Acronyms

25 YEP	25 Year Environment Plan
ALDFG	Abandoned Lost or otherwise Discarded Fishing Gear
EC	European Commission
EU	European Union
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
CFP	Common Fisheries Policy
EFH	Essential Fish Habitats
ETI	Ethical Trade Initiative
FAO	Food and Agriculture Organisation of the United Nations
FWP	Fisheries White Paper
GHG	Greenhouse gas
JNCC	Joint Nature Conservation Committee
LIFE	Low Impact Fishers of Europe
LOA	Length overall
MRF	Marine Recreational Fisheries
MSEP	The Marine Socio-Economics Project
MSC	Marine Conservation Society
MSY	Maximum Sustainable Yield
NEF	New Economics Foundation
NFFO	The National Federation of Fishermen's Organisations
NUTFA	New Under Tens Fishermen’s Association
RASS	Risk Assessment for Sourcing Seafood
RFS	Responsible Fishing Scheme
SDG	Sustainable Development Goals
SSB	Spawning Stock Biomass
SSCF	Small Scale Local Fisheries
TSS	Tools for Ethical Seafood Sourcing
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention for the Law of the Sea
US	United States of America
UV	Ultraviolet
VGSSF	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries

1 Introduction

Through a review of relevant literature, including key policy documents, we explore definitions related to 'low impact fishing' in commercial and recreational sea fishing. The review examined similarities and differences between the definitions that are commonly used and the kinds of impacts that are associated with these definitions. As well as reviewing the definitions themselves, the processes by which examples of each of the terms have been defined are examined. For this, indicators of successful stakeholder engagement and meaningful participation have been developed following Reed (2008). These have been used to examine the extent and nature of co-production of the definitions, highlighting differences in approach. The section begins with an overview and then examines each of the definitions in turn.

This report identifies some of the terms in common use that relate to 'low impact' and examines the evidence around the types of impacts associated with different types of fishing activity. To begin with, the report reviews the types of impacts that fishing can have, and the international and national (England) context within which these are considered. Following this, the terms that are broadly analogous to or have common usage with 'low impact' are defined, and then the environmental impacts of fishing discussed and reviewed, and the evidence for each category of impact explored and summarised.

Impacts of fishing

Fishing is recognised to have impacts. These include the contributions to society in the form of social and economic benefits as well as possible harm to the ecological and biophysical environment (e.g., Hall, 1999). Commercial and recreational fisheries can make important contributions to individual and collective welfare and wellbeing (e.g., Allison and Ellis, 2001; Béné et al. 2010; Béné et al., 2016; Hyder et al., 2018). While the focus is often on the contribution in terms of ecosystem services, such as income, employment and food, there can also be important contributions beyond this in less tangible forms that are based on inter-personal interactions and individual satisfaction and self-worth that are associated with the activity of fishing, post-harvest and ancillary activities (e.g., MRAG et al, 2016).

While the nature and type of social and economic contribution will vary from fishery to fishery but the aim of fisheries policy and management interventions will often be to increase wherever possible these positive societal contributions. Underpinning these social and economic benefits is the ecological and biophysical resource base, also described as the natural capital that enables the benefit flows to society. Thus, it is widely accepted that any negative effects of fishing on the overall health of the ecosystem are limited. This is clear from the regular reporting from the Food and Agriculture Organisation of the United Nations (FAO) where they note that marine fisheries resources continue to decline:

"*The fraction of marine fish stocks fished within biologically sustainable levels has exhibited a decreasing trend, from 90.0 percent in 1974 to 66.9 percent in 2015. In contrast, the percentage of stocks fished at biologically unsustainable levels increased from 10 percent in 1974 to 33.1 percent in 2015*" FAO (2018) p.6

Widespread concern is also apparent from the number of publications suggesting that fisheries are facing a 'crisis' or 'tragedy' (e.g., McGoodwin, 1990; Webster, 2015) and voicing concerns about the environmental impacts associated with fishing and fisheries (e.g., Hall, 1999). As a result, there are increasing calls to minimise the negative environmental impacts and externalities of fishing that have led to policy positions, certification schemes and regulations to monitor and reduce these impacts. However, it is also important to recognise that, even for the same species, there may be different fishing techniques (in terms of the gears used and manner in which they are fished), that may use different amounts of energy (fuel) and have differing impacts on the target / non-target species and wider marine ecosystem. It is therefore important to examine the types of impacts that are identified in relation to commercial and recreational fishing and how these are reflected in definitions associated with 'low impact fishing'.

The 2030 Agenda for Sustainable Development

At the international level, the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs) provide an important global vision for world development. The agenda and SDGs are highly relevant to capture fisheries (e.g., Blanchard et al., 2017), in particular through the SDG 14, to 'Conserve and sustainably use the oceans, seas and marine resources for sustainable development'. SDG 14 includes a number of targets that relate to capture fisheries (Table 1).

Table 1: SDG14 Targets and their relevance to fisheries and the impacts of fishing and fisheries

Target	Relevance to fisheries
14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	Reduce pollution, including greenhouse gases, ghost fishing, plastic, oils etc.
14.2: By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	Reduce impacts on target stocks, non-target stocks, habitats and marine ecosystems.
14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	Reduce CO_2 emissions and other pollutants that can contribute to ocean acidification, reduce ecosystem impacts from fishing to enhance resilience of marine ecosystems to the effects of acidification.
14.4: By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	Reduce impacts on target stocks in particular but also non-target stocks, habitats and marine ecosystems.
14.5: By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	Reduce impacts on habitats critical to healthy and productive ecosystem functioning.
14.6: By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	Reduce impacts on stocks, associated species, ecosystems and habitats associated with overfishing.
14.7: By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	Increase social and economic benefits from fisheries in developing countries while maintaining the natural basis of productivity.
14.A: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of	Reduce the impacts of fishing on ocean health.

Target	Relevance to fisheries
Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	
14.B: Provide access for small-scale artisanal fishers to marine resources and markets	Reduce sectoral conflict and increase benefits to small-scale artisanal fishers.
14.C: Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want	New fisheries legislation, that aim to enshrine social economic and environmental sustainability into fisheries governance.

The issue of the impacts of fisheries are recognised in other key international policies, including UN Convention on the Law of the Sea (UNCLOS). The initial focus has been on the impacts of fishing on fish stocks and the use of Maximum Sustainable Yield (MSY) as a key reference point for fisheries management. The determination of sustainable yields and management of fishing effort and yields to ensure harvests do not compromise the resource available in the future have been a fundamental aspect of most fisheries management theory and practice (e.g., Hoggarth et al, 2006; Charles, 2001; King, 1995). The impacts on wider ecosystems have also been gaining increasing attention (e.g., Hilborn and Walters, 1992). For example, according to the Convention on Biological Diversity (CBD), Article 10 recognises the effect of human activities on the natural world and requires a commitment to "*Adopt measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity*".

Related to this, the Strategic Plan for Biodiversity 2011-2020, the ten-year framework for action to save biodiversity and enhance its benefits for people under the CBD, includes Aichi biodiversity Target 6 related to wild capture fisheries that specifies by 2020 that:

"*…fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits*"

Within the international policy frameworks, the fact that there are differences in the contributions and impacts across fisheries is recognised, primarily through the provisions for developing countries and for small-scale fisheries.

The case of small-scale fisheries

At a global level there is typically a distinction between small-scale fisheries and large-scale and industrial fisheries. A common feature of these distinctions is an attempt to highlight the key differences between these categories that is often done in terms of the impact of the fisheries (socio-economic as well as environmental). Figure 1 shows a typical attempt to do this, and one of the earliest, in the table developed by Thompson (1980) that has been reworked or adapted subsequently, for example by Berkes et al. (2001), Sumaila et al. (2001), Jaquet and Pauly (2008), Pauly and Zeller (2016) and Sumaila (2017), amongst others. In practice, these distinctions are made for a number of reasons, some practical and others political (e.g., Johnson, 2006; Smith and Basurto, 2019). However, for the purposes of this study it is important to recognise that important social, economic and environmental impacts are suggested by the analysis. It is also important as many other terms (e.g., artisanal, subsistence, inshore) are often used synonymously with small-scale, and the differences in impact are also suggested in comparison with other types of fisheries.

FISHERY BENEFITS	SMALL-SCALE	LARGE-SCALE
Number of fishers	18,592	3,242
Number of vessels	12,957	294
Annual Catch (1,000 tonnes)	858	1,993
Annual catch (1,000 tonnes) of marine fish for human consumption	724	816
Annual catch (1,000 tonnes) of marine fish for industrial reduction to meal and oil, etc.	134	1176
Landed value (million US$)	711	674
Total fuel consumed (million litres)	350	300
Energy intensity (litres/tonne)	410	150
Fishers employed for each $1 million landed value	26	5

Figure 1: Relative benefits and impacts associated with small-scale and large-scale fishing in Norway[1]

Small-scale fisheries have been the focus of significant attention in recent years with regards to establishing the scale and diversity of small-scale fisheries (e.g., World Bank, 2012, Chuengpagdee, 2011). One of the most significant global initiatives has been the development of the FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (VGSSF) in 2014 (FAO, 2015). There were two important aspects of the development of these guidelines. The first is that they emphasise the significance of the economic and social contributions of small-scale fishing and fisheries (the human side), rather than focusing on the fish and fishing, as the CCRF does (see also Johnson et al., 2018). The VGSSF therefore suggests that these benefits are important to recognise when considering access to resources. Secondly, and equally important, was the way in which the guidelines were developed through an inclusive, participatory process. This is returned to when considering definitions in the sections below.

Recreational Fisheries[2]

Recreational fisheries (non-commercial fishing for mainly leisure or pleasure) that can make important contributions to economies and well-being. It is also important to note that for certain species, recreational catches may be much higher than commercial catches. within the North Sea / North Atlantic area, the main species targeted by recreational anglers are Atlantic cod (*Gadus morhua*), Atlantic salmon (*Salmon salar*), European seabass (*Dicentrarchus labrax*)

[1] Source: Sumaila et al. (2001)

[2] The discussion surrounding recreational fisheries within this review drew primarily on Lewin et al (2019), but included work from other authors and studies where they fit. These are referenced in the text.

and pollack (*Pollachius pollachius*). Recreational fisheries often overlap with subsistence and artisanal fisheries, exacerbated in some countries where limited sales of recreationally caught fish is permitted, blurring the line between recreational and commercial fishing (Freire, 2020).

In general, the impacts of marine recreational fisheries (MRF) on fish stocks and ecosystems are primarily driven by the high number of participants, through individual removals from the fishery or post-release mortality. Despite this, they rarely feature explicitly in fisheries management plans or governance structures. Recognition of sea angling as a sector is therefore varied and where this recognition features it is often not suitably defined, to include the capture for leisure and / or personal consumption. Recreational fisheries have also been shown to compete more directly with coastal small-scale fisheries, through direct competition for the same species and applying further pressure on the stocks, which can be exacerbated by illegal commercial sales of 'recreationally caught' fish (Potts et al, 2019).

