Regenerative Fishing to deliver a Sustainable Marine Environment

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Contents

Abstract

To secure the future of ocean health, and the services it brings to wider ecosystems and humans, we must achieve objective sustainability amongst the industries which operate within marine environments. Amongst the plethora of threats our oceans face from anthropogenic interaction, the fishing industry has and continues to deplete fish stocks, destroy habitats and pollute our oceans through poor management, illegal activity, destructive and non-selective fishing gears.

Fuelled by opaqueness and economical gain at the expense of ecological security, our global fishing industry has historically perpetuated a downward spiral towards total collapse. Here, we identify the key indicators of a healthy, sustainable marine environment to define a new fishing industry under a regenerative approach, which aims to rebuild fish stocks and marine habitats rather than simply sustaining them.

Under the principles of Regenerative Fishing, we have devised a framework for sourcing and species selection, and identified the role other stakeholders must fulfil to deliver Regenerative Fishing. In doing so, we hope to serve as an example to the rest of the industry and begin our journey to delivering an ecologically and economically sustainable market for Regenerative Fishing.

1. The threat to our oceans

Our oceans face a huge diversity of pressures from humans. Climate change, pollution, habitat and biodiversity loss threaten the health of our oceans every day, and fishing is one of its largest threats.[1]

Fish and seafood is an incredibly important source of food for humans. Over 2 billion people rely on it as their primary source of protein.[2] Coastal marine environments make up just 4% of the world's land area, but contain one third of the earth's population and provide 90% of the catch from marine fisheries.[3] With population increase inevitable, mounting pressure builds on our oceans to provide us with food for generations to come.

But decades of pressure, increased efforts, and technological advancement has already seen fish stocks collapse and habitats suffer immensely. In the UK alone, fish landings have fallen by over 50% despite fishing effort tripling since the 1950s.[4] Today, 94% of fish stocks globally are fully or overexploited.[5]

1.1 Overfishing

The proportion of fish stocks that are overfished has increased by threefold in the last 50 years. Now, over a third (34%) of the world's fish stocks are overexploited[6], where catches exceed maximum sustainable yield; the theoretical maximum catch that can be harvested from a stock year on year, whilst maintaining the population size.

Many stocks of key species have been significantly depleted, such as Cod and Tuna. Southern bluefin tuna stocks have fallen by more than 90% in the last century, whilst Cod stocks in the West of Scotland are less than 5% of those seen in the 1980s.[7]

Shark and ray populations are in serious decline, too. In the IUCN's 2020 Red List update, 37% of the world's sharks and rays are now threatened with extinction.[8] Perhaps more alarmingly, these are only in assessed populations. Many more stocks have not been assessed, and are likely to be in regions where monitoring is poor and illegal catch is poorly regulated.

1.2 Habitat Destruction

Dredging and intensive trawling damages seabeds, cutting into the sediment and destroying delicate reef structures, particularly on seabeds not previously fished.[9]

Each year, approximately 5 million km^2 of seabeds are trawled or dredged, equivalent to the area of the Amazon rainforest.[10] In one of the UK's largest Marine Protected Areas (MPA) situated in Lyme Bay, Dorset, populations of slow growing pink sea fans increased eightfold in the first 5 years following the banning of dredging and trawling gears through the area.[11] Pink sea fans (*Eunicella verrucosa*) are a representative species of reef features that provide habitat for many others.[12]

In aquaculture, habitats and wild areas may be cleared to make way for farms and ponds to be built. Prawn and shrimp farming may be responsible for as much as 38% of global loss in mangrove forests.[13] Mangroves provide a unique habitat, securing sediments and protecting coastlines from erosion.

1.3 Bycatch and Discards

Not all fishing gears are entirely selective, either, and will often catch unwanted or unintended species. Estimates predict that bycatch may account for almost 20% of total catch in the North Atlantic, though this figure includes unmanaged catch that may still be utilised.[14]

Discards, however, are a bigger cause for concern since they represent an entirely wasted resource, often composed of juvenile fish or non-target species which can include marine mammals and birds. In the Mediterranean, discards in bottom trawl fisheries have been estimated at 45-50% of total catch.[15]

One of the greatest threats to marine mammals today is from fisheries bycatch.[16] Many species have experienced severe declines as a result of entrapment, entanglement and fatal injury from fishing gears and ghost fishing, where lost gear continues to fish. Entanglement in nets was a major contributor to the recent extinction of the Yangtze river dolphin (*Lipotes vexillifer*), and the same is true for the near-extinct Atlantic humpback dolphin (*Sousa teuszii*).[17]

