What Hope for Shellfish Farmers?

A look at issues of direct relevance to water quality and to shellfish aquaculture.

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Initial Summary

Shellfish aquaculture, currently limited to molluscs such as mussels and oysters rather than crustaceans like crabs and lobsters (although this could change in the years to come), has the potential to make a significant contribution to national food security at a time when yields from capture fisheries are shown to be static or falling. This potential has been recognised for many decades.

The Marine and Coastal Access Act 2009, carried with it hopes of a bright future for shellfish aquaculture. More than a decade after its enactment however, the prospects of shellfish aquaculture look dire. The pollution of all our waterways and thus of our coastal waters puts shellfish farmers at the forefront of those businesses that are damaged, even destroyed, by that pollution.

Of the greatest significance among (but not the only) causes of water pollution are sewage discharges and effluent from agriculture. The Environment Agency lacks the resources for the effective enforcement of its powers to penalise and stop all sources of water pollution. Even if resources become available, remedial action will be very costly and take decades. There is no route to compensation for the shellfish farmer.

The Marine Policy Statement for the United Kingdom, published in March 2011, contained these words – "*In developing Marine Plans, marine plan authorities should take account of existing aquaculture activity in the area and seek information on possible future aquaculture operations in areas not previously used, assessing the suitability of those areas for development.*"

The Marine Plans that have emerged since 2011 indicate that those charged with the production of those plans have paid scant attention to the words just quoted. The recent plans, in particular, pay little more than fleeting lip service to the significance of aquaculture.

There are indications that Defra and perhaps also the Marine Management Organisation may lack the special expertise to discharge the responsibilities they have with regard to shellfish aquaculture. They are heavily reliant upon contributions from external consultants. Necessary regulatory improvements, recognised over decades, have not materialised.

Marine Protected Areas, where water quality can be better and there is the possibility of minimising disturbance by human activities such as dredging and bottom trawling, offer huge potential for the expansion of shellfish farming. The futile and ultimately doomed policy of Natural England towards the Pacific oyster has had the effect of excluding shellfish cultivation from those areas.

There are signs that this advice of Natural England, lacking any concern for (let alone direct responsibility towards) shellfish farmers, has developed into a powerful negative influence over the thinking and policies of Defra and the Marine Management Organisation in the discharge of their responsibilities towards those engaged in shellfish aquaculture.

Chapter 9 – What now? – A bleak future?, commencing on page 57, lists all the many conclusions reached in the chapters that follow.

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Chapter 1 – Introduction

Why shellfish aquaculture?

It makes sense to start by asking this question.

Twenty years ago

In late 2004, The Royal Commission on Environmental Pollution published its long-awaited report. It was entitled "*Turning the Tide: Addressing the Impact of Fisheries on the Marine Environment*". Chapter 6 of that Report was entitled "*Is Aquaculture the Answer?*" and its opening sentence set the scene – "*At the global level, aquaculture is growing faster than any other means of animal food production. World-wide, aquaculture production is expected to nearly double in the next two decades, climbing from 29 million tonnes in1997 to 54 million tonnes in 2020.*"

The principal focus of that section of the Report was fish (rather than shellfish) farming, but there were a few interesting comments on the farming of shellfish. "*the Environment Agency pointed to the growing number of applications for shellfish culture, ...* [and] *considered that these could increase significantly over the next decade, although others have suggested that water quality might be a limiting factor.*" Further, it (the EA) "*considered that there was a lack of robust microbiological water quality criteria to facilitate the design of remedial schemes to improve shellfish harvesting areas and ensure that hygiene requirements for shellfish products can be met. Other agencies have also highlighted the need for action to improve water quality in shellfish growing areas.*"

The key points were made then – and not for the first time. Twenty years ago, everyone who needed to know (or should have known) was (or should have been) aware, first of the contribution that shellfish aquaculture can make to food security and secondly that water quality is critical to shellfish cultivation.

Move forward a decade

In January 2012, the Department for Environment Food and Rural Affairs (Defra) launched a consultation entitled "*Planning for sustainable growth in the English Aquaculture Industry*". It covered the wide range of factors inhibiting the growth of aquaculture, laying emphasis on "*The Food Security Driver*" identified following the 1996 World Food Summit. Four specific and pressing challenges were highlighted – climate change, population growth, increasing affluence and global financial security.

That document stated – "*Aquaculture provides a means of producing consistently good quality, highly nutritious, good value for money seafood ... All forms of aquaculture are subject to stringent environmental legislation.*" And – "***The production of bivalve molluscs (clams, oysters, and mussels) can provide positive environmental impacts. These farms do little to disturb the ecosystem and they can even improve water quality***". [Emphasis added.]

The Defra plan for shellfish aquaculture

Defra's subsequent plan published in October 2015 and called '*Development of Sustainable Aquaculture (2014 – 2020)*' quoted shellfish aquaculture growth targets for Scotland (13,000 tonnes – up from 7,980 in 2014) and Wales (16,000 tonnes – up from 8,376 in 2011), but no targets for England or Northern Ireland.

This document told its readers that – "***Aquaculture in the UK is EU-leading in terms of knowledge (practical and academic), innovation, good practice and health status. Our coastal topography provides numerous excellent sites for .... shellfish farms. We are also well placed to develop marine aquaculture in more exposed locations - technologically and economically challenging but with great potential to contribute to Blue Growth and helping meet food security concerns.***" [Emphasis added.]

Defra's report looked at the challenges then seen to be faced by those engaged in aquaculture commenting that – "***the challenge that the authorisation process provides for the development of aquaculture in the UK should be noted***" and "***Some in the industry contend that the way the [Environmental Impact Assessment] and Habitats Directive has been applied in some cases, has not supported the efficiency, transparency and predictability which a regulatory process needs to support in order to foster investment confidence***". [Emphasis added.]

It went on to address – "*the expertise available within the regulatory organisations, and the confidence to take speedy and perhaps controversial decisions*", pointing out that – "*There may be a lack of scientific or other objective knowledge about the possible impacts - or not - of aquaculture, rather than lack of expertise, in some situations* [and] *In many cases,* ***there is significant interest in regulatory applications for aquaculture developments on the part of key stakeholder groups, some of whom are, according to industry, inherently opposed to aquaculture development for different reasons. This interest, and the lobbying that may accompany it, creates an additional pressure on regulators.***" [Emphasis has been added.]

As will be shown in subsequent Chapters, there are indications that Natural England is prominent among those 'key stakeholder groups'. With the resources of public funding, it has the people, the time, the status and the power to impress its views on regulators. The contrast with the meagre resources available to the scattered shellfish cultivation enterprises around our coastline is a stark one. Of course, Natural England has no direct responsibility towards shellfish farmers.

The EU approach to aquaculture

At about the same time as the Defra consultation was launched in 2012, the EU 'Guidance on Aquaculture and Natura 2000' was published. It acknowledged that "*the goods and services of shellfish to the environment ... are an intrinsic contribution of shellfish culture to natural processes*" and "*extensive aquaculture also acts as an instrument in nature management and conservation, thereby invoking positive effects on maintenance goals*". The significance of 'Natura 2000' will be covered in Chapter 4 concerned with Marine Protected Areas.

The Defra plan mentioned earlier said that – "*There is evidence that the aquaculture industry across Europe has stagnated, despite some areas of the UK experiencing growth in the sector. ..... Aquaculture is therefore being promoted strongly in the Blue Growth Strategy, the Atlantic Strategy and the reformed Common Fisheries Policy (CFP).*"

The 'Blue Growth Strategy' referred to was (and is) the EU's long term strategy for supporting sustainable growth in the marine/maritime sector. A little over a year after Defra launched its consultation mentioned above, the European Commission released its '*Strategic Guidelines for the sustainable development of EU aquaculture*'. It started with the worrying statement that – "*EU aquaculture production is stagnating, in contrast with strong growth in other regions of the world.*"

To set the scene, it pointed out that – "*Most aquaculture producers are [Small to Medium Enterprises], and they are disproportionately affected by red tape: ..... Reducing unnecessary*

regulatory burden remains on the top of the Commission's political agenda." Regarding environmental concerns, it went on – "*positive experiences with the integration of aquaculture in Natura 2000 sites show the possible compatibility of a profitable commercial activity with the conservation of biodiversity.*"

A range of targets to promote aquaculture were set for member states and, pursuant to this document, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) was engaged by the European Commission to deliver its project '*Background information for sustainable aquaculture development addressing environmental protection in particular*'. It was published late in 2014 and remains very significant to this day (see later comments).

This formidable document contained valuable descriptions of the shellfish cultivation systems in common use. They are quoted verbatim in Appendix A. It also contained a table in which the impacts – Beneficial and Negative – were summarised. The aim to achieve 'good environmental status' in marine waters by 2020 was analysed and evaluated

More recently

In the realms of science, the European Union's policy makers are advised by a body called Science Advice for Policy by European Academies (SAPEA). The UK is no longer a member of the EU but this is not a good reason to ignore its scientists. In 2017 (when the UK was still a member), the EU scientific advice mechanism produced a report entitled "*Food from the Oceans - How can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits?*"

The opening paragraphs of that report set the scene. "*the greatest and most feasible potential identified for expansion globally lies in mariculture (i.e. marine aquaculture) – notably of herbivore filter feeders (e.g. molluscs) for direct human consumption or, together with cultivated algae, as a more ecologically-efficient source of feed for farmed marine carnivores (e.g. finfish, shrimp, etc.)*" and "***Threats to [the] food supply from declining fish stocks and underdeveloped mariculture are ... of global concern.***" [Emphasis added.]

Later in that same report can be found this statement "*farming macro algae and molluscs (oysters, mussels) seems to be one of the best candidates to increase harvest in the short term. Given its labour intensity, such development would create valuable local employment.*"

Looking at the situation today, any signs of growth or progress since 2017 along the lines suggested to be promising by the above quotations are elusive. Indeed, there are indications that the situation in England may have deteriorated.

English Aquaculture Strategy

The Seafish Industry Authority (Seafish) published The '*English Aquaculture Strategy*' in November 2020. Its purpose was to provide – "*a Strategy and Delivery Plan for the sustainable development of English aquaculture over the next twenty years*". Its Strategy Objectives included – "*A ten-fold growth and diversification of aquaculture in England.*"

Within its text, the document asked – "*why has English aquaculture production declined by 5.6% per annum since 2009*". Among the list of six reasons for this, it pointed to – "*The vulnerability of marine shellfish farming to poor water quality.*"

The shellfish farmer will tell you that water pollution is a major issue (but by no means the only one) at the heart of the problems facing shellfish aquaculture. It will be looked at next

after a brief mention of one form of water pollution of which the impact on any shellfish farm must be classified very largely as an 'unknown'.

Forever chemicals – PFAS

'Fidra', a Scottish charity "*working to reduce chemical and plastic pollution in our seas, on our beaches and in the wider environment*" tells us that – "*PFAS are often referred to as the 'forever chemicals' because of their extreme persistence in the environment. Some forms of PFAS can take over 1000 years to degrade.*"

That class of chemicals were added to certain manufactured products in order to reduce the chances that the products will catch on fire. Examples are furniture foam, plastics for TV cabinets, consumer electronics, wire insulation, and back-coatings for draperies and upholstery, and plastics for personal computers and small appliances.

They have been detected in coastal and estuarine environments and have also been found in the air, soil, sediments, humans, wildlife, fish and other marine life, and sewage treatment plant biosolids.

It is said that the long history of use of some of these chemicals (there are literally thousands of them) means that there is a legacy of environmental contamination that is challenging (to say the least) to remediate. Biodegradation is their slow environmental fate.

To quote Fidra again – "*When we release PFAS into our water, it flows from stream, to river, to sea, circulating in ocean currents. Once it gets into the tiniest of organisms, its position in the food chain simply grows. From plankton to small fish, to big fish, to sea bird (unless of course we catch the big fish and take it straight to our plates). They are in the air we breathe, the soil our food is grown in, the water we drink and from the environment PFAS can reach people and wildlife worldwide.*"

Knowledge of what these chemicals do to shellfish, or to us when we consume those shellfish, is sparse.

These things seem clear from what has been said in this Chapter –

- The expansion of shellfish aquaculture represents a genuine way in which to enhance national food security.
- Good water quality is vital to all shellfish aquaculture and a critical factor in any planned expansion.
- There are indications that some key stakeholder groups are inherently opposed to all forms of aquaculture, including shellfish aquaculture.
- There are 'forever chemicals' in our waterways that may have an impact on shellfish and those who consume shellfish but the nature and significance of that impact is unknown.

Chapter 2 – The Burden of Pollution

The burden imposed by water pollution on shellfish aquaculture requires little explanation. Shellfish, that is to say molluscs, may only be gathered and dispatched direct to the market if they are harvested in Class A waters. Those waters are few (only 14.93% of all production areas in 2021 – and more than half of those were not so graded throughout the year). Their classification can change with little or no notice – see the further comments below.

Those who harvest shellfish in Class B or Class C waters are faced with a range of hurdles that must be overcome before those shellfish can be marketed. These involve time delays and significant costs. That price must be paid before anything can be sold. It is the price of pollution – but the polluter does not pay.

The Source of Pollution

Pollution of rivers and waters around the coastline comes in many different forms and from a vast range of sources. Those best known are sewage discharges, agriculture, industrial and domestic wastes and run-off from roads and highways. The range of polluters is massive. One way or another, every member of the population contributes to that pollution.

Remedy in Law

We now come to the law. Is there a remedy that the shellfish farmer can pursue through the courts to secure compensation for the damage caused by pollution to the aquaculture business?

There was a decision in a case before the House of Lords in 1868. The defendants in that case constructed a reservoir on their land over the top of a disused mine. Water from that reservoir filtered through the disused mine shafts and flooded the working mine next door belonging to the plaintiffs. It was held that the defendants were liable for the 'non-natural' use to which their land had been put and the consequences flowing from it.

In the last 150 years, that concept has been developed, largely within the principles of the law of negligence, by courts around the world. Along the way, the decision has also been the subject of significant criticism.

In theory, it is possible to sue for damages caused to a business if (a) the nature and cost of the damage can be proved; (b) the cause of the damage can be proved; and (c) the identity of the person responsible for causing that damage can be proved.

Burden of Proof

This 'burden of proof' contains a significant problem for the shellfish farmer, who may be able to prove the damage and the financial loss but will struggle to prove the precise causation and the precise identity of the person(s) responsible.

The array of sources of the pollution coupled with the manner in which those pollutants are mixed together in watercourses and coastal waters presents a virtually insurmountable barrier to the presentation of an indisputable claim.

In practice within the law of tort (remedy for a civil wrong), there is thus little realistic hope of pursuing a successful claim through the courts for the pollution of an area of shellfish cultivation. The potential cost is terrifying and the risks are too big.

Compensation or insurance

It is also unrealistic to propose the creation of some alternative (inevitably complex and very expensive), statutory 'compensation scheme' for that occurrence. The bureaucracy alone would have to be enormous. There is no political 'will' for such a step.

The cost of insurance cover against the impact of water pollution on a shellfish farm (if it were available – but the market now offers no relevant cover) would be prohibitive.

Classification of waters

The waters around the coastline from which molluscs are harvested are tested and classified so as to determine when those molluscs are fit for human consumption. Molluscs acquire their nutrition by filtering the water in which are living through their bodies. If that water contains a harmful level of a pathogen such as E-coli, it can be retained within the flesh of the mollusc and become the cause of human sickness.

A detailed summary of the classification rules, originating under EU law, can be found in Appendix B.

The testing method for the classification of Class A waters is designed to check that there is no more than an acceptable trace of E-coli in those waters. Waters failing that test will be Class B waters. Those that are heavily polluted will be Class C or even deemed unfit for any harvesting process. Molluscs harvested in Class B or Class C waters must be re-laid in Class A waters for a significant period and/or pass through another process to wash out or eradicate the E-coli from their bodies.

Current testing is geared to the presence of E-coli. That can be derived either from human sewage or from animal faeces such as those from wild animals or agricultural livestock. This test does not however detect the presence of Norovirus (NoV). That can only come from human sewage. This weakness in the testing regime is well-known and gives rise to further concerns and precautionary measures.

It is said that certain viruses, formally known as bacteriophages, that solely kill and selectively target bacteria may provide an alternative and more effective testing regime. Those that are called 'F-specific RNA phages' (FRNAPHs) are said to be potential viral indicators of water pollution such as NoV. This is due to their occurrence and stability in a water environment.

It is probable that testing methods will develop and change as scientific knowledge grows.

While hoping that methods for the testing of waters for pollution continue to evolve and increase in accuracy, the shellfish farmer remains at the mercy of those tests. Their reliability is inevitably affected by their scope and the frequency with which they are conducted and the manner and speed with which their outcomes are assessed and promulgated.

An adverse test result can bring about a downgrade of classification and with it the cesser of harvesting or a significant increase in costs. Conversely, a favourable test result can lead to an upgraded classification and give the green light to harvesting and a speedy transfer to the market.

History reveals a number of differing ways in which the law has addressed shellfish aquaculture and they come to be considered next.

The conclusions from this Chapter –

- The sources of water pollution known to be capable of having a deleterious effect on shellfish aquaculture are wide and diverse.
- Due to the heavy 'burden of proof' there is no realistic remedy in law to compensate the shellfish farmer for damage suffered as a consequence of water pollution.
- Improvements in the testing methods and the manner and frequency of testing for the classification of waters may make the determination of the optimum time for shellfish harvesting more predictable (i.e. when Class A water is available).

Chapter 3 – Previous Approaches – Shellfish and Water Pollution

The logical next step is to consider the various means in law by which any attempts have previously been made (1) to regulate and protect the cultivation of shellfish and (2) the use and quality of the waters in which that cultivation is capable of taking place.

Several and Regulating Orders

"*There is special legislation to encourage the setting up and management of private and natural shellfisheries. Under the legislation, orders known as Several Orders and Regulating Orders may grant exclusive fishing or management rights within a designated area. Several Orders allow legal ownership of certain named shellfish species in a private shellfishery. Regulating Orders allow management rights to designated natural shellfisheries.*"

These words are quoted from the Defra website (last updated in 2013). They refer back to The Sea Fisheries (Shellfish) Act 1967. That Act provided for the establishment and improvement of commercial shellfisheries through a Several Order. It also allowed for the preservation and improvement, through a Regulating Order, of wild shellfisheries that might be at risk of over-exploitation. Private legal rights of fishery can also exist and receive protection.

The protection afforded by such Orders applies to oysters, mussels, clams, cockles, scallops, crabs and lobsters. It is possible for other types of mollusc and crustacea to be specified.

Regulating Orders and the management powers they confer are now only granted to Inshore Fisheries and Conservation Authorities (IFCAs). Arguably, these Orders may now only be of academic interest since the Marine and Coastal Access Act of 2009 allows IFCAs to create bylaws said to provide a more flexible alternative solution. Defra now says that "*It is our view that that these byelaws offer a more agile and modern method of managing these fisheries and should be seriously considered as an alternative to Regulating Orders.*"

A Several Order gives exclusive rights over a defined area of "*sea shore*" (see the further comments below regarding this term) for the purpose of fishing, dredging and taking of the specified shellfish. The Grantee of the Order is the legal owner of those shellfish and may move them around and deposit them anywhere within that area. This property right may be leased or transferred.

Unauthorised injury to the shellfish covered by such an Order and the rights granted by it can attract a fine of up to £50,000 and the Grantee of the Order can recover compensation. The wording of the Act (which updated legislation originally restricted to oyster cultivation going back as far as the 1860s) says that anyone who "*within the limits of the area of the fishery ..... disturbs or injures in any manner, except for a lawful purpose of navigation or anchorage, any such shellfish, bed or fishery*" attracts these penalties.

Whether such penalties could apply to the pollution of the water flowing over or through a fishery subject to a Several Order or private rights is open to legal debate. The burden of proof mentioned earlier remains relevant. Because of this (let alone the legal quibble as to whether the originator of the pollution is "*within the limits of the area of the fishery*"), it is unlikely that a Several Order can provide significant (or indeed any) protection against pollution.

This does not mean that Several Orders are now redundant because they are unlikely to provide a remedy for water pollution. That was not such a significant issue over 150 years ago when the concept of Several Orders was first developed by those responsible for regulating the

cultivation of shellfish. By contrast, water pollution should be at the forefront of the minds of those now faced with that duty.

Sadly, it seems that those minds have a different focus. A recent submission by Defra to the Shellfish Association of Great Britain contains the following statement – "*Several Orders are currently the only means to grant an exclusive right of shellfishery in public waters. Although the use of these Several Order shellfish beds has changed little over very many years, the legislative landscape that they exist within has changed considerably, increasing their complexity.*"

The shellfish farmer will naturally be tempted to comment that of course this form of aquaculture is complex. It always has been. The shellfish farmer not only has to worry about ocean tides and currents in addition to the weather affecting the stock under cultivation. Unlike agriculture, the shellfish farmer has tenuous rights over those areas of cultivation and those rights only exist under a Several Order.

Furthermore, the shellfish farmer will point out, the cultivation of shellfish is a business and, like agriculture, it requires significant investment in terms of organisation, money, physical effort and time if it is to thrive. Without the security provided by a Several Order, the basis on which the business is founded will be fatally undermined. Arguably, the necessary protection should be extended still further to inhibit navigation and anchorage within the areas of designated shellfish beds.

The shellfish farmer may go on to point out that the 'complexity' referred to is not caused by shellfish farmers but by the increasing pressures created by other users of the nation's estuaries and coastal waters and by the legislative steps (of which the benefits to the shellfish farmer are hard to discern) taken to regulate those pressures.

There is no comfort for the shellfish farmer in the further statements by Defra on the future of these orders – "*We would encourage prospective applicants to carefully consider if a Several or Regulating Order is the most appropriate method for managing their fishery/aquaculture lays ahead of application. We would also encourage applicants to plan well in advance if they do deem it appropriate, as these Orders take significant time (in the order of years) and resource to complete. On both Several and Regulating Orders we will be looking to applicants to fund all costs.*"

To describe these words as 'disappointing' is an understatement. There is a clear indication here that Defra finds these Orders inconvenient and now seeks to prepare the ground for their abolition. The establishment of shellfish aquaculture is an expensive and high-risk undertaking. The writing is on the wall. It will take longer. The price is an increasing one. Quite clearly Defra has no plans to replace Several Orders with "*a more agile and modern method*" as is planned for Regulating Orders.

A list of current Several and Regulating Orders can be found in Appendix C.

"sea shore"

This is a special term which the 1967 Act defines as being "*any portion of the shore and bed of the sea, or of an estuary or tidal river, above or below, or partly above and partly below, low water mark and within waters adjacent to England and Wales to a distance of six nautical miles measured from the baselines from which the breadth of the territorial sea is measured*".

As will be appreciated, it describes a significant marine area extending far beyond the layperson's understanding of what comprises the 'sea shore'. It is effectively an attempt to define the marine area in which shellfish aquaculture can be undertaken. The six-mile limit fits neatly within the territorial limit applied to the jurisdiction of Inshore Fisheries and Conservation Authorities.

Arguably, this six-mile limit might have to be adjusted when an appropriate synergy can be developed to allow shellfish aquaculture and a wind farm more than six nautical miles offshore to share space and operate side by side. That is for the future, however.

This expression is worth bearing in mind. It was not considered (it would appear) when European Union rules about water quality were brought into national law. That is the next topic for consideration.