Recreational and commercial fisheries both provide economic benefits to the UK, though these are via different mechanisms. However, the social and environmental impacts of both these fishing methods (EFTEC, 2015; Hyder et al., 2017) is increasingly becoming more recognised and there is a need to develop a 'trade-off' to find balance between the sectors. In the report, value is defined as the total economic value (i.e. use and non-use values for the Ecosystem Services they provide, including provisional and cultural services) a holistic approach as used as proposed in the 25year Environmental plan (including Natural Capital and the UKNEA approach as supported by Defra – see (Defra, 2007)).

The English national policy context

The policy context within which fishing in England is situated is the EU Common Fisheries Policy and the recent UK 25 Year Environment Plan[3] and Fisheries White Paper[4]. Paragraph (4) of the Common Fisheries Policy (CFP) recitals states that the CFP should "*contribute to long-term environmental, economic, and social sustainability*": The objective of the CFP is to provide for sustainable exploitation of living aquatic resources and of aquaculture in the context of sustainable development, taking account of the environmental, economic and social aspects (Article 2).

However, while the CFP highlights social and economic benefits, such as employment, food supply and a "*fair standard of living*" and the need to take into account both producers and consumers, the main actions and policy measures appear in terms of control of fishing activities and opportunity in response to risks or threats to the conservation of living aquatic resources. Identified threats include those to the fish stocks themselves, wider impacts on the marine environment and ecosystems, the capture of endangered, threatened and protected species, discarding, habitat damage and energy consumption.

In the recitals it is also recognised that: "Recreational fisheries can have a significant impact on fish resources" and that "*Member States should, therefore, ensure that they are conducted in a manner that is compatible with the objectives of the CFP*". Member states are asked to take into account the social and economic benefits and environmental impacts when making decisions on allocating fishing opportunities. Article 17 states that criteria used to allocate opportunities "… *may include, inter alia, the impact of fishing on the environment, the history of compliance, the contribution to the local economy and historic catch levels. Within the fishing opportunities allocated to them, Member States shall endeavour to provide incentives to fishing vessels deploying selective fishing gear or using fishing techniques with reduced environmental impact*…". In the context of the CFP, 'low impact fishing' is defined and "…*means utilising selective fishing techniques which have a low detrimental impact on marine*

[3] https://www.gov.uk/government/publications/25-year-environment-plan
[4] https://www.gov.uk/government/consultations/fisheries-white-paper-sustainable-fisheries-for-future-generations

ecosystems or which may result in low fuel emissions, or both" (Article 4). This clearly focuses attention towards the environmental impacts.

The UK 25 Year Environment Plan (25 YEP) has been developed in the context of commitments to leave the CFP. In its stead, the 25 YEP commits to the development of "*a sustainable fisheries policy*" that is intended to protect both fish stocks and the marine environment. Ending discarding is also identified as an important element of fisheries management together with minimising impacts on non-commercial species and "*the marine environment generally*". These commitments are set out in more detail in the 2018 Fisheries White Paper (FWP) that aims to deliver a "*competitive, profitable and sustainable fishing industry*". The main emphasis in the FWP is on sustainability in terms of maintaining or restoring fish stocks to at or above the stock size that can produce Maximum Sustainable Yield (MSY) and "*ending the wasteful discarding of fis*h". Furthermore, fishing activities that have negative impact on the health of the marine environment should be reduced and, where possible, avoided. This includes tackling bycatch cetaceans and seabirds to identify and implement effective risk-based mitigation.

Allocation of fishing opportunities are to be based on alternative criteria to Article 17 of the CFP (e.g., Williams et al., 2018). While these have not been developed yet, it is anticipated that there would be more emphasis on partnership with the commercial fishing industry and the recreational sector, the needs of different parts of the industry and creating incentives to reduce discards. Within the FWP, the English inshore fleet are identified as relatively low impact, with the example of "*artisan fishers with close ties to their coastal communities*" highlighted but 'low impact' is not clearly defined. For these fleets however, it is suggested that alternative management arrangements and regulatory frameworks could be developed. Significantly, the FWP suggests that some stocks could be managed "*specifically for the recreational angling sector only*". This highlights the importance of understanding the impacts of the activities this sector as well.

2 Definitions relevant to 'low impact' fishing

In this section we consider in turn each of the selected definitions: 'low impact', 'sustainable', 'marine stewardship', 'small-scale', 'artisanal', 'responsible', 'ethical', 'environmentally friendly', 'inshore' and 'catch and release' angling and explore through the literature the scope, nature and types of impacts that are included within the definitions. This is then summarised in a comparative table (Table 2).

2.1 Low impact

Low impact is a term that is widely used without a shared definition. For example, Article 4 of the Common Fisheries Policy (CFP) defines low impact fishing as "*utilising selective fishing techniques which have a low detrimental impact on marine ecosystems or which may result in low fuel emissions, or both*"[5]. The 25 YEP and the Fisheries White Paper call for the need to minimise impacts on the marine environment by following an 'ecosystem approach' to fisheries management, but do not provide a specific definition of low impact fishing to support it. New Economics Foundation (NEF) argue that without an agreed definition, the ambition set out by UK government cannot be realised (Williams, 2019).

The Fisheries White Paper states that the UK government will "*consider new criteria to define low impact inshore fishing vessels to replace the current 'under 10 metre' category*" and associate low impact with 'inshore' and 'artisanal'. This is exemplified by the following statement: "*the English inshore fleet, many parts of which could be viewed as relatively low impact (such as artisan fishers with close ties to their coastal communities)*". The National Federation of Fishermen's Organisations (NFFO), who represent part of the fishing industry, appear supportive of this approach. The NFFO are calling for an end to the '*artificial division of the fleet at 10 metres*', to be replaced with a new classification based on impact, which links 'low impact' with 'inshore', 'small scale' and 'artisanal' fishing[6]. According the NFFO, a definition of low impact should draw on an assessment of fisher impacts in five key areas; target species, non-target commercial species, cetaceans and other non-commercial species, Seabed ecosystems and carbon footprint[7]. Similarly, LIFE link low impact with small scale, stewardship and sustainability. Representing small scale fishers, the organisation emphasises that members use low impact fishing methods and selective gears to have minimal environmental impact on marine habitats, applying the principle of 'right gear, right place, right time'. According to LIFE, members have a low impact by respecting management rules, undertaking short fishing trips, have minimal "*greenhouse gas emissions per kilo of fish landed*", and fish sustainably with low bycatch[8].

2.2 Sustainable

Sustainable Development is a widely used term following the World Commission on Environment and Development, 1987. Definitions of sustainability emphasise the three 'pillars' of sustainability: environmental, social and economic. To some extent 'sustainability' represents what Molle (2008) refers to as a 'Nirvana Concept' as it is intuitively something to be desired yet, at the same time, the term tends to obscure the difficult trade-offs that need to be addressed in managing across the three pillars. Frequently in fisheries management, while there may be reference to other impacts, sustainability is often taken to imply sustainable yield from the resource and fisheries assessed in terms of their position relative to MSY (e.g., FAO, 2018; Hoggarth et al., 2006; Charles, 2001). The objective of the CFP is to provide a

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1380&from=EN
[6] https://nffo.org.uk/news/fishing-quota-allocation-developing-a-new-approach-for-allocating-additional-fishing-quota-in-england.html
[7] Ibid
[8] https://lifeplatform.eu/about-us/

framework for sustainable exploitation of living aquatic resources in the context of sustainable development, taking account of the three pillars of sustainability; environment, economics and social (Article 2). However, there is an understanding that "*economic and social sustainability require productive fish stocks and healthy marine ecosystems*"[9] and, as a result, the main actions and measures appear in terms of environmental sustainability. This is achieved mainly through the use control of fishing activities and opportunity in response to risks of a threat to the conservation of living aquatic resources, to achieve Maximum Sustainable Yield (MSY).

Within the UK, the FWP and 25 YEP also frame sustainability in relation to MSY, stating the intention that "*all fish stocks are recovered to and maintained at levels that can produce their maximum sustainable yield*"[10]. The FWP states that the success of any future fisheries management system will ultimately come down to its ability to rebuild and maintain stocks and improve ecosystem health and resilience[11], which will be used to define sustainability in a fisheries context within this study.

2.3 Responsible

Responsible fishing was established as a global commitment through the FAO Code of Conduct for Responsible Fisheries (CCRF). This establishes that "*The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources*" (FAO, 1995). This requires that everyone engaged in fisheries or as users of the aquatic environment (e.g., recreational anglers) ensure that fishing and fisheries activities are conducted in such a way as to minimise the negative impacts. This includes conserving fisheries resources and aquatic ecosystems, reducing waste, protecting habitats, ensuring "*safe, healthy and fair working and living conditions*", minimising discards, loss of gear and ghost fishing and prohibiting destructive fishing practices (e.g., dynamite fishing and fishing with poisons). The Code of Conduct also requires that states should promote energy efficiency, prevent pollution (including of ozone depleting chemicals) and ensure that there are adequate waste disposal facilities. These aspects of responsible fishing are echoed in the UK 25 Year Environment Plan, which contains commitments to sustainably exploit stocks (in line with the definition above), protect marine ecosystems and end discarding.

Responsible fishing and responsible sourcing have also been championed in the UK by Seafish as a means to protect fish stocks and ecosystems and promote "*best environmental practice*". To this end, Seafish has developed the 'Responsible Fishing Scheme' (RFS), a vessel-based certification scheme and Risk Assessment for Sourcing Seafood (RASS)[12] that that audit compliance on board fishing vessels, including catching, catch quality and crew welfare criteria. Performance criteria related to 'care for the environment' in the RFS are based inter alia on standards in the CCRF (Seafish, 2015).

It is generally recognised that the impacts of fishing activities differ with different types of fishing operations (e.g., Huse et al., 2003, Hall, 1999), and that the precise measures that are required to minimise impacts can differ. To address this, and to promote responsible practices, various technical measures and ecosystem-based approaches have been developed, including the use of fishing credits and real-time incentives to influence fisher behaviour towards minimising impacts on the environment (e.g., Kraak et al., 2012). Thus, 'responsible' may have a fairly technical definition for fishing. However, the same is less true further along

[9] EC 2009. GREEN PAPER Reform of the Common Fisheries Policy. Brussels, 22.4.2009 COM(2009)163 final
[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/722074/fisheries-wp-consult-document.pdf
[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/722074/fisheries-wp-consult-document.pdf
[12] Seafish. (n.d.). RASS scoring guidance. Available at: https://www.seafish.org/rass/wp-content/uploads/2016/01/RASS-scoring-guidance_v1.51.pdf

the value chain, where terms such as ‘responsibly sourced’ can be more problematic for consumers seeking sustainable seafood (e.g., MRAG et al., 2016).

2.4 Small-scale

Kurien (1996, ii) states that as each small-scale fishery is different, attempts to define small-scale are “*an exercise in futility*”. Despite this, references to small-scale fisheries are widespread and there have been numerous attempts to define them. This is because small scale fisheries are a feature of global wild capture fisheries, both inland and marine, and may play a variety of roles in the livelihoods of fishers, fisher communities and national economies (e.g., Johnson et al., 2018; Béné et al., 2016; Arthur et al., 2016). One reason for this is that it was recognised that there are important differences between small-scale and large-scale fisheries that have implications for management (e.g., Crilly and Esteban, 2013; Berkes et al., 2001).