1.4 Illegal, Unreported and Unregulated (IUU) Fishing

IUU fishing remains one of the most severe threats to the marine environment, given its ability to undermine conservation and management efforts at huge scale.[18] Up to 26 million tonnes of IUU seafood is caught each year, often from international, high seas water but is also common closer to shore with the trade of 'black fish' caught and sold illegally.[19]

IUU fishing has the potential to collapse entire fisheries. Between 1987-2001, following the illegal harvest and trade of huge quantities of rock lobsters from South Africa for export to the USA by three men alone, the fishery collapsed and cost almost US$30 million in restorative measures to rebuild the fishery.[20] Bycatch of albatross in IUU toothfish fisheries in the Antarctic is predicted to be a primary driver in the decline of some localised albatross populations.[21]

1.5 Poor management

Even under regulation and governmental management, fisheries and ocean systems are not fully protected. In the EU under the Common Fisheries Policy, quotas have consistently been set higher than scientific advice. In 2020, 48% of quotas were set higher than advice from ICES (The International Council for the Exploration of the Sea), who calculate the recommended annual quotas to EU policymakers each year.[22] More alarmingly, quota for data limited stocks were set 71% higher than the advice.[23] Without a full understanding of the stock dynamics and status in data limited stocks, ignoring scientific advice significantly increases the risk of stock collapse.

Insufficient protection within MPAs is another example of poor management. In 2021, a total of 31,854 hours were spent fishing with bottom-towed gear in 510 MPAs across the UK and EU, representing 86% of MPAs which were assessed permitting fishing with bottom-towed gears.[24]

1.6 Pollution and waste

Regardless of effective management, pollution and waste within our oceans is of great concern also. Recent studies estimate over 48,000 tonnes of lost and discarded fishing gear enters the ocean each year.[25] Marine species can become entangled in discarded fishing gear, or ingest them as they break down into microplastics. In the English Channel, microplastics are now present in over 35% of fish.[26]

Polystyrene is the default insulent and container to transport seafood within the supply chain, yet expanded polystyrene (EPS) boxes are too light and too big to be recycled in a cost effective way.[27] Unsurprisingly, EPS is one of the most predominant materials in ocean plastic waste.[28] Ingestion of polystyrene can have a wide range of impacts on marine life: in oysters, ingestion of polystyrene results in decreased reproductive success and reduced larval development.[29]

It is clear that fishing has the capacity to damage and disrupt our oceans immensely. As pressure for food security increases with population rise, the impacts from overfishing, habitat destruction, bycatch, IUU fishing, poor management, and pollution must be mitigated to ensure a healthy, thriving ocean environment that will continue to provide food for humans for generations to come.

2. A Sustainable Marine Environment

So that we can continue to leverage ocean resources, such as food from fisheries, medicines from genetic research, and fuel from mining, it is important to have an understanding of what ocean systems are, how they are connected to one another, and their indicators for health. With this understanding, their successful stewardship can be realised, and the impacts of anthropogenic activity, such as threats from fishing, can be correlated with the indicators for health to guide management and conservation efforts.

2.1 The Marine Environment

The marine environment comprises the largest physical collection of ecosystems on the planet, encompassing coastal and nearshore waters, the seas and ocean systems, their seafloors and subsoils, and all life that resides within.[30]

Supporting a rich pool of distinct and rare habitats that host a plethora of life, with over 240,000 known species, these massive and connected ecosystems cover over 70% of the Earth's surface.[31] Collectively, the marine environment accounts for more than 97% of Earth's water supply, and 90% of habitable space.[32]

Marine ecosystems provide food, water, and jobs for many populations globally. Our oceans produce over half of the world's oxygen and store 50 times more carbon dioxide than our atmosphere. They regulate global temperature and weather patterns by distributing heat between the tropics and the poles.[33]

2.2 Ecosystem services

The collection of functions and assets an ecosystem provides to humans and other species are known as ecosystem services. In addition to the functional role the marine environment performs, it also provides a number of social, economical and biological assets for humans too, such as food, building materials, genetic and medicinal resources, recreation and tourism.[34]

Similar services can be found in terrestrial ecosystems, too, such as carbon sequestration from forests, hydroelectric power from rivers, provisioning for the farming of cattle for food, and the reflection of solar energy from ice caps.[35]

However, without healthy oceans our life on Earth would be severely challenged, and perhaps impossible. The oceans are the life support system of all living beings - life on Earth can thrive without land, but it cannot exist without the oceans.

