group TAC is much higher and does not hinder a fishing vessel's opportunity to fish. By adjusting possession limits downward when catch levels approach the 85% threshold, the NEFMC prevents exceeding the set catch limit. This adaptive management approach helps to maintain the long-term sustainability of the skate fishery.	Yes

Measure	Class	Description	Assessment	Effective
		500 lb of skate wings (1,135 lb whole weight) for all vessels for the remainder of Season 1. This measure is in place to prevent overfishing from occurring, provided that doing so would not prevent the skate wing TAL from being attained.		
		DFO: enforces live release of skate species in particular fishing areas in Canada once their biomass index reaches a predefined limit reference point (LRP). Currently, three bycatch species are below this in at least one fishing area, meaning their release is enforced through the most recent fishing season in the respective fishing area.	OVI: YES (Survey biomass average versus a set LRP) This measure is a retrospective passive style of monitoring. Employing precautionary active management through species-specific TACs (or ACL/TALs) would prevent population indices from falling below the LRP where the population size becomes a concern.	No
Prohibited species	Monitoring, reporting and evidence; Education/ outreach	NEFMC: Since 2003, possession and landing of thorny skate (*Amblyraja radiata*), known as starry ray in the UK, smooth skate (*Malacoraja senta*) and barndoor skates (*Dipturus laevis*) have been prohibited due to their low levels of relative abundance (NEFMC, 2003). All three species were regarded as overfished and are presently subject to legally required stock rebuilding programmes.	OVI: YES (Catches of prohibited species) For this measure, catch rates of prohibited species would be monitored to ensure a zero-catch rate. A study by Curtis and Sosebee (2015) investigating the species composition of the north-east US skate wing fishery demonstrated high compliance with prohibited species regulations. Curtis and Sosebee (2015) found the sharp decline in thorny skate landings concurred with the	Yes

Measure	Class	Description	Assessment	Effective
			release of a letter sent out by the NMFS in 2007 to notify fishers of the prohibition and this has likely had a significant impact. Furthermore, while barndoor skates have recently increased in localised abundances, their increased availability was not reflected in the landing's composition, indicating high compliance with the prohibition regulation (Curtis and Sosebee, 2015). This is supported by a recent report by NEFMC (2018) which stated the assumed effectiveness of the prohibition regulations is thought to be 98%, based on recent work that examined port sampling data (90 day finding for thorny skate).	
		NEFMC: a 25-year rebuilding programme for thorny skate has been in operation since 2003 due to substantial biomass declines throughout the southern part of their range in the North Atlantic, including the Gulf of Maine. Since 2003, thorny skate have been declared overfished and biomass has steadily decreased from 5.6 kg / tow in the Northeast Fisheries Science Center bottom trawl survey conducted in the 1970s. When the rebuilding plan was	OVI: YES (Catch rates of thorny skate versus previous catch rates) While the enforced prohibition on possession has led to a reduction in thorny skate landings, a white paper released by the NEFMC has indicated that thorny skate populations are not displaying signs of recovery. In 2019 and 2021, thorny skate biomass was reported at 0.15 kg/tow, which is equivalent to only 3.5% of the rebuilding target (NEFMC, 2023). This suggests that	No

Measure	Class	Description	Assessment	Effective
		initiated, it was estimated that, based on the biomass at the time (0.42 kg / tow in 2007), an average annual increase of 13.2% would be required to reach the B_{MSY} target of 4.41 kg / tow by 2028 (which has subsequently been adjusted to 4.13 kg / tow) (NEFMC, 2023). The current strategies to rebuild this stock primarily revolve around the prohibition of possession, with potential measures including gear modifications or time-area closures tailored to the specific gear types and areas where thorny skate encounters are most frequent, along with a reassessment of the thorny skate rebuilding plan.	the current management approach is ineffective, and further action is necessary to implement suitable measures aimed at minimizing thorny skate bycatch. However, thorny skate are characterised as being a cold-water and largely sedentary fish, therefore climate change has also been recognised as a constraint on rebuilding the stock (NEFMC, 2023). This is supported by a study which found thorny skate to have both a high exposure to climatic stressors as well as a high biological sensitivity to those stressors (Hare *et al.*, 2016).	
Mesh size changes	Technical measures (gear restrictions)	North American fisheries: mesh size regulations exist in many of the mixed demersal trawl and gillnet fisheries, although these measures are not specifically dedicated to the skate fishery (Ellis *et al.*, 2009). However, all vessels fishing for skates must follow Northeast (NE) multispecies, monkfish, or scallop regulations when fishing under a Day-at-Sea (DAS) for one of those fisheries. For	OVI: YES (Mesh sizes versus mesh size regulations) For this measure, discard and retention rates reported by observers would indicate if mesh size changes were reducing the bycatch of juvenile populations and other unwanted catch. Sample biological data (e.g. length of disc width and total length) could be assessed to ensure only the mature stock was being targeted. The	Yes

Measure	Class	Description	Assessment	Effective
		commercial fisheries targeting monkfish, all gillnets must have a minimum mesh size of 10 inch (254 mm) diamond mesh throughout the net. However, in waters managed by NEFMC, the southern New England sink gillnet fishery targets winter skates seasonally along with monkfish, using 12 inch (305 mm) mesh gillnets (NEFMC, 2018). This is in line with projected changes to the minimum mesh size for gillnet gear from 10 inch (254 mm) to 12 inch (305 mm) diamond mesh. This change would go into effect at the beginning of May 1, 2026. In trawl fisheries, the minimum mesh size is 10 inch square or 12 inch diamond mesh throughout the cod end for at least 45 continuous meshes forward of the terminus of the net.	implementation of gear restrictions, alongside a regulatory mechanism to adjust the mesh size in response to monitoring and conservation efforts, is important to promote proactive management of fish stocks. As skate is often associated with commercial fisheries for monkfish, the proposed changes to increase the minimum gillnet mesh size to 12 inch aligns with research observations which found skate bycatch in sink gillnet hauls primarily occur in gear with mesh sizes below 11 inch (279 mm) (Hatch and Orphanides, 2014; 2015). Therefore, increasing the mesh size to 12 inch for targeted fisheries will be effective in reducing unwanted bycatch.	
Mesh configuration changes	Technical measures (gear restrictions	DFO: enforced mandatory use of separator panels in otter trawl nets. These may be effective in the removal of unwanted bycatch from the main compartment of the trawl net (Ferro *et al.,* 2007). This is designed to ensure the better condition of bycatch to maximise the likelihood of post-release survival.	OVI: YES (Bycatch survival rates with a separator panel vs those without) For this measure, bycatch survival data would need to be compared between commercial trawls operating with the use of a separator panel and survey trawls operating a standard otter trawl net.	Yes