Shellfish Waters

By virtue of Regulation 9 of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, the Secretary of State or Welsh Ministers can designate "*a shellfish water protected area*" if it is considered that "*to do so is necessary or desirable in order to protect or develop economically significant shellfish production*." In this context, the word "*shellfish*" means "*any bivalve or gastropod mollusc*".

The expression "*a shellfish water protected area*" is stated in the Regulations to be "*any area of coastal or transitional water within a river basin district*". This introduces the two highlighted terms, each of which is given a special meaning. "Coastal water" is "*surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters*."

This formula adopts a basis similar to that adopted by the old 1967 Act but is marginally more cumbersome to decipher. (For example "*where appropriate*" allows plenty of room for argument and confusion.) The distance is one nautical mile rather than six. "Transitional waters" are "*bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flow*." (The word "*substantially*" does not help either.)

Shellfish aquaculture is capable of thriving in both these "*coastal waters*" and "*transitional waters*". Protection from the Regulations against pollution (if any such exists) only extends out to one nautical mile, however.

These Regulations brought the water policies and environmental quality standards of the European Union into national law "*to prevent deterioration of the surface water status or groundwater status*" and to "*support the achievement of the environmental objectives*". 'Shellfish Waters', the shorthand commonly used for "*a shellfish water protected area*", are on the list of waters that must be protected.

Each such protected area must be monitored and environmental objectives applied to it. These include preventing deterioration, protection, enhancement and restoration, and the progressive reduction of pollution from "*priority substances*" and the cesser or phasing out of emissions, discharges and losses of "*priority hazardous substances*". There is a lengthy list of all these 'substances'.

Shellfish waters are also to be given – "*such objectives as are necessary or desirable to improve or protect the shellfish water protected area in order to support shellfish life and growth and to contribute to the high quality of shellfish products suitable for human consumption*".

So, what does it all mean to the shellfish farmer whose business has been affected, perhaps even destroyed, by the pollution of shellfish waters? The answer – not a lot.

The 'burden of proof' problem persists and is not going away. The Environment Agency responsible for the registration and monitoring of protected areas is under resourced.

The EA can develop plans and objectives under the Regulations. It has powers that enable it to prosecute those responsible for the pollution of waterways. It also has powers to inspect farms and to enforce the 'Farming Rules for Water' published in 2018. Despite this, the Report of the House of Commons Environmental Audit Committee published on 13th January 2022 revealed a woeful situation with regard to the quality of waters on our waterways.

"*A 'chemical cocktail' of sewage, agricultural waste, and plastic is polluting the waters of many of the country's rivers. Water companies appear to be dumping untreated or partially treated sewage in rivers on a regular basis, often breaching the terms of permits that on paper only allow them to do this in exceptional circumstances. Farm slurry and fertiliser run off is choking rivers with damaging algal blooms. ... Not a single river in England has received a clean bill of health for chemical contamination. Disturbing evidence suggests they are becoming breeding grounds for antimicrobial resistance.*"

A backdrop like this is hardly encouraging for an existing shellfish farmer or anyone contemplating such an enterprise. There is nothing in these Regulations that provides any form of legal redress for the proprietor of an aquaculture business damaged by water pollution.

It seems that any prospect of effective enforcement action by the Environment Agency on a significant scale remains elusive. On 23rd June 2023, the EA reported that it was – "*conducting its largest ever criminal investigation into potential widespread breaches of environmental permit conditions at wastewater treatment works by all water and sewerage companies*" and "*Our initial assessment indicates that there may have been widespread and serious non-compliance of environmental permit conditions by all companies.*"

Clearly, we must wait a little longer to see how serious the EA is to be about pursuing the matter.

Over a year prior to that report, a newspaper report quoting a leaked internal document from the EA, claimed that "*Between April 2016 and December 2020, investigators within the agency gathered evidence and prepared case files on 495 serious incidents, involving the worst type of pollution of rivers and coastal waters as well as serious waste crimes, according to the internal document.*" And – "*They recommended that the agency prosecute in all the cases. But the document shows that after intervention by managers just 35 cases were taken forward to prosecution, the rest being dealt with via a lower sanction such as a warning letter, or dropped all together and marked for no further action.*"

Of course any fines for water pollution that may ultimately be levied (assuming they are paid) do not go to shellfish farmers.

We move on to other legal devices that might serve shellfish aquaculture.

The conclusions from this Chapter are –

- There is no indication that the grant of a Several Order will provide the shellfish farmer with realistic protection against water pollution.
- There are strong indications that Defra is developing approaches that will ultimately result in the abolition of both Several and Regulating Orders.
- Designated Shellfish Waters provide no remedy for the shellfish farmer against water pollution.
- There is no evidence that effective enforcement of the Regulations protecting Shellfish Waters will provide any measure of comfort for the shellfish farmer in the foreseeable future.

Chapter 4 – Marine Protected Areas (MPAs)

The Concept

Historically, the concept of establishing protection for areas of the sea is an international one. The International Union for Conservation of Nature (IUCN) is the leading organisation. It defines a 'protected area' as "*a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*".

An early development of the concept arose with the Ramsar Convention in 1975 aimed at designating 'wetland sites' (*areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season*) of international importance. As of May 2023, there were 2,491 Ramsar sites around the world and around 130 of them in England.

In the wider picture of MPAs generally, it is claimed that "*as of April 2023 there are more than 16,615 MPAs, encompassing 7.2% of the world's oceans (26,146,645 km^2), with less than half of that area – encompassing 2.9% of the world's oceans – assessed to be fully or highly protected according to the MPA Guide Framework.*" The Framework is that created by the IUCN.

There is another expression that is used internationally. A "No Take Zone" (NTZ), is an area that can be designated in a number of the world's marine protected areas where all forms of exploitation are prohibited. There, all human activities are severely limited. An NTZ can cover the whole of an MPA or be limited to a specific part (or parts) of it.

The Management of MPAs

In 1999 the IUCN published 'Guidelines for Marine Protected Areas'. Its Foreword pointed out that – "*MPAs are a vital part of broader programmes to conserve the marine heritage and life-support system of the world, and to ensure that where living marine resources are used, that use can be sustained ecologically. The world urgently needs a comprehensive system of MPAs to conserve biodiversity and to help rebuild the productivity of the oceans.*"

The references to the use of living marine resources and the rebuilding of the productivity of the oceans are both of direct relevance to shellfish aquaculture. However, the initial reference to aquaculture in the document reads – "*The guiding principle is that aquaculture, whether inside or outside the MPA, should be carried out in such a way that it does not damage the MPA, from the transmission of disease, the release of nutrients or in other ways.*"

No shellfish farmer will deny the relevance or importance of that statement. He or she will however be quick to point out that there is an essential difference between fish farming and molluscan aquaculture.

The environmental issues and problems caused by the intensive cultivation of fish (primarily the salmon that command such a high price in the marketplace) are now well publicised. The spread of disease to wild stocks, escapees, the contamination of the sea bed with uneaten food and faeces and the proliferation of sea lice and other parasites are examples of these issues.

By contrast, molluscs do not need to be fed. They extract their nutrition from the water that passes through their bodies. It is only when that water is polluted by an external source that problems arise.

One of the guidance documents produced by Cefas and published by Seafish that is covered in more detail in Chapter 7 echoes the above comment from IUCN Guidelines – "*Aquaculture can and does exist within MPAs as does agriculture within national parks and terrestrial nature designations. The type of aquaculture and the type of protected features and their sensitivity within the MPA will determine the compatibility levels and risk based decisions in line with the relevant legal framework will need to be made by regulators.*"

At this juncture, it makes sense to refer back to the very detailed advice and guidance within the '*Background information for sustainable aquaculture development addressing environmental protection in particular*' published by Cefas in 2014.

Its concluding paragraph reads as follows – "*This project represents a very large information gathering exercise ... An enormous amount of information has been produced which may be helpful ... in developing guidance documents and associated material in the future. ..... That information is a valuable resource that could potentially form the basis of an information portal on good practice in sustainable aquaculture development and regulation in relation to environmental protection. It is important that this information is retained and made available in an accessible manner.*"

That aspect will be discussed further in Chapter 7. It is now necessary to look closer to home to see how MPAs are addressed in this country, starting with the bodies responsible for them.

Statutory Nature Conservation Bodies (SNCBs)

Along with the Marine Management Organisation and the Department for the Environment Fisheries and Rural Affairs, there are two Statutory Nature Conservation Agencies that have a role to play in the context of MPAs. The first of these is the Joint Nature Conservation Committee (JNCC), which has responsibility for offshore waters (from 12 to 200 nautical miles). English inshore waters (out to 12 nautical miles) are the responsibility of Natural England (NE).

Joint Nature Conservation Committee (JNCC)

The Joint Nature Conservation Committee describes itself as "*the only statutory nature advisor to all four countries of the UK. We provide robust scientific evidence and advice to help decision makers turn science into action for nature to guide the UK on a sustainable path.*"

Its website also discloses that "*JNCC experts have provided scientific advice to help identify and designate marine protected areas (MPAs) in the UK's offshore waters, extending from the edge of territorial waters (12 nm from the coast) out to the UK Continental Shelf. The first offshore sites were designated in 2008. As of 2022, there were 76 MPAs with a total extent of over 260,000 km2 in UK offshore waters, larger than the land area of the UK. These sites provide vital protection to conserve and recover marine biodiversity.*"

The last sentence of that statement plus the word 'Conservation' that appears in most of their titles is a clue to what lies behind the identification of, the monitoring of, the policies of and the management of all the following MPAs. In England, they are within the remit of Natural England out to twelve nautical miles from the coast.

Natural England (NE)

In October 2016, Natural England published an interesting 'Conservation Strategy for the 21st Century' that contained this memorable statement – "*Conservation processes and practices,*

conceived to protect the environment, often no longer represent the most effective means of achieving real and lasting environmental outcomes. Instead, they can frequently alienate the very people we need to engage."

The document went on to state that – "*We want to demonstrate that 21st century conservation is not about holding things back, but about moving things forward. We want conservation practice which reconnects people with their environment; restores and recovers ecosystems; and where a thriving economy with a rich and resilient natural environment is integral to everyday life, rather than fenced-off from it.*" And – "*We need to understand how to align statutory conservation ambitions with the wider objectives of the people we depend on to achieve them in any given place. We need to become more fluent in other people's language.*"

Statements like these should be music to the ears of those engaged or wishing to engage in shellfish aquaculture. Good water quality is an essential ingredient. So is the exclusion of activities such as dredging, waste disposal, bottom trawling and other forms of destructive human interference. It is possible for the latter to be inhibited within the confines of an MPA, which would make that MPA perfect for shellfish cultivation.

The influence of Natural England on the prospects of shellfish aquaculture is such however that these fine words that have just been quoted may be no more than a smokescreen to conceal an unhappy reality.

The Pacific oyster (*gigas*)

There is no legal bar to shellfish aquaculture in an MPA but there is one significant impediment that cannot be ignored. For many years, the Pacific oyster (*gigas*) has been the mainstay of oyster production within English shellfish aquaculture. The demise of wild native oyster (*edulis*) fisheries came about progressively in the 20th century due to dredging, pollution, changing habitats, and disease. The Pacific oyster, anecdotally said to have been first introduced to UK waters in the 1890s, was adopted as – and (with the exception of mussels) remains – the main and most viable species to farm on a significant scale.

Despite the issue of a General Licence for the cultivation of the Pacific oyster in 1982, current policy dictated by Natural England classifies the Pacific oyster as 'invasive non-native species' and prevents the creation of new farms and the expansion of existing ones, particularly in MPAs. The trend can only lead to the shrinkage and ultimate closure of existing oyster farms now surviving around the coastline.

It should be noted that, throughout the EU, including the Republic of Ireland, the Pacific oyster is regarded as a naturalised species. Its cultivation has strong government support, and that cultivation has grown to provide a considerable contribution to the economies of EU states.

In this context, the 2020 '*English Aquaculture Strategy*' published by Seafish and quoting an independent report has this to say – "*Total eradication of the Pacific oyster is not feasible. Indeed continental experience suggests that if predictions of continued sea water warming under current [UK Climate Projection] scenarios (Met Office, 2019) are realised, the frequency and magnitude of settlement will increase, causing existing populations to expand and new populations to become established.*"

The document goes on to say – "*The issue of Pacific oysters is located between two policy areas: one concerning the conservation of protected habitats, the other relating to livelihoods and the socio-economics of coastal fishing and farming communities*" and "*regional management of wild Pacific oysters in the UK is likely to be the most effective approach, based*

on (i) the extent of biodiversity / habitat risk and (ii) a socio-economic opportunity costs analysis."

The '*Background information for sustainable aquaculture development addressing environmental protection in particular*' published by Cefas in 2014 had this to say on the topic – "*once an aquatic organism has been introduced and becomes established in a new environment, it is often nearly impossible (or at least financially not feasible) to eradicate. At that stage, policy measures can practically only focus on containment and control. Consequently,* ***defining areas as "bad" status, depending on the presence of invasive species, could mean that an area would stay that way without a possibility for remediation to "good" status***". [Emphasis added.] That comment was based on evidence derived from the Baltic.

The Pacific Oyster, the role of Natural England and the approach of Defra to the issue will be covered in more detail in Chapter 8.

English MPAs

Within England, there are several other terms apart from 'Ramsar site' that can indicate the presence of an MPA. Thus we have a Site of Special Scientific Interest (SSSI), a Specially Protected Area (SPA), a Special Area of Conservation (SAC) and a Marine Conservation Zone (MCZ). Different rules and considerations apply to each.

The key question now is to ask whether (and how) any of these measures address the water quality issue and, if they do, whether their existence coupled with the arrangements for their management are of any assistance to the shellfish farmer.

Site of Special Scientific Interest (SSSI)

Created by the Wildlife and Countryside Act 1981, such a site is one notified by the Statutory Nature Conservation Agencies, who have a duty to identify any area '*of special interest by reason of any of its flora, fauna, or geological or physiographical features*'. Most of these are inland but coastal areas fall within the net too – specifically "*marine (intertidal and subtidal) habitats, including their associated biological communities and species*".

In addition to its powers to create management schemes and byelaws for an SSSI, Natural England has power to take enforcement action against anyone who intentionally or recklessly damages such an area, destroys any feature of special interest, disturbs wildlife or carries out any of a number of "*listed operations*" without consent.

As ever, the devil is in the detail. Close examination of the list of such operations discloses a range of activities that would be essential for the pursuit of aquaculture – *cultivation, release, killing or removal of any wild, feral or domestic fish or invertebrate*, and so on.

(As an aside, the list of restricted activities having application to a small section of the North Cornish coast between Bedruthan Steps and Park Head contains over thirty specific operations requiring the consent of Natural England!)

The guidance for the selection of a marine SSSI contains one reference to 'water quality'. This is the statement that "*habitat succession can be encouraged, reversed or amended by management, e.g. amendment of fisheries activities, improvement in water quality*". This implies that amendment of 'fisheries activities' is allied to an improvement in water quality. The shellfish farmer might view this assertion as unhelpful.

Anyone contemplating shellfish aquaculture could be forgiven for concluding that, although there is no bar to the activity, any SSSI strongly precludes, indeed discourages, the possibility of shellfish cultivation/farming. This is unfortunate, to put it mildly.

Specially Protected Area (SPA) and Special Area of Conservation (SAC)

The European Union Directive on the Conservation of Wild Birds, on which The Conservation (Natural Habitats etc.) Regulations 1994 were based, provided the initial thrust for the creation of Specially Protected Areas for migratory and rare, threatened or vulnerable species of birds.

In parallel Special Areas of Conservation were created for conserving habitats and species other than birds. The European network of such sites was called 'Natura 2000' – the focus of the guidance mentioned earlier.

The Conservation of Habitats and Species Regulations 2017 were the source of the current ground rules for SPAs and SACs. In 2019, further Regulations (necessitated by the UK's departure from the EU) created a national site network for all former Natura 2000 sites and brought all the rules back within national competence. The objectives are to maintain and restore habitats and species to 'favourable conservation status' (FCS). As of 30 September 2022 there were 286 UK SPAs and as of 20 April 2023, there were 656 UK SACs.

It is instructive to note that the public records for each of the current areas contain a mass of data concerning the birds, species and habitats identified. That data also contains significant information about the condition of each site.

The 'Natura 2000 - standard data form' is used for this purpose with an extensive list of codes. In this way, site descriptions can be standardised. On the topic of water quality, there are codes for (1) *Pollution to surface waters (limnic & terrestrial, marine & brackish)*, (2) *Pollution to groundwater (point sources and diffuse sources)* and (3) *Marine water pollution*.

Thus, significant water quality data on these sites is available now.

Marine Conservation Zone (MCZ)

"*Marine Conservation Zones are areas that protect a range of nationally important, rare or threatened habitats and species. There are 91 MCZs in waters around England.*" These words come from the Defra website. The objective of each MCZ established pursuant to s116 of the Marine and Coastal Access Act 2009 is that each of the features being protected within it will be restored to and/or maintained in 'favourable condition'.

The guidance note on MCZs tells us that – "*The aim is to find an appropriate balance between safeguarding the marine environment and the sustainable use of marine resources. Anthropogenic impacts that do not have a significant adverse impact on the features will be allowed.*" Anthropogenic impacts are those caused by human activity. On the face of it, shellfish aquaculture that does not have a 'significant adverse impact' is not precluded.

Some designated MPZ areas may become Highly Protected Marine Areas (HPMAs). This concept is in its early stages and is still being developed. It is possible (even likely) that, as with SSSIs, shellfish aquaculture will not be encouraged in these areas.

The question arises – If SSSIs and HPMAs are perhaps intended to be less than welcoming for shellfish aquaculture, what can the other MPAs contribute to the highly desirable expansion of the areas in which the cultivation of shellfish can thrive?

The shellfish farmer will point out that, subject of course to the quality of the waters within them (a matter of concern for everyone), MPAs are capable of providing the perfect environment for effective shellfish cultivation and, furthermore, shellfish aquaculture needs a level playing field and to be accorded the same considerations that in terrestrial terms are accorded to food production by agriculture.

The conclusions to be derived from this chapter are as follows –

- Marine Protected Areas are well suited to shellfish aquaculture. Shellfish aquaculture that has no significant adverse impact is to be encouraged within them.
- The policy of Natural England towards the cultivation of the Pacific oyster (which arguably runs counter to common sense and the pragmatic views of scientists) is a significant bar to any planning for the expansion within MPAs of the contribution that shellfish aquaculture can make to food security.

Chapter 5 – Future Strategy for Aquaculture

Building on its 2012 Consultation, the European Union's Strategic Guidelines published in the following year and the '*Background information for sustainable aquaculture development, addressing environmental protection in particular*' produced by Cefas in 2014 as a result of the EU initiative, Defra published its '*United Kingdom multiannual national plan for the development of sustainable aquaculture*' in October 2015.

This plan provided the statistics below for the shellfish sites in the United Kingdom, of which 328 were on Scotland, 73 in England and Wales and 55 in Northern Ireland. The map in Appendix D, copied from this Plan, shows the sites in England and Wales.

Shellfish (Source: Cefas)	**Tonnage (tonnes)**	**Value (£)**
Tonnage and Value	**UK Total 27,360**	**UK Value ca £32M**
England	6,915	£10,060,882
N. Ireland	4,920	£4,539,207
Scotland	6,525	£8,773,900
Wales	8,999	£9,008,000

On water quality, the plan stated that – "*the Environment Agency is carrying out investigations to identify sources of pollution and take forward remedial work as necessary*" and that the Water Companies had – "*committed £68m to investigating and improving shellfish waters alone.*" The pollution issue has already been covered in Chapter 3. Despite these assurances from Defra, no progress appears to have been made in the last eight years.

Defra was – "*committed to reviewing and renewing the guidance which is available to applicants for Several and Regulating Orders (SROs) ... to update the application form for SROs ...* [and] *to completing this update of guidance before the end of 2015*". The application form for such an Order, accessible on the Defra website, remains that contained in the 'The Several and Regulated Fisheries (Form of Application) Regulations 1987'!

It also said that the 'Background information' from Cefas that is mentioned in Chapter 1 and was published ten months before the plan – "*will be turned into guidance.*" Fortunately, that has happened – see Chapter 7.

The 2020 strategy

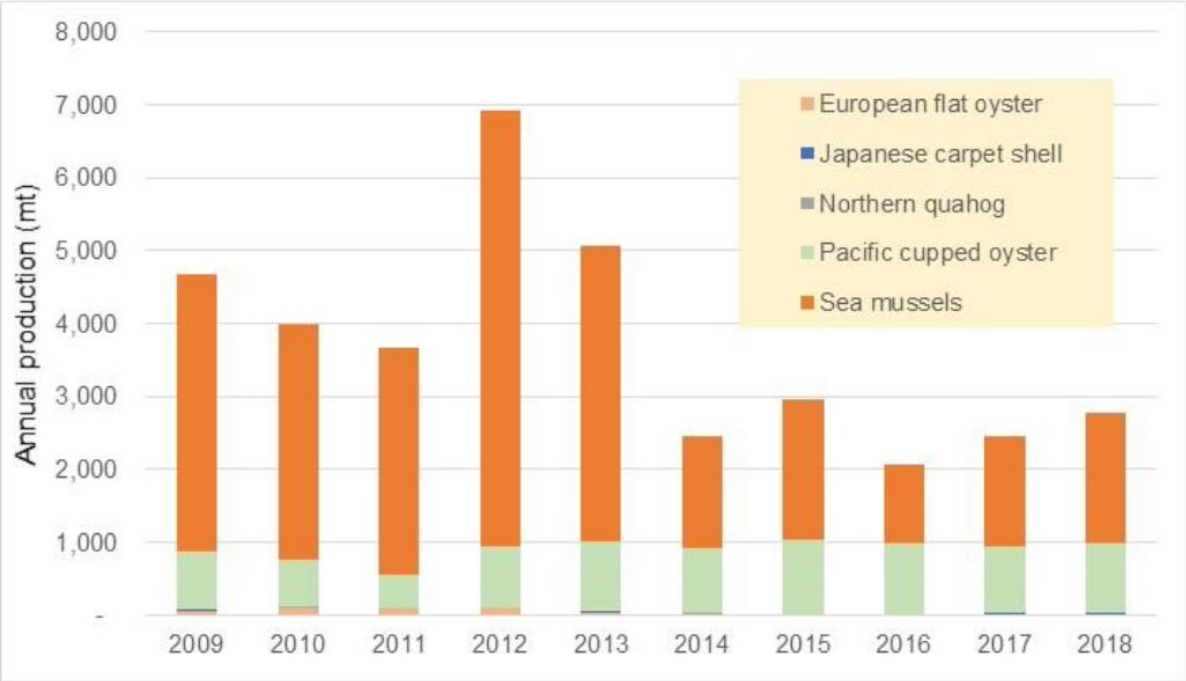
At this point, it pays to return for a detailed look at the 2020 '*English Aquaculture Strategy*' published by Seafish. It has been mentioned earlier in Chapter 1.

Among "*Key Externalities*", the document includes the issue reported in Defra's '*Development of Sustainable Aquaculture (2014 – 2020)*' quoted in Chapter 1 – "***In some cases, there is significant opposition to development applications from non-local stakeholder groups that are committed to opposing aquaculture (Hambrey and Evans 2016) through the planning system.***" [Emphasis has been added.]