2.3 Health indicators

Crucially, ecosystem services are a byproduct of a healthy, functioning ecosystem. Where the ecosystem becomes significantly disrupted or damaged, its functioning is interrupted and the services they provide jeopardised.[36]

Ecosystems form a complex web of interdependencies between their biotic and abiotic components in order to thrive. But despite their complexity, the core components that dictate ecosystem health can be distilled down into four overarching ecological markers:[37]

1. Species Diversity

> *Definition* - The number and relative abundance of species.
>
> *Why is it important?* - A more complex composition of species creates functional redundancy; the ability for multiple species to perform similar ecological tasks and functions. This allows ecosystems to re-establish and recover from stress and loss events. Species diversity also helps maintain productivity and the flow of energy through the food web.
>
> *What happens if it is not sustained?* - Loss in species diversity makes an ecosystem more susceptible to collapse. Species rely on each other for survival and functioning. As you remove species from an ecosystem, you increase the chances that ecological tasks can no longer be performed, and that other species cannot be supported due to their interdependencies (e.g. for food).

2. Habitat Diversity

> *Definition* - The range, state and quality of habitats
>
> *Why is it important?* - Maintaining a diversity of habitats promotes both a greater species diversity and a better connected environment, allowing

individuals and their associated nutrients to move through stages of life which require differing habitats. Habitat diversity also influences the ‘ecology of fear’ where prey species can take refuge against predation, and can also ease competition between species. Differing habitats additionally support rare and unique species that may have specific requirements and functions in an ecosystem.

What happens if it is not sustained? - Loss of habitat will result directly in loss of species and therefore species diversity. Habitat loss and destruction risks local species no longer being supported and therefore may migrate away from the ecosystem, or become displaced and risk death.

3. Key Species

Definition - The species which help define an ecosystem.

Why is it important? - Often, a few species have a strong effect on community structure and ecosystem functioning. Fluctuations in their populations can greatly influence their environment’s health. Conserving keystone species (e.g. Orcas), foundation species (salt marsh grasses), basal prey species (macroalgae), and top predators (sharks) is necessary because limited species perform their roles in the community.

What happens if it is not sustained? - Because key species perform relatively unique roles or have a disproportionate influence in an ecosystem, their removal or introduction can have knock-on effects to other species and ecosystem services. For example, removing a single predator can result in disproportionate growth of a prey species which may grow to outcompete others, reducing the species diversity of the ecosystem and the relative loss in functional roles.

4. Connectivity

Definition - The degree of connection between natural environments, in terms of their components, spatial distribution and ecological functions.

Why is it important? - It is crucial that local species populations are connected to one another to form their metapopulation. These natural corridors help the movement of individuals, nutrients, and materials. Better connection facilitates successful recruitment and migration.

What happens if it is not sustained? - Fragmentation of natural corridors restricts the free flow of individuals, nutrients and materials, restricting genetic diversity and mixing, isolating habitats and ecosystems. Without these exchanges, ecosystem functioning may become restricted or even lost.

2.4 What is a 'Sustainable Marine Environment'?

A sustainable marine environment represents one in which its ecosystem services are being leveraged and utilised in full, without compromising ecosystem functioning.

By protecting and conserving each of the four markers of a healthy marine environment outlined above, we can ensure ecosystem functioning thrives, and therefore the services they provide can continue to benefit humans in a sustainable way.

3. Regenerative fishing to deliver a Sustainable Marine Environment

3.1 Definition and Objective

Regenerative Fishing is the adoption of practices which support the rehabilitation of fish stocks and their habitats within the marine environment.

In order for fishing industries to operate within a sustainable Marine Environment, and continue to benefit from its ecosystem services, its activities must not jeopardise ecosystem functioning.

Therefore, our single objective for regenerative fishing is to secure and conserve total ecosystem functioning within the marine environment.

3.2 Our vision for a Regenerative Fishing industry

Through Regenerative Fishing, we want the industry to:

1. Rehabilitate all commercially exploited fish stocks and support their continued growth.

2. End irreversible damage to ecosystems from fishing, aquaculture and supply chain practices (such as habitat destruction, bycatch, pollution and waste).
3. Deliver an ecologically and economically sustainable market for Regenerative Fishing, with end-to-end traceability.

Considering the state of global fish stocks today, compared to their levels only decades ago, sustaining today's fisheries is not enough. Instead, we should strive to rebuild every element of the industry to ultimately achieve sustainability in our marine environment and meet the ecological and economic needs of our fisheries for decades to come.