Measure	Class	Description	Assessment	Effective
Move-on rule	Operational measures (Effort Caps)	NAFO: Fisheries must abide by a move-on rule which is activated when bycatch becomes the dominant portion of the total catch (by weight) within a single haul. When this occurs, the vessel must immediately move a minimum of 10 nautical miles. If the next catch after moving exceeds the bycatch limits, the vessel must leave the area and stay away for at least 60 hours (NAFO, 2019). This measure serves as a mechanism to encourage vessels to alter their fishing locations or tactics in cases where bycatch becomes disproportionately high compared to the targeted catch.	OVI: YES (Catch rates target vs bycatch versus defined move-on limit) For this measure, catch reports would indicate if the bycatch threshold was reached. Subsequently, logbook and observer reports would indicate if the vessel had left the area of high skate bycatch and if the required minimum distance was met. This is an effective measure as it aims to promote more sustainable fishing practices by reducing the unintentional capture of non-targeted species and helps to safeguard the overall health and diversity of marine ecosystems.	Yes
Closed season	Operational measures (Effort Caps)	NOAA: seasonal closures are enforced, although these management areas are not specific to the conservation of skate species. Notably, spawning closures have been part of a suite of fishery management actions to rebuild the Gulf of Maine stock of Atlantic cod (*Gadus morhua*), primarily in Massachusetts Bay during the winter-spawning period.	OVI: YES (Vessel activity in closed season) For this measure, catch rates and temporal data from catch reports and observer data will be used to ensure a zero-catch rate during the closed season for the cod fishery. This is an indirect benefit for skate populations as it reduces the potential for fishery mortality.	Yes

Measure	Class	Description	Assessment	Effective
Closed area	Operational measures (Effort Caps); Monitoring, reporting and evidence	NOAA: a wide range of spatial management measures are in place to conserve fish stocks and vulnerable habitats. Closed areas with relevance to skate species include the western Gulf of Maine and Cashes Ledge groundfish closure, a year-round closure to all fishing vessels. These areas overlap with the spatial distribution of skate species, such as thorny skate, providing an indirect benefit to reduce fishing mortality and general interactions with fishing gear. In addition, there are some areas where vessels fishing for skate and monkfish are exempt, namely the Southern New England Monkfish and Skate Trawl Exemption Area and Southern New England Monkfish and Skate Gillnet Exemption Area (NOAA, 2023). Skate may only be landed under this exemption if at least one of the following conditions are met: 1) the vessel is called into the monkfish DAS program and complies with the skate wing possession limit restrictions; 2) the vessel has a Letter of Authorization on board to fish for skates as bait only; or 3) the vessel possesses	OVI: YES (Vessel activity in closed area) For this measure, catch rates and spatial data from catch reports and observer data will be used to assess compliance with this spatial measure. Overall, the outcome would be a reduction in fishing mortality for skate. Skate are known to have high residency to localised areas and inter-species variations in migratory distances. Previous work in the Cashes Ledge groundfish closure found that 90% of satellite-tagged skates remained inside the closure for at least 300 days (Kneebone *et al.* 2020). This supports the conclusion that species, such as thorny skate, are largely sedentary and suggests that well-placed area closures or gear-restricted areas might promote the conservation and recovery of species.	Yes

Measure	Class	Description	Assessment	Effective
		and/or lands skates or skate parts in an amount not to exceed 10 percent by weight of all other species on board.		
Observer programme	Monitoring, reporting and evidence	NOAA: the Fisheries Monitoring Operations Branch manages fishery observers and electronic monitoring in the Northeast and Mid-Atlantic fisheries. This includes the Northeast Fisheries Observer Program whereby observers report on the catch, gear, discards, fishing effort, and biological data over a range of commercial fisheries. This information is used to monitor quota use throughout the year and helps to evaluate fishery management measures and ensuring regulatory compliance.	OVI: YES (Level of observer coverage versus requirement) To assess the effectiveness of this implementing an observer programme, monitoring the percentage of observer coverage to make sure it meets required levels of coverage. Data collected by observers should also meet a range of data collection requirements. The implementation of an observer programme is an effective management strategy to verify area-specific catch composition and quantity, including catch discarded at sea, and to collect biological information on marine resources. Observers help ensure fishing activities comply with regulations and adhere to quotas, preventing overfishing and depletion of fish stocks.	Yes

Measure	Class	Description	Assessment	Effective
Identification guide	Education/ outreach	NOAA: there is a skate identification guide[5] available to help fishers identify each potential species of skate in the Northeast Skate Complex, in particular prohibited species. This aims to help fishers assess and correctly identify their catches to minimise the risk of misreporting and enhance the collection of species-specific landing data.	OVI: YES (Identification guide developed and operational) For this measure, increased identification of skate landings at species level would indicate if the identification guide has been successful. This would be assessed from both catch reports and observer reports. This would increase the accuracy of species reporting to provide robust data on species composition, as well as enhance catch composition at species levels for fishing fleets.	Yes

[5] Northeast Skate ID Guide

Western North America

Measure	Class	Description	Assessment	Effective
TAC controls	Operational measures (Catch limits)	NPFMC: Skate are caught and landed as part of the groundfish fisheries in the Bering Sea and Aleutian Islands (BSAI) and the Gulf of Alaska (GOA), both managed under FMPs. In federal waters, skates are managed by a tiered system depending on the availability of data and information surrounding the stock in question. Harvest specifications are reviewed annually based on information from the Groundfish Plan Teams, Scientific and Statistical Committee, Advisory Panel, the public, and any other relevant information. In the BSAI groundfish FMP, there is currently no target fishery for skates. Most of the skate is caught incidentally in the hook and line fishery for Pacific Cod, and trawl fisheries for pollock and flatfish. Since 2011, a bycatch TAC has been set for the Alaska skate (*Bathyraja parmifera*) under a Tier 3 harvest control rule compared to all other skates which use Tier 5 rule. The Tier 3 and Tier 5 recommendations are combined to	OVI: YES (Catch versus TAC limits) For this measure, catch rates from landings data will be used to assess compliance with fishing effort regulations. The annual review of skate harvest limits ensure stocks are fished at sustainable levels. In the absence of a target fishery for skate, species are regulated through a bycatch TAC, the setting of which is based on a tiered system corresponding to the availability of data. An in-season management report of the GOA groundfish fishery reported catches of big skate, longnose skate and other skates were all within their TAC limits, reaching 34%, 35% and 92%, respectively. The retention rate for skates within trawl fisheries was 46% and 8% in hook and line fisheries. (NOAA, 2022a). This indicates overfishing is not taking place and the management is effective. A similar report for the BSAI groundfish fishery reported catches of BSAI skate	Yes