Fisheries management has been an important driver of interest in small-scale fisheries, with a number of concerns raised about the aggregate impact of small-scale fishing on fish stocks and ecosystems (e.g., Vincent and Harris, 2014). Small-scale fisheries are typically diverse, multi-metier and, in the context of European fisheries, may target both quota and non-quota stocks. Definitions of small-scale fisheries in relation to management have, as the title suggests, tended to focus on vessel size (Davies et al, 2018; Guyader et al., 2013). For example, Smith and Basturto (2019) found that the most common characteristics used to define small-scale fisheries were fishing gear type, vessel attributes such as length and power and socio-cultural factors such as ethnic group. Similarly, Smith (1979), describing small-scale fisheries in developing countries, suggests that classifying groups by vessel size, units of power, gear type and distance from shore can be important. Across the EU, small-scale is typically defined as a vessel less than 12 metres length using non-towed gear (EC, 2006; Guyader et al., 2013) and within the UK it is often synonymous with ‘inshore’ (see definition below). Davies et al. 2018, have illustrated how this varies in practice across countries within the EU, see Table 2 (below).

Table 2: Definitions of small-scale coastal fleets used in major European fishing nations. kW (kilowatts) = engine power, Gt (gross tonnage) = cubic capacity, nm = nautical miles, m = vessel length in metres[13]

Country	Name	SSCF vessel definition	Purpose	Source
Belgium	Coastal fleet	< 221 kW, < 70 Gt, passive gear, trip length and port restrictions	Quota allocation	[21]
	Small-scale segment	< 221 kW	Quota allocation	[21]
Denmark	Coastal fleet	< 17 m, conduct 80 or more fishing trips/year of < 48 h	Quota allocation	[22]
	Coastal fleet	< 15 m & conditions	Quota allocation	[22]
Finland	Coastal fleet	Trap net fishery	Quota allocation	[23]
France	Tax regulation	< 24 h at sea	Administrative division	[24]
Germany	No national regulation	None	None	[25]
Iceland	Coastal fleet	< 15 m, < 30 Gt, < 5 jig machines, May–August, < 14 h per day Monday–Thursday, < 650 kg per day cod equivalents	Quota allocation	[26]
	Small-boat ITQ system	< 10 Gt	Protected quota	[27,28]
	Hook-and-line ITQ system	< 15 m, < 30 Gt, hook and line	Protected quota	[27]
Ireland	Small-scale fleet	< 16.76 m	Quota allocation	[29]
	Inshore fisheries	< 12 m	Management forum 0–6 nm	[30]
Netherlands	No national regulation	None	None	[31]
Norway	Sami Parliament agreement	< 11 m	Protected fishing opportunities	[32]
	Sami Parliament agreement	< 15 m	Protected fishing opportunities	[32]
Poland	Common quota pool	< 8 m demersal/ < 12 m pelagic	Quota allocation	[33,34]
Portugal	Local fleet	< 9 m, < 75 kW, operating near registered ports	Protected fishing opportunities	[35]
Spain	No national regulation	'Minor gears'	Quota allocation	[36]
Sweden	Coastal fleet	< 12 m, passive gear	Quota allocation	[37]
	Coastal fleet	Flexible definition of seven criteria	General	[37]
UK	Under 10 m quota pool	< 10 m	Quota allocation	[38]
EU	Small-scale coastal fleet	< 12 m, excluding towed gear	Data reporting and EMFF funding	[39]
	Small-scale coastal fleet	4 conditions	General	[40]

From a fisheries management perspective there is a lack of data on the environmental impacts of fishing operations for which vessel length is not an effective or realistic proxy. For this reason, there has been greater emphasis on data collection describing small-scale fisheries and on developing frameworks for integrated assessment, for example through the 'Illuminating Hidden Harvests' project (e.g., Garcia et al., 2008; Basurto et al., 2017). This emphasis has led to the identification of a variety of attributes for defining small-scale fisheries, including time commitment, catch rates and the importance of fishing to livelihoods (Smith and Basturto, 2019). Overall, there has been greater attention given to the technical and socio-economic characteristics of fishing activities to provide a broader understanding of fishing groups (e.g., Smith, 1979). Based on the general characteristics of small-scale fisheries identified in the Hidden Harvests report (World Bank, 2012), FAO have been developing a matrix approach for the characterisation of small-scale fisheries based on assigning a value for each characteristic that can be aggregated into a single overall score, allowing for clearer disaggregation between large-scale fisheries and small-scale fisheries (Basurto et al., 2017). The matrix (see Table 3) has been developed from an example used to characterise inland fisheries across characteristics including scale (both vessel and fishing methods), labour and employment, the nature of fishing trips and area, and the disposal of the catch (Funge-Smith, 2018).

13 Source: Davies et al. 2018

Table 3: Scoring matrix to characterise different types of fisheries[14]

Score	0	1	2	3
Indicative gears				
Passive/ no gear	Foraging by hand, traps, pots	Gill nets, baited longlines	Pumped trap ponds	Large fence traps, large river traps/bagnets
Active gear	Cast net, handheld lift net, scoop, spear, baited hook	Seine net, lift net	Large lift net	Actively hauled dredge/trawl net
Mechanization	No mechanization	Battery powered equipment / lanterns	Generator/ engine powered attracting lights	Small power winch/ hauler powered off engine
Vessel				
Size of fishing vessel	No vessel	<4m	>4 m to <8 m	>8 m
Motorized or not	n.a.	No engine	Outboard engine <25 hp	Inboard engine >40 hp
Operations				
Daily trip/multi-day	Occasional foraging	Seasonal fishing, short trips	Regular fishing trips, all-day	Multi-day fishing trip
Fishing area/waterbody type	Seasonal waterbodies, wetlands and small streams, ricefields	Less than ~5 km from shore in permanent rivers, medium waterbodies, wetlands	Large rivers, large waterbodies, reservoirs <500 km^2	Inland seas, large lakes and waterbodies >500 km^2
Storage / preservation				
Refrigeration/ storage	No storage	Insulated box / ice box	Ice hold	Refrigerated hold
Employment / labour				
Labour/ crew	Individual and/or family members	Cooperative group	<2 paid crew	>2 paid crew
Fishing unit/ ownership	Owner/operator	Leased arrangement	Owner	Corporate business
Time commitment	Part-time/occasional	Full-time, but seasonal	Part-time all year	Full-time
Use of catch				
Disposal of catch	Household consumption/barter	Local direct sale at landing site	Sale to local market traders	Sale for export
Utilization of catch, value adding/ preservation	For direct human consumption	Preserved: chilled, fermented, smoked , salted, dried	Frozen, filleted	Factory processed
Integration into economy and/or management system	Informal not integrated (occasional, no fees required)	Integrated (registered/ recognized fisher, untaxed)	Formal integrated (licensed fisher, payment of landing fees /personal taxes)	Formal, integrated (registered, licensed, taxed as a commercial concern)

In contrast with this management-oriented, more instrumental approach to small-scale fisheries, there are others, often fishers and those associated with small-scale fisheries, for whom it is governance rather than management that is the primary concern (e.g., Armitage et al., 2017). The interest amongst this group is in securing the ability of fishers and fisheries-dependent peoples to benefit from the resource in a more just or equitable manner. As a result,

[14] Source: Funge-Smith (2018)

there is a much greater emphasis on highlighting both the extent and importance of small-scale fisheries globally, their contributions to individual and collective wellbeing at the local level as well as coastal economies (e.g., Johnson et al., 2018; Acott et al, 2014; Urquhart and Acott, 2013a) and the 'life mode' of fishers (e.g., Højrup and Schriewer, 2012; Højrup, 2003). This work has contributed to a recognition that small-scale fisheries play a significant role in supporting household and community livelihoods, supporting both income and food security (Kittinger et al, 2013; Funge-Smith, 2018).

The social and economic importance of small-scale fisheries is emphasised in the World Bank's Hidden Harvest (2013) report and in the FAO's (2015) VGSSF. The latter is particularly significant as it represents the first international agreed instrument for the small-scale fisheries sector, the VGSSF describe small-scale fisheries as "*a diverse and dynamic subsector*" that "*tend to be strongly anchored in local communities, reflecting often historic links to adjacent fishery resources, traditions and values, and supporting social cohesion*". The VGSSF acknowledge the multiplier effects of small-scale fisheries to local economies and the role women play in post-harvest and processing activities that have been identified within European fisheries (e.g., MRAG et al., 2016; Zhao et al, 2014; Zhao et al., 2013). Within the UK, the New Under Tens Fishermen's Association (NUTFA) use 'small-scale' to refer to the 10 metre and under fleet. As such, inshore vessels are considered by NUTFA to be a component of the small-scale fleet.

2.5 Inshore

In England, inshore vessels are generally considered to be under 10 metres (m) in length that do not fish against quota allocations managed by fish producer organisations (POs) (Davies et al, 2018; MSEP, 2014). In an Evidence Review of the English Inshore Fisheries sector (2015-2016)[15], length-based threshold was used as a means of defining inshore and groups such as NUTFA continue to refer to inshore vessels as 'under 10s'. While in England the inshore fleet is used for small-scale coastal fisheries (SSCF), European definitions of SSCF include aspects of tonnage, engine power and gear type (Davies et al, 2018). In Portugal, for example, an SSCF vessel is defined by being less than 9m in length, having engine power of less than 75 kilowatts (kw) and operating near registered ports, while vessels in Iceland's coastal fleet are defined by being less 15m in length and having a displacement of less than 30 gross tonnes (Davies et al, 2018).

For Inshore Fisheries and Conservation Authorities (IFCAs) around the coast of England, inshore has a more spatial dimension as it represents waters within six nautical miles of coastal baselines[16]. This spatial characterisation differs in Scotland where inshore is defined as the waters within twelve nautical miles of the coast[17]. There are, however, inconsistencies with this spatial definition. Marine Scotland Science (2014), for example, define inshore as the 0-6 nautical mile area, while JNCC consider inshore to mean waters between the coast and the UK Territorial Sea limit[18].

At a 2019 workshop on the Future of Inshore Fisheries, stakeholders representing the UK fishing industry, research community and government acknowledged that while the use of the 'under 10m' length category was a simple way of defining inshore in the UK, the use of a single criterion to define inshore may no longer be appropriate as smaller vessels become more powerful[19]. Reflecting the discussions at the workshop, Seafish (2019) concluded that there is *"no consistent or overarching definition"* of inshore fisheries in the UK, but *"regional definitions"*

[15] http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=19745
[16] http://www.association-ifca.org.uk/Upload/About/ifca-review-2010-2014.pdf
[17] https://www2.gov.scot/Topics/marine/Sea-Fisheries/InshoreFisheries
[18] https://jncc.gov.uk/our-work/uk-marine-protected-area-network-statistics/
[19] https://seafish.org/media/Inshore_Fisheries_Issues_&_Ideas_Workshop_Report.pdf

that include the target species, type of gear used and distance from shore[20]. This finding mirrors conclusions made in the 2015-2016 evidence review[21] that, as different actors and groups across the UK hold different perspectives on what comprises inshore, defining inshore is problematic.