The threats our industry poses to the marine environment need to be reversed; fish should be caught using non-destructive methods, all species should be managed under a system that follows scientific advice, and traceability throughout the whole chain should be standard practice, if not legislated, to combat IUU fishing and empower consumers to make the right purchasing decisions.

Visibility and transparency should be leveraged to enable access to all commercially exploited species and more evenly distribute demand, supporting mixed fisheries.

Single-use plastics, polystyrene and excessive refrigeration plague the supply chain, posing a constant threat to the marine environment with pollution, contamination and climate change. Novel alternatives to plastic packaging, shorter supply chains, and more efficient markets should be used to reduce their severity.

Under the principles of Regenerative Fishing, and the beginning of a collaborative industry-wide revolution, there is huge scope to reverse the threats we currently put on our oceans.

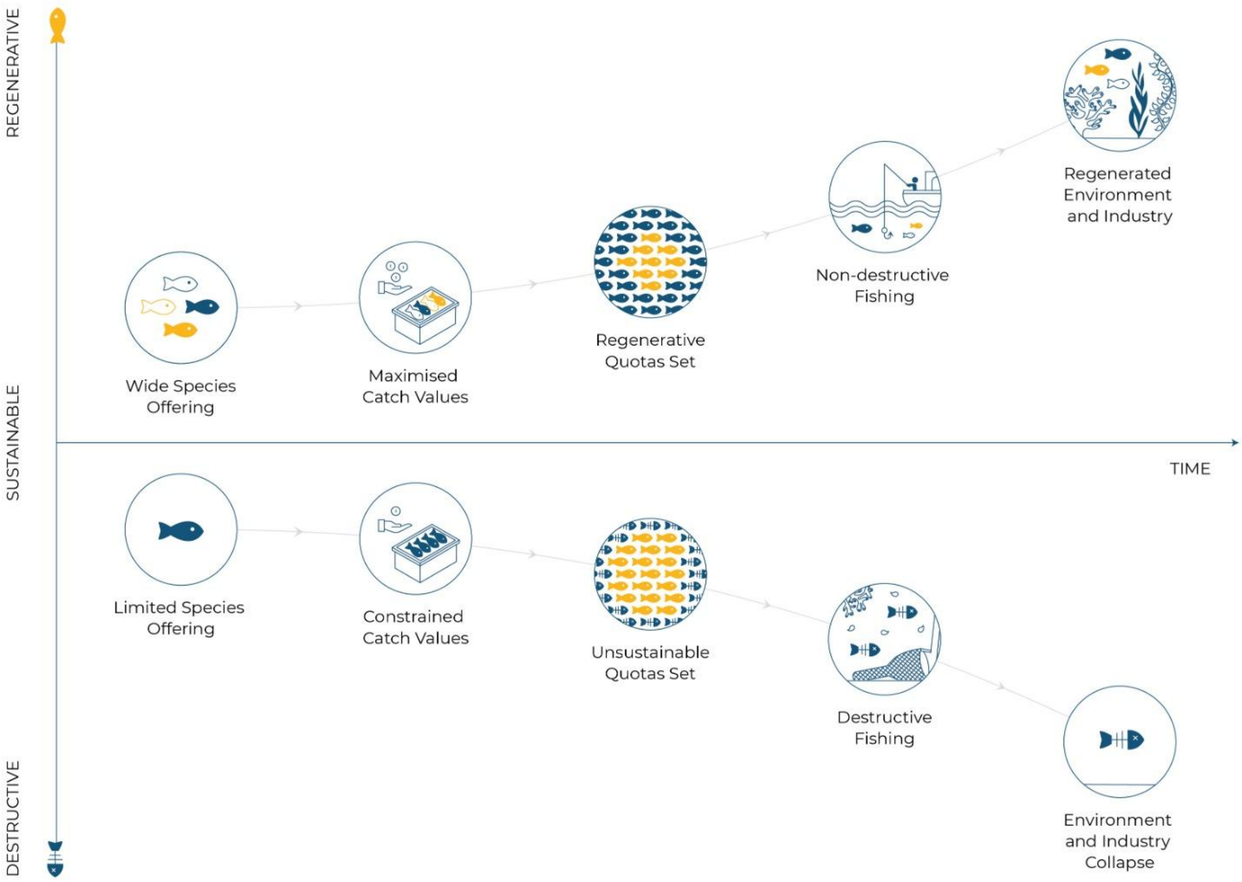

Figure 1. Regenerative Fishing versus Destructive Fishing. Outlining the principles of Regenerative Fishing to regenerate and rehabilitate marine environments and deliver an ecological and economically sustainable industry.

