PART II

The Blue Economy Sectors

6

Fisheries

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6.1 Introduction

The catching of wild fish is one of the two oldest maritime industries, the other being shipping. Its roots are lost in pre-history and it remains pre-eminent today in its spatial and social impacts. For centuries fishing has been a cornerstone of the Blue Economy. In recent times it has been of less significance in monetary value when compared to other maritime industries such as offshore oil and tourism. However, catch fisheries remain enormously important in terms of employment and subsistence to coastal communities everywhere. They are the largest maritime employer by an order of magnitude, over five times their nearest rival [OECD 2016]. Arguably, of all maritime human activity, they have the greatest impact on the environment. The ancient rights of individuals to navigate and fish the oceans and seas are under pressure from overfishing, illegal fishing, market competition from farmed fish and spatial exclusion due to new industries and conservation areas.

In helping to feed the world, fish are an important source of animal protein. Consumption of fish exceeded a global average of 20 kg per person per year for the first time in 2014 although recent growth in consumption has been supported entirely from aquaculture. Wild fish consumption has flat lined at an annual rate of about 10 kg per person for some time. Farmed fish consumption, on the other hand, has soared from next to nothing in 1974 to around 10 kg or just over 50% of total consumption in 2014. In nearly half the countries of the world, fish contribute more than 20% of protein in the diet [FAO 2016]. As the largest maritime employer, the social importance of

catch fisheries exceeds its commercial importance by quite a wide margin. The artisanal and subsistence fishing sector is very large. The OECD [2016] estimate global catch fisheries employment in the commercial sector at more than 11 million but, when the artisanal sector is added, total employment in all wild fisheries is estimated by the FAO [2016] at nearly 40 million. More are employed in processing and support industries. The artisanal sector is catching for subsistence and for small scale commercial sales where possible.

Global fisheries policies are aimed at food security and a sustainable level of stocks for the future and farmed fish are seen as one way to reduce pressure on the wild stocks. However, levels of illegal, unregulated and unreported (IUU) fishing are high, including elements from both commercial and artisanal sectors [FAO 2016]. Fish catching is a free roaming activity where access is of critical importance but environmental damage is caused, from trawls for example. Public rights to navigate and fish the ocean commons are enshrined in international and national law but pressures on stocks create ever more stringent management measures in response. At the same time, new maritime industrial sectors and platforms for energy and aquaculture require exclusive use of marine space with inevitable consequences of displacement for fishers. The sector is therefore under scrutiny and facing increased restriction. However, its social importance attracts high levels of political support often combined with strong national or regional feelings about boundaries and rights.

This chapter describes the fishing industry and its role in the Blue Economy. As a start, Section 6.2 examines the market for fish including the policy ambition of food security and the consumption of fish as an important part of diet. Section 6.3 reviews the structure and lifecycle of the industry highlighting the differences in the business models of the various sectors. It also reviews regulatory and management measures as drivers in strategy. Section 6.4 describes the working environment of fisheries, including safety, because fishing is one of the most dangerous jobs in the world, the nature of fishing communities and the pressure on labour supply. Section 6.5 is about innovation, reducing costs and boosting productivity while at the same time coming to terms with extensive and complex regulatory frameworks aimed at sustainability. Section 6.6 looks at investors and investment, private and public. Some sectors of the industry continue to attract substantial private investment into large and technologically advanced vessels and methods. Extensive public investment is aimed at monitoring and control which supports the industry in a sustainable future for fishers and the world

at large. Section 6.7 summarises the uncertainties and makes concluding remarks.

The global fishing industry is huge in numbers and complexity. This chapter has a focus on Europe but set in an international context. Specific area examples are used to exhibit generic points. The chapter tries to capture the essence of fishing as a business within the expanding maritime economy.

6.2 Market

6.2.1 The Demand for Fish

The market for catch fisheries is driven by the demand for food and is a valuable source of animal protein as shown in Figure 6.1. World fish production, catch and farmed, contributes about 180m tonnes per year while meat production (chicken, cattle, pig, and sheep) totals around 265m tonnes per year. It is supported by the availability of catch and the accessibility of catching areas in the marine commons. The pre-eminence of aquaculture in recent fish consumption records reflects the very high figures from Asia which

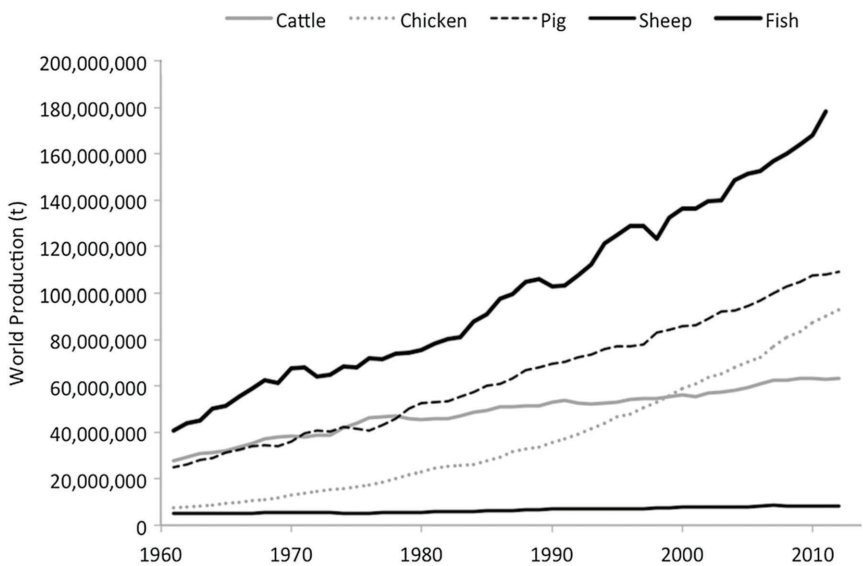

Figure 6.1 World Production of the main sources of animal protein over the period 1960–2010.

Source: FAO Statistics.