Measure	Class	Description	Assessment	Effective
		generate recommendations for the complex (Ormseth, 2018). In 2022, the TAC for BSAI skates was set at 31,000 metric tons. The GOA Skate complex is comprised of at least 15 skate species, of which the main target species are big skates (*Beringraja binoculata)* and longnose skates (*Raja rhina*). Skates in the GOA are managed under a Tier 5 harvest control rule, based on estimates of biomass, natural mortality rate and adjusted using a precautionary factor. This approach is intended to be conservative to account for the uncertainty associated with the low level of information. Since 2005, skate can only be retained and landed as bycatch. Big Skate and Longnose Skate are managed under species-specific TACs due to concerns about disproportionate harvests while the remaining skates are manged under a group TAC. In 2022, the TAC was 2,867 metric tons for big skate; 2,721 metric tons for longnose skate and 984 metric tons for all other skates. In season management occurs tracking TAC and the acceptable biological catch. If the acceptable biological catch is taken and the	were within set annual limits, reaching 90% of the allocated TAC. In addition, there was a marked decline in retention rate from 41% in 2021 to 29% in 2022 in the trawl fishery, albeit similar number of discards (NOAA, 2022b). In contrast, the retention rate remained the same in the hook and line fishery, although the number of discards increased significantly from 7,299 metric tons in 2021 to 12,189 metric tons in 2022. The reason for this is unclear. Overall, the setting of TACs to control bycatch of skate species has shown to be effective, with high compliance to adhere to the set limits.	

Measure	Class	Description	Assessment	Effective
		trajectory of catch indicates the overfishing limit may be approached, additional closures are imposed. To prevent overfishing, specific fisheries identified by gear and area that incur the greatest incidental catch are closed. Closures expand to other fisheries if the rate of take is not sufficiently slowed. If a prohibited species catch limit is reached then a fishery may also be closed (NPFMC, 2020).		
Bycatch measures	Operational measures (Catch limits)	NPFMC: one of the primary bycatch management tools in US commercial fisheries is the maximum retainable amount (MRA). This refers to the amount of bycatch that can be landed within a trip in relation to the amount of target species being landed. Although MRAs do not prevent bycatch, they limit the extent to which harvesters stand to benefit from retaining bycatch, thereby reducing the incentive to fish in areas or at times when high bycatch rates are likely. Once the TAC for a bycatch species is reached, it becomes a “prohibited” species and cannot be retained for the remainder of the fishing season. The MRA is the principal management mechanism for regulating	OVI: YES (Catch versus catch limits Catch landings and discard and retention rates reported by observers would be monitored to notify fishery managers when the skate bycatch threshold was reached. Following the point in the season when skates become prohibited, catch rates would be monitored to ensure a zero-catch rate. However, a study by Farrugia (2017) found inherent flaws in the MRA approach whereby changes in the MRA directly correlate to the discard rate of skates and created an inverse relationship between MRA and the number of fishing trips necessary to reach the TAC. For example, at an MRA of	No

Measure	Class	Description	Assessment	Effective
		skate catches in the GOA, intended as a way of slowing skate harvest rates. Until recently, the MRA for GOA skates was 20% meaning that up to 200 kg of skates could be retained for each 1,000 kg of target species (e.g. Pacific cod *Gadus macrocephalus*) retained. In 2016, the NPFMC reduced the GOA skate MRA to 5% (e.g. 50 kg of skates per 1,000 kg of Pacific cod) to reduce the possibility that the skate TAC would be reached early in the year (NPFMC 2015).	20%, each metric ton of skate catch allows harvest of 5 metric ton of Pacific Cod; while at a reduced MRA of 5%, each metric ton of skate catch would allow harvest of 20 metric ton of Pacific Cod. Therefore, decreasing the MRA increases the number of fishing trips to reach the TAC, while a greater MRA would mean the TAC is exhausted quicker, and led to greater discarding. Overall, the MRA does not align with ecosystem-based fisheries management (EBFM) principals, to holistically manage fishery interactions with all elements of the ecosystem, not just the target species.	
Closed area	Operational measures (Effort Caps); Monitoring, reporting and evidence	NPFMC: several closed areas are established, such as the Gulf of Alaska Slope Habitat Conservation Area (closed to nonpelagic trawling year-round) and Marmot Bay Tanner Crab Protection Area. In addition, closed areas are also implemented in the Bering Sea and Aleutian Islands. However, skates are not a designated feature for any of these sites.	OVI: YES (Vessel activity in closed area) For this measure, catch rates and spatial data from catch reports and observer data will be used to assess compliance with this spatial measure. Overall, the outcome would be a reduction in fishing mortality for skate.	Yes

Measure	Class	Description	Assessment	Effective
Observer Programme	Monitoring, reporting and evidence	NOAA: The North Pacific Observer Program (Observer Program) is essential for conserving and managing the groundfish and halibut fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska. In 2013, the North Pacific Observer Program was restructured on how observer coverage is funded and the observer coverage requirements for processors and vessels. All sectors of the groundfish fishery, including previously uncovered sectors such as vessels less than 60 feet in length overall and the commercial halibut sector, are now included in the Observer Program. There are two categories for observer coverage: full coverage, where vessels always have an observer on board, paid for by the industry, and partial coverage. For partial coverage, NMFS decides when and where to deploy observers or electronic monitoring based on conservation needs and a scientifically sound plan.	OVI: YES (Level of observer coverage) To assess the effectiveness of implementing an observer programme, the percentage of observer coverage should be monitored to ensure it meets required levels of coverage. Data collected by observers should meet a range of data collection requirements. The implementation of an observer programme is an effective management strategy to verify area-specific catch composition and to collect biological information on marine resources. Observers help ensure fishing activities comply with regulations and adhere to quotas, preventing overfishing and depletion of fish stocks. The data collection on discard and retention rates for skates within the FMPs for Groundfish of the BSAI and GOA Management Area will inform adaptive management such as when the bycatch TAC for skates is nearly reached and triggers management actions to prohibit vessels from retaining catches for the rest of the season.	Yes

Applicability to UK fisheries

Based on the outcome of the assessment, the measures deemed to be effective in meeting their OVI and enhancing the sustainability of skate and ray populations were put forward for further analysis regarding the feasibility of integrating these measures into UK legislation. For this phase, a set of questions was developed to help guide the analysis:

1. Do the measures meet the Fishery Objectives set out in the JFS?
2. Are there examples of these measures already established in the UK for other species?
3. Will the measure be accepted by the MMO and Defra (fishery administrations) as an effective measure which can be easily enforced?
4. Will there be any challenges with compliance?