3.3 Rationale and examples from other industries

To build a food system that is not only sustainable, but actively rebuilds and regenerates the ecosystem services yielded from its environment, follows an approach which has gained significant traction in recent years.

In terrestrial farming, Regenerative Agriculture has taken a conservation and rehabilitation approach to farming and food production, focusing on fixing the fundamental issues which threaten the sustainability of terrestrial food production[38], including:

- topsoil erosion,
- loss of biodiversity,

- reduced biosequestration,
- deterioration of water and nutrient cycling.

In aquaculture, the farming of bivalves (mussels, clams and oysters), algaes, and sea vegetables (seaweeds and coastal plants) represents one of the most sustainable sources of protein and food on the planet, requiring no feed, fresh water or treatments.[39] Regenerative Ocean Farming is quickly establishing itself as a solution for improving biodiversity, ocean nutrient cycling, water quality and biosequestration of carbon in our seas.[40]

We believe the same principles can be applied to wild fisheries. To demonstrate this, we have developed an Impact Framework which sets out the guiding principles to sourcing, resource use and economic stability in the industry for ourselves and other businesses to follow. In doing so, we hope to lead an example of how global fishing industries can transition to regenerative ones.

By focusing on the fundamental attributes of a healthy ecosystem, the sustainable production of food becomes a byproduct of good environmental stewardship.

4. Impact Framework to deliver Regenerative Fishing

Our role as a key intermediary between consumers and producers within the supply chain provides us with the opportunity to deliver an ecologically and economically viable Regenerative Fishing industry.

To do so, we created a market that actively rewards regenerative practices, where consumer purchases drive the necessary changes at the base of the chain. Supported by the latest scientific data and advice, Pesky's Impact Framework guarantees that our marketplace delivers on the principles we have set out for a Regenerative Fishing industry.

4.1 Regenerate Fish Stocks and Marine Environments

To guarantee a thriving global fishing industry for centuries to come, today's fishing must actively support not simply the sustainability of fish stocks and the environments they live in, but their regeneration as well.

To meet the objectives of Regenerative Fishing, by [1] rehabilitating all commercially exploited fish stocks, and [2] ending irreversible damage to ecosystems from fishing, aquaculture and supply chain, we must ensure that all fish sold on our marketplace follow strict sourcing criteria.

Both wild fisheries and aquaculture have an impact on fish stocks and the marine environment in different ways, and so each must be given their own criteria unique to the respective threats they pose.

4.1.1 Wild Fisheries Sourcing Criteria

For wild capture stocks, our criteria for sourcing follows three distinct principles to ensure every fish is:

1. **From healthy stocks**

   Is the species threatened, overfished, poorly managed, or has reduced reproductive capacity?

2. **Old enough to have reached maturity and reproduced.**

   Is the fish large enough to be sexually mature and therefore had the chance to reproduce and contribute multiples back to the species' population?

3. **Caught using non-destructive fishing methods.**

   Has the capture method caused irreversible damage to the marine environment or other species through bycatch?

Under these guiding principles, every species is assessed against a sourcing matrix, supported by the latest advice from the Marine Conservation Society (MCS) and fisheries scientists (Appendix 1.1), to determine if it is representative of Regenerative Fishing.

An executive summary of the scientific rationale for our wild capture sourcing methodology can be found in Appendix 1.2.

4.1.2 Aquaculture Sourcing Criteria

The primary threats aquaculture poses to the marine environment is the reliance on wild fish meals, and the direct impact the farm and practices have on their surrounding environment, rather than the specific species itself being farmed. Therefore our criteria ensures that all aquaculture products sourced are:

1. From net protein production practices

Has more wild fish protein been used in feed than produced at harvest?

2. Fed with marine fish meals harvested from healthy stocks

Are fish meals from stocks where the species is not threatened, overfished, poorly managed, or has reduced reproductive capacity?

3. Produced using non-destructive aquaculture methods

Has the production method caused irreversible damage to the marine environment, or are other species impacted significantly? Is there effective management to control practices?

Under these guiding principles, every species and farm is assessed against a sourcing matrix, supported by the latest advice from the Marine Conservation Society (MCS) and fisheries scientists (Appendix 2.1), to determine if it is representative of Regenerative Fishing.

An executive summary of the scientific rationale for our wild capture sourcing methodology can be found in Appendix 2.2.