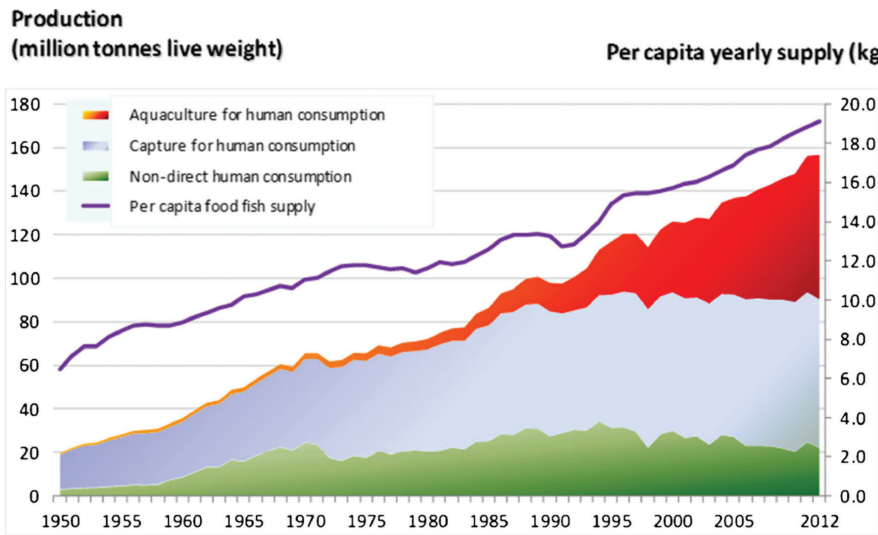

Figure 6.2 Relative contribution of aquaculture and capture fisheries to production and food fish supply.

Source: FAO Statistics.

is the leading fish producing and consuming area in the world Figure 6.2. Aquaculture in Asia supplies nearly 60% of consumption there, while for the rest of the world and Europe it is more in the range 12%–20%. Greenland leads per capita fish consumption with more than 60 kg/year for each resident; Norway, France, Spain and China follow in the range 30 kg to 60 kg; North America, Russia, Australia, UK and most of SE Asia consume 20 kg to 30 kg; Central Europe, Latin America, India and most of Africa eat 2 kg to 20 kg while countries like Afghanistan, Sudan and Ethiopia get by on less than 2 kg of fish per person per year.

6.2.2 Pressures on Price

The world population has more than doubled in the period from 1950 to 2014, from three to seven billion, while fish utilisation has more than trebled, from 40 to 130 million tonnes, in the same period. The FAO catch fish price index hovered around the base of 100 for a decade or more before surging to 160 in the period 2004–2014 and falling back to about 140 in 2016 (Figure 6.3). The farm fish index has fluctuated around 120 for three decades but is also currently at about 140. The global market for fish appears strong and has been growing for several decades. Prices are also strong. However, future growth

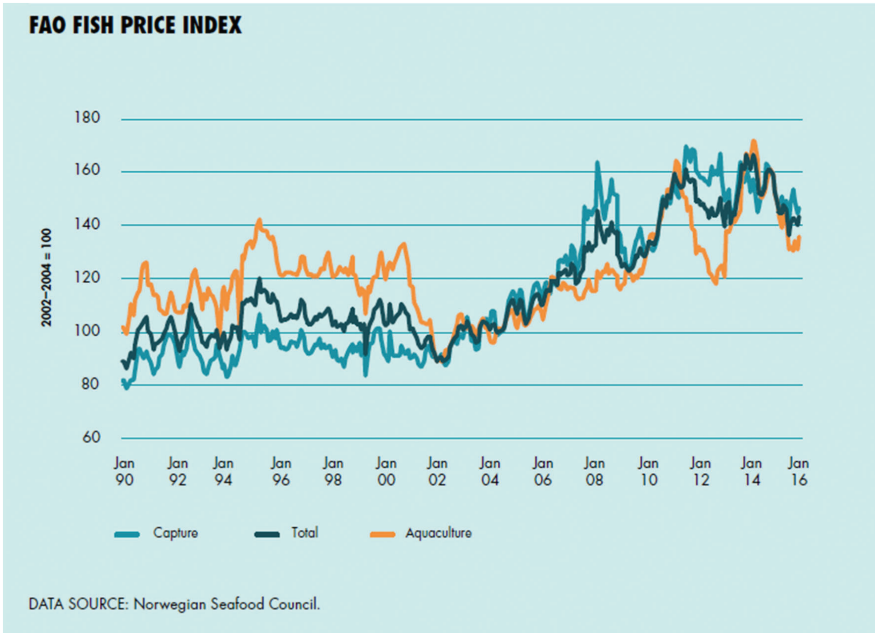

Figure 6.3 FAO Fish Price Index 1990–2016.

Source: FAO 2016.

of the catching industry is uncertain and dependent on several factors. A key question is the extent to which aquaculture and farmed fish will substitute for catch fish. The sectors are inextricably linked as some catch fish are also processed as fish meal for farm fish feed. The proportion of farm fish consumed has grown every year from almost nothing in 1974 to a world average of 50% today and continues to grow. Capture production plateaued in the range 80/85 million tonnes in 1985 and shows no signs of an upturn (Figure 6.4). Pressure on the catch industry also comes from increased sustainability measures and management of wild stocks. In Europe this includes market pressure with major retailers demanding Marine Stewardship Council (MSC) sustainability accreditation, or similar, in the sourcing of the fish they buy and sell [Bell *et al*. 2015]. The MSC is global in its reach [MSC 2016].