With the majority of inshore vessels skipper-owned, the UK's inshore fleet uses a variety of different fishing gears and encompasses netters, potters/creelers, dredgers and trawlers as well as line fishing amongst others (e.g., Nightingale, 2013). In the UK, inshore fishing is recognised as playing an important role in providing employment and income to coastal communities. For these communities, the direct impacts of inshore fishing are social and cultural, as well as economic (e.g., Reed et al., 2013; Urquhart and Acott, 2014; Urquhart and Acott, 2013b). Participants at the 2019 workshop on the Future of Inshore Fisheries suggested that, moving forward, local or regional fisheries should have the capacity to define themselves as inshore or offshore, and that the definition *"should go beyond the physical characteristics of a vessel, and instead look at social, environmental and economic impacts"*.

2.6 Artisanal

While the FAO describe artisanal fisheries as "*traditional fisheries*" that involve "*fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption*"[22], Rousseau et al. (2019) argue that there is no globally agreed definition of artisanal fisheries. As exemplified by the FAO definition, a number of different terms are used interchangeably to refer to artisanal fisheries such as 'traditional', 'small-scale' and 'coastal'. The EU fishing fleet operating in the Indian Ocean, for example, refer to their artisanal fleet as 'coastal' and characterise these vessels as those less than 12m in overall length (LOA). The FAO recognise, however, that artisanal fisheries may comprise of 20m trawlers, long-liners or seiners and be commercial fisheries providing seafood for export[23]. As the meaning of each of these terms varies between countries and regions, the proportion of global catch estimates by the artisanal sector varies accordingly; from 25% to 50% (Rousseau et al., 2019).

The 'artisanal' category encapsulates a substantial range of different technical and economic characteristics, market niches, and fishing power and, in the Western Mediterranean, play an important role in the social and economic sector (Forcada et al., 2010). It is these aspects of links to local markets that ae often highlighted, e.g., in the UK Fisheries White Paper. With similarities to small-scale fisheries, Rosseau et al. (2019) argue that defining artisanal is dependent on the specific objectives of classification and should be done on a case-specific basis. In terms of impact, this category of definitions tends to highlight the social and economic benefits and links to local communities (e.g., García-Flórez et al., 2014). This is also the case in the UK Fisheries White Paper, where there is reference to of "*artisan fishers with close ties to their coastal communities*".

2.7 Ethical

Many of the terms used to define the impact of fishing tend to focus on environmental issues, with less concern for social impacts and implications. Ethics, as it applies to fisheries, however, is based around the understanding that fisheries, fishing rights and fisheries policies can have a significant effect on both the ecosystems exploited and the communities and living conditions of those that rely on these resources (Lam and Pitcher, 2012; FAO, 2005). In 2005 the FAO

[20] https://seafish.org/media/Inshore_Fisheries_Issues_&_Ideas_Workshop_Report.pdf
[21] http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19745
[22] www.fao.org/family-farming/detail/en/c/335263/
[23] www.fao.org/family-farming/detail/en/c/335263/

published the latest in its 'Ethics in Fisheries' series: Ethical issues in fisheries #4. This contained a framework for defining fisheries ethics that assessed seven components of the fisheries sector (the ecosystem, fish stocks, fisheries, fishers and their communities, other stakeholders, consumers and politicians) against three principles of ethics (welfare, freedom and justice). Many of the environmental aspects of this framework are mirrored in the UK's 25 YEP, but implicit are social considerations as well. For example, one of the 25 YEP's core tenets is to "*leave that environment in a better state than we found it and pass on to the next generation a natural environment protected and enhanced for the future*".

Since 2006 the conversation around fisheries ethics has placed a greater emphasis on workers' rights and abuses, including modern slavery and human trafficking, which has gained significant media attention since 2014[24]. Following this, in 2015, the UK passed the Modern Slavery Act, which requires that companies report efforts to eradicate slavery and other abuses within their supply chains. As a result of this pressure, ethics has becoming a significant issue in downstream fishery supply chains, for example in the standards for seafood ecolabels. As part of the focus on ethics, there has been greater attention in recent years on incorporating social issues. This can be seen in both Seafish's Tools for Ethical Seafood Sourcing (TESS), and the Ethical Trade Initiative's (ETI) nine-point "*Base code*" as well as amongst companies in the supply chain. For example, Sole of discretion presents itself as an 'ethical fishmonger'. For the purposes of comparing across definitions, it is the criteria laid out by the FAO (FAO, 2005), which includes these social issues and their modes of impact, that will be used to define 'ethics' as it applies to fishing and fisheries. Animal welfare is also emerging as an ethical issue in both recreational and commercial fisheries and can be expected to receive more attention in coming years and within the next reform of the CFP (e.g., Browman et al., 2018).

2.8 Marine stewardship

Environmental stewardship can be defined as striving for the best options for mitigating human impacts on ecosystems (Peachey, 2008). For UK government bodies such as Natural England, environmental stewardship embodies a sense of '*looking after*'[25], while the UK government's 25 YEP refers to acts of stewardship as initiatives that protect and improve cultural heritage and the natural world. This concept of stewardship is used by inshore and recreational fishers in the marine environment. The Low Impact Fishers of Europe (LIFE), for example, describe their membership as "*good stewards of the environment*" who use low impact, selective fishing gear to minimise environmental impacts[26]. The idea of fishers as stewards of the marine environment is formalised in the Marine Stewardship Council (MSC) ecolabel. The MSC link marine stewardship with sustainability as its ecolabel or 'blue tick' is applied to produce that is certified to the MSC Standard. The Standard measures sustainability by considering three principles: the sustainability of fish stocks, low ecosystem impacts and effective management[27]. These principles are the criteria that were developed to assess fisheries are based on the FAO CCRF. The principles and criteria are used to assess fisheries and implicitly define sustainability and stewardship, the MSC's three principles predominately give focus to minimising environmental impacts.

2.9 Environmentally friendly

Concern about the environmental impact of fishing has increased in recent years (e.g., Hall, 1999), in particular regarding the impact of fishing on fish populations in the form of 'growth' and 'recruitment' overfishing (e.g., King, 1995). While fishing can have a number of other impacts on the environment, some of the first specific concerns were in response to concerns

[24] https://www.seafish.org/article/why-social-responsibility-matters
[25] http://adlib.everysite.co.uk/resources/000/262/582/NE226.pdf
[26] https://lifeplatform.eu/our-mission/
[27] https://www.msc.org/standards-and-certification/fisheries-standard

about by-catch in tuna fisheries in the 1980s. The initial concern was with yellowfin tuna fisheries in the Eastern Tropical Pacific Ocean, where dolphins are known to associate with tuna and where dolphins had been killed or injured during the capture of tuna using purse seines (Washington and Ababouch, 2011). Wider concerns about the sustainability of seafood supplies have created incentives to identify the most sustainable sources and this has resulted in specific examples of ‘friendliness’, such as the dolphin friendly tuna or mangrove friendly shrimp production (e.g., Yap, 2002) as well as broader examples such as ‘climate friendly’ fisheries (e.g., Seas at Risk and North Sea Foundation, nd), ‘environmentally friendly’ or ‘environmentally responsible’ (Elson et al., 2010). Across all these examples, the primary concern has been for the impact of fishing on the fish stocks and wider environment, with less immediate concern for the social and economic impacts.

2.10 Catch and release

Recreational fishing, and in particular angling, is a popular pastime worldwide (Arlinghaus and Cooke, 2009; Brownscombe at al., 2016; Hyder *et al*., 2017), with a recognised potential to significantly impact certain fish stocks (e.g., Arlinghaus at al., 2007) as well as the wider environment, for example through litter and bait-digging (e.g., Lewin et al., 2006). Various methods are employed by recreational fishers to reduce the wider environmental impact of recreational fishing, including the Anglers National Line Recycling Scheme[28], set up to recycle recreational fishing line, and the Angling Trust’s Take 5 Campaign[29], where anglers are encouraged to remove five items of litter when they finish fishing. To address the direct impacts on fish stocks, catch and release is increasingly deployed and promoted as a management measure and conservation technique (Brownscombe at al., 2016). This refers to the capture of fish by hook and line (i.e., recreational angling), and the subsequent release of the fish back into the waterbody; alive (Arlinghaus at al., 2007). Global estimates put the live release of all recreationally caught fishes at around 64% (Cooke and Cowx, 2004; Ferter *et al*., 2013). However, some post-release mortality, injury and stress is considered unavoidable and the success of this strategy depends largely on post release survival and fitness (Cowx et al., 2017). The potential impact of this is highlighted by various case studies investigated by Cook et al. (2016), which showed that even low levels of post release mortality may impede the recovery of particular threatened species.

There are several factors that can affect post release mortality rates and that, therefore, need considered when assessing the potential impact of a catch and release programme. These factors, including gear type, fish handling, biological characteristics, environmental conditions, fisher behaviour, data collection and use to inform management, *et cetera*. (Halttunen *et al*., 2010; Cooke *et al*., 2013; Weltersbach *et al*., 2013; Mandelman *et al*., 2014; Ferter *et al*., 2015; Capizzano *et al*., 2016; Lewin *et al*., 2018). Research by High and Meyer (2014), for example, found that hook type and fishing method had a significant effect no trout mortality; “*relative mortality rate was higher for trout captured with baited J hooks (25%) and spinners (29%) than for trout captured with baited circle hooks (7%) and dry flies (4%)*”. While Wilkie et al. (1996) found that post release mortality of Atlantic salmon (*Salmo salar*) increased with water temperature; zero mortality at 6°c but 40% motility at 22°c. At a national level, Lewin et al (2018) found that “*depending on country-specific angling practices*” post release mortality rates of European sea bass (*Dicentrarchus labrax*) ranged from 2.8% to 9.1%. Therefore, a better understanding of these factors will aid in the design of more effective catch-and-release techniques, that could minimis the stress, injury and mortality of the fish involved (Cooke and Schramm, 2007; Capizzano *et al*., 2016; Pinder at al., 2017). This could help to address some of the ethical, welfare, related issues with catch and release fishing, where any stress induced is seen by some as unnecessary suffering (Browman et al., 2019). Improved survival rates

[28] https://www.anglers-nlrs.co.uk/
[29] https://www.anglingtrust.net/page.asp?section=1773&sectionTitle=Take+5

also align with several of the goals set out in the UK's 25 YEP, including "*Thriving plants and wildlife*" and "*Using resources from nature more sustainably and efficiently*".

2.11 Summary of impacts

Table 4 highlights the different types of impacts that have been identified in the literature as associated with the reviewed definitions. Deemed to be most relevant, these definitions have been identified through a review of policy documents, academic literature and organisational statements. While there is no overarching definition for 'Inshore', 'Marine Stewardship' is defined by the MSC's three principles for measuring sustainability. 'Ethical' is defined using FAO criteria in the Ethics in Fisheries series; issue 4, and the FAO's Code of Conduct for Responsible Fishing (CCRF) is used to interpret 'Responsible'. A statement put forward by Arlinghaus et al (2007) is used to define 'Catch and Release', while 'Sustainable' is understood to be the ability of a fishery management system to rebuild and maintain stocks and improve ecosystem health and resilience, as outlined in the Fisheries White Paper. Furthermore, this study employs the FAO's definition of 'Artisanal', draws on LIFE and the NFFO's description of 'Low Impact' and uses the VGSSF to define 'Small-Scale'. As seen in Table 4, associated environmental and socio-economic impacts are identified across these definitions and are presented to showcase overlaps and differences between types of impacts and the definitions.