The assessment process involved a systematic evaluation of each identified measure in the context of achieving one or more of the specific fishery objectives, as outlined in Table 4. The fishery objectives served as a critical framework for determining the relevance and effectiveness of each proposed measure in addressing the goals of the JFS to achieve sustainable fisheries management. To present the assessment results in a clear and accessible manner, a summary table is provided, as denoted in Table 4. This table serves as a visual representation of which measures align with the defined fishery objectives, allowing for easy identification of those measures that contribute to specific objectives.

Furthermore, an additional column within this table was dedicated to indicating whether these identified measures have already been integrated into the existing legislative framework governing fisheries management in the UK, including the management of skate and ray stocks. This component of the assessment process is instrumental in assessing the feasibility and practicality of adopting these management measures within UK fisheries legislation. The inclusion of measures that have already been implemented under UK legislation provides insights into the readiness of the regulatory framework to accommodate these measures, potentially streamlining their adoption and integration into established practices.

Table 4 Summary table of effective management measures and if they meet the JFS Fishery Objectives and are already enforced under UK legislation for other species, as well as skate and ray fisheries.

Measures	Sustainability	Precautionary	Scientific Evidence	Ecosystem	Equal Access	Is this measure already enforced in UK legislation?
TAC controls / Total allowable effort	Yes		Yes	Yes	Yes	Yes*
Prohibited species	Yes		Yes	Yes	Yes	Yes*
Mesh size changes	Yes		Yes	Yes	Yes	Yes
Mesh configuration changes	Yes		Yes	Yes	Yes	Yes
Minimum conservation reference sizes (MCRS)	Yes		Yes	Yes	Yes	Yes
Move-On Rule	Yes	Yes		Yes	Yes	Yes
Bycatch measures	Yes	Yes		Yes	Yes	Yes*
Closed season	Yes		Yes	Yes	Yes	Yes*
Closed area	Yes		Yes	Yes	Yes	Yes*
Observer Programme	Yes		Yes		Yes	Yes
Tagging programme	Yes		Yes		Yes	Yes
Identification guide			Yes		Yes	Yes*

(*) Indicates fishery management measures which have been implemented for an individual or a group of skate and ray species.

From Table 4, it is clear the majority of measures meet the requirements of the five Fishery Objectives and all these measures are already implemented within the UK regulatory framework for fisheries management.

The last step involves refining the identification of the most efficient measures to be proposed for inclusion in the Fishery Management Plans (FMPs) that pertain to skate and rays: Celtic Sea and Western Channel Demersal FMP (ICES subarea and division 7.e, 7.f, 7.g, 7.h: Welsh and English waters only) and Southern North Sea and Channel Skates and Rays FMP (ICES subarea and division 4.b, 4.c, 7.d, 7.e – English waters only).

TAC controls / Total allowable effort

Quota allocations are in place for most commercially targeted species, including skates and rays in defined ICES areas. However, these regional TAC cover a wide range of species with various life histories which are largely ignored when the advised ICES landings data for specific species are pooled together into a single TAC. Greater consideration should be given to the development of a species-specific approach to better safeguard the more vulnerable species included within the group complex, either by implementing individual TACs or removing species with greater vulnerabilities to exploitation and creating a low-level TAC or bycatch TAC. This would also help to alleviate restrictive measures for skate species that have shown to be locally abundant.

The implementation of a bycatch TAC has shown to be effective in Gulf of Alaska and Bering Sea and Aleutian Islands groundfish FMP which set a bycatch allowance for skates in non-target fisheries. In-season management occurs to ensure catches stay within the TAC limits. In the UK, the monitoring of catch landings, and in some cases observer data, would ensure bycatch limits of restricted skate species are not exceeded. This would be similar to the current species specific TACs set for undulate ray and small-eyed ray.

To support transition to single species TACs for all seven skate and ray species included under the two proposed FMPs, species-specific stock advice would be beneficial to obtain information on the distribution, population dynamics, and stock structure of each species (thornback ray, small-eyed ray, blonde ray, spotted ray, cuckoo ray, undulate ray and starry ray). As a step towards this, since October 2022, ICES has provided species-specific advice, based on the MSY approach, for each species listed under the Southern North Sea and Channel Skates and Rays FMP. This includes blonde ray, spotted ray, cuckoo ray, starry ray[6] and thornback ray for ICES Subarea 4 and in divisions 3.a (excluding blonde ray) and 7.d (except cuckoo ray). In addition, species-specific advice is provided in divisions 7.d - e for undulate ray (where undulate ray have an allocated bycatch TAC) and small-eyed ray (where 5% of its allocated TAC can be fished in division

[6] For starry ray in subareas 2 and 4 and Division 3.a, a zero catch is advised.

7.d, but not in 7.e), as well as division 7.e for thornback ray as it is unclear whether it is a discrete stock or associated with neighbouring stocks in Subarea 4 and Division 7.d or with the stock in divisions 7.a and 7.f–g (ICES, 2023). Species-specific advice is also provided for small-eyed ray in divisions 7.f and 7.g where regulations for fishing opportunities have a TAC for small-eyed ray in divisions 7.f and 7.g within the overall TAC for skates and rays in divisions 6.a, 6.b, 7.a–c, and 7.e–k (ICES, 2023).

Therefore, the species-specific advice to inform single species TAC is already available. The regulatory framework to implement single species TAC is already in place and has been used for some individual skate species already. Therefore, the introduction of single TACs for skate species should be a high priority conservation measure under the Southern North Sea and Channel Skates and Rays FMP.