This may be a reference to Natural England's approach to the Pacific oyster issue mentioned in Chapter 4 because the Strategy document says – "***In January 2020 after protected features in two MPAs shifted into 'unfavourable condition' as a result of an increase in Pacific oyster numbers, NE instructed that they now advise against authorisation of new Pacific oyster aquaculture businesses in MPAs as adverse effects on conservation features could not be ruled out.***"

The document provided statistics for English shellfish aquaculture during the previous decade saying – "*Mussels have declined by 10% in volume and 4% in value and Pacific oysters have grown by 1% and 11% respectively. Over the last ten years English aquaculture has declined by 5.6% in volume and increased by 1% in value, a slight decline in real terms.*"

Figure 6: Shellfish aquaculture production in England (2009 - 2018)



The six reasons given by the Strategy document for the apparent decline of English aquaculture require closer attention in order to assess the relevance and impact of marine planning and future strategies.

The reasons for decline

The first reason – "*Competition for space and resources in a densely populated country with mostly exposed, shallow and heavily utilised sea areas*" is a factor that affects all marine activities. If shellfish aquaculture is to make a realistic contribution to food security, it demands decent water quality and protection from interference. Others have the same needs. The potential for the allocation or sharing of scarce space is the challenge to be addressed by marine planning and all regulators.

The second reason – "*An opaque and sometimes highly precautionary approach to aquaculture authorisations*" is possibly an understatement of the regulatory burden that confronts anyone engaged in shellfish farming or contemplating such a step. (Examples of this that have been publicised in recent years appear in Appendix E) Its clarification and reduction is the second challenge for those looking to the future, among them all regulators. It will be discussed in more detail in Chapter 7.

The third reason – "*Limited domestic consumer demand in traditionally farmed species*" is an issue that has long been of concern to those engaged in shellfish aquaculture and in the shellfish capture industry. Shellfish production and consumption in this country is dwarfed by the production and consumption in, for instance, France and Spain. Traditionally, shellfish products from this country have secured a ready market in the European Union. The challenge for planners and regulators is to find ways to break the export logjam that has arisen and to develop the domestic appetite for shellfish products. This is the 'elephant in the room' that will be discussed later in this Chapter.

The fourth reason – "*The sometimes pervasive negative public perception and understanding of larger-scale aquaculture development and farmed products versus wild-caught equivalents*" points to a public image that is largely the end product of intensive fish farming. Salmon farming in particular has been the subject of poor reports due to the problems mentioned in Chapter 4. The challenge for those charting the way ahead, including all regulators, is to propagate and develop the concept that –

'There is no such thing as a bad shellfish only bad things in the water in which it has been nurtured'.

Norovirus and E-coli are too often associated with shellfish. As mentioned earlier, the latter is used as the measure for the classification of waters from which shellfish are harvested. Both come from discharges into our waters. The former from human sewage. We are back to the pollution issue.

The fifth reason – "*Current poor linkages between industry and research, despite breadth and depth of experience and knowledge at UK / English universities*" is a challenge to do better. It must be a two-way flow and knowledge constantly updated to achieve true effect.

The sixth reason – "*The vulnerability of marine shellfish farming to poor water quality*" was mentioned earlier and requires no additional comment at this point.

The document contains a useful addendum that should be quoted in full. "*An additional reason for the inconsistent, variable growth is **the lack of strategic direction**. Any sector needs to overcome emerging challenges and to take advantage of opportunities for sustainable growth. **This strategic direction needs to be holistic, wide-ranging and long-term**, and must allow both industry and supporting sector actors (such as research, capacity-building and governance) to invest time and effort into ensuring that that sector remains relevant and competitive well into the future.*" [Emphasis has been added.]

This last point is the seventh and final challenge for those engaged in marine planning and all regulators. It will be addressed in Chapter 7.

There is however one further point that must be made in the context of this, the seventh and final challenge. It appears in a section of the Strategy document concerned with the need for the aquaculture industry for – "*a delivery and support service that helps establish and grow aquaculture businesses through a combination of **informed permitting, targeted financial support where needed and assurance of a 'level playing field'***". [Emphasis added.]

The Strategy document points out that – "*Defra needs to have a <u>permanent</u> group of specialists tasked with supporting policy development and strategic planning (Defra) and implementation (MMO).*"

In a footnote, it is stated that – "*It is recognised that the UK's Civil Service policy is that staff are employed as generalists, and thus there are structural barriers to achieving this aim*."

This appears as another hurdle for those engaged in shellfish aquaculture.

Grounds for optimism

The '*English Aquaculture Strategy*' was published by Seafish less than eight months after the commencement of the first Covid-19 lockdown and much of it was written at a time when the full impact of that lockdown had not been experienced, let alone assessed.

Furthermore, four of the Marine Plans were then still in draft with their publication a year away. To compound things further, the UK's departure from the EU was approaching. Three years later the impact of that is still under assessment and will remain so for some years to come.

It was, perhaps, not a good time at which to record a future strategy, but it did suggest that there might be some grounds for optimism notwithstanding the reasons for decline just discussed.

It pointed out that – "*especially mussels – the current mainstays of production - have potential to expand their UK / export markets. Costello et al. (2020) considers that bivalves in particular may contribute substantially to food security by providing relatively low-cost and thus accessible food, because they have a high production potential at low costs compared to finfish production.*"

The health benefits, against the decline in household purchases of fish and fish products, provide a huge opportunity for growth – "*From a dietary perspective, seafood provides many human health benefits, especially the provision of important omega 3 fatty acids*" and – "*National Health Service (NHS) guidelines recommend that "a healthy, balanced diet should include at least two portions of fish a week, including one of oil rich fish*".

These factors were set against the backdrop – "***At a global level all currently available estimates of future seafood production show limited growth for the capture sector, indicating that the majority of future seafood demand will have to be produced through aquaculture***". [Emphasis has been added.]

It goes on to say – "*There are prospects for transition to an improved risk-based approach to shellfish production area testing in English waters. There is also the opportunity for increased recognition of aquaculture as an aspiring [Maritime Economic Activity] in English waters, which will encourage both new entrants and successful current operators to grow and diversify the sector as a more integrated 'blue economy' emerges.*"

But – "*This process will not be easy. In order to succeed,* ***the Strategy will require considerable commitment from central and regional government*** *to facilitate sustainable aquaculture growth and diversification as a key component of the blue economy, UK food security and preventative healthcare.* ***If this fails to materialise, the ambitious growth aspirations within this Strategy ... will simply not be possible and the sector will continue on its current static trajectory.***" [Emphasis has been added.]

Serious issues

By far the most significant section of the 2020 '*English Aquaculture Strategy*', at least so far as the cultivation of shellfish is concerned, appears on pages 33 to 40. (It is followed by an

informative section on macroalgae – seaweed farming). The section on shellfish lists a range of serious issues – "*as immediate threats to the short-term viability of this sub-sector*" and – "*Barriers to Growth*".

By way of addition to the reasons for decline mentioned earlier, the effects of these issues are listed –

1. Increased pressure on space;
2. Uncertainty over the future policy for Pacific oysters;
3. Lack of seed supply for some species e.g. oysters, scallops & clams;
4. Variable coastal water quality;
5. Precautionary testing regime;
6. Supply chain challenges resulting from EU-Exit and continuing COVID-19 resurgences;
7. Coastal and estuarine shellfish testing;
8. Hatchery capacity and capability;
9. The need for more regional management of shellfish farm permitting and monitoring;
10. Limited infrastructure;
11. Development of distinct markets for farmed shellfish products; and
12. Ecosystem services from aquaculture.

Priority issues

The list of actions given first priority by the Strategy are –

1. *Finalise a formal policy for the use of Pacific oysters in English waters balancing the potential harm from further farmed introductions with the socio-economic benefits of producing this now established species.*
2. *Develop the risk-based approach to the classification of shellfish production waters that ensures food safety for consumers but provides increased assurance and certainty to shellfish farmers, investors and markets.*
3. *Improve industry dialogue and partnership with the EA, Defra and other agencies, as well as local government bodies and the water companies to make the case for and encourage further investment into improving coastal water quality, especially through the prevention of spikes in faecal contamination following intermittent sewage overflows as well as reduced agriculture waste entering England's waters. This dialogue should be extended to other Maritime Economic Activities with a common interest in better water quality e.g. tourism.*
4. *Review and revision of seabed lease and Several Order mechanisms to provide long-term security and promote investment in shellfish growing areas, both inshore and offshore.*
5. *Develop a certified hatchery network for different shellfish species with increased public support to develop, test and demonstrate new technologies in polyploidy, live feed and larval rearing systems.*
6. *Explore opportunities for hi-value invertebrate aquaculture e.g. sea cucumber, sea urchins, abalone etc. in both open water and closed systems, including Integrated Multi-Trophic Aquaculture and Recirculating Aquaculture Systems.*

Three years later, there seems to be little evidence of progress on any of these. This will be considered further in Chapter 8.

Another view – a year later

This chapter would be incomplete without reference to a contribution from another source. In November 2021, the Marine Conservation Society (MCA), a registered charity, published '*Our Recommendations for the Diversification and Development of Responsible UK Aquaculture*'. The charity pointed out that – "*There is an opportunity for responsible aquaculture to deliver a number of the Sustainable Development Goals. ...* ***if the sector was underpinned by comprehensive planning****, securing the right investment and utilising the best technology to overcome existing environmental challenges, including those induced by climate change.*" [Emphasis has been added]

On shellfish cultivation, this document was encouraging, saying that – "***Moving into offshore waters, such as seen in rope grown mussels in Lyme Bay, may be necessary to facilitate substantial sector growth,*** *[but]* ***improved marine spatial planning will be required*** *[and]* ***Regulation, in particular relating to water quality classification, of the shellfish aquaculture industry will also need to be reviewed***". [Emphasis has been added]

The elephant in the room

This document then referred to what was then (and still remains) 'the elephant in the room' – "*the biggest limiting factor is loss of the export market. With the UK, exiting from the EU a large percentage of the shellfish market has been lost. Whilst in the EU, the UK was able to export shellfish from Grade B shellfish waters; these were then depurated* abroad before being sold within Europe. Now the UK is classed as a third country, as such EU countries cannot import shellfish from Grade B waters outside of the Union. Until the regulation is reviewed and changed, or a derogation facilities are in place to circumvent this restriction, the export market has been lost.*"

* Depuration is a process whereby pathogens can be flushed from the flesh of molluscs.

Rewilding/restorative aquaculture

There was however one upbeat note in a reference to '*Rewilding/restorative aquaculture*'. It is worth quoting in full – "*A study carried out by The Nature Conservancy in collaboration with its partners at the Universities of Melbourne, Adelaide and New England, assessed the biodiversity benefits of mussel, oyster, clam and seaweed farming. The study found that a great number of fish and invertebrates were found at mussel, oyster, clam and seaweed farm sites when compared to similar nearby locations without farms. The highest density found a mussel farms, that showed 3.6 time more fish and invertebrates than other locations.*

These farms are able to provide ecosystem services such as improved water quality, excess nutrient removal, carbon sequestration and increasing biodiversity. Not only this, but the sites provide foraging ground for other species, protection from predators and reproduction from spawning farmed adults, which spill over into the surrounding environment."

This aspect will be discussed further in Chapter 6.

Other opportunities

This document went on to mention opportunities provided by 'Integrated multi-trophic aquaculture (IMTA)', 'Offshore development' – "***There are already existing UK offshore farming sites in commercial operation, for example mussel production in Lyme Bay. The***

regulatory process in developing this farm was both lengthy and costly, thus discouraging similar future developments." [Emphasis has been added]

'*Colocation*' provides another opportunity – "*In 2014, a study was undertaken in Wales for the Shellfish Association of Great Britain, to look at the potential for collocating aquaculture with offshore windfarms. The study found there are a number of benefits colocation, including access to deeper, cleaner water; more dispersive sites; free from viral health threats and harmful algal blooms. However, there are also disadvantages, in particular the risks associated with working in higher energy and therefore more risky locations.* ***While a number of shellfish species were considered, the report recommended that blue mussel was the most suitable species to trial. However, there are a significant number of technologies, licensing and operating issues to be addressed before this can be seen as a viable option in the near future.***" [Emphasis has been added.]

Finally, '*Land based recirculating aquaculture systems (RAS)*' – "*avoid many of problems created by a changing climate*" but their carbon foot print and contribution to greenhouse gas emissions are significant.

The MCA document ends with Recommendations and, so far as they relate to shellfish aquaculture, will be quoted in full –

- *UK Government and devolved administrations to undertake a regulatory review, with regard to shellfish production including species farmed, to ensure that the process is streamlined, enabling and ensuring the industry is managed using an integrated ecosystem based approach in accordance with achieving Good Environmental Status under the Marine Strategy Regulation 2010 and objectives of the Fisheries Act 2020.*
- *For shellfish aquaculture to be fully integrated into marine spatial planning, with the objective of identifying opportunities for integrated multi trophic aquaculture (IMTA), offshore development and colocation.*
- *For the development of a shellfish hatcheries to be incentivised and encouraged to aid diversification of species and secure spat supply to support both an expanding shellfish aquaculture industry and restorative aquaculture.*
- *For restorative aquaculture to be seen as a viable mitigation tool for species and habitats, such as native oyster and kelp, and to be supported and promoted via policy and finance.*

All of these recommendations could be repeated – without amendment – today, two years later. Their message will be echoed in later chapters.

Among the 'main policy drivers' for English aquaculture, the Seafish 2020 Strategy document picks out – "***The English Marine Plans and their more detailed local interpretation will be the primary mechanism for identifying areas for potential sustainable growth in marine aquaculture production – this will enable more focused investigation and the most suitable location(s) for a particular species and/or culture method to be identified***". [Emphasis has been added.]

A consideration of marine planning is the next logical step.

From what is said in this chapter, there are the following conclusions –

- At least one of the assurances given in Defra's 2015 multi annual plan does not seem to have been met. The situation seems worse.

- Seafish produced an excellent Strategy document in 2020 but there are clear indications that it may be over-optimistic.
- There are structural staffing issues within Defra supporting this view.
- There seems to be little evidence of progress on the priority issues listed in the 2020 '*English Aquaculture Strategy*'.
- The loss of the export market following the departure of the UK from the EU is the biggest limiting factor and thus 'the elephant in the room' so far as shellfish aquaculture is concerned.
- Marine spatial planning is critical to the future of shellfish aquaculture and, if this aspect is addressed effectively, there remain several encouraging opportunities.

Chapter 6 – Marine Planning

Aquaculture

We come now to look at the Marine Plans of the Marine Management Organisation (MMO) and the manner in which (and the extent to which) they address shellfish aquaculture.

Perhaps spurred on by the outcome from the Defra consultation mentioned in Chapter 1, the East Marine Plan published in 2014 made an encouraging start. The North Norfolk coast was identified as the promising "*area for development through its potential to contribute to the sustainability and security of the United Kingdom food supply which, in turn, may encourage growth in small and medium enterprises supporting the industry.*"

The East Marine Plan included a detailed map showing the "*Optimum sites of aquaculture potential*".

The Marine Plans for the South (2018), South East Inshore (2021), South West (2021), North West (2021) and North East (2021) were less encouraging. They contained no maps or other indications of promising aquaculture sites and there were no sections of their narratives devoted to aquaculture. Instead, virtually similar texts, of which an extract from one of them appears below, have been pasted into each Plan –

"*... aquaculture is an important industry with the potential to grow, contributing to food supply and security.* [The plan] *seeks to protect both existing aquaculture operations as well as potential future opportunities for aquaculture, within spatially defined strategic areas of sustainable aquaculture production. These strategic areas have been spatially defined for species of commercial importance by considering environmental factors, technical constraints, planning constraints and other users of the sea. .... While protecting opportunities for sustainable aquaculture production, the policy makes allowances for both non-significant adverse impacts on aquaculture, and significant adverse impacts that are outweighed by the benefits of the proposal.*"

This wording, in terms reminiscent of prose favoured by those charged with the drawing up of official policy documents, is empty of any real (as opposed to depressing) significance for anyone engaged in, or planning to engage in, shellfish aquaculture. The fact that significant adverse impacts on aquaculture are to be 'outweighed' by the benefits of other 'proposals' (no details given) is distressing to put it mildly.

We are faced with the clear conclusion that aquaculture has slipped down the list of priorities since the initiative of the 2012 Consultation even though the South Marine Plan, published in 2018, was marginally less dismissive and admitted that the area supports significant aquaculture activity amounting to 32% of England's aquaculture tonnage.

Water quality

The East Marine Plan in 2014 contained a short section on water quality and its importance to tourism and recreation. It also mentioned 16 beaches with blue flag status. Its sixth objective was – "*To have a healthy, resilient and adaptable marine ecosystem*" and mentioned the need for – "*Good Ecological Status or Potential and Good Chemical Status*". Development proposals must consider - "*the impacts to water quality and the local marine environment*".

Four years later, when the South Marine Plan was published, the only references to water quality were – "*S-WQ-1 Proposals that may have significant adverse impacts upon water*

environment, including upon habitats and species that can be of benefit to water quality must demonstrate that they will, in order of preference: a) avoid, b) minimise, c) mitigate significant adverse impacts" and – "*S-WQ-2 Activities that can deliver an improvement to water environment, or enhance habitats and species which can be of benefit to water quality should be supported.*"

The aims behind these statements were given as – "*Much of the economic and cultural prosperity of the south marine plan areas is reliant on water quality. Activities can place stress on water bodies such that, in parts of the south marine plan areas water quality requires improvement. S-WQ-1 seeks to manage impacts on water quality, and the habitats and species which benefit water quality through the ecosystem service they provide*" and – "*Habitats such as coastal saltmarsh, intertidal mudflats, seagrass, reed beds and natural blue mussel beds provide ecosystem services which maintain and can improve water quality. S-WQ-2 encourages activities improving water quality including habitat restoration, bioremediation and voluntary measures.*"

The above quotations from the formulaic and cliched terminology of the South Marine Plan were copied almost verbatim into the North West Marine Plan, The South East Inshore Marine Plan and the South West Marine Plan when all three were published in 2021. It is hard to avoid the conclusion that this aspect of those plans involved little more than mindless copying and pasting – a box-ticking exercise.

Areas suitable for shellfish aquaculture

Shellfish aquaculture has not been wholly overlooked, however. Early in 2020, the MMO published a document entitled "*Identification of areas of aquaculture potential in English waters: Modelling methods*". The objective behind it was prompted by the growth potential of aquaculture and food security. "*However, regulatory barriers and a lack of availability of new production sites are among limiting factors for growth in the UK aquaculture sector.* ***In England, industry challenges could be reduced by enabling the sustainable use of sites that are most suitable for aquaculture, streamlining regulatory and licensing procedures and improving policy.***" [Emphasis added.]

In the background behind this document was a report bearing the same name (less "*Modelling methods*") prepared by Cefas and published by the MMO in the spring of 2019. It is this latter document that is of particular interest to the shellfish farmer since it aimed to "*delineate areas of potential for aquaculture development in English waters*" and five mollusc species were among the fourteen species that were the focus of the report – "*Crassostrea gigas (Pacific oyster), Ostrea edulis (native oyster), Mytilus edulis (blue mussel), Ruditapes philippinarum (Manila clam) and Pecten maximus (King scallop)*".

Oysters (both Pacific and native) and blue mussels "*appeared the most suitable* [mollusc] *species for aquaculture, based on their environmental ranges for optimal/suboptimal growth.*" After Atlantic salmon, "*The second most important category in UK aquaculture is 'Mussels' and particularly blue mussel (Mytilus edulis), which represented on average (between 2010-2016) 12% of the total UK production in weight, and 4% of production in value ...* [and] *The* ***remaining 1% of UK aquaculture production is represented by 'Oysters', with Pacific oyster (Crassostrea gigas) accounting for almost all the production.***" [Emphasis added.]

On the subject of the Pacific oyster, already mentioned in Chapter 4, the report had this to say – "*The Pacific oyster is a commercial aquaculture species that is cultivated around the world (see FAO, 2004). It is not native to the UK, unlike the native flat oyster, but was introduced into the UK for commercial exploitation from 1926 to 1978 (Utting and Spencer, 1992).* ***The***

fast growing and robust nature of Pacific oyster has resulted in an increase in its aquaculture and in 2012 it yielded 10 times the harvest weight of the native European oyster *(Ellis et al., 2015). Popularity of the native oyster has declined, driven largely by outbreaks of diseases ... which has caused high levels of mortality in commercial oyster beds*". [Emphasis added.]

This document produced by Cefas discusses the environmental and technical constraints having their impact on cultivation. These include water temperature, salinity, dissolved oxygen, etc and also practical considerations such as wave heigh and the speed of ocean currents. There are maps showing optimal and suboptimal waters around the English coastline for each of the species on which the report is focussed.

It summarises the position for the five mollusc species as follows –

- "*The bivalve mollusc aquaculture suitability maps suggest that the two species of oyster have the greatest potential across the English component of the UK EEZ (see Figure 18). The Pacific oyster has a suitability level above 0.5 across 98.5% of the English waters. The North West region and areas off the coast of Norfolk, Lincolnshire and Yorkshire show a very high potential. There are a number of smaller regions identified along the south coast such as regions around the Solent and West Sussex. A very similar pattern is observed with the native oyster due to very similar threshold levels for both species (compare Table 11 with Table 12).*
- *"The Blue mussel also shows a relatively good potential throughout English waters (Figure 19) but it is less pronounced that for the oyster species. Aquaculture potential is reduced due to suboptimal levels of the maximum salinity, minimum sea surface temperature (except for the south-west extent of the EEZ) and maximum sea surface temperature for regions south of Norfolk (above 30 for maximum salinity; below 8°C for minimum SST and above 12°C for maximum SST).*
- *With regard to the Manila clam there are large areas that appear suitable for exploitation along the South Coast (English Channel and Celtic Sea) and off the coast of Yorkshire and Northumberland (see Figure 20). Cultivation appears to be unsuitable off parts of the East coast of England around Norfolk and Suffolk and off the North West coast. This is due to the minimum sea surface temperature in these regions being below that considered unsuitable for Manila clam culture.*
- *For the five species of bivalve, the king scallop shows the largest area of English waters where aquaculture is deemed unsuitable. King scallop cultivation is unsuitable all along the East coast of England from Dover to Northumberland (see Figure 20). In addition, it is considered unsuitable along the North West coast of England. In both cases this is driven by a minimum temperature below that considered suitable for this species (minimum SST below 6°C). In comparison, aquaculture potential is strong along the English Channel and into the Celtic Sea.*"

There is one important cautionary note at the end of the report to the effect that it would be – "*important to consider proximity to potential sources of contamination (e.g. discharges from industry or treatment plants). This is important for the bivalve filter feeders as they can accumulate heavy metals and viruses which can be a problem with human health if they are consumed.*"

Incidentally, the 2020 report covering "*Modelling methods*" mentioned at the commencement of this section in this Chapter correctly mentions all the shellfish species that were the focus of the earlier Cefas report but the "*Crassostrea gigas (Pacific oyster)*" appears to have slipped off the list given for the 'Model structure' – "*To produce the final suitability layer*".

Could this be, the shellfish farmer will ask, an example of the influence of "*key stakeholder groups*" now affecting marine planning? (It should be added that "*Alaria esculenta* (winged kelp – a form of seaweed)" is also not listed. No reason is given for the reduction of the list of species from fourteen to twelve.)