4.1.3 Measures of progress

We will continue to measure our progress against our objective by recording the following indexes:

- ➢ Number of regenerative fishing vessels on the Pesky Market
- ➢ KG of regenerative seafood landed to Pesky's market
- ➢ KG of MCS 'Best Choice' wild fish sold
- ➢ KG of MCS 'Best Choice' Aquaculture produce sold

4.2 Deliver an ecologically and economically sustainable market for Regenerative Fishing.

The objective for a regenerative marine environment can only be achieved if we can achieve both the ecological and the economic goals of the industry as a whole. It is therefore vital that the seafood supply chain supports the interests of fishermen, invests in its infrastructure, and reduces its resource use.

We have therefore tasked ourselves to create:

1. Sustainable incomes for fishermen and aquaculture producers

Ensuring they are able to create sufficient, profitable incomes from their landings and products.

2. Infrastructure to support domestic processing

Ensuring that landings can be processed domestically, supporting domestic consumption, and sustaining skills and employment within the supply chain.

3. Sustainable resource use in the chain

Reducing the impact of the supply chain with an aim of net zero from catch to kitchen.

To achieve these goals, our resources will be focussed on delivering:

- An open, transparent market direct to consumers and buyers towards the end of the chain (home consumers, retailers, meal kit companies, hospitality)
- Maximise a fishermen's total catch value by marketing the entire spread of species caught by boats, rather than the select few offered within the conventional supply chains.
- Distribute direct to homes through carbon neutral delivery networks, using 100% recyclable packaging with a goal of net zero impact supply chain from coast to kitchen.

4.2.1 Measures of progress

We will continue to measure our progress against these goals by recording the following indexes:

- ➢ Number of buyers on the market,
- ➢ KG processed domestically,
- ➢ KG processing waste sold for consumption,
- ➢ Number of boxes delivered via carbon neutral network and in 100% recyclable packaging.

5. The Role of the wider industry to deliver Regenerative Fishing

Our efforts individually will not be enough to reverse the impacts the global fishing industry has on our Marine Environment. Success will be contingent on the collaboration not only within the fishing industry, but other sectors which also rely on the ecosystem services provided by the oceans.

5.1 Fisheries Management, Government and Policymakers

Role - The role of fisheries management is to maximise the sustainable production of biological, social, and economic benefits from an aquatic resource.

Remit & Impact - Government and policymakers leverage legislation and regulations to control human activities which protect a fishery from overexploitation. The remit of fisheries management is the most pivotal one in shaping a Sustainable Marine Environment, since policymakers and government have the most control over our fishery.[41] They are responsible for observing and following scientific advice to define new legislation and ensure measures remain appropriate for the protection of fisheries and to facilitate a buoyant market.

The consistent setting of quotas above scientific advice, lack of regulation within MPAs, and the continued support of destructive fishing gears like dredging and beam trawling undermines management objectives and perpetuates an unsustainable fishery. This short-sighted view taking preference to economic gain threatens the long term survival of commercially exploited stocks, particularly for those which are data deficient.

Required Actions:

- Follow scientific advice more closely, setting TAQ (Total Allowable Catches) for all species at or below MSY (Maximum Sustainable Yield).
- Invest in closing the data deficiency gap for all commercially exploited species, so that MSY can be achieved.
- Legislate stricter regulations of fishing activities within MPAs, banning the use of bottom-towed gears.
- Prohibit the dredging of new fishing grounds to protect undamaged habitats.

5.2 Fishing businesses and producers

Role - As the producers at the base of the chain, the role of fishing and aquaculture businesses is to harvest and farm primary produce to supply food and fishery products for the industry.

Remit & Impact - Fishing businesses work within the remit of policy and regulation. They follow the gear type, fishing effort and quota restrictions placed on them in order to make a viable business. If management fails and stocks collapse, fishing businesses are the first to be directly impacted from an economic standpoint. However, as seen in IUU fishing, failing to comply with fishery regulations can quickly yield catastrophic damage to fish stocks and habitats, and therefore the impact fishing businesses can have on marine environments is substantial under non-compliance or non-regulated scenarios.

Required Actions:

- With the support from wholesalers and consumer demand, increase the voluntary adoption of regenerative practices, such as increasing mesh size, use of acoustic pingers, and cessation of dredging gears.
- Improve reporting of suspected IUU fishing activities to authorities.
- Assist scientific research more readily to help close data deficiency gaps and improve long term fishery status.

5.3 Supply Chain

Role - For the rest of the supply chain, their principal role lies in the brokering of fish caught. Sellers and processors like wholesalers, supermarkets and fishmongers provide the fundamental access to catch for consumers.