Prohibited species

The prohibition of critically endangered or endangered species is an effective measure which is currently implemented in the UK. No landings of these listed species are allowed in both the UK and EU waters and therefore it is easily monitored, through physical checks on landings, to ensure a zero-catch rate. However, while these species cannot be targeted, they can still be caught by bycatch in mixed fisheries and undergo discarding at sea. This can be reduced through observer and remote electronic monitoring programmes. To help further protect these species, improved knowledge of important ecological areas, such as spawning and nursery grounds, could help inform spatial measures to protect vulnerable populations, such as the MPAs in Scotland.

Under the Southern North Sea and Channel Skates and Rays FMP, undulate ray, small-eyed ray and starry ray are the only skates with protective measures in place, through alternative management measures to a simple ban i.e. a species based TAC, closed area (ICES Subareas 6, 9 and 10), closed season and minimum and maximum landing size for undulate ray; a single TAC and closed area (ICES Subarea 4 and Divisions 2.a, 6.a-b, 7.a-c and 7.e, 7.h-k) for small-eyed ray; and a zero TAC in place for starry ray in in ICES Subareas 2 and 4 and Division 3.a. Therefore, for the species of conservation concern included in the Southern North Sea and Channel Skates and Rays FMP, no further measures related to prohibited species is required.

Mesh size changes and mesh configuration changes

When recommending management measures for skates and rays, it is important to note that most species are caught and landed in mixed demersal fisheries. For example, for blonde ray landings in ICES divisions 4b, 4c, and 7d (ICES, 2023) in 2022, 60% came from beam trawls and 15% from all other beam trawls. Nevertheless, there are some targeted fisheries which are regulated under retained EU law, which stipulate towed gear to meet specific specifications, such as a minimum mesh size of 80 mm in the cod-end, a 90 mm square mesh panel, and a 140 mm headline panel (as outlined in EU Regulation 2019/1241). Similarly, static nets must adhere to a minimum mesh size of 220 mm

(equivalent to an 8.5 inch mesh) when skates and rays comprise over 30% of the catch (Council Regulation (EC) 850/98). In contrast to other fisheries systems, these gear restrictions are not restrictive. For example, the targeted skate fishery in the Falkland Islands mandates a 110 mm diamond mesh cod-end. Moreover, static net fisheries for monkfish and skate in northeast America currently employ a minimum mesh size of 10 inch (254 mm) diamond mesh throughout their nets, with plans to increase the minimum mesh size to 12 inch (305 mm) diamond mesh in 2026. This comparison underscores that the UK has been somewhat slow in adopting conservative measures to increase gear selectivity for fisheries targeting skates.

Whitley (2019) found that commercial fishermen in Lyme Bay use set gill nets with mesh sizes of 10.5 inch (266 mm) and 12.5 inch (305 mm) to target adult rays and would usually release smaller, but legal-sized, rays due to poor market prices. This study supports the recommendation that the minimum mesh size should be increased from 220 mm (8.5 inch) to at least 266 mm (10.5 inch) when skates and rays comprise over 30% of the catch. Additionally, it demonstrates that fishers are already adhering to this recommendation, indicating there would likely be high compliance with this measure.

For trawl fisheries, it has been reported that technical measures, such as increasing the cod-end mesh sizes and square mesh panels, are ineffective in increasing size selectivity for skates and rays due to their large, flattened body shape which make them vulnerable to capture and subsequently hinder their escape once inside fishing gears (Ellis *et al.*, 2018). However, these gear modifications can enhance the well-being of skate when caught due to the reduced volume of catch in the cod-end, improving their survivorship once released (Enever *et al.*, 2010; Santos and Lawler, 2018). Therefore, increasing the minimum cod-end mesh size to at least 100 mm would be recommended, similar to the required mesh size mandated for directed fishing for plaice and sole with otter trawls, beam trawls, and seines (EU Regulation 2019/1241).

Minimum conservation reference sizes (MCRS)

Across all the fishery systems included within the literature review and assessment, only the EU enforced a landing size for a specific skate species (undulate ray). This emphasises the limited research and management interest given to skate species, as a minimum landing size is considered a fundamental regulation in sustainable fisheries.

In the UK, most quota species have a national minimum size of landing for fish and shellfish stocks. Immediately, this indicates the feasibility and ease of application to introduce a national MCRS for skates landed by UK fisheries. The fact that some IFCAs are already mandating a MCRS, although the specific measurement varies (between 40 cm in the Kent and Essex IFCA and 45 cm in the North Western IFCA), shows the rollout of this measure across the 10 IFCAs is viable, with fishers in other areas outside of the applicable IFCA districts already adhering to this measure (Whitley, 2019). However, it is important to note that a one size MCRS does not fit all species of skate and ray. The inter-species difference in length of maturity between commercially landed skate has been demonstrated by multiple authors (McCully *et al.*, 2012; Philips *et al.*, 2020; Thys *et al.*,

2023). Therefore, while the implementation of a 45 cm disc width MCRS would be beneficial as a first step towards protecting juvenile populations of skate, it should not stop there. Further introductions of species specific MCRS which are more appropriate for larger bodied skate (maturing at larger sizes beyond 45 cm) should be considered. Further research into gaining an understanding of the variability in biological parameters pertaining to length of maturity is recommended.

In accordance with EU and UK regulations, in areas where capture and landing of undulate rays is permitted, a minimum and maximum landing size is enforced. This further demonstrates the applicability of introducing a MCRS for individual skate species. However, the specifications for undulate ray landing sizes are measured from snout to tail (total length), as opposed to the disc width measurement used by local IFCAs. Total length is also the metric used to indicate size at sexual maturity for skate species in many research papers (McCully *et al.,* 2012; Philips *et al*., 2020). For this reason, it is suggested that total length should be considered as the metric to inform and regulate MCRS in UK waters.

Move-On Rules

Based on the literature review and assessment, it is evident that a move-on rule is a widely employed fishing regulation to mitigate bycatch issues, especially in areas where skate species demonstrate localised abundance during specific time periods. This measure is actively enforced in fisheries within the Falkland Islands and those managed by NAFO in the Atlantic. From the findings of the assessment, measures of this type can be considered to be an effective measure to reduce the unintentional bycatch of non-target skate species.