MMO Strategy

In July 2022, the Marine Management Organisation published its "*MMO2030 Healthy, Productive Seas and Coasts MMO Strategic Plan*" telling the world that – "*Our MMO Story places the protection and sustainability of our marine environment at the heart of everything we do, balancing this with the need to use the sea's precious resources wisely for the benefit of our seas, coasts and communities*" and that "*Our aspiration is to be recognised as a world leader, and share our expertise, experience, evidence and data with others who share our ambitious agenda.*"

This short document makes no mention of aquaculture or water quality. It is equally silent regarding shellfish. There is brief reference to fisheries, with "*Goal 6 Assuring sustainable fisheries*". The focus is clearly 'capture' fisheries not aquaculture.

Two of the projected outcomes are given as – "*Fishing opportunities are economically available to all who meet sustainable criteria*" and – "*The eco system services delivered by fish stocks are fully recognised and accounted for in fisheries management decisions*" but any hope that these statements might give to the shellfish farmer is dampened by the final 'outcome' – "*Marine development takes place based on a full understanding of fisheries as defined in the integrated single marine plans*". The scant reference to shellfish aquaculture in all but the first of the Marine Plans has already been noted.

Looking ahead

In 2017, a few months before the publication of the South Marine Plan and while the remaining batch of Marine Plans was in early preparation, the MMO published its 'Futures analysis for the north east, north west, south east and south west marine plan areas'. The Report was prepared by Consultants ABPmer and ICF and considered three possible scenarios – first, a continuation of current policies (Business as Usual), secondly, maximising ecosystem services (Nature at Work) and, thirdly, what was described as Local Intervention "*local decision-making and differentiation*".

On shellfish aquaculture, the Report stated that – "*Although shellfish farming occurs in all areas around England, the highest number of shellfish farming businesses are in the south east and south west, with far fewer [Aquaculture Production Businesses] in the north east and north west marine plan areas ... Mussels are the main species produced by volume and value. ... There is no marine-based crustacean production and hence this is not considered further. ... For the purpose of this study, production from Several Fishery Orders would be classified as 'aquaculture', whilst harvest from Regulating Fishery Orders would be considered to be wild capture.*"

The areas of five different Several Orders fell within the scope of the Report. Three of them in the south east and two in the south west. The 'key drivers' identified as affecting the sector included "*Food security, ... Market demand - increasing demand for shellfish in some markets (e.g. Europe, Asia).*" (The limited domestic demand has already been mentioned in Chapter 5.)

Water quality is critical and the Report says – "*For shellfish farming, water quality is a key factor in determining the economic viability of production. Achievement of [Water Framework Directive] targets, and improved land management, would likely increase the available marine space for shellfish aquaculture to expand into if improvements occur in areas of good aquaculture potential (i.e. suitable environmental conditions for cultivation)*".

Intriguingly, the Report also says – "*It is assumed that expansion of the oyster production sector is facilitated by clarity being provided on the production of Pacific oysters (non-native species) by Government and regulators.*" Today, six years later that has still not happened.

Seafood 2040

In 2017, in initiative called 'Seafood 2040' (shortened to 'SF2040') was born under the sponsorship of Seafish. It was described in its updated Strategic Framework published in 2021 as – "*an England-only, ambitious and shared Programme with clear opportunities across the seafood supply chain. It is a collaboration between government and industry. Stakeholders from across the English seafood supply chain, government and regulators work together through the now established Programme in pursuit of a single, compelling vision: a thriving and sustainable English seafood industry by 2040.*"

It was this impressive and far-sighted initiative that produced the 'English Aquaculture Strategy' mentioned in Chapters 1 and 5. As part of the initiative, a Seafood Industry Leadership Group and an Aquaculture Leadership Group were formed each containing a wide range of representatives from across the industry to provide input to the project.

The initiative's Strategic Framework in 2021 comprised a series of nineteen 'Recommendations' (down from twenty-five in 2017). These were updated and re-published "*for 2021 – beyond*" due to – "*a number of significant changes to the seafood industry both at home and abroad, not least the impacts from both Brexit and the COVID-19 pandemic*". The Fisheries Act 2020 had also come into force. The Recommendations were arranged under the following headings –

- Foundation Recommendations (best practice, science, nutrition, environment)
- Marketing Recommendations
- Catching and Aquaculture Recommendations
- Enabling Business Growth Recommendations (infrastructure, training, supply chain resilience, maximizing seafood resource)
- Trade Recommendations (export and import).

By way of example, the second Recommendation is – "*Progress the activities identified by stakeholders as important for the development and improved understanding of the England seafood industry's science, innovation and technological needs.*" The eighth is – "*Explore options that will support a domestic market demand for a wider variety of English-caught species and farmed fish and shellfish.*"

Of particular interest to shellfish farmers is the twelfth Recommendation – "*Enhance the now established SF2040 Aquaculture Leadership Group (ALG) in its efforts to more widely represent English aquaculture, to encourage innovation and technology, and to support export and domestic growth. Provide strategic vision and support to enable the expansion of aquaculture. Aim to strengthen relationships between academia, industry, government, and regulators, and encourage collaboration.*"

Under this heading, it was proposed (among a range of workstreams) to – "*Support the Government review of current regulation impacting on shellfish aquaculture and further reviews ...* [to] *Determine a project with a regional approach that identifies potential areas of aquaculture across the English coast, including co-location opportunities. Build on any relevant mapping work ...* ***Secure funding and commission the work*** [and to] *Feed into and support discussions and projects that ensure the shellfish testing regime is fit for purpose to reduce duplication across different agencies, reduce costs and grow public confidence in shellfish aquaculture*".

The wording that has been highlighted above (or similar), appears in a number of places in relation to virtually every one of the nineteen Recommendations. If now there were signs of significant progress on any of these workstreams, every shellfish farmer would applaud. Sadly those signs of progress are lacking. After the publication of the Annual Report for the year ended September 2021, no indications of the further progress of Seafood 2040 can be found on the Seafish website.

Has the funding dried up? Has the initiative been killed off?

It is time now for a closer look at the regulation of shellfish aquaculture.

The conclusions –

- Between 2013 and 2021, the approach to aquaculture in the published Marine Plans was downgraded to what appears to be unthinking and repetitive lip service.
- Significant progress has been made in the identification of marine areas suitable for shellfish aquaculture.
- There is little or no encouragement for shellfish aquaculture to be derived from the current MMO Strategy.
- Marine planning may now be turning away from the Pacific oyster in particular.
- Failure by Government and regulators to address the issue continues.
- The exciting initiative provided by Seafood 2040 seems to have died.

Chapter 7 – The Regulation of Shellfish Aquaculture

The provisions in law for the regulation of shellfish aquaculture have been described as a 'complex nightmare'. The 'United Kingdom multiannual national plan for the development of sustainable aquaculture' published by Defra in 2015 listed the following as "*The key aquaculture consenting framework in England*" –

- A Several Order from Defra;
- Planning permission from the Local Authority;
- Authorisation by the Fish Health Inspectorate under Aquatic Animal Health (England and Wales) Regulations 2009; and the Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011;
- Land use consent from The Crown Estate or any other land owner;
- Abstraction licence from the Environment Agency;
- Food Hygiene and Safety permission from the Local Authority;
- Marine Development and/or Marine Construction licence from the Marine Management Organisation;
- Discharge consent from the Environment Agency;
- Compliance with the Gangmasters (Licensing) Act 2004.
- Compliance with environmental regulations if in an area of statutory protection (such as SSSI, European Marine Site, or Marine Conservation Zone) and Consent and/or Assessment accordingly by the Competent Authority in question:
    - Natural England;
    - The local Inshore Fisheries and Conservation Authority (IFCA).

Not all of these requirements will apply to every shellfish aquaculture enterprise but those that do apply constitute a formidable, time consuming and expensive array of hurdles to be overcome if shellfish cultivation is to be undertaken.

The tool box for shellfish farmers

The Seafish website now holds the guidance on aquaculture prepared by The Centre for Environment, Fisheries and Aquaculture Science (Cefas) pursuant to its work on the subject commissioned by the EU as mentioned in Chapter 1. It is called '*Aquaculture Regulatory Toolbox for England*'.

There are seven documents of direct relevance to the shellfish farmer. Their most recent versions are dated 2020. The first is for those activities that are 'marine based' – "*Including the following culture methods: on-bottom (using trestles or other ground anchored support system in the inter- tidal marine or estuarine area; or relaying directly on or in the ground); off-bottom (rafts, float supported systems or longlines in the offshore marine area).*"

It explains the exemptions under the Marine Licencing (Exempted Activities) Order 2011 and lists all the consents required, giving the functions of the regulators and extensive contact details. It is a much longer list than that from the multi-national plan mentioned above. It runs to seven pages and even provides timescales for applications.

The second document is for 'land based' activities – "*Including on-shore facilities for holding and rearing marine molluscs (shellfish hatcheries, including algal culture systems; abalone farming tanks using pumped sea water)*" and is as helpful and informative as the former. It runs to five pages.

These two documents are supplemented by at third five-page document providing guidance for a Shellfish Purification Centre. Purification is needed – usually essential – when shellfish are harvested from Class B waters. Class A waters in which those shellfish can be re-laid are currently very scarce as mentioned in Chapter 2. Purification centres (providing 'depuration' as mentioned in Chapter 5) are costly to establish and the list of regulators is a long one.

'Marine – Crustacean Cage Culture' is the focus of the fourth guidance document running to six pages. Large scale cultivation of lobsters and crabs using cage culture is still in its infancy. They are highly mobile and cannibalistic carnivores giving rise to novel cultivation issues. Ground-breaking work by organisations like The National Lobster Hatchery in Padstow are demonstrating that this is a promising field for shellfish aquaculture. This guidance extends to six pages.

The tool box for shellfish farmers and regulators

Those five guidance documents for shellfish farmers are supplemented by three further documents aimed at both farmers and regulators. The first covers – "*Processes and flowlines for establishing classification and bio–toxin status of new offshore shellfish growing areas.*"

An 'offshore growing area' is – "*An area where no human or animal sources had been shown to impact on the fishery in the sanitary survey and where no potential changes to sources have been identified during the annual review process. An offshore bivalve shellfishery (≥5 km from shore) not impacted by long sea outfalls is an example of a remote area.*"

It is encouraging that this potential growth area for shellfish aquaculture is thus addressed. On water quality, it is noteworthy that this document says – "*The factors affecting water quality at a particular site can be complex. Whilst better water quality might be expected the further offshore you go, influences from long sea sewage outfalls and river plumes can extend over long distances so good water quality cannot be assumed.*"

The second of these documents is concerned with – "*Potential aquaculture areas in marine plans – What they mean for potential new aquaculture businesses and their relationship with Marine Protected Areas (MPAs)*". The first edition of this document was issued in January 2018, when only the East and South Marine Plans had been published.

It makes the point that the Marine Policy Statement, published in 2011 following the enactment of The Marine and Coastal Access Act 2009, requires marine planners to – "*seek information on possible future aquaculture operations in areas not previously used, assessing the suitability of those areas for development*".

Pursuant to that requirement, it records that – "*consultants ... conducted a review of best available information and provided the MMO with a GIS computer model and an assessment of the spatial potential for aquaculture in the East and South Marine Plan Areas.*"

Is it possible that this step was not taken for the South East Inshore, South West, North West and North East regions before the other Marine Plans were published in 2021?

This would certainly help to explain the cursory approach to aquaculture in those documents that has been noted in Chapter 6. This second document says – "*The processes for any future mapping and the specifications for doing this have still to be determined.*"

The third and final one of these three documents is concerned with – "*Clarification and guidance on the shellfish exemption from marine licensing and subsequent variations to*

licences". Its focus is offshore shellfish sites and possible dangers to navigation. The exemption under the Marine Licensing (Exempted Activities) (amendment) Order 2013 is explained. It also clarifies the need to consult with the Maritime & Coastguard Agency, Trinity House or a Harbour Authority.

The Marine Policy Statement

This document, published in 2011 as mentioned above, makes the Secretary of State responsible for marine planning for England. The work is delegated to the MMO.

Objectives

This document's – "*vision for the marine environment* [for] *'clean, healthy, safe, productive and biologically diverse oceans and seas'*" underpins all Marine Plans and the duties of all the relevant Regulators.

There are 'high level marine objectives' and those likely to catch the attention of shellfish farmers and those planning a career in the field include "*a sustainable marine economy*", "*the functioning of healthy, resilient and adaptable marine ecosystems*", "***clear, timely, proportionate and, where appropriate, plan-led regulation***" and "***using sound science responsibly***" [Emphasis added.].

The Statement has a section on aquaculture, saying – "*Food security is an objective of the UK Administrations and aquaculture makes an important and growing contribution to this. ... the development of efficient, effective, competitive and sustainable aquaculture industries* [is supported and encouraged] *subject to suitable governance and safeguards*" Later, it says – "*UK environmental policy will continue to improve the quality of shellfish harvesting areas (including those for wild shellfish) by seeking to adopt appropriate microbiological standards*".

In the light of what is said in Chapter 2 about water pollution, that last statement might encourage the shellfish farmer to comment, after the first decade, that the policy has not been implemented very successfully so far.

Water Quality

Water quality receives only brief mention in the Statement – "*Developments and other activities at the coast and at sea can have adverse effects ... There may also be an increased risk of spills and leaks of pollutants into the water environment and the likelihood of transmission of invasive non-native species, for example through construction equipment, and their impacts on ecological water quality need to be considered.*"

Also – "*The marine plan authority should satisfy itself where relevant that any development will not cause a deterioration in status of any water...* [and] *... should also take into account impacts on the quality of designated bathing waters and shellfish waters from any proposed development.*"

The Statement, with its focus on the future, seems to place no other responsibility for water quality on those responsible for the creation and implementation of Marine Plans. It does however mention – '*Surface water management and waste water treatment and disposal*' and – "*the effective drainage of storm water and runoff to the sea*" as one of the – "*key activities to achieve*" – "*modern, high quality management and treatment of surface and waste water.*"

Not only, it seems, may there be little responsibility for water quality, but marine planners also seem to be required to assist drainage. This impression is mitigated (slightly) by the mention of – "*mitigating the effects of diffuse pollution from urban areas and agriculture by improved management and improvements to drainage design*" as another key activity.

It begs the question as to whether the Marine Management Organisation now bears shared responsibility for water quality around the coastline. It tells us that – "*allocating sufficient space to facilitate future growth of current sewerage services is essential to the integration of land-use plans with Marine Plans.*"

Among the "*Potential impacts*" that are mentioned in this section of the Statement, it is stated that – "*Waste water collection, treatment and discharge is governed by requirements in European legislation including the Urban Waste Water Treatment Directive, Shellfish Waters Directive, Bathing Water Directives and Water Framework Directive.* ***These requirements aim to protect and where necessary improve the quality of water in the aquatic environment.*** *Proposals for new or extended waste water collection and treatment facilities are bound by these requirements ensuring minimal impact and a sustainable co-existence with other existing marine activities such as aquaculture, fishing and bathing.*" [Emphasis has been added.]

There is one further requirement that needs consideration – "*A precautionary and risk-based approach ... should be taken in terms of understanding emerging evidence on coastal processes.*" This has particular relevance to the development and expansion of shellfish aquaculture and will be examined next.

The precautionary principle

What is known as 'the precautionary principle' as a concept in environmental policy has evolved over the last half century. It is perhaps best known for the wording of Principle 15 recorded at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. It reads –

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

The principle has been adopted in international conventions and treaties and is widely used within the European Union. One re-statement of it reads – "*if a product, an action or a policy has a suspected risk of causing harm to the public or to the environment, protective action should be supported before there is complete scientific proof of a risk*".

There are widely held and differing views on the use of the concept. What is perhaps the most commonly held one has been summarised as follows – "[It] *must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action*".

Any assertion that "The precautionary principle says 'no'" is a misuse of the term if it is not preceded (or immediately followed) by an extensive (and authoritative) examination of the 'risk' of what is proposed. Any subsequent examination must be timely. If it not, there is a danger that the issue becomes locked away without time limit.

Further, in examining any 'risk', it must be accepted that perceptions of that risk can be variable. (By way of simple illustration, a fit, young athlete will have no qualms about jumping over a five-barred gate. A pensioner may have a very different view.) Likewise any suspected 'harm' will be open to different interpretations. A perception of 'suspected harm' must not be confused with actual harm.

The expression 'precautionary principle' cannot be used as an excuse to shut down debate or to kick the issue into the long grass. If it is employed in that manner, it is not being used properly. It is being abused. A comparable expression – 'for reasons of national security' – is an analogous excuse that (history has shown) lends itself to abuse.

Regulators face a formidable and challenging task. For those who are either lazy or alternatively overworked, the use of 'the precautionary principle' can be a tempting smokescreen with which to remove a problem from the current workload and to place it in the 'too difficult' box where it can lie unchallenged for an indefinite period – perhaps banished forever.

This is a misuse of the principle because it means 'no'. The regulators duty is to ask the question 'how?'. Only when that question produces the answer 'no' with the indisputable support of science will the duty be discharged. By asking the question 'how?', a very different answer is capable of emerging.

Fisheries Act 2020

It should be mentioned here that Section 1 of the Fisheries Act 2020 contains a "*precautionary objective*" for policies and statements, meaning, according to sub-section (3), that – "*(a) the precautionary approach to fisheries management is applied, and (b) exploitation of marine stocks restores and maintains populations of harvested species above biomass levels capable of producing maximum sustainable yield.*"

Sub-section (b) just quoted is clearly encouraging to a shellfish farmer, who is ever anxious to aim for the maximisation of the harvest and indeed its expansion. Any trend moving in the opposite direction spells ruin for the shellfish farmer.

Sub-section (10) of Section 1 reads – ""*precautionary approach to fisheries management" means an approach in which the absence of sufficient scientific information is not used to justify postponing or failing to take management measures to conserve target species, associated or dependent species, non-target species or their environment.*"

There is no reference here to "`threats of serious or irreversible damage`" being present as mentioned in Principle 15. It is applied to "*management measures to conserve*". They may not be quite the same as "`cost-effective measures to prevent environmental degradation`".

There are other worries that this provision engenders from the standpoint of the shellfish farmer. They lie in the terms "*sufficient scientific information*" coupled with the "*management measures*" envisaged by this provision. The shellfish farmer might be tempted to ask (a) how the sufficiency of the information is to be determined, (b) how long will be the duration of the postponement or failure to take action and whether either of these can be susceptible to challenge.

This issue becomes very pertinent if any such decision or action relates to the commencement of, expansion of or, for that matter, operations in the course of shellfish aquaculture. It is an

activity unusually fraught with risks and uncertainties such as these. It is expensive and certainly not for the faint hearted!

Back to water quality

It would be wrong to suggest that attention to water quality has been limited to those brief quotations from the 2011 Marine Policy Statement or indeed the references in the Marine Plans mentioned in Chapter 7.

In February 2016, the MMO published an interesting Report entitled – '*Evidence Supporting the Use of Environmental Remediation to Improve Water Quality in the South Marine Plan Areas*'. Its purpose was to – "*to support marine planning regarding the possible use of environmental remediation to improve water quality in the South Inshore and South Offshore Marine Plan Areas*". Those Plans were ultimately published in 2018 and have already been mentioned in Chapter 6.

The focus of the Report was – "*potential bioremediation options for improving water quality in relation to reducing nutrient loading, microbial contamination, chemical contamination and turbidity*" and "*four main types of bioremediation (using filter feeders, seaweeds, seagrasses, and saltmarsh and Phragmites reedbeds)*".

The Executive Summary of that Report concludes – "*Although marine bioremediation and ecosystem restoration has not yet been used significantly in the UK (other than for managed re-alignment), evidence presented in this report suggests that its use should be encouraged, for example through policy and associated objectives.*"

Using Poole Harbour as one of its examples, this long and detailed report demonstrated that – "*Treatments for improving coastal water quality can be expensive* [and] *reversal to good quality in the receiving water may not be guaranteed.*" It confirmed that Defra "*has responsibility for water quality*" and that "*The Environment Agency, the MMO and other regulators will work together across the land-sea interface to ensure that water quality objectives are met.*"

Four water quality issues were said to be "*of concern*", namely: "*excessive nutrient concentrations and disturbed ecological quality, microbial contamination of shellfish and bathing waters, chemical pollution, and elevated turbidity.*"

The issue in this Report that is of interest to those involved in shellfish cultivation is the role that filter feeding species such as oysters and mussels can play in removing suspended material such as phytoplankton, sediment and detritus from coastal waters. The Report says – "***Such is the potential of some bivalve species to influence the environment and provide physical habitat for other species, they are often referred to as naturally-occurring ecosystem engineers***". [Emphasis has been added.]

The Report also tells us that – "***Bivalve species capable of building reefs may also alter the hydrodynamic conditions at a site and thereby improve bioremediation activity***. *The increased bed roughness associated with these biogenic structures both increases the potential surface area to volume ratio within a habitat and the flow turbulence above the reef, thereby increasing larval retention, improving water column mixing and enhancing filtration (Nelson et al., 2004).* ***This suggests that bivalve species that are able to form biogenic structures and that are deployed in a manner that allows this, may be more effective as bioremediation agents.***" [Emphasis has been added.]

A lot of the evidence on which the Report is founded relates to the American oyster but it does say – "***As both O. edulis* [European oyster] *and Crassostrea gigas (the Pacific oyster) are established aquaculture species, there are a variety of proven, high-density culture methods are available for both species. This greatly improves the ease with which oyster-based bioremediation projects could be established and expanded***".

So far as mussels are concerned, the Report indicates that aquaculture for human consumption may – "*limit the bioremediation scope and areas available for existing shellfish management practices to nutrient control rather than pollutant or bloom-forming species control.*" But – "***Rope culture greatly increases the surface area to volume ratio between the mussels and the target water body. This facilitates a faster turn-over of the water body and a greater clearance rate. ... [and] (although still requiring seafloor moorings), rope culture can also be deployed over larger areas compared with bottom culture***." [Emphasis added.]

In its conclusion, the Report says – "*the evidence base in this report shows that an active restoration of ecosystem services is likely to bring about water quality improvements.*"

It is time now to look as some of the Regulators and those who call the shots.

The conclusions that may be drawn from this Chapter are –

- For a variety of reasons, shellfish aquaculture is faced with a complex bureaucracy that requires the shellfish farmer to deal with, to seek consent from and, in some cases, make significant payments to a wide range of bodies.
- There is only the helpful guidance produced by Cefas and available from Seafish to assist with this.
- Those responsible for the creation and implementation of Marine Plans seem to have modest duties with regard to water quality but may have a shared responsibility for drainage.
- When environmental issues arise, the 'precautionary principle' applies and the way in which it could be employed in the context of shellfish farming gives rise to concerns and significant uncertainties.
- Shellfish aquaculture, involving mussels and both European and Pacific oysters, can provide an effective means of bioremediation where there are water quality issues.

Chapter 8 – Who calls the shots?

The point has been reached when it is necessary to take a closer look at one or two of the Regulators that feature so large in the prospects of the shellfish farmer.

To start with questions – where lies the ultimate responsibility for –

- Water quality?
- Applicable marine policies?
- Applicable marine planning?
- Regulation of shellfish cultivation?