Remit & Impact - As a conglomerate, the supply chain has huge purchasing power, and is able to alter market dynamics, including the sale and purchase price of fish, on a daily basis. The supply chain is directly responsible for visibility and access to catches. Their choices to market or avoid certain species from one day to the next can have large implications on waste and prices in the marketplace. When the sale of fish is biassed towards economic decisions, rather than ecological ones, it leads to opaqueness in the chain, a concentration of demand, and increased fishing pressure on fewer species.

The supply chain plays an equally important role in traceability. The transfer of traceability data between ownership of fish is vitally important, since it empowers consumers to make an informed decision when they come to buy their seafood, and helps to combat IUU fishing.

Required Actions:

- Adopt sourcing strategies which support and deliver on the objectives of Regenerative Fishing.
- Enable full end-to-end traceability for consumers.
- Provide complete visibility on available supply to better allocate demand.
- Reduce the use of single-use plastics, such as EPS boxes, switching to fully recyclable, reusable and/or plastic free alternatives.

5.4 Consumers

Role - Consumers provide consistent demand for fishery products, and generate demand for new or previously underutilised catch. Their principal role when considering the successful stewardship of our oceans, though, is to hold the rest of the supply chain to account and show support for good practice, and contempt for bad practice.

Remit & Impact - Consumers are key drivers in market and fisheries dynamics, albeit indirectly. Consumer demand drives fishing effort towards particular species, and the prices they are willing to pay dictates the economic potential of a fishery all the way down to the base of the chain. Historically, examples of this effect have been seen, and perhaps most notoriously in cod stocks. As demand for cod in the past few decades soared, fishing pressure intensified. Despite quotas being set, cod stocks collapsed across the NE Atlantic, and would not recover for some 10 years afterwards. Even today, their stocks are a shadow to those seen only 50 years ago.[42]

Today, consumers are becoming increasingly aware of their responsibility to insist on more robust regulation, stricter sourcing policies evidenced by scientific advice, and continue to lead in the campaign for traceable produce. Their support and demand for Regenerative Fishing will become the principal driver of change.

Required Actions:

- Continue and grow support for sustainable seafood and supply chains under the principles of Regenerative Fishing.

- Educate themselves and reduce reliance on suppliers to make ecological decisions on their behalf.
- Hold suppliers accountable for their sourcing
- Insist on traceable produce.

6. Summary

- Fishing poses a huge plethora of threats to the marine environment.
- In the past 50 years alone, fish stocks have declined significantly, and habitats the size of the Amazon rainforest have been destroyed.
- Our Marine Environment provides a huge number of ecosystem services vital to humans, and fishing plays a significant role in its health and continued functioning.
- The health of our Marine Environment can be measured, and markers of its sustainability can be associated with fishing activity to quantify our impact.
- Using these indicators for health, Regenerative Fishing provides an opportunity to reverse negative trends in the fishing industry and rebuild the industry to deliver a sustainable marine environment by securing its ecosystem functioning.
- Under Regenerative Fishing, we have devised a sourcing strategy that ensures the objectives of Regenerative Fishing can be met, and hope to act as a role model for other businesses occupying the same space as us within the industry.
- However, the role of the wider industry will be pivotal to the success of Regenerative Fishing and securing a Sustainable Marine Environment;
- Primarily focused on government and consumer demand to drive the necessary changes at the base of the chain and to introduce the legislative framework to deliver Regenerative Fishing.
- Through collaboration amongst stakeholders, and by focusing on the fundamental attributes of a healthy ecosystem, the sustainable production of seafood will become a byproduct of good environmental stewardship.

Appendices

Appendix 1.1 - Wild capture sourcing matrix

Each species considered for supply is assessed against the following sourcing matrix, supported by the latest advice from the Marine Conservation Society (MCS) and fisheries scientists, to determine if it is representative of Regenerative Fishing.

Table 1. Sourcing matrix for wild capture fish.