In a UK context, this measure would likely be effective in improving existing conservation measures for prohibited skate species. Given skate species exhibit high site fidelity and aggregating behaviour at certain times of year, the incidental capture of a prohibited species would trigger fishing vessels to exit important habitats where spatial protection has not otherwise been implemented. This would prevent further capture of threatened species and reduce any disturbance to the integrity of the seabed habitat, such as nursery grounds or important egg-laying grounds of the critically endangered flapper skate. It is recommended, that the bycatch threshold should be set very low in order to reduce bycatch and subsequently discarding, as well as any damage to important seabed habitats. The requirement to implement move-on rules and the subsequent adherence by fishing vessels, can be verified by a combination of means. Such as observer programmes (though the rate is low at only 100 vessels of the 800 deployed in the target fisheries that implement move-on-rules); though if possible, remote electronic monitoring systems. The latter can remotely identify species at the point of capture, may be a better option in ensuring areas subject to these rules are identified when a trigger point is reached and vessel monitoring systems are ideally placed to monitor adherence to the closures.

Bycatch measures

Due to their large size and typically rhomboid or round shape, skates and rays are highly susceptible to capture in non-target trawl and static netting fisheries. Their aggregating behaviours associated with spawning also mean they can dominate a vessel's catch in a short span of time, making them a "choke species". This high potential for skate and ray bycatch stresses the importance of sound management measures to both minimise this bycatch, and to maximise survivorship of individuals once they are caught. Skates are currently exempt from the EU LO on account of their suspected high survival rate (Catchpole *et al.*, 2007; Ellis *et al.*, 2008; Enever *et al.*, 2009, 2010; Catchpole *et al.*, 2017; Ellis *et al.*, 2018; Van Bogaert *et al.*, 2020). However, the difference in species survivorship is thought to be significant, with a 50% difference between the most resilient species, the blonde ray (67% discard survival rate), and the most susceptible, the spotted ray (27%) (Van Bogaet *et al.*, 2020). This variance in survivorship highlights the need for species-specific bycatch management measures where possible. For this to be possible, further research into species-specific indicators for survival should be completed. A simple and applicable bycatch management measure would be the introduction of a UK-wide handling best practice guide for skates and rays. This could improve the handling and releasing of skates and rays, giving them a higher likelihood of post-capture survival. Bycatch measures for skate and rays from other regions typically are based on either the condition of the individual or whether a species is prohibited. These measures applied in the UK should be widely applicable providing they are based on sound scientific evidence that is specific to skate and ray species found in UK waters.

Closed season

Closed seasons are already used in parts of the UK as protective measures for skates and rays. These are typically spatial closures for spawning aggregations (the "Ray Box") or are species specific for endangered skates such as the undulate ray. The success of these specific measures points towards the introduction of further measures being widely applicable to UK fisheries. It will be important to ensure measures are as specific as possible and clearly align with important life history traits of the intended protected species. This is not only crucial to ensure the success of the management measure but is also important for gaining support from stakeholders. Measures that have such support are more likely to be implemented and may reap the benefits of monitoring and reporting of transgressions by local fishers (Stewart, *pers comms*). Clear communication with stakeholders, particularly fishers, as to the reasons for proposed seasonal closures will be important for gaining the required stakeholder support. Once temporal closures are in place the specific details of the regulation, such as the defined area and the timeframe of the closure, should be clearly provided to all licence holders to maximise the likelihood of compliance.

Closed area

There are currently several closed areas that have been designated specifically for skate. Closed areas are thought to be an effective protection measure for skate due to their philopatric behaviour, high degree of site fidelity, and aggregating behaviours associated with spawning (Chevolot *et al.*, 2006; Wearmouth and Sims, 2009; Ellis *et al.*, 2011; Neat *et al.*, 2015; Sousa *et al.*, 2019; Simpson *et al.*, 2020; Papadopoulo et al., 2023). Further understanding of skate life history is essential for the introduction of more effective closed areas like the ray box in the "Ray Box" in the Bristol Channel. The existence of this closed area provides evidence of fishers collaboratively working to implement an effective management measure that is tailored for skate life history; further work in the UK should look to legally enforce voluntary measures like the "Ray Box". Closed areas for endangered species like the undulate ray should be continued and, as understanding of various skate species' life history traits improves, more specific closures should be introduced for skate. The willingness of fishers in the Bristol Channel to protect skates and rays demonstrates that the introduction of further closed areas should be widely applicable to the UK.

Observer Programmes

UK fisheries observers already work across the UK fishing fleet, taking biological samples, and ensuring fishers comply with fisheries regulations. However, observers do present an additional opportunity for on-vessel training of fishing vessel crew members to improve species identification. Changes to observer protocol to extend biological sampling of skates and rays could also be considered to fill data gaps on UK skate and ray stocks. This would help further our understanding of skate life history traits such as size at maturity, an important metric for managing a stock's sensitivity to various fishing gears. This will require investment in further training for observers and potentially a greater requirement for the analysis of any new data collected. Currently, UK observers are deployed on vessels in UK waters operating a variety of gear types and with various target species. The UK observer programme conducted by Cefas conducts sampling across a subset of 800 of the total of 5,783 UK registered fishing vessels (approximately 14% of the fleet based on 2021 figures). Those vessels involved are trawlers that predominantly target, demersal finfish, *Nephrops* and shrimps Cefas randomly selected vessels to deploy observers on with an annual sample size of about 100 vessels from the 800 possible selected within a year. The review undertaken in this report was unable to find any statistics pertaining to species specific observer coverage.

Tagging programme

While local-scale tagging studies have been carried out to assess spatio-temporal behaviour of skates, no national (or EU wide) scale tagging program is in place in the UK. Tagging programmes currently contribute to the management of numerous fisheries worldwide, with CCAMLR representing an exemplary programme. The use of the release-

recapture approach is carried out by fishers who are required to tag and release skates at a defined rate during their normal fishing operations (CCAMLR, 2023). Any tagged skate that are recaptured must be retained unless otherwise specified by observers, with tags being returned to CCAMLR. This tagging programme helps provide a more detailed understanding of skate spatio-temporal dynamics so that the most appropriate fisheries management measures may be applied to the fishery (e.g. closed areas for spawning aggregations). While tagging programmes do have associated costs, a programme implemented by fishers (as demonstrated in CCAMLR) could help lower these costs. However, stakeholder consultation and then training would be required prior to the programme beginning.

While national tagging programmes are a powerful fisheries management tool, insufficient funding for fisheries management and stakeholder resistance may present barriers to the establishment of one in the UK.