While it is in part likely to reflect the particular definitions selected for the comparative analysis, from the review, the evidence in Table 4 suggests that most of the definitions consider only the impacts in relation to the fishing activity. There is less attention paid to wider impacts, such as who ultimately benefits from the allocation of resources or issues associated with supply chains and consumption, including food miles, use efficiencies and food waste. Finally, it is interesting to note that within fisheries, there is a high degree of emphasis on environmental impacts and less on fish welfare. This is in contrast to many other forms of animal protein production where the focus tends to be limited to issues of animal welfare and food quality (e.g., MRAG et al 2016).

Table 4: Summary of the types of impacts identified across the definitions from the literature

Definition	Environmental Criteria									Socio-Economic Criteria				
	Direct				Indirect		Habitats			Direct			Indirect	
	Target stock population	Fish Bycatch	Genetic	Fish Welfare	Bycatch (other marine organisms)	Ghost Fishing	Benthos	Plastics / Pollution	Fuel use / Greenhouse Gases	Income	Food	Employment	Cultural	Human Rights
Low Impact	x	x			x	x	x		x	x		x	x	
Sustainable	x	x			x		x							
Responsible	x			x		x	x	x	x					x
Small Scale	x	x			x		x		x		x	x	x	x
Inshore														
Artisanal	x	x			x		x		x	x	x	x	x	
Ethical	x	x	x	x	x		x	x	x	x	x	x	x	x
Marine Stewardship	x	x			x	x	x							
Environmentally Friendly	x			x										
Catch and Release	x			x										

What is clear from Table 4 is that the majority of the definitions focus on the environmental impacts of fishing and fisheries, in particular related to the target stock. This is unsurprising as fisheries ecology is often the starting point for framing what is desirable or not within fisheries management, often with reference to management concepts of sustainability (e.g., Arthur et al., 2016). Notable exceptions are ‘ethical’, ‘artisanal’ and ‘small-scale’ fishing where the definitions instead highlight the social and economic contributions, often at the local scale, including the contributions to coastal communities.

In the next section we have examined how these definitions were developed and sought to assess whether the different processes might account for the differences in impacts included (or not) for each.

3 Developing definitions related to low impact fishing.

The extent to stakeholder engagement and participation in the development of each of the selected definition is illustrated in Table 5. In this table, criteria for assessing participation at different stages of the development of the definition were developed based on the approach of Reed (2008).

On reviewing the selected definitions, it was unclear how some of them came about e.g. ‘Inshore’ and these were not considered in this analysis. For others, e.g. ‘small-scale’ the process of developing some selected definitions involved more systematic stakeholder representation. For others, however, input was restricted to a more limited set of stakeholders. For example, in the process of defining ‘Low Impact’, participation was limited to fisher groups.

Table 5 also outlines opportunities for knowledge sharing in the development of each definition and the extent of co-ownership of each definition. The definition of ‘Marine Stewardship’ held by the MSC is, for example, informed by expert groups, the development and application of this particular definition is relatively ‘top down’ in nature, while a more ‘bottom up’ process has been undertaken in the process of defining ‘small-scale’. Table 5 therefore showcases that each term has been defined in a different way.

Table 5: Summary, for each definition, of the process by which each were defined, including the extent of stakeholder engagement and participation

Definition	Systematic stakeholder representation	Opportunities for knowledge sharing	Co-ownership
Low Impact	Participation was achieved via the European Artisanal Fishermen’s Congress in 2012. Participation was limited to fisher groups.	The Artisanal Fishermen’s Congress enabled fishers from across Europe to come together, share experiences and discuss challenges. Discussions focussed on how to improve representation and the situation of low impact fishers[30].	LIFE is run by fishers for fishers. Members pledge support to LIFE’s Common Declaration and Mission Statement, which sets out the organisation’s ethos, objectives and aims.
Responsible	Development of the FAO CCRF carried out in consultation with UN Agencies and international organisations included NGOs[31]. The General Principles of the CCRF were reviewed by an informal Working Group of Government nominated experts.	Drafts of the CCFR were circulated to FAO Members, Associate Members, intergovernmental and no-governmental organisations for comment. The second version of the General Principles was subjected to informal consultation with NGOs. Draft text of Code reviewed by Working Group.	Individuals and organisations involved in the development of the CCRF have co-ownership over the definition.
Small Scale	Development of the SSF Guidelines	Based on the recommendations of the	Individuals and organisations,

[30] https://www.seafish.org/media/1327198/clg_nov2014_lowimpactfishersofeurope.pdf
[31] http://www.fao.org/3/v9878e/V9878E.pdf

Definition	Systematic stakeholder representation	Opportunities for knowledge sharing	Co-ownership
	involved participation from a range of stakeholders including governments, researchers, fish workers and their organisations, development partners, civil society organisations and small-scale fishers[32]. The FAO held three regional workshops and undertook regional stakeholder consultations as part of the development process.	Twenty-ninth and Thirtieth Sessions of the FAO Committee on Fisheries, the SSF Guidelines are described as a product "*of a bottom up participatory development process*"[33]. Fishers and fish workers provided input by describing how livelihoods along the small-scale fisheries value chain could be sustainable[34] and regional workshops served to "*identify good practices in the governance of small-scale fisheries*" and to discuss how these practices could be achieved[35].	including FAO members, involved in the development of the SSF Guidelines have co-ownership over the definition.
Marine Stewardship	MSC Standard defined through meetings with key stakeholders including "*scientists, activists, industry representatives, policy makers*"[36].	Opportunities for knowledge sharing limited to invited stakeholders. These stakeholders "*shared a common understanding of the issues in fishing in their individual, rather than organisational capacities*"[37]. Focus given to identifying indicators in line with the CCRF.	Invited stakeholders described as "*a representative group of experts*" co-own the MSC's "*foundational 'Principles and Criteria for Sustainable Fishing'*"[38].

A comparison of Table 5 with Table 4 suggests that the nature of the process for defining the terms gives rise to different types of impacts being highlighted. For example, 'bottom up' approaches to developing selected definitions also recognise, to a greater extent, the social and economic values and benefits of fisheries. On the other hand, more 'top down' processes appear to have a more limited environmental agenda, with less emphasis on socio-economic criteria.

[32] http://www.fao.org/3/a-i4356en.pdf
[33] http://www.fao.org/3/a-i4356en.pdf
[34] www.fao.org/voluntary-guidelines-small-scale-fisheries/en/
[35] http://www.fao.org/voluntary-guidelines-small-scale-fisheries/background/en/
[36] http://20-years.msc.org/#two-the-msc-is-born-32155
[37] http://20-years.msc.org/#two-the-msc-is-born-32155
[38] http://20-years.msc.org/#two-the-msc-is-born-32155

3.1 Environmental impacts of fishing

As Table 4 indicates, there are a number of environmental impacts of fishing that are addressed within the different definitions. In the next section we examine the evidence base associated with these impact categories to see how they relate to fishing activities in the UK. In the following sections we highlight some of the types of environmental impacts that are associated with fishing and fisheries, together with differences in impacts that may arise from different fishing operations, for example gears, species targeted, and habitats fished. The section ends by summarising the available evidence and highlighting any evidence gaps that could be the focus for future research.

3.1.1 UK fishing fleet

Fish and shellfish species caught in English fisheries are caught using several different fishing techniques including pots, nets, hooks, and trawls. For certain species they can be caught by multiple gears which use different amounts of energy (fuel) and have differing impacts on the target and non-target species and wider marine ecosystem. The impacts of fishing gears on seabed ecosystems are a central component in ecosystem-based fisheries management and the ecosystem approach to fisheries management and a key consideration in the development of management measures and byelaws for Marine Conservation Zones (MCZs) and other Marine Protected Areas (MPAs)[39].

Figure 2 below shows the range of fishing gears used by the UK fleet. The main distinction is between active and passive gears. Active gears include trawls and dredges which are towed, whereas passive gears are those which are fixed or drift (these include fixed nets, drift nets, pots and traps as well as hook and lines). The selectivity, survivability of non-target catches, fuel use and impacts on the seabed are the main distinctions between active and passive gears, with active gears having a higher environmental impact. In general terms, pots and traps are used in shellfish fisheries (e.g., crab, lobster, whelk) as are dredges (scallops), whereas nets, hook and line and trawls are used in finfish fisheries, whether demersal (seabed e.g., cod or sole) or pelagic (water column – e.g., mackerel or herring).

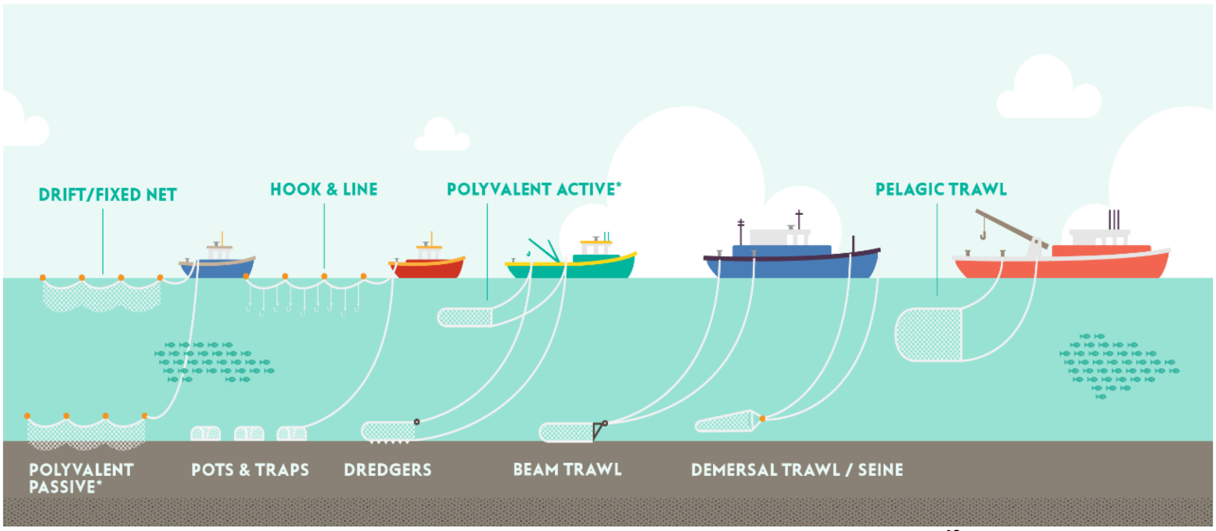

Figure 2: UK fishing gears in the Data Collection Framework classification[40]

Many species can be caught by either active or passive gears. For example, Nephrops (langoustine) are caught by trawls as well as creels (pots). The rates of bycatches, and seabed impacts are very different for these two fisheries (Williams and Carpenter, 2016). The same is

[39] https://neweconomics.org/uploads/files/Griffin-Nephrops-latest.pdf
[40] Source: Carpenter, 2017

true of cod, where trawls and nets both catch cod in the North Sea and these gears also have different environmental impacts, from fuel use to bycatch (Esteban and Crilly, 2013).