6.2.3 Trade across the World

International trade in fish is strong with flows and counter flows of product often reflecting differences in national tastes for certain species. Historic and cultural links to diet are hard to break. Velvet crabs caught in Scotland,

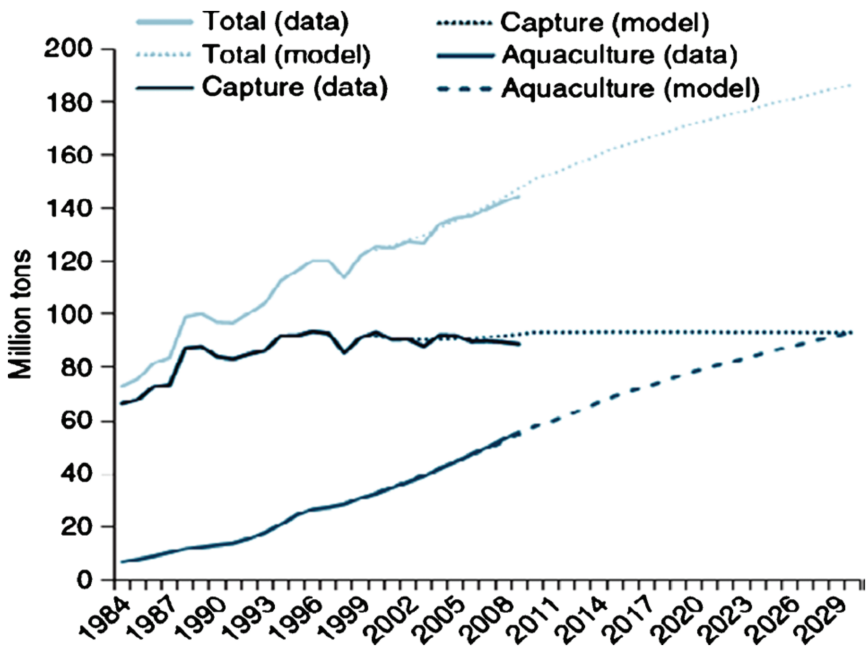

Figure 6.4 Global fish production: Data and projection 1984–2030 from the IMPACT model.

Source: World Bank 2014.

where they are rarely eaten, are exported almost in their entirety to Spain where they are an everyday food. Sea cucumbers from around the world are exported to China and surrounding countries where they are highly valued, the only place in the world where they are. Cod has especial value in UK for fish and chips and salted in Portugal for bacalhau. The strongest exporting region of the world for fish and fish products by value is Europe at over US$50bn. However, it is also the largest importer of fish and fish products at US$60bn. Fish and related products are one of the most traded segments of the world food sector with about 78% of seafood products estimated to be subject to international trade competition. In several countries the fishery is economically essential; in Greenland and Iceland it represents more than 40% of all traded commodities. In overall terms the fishery trade in 2014 was 9% of global exports in the fisheries and agriculture sector and 1% of all world trade [FAO 2016]. The trade values include a wide range of segments essential to the industry including management, harvesting, processing, monitoring, port services, maintenance, crew supply and training, vessel charter, infrastructure

and research. Demand for fish and the globalisation of trade, together with improved transport and technology, have all contributed towards a geopolitical role in enforcing these global trends. World trade in fish and related products has increased in the value of exports from about US$72 billion in 1976 to over US$148 billion in 2014 (Figure 6.5).

Catch fish compete in the market with other forms of protein both animal and vegetable. Taste for particular species plays an important role and there will always be a limited demand for high quality high price fish such as tuna and turbot. However, at the general level, the bulk protein

TOP TEN EXPORTERS AND IMPORTERS OF FISH AND FISHERY PRODUCTS

		2004	2014
		(US$ millions)	
EXPORTERS	China	6 637	20 980
	Norway	4 132	10 803
	Viet Nam	2 444	8 029
	Thailand	4 060	6 565
	United States of America	3 851	6 144
	Chile	2 501	5 854
	India	1 409	5 604
	Denmark	3 566	4 765
	Netherlands	2 452	4 555
	Canada	3 487	4 503
	Top ten subtotal	**34 539**	**77 801**
	Rest of world total	**37 330**	**70 346**
	WORLD TOTAL	**71 869**	**148 147**
IMPORTERS	United States of America	11 964	20 317
	Japan	14 560	14 844
	China	3 126	8 501
	Spain	5 222	7 051
	France	4 176	6 670
	Germany	2 805	6 205
	Italy	3 904	6 166
	Sweden	1 301	4 783
	United Kingdom	2 812	4 638
	Republic of Korea	2 250	4 271
	Top ten subtotal	**52 119**	**83 447**
	Rest of world total	**23 583**	**57 169**
	WORLD TOTAL	**75 702**	**140 616**

Figure 6.5 Top ten exporters and importers of fish and fishery products in 2004 and 2014.

food market is working in the range of €15–€25 per kg for catch fish, farmed fish, beef and lamb. Chicken and vegetable proteins can be considerably cheaper in the market with chicken offered for as little as €5 per kg [https://ec.europa.eu/agriculture/index_en]. Public taste for fish is stubbornly fixed on traditional but threatened species such as cod, and reluctant to move to more prolific species such as mackerel and farmed varieties such as Vietnamese tilapia. Education, marketing and innovation in product design, such as supermarket ready meals, are key tools in retaining or increasing market share but price remains a key metric. In relation to farmed fish, catch fish have the advantage of a far greater range of species. Both catch and farm industries face significant problems of sustainability for different reasons – catch because of the problems of overfishing, and farmed because of environmental pollution and disease.

6.3 Structure and Lifecycle

6.3.1 Sectors

The catch fishing sector can be divided and classified into a number of subsectors each with its own characteristics and lifecycle. A major division is between commercial, fishing for the market, and artisanal, fishing for subsistence and small scale sales. The commercial fishery, the main subject of this chapter, can be classified in numerous ways including location, target species, catching method and equipment. Particular locations considered in this book are the EU sea basins of the Atlantic (Chapter 10); North and Baltic Seas (Chapter 11); Mediterranean and Black Seas (Chapter 12); and Caribbean Basin (Chapter 13). These broadly correlate to the fishing areas coded by the FAO with the catch data listed in Table 6.1. The European Atlantic area is the most significant of the European areas for catch measured by weight of fish landed. Differences in the businesses related to fishery subsectors are illustrated by reference to pelagic, demersal and shellfish species. Each of these groups hosts a fishing industry of different character in respect of impact, value and employment.

a. **Pelagic Sector (mid-water species).** Typical target species for the pelagic fleets in Europe are herring, mackerel and blue whiting. The pelagic fleets tend to the offshore and employ the largest and most valuable vessels costing in the range £10–20 million each. They are relatively few in number with lengths up to 80 m, displacement of 3000 tonnes and power sometimes in excess of 6000 kw. Taking the