The Department for Environment Food and Rural Affairs (Defra)

This is the government department that has the ultimate responsibility for all four of these activities. It also has a vast range of other responsibilities. As mentioned in Chapter 5, its people are all 'generalists'. This aspect can give rise to comments (whether they are justified or not) along the following lines –

- There are only two and a half people in Defra at any one time who know anything at all about shellfish.
- It can take a couple of years before they really understand what shellfish involves.
- As soon as they understand it and are any good at the job, they get moved on to something else.

Comments such as these, or along similar lines, are not uncommon. They may be unfair or untrue. They may overlook the devotion, talent, dedication and commitment of individuals. They do however point to the possible existence of a problem that is noticed and does not appear to be imaginary.

There are other indications that this is not just an issue that features in the fevered imaginations of shellfish farmers. A book published earlier this year – '*How Westminster Works ... and Why It Doesn't'* by Ian Dunt with a comment in the 'blurb' on the cover by Alastair Campbell – "*Ian Dunt is an acute observer of what's gone wrong with our politics and why*" – provides further insight.

The Chapter on '*The Civil Service*', tells the reader that – "*The idea of the civil service as a uniquely effective and clear-sighted bureaucratic entity ... is largely a myth and probably always has been.*" There have been a succession of attempts since as far back as the 1960s (at least) to address the twofold problem of 'generalism' and 'churn', the effect of which has been to make the civil service what the book describes as "*the cult of the amateur*".

All those attempts failed. The then Cabinet Office minister, Michael Gove, is quoted as saying in 2020 that – "*The current structure of the civil service career ladder means that promotion comes from switching roles, and departments, with determined regularity.*" The mechanism for promotion thus actually distains the acquisition of expertise. Every career switch necessary to secure promotion has the effect of abandoning any expertise and knowledge that may have been acquired in performing the previous role.

The book points out that the effects of austerity and Brexit, bringing a freeze on civil service recruitment coupled with the need to staff new departments led to rapid grade inflation and a drop in the quality and experience of those going into the upper echelons of the civil service.

"*Civil service churn has now reached unprecedented levels.*" and "*The Treasury ... often has the highest rate of annual staff turnover of any Whitehall department.*"

The book comments that – "*The lack of specialism is particularly painful when it comes to commercial skills.*" and – "*It pushes the civil service towards the use of private sector consultants.*" Thus – "*It amounts to a degradation of its institutional capacity: a form of conscious deprofessionalisation.*"

With a backdrop like this, the comments noted earlier about generalists come into sharp focus. These are the people in Defra (and thus also the MMO, the EA and NE) upon whom the shellfish farmer must rely to sort out the manifest problems. It is not a happy picture.

As the Seafish 2020 strategy document made clear, specialists are needed to get some jobs done if they are to be done effectively. This is a lesson that is well understood (and followed) in medicine, in the law, in science and in many other fields of human endeavour. The maximisation of an individual's personal achievement in all of these fields tends to involve the acquisition of more and more knowledge almost certainly about less and less.

(The converse of that is politics – involving the knowledge of less and less about more and more – but that is politics! This is about shellfish cultivation and improving food resources.)

If the mix of skills available to Defra does not include the required specialists, those skills must come from outside sources (but Consultants are expensive) or from one of the other bodies (there are several) to which Defra delegates its responsibilities.

Apart from its overall responsibility for the issues listed above, Defra is the only Regulator responsible for the oversight and grant of Several Orders mentioned in Chapter 3. These Orders provide the only security for shellfish aquaculture in the marine environment and, as has been mentioned, that security in the context of water quality is dubious to say the least. There are worrying indications as mentioned in Chapter 3 that the abolition of Several Orders is under contemplation.

The issue needs to be addressed. Finance is needed for every business and shellfish aquaculture is no exception. The investment that has to be made to establish and operate a successful shellfish aquaculture enterprise is enormous. The absence of security for that investment represents a major obstacle to the attraction of investors (and that includes lenders) and thus to the expansion of this contribution to food security.

Furthermore the regulatory quagmire confronting those engaged in shellfish aquaculture is widely recognised. It remains a major problem. Its simplification is also down to Defra. Are the necessary skills and knowledge available? Is there a will to do something about it?

The Environment Agency

The EA comes under Defra and has primary responsibility for water quality. Around the coastline, that responsibility may be shared (but arguably only marginally) with the MMO. The EA seems to be vastly under-resourced and has a massive range of other major responsibilities.

To give but one example of the latter, flooding is increasingly a major problem that can dominate the headlines (and no doubt the undivided attention of the EA) for weeks on end.

The failings of the EA in the context of water quality were exposed in the Report of the House of Commons Environmental Audit Committee quoted in Chapter 3.

More recently, public attention has increasingly been drawn to the impact of agricultural discharges on waterways – for instance the River Wye. Fertilisers (nitrates and phosphates) encourage the growth of algal blooms and eutrophication. The water becomes starved of oxygen. The carbon dioxide content increases, lowering the pH (potential hydrogen) of rivers and thus of seawater. This is one of the causes of ocean acidification.

Although the 'Farming Rules for Water' have been in force since 2018, Sir James Bevan, the CEO of the EA told the House of Commons Environmental Audit Committee when it was gathering information for that Report mentioned in Chapter 3 that – "*because of the reduction in our grant and because most farming is not regulated and, therefore, we do not get income from the cost of regulating farms in those cases, we have been able to do fewer and fewer farm inspections over the last several years.* ***Right now, at least last year, we had sufficient resource that would allow us, in theory, to visit every farm in Britain less than once every 200 years. That is not a great disincentive to a farmer to stay on the right side of the line, so there is an issue about resourcing and about the overall regulatory framework for farming***." [Emphasis has been added.]

Water quality is one of the biggest issues in the context of the environment. All life depends on it. Throughout history, the size and capacity of the oceans have made them a convenient dumping ground for mankind where "out of sight is out of mind" but we know (and have known for many centuries) that this resource is not inexhaustible.

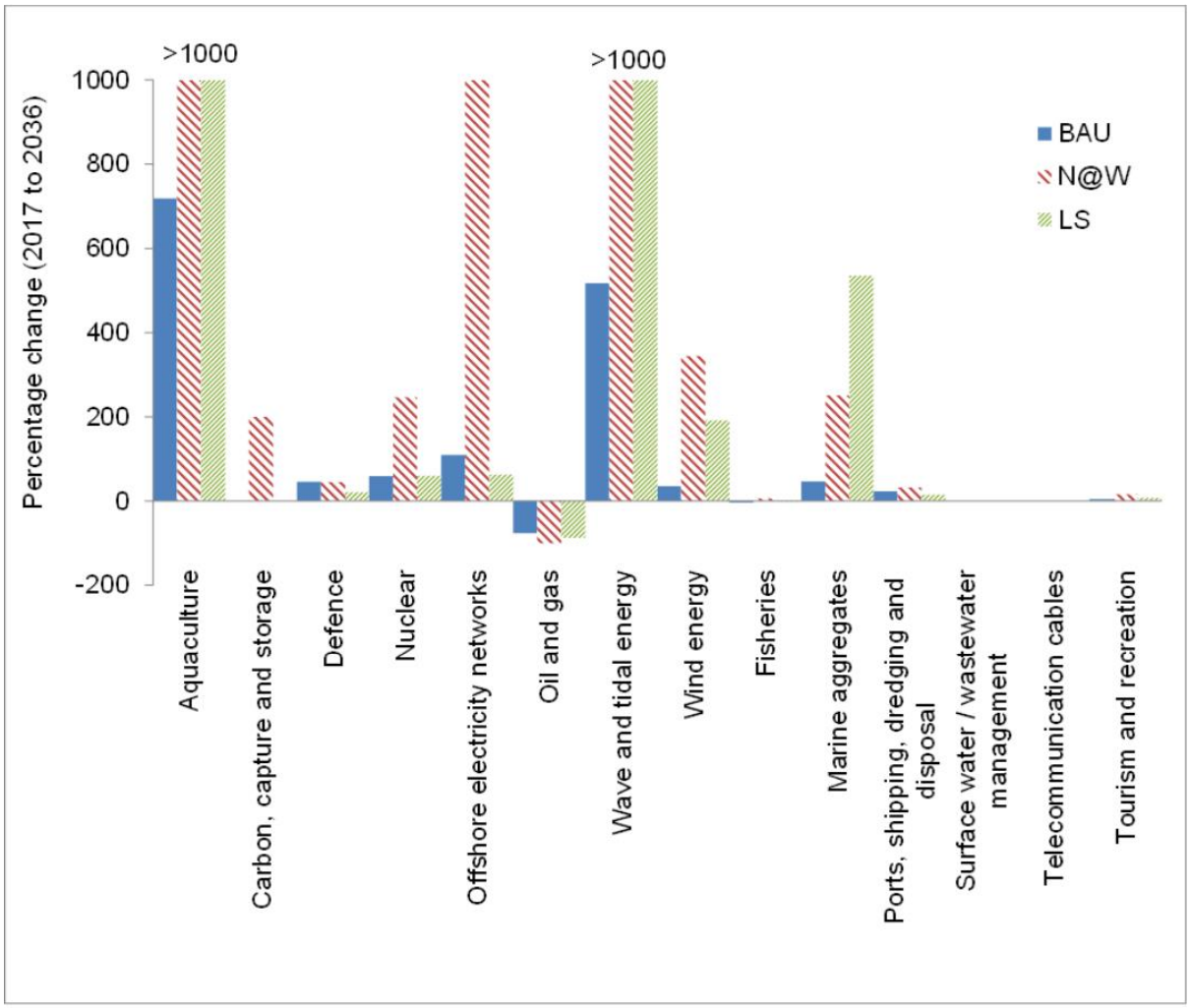
That part of the EA that carries responsibility for water quality requires significant (and ring-fenced) additional funding that can be applied to water quality and the enforcement of the duties of all those whose activities are capable of affecting the quality of all waters within and surrounding our shores.

The Marine Management Organisation

The MMO is the "new kid on the block" having been created by the Marine and Coastal Access Act 2009. Like the EA, it is answerable to Defra and bears some responsibility for water quality, certainly the waters around the coastline. Responsibility for Marine Planning in accordance with its Marine Policies is delegated by Defra to the MMO.

In the first decade or so of its existence, the MMO has worked hard to develop knowledge of the marine environment and to create Marine Plans. Whether it has been able to develop a core team of specialists on marine issues such as could provide effective input to Defra is not known. All the reports published by the MMO that have been mentioned earlier were produced either by Cefas or by outside Consultants.

This also gives rise to the question as to whether those working for the MMO have been able to absorb the advice that those Consultants have provided to an extent sufficient to provide knowledgeable input to marine plans. As noted in Chapter 6, aquaculture has been allowed to slip down the list of priorities in recent years. This makes the following table, with its focus on aquaculture, of more than passing interest.



This table, reproduced from 'Futures analysis for the north east, north west, south east and south west marine plan areas' mentioned in Chapter 6 shows a summary of advice to the MMO by Consultants in 2017 and showing their forecast of 'Unweighted average percentage change across sectors between 2017 and 2036 under three scenarios'. (The three scenarios are those mentioned in Chapter 6 – Business as Usual, Nature at Work and Local Stewardship.)

The comments in that Report included – "*The offshore electricity networks sector is predicted to grow by a large amount and* ***aquaculture is also projected to grow significantly compared to baseline****, reflecting the potential scale of opportunity for these sectors.*" [Emphasis added.]

The shellfish farmer might be tempted to observe that, six years later and despite the advice in this Report, there is not much sign of that significant growth.

So far as the MMO is concerned, there is one question to which the answer is required. Have the specialist skills been developed within its personnel to provide essential, appropriate, effective and knowledgeable management? Or, are they all civil service 'generalists'?

The MMO is still a teenager in terms of regulation. It has the remit. It has some powers that enable it to address water quality and all the powers it needs to promote shellfish aquaculture. It has the benefit of a vast range of advice and guidance from Consultants. Some signs are not encouraging. The jury is still out. The clock is ticking.

Natural England

Natural England (NE) is a public body created by the Natural Environment and Rural Communities Act 2006. It took over the responsibilities of English Nature and the Countryside Agency. Section 2(1) of that Act tells us that – "*Natural England's general purpose is to ensure that the natural environment is conserved, enhanced and managed for the benefit of present and future generations,* ***thereby contributing to sustainable development***." [Emphasis has been added.]

That general purpose includes a range of responsibilities, among them – "*promoting nature conservation and protecting biodiversity*" and "***contributing in other ways to social and economic well-being through management of the natural environment.***" [Emphasis added.] The latter responsibility – "*may, in particular, be carried out by working with local communities.*"

The remit given by the Act to NE is a wide one and it includes a widely drawn advisory and consultancy function. Thus, it provides advice within the scope of its responsibilities to other public bodies such as Defra, the MMO and the EA.

In the private sector, a Consultant in, say, medicine, architecture, engineering, accountancy or the law faces the risk that, if some aspect of that advice or the outcome that such advice leads to is deficient there may well be the prospect of an expensive lawsuit. Between parties such as Defra, the MMO, the EA and NE such a prospect appears so remote as to be non-existent. It could be said that NE's consultancy function confers power without responsibility.

NE may be one of the 'stakeholders' mentioned in Chapters 1 and 5 that are opposed to aquaculture and development. Certainly, it is the driver behind the policy mentioned in Chapter 4 that regards the Pacific oyster as 'invasive non-native species' and, since January 2020, has advised against authorisation of new Pacific oyster aquaculture businesses in MPAs as mentioned in Chapter 5.

Most importantly, NE has responsibility as a regulator in the context of SSS1s and published the deceptively upbeat '*Conservation Strategy for the 21st Century*' from which quotations appear in Chapter 4.

Needless to say, the role that is given to NE means that it must be one of the principal advocates and users of the 'precautionary principle' on which comments have already been made in Chapter 7. As has been shown, that principle's application under the Fisheries Act 2020 as it can be applied to shellfish aquaculture gives rise to significant concerns and uncertainties.

The Pacific Oyster

It is time for a closer look at this issue. In Appendix F, will be found a copy of the entries in the Register maintained by the GB Non-Native Species Secretariat. *Crassostrea gigas* is a synonym for *Magallana gigas*. The map there shows the extent to which the species were known to be found around the shores in January 2012, when that entry was last edited.

The species was first recorded in 1926 and was deliberately introduced for commercial purposes by the Ministry of Agriculture Fisheries and Food in the 1960s. Some spatfall may have migrated from France because farmed populations are widespread in Europe, as they are in the UK.

The apparent 'risk' represented by the Pacific oyster comes in two forms. First, they are said to – "*form reefs consisting of dense layers which can alter the natural state of the ecosystem, posing a potential threat to native species and altering habitats*" and secondly – "*sharp oyster shells pose a hazard to humans*".

Given that the national shoreline can in some places be littered with sharp objects of natural origin, it is difficult to understand why the shells of Pacific oysters have been singled out in this way! The identification of the second 'risk' in this context smacks of a determination to conjure up more than one risk!

The first 'risk' is the one that matters. The Register entry tells us that – "***it has been suggested*** *that these reefs could cause major shifts in benthic filter feeding populations, which* ***could*** *have detrimental knock-on effects on bird populations.*" And – "*economic losses* ***may*** *occur through the loss of mussel and other bivalve fisheries.*"

Note the emphasis that has been added. There is no certainty in these assertions. The suggested 'risk' created by Pacific oysters seems to be driving the policies of Natural England and its employment of 'the precautionary approach to fisheries management'.

The question must be asked – What is the "scientific information" (if any) that prompted NE's decision in January 2020 to advise against authorisation of new aquaculture businesses in MPAs as mentioned in Chapter 5? There must be more than these seemingly speculative comments. If the Pacific oyster was driving that decision, it has been in UK waters for just on a century – at the least – and the suggested 'risk' is imprecise, even nebulous.

Risk Assessment

The 2011 risk assessment provided by the GB Non-Native Species Secretariat is helpful. It contains answers to over seventy questions about the need for the assessment and the "*probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences*" applying to Pacific oysters. There are significant levels of uncertainty.

In Appendix G will be found an extensive selection of quotations from this risk assessment. Typographical and spelling errors have been corrected.

The wide distribution of the species is recognised as is the fact that it will continue to spread rapidly almost certainly assisted by climate change. That spread will have been significant during the period (more than a decade) since the risk assessment was prepared.

A lot of the evidence refers to studies relating to the Wadden Sea in the Netherlands but UK habitats directly comparable to the Wadden Sea area are limited. There is reference to "illegal" importation despite the known involvement of the Ministry of Agriculture Fisheries and Food. The Pacific oyster outcompetes both the native oyster and the blue mussel and is said to reduce suitable habitat for cockles.

Eradication is impossible, not least because chemicals must be ruled out due to their effect on other marine life. Attacking individual oysters with a hammer is, not unexpectedly, said to be effective! The value to the oyster farming industry is recognised and it is pointed out that Pacific oysters are the most important commercial oyster species in the UK and Europe.

Natural England has also secured other reports about Pacific oysters. They must be considered.

Natural England – First Report

External contractors are used by NE to provide reports in the form of evidence and advice. In July 2009, NE published its 'Pacific Oyster survey of the North East Kent European marine sites'. This report was produced by a Contractor, Willie McKnight, CT11 8AN with acknowledgements to Thanet Coast Project and Kent Wildlife Trust. As with other reports, it included this cautionary wording – "*The views in this report are those of the authors and do not necessarily represent those of Natural England.*"

The background to this Report is of interest and is not mentioned in the risk analysis prepared two years later. It says – "*Pacific oysters are native to south east Asia and Japan. In 1965 the Ministry of Agriculture, Fisheries and Food introduced them from Canada to their fisheries laboratory at Conwy to find an alternative species to supplement the shellfish industry following the decline of the native oyster.* The purpose of that step was – "*to find an alternative species to supplement the shellfish industry following the decline of the native oyster Ostrea edulis and the ending of imported American oysters Crassostrea virginica and Portuguese oysters Crassostrea angulata.*"

The trials confirmed the hardiness and fast growth of Pacific oysters in UK waters and commercial hatcheries and cultivation sites were established around the UK.

Pacific oysters were not considered capable of proliferation in northern Europe as water temperatures in excess of 20°C are necessary for reproduction. However, rising sea temperature, warmer summers and milder winters may be factors contributing to the spread of the species and in 1994, wild populations of Pacific oyster were recorded in Devon and further populations were found in Essex and Kent.

Pacific oysters are regarded as invasive in Holland, where they have been recorded since the nineteen seventies. They form extensive biological reefs and in some places have covered common mussel beds.

In March 2007, Kent Wildlife Trust conducted a Shoresearch at Ramsgate's Western Undercliff to record inter-tidal species and their abundance. During this event, Pacific oysters were seen at levels not previously recorded.

This raised concern about their possible impact on the features of the North East Kent European marine sites (NEKEMS) and, as a result, this research project was commissioned to establish a baseline record of inter-tidal distribution and density."

Among the factors noted within the body of the report is this – "*A shellfish hatchery and nursery, producing Pacific oysters, operates from a site at Reculver (Section 9A) within the NEKEMS. Pacific oysters are also farmed on the sea bed in the Swale estuary at Whitstable & the Isle of Sheppey. In addition, commercial operations are sited on the Essex coast on the north side of the Thames estuary.* ***There is no indication from baseline distribution data that there is a direct relationship between Pacific oyster density and the proximity of commercial sites.***" [Emphasis added.]

The Report concluded that there was – "*A well established and dynamic population of Pacific oysters ...* [with] *the capacity to expand in number, density and range ... Mussel beds ... situated between Birchington and Westgate host the peak volumes of Pacific oysters. Concentration is such that this area is likely to produce the first oyster reef ...* ***If mussels beds are replaced by oyster reefs then the consequences for the ecosystem are unpredictable.***" [Emphasis added.]

Another factor was noted – "*The presence of* ***Pacific oysters may pose a hazard to bathers, surfers and other shore users due to the extremely sharp edge on its shell****. In Holland, recreational activities have been affected in some areas of the Oosterschelde estuary (Nehring 2006)*". [Emphasis added.]

Natural England – Second Report

A year later, in June 2010, another Report was published by NE, this time from Willie McKnight, North East Kent Scientific Coastal Advisory Group. It was entitled 'The sustainability of shellfish harvesting and its effects on the reef habitats within the Northeast Kent European Marine Sites (inter-tidal)'.

This report was not concerned with shellfish aquaculture but with those harvesting wild shellfish, including holidaymakers, local harvesters operating throughout the year and organised groups of up to 30 individuals in certain areas mainly in the summer. Apparently, "*Harvesting is a long established local tradition but since 2004 increasing public concern regarding the levels, progressing from low impact recreational activity towards a high impact commercial activity, has prompted the set up of this project.*"

The Report concluded that – "*Present levels of harvesting indicate that the species taken, quantity and modus operandi of* ***"Casual" and "Local" harvesters is likely to have a negligible impact on reef habitats and can therefore be considered sustainable.*** *.... However, for* ***"Organised Groups"*** *the variety of species, quantity and operating methods, particularly the concentration at favoured sites,* ***must raise concern****. Natural disturbances, climate change and rising sea levels amplify the unpredictability of the effect that this group of harvesters may produce.*" [Emphasis added.]

The Report mentioned several species. Edible Periwinkle (*littorina littorea*) was the main targeted species, but Common Limpet (*patella vulgate*), Common Mussel (*mytilus edulis*), Edible Crab (*cancer pagurus*), Shore Crab (*carcinus maenus*) and Pacific Oyster (*crassostrea gigas*) were all mentioned. The apparent under-foot hazard created by the last of these for 'shore users' and others is not mentioned here.

Natural England – Third Report

Five years later in 2015, the EA and NE published an '*Invasive species theme plan - Strategic principles for the management of invasive species on Natura 2000 sites*'. It stated that – "*Invasive non-native species (including disease) impact biodiversity and ecosystems through resource competition, consumption and interbreeding (Wittenberg and others, 2001).*"

The acronym 'INNS' is used, meaning "*any non-native animal ... that has the ability to spread causing damage to the environment, the economy, our health and the way we live.*" Among the 'key messages' – "*INNS are considered the second biggest threat to global biodiversity following habitat loss (Defra, 2008).*"

Further on, the plan says – "*Some invasive species may be harvested for food as part of control programmes, eg deer and signal crayfish. It could also be argued that by adding more species to an ecosystem, resilience to climate change is increased. In the context of Natura 2000, however,* ***any positive services potential provided by invasive species must be weighed against the requirement to protect Natura 2000 interest features***." [Emphasis added.] There is no mention of the significant market for Pacific oysters – not a market of recent origin but one which has developed and grown over many decades. It would be interesting to learn what

'*Natura 2000 interest features*' are threatened. It does say however that NE "*are active players in advancing work on invasive species*".

The Pacific oyster (Crassostrea gigas) is mentioned on several occasions in the Annex to this plan. Its presence is recorded at Chesil Beach & The Fleet, Essex Estuaries, Fal & Helford, Greater Thames Complex, Morecambe Bay, North East Kent (Thanet), Northumberland Coastal, Plymouth Sound and Tamar Estuary and Solent. This is unlikely to be a comprehensive list of all the locations.

The 'Typical actions' for 'Site Improvement Plans' are – "*Monitor; control; investigate extent and impacts; identify potential management options; establish baselines; improve biosecurity; develop management plans; investigate dispersal pathways*".