Beyond simple distinctions between active (mobile) and passive (static) gear, the configuration of gears, their footprint and the mesh sizes and panels used also mean there are distinctions between similar gear types, which also determine their impact. These are further complicated by both the fishery (mixed or single species) and the location (grounds / habitat) where the fishing takes place as well as other factors, e.g., how the gear is towed, the weight of the gear etc. For example, Figure 3 below shows schematics of how towed demersal mobile gear (trawls, seines and dredges) behave in the water, thus indicating the 'footprint' (or area of contact with the seabed) of the different gears (Eigaard et al, 2015). The impacts of these different gears have been estimated alongside the respective footprints for the North Sea and North Western waters. Some trawlers are 'twin rig' doubling the footprint and some scallop dredgers can tow up to 18 dredges a side.

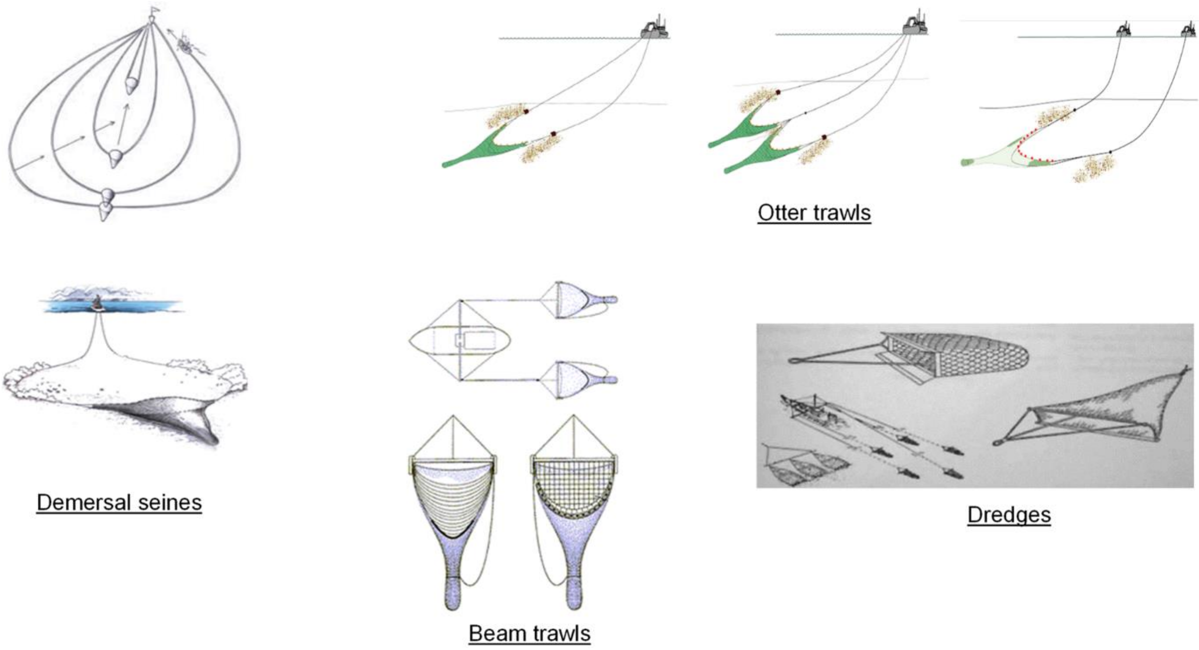

Figure 3: Towing principles of the four main high-impact demersal gear groups identified: demersal seines (left), otter trawls (top right), dredges (bottom right), and beam trawls (centre, bottom)[41]

3.1.2 Impact Category

Within this section we will examine the evidence around the impacts of different types of fishing activity. The terms listed below have been developed using the NEF Waterloo Briefing - Defining criteria for low-impact fisheries in the UK (Annex 1), and a broader review of the available literature.

3.1.2.1 **Target stock population**

Fishing causes mortality of the target species and stock. Fishing mortality is a primary concern of fisheries scientists and managers with concern about both growth and recruitment overfishing (e.g., Hoggath et al., 2006). Fishing during particular seasons and in particular

[41] Illustrations from FAO: http://www.fao.org/fishery/geartype/search/en

areas can damage a fish stock when it is reproducing. This leads to lower fish populations than would result from the fishing activity itself (Van Overzee and Rijnsdorp, 2014).

Removal of mature individuals from the spawning stock biomass (SSB) and excessive overall fishing induced mortality can affect future recruitment to the fishery. This is also an issue in MRF, where larger specimens may be specifically targeted, potentially increasing mortality among those individuals that are generally greater contributors to egg production (Shiffman et al, 2014). Even at lower levels of fishing it is suggested that there can be effects on the stock, for example changes in size at maturity (e.g., Hunter et al., 2015). However, the evidence base for fisheries induced evolution remains low, and it has not been conclusively proven (e.g., Heino et al. 2015). There are also differences of opinion regarding the effects of harvesting small fish (e.g., Kolding and van Zwieten, 2014). This issue is further complicated when there are multispecies fisheries and where wider ecosystem impacts need to be considered. Under such conditions, debates arise about the relative balance of mortality across size, species and trophic level (e.g., Kolding et al, 2015; Froese et al., 2015; Garcia et al., 2012; Garcia et al., 2005).

Recreational impacts

In general, the impacts of marine recreational fisheries (MRF) on fish stocks and ecosystems are primarily driven by the high number of participants distributed around the coast. Due to the high number of participant retaining fish from the ecosystem, regionally the total biomass removal from recreational fisheries can reach or exceed the commercial catch in some fisheries. Thereby, anglers prefer to catch often certain species, in particular large predatory fish of high trophic level – thus show high size-selectivity. The main species for recreational anglers in the North Sea and North Atlantic area are Atlantic cod (*Gadus morhua*), European seabass (*Dicentrarchus labrax*), and pollack (*Pollachius pollachius*) (Lewin et al., 2019).

Recreational fishers tent to target larger, ‘prize’, fish, which can have both direct and indirect impacts on the stocks. Hence, the biomass removal is not equal over the population and larger/older fish are over-proportionally removed from the stock (Shiffman et al, 2014). This can have a particularly large impact on the reproductive potential of many fish populations as the larger, more fecund, fish are preferentially removed. Additionally, size-selective MRF can decrease the natural length range of the stock as well as impact the life history traits and demography of the stock due the correlation between size and age, sex, fecundity and egg size. Therefore, the size-selectivity of MRF can reduce the resilience of the exploited marine fish population to pressure caused either by human activity or environmental changes. Moreover, due to MRF’s selectivity, certain life history traits that affect catchability and discard survivability by some gear types may be selected for. Removing the larger fish from the food web can lead to changes in the ecosystem due to prey-predator relationships. However, these changes are rather indirect and more difficult to measure due to being subject of the fish community composition, habitat structure, and environmental conditions.

Recreational fisheries have high participation rates globally, can contribute to a large proportion of the total catches from several stocks (Radford *et al*., 2018) and have substantial socioeconomic impacts. Despite this, MRF is rarely explicitly featured in fisheries management plans or governance structures. In countries where MRF is recognised as a sector the definition of MRF often varies depending on the context (e.g. legal and scientific definitions differ) and between countries; for example, Norwegian recreational fishers can sell a portion of their catch whereas this is illegal semi-subsistence fishing in other nations. Recreational fisheries have also been shown to compete with coastal small-scale fisheries as these fisheries have access to, and target, similar species. Moreover, there are known cases of fish caught recreationally being sold illegally (Potts et al, 2019). MRF also overlaps with subsistence and artisanal fisheries, an effect further exacerbated in countries such as Norway where the sale of a portion recreational catch is permitted for recreational fishers, thus blurring the line between those and commercial fishing even further (Freire et al, 2020).

3.1.2.2 **Bycatch**

Bycatches[42] are those species not being targeted but caught incidentally in the fishery. This includes both unwanted examples of target species (e.g., undersized) as well as catch of other, non-target, species. Bycatch, and associated discard rates, will vary depending on season, fishing areas and across gears types. Depending on survivability when discarded this will affect fishing mortality.

Although, reliable data is limited, it is thought that due to the high selectivity of the gear used in MRF, the bycatch from recreational fishing is considered to be low – in particular compared to commercial fisheries. Indeed, it is argued that recreational fisheries have very limited bycatch, as many anglers are happy catching fish, irrespective of species or size. However, some post-release mortality cannot be ruled out which is a particular issue for protected and endangered species (e.g., some shark or skate species).

Recreational impacts

Catch-and-release fishing, where fish are caught and subsequently released alive back into the water, is usually a voluntary conservation action but some MRF management measures employed require recreational fishers to release fish, inflating discard rates. Adoption of catch-and-release based management measures is becoming more common despite the increasing evidence for both a lethal (i.e. post-release mortality) and sub-lethal (e.g. energy consumption) effect of catch-and-release on fish. Further, various case studies investigated by Cook et al (2016) showed even low levels of post release mortality may impede the recovery of particular threatened species.

Although, reliable data is missing, it is assumed that due to the high selectivity of the gear used in MRF, the bycatch is rather low – in particular compared to commercial fisheries. However, some post-release mortality cannot be ruled out. This can be a substantial conservation issue for protected and endangered species (e.g. some shark or skate species), which are often targeted by MRF. Additionally, there are indications that recreational rod and line anglers may catch seabirds if natural baits are used where birds are foraging. Of more importance, however, is the disturbance and stress created for marine birds and mammal by boat-based MRF due to noise, collisions and wave production. In shallow waters, boats can further affect the marine fauna and flora by increased sediments and nutrient resuspension of the propeller or damaging the habitat by mooring and therewith have a knock-on impact on the local ecosystem as far as destroying seagrass beds or coral reefs (Lewin et al., 2019).

3.1.2.3 **Bycatch of other marine life**

This represents the unintended capture of marine wildlife such as dolphins, birds, turtles or seals. This can injure or kill the captured wildlife which, in some instances, may represent endangered species. Both mobile and passive gear can do this, for instance cetaceans caught in (active) pair trawls in the bass fishery have been documented by UK vessels (which were then banned) and in the French bass and hake fishery in the Bay of Biscay. Seabird bycatch was noted in the passive drift net fishery for bass in the English Channel as this was undertaken at night and birds became entangled in the nets.

Additionally, in MRF there are indications that where natural baits are used in proximity to foraging birds some incidental catch and mortality may occur. Of more importance to seabirds and marine mammals, however, is the disturbance and stress generated by boat-based MRF due to noise, collisions and wave production.

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[42] "*Discarded catch and incidental catch"* - Hall, S.J. (1999) The effects of fishing on marine ecosystems and communities.

3.1.2.4 **Ghost Fishing**

Abandoned Lost or otherwise Discarded Fishing Gear (ALDFG) in the aquatic environment can continue to operate or to entangle fish, causing mortality. This is called ‘ghost fishing’ and is more common, and deadly (Kaiser, 2014), among passive gears (e.g., lost pots, fixed and drift nets) rather than mobile gears (e.g., dredges and trawls). Mobile gears, which tend to be more expensive than passive ones, are often associated with attempted recover using a creep (e.g., Richardson et al., 2019), in cases where loss is accidental. It was shown that water birds ate artificial baits lost during MRF as they were mistaken as food, while birds and marine mammals got entangled in lost fishing lines and can be injured by hooks.