Table 6.1 Wild Fish capture by sea basin

Location	Marine Capture 2014	Major Fishing Countries by Basin (Rounded Figures)
Atlantic, North East (FAO Code 27, includes North and Baltic Seas)	8.7 million × tonnes	Norway (2,300,000t) Iceland (1,100,000t) Spain (1,000,000t) Denmark (700,000t) UK (700,000t) France (500,000t)
Mediterranean and Black Seas (FAO Code 37)	1.1 million x tonnes	Italy (114,000t) Algeria (97,000t) Tunisia (91,000t) Spain (73,000t) Croatia (73,000t) Turkey (58,000t)
Atlantic, Western Central (FAO Code 31, includes Caribbean and around)	1.2 million × tonnes of which about 50% (0.6mt) are sourced from the Caribbean Basin	(Caribbean Basin only) Mexico (190,000t) Venezuela (119,000t) Guyana (48,000t) Suriname (39,000t) Jamaica (25,000t)
WORLD total all species all areas	81.5 million × tonnes	China (14,800,000t) Indonesia (6,000,000t) United States (5,000,000t) Russia (4,000,000t) Japan (3,600,000t) Peru (3,500,000t)

Source: FAO 2016; FAO Statistics 2015.

UK as the example, there are only twenty pelagic vessels, of over six thousand in total registered for all fishery sectors. The twenty vessels are registered in just two Scottish ports – Peterhead and Lerwick. In Scotland, the pelagic catch in 2015 was 291,500 tonnes which represents 66% of the total Scottish catch of 440,000 tonnes. The total Scottish catch is 63% of the whole UK catch of 702,000 tonnes for all species [MMO 2017]. Quota and other management restrictions meant that these twenty pelagic vessels only spent about one month each at sea last year. Not all the Scottish catch is landed in the UK and in addition there is an active import and export business. For example in 2015, 95,000t of mackerel were landed into the UK in addition to which 19,000t were imported. 80,300t of the total were exported with 40% of exports

going to the Netherlands. Typical methods and gear include purse seine netting, mid-water trawling or pair trawling. The pelagic fishing industry is the largest by value in Europe, it is big business, and it is concentrated into very few hands.

b. **Demersal or Whitefish Sector (bottom living species).** European targets include cod, haddock and plaice. Fishing methods tend to bottom trawling although hook and line is increasingly promoted for more sustainable fishing. The demersal fishery is working closer to shore and is more likely to be in conflict with static gear fisheries and other activities. It is difficult to draw a distinction between the major commercial demersal vessels and the smaller shellfish vessels which take a significant quantity of finfish in total by virtue of their numbers alone. Taking the example of the part of the Shetland fleet which is defined as demersal, all the vessels are over 20m, and so this delineation is taken here. By this definition about 500 of the 6200 UK registered vessels represent the demersal fleet. These vessels normally fall into the range of 20m–30m in length with registered tonnage of 200t–300t each. Power is in the order of 600 kw. The demersal fishery is the second largest by value in Europe and again is concentrated into few hands in relatively well organised businesses.

c. **The European Inshore Fleet.** The inshore sector of the industry is mainly a shellfish fleet with targets of non-quota species such as lobster, crab, scallops and nephrops. Finfish will also be targets where possible and quotas allow. This is the largest fleet by far numbering about 80,000 across Europe with the great majority of vessels less than 10m in length. Greece has the largest fleet of about 16,000 vessels. In the UK 5700 vessels (of 6200 registered vessels in total) fall into the less than 20m category. Nearly 5000 of these are less than 10m. This is a very different fishery business model in comparison to the demersal and pelagic sectors. It is dominated by owner operators often working by themselves and frequently without crew. The vessels and their equipment are low cost and low tech. Fishing methods include static traps, dredges for molluscs, trawls for nephrops, line fishing for finfish and gill netting. These fishers tend to be poorly organised as a group and less easy to regulate as a result. The majority will not join fisheries associations or federations which they see to be dominated by the 'big fishers' [Noble 2003]. Fishing cooperatives are common whereby fishers in an area band together for purposes of self-management enforced by peer pressure and marketing of product. There are some government supported schemes,

such as the 'Regulating Order' (RO) scheme in Scotland, which offers groups of fishers the statutory right to manage their own fishery. The costs of management and rivalry among fishers are an obstacle and this measure has so far only been adopted in Shetland. The inshore sector is often important, and sometimes essential, to vulnerable and peripheral coastal communities feeding into all aspects of way of life and culture. It is also the fishery with least power and participation in regulatory and institutional structures, especially at higher levels of EU governance.

The pelagic, demersal and inshore fisheries sectors exhibit three very different business models and are at different stages in their respective lifecycles, although all may be regarded as mature or even post-mature. The high value pelagic and demersal sectors are big business with a large investment in vessels and equipment. They are capital intensive and are often highly geared with high levels of debt and susceptible to variances in cash flow. They have to keep fishing to service their debts as well as showing significant profits to shareholders and for re-investment. Adequate stocks and regulatory restrictions are their main concerns but they are politically powerful and 'own' most of the available quota for key species. Data about their activities are detailed with programmes of monitoring and evaluation. They range over huge distances in pursuit of stocks which roam freely across national boundaries and into areas beyond national jurisdiction (ABNJ) aka 'the high seas'. They have freedom to move and are the least spatially affected by other maritime activities and 'Blue Growth' ambitions. They employ few people at sea but by virtue of their catch volume but they create substantial shore based employment at the major landing ports in processing and marketing of product – the economies of scale.

Far less is known about the inshore sector and the small vessels which are employed. These tend to focus on non-quota species, only because quota is not available to them for reasons of government distribution policy or cost. As such it is much more open access and vessels below 15m in length are not required to be subject to VMS (vessel management system) tracking. For larger vessels (over 15m), VMS identifies where vessels are steaming and fishing at all times leaving a permanent record. The 'at sea' employment in the inshore sector is large and localised. These fishers do not roam over large distances and tend to have informally specified areas as 'their' area close to home. Their fishing activity in the coastal zone is highly susceptible to other maritime activities which also tend to this area of sea. Available fishing areas can easily be eliminated by developments such as marine energy or

the designation of MPAs leaving some fishers with nowhere to go. A lack of knowledge about this very individual and poorly organised sector was clearly exposed in Scottish marine planning in 2010 leading to a concentrated consultation and mapping of inshore fishing areas [Marine Scotland 2016].