Identification guide

Accurate species identification is crucial in underpinning sustainable fisheries management. Inaccurate species identification causes inaccurate data for stock assessment, which in turn leads to inaccurate biomass estimations. This leads to inappropriate TACs being set for these stocks, potentially causing their decline or stocks not able to be exploited to the maximum biological or commercial potential. The importance of proper species identification is highlighted in the New Zealand skate fishery, where historical difficulties in discerning between rough skate and smooth skate led to large uncertainty surrounding historic landings of each species (Fisheries New Zealand, 2022). The Falkland Islands fisheries department produced an identification guide in 2003 (Bizikov *et al.,* 2003). This helped fishers more accurately identify the various skate species in the FCZ. Species of skate found in UK waters may be susceptible to misidentification, particularly the blonde ray (*Raja brachyura*) and the spotted ray (*Raja montagui*) which are often misidentified as one another. A detailed species identification key should be developed and distributed to all fishers that may encounter skates and rays as part of their catch. This is a very low-cost management measure which will improve species-specific catch and landings data used in future stock assessments.

Conclusions and recommendations

Based on the findings of this report, recommendations are outlined below for the improved management of target and non-target skate and ray fisheries in the UK.

Introduce species-specific Total Allowable Catches (TACs).

The current regional TACs cover a wide range of species with different life history traits. Developing a species-specific approach would facilitate more appropriate catch limits for each species, allowing greater catches of locally abundant skate and ray species while affording greater protection to species with higher vulnerability to exploitation. Transitioning towards single-species assessments for skates and rays in the UK would also provide more information on the population dynamics and stock structure of these distinct species, which in turn will feedback to improve stock management. Furthermore, the species-specific advice required for the setting of single species TACs for skates and rays is already available from ICES. This conservation measure is both achievable and of high priority for the Southern North Sea and Channel Skates and Rays FMP. This would require the distribution of an updated identification guide and relevant training of fishers.

Increase the minimum mesh size in static net fisheries to at least 266 mm (10.5 inch) where skates and rays comprise more than 30% of catches.

There is evidence that static net fishers in the UK already deploy nets with mesh sizes of 267 mm (10.5 inch) and 318 mm (12.5 inch) when targeting adult rays and skates. Where smaller individuals of legal size are caught, they are typically returned as a result of low market value. A similar fishery in the northeastern USA currently mandates a minimum mesh size of 254 mm (10 inch), with plans to increase this limit to 305 mm (12 inch). UK static net fishers are likely to accept this change as many already set nets with these mesh sizes voluntarily, so compliance would likely be high. The potential ease of implementation of this measure makes it a high priority recommendation.

Increase the minimum cod-end mesh size to at least 100 mm in trawl mixed fisheries that encounter skates and rays.

Evidence suggests that increasing the cod-end mesh size and use of square mesh panels does not increase the selectivity of trawl nets for skates and rays due to their rhomboid or circular body shape. Nevertheless, these gear modifications can reduce the volume of catch in the cod-end, including of non-target and undersized specimens. Consequently, this would enhance the post-release survivorship of skates and rays while concurrently enhancing the selectivity of fishing gear to capture targeted fish stocks (Ellis *et al.,* 2018; Enever *et al.*, 2010; Santos and Lawler, 2018). The suggested increase to at least 100 mm (3.94 inch) would bring mixed fisheries that encounter skates and rays to a similar mesh size of the directed sole and plaice otter trawl, beam trawl, and seine fisheries in the EU.

Implement a 45 cm disc width minimum conservation reference size (MCRS), with future research into the potential for species-specific MCRS.

In the UK, there is no national MCRS to regulate the landing size of skates and rays in commercial fisheries, except for undulate ray. Nevertheless, certain local byelaws within three IFCA districts (Kent and Essex, North Western and Southern) specify a MCRS from 40 (Kent and Essex) to 45 cm (North Western) disc width. Additionally, local fishers from the North Devon Fishermen Association (NDFA) voluntarily adhere to a minimum landing size of 45 cm disc width. Evidence supporting the implementation of an MCRS indicates that this would be an effective initial step to safeguard juvenile and undersized individuals, ensuring that the majority of landed skate species are sexually mature. The widespread use of MCRS as a standard fishing regulation for most quota fish and shellfish stocks underscores the readiness and feasibility of the current fishery management framework to legally introduce a national MCRS for skate and ray. Moreover, the ease of implementing and enforcing this measure is substantiated by the fact that fishers are already compliant, both within and outside IFCA districts where it is mandated. Consequently, the adoption of a 45 cm disc with MCRS should be regarded as a high priority and easily achievable measure for future management plans and will likely encounter minimum resistance from stakeholders.

Additional considerations:

1. Further research is needed to develop species-specific MCRS based on life history traits, most notably length at maturity.
2. An evaluation should be conducted to determine whether disc width or total length is the most appropriate metric for enforcing MCRS.

Establish move-on rules for species that are endangered or particularly vulnerable to a fishing method.

Move-on rules are typically triggered by a bycatch limit of a certain species or group of species. Where a vessel catches a predetermined percentage or weight of a species or taxa as a proportion of catch in a single haul, they are forced to cease fishing by that method and must move a certain distance from the location of their previous haul. This management measure is particularly effective where vulnerable species aggregate (e.g., skate). In the UK, this measure could be applied to prohibited species such as undulate ray in certain areas, or to species with low post-release survivorship such as the spotted ray. These rules can be verified by a combination of remote electronic monitoring and catch reports, or by the presence of observers where possible. This type of management measure may be difficult to implement as one would expect strong opposition from fishers on the basis of fuel costs and the potential costs of observer programmes or remote electronic monitoring.

Develop species-specific bycatch measures via further research into species survivorship and life history traits.

Currently, skates and rays are exempt from the EU landing obligation on account of high post-release survivorship (Catchpole *et al.*, 2007; Ellis *et al.*, 2008; Enever *et al.*, 2009, 2010; Catchpole *et al.*, 2017; Ellis *et al.*, 2018; Van Bogaert *et al.*, 2020). This one-size-fits-all measure does not reflect the observed variance in survivorship (Van Bogaet *et al.,*

2020). More research is required into the life history traits of individual species and their post-release survivorship to create bycatch rules that are species-specific.

Develop a best practice guide for handling skates and rays.