There is limited analysis the regarding global losses of fishing gear, the most common estimate is approximately 640,000 metric ton per year (Macfadyen et al. 2009). However, this figure is an extrapolation from a 1975 report (US Academy of Sciences, 1975). This, combined with the fact that survey efforts for ALDFG are often poor or sporadic, means that the current understanding of the volume of loss, and the issue of entanglement, is poor (Jepsen and de Bruyn, 2019; Pawson, 2003; Stelfox et al. 2016).

3.1.2.5 **Seabed impacts**

As shown above, and presented in detail by Eigaard et al (2015), different fishing gears have different impacts on the seabed. These range from almost none (rod and line fishing where only a weight may be in contact with the seabed, through to scallop dredging where the seabed is repeatedly raked. In addition, some habitats may be particularly sensitive to damage and others less so. In particular, Essential Fish Habitats (EFH), for example kelp forests, can be damaged through the interaction with certain fishing gear (such as bottom towed gears) reducing their ability to support the reproducing, growth and feeding of fish populations. This can lead to lower fish populations and a loss of biodiversity, species composition and habitat complexity (Kaiser et al; 2003, Puig et al. 2012). The nature of the impact will depend on the weight of the gear, the surface area interacting with the seabed, the speed of tow and sensitivity of the habitat. For example, an area of ground which is regularly fished by heavy towed gear would experience less damage than a pristine seabed. In shallow waters, which is often a feature of MRF, boats can further affect marine fauna and flora by increasing sediment and nutrient resuspension, or by damaging habitat structure through mooring, with knock-on impacts to local ecosystems, potentially destroying seagrass beds or coral reefs.

Recreational impacts (bait collection)

Specific to MRF is the impact caused via bait collection. If intensive bait collection is conducted in sensitive habitats such as the intertidal region, crucial forage habitats can be damaged and degraded, reducing their ability to provided ecosystem services. For example, intensive bait collection can impact the invertebrate community which often acts as a crucial food source for other species, which could trigger impacts to cascade down along food chain. Additionally, constant bait digging may add to coastal pollution, releasing lead and cadmium from the sediment into the benthic system. The global trade in live bait also increases the risk of the release of invasive species.

Another important environmental impact of MRF is bait collection. If intensive bait collection is conducted in sensitive habitats, such as intertidal regions, crucial habitats could be damaged hampering their ability to provide essential ecosystem services. In addition, intensive bait collection can substantially lower the abundance of essential prey species, which has a knock-on effect of lower food availability for other predatory fish. Therewith, wider impacts cascading down the food web can be triggered. Moreover, constant bait digging may add to coastal pollution by releasing lead and cadmium from the sediments into the benthic system. Live bait is often traded world-wide and could therefore increase the introduction of non-native species in the local ecosystem.

Apart from natural baits, another environmental impact is the loss of gear or artificial baits into the marine ecosystem. In particular, some of the artificial baits contain lead which is a toxic heavy metal and can cause harm to plants, birds, mammals and humans. Furthermore, lost artificial lures are known to be mistaken for food by foraging seabirds, which can be lethal due to the large hooks present.

3.1.2.6 **Pollution (plastics, chemical, etc)**

Fishing activity is one of the main contributors to ocean-based plastics globally, along with other nautical activities and aquaculture (Lebreton et al. 2018; Sheavly, 2007). Collection and recycling of fishing gear is necessary to reduce plastic pollution. Marine plastics in the form of fishing line or nets can also harm marine wildlife, through entanglement, suffocation or ingestion. Lost fishing line and rigs in recreational fisheries is a frequent occurrence. Once lost, ultraviolet (UV) radiation, wind, currents and other factors break plastics into smaller particles (micro- and nano-plastics) which can be ingested by marine species and accumulate in the food web over time. Floating plastic can also spread marine bacteria which can be harmful to marine ecosystems.

The loss of gear from MRF in the marine ecosystem can also have an environmental impact. In particular, some of the artificial baits contain lead which is a toxic heavy metal and can cause harm to plants, birds, mammals and humans.

3.1.2.7 **Greenhouse gas emissions**

Fuel use from fishing generates greenhouse gas emissions, which contribute to climate change. (Crilly and Esteban, 2013; Williams and Carpenter, 2016; Parker et al., 2018).

3.1.2.8 **Animal welfare**

Growth of commercial aquaculture practices meant that welfare issues previously associated with terrestrial farming began to be discussed in relation to aquatic animals, first in relation to aquaculture and then capture fisheries (Diggles et al., 2011). The emergence of fish welfare as a more mainstream issue, however, has emerged in particular following the Dutch pulse trawl ban, where coverage in the media balanced concerns over fish welfare with those of wider environmental impacts. This highlights the growing weight behind animal welfare considerations in the debate over gear use (e.g., De Haan et al., 2016) and the increasing appearance of fish welfare issues raised in relation to the ‘social licence’ to operate (e.g., Hampton and Teh-White, 2019).

The way in which target species are caught, handled and dispatched (and the speed at which that happens) needs to be considered as an animal welfare impact (Browman et al., 2019). This includes both recreational and commercial fisheries, but also extends past capture to the onward supply chain in some cases, where animals are caught, sold and transported live. Current European legislation does not contain specific requirements for live storage of lobsters and therefore, in many cases these decisions are often made by food business operators (Coppola et al., 2019). This raises questions as to whether the welfare needs of decapod crustaceans (i.e., crabs and lobsters) are being met while in storage or transport. This is an issue that is likely to gain further attention, given the evidence that decapods exhibit the “*neuroanatomical, pharmacological and behavioural criteria that are consistent with a pain response*” (Rowe, 2018). Indeed, there have been calls for more humane care for these animals (Elwood, 2019), and to conduct further research into welfare research, throughout the supply chain (Carder, 2017). Annex 2 presents a matrix of fishing gears and their animal welfare impacts by gear type, as an example of how different gears have different impacts on animal welfare of the target species (from Carpenter, 2019).

3.1.3 Evidence base for environmental impact

The environmental impacts discussed above have been studied to varying degrees. As a result of this, there are differences in the amount of evidence (in terms of number of studies), and consistency of findings. Table 6 (below) summarises, for each type of impact, the extent of the evidence base, consistency and the key gaps in the current understanding that remain to be addressed.

Table 6: Summary of the evidence base relating to the environmental impacts of fishing

Criteria	Existing evidence base (L/M/S)	Consistency of evidence (Consistent/ inconsistent)	Identified evidence gap
Target stock population	Large	Consistent	Lack indicators for impact in the context of mixed fisheries. There is also a knowledge gap around "*understanding the nature of phenotypic changes in exploited fish populations*" (Heino and Diekmann, 2009) and the possible evolutionary implications of alternative harvesting patterns.
By-catch	Large	Consistent	There is a large body of work on by-catch issues and mitigation measures. One area where there is less evidence concerns the effect of displacement on bycatch rates.
Bycatch (other marine life)	Large	Consistent	There are relatively few published estimates of the scale bycatch in many marine mammal populations and groups (Read et al., 2006). There is also a reporting bias, and a lack of data on sex, age and provenance of bycatch which makes it difficult to identify areas, fisheries and fishing techniques that are likely, or more likely, to result in population level impacts (Gianuca et al., 2017)
Ghost Fishing	Medium	Consistent	There is a lack of published data on ALDFG worldwide, and often a reporting bias due to higher effort in some areas (Richardson et al. 2019). Similarly, there is a need for greater understanding of how different types of gear fish when they have been lost to inform appropriate indicators.
Seabed impact	Large	Inconsistent	While there is evidence that fishing activity affects seabeds, there is currently some inconsistency as to where and when this can be considered harmful.
Plastic / pollution	Large	Consistent	There is a good deal of evidence to suggest that pollution should be minimised. Recent attention to plastics in the ocean has highlighted the hazard that this may pose, although the toxicological effect on humans and other biota is not yet well understood (e.g., Xanthos and Walker, 2017; Rezania at al., 2018)
Fuel use / greenhouse gasses	Small	Consistent	Food production accounts for approximately a quarter of anthropogenic greenhouse gas (GHG) emissions worldwide. However, fisheries are typically excluded from global assessments, or included as rough estimates. There is, therefore, a significant gap surrounding the level of GHG emissions from fisheries and how this varies between fishing techniques (Parker et al., 2019)
Fish welfare	Small	Consistent	While it has received some attention, there is still a lack of evidence of welfare impacts across fishing different techniques and activities.

It is clear from Table 6 (above) that, although there are still significant gaps in the scientific understanding of these impact categories, in general, there is a significant quantity of scientific literature available on each. Indeed, there is enough evidence to suggest that each represents a mode of impact on the environment brought on by fishing, which, depending on a number of factors (e.g., species, habitats, gear type; see section on impact categories above), can be significant.

4 Conclusions

The review of the literature highlighted a number of issues relevant to the definition of ‘low impact’. In the first instance, there were some key differences within and between the definitions as to the types of impacts that are considered. Common to many were the objective of reducing environmental impacts from fishing activities and reducing fish mortality (e.g., sustainable fishing and catch and release). In other cases, the aim of the definition was different in that the focus was on establishing legitimacy in relation to claims to fishing opportunity (e.g., some definitions of small-scale, artisanal and inshore fishing). These definitions, used in this way, are often also emphasising the positive social and economic benefits of that particular type of fishing. There was therefore a distinction that can be made between the use of definitions in relation to managing fishing mortality or managing fishing opportunity, including between recreational and commercial fisheries.

Regardless of the aim, reducing environmental impacts, in particular on stocks and the wider marine environment, are a common feature of the definitions. In some cases (e.g., marine stewardship), this has led to the formalisation of the definition as a set of criteria and development of an ecolabel to certify fisheries that meet the criteria. Looking more closely at the environmental impacts showed that for all impacts there was sufficient evidence to suggest that action is warranted to address the issue. In some cases, e.g., the patterns of exploitation and fish welfare, there is some uncertainty as to the most appropriate course of action. For other issues, e.g., seabed impact the evidence suggests that it is a matter of context and/or frequency. Finally, there are areas for further research, e.g., determining approaches to fish welfare by gear type and identifying effective indicators for ghost fishing, to inform future efforts to reduce the environmental impacts of fishing.