Nobody involved in shellfish aquaculture would dispute the thought process behind this list of actions but they might be tempted to comment that it smacks of an unthinking desk-based approach and, given the context, it is somewhat late in the day to be coming up with these largely meaningless 'actions'. The stereotype wording obscures an impossibly huge, futile and certainly unachievable pursuit of nebulous ojectives.

Furthermore, time, ocean currents and tides (to which climate change should perhaps be added) pay no more attention to today's regulators than they did to King Canute a thousand years ago!

Another view on the Pacific oyster

In October 2016, a research paper was published by Roger J. H. Herbert, John Humphries and Clare J. Davies, all from Bournemouth University, Caroline Roberts from ABP Marine Environmental Research Ltd, Steve Fletcher from Plymouth University and the UN Environment Programme and Tasman P. Crowe from University College , Dublin. Much of the research it contained was conducted for the Shellfish Association of Great Britain (SAGB).

Funding was provided by the European Commission and the British Government (Defra) and there were contributions from SAGB, Defra, the MMO and Seafish, all on the project steering committee. The title of the paper was '*Ecological impacts of non-native Pacific oysters (Crassostrea gigas) and management measures for protected areas in Europe*'. Its purpose was to address this issue, the impact of which was imperilling the future of a significant part of shellfish aquaculture.

No emphasis is added to the extracts from the paper that appear below. All are directly pertinent to the issue.

This paper states at an early stage that – "*Although of considerable importance for coastal economies around the world, the introduction of C. gigas has also been very significant in maintaining the oyster fishing and cultivation culture and traditions of communities that have previously relied on native oysters, which in many regions are now declining*".

It goes on to say – "*It is likely that a combination of factors enable wild establishment* [of Pacific oysters], *including a lack of natural predators within receiving systems, beneficial traits such as rapid growth and rising air and sea temperatures as a result of global warming*" but – "*Conservation agencies and regulators are concerned that habitats and species of conservation interest are at risk from competition, displacement and proximity to non-indigenous species.*"

In the context of the EU Habitats Directive, the paper tells us that – "*In Britain, conservation agencies have concluded that even the loss of considerably less than 1% of designated sites could be significant and in some cases would adversely affect site integrity, though not specifically for non-native species. The risk of ecological impacts of wild settlement in a warming world has unnerved conservation agencies and the aquaculture industry.*"

It points out that the UK regulators may require proof from those planning a Pacific oyster farm within or in the vicinity of a protected area that it will not have an adverse effect on habitats and species. Proof of such a negative in those circumstances is certainly expensive and probably impossible. In the context of the wide distribution and establishment of the species in the wild, the need for such proof is questionable.

The paper then points out that – "*Due to wide ranging impacts of non-native species, provisions are included in EU policies aimed at the protection of ecosystems and sustainable use of natural resources. However, species that have had a long history of aquaculture and which are of economic value are excluded from the scope of the EU Regulation on the prevention and management of the introduction and spread of invasive alien species*".

The EU Water Framework Directive, the EU Marine Strategy Framework Directive and are also considered in the paper. The transfer of oysters may be prohibited but – "*it is the impact of the species on the habitat and not the presence that is a concern*". This statement is a particularly significant one. As already noted, Natural England regards the presence of Pacific oysters to be sufficient to ban shellfish cultivation from Marine Protected Areas.

The paper continues – "*pathways for introduction of Pacific oysters other than aquaculture have also been implicated. Wild establishment as a direct result of introductions into marinas, harbours and ports from boat traffic as fouling or entrained larvae are as yet unproven but suspected. In the UK there are coastal regions where wild settlement is occurring that is distant from Pacific oyster production.*"

Going on from there, the paper mentions that – "*In some regions of France, wild spat has now become so economically important for the oyster industry that it is protected and carefully managed by fisheries administrations. Moreover the environmental sensitivity and impracticability of removing large areas of wild settlement has led some countries to adopt the species as naturalised. ...* [and] *Although C. gigas is listed as one of the worst 100 Alien species there appears to be no technical or political consensus on its environmental impact and management across Europe.*"

Against this backdrop, the authors of the paper advise that – "*In circumstances where the eradication of species that are potentially damaging to ecosystems and the economy is not possible then management measures, that are proportionate to the impact on the environment, should be proposed.*"

Furthermore – "*there is some inevitability that, should predictions of continued warming under the [Intergovernmental Panel on Climate Change] scenarios be realised, the frequency and magnitude of settlement will increase, causing existing populations to rise and new populations to become established.*" And thus – "*a local or regional approach to the management of wild Pacific oyster settlement is likely to be more effective than broad-scale measures that in some areas may currently be irrelevant.*"

There is more than a hint in the above comments that UK conservation agencies – which in practice for shellfish aquaculture means Natural England – and the regulators advised by NE –

in practice Defra and the MMO – are adopting an over cautious, even impractical, approach to the Pacific oyster, which does not match that adopted in the EU.

The Pacific oyster issue now dominates the UK regulatory approach to shellfish aquaculture. Since 2020 (four years after this scientific paper entered the public domain) shellfish aquaculture has been banned from MPAs because "*two MPAs shifted into 'unfavourable condition' as a result of an increase in Pacific oyster numbers*" (see Chapter 5).

The shellfish farmer (who is also only too well aware of the 'elephant in the room' involving export to Europe mentioned in Chapter 5) might be tempted to wonder whether the demise of shellfish aquaculture is seen as a 'necessary' price to pay for the 'freedoms' (for conservation agencies and regulators) that have been provided by Brexit.

Triploidy

The paper tells us that – "*One of the only feasible modes of containment for non-native species within the aquaculture industry is reproductive sterility.*" What it calls '*induced triploidy*' is a "*method of achieving sterility ... a condition in which a cell or organism has three sets of chromosomes as opposed to the normal two sets of chromosomes. The triploid condition can confer a level of sterility through rendering the oysters unable to produce viable gametes and hence preventing spawning and wild settlement.*"

This is not a magic solution however because – "*Triploid oysters cannot be considered to be 'non-reproductive' and there is evidence that gonad development and spawning in triploid C. gigas may be enhanced in unusually hot summers which are predicted in current climate change scenarios.*" So, if global warming continues (as is predicted), triploids may cease to be non-productive.

This possible way forward is undercut still further because – "*The relative reproductive potential of triploids is increased when they are crossed with diploids, so their introduction into regions where there is wild diploid stock is unlikely to be effective at containing outbreaks.*" Thus, triploid reproductivity increases if there are any wild stock around – as there are increasingly around the coastline.

There is one small sop – "*in regions where diploid stocks are zero or very low, there may be merit in using triploid oysters as a practical measure to reduce the probability of wild settlement. It has been shown that there is no significant difference in growth when the growing conditions of the area are poor.*"

The conclusion regarding triploids is that – "*Although there are uncertainties concerning the stability of their sterile condition and effectiveness, in areas where wild settlement is currently absent or where stocks are very low, the use of triploid Pacific oysters within aquaculture should be considered. The spatial extent of any removal of wild settlement would need to be agreed between growers and agencies but a focus on particularly sensitive habitats, such as Sabellaria reefs, might be prioritized.*"

The paper's conclusions

The paper goes on to describe attempts in Strangford Lough, Northern Ireland and in Kent to remove Pacific oysters with hammers, spades, rods, pliers and safety equipment. The work in Kent involved 43 site visits and 96 man hours. The results – "*could be beneficial at reducing population expansion in the early stages of invasion*" (Strangford Lough) and –"*it remains to*

be seen if the rate of wild settlement in this region is reduced" (Kent) can hardly be described as conclusive.

The authors of the paper are clear in their conclusion. "*Few could have predicted the enhanced fecundity and growth of wild populations of Pacific oysters in Europe as result of higher temperatures, and the potential and actual environmental impacts. We conclude that in view of the potential risks to biodiversity, all stakeholders, including growers, port and harbour authorities and statutory environmental agencies must engage in regional decision making to help minimise any negative environmental impacts of wild settlement on features of conservation interest, while at the same time, and within those constraints, maximising opportunities for sustainable industry development.*"

They continue – "*Without stakeholder co-operation and managed interventions, the ecological impacts of wild settlement on species and habitats are likely to be exacerbated. To maintain habitats in good condition and protect features of conservation interest it is important to develop strong partnerships between agencies and fisheries*"

The questions must be asked –

- What has NE done to identify "*any negative environmental impacts of wild settlement on features of conservation interest*"?
- What has NE done to maximise "*opportunities for sustainable industry development*"?
- How does NE address the issue that "*Triploid oysters cannot be considered to be 'non-reproductive' and there is evidence that gonad development and spawning in triploid C. gigas may be enhanced in unusually hot summers which are predicted in current climate change scenarios*"?
- How does NE address the issue that "*The relative reproductive potential of triploids is increased when they are crossed with diploids, so their introduction into regions where there is wild diploid stock is unlikely to be effective at containing outbreaks*"?
- What has NE contributed to the development of "*strong partnerships between agencies and fisheries*"?
- What evidence is available of action on the part of NE to – "*Monitor; control; investigate extent and impacts; identify potential management options; establish baselines; improve biosecurity; develop management plans; investigate dispersal pathways*"? (These words are copied from NE's '*Typical actions*' it its third report mentioned above.)

And the key question –

- How does NE plan to achieve a more effective result than King Canute achieved?

Defra's Views

The current views of Defra on the subject of Pacific oysters were revealed to SAGB a short time ago. They are as follows – "*We recognise that industry is keen to grow and that the English Aquaculture Strategy sets out an aspiration for the English industry to produce over 5,000 tonnes of Pacific oysters p.a. by 2040. You've told us that a key challenge to expanding the industry is demonstrating that Pacific oyster farming doesn't risk having a significant effect on a protected site (MPA). Natural England have been clear that the use of triploid, as opposed to diploid, Pacific oysters would mitigate a lot of the risk to protected sites. We're keen to understand more about the barriers to farming triploid Pacific oysters and how these could be mitigated.*"

As for "*demonstrating that Pacific oyster farming doesn't risk having a significant effect*", all the evidence in the 2016 research paper seems to have been overlooked (the personnel in Defra will almost certainly have changed since then). Likewise the 2011 Risk Assessment (see Appendix G) details no significant risks and there are benefits identified in the Report entitled "*Evidence Supporting the Use of Environmental Remediation to Improve Water Quality in the South Marine Plan Areas*" commissioned by the MMO as mentioned in Chapter 7.

The final sentence suggests that the knowledge and understanding of the issue on the part of those communicating Defra's views is slender. It comes across as no more than a further attempt to obfuscate deliberations and delay any real progress.

The conclusions from this Chapter are as follows –

- The process for granting (and the security provided by) Several Orders needs to be updated. Only Defra can do that but Defra's plans seem to go in the opposite direction.
- Despite repeated evidence that the complex regulatory system confronting shellfish aquaculture is recognised and urgently needs to be simplified and updated there is no evidence of any steps in that direction. This is also down to Defra.
- The EA is in urgent need of more resources that can be applied with appropriate focus to the enforcement of the responsibilities of all those whose actions (or lack of action) are capable of affecting the quality of the waters in our rivers and around the coastline.
- The role and influence of NE over Defra, the MMO and the EA, particularly in relation to the cultivation of the Pacific oyster, seems to have had the effect of damaging, even threatening to destroy, the growth prospects of shellfish aquaculture. The adverse effects have become even more evident in recent years.
- The valuable work done by the authors of the 2016 report conducted for SAGB and the excellent advice it contained concerning ways forward appear to have been ignored by NE and by Defra. Seven years later, the prospects for shellfish cultivation look worse.
- Triploids may help, but only marginally and probably not for any significant duration.
- The policy adopted by NE and the actions taken pursuant to that policy are opaque and there are serious questions that must be answered if it is to continue unchanged and be further embraced by other regulators.

Chapter 9 – What now? – A bleak future?

Water quality and shellfish aquaculture are the focus of this commentary. From what has been said in the previous eight Chapters, these conclusions have been noted –

Chapter 1 – Introduction

- The expansion of shellfish aquaculture represents a genuine way in which to enhance national food security.
- Good water quality is vital to all shellfish aquaculture and a critical factor in any planned expansion.
- There are indications that some key stakeholder groups are inherently opposed to all forms of aquaculture, including shellfish aquaculture.
- There are 'forever chemicals' in our waterways that may have an impact on shellfish and those who consume shellfish but the nature and significance of that impact is unknown.

Chapter 2 – The Burden of Pollution

- The sources of water pollution known to be capable of having a deleterious effect on shellfish aquaculture are wide and diverse.
- Due to the heavy 'burden of proof' there is no realistic remedy in law to compensate the shellfish farmer for damage suffered as a consequence of water pollution.
- Improvements in the testing methods and the manner and frequency of testing for the classification of waters may make the determination of the optimum time for shellfish harvesting more predictable (i.e. when Class A water is available).

Chapter 3 – Previous Approaches – Shellfish and Water Pollution

- There is no indication that the grant of a Several Order will provide the shellfish farmer with realistic protection against water pollution.
- There are strong indications that Defra is developing approaches that will ultimately result in the abolition of both Several and Regulating Orders.
- Designated Shellfish Waters provide no remedy for the shellfish farmer against water pollution.
- There is no evidence that effective enforcement of the Regulations protecting Shellfish Waters will provide any measure of comfort for the shellfish farmer in the foreseeable future.

Chapter 4 – Marine Protected Areas (MPAs)

- Marine Protected Areas are well suited to shellfish aquaculture. Shellfish aquaculture that has no significant adverse impact is to be encouraged within them.
- The policy of Natural England towards the cultivation of the Pacific oyster (which arguably runs counter to common sense and the pragmatic views of scientists) is a significant bar to any planning for the expansion within MPAs of the contribution that shellfish aquaculture can make to food security.

Chapter 5 – Future Strategy for Aquaculture

- At least one of the assurances given in Defra's 2015 multi annual plan does not seem to have been met. The situation seems worse.
- Seafish produced an excellent Strategy document in 2020 but there are clear indications that it may be over-optimistic.
- There are structural staffing issues within Defra supporting this view.

- There seems to be little evidence of progress on the priority issues listed in the 2020 '*English Aquaculture Strategy*'.
- The loss of the export market following the departure of the UK from the EU is the biggest limiting factor and thus 'the elephant in the room' so far as shellfish aquaculture is concerned.
- Marine spatial planning is critical to the future of shellfish aquaculture and, if this aspect is addressed effectively, there remain several encouraging opportunities.

Chapter 6 – Marine Planning

- Between 2013 and 2021, the approach to aquaculture in the published Marine Plans was downgraded to what appears to be unthinking and repetitive lip service.
- There is little or no encouragement for aquaculture to be derived from the current MMO Strategy.
- Marine planning may now be turning away from the Pacific oyster in particular.
- Failure by Government and regulators to address the issue continues.
- The exciting initiative provided by Seafood 2040 seems to have died.

Chapter 7 – The Regulation of Shellfish Aquaculture

- For a variety of reasons, shellfish aquaculture is faced with a complex bureaucracy that requires the shellfish farmer to deal with, to seek consent from and, in some cases, make significant payments to a wide range of bodies.
- There is only the helpful guidance produced by Cefas and available from Seafish to assist with this.
- The MMO, responsible for the creation and implementation of Marine Plans, seems to have modest duties with regard to water quality but may have a shared responsibility for drainage.
- When environmental issues arise, the 'precautionary principle' applies and the way in which it could be employed in the context of shellfish farming gives rise to concerns and significant uncertainties.
- Shellfish aquaculture, involving mussels and both European and Pacific oysters, can provide an effective means of bioremediation where there are water quality issues.

Chapter 8 – Who calls the shots?

- The process for granting (and the security provided by) Several Orders needs to be updated. Only Defra can do that but Defra's plans seem to go in the opposite direction.
- Despite repeated evidence that the complex regulatory system confronting shellfish aquaculture is recognised and urgently needs to be simplified and updated there is no evidence of any steps in that direction. This is also down to Defra.
- The EA is in urgent need of more resources that can be applied with appropriate focus to the enforcement of the responsibilities of all those whose actions (or lack of action) are capable of affecting the quality of the waters in our rivers and around the coastline.
- The role and influence of NE over Defra, the MMO and the EA, particularly in relation to the cultivation of the Pacific oyster, seems to have had the effect of damaging, even threatening to destroy, the growth prospects of shellfish aquaculture. The adverse effects have become even more evident in recent years.
- The valuable work done by the authors of the 2016 report conducted for SAGB and the excellent advice it contained concerning ways forward appear to have been ignored by NE and by Defra. Seven years later, the prospects for shellfish cultivation look worse.
- Triploids may help, but only marginally and probably not for any significant duration.

- The policy adopted by NE and the actions taken pursuant to that policy are opaque and there are serious questions that must be answered if it is to continue unchanged and be further embraced by other regulators.

To summarise

Those involved in shellfish aquaculture have faced tough times and major challenges over the years, particularly since 2020 with the fallout from Brexit and Covid-19. Their experiences have been such as might discourage those who could be contemplating entry into, making an investment in or perhaps commencing a career in shellfish aquaculture.

Of major concern is what seems to be a very evident lack of interest in, even downright opposition to, shellfish aquaculture on the part of those charged with regulation. Thus, the securing and supporting of the healthy and valuable contribution that shellfish aquaculture can make to the nation's food security appears to have stalled or perhaps even been reversed.

To put the current position in context, here are some basic statistics for recent production –

Reported English aquaculture production - Source Cefas

	Sea mussels		Pacific oysters		European oysters	
Year	**Tonnes**	**Values £**	**Tonnes**	**Values £**	**Tonnes**	**Values £**
2008	4,054	£4,054,000	591	£2,925,450	44	£198,000
2009	3,800	£2,603,000	811	£892,100	54	£162,000
2010	3,233	£2,214,605	646	£710,600	89	£265,500
2011	3,127	£2,141,995	447	£491,700	86	£94,600
2012	5,966	£5,965,700	850	£3,400,000	86	£653,106
2013	4,149	£7,883,393	953	£2,954,632	29	£145,250
2014	1,179	£2,240,062	1,012	£2,428,279	9	£44,680
2015	1,889	£2,825,645	1,036	£2,072,522	8	£30,267
2016	1,072	£1,279,206	979	£1,958,080	7	£26,600
2017	1,507	£1,797,603	913	£2,282,200	11	£38,500
2018	1,793	£2,138,390	1,064	£2,660,625	8	£26,250
2019	2,944	£2,943,500	1,220	£3,638,037	11	£38,129
2020	2,674	£2,674,250	682	£2,035,032	18	£63,175
2021	2,351	£2,351,100	1,147	£3,442,170	11	£55,750

Trends indicated by statistics must always be treated with caution and these statistics are limited to the three main species for English shellfish aquaculture. That said, the potential for an expansion of mussel production seems significant, particularly if it proves possible to build on the positive example demonstrated using rope grown mussels in Lyme Bay and the advantages of that method (see Chapters 5 and 7).

The lower tonnages for Pacific oysters also show exciting potential, not least because of the much higher prices they can command. That potential is however threatened, even cancelled by NE's approach and lobbying in relation to that species. Sadly, the figures for the European flat oyster remain low – confirmation (if such were needed) of the decision by the Ministry of Agriculture Fisheries and Food in the 1960s to boost oyster production by other means.

The ‘elephant in the room’ (not one of the greatest benefits to flow from Brexit) mentioned in Chapter 5 remains with us. The re-growth of exports to Europe to pre-Brexit levels demands a political solution in the form of a derogation from EU rules to allow export from Class B waters and depuration in the EU.

Alternatively, if a significant drop in pollution levels and a concomitant increase in Class A waters is not on the cards (at least in the foreseeable future), a massive investment must be made to increase depuration facilities on this side of the Channel. The question is – where will that money come from?

Apart from that, these are the three major issues –

1. Attitudes towards the cultivation of Pacific oysters – present around the coastline for a century or more. They are influencing and distorting both thinking and policies.
2. Security for shellfish aquaculture is deficient and regulation is over-complex as has been known for decades.
3. An improvement in water quality is essential if shellfish aquaculture is to grow and thrive.

The future looks bleak, but there are opportunities that remain to be exploited – if the political will can be generated and regulatory procrastination and opposition downgraded. This demands actions, not words.

Jeremy B. C. Simmonds, RD, BA (Oxon), Retired Solicitor

Past President, The Shellfish Association of Great Britain

Sunday, 12 November 2023

Appendix A

(From The EU approach to aquaculture)

Shellfish cultivation systems – copied from the 2014 Cefas background information

Bivalve mollusc aquaculture has been practised globally for centuries, and records of oyster management in Europe date back to at least 77AD when Pliny the Elder described the process of relaying oysters for fattening (Pliny the Elder). The culture methods in use today range from modern, highly mechanised and intensive systems capable of producing thousands of tonnes of shellfish, through to low input, extensive systems that have changed little over the centuries. All take advantage of the low trophic level occupied by bivalve molluscs (Duarte et al 2009; National Research Council 2010), and are generally sited in estuarine and coastal areas with high levels of primary productivity. The three basic types of shellfish cultivation are described below.

Rafts and longlines

Rafts and longlines are anchored floating systems, used in open sea or estuarine environments, from which a variety of culture systems can be suspended. They are very adaptable (allowing for the cultivation of a wide variety of shellfish species) and highly efficient (the raft culture farms in Spain being the largest producers of mussels in Europe).

Rafts are solid floating platforms traditionally constructed of wood, although modern rafts can be made of steel or polyethylene (PE), with a structure of cross beams used to support the shellfish in cultivation. They are compact units allowing for large carrying capacity in a small area and are usually used in sheltered areas, although modern PE systems are now robust enough to be used in exposed offshore sites. They are more effective in areas of high current due to the high stock density achievable. Rafts are used to cultivate mussels on ropes, oysters in cages and scallops in lantern nets. They are often used to rear juvenile oysters prior to transfer to other systems.

A **longline** is a floating line anchored at both ends and supported along its length by a series of floats; this floating line can be at the surface or semi-submerged, the latter offering protection in exposed locations. The shellfish are suspended from this line on dropper lines. They are often used in offshore areas, or those with low current flows, where only a low stock density can be held. Longlines can be used to cultivate a variety of species; mussels attach directly to the dropper lines, and lantern nets or cages are used for other species.

New developments in longline technology include "SmartFarm" mussel systems using floating PE tubes supporting a length of square mesh net, to which the mussels attach. This design allows for more mechanisation and easier harvesting.

Intertidal shellfish culture

Shellfish culture between the high and low water marks can be either on-bottom culture (benthic) or near bottom (epi-benthic) culture. Epi-benthic systems include stakes, racks and intertidal longlines; these systems can be effective where the substrate is not suitable for shellfish cultivation, but are not limited to these locations. It is one of the oldest forms of shellfish cultivation: the bouchot culture system has been used in Europe since the 13th Century (Goulletquer and Heral 1997). The use of inter-tidal areas means easy access for stock management although, depending on the culture method in use, this can be limited to the period when the shellfish are exposed at low tide. The exposure time also affects the growth rate of

shellfish, with those exposed for the least time having the highest growth rate, as they are able to feed for longer.

Sub-littoral bottom shellfish culture

In its simplest form, this is the relaying of shellfish directly onto the seabed, where the stock is left to grow until it reaches market size, with occasional stock thinning where required to encourage growth. Growth rates depend upon the size of seed shellfish, stock density and the productivity of the water body. Species cultivated by this method include mussels, oysters and clams.