Principle	Criteria	Source	References
[1] From healthy stocks	No species listed as vulnerable or above are supplied	IUCN Red List	Available at: https://www.iucnredlist.org/
[1] From healthy stocks	No species listed as 'Fish to Avoid' by MCS are supplied	MCS Good Fish Guide	Available at: https://www.mcsuk.org/goodfishguide/
[2] Old enough to have reached maturity and reproduced.	Supply only mature fish. Using length vs. weight data, determine the minimum weight at which the species is mature. For protogynous hermaphrodites, e.g. many bream species, also apply a maximum weight to ensure one gender is not disproportionately marketed. For variances in weight at maturity between sexes, the larger size is used.	Fishbase.se CEFAS	Available at: https://www.fishbase.se/search.php https://www.cefas.co.uk/publications/techrep/TechRep150.pdf
[3] Caught using non-destructive fishing methods.	No species caught using beam trawl, dredging or pulse trawl.	Direct purchase at first sale	-

Appendix 1.2 - Wild capture sourcing rationale

Stock levels will broadly help assess whether a species should or should not be targeted, and therefore using the assessment from IUCN and MCS provide an excellent 'first defence' to ensure we are sourcing appropriate species. However, what helps us determine the sustainability of a specific fish within a stock is the size it must have reached in order to have reproduced. This becomes our absolute baseline to ensure every wild fish we source is contributing to a regenerative fishery.[43]

Marine species have huge reproductive ability, producing tens of millions of eggs during each spawning event, many of which will go on to produce multiples of fish that reach maturity.[44]

As an example, while the stocks of a species may be abundant today, the continued removal of juvenile fish from that stock will undermine its ability to continue to grow and deplete stocks in the long run, making it at higher risk of collapse than a fishery where only mature individuals are targeted.

In some cases, the size that a fish becomes sexually mature is larger than Minimum Conservation Reference Size (MCRS), if there is one set for that species.[45] By applying a minimum sourcing size for all species, we are ensuring that all fish are regenerating their fishery, regardless of having an MCRS associated with them or not.

Catch method is not a direct determinant of an individual fish's sustainability, but it does, of course, have significant bearing on the health of the marine environment supporting fish stocks. For beam trawl and dredge fisheries, there is continual evidence that these gear types can cause destruction to habitats which may take multiple years to recover, and therefore risk displacing many species and altering local ecosystem functioning and servicing.[46, 47] As a new gear technology, the impacts of pulse trawl fishing are still in debate. Whilst its physical impact on the seabed and habitats is improved over beam trawling, the physiological effects on non-target species, particularly benthic species which live in the seabed, is still unknown [e.g. 48, 49] and therefore is currently too great a risk to support.

Appendix 2.1 - Aquaculture sourcing matrix

Each species, and the farm they are produced at, which may be considered for supply is assessed against the following sourcing matrix, supported by the latest scientific advice, to determine if it is representative of Regenerative Fishing.

Table 2. Sourcing matrix for aquaculture fish.

Principle	Criteria	Source	References
[1] From net protein production practices	The farm can demonstrate a Fish Feed Dependency Ratio (FFDR) of less than 1:1	Direct comms with farm, or MCS Good Fish Guide where available	Available at: https://www.mcsuk.org/goodfishguide/
[2] Fed with marine fish meals harvested from healthy stocks	No species listed as vulnerable or above are used in feed	IUCN Red List	Available at: https://www.iucnredlist.org/
[2] Fed with marine fish meals harvested from healthy stocks	No feed species listed as 'Fish to Avoid' by MCS are used	MCS Good Fish Guide	Available at: https://www.mcsuk.org/goodfishguide/
[3] Produced using non-destructive aquaculture methods	No species/production methods listed as 'Needs Improvement' or 'Avoid' by MCS Good Fish Guide are supplied	MCS Good Fish Guide	Available at: https://www.mcsuk.org/goodfishguide/

Appendix 2.2 - Aquaculture sourcing rationale

Farming methods which contribute to a net drain of fish protein create an imbalance to natural ecosystems. Farmed protein represents additional protein production above the natural production by an ecosystem. In a natural environment, the transfer of nutrients and energy (e.g. protein) through the food chain exists in a state of balance, where lower trophic levels support those above them.[50] In aquaculture systems where the FFDR is greater than 1, it represents gross removal of wild stocks of low trophic species. This can result in 'top heavy' food chains where the biomass of predator species becomes disproportionately larger than that of prey populations and can result in ecosystem collapse.[51]

Aquaculture spans a huge range of practices and techniques depending on the species being farmed, and therefore may impact the environment in many ways. Leveraging scientific advice from MCS provides robust assessment of the environmental impact a particular species and/or production method has, to inform whether or not those species should be sourced. Under the criteria used by MCS for ranking aquaculture production systems, those ranked as ‘Needs Improvement’ or ‘Avoid’ represent practices which may cause irreversible damage to the environment, be poorly managed, use unsustainable feed sources, or have poor welfare standards, and therefore are not representative of Regenerative Fishing and must be avoided.[52]

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