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Annex 1 – Impact criteria proposed by NEF (2019)

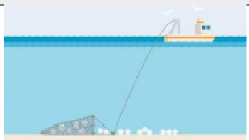
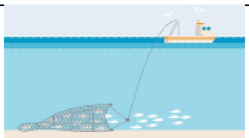
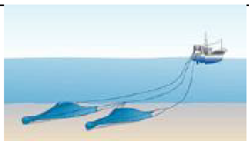
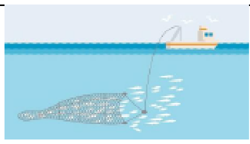
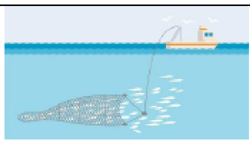
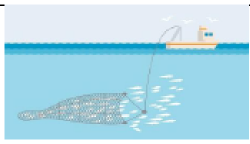
Environmental Criteria	Description	Indicator	Data source
1. Greenhouse gas emissions	Fuel use from fishing generates greenhouse gas emissions, which contribute to climate change.	Kgs of CO2/kg landed weight	STECF data / Academia
2. (Fossil Fuel) Subsidies	The fishing industry receives subsidies in different forms[43]. This masks true performance and deprives governments of funds for other purposes.	£/Kg landed weight	STECF data
3. Target species discards	Discards result from undersized fish being caught. Depending on survivability when discarded this can increase fishing mortality.	Kgs of target species/kg of all species landed	Cefas / MMO / Academia
4. Other bycatches and discards	Discards of other (non-target) species result from undersized or non-commercial fish being caught. Depending on survivability when discarded this can increase fishing mortality.	Kgs of discards/kg landed weight	Cefas / MMO / Academia
5. Spawning season mortality	Fishing during particular seasons and in particular areas can damage a fish stock when it is reproducing. This leads to lower fish populations than would result from the fishing activity itself.	Spawning stock damage/Kg landed	Academia / Cefas / IFCA and interviews
6. Bycatch of other marine life	Bycatch is the unintended capture of marine wildlife such as dolphins, birds, turtles or seals. This can damage or kill the captured wildlife.	RASS score (1 low risk - 5 high risk)	Seafish / Cefas / Academia
7. Ecosystem damage	Fishing activity can harm the marine environment and destroy habitats. This can lead to lower populations and a loss of biodiversity.	RASS score (1 low risk - 5 high risk)	MMO[44] / Seafish RASS / Cefas/ Seafish gear database
8. Ghost fishing	Ghost fishing occurs when fishing gear is lost in the water. This entangles fish and continues to cause fishing mortality.	Descriptive	Cefas / IFCA

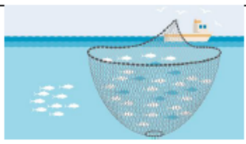
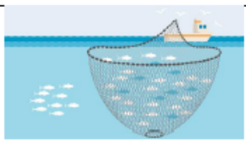
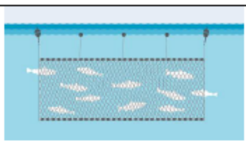
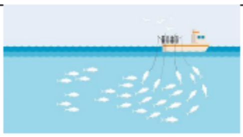
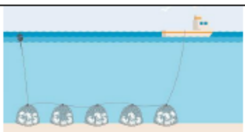
[43] Direct subsidies: EU funding includes support fishers transitioning to more sustainable fishing and assist coastal communities in diversifying their economies. The UK has chosen to spend €19.3m of its EU funding on improving sustainability in the sector during 2014-2020. Indirect subsidies: by not paying fuel duty and using 'red diesel', fishing vessels are receiving indirect subsidies that artificially enhance the viability of their businesses and the type of fishing they engage in.

[44] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/310811/matrix.xls

9. Plastic/pollution	Fishing is one of the main contributors to marine plastics globally. Collection and recycling of fishing gear is necessary to reduce plastic pollution.	Recycling of nets (%) per annum	Fishers data / IFCA / MMO
10. Animal welfare (target species)	The way that target species are caught, handled and dispatched (and the speed at which that happens) needs to be considered.	Descriptive	Academia / Cefas

Annex 2: Fishing gears used in EEA fisheries, their method of capture, and their impact on fish welfare. From: New Economics Foundation (2019) Catching Up - incorporating fish welfare into the Eu Common Fisheries Policy.

Fishing gear	Diagram	Method of capture	Species impacted	Impact on fish welfare
Dredge		A rigid structure towed along the seabed to target shellfish. A dredge consists of a frame and a toothed bar at the front to dig the scallops out of the sand with a collecting bag behind it. This bag is made of a chain mesh on the bottom netting on top. Dredges are towed either side of the vessel and can be single or up to 22 dredges per side. Tows are often long and whole areas are methodically harvested.	Shellfish, particularly scallops.	Target shellfish will come to the surface alive as is often a requirement for sale. Non-target species may be suffocated or crushed during fishing activity. Impacts on the seabed are considerable in terms of removal of seabed fauna.
Bottom trawl		Trawl towed on the seabed, held open by a pair of trawl doors. Usually a much larger net than a beam trawl. In a twin rig trawl two otter trawls are towed side by side. The net is towed from the bow or stern and tow times can vary from a few minutes to a few hours depending on the density of target species and the size and power of the vessel. Trawl length ranges from minutes to hours.	Demersal species (cod, sole, plaice, rays, anglerfish, bass, whiting). Also shellfish (Nephrops) with rigged trawls for muddy sediment.	Target species are suffocated and crushed in longer tows and hauls, but can come to the surface alive after shorter tows (determined by vessel size/capacity and the density of target species). Often large catches of non-target species. Bottom trawling can have a significant impact on seabed fauna depending on the seabed.
Beam trawl		Trawl towed on the seabed in which the net is held open by a wood or steel beam. The beam is towed behind the vessel and tow times can vary from a few minutes to a few hours depending on the density of target species and the size and power of the vessel. Generally longer tows.	Mainly flatfish and demersal species (plaice, sole, cod).	Target species are suffocated and crushed in longer tows, although some species may come to the surface alive. Often large catches of non-target species. Beam trawling can have a significant impact on seabed fauna depending on the seabed.
Pulse trawl		An adaptation to the standard beam trawl as a method of targeting bottom living species but in particular uses electric 'pulses' to cause fish to leave the seabed and come into the net. The pulse beam is towed by the side or behind the vessel for a few minutes to a few hours depending on the size and power of the vessel and the capacity for the haul. Lower towing speed than beam trawls.	Flatfish and demersal species (plaice, sole, cod) but primarily dover sole.	Target species are given an electric shock (pulse) which can vary from causing muscle spasm to breaking their spine. Subsequent impacts are the same as beam trawling although the gear is lighter and has lower impacts on the seabed fauna than beam trawls. Non-target species can be harmed.
Mid-water trawl		Trawl towed in mid-water to catch pelagic fish. The net is towed from the bow or stern and tow times can vary from a few minutes to a few hours depending on the density of target species and the size and power of the vessel. Ranges from minutes to hours.	Generally a single pelagic species (mackerel, herring) with small bycatch (whiting, bass).	Target species are suffocated and crushed in longer tows and hauls. Pelagic species caught by smaller vessels in a short tow through a shoal can come to the surface alive. Low impact on seabed fauna. Risk of bycatch in larger vessels.
Pair trawl		Trawl towed between two boats, either on the seabed or in mid-water, held open by the distance apart of the two vessels. The net is towed between two vessels and tow times can vary from a few minutes to a few hours depending on the density of target species and the size and power of the vessel.	Demersal or pelagic species depending on the speed of the tow.	Target species are suffocated and crushed in longer tows and hauls, but can come to the surface alive after shorter tows. Vessel size and capacity as well as density of target species will be the main determinants. Generally very mixed catches.
Danish/Scottish seine		An encircling net shot in the open sea using very long ropes to lay out the net and ropes on the seabed. The marker buoy is anchored while hauling, and the warps and net are closed entirely by winch. The operation is carried out directly by the main vessel (the seiner) or from an additional smaller boat.	Pelagic species for Danish seine and demersal species for Scottish seine.	Target species are contained and then crushed when they are lifted onto the deck alive (where they subsequently suffocate or are flash frozen). Bycatch can include seabirds and cetaceans.

Purse seine		A large net is used to surround a shoal of pelagic fish, the bottom of which is then drawn together to enclose them. A headrope carrying numerous floats is used to keep the net on the surface. The net is equipped with rings along its lower edge where a cable is passed forming a bowl-like shape and preventing fish from escaping downwards.	Pelagic species, often smaller varieties (herring, sprats, sardines).	Target species are contained and then crushed when they are lifted onto the deck alive (where they subsequently suffocate or are flash frozen). For some species like tuna they may also be gaffed (hooked in the flesh). Bycatch can include seabirds and cetaceans.
Ringnet		A net operated by surrounding a shoal of pelagic fish with a 'wall' of netting, often operated by two boats. The ring (a long net) is shot to surround a shoal of pelagic fish with a 'wall' of netting. It can be operated by a single vessel or by a pair of vessels.	Pelagic species, often smaller varieties (herring, sprats, sardines).	Target species are contained and then crushed when they are lifted onto the deck alive (where they subsequently suffocate or are flash frozen). Bycatch can include seabirds and cetaceans.
Drift net		The net is suspended in the water from buoys to drift on the prevailing currents, usually just below the surface, but can be deployed anywhere from the seabed to the surface to target pelagic species. The nets are attached at one end to the boat that is fishing them or left to drift free to be recovered later. Fish become entangled in mesh and the net caught behind their gills. Soak time is generally a few hours.	Mainly pelagic species (mackerel, herring) but can be set to drift along the bottom in sandy areas to catch prawns.	Suffocation, entanglement and abrasion. Bycatch can include seabirds and cetaceans in greater numbers than a fixed net.
Fixed/set net		Nets are attached to poles fixed in the substrate or by an anchor system to prevent movement of the vertical net. A gill net is a single wall of netting weighted at the bottom and supported at the top by floats attached to a headline. A trammel/tangle net is a wall of small fine mesh between two outer layers of footrope. Soak times vary from one tidal cycle to multiple days.	Demersal species (cod, hake, flatfish, monkfish, turbot, rays).	Suffocation, entanglement and abrasion. Bycatch can include seabirds and cetaceans in lesser numbers than a drift net.
Longline		Long lines can be left either anchored or drifting, with numerous baited hooks. The main line is made of light rope or heavy nylon monofilament and can be many miles in length. Longlines target particular species and can minimise bycatch based on the time of the year, the depth the lines is set to, the soak time, the type and size of bait, and hook type.	Can be rigged for demersal or pelagic species. Demersal species (cod, bass, rays, spurdog).	Hooking in the mouth and dispatch on deck. May swallow bait and remain hooked underwater for multiple hours or days. Bycatch can include seabirds and cetaceans.
Pole and line		Single or multiple hooked rod and reel set ups using live or dead bait or artificial lures and feathers. Can also include trolling (towing baited lines behind the vessel). In handlining, trolling, jigging the fisher physically is in contact with the line and strikes when a fish bites the bait. Fishing trips usually are during daylight hours only.	Demersal species (mackerel, bass, cod, pollock).	Hooking in the mouth and dispatch on deck. May swallow the bait (deep hooked) and being unhooked may result in damage to the gut and throat. Some bycatch.
Pots and traps		Pots, creels, and other fish traps are structures where fish are guided through funnels that encourage entry but limit escape. Traps differ in shape, size, and material according to local practices and target species. They can be set on the bottom singly or in strings with a marker buoy at each end. Traps are usually baited and can be left down overnight or for multiple days.	Shellfish (Nephrops, Lobster, crab, whelk). Also trap fisheries for wrasse for use in salmon farms.	Shellfish and some non-target species are trapped for multiple days and are usually captured alive. The main impacts are on non-target species which are trapped, and the capture of the bait species.