Appendix B

(From Classification of waters)

Extracted from '*Evidence Supporting the Use of Environmental Remediation to Improve Water Quality in the South Marine Plan Areas*' – MMO Project No: 1105 – February 2016

Food hygiene (shellfish)

In addition to the classification for transitional and coastal waters under [Water Framework Directive], designated shellfish waters have their own quality assessment systems under EC Regulation 854/2004, Annex II, Chapter II, A. Shellfish flesh samples for microbiological testing are collected from each production area on a monthly basis and counted for *E. coli*, the statutory indicator organism. The highest quality for shellfish is Class A where shellfish contain less than 230 *E. coli* bacteria per 100 g of flesh; molluscs from Class A waters can be harvested directly for human consumption. To obtain Class B, 90% of sampled animals must contain less than 4600 *E. coli* bacteria per 100 g of flesh and 10% of samples must not exceed 46,000 *E. coli* bacteria per 100 g of flesh. Class B shellfish can go for human consumption after purification in an approved plant, or after relaying in a Class A area, or after an EC approved heat treatment process. The lowest category, Class C, is given when all samples contain between 4600 and 46,000 *E. coli* bacteria per 100 g of flesh. In this case, in order to use for human consumption, the harvest must be relaid for at least two months in an approved relaying area followed, where necessary, by treatment in a purification centre, or after an EC approved heat treatment process. Harvest from shellfish waters is prohibited if a sample contains above 46,000 *E. coli* bacteria per 100 g of flesh. Sampling for shellfish hygiene takes place throughout the year. The classification of a shellfish bed can be given either as an annual status (also called seasonal status), or as a long-term status denoted as 'LT'.

Appendix C

(From Chapter 3 – Previous Approaches – Shellfish and Water Pollution)

Current Several and Regulating Orders (SROs)

SROs in England

- The Thames Estuary Cockle Fishery Order 1994. Regulating – expires 27/09/24. Ongoing renewal.
- The River Teign Mussels Fishery (Variation) (Oysters) Order 1996 (originally 1966). Shellfishery – expires 06/02/26.
- The Waddeton Fishery Order 2001 (Dart). Hybrid – expires 27/04/26.
- Blakeney Harbour Mussel Fishery Order 1966. Shellfishery – expires 15/08/26.
- The River Camel Mussel and Oyster Fishery Order 2013. Several – expires 31/08/28.
- Poole Harbour Several Order 2015. Several – expires 01/07/35.
- The Tollesbury & Mersea (Blackwater Fishery) Order 2019. Several – expires 14/07/39.
- The Fal Fishery Order 2016. Regulating – expires 31/07/46.
- The Dee Estuary Cockle Fishery Order 2008. Regulating – expires 01/07/28. Cross-border Wales and England.

SROs in Wales

- The Burry Inlet Cockle Fishery Order 1965. Regulating – expires 16/06/25.
- The Mumbles Oyster Fishery Order 2013. Several – expires 10/09/28.
- The Lydstep Haven Mussel Fishery Order 2013. Several – expires 12/12/28.
- The Swansea Bay (Thomas Shellfish Limited) Mussel Fishery Order 2012. Several – expires 18/09/32.
- The Menai Strait (East) Mussel and Oyster Fishery Order 2022. Hybrid – expires 02/04/57.

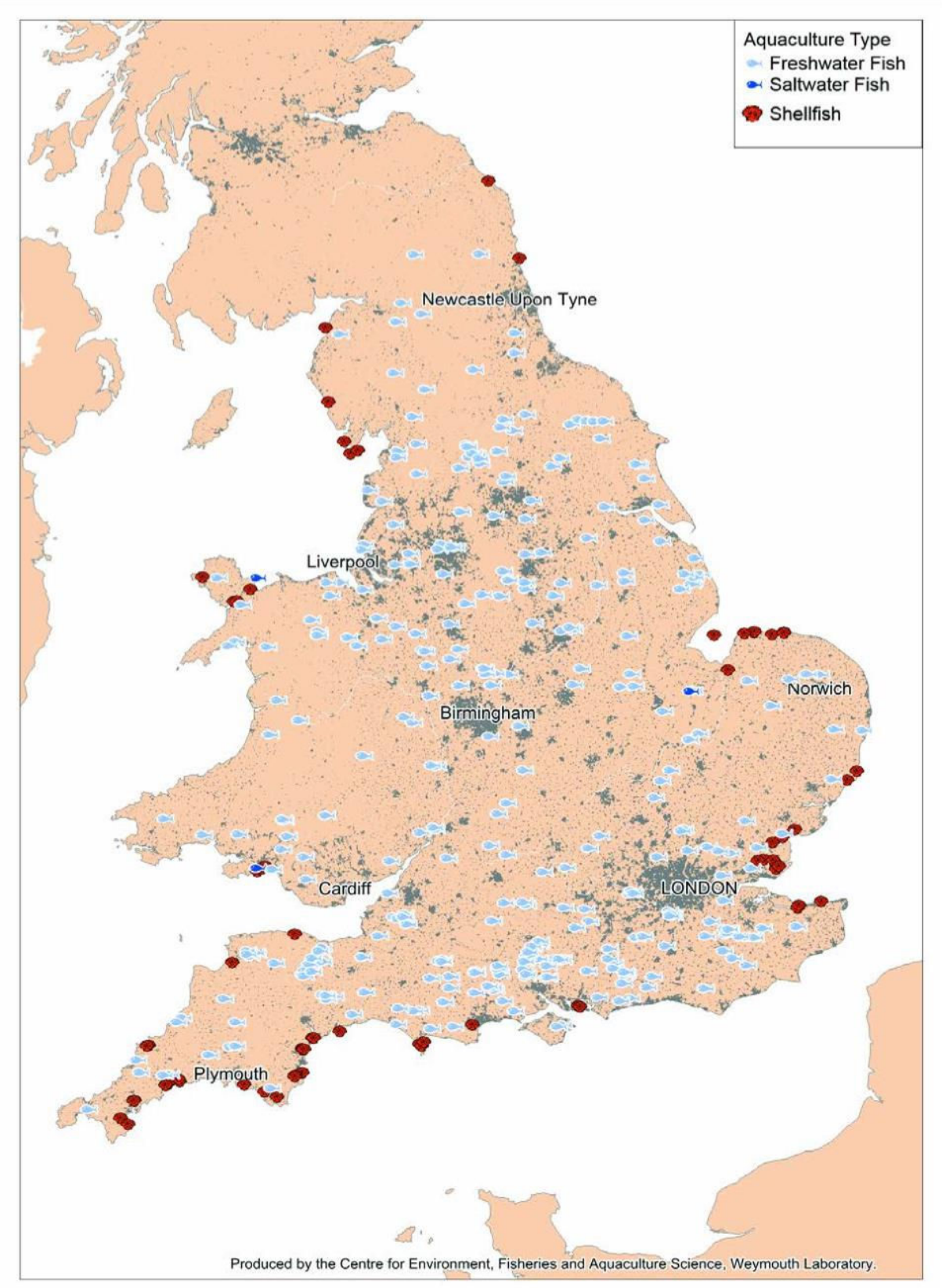
SROs in Scotland

- The Little Loch Broom Scallops Several Fishery Order 2015. Several – expires 09/03/25.
- The Loch Ewe, Isle of Ewe, Wester Ross, Scallops Several Fishery Order 2015. Several – expires 09/03/25.
- The Little Loch Broom Scallops Several Fishery Order 2017. Several – expires 07/05/27.
- The Shetland Islands Regulated Fishery (Scotland) Order 2012. Regulating – expires 31/01/28.
- The Loch Sligachan, Isle of Skye, Scallops Several Fishery Order 2013. Several – expires 16/11/28.

Appendix D

(From Chapter 5 – Future Strategy for Aquaculture)

Aquaculture Sites in England and Wales



Appendix E

(From The reasons for decline)

Bureaucracy Affecting Shellfish Exports

Preparing	Selling	Exporting	Transporting
Register for Fish Export Service	On first-sale of fish submit sales notes to relevant authority*	Consignment must be correctly labelled	Haulier must know EU driving requirements
Get EU Economic Operators Registration and Identification (EORI) number	Export via local authority approved premises	Obtain Export Health Certificate and send for checking to Animal and Plant Health Agency (APHA) (England, Scotland, Wales) or DAERA – Northern Ireland	Original EHC must travel with consignment and copies sent electronically to EU importer
Engage an approved vet or body to certify future Export Health Certificates (EHC)	EU importer requires approved import premises	Lodge Catch Certificate for each consignment with Fish Export Service. Send validated certificate to EU importer within the deadline $	Put commercial seal on means of transport. Seal must be certified on the EHC
Register for Export Health Certificate	**Extra Requirements for UK Vessel Owner**	Give EU importer details of consignment and EHC at least 24 hrs before arrival	Inform EU importer if time of arrival or means of export changes
Register as seller of first-sale fish	Provide e-mail address to MMO	Lodge customs export declaration	Export from any UK port. EU entry only through Border Control Post that handles fisheries products
Register for Trade Control and Export System (TRACES)	If vessel is over 12 m or 100 tons - get International Maritime Organisation (IMO) number	If permit under Convention on International Trade in Endangered Species of Flora and Fauna (CITES) is needed, obtain CITES permit and send to relevant authority*	Consignment may be inspected at Border Control Post. Once cleared, EU importer will get completed Common Health Entry Document allowing EU entry.
Register for HMRC customs export and VAT declarations	Register with Fish Export Service	Complete Common Health Entry Document via TRACES	If consignment does not pass inspection, EU importer must deal with it as directed by the Border Control Post
Extra Requirements for UK Food Establishment	Submit (1) logbook, (2) landing declaration and (3) catch record within deadline #	May require UK storage document	
Get local authority approval		May require UK processing statement	
Request EU listing			

* England – MMO, Scotland – Marine Scotland, Northern Ireland – DAERA, Wales – Welsh Government

Over 12m – within 24hrs, 10-12m – within 48 hrs, under 10m – as per licence conditions

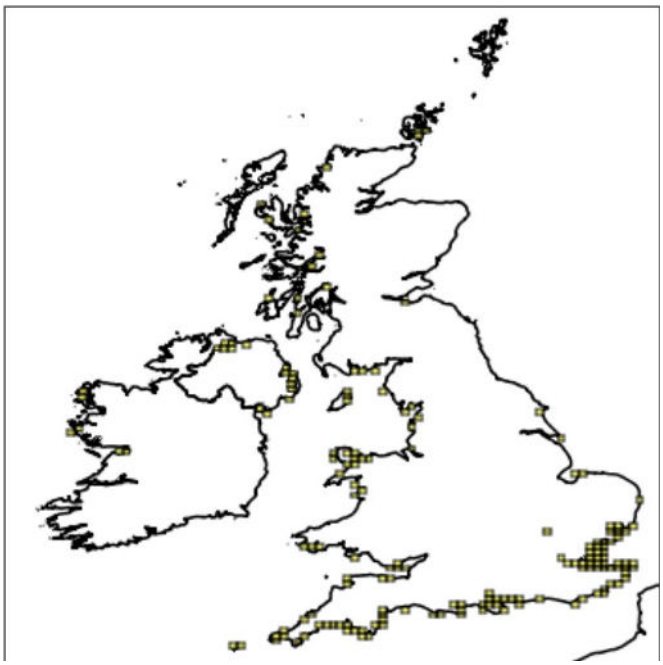
$ Sea – 72 hrs before landing, Air/Rail – 4 hrs before arrival, Road – 2 hrs before arrival

Tripwires On the Way to Establishing a Shellfish Aquaculture Business

Step in the Process	**Involved Parties**
Screening of licence application	Marine Management Organisation
Lease of site	Crown Estate or Landowner
Safety of Navigation impact	Trinity House
Sanitary Survey (to identify monitoring points for shellfish waters classification)	Food Standards Agency
Classification of the shellfish farm/beds for human consumption	Food Standards Agency and Local Environmental Health Authority
Assessment for harmful algal species – Biotoxin Monitoring programme	Food Standards Agency and Local Environmental Health Authority
Authorisation of Aquaculture Production Business	Fish Health Inspectorate
Permit for farming of alien species	Fish Health Inspectorate
Environmental Risk Assessment	Marine Management Organisation
Habitats Risk Assessment – if in a Conservation Area	Centre for Environment, Fisheries and Aquaculture Science, Natural England, Natural Resources Wales or Inshore Fisheries and Conservation Authority
Fishery Regulations and any Byelaw Dispensation needed	Inshore Fisheries and Conservation Authority
Rules on Disposal of Mortalities	Local Harbour Authority, Harbour Master
Construction of Depuration Facilities	Planning Authority
Cultivation of the Pacific Oyster	New project or expansion of existing facility impossible due to Natural England advice. Increasing opposition is encountered by established operations.
In all of the above, lack of knowledge on the part of relevant staff and local interpretations and policies (sometimes conflicting/contradictory) can give rise to issues and cause delays as can the lack of (or failure of) communications between the responsible bodies. To these considerations must be added the fact that a single objection, well founded / well intentioned or not, can create apparently insuperable delays and complexity that can deter even the most determined newcomer to shellfish aquaculture.	

Appendix F

(From The Pacific Oyster)



***Magallana gigas* (synonym *Crassostrea gigas*)**

Pacific oyster

Magallana gigas

Last edited: January 6th, 2012

Overview

Short description of Magallana gigas, Pacific oyster
Variable and irregular in appearance. Off-white to yellow or bluish grey in colour, often with deep purple patches. Grows up to 30 cm in length with a teardrop shape and rough shell. The right valve is deeply cupped with six or seven bold ribs; the left valve is flat or slightly convex.

Impact summary: Magallana gigas, Pacific oyster
Once established the Pacific oyster may out-compete and displace native species. It also has the potential to smother or exclude other marine life (including reef-building species) and alter habitat type.

Habitat summary: Magallana gigas, Pacific oyster
Lives permanently attached to any hard substrate in intertidal and shallow subtidal zones of estuaries and coastal waters. In muddy or sandy areas Pacific oysters will settle on small rocks, shells or other oysters and can create reefs by cementing their shells to each other, forming dense layers.

Overview table

Environment	Marine
Species status	Non-Native
Native range	Kazan-retto, Ogasawara-shoto
Functional type	Filter-feeder
Status in England	Non-Native
Status in Scotland	Non-Native
Status in Wales	Non-Native
Location of first record	River Blackwater, Essex
Date of first record	1926

Invasion History

Origin
Native to Japan and North-East Asia.

First Record
Pacific oysters were deliberately introduced to GB from Canada during the 1960s for commercial purposes. The first record from the wild was 1965.

Pathway and Method
Imported into GB from Canada for commercial aquaculture. Natural spatfall now occurs in several GB sites. Some spat settlement in the southwest of England may have come from French stock, with possible vectors including transport by current systems, discarded food waste, transport on ship's hulls and intentional (illegal) introductions.

Species Status
Farmed populations occur throughout England, Scotland, Wales and Ireland, and are widespread in Europe. It was initially presumed that temperatures in GB waters would not be suitable for Pacific oysters to successfully spread, settle and spawn in GB waters, but escapees have established feral populations in south-east and south-west England and Wales. There are extensive beds of naturally recruited Pacific oysters in some southern estuaries of England and sparse settlements are known from the north coast of Wales near Conwy.

Ecology & Habitat

Dispersal Mechanisms
Pacific oyster larvae are planktonic for three to four weeks, during which period they are dispersed by tidal currents; larvae are documented to travel up to 1000 km on ocean currents although such distances are unlikely in GB waters. Dispersal of larvae may allow new populations to colonise areas too cold for successful reproduction.

Reproduction
Pacific oysters change sex during life, most commonly maturing first as males before subsequently transforming into females. Spawning is temperature dependant and breeding occurs during summer months at temperatures of around 18 °C. Each individual may release 50 to 60 million eggs up to a maximum of 100 million eggs although juvenile mortality is high. Fertilisation takes place externally and larvae are planktonic for three to four weeks before settling; the lower shell valves are cemented onto hard substrate.

Known Predators/Herbivores
Pacific oyster larvae are consumed by filter feeding animals. Juveniles are eaten by a variety of species including worms, snails, starfish, fishes, birds and crabs. Adults are less vulnerable to predation, but may be preyed upon by birds, starfish and large crustaceans.

Resistant Stages
None known.

Habitat Occupied in GB
Pacific oysters inhabit intertidal and shallow subtidal estuarine and coastal waters, settling on hard substrate. Where rocky substrate is scarce the oysters settle on any available hard substrate including rocks and other shells, and can form dense reefs by cementing their shells to each other.

Distribution
Native range Japan and Northeast Asia. In GB the Pacific oyster is farmed at several locations around GB coasts and estuaries. Escapees have established populations in estuaries in the south-west and south-east of England, and sparse settlements are known from the north coast of Wales near Conwy.

Impact

Environmental Impact
In North America the Pacific oyster is known to settle in dense aggregations, excluding other intertidal species. In the Dutch Wadden Sea and more recently in the GB the oysters have started to form reefs consisting of dense layers which can alter the natural state of the ecosystem, posing a potential threat to native species and altering habitats, some of which are protected under European law. In the Wadden Sea it has been suggested that these reefs could cause major shifts in benthic filter feeding populations, which could have detrimental knock-on effects on bird populations.

Health and Social Impact
The sharp oyster shells pose a hazard to humans; the formation of reefs on mudflats may render the intertidal zone unsuitable for human leisure activities.

Economic Impact
The Pacific oyster is presently the most widely grown bivalve in aquaculture around the world. In 2006 1400 tonnes were produced in the GB. However, where oysters establish wild populations economic losses may occur through the loss of mussel and other bivalve fisheries.

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Appendix G

(From The Pacific Oyster)

Extracts from the 2011 Risk Assessment

Question, Answer and Uncertainty	**Comment**
What is the Risk Assessment area? GB coastline, in particular the south and south east coast of England, but also the south west of England, Wales and the North West.	Habitats comparable to those in the Wadden Sea are considered most at risk, including intertidal mudflats and sand flats and shellfish beds. Also considered at risk are areas of intertidal biogenic reef. Note references to the Wadden Sea reflect its similar habitats and species, **although UK habitats directly comparable to the Wadden Sea area are limited**.
Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank? YES	Phyla: Mollusca, Class: Bivalvia, Order: Ostreoida, Family: Ostreidae, Genus/species: Crassostrea gigas **There is currently some debate over whether or not C. angulata (the Portuguese oyster) is in fact the same species**. Whilst the 2 species are often considered synonymous, **recent research suggests that both are separate species of Asian origin** (Batista et al 2006).
List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on? moderate number - 2 LOW - 0	Further aquaculture introductions. A study (Child et al 1995) has shown that some spat settlement in the southwest of England has come from French stock. Authors suggest a number of possible vectors of this stock including transport by current systems, discarded food waste transport on ship's hulls and **intentional (illegal) introductions**.
How likely is the organism to be associated with the pathway at origin? **very likely – 4** LOW - 0	Following **initial importation of a small number of individuals from Canada to the UK in 1965** (Drinkwaard 1999) C. gigas is now bred in 3 UK hatcheries and oyster seed is distributed widely to sites around the UK and Ireland where on-growing takes place in open systems. This involved the release of 206 million individuals in 2005 and 708 million in 2006, (Cefas 2007).
Is the concentration of the organism on the pathway at origin likely to be high? **very likely – 4** LOW - 0	In 2006, 708 million individual spat were distributed from hatcheries around the UK and Ireland (Cefas 2007). Relative to existing feral populations and in terms of proximity to conspecifics, oysters in culture represent high concentrations of individuals. However, the level of concentration varies between sites and stages of development/ size. The majority of UK growers produce around 5 tonnes of oysters per annum with only a few producing over 10 tonnes (Anonymous reviewer pers com).

How likely is the organism to survive existing cultivation or commercial practices? likely – 3 LOW - 0	**Spatfall has been witnessed outside of the commercial fishing areas. Natural spatfall found in several UK sites.** (Child et al 1995, Drinkwaard 1999)
How likely is the organism to survive or remain undetected by existing measures? likely – 3 LOW - 0	As a benthic species cohabiting with other marine bivalves chemical controls are deemed inappropriate. Recent studies have shown that **early culling of settled individuals and destruction of both valves using a hammer before establishment occurs may be effective** at preventing establishment (particularly in areas where spawning does not take place every year) with minimal impact on surrounding biological assemblages (Guy & Roberts 2010).
What is the volume of movement along the pathway? moderate – 2 HIGH -2	According to the Shellfish Association GB figures, the UK produced 1016 tonnes of farmed pacific oysters in 2004, in 2006, 708 million spat were distributed from UK hatcheries to sites around UK and Ireland (Cefas 2007) A female has the potential to spawn 50-60million eggs (NIMPIS, 2002) Mortality is extremely high at the larval phase and is likely comparable to the >90% mortality rates observed in C. virginica (Gosselin & Qian 1997). Levels of larval mortality are largely dependent on environmental conditions, in particular food availability and temperature (Rico-Villa et al 2009) Settlement success will also be dependent on environmental conditions and availability of suitable settlement habitat. In more northerly locations and in years where water temperatures fluctuate widely the success of larval settlement is likely to be reduced (Syvret et al 2008 and anonymous reviewer pers com). It should be noted that spawning by oysters in an on growing situation is looked upon unfavourably by the industry due to reduced product quality and other negative impacts to the industry associated with wild spat settlement. Some growers therefore take actions to discourage spawning (Anonymous Peer revier pers com). **The high level of uncertainty reflects the need for far more research into potential for larval success and movement in the risk assessment area.**
How frequent is movement along the pathway? **often – 3** LOW - 0	**Frequency of oyster farming is continuous**. Spawning occurs only when water temperatures exceed 18 C (Mann 1979) and recruitment is likely to be sporadic and limited to unusually warm summer temperatures (Diederich et al 2005).
How widely could the organism be distributed throughout the Risk Assessment area? **widely – 3** MEDIUM - 1	**Suitable habitats exist for C. gigas throughout the UK** with 290,000 hectares of mudflats/sandflats, 283,060 hectares of shallow bays and inlets some of which are likely to include suitable habitat for C. gigas settlement. C. gigas are also likely to inhabit rocky shores and man-made hard structures, which are widely spread around the UK. A variety of Biotic and Abiotic factors will affect the successful spawning and