6.3.2 Management

The structure of the fishing industry is shaped primarily by the market and the availability of fish for capture. However, there are significant external drivers which are pushing and pulling the industry in strategic directions. The most significant of these is management and regulation aimed at the prevention of overfishing, the mitigation of conflict among users and the promotion of best practice. The seas and their resources are not owned by anyone. The international community and governments are responsible for management of the 'right to fish' and in deciding how the rights, or fishing opportunities, should be allocated [NEF 2016]. There can be three approaches within the overall government ambit although in practice they can overlap to a large degree:

1. Government Management. This is usual for large-scale fisheries because of their over-arching power and relative impartiality among fishers. It also involves intergovernmental organisations called Regional Fisheries Management Organisations (RFMOs) and sometimes supranational governments like the European Union (EU).
2. Common Pool Management. In a small-scale or local context where the same group of fishers target the same stock, the fishers might set and apply the rules, sometimes supported by a statutory mechanism [Dietz *et al.* 2002].
3. Private Management. Privatisation or quasi private mechanisms are often argued as a solution to overfishing because the 'owners' will take care to manage their assets better than if they were in a common pool. In practice this usually means a fishing right or opportunity granted to a private entity and not ownership of the stock itself.

At the international level fisheries regulation is established under several conventions or treaties of which the most comprehensive is the 1982 United Nations Convention on the Law of the Sea (UNCLOSIII). UNCLOS sets zones of sovereign rights to marine resources and stipulates that total allowable catches (TACs) should reflect the best scientific advice available. Wild fish in national waters are considered 'unowned' until captured and then owned by the captors. Additionally, Regional Fisheries Management

Organisations (RFMOs) are intergovernmental institutions composed of member states and play a crucial role in international, deep-sea and migratory stocks which cross borders (straddling stocks).

At the European level, the Common Fisheries Policy (CFP), applies to the waters of all member states and is highly influential under collaboration agreements with neighbouring non-member states such as Norway and Iceland. About two hundred fishing opportunities are set by the EU every year as TACs for the commercial fish stocks in EU waters. Multi-annual management plans (MAPs) specify long-term objectives including rules on effort controls, TAC setting, landing and transport. TAC setting employs the scientific expertise of the International Council for the Exploration of the Seas (ICES) in annual stock assessments. The full annual TAC process comprises:

1. Pooled international dataset made up of sampling landings and research surveys;
2. ICES working groups carrying out annual stock assessments and providing scientific advice;
3. ICES management committee examining annual assessments and providing management advice;
4. European Commission (EC) reviewing ecological, social and economic evidence with additional advice from the Science, Technical and Economic Committee for Fisheries (STECF);
5. EC submits TAC proposals;
6. Annual TAC negotiations with EU member states allows individual TACs to be set by the EU for each member state.

After TACs have been set, it is for Member States to decide on the distribution of national allocations to producer organisations, fishing companies and individual fishers. However, European law also legislates for several technical measures in the form of 'input control' or controls over gears, techniques and other specifications. These input measures are aimed at selectivity in species capture and ecosystem impacts in contrast to the 'output controls' of TACs focusing on what is caught rather than how it is caught.

At the national level the authorities set rules for licensing on who is allowed to enter the industry and the conditions for holding fishing rights. Fishing opportunities are the enforceable restrictions within which fishers can legally fish. They can be grouped into quota management (QM) which are quantitative output controls and effort management (EM) which are input controls. Significant elements of QM and EM fall within the definition of Rights-Based Management (RBM) defined as "*Fishing opportunities that*

convey secure and exclusive fishing rights to individual fishers or defined groups of fishers" [NEF 2016].

Quota (output) measures fall into several categories whose use varies by country:

- National Quotas (NQs) applied to the whole fleet;
- Rationed Quotas (RQs) centrally determined often on the principle of equal access;
- Individual Quotas (IQs) made to individual vessels based on quota shares;
- Individual Transferable Quotas (ITQs) similar to IQs but transferable and leasable;
- Community Quotas (CQs) similar to IQs but to a collective unit.

In addition to government reallocation, quotas may be transferred, where allowed, by swaps, leasing and the transfer of quota shares. Quota shares do not normally confer property rights to the owners as the government retains the right to reallocate or reform the system. Some countries have granted rights that guarantee shares for a specified period which gives them a kind of legal status although still ambiguous. Critics of quota management refer to the injustice of the market which has developed in quota sale and purchase. The result has tended to a concentration of fishing opportunities into fewer hands at the expense of the myriad of small and artisanal fishers. Additional tensions are introduced by a trans-national trade in quota with foreign fishers owning quota in other states.

Effort (input) measures include:

- Individual effort quotas (IEQs) granting fishers an allowance for effort usually by gear type (e.g. kilowatt days at sea);
- Territorial Use Rights for Fisheries (TURFs) giving fishers a defined territory with exclusive harvesting rights;
- Limited Licensing (LL) controlling the number of vessels with conditions such as capacity, gears, spatial limits and target species;
- Spatial Management (SM) restricting access to defined areas for reasons of conservation or gear conflict. Marine Protected Areas (MPAs) are one such mechanism;
- Fishing Seasons (FS) determining times of year when fishery may open perhaps to match migratory patterns or to avoid spawning periods;
- Days at Sea (DAS) granting individual vessels the time when they can fish. The catch is therefore limited to the amount possible in their

time allowance. DAS are often linked to the vessel power in kilowatts to make a combined measure.
- Fishery Closures banning all fishing or specified types of fishing.

Taken as a whole the management system has grown piece by piece over decades. As one thing has not worked, another has been tried and so on. Many fishers, from all states see the result as clumsy, unworkable and unfair to their industry. This criticism may be seen clearly in respect to the CFP and the UK referendum decision to leave the EU. 'Fishing for Leave' is an influential organisation with a high public profile and features strongly in the BREXIT negotiation [HoL 2016]. Their argument is not purely nationalist, but is built on a view that a new system of management is needed and that it can be much better [Author interview with the Scottish fishing sector 2017].