Currently, the UK does not have a standardised best practice guide for handling skates and rays. The development and national distribution of a best practice guide for on-deck handling and discarding of undersized and prohibited species will help maximise the likelihood of post-release survivorship. This should be considered a high priority ‘easy win’ for future management plans and will likely be met with minimum resistance from stakeholders, making it easy to develop and roll-out.

Research and establish temporal and or spatial closures for skates and rays.

The UK currently has several spatio-temporal fishery closures for the protection of skates and rays. The “Ray Box” in the Bristol Channel protects skates and rays during spawning aggregations through a voluntary system. Making this a legally enforced closure would cement this protection into the long-term. Future spatio-temporal closures should look to protect species where they are at their most vulnerable (e.g. closures for nursery grounds or for spawning aggregations). Continued research into life history and population dynamics of skates and rays will be essential in informing the most effective areas to enforce spatial management and seasonal closures.

Where possible, enhance data collection from skate and ray target and non-target fisheries through high observer coverage, the implementation of a national tagging programme, and the development of an identification guide for skates and rays.

Fisheries managers should constantly be exploring avenues for improved data collection methods. High data quality facilitates accurate stock assessments, which in turn inform effective management strategies. The highest priority should be given to measures that improve data collection at a low cost. For example, currently there is no official identification guide for the skates and rays of the UK. The development of an identification guide would be fast, cheap, and would markedly improve catch and landings reports. Identification issues can seriously hinder the accuracy of stock assessments, leading to sub-optimal management of stocks. This should be a high priority and would be easy to implement while being well received by fishers and other stakeholders.

Further investment in other data collection methods will help improve fisheries data quality. Increasing observer coverage will increase the amount of biological data that are relevant to life history traits of skates and rays. This may help inform decisions around spatio-temporal management and the handling and discarding of bycatch. Tagging programmes have also been shown to provide useful data for understanding population dynamics and stock structure which can help with the spatial partitioning of TACs. The implementation of both these measures is dependent on the funding available to fisheries management in the UK.

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List of abbreviations

ACL	Annual catch limit
ACT	Annual catch target
AFMA	Australian Fisheries Management Authority
ASFIS	Aquatic Sciences and Fisheries Information System
BCA	Benthic Closed Area
BSAI	Bering Sea and Aleutian Islands
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources.
DAFF	Department of Agriculture, Forestry and Fisheries (SA)
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DFO	Department of Fisheries and Oceans (Canada)
EAFM	Ecosystem approach (to) fisheries management
EBFM	Ecosystem based fisheries management
FCZ	Falkands Conservation Zone
FIG	Falkland Islands Government
FMP	Fisheries Management Plan
FNZ	Fisheries New Zealand
GOA	Gulf of Alaska
GOM	Gulf of Maine
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries Conservation Authority (UK)
IFQ	Individual Fishing Quota
IUCN	International Union for Conservation of Nature
JFS	Joint Fisheries Statement
LOA	Length Overall
LRP	Limit Reference Point
MarLIN	Marine Life Information Network
MCRS	Minimum Conservation Reference Size
MCS	Monitoring, Control and Surveillance
MMO	Marine Management Organisation (UK)
MPA	Marine Protected Area
MRA	Maximum Retainable Amount
MSY	Maximum Sustainable Yield

NAFO	North Atlantic Fisheries Organisation
NASCO	North Atlantic Salmon Conservation Organization
NDFA	North Devon Fishermen's Association
NEAFC	North East Atlantic Fisheries Commission
NEFMC	New England Fisheries Management Council
NEFSC	Northeast Fisheries Science Center (US)
NMFS	National Marine Fisheries Service (US)
NOAA	National Oceanic and Atmospheric Administration (US)
NPFMC	North Pacific Fisheries Management Council
OVI	Objectively Verifiable Indicator
PFMC	Pacific Fisheries Management Council
QMS	Quota Management System
RFMO	Regional Fisheries Management Organisation
SGSSI	South Georgia and South Sandwich Islands
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TAL	Total Allowable Landings
WGEF	(ICES) Working Group on Elasmobranch Fishes

Annex 1 Set of Standardised Fisheries Measures (sourced from the European Commission, 2022)

Measure Number	Measure Type
1	Input measures
1.1	TCMs
1.1.1	Gear based TCMs
1.1.1.1	Size selectivity targeted measures
1.1.1.1.1	Mesh size changes
1.1.1.1.2	Mesh configuration changes
1.1.1.1.3	Square mesh panels
1.1.1.1.4	Square mesh cylinder
1.1.1.2	Species selectivity targeted measures
1.1.1.2.1	Bycatch reduction devices
1.1.1.2.2	Sorting grids
1.1.1.2.3	Separator Panels
1.1.1.2.4	Benthos Release Panels Dutch or Belgian Beam trawlers
1.1.1.2.5	Longline circle hooks
1.1.2	Spatial and temporal TCMs
1.1.2.1	Spatial TCM

Measure Number	Measure Type
1.1.2.1.1	Strict Nature Reserves (SNR)
1.1.2.1.2	Habitat / Species Management Area
1.1.2.1.3	Protected Seascape - No take zones
1.1.2.1.4	Protected Area with Sustainable Use of Natural Resources
1.1.2.2	Temporal TCM
1.1.2.2.1	Closed seasons
1.1.2.2.2	Real-time closures (RTC)
1.1.2.2.3	Move-on rules
1.2	Capacity and effort restrictions
1.2.1	Capacity control measures
1.2.1.1	Decommissioning
1.2.1.2	Entry restrictions on the number of fishing licences
1.2.1.3	Jointly entitled “Capacity reduction schemes (CRS)”
1.2.2	Effort control measures
1.2.2.1	KWhour or days at sea controls
1.2.2.2	Total allowable effort
2	Output measures
2.1	TAC controls
2.2	Landing size controls

Measure Number	Measure Type
2.3	Discard bans
3	Alternative governance and economic instruments
3.1	Tradeable fishing concessions (Individual transferable quota)
3.2	Co-management and Results-based-management
3.3	Self-management
3.4	Payments for ecosystem services/alternative fishing method
3.5	Economic measures within ecosystem based approach
3.5.1	EBFM Measures regarding D3/Objectives CFP
3.5.2	EBFM Measures regarding D1 & 6 (Biodiversity, Sea floor integrity)
3.5.3	EBFM Measures regarding D10 (Marine litter)
3.5.4.1	Restocking schemes and stock enhancement
3.5.4.2	Artificial reefs
3.5.4.3	FAD management

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