	recruitment of *Crassostrea gigas*, including temperature (including biological resource debt resulting from prolonged exposure to cold winter conditions), trophic interactions and nutrient availability, adverse hydrodynamics and pollution (e.g. TBT). Syvret et al (2008) undertook analysis of risk of natural recruitment of C. gigas for regions of the British Isles. Based on his results, Scotland and the North-East of England are considered low risk. Northern Ireland, Wales and South West England are considered moderate risk and South and South East England are considered to be high risk.
How likely is the organism to arrive during the months of the year most appropriate for establishment? **very likely – 4** **LOW - 0**	**Organism is already present within the marine environment** and as such is present during times of optimal environmental conditions required for spawning and natural spatfall.
How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat? likely – 3 MEDIUM -1	Introduction of C. gigas for aquaculture into new sites where conditions are suitable for reproduction is likely to lead to spatfall and is likely to contribute to the establishment of further populations. Elsewhere **in North West Europe, spread of feral populations of C. gigas have been documented on numerous occasions following release of Spat for culture** (Troost 2010). Processing and consumption is unlikely to aid transfer although it has been suggested that discards from the food industry are a potential vector of introduction (Child et al 1995).
How likely is the organism to be able to transfer from the pathway to a suitable habitat? **likely – 3** MEDIUM -1	Dependant on suitable environmental conditions such as temperature. **These optimal temperature conditions have already occurred in and aided transfer along the North West Coast of Europe from Denmark to Portugal, and several sites in the South West of the UK** (See for example Troost 2010 & Child et al 1995)
How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution? similar – 3 MEDIUM - 1	Salinity gradients will vary within estuaries. C. gigas is tolerant of wide ranges of salinity (Chu et al.,1996) **Habitats exist throughout the risk assessment area with abiotic conditions similar to areas in North West Europe, where C. gigas has become established**. However, certain factors, including pollution and hydrodynamic regimes may influence establishment in some areas. **Suitable substrata are varied** with C. gigas being found on rocky shores as well as more traditional oyster/mussel reefs.
How many species (for herbivores, predators and parasites) or suitable habitats vital for the	As a benthic bivalve **there are many suitable habitats**, the primary habitats for forming reefs are seen to be shallow intertidal mudflats as per the Wadden sea. C. gigas may live both in intertidal and subtidal habitats. In the Wadden Sea, it

survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the number. **very many – 4** LOW - 0	mainly lives in the intertidal in the same zone as blue mussels. **Pacific oyster larvae may settle on all kind of natural and artificial hard substrates as mollusc shells, living molluscs, wood, stones, concrete and others.**
How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area? **likely – 3** MEDIUM - 1	**C. gigas is seen to outcompete both the native oyster (O. edulis) and the blue mussel (M. edulis), and has been found to reduce suitable habitat for cockles** (Diedrich, 2006). Competition for space and resources may be caused by another invasive species, the slipper limpet *Crepidula fornicata*. There is also anecdotal evidence that settlement of the blue mussel (M. edulis) and barnacles on C. gigas in cultivation occurs to levels which may inhibit the life functions of individual oysters or smother stocks. (anonymous peer reviewer pers com)
How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area? **moderately likely – 2** MEDIUM - 1	There is some conflicting information between Australian reports (NIMPIS, 2002; Shatkin et al., 1997) and European reports (Wadden Sea). **Pacific oysters are consumed by a variety of marine animals** as Asteroid echinoderms, boring gastropods, boring bivalves, spionid polychaetes. Carcinus maenas in the intertidal, benthic feeding fish, lobsters in the subtidal zone, black ducks, eider ducks, and wading birds (NIMPIS, 2002). **Predation is likely to be far higher in newly settled juveniles**, so much so that the industry now seeks to purchase seed stock at the largest economic size to reduce predation (anonymous reviewer pers com). In the Wadden Sea, predation from birds seems to be very limited. Unlike blue mussels, **oyster are only consumed by a few bird species** (herring gulls and the oyster catcher)(reviewed in Troost 2010). Juveniles apparently have far more natural enemies, including the shore crab (Carcinus maenus) which will take individuals up to 40 mm and common starfish (Asterias rubens) taking individuals up to 60 mm although in laboratory studies both have been shown to feed preferentially on mussels (m. edulis) predatory gastropods are also known to consume juvenile oysters and another invasive non-native species, the American oyster drill (Urosalpinx cineria), known to be present in the UK in a limited geographical range is a particularly voracious predator of young oysters (Troost 2010). In the Wadden Sea, it is considered that a reduced number of natural predators compared to the native range supports the 'enemy release hypothesis' (Troost 2010) a similar situation is likely to be the case in the UK. Infestations by the polychate worm Polydora ciliata have adverse impacts on the biology of C. gigas and may increase vulnerability to predators and impair other life processes (Chambon et al 2007). In cultivation practices, removal of fouling and predator species is the main

	husbandry task, suggesting that unprotected stock may be more vulnerable (Anonymous referee pers com) Energy flow of an oyster reef is anticipated to be highly different from mussel beds and not directed to higher trophic levels. **Oyster reefs are apparently of little value for mussel eating birds** and especially eider ducks Somateria mollissima cannot make use of adult oysters (Diedrich, 2006; Nehls & Buttger, 2007;). Pathogens and parasites impacting stocks in Europe have not currently arrived in UK waters, but if they did, risks to feral and farmed C. gigas would be high (Anonymous reviewer pers com)
How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism? **likely – 3** **LOW - 0**	**Existing controls are predominantly detrimental to other marine organisms in the area. Current husbandry practices are unlikely to prevent establishment.** Internationally the use of triploidy has been effective, but UK experience has shown the technique is not always effective and may have marketability implications for the product (Anonymous referee pers com). Management of feral stocks by harvesting may also be effective at controlling feral populations (Anonymous referee pers com) but would only be limited to specific sites and conditions. **Current existing controls have failed to prevent establishment in some areas.**
How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment? **very likely – 4** **LOW - 0**	As in other bivalves, Pacific oysters have pelagic larvae spending 3 to 4 weeks in a free-swimming phase. In the right conditions **some authors have postulated that larvae may be capable travelling distances of up to 1,300 km** (Global Invasive Species Database 2005 & Stenzel 1961 cited in Ozaka & Fujio 1985) however **such distances would be very unlikely in GB waters. Studies in the German Wadden Sea found larval dispersal distances between 0 and 50 km** (Brandt et al 2008).
How likely is it that the organism's capacity to spread will aid establishment? **very likely – 4** **LOW - 0**	**Whilst the thermal conditions in Northern Europe were thought to be beyond optimal for C. gigas, natural spatfall has occurred**. Therefore it is very likely that the organisms ability to spread via spawning will aid establishment (Spencer et al., 1994).
How adaptable is the organism? adaptable – 3 MEDIUM - 1	**Once adult C. gigas can survive in a wide range of temperature, salinity, dissolved oxygen, and pH conditions** (Eno et al., 1997; NIMPIS, 2002). Larvae are less adaptable and more vulnerable to extreme/ changing environmental conditions (Miossec et al 2009, Anonymous reviewer pers com).
How likely is it that low genetic diversity in the founder population of the	There are a number of founder populations and it is thought that natural spat from France has settled in UK waters (River Teign) (Child et al., 1995).

organism will not prevent establishment? unlikely – 1 MEDIUM - 1	
How often has the organism entered and established in new areas outside its original range as a result of man's activities? **many – 3** **LOW - 0**	**Throughout the North Sea, Wadden Sea, and Atlantic coasts C. gigas has been able to establish itself as a result of natural spatfall within mariculture** (Nehls & Buttger, 2007; NIMPIS, 2002).
How likely is it that the organism could survive eradication campaigns in the Risk Assessment area? **likely – 3** **LOW - 0**	The majority of eradication campaigns would involve destruction of the organism in the environment and it is likely that this would result in environmental degradation, including non-target species.
Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)? **likely – 3** **LOW - 0**	**Given the correct environmental conditions i.e. temperature and substrata, it is very likely that C. gigas will spread through natural migration or anthropogenic activities.**
How rapidly is the organism liable to spread in the Risk Assessment area by natural means? intermediate – 2 MEDIUM - 1	This is **very dependent on optimal temperature conditions** (Song et al., 2007), but in recent years and using case studies such as the Wadden Sea and the Yealm estuary **the spread is likely to be increasingly rapid**. The spread of the Pacific oyster in the Wadden Sea follows the classic pattern of biological invasions with a long phase of stagnancy followed by a fast increase (Diedrich et al., 2005; Nehls & Buttger, 2007; Spencer et al.,1994). A small founder generation has to reach a certain size before a fast growth is possible. However, in the case of the Pacific oyster, **it is likely that the recent spread is facilitated by changing environmental conditions,** especially an increase in summer temperatures (Nimpis, 2002).
How rapidly is the organism liable to spread in the Risk Assessment area by human assistance? slow – 1 HIGH - 2	This is largely dependent on the licencing of further oyster farms and movement of spat and half grown adults.
How difficult would it be to contain the organism	Controlling release of natural spatfall will involve closed systems, which is not currently used by the vast majority of

within the Risk Assessment area? **very difficult – 4** **LOW - 0**	shellfish farming. Or would involve the use of triploidy within the species, this is unlikely to affect areas where C. gigas is already established.
Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.	Areas with suitable substrate, temperature, and salinity conditions and potentially endangered by C. gigas. This includes areas used for wild harvest of cockles, mussels and native oysters.
How important is economic loss caused by the organism within its existing geographic range? moderate – 2 HIGH - 2	**In the Wadden Sea C. gigas has affected mussel, native oyster and cockle beds**, resulting in many studies to ascertain the economic impacts. **Cockles are considered to be more resilient due to mobility but some evidence has been found that *C. gigas* alters both reefs and substrate** (Diedrich, 2006). **It is possible that oyster beds increase settlement opportunities for mussels although the extent to which this will benefit the mussel industry is unclear** (Troost 2010). Feeding interactions and competition with native, commercially important bivalves is likely to be complex **It is likely that the feeding mechanisms of C. gigas and structure will interfere with the feeding success of native bivalve species of commercial importance** (Troost 2010). **Again the possible economic significance of such impacts are unclear**. Escaped spat and feral oyster populations may also represent a cost to the cultured oyster industry. At sites in France, feral oyster are trophic competitors of farmed oysters (e.g. Cognie et al 2007) and in the UK, settlement of spat on farmed oysters and gears creates additional operational costs and may lead to reduced product quality
Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe) in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, likely to be? **minor – 1** MEDIUM - 1	**In the Wadden Sea the C. gigas invasion has been thought to affect mussel and cockle beds, resulting in losses in these commercial fisheries** (Diedrich, 2006; Nehls & Buttger, 2007). Because of the morphology of the shell it has also affected tourism, the shells potentially damaging people because of the sharp edges. Given the current value of wild mussel fisheries of £2.0 million, native oysters of £0.1million, and cockles of £10.1million (all values for wild harvest, 2004 (shellfish.org.uk) economic loss could represent £12.2million per year in an absolute scenario. **However, in terms of community structure no species losses were observed in a 2006 report** (Diedrich, 2006). It also concluded that: **Blue mussels are able to coexist with Pacific oysters in their reefs, and Pacific oyster reefs offer species of blue mussel beds an alternative habitat.** Blue mussel fisheries in the Wadden may be affected by the spread of the Pacific oyster in the future for two reasons. First, **Pacific oysters may settle on culture lots and overgrow the blue mussels. At present, it seems to be unlikely that this will be a major problem** for the fisheries, as Pacific oysters apparently rarely settle on young blue mussels and in general do not settle in high

	densities in the subtidal. As blue mussel cultures are stocked with young seed mussels and are located always in the subtidal it seems at present to be unlikely, that they might be overgrown by Pacific oysters. Second, **oyster may be present on seed mussel beds and make it impossible to fish purely for blue mussels**.
How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area? **minor – 1** HIGH - 2	Although reports are contradictory in the ability of C.gigas to substantially alter the environment through out- competition, or to minimise commercial stocks, there is a risk that overtime **mussel seedbeds will be difficult to fish** because of the presence of oysters. There is also a risk that **cockle beds will be affected, through the substrate changing** to oyster reefs from mud/sand flats resulting in economic consequences for cockle fishers.
How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area? **minor – 1** HIGH - 2	**No evidence has been found to suggest whether or not consumer demand for shellfish products will be affected** and this is an area which warrants further study. In terms of consumer demand for recreational activities in coastal and marine areas, ICES (Miossec et al 2009) suggest that the presence of **C. gigas can affect recreational activities in positive and negative ways** and that it's sharp shells make it a nuisance to many recreational activities and lead to injury.
How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets? **unlikely – 1** HIGH - 2	The cockle fishery is predominantly for export, and as such should this fishery be effected it will result in negative consequences for export markets. Native oysters and mussels that are for export may also be affected. Similar to 2.6, these statements are based on an absolute scenario and for the reasons described in section 2.6, **based on current information, serious impacts on export markets are considered unlikely**. Opportunities may exist to market products derived from feral oyster harvesting overseas, for example to Asian countries if legislation allows (Anon Referee pers com 2010).
How important would other economic costs resulting from introduction be? (specify) **minor – 1** HIGH - 2	Other economic costs are likely to be recreation based. Impacts on the amenity value of shore areas (Miossec et al 2009) may reduce recreational activity and tourism in some areas although **negative impacts may be offset by potential positive impacts. It is likely that there will be positive impacts to the oyster farming industry resulting from introduction and sale and export of oysters**.
How important is environmental harm caused by the organism within its existing geographic range? **moderate – 2** MEDIUM - 1	**C. gigas is a trophic competitor for other bivalves**, in the context of end-member supply limitation (Decottignes et al., 2007).Other non-native species have been introduced as a result of C. gigas introduction elsewhere in the . **In Sylt, Wadden Sea previously known mussel beds have now been transformed to oyster reefs within the intertidal.** Pacific oysters are today found in all parts of the Wadden Sea. **They**

	form dense layers which have all characteristics of reefs on former beds of the blue mussel Mytilus edulis and settle on all other kind of hard substrates. Within the Yealm estuary, community composition within the oyster beds is found to be high, with species density also being high within those species observed.
How important is environmental harm likely to be in the Risk Assessment area? **moderate – 2** MEDIUM - 1	**C. gigas is a trophic competitor for other bivalves**, in the context of end-member supply limitation (Decottignes et al., 2007). And would likely impact populations of native bivalve species, including mussels and the native oyster. **Other non-native species, including oyster pests, pathogens and algae have been introduced worldwide, including North West Europe as a result of C. gigas introductions and movement** (Miossec et al 2009, Verlaque et al 2007). A number of potentially damaging species are already present in the Britain and Ireland (for example the sting winkle *Urosalpinx cinerea* and the algae *Undaria pinnatifida*) and **transport of oyster stock from infected to uninfected sites could potentially facilitate the spread of these species**. Introductions of the non-native copepods *Mytilicola orientalis* and *Myicola ostrea* took place in Ireland in 1993 when half grown oysters were imported from France (Holmes and Minchin 1995 cited in Miossec et al 2009) . Illustrating the need to maintain the currently strict regulations in the UK. **In Sylt, Wadden Sea previously known mussel beds and mud flats have now been transformed to oyster reefs within the intertidal. It is likely that similar habitats will be affected should C. gigas spread**. A loss of mudflat, mussel beds and other habitat, exacerbated by the **expansion of C. gigas reefs may impact wider ecosystems by reducing feeding sites for fish, birds and other organisms**. A study in British Columbia found that while oysters and eelgrass coexist at a regional scale, eelgrass is typically absent directly seaward of oyster beds. Concluding that, the below-oyster zone is unsuitable for eelgrass growth; **if a causal link exists between oyster presence in the high intertidal zone and eelgrass absence directly seaward, then expansion of feral and farmed oyster beds may result in further eelgrass loss** on Cortes Island (Kelly & Volpe, 2007). It is reasonable to expect that if C. gigas spreads to areas where eelgrass beds exist in the UK, eelgrass loss may occur. **Recent studies in the USA (Wall et al 2008) suggest that the presence of filter feeding bivalves may increase eelgrass productivity. However, the study was undertaken using native species to the area in specific environmental conditions and whether similar benefits would occur in UK waters with the introduction of C. gigas is not clear**. Cognie et al (2007) suggest that wild C. gigas may be trophic competitors and compete for space with the reef-forming polychaete Sabellaria alveolata (protected under the habitats directive).

How important is social and other harm caused by the organism within its existing geographic range? **minor – 1** MEDIUM – 1	This has been very much dependent on the impacts on coastal communities. **In some areas of the Wadden Sea the coastline has become less desirable to walk on** because of the sharp shells (NIMPIS, 2002), As noted above the oysters have potentially affected eelgrass beds which will have potential impacts ecologically that may further impact economically important fish stocks.
How important is the social harm likely to be in the Risk Assessment area? **minimal – 0** HIGH - 2	This is very much dependant on the impacts on communities that rely on commercial species such as mussels, and any resultant drop in the value of commercial stocks as a due to *C. gigas* . Loss of seaside amenity due to hazardous/ nuisance feral oysters is another potential impact (Miossec et al 2009 and Syvret et al 2008). There have been few studies which the authors are aware of to quantify this issue.
How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious Unlikely – 1 HIGH - 2	**There has been no evidence, to date, of *Crassostrea gigas* modifying their genetic nature. This is an area that minimal literature exists.**
How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced? Moderately likely – 2 MEDIUM - 1	Natural enemies such as the common shore crab, and barnacles will effect settlement and the spread of C.gigas. These predators and other natural predators such as avian species have had little effect on the rate of spread in other areas.
How easily can the organism be controlled? **Very difficult – 4** MEDIUM - 1	**Eradication is unlikely to be an option in many areas. From the social and economic perspective, Pacific oysters are the most important commercial oyster species in the UK and Europe. There is no compensation measure in place to reimburse the financial investment made by commercial producers into Pacific oyster cultivation (at the national and European level).** Unilateral action by the UK is unlikely to be an option, due to the potential for spat settlement from Europe (Child et al 1995). Secondly, Pacific oysters occur in many other European countries (see reports of the ICES Introduction and Transfer of Marine Organisms Working Group) from where natural spread is likely to occur in the future, whether by natural spread linked to climate change or accidental introduction through human activities, e.g. leisure boats, marinas (Anon referee pers. com.). Miossec & Goulletquer (2007) report that In an enclosed lagoon In France removal of feral C. gigas, associated pests (oyster drills and the slipper limpet C. fornicata) and suitable settlement structures (in particular abandoned shellfish gear) was undertaken using

	adapted caterpillar tractors and a barge. In 2004 a total of 600 Hectares was cleared at a cost of 610,000 Euros. An assessment of potential environmental impacts resulting would be required before any such clearance operations could be recommended in other areas.
How likely are control measures to disrupt existing biological or integrated systems for control of other organisms? **Very likely – 4** **LOW - 0**	
How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms? Moderately likely – 2 MEDIUM - 1	Globally and elsewhere in Europe, other invasive species have settled as a result of introducing the organism, such as: Mytilicola orientalis, Undaria pinnatifida, Crepidula fornicata. P.35 Nehl and Buttger (2007) gives a comprehensive list of associated introductions. **In the UK we have no evidence that C. gigas has introduced pathogens or parasites to native aquatic animal species.** However, C. gigas are a susceptible species for two of the three exotic molluscan pathogens listed in 2006/88 (Perkinsus marinus and Microcytos mackini, both currently found in the USA). **It is not recognised as a susceptible species of the two endemic molluscan diseases, Bonamia ostreae and Marteilla refringens. there have been large scale movements of C. gigas and no field evidence that they have spread these diseases within the EU** (e.g. by acting as mechanical vectors). The movement of Pacific oysters to France (from the US) appears to have resulted in the introduction of Haplosporidium nelsoni (not listed by OIE or EU) but seemingly with no identified consequences to date. We do not have evidence that H. nelsoni is present in the UK, but its introduction might be possible if oysters are transferred from France to the British Isles for aquaculture.
Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur	Areas in the vicinity of c. gigas growing sites or feral populations or down-stream of these sites are likely to experience spatfall if conditions are favourable. This is most likely at sites in the South and South East of England, moderately likely and less regularly in Northern Ireland, Wales and the south west of England and less likely in Scotland and North West England due to water temperatures (Syvret et al 2008). Within these areas, sites used for recreation/ tourism and sites containing species of commercial interest, likely to be adversely impacted by the presence of C. gigas are likely to be most impacted. **Genetic evidence shows that spatfall in the River Teign originated from French stock (Child et al 1995), although it is unclear whether this was from adult specimens discarded at English sites or from larvae that crossed from the French side of the channel. Should the latter be the case, it would appear that, under favourable**

	conditions for larval development, Crassostrea gigas has the capacity to spread substantial distances.
Summarise Entry **Very likely – 4** **LOW - 0**	**Entry and spread into new areas very likely due to connectivity of suitable habitat and suitable environmental conditions and wide dispersal potential of larvae.** Most likely to spread from feral populations given high dispersal potential. Spat settlement from new and existing oyster farms is possible given the right environmental conditions. Spread from food or processing activities is unlikely.
Summarise Establishment **Very likely – 4** **LOW - 0**	Establishment is likely due to abundance of suitable habitat, favourable environmental conditions. Known to out compete native species sharing similar habitat requirements. Establishment is unlikely to be prevented by predation.
Summarise Spread Intermediate – 2 MEDIUM - 1	Once established, spread is likely given the appropriate environmental conditions (primarily temperature). Further anthropogenic spread is also possible. Further spread may endanger a variety of areas around the coast, including estuaries, mudflats, eelgrass beds and rocky shores within the vicinity of existing feral and farmed populations.
Summarise Impacts Moderate – 2 **HIGH - 2**	**Primary economic loss may be though loss of mussel bed fisheries and loss of habitat for other intertidal bivalve species**. Economic and social impacts may also be associated with loss of visitors to sites as oysters create a hazardous substrate. Environmental impacts are largely associated with loss of intertidal habitats, including mudflats and bivalve beds. Such impacts may affect habitats of high conservation value, including mudflats, estuaries, eelgrass beds and biogenic reefs. Spread by humans may also facilitate the spread of further non-native and 'pest' species.
Conclusion of the risk assessment MEDIUM – 1 MEDIUM - 1	**Entry and spread into endangered areas is very likely due to connectivity of suitable habitat, suitable environmental conditions and wide dispersal potential of larvae.** C. gigas is most likely to spread from feral population. However spat settlement from new and existing oyster farms is possible given the right environmental conditions and suitable settlement substrate. Spread from food or processing activities is unlikely. Given the quantity of suitable habitat in the UK and increasing suitability of conditions for reproduction (as seas become warmer with climate change), establishment is very likely in the endangered area. Predation and competition are also unlikely to prevent the establishment of C. gigas in these areas. **The extremely high dispersal distance and fecundity of C. gigas, coupled with tolerance of wide salinity and temperature ranges and wide range of suitable habitat type means that once established in endangered areas, spread is highly likely**. This spread may however be limited by temperature. The most important economic loss is likely to be

	through loss of mussel bed fisheries and loss of habitat for economically important intertidal bivalve species such as cockles. Economic and social impacts may also be associated with loss of visitors to sites as oysters create a hazardous substrate. Environmental impacts are largely associated with loss of intertidal habitats, including mudflats and bivalve beds. Such impacts may affect habitats of high conservation value, including mudflats, estuaries, eelgrass beds and biogenic reefs. The loss of bird feeding grounds may also result in impacts on native bird populations. Spread by humans may also facilitate the spread of further non-native and 'pest' species.
Conclusions on Uncertainty MEDIUM - 1	**Overall, the information available with, which to complete this risk assessment for C. gigas is considered to be fairly good**. Some areas require further study, particularly the source of new oyster spat in the South of England and whether or not spat is released by UK farmed stock needs to be identified. **A good amount of information about the life history of C. gigas is available, reflecting the commercial importance of the species.** Trophic interactions, competition for space and rate of spread is quite well studied in Europe (e.g. French lagoonal and Wadden Sea studies), but less studied in the UK. **Due to climatic differences and other variables, further study should be undertaken to establish whether potential impacts are similar in UK waters.** Studies into the potential impacts of oysters on features of particular conservation importance (e.g. Eel grass beds and biogenic reefs such as *Sabellaria alveolata*) are also limited, particularly in the UK.

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