6.4 Working Environment

The working environment of the fishing industry is unrelentingly tough. It is a dangerous occupation. Accurate global figures are not available but in the sophisticated United States (US) regime the average fatality rate over the last ten years among commercial fishermen is 1.15 per 1000 per year. This is three times greater than the next most dangerous job (construction) and twenty five times the average across all occupations in the US [Davis 2001]. Severe weather, fatigue and inconsistent use of safety equipment are all contributing factors. An extrapolation across the world is perhaps a step too far, but it is a guide to the sort of figures that might be expected among the 40 million employed in fishing globally, many of whom are working in far less regulated fisheries than those found in North America. Like other hazardous occupations before it, such as coal mining and steel smelting, the danger and the peripheral coastal location of many of the fishing centres breeds strong, tightly bound and self-reliant communities. Outside interference in their way of life and regulation of their livelihoods by distant scientists and politicians can be deeply resented. Fishing permeates every aspect of community life, at sea and onshore. The families and many of those who never go to sea are involved in shore based support. A whole culture of art, music and writing has evolved around fishing communities which these days is highly valued by tourists and urban migrants moving to the coast. So, long established fishing villages like St Ives in Cornwall or Stromness in Orkney are filled with visitors and resident artists.

Take the Shetland Islands and its capital of Lerwick as an example. Shetland is a fishing county with a population of about 23000 and Lerwick is the second most important fishing port in the UK, after Peterhead on the Scottish mainland. It is situated at the junction of the Atlantic Ocean with the North Sea, over 100 miles north of Scotland and half way between Scotland and Norway. Shetland is at the centre of the UK's richest fishing waters and its fleet operates in all three sectors, pelagic, demersal and inshore. It could be seen as remote but sees itself as a North Atlantic hub [Coull 1996] Nearly half the UK pelagic fleet, eight large vessels, is based here. Twenty one demersal vessels are based in Shetland in addition to which Lerwick is the chosen port of landing for vessels from all over the UK and Europe. The inshore fleet numbers about 150 vessels fishing mainly for shellfish. Most of the catch is now exported fresh or processed and exported. In times past it was the main source of food for the islands in common with subsistence fisheries over very large areas of the world today.

The Shetland fleet could not operate without comprehensive and extensive support industries onshore – ports and harbours for shelter, slipways and engineering bases for maintenance, chandlers and fuel merchants to keep the crews and boats going, the fish market itself, shipping and marine transport hubs to export the catch including live crab in vivier trucks to Spain. The 'Shetland Catch' pelagic processing plant in Lerwick is the largest in Europe. To meet a constant demand for officers and crew, the North Atlantic Fisheries College (NAFC) in Scalloway takes trainee deck crew and officer cadets from all over the UK and Europe. In terms of labour, skilled crews can be found and exchanged here. A 'Fishermen's Mission' helps them with their spiritual and welfare needs.

Crew supply has become a controversial matter with recruitment of foreign crews to man European vessels at greatly reduced rates of pay – a much discussed feature of globalisation. The International Transport Workers' Federation (ITF) has reported on 'Migrant Workers in the Scottish and Irish Fishing Industry' [ITF 2017]. They report migrant fishers earning as little as £268 per month at an equivalent rate of £1.29 per hour. The minimum wage in the UK is £7.20 per hour in 2017. Most of the foreign crews are from the Philippines with over 1400 believed to be employed in Scotland and Ireland. This can only happen outside of the territorial sea and so mainly the pelagic and demersal sectors will be involved. Seafish is a UK Non-Departmental Public Body (NDPB) set up by the Fisheries Act 1981 to improve efficiency and raise standards across the seafood industry. It is funded by a levy on the first sale of seafood products in the UK, including

imported seafood in accordance with the Fisheries Act 1981. It has found it necessary to issue guidance to vessel owners on their responsibilities under the new UK Modern Slavery Act 2015 and human trafficking legislation [Seafish 2016].

Both literally and figuratively the working environment of the fishing industry is at the edge. It is at the edge in terms of physical location and of safety, employment practice, sustainability and in some respects, legality.

6.5 Innovation

Catch fishing is an industry under pressure. Widespread overfishing in excess of sustainable stocks has long been alleged and in many cases documented. The pressure of public opinion drives a search for sustainable solutions in management, methods and equipment. The demand for fish and fish product is strong and continuing to rise but the growth is entirely with farmed fish and the World Bank forecast zero growth in the catch industry up to 2030 (Figure 6.4). Fish prices are buoyant but management and environmental safeguards push up costs, leading to a search for efficiencies and cost saving technologies in order to stay competitive with surging farm fish supply and meat sources of animal protein. In addition to all these factors the fish catch industry is threatened with increasing spatial pressure as new 'Blue Growth' industries for energy, aquaculture and other uses take hold. Displacement from some traditional fishing areas seems certain. Everything points to an industry which is mature or even post-mature in its lifecycle but with a lot of potential life left in it, but only if it can meet the challenges through innovation and change.

These challenges fall to three main headings:

1. Innovation in sustainability
2. Innovation to meet technical and operational demands including cost reduction
3. Innovation in the market and marketing.

The implementation of an ecosystem approach to fisheries management is highlighted by the OECD [2017] as a key priority for fisheries innovation as well as improving the selectivity of gears; employing genetics and stock boundaries; introducing novel fishing techniques; reducing seabed impact; and mitigating the interaction with protected species and bycatch. Other necessary research is directed at the design of fishing vessels including fuel efficiency, emissions, maintenance, product conservation, safety and working

conditions for the crew. The OECD have tracked and reported on patents in several countries as a means to measure activity in fisheries innovation [OECD 2017]. The United States leads in fish harvesting technology innovation with over 1000 patents closely followed by South Korea. Russia and South Korea lead in the field of 'New Products and Markets' with technologies helping the production of food from sea products such as fish meal.

Fisheries Innovation Scotland (FIS) is one of a number of organisations across the world designed to provide a formal structure of collaboration in fisheries research and innovation [FIS 2017]. The members of FIS are a diverse group of interests including government, scientists, industry, retailers and other key stakeholders. Marine Scotland, the Scottish government agency responsible for fishing, is working alongside the fishing industry and statutory agencies like Scottish Natural Heritage (SNH) and Seafish and also large food retailers and producers like Sainsbury's and Young's. An aim of FIS is to support the innovation objectives listed under the provisions of Article 26 of the European Maritime and Fisheries Fund (EMFF) which is described under 'investment' in the next section [EU 2017]. The presence of retailers in projects to enhance the sustainability of the fishing industry is a recent and important innovation. NGOs like the WWF and individuals, like the food broadcaster Hugh Fearnley-Whittingstall, have succeeded in mobilising public opinion to the extent that retailers want to show that their fish is sourced from sustainable fisheries. Other NGOs and charities have been formed to monitor and evaluate fisheries and issue certification of their fishing practices. The most prominent of these is the Marine Stewardship Council (MSC) who will inspect and certify those fisheries which employ sustainable methods in management. Increasing numbers of retailers have, in turn, committed to only buying fish from MSC certified fisheries or their equivalent. The effect is to integrate the industry from catch to plate and promote sustainable practice.

An example is the Orkney inshore fishery where the Orkney Sustainable Fisheries Project is aimed at MSC certification and beyond [Bell *et al.* 2015]. Orkney Sustainable Fisheries (OSF) is established as a cooperative consortium of local stakeholders. One of the first actions was to commission a pre-assessment for the creel fisheries (brown crab, European lobster and velvet crab) against the MSC standard for sustainable fishing [Hough, 2006], which identified three main issues: defining the extent of stocks, particularly the inshore and offshore components in brown crab; the lack of explicit objectives and effort controls; recording of catches and bycatch. The subsequent Orkney Shellfish Project has been established to respond to the licensing

of areas of Pentland Firth and Orkney Waters for wave and tidal energy developments; and a second pre-assessment of the creel fisheries against the MSC standard. This identified the main issues as a lack of biological reference points, harvest control rules and monitoring of fishing effort [Bell and Gascoigne 2012]. The Crown Estate, a public body which manages UK assets including the seabed, funded the monitoring of spatial patterns of fishing effort in Orkney waters with vessel monitoring systems supplied by Marine Scotland, their interest being in developing a resource for wave and tidal energy developers in informing consenting activities. At the same time, the project has involved the development of a Fisheries Improvement Project to formally progress the brown crab fishery towards meeting the MSC standard for sustainable fishing, this being supported by WWF-UK and Marks & Spencer as a retailer working towards sourcing seafood products only from sustainable fisheries.

A key focus for innovation in all sectors of the fishing industry is selectivity. Catching the wrong species (by-catch including cetaceans and seabirds) or too many of the right species without quota, is wasteful and deeply unethical when it results in avoidable deaths and the discarding of unwanted or unauthorised catch. The reform of the EU Common Fisheries Policy (CFP) in 2012 introduced measures to prevent the practice of throwing unwanted catches overboard [Seafish 2017]. Introduced gradually, the general rule will be fully in place by 2019 by which time no commercial fishing vessel may return any quota species of fish, of any size, back to the sea once caught. Everything must be landed where it will be counted against quota with special rules for disposing of undersized or prohibited catch. This is the regulatory response but the industry is anxious to find technical solutions to the catching of the wrong species in the first place. The main instrument in the past has been mesh size in the nets but this is a crude and frequently ineffective method.

Fisheries regulation in Europe and the CFP has grown up over fifty years or so developing into a sophisticated but complex mechanism which underpins the whole approach of the industry to its work. The extent to which the CFP has helped conserve stocks is disputed although clearly it has its successes such as the conservation of North Sea cod and herring. Fishers in the UK, and in some other member states, have blamed the CFP for a downturn in their industry and its closure in some of the old fishing centres in England like Grimsby and Lowestoft. UK fishers were key drivers behind the campaign to leave the EU in the BREXIT referendum of 2016. They foresaw a chance to ‘take back control’ of UK waters with the exclusion of foreign

vessels and a new management regime. At the time of writing it is impossible to say how this will work out. How far will the requirements of international law, transboundary relations with neighbours and the needs of free trade allow these sentiments of 'independence' to be realised? The negotiation could be long and hard and the fishers already fear their sacrifice in the interests of trade. However, looking beyond the chauvinism, there is a chance, just a chance, that root and branch innovation for the needs of modern fisheries management could introduce a more effective regime. In interviews with Shetland fishers there are ideas for high-tech solutions to selectivity which fail to get a hearing under the CFP because of its complexity as a mechanism, they say. There are both regressive and progressive ideas at play in the push for a UK fishery out of the EU.

A further area for research and innovation is the question of coexistence. New maritime industries, such as offshore wind power, can occupy very large areas of sea and threaten displacement of fisheries. Questions are raised of the opportunities for coexistence between wind farms and fishing or even enhancement of the fisheries. Most research and evidence to date has derived from the burgeoning offshore wind industry (Chapter 5) and the already well established operations around the coasts of Europe. Offshore wind turbines are usually sited in rows at distances apart of 500m or more so the waters between them might be used as nursery areas or possibly for trawls. The fishing obstacles are largely those of risk to the safety of power infrastructure and vessels and the apportionment of blame if things go wrong, a broken down vessel colliding with a turbine for example, or trawling through a power line. Other possibilities considered are the exploitation of turbine foundations as new habitats for crustaceans and the siting of fish farms within the confines of the wind farm.

6.6 Investment

Private sector investment in the fishing industry as a business follows a conventional model of equity and debt with little public support now available in the form of development grants for vessels and conventional equipment. There are no direct subsidies such as those available under the Common Agricultural Policy (CAP). Fishers with a good business plan and realistic projections of profit and cash flow will be able to access equity from shareholders and loans from banks to finance their operations and grow their businesses.

The target for public investment has changed. At its outset the CFP also supported investment to encourage growth in the output of European fisheries. Today, public investment, supported in some of its facets by private and volunteer investment, has evolved. It is focused on research, stock assessment, monitoring and evaluation, enforcement, infrastructure, sustainability and coexistence. Some of this public investment will be recovered in the form of levies and fees which will be reflected in the wholesale and retail prices of the end product.

Central governments will pay to be part of the international network of maritime law through conventions, treaties and institutions. The scientific work of ICES in undertaking the science of stock assessment will be met by governments paying to be members of the organisation with access to their results. Similarly work with international conventions like OSPAR aimed at the prevention of pollution and marine conservation in the NE Atlantic. On a national levels there is taxpayer funded investment into a host of promotional and regulatory organisations focused in the end at enforcement with fisheries protection vessels at sea and fisheries officers in landing ports.

The EU European Maritime and Fisheries Fund (EMFF) is established to provide grant aid in the promotion of sustainability in fisheries and to foster the implementation of the CFP [EU 2017]. It offers support under five headings:

1. Innovation in fisheries (Article 26) – improved equipment such as that needed for selectivity, techniques and management;
2. Conservation measures and regional cooperation (Article 37) – technical and administration measures and stakeholder participation across borders;
3. Reduced fishing impacts and protection of species (Article 38) – selectivity of species, elimination of discards, elimination of seabed damage;
4. Innovation for conservation (Article 39) – projects for sustainability and coexistence with protected predators;
5. Restoration of ecosystems and sustainability (Article 40) – wide ranging provisions from the collection of marine litter to compensation schemes, fisher education and Marine Protected Area (MPA) management.

The volunteer and charity sectors invest in fisheries monitoring and management raising funds through programmes of public awareness and providing services. The work of organisations like WWF and the MSC are effective in mobilising public opinion for investment in sustainable fishing. The MSC

raises over £15m annually to finance its operations of inspecting and certifying fisheries. Of this 25% comes from volunteer and business donations and 75% comes from the selling of services, almost all of which is for the licensing of its logo on retail fish products [MSC 2017]. The act of certification also levers in funds from the major retailers and the fishing industry for more investment in sustainability. So, companies like Tesco, Sainsbury, Marks and Spencer, Waitrose and Lidl invest in research and projects which will increase in their sourcing capacity for the fish from sustainable sources which their customers demand. The 2016 results from the MSC identify 286 certified fisheries in 36 countries representing over 10% of global catch. About 40 fisheries are newly certified each year and nearly 100 are in assessment.

More investment comes to the fisheries affected by the new industries such as offshore wind power and aquaculture. The focus of this investment is coexistence aimed at reducing fishery objections to their use of marine space. It recognises the political power of fishing communities in the coastal regions where their industry is to be sited. Typical of this investment is the establishment of 'The West of Morecambe Fisheries Ltd' covering the waters between England and Ireland. It is a not-for-profit UK company established in 2013 and funded by the owners of several UK offshore wind farms including Dong Energy, Vattenfall, Scottish Power and Scottish and Southern Energy. It manages funding donated by offshore wind farm owners, provided for the purpose of supporting and developing commercial fishing activities [WMFL 2017]. The companies are cagey about the actual level of their support but the web-site is very professional and Dong energy recently donated £300,000 to a particular project. A 'going-rate' for community support donations from companies related to new onshore wind farms has been established at around £5000 per kw of capacity per year [Kerr *et al.* 2017]. At sea it varies but similar sums are sought by coastal communities for offshore farms in their vicinity. The donations are used to finance, set up and support Community Projects including those for the fishing industry that operates in the same areas as the wind farms. It works closely with relevant sectors of the fishing industry to invest in a number of Fishing Community Projects aimed at business, sustainability and safety.

6.7 Uncertainties and Concluding Remarks

The commercial capture of wild fish is based purely on harvest and harvest technologies. There is no nurture or production element. It depends entirely on the vagaries of the wild environment, such as natural climate change,

and anthropological activities which directly affect stocks, such as fishing itself, or indirectly, such as pollution or human induced climate change. These anthropological factors are of prime consequence.

The demand for food fish is strong and growing with population growth and more sophisticated diets among developed and developing countries. However, price competition with rival sources from both animal and vegetable proteins will have an effect and the rapidly expanding availability of farmed fish by quantity and species is forecast to take up all the anticipated growth in fish consumption over the next decades. The World Bank anticipates zero growth in wild fish catch while farmed species output continues to grow at a rate of about 2.5% per annum.

Demand, therefore, is strong but catch is increasingly constrained by supply. Supply of the main finfish targets is constrained by significant and ongoing change in key factors:

- Stock availability – reduced availability in key species due to overfishing and climate change (natural and human induced);
- Reduction in permitted fishing targets – by specie and by quantity as stock assessment and quota allocation increases in sophistication and effect (output controls);
- Reduction in permitted fishing effort – (input controls)
- Increased sustainability measures in fishing methods – aimed at efficient selectivity of catch and reduced atmospheric emissions and seabed damage.
- Reduction in permitted fishing areas – developments in international and national marine governance and control reducing the open access nature of the High Seas and the marine commons. Also, increased spatial exclusion from the new 'Blue Growth' industries and MPAs.

These factors are mainly of concern to the bulk pelagic and demersal commercial fisheries which are very likely to see stasis in catch while facing increased costs in capture. Investment is aimed at preserving the industry at more or less current levels but reductions in activity are also highly possible. Growth in catch appears to be unlikely.

A different outlook applies to the inshore (small commercial) and artisanal fisheries. Almost every metre of coastline around the globe is fished to some degree, much of it at subsistence levels of activity. In these sectors are very high levels of formal and informal levels of employment and very significant social and economic issues affecting vulnerable and peripheral communities. In Europe, small commercial, owner operated fisheries in the inshore have flourished of late. Denied access to large finfish quotas they have

specialised in non-quota species such as crustaceans and molluscs, which may have increased in stocks as finfish predators have been reduced. Firm evidence is awaited but the nephrops fishery has expanded enormously. These inshore fisheries are more likely to be affected by the spatial pressures of coastal activities and new industries but their methods are more adaptable to coexistence.

The catch fish industry is under pressure but it has been the cornerstone of the Blue Economy for centuries and remains so. No other sector is as widespread or as important in employment and social terms. As long as there are fish in the sea, there will be a business model to catch them, sustainably of